1. Che Zalina Zulkifli[1*], 2. Roswan Ismail[1], 3. Satria Abadi[2,3], 4. Abu Bakar Ibrahim[1], 5. Wasana Boonsong[4]

Faculty of Computing and Meta-Technology, Universiti Pendidikan Sultan Idris, Perak, Malaysia (1)
Postdoctoral, Faculty of Computing and Meta-Technology, Universiti Pendidikan Sultan Idris, Perak, Malaysia (2)
Faculty of Technology and Computing, Institut Bakti Nusantara, Lampung, Indonesia (3)
Department of Electrical education, Rajamangala University of Technology Srivijaya, Sonkhla, Thailand (4)
Orcid: 1. 0000-0003-1493-6291, 3. 0000-0001-7355-9428

doi:10.15199/48.2023.08.17

Performance Analysis of Proactive Routing Protocol Based on Different Network Load in Mobile Ad-hoc Network (MANET)

Abstract. *Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes that dynamically form a network temporarily without any support of central administration. Moreover, every node in MANET movesarbitrarily making the multi-hop network topology to change randomly at unpredictable times. Therefore, the routing protocol that able to cope with the dynamic nature of the MANET is needed to maintain the communication data between mobile nodes in the network. This paper presents the performance compariso of OLSR and DSDV, protocols based on metrics such as packet delivery ratio, average end-to-end delay, and routing overhead by using the NS-2 simulator. The simulation results show that the performance of DSDV outperformed OLSR protocols in terms of average delay and routing overhead.*

Streszczenie. *Mobile Ad hoc Network (MANET) to zbiór bezprzewodowych węzłów mobilnych, które dynamicznie tworzą tymczasowo sieć bez wsparcia centralnej administracji. Co więcej, każdy węzeł w MANET porusza się w sposób arbitralny, co sprawia, że topologia sieci z wieloma przeskokami zmienia się losowo w nieprzewidywalnych momentach. Dlatego protokół routingu, który jest w stanie poradzić sobie z dynamiczną naturą MANET, jest potrzebny do utrzymania danych komunikacyjnych między węzłami mobilnymi w sieci. W artykule przedstawiono porównanie wydajności OLSR i DSDV, protokołów opartych na metrykach, takich jak współczynnik dostarczania pakietów, średnie opóźnienie między punktami końcowymi oraz obciążenie trasowania przy użyciu symulatora NS-2. Wyniki symulacji pokazują, że wydajność DSDV przewyższała protokoły OLSR pod względem średniego opóźnienia i narzutu routingu.* (***Analiza wydajności proaktywnego protokołu routingu opartego na różnym obciążeniu sieci w mobilnej sieci Ad-hoc (MANET***)

Keywords: DSDV; MANET; OLSR; Routing Protocols
Słowa kluczowe: protokoł routingu, MANET

Introduction

A mobile ad hoc network (MANET) is a wireless network consists of two or more mobile nodes which communicate to each other without any support of fixed infrastructure or centralized administration [1-7]. These mobile nodes, which are free to move in any directions, and rely on batteries to operate may connect or leave a network at any time without restriction. Basically, this self-organized and self-configured MANET comprises of multiple nodes such as laptops, personal digital assistants (PDAs), smart phones, MP3 players, and digital cameras. This network which can be set up anytime and anywhere is an appropriate network for emergency situation, in which the infrastructure is inadequate or infeasible i.e. in disastrous areas, where an existing infrastructure maybe totally damaged, cause a serious communication breakdown.

Routing protocols is one of the key issues in MANET. It is used to establish and maintain valid routes to allow communicating nodes to transmit and deliver the packets between them. In essence, the routing protocols help nodes or devices to decide in which way to route packets in the network. The process of route packets from source to destination node involves two steps; route selection for the source node and packet delivery to the correct destination. Thus, the routing protocols designed for MANET, should be able to cope with the dynamic nature of the MANET, which are mobile and rapidly changing topologies.

Generally, the routing protocol designed can be classified into two main classifications: proactive and reactive routing protocols depending on whether they keep routes continuously updated or react on demand [7-14]. Proactive protocols i.e. optimized link state routing (OLSR) and destination-sequenced distance vector (DSDV), maintain the network topology information within routing by broadcasting periodic routing updates through the network [11]. Each node maintains routing tables which are consistent and up-to-date holding routing information about every node in the network. Meanwhile, reactive protocols i.e. ad hoc on-demand distance vector (AODV) and dynamic source routing (DSR) maintain the routes to destinations only when they are needed [11]. Thus, each node in the network discovers or maintains a route between source and destination based on demand.

