Simulation and Analysis of Energy Consumption and Performance of Routing Protocol DSDV and OLSR on IEEE 802.11ah Standard

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Abstract — There is a current need for simple and efficient information technology for ad hoc networks. The ad hoc network is a wireless LAN technology that doesn’t require any infrastructure on its network. But wireless technology usually has limited resource. The IEEE 802.11ah standard was created to solve that problem. The IEEE 802.11ah is designed to work at sub-1 GHz frequency band, the transmission range up to 1 Km, has over 100 Kbps for data rate, small power consumption, and can serve up to 8191 Station. This research has compared Destination Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR) routing protocols on IEEE 802.11ah standard using Network Simulator 3. The simulations have performed with two scenarios, i.e. the increment number of node and the increment of distance between station (STA) and access point (AP). Whereas the parameters for comparison are energy consumption, throughput, packet delivery ratio, and average delay. Based on the results and analysis, the OLSR routing protocol has better performances than DSDV for all parameters comparison. The ratio of energy consumption between OLSR and DSDV is 1,03% for the increment number of node scenario and 2,43% for the increment of distance between station (STA) and access point (AP) scenario.

Keywords – IEEE 802.11ah, Ad hoc Routing, QoS, Energy Consumption.

I. INTRODUCTION

Wireless network has expanding very quickly [1] because of its superiority as it can be used without regard to the network infrastructure that already exists and is always moving or mobile so that they can exchange information in real-time, reliable and flexible. But wireless technology also has some drawbacks such as frequently changes of topology due to the nature of the mobile wireless, high error rate, power consumption is quite large, bandwidth and link capacity limitations, and limited coverage area as well [2][3].

Ad hoc mode is a type of wireless network topology that doesn’t require infrastructure. Ad hoc mode has no fixed router where each node can move freely and be able to connect dynamically to any condition [4] without any intermediaries such as an access point. Ad hoc topology has the characteristics of fast-changing and unpredictable because the nodes have movement or mobility [5] so that routing protocol has a very important role. In general, a topology-based routing protocol in ad hoc divided into three types: proactive, reactive and hybrid.

However, ad hoc network have the challenge of limited bandwidth and access link and the issue with energy consumption [6]. IEEE 802.11ah designed to support wireless networking scenarios such as the number of devices, breadth of coverage, and limited energy [2]. In its use, the IEEE 802.11ah standard meet the needs for wireless M2M standards as used in metering and control utilities, intelligent transport systems, etc [2].

This paper is organized in seven sections: Section 1 is the introduction. Section 2 presented some related research that have been done and the contribution of this research. The IEEE 802.11ah standard is introduced in Section 3. Section 4 presented the ad hoc routing protocol. The scenario and design system are presented in Section 5. The simulation result and performance evaluation are presented in section 6. Finally, the conclusions are presented in section 7.

II. RELATED WORK

Recently, research has studied the feasibility of 802.11ah standard for IoT and M2M use case [7]. The research in [7] study the packet size, achievable data rate, and the link budget in some scenarios. In many conditions, the wireless node must operate for a long time. Energy consumption mechanism must be more efficient for support an IoT network. The modification on MAC and PHY layer be required for supporting energy efficiency mechanism and managing a large number of STA connected to an AP. According to [8], a new MAC enhancement algorithm for 802.11ah has been proposed for increasing the system performance and define an optimal size of RAW with high number of devices. In addition, the research from [2] has evaluate the energy consumption and network performance in several machine – to – machine (M2M) scenarios such as industrial automation, smart metering, etc. A research from [9] has successfully modified NS – 3 which can simulate
802.11ah features such as RAW mechanism. In [10][11], the research has been simulate some scenarios in NS – 3 to study the influences of traffic load, number of stations, number of RAW slots, and number of groups and also has successfully evaluate the network performance such as throughput and latency. The contribution of this research is to evaluate a simulations for 802.11ah in NS3 with DSDV and OLSR routing protocol. This research affirmed on the performance metrics of energy consumption, throughput, packet delivery ratio, and average delay. This research presents the performance of OLSR and DSDV with different scenarios. At the end, DSDV and OLSR have been compared by its network performance and energy consumption.

