International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Innovations in Wireless Networking: Understanding Wi-Fi 6

Siva Kumar Mamillapalli

siva.mamill@gmail.com

Abstract:
In recent decades, there has been a significant rise in global Internet users, devices, and connectivity. This, coupled with widespread digital transformation across industries and the increasing demand for bandwidth-intensive applications, has created a pressing need for faster and more universally accessible wireless networks. To address these challenges, the next generation of Wi-Fi, known as Wi-Fi 6 or IEEE 802.11ax, was initiated in 2014 and officially released in 2019. Wi-Fi 6 introduces technologies such as uplink Multi-User MIMO (MU-MIMO), Orthogonal Frequency Division Multiple Access (OFDMA), and higher-order coding (1024-QAM) to enhance network capacity and transmission efficiency. Its primary goals include improving average user throughput by at least four times and supporting more concurrent users, particularly in dense environments, compared to its predecessor, Wi-Fi 5. Wi-Fi 6 represents a significant advancement in wireless technology, promising enhanced coverage, capacity, and performance to meet evolving Wi-Fi usage needs effectively.

Keywords: Wi-Fi6,MU-MIMO,OFDMA,802.11ax,IEEE,1024-QAM, TargetWakeupTime (TWT)

1. Introduction

Wi-Fi networks have undergone a major transformation, shifting from being a luxury to an essential service. Today, Wi-Fi supports bandwidth-heavy media content and multiple devices per user, making reliable connectivity a critical factor for both employees and consumers. The ability to offer dependable Wi-Fi is now crucial for businesses, as the lack of a stable connection can affect customer decisions to enter or leave a place. In the coming years, networks will face the challenge of managing an explosion in the number of connected devices, a dramatic increase in global IP traffic, and the integration of a variety of new technologies all of which heavily depend on Wi-Fi.

Wi-Fi 6, or 802.11ax, is designed to address these challenges and promises to enhance network performance with better throughput, lower latency, greater capacity, and improved security. As IoT devices proliferate, the need for more efficient Wi-Fi networks that can handle congestion and meet growing capacity demands becomes crucial for businesses to remain competitive. Wi-Fi 6 is set to accommodate the increasing data needs across a range of applications, from mission-critical tasks to machine-to-machine communication, unlocking new opportunities for business models in sectors like manufacturing, virtual reality, and telepresence.

2. Literature review of Wi-Fi Technology

Wi-Fi technology has evolved significantly, especially in terms of transmission speed. Over nearly two decades, Wi-Fi 6 boasts a transmission rate approximately 872 times faster than the original Wi-Fi 1.

Since the introduction of Wi-Fi 5, the average number of devices per US household has grown from nearly 5 to about 9 today. This increase in connected devices places greater strain on networks, resulting in slower overall speeds. To meet the growing demand for bandwidth and enhance performance, there is an urgent need for the latest technological advancements.