In this paper, OLSR and DSDV routing protocols has been selected to be discussed further. The rest of the paper is organized as follows. Section II briefly reviews about OLSR and DSDV routing protocols. Section III discusses about research methodology used in this paper. Section IV presents the results of comparison performance for OLSR and DSDV. Finally section V concludes the paper with conclusion and future work.

Routing protocols

In general, the routing protocols can be classified into two main categories [15], namely proactive (or table-driven) and reactive (or on-demand) protocols, which depend on whether the routes are being updated either continuously or on demand [13, 16-17]. There are a number of proactive routing protocols used, of which Optimized Link State Routing (OLSR) [18] and destination-sequence distance vector (DSDV) are very popular [19-20]. For reactive routing protocols, Dynamic Source Routing (DSR) [21-22] and Ad Hoc On-demand Distance Vector (AODV) [19, 21] are widely used. The following are the detail descriptions of the commonly used proactive routing protocols used in MANETs.

Optimized Link State Routing Protocol (OLSR*)*

OLSR [24] is an optimized version of the classical link-state algorithm, where every node broadcasts messages and thus generates heavy overhead traffic. Hence, for optimization, OLSR uses MPRs selection technique to reduce the overhead of packet transmission during the flooding process. Using such technique, only a small number of nodes will be selected as Multi Point Relays (MPRs) to broadcast the messages for link detection in the network. To select the MPRs, each node periodically will broadcast a list of its one-hop neighbors using hello messages. From the list of nodes in the hello messages, each node will then select a subset of one-hop neighbors that encompasses all its two-hop neighbors.

For example, as shown in Fig. 1, node 'A' can select nodes B, C, K and N to be the MPR nodes. Each node will then determine an optimal route (in terms of hops) to every known destination using its topological information (recorded in the topology table and neighboring table) and subsequently store this information in a routing table. Therefore, routes to every destination will be immediately available when data transmission begins [18, 23].

OLSR protocols perform hop-by-hop routing, where each node uses its most recent routing information to route packets, with MPRs covering all nodes (i.e., immediate neighbors) that are two hops away. Essentially, a node uses the control messages called HELLO messages to detect and select its MPRs. In principle, these messages are sent at a certain interval to ensure there is a bidirectional link between the node and its neighbor. Furthermore, nodes broadcast the Topology Control (TC) messages to determine their MPRs. In this case, only the control messages are relayed and exchanged among such MPRs, thus eliminating the need to relay this information to all the entire nodes, with each node maintains its own routing table. By being proactive, the OLSR protocols update and store the information of all routes in the network. Therefore, the routes in the network will always be available when they are needed [24].

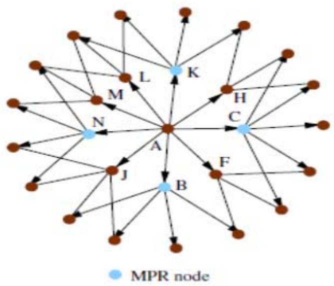

Fig 1. Multipoint relays [26]

Destination-Sequenced Distance-Vector (DSDV)

DSDV, which was introduced by C. Perkins and P. Bhagwat [20], is one of the earliest ad hoc routing protocols. Essentially, this protocol is based on the improved version of Bellman-Ford algorithm, the improvements of which include the freedom from loops in routing tables by using sequence numbers [20]. In DSDV, each node periodically transmits routing information to its intermediate neighbors to update a routing table, and the updating of such routes can be either time-driven or event-driven. Each entry in the table contains the destination address, the number of hops to reach the destination, the next hop address, and the sequence number provided by the destination node.

The destination node chooses the shortest path according to the hop count and sequence number such that the route with the highest sequence number will be selected. Once the routes are selected, the destination node then forwards the RREP control messages for route establishment. In order to reduce the amount of overhead transmitted through the network; the routing table can be updated in two ways, namely full dump update and incremental update. For the full dump update, complete information of the routing table is sent to the neighbors by a packet. On the other hand, the incremental update involves only those entries that have changed since the last update, with a packet carrying only the information that has changed since the last full dump. Between the two types of update, the incremental update messages are sent more frequently than that of the full dump packets [20, 23].

Methodology

The simulation was conducted using NS-2 network simulator tool, running on a windows laptop with specifications as listed in Table 1. The simulation was carried out to determine the performances of two commonly used proactive routing protocols, namely OLSR and DSDV. The details of simulation parameters settings to measure the performances are summarized as in Table 2.

