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Implementation of Ad-Hoc Protocol On Tandem Multihop Wireless Network

Agussalim[1], Dhian Satria Yudha Kartika[2], Ani Dijah Rahajoe[3]
[1,2] Information Systems Department, UPN Veteran Jawa Timur, Surabaya, Indonesia
[3] Informatics Department, UPN Veteran Jawa Timur, Surabaya, Indonesia

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ABSTRACT

The utilization of Internet of Things (IoT) technology, especially in remote areas, is still relatively low, even though the technology is required to implement smart farming or smart villages, which aims to improve the quality of life of people in rural areas. The high investment cost for IoT networks that still use cellular networks or Wi-Fi is one of the causes of the slow implementation of this technology. Our previous research has developed an alternative network for IoT devices in remote areas with the concept of a Tandem Multihop Wireless Network focusing on developing simple message scheduling. This research focuses on implementing ad-hoc routing protocols in tandem with multi-hop wireless to analyze the advantages and disadvantages of the protocol. Each sensor periodically sends data to the monitoring server via IoT devices on each tower. The scenario was implemented using MININET-WIFI. Evaluations were carried out to determine delivery probability, latency average, and jitter. In general, the two Ad-Hoc protocols tested, namely OLSR and BATMAN, had the same performance when the data sent was 1 MB, but when the data size was increased to 2 MB, the OLSR routing protocol on several nodes had better performance than BATMAN.

Corresponding Author:

Agussalim
Information Systems UPN Veteran Jawa Timur, Surabaya, Indonesia
Email: agussalim.si@upnjatim.ac.id

1. INTRODUCTION

The utilization of IoT-based technology is still constrained by the availability of telecommunication networks, where the technology requires WiFi and 4G networks to communicate and send sensor readings to the server so that they can be processed into useful information. On the other hand, the use of expensive WiFi and 4G networks and the uneven coverage of telecommunication networks keep IoT technology penetration in Indonesia relatively slow, especially for smart agriculture, smart farming, and small villages in rural areas. Where usually, the area is not yet available adequate telecommunications services. So like it or not, it is necessary to build a telecommunications network infrastructure, which requires investment costs that are not cheap.

In previous research [1,2], we have developed a global time slot assignment on a tandem multi-hop wireless network as a low-cost alternative network that IoT devices can use. The development uses a case study by utilizing pre-existing infrastructure, namely the High Voltage Air Line (SUTET) tower, as shown in Figure 1. Each tower is equipped with IoT devices that provide information about the current condition of the tower and transmission lines. IoT devices in each electric power transmission tower send data to the monitoring server through a gateway located in the power generation unit. Many SUTET

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passes through remote areas, mountains, and through river routes, where most of the locations of these transmission lines do not have communication lines at all.

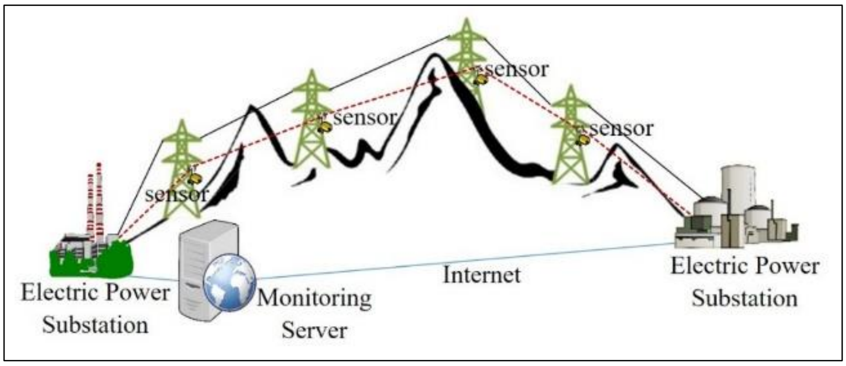

Figure 1. Scenarios of using the wireless sensor network as a monitoring system for very high voltage electricity transmission facilities