III. IEEE 802.11AH

A. General Overview

IEEE 802.11ah is an enhancement of IEEE 802.11 to meet the needs of wireless sensor network and machine to machine (M2M) [12]. IEEE 802.11ah offers smart solutions for smart metering, plan automation, eHealth, and also intelligent transport system. IEEE 802.11ah can handle a high number of station (STA) because it has a hierarchy of signalling and presence of power saving management [13]. IEEE 802.11ah standard protocol using bands sub 1 GHz [14] to provide additional Wi-Fi network coverage, compared with conventional Wi-Fi network that operates using bands 2.4 GHz and 5 GHz. It is also helpful in making the energy consumption is quite low, with allowing creating a group of station or sensor to share the signal, in which it supports the concept of the Internet of Things (IOT) [15]. Also, the low power consumption because there are some changes in the MAC protocol as a smaller frame format, priority traffic sensors, and beaconless paging mode [15].

IEEE 802.11ah has designed to operate at frequency band sub 1 GHz [14], with a range transmission up to 1 km [12][13], has a data rate over 100 kbps, small power consumption, and can serve up to 8191 STA [2][13]. IEEE 802.11ah has one-hop network topology, also has shorter transmission mode with 1 MHz bandwidth channel [13]. The IEEE 802.11ah improves the link budget when compared to the Wi-Fi 2.4 GHz technology. IEEE 802.11ah supports 1 and 2 MHz of bandwidth operation and supports 4, 8, and 16 MHz bandwidth operation for the use of applications with high data rate [15]. In [14], the needs of IEEE 802.11ah standard can be summed up as follows:

- Coverage transmission up to 1 km
- Data rate > 100 kbps
- Maintain the compatible of use 802.11 WLAN for outdoor, fixed, and point to multi-point applications.

The requirement of coverage transmission is relatively high when compared to previous technologies that are also paying attention to low-energy applications such as Ultra-Wide Band (UWB), Bluetooth, ZigBee, etc [16][17][18] as can be shown in Table 1 [7]. Then the requirement of data rate is relatively small. The IEEE 802.11ah standard should be able to handle the compatibility with the earlier IEEE 802.11 standards such as 802.11ac, so the MAC and PHY layer on 802.11ah probably somewhat similar from the 802.11ac standard [7].

Another purpose of 802.11ah protocol is to allow sub-gigahertz spectrum use low rate access of 802.11 wireless stations [15]. IEEE 802.11ah protocol is one of the most different from other LAN models, especially regarding the contention of media access. Striking aspect of 802.11ah is the behavior of the stations which made in groups to minimize the occurrence of contention in the medium, use a relay to extend its coverage, using less power because a period of wake/sleep has been established, capable of sending data at high speed with different conditions, and using sectorial antenna. IEEE 802.11ah using 802.11a/g specifications to provide 26 channels, wherein each channel capable of providing throughput about 100 kbps.

B. Physical Layer (PHY)

IEEE 802.11ah worked at sub 1GHz for channelization which is 10x downclock version of 802.11ac [13]. The IEEE 802.11ah standard has a bandwidth channel of 1MHz, 2MHz, 4MHz, 6MHz, and 16MHz. Channel that 802.11ah generally used are 1MHz and 2MHz, therefore the physical layer can be classified into two categories, there are the transmission mode with bandwidth channel ≥ 2 MHz and transmission mode with 1 MHz bandwidth channel [13].