Table 1. The Hardware and Operating System Specifications

Model	**Fujitsu**
Processor	Intel® Core™ i3-3110M CPU @ 2.40GHz
Memory (RAM)	10.0 GB (9.87 GB usable)
Storage	500 GB HDD Drive
Operating System	Windows 7
System Type	64-bit Operating System
Other Device	DVD RW Drive, External Hard Disk

Table 2. Simulation Parameter Settings

Parameters	Value
Protocols	OLSR, DSDV
Number of Nodes	20
Simulation Area	600 m * 600 m
Mobility Model	Random Way Point (RWP)
Packet Size	512 bytes / packet
Traffic Type	Constant Bit Rate (CBR)
Node Energy	10 Joules per node
Receive Power	300 mW
Transmit Power	2 Mbps
Simulation Time	800 mW
Pause Time	2 seconds
Mobility Speed	10 m/s
Packet Rate	10 packets/sec
Number of Connections	10

To access the merit of a routing protocol, a number of important performance evaluation metrics must be utilized for such assessment. The performance metrics we used for evaluation are as follows:

Packet Delivery Ratio

Packet delivery ratio refers to the ratio of the total number of packets received at the destination node to the total number of packets sent by the source node [25], which is expressed as follows:

(1) $P = P_r / P_s$

where: P = Packet delivery ratio; P_r = total number of packets received; P_s = total number of packets sent

Routing Overhead

Routing overhead refers to the total number of control messages (route request messages, route reply messages, and route error messages) transmitted by the source node to the destination node during the route discovery process [25], which can be expressed as follows:

(2) $RO = (R_{req} + R_{rep} + R_{err})$

Where: RO = Routing Overhe; R_{req} = total number of route request messages; R_{err} = total number of route error messages

End-To-End Delay

End-to-end delay refers to the average time taken by a packet to arrive at the destination node from the source node [25], which can be expressed as follows:

$$AE = (P_{rt} - P_{st})/P_r \quad (3)$$

where: AE = average end-to-end delay P_{rt} = packet receiving; timeP_{st} = packet sending time

Results and Discussions

The simulation results of the performance of OLSR and DSDV routing protocols are presented and discussed as following.

Packet Delivery Ratio

As shown in Fig. 2, the packet delivery ratio of the network decreased significantly when the traffic load connection increased fivefold, with OLSR had a better overall packet delivery ratio than that of DSDV. Moreover, at a higher connection rate, DSDV is less effective routing protocol in terms of packet delivery ratio.

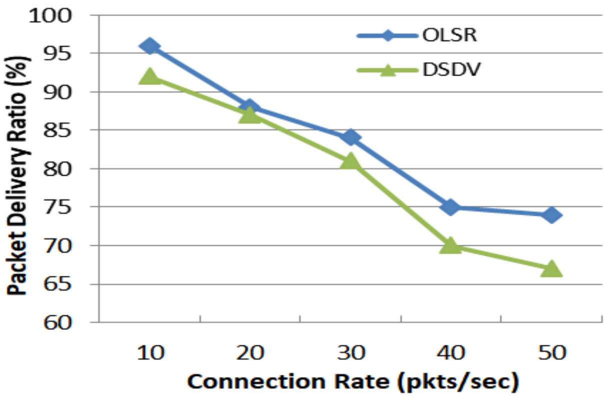

Fig 2. Packet Delivery Ratio

Routing Overhead

Fig. 3 shows the routing overheads of proactive routing protocols based on the connection rate. As shown, OLSR and DSDV had relatively constant amounts of routing overheads at all rates of connection loads. However, in terms of routing overheads, OLSR had the poorest performance compared to DSDV routing protocol.

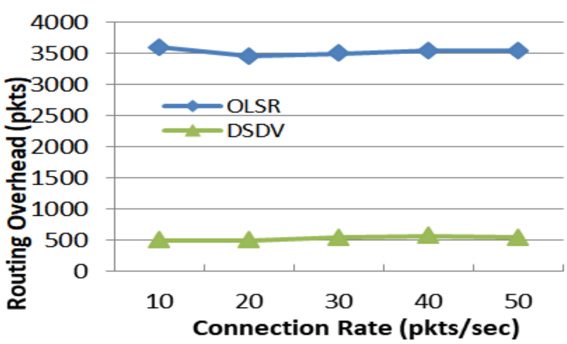

Fig 3. Routing Overhead

End-to-End Delay

Fig. 4 shows the average network delays plotted against the connection rates. As depicted, DSDV attained the best performance, as evidenced by its low average network latency for all connection rates compared to OLSR protocol.

