Performance Evaluation of Routing Protocols in MANET: DSR/AODV

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***Abstract* — This paper presents the comparative performance evaluation of routing protocols, specifically the Dynamic Source Routing (DSR) and Ad hoc On-Demand Distance Vector (AODV) protocols, in Mobile Ad hoc Network, commonly known as MANET. The goal of this paper is to determine which of these reactive or on-demand routing protocols are superior compared to the other, with variables integrated in the NETSIM simulation. Other than that, it is also aimed to prove whether the results achieved are true to the previous studies that have been done with similar properties and application settings. However, compared to the common amounts of nodes of 50 and above, the outcome of this simulation will contribute to the studies consisting of a lesser number of intermediate nodes and implementing a variable of the power source as it may show a difference considering one of the downsides of MANET is the limited power source of the intermediate nodes. This paper also gives way to future studies possibly with different properties integrated as technology continuously resumes its advancements.**

Keywords—routing protocols, DSR, AODV, MANET, mobile ad hoc network

I. INTRODUCTION

Ad-hoc network has been introduced to the society for more than a decade – one of the more popular implementations of ad-hoc network being the integration of Bluetooth in mobile phones, as prior to the age of smart phones and the availability of wireless internet and sending media through mobile applications such as WhatsApp and Telegram, media was transferred mobile to mobile, pc to mobile, and vice versa, via Bluetooth connection. But truthfully does anyone really know what goes on behind the connectivity of these transfers without having in-depth knowledge in the field?

A. Introduction to Network

According to [4], in order for a communication to exist and to be executed successfully, 3 things are required to be present: Parties consisting of the sender and receiver, the medium of the communication that will be transmitted through, and the rules or protocols of the communication that the parties have agreed upon. Similar to that, a computer network is defined as a distributed system that consists of a group of not only computers but other devices that are technically known as network elements or nodes. Any two or more of these devices would act as parties in the network, able to communicate through a transmission medium, provided with a set of rules or protocols that each device must abide to successfully communicate with and amongst each other in a network.

B. Types of Network

In general, there are 2 main network types: the local area network and the wide area network, commonly known by laymen and experts alike, as LAN and WAN. There is also one in between LAN and WAN that many may not be familiar with, that is referred to as the metropolitan area network (MAN). [4]

- Local Area Network (LAN): LAN refers to a connection of devices communicating within a small area. The area size can range from being as small as within the same floor of a building to being as big as the area within a small group of buildings. LANs are commonly known for its constant fast data movement due to the closely placed network elements in the vicinity. [4]
- Metropolitan Area Network (MAN): A MAN defines the connection of devices communicating within a medium-sized area. This scope of network is not usually discussed due to the unobvious distinction of the network being categorized as a MAN in comparison to either a LAN or WAN. [4]
- Wide Area Network (WAN): WANs signify the connection of devices within an area larger than both LANs and MANs, ranging from a state of a country, to a global scale entirely. WANs are ideal for dispersing data to and from a further destination, thus covering a wider scale of network elements and offering more availability in terms of both hardware and software resources that LANs potentially lack of. On the other hand, due to the widely spread out placements of network elements, this results in WANs poor network performance compared to LANs. [4]

II. LITERATURE REVIEW

This section is focused on an introduction into mobile ad hoc networks and the routing protocols commonly implemented, followed up with a discussion of 2 common routing protocols that would be integrated thus leading to the key purpose of this paper.

A. Mobile Ad hoc Network

In this situation, “Mobile” defines the ability to move freely and “Ad Hoc” refers to “for this purpose” in Latin. Thus, the mobile ad hoc network promotes it being a

temporary connection generated for specific situations where a connection is required on the spot, regardless of the time and place, without having or needing any specific infrastructures or frameworks beforehand. Similarly, in [10] and [13], a mobile ad hoc network (MANET) refers to a type of wireless network that could be self-configured without it requiring a pre-defined infrastructure or a centralized administration.

