

Comparative Performance Analysis of Network Throughput for Wi-Fi6 and Wi-Fi5

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ABSTRACT

Wi-Fi 6, designated as the IEEE 802.11ax protocol, represents the latest generation of Wi-Fi standards, offering significantly higher throughput than its predecessor, IEEE 802.11ac (Wi-Fi 5). Both standards incorporate substantial physical (PHY) layer advancements, such as increased channel bandwidths and Multi-User Multiple-Input Multiple-Output (MU-MIMO) technology. However, while Wi-Fi 5 supports MU-MIMO only in the downlink, Wi-Fi 6 extends support to both uplink and downlink communications. Additionally, Wi-Fi 6 adopts Orthogonal Frequency-Division Multiple Access (OFDMA) to enhance spectral efficiency, enabling improved throughput in dense network environments. The introduction of higher Modulation and Coding Schemes (MCS 10 and 11) further increases data rates. In this study, network simulations were conducted using NS-3, revealing that Wi-Fi 6 can deliver a substantial improvement in system performance compared to Wi-Fi 5.

Keywords: IEEE 802.11, Modulation and Coding Schemes (MCS), Multi-User Multiple-Input Multiple-Output (MU-MIMO), network performance, Orthogonal Frequency-Division Multiple Access (OFDMA), protocol, throughput, Wi-Fi 5, Wi-Fi 6

INTRODUCTION

Wi-Fi 6, developed in accordance with the IEEE 802.11ax standard, stands apart from its predecessors due to its distinctive technical features and performance enhancements (Aliev, 2022). With the introduction of new functionalities, improved efficiencies, and an updated naming convention, Wi-Fi 6 quickly generated significant interest within networking communities (Gao and Schmöcker, 2022). The Wi-Fi Alliance officially launched Wi-Fi 6 in late 2018, introducing a simplified nomenclature system for earlier standards: 802.11b as Wi-Fi 1, 802.11a as Wi-Fi 2, 802.11g as Wi-Fi 3, 802.11n as Wi-Fi 4, and 802.11ac as Wi-Fi 5 (Khan et al., 2022). Although versions prior to Wi-Fi 4 are not formally included

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in this convention, the differences between Wi-Fi 6 and Wi-Fi 5 are considerable.

Wi-Fi 6 is designed to enhance connectivity for applications such as the Internet of Things (IoT) and adopts Orthogonal Frequency-Division Multiple Access (OFDMA), along with support for both uplink and downlink Multi-User Multiple-Input Multiple-Output (MU-MIMO) (Aliev et al., 2022). In contrast, Wi-Fi 5 supports MU-MIMO only in the downlink (IEEE, 2013). Both IEEE 802.11ac and IEEE 802.11ax employ flexible channel bandwidths of 20, 40, 80, or 160 MHz in the physical (PHY) layer, enabling efficient utilization of multiple transmission paths (Bellalta, 2016). Wi-Fi 6 improves spectral efficiency through OFDMA and introduces higher Modulation and Coding Schemes (MCS 10 and 11) using 1024-QAM, which significantly increase communication bandwidth (Sharon and Alpert, 2018).

Further enhancements include an increased Fast Fourier Transform (FFT) size, reduced subcarrier spacing, and extended symbol duration, all contributing to improved robustness and throughput under both reliable and challenging network conditions (ns-3, 2022). A key distinction between the two standards is the greater subcarrier density in Wi-Fi 6, resulting in narrower subcarrier gaps and better spectrum utilization (Frommel et al., 2021). Studies indicate that in single-user (SU) and multi-user (MU-MIMO) scenarios, IEEE 802.11ax consistently outperforms IEEE 802.11ac in throughput (Lee et al., 2020). Consequently, this paper focuses on evaluating network performance improvements in Wi-Fi 6 compared to its predecessor, Wi-Fi 5.

LITERATURE REVIEW

Both IEEE 802.11ac and IEEE 802.11ax employ channel bonding capabilities in the physical (PHY) layer, enabling operation with channel widths of 20, 40, 80, or 160 MHz. These protocols leverage multiple transmission paths to enhance performance (IEEE, 2013). Wi-Fi 6 incorporates MU-MIMO technology for both uplink and

downlink transmissions, whereas IEEE 802.11ac supports MU-MIMO only in the downlink (Bellalta, 2016). In addition, Wi-Fi 6 improves bandwidth utilization through OFDMA, increasing spectral efficiency. It also introduces Modulation and Coding Schemes (MCS 10 and 11), utilising 1024-QAM to achieve higher data rates (Sharon and Alpert, 2018).

