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Review Paper on 802.11ax Scheduling and Resource Allocation

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ABSTRACT

Nowadays a fast remote Internet association is a need as opposed to a luxury. IEEE 802.11ax could be a revolution to present an improvement over this age of 802.11. 802.11ax has been accepted to convey next-generation Wireless Local Area Network (WLAN) techniques. 802.11ax using multiple techniques as using modulation 1024 Quadrature Amplitude Modulation (QAM), Orthogonal Frequency Division Multiple Access (OFDMA), robust high efficiency signaling for better operation at a significantly lower Received Signal Strength Indication (RSSI), Target Wakeup Time (TWT) where the station can request to wake up at any time in the future and more. 802.11ax achieves multiple benefits as enabling a more than 35% speed burst, reduce overhead and latency, and more. This paper gives a review of the IEEE 802.11ax resource allocation scheduling in both: 1) Downlink (DL) data transfer 2) Uplink (UL) data transfer.

KEYWORD: *IEEE 802.11ax, Scheduling, MU-MIMO, Resource allocation, Wi-Fi, OFDMA*

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INTRODUCTION

While the beginning of Wi-Fi can be followed back to 1971, it has drastically developed from that point forward to turn into a regular basis in both our own and professional lives with access focuses now accessible at home, in the work environment, and in open areas. Many are obsolete and do not facilitate the necessities of their customers. Despite the fact that Wi-Fi's improvement has seen more conspicuous convenience and usages for devices, significant slow can cause ruin for customers and stopped their work[1]. The 802.11ax execution of OFDMA separates channels into smaller and not fixed size Resource Units (RUs) of a multiple number of subcarriers and a short time selects the RUs to different users. This engages the 802.11ax path to have the limitless authority of UL and DL transmissions to various users simultaneously[2].

In 802.11ax networks OFDMA works upon "Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)" technique. Here the Access Point (AP) first accesses the channel by the legacy Wi-Fi rules then we can be initiating the MU frame in both DL and UL[3]. In addition, the frame of the OFDMA has two sections: Physical layer (PHY) preamble is the equivalent for all Stations (STAs), and information created by or bound for different users is communicated with it. The OFDMA frame must start and complete at the same time. In the DL transmission, there is no problem because the OFDMA frame is made in the AP. While in UL transmission we faced this issue, a synchronized the transmitting frames from users and the preambles of PHY produced by users will be the equivalent of size and controls. the APs sent Trigger Frame (TF) to control multiple things as allow channel access, and to give the STAs transmission information such as Modulation and coding plans (MCSs), parameters to change transmission power, Multiple Input and Multiple Output MIMO, transmission period, the data inside of PHY preamble, and so on. The TF is befitted too in synchronize sending STAs. The "Multi-STA Block Acknowledgment frame (MSBA)" to users to tell them it got the frames successfully[4].

To highlight the review in hand, we divide the review into three sections: a review based on general scheduling, a review based on DL scheduling, and a review based on UL scheduling.

A. Review based on General Scheduling:

Progressed IEEE 802.11ax TCP-mindful scheduling systems for upgrading the AP activity under the unidirectional transmission of TCP traffic had suggested. The efficiency and performance have upgraded in this scheduling procedure by utilizing the benefit of Multi-User (MU) transmissions in the UL and DL Transmission, in view of Transmission Opportunities (TXOP)[5].

The investigation in [6], was about an algorithm over OFDMA in 802.11ax network to allocate the resources and propose a novel algorithm pointed toward giving a delay of short of what very short time (less than one millisecond) and high quality so it is ideal for real-time applications. A novel allocation algorithm called "Cyclic Resource Assignment (CRA)" had designed. The algorithm plans to schedule the resources at the start of each scheduling step by allocates just the littlest, 26-tone RUs for STAs, so this empowered the AP to set the maximal of RUs and to increase the quantity of all the while served STAs. Finger 1 indicated the flowchart of the algorithm.

