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PERFORMANCE WISE OF THE LEGACY AND AP TRIGGER IN 6G-WIRELESS TRANSMISSION

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Abstract

Based on industry research, the utilization of wireless communication is expected to continue to increase quickly. By 2021, it is predicted that there will be 500 million wireless devices installed, which will lead to a significant increase in cellular traffic. To address this challenge, the 802.11ax Wi-Fi standard is ideal because it not only focuses on data rate speed but also on communication efficiency. This paper provides a mathematical analysis and simulation comparing the 802.11ax standard to legacy standards, and determines performance throughput and collision based on the number of ax and legacy stations. The study shows that using the 802.11ax standard not only increases speed but also decreases collisions on the coexistence system. Therefore, the 802.11ax standard can be a solution for achieving efficiency and high-speed data rates for future Wi-Fi communication systems.

Keywords: *Legacy, Standard, Transmission, Performance, Wireless*

1. INTRODUCTION

The IEEE standard 802.11ax offers a solution to the challenges of high density and performance faced by Wi-Fi networks. With the ability to increase capacity up to four times more than its predecessor, 802.11ac, and improve spectral efficiency in arbitrary frequency spectrums, this standard has the potential to revolutionize unlicensed communication [1], [2] . Data demand increased by 63% in 2016, and it had increased eighteen times in the previous five years [3]. As smart and mobile devices using wireless communication networks become increasingly prevalent, it is critical to ensure that data rate speed and communication efficiency are suitable for internet-of-things (IoT) [4]–[6]. This technology will have a significant impact on manufacturing systems and business strategy.

With the emergence of Industry 4.0 and the Internet of Things (IoT), there is a growing need for suitable data rate speed and communication efficiency in the internet network, which impacts manufacturing systems and business strategy. While the previous Wi-Fi standard 802.11ac introduced new technology to achieve higher data rates, it has limitations in addressing the challenges faced by next-generation Wi-Fi systems, such as network traffic, Wi-Fi density growth, and the high use of small data frames, such as Voice over Wi-Fi (VoWiFi) [7]. In addition, the growth of client devices and streaming video services has led to the need for Wi-Fi standards to maintain parity with the rapidly evolving 5G cellular network.

The 802.11ac specifications brought in some cutting-edge new technologies, such as improvements to the medium access control (MAC) and physical (PHY) layers, that aid in achieving faster throughput [8]. Network traffic, increased Wi-Fi density, and the widespread usage of tiny rates are among the problems facing next-generation Wi-Fi systems. A crucial reason to implement 6G-wireless technology changes is streaming video services and the massive rise of client devices. According to the Ericsson Mobility Report, until 2023, worldwide wireless traffic is expected to increase by around 50% yearly, from 14 to 110 exabytes per month. Approximately 75% of all mobile data traffic comprises this video content. According to this estimate, between 65 and 95 percent of mobile data is diverted to wireless internet by users. Therefore, network standards need to stay up to date with the quickly developing fifth-generation (5G) cellular technology. Furthermore, because social networks and video streaming are overused, video traffic as the downlink traffic influences traffic loads. It was recommended in several research on the latency of the communication system that the delay be kept as low as feasible [9]. In communication, network congestion causes transmission delays that can cause various issues, such as message buffering. For example, most high-definition (HD) video traffic needs between 2 and 20 Mbps. On the other hand, 4K video streams at 82–128 Mbps.

The 802.11ax standard strives to reach even higher speeds, up to 10 Gbps, and focuses not only on data rate speed but also on efficiency. This standard is perfect for addressing the challenge of increased cellular traffic. By improving the performance of the 802.11ac standard, the 802.11ax standard can ensure that there is enough throughput and efficiency to address the aggregate demand for wireless communication. The latest Wi-Fi standard, 802.11ax, is a game-changer in terms of performance improvements as compared to its predecessors. Unlike the previous amendments that were called "High Throughput," this amendment, "High Efficiency," hints at the improvements in system efficiency. The changes in the 802.11ax standard boost the network capacity, improve coverage, and reduce congestion, resulting in a significantly improved user experience overall.