A Tandem multi-hop wireless network utilizes Ad hoc network technology which does not require an access point/router to connect multiple nodes. In an Ad-hoc network, each node not only acts as a host but also acts as a router. Nodes on an ad-hoc network can be classified as static or dynamic nodes. Therefore, several routing protocols in ad-hoc are made to work if the topology changes dynamically, where the protocol is divided into three classifications: proactive, reactive, and hybrid. [3,4]

Proactive routing protocols periodically update the routing table by sending information about the presence of each node on the network. O.L.S.R., D.S.D.V., and BATMAN are examples of proactive routing. BATMAN has been implemented by several researchers, one of them in research [15], by adapting and implementing the BATMAN protocol for lower-end devices with MCU and IEEE 802.15.4 transceivers. In addition, there is also reactive routing which does not update the routing table periodically after the existence of a node. When communication is in progress, the node makes a route from source to destination. In addition, there is a combination of the two types of protocols, namely Hybrid routing protocols (Z.R.P. and T.O.R.A.) [5].

Routing protocols play an important role in influencing the performance of ad-hoc wireless networks. This research analyzes the advantages and disadvantages of ad-hoc routing protocols implemented in a tandem multi-hop wireless network using a scenario, as shown in Figure 1. The evaluation scenario was implemented in the Mininet-WiFi emulator to evaluate the performance of popular routing protocols on ad-hoc networks, namely O.L.S.R. and B.A.T.M.A.N., in terms of delivery probability, latency average, and Jitter.

2. LITERATURE REVIEW

2.1. Tandem Multi-hop Wireless model

We developed this model in a previous study [1.2], a simple message transmission model using tandem multi-hop, as shown in Figure 2.2. Where n nodes (j=1,2…n,) are connected in tandem, each node creates messages periodically at the beginning of time in 1 cycle. Messages created on each node can be transmitted from a node to neighboring nodes in a one-time slot. And sent using a store-wait-forward rule from the source node to gateway X or Y as the center of each tandem and will be forwarded from the gateway to the other node Server (S) over the internet. Each link has a loss rate value that describes the possibility of message transmission failing to be sent to the following link.

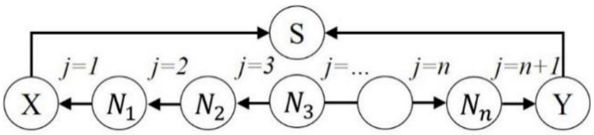

Figure 2. Tandem Multi-hop Wireless Network Scenario

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2.2. Wireless Mesh Network

The wireless mesh network is one of the wireless telecommunications network technologies. The network consists of a series of interconnected nodes where each node has two or more communication lines. Nodes in the WMN topology can function as mesh hosts or mesh routers. The node, as a mesh router, serves to forward data transmission packets to other nodes that cannot communicate directly with the destination node. WMN can manage and configure its network (self-configure/self-organize). Therefore, WMN can establish and maintain its connectivity in case of problems in other nodes. The ability of WMN makes the nodes in the network have a high level of toughness and reliability because they are always connected even though there are damaged nodes [6, 7].

2.3. Adhoc Routing Protocol

The routing protocol is a rule used to determine the communication path when sending data from the sending node to the destination node. There are three types of routing protocols in ad hoc network technology: proactive, reactive, and hybrid. This study will compare the performance of two proactive routing protocols: OLSR (Optimized Link State Routing) and BATMAN (Better Approach to Mobile Ad-hoc Network). OLSR is a proactive routing algorithm that regularly communicates topology data between nodes in a network. Each network node selects a group of neighboring nodes to act as a Multipoint relay (MPR). OLSR operates separately from other protocols in the network. OLSR does not perform any calculations based on the connection layer behind it [8]. It was adopted for ad hoc network families such as MANET, VANET [9], and FANET [10].