[3] MANET's network topology is flexible, thus the constant ins and outs of intermediate nodes. The uniqueness of this network is that the network elements that communicate in a hop-by-hop manner with each other act as their own hosts simultaneously. By hop-by-hop manner simply refers to the intermediate nodes transmitting data to the next hop intermediate nodes based on the routing protocol used. [9]

According to [7], there are many advantages of MANET. It is deemed as a high affordability network consequent to the fact that it could be constructed without any frameworks, and the low capital investment when it comes to the installation, maintenance, and repair processes. In addition, as the name suggests, the MANET's flexibility results in high mobility within a certain range from one another, thus easing the repairing and constructing of the network. Lastly, its decentralized demeanor contributes to it having little to no risk of lost connection between each intermediate node.

However, MANETs do possess a few drawbacks. According to [7] due to its high level of mobility, the boundaries of the network is limited to a specific radius, thus making data transfer within a long range an obstacle in the network. Other than that, the decentralization of MANET results in low security of the network itself which allows easy access of third-party participation of malicious intent – Active attacks which consists of the outsider modifying and deleting messages transmitted through the network, and Passive attacks being Man-In-The-Middle or similar. On the other hand, according to [14] one of the few downsides of MANET is of its nodes possessing limited battery life span which brings in a potential network failure when a power source is unavailable at the time of need.

B. Routing Protocols

The main purpose of routing protocols refers to defining a set of conditions that monitors the route of data transmission in the network that are to be abided to by the intermediate nodes participating in the network. These protocols are able to result in great performance under specific circumstances they are designed for, whereas poor performance for situations where they are not.

[7] The basic algorithm of routing protocols touches on deciding a route to transmit data successfully between two intermediate nodes. [17]

B1. Types of Routing Protocols in MANET

According to [3] generally, routing protocols used in wireless networks are categorized based on various characteristics and classified in various ways.

Thus, there are three types of routing protocols that are commonly being used in MANET: Proactive Protocols, Reactive Protocols, and Hybrid Protocols. [3][9] [13]

TABLE I. ROUTING PROTOCOLS OF MANET

Proactive Routing Protocols	***Reactive Routing Protocols***	***Hybrid Routing Protocols***
Table-driven	On-Demand	Combination
Ability to produce routing tables and to identify the network topology	Able to produce routing tables on demand, following data transmission of a sensor node	Combines both advantages and disadvantages of both proactive and reactive protocols
Attempts on conserving the superior existing paths to every possible destination node	A mechanism that discovers paths to destination nodes is invoked upon generation of routing tables	Utilizes reactive protocol's flooding techniques to acquire routes to further nodes
Utilizes standard exchange of control messages to keep the routing tables up to date to all destination nodes	Routes created will remain until they are no longer in use, provided the destination nodes are still reachable	Utilizes proactive protocol's standard exchange of control messages to discover routes

B2. DSR & AODV

This paper will focus on the comparative study of both reactive routing protocols: Dynamic Source Routing (DSR) & Ad hoc On-Demand Distance Vector (AODV).

a) Dynamic Source Routing (DSR):

According to [7], the DSR protocol is known for its simple method of communicating: using the source path discovery approach. This refers to information like routing paths, destination nodes, and source addresses, attached to the data packet before transmitted onto the next hop intermediate node. According to [17] the prominent difference in comparison between DSR and the other reactive routing protocols is that sending 'hello' messages to signal its presence to the neighboring intermediate nodes is not necessary.

There are two phases in this protocol: the route discovery and the route maintenance. The route discovery phase is executed via the flooding technique as mentioned in the previous table. The major advantage of DSR is that it reduces the flooding of table update messages. Besides that, consequent to the fact that nodes do not exchange routing table data when there are no topology updates or modifications, it also lessens the overhead significantly. However, a significant disadvantage of DSR refers to the lack of ability of its route discovery mechanism to repair broken links locally.

b) Ad hoc On-Demand Distance Vector (AODV):

According to [13], AODV is a combination protocol of Dynamic Source Routing (DSR) and Destination-Sequenced Distance Vector (DSDV) routing protocols. It extracts, merges, and implements DSR's route discovery and route maintenance on demand with DSDV's hop-by-hop routing, periodic beacons, and use of sequence numbers.

According to [3], due to AODV categorized as a reactive routing protocol, similar to DSR, its on-demand demeanour reduces the quantity of broadcasts to obtain routes and conserving only the routes that are needed in the network. Consequently, the aim of this routing protocol is to make a distinction between general topology management and local connection management.