The transmission is based on OFDM and the modulation use 16-256 QAM, QPSK, and BPSK [2]. Table 2 [9] shows

<p>| Table II. Range of Some Low-Energy Technology [7] |</p>
<table>
<thead>
<tr>
<th>System</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZigBee</td>
<td>10 – 100 m</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>1 – 10 m</td>
</tr>
<tr>
<td>UWB</td>
<td>10 m</td>
</tr>
<tr>
<td>IEEE 802.11ah</td>
<td>&gt; 1000 m</td>
</tr>
</tbody>
</table>

<p>| Table II. IEEE 802.11AH Modulation and Coding Scheme with The Code and Data Rate for Bandwidth (BW) = 1 MHz and 2 MHz and Number of Spatial Stream (NSS) = 1 [9] |</p>
<table>
<thead>
<tr>
<th>MCS Index</th>
<th>Modulation</th>
<th>Coding Rate</th>
<th>Data Rate (kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>BPSK</td>
<td>1/2</td>
<td>300</td>
</tr>
<tr>
<td>1</td>
<td>QPSK</td>
<td>1/2</td>
<td>600</td>
</tr>
<tr>
<td>2</td>
<td>QPSK</td>
<td>3/4</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td>16 – QAM</td>
<td>1/2</td>
<td>1200</td>
</tr>
<tr>
<td>4</td>
<td>16 – QAM</td>
<td>3/4</td>
<td>1800</td>
</tr>
<tr>
<td>5</td>
<td>64 – QAM</td>
<td>2/3</td>
<td>2400</td>
</tr>
<tr>
<td>6</td>
<td>64 – QAM</td>
<td>3/4</td>
<td>2700</td>
</tr>
<tr>
<td>7</td>
<td>64 – QAM</td>
<td>5/6</td>
<td>3000</td>
</tr>
<tr>
<td>8</td>
<td>256 – QAM</td>
<td>3/4</td>
<td>3600</td>
</tr>
<tr>
<td>9</td>
<td>256 – QAM</td>
<td>5/6</td>
<td>4000</td>
</tr>
<tr>
<td>10</td>
<td>BPSK</td>
<td>1/4</td>
<td>150</td>
</tr>
</tbody>
</table>

IEEE 802.11ah worked at sub 1GHz for channelization which is 10x downclock version of 802.11ac [13]. The IEEE 802.11ah standard has a bandwidth channel of 1MHz, 2MHz, 4MHz, 6MHz, and 16MHz. Channel that 802.11ah generally used are 1MHz and 2MHz, therefore the physical layer can be classified into two categories, there are the transmission mode with bandwidth channel ≥ 2 MHz and transmission mode with 1 MHz bandwidth channel [13].
a modulation and coding scheme for 1 MHz and 2 MHz. Technologies such as single-user beamforming, MIMO, downlink multi-user MIMO which has been introduced in the 802.11ac standard is also adopted in 802.11ah [2].

C. MAC Layer

IEEE 802.11ah groups the STA by AIDs [19] to manage a large number of STA which associated with an AP with four part, shown in Figure 1 [20]. When STA make an association with AP, AID (association identifier) will allocated to each STA by the AP. Every STA has a different AID and has a length of 13 bits [19]. AID is classified into pages, blocks, sub-blocks, and index of STA on sub-blocks. A number of pages and blocks can be configured according to the network needs.

With taking the station into a group which has same characteristics such as the page, block, and sub-blocks will minimize overhead and allowing many mechanisms. So AID will be assigned according to the type of device, station’s traffic, location, power management mode, etc [19]. The AID will be re-established when a station has change their characteristics. Afterward, when the station has direct links with all its peers, so the station will tell about AID changes.

![AID Hierarchy](image)

The TaskGroup ah (TGah) has develop a new mechanism to reduce the possibility of collisions in networks because of a large number of stations and to decrease power consumption, called Restricted Access Window (RAW) [19]. The RAW mechanism makes the stations divided into groups and share the channel access time into slots wherein each slot assigned to a group. So, The RAW mechanism cause the station will be restricted to accessing the channel and divide in a period of time for them to access the channels. In other words, the stations can only transmit in their slots [19]. RAW allocated by the AP with broadcasting RAW Parameter Set (RPS) beacons. The medium can be accessed during RAW for a group of STA which assigned by the AIDs [21]. During RAW, the channel can not be accessed by the station if not already in its slot.