The MPR is responsible for forwarding control traffic intended for dissemination throughout the network in the OLSR. MPR provides an effective and reliable mechanism for broadcasting control messages by reducing the number of transmissions required. Furthermore, the MPR has a special responsibility when announcing link status information on the network [11]. It is used in route computing to establish a route between two nodes in the network, starting from one source node and ending at another destination node in the network. Each node in the network controls topology control messages to maintain the databases required for packet routing. Different nodes broadcast TC messages regularly to create their MPR voter sets. OLSR is optimized regularly by sending TC messages reactively and reducing the maximum periodic time interval [12].

The BATMAN routing protocol (Better Approach to Mobile Adhoc Network) is a proactive routing protocol in which all decisions and information are distributed evenly to all nodes, so all nodes that are members of the BATMAN routing protocol know information on all nodes incorporated in the BATMAN routing protocol. one network routing protocol, BATMAN. If there is maintenance or disruption to the BATMAN routing protocol network, it will quickly update information regularly. The message used in the BATMAN routing protocol is referred to as OGM (Originator Message). OGM is used to determine the existence of neighboring nodes.

2.4. Mininet-WiFi

Mininet-WiFi is developed from the Mininet SDN network emulator by extending the functionality of Mininet with the addition of WiFi and a virtualized Access Point based on the standard Linux wireless driver and 80211_hwsim wireless simulation driver. Mininet-WiFi is developed based on the code base of Mininet by adding or modifying classes and scripts. So with the new functionality, it still supports all the SDN emulation capabilities of the Mininet network emulator.

The main components of developing Mininet-WiFi are illustrated in figure 3. In the kernel, the mac80211_hwsim module is responsible for creating virtual WiFi interfaces for stations and access points. In addition, MLME (Media Access Control Sublayer Management Entity) is realized on the station side, while in the user room, hostapd is responsible for this task on the AP side.

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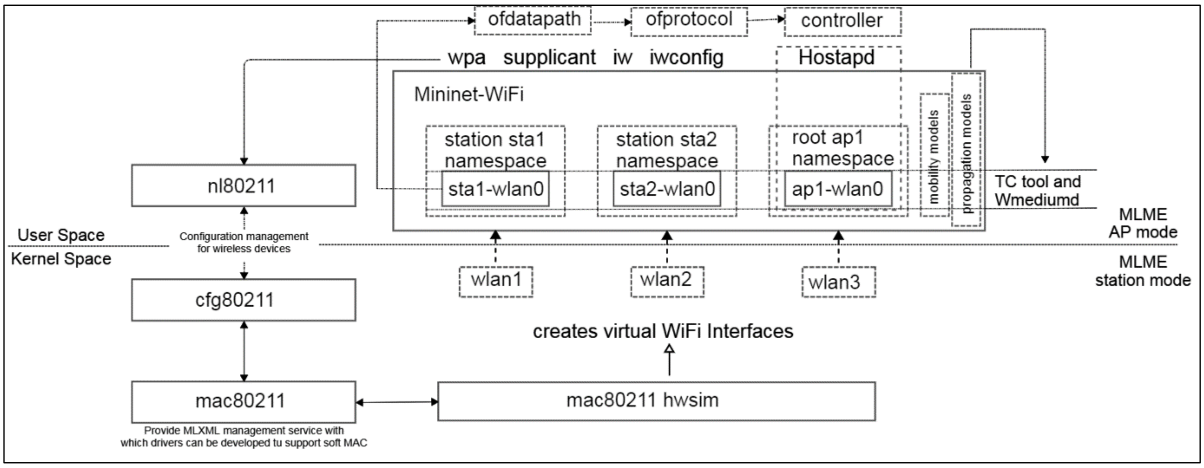

Figure 3. Mininet-WiFi architecture

3. RESEARCH METHODOLOGY

The research method used is a quantitative research method that emphasizes the aspect of measuring objectively the phenomenon. An artificial model of the real system was built to obtain measurement data. Emulation is used to select the appropriate model for the real system. In the emulation process, we use Mininet-WiFi. Table 1 shows the emulator parameters that we used in this study. As shown in Table 1, each node will generate 1 data per second, with the size of each data being 1 MB and 2 MB. The intermediate node then forwards the data to the gateway. So each node in this scenario, apart from creating data, is also tasked with forwarding data so that the gateway node can receive data.

