MANET Performance Measurement of DYMO Routing Protocol by Varying Density and Mobility Speed

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ABSTRACT

A mobile ad hoc network (MANET) is a collection of wireless mobile nodes that able or allow communicating with each other without the use of network infrastructure or any centralized administration. The mobile nodes can perform as a host and a router forwarding packets from the source node to the destination nodes. This paper describes some characteristics of Dynamic MANET On-demand (DYMO) as ad hoc routing protocols. Different conditions will affect the performance of the DYMO routing protocol due to the small size of the network area and low mobility speed, it will degrade the performance of DYMO because it can cause more overhead for the protocol. By varying number of nodes and mobility speed in the network, performance metrics such as packet delivery ratio, throughput, and packet loss rate measured. Simulations of routing protocols are to analyze the performance of DYMO in different conditions performed in OMNeT++.

Keywords: *DYMO, routing protocol, MANET, density, mobility speed.*

I. INTRODUCTION

MANET is a network consists of mobile nodes characterized by infrastructure fewer networks, which makes any node in the network act as a potential router. MANET characterized by a dynamic and rapidly changing topology. It causes classical routing algorithms to fail to perform correctly since they are not robust or strong enough to assist in such a changing environment. In MANET, communication between mobile nodes always requires routing over multi-hop paths instead of using static network infrastructure to provide network connectivity. MANET also has few important characteristics which including dynamic topology, bandwidth-constrained, links, energy constrained operation and limited physical security. Routing protocols can classify into three categories as shown in Figure 1.

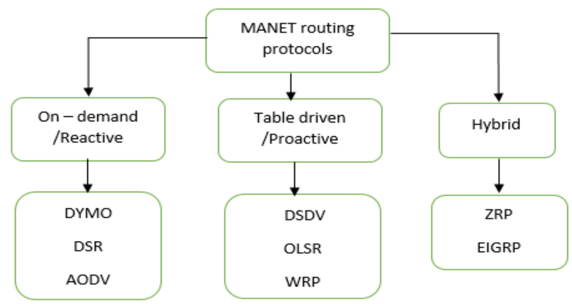

Figure 1: Routing protocols in Mobile ad-hoc network [1]

The DYMO routing protocol was one of the reactive protocol or on-demand. DYMO is an inherited or enhancement of the existing AODV routing protocol and has been proposed by Perkins & Chakeres [2].

DYMO consists of two basic protocol operations includes route discovery and route maintenance. Route discovery is responsible for identifying the right route (valid path) from the source node to the destination node, including route request (RREQ) and route reply (RREP). Route maintenance is responsible to keep an established new route, including route error (RERR) and to prevent existing stale routes from routing tables in order to reduce packet loss due to the node and link failure. DYMO determines unicast routes between nodes in the network. When a node wants to transmit information to another node, a route request (RREQ) transmitted to all nodes in the range. When a node receives a route reply (RREP), it attaches information about itself in the RREP and sends it as a unicast packet to all nearby nodes [3].

The discussion of routing protocols classification as below:

A. Reactive or On-demand Routing Protocols

The reactive routing protocol also called on-demand routing protocols because the route only constructed when nodes want to communicate with each other. The reactive routing protocol will start searching route in an on-demand way and build a connection for sending and receiving data if there is any node wants to send data to other nodes or wants to communicate. The main goal of on-demand routing protocols is to minimize the network traffic overhead. Route discovery and route maintenance processes used to communication between any nodes in the network [4]. Some common examples of reactive or On-demand routing protocols are as following:

- AODV (Ad-hoc on-demand routing protocol)
- DYMO (Dynamic MANET On-demand protocol)

B. Proactive or Table-driven Routing Protocols

Proactive routing protocols also known as table-driven protocols because each node maintains routing information to each node in the network regularly. The routing tables are periodically updated when the topology of the network changes [5]. Proactive protocols require more power and bandwidth for transferring updated routing information. The main limitation is the chance to create loops within the network increases. Some common examples of table-driven or proactive routing protocols are as the following:

- DSDV (Destination Sequenced Distance Vector Routing Protocols)
- OLSR (Optimized Link State Routing Protocol)

C. Hybrid routing protocols

The hierarchical routing protocol also called a hybrid routing protocol because it combines the features of reactive and proactive routing protocols. The main advantage of the hybrid routing protocol is that the proactive routing used for a small distance and reactive routing used for long distance. Routes overlapping and longer delay are the main disadvantages of hybrid routing protocols, and nodes consume more memory and battery [6][7][8]. Some common examples of hybrid routing protocols are as the followings:

