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REAL-TIME TRAFFIC THROUGH IEEE 802.11ah WIRELESS LAN WITH QUALITY-OF-SERVICE SUPPORT USING DYNAMIC GROUPING SCHEME

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Abstract

In recent years WLAN with IEEE 802.11 has been widely used for data communication these days there is also an increasing interest in Real-time traffic e.g. Voice, Video, Multimedia over wireless LANs because of its low cost. QOS support for real-time services in the IEEE 802.11 WLAN is a crucial matter. In order to raise the quality of service, we are putting forth a single, fair, dynamic channel grouping method in this project. Agglomerative Hierarchical Clustering is suggested as a method for station clustering, using fairness and throughput as matrices for level selection and distance measurement. Neural Networks can be used to estimate levels throughout form group clusters.

Keywords: Agglomerative, Channel Grouping, IEEE 802.11ah, QoS, RAW, VoIP, WLAN.

1. INTRODUCTION

In the last few years, there has been a rapid increase in wireless technology due to its low cost & less infrastructure compared with wired one. It gives us the freedom to use wires. Also, it supports largely increasing sensor technology.

In the 1990s, wireless local area networks (WLANs) were first made available. Since then, WLAN adoption has increased as a result of advancements in transmission speed, adaptability, and affordability. The need for additional media, including teleconferencing, video streaming & VoIP (Voice over Internet Protocol) over WLANs, is growing as the communications sector shifts towards networks. As a result, QoS assurances are receiving more attention for WLAN applications that are sensitive to jitter and delay. The fast expansion of WLAN functions that are built into appliances and gadgets only serves to increase demand for these features. Wireless networks' future depends on their ability to support applications that require integrity, especially those that are jitter- and latency-sensitive. However, maintaining integrity while delivering dependable QoS for applications that are sensitive to jitter and latency presents some difficult challenges. The main challenge for modern systems is congestion.

IoT is also a rapidly growing technology nowadays where a large number of nodes can be connected in WLAN. The communication between different nodes can be achieved by cellular networks also. But comparatively, WLAN is most suitable for the IoT network as

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a free frequency band can be used in WLAN. It is very cost-effective to use for smart home office applications.

IEEE 802.11 is the most popular WLAN standard with its own frequency bands and special features that support IoT applications. It is more expensive than mobile phones. Providing QoS to multiple nodes connected to a WLAN is a major challenge in IoT applications. Such applications must maintain a minimum number of applications in real-time and provide integrity to all nodes. Node mobility is another issue for QoS management.

2. IEEE 802.11 STANDARD

The IEEE committee established 802.11, the first WLAN standard, in 1997. However, the 802.11 standard only provided 2 Mbps of capacity, and it was out of date very soon. IEEE then developed 802.11 a & 802.11b standards. The IEEE 802.11 standard has the following benefits over 802.11b:

1. Because 802.11a operates in the less congested 5GHz frequency band, interference is not a major issue.
2. More bandwidth is supported by 802.11a—up to 54 Mbps—than by 802.11b standard equipment, which only offers 11 Mbps.
3. 802.11a provides up to 12 non-overlapping paths. With multiple channels, multiple users can monitor performance without interrupting.

A few disadvantages of implementing the 802.11a standard are as follows:

1. PDAs and notebook PCs are examples of client devices that do not commonly support the 802.11a protocol. Most of these follow Bluetooth or 802.11b protocols.
2. It costs more when compared to other contemporary technologies like Bluetooth and 802.11b.
3. 802.11b is incompatible with the 802.11a standard. As a result, equipment made to support 802.11a or 802.11b cannot interfere with one another.
4. Because 5 GHz is a higher operational frequency than 802.11b, coverage will be significantly less there. Keep in mind that the expansion will be shorter the higher the RF frequency for output power.

It could be preferable to utilize 802.11g rather than 802.11a due to cross-compatibility.

2.1 Features of IEEE 802.11ah

The recently released IEEE 802.11ah wireless standard, commonly referred to as Wi-Fi HaLow, distinguishes between LPWANs and WPANs and provides a reach-range balance. IEEE 802.11ah offers communication between 8192 low-power devices and runs in the unlicensed sub-GHz frequency spectrum (863-868 MHz in Europe, 755-787 MHz in China, and 902-928 MHz in North America). For a distance of one kilometer, the speeds range from 150 kbps to 78 Mbps. IEEE 802.11ah hence supports more.