Table 1. Evaluation parameter

Item	Parameter
Environment Size	2000x3000m
Node Number	18
Routing Protocol	OLSR dan BATMAN
Performa Metric	Delivery Probability, Average Latency, dan Jitter
Packet Data Size	1 MB dan 2 MB
Application Traffic	PING
Log Distance Path	2.8
Simulation Time	60 minutes
Number of transmitting Data	3600

3.1. Desain System of Simulation

The Tandem Multihop wireless network scenario used to evaluate the performance of the OLSR and BATMAN routing protocols consists of 18 nodes where one of the nodes acts as a gateway. Each node periodically, for 60 minutes, sends as much as 3600 data to the gateway node through several nodes as intermediate nodes. The intermediate node is in charge of forwarding sensor data. The node also creates and sends data to the gateway node. The network topology used can be seen in Figure 4. From a total of 18 nodes, one node will serve as a gateway. So 17 types of data are generated every second, namely data from Node 1 and Node 2 until Node 17.

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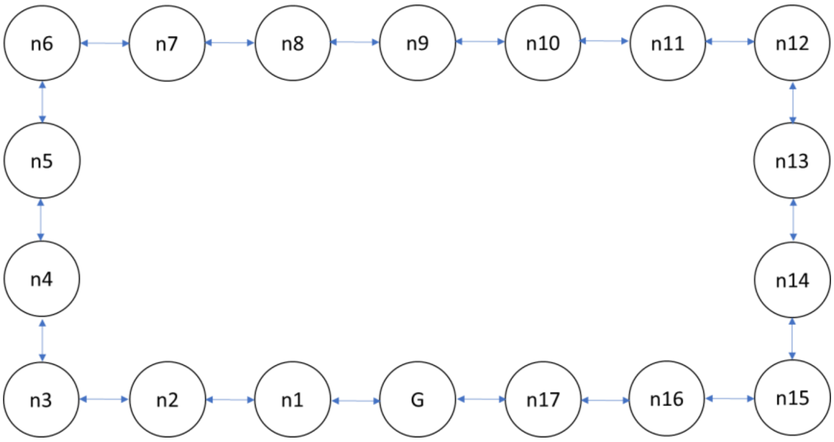

Figure 4. Topology of tandem multihop wireless network

There are 18 nodes with static positions. For routing protocol selection, declared in the creating links section, each node is defined as class Adhoc, mode='g', channel=5, ht_cap='HT40+', and proto='' Adhoc''. Each node is also defined with a different Mac Address. After the configuration script is executed, the Mininet-Wifi emulator will run, displaying a tandem multi-hop wireless network model, as shown in Figure 5. There are 18 nodes, where Node 18, with the label s18, acts as a gateway, and the other nodes labeled s1 to s7 are tasked with generating data and forwarding data to node s18.

