PERFORMANCE EVALUATION OF AODV, DSR AND DYMO ROUTING PROTOCOL IN MANET

Siti Rahayu Abdul Aziz[1], Nor Adora Endut[2], Shapina Abdullah[3] and Mior Norazman Mior Daud[4]

[1]*Faculty of Information Technology and Quantitative Sciences, Universiti Teknologi MARA, Shah Alam, MALAYSIA*
rahayu@tmsk.uitm.edu.my, adora@tmsk.uitm.edu.my, piena@tmsk.uitm.edu.my, mior_azmann@yahoo.com

ABSTRACT

A mobile ad-hoc network (MANET) is a kind of wireless ad-hoc network, and is a self-configuring network of mobile routers connected wirelessly. MANET may operate in a standalone fashion, or may be connected to the larger Internet. Many routing protocols have been developed for MANETs over the past few years. This project evaluated three specific MANET routing protocols which are Ad-hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Dynamic MANET On-demand routing protocol (DYMO) to better understand the major characteristics of these routing protocols. Different performance aspects were investigated in this project including; packet delivery ratio, routing overhead, throughput and average end-to-end delay. This project used Linux as an operating system based platform and discrete event simulator NS-2 as simulation software to compare the three MANET routing protocols. This project's results indicated that all routing protocols perform well according to the performance metrics that have been selected. For packet delivery ratio metric, performance of AODV, DSR and DYMO routing protocols are quite similar to each other. The DSR performance is better compared to AODV and DYMO and has stable normalized routing overhead. In terms of throughput, DYMO routing protocol performs the best as compared to AODV and DSR. Finally, for average end to end delay, DYMO and AODV perform well in comparison with DSR.

Keywords: MANET, AODV, DSR, DYMO, NS-2

1. INTRODUCTION

In the next generation of wireless communication systems, there will be a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity, and can be conceived as applications of mobile ad hoc networks. A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves (nist.gov 2004).

Many routing protocols developed for MANETs over the past few years. MANET routing protocol is a convention or standard that controls how nodes select the route to route packets between computing devices in a mobile ad-hoc network (MANET). In Mobile ad hoc networks, nodes do not have a priori knowledge of topology of network around them, they have to discover it. A new node announces its presence and listens to broadcast announcements from its neighbours. The node learns about new near nodes and ways to reach them, and the node may announce that it can also reach those nodes. As time goes on, each node knows about all other nodes and one or more ways how to reach them.

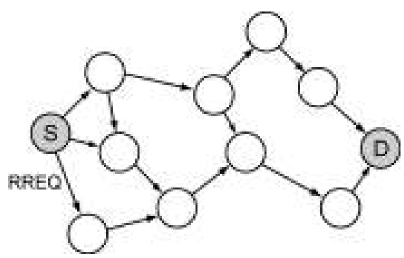
2. LITERATURE REVIEW

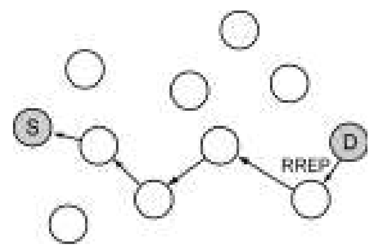
2.1 Routing Protocol Overview

This project evaluated performance three of MANET Routing Protocols which are AODV, DSR and DYMO routing protocol.

2.1.1 Ad Hoc On Demand Distance Vector Routing Protocol (AODV)

Ad Hoc On-Demand Distance Vector routing protocol uses broadcast discovery mechanism, similar to but modified of that of DSR. To ensure that routing information is up-to-date, a sequence number is used. The *path discovery* is established whenever a node wishes to communicate with another, provided that it has no routing information of the destination in its routing table. *Path discovery* is initiated by broadcasting a route request control message "*RREQ*" that propagates in the forward path. If a neighbor knows the route to the destination, it replies with a route reply control message "*RREP*" that propagates through the reverse path. Otherwise, the neighbor will re-broadcast the *RREQ*. The process will not continue indefinitely, however, authors of the protocol proposed a mechanism known as "*Expanding Ring Search*" used by Originating nodes to set limits on *RREQ* dissemination. AODV maintains paths by using control messages called *Hello* messages, used to detect that neighbors are still in range of connectivity. If for any reason a link was lost the node immediately engages a *route maintenance* scheme by initiating route request control messages. The node might learn of a lost link from its neighbors through route error control messages "*RERR*" (A. Al-Maashri and M. Ould-Khaoua, 2006).