The 802.11ax aims to enhance wireless performance, especially in high-dense user scenarios. With 802.11ax, devices can communicate simultaneously to corresponding pairs, which improves capacity by enhancing throughput performance. This capacity improvement benefits arbitrary bands ubiquitously, including industrial, medical sites, and among others. As per the early 802.11ax standard development, it was primarily intended for high-density network environments, such as extensive area, where an acceptable level of service for all users must be guaranteed. A sophisticated wireless network with hundred devices can be considered a high-density environment, and it poses extensive challenges in wireless communication from a business perspective. These challenges become more complicated as the IoT provides unlicensed spectrum for numerous fields. Therefore, Wi-Fi networks need to improve their performance to tackle data traffic congestion issues and a vast diversity of applications, which characterized by (QoS) requirements

There have been several efforts to enhance the performance of Uplink OFDM. In [3][21], analytic interactions of IEEE 802.11ax between AP and legacy STA protocol are proposed by considering unsaturated traffic conditions using statistical of data rate. In [22], an additional back-off stage (EBO) is proposed to reduce collisions in the system. This involves each contending STA sending a busy signal to establish priority. Meanwhile, in [23], the authors use a simple analytical model to study the efficiency and delay performance of Uplink OFDMA RA under saturated conditions with a limited number of stations and favorable channel conditions. The processes, features, and challenges of IEEE 802.11ax standardization are summarized in [24][25], which is expected to facilitate the development of new WLAN protocols. Moreover, [26] presents an adaptive STA grouping algorithm that separates competing STAs into different groups based on Target Wake Time (TWT) to enhance throughput. Furthermore, [27] proposes adjusting the back-off mechanism parameters to increase throughput until the maximum throughput is achieved, while [28] shows that the AP must estimate the number of contending STAs by using collision probabilities to determine the optimal OCW size that maximizes throughput. Finally, this paper employs Markov chain-based mathematical models to analyze the performance of the IEEE 820.11ax standard, which is one of the most popular methods for assisting in performance analysis.

This paper is organized as follows: Section 1 provides the background of the research. Section 2 describes the system model that we use. Section 3 presents our preliminary investigation results, which include a correlation performance graph between the number of stations and throughput and collision. In Section 4, we draw our conclusions based on these findings. Finally, Section 5 discusses future work that we plan to undertake.

2. System Model

The multi-input multi-output (MU-MIMO) and orthogonal frequency divide multiple access (MU-OFDMA) of multi-user advancement are specified by the IEEE 802.11ax standard [30][31]. Depending on the assisting feature, multi-user allows communications between an access point (AP) and several wireless devices to take place concurrently. As illustrated in Fig. 1 [1], OFDMA splits a wireless networking spectrum into resource units (RUs) with small frequency assignment. Depending on client traffic demands, the AP can divide the channel to serve numerous users concurrently or dedicate the entire channel to a single user. Through new and efficient throughput improvements, 802.11ax handles client density more efficiently than 802.11ac [32]. The multi-user uplink transmission in the IEEE 802.11ax network standard was managed by the AP's Trigger frame.

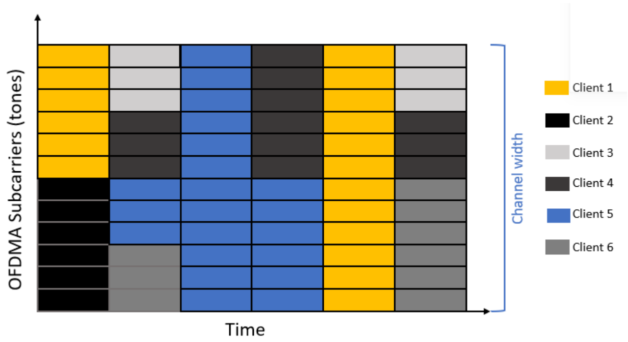

Figure 1 *MU-OFDMA*

In direct response to the downlink trigger frame that the AP deliver data, the uplink MU procedure starts. The necessary RU allocation data for the STA is contained in the trigger frame. Fig. 2 illustrates if at least one STA provides the AP with accurate UL MU data, the frame exchange with trigger frame is deemed successful. In addition, the Multi-Block Acknowledgment (M-BA) sent by the AP indicates that it has received the right MAC Service Data Unit (MDPU) [21]. A detailed discussion of the legacy device UL MU transmission protocol may be found at [33].