In addition, AODV is aimed to disperse valuable information to nearby or neighboring intermediate nodes regarding the latest modifications in a local connection. A mentioned in the table, AODV utilizes a mechanism that discovers paths based on routes established by previous and current intermediate nodes in the network.

As mentioned before, this paper is emphasized on studying the performance of MANET according to the routing protocols used and is aimed to present a comparative study of performance on 2 different reactive routing protocols (DSR & AODV) based on the Throughput and Delay shown following the simulation to assist in determining the optimum routing protocol for future studies. The next chapter will be focused on the related works regarding the performance of MANET and its routing protocols.

B3. Related Works

Undeniably, there were previous comparative studies focusing on similar, if not the same, network and routing protocols. According to [7], their study is on the comparison of Quality of Service (QOS) of both AODV and DSR in MANET. An experiment had been conducted based on the node density in the network. They had concluded that in terms of Throughput, both DSR and AODV initially flopped; the difference being that DSR still managed to spike before steadily declining. On the other hand, in terms of the Delay, AODV displayed a significant spike compared to DSR.

Besides that, [17] had also conducted a study on random mobility models between DSR and AODV routing protocols, that produced results of throughput, end-to-end delay, packet delivery ratio, and overhead, which concluded DSR being the superior routing protocol compared to AODV on average in all mobility models.

On the other hand, there are various studies conducted to analyse the performance of AODV and DSR compared to other routing protocols, such as DSDV, ZPR, TORA, FSR, and OLSR. According to [18], their study had revealed an excellent network performance on AODV and DSR's sides compared to the rest. In addition, a study conducted by [6] had concluded in DSR performing better in comparison to AODV and DSDV. Whereas, according to [14], the OSLR outperforms both AODV and DSR protocols, specifically with 50 intermediate nodes.

III. RESEARCH METHODOLOGY

A. Simulation Tool

This chapter focuses on the methods of conducting the experiment between the protocols. For this study, NETSIM will be utilized to evaluate the performance of both DSR and AODV in MANET. NETSIM is a network simulation software commonly used for network design modelling and simulation. It possesses the right tools and abilities to analyse networks with accurate depth, power and flexibility. Besides that, it is also known for its open, modular and flexible architecture. The results of this study will determine the performance of both these routing protocols. [8][11]

B. Simulation Scenario

The results that will be achieved is focused on the throughput and delay of both these routing protocols according to NETSIM's Application Metrics results, though there will be other end products displayed by NETSIM's Network Metrics provided as well to assist in future studies.

Throughput, measured in Mbps, is the measurement of speed for the data packets to be successfully transmitted to the destination nodes from the source nodes. Ideally, the higher the throughput, the better the network. Delay, on the other hand, refers to the amount of time it takes for the data packets to be successfully transmitted to the destination nodes from the source nodes. Delay is usually measured in microseconds, thus ideally, the less the delay, the better the network. [8] [11].

As NETSIM only allows the number of nodes being in squares if uniformed placement is selected, both routing protocols will be conducted with 16 intermediate nodes. The power source of the wireless nodes was set to Main_ Line to determine whether or not the power source could be a potential variable between both routing protocols.

IV. SIMULATION

This section elaborates on the study conducted to obtain the results of the comparative study between reactive routing protocols: DSR & AODV in MANET.

A. Performance analysis of DSR

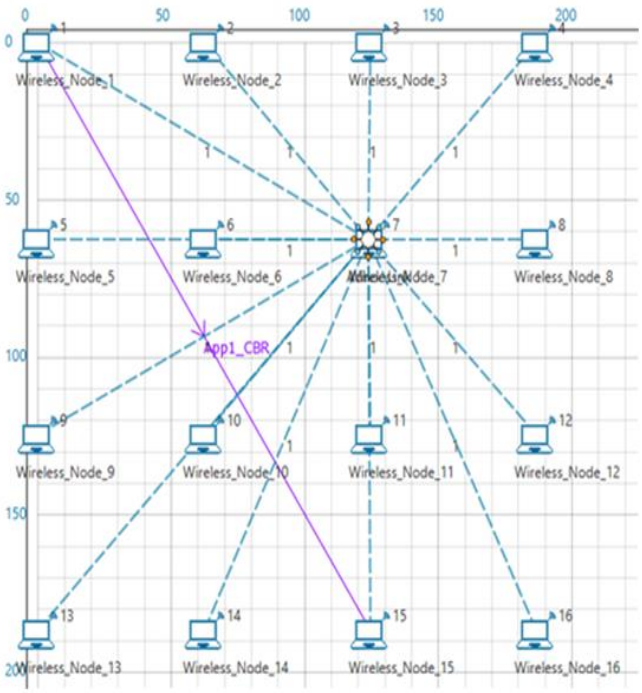

Fig. 1. The uniformed network design in NETSIM.