Another significant enhancement in Wi-Fi 6 is the increased Fast Fourier Transform (FFT) size, which reduces subcarrier spacing and extends symbol duration, leading to improved resilience in challenging network conditions. This change increases subcarrier density, further improving spectral efficiency (ns-3, 2022). In single-user (SU) scenarios, IEEE 802.11ax provides higher throughput over both reliable and unreliable channels when compared to IEEE 802.11ac, and this performance advantage persists in multi-user (MU-MIMO) environments (Frommel et al., 2021).

The IEEE 802.11ac standard operates solely in the 5 GHz frequency band to minimise interference, whereas IEEE 802.11ax supports both 2.4 GHz and 5 GHz bands, thereby offering greater coverage flexibility (Lee et al., 2020). Using the 2.4 GHz band allows broader coverage at the expense of speed, while the 5 GHz band supports higher speeds over shorter ranges. Wi-Fi 6 is also expected to extend to the 6 GHz band in future implementations (Masiukiewicz, 2019).

Hardware limitations prevented IEEE 802.11ac from achieving its theoretical maximum throughput of 6.9 Gbps. In contrast, IEEE 802.11ax is better positioned to reach its projected peak of 9.6 Gbps, thanks to advances such as 1024-QAM and improved modulation techniques (Rochim et al., 2020). Additional innovations, such as Basic Service Set (BSS) colouring, help reduce interference from overlapping networks, further increasing total system throughput (Sharon and Alpert, 2018).

Previous studies highlight that IEEE 802.11ac performs sub-optimally in high-density

environments due to the limitations of Orthogonal Frequency-Division Multiplexing (OFDM), which can only serve one user per transmission cycle. This leads to delays when multiple devices attempt to transmit simultaneously (Lee et al., 2020). IEEE 802.11ax addresses this challenge through OFDMA, allowing multiple users to transmit concurrently without interference by dividing available bandwidth into smaller Resource Units (RUs) (Frommel et al., 2021). This capability makes Wi-Fi 6 particularly well-suited for dense network environments.

METHODOLOGY

The comparative analysis between Wi-Fi 6 (IEEE 802.11ax) and Wi-Fi 5 (IEEE 802.11ac) was conducted to examine shared features, performance differences, and improvements in throughput. (Figure 1). Both standards have similar maximum data rate and channel bandwidth capabilities; however, Wi-Fi 6 offers a greater probability of achieving peak speeds due to its ability to serve multiple users and devices simultaneously through advanced features such as OFDMA (Sharon and Alpert, 2018).

Wi-fi 5 (802.11 ac)	Feature	Wi-fi 6 (802.11 ax)
Single user support (OFDM)	Access point capacity	Support for multiple users(OFDMA)
From four to eight	Access Point Spatial Streams	Eight
5GHz	Frequency range	2.4 Ghz and 5 Ghz
6.9 Gbps	Maximum data rate	9.6 Gbps
Downlink MU-MIMO	MU-MIMO	Uplink and downlink MU-MIMO

Figure 1. Variations Among Wi-Fi 6 and Wi-Fi 5

Figure 1 illustrates the key differences between Wi-Fi 6 and Wi-Fi 5, highlighting variations in contact intervals, longitudinal flows, occurrence groupings, and maximum data transmission rates.

The IEEE 802.11ac standard operates exclusively in the 5 GHz frequency band to avoid high interference levels, whereas IEEE 802.11ax operates in both the 2.4 GHz and 5 GHz bands (Lee et al., 2020). This dual-band capability results

in higher throughput potential compared to Wi-Fi 5. The 2.4 GHz band enables greater coverage but at reduced speeds, while the 5 GHz band delivers higher speeds over shorter ranges. Additionally, Wi-Fi 6 is designed to operate in the 6 GHz band in future deployments.