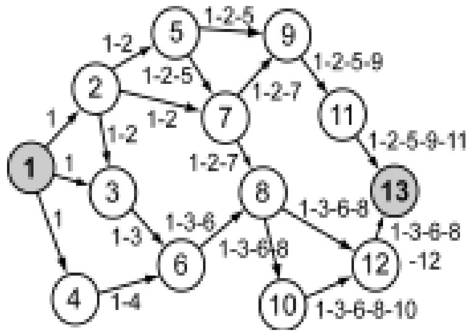
Source: (Ahmad Al-Maashri and Mohamed Ould-Khaoua, 2006)

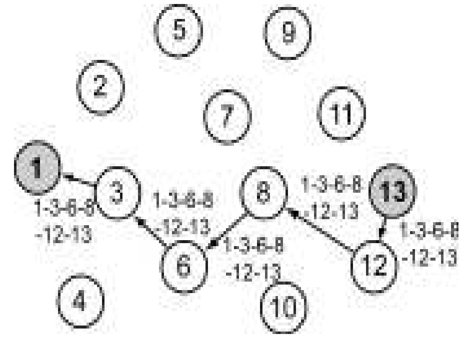
Figure 2.1: Source node S initiates the path

Figure 2.2: A RREP sent back to the source

2.1.2 Dynamic Source Routing Protocol (DSR)

Dynamic Source Routing protocol is a reactive routing protocol, which means that nodes request routing information only when needed. DSR is based on source routing concept, where the sender constructs a source route in the packet's header. This source route lists all the addresses of the intermediate nodes responsible of forwarding the packet to the destination. When a sender wants to communicate with another node (destination), it checks its *route cache* to see if there is any routing information related to that destination. If *route cache* contains no such information, then the sender will initiate a *route discovery* process by broadcasting a *route request*. If the *route discovery* is successful, the initiating host receives a *route reply* packet listing a sequence of network hops through which it may reach the target. Nodes may reply to requests even if they are not the destination to reduce traffic and delay. It is also possible that intermediate nodes which relay the packets can *overhear* the routes by parsing the packet and thus learning about routes to certain destinations. DSR also utilizes a *route maintenance* scheme. This scheme, however, uses the data link layer acknowledgments to learn of any lost links. If any lost link was detected, a route error control packet is sent to the originating node. Consequently, the node will remove that hop in error from the host's *route cache*, and all routes that contain this hop must be truncated at that point. (A. Al-Maashri and M. Ould-Khaoua, 2006)





Source: (Ahmad Al-Maashri and Mohamed Ould-Khaoua, 2006)

Figure 2.3: Building of the route record **Figure 2.4**: Propagation of route reply

2.1.3 Dynamic On-Demand MANET Routing Protocol (DYMO)

The Dynamic MANET On-demand (DYMO) routing protocol enables reactive, multihop unicast routing between participating DYMO routers. The basic operations of the DYMO protocol are route discovery and route maintenance. During route discovery, the originator's DYMO router initiates dissemination of a Route Request (RREQ) throughout the network to find a route to the target's DYMO router. During this hop-by-hop dissemination process, each intermediate DYMO router records a route to the originator. When the target's DYMO router receives the RREQ, it responds with a Route Reply (RREP) sent hop-by-hop toward the originator. Each intermediate DYMO router that receives the RREP creates a route to the target, and then the RREP is unicast hop-by-hop toward the originator. When the originator's DYMO router receives the RREP, routes have then been established between the originating DYMO router and the target DYMO router in both directions. Route maintenance consists of two operations. In order to preserve routes in use, DYMO routers extend route lifetimes upon successfully forwarding a packet. In order to react to changes in the network topology, DYMO routers monitor links over which traffic is flowing. When a data packet is received for forwarding and a route for the destination is not known or the route is broken, then the DYMO router of source of the packet is notified. A Route Error (RERR) is sent toward the packet source to indicate the current route to a particular destination is invalid or missing. When the source's DYMO router receives the RERR, it deletes the route. If the source's DYMO router later receives a packet for forwarding to the same destination, it will need to perform route discovery again for that destination. DYMO uses sequence numbers to ensure loop freedom. Sequence numbers enable DYMO routers to determine the order of DYMO route discovery messages, thereby avoiding use of stale routing information. (C. Perkins, 2008)

2.2 Performance Metrics

This project had considered several metrics in analyzing the performance of routing protocols. These metrics are as follows.

2.2.1 Packet Delivery Ratio

According to David Oliver Jörg (2003), packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source (i.e. Constant Bit Rate (CBR)). It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol.