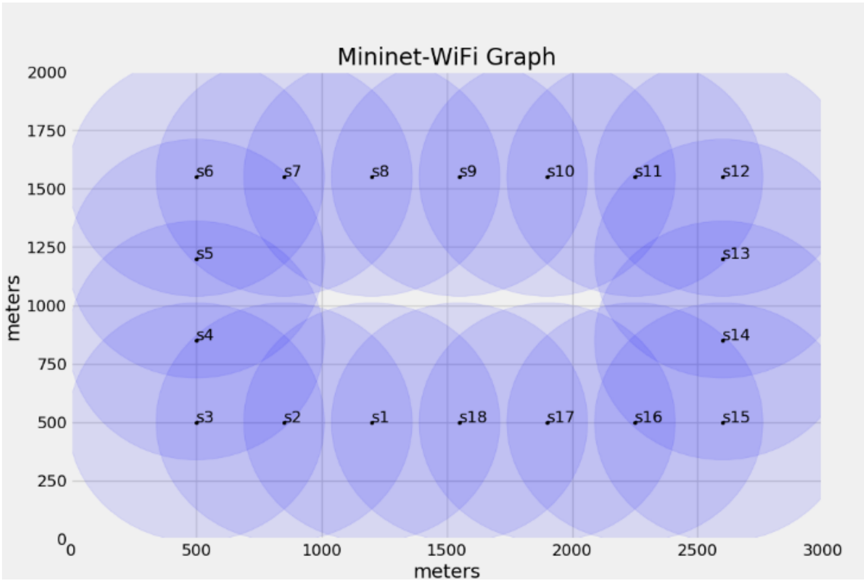

Figure 5. Mininet-WiFI graph topology of tandem multihop wireless network

3.2. Performance Evaluation

The performance of a tandem multihop wireless network and the advantages and disadvantages of the two protocols in a tandem multihop wireless network scenario evaluate using three metrics, namely Delivery probability, Latency average, and Jitter. Delivery probability measures the performance of the probability of the number of messages received at the gateway node. Delivery probability is the ratio of the total number of messages sent to the destination to the total number of messages created at the source, as shown in formula 1.

$$delivery\ probability = \frac{Delivered\ Data}{Created\ Data} \tag{1}$$

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Latency or delay is defined as the average travel time of data sent from the source node to the destination node. A jitter determines the time delay in sending data from the source node to the destination node through the network. Jitter shows the many variations of delay in data transmission on the network. This is caused by network congestion and sometimes route changes.[14]

4. RESULTS AND DISCUSSION

4.1. Delivery Probability

Figure 6 shows the delivery probability of the data for each node. The higher the value of delivery probability, the better the performance of the routing protocol, where the percentage of packet loss on the way to the gateway node is getting less and less. With a data size of 1 MB, almost all data sent by each node can be received by the gateway node. This can be seen from the average delivery probability for each data above 0.98. Even in the BATMAN routing protocol, the delivery probability for data from each node is constant at a value of 1. This means that the network configuration and routing protocol can still anticipate the volume of data sent by each node. In this case, each node sends one data per second for 60 minutes.