- ZRP (Zone Routing Protocol)
- EIGRP (Enhanced Interior Gathering-based Routing Protocol)

II. RELATED WORKS

Dynamic MANET On-demand routing protocol is one of the reactive routing protocols. DYMO implements three messages that are route request (RREQ), route reply (RREP) and route error (RERR). RREQ used by the source node to discover any valid path to that particular destination node. RREP roles are to set up a route between destination and source node and all the intermediate nodes that are involved between them. RERR used to indicate an invalid route from any intermediate node to the destination node. DYMO consists of two basic operations that are route discovery and route maintenance. In route discovery, if the source node has no route entry to the destination node, it will broadcast the RREQ message to its intermediate neighbor node. If the neighbor node has an entry destination, it replies with the RREP message.

Otherwise, it broadcasts an RREQ message. While broadcast the RREQ message, the intermediate node will attach its address to the message. Every intermediate node that distributes the RREQ message makes a note or mark of the backward path or accumulation path. Route maintenance happened with the help of the RERR message. If there is any link failure or broken, the RERR message will be generated. Generating node multicasts RERR message to only nodes that involved with a link failure. If there are any nodes that have a packet to the same destination after deletion route entry, the route discovery process needs to initiate again.

With respect to Figure 2, source node 1 wants to communicate with destination node 7. It generates an RREQ packet that contains its own address, sequence number, hop count, a destination address, and broadcasts it on the network. Each intermediate node having a valid path to the destination keeps on adding its address and sequence number to the RREQ packet as shown with nodes 2 and 5 to reach the destination. The source node will be waiting for an RREP message from the destination node. If the source does not receive RREP within a specified time to live (TTL) value, RREQ will resend. TTL is a lifespan limit for data transmission in the network.

Each node maintains a unique sequence number in order to avoid loops in the route and to delete the stale packets. As mentioned before, DYMO ensures a free loop. Every time an RREQ sent to other nodes, the router updates its sequence number. If the incoming packet has the same or lower than the previous sequence number, the information deleted while for messages with superior sequence numbers will be updated in the routing table.

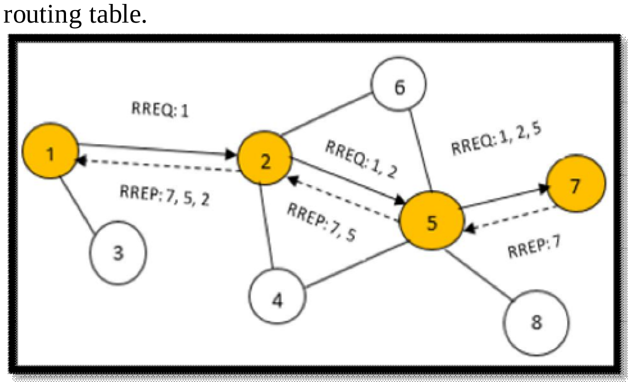

Figure 2: DYMO route discovery [10]

The route maintenance process occurs due to the link failure between intermediate nodes to the destination node. The RERR message generated by a node when a link to any other node breaks. The generating node multicasts the RERR message to only those nodes that are concerned with the link failure. Broken link deleted and routing table updated. If any of the nodes have the same destination after the deletion of the route entry, the route discovery process will re-initiate [9].

Figure 3 shows node 2 has received a packet that needs to go to node 5. However, the route from node 2 to node 5 is broken. In this case, a RERR message generated by node 2 and forward towards the source node 1 in order to inform that the failure link could not be used anymore for packet transmission. All the intermediate nodes on the path update their routing table entries with the new updated information regarding link failure and will discover a new route. Now the packets will be forwarded from node 2 towards node 4 and then to node 5 and lastly to node 7, the destination node.