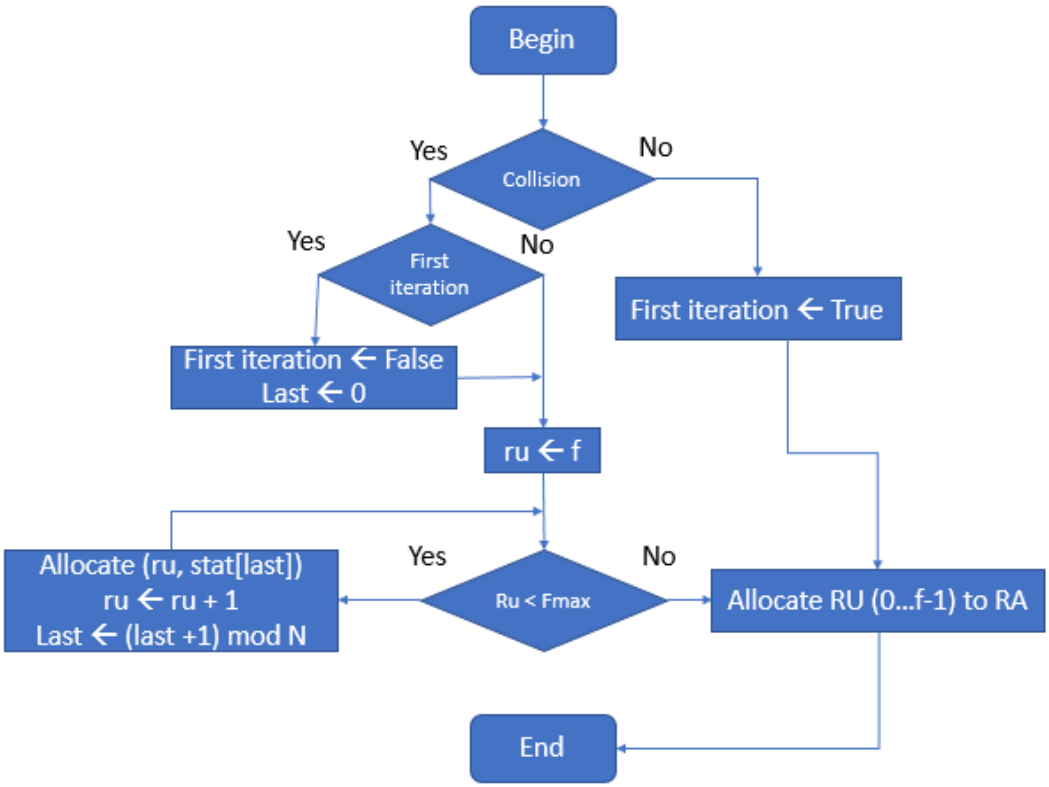

Figure 1 Block scheme of CRA [6]

In the paper [7],three scheduling procedures over 11ax unidirectional TCP data transmission of DL from AP to STAs have proposed. Two of them depend on the Single User (SU) activity and one depends on MU activity, utilizing MU-MIMO and OFDMA techniques:

- Reverse Direction (RD) is an instrument by which the proprietor of a "Transmission Opportunity (TXOP)", the AP, in this case, can empower its recipient to promptly send back the TCP Acks during the TXOP so the collector does not have to start UL transmission by utilizing the Extended Distributed Coordination Function (EDCF) divert access strategy characterized in IEEE 802.11e.

- In this strategy, the AP utilizes TXOPs yet not RD, when the AP gains admittance to the channel it communicates DL, HE SU A-MPDU frames containing TCP Data portions to a station in succession. Each transmission of a single DL HE SU A-MPDU frame from the AP is trailed by a Back-frame transmission from the objective station.

- In this HE DL MU scheduling procedure, after waiting for the Back Off and AIFS stretches, the AP getsaccess and begin a TXOP by sending DL HE MU A-MPDU frames containing TCP Data portions to a gathering of STAs at the same time. To communicate to a gathering of stations at the same time, the AP allocates Resource Units (RU), i.e., subchannels, per served station. The RU allocation will finish by using TCP Data portions for DL and TCP Acks for UL.

In [8], two algorithms had suggested. The first one:a practical algorithm wherein the scheduling period is fixed and again has proposed. The other proposed scheduling where the scheduling period is not fixed decided in a resource allocation framework by thinking about the fairness, padding overhead, and energy utilization of the STAs. Where the AP first transmit a TF frame which currently just indicates the ID of the gathering such as the IDs of the selected users, and the selected subchannel to each selected user. While in [9],Using a variation of IEEE 802.11e "Enhanced Distributed Channel Access (EDCA)", a conflict based resource unite (RU) selected in OFDMA based on 11ax networks had Proposed. The strategy is to stretch out EDCA inside the OFDMA framework where the AP communicates with "Physical Protocol Data Units (PPDUs)" by deciding the RUs to be selected to its related STAs.