![Beacon Structure](image)

The beacons have two types of signalling, i.e. DTIM and TIM [13]. Delivery Traffic Indication Map (DTIM) informed the AP about STA group which has pending data and also about the broadcast and multicast messages. Traffic Indication Map (TIM) informed the AP about where among those which have pending data on STA group. By using the page segmentation mechanism, each STA may get into a power - saving state during the entire period of RAW if doesn’t have any packets to be delivered.

Types of Stations

MAC layer designed to make the network support a large number of STA while making sure about energy efficiency. IEEE 802.11ah specify three types of stations which have different mechanism to access a channel, there are Traffic Indication Map (TIM), non - TIM, and unscheduled station [2].

- TIM station : to transmit or receive data, this type of STA requires to listen to the access point beacon. The transmission can only finished within RAW period. This procedure suitable for stations with high traffic load because it combining the data transmission segment periodically with energy efficiency mechanisms. TIM mode should consider to the DTIM and TIM beacon to transmit and receive data.

- Non-TIM Station : to transmit data, this STA doesn’t need to listen to each beacon or only listen to DTIM beacon [13]. The station negotiates directly to an access point to get the transmission time that allocated in the periodic restricted access window (PRAW) during the association process. Even though non stations - TIM can send data regularly but it is recommended to use TIM stations for applications with high traffic load. This type of station only pay attention to the DTIM Beacon to send and receive data.

- Unscheduled Station, same as non - TIM stations, STA doesn’t need to listen to each beacon. Even in RAW, this station can request direct channel access by sending a poll frame to the AP. Response frame indicates interval where the unscheduled station can access into the channel. This procedure is intended for stations which need to join in the network infrequently. This type doesn’t need to pay attention to the beacon and can send and receive data.

By the scheme of IEEE 802.11ah page segmentation, it has two modes of advance signalling [2], there are :

- Non-TIM offset, a specific TIM group transmit the signalling information into the same beacon according to the number of network pages.

- TIM offset, This mode includes 5 bits at DTIM beacon which allows the TIM group from a different page separately scheduled with its own TIM beacon.
IV. AD HOC ROUTING PROTOCOL

Ad hoc routing protocol generally divided into two types, i.e. proactive and reactive routing protocol. However, some of the concepts have defined a protocol type that is a combination of the two protocols, namely Hybrid routing protocol. The ensuing discussion involves only two routing protocols are DSDV (proactive) and OLSR (proactive).

A. Destination Sequenced Distance Vector (DSDV)

DSDV oriented from the conventional routing protocol i.e. routing information protocol (RIP) for use on an ad hoc network [22]. DSDV add new attributes such as sequence number for each entry in the routing table of conventional RIP. By using this sequenced number, the mobile node can differentiate the route which is a loop. In DSDV, every mobile node in ad hoc network should be keeping and maintaining a routing table that contains all the nodes destination, metric, next hop, and the sequence number generated by the nodes destination [22]. Each node in the ad hoc network will update the contents of the routing table by make a broadcast periodically or when significant changes occur in the network to ensure that already have the newest routing table.

B. Optimized Link State Routing (OLSR)

OLSR is an optimization of the link-state algorithm [23]. The main concept of OLSR is the MPR (Multipoint Relay) mechanism. MPR is a neighboring node which selected by a node with certain specification. The node which selected as a MPR can include two-hop neighbors of the node. The idea of MPR is to reduce the number of broadcast message which has a same information message in some network areas. The advantages of the implementation of the OLSR on an ad hoc wireless network, especially with the use of MPR concept, is the available bandwidth can be used more optimally [23]. But the MPR concept will be optimal with large-scale and heavy traffic condition.

V. DESIGN AND SCENARIO SYSTEM

The simulation using Network Simulator 3 (NS3) to compare DSDV and OLSR routing protocols. The limitations of the simulation is carried out as follows:

- Simulations run on software Network Simulator 3 (NS3) version 3.23 which release on may 2015.
- The simulation scenarios used are increasing the number of STA and increasing the distance between STA and AP. Modification for 802.11ah model on NS3 used by references from [9]. The configuration of the simulation will be created using a single AP and some STA with communications carried from STA to AP only. The analysis will be performed on all devices. Whereas the parameters for comparison are energy consumption, throughput, packet delivery ratio, and average delay.