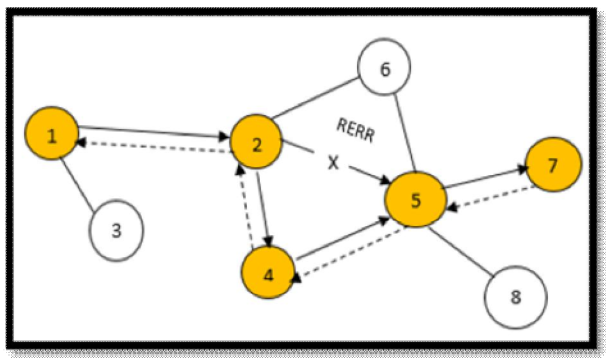

Figure 3: DYMO route maintenance [10]

In addition, based on the performance analysis of reactive routing protocols AODV, DYMO, DSR, LAR in MANETs, [1] analysed the performance and compare the routing protocols Adhoc on-demand distance vector (AODV), Dynamic MANET On-demand (DYMO), Dynamic Source Routing (DSR) and Location-Aided Routing (LAR) by varying network size and mobility speed to different levels. Performance metrics analysed were throughput, average end-to-end delay, average jitter, energy consumed in transmit mode and energy consumed in receive mode with the help of the Exata simulator. From the results, DYMO and AODV showed a steady state of performance for all mobility speed and network sizes.

On the other hand, performance analysis of different routing protocol for Mobile Ad-Hoc Network has been observed on 36 nodes with a traffic load of 10 using Qualnet simulator for different routing protocol including ANODR, AODV, DSMO, FISHEY, LANMAR, LAR, OLSR, STAR, and ZRP [2]. For the quality of service (QoS), end to end delay and average jitter are measured in the application layer while transmitting power, receive power and ideal power are measured in the physical layer. Based on the simulation results, DYMO has a high average end-to-end delay compared to other routing protocols. However, LAR showed the highest average end-to-end delay.

Furthermore, according to Antonio Russoniello and Eric Gamess [3] analysis, both reactive and proactive routing protocols (AODV, DSR, DSDV, BATMAN, DYMO, OLSR) in scenarios with high-speed mobility by using OMNeT++. Results analysis show DYMO has better performance in terms of packet delivery ratio despite that DYMO presents the higher average end-to-end delay in all scenarios. By varying number of nodes, the performance comparison of routing protocols in MANETs shows in terms of packet delivery ratio, AODV, DSR has a higher value than other protocols (DSDV, OLSR, and DYMO) [7].

Evaluating performance to determine the effects of pause time on DSR, AODV, and DYMO routing protocols in MANET by varying number of the pause time (30, 50, 70, 90 and 110)m/s showed that DYMO performs better than DSR and AODV due to less end-to-end delay [8].

On the other hand, [10] varying pause time for network size of 40 nodes against different performance metrics which are end to end delay, routing overhead, packet delivery ratio and throughput which the simulations have performed on Fedora 10 as the operating system and NS2 as the platform for simulating the protocols along with software such as "Trace graph" which is software for plotting graphs from the trace files. The results showed that DYMO has the highest throughput since DYMO has the ability to search route faster because it prevents expiring good route by updating route lifetime appropriately.

To improve the QoS performance of DYMO routing protocol in cognitive radio ad hoc networks, it has been observed the performance of modified CR-DYMO, DYMO, and CR-DYMO through performance metrics such as average throughput, packet delivery ratio, average end-to-end delay, routing overhead, normalized routing load, energy left through responsive (TCP) and nonresponsive (UDP) traffic agents with the help of NS2 simulator. The simulation results are statistically proved using the ANOVA tool. From the experimental results indicate that the Modified CR-DYMO routing protocol performs better in all terms of performance metrics under FTP and CBR traffic when compared to DYMO and CR-DYM [11].

Thus, [12] evaluate the performance of DYMO and AODV routing protocols in terms of routing overhead, average end to end delay and packet delivery ratio. By varying pause time (0, 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 seconds) with 50 number of nodes by using NS2 simulation tools. Simulation results showed that DYMO has a lower average end to end delay than AODV due to an increase in data packet transmission delay with decrease node pause time indicate the mobility reduced lead to changes in network topology were decreased.

Performance analysis of AODV and DYMO routing protocols in MANETs using cuckoo search optimization [13] analyse and compares AODV and DYMO performance by using Network Simulator-2. Analysis results revealed the end-to-end delay of AODV and DYMO protocols with cuckoo search optimization algorithm is less as compared to simple AODV & DYMO routing protocols. Hence, the performance of cuckoo search based AODV & DYMO routing protocols is better as compare to simple AODV & DYMO. The packet delivery ratio of AODV and DYMO protocols with the Cuckoo Search Optimization algorithm is higher as compare to simple AODV & DYMO routing protocols.