2.2.2 Normalized Routing Overhead

Normalized routing overhead is the total number of routing packets divided by total number of delivered data packets (A. Al-Maashri and M. Ould-Khaoua, 2006). In the context of this project, the average number of routing packets required to deliver a single data packet is analyzed. This metric provides an indication of the extra bandwidth consumed by overhead to deliver data traffic. It is crucial as the size of routing packets may vary.

2.2.3 Throughput

The throughput (messages/second) is the total number of delivered data packets divided by the total duration of simulation time (A. Al-Maashri and M. Ould-Khaoua, 2006). In this case, the throughput of each of the routing protocol in terms of number of messages delivered per one second is evaluated.

2.2.4 Average End-to-End Delay

Average End-to-End delay (seconds) is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting "time at which first packet was transmitted by source" from "time at which first data packet arrived to destination". This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metric is significant in understanding the delay introduced by path discovery.

3. METHODOLOGY

Three MANET routing protocols which are Ad-hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Dynamic MANET On-demand routing protocol (DYMO) were used in this study. The Ubuntu Operating System was used because it is a user-friendly platform and easy to manage and to setup a simulator. For simulation software, Network Simulation 2(NS2.29) was used as the simulator to evaluate the performance of AODV, DSR and DYMO routing protocols. Some parameters need to be setup to standardize the results. In this project, the simulation environment consists of 3 different numbers of nodes which are 10, 30 and 50 wireless nodes forming an ad hoc network. Every node will move around over 3 different simulation areas which are 500m X 500m, 670m X 670m and 1500m X 500m.

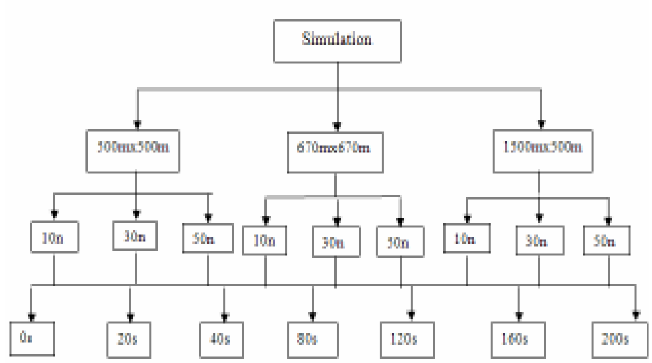


Figure 3.1: Overall simulation scenario flow chart

The simulation will run using movement patterns generated for 7 different pause times: 0, 20, 40, 80, 120, 160, 200 seconds and constant speeds of 20s. A pause time of 0 seconds corresponds to continuous motion, and a pause time of 200 (the length of the simulation) corresponds to no motion. Constant Bit Rate (CBR) traffic generators will be used as sources to run the simulation. Figure 4 shows the procedure chart to execute simulation on NS2.

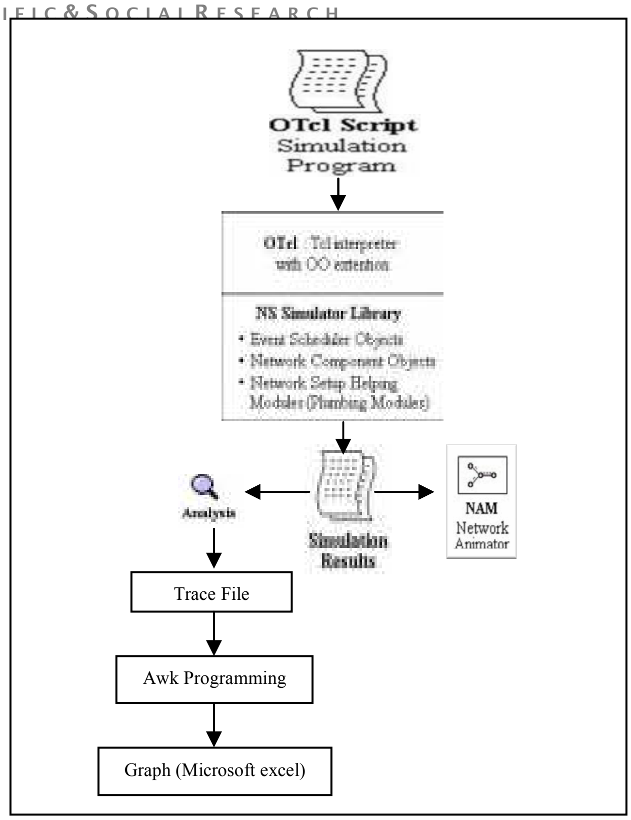


Figure 3.2: Procedure chart to execute simulation on NS2

4. RESULTS AND DISCUSSIONS

It has been mentioned in the previous section that the simulation environment consists of 3 different numbers of nodes which are 10, 30 and 50 wireless nodes forming an ad hoc network. However, for the purpose of brevity the following sections will only discuss on the results for 30 and 50 wireless nodes.