In OFDMA 802.11ax resource allocation scheduling the user or user groups can be just in one of RU in each scheduling timeIn [10],present a divide and conquer based algorithm but here we can get the scheduling as the user can allocate in multiple RUs at the same scheduling time. Here two practical algorithms for the genuine issue had presented. A greedy one and a recursive one that mutually parts the bandwidth into RUs and timetables users on them. A recursive algorithm given in Figure 2.

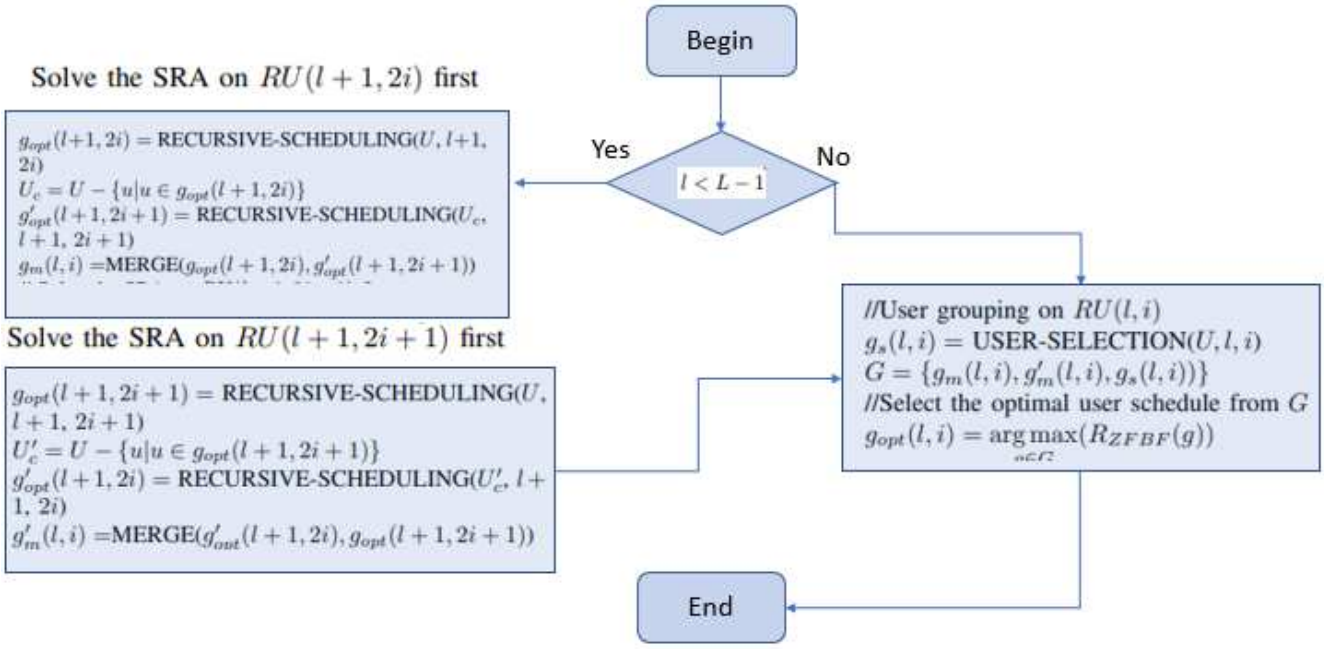

Figure 2 pseudocode of provided algorithm [10]

In [11], a novel resource allocation algorithm based on OFDMA called MUSE had presented. The critical idea of MUSE is that an AP secures Channel State Information (CSI) from the UL OFDMA sending after that endeavors this serves MU-MIMO SATs.To accomplish this as appeared in Figure 3, when the AP gets access to the channel the AP starts a UL transmission of users then begins to send by means of DL MU-MIMO. This continuous transmission is intended to happen within just a single TXOP.