Based on energy optimization in MANET using on-demand routing protocol implemented an adaptive HELLO messaging scheme to determine the local link connectivity information and to monitor the link status between nodes of DYMO in order to reduce the energy consumption of mobile nodes to a certain range. In this project, Optimized Network Engineering Tool (OPNET) is used for computer network modelling and simulation. Two simulation runs with different packet inter-arrival times in order to examine the effect of the packet generation rate. End to end delay and link utilization measured when packets transmitted and received. End to end delay will be affected if the packet inter-arrival time is varied. It showed that if packets are sent quickly to a transmitter, some of the packets be delayed in the transmitter's queue [14] [15].

Performance evaluation of routing protocols [16] in WSN using QualNet simulation tools indicated routing protocol that includes DYMO, DSR, OLSR and ZRP using Random Waypoint model showed high throughput values compare to OLSR and ZRP. However, DSR is the highest performance in terms of throughput and total packet received.

Mayur et. al investigated the effects of transmission range to QoS to evaluate the performance of the World Wide Interoperability for Microwave Access (WiMAX) network that used to provide a wireless solution in the metropolitan area networks in term of throughput, end to end delay, and jitter. AODV, DYMO, and ZRP routing protocols applied for created mobility scenarios with variable transmission range. Qualnet used a simulator to perform the simulation. Regarding the result analysis, DYMO showed the best performance among the other protocols in terms of end-to-end delay and jitter for MANET since it has the lowest values. However, ZRP has high throughput in varying transmission range scenarios. Meaning that AODV and DYMO protocol is the ideal choice for communication under the 40dbm transmission range [17].

Stuti et. al [18] examined two mobility models performance such as Random Waypoint and Group over the increasing number of number of nodes over different mobility models. Different routing protocols that implement in this research are AODV, DSR, DYMO, and ZRP. The result exposed that DSR record the best performance compared to others in terms of the four performance metrics as mentioned above. Despite that, DYMO performs best compared to ZRP and AODV in terms of average end-to-end delay and jitter because it has the second lowest values.

III. PROTOCOL DESCRIPTION

This section gives some descriptions of ad-hoc routing protocol studied in this work which is the DYMO routing protocol.

A. Dymo

Dynamic MANET On-demand (DYMO) routing protocol is one of the reactive routing protocols and implements three messages during routing are route request (RREQ), route reply (RREP) and route error (RERR). [18] RREQ used by source nodes to discover a valid path to the specific destination node. RREP roles are to set up a route between destination and source node and all the intermediate nodes between them. RERR used to indicate invalid routes from any intermediate node to the destination node. DYMO consists of two basic operations are route discovery and route maintenance [7] [19]. In route discovery, if source no route entry destination, it will broadcast RREQ message to its intermediate neighbor. If the neighbor has an entry destination, it replies with the RREP message. Otherwise, it broadcasts an RREQ message. While broadcast the RREQ message, the intermediate node will attach its address to the message. Every intermediate node that distributes the RREQ message makes a note of the backward path. Route maintenance accomplished with the help of the RERR message. If there is any link failure, the RERR message will be generated. Generating node multicasts RERR message to only nodes are concerned with a link failure. If there are any nodes face packet to the same destination after deletion route entry, the route discovery process needs to initiate again. [4] [20] DYMO uses sequence numbers as they have proven to ensure loop freedom. DYMO does not store the network topology but nodes compute a unicast route towards the desired destination only when needed. As a result, little routing information exchanged, which reduces network traffic overhead.

B. Flowchart of DYMO routing protocol

In this section, the flowchart for implementing the project will be described. Figure 4 shows the flowchart of the DYMO routing protocol. For transmission packets, if there is any available route, the RREQ message forwarded until reach the destination. Then, proceed to send the RREQ message in order to transmit data. However, if there is no available route for forwarding the RREQ message, then we need to broadcast RREQ to the neighbors until reach the destination node. When its success to reach the destination node, the RREP message will be sent towards establishing a route to send data. If there is any available route to forward RREQ message but cannot reach the destination, then it needs to broadcast RREQ to neighbors until reach destination then it can proceed to send RREP message. When the route is established, data will be sent. When the route is available, the RREQ message will be forwarded until reach destination. However, if it cannot reach the destination, broadcast RREQ to the neighbors to reach the destination node. Then, if it did not succeed to reach the destination node. It proceeds to add node information to RREQ in order to broadcast again RREQ to neighbors until reach destination node so that it can send RREP message. When the route is established, data will be successful in sending.