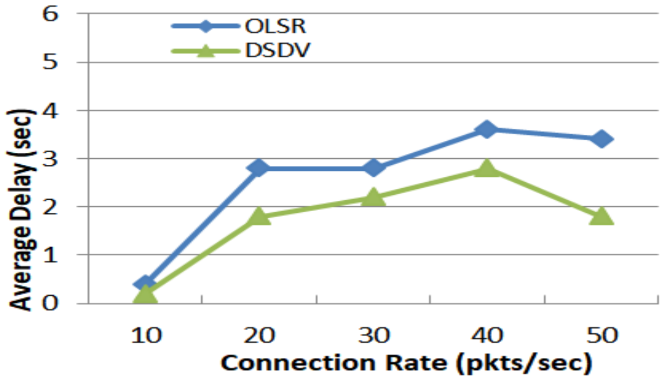

Fig 4. End-to-End Delay

Conclusion

In this paper, the network performance of the most commonly used proactive routing protocols were simulated and measured in terms of packet delivery ratio, network latency, and routing overhead under a different network load. The simulation results showed that DSDV performed better than OLSR protocol in terms of average end-to-end delay and routing overhead. Closer examination shows the increasing overall network load (by increasing the connection load between pairs of nodes in the network) resulted in a significant drop of packet delivery ratio. In light of the above interesting findings, it can be reasonably concluded that the DSDV are the most appropriate routing protocol for wireless networks in which delay-sensitive applications are deployed.

Future work will involve an experimental study to compare and evaluate the performances of both proactive and reactive routing protocols in different routing load environment. Notably, the evaluation will be carried out based on routing overhead, end-to-end delay, and packet delivery ratio. In addition, the performance in different environment settings (i.e. different network density, different mobility speed, and different size of simulation area) will also be analyzed. The findings from the proposed experiment will provide greater insight of different characteristics of each protocol on the overall performance of an entire network. Moreover, the effects of contributing factors (e.g., the number of nodes, network size, mobility speed, and data transmission rate) on network performance will help practitioners and researchers to formulate better solutions for increasingly complex networks.

Acknowledgement

This paper is based on the research project entitle Prototype Long Range RF Mobile RFID Reader for Material Flow and Asset Tracking System in Industrial Manufacturing. The authors would like to extend their gratitude to Univerisiti Pendidikan Sultan Idris (UPSI) for sponsoring this research under PRGS KHAS grant code 2016-0210-104-51.

REFERENCES

[1] Singh, G., and Singh. J., "MANET: A Study of Challenges and Routing Principles," *International Journal of Advanced and Innovative Research*, vol. 1, no. 1, pp. 2278-7844, 2012.