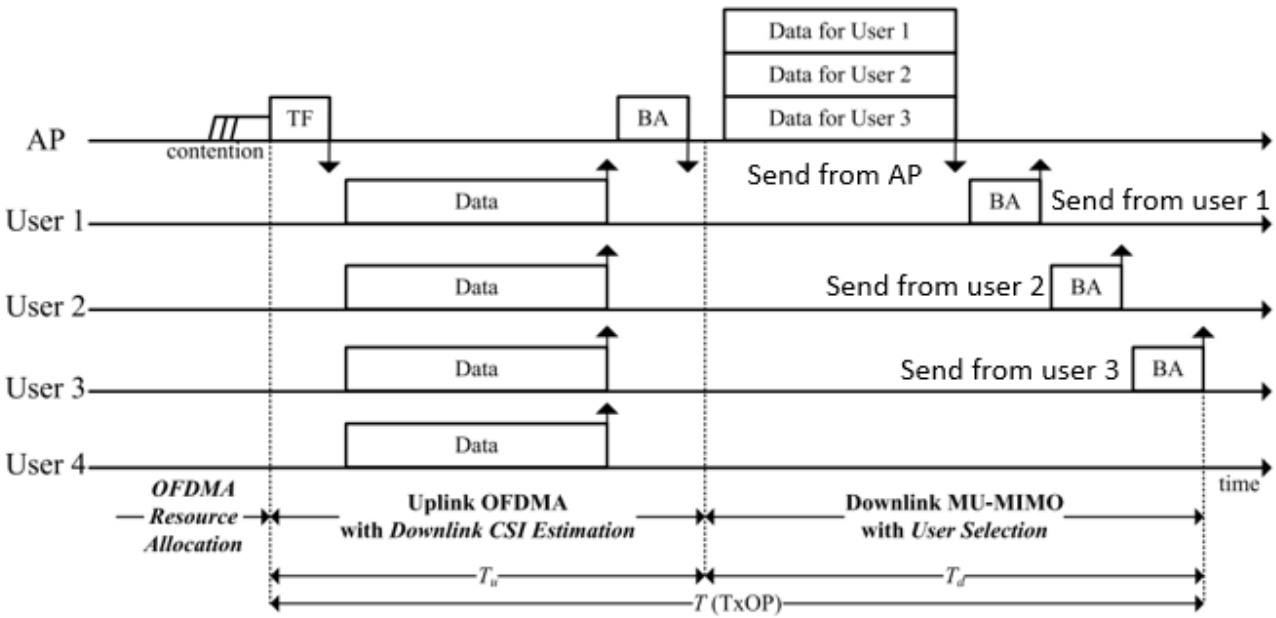

Figure 3 Operational example of MUSE [11]

B. Based on Downlink (DL) Scheduling:

In [12], the station-resource unit scheduling problem in the DL OFDMA of 11ax subject to minimum throughput requirements had addressed. A novel scheduling policy based on weighted max-min fairness had proposed, which maximizes the minimum fraction between the achievable and minimum required throughputs.

In [13],an efficient rate and allocation algorithm for OFDMA DL frameworks had proposed where each tone is taken by one user at most. This algorithm has demonstrated that with a practical number of tones, the duality hole is basically zero and the ideal arrangements can be efficiently acquired. While in [14], resource allocation for DL OFDMA frameworks with the target to enable ultra-reliable lower latency communication (URLLC). In this manner, an algorithm dependent on progressive raised enhancement is proposed to find a solution with polynormal time complexity as shown in figure 4.