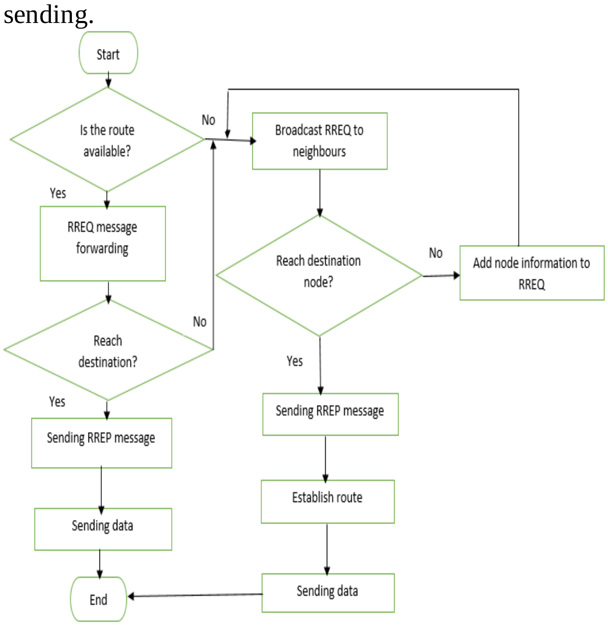

Figure 4: Flowchart of DYMO protocol [21]

DYMO is energy efficient when the network is large and demonstrates high mobility so the overhead for the protocol decreases with the increase in network size and high mobility. [20] On the other hand, DYMO does not work well with low mobility; that the overhead of the control message is high enough and not needed. DYMO shows performance degradation at very low traffic, and the overhead of routing outstrips actual traffic. Despite the fact that DYMO works well when traffic is routed from one part of the network to another.

IV. PROBLEM DESCRIPTION

Problem statements that occurred in this project are DYMO routing protocol does not perform well with low mobility and small network area. Therefore, it will lead to increased overhead and degrade the performance of DYMO. If there are many nodes moves in a small area network with low speed, the potential of the node's transmission successful from the source node to destination node decreasing due to the overhead that occurs between those nodes during transmission. When nodes exchange routing information using the same bandwidth used by data packets, incur overhead to the network which known as routing overhead as the packets are exchanged periodically in certain intervals of time. For instance, it can be hello packets or undesired data packets but consume the bandwidth of the network causing overhead to the network.

A. Random Waypoint Mobility model (RWP)

In the RWP mobility model, nodes move randomly in the simulation area independent of each other because there is no restriction forced on them. The mobile node chooses a random destination and speed at the predefined range and proceeds towards the chosen destination with mobility speed chosen. During transmission to reach the destination, the mobile node pauses for a fixed time before re-initiate the same process again. Speed and pause time help in interpreting the mobility behavior of nodes. Low speed and long pause time result in stable network topology but high speed and short pause time lead to the dynamic topology [18]. A node chooses a destination randomly and moves towards the desired destination node [23]. After reaching its destination, it stops for a specific time known as pause time and the process will be repeated. Each node implemented within a fixed simulation area. RWP model is widely used to simulate MANETs since it imitates the condition where people use mobile phones in a given and selected area, while at the same time they move randomly within the area. Connectivity is an important issue to be deal as it is the random mobility of each node [22].

V. SIMULATION ENVIRONMENT

The simulation used to analyze the performance of the DYMO routing protocol by using OMNET++ version 4.6 with the implementation of INETMANET. The simulation environment discussed the parameter implemented to simulate the MANET environment in the simulation tool. Simulation area 1500m x 1500m with fixed simulation time 1000s. The number of nodes is varying from 20 to 60 nodes. Summary of simulation parameters as shown in table 1.