4.1 EFFECT ON PACKET DELIVERY RATIO

4.1.1 30 Nodes

Figures 4.1, 4.2 and 4.3 illustrate graphs for packet delivery ratio of AODV, DSR AND DYMO versus pause time. In these graphs, 30 nodes of routing protocols have been used to move randomly over 500m x 500m, 670m x 670m and 1500m x 500m area space. It can be seen that as the pause time approaches 200 (no motion), each of the routing protocol achieves 100% for packet delivery ratio for each category of area space. In figure 4.2, DSR is the best routing protocol in the 670m x 670m area space because from pause time 80 to 200, DSR achieves 100% packet delivery ratio. In conclusion, DSR is the best routing protocol in term of packet delivery ratio for 30 nodes.

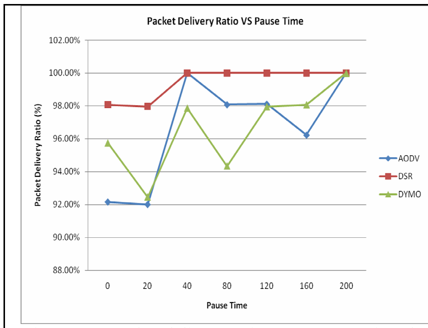


Figure 4.1: Packet delivery ratio versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 500m x 500m)

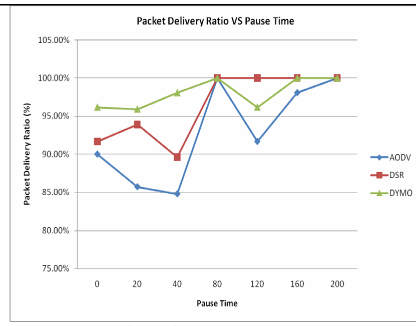


Figure 4.2: Packet delivery ratio versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 670m x 670m)

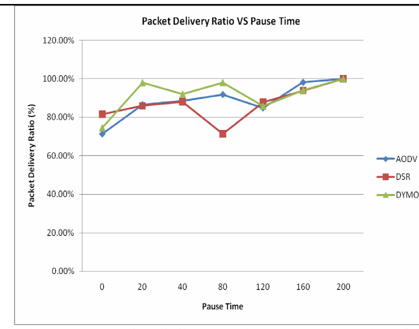


Figure 4.3: Packet delivery ratio versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 1500m x 500m)

4.1.2 50 Nodes

Figures 4.4, 4.5 and 4.6 illustrate graphs for packet delivery ratio of AODV, DSR AND DYMO versus pause time with 50 wireless nodes. Figure 4.4 illustrates that when pause time set to 0 (continuous motion), each of the routing protocols obtained around 90% to 96% for packet delivery ratio except DYMO which obtained 77%. In figure 4.5, as the pause time reaches 200 (no motion), packet delivery ratio reaches 100% except DYMO because the area space is small compared to the larger number of node. DSR and AODV reached 100% packet delivery ratio when pause time equal to 200 while DYMO obtained only 91% packet delivery ratio. In figure 4.6 the packet delivery ratio at pause time 0 for AODV and DYMO routing protocols are around 72% to 90% while DSR only obtained 28%. Before reaching pause time of 200, each routing protocol's packet delivery ration fluctuated. At pause time 200, packet delivery ratio of AODV and DSR reached 100% while DYMO only achieved 97% of packet delivery ratio. In summary, for nodes equal to 50 AODV perform wells and is more stable than DSR and DYMO.

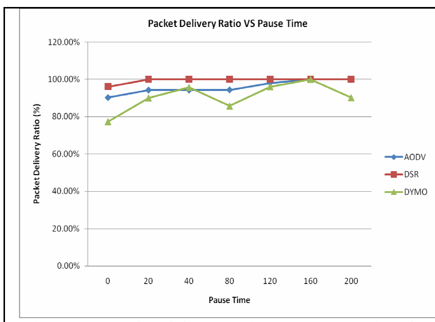


Figure 4.4: Packet delivery ratio versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 500m x 500m)