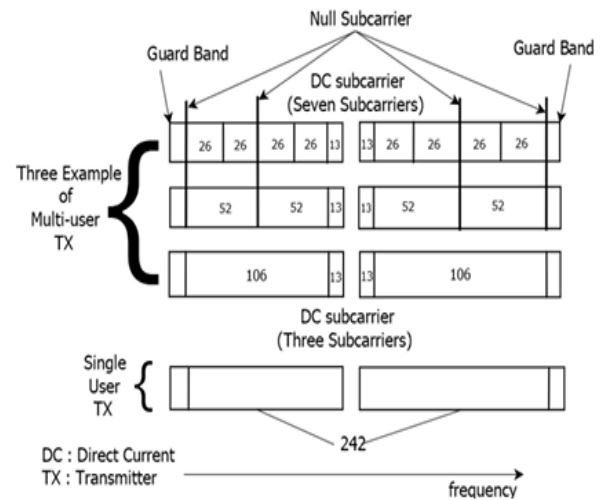


Figure 2 Capacity Component Assignment in OFDMA

Due to hardware limitations, IEEE 802.11ac has not reached its theoretical peak throughput of 6.9 Gbps. In contrast, IEEE 802.11ax is more likely to achieve its maximum projected data rate of 9.6 Gbps, aided by 1024-QAM modulation, extended symbol durations, and BSS colouring to reduce interference from adjacent cells (Masiukiewicz, 2019).

IEEE 802.11ac utilises Orthogonal Frequency-Division Multiplexing (OFDM) (Figure 2), which transmits to one user per cycle, causing inefficiencies in dense networks. IEEE 802.11ax improves on this by employing Orthogonal Frequency-Division Multiple Access (OFDMA), allowing multiple users to transmit simultaneously without interference. OFDMA divides the available spectrum into smaller Resource Units (RUs), enabling more efficient use of bandwidth and improved performance in crowded environments (Frommel et al., 2021).

Wi-Fi 6 introduces features that allow devices not actively transmitting to enter low-power states,

conserving battery life—an advantage for IoT devices and battery-dependent equipment (Bellalta, 2016).

RESULT AND DISCUSSION

A performance evaluation was conducted for both IEEE 802.11ac and IEEE 802.11ax using the NS-3 network simulator (ns-3, 2022). Each simulation scenario was executed ten times, with mobile channel conditions varied randomly to test transmission performance under different MCS levels and channel widths. The total number of stations was set to ten for baseline tests (Figure 3)

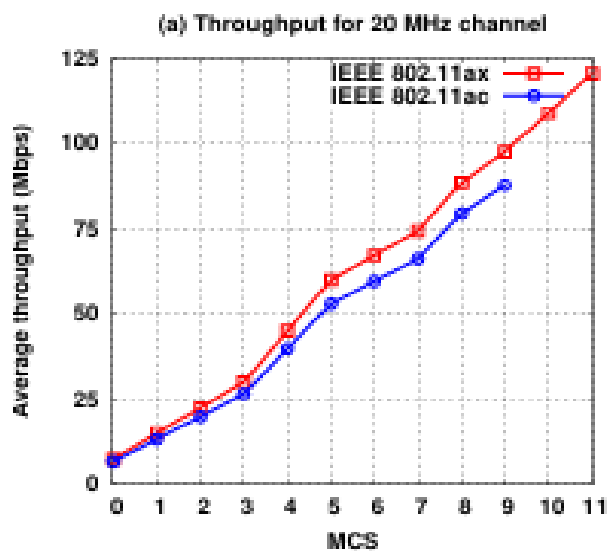


Figure 3. 20 MHz channel

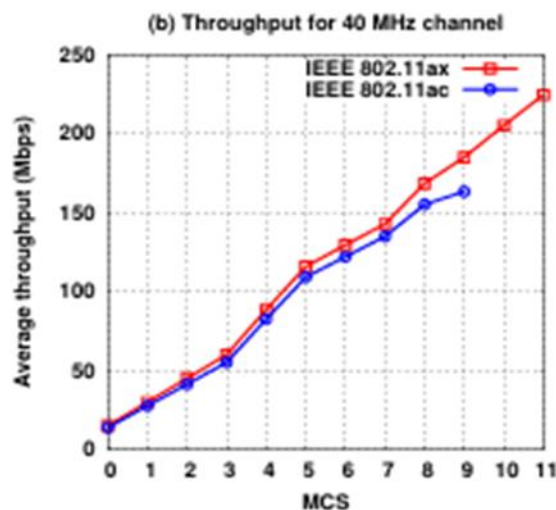


Figure 4. 40 MHz channel

At 20 MHz and 40 MHz channel widths (Figure 4), Wi-Fi 6 supports MCS 11 with 1024-QAM, while Wi-Fi 5 supports up to MCS 9 with 256-QAM. At lower MCS values, both standards perform similarly, but Wi-Fi 6's advantage grows with increasing MCS levels, achieving around 160 Mbps at 40 MHz compared to lower speeds for Wi-Fi 5.