### TABLE III. SIMULATION PARAMETERS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing Protocol</td>
<td>DSDV / OLSR</td>
</tr>
<tr>
<td>Physical Layer</td>
<td>WLAN / IEEE 802.11</td>
</tr>
<tr>
<td>Transport Layer</td>
<td>UDP</td>
</tr>
<tr>
<td>Payload Size</td>
<td>100 Bytes</td>
</tr>
<tr>
<td>Data Rate</td>
<td>1,2 Mbps / 1,3 Mbps</td>
</tr>
<tr>
<td>Max. Packet Queue</td>
<td>10</td>
</tr>
<tr>
<td>Max. Packet Sent</td>
<td>100</td>
</tr>
<tr>
<td>Frequency Operation</td>
<td>900 MHz</td>
</tr>
<tr>
<td>Number of STA</td>
<td>10 - 1000</td>
</tr>
<tr>
<td>Number of AP</td>
<td>1</td>
</tr>
<tr>
<td>Beacon Interval</td>
<td>200 ms</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>1 MHz/2 MHz</td>
</tr>
<tr>
<td>RAW Group</td>
<td>5</td>
</tr>
<tr>
<td>RAW Slot</td>
<td>25</td>
</tr>
<tr>
<td>Time Duration of Slot</td>
<td>2 ms</td>
</tr>
<tr>
<td>Mobility of STA</td>
<td>Random Direction 2D Mobility Model</td>
</tr>
<tr>
<td>Speed of STA</td>
<td>1,2 m/s ~ 1,8 m/s</td>
</tr>
<tr>
<td>Tx Current</td>
<td>0,260 amperes</td>
</tr>
<tr>
<td>Rx Current</td>
<td>0,264 amperes</td>
</tr>
<tr>
<td>Idle Current</td>
<td>0,178 amperes</td>
</tr>
<tr>
<td>Sleep Current</td>
<td>0,014 amperes</td>
</tr>
</tbody>
</table>

Parameter Analysis

Parameters to be measured and analyzed in this research are as follows:

- **Packet Delivery Ratio (PDR)**, which is the ratio between the number of packets successfully received and the number of packets sent [13]. In this research the package to be inspected only limited for packet data and be produced through flow monitor in NS3.

\[
PDR = \frac{\text{Total Packets Received}}{\text{Total Packets Sent}} \times 100\% \tag{1}
\]

- **Average End to End Delay**, is the average time needed for the delivery packet from sender end-node to the receiver end-node. In this research the package to be inspected will be limited to only the data packets and be produced through flow monitor in NS3.

\[
\text{Delay} = \frac{\text{Time packet destination} \times \text{packet sent sources}}{\text{packet received}} \tag{2}
\]

- **Energy Consumption**, is the amount of energy required needs a node to perform packet transmission and receiving packets and be produced through NS3 modules, i.e basic energy source and wifi radio energy model.

\[
\text{Energy Consumption} = \text{Energy}_{\text{trans}} - \text{Energy}_{\text{recv}} \tag{3}
\]

- **Throughput**, is defined as the speed (rate) effective data transfer, which is measured in bytes per second (Bps) as the total number of packets received in bits.
The throughput has been produced by software wireshark.

\[
\text{Throughput} = \frac{\sum \text{Received packet size}}{\sum \text{Delivery time}}
\]  

(4)

A. The Increment Number of Node Scenario

This scenario is a scenario that aims to analyze the performance of the network with the network conditions that change the number of STA. Then the performance parameters are obtained based on performance routing protocol and other simulation parameters to be analyzed. There is also a specialized parameter that will be used are 1,2 Mbps for data rate and 1 MHz for bandwidth while Max. Packet Queue is 5 packets. In this scenario will also be performed several simulations with different STA amount, there are 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000 STAs with the maximum distance between STA and AP is 100 m.