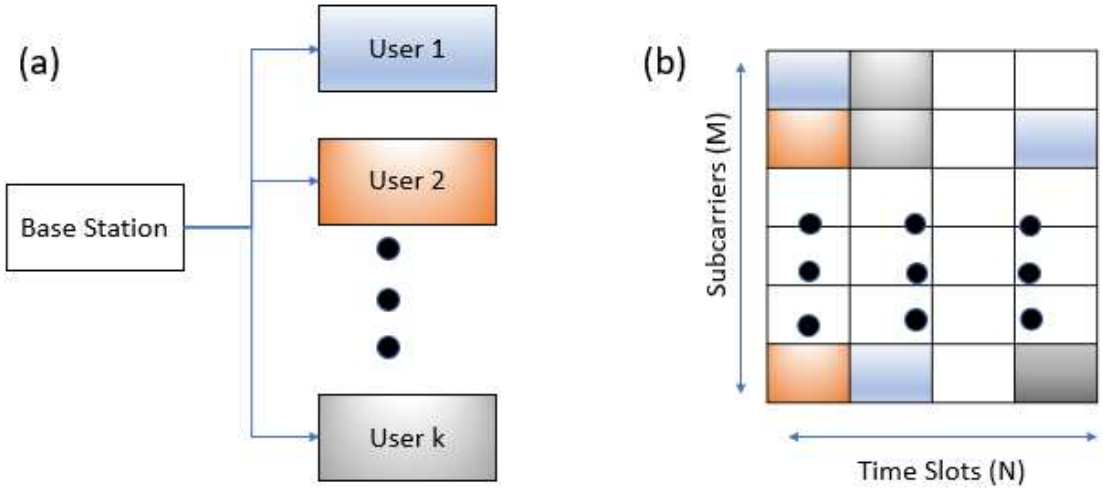

Figure 4 MU DL URLLC-OFDMA system:(a) Base station and, users; (b) Structure of the frame[14]

C. Based on UL Scheduling:

In [15], a new scheduling algorithm called MUTEX, Minimize time of uploading in 802.11ax system had formatted. That means limiting the transfer period in a situation with a huge number of users. Contingent upon the situation in some cases it merits utilizing an exemplary SRTF technique, while in different situations the channel had to be a part of a few STAs to limit the transfer period. The MUTAX, which dynamically picks the best procedure so it significantly beats old solutions.

In [16], a set of algorithm schedulers for 802.11ax had proposed:

- Max Rate: probably the easiest scheduler, called Max Rate (MR) expects to increase and optimate network throughput by maximize it.
- Proportional Fair (PF): selected RUs to STAs in a manner that boosts service rate by maximize it.
- Shortest Remaining Processing Time (SRPT): intends to limit the work time that be in the framework. Workflow of SRPT schedulers shown in Figure 5.

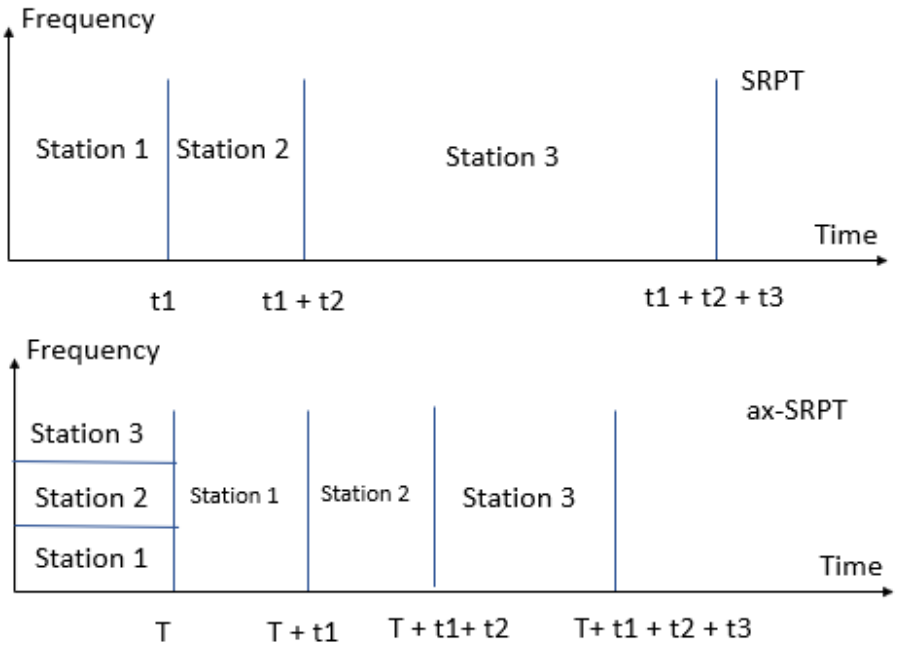

Figure 5 UL Workflow of SRPT schedulers [16]

In [17], the more broad issue of stochastic network utility boost had addressed. Specifically, it boosts the benefit of long-term normal paces of SATs to the optimal rate (average) and force imperatives utilizing "Lyapunov" improvement. The subsequent resource selection arrangements perform self-assertively near ideal and have polynomial time intricacy. A significant bit of leeway of the suggested algorithm is that it tends to be utilized alongside the objective active time instrument of 11ax networks to give ensures the ideal power (average) utilization and reachable paces of STAs at whatever point possible. UL OFDMA transmissions shown in Figure6.