By defining N as the total number of stations, nAx as the total number of AX stations, and nLe as the total number of Legacy stations, we may get the formula $N = nAx + nLe$. Because the STA Legacy only uses back-off to calculate the AP's data transmission schedule, collisions are still likely to occur with this scheme, which results in a reduction in system performance. Additionally, there is competition when data is transmitted to AP from these two stations (STA AX and STA Legacy). The performance of the system under study will be greatly impacted by each station's domi nance in the system.

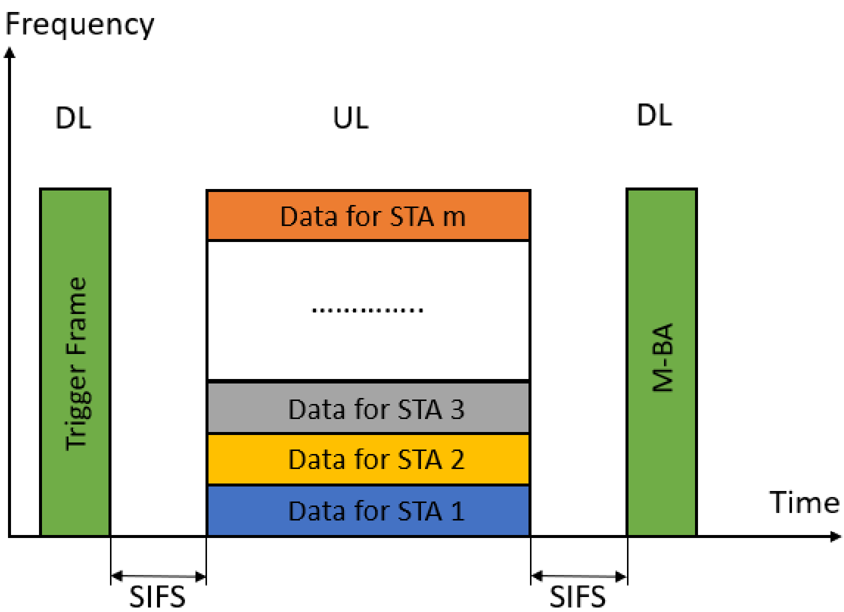

Figure 2 *An example of UL OFDMA transmission*

In this research, we considered some assumptions, i.e., all stations have the data; AP knows all states of STA AX (No hidden STA). Hidden nodes problems occur if STA 1 and STA 2 can see AP, but they do not see each other as in Fig. 4 ; AP AX support with STA AX and STA Legacy; the amount of data STA AX is the same with the amount of all resource unit (RUs) in a period; the collision occurs when AP transmit Trigger Frame, and STA LE transmit data simultaneously, and when more than one STA LE transmits data simultaneously.

Every station has the same STA specifications, and the minimum and maximum back-off stages between STA LE and AP are the same, as well as the contention window. A potential collision situation that could happen in the system. When multiple STA LEs broadcast data concurrently at the same timeslot, a collision occurs. Collisions will happen as in the state of the collision section in Fig. 5 when the AP transmits the trigger frame while at least one STA LE is also transmitting data simultaneously. In order to enhance system performance, collisions must be prevented. In this system, the Contention Window is doubled successively.

3. Performance Simulation

The simulation scenario, parameters, and suggested mechanism for the uplink performance comparison of the Legacy vs. AP Trigger-Based Tx are explained in this section. We use MATLAB software to assess the performance of the proposed system plan, taking into account a range of stations from 0 to 40. The difference between STA AX and STA Legacy is indicated by the number of STAs (STAs = STA AX + STA Legacy). When STA is zero, it indicates that STA AX is 0 and STA Legacy is 40. When STA is five, it indicates that STA Legacy is 35 and STA AX is five. Finally, when STA is worth forty, it indicates that STA Legacy is 0 and STA AX totals forty. When STA AX is increased and STA Legacy is decreased, the collision rate lowers. Consequently, the 802.11ax Wi-Fi standard can meet the demands for efficiency and high speed.

4. Conclusion

This paper provides mathematical analysis and simulation of the IEEE 802.11ax standard (AP AX and STA AX) when applied with the STA Legacy device. From simulations and analyzes conducted using MATLAB software, we found that the use of the 802.11ax standard provides increased speed and, at the same time, decreases the chance of collisions on the system. So the 802.11ax standard can be one solution for the needs of efficiency and high speed. Future work includes considering the impact of fading and attenuation on the transmission of data frames on the channel. In addition, the hidden node's effect will be considered on system performance and ways to avoid this problem.

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