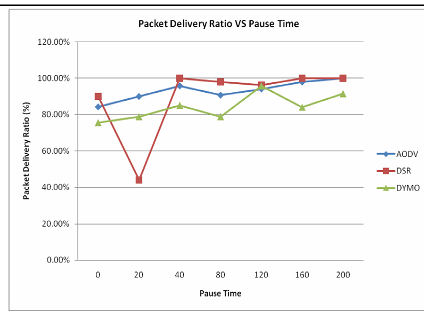


Figure 4.5: Packet delivery ratio versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 670m x 670m)

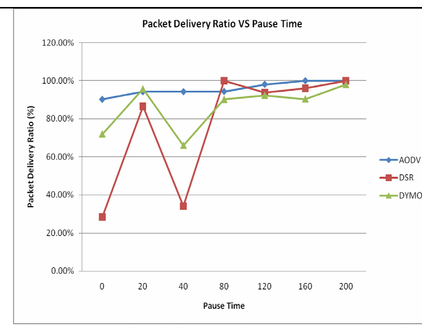


Figure 4.6: Packet delivery ratio versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 1500m x 500m)

4.2 EFFECT ON NORMALIZED ROUTING OVERHEAD

4.2.1 30 Nodes

Figures 4.7, 4.8 and 4.9 illustrate normalized routing overhead required to deliver a single data packet versus pause time. This metric gives an idea of the extra bandwidth consumed by overhead to deliver data packet. In figure 4.7, DYMO exhibited the highest normalized routing overhead compared to AODV and DSR. It is because more routing packets are generated and delivered by DYMO than AODV and DSR. AODV and DSR are quite similar in term of lowest routing overhead, but DSR has slightly higher routing overhead than AODV because of the route cache property in the DSR routing protocol in small area space will lose more packets frequently. In conclusion, for nodes equal to 30, DSR has the lowest and most stable normalized routing overhead compared to AODV and DYMO in the intermediate and large area space, while for small spaces AODV performs better in terms of low normalized routing overhead.

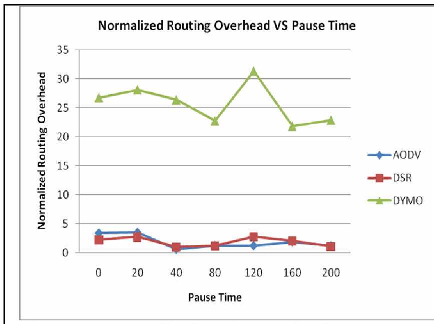


Figure 4.7: Normalized routing overhead versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 500m x 500m)

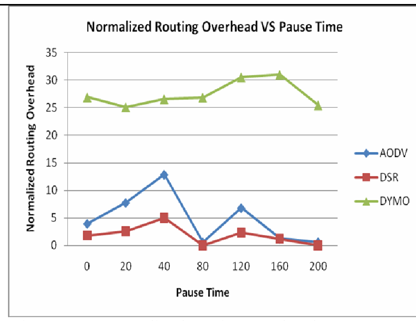


Figure 4.8: Normalized routing overhead versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 670m x 670m)

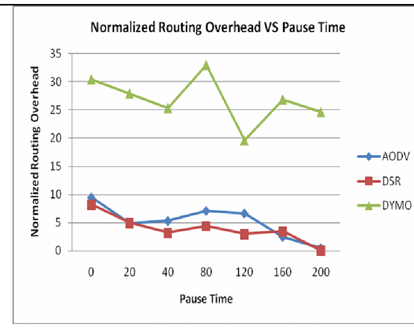


Figure 4.9: Normalized routing overhead versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 1500m x 500m)

4.2.2 50 Nodes

Figures 4.10, 4.11 and 4.12 illustrates graphs normalized routing overhead for 50 wireless nodes. In this scenario, the performance of each routing protocols is to an extent equal to the performance for 30 nodes. To summarize, DSR and AODV results in low and stable normalized routing overhead compared to DYMO.

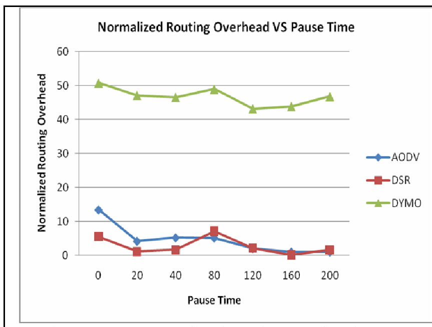


Figure 4.10: Normalized routing overhead versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 500m x 500m)