Media Access Control's (MAC) Restricted Access Window (RAW) functionality is introduced by IEEE 802.11ah. It doesn't, however, specify how to set up RAW & Traffic Indicator Map (TIM) methods. This independence can improve performance but can also result in decreased network performance because the effectiveness of this process depends on traffic patterns. TIM and RAW need to be configured properly in order to be used to their best potential and to provide benefits.

3. CHANNEL GROUPING

A communications protocol known as IEEE 802.11ah—also sold as Wi-Fi HaLow—was created in 2017 as part of the IEEE 802.11 standard. The strategy uses a "RAW (Restricted Access window)-based channel access method with the primary goals of lowering power consumption and increasing support for massive IoT networks. IEEE 802."1ah permits a single access point to connect up to 8191 stations to the internet; under IEEE 802.11, the most stations that can be connected to a single access point is 2007. Assign each station linked to the access point a distinct 13-bit Association Identification Number (AID).

A. RAW Channel Access

Because there is less restriction on accommodating power in these locations, RAW channel access aims to minimize conflicts between sensor stations (nodes) and boost energy efficiency in Internet of Things scenarios. Beacon intervals are the intervals that makeup channel time. During each beacon time, stations are grouped, and only those stations in that group have channel access for the duration of that group. Similarly, a group has RAW slots; where stations for groups are assigned RAW slots in a sequential manner (by AID). During a predetermined RAW period, only the producer competes "for channel access via CSMA/CA (standard IEEE 802.11 channel access).

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At the beginning of each beacon period, a beacon frame containing information about the RAW Parameter Set (RPS) is broadcast. The RPS includes the number of RAW groups, station group, number of RAW slots in each group, and group start time (duration of RAW group)." In addition, stations are distributed equally via round-robin assignment, and the RAW time group is divided into equal portions of RAW slots (depending on the AID).

B. Previous Works

IEEE 802.11ah gives the user the option to select between static, discrete, and random grouping protocols; it does not specify how the grouping is carried out. Uniform grouping distributes stations equally among all groups and time slots, while random grouping gives stations to groups and time slots without consideration of any specific order or restriction. Station grouping methods for calculating RAW characteristics are the subject of numerous studies in the literature. Based on the present network characteristics, such as

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the number of operational stations, the traffic demand of stations, and their placements, these studies include station grouping. The only optimization goals that set these methods apart are throughput, energy, and hidden node problem mitigation. The major tools employed in analytical modelling-based works were maximum likelihood estimation [6], Markov chains [3,4,5], and probability theory [1,2]. The computational burden of analytical modelling is higher than that of set partitioning techniques. They divide the stations among them using a predetermined partitioning technique, accounting for a given number of groups and time periods. Set partitioning techniques are simple enough to be included in real networks at a reasonable cost.

In his publications, Le Tian [8][9] goes into great detail about the "algorithmic implementation of real-time station grouping under dynamic traffic conditions as well as the surrogate model for real-time station grouping (set partitioning").

C. 802.11AH Group Modelling For Throughput

Network efficiency must be calculated by first analytically modelling the network and then exporting the model's efficiency. The laborious process of analytical modelling and throughput derivation adds to the access point's load.

A. Predictive Model's Scope in Networking

When it comes to certain aspects, predictive models outperform empirical models. The main reason for this is that the prediction model adapts to the current situation in the network and gives results accordingly, while the analysis model is static and independent of the network.

1) Artificial Neural Networks:

Inspired by the biological brain, ANNs use the brain's activities to create algorithms used to solve complex problems. An ANN's ability to simulate non-linear interactions is aided by this intricate process, which makes it perfect for real-time network assessment. The input vectors are transferred to the ANN model, as seen in Figure 1, and the hidden layer processes them further to create the input vectors that are employed in decision-making. Its main advantage, unlike other estimation methods or other initialization methods, is that it does not make assumptions about ideas such as linearity or quadratic Gaussian assumptions.