The properties of the study conducted is as follows:

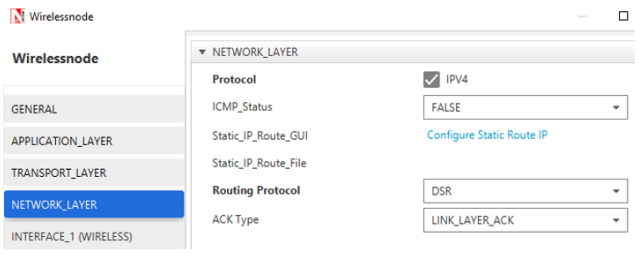

Fig. 2. The Routing Protocol of the first study.

Application_metrics Detailed View

Application Id	Application Name	Packet generated	Packet received	Throughput (Mbps)	Delay(microsec)
1	App1_CBR	4750	4757	0.555618	1813.574441

Fig. 3. Modified PowerSource panel.

As shown in the Figure 3, the data packets in this simulation was sent from source node 1 to destination node 15. The results of the simulation are as below:

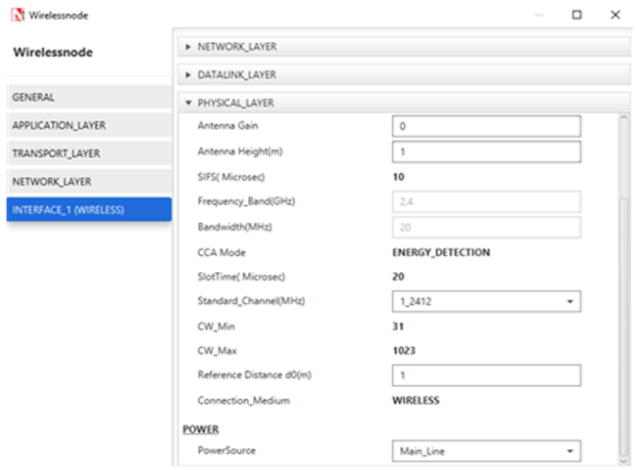

Fig. 4. The results of DSR's Application_Metrics.

Network_Metrics Detailed View

Link_id	Link_throughput_plot	Packet_transmi...		Packet_errored		Packet_collided	
		Data	Control	Data	Control	Data	Control
All	NA	4985	4774	228	7	0	0
1	NA	4985	4774	228	7	0	0

Fig. 5. The results of DSR's Network_Metrics.

B. *Performance analysis of AODV*

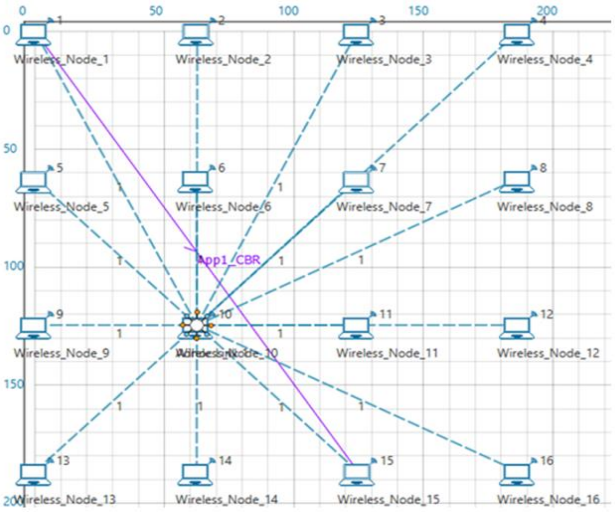

Fig. 6. The uniformed network design in NETSIM.

For AODV's case, the ad hoc connection is changed from being intermediate node 3 to intermediate node 10. However, the source and destination of data packets transmitted remain constant.