[2] Quispe, L. E., and Galan, L. M., “Behavior of Ad Hoc routing protocols, analyzed for emergency and rescue scenarios, on a real urban area,” *Expert Systems with Applications,* vol. 41, no. 5, pp. 2565-2573, 2014.
[3] Suganya, S., and Palaniammal, S., “An Optimized Energy Consumption Algorithm for Manet. *Procedia Engineering,”* vol. 38, pp. 903-910, 2012.
[4] Zafar, H., Zuhairi, M., Harle, D., and Andonovic, I., “A Survey of Quality Service-aware Routing Approaches for Mobile Ad Hoc Networks,” *IETE Technical Review*, vol. 29 no. 3, pp. 188-195, 2012.
[5] Sanandaji, A., Jabbehdari, S., Balador, A., and Kanellopoulos, D.,”MAC Layer Misbehavior in MANETs,” IETE *Technical Review*, vol. 30, no. 4, pp. 324-335, 2012.
[6] Muhit, D., “Performance Evaluation of Aodv, Dsr, Dsdv Mobile Ad-Hoc Protocols On Different Scenarios: An Analytical Review,” *International Journal of Advances in Computing and Information Technology,* vol. 1, no. 1, pp. 26-45, 2012.
[7] Jacob, J., and Seethalakshmi, V., “Efficiency Enhancement of Routing Protocol in Manet,” *International Journal of Advances in Engineering & Technolog,* vol. 3, no. 2, pp. 2231-1963, 2012.
[8] Manickam, P., Baskar, T. G., Girija, M., and Manimegalai, D. D., “Performance comparisons of routing protocols in mobile ad hoc networks,” *International Journal of Wireless & Mobile Networks,* vol. 3, no. 1, pp. 98-106, 2011.
[9] Kioumourtzis, G., Bouras, C., and Gkamas, A., “Performance evaluation of ad hoc routing protocols for military communications,” *International Journal of Network Management,* vol. 22, no. 3, pp. 216-234, 2012.
[10] Asma, A., and Nagib, G., “Energy efficient routing algorithms for mobile ad hoc networks—a survey,” *International Journal of Emerging Trends & Technology in computer Science,* vol. 3, no. 1, pp. 218-223, 2012.
[11] Sharma, A. K., and Bhatia, N., “Behavioral study of MANET routing protocols by using NS-2,” *IJCEM International Journal of Computational Engineering & Management,”* vol. 12, pp. 100-104, 2011.
[12] Prakash, S., Saini, J. P., and Gupta, S. C., “A review of Energy Efficient Routing Protocols for Mobile Ad Hoc Wireless Networks,” *International Journal of Computer Information Systems,* vol. 1, no. 4, pp. 36-46, 2010.
[13] Kuppusamy, P., Thirunavukkarasu, K., and Kalaavathi, B., “A study and comparison of OLSR, AODV and TORA routing protocols in ad hoc networks,” *Electronics Computer Technology (ICECT), 2011 3rd International Conference,* pp. 143-147, April 2011.
[14] Selvi, M., Prathap, J., and Yuvaraj, P. M. N., “Survey on Energy Efficiency in DSR/AODV Protocols in Wireless Network,” *International Journal of Electronics Communication and Computer Technology (IJECCT,* vol. 3, no. 3, pp. 2249-7838, 2013.
[15] Khamayseh, Y., Obiedat, G., & Yassin, M. B., “Mobility and Load aware Routing protocol for ad hoc networks,” Journal of King Saud University - Computer and Information Sciences, vol. 23, no. 2, pp. 105–113, 2011.
[16] Khan, J., & Hayder, S. I., “A Comprehensive Performance Comparison of On-Demand Routing Protocols in Mobile Ad-Hoc Networks,” Communication and Networking, pp. 354–369, 2010.
[17] Uma Mani, R. C., & Dhulipala, V. R. S., “STUDY AND ANALYSIS OF ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORK,” Journal of Computer Science, vol. 9, no. 1, pp. 1519–1525, 2013.
[18] Adoni, K. A., & Joshi, R. D., “Optimization of energy consumption for OLSR routing protocol in MANET,” International Journal of Wireless & Mobile Networks (IJWMN), vol. 4, no. 1, pp. 251–262, 2012.
[19] Li, H., Pan, L., & Fan, R., “Simulation Research on DSDV and AODV Protocol in Tactical Unit Network,” In AsiaSim 2012, pp. 27–36, 2012.
[20] Ade, S. A., & Tijare, P. A., “Performance comparison of AODV, DSDV, OLSR and DSR Routing Protocols in Mobile Ad hoc Networks,” International Journal of Information Technology and Knowledge Management, vol.2, no.2, pp. 545-548, 2010.
[21] Jasani, H., “Evaluations of AODV and DSR for QOS Requirements,” In Proceedings of the 1st Annual Conference on Research in Information Technology, pp. 1–6, 2012.
[22] Khan, R., Azad S., A. M. N., & Vishwakarma, A., “Enhancement of manet routing protocol,” In 2014 Conference on IT in Business, Industry and Government (CSIBIG), pp. 1–6, 2014.
[23] Boukerche, A., Turgut, B., Aydin, N., Ahmad, M. Z., Bölöni, L., & Turgut, D., “Routing protocols in ad hoc networks: A survey,” Computer Networks, vol. 55, pp. 3032–3080, 2011.
[24] Ismail, R., Zulkifli, C. Z., & Samsudin, K., “Routing Protocols for Mobile Ad-hoc Network: A Qualitative Comparative Analysis,” Jurnal Teknologi, vol. 78, no. 8, pp. 1–10, 2016.
[25] Ismail, R., Zulkifli, C. Z., & Samsudin, K., “Reducing Broadcasting Route Request Packet through LF-AODV,” Journal of ICT in Education (JICTIE), vol. 4, pp. 100–117, 2017.
[26] Abolhasan, M., Wysocki, T., & Dutkiewicz, E., “A review of routing protocols for mobile ad hoc networks. Ad Hoc Networks, vol. 2, no. 1, pp. 1–22, 2004.