Using the algorithm described above, we model the 802.11ah cluster to estimate the normalized throughput of the cluster. The input parameters of this model include the no. of stations in the group, the no. of slots, & the group duration—all of which contribute to the 802.11ah group. Using this methodology, the total network's normalized throughput is determined, and the configuration offering the maximum throughput is chosen.

4. PROPOSED MODEL

In this paper, we propose the Dynamic Channel Grouping Scheme for IEEE 802.11ah networks with uniform traffic generation rates, with the goal of enhancing both node fairness and performance (normalized throughput). In light of the quantity of closest

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packets that two clusters receive, stations are grouped using an Agglomerative Hierarchical clustering algorithm.

The avg. no. of packets received during the preceding beacon period was utilized as the cluster measure in order to give the cluster that received fewer packets more time. In addition to being the only sensor station parameter that may be accessed at the access point level, this is done to promote equity.

A. Agglomerative Hierarchical Clustering

In the beginning, every sensor station is regarded as a group (cluster), and the packet that the station receives is determined by averaging the packets it receives from each group. The following stage is created by connecting the 2 closest groups based on the averaged packet received measurement and updating the averaged packet to the combined group.

$$AvgPkt = \sum_{i=1}^{n_{sta}} \frac{Pkt[i]}{n_{sta}}$$

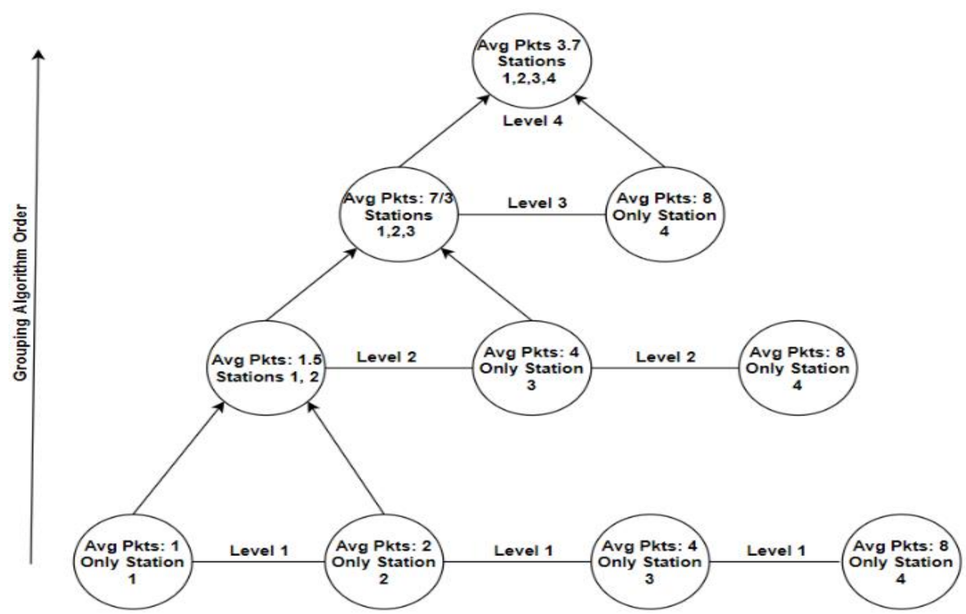

Figure 1: Agglomerative Hierarchical Clustering Example

Where n_{sta} is the no. of stations in the cluster at any given time, Pkt[i] is the no. of stations in the cluster at any given time, and AvgPkt is the avg. no. of packets received from each cluster. Is the quantity of packets that the station has sent to you.

Aggregator hierarchical clustering at four stations is demonstrated in Figure 2. There are four levels (group configurations) to select from, with an average of one to four packets received from each station.

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As a station receives more packets over time, every 20 beacon periods, all of the packets it receives will be purged from its station, leaving at least one-third of the packets to be used for updating the rate. The “number of packets received by a newly added station to the access point is updated using the average of the maximum and lowest number of packets received between the stations. The throughput of the present cluster at each level—there can only be one cluster at the top—is used to compute the throughput at each level once the entire tree has been built.

$$U = \sum_{i=1}^{n_{gr}} \frac{U_i T_i}{T_R}$$

Where n_{gr} is the number of groups present, i is the ith group duration, TR is the beacon interval, and Ui is the” ith group normalized throughput. The next beacon interval transmits the same configuration based on the selection of the level with the highest throughput.