Table 1: Summary of simulation parameters

Simulation parameters	Values
Simulation area	800m x 800m
Simulation tool	OMNET++ version 4.6
Number of nodes	20, 40, 60
Routing protocol	Dynamic MANET On-demand (DYMO)
Speed	0, 1, 2, 3 (m/s)
Simulation time	200s
Mobility model	Random waypoint
Pause time	2 seconds

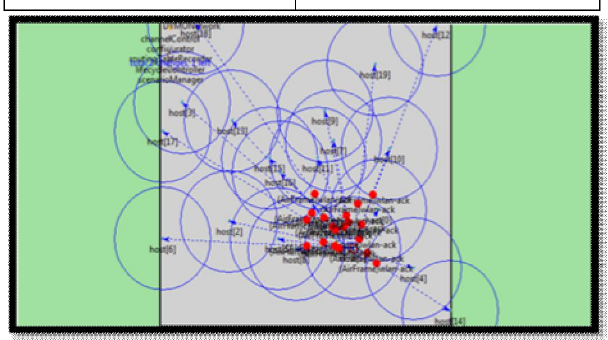

Figure 5: Simulation of MANET area

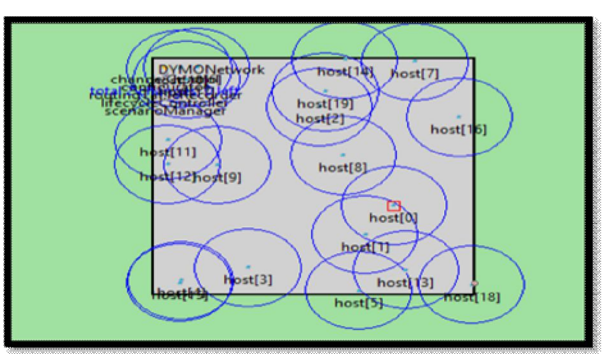

Figure 6: Simulation running with 20 nodes

VI. PERFORMANCE EVALUATION AND RESULT ANALYSIS

The performance evaluation of the DYMO routing protocols analyzed and evaluated through the following performance metrics:

i. Throughput (TP): Throughput is the number of packets successfully delivered per unit time. This is referred to the amount of transmission data from source to destination node [21] [25].

$$TP = (Pr \times \mathrm{SP}) / T$$

ii. Packet Delivery Ratio (PDR): Ratio amount of data packets received by the destination node and total data packets sends by source [2]. It specifies the packet loss rate, which limits the maximum throughput of the network [24].

$$PDR = Pr / Ps \times 100\%$$

iii. Packet loss rate: the difference between a total number of packet received by the destination node and the packet sent by the source node [25].

Where:
SP is the size of packets
T is the time measurement process
Pr is the packet number received by the destination node
Ps is the packet number sent by the source node

Figure 7 shows that the packet delivery ratio increases as the mobility speed increase. It indicates that a reduced number of nodes with high mobility speed contributes to the network topology tending to be stable. Hence, the chance of routing errors is lower, leading to reduce the packet loss rate.

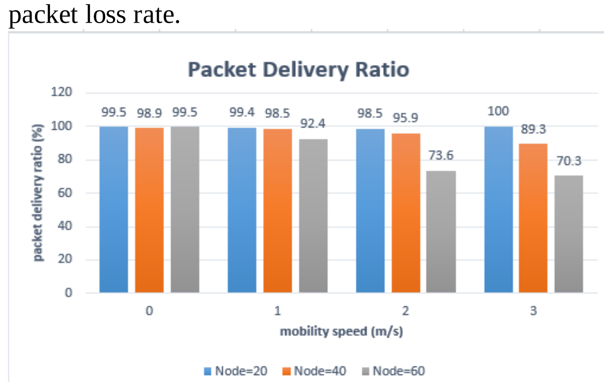

Figure 7: Packet delivery ratio at different number of speed and nodes

Figure 8 shows that the lowest throughput at node 60 with mobility speed 3 m/s which has the highest packet loss rate while for node 20 with mobility speed 3 m/s shows the highest throughput with the lowest packet loss rate.

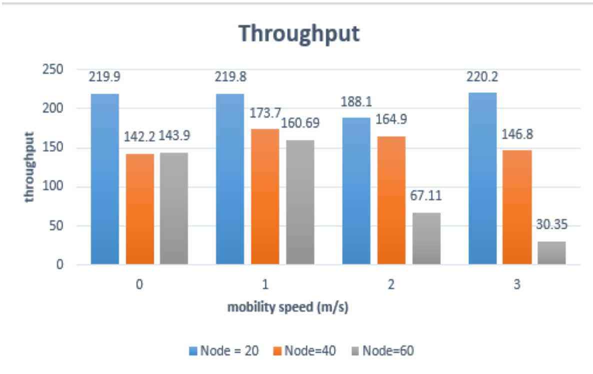

Figure 8: Throughput at different number of speed and nodes

Figure 9 below shows the results of the packet loss rate at node 20 with mobility speed 3 m/s is the lowest percentage meaning that there is no packet loss during transmission of packets that give the optimum performance.