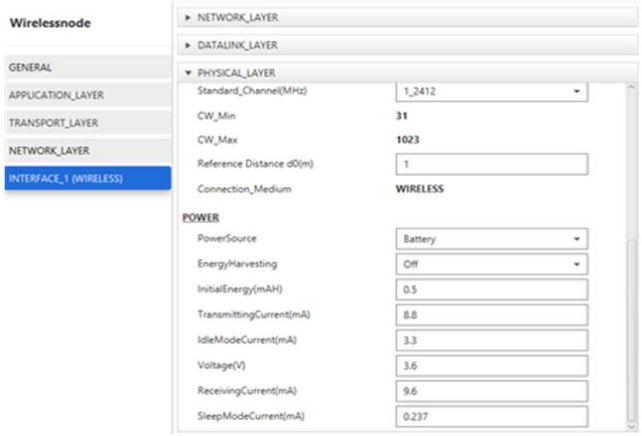

Fig. 7. The modifications of Routing Protocol panel to AODV

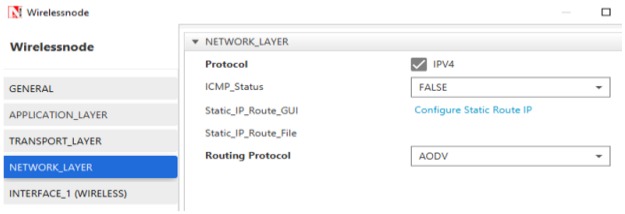

Fig. 8. PowerSource set to Battery without EnergyHarvesting.

Initially, NETSIM pre-sets the nodes to having battery power-sourced with energy harvesting settings enabled, but for this study, the energy harvesting setting is switched off.

Application_metrics Detailed View

Application Id	Application Name	Packet generated	Packet received	Throughput (Mbps)	Delay(microsec)
1	App1_CBR	4750	4753	0.555150	2061.134820

Fig. 9. The rresult of AODV's Application Metrics.

Network_Metrics Detailed View

Link_id	Link_throughput_plot	Packet_transmi...		Packet_errored		Packet_collided	
		Data	Control	Data	Control	Data	Control
All	NA	5072	27331	307	10	12	4375
1	NA	5072	27331	307	10	12	4375

Fig. 10. The result of AODV's Network Metrics.

V. RESULTS & DISCUSSION

As for the results shown in the Network Metrics, AODV had displayed the presence of collided data packets in the network, whereas DSR presented nil. AODV had also displayed more packet data error in comparison to DSR. However, AODV managed to transmit slightly more data packets compared to DSR.

In this case, the power source variable did not deter the throughput of AODV as the difference displayed is less than DSR by just a mere 0.001 Mbps. On the other hand, the variable may have made a bigger impact on the delay of AODV as the result showed a significant difference of 248 microseconds more than DSR's delay.

Overall, based on this simulation conducted through NETSIM, it is concluded that DSR is superior to AODV, taking into consideration of the variables being made. Future studies could include more variable in terms of the properties of the battery as a power source to the nodes.

TABLE II. VARIABLES IN THE SIMULATION

	DSR	***AODV***
Power Source	Main_Line	Battery
Energy Harvesting	-	Off
Distance of the ad hoc network (m)	Similar to both source and destination nodes	Nearer to the destination nodes

TABLE III. THROUGHPUT & DELAY (ROUNDED OFF)

	DSR	***AODV***
Throughput (Mbps)	0.556	0.555
Delay (Microsec)	1813.574	2061.135

V. CONCLUSION

Consequent to routing protocols playing a huge part in a network's performance, it is crucial for a network expert to conduct comparison analysis between various routing protocols, taking into consideration of different factors. Previous studies have shown the superior performance of the DSR routing protocols when competed with other routing protocols, despite there being a few studies here and there suggesting another routing protocol achieving better performance. Coming back to MANET, though unlike most wireless connections, this connection does come with a challenge of overcoming data transmissions over long ranges as it is more focused on its mobility and low installation features. Due to that, in order to achieve optimum performance of the MANET, it is highly recommended to stick to short range data transmissions when it comes to this network, and leave the long range data transmissions to the other types of wireless networks.

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