At 80 MHz (Figure 5), Wi-Fi 6 achieves over 400 Mbps at MCS 11, roughly double the throughput at 40 MHz. At 160 MHz (Figure 6), Wi-Fi 6 reaches over 600 Mbps, consistently maintaining a throughput advantage of approximately 100 Mbps over Wi-Fi 5 across all MCS levels.

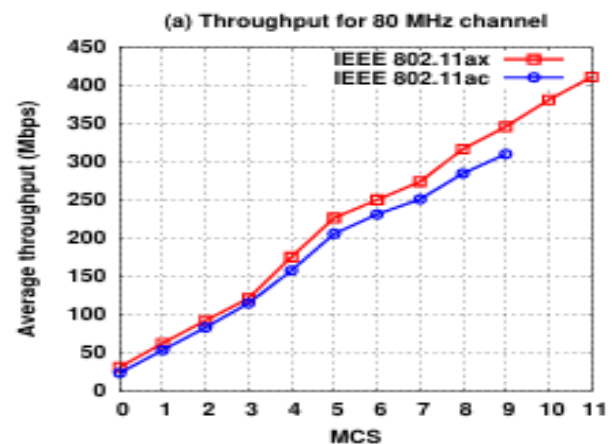


Figure 5. for 80 MHz channel

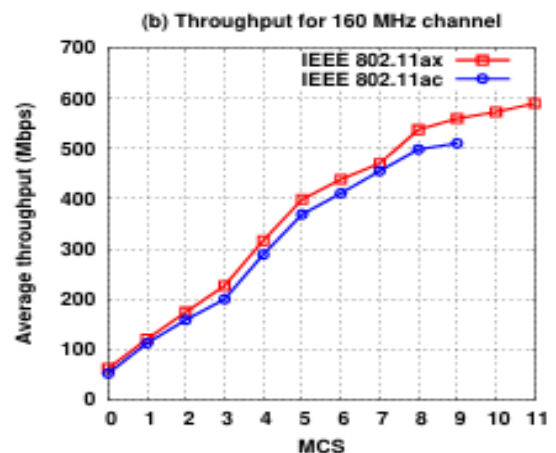


Figure 6. for 160 MHz channel

With varying numbers of stations, the highest median throughput for both Wi-Fi 5 and Wi-Fi 6 occurs when there are only 10 stations, due to reduced delays and interference. However, Wi-Fi 6 outperforms Wi-Fi 5 when the number of stations is below 50, demonstrating better spectral efficiency and higher throughput in congested network environments (Rochim et al., 2020).

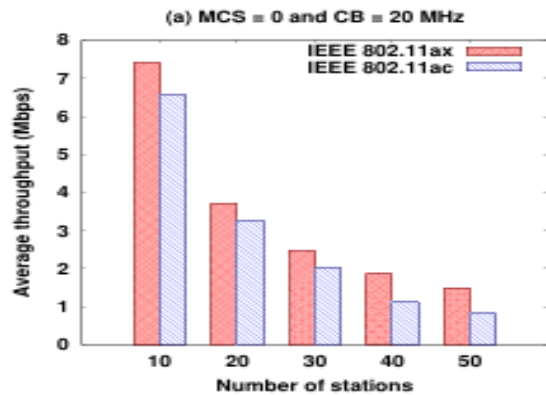


Figure 7 Number of units as 0 and 20 MHz

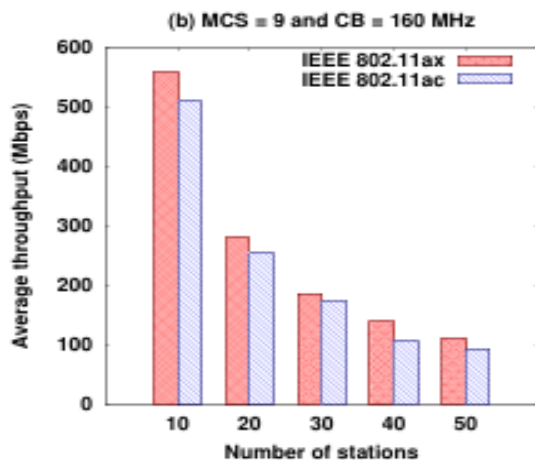


Figure 8 Number of units as 9 and 160 MHz

The results confirm that throughput increases with both MCS level and channel width, with Wi-Fi 6 consistently outperforming Wi-Fi 5 (Figures 7 and 8). The improvement is most pronounced in high-density and wide-channel scenarios due to Wi-Fi 6's enhanced spectral efficiency, OFDMA capabilities, and higher-order modulation schemes.

