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# A study on the impact of various modulation and coding schemes on wireless (WiFi-6) performance

Ankit Saxena*(C.A)

**Abstract:** The performance of wireless networks depends on measuring the radio characteristics between the Access Point (AP) and Client Station (STA) within the same Base Service Set (BSS). In areas with high demand for wireless services, multiple wireless networks may overlap, causing interference and negatively impacting the performance of individual users and networks. This interference makes wireless radio channels more susceptible to interference from surrounding energy, directly affecting wireless networks' throughput. A new spatial reuse IEEE802.11ax standard has provided the solution to address this issue. This standard performs a clear channel assessment procedure between the AP and STA before assigning the channel for traffic, thus reducing channel collision and improving the effectiveness of radio resources in wireless networks. Additionally, the quality and availability of radio resources of overlaying networks would improve the usage of radio channels. This study assesses how spatial reuse, combined with different modulation with coding schemes and clear channel assessment, affects channel throughput. The results show that integrating spatial reuse can boost channel throughput by 18-20%, significantly enhancing network performance.

**Keywords:** IEEE802.11ax, OBSS, Wifi-6.

## 1 Introduction

CONNECTING computers without cables is made possible by a wireless local area network (WLAN or Wi-Fi). WLANs bridge the gap between traditional wired networks and wireless users. Work on WLANs was initiated in 1987 by the IEEE committee to improve wireless communication in the 915 MHz, 2.4 GHz, and 5 GHz bands for industrial, scientific, and medical applications. Medium Access Control protocol and Physical Layer specifications development were the primary focuses of the 802.11 standards [1]. The IEEE 802.11 standard, the first of its kind, was released in 1997. However, the maximum throughput of this 802.11 standard is only 2 Mbps at 2.4 GHz. New IEEE 802.11a and IEEE 802.11b [1] standards were released in 1999. Orthogonal frequency division multiplexing is used in the 802.11a standard, providing a data rate of 54 Mbps on the 5 GHz bands to the next Generation (Wi-Fi6) deployed in a massive density of Wireless Networks and an uncoordinated manner.

### 1.1 Background

It is expected to observe independent overlapping Wireless Networks sharing the same channel resources, especially systems based on the IEEE 802.11 standard. That affects the sharing of resources and poor performance of the network. The carrier senses multiple access/collision avoidance protocols to prevent simultaneous transmissions on the same channel and applies a defensive line. The 802.11af [1] standard specifies a physical carrier sense mechanism for determining if the radio frequency channel is available. The Basic Service Set (BSS) and the Extended Service Set (ESS) comprise the WLAN framework. Every BSS shows the range of Access Points, while ESS is connected to several BSSs, making it easier to move around in WLAN. An access point (AP) service area offers mobility zones for wireless clients to move around

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* The author is with the Electronics and Communication Department of Indore Institute of Science and Technology, Indore MP India, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal India.
E-mail: ankitsaxena_17@hotmail.com ankitsaxena4u@gmail.com ankit.saxena@indoreinstitute.com.
Corresponding Author: Ankit Saxena.

or stay connected with the respective APs, as shown in Figure 1.

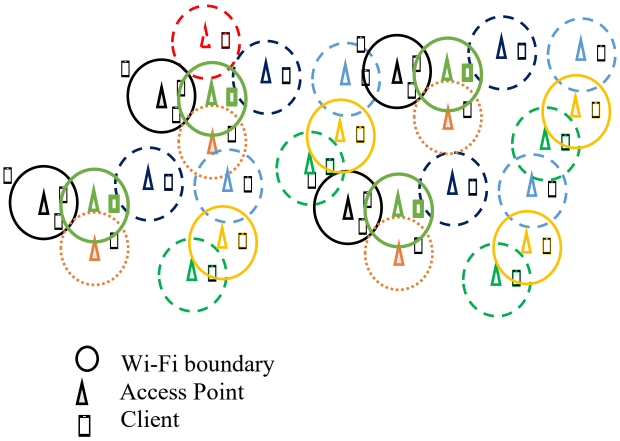



**Fig 1.** Residential Layout consists of different basic service sets that coexist in an overlapping area.

### 1.2 IEEE802.11ax (Wifi6)

To improve the success rate of wireless data transmissions, IEEE 802.11ax devices make use of Dynamic Sensitivity Control (DSC), which utilises a moving average algorithm and a Margin value based on the Received Signal Strength Indicator (RSSI) of beacons. Additionally, BSS Color is employed to enhance transmission capabilities further, utilising a 6-bit value and Uplink (UL) Flag to identify each Basic Service Set (BSS) with a colour value ranging from 1 to 63. Access Points (APs) send this value to STAs (Stationary Access Points) during association. The effectiveness of BSS Color has been thoroughly evaluated across various deployments, making it a valuable addition to wireless communication [2]. The IEEE 802.11ax amendment has introduced OBSS/PD and Spatial Reuse-based operation strategies to enable Smooth Roaming (SR) operation. BSS Color can interfere with ongoing transmissions from nearby OBSSs, so it's essential to prevent it. The Supernetworks' Secure Programmable WiFi Router (SPR)- based operation technique sends a Trigger frame from an STA during the current Physical Layer Convergence Protocol (PLCP) Protocol Data Unit (PDU) transmission. Access points (APs) manage the transmission opportunities of related STAs (stationary terminals) in certain situations. This work primarily focuses on the OBSS/PD-based operation, which operates dispersedly without needing control frame exchange, as shown in the research.

