Energy Consumption Performance on IEEE 802.11ah Networks with Station Grouping Scheme

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Abstract. Sending packages from the sender to the recipient at the station requires adequate resources. To ensure messages in the form of text, data, images, and videos are received in real-time, reliably, and flexibly, power performance with low energy consumption is required at the station. IEEE 802.11ah can be one of the wireless technologies to overcome this problem by saving low power consumption, the transmission range of 1 km and access points can reach 8191 stations. The purpose of this study was to determine the performance of energy-saving consumption by station grouping which is regulated in the regulation of the number of RAW slots. From the results of this study, energy savings were obtained by dividing the two groups when the station numbered 900 stations with an energy consumption of 8.105 joules while in one group with a smaller station scale the total energy consumption of 8.124 joules was obtained. The second scheme is by dividing slots (NRawSlot) to reduce energy consumption in large station capacities. The NRawSlot division is divided into seven-slot with energy consumption of 8,105 joules. It is proven that energy consumption is more efficient by grouping with more station capacity.

1. Introduction
The increase in internet users is arguably very much. One person can use more than one laptop and handphone. All of these devices must be connected to the internet with various services used such as sending packages in the form of data, voice, video, and others. the pandemic in 2020 that had not been predicted before, had resulted in changes inhabits. all on-site activities become online. From workers, students, employers, companies, etc. quickly adjusting the situation by switching to a digital platform so that activities continue to run normally. According to sources, Cisco IBSG predicts that there will be 25 billion devices connected to the Internet by 2015 and 50 billion by 2020. It is important to note that these estimates do not take into account rapid advances in the internet or device technology; the numbers presented are based on what is known to be true today.

To support devices in cellular networks, a large fee is required. Therefore, people will look for alternative bands at cheaper prices. IEEE 802.11ah is a new WLAN network protocol and is the result of the development of the IEEE 802.11-2007 WLAN standard. IEEE 802.11ah is designed to work on sub gigahertz frequency spectrums, where the lower frequency spectrum is juxtaposed with pre-existing WLAN standards. this causes the energy consumption used to also be lower [2].

One of the new standards in wireless is IEEE 802.11ah, which is to provide low energy consumption, handling many users, and a higher coverage area up to 1000 meters[1]. To address the collision problem caused by the increasing number of contenders, IEEE 802.11ah introduces a Restricted
Access Window (RAW) mechanism to realize the grouping based MAC protocol[3]. In particular, sensors are partitioned into groups, each assigned to a RAW slot. The clients in a group can only contend for access in the assigned RAW slot, as a result alleviating the cost (i.e., overhead and energy consumption) of contention[4]. In the RAW mechanism, there is a RAW group. In the RAW group, there are slots called RAW slots. RAW slots are small groups that are in one RAW group that is used to limit the channel access of each group in one RAW group [5]. Each RAW slot has a duration or time interval and turns to access the channel. If the RAW slot is not in a condition allowed to access the channel, then the RAW slot is not allowed to access the channel and all stations in the slot are in sleep [6]. With this RAW slot mechanism, it can limit channel access aimed at reducing collisions and saving energy [7]. The purpose of this study was to determine the performance of energy-saving consumption by station grouping which is regulated in the regulation of the number of RAW slots. Several previous studies have discussed the grouping of IoT sensor types with a grouping scheme and the division of stations based on traffic [4]. In research [8], research focuses on improving throughput and delay on the 802.11e standard. In this study, the focus is more on station grouping to save energy.

2. Method

2.1. 802.11ah
IEEE 802.1ah is designed to operate in the sub gigahertz frequency band, with communication coverage up to 1 kilometer, has a data rate above 100 Kbps, low power consumption by adopting a power-saving strategy, capable of serving up to 8192 stations through a hierarchical identifier structure, and solutions economical for manufacturing network devices. IEEE 802.11ah has a one-hop network topology and data transmission is short and not too frequent (data packet size approaches 100 bytes and interarrival time is greater than 30 seconds) [7].

2.2. Restricted Access Window (RAW)
To support several devices associated with the AP, TGah has developed a new mechanism to reduce congestion in channel access. In this mechanism during the time window (RAW), a group of stations is allocated with a specific time slot that is used to access the channel. Stations are not permitted to access the channel when outside the RAW slot of the station. Besides, in the beacon interval, several RAWs are allowed to access the channel [7].

![Figure 1. Grouping Station by 2 NRawSlot](image-url)

When an STA gets an uplink data from the upper layer, the STA can request channel access at the beginning of the RAW slot allocated for the STA. But STAs must be allowed to access channels in
certain RAW slots. The STA will stop immediately to transmit the packet after the specified time for the slot has ended. It is also possible that STA might not be allowed to use RAW slots [9].