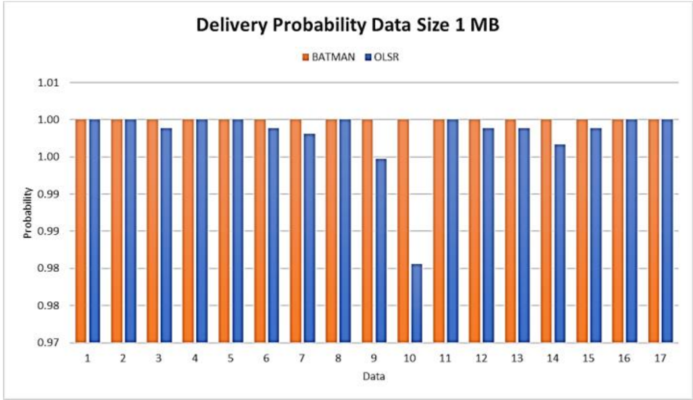

Figure 6. Delivery probability data from each node with a data size of 1 MB

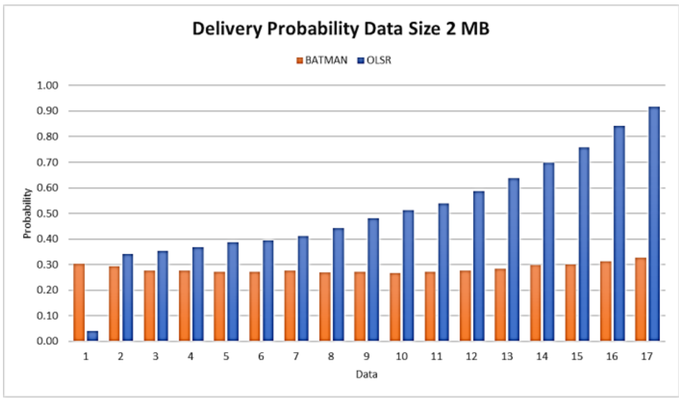

Figure 7. Delivery probability data from each node with a data size of 2 MB

Performance degradation is seen when the data sent's size is increased from 1 MB to 2 MB. The more data packets in the network, the higher the probability of data being dropped (dropped), the occurrence of data collisions (collision), and the accumulation of data queues (congestion) during the transmission process from the source node to the gateway node. Figure 7 shows that the performance of each routing protocol decreases with increasing data volume. In the BATMAN routing protocol, there is a significant decrease in delivery probability, from the delivery probability value of 1 when the data size of 1MB drops to an average of 0.3 for data on each node. In contrast to the OLSR routing protocol, the decrease in delivery probability is not evenly distributed at each node. Node 1 has the lowest delivery

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probability and node 17, on the other hand, has the highest delivery probability even though the position of the two nodes is right next to the gateway node.

Differences in the workings of each routing protocol greatly affect the value of delivery probability. The route chosen by the OLSR routing protocol is centered on one node, node 1. So data accumulation occurs at node one, resulting in a very low delivery probability compared to node 17. On the other hand, the BATMAN routing protocol works by choosing a route fairly so that every node with the same route causes the delivery probability value to be almost the same at each node.

4.2. Average Latency

Figure 8 and 9 shows the average latency of data from each node. The lower the average latency value, the faster it takes for data to reach the gateway node. Here, it can be seen that the farther the node's position from the gateway node, the higher the average latency of the node. In general, BATMAN has a higher average latency than OLSR. Even in OLSR, some nodes have a lower average latency even though their position is further from the gateway node, namely at node 8 and node 10. But when the data size increases from 1 MB to 2MB, there is a significant change in the average latency value of OLSR. Route selection in OSLR causes an unbalanced data accumulation at node 1, causing several nodes adjacent to node 1 to have very high average latency. In contrast to BATMAN, the average latency value is almost evenly distributed according to the distance of the node position from the gateway node. The farther the node is from the gateway, the higher the average latency of the node.