The authors [3] discussed the design of a 2×2 dual-polarised patch Antenna Array for transmitting multiple waves in Wi-Fi 6 MIMO Spatial Streams. The authors highlighted high isolation between the waves. The authors successfully deployed Wi-Fi 6 in a densely populated area using the 6 GHz band, supported by an automated frequency coordination (AFC) system that dynamically allocates channels and transmits powers based on APS and incumbent systems. The author's [4] show AFC implementation is thriving despite spectrum re-farming and protection zone challenges. The authors [5] discussed the need to improve Wi-Fi 6 in terms of latency and throughput, while also addressing the issue of channel congestion caused by a high number of users. This congestion can lead to packet drops and delays. To combat this problem, the authors suggested a solution called Multi-Agent Deep Q-Learning for Fast Roaming (MADAR).

### 1.3 Motivation

The new concurrent transmission mechanism in IEEE 802.11ax [1] WLANs has exacerbated severe unmanaged interference from overlapping BSS. The IEEE 802.11ax standard has adopted orthogonal frequency-division multiple access(OFDMA) for uplink and downlink transmissions to improve spectrum efficiency and reduce latency using Spatial Reuse (SR). The main focus is to increase the number of parallel transmission streams in the Overlapping Basic Service Set (OBSS), especially during interactions within multiple WLANs that occupy transmission channel and adjacent channels that causes interference, which affects the channel usage and throughput of the individual BSS. The physical carrier's sense of the network was performed through the Access Point while in the receiving state. The physical carrier sense method fulfilled two purposes. Firstly, it helps to determine a frame transmission bound for an access point to receive corresponding frames. Secondly, it helps to identify the state of the physical medium and whether it is available for transmission at the access point. The transmission frames may collide with overlaying Wi-Fi networks and add interference. To overcome this problem, IEEE802.11ax added a spatial colour reuse scheme that enables simultaneous transmission in the same channel when the level of interference is below a given threshold. For the wireless channel to perform well, the physical medium must be available at the access point before transmission. Further, if some other access points in overlay networks use the physical medium, then the access points will attempt synchronization between the corresponding channel transmissions.

### 1.4 Related Work

The authors [6] discussed the issue of uplink OFDMA channel collision and network efficiency in IEEE802.11ax networks. The authors proposed a method that adjusts the backoff countdown rate according to the likelihood of uplink transmission failures. The solution shows the access point improves throughput, efficiency, and collision probability. Further, due to concurrent transmissions, the authors [7] considered the topic of uncontrolled interference in IEEE 802.11ax.

**Table 1.** Literature review. Evaluation types: theoretical (T) and simulation (S).

| Goal | Key | Enhancement | Result | Evaluation Type | Amendment | Year |
|---|---|---|---|---|---|---|
| Spectral Efficiency and resource assignment | [8] [21] | Modulation and Coding Scheme, SINR and Throughput | Improved minimal throughput | T+S | IEEE 802.11ax | 2021, 2023 |
| Parallel transmission Spectral Reuse | [9] [19] [24] | Throughput and Channel Utilization | Improved throughput | T+S | IEEE 802.11ax (Draft D4.0) | 2013, 2019, 2022 |
| Reinforcement learning model | [10] [11] [22] | Throughput and fairness of resource | Reduce throughput variability and fairness | T+S | IEEE 802.11ax | 2019, 2019, 2024 |
| Channel Collision and Network Efficiency | [6] [25] | Throughput, Efficiency and collision probability | Uplink Transmission failure, error rate | T+S | IEEE 802.11ax | 2022, 2022, 2024 |
| Uncontrolled interference | [7] [16] | Latency and queue size | Error rate, Latency and Fairness | T+S | IEEE 802.11ax | 2018, 2021 |
| Rate Control and CCA Threshold adjustment | [12] [23] | Spectral Efficiency | Throughput, Error rate | T+S | IEEE 802.11ax | 2019, 2024 |
| Transmission efficiency using MIMO | [13] [17] | User Selective throughput | Throughput and channel state information | T+S | IEEE 802.11ax | 2018, 2019 |

After applying a reinforcement learning system, the authors optimise transmission queue size and latency. Additionally, the authors implement a method with a deterministic policy to satisfy the queue size limitation and latency constraints. The authors demonstrated that concurrent transmission preserves a significant fairness index. The authors [8] discussed constraints between throughput and estimation of SINR margin to support MCS. The authors proposed work on the suboptimal method of controlling STA to gain access to the primary channel and improve the network performance. Further, the authors suggest exploring optimisation aspects of MCS corresponding to the time-based assignment bandwidth. The authors [9] analysed spatial reuse operations in the IEEE802.11ax using the Komondor simulator and showed significant improvement in channel utilisation under high traffic density. The authors presented different scenarios and recommended implementing spatial reuse operations to improve throughput and reduce latency.