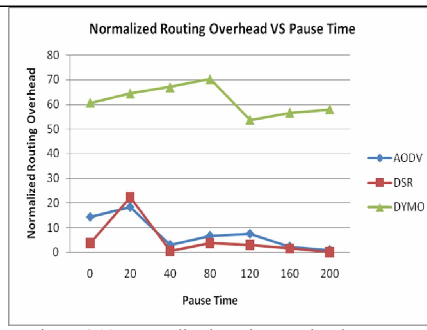


Figure 4.11: Normalized routing overhead versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 670m x 670m)

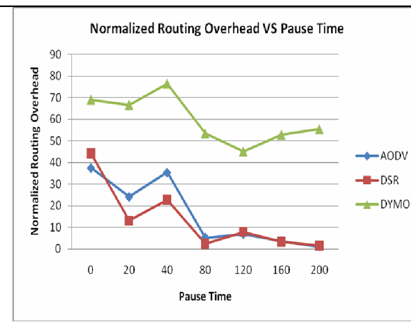


Figure 4.12: Normalized routing overhead versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 1500m x 500m)

4.3 EFFECT ON THROUGHPUT

4.3.1 30 Nodes

Figures 4.13, 4.14 and 4.15 illustrate the comparison of throughput for AODV, DSR and DYMO for 30 nodes in specific are spaces. In this metric, the throughput of the protocol in terms of number of messages delivered per one second (Mbps) is analyzed. In figure 4.13, DYMO exhibited the highest throughput compared to AODV and DSR since more routing packets are generated and delivered by DYMO than AODV and DSR. The throughput for each routing protocol continues to fluctuate as the pause time progresses and as it reaches 200, DYMO still produces the highest throughput compared to DSR and AODV.

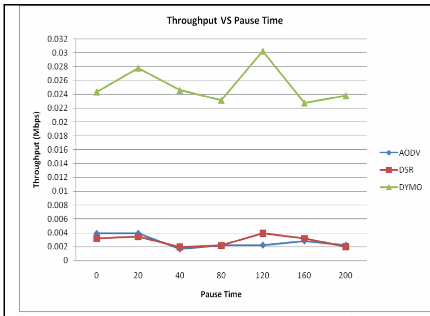


Figure 4.13: Throughput versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 500m x 500m)

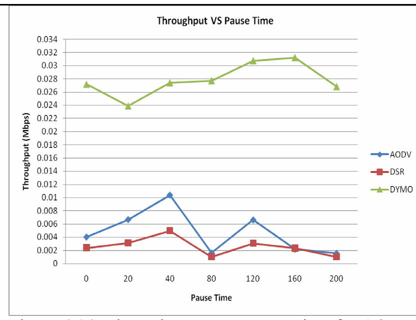


Figure 4.14: Throughput versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 670m x 670m)

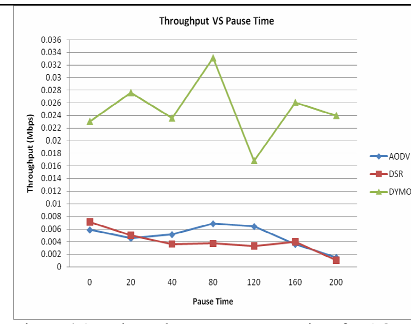


Figure 4.15: Throughput versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 1500m x 500m)

4.3.2 50 Nodes

Figures 4.16, 4.17 and 4.18 illustrate the throughput for 50 wireless nodes. In this scenario, the performance of each routing protocols can be concluded as somewhat equal to the performance for 30 nodes whereby in all area spaces, DYMO achieves the highest throughput compared to AODV and DSR since more routing packets are generated and delivered by DYMO.

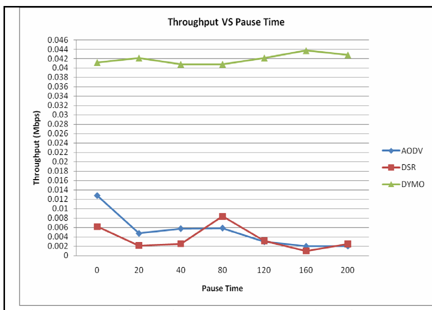


Figure 4.16: Throughput versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 500m x 500m)

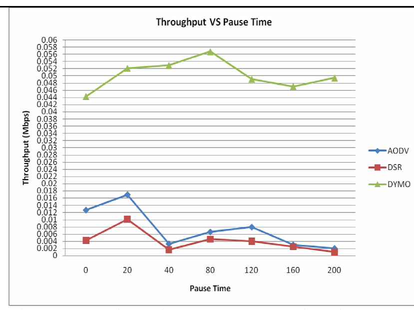


Figure 4.17: Throughput versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 670m x 670m)