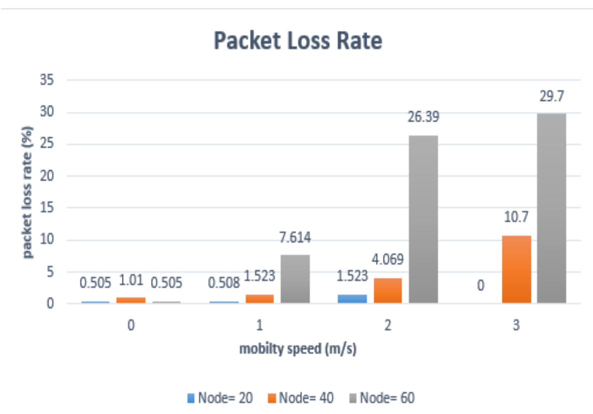

Figure 9: Packet loss rate at different number of speed and nodes

Table 2: Summary results of DYMO

Number of nodes	20				40				60			
Mobility speed (m/s)	0	1	2	3	0	1	2	3	0	1	2	3
Packet delivery ratio (%)	99.5	99.4	98.5	100	98.9	98.5	92.4	89.3	99.5	92.4	73.6	70.6
Throughput	219.9	219.9	188.1	220.3	142.2	173.7	164.9	146.8	143.9	160.69	67.11	30.35
Packet loss rate	0.505	0.508	1.523	0	1.01	1.523	4.069	10.7	0.505	7.614	26.39	29.7

Random waypoint is a mobility model that has been applying in this project in order to change mobility speed. From results analysis, optimum performances can be identified at node 20 with mobility speed 3m/s since all the packets transmission are successfully received by destination node and packet loss rate showed 0% and throughput is the highest at node 20 with 3m/s mobility speed. All the nodes with a variety of speeds are moving randomly and will stop at a certain time for pause time 2 seconds. The nodes move and stop not at the same time, incur a different delay. As a result, packet delivery ratio and throughput increasing, packet loss rate degrading at node 20 with highest mobility speed 3m/s while for node 60 with highest mobility speed 3m/s record as the lowest performance due to decreasing in terms of packet delivery ratio and throughput but increasing in the packet loss rate.

VII. CONCLUSION

The DYMO routing protocol designed for MANET in small, medium, and large node populations with various mobility speed. In this paper, simulation analysis of DYMO conducted and performances measured under various performance metrics, including packet delivery ratio, throughput, and packet loss rate. It can be significant to consider other metrics like congestion control of packets, fault tolerance and bandwidth. We propose conducting complex simulations using other mobility models that are RWP. This protocol can generalize for other ad hoc networks, such as vehicular ad hoc network (VANET) and flying ad hoc network (FANET).

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REFERENCES

[1] Manohar, M. P. (2018). "*Performance Analysis of Reactive Routing Protocols AODV, DYMO, DSR, LAR in MANETs*". International Journal on Future Revolution in Computer Science & Communication Engineering, 4(3), 01-07.

[2] Chattopadhyay, A. S., & Agarwal, N. (2018). "*Performance Analysis of Different Routing Protocols for Mobile Ad-Hoc Network*". IOSR Journal of Engineering (IOSRJEN), 8(7), 20-27.

[3] Russoniello, A., & Gamess, E. (2018). "*Evaluation of Different Routing Protocols for Mobile Ad-Hoc Networks in Scenarios with High-Speed Mobility*". International Journal of Computer Network and Information Security, 9(10), 46.

[4] Singh, J. P., & Gupta, A. K. (2013). "*A Review on dynamic manet on-demand routing protocol in manets*". International Journal of Advanced Trends in Computer Science and Engineering (March 2013).

[5] Jha, R. K., & Kharga, P. (2015). "*A comparative performance analysis of routing protocols in MANET using NS3 simulator*". International Journal of Computer Network and Information Security, 7(4), 62-68.

[6] Sharma, R., Sharma, T., & Kalia, A. (2016). "*A comparative review of routing protocols in MANET*". International Journal of Computer Applications, 133(1), 33-38.