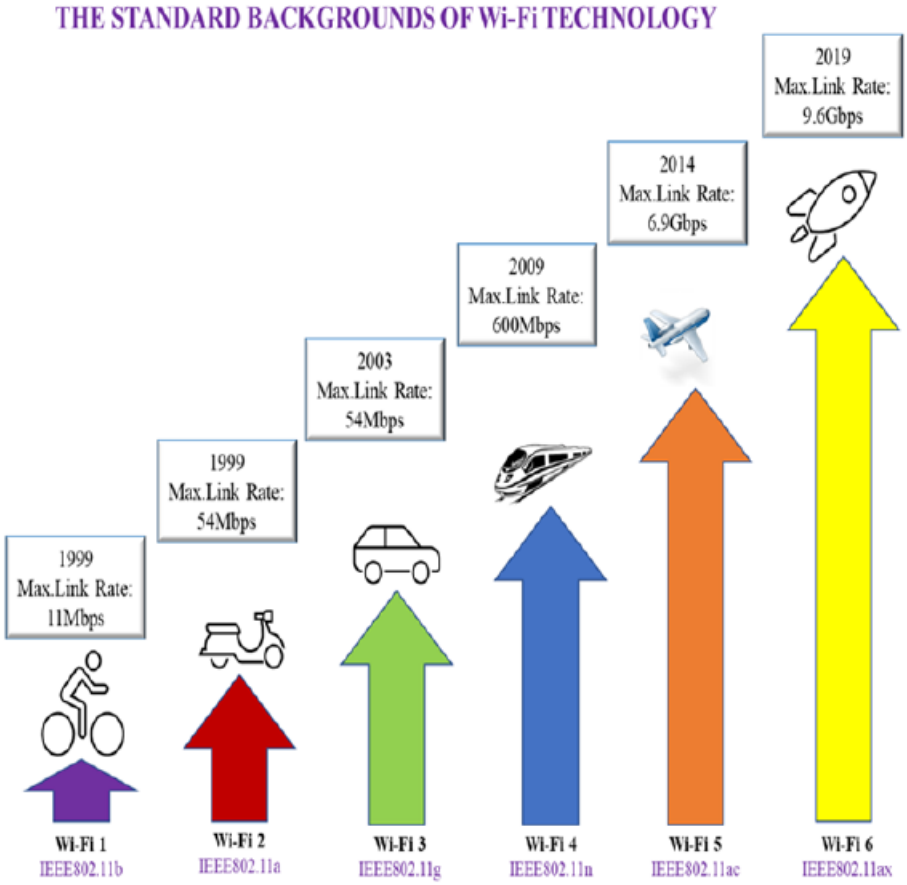

Figure 1: Evolution of wi-fi technology

2.1 Features and benefits of Wi-Fi 6

Wi-Fi 6 is poised to revolutionize mobile connectivity, offering faster speeds ideal for immersive applications and supporting a greater number of devices and IoT connections in dense environments like shopping centers, stadiums, and university lecture halls.

Key technologies such as MU-MIMO and OFDMA enhance Wi-Fi 6 performance significantly. Additional features like TWT and 1024-QAM modulation improve data throughput, reduce power consumption, and enable simultaneous connectivity for up to 32 clients. These advancements underscore the benefits of adopting Wi-Fi 6 technology.

Technological Benefits of Wi-Fi 6	
Simultaneous Multi-User Transmissions	This is achieved efficiently through MU-MIMO and OFDMA, widely employed in cellular networks. These techniques focus on average throughput per station rather than aggregate output. They complement each other in both uplink and downlink directions, effectively handling various types of traffic such as text messages and video streaming for multiple users simultaneously. MU-MIMO is beneficial when multiple users have large amounts of data to transmit, while OFDMA maximizes efficiency when users have smaller data requirements.
Increased Capacity and Higher Data Rates	Wi-Fi 6 can offer a 25% increase in capacity over 256QAM by utilizing 1024QAM, especially at short distances, compared to earlier Wi-Fi generations.
Target Wake Time (TWT) Improves Power Efficiency Of Station	Target Wake Time (TWT), a feature in Wi-Fi 6, allows routers to schedule check-in times with devices. This lets devices plan their communication with the router ahead of time, minimizing the duration their antennas need to stay powered on for transmission and signal searching. As a result, it enhances the battery life of both devices and routers, especially for low-power Wi-Fi devices. The TWT mechanism was first introduced in the IEEE 802.11ah amendment.
Performance in Hyper-dense Environments	In Wi-Fi 6, multiple access points deployed in high-density device environments can work together to provide the desired Quality of Service (QoS) to clients with varying usage profiles. This approach can significantly boost the overall wireless network throughput.
Uplink Resource Scheduling	This feature is likely the most significant innovation and the most challenging aspect of Wi-Fi 6 (802.11ax). With uplink resource scheduling, the access point (AP) allocates resources in a deterministic manner, coordinating and scheduling the simultaneous transmission of multiple clients
Spatial Reuse Technique	Multiple APs operate on a shared channel by mitigating co-channel interference. This is made possible by a spatial reuse technique known as BSS Coloring, which enables devices in one BSS to ignore frames from other BSSs on the same channel, which are typically some distance away.
Strengthen Indoor and Outdoor Operations	Wi-Fi 6 (802.11ax) includes mechanisms such as long OFDM symbols to optimize multi path and supports robust outdoor deployments.