B. The Increment of Distance between STA and AP

This scenario is a scenario that aims to analyze the performance of the network with the network conditions that change the distance between STA and AP. Then the performance parameters are obtained based on performance routing protocol and other simulation parameters to be analyzed. There is also a specialized parameter that will be used are 1,3 Mbps for data rate and 2 MHz for bandwidth, Max. Packet Queue is 10 packets, while the STA used is 10 STA. In this scenario will also be performed several simulations with different maximum distance between STA and AP, there are 100, 200, 300, 400, and 500 meters.

VI. RESULT AND ANALYSIS

A. The Performance Evaluation Based on The Increment of STA

The resulting graph computation throughput, delay, PDR and energy consumption in comparison of DSDV and OLSR routing protocol based on simulations for the node additions condition that have been made can be seen in Figure 2 - Figure 5.

Figure 2 shows that the performance of OLSR routing protocol is better than DSDV when compared to a value of the average throughput performance with the increment of STA. The average value of throughput toward the increment of STA for OLSR is 34200 and DSDV is 9088.1. This is due to DSDV store all information to all STA and periodically broadcasts for update the routing table. Then, when one STA out of the route, then DSDV will broadcast to all STA to tell there is a route has been damaged. Such behavior caused much bandwidth usage on DSDV used for broadcast when it should be used to transmit packets data. In addition, DSDV only stores one route to the destination STA and still use the traditional routing table. Whereas OLSR using the MPR system in updating its routing table, so only the node designated as MPR which will send the broadcast messages. This will reduce the routing overhead and saves the bandwidth usage.

Figure 3 shows that the performance of OLSR routing protocol is better than DSDV when compared to a value of the average PDR performance with the increment of STA. The average value of PDR toward the increment of STA for OLSR is 5,9352% and DSDV is 1,664%. This is due to a STA density large enough causes the number of hops that quite a lot anyway. A large number of STA allows a change in routes that connect between one node to another node frequently. OLSR can overcome this situation because it has
the MPR system. Different from DSDV which is proactive and continuously update a routing table. Thus, allowing more low packet successfully sent because when they lose paths, DSDV will perform trigger update for searching a new path and can not send packets directly because they have to wait until the time limit of settling time, then making the process of sending packets data canceled or wait until update routing table process is done at a given time. In addition, the parameters are also influential factors in the simulation which has a configuration for Max. Packet Queue only made as many as 5 packets. So when the number of packets in the queue exceeds this value then the others will be dropped.

Figure 4 shows that the performance of OLSR routing protocol is better than DSDV when compared to a value of average delay performance with the increment of STA. The average value of average delay toward the increment of STA for OLSR is 0.24757144 and DSDV is 0.4938553. This is due to the proactive characteristic of DSDV that updating and maintaining route request to all destination periodically and stored in the routing table. Then, when packets data are sent and the route was broken, DSDV will not transmit packets data and wait for the trigger routing table, so that no packets data sent and no delay because the delay is calculated based on time of received packet until the packet is sent. Triger update is routing table mechanism for DSDV by finding a new route but does not directly perform an updating and broadcast a new route until the time limit of settling time for ensuring the old neighbor STA does not send an update message again and the new route is not changed again. However, it has a big impact for PDR. In addition, OLSR longer in searching new paths because it has MPR system so that it will take a time for STA for sending packets.

Figure 5 shows that energy consumption both of those routing protocols is almost equal when compared to a value of average energy consumption with the increment of STA. This is because DSDV and OLSR have a proactive characteristic and the number of packets that was sent also equal. But overall, average energy consumption in OLSR (14.96142791) slightly larger than DSDV (14.80851968). It shows that energy efficiency mechanism on 802.11ah works very well. Because when the number of nodes increasing, the value of average energy consumption increases slightly.

B. Performance Evaluation Based on The Increment of Distance Between STA and AP

The resulting graph computation throughput, delay, PDR and energy consumption in comparison of DSDV and OLSR routing protocol based on simulations for the change of distance between STA and AP condition that have been made can be seen in Figure 6 - Figure 9.