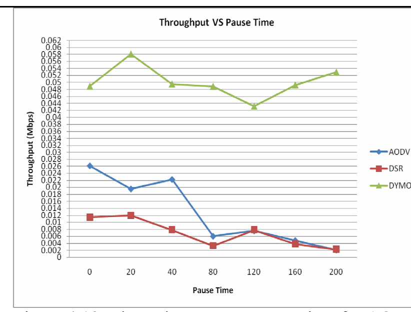


Figure 4.18: Throughput versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 1500m x 500m)

4.4 EFFECT ON AVERAGE END TO END DELAY

4.4.1 30 Nodes

Figures 4.19, 4.20 and 4.21 illustrate the average end to end delay for 30 wireless nodes. Average end to end delay (milliseconds) is the average time it takes a data packet to reach the destination. As routes break, nodes have to discover new routes which lead to longer end-to-end delays (packets are buffered at the source during route discovery). In this case, the area space plays a role in affecting the performance of each routing protocol. For small spaces, for example 500m x 500m, AODV perform well in terms of stable and low average end to end delay. For intermediate space, DSR performs better as it results in stable and low average end to end delay. Finally, for large spaces as presented by 1500mx500m, DYMO performs slightly better compared to AODV and DSR.

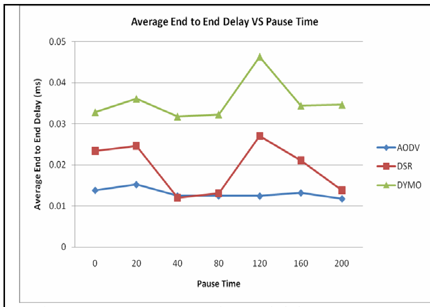


Figure 4.19: Average end to end delay versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 500m x 500m)

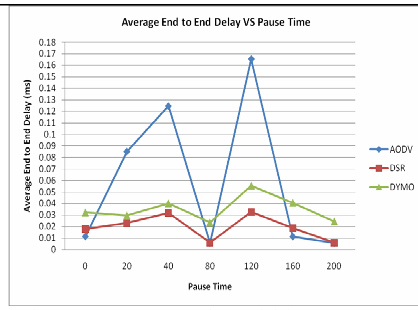


Figure 4.20: Average end to end delay versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 670m x 670m)

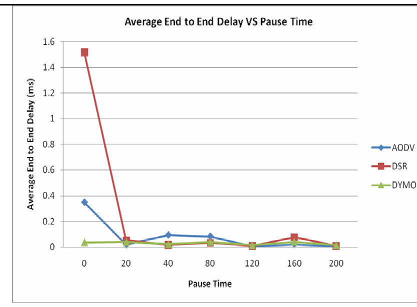


Figure 4.21: Average end to end delay versus pause time for AODV, DSR and DYMO
(Number of node = 30, Area space = 1500m x 500m)

4.4.2 50 Nodes

Figures 4.22, 4.23 and 4.24 illustrate the average end to end delay for 50 wireless nodes. At the pause time 0 second, AODV obtain highest value in average end to end delay than DYMO and DSR. In the conclusion, for nodes equal to 30 and 50, AODV perform better than DSR and DYMO routing protocol in term of stable and low average end to end delay.

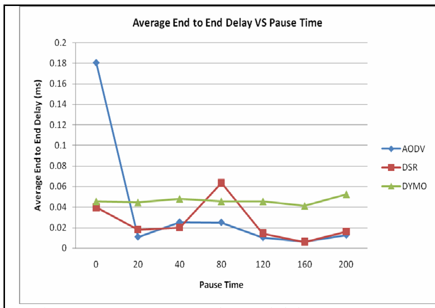


Figure 4.22: Average end to end delay versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 500m x 500m)

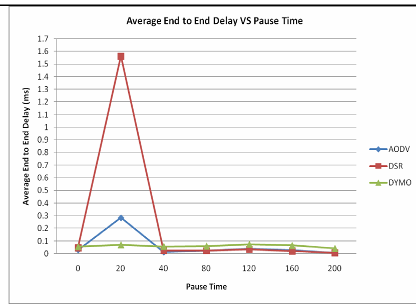


Figure 4.23: Average end to end delay versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 670m x 670m)

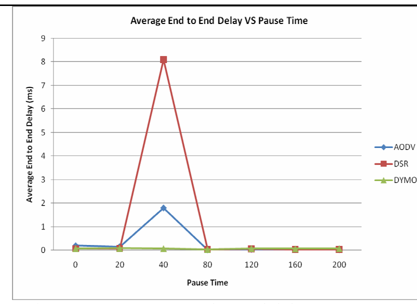


Figure 4.24: Average end to end delay versus pause time for AODV, DSR and DYMO
(Number of node = 50, Area space = 1500m x 500m)