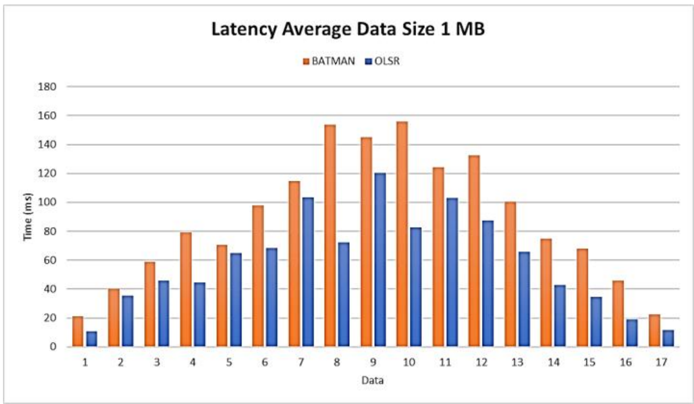

Figure 8. Latency average of each data node with a data size of 1 MB

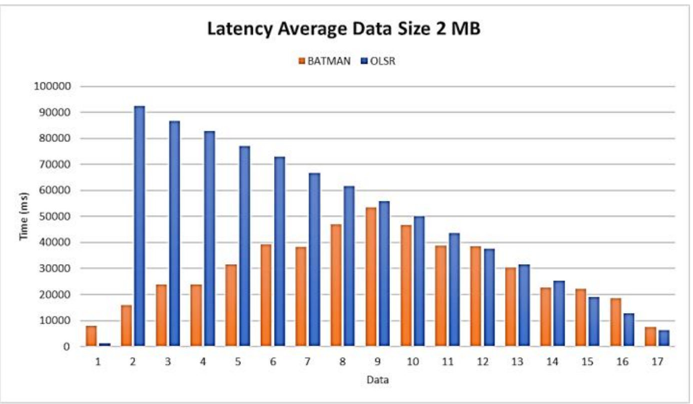

Figure 9. Latency average of each data node with a data size of 1 MB

4.2. Jitter

The jitter value of each routing protocol fluctuates based on the node's location. The lower the jitter value, the better the performance of a protocol. In BATMAN, the farther the node is from the gateway, the greater the jitter value generated. On the other hand, the OSLR routing protocol generally has the same jitter value pattern as BATMAN, but the jitter value in data 8 is smaller than in data 7 even though the location is further from data 7. Likewise, data from node 11 has a lower jitter value than data from

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node 10 as shown in Figure 10 and Figure 11. Meanwhile, when the data size is increased from 1 MB to 2 MB, there is an increase in the jitter value for both routing protocols. The jitter value in BATMAN is consistent with the node's position with the gateway node. The farther the node from the gateway, the higher the jitter value. On the other hand, in OLSR, there is an anomaly in the jitter value, especially in data from node 2 to node 8. This is due to the selection of a different route from OLSR, which results in conjunction that occurs at that node.

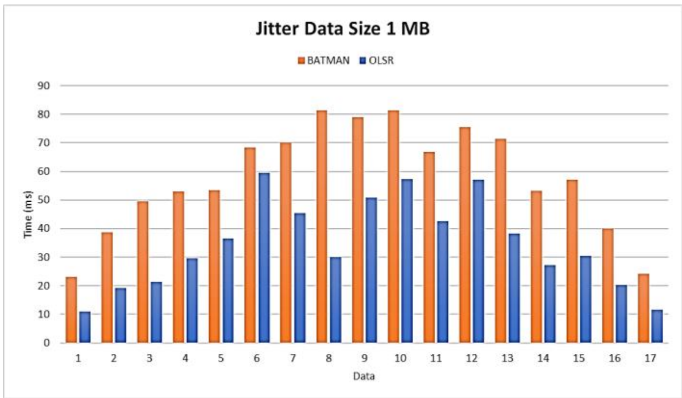

Figure 10. Jitter of each data node with a data size of 1 MB

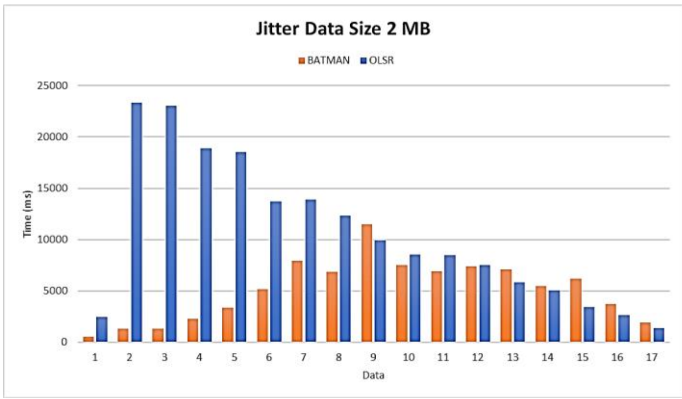

Figure 11. Jitter of each data node with a data size of 2 MB

5. CONCLUSION

In general, both protocols have the same performance when the size of the data sent is 1 MB, but when the data size is increased to 2 MB, OLSR routing on some nodes has better performance than BATMAN, but there is one node that has a very low delivery probability, and of course, it will affect the overall performance when it is implemented in actual conditions. On the other hand, BATMAN has a more consistent delivery probability value for each node, even though the value is still below the OLSR. Likewise, for average latency and jitter, when the data size is still 1 MB, all routing protocols provide good performance, but when the data size is increased to 2 MB, performance anomalies occur, especially in the OLSR routing protocol. Furthermore, the development of the following Tandem Multihop Wireless network is to compare the performance of several protocols, such as BABEL, AODV, and others, as well as the need to develop message scheduling that is integrated with the routing protocol.

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