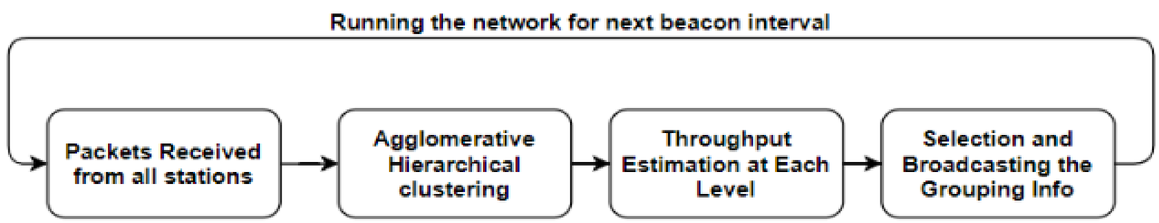

Figure 2: Agglomerative Hierarchical Clustering Flow

4. RESULTS & FINDINGS

A. Dataset

MATLAB is employed to model the IEEE 802.11ah Group, with the 1Mbps data rate and PHY instructions provided. The networks' parameters are provided as group parameters that vary according to step size and range (Table II). After running the network for 100 beacons, the mean normalized throughput for all devices was noted. To train the model, 500,000 points were created in a database.

TABLE II
GROUP PARAMETER CONSTRAINTS

Parameter	Values		
	Min	*Step*	*Max*
Number of Stations	30	20	4000
Group Duration (us)	40960	10240	204800
Number of Slots	1	5	No. Stations

B. Fairness Metric

A lower standard deviation suggests that there is a fair distribution of resources because all of the packets are near the mean. The fairness value was 20% higher with the

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suggested approach than with uniform grouping schemes. There was a max. fairness of 0.99 when there were 1000 competing stations.

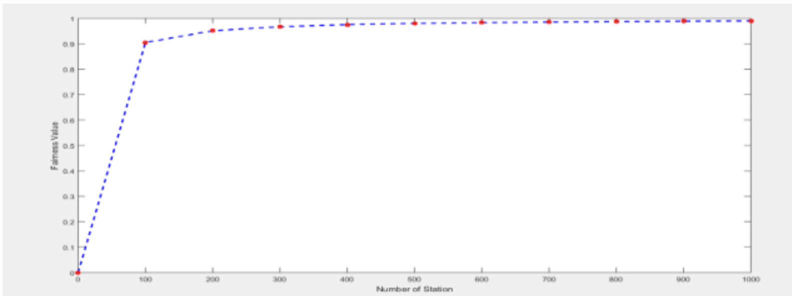

Figure 3: Fairness metrics

A. Throughput

Generally speaking, throughput will decrease if the number of stations increases. Here normalized throughput is estimated using both uniform grouping & proposed grouping model. The throughput value was increased by 50% with the use of the proposed model as compared to the uniform grouping scheme. When there were approximately 100 competing sensor stations, the recommended method yielded a peak normalized throughput of 0.77.

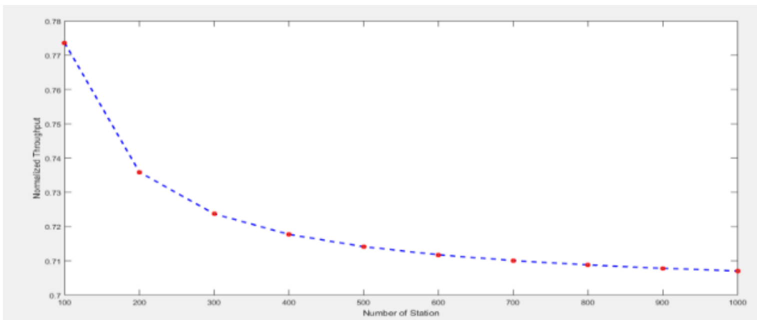

Figure 4: Throughput

5. CONCLUSION

Comparing the above-proposed method against random and uniform grouping strategies greatly increases packet fairness and throughput. Comparing the above-proposed method against random and uniform grouping strategies greatly increases packet fairness and throughput.

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