Figure 6 shows that the performance of OLSR routing protocol is better than DSDV when compared to a value of the average throughput performance with the increment of distance between STA and AP. The average value of throughput toward the increment of distance for OLSR is 6637.8 and DSDV is 1085. The result is much lower when compared to the increasing number of node scenario because this simulation only uses 10 STAs. But overall,
both of OLSR and DSDV run into decreasing. On OLSR a substantial decline occurred when the distance of STA and AP as far as 500 meters.

Figure 7 shows that the performance of OLSR routing protocol is better than DSDV when compared to a value of PDR performance with the increment of distance between STA and AP. The average value of PDR toward the increment of distance between STA and AP for OLSR is 71.54% and DSDV is 6.48%. The result is much higher when compared to the increment number of node scenario because this simulation only uses 10 STAs. Whereas the simulation set Max. Packet queue with 10, in other words packets opportunity for transmitted is much greater. But overall, both of OLSR and DSDV run into decreasing because when the distance increased it will be a lot of packets which will not be received.

Figure 8 shows that the performance of OLSR routing protocol is better than DSDV when compared to a value of average delay performance with the increment of distance between STA and AP. The average value of average delay toward the increment of distance between STA and AP for OLSR is 0.00215684 and DSDV is 0.23936. A large delay caused due to distance increasing between STA and AP so the delay will also increase.

Figure 9 shows that energy consumption both of those routing protocols is almost equal when compared to a value of average energy consumption with the increment of distance between STA and AP. This is because DSDV and OLSR have a proactive characteristic and the number of packets that was sent also equal. But overall, average energy consumption in OLSR (14,16508545) slightly larger than DSDV (13,82875636). It shows that energy efficiency mechanism on 802.11ah works very well. Because when a distance increasing, the value of average energy consumption increases slightly.

C. IEEE 802.11ah Features Analysis

The RAW mechanism will be very influential for the network performance, thus setting the number of RAW group and RAW slot used will affect the result obtained. The number of RAW group and RAW slot which too much or little will affect the traffic for STA which will accessing the channel [25]. Therefore, it takes setting the number of RAW groups and RAW slot that corresponds to the desired conditions. Moreover, allocations for a RAW duration will give impact for the network performance [11]. The use of sub 1GHz frequency can also be seen its influence on the simulation results. It can be seen that the energy consumption calculations, the results are only has a minor change and tend to be stable. In addition setting the type of MCS is also influential, in which the use of a higher type of MCS would generate better throughput and energy consumption [25]. But, using a higher type of MCS would make the transmission range more shorter [11].

D. Comparison Between 802.11ah and 802.11n

The resulting graph computation throughput, delay, PDR and energy consumption in comparison of DSDV and OLSR routing protocol with different standard that have been made can be seen in Figure 10 - Figure 11.
IEEE 802.11ah has advantages for range, throughput and energy efficiency than other standard. It has different PHY and MAC layer protocol that operates in the unlicensed sub-1GHz frequency bands. Figure 11 shows the comparison between IEEE 802.11ah and IEEE 802.11n for energy consumption. Both of DSDV and OLSR on 802.11n has a larger energy consumption than 802.11ah. The ratio between 802.11ah and 802.11n for DSDV routing protocol is 236.83%. While the ratio between 802.11ah and 802.11n for OLSR routing protocol is 268.37%. It shows that energy efficiency mechanism on 802.11ah works very well compared to 802.11n.

VII. CONCLUSION

This research has proposed a simulation and comparison for DSDV and OLSR routing protocols on IEEE 802.11ah standard. In this paper, the research evaluated the four performance measures i.e. throughput, packet delivery ratio, average delay and energy consumption with the different number of nodes and the different distance between stations and access point. From the simulation results, OLSR has a better performance than DSDV for all scenarios. In the increment number of node scenario, the ratio between OLSR and DSDV for energy consumption is 1,03%. While in the increment of distance between STA and AP scenario, the ratio between OLSR and DSDV for energy consumption is 2.43%. Energy efficiency which features from IEEE 802.11ah has been proven through the simulations. In future, by using these performances we can design such a protocol that can suitably provide the best network performance in IEEE 802.11ah standard.

REFERENCES