The authors [10] [11]discussed the reinforcement learning model using machine learning to address the spatial reuse problem and focused on channel selection and transmission power control. Based on the reinforcement learning model, the authors define the best network configuration and improve the network performance. Further, the authors compare the results with the existing approaches and validate that reinforced learning gives better results. The authors [12] focus on improving spectrum efficiency in dense networks using IEEE 802.11ax Spatial Reuse. The authors proposed a rate control algorithm with a BSS Color scheme that shows significant performance improvement in terms of throughput for a dense network. The authors used the Overlapping BSS Packet detection (OBSS/PD) threshold to control the transmission opportunities and adjusted the CCA threshold to limit the contention and interference levels.The authors [13] proposed a multi-user transmission scheme for the 802.11ax network where Access Point estimates and collects multiple user uplink OFDMA MU-MIMO channel state information and calculates the optimal downlink MU-MIMO receiver group that maximises the system utility. In simulation results, the authors show that MU-MIMO User SElection (MUSE) significantly improves the network throughput for dense networks in co-existence with legacy nodes. The authors [14] describe a K-APCS technique that uses IEEE 802.11k to modify the carrier sensing threshold. STAs can adjust the threshold by recording RSSI from the AP's beacon frames. Recording the Received Signal Strength Indicator (RSSI) from the beacon frames emitted from the associated AP is another method for adjusting the carrier sensing threshold, suitable exclusively for the Stations (STAs) [15, 12].

The authors [16] provided theoretical evaluations of OBSS PD with limited analysis of its impact on throughput. Some studies [17] explored OBSS PD tuning (-69 dBm to -81 dBm) but lacked thorough performance validation. Research on Modulation and Coding Scheme (MCS) [18] focused on generic throughput trends without detailing how MCS levels affect network performance. Prior work [19] offered limited insights on spatial reuse in dense networks, especially regarding concurrent transmissions and interference management. Studies on Packet Error Ratio (PER) and SINR [20] conducted only basic SINR analysis, without assessing how PER varies across MCS levels. The authors [21] proposed the Optimized Transmission Power-based OBSS PD (OTOP) SR scheme, which enhances parameter control while minimizing signalling overhead. Utilizing stochastic geometry analysis, OTOP optimizes transmission power to maximize transmission success probability. Simulation results further demonstrate that OTOP achieves higher throughput, lower frame error rate, and improved fairness compared to existing SR schemes in dense network environments. The authors [22] proposed Contextual Bandit - Distributed Coordination Function (CB-DCF) and Contextual Bandit - Overlapping Basic Service Set / Preamble Detection (CB-OBSS/PD), leveraging contextual bandit agents to optimize transmission decisions. ns-3 simulations demonstrate that these methods effectively enhance throughput and fairness by intelligently managing interference in wireless networks. The authors [23] proposed a multi-UAV-aided multi-access edge computing framework that optimizes task offloading, Ocean Beacon Station (OBS) selection, and transmission strategies to enhance energy efficiency. Simulation results demonstrate that the proposed framework achieves superior system revenue performance compared to benchmark algorithms.

The authors [24] developed an analytical model for IEEE 802.11ax spatial reuse, optimizing network area throughput using the BSS color feature. The study establishes a link between spatial reuse gain and interference range properties, with ns-3 simulations validating the model using the 802.11 ax WLAN spatial reuse enhancements. The authors [25] proposed GTSO (Grouping-based Target Wake Time Scheduling Optimization), a Medium Access Control (MAC) protocol for IEEE 802.11ax Overlapping Basic Service Sets (OBSSs) to enhance Resource Unit (RU) reutilization and maximize parallel transmissions. By leveraging graph-based grouping and contention-free access, GTSO optimizes sleep/wake-up scheduling, improving throughput and energy efficiency in dense networks, as demonstrated through simulations. In Table 1, we elaborate on the simulation methods and contributions of the referred literature.

### 1.5 Problem Statement

In this paper, we focus on optimising the threshold of the Overlapping Basic Service Set Preamble detection feature of IEEE 802.11ax [1] [6] [7] to help reduce interference with the neighbouring BSS. The optimised threshold values of Signal Detection (SD) and Energy Detection (ED) for a particular OBSS in correspondence with neighbouring the OBSS implicitly influence selecting a modulation and coding scheme that enhances network throughput performances.

### 1.6 Contributions

The key contributions of this paper are as follows:

**1.** We analyzed wireless network performance with the Overlapping Basic Service Set Preamble-Detection (OBSS PD) feature of IEEE 802.11ax and found that spatial reuse enhances network throughput. Devices without spatial reuse capabilities cannot transmit concurrently in neighboring networks.

**2.** Spatial reuse capabilities were validated by adjusting OBSS PD thresholds (-69 dBm to -81 dBm). While throughput and SINR remained largely unaffected by OBSS PD threshold variations, spatial reuse significantly improved network throughput by enabling concurrent wireless transmissions.