2.2 6th Generation of wi-fi security

sing a wireless medium to transmit data means that anyone can intercept the signal, unlike with cable communication which has physical boundaries preventing unauthorized access. Therefore, additional security measures are necessary. This article discusses the latest advancements in Wi-Fi 6 security with WPA3. In early 2018, the Wi-Fi Alliance announced the introduction of WPA3 to improve security by enhancing cryptographic strength and enabling robust authentication. WPA3 comes in two variants: WPA3-Personal and WPA3-Enterprise.

In addition to WPA3, the Wi-Fi Alliance introduced Wi-Fi Enhanced Open to address security concerns with open networks found in places like airports, coffee shops, and shopping centers. These networks typically lack encryption, despite often using captive portals. Wi-Fi Enhanced Open offers unauthenticated data encryption through Opportunistic Wireless Encryption (OWE).

In summary, WEP should always be avoided due to numerous vulnerabilities. Devices with older hardware should upgrade to WPA, which uses a more secure RC4 algorithm with fewer key collisions and introduces temporal keys. For devices supporting WPA2, it should always be used as it provides superior security in message integrity and encryption. Wi-Fi 6 with WPA3 significantly enhances security across all aspects, surpassing what can be achieved with WPA2.

2.3 Reasons to upgrade to wi-fi6 from wi-fi5

Let’s explore how Wi-Fi 6 is transforming the modern workspace. Today's work environments are increasingly designed to foster team collaboration by allowing seamless connectivity across private networks. With the proliferation of devices such as video conferencing systems, smart meeting rooms, cameras, and IoT devices, there’s a growing need for flexible, application-specific services. These services need to accommodate various requirements, including low-latency applications for collaboration, high-bandwidth needs for video calls, and reliable connectivity for massive IoT networks. Wi-Fi 6 addresses these demands by optimizing the network’s efficiency and capacity, ultimately enhancing overall performance within the crowded frequency spectrum.

In practical terms, Wi-Fi 6 can significantly boost collaboration, potentially improving global productivity by 30% each year. One example of this is smart meeting room management. Wi-Fi 6 enables the integration of wireless HD screens, projectors, laptops, and phones, along with environmental sensors that control temperature and lighting. Additionally, real-time scheduling and reservation information can be displayed outside meeting rooms, while smart whiteboards contribute to enhanced collaboration. This system can also connect key IT assets for preventive maintenance and better resource management, improving operational efficiency and user comfort.

In more traditional cubicle-based environments, Wi-Fi 6 enables fully wireless setups for internet access, IP phones, and seamless IoT integration (including ZigBee and Bluetooth). This eliminates the need for separate networks, reducing deployment costs and streamlining the time to market. For mobile office scenarios, where employees are constantly on the move, Wi-Fi 6 ensures consistent, high-quality

coverage. It intelligently addresses network blind spots, such as in corners or near windows, providing reliable service across the workspace as employees move freely between areas, even during video calls.

3. Conclusion

This research paper evaluates the advancements brought by the sixth generation of Wi-Fi technology, known as Wi-Fi 6. Wi-Fi 6 promises to deliver high-performance wireless connectivity that is easy for consumers to understand and experience. Importantly, it enhances network efficiency to a level that enables innovative applications across various sectors, some of which are already visible while others will emerge as Wi-Fi 6 adoption reaches critical mass. Wi-Fi 6 offers immediate benefits in terms of network speed, capacity, and responsiveness, with ongoing market advantages as more devices leverage its advanced connectivity capabilities. Key enhancements such as 1024-QAM, OFDMA, and improved MAC features ensure better performance for wireless users, while also supporting smart homes, IoT, and large-scale deployments. Overall, Wi-Fi 6 (802.11ax) addresses the challenges of high-density environments by significantly increasing network capacity compared to its predecessor, Wi-Fi 5 (802.11ac), thereby paving the way for collision-free, deterministic Wi-Fi that enhances cumulative network throughput.

4. References

1. https://www.cisco.com/c/en/us/solutions/enterprise-networks/802-11ax-solution/index.html#~features, Accessed on Feb,2020
2. RCRWireless News-Exploring the benefits of Wi-Fi 6 (Reader Forum) by Rishi Grover