[7] Elboukhari, M., Azizi, M., & Azizi, A. (2015). "*Performance Comparison of routing protocols in Mobile Ad hoc Networks*". International Journal of UbiComp, 6(1/2), 1.

[8] Bisen, D., Suman, P., Sharma, S., & Shukla, R. (2010). "*Effect of Pause Time on DSR, AODV and DYMO Routing Protocols in MANET*". International Journal of sharmaIT & Knowledge Management, 3(1).

[9] A. Khair, M. Makhtar, M. Mazlan et al. (2019). "*An ant colony algorithm for universiti sultan zainal abidin examination timetabling problem*". Indonesian Journal of Electrical Engineering and Computer Science 13(1), (pp. 191-198)

[10] Gupta, A. K., Sadawarti, H., & Verma, A. K. (2013). "*Implementation of the DYMO routing protocol*". arXiv preprint arXiv:1306.1338.

[11] Manohar, P. M., & Pallamsetty, S. (2018). "*Improving the QoS Performance of Dymo Routing Protocol in Cognitive Radio Ad Hoc Networks*". i-Manager's Journal on Computer Science, 6(2), 16.

[12] Miao, Q. X., & Xu, L. (2010, October). "*DYMO routing protocol research and simulation based on NS2*". In 2010 International Conference on Computer Application and System Modeling (ICCASM 2010) (Vol. 14, pp. V14-41). IEEE.

[13] Kaur, J., & Gurm, R. K. (2014). "*Performance analysis of AODV and DYMO routing protocols in MANETs using cuckoo search optimization*". International Journal of Advanced Research in Computer Science and Management Studies, 2(8), 236-247.

[14] Sumathi, K., & Priyadharshini, A. (2015). "*Energy optimization in manets using an on-demand routing protocol*". Procedia Computer Science, 47, 460-470.

[15] Pahal, S., & Dalal, K. (2016). "*Performance evaluation of routing protocols in WSN using QualNet 5.3*". Int J Recent Trends Eng Res, 2(6), 223-231.

[16] R. Hasyifah, A. Muhammed, M. A Mohamed (2019). International Journal of Recent Technology and Engineering (pp. 656-659)

[17] Jain, M., & Priya, A. (2017). "*Impact Analysis of Transmission Range on AODV, DYMO and ZRP Routing Protocol on QoS*" Issues in WiMax.

[18] Pant, S., Nitin, N., Das, A. X., & Jaiswal, A. K. (2016). "*Performance Analysis of Various MANET Routing Protocols with Change in Number of Nodes over Different Mobility Models*".

[19] Gupta, A. K., Sadawarti, H., & Verma, A. K. (2011). "*Review of various routing protocols for MANETs*". International Journal of Information and Electronics Engineering, 1(3), 251.

[20] Nand, P., & Sharma, D. S. (2011). "*Routing Load Analysis of Broadcast based Reactive Routing Protocols AODV, DSR and DYMO for MANET*". International journal of the grid and distributed computing, 4(1), 81-92.

[21] A. Rabileh, K. Azmi, A.Bakar et al. (2018). "*Enhanced Buffer Management Policy and Packet Prioritization for Wireless Enhanced Buffer Management Policy and Packet Prioritization for Wireless Sensor Network*". International journal on Advanced Science, Engineering and Information Technology, (pp. 1770-1776)

[22] Palaniammal, M., & Lalli, M. (2014). "*Comparative Study of Routing Protocols for MANETs*". International Journal of Computer Science and Mobile Applications, 2(2), 118-127.

[23] Jain, T., & Shiwani, S. (2014). "*Analysis of OLSR, DSR, DYMO routing protocols in mobile Ad-Hoc Networks using OMNeT++ Simulation*". Global Journal of Computer Science and Technology.

[24] Pramanik, A., Choudhury, B., Choudhury, T. S., Arif, W., & Mehedi, J. (2015, April). "*Simulative study of random waypoint mobility model for mobile ad hoc networks*". In 2015 Global Conference on Communication Technologies (GCCT) (pp. 112-116). IEEE.

[25] Moudni, H., Er-rouidi, M., Mouncif, H., & El Hadadi, B. (2016, May). "*Performance analysis of the AODV routing protocol in MANET under the influence of routing attacks*". In 2016 International Conference on Electrical and Information Technologies (ICEIT) (pp. 536-542). IEEE