Station grouping can be done by the AP that assigns groups to the station by using the RAW Parameter Set (RPS) element that is broadcasted in the beacon frame. In addition to group assignment information, the RPS element contains essential control information about RAW operations including slot duration and several RAW slots (NRAW) [10]. This information is used by stations to calculate the total duration of RAW (TRAW) [7].

2.3. Simulation Scenarios
In this research, energy consumption savings will be made by using a grouping scheme. This grouping scheme is carried out with several kinds of scenarios. The first scenario is done by adjusting the change in the number of Groups as Ngroup. In dividing the number of groups into two groups, after that, there will be changes in the number of RAW Slots that differ between two to seven RAW Slot as NRawSlot. In addition to determining the two-division changes, group changes will be made to the number of stations. Because in this study the aim is to make energy savings in a large amount of capacity.

![Figure 2. Energy Consumption Simulation Scenario](image)

| Parameters | Value |
|------------|-------|
| Ngroup Change Scenario | |
| NRawSlotNum Change Scenario | |
| Data Collection Simulation | |
| Energy Consumption | |

Table 1. Common Scenario Parameters
3. Result And Discussion

3.1. Analysis of the First Scenario: Changes in the Amount of Ngroup and Nsta
In this scenario, a change in the number of Ngroup and Nsta is implemented, where the value of Ngroup = 1 and Ngroup = 2. Changes are also made to the number of Nsta. Changes in the number of NSTAS are 700, 800, and 900. Scenarios are performed on a network with 802.11ah standard.

| Number of RAW groups (Ngroup) | 1, 2 |
|------------------------------|-----|
| Number of slots per RAW group (NrawSlotNum) | 6 and 7 |
| Number of total stations (Nsta) | 700, 800 and 900 |
| Distance Access Point with Stasiun | ~ 100 meters |

*Ngroup = Number of RAW groups; NrawSlotNum = Number of slots per RAW group; Nsta = Number of total stations.

![Figure 3](image_url)

**Figure 3.** Energy Consumption by Station Grouping

In Figure 3, two-line graphs represent the two types of the number of Ngroup divisions. With the increase in the number of group divisions, the energy consumption will be lower along with the increasing number of stations. The division of several STAs into groups can help network performance to be better in packet delivery. This is because increasing the number of Ngroups reduces contention, collision, and supports retransmission of failed packets. Without the division of Ngroups, increasing the number of STAs will make STAs wait even longer to be able to deliver their packages. However, the development of re-transmission activities can make the throughput decrease and increase the delay time. Then, the use of RAW also allows the STA to be idle or sleep or inactive if their RAW slot is not in a state of having to send packets, where this can affect the value of energy consumption to be smaller as the number of sta increases [9].

3.2. Second Scenario Analysis: Change in the Amount of Share Nsta
In this scenario, it is implemented by changing the number of Nsta. This scenario consists of 6 and 7 RAW slots and uses a change in the number of NSTA with a total of 700, 800, and 900 stations.
3.3. Third Scenario Analysis: Change in the Number of NRawSlot Shares
In this scenario, it is implemented by changing the number of NRawSlot and Nsta. This scenario consists of 6 and 7 RAW slots and uses a change in the number of NSTA with a total of 700, 800, and 900 stations.

3.4. Energy Consumption Performance Analysis
By the initial objective to see the performance of energy consumption in 802.11ah with the station grouping method, simulations were carried out with several scenarios of changes in the number of Ngroups, NRawSlot, and NSTA. This test is carried out in various steps; initially with a smaller number of stations. Starting from 50, 100, 150, 200, 250, and 300 then with the division of NGroup 1 and 2, and NRawSlot 2 to 7 slots. The data presented in the research above is the second test with an increase in the number of stations. 802.11ah is recommended to be used in supporting IoT and a large
number of stations (up to 8191 stations). The increase in stations from 700, 800, and 900 stations, of course, was accompanied by changes to the NRawSlot and Ngroup. the more NGroups and NrawSlots, the lower the energy consumption is consumed. On the IEEE 802.11ah network, dividing stations into the same group to access channels simultaneously can reduce collisions. thereby achieving better performance, proven by the simulation results above.

4. Conclusion
In this paper, we introduce the savings in energy consumption at the station. By using a grouping scheme it is proven that consumption is lower when the station is getting bigger in number. The NRawSlot, Ngroup grouping scheme depends on the number of jugs stations. For further research, it can also be seen from a load of each station. Because it will also affect the energy consumption that will be spent at each station.

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