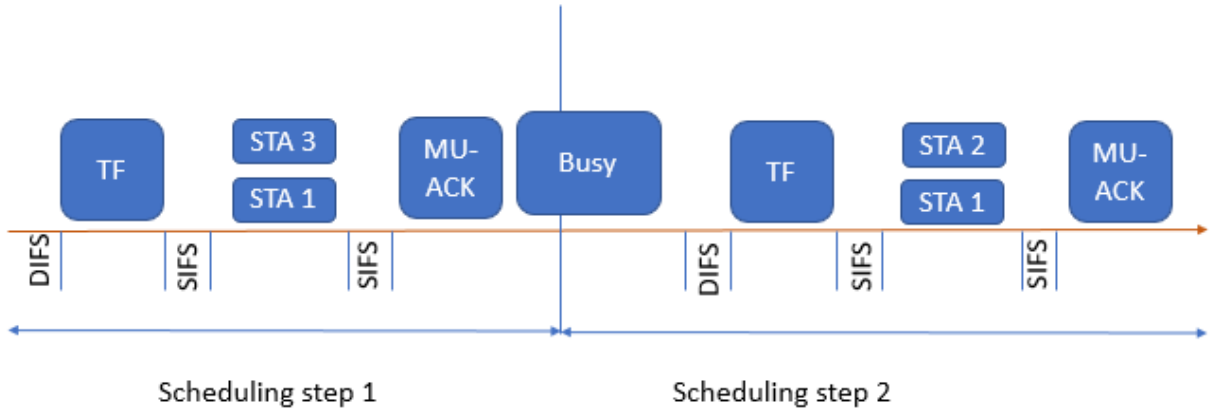

Figure 6 an example of UL OFDMA transmissions considered in the system mode[17]

In [18],a general study of the UL MU OFDMA and an analytical model for describing the presentation of the MAC layer over 802.11ax had given. where research the tradeoff between giving maximize network performance and serving new users. While in [19],a novel UL scheduling techniques over IEEE 802.11ax and analyze it over the most extreme throughputs of the single direction of UDP MU triadic had investigated. The assessment is led dependent on MIMO and OFDMA techniques over 11ax networks versus the CSMA and proposed an optimal technique to IEEE 802.11ac and IEEE 802.11ax that looks at maximizing the throughputs while considering UDP sending and that many STAs are communicating in the framework.

The study at [20], explores 802.11ax MAC empowers MUOFDMA sends in the UL by utilizing two kinds of RUs: "Random Access (RA)" RUs, and "Scheduled Access (SA)" RUs,and study the effect of various dispersions of the two kinds on the MAC layer execution. The algorithm shown in Figure 8.

while true **do**
  Compute $N_{SA} = \min(|\Psi|, N_{RU})$
  Sort BSRs in descending order
  Select N_{SA} STAs with largest BSRs in Ψ
  BSR[s] = BSR[s] - #scheduled_packets $\forall s \in \phi$
  if BSR[s] $= 0, \quad \forall s \in \Psi$ **then**
    $\Psi = \Psi \setminus \{s\}$
  end if
  Allocate $N_{RA} = N_{RU} - N_{SA}$ RUs for random access
  Transmit Trigger Frame
  if $N_{RA} > 0$ and BSR received on RA RU k **then**
    $\Psi \cup \{k\} \quad \forall k \in \psi$
    Update BSR[k] $\forall k \in \psi$
  end if
end while

Figure 7 Algorithm for optimal RU allocation in 802.11ax [20]

Conclusion:

To fulfill the constantly expanding needs for high throughput in wireless networks. 802.11ax has approved as the next generation of Wi-Fi technique. In this paper, a review on 802.11ax scheduling and resource allocation has presented. Thus, this review contributes to give the researchers who work on 802.11ax scheduling good information. Artificial intelligence can give the investigation to make algorithms more brilliant, comprehend network gives quicker, and make designs more effective. So, if we can use machine learning with the 802.11ax it will make it more efficient and used the best of OFDMA properties.

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