**3.** We investigated BSS throughput performance under different modulation techniques with the OBSS PD feature. Results showed that MCS values from 0 to 3 led to BSS throughput variance, whereas higher MCS values had minimal impact on throughput.

**4.** Through system-level simulations, we examined spatial reuse capabilities and found that the average packet error ratio increases as the MCS order rises. Additionally, higher MCS orders increased the Signal-to-Interference-Noise Ratio (SINR).

### 1.7 Outline

The following sections follow the article: Section 2 summarises the IEEE 801.11ax standard and overlapping Basic Service Set Preamble detection. Section 3 details the Spatial reuse procedure and performance metrics. In Section 4, simulation results confirm throughput improvement in different configurations with spatial reuse features and compare network performance between the OBSS PD enabled and disabled parts on the Network Simulator [26] and

MATLAB [27]. The conclusion and future scope are in Section 5.

## 2 IEEE 11.AX STANDARD AND SPATIAL REUSE CAPABILITIES

### 2.1 Overlapping Basic Service Set Preamble Detection

The IEEE802.11ax mode enables the OBSS PD spatial reuse capability [1]. Overlapping Basic Service Set Preamble-Detection (OBSS PD) is an 802.11ax-specific feature that allows an STA to ignore an inter-BSS Physical layer Protocol Data Unit under certain conditions. As shown in Figure 2, Station (STA1) and Access Point (AP1) are in the same Basic Service Set (BSS) (with the colour set to 1), but Station (STA2) and Access Point (AP2) are in a separate BSS (with the colour set to 2). The distances between Stations and Access Points are configurable (d1, d2 and d3). The STA1 and STA2 communicate with corresponding AP1 and AP2. The STA1 and STA2 communicate with corresponding AP1 and AP2. Each STA has traffic loads that can be customised (inter-packet interval and packet size).

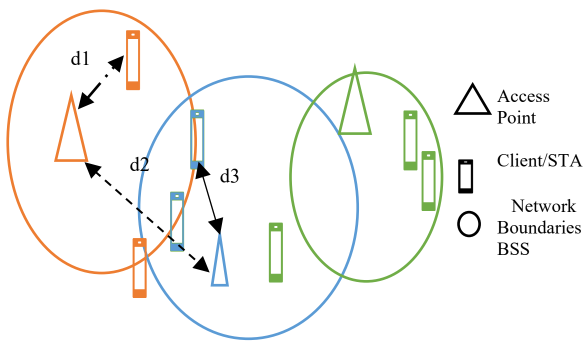



**Fig 2.** Adjacent Basic Service Set Network

### 2.2 Spatial Reuse Mechanisms of 802.11ax

With spatial reuse capabilities, devices can establish concurrent transmission sessions with a network. With the adoption of Spatial-reuse Capabilities, every OBSS was assigned a distinct colour for every wireless transmission. The labelling of wireless signals allows nearby devices to detect whether concurrent wireless channel usage is permitted. Further, stations were allowed to consider the wireless medium idle and initiate a new transmission after seeing the signal level from a nearby network. In IEEE802.11ax, access points were deployed by a clear channel assessment (CCA) procedure. That helps to verify the status of the physical medium. The CCA procedure begins with the RF waves linked with the RF physical medium. The IEEE802.11ax Wi-Fi defined two CCA thresholds: Signal preambles Detect (SD) and Energy Detect (ED).

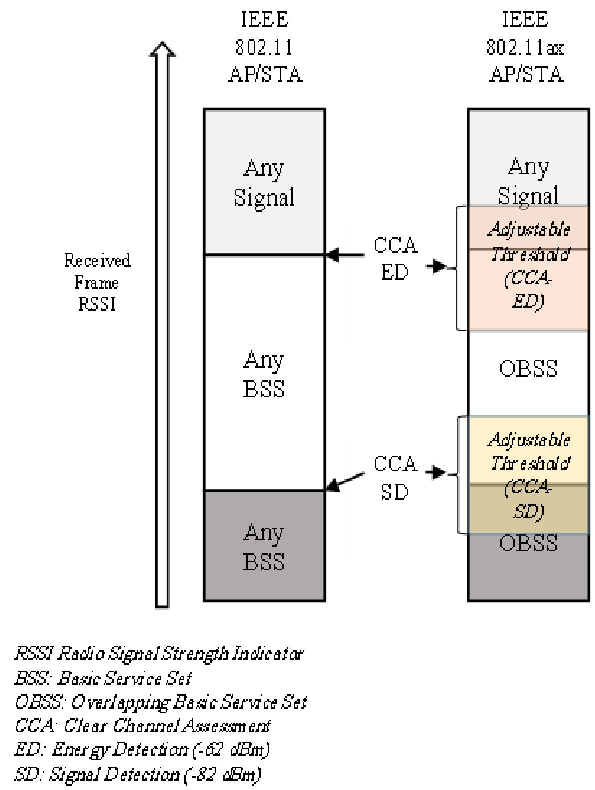



**Fig 3.** Clear Channel Assessment

At the Physical layer, the CCA comprises listening for RF waves. When listening to the RF medium, the IEEE 802.11ax radios use two different CCA thresholds, SD and ED. In 802.11ax frame transmissions, the preamble was part of the physical layer header referred to as SD. These preambles were used to decode the link corresponding to BSS, transmitting and receiving IEEE802.11ax radio synchronisation with the related channels. The SD threshold was defined to differentiate multiple IEEE802.11ax transmissions, as shown in Figure 3. The ED threshold was to verify the usage status of the physical carrier in the network.

The Clear Channel Assessment – Energy Detection (CCA-ED) determines whether the medium is occupied based on received signal strength (RSSI). If the detected energy exceeds a predefined threshold, the device defers transmission, preventing collisions but sometimes causing unnecessary delays. Clear Channel Assessment – Signal Detection (CCA-SD) refines this process by identifying specific Wi-Fi signals rather than just overall energy levels, reducing deferrals caused by non-Wi-Fi interference. Overlapping Basic Service Set Packet Detection (OBSS PD) further optimizes spatial reuse by dynamically adjusting sensitivity to overlapping transmissions. Lower OBSS PD thresholds allow more simultaneous transmissions, improving spectral efficiency but increasing the risk of interference. Conversely, higher thresholds reduce interference but limit spatial reuse, potentially leading to underutilization of the channel. Striking the right balance is crucial for maximizing throughput while minimizing packet loss and congestion in dense Wi-Fi deployments.

## 3 OBSS SPATIAL RE-USE AND PERFORMANCE METRICS

### 3.1 Spatial Re-Use Procedure

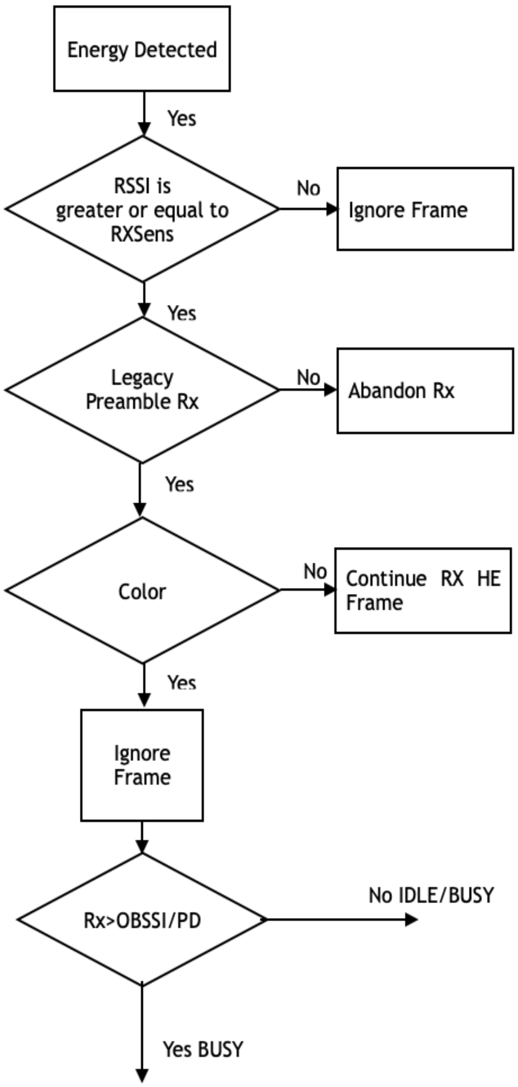



**Fig 4.** Flow procedure of OBSS Spatial Re-use Preamble Detection[17]

We configure parameters using the Wi-Fi-6 model with IEEE11ax spatial reuse capabilities, using the OBSS PD threshold and defining the power threshold, CCA ED threshold for the station, and CCA ED threshold for the access point on individual BSSs. To measure the throughput performance, both BSS are set as uniform in terms of threshold; however, we change the modulation and coding scheme for different configurations.

**Table 2.** IEEE 11ax Network Parameters for Network Simulator

| | |
|---|---|
| Simulation Time | 10 second |
| Frequency | 5.180 GHz |
| Bandwidth | 20 MHz |
| Payload Size | 1500 bytes |
| Modulation Coding Scheme (MCS) Values | 0,1,2,3,4,5,6,7,8,9 |
| Channel Model | Extended Pedestrian A (EPA) |
| | |
| Network Dimension | |
| d1 meters | 30 meters |
| d2 meters | 30 meters |
| d3 meters | 150 meters |
| Speed of Wi-Fi station | 0 |
| OBSS PD | Enabled |
| Power Configuration | |
| | |
| OBSS PD Threshold | -72 dBm |
| | |
| Power Station A | 10 dBm |
| Power Access Point A | 21 dBm |
| CCA ED Threshold Station A | -69 to -81 dBm |
| CCA ED Threshold Access Point A | -69 to -81 dBm |
| | |
| Power Station B | 10 dBm |
| Power Access Point B | 21 dBm |
| CCA ED Threshold Station B | -69 to -81 dBm |
| CCA ED Threshold Access Point B | -69 to -81 dBm |
| | |
| Traffic model Λ | Downlink |
| Traffic load | 1 to 100 Mbps |

In this section, the performance of spatial reuse capability is evaluated and analysed via Network Simulator (NS3) [26] and MATLAB simulations [27]. Table 2 defines the network configuration for the individual Basic Service Set, followed by Figure 3, a network diagram using Network Simulator (NS3) [1] [6] [7] [28] [29] [30] [31]. The OBSS PD threshold range (-69 dBm to -81 dBm) balances spatial reuse and interference mitigation in dense Wi-Fi 6 deployments. Lower values (-81 dBm) reduce interference but limit reuse, while higher values (-69 dBm) increase reuse but risk collisions. This range was chosen based on empirical studies and simulations to optimize throughput, latency, and network efficiency.

### 3.2 Evaluation Metrics

Modulation and Coding Schemes [28] combine different modulation techniques with corresponding coding methods that select channel width, the number of antennas and the spatial stream applied between the wireless Client and the Access Point. These schemes are indexed as MCS 0 to 9 and deployed to the radio channel between the Client and AP—the higher order index MCS offers higher throughput over the lower MCS scheme. Selecting the appropriate modulation coding scheme would increase the system performance, which depends upon multiple factors, such as wireless communications link quality, the capabilities of the devices, and the spectrum available.

Packet Error Ratio or Average Packet Error Rate [26] is described as the ratio of the sum of the erroneous packet corresponding to the total packet received in the network as mentioned in eq.(1)

$$\text{Average Packet Error Rate} = \frac{\text{sum(Number of Packet Error)}}{\text{sum(Total Packets)}} \tag{1}$$

As mentioned in eq. (2) the throughput data rate [26] is described as the number of bits transferred (in Mbps) from the access point to the user in the network (2).

$$Throughput = \frac{Total\ Packet * Pay\ Load\ Size}{Simulation\ Time} \tag{2}$$

## 4 SIMULATION AND RESULTS

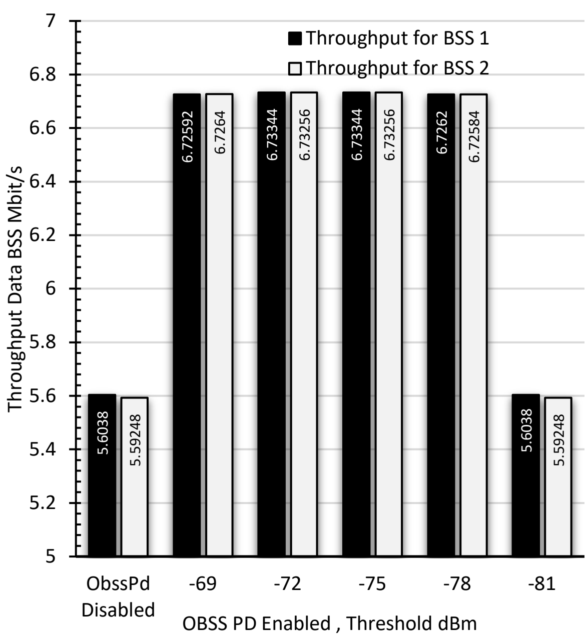
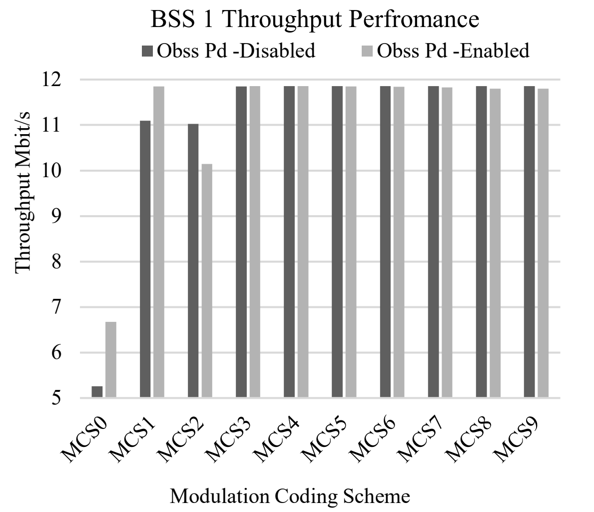



**Fig 5.** Throughput of BSS 1 and BSS 2 without ObssPd and with different values of ObssPd

In the work, we simulate IEEE 802.11ax on Network Simulator–3 configured as per Table 2 and measure the performance metric for different modulation and coding schemes under throughput and packet error rate. The networks are configured to overlay two OBSS PDs (Disabled) and two OBSSs with PDs (Enabled). For the signal-noise ratio of the network, we estimated Packet Error Rate (PER) performance with an additive white Gaussian noise (AWGN) channel as with the fading channel. A pre-computed lookup table generates and provides the PER for an SNR under an AWGN channel for a given channel coding, modulation scheme, and coding rate[27].



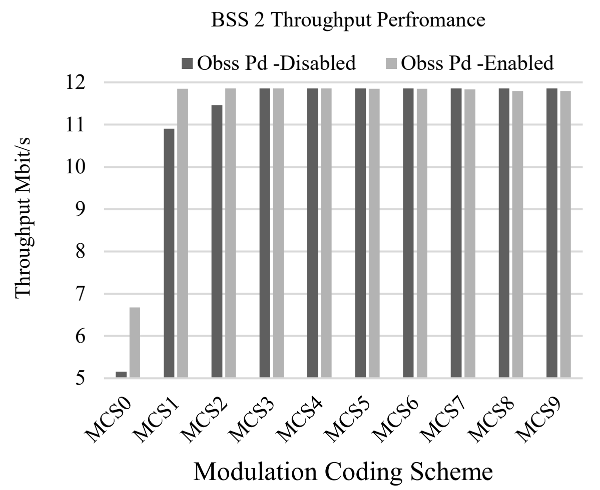




**Fig 6.** Comparison of both the BSS in terms of Throughput vs. Modulation Coding Scheme without ObssPd and with ObssPd

In Figure 5, we observed a significant improvement in throughput by enabling the OBSSPD feature. However, reducing PD below -81 dBm throughput is equivalent to the OBSSPD disabled network. Upon calculation, the BSS throughput percentage increases to 20 per cent (%) for the OBSS PD-enabled network compared to the OBSS PD-disabled network. The throughput gains saturate beyond a certain OBSS PD threshold due to increased interference, higher packet loss, and excessive retransmissions. While spatial reuse initially improves efficiency, excessive concurrent transmissions cause congestion, reduce CSMA/CA effectiveness, and increase medium access delays, ultimately offsetting gains and capping overall network throughput. In Figure 6, we measured an individual BSS data throughput vs. Modulation Coding Scheme with and without OBSSPD, where we found throughput variance in the lower order of MCS (0–2). However, the higher-order MCS does not show data throughput variance. The OBSSPD threshold affects the lower order of MCS rather than the higher order of MCS. Lower MCS values (0-2) are more affected by OBSS PD due to longer transmission times, greater exposure to interference, and weaker resilience. They require a stronger SNR, making them more vulnerable to aggressive OBSS PD settings. In contrast, high-MCS transmissions are shorter and less impacted. Additionally, control frames depend on low MCS, increasing the risk of network disruptions. Properly balancing OBSS PD is crucial for ensuring reliability while maximizing spatial reuse in dense environments.

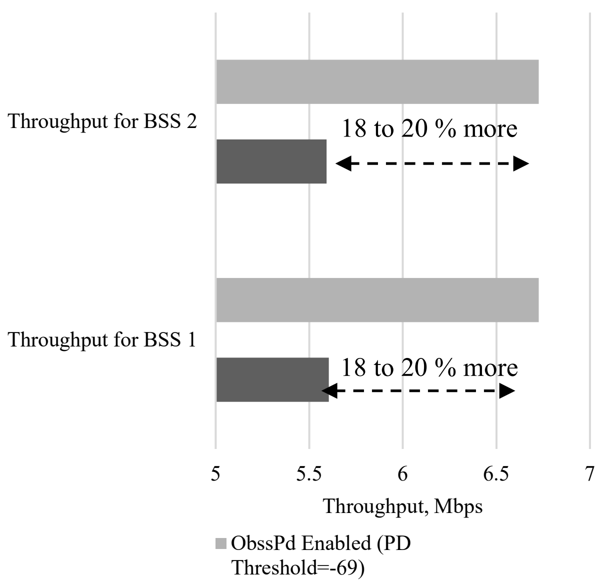



**Fig 7.** OBSS PD enabled and Disabled BSS WLAN.

Figure 7 shows a 18%–to 20% increment of individual BSS throughput in OBSS PD-enabled BSS compared to a PD-disabled BSS network. The incremented throughputs are effects of the marginal possibility of retaining information above the threshold boundary (in the region of PD < 80 to the maximum power of BSS) for the specific BSS. Another fact is that over -80 dBm of BSS, PD-enabled OBSS and PD-disabled OBSS networks offer the same throughput, and zero packets were recovered below the -80 dBm threshold. The power of OBSS helps to determine the range of a particular BSS, although the range estimation is affected by path loss and wireless environment factors. Figure 8 results infer that throughput associated with lower modulation coding schemes gives a lower error rate than higher coding schemes. The signal detect threshold helps to determine extended throughput capacities linked with the corresponding modulation coding scheme.

The 18-20% throughput gain from OBSS PD optimization depends on network density, traffic load, and interference. While spatial reuse improves efficiency, excessive OBSS PD tuning increases interference, causing packet loss and congestion. Balancing reuse and interference is crucial to prevent diminishing returns in high-density networks.

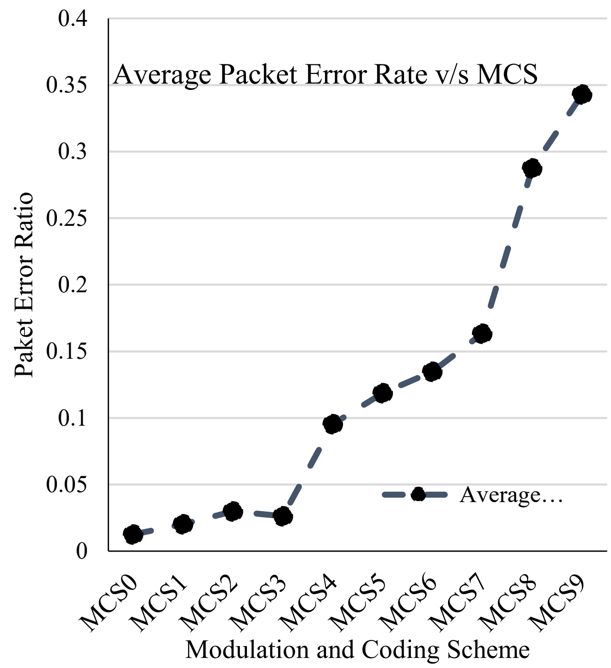



**Fig 8.** Average Packet Error Rate vs Modulation Coding Scheme

The impact of OBSS PD in dense, high-interference environments relies on balancing spatial reuse and interference control. Lower thresholds enable more simultaneous transmissions but increase collision risks, leading to packet loss and retransmissions. Higher thresholds reduce interference but may underutilize the channel, limiting efficiency.

The optimal OBSS PD threshold varies with network density and interference levels. In low-density networks, higher thresholds (-69 dBm) enhance spatial reuse. In high-density networks, lower thresholds (-81 dBm) minimize interference and collisions. Adaptive tuning, using real-time congestion data or machine learning, optimizes throughput dynamically. No single threshold is universally optimal—dynamic adjustments ensure the best balance between efficiency and reliability.

Performance depends on network density, modulation schemes, and environmental factors like multipath effects. A comprehensive analysis should evaluate throughput, latency, packet loss, and fairness using simulations and real-world tests. Optimizing OBSS PD settings enhances network efficiency by mitigating interference while maximizing channel utilization in congested environments. Table 3 shows a comparison between the recent research with the presented work under various aspects.

**Table 3.** Comparison between the previous research and the work

| Aspect | Previous Research | This Work |
|---|---|---|
| OBSS PD Impact on Throughput | Limited analysis, mainly theoretical evaluations. [16] | Empirical results show that spatial reuse significantly boosts throughput. |
| Threshold Range (-69 dBm to -81 dBm) | Some studies considered OBSS PD tuning but lacked performance validation. [17] | Verified that throughput and SINR remain mostly unaffected by OBSS PD adjustments. |
| Modulation and Coding Scheme (MCS) Analysis | Focused on generic throughput trends. [18] | Found that MCS 0-3 affects BSS throughput, while higher MCS remains stable. |
| Spatial Reuse in Dense Networks | Limited insights on concurrent transmissions and interference. [19] | Demonstrated spatial reuse benefits, enabling simultaneous transmissions. |
| Packet Error Ratio (PER) vs. SINR | Basic SINR analysis without detailed PER trends. [20] | Showed higher MCS increases SINR but also leads to higher packet error ratio. |

## 5 CONCLUSION

The performance of a wireless local area network is a function of radio characteristics between the peer users in a particular basic service set of BSS. The design of a wireless communication system (Wi-Fi) is described as an amplified signal transmitted over the channel and received or recovered by a sensitive receiver. However, wireless radio channels are influenced by ambient energy, interfering signals, and adjacent co-channel that may or may not be affected by other peer communications. The unmanaged channel attributes significantly impact the throughput performance of the individual wireless network. To overcome the problem, IEEE 802.11ac, a new facilitation of a Clear Channel Assessment procedure, was introduced in IEEE 802.11ax regarding power detection on the same channel to avoid collision and interference. In the paper, we observed that the spatial reuse capabilities by optimising the OBSS-PD threshold help to improve the throughput performance by 18-20% more than the conventional methods for the lower Modulation and coding scheme (i.e. MCS 0 to MCS2) in the BSS network. Further, for the higher-order modulation coding scheme, the throughput performance for OBSS still needs to be improved. As a future scope, we investigate factors and procedures to loosen the block and packet error rate for the higher order modulation and coding scheme, reduce throughput variance and maintain the degree of fairness in allocating resources.

**Conflict of Interest**

*The authors declare no conflict of interest.*

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**Biography**

Ankit Saxena, (Senior Member, IEEE), holds an engineering diploma in Electronics Communication, a Bachelor of Engineering in Electronics and Instrumentation, a Master of Business Administration (System), and a Master of Electronics Engineering (Electronics and Telecommunication Engineering).

Currently, he focuses on the Disruption of 5G/NB-IOT and RF in Telecom and Energy Utilities. He had a variety of positions in Ericsson, Alcatel-Lucent, Reliance Communications, and Tata Teleservices (TTSL), where he contributed to the administration and enhancement of various communications networks. The Faculty of Engineering of DAVV University, Indore, has awarded him a PhD in Engineering (2018). He has thus far published a number of research papers on wireless mobility in Science Citation index Journals. Email: ankitsaxena4u@gmail.com;ankitsaxena_17@hotmail.com; ankit.saxena@indoreinstitute.com