CONCLUSION

This study compared the performance of Wi-Fi 5 (IEEE 802.11ac) and Wi-Fi 6 (IEEE 802.11ax) across varying modulation and coding schemes (MCS) and channel widths. The results demonstrate that Wi-Fi 6 consistently outperforms Wi-Fi 5, particularly when higher MCS levels and wider channels are employed. Under strong signal conditions, increasing both channel width and MCS yields substantial improvements in throughput distribution.

Across tests conducted at 80 MHz and 160 MHz, a consistent average throughput gap of approximately 100 Mbps was observed in favour of Wi-Fi 6. While IEEE 802.11ac can maintain stable performance under high node densities, Wi-Fi 6 delivers greater average throughput, especially in congested environments. This advantage is largely attributed to its enhanced spectral efficiency, OFDMA capabilities, and higher-order modulation.

In conclusion, Wi-Fi 6 offers measurable performance improvements over Wi-Fi 5 across a range of network conditions, making it a more efficient choice for high-density deployments and bandwidth-intensive applications. These findings reinforce the potential of Wi-Fi 6 to meet the growing demands of modern wireless communication systems.

REFERENCE

- Aliev, R. (2022) Topical Drifts in Intelligent Computing: Proceedings of International Conference on Computational Techniques and Applications (ICCTA 2021). Singapore: Springer Nature Singapore.
- Aliev, R., Aliev, M. and Tokhirov, E. (2022) AIP Conference Proceedings. AIP Publishing LLC. <https://doi.org/10.1063/5.0094332>
- Bellalta, B. (2016) 'IEEE 802.11ax: High-efficiency WLANs', IEEE Wireless Communications, 23(1), pp. 38-46. <https://doi.org/10.1109/MWC.2016.7422404>

Frommel, F., Capdehourat, G. and Rodríguez, B. (2021) 'Performance analysis of Wi-Fi networks based on IEEE 802.11ax and the coexistence with legacy IEEE 802.11n standard', in 2021 IEEE URUCON. IEEE, pp. 492–495. <https://doi.org/10.1109/URUCON52409.2021.9646874>

Gao, J. and Schmöcker, J-D. (2022) 'Asian Transport Studies'. Asian Transport Studies, 8, 100081. <https://doi.org/10.1016/j.eastsj.2022.100081>

IEEE (2013) Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications – Amendment 4: Enhancements for very high throughput for operation in bands below 6 GHz. IEEE Standard 802.11ac-2013. Piscataway, NJ: IEEE.

Khan, F.U., Mian, A.N., Mushtaq, M.T. and Tahir, M. (2022) 'Experimental testbed evaluation of cell level indoor localization algorithm using Wi-Fi and LoRa protocols'. Journal of Network and Computer Applications, 205, 103410. <https://doi.org/10.1016/j.jnca.2022.103410>

Lee, J., Lee, K., Lee, Y., Kang, S., Kim, B. and Bahk, S. (2020) 'Performance evaluation of channel bonding in dense scenario', in Proceedings of the 2020 International Conference on Information and Communication Technology Convergence (ICTC). IEEE, pp. 434–436. <https://doi.org/10.1109/ICTC49870.2020.9289296>

Masiukiewicz, A. (2019) 'Throughput comparison between the new HEW 802.11ax standard and 802.11n/ac standards in selected distance windows', International Journal of Electronics and Telecommunications, 65(1), pp. 79–84. <https://doi.org/10.24425/ijet.2019.126284>

ns-3 (2022) 'ns-3.36 – nsnam'. Available at: <https://www.nsnam.org/releases/ns-3-36> (Accessed: 5 August 2024).

Rochim, A.F., Harijadi, B., Purbanugraha, Y.P., Fuad, S. and Nugroho, K.A. (2020) 'Performance comparison of wireless protocol IEEE 802.11ax vs 802.11ac', in Proceedings of the 2020 International Conference on Smart Technology and Applications (ICoSTA). IEEE, pp. 1–5. <https://doi.org/10.1109/ICoSTA48221.2020.1570613885>

Sharon, O. and Alpert, Y. (2018) 'Scheduling strategies and throughput optimization for the uplink for IEEE 802.11ax and IEEE 802.11ac based networks', arXiv preprint arXiv:1803.10657. Available at: <https://arxiv.org/abs/1803.10657>