5. CONCLUSIONS

This study was conducted to evaluate three of MANET routing protocols which are AODV, DSR and DYMO. These routing protocols are compared in term of packet delivery ratio, routing overhead, throughput and average end to end delay using network simulation 2 on the Linux platform. Performance of each routing protocol has been analyzed and evaluated accordingly based on different number of nodes over different area size with different pause time. For the simulation result, all routing protocols perform well according to performance metrics that have been selected. For packet delivery ratio metric, performance of AODV, DSR and DYMO routing protocols are quite similar to each other. In terms of routing overhead, DSR perform low and stable routing overhead compared to AODV and DYMO for the nodes equal to 10 and 30. Meanwhile for nodes equal to 50, DSR and AODV perform low and stable routing overhead than DYMO. In terms of throughput, DYMO routing protocol performs the best as compared to AODV and DSR. Finally, for average end to end delay, DYMO is better than AODV and DSR for the nodes equal to 10. For nodes equal to 30 and 50, AODV perform better than DSR and DYMO routing protocol in term of stable and low average end to end delay. Hopefully, the result of this study can be used as reference for the future work.

REFERENCES

Al-Maashri, A. and Ould-Khaoua, M. (2006). *Performance analysis of MANET routing protocols in the presence of self-similar traffic*. Proceedings of the 31st IEEE Conference on Local Computer Networks, 2006, 14-16 November 2006, pages pp. 801-807, Tampa, Florida, USA. Retrieved February 3, 2008, from http://eprints.gla.ac.uk/3545/01/almaashri3545.pdf

Ari, Ismail, Jethani, Neelu, Rangnekar, Aniruddha, & Natarajan, Sushma. (2000). *Performance Analysis and Comparison of Ad-Hoc Routing Protocols*. Retrieved February 6, 2008 from http://www.soe.ucsc.edu/~ari/adhoc-mobile-691t-umbc.pdf

Chenna Reddy, P and Chandrasekhar Reddy, P (2006). *Performance Analysis of Ad-hoc Network Routing Protocol.* Retrieved February 5, 2008 from http://www.acadjournal.com/2006/V17/part6/p3/

Ghosh, Joy, Philip, Sumesh J., Qiao, Chunming. (2004). *Performance Analysis of Mobility Based Routing Protocol in MANET*. Department of Computer Science and Engineering University at Buffalo, The State University of New York201 Bell Hall, Buffalo, NY 14260-2000. Retrieved March 5, 2008, from http://www.cse.buffalo.edu/tech-reports/2004-14.pdf

Gowrishankar, S, Basavaraju, T.G.j Singh, M, Sarkar, Subir Kumar (2007). *Scenario based Performance Analysis of AODV and OLSR in Mobile Ad hoc Networks*. Proceedings of the 24th South East Asia Regional Computer Conference, November 18-19, 2007, Bangkok, Thailand. Retrieved March 3, 2008,from http://www.ijcim.th.org/v15nSP4/P08SEARCC_ScenariobasedPerformanceAnalysis.pdf

Jörg, David Oliver. (2003). *Performance Comparison of MANET Routing Protocols in Different Network Sizes*. Retrieved February 5, 2008, from http://www.iam.unibe.ch/~rvs/research/publications/projekt_david_joerg.pdf

Krasnovsky, Marek, Wieser Vladimir. (2007). *A Performance of Wireless Ad-Hoc Network Routing Protocol*. Department of Telecommunications, University of Zilina, Univerzitnai 1, 010 26 Zilina, Slovak Republic. Retrieved March 3, 2008, from http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/4234163/4234164/04234225.pdf

MANET definition– Articles from National Institute of Standard and Technology Retrieved February 2, 2008, from http://www.nist.gov/wahn_mahn.shtml

Sauti, Mohd Suhaimi. (2006). *Penilaian Prestasi Kualiti Perkhidmatan (QOS) Protokol Penghalaan Dalam Rangkaian Ad-Hoc*. Fakulti Kejuruteraan Universiti Kebangsaan Malaysia Bangi.

Thorup, Rolf Ehrenreich. (2007). *Implementing and Evaluating the DYMO Routing Protocol*. Department of Computer Science University of Aarhus Denmark. Retrieved February 2, 2008, from http://www.daimi.au.dk/~rolft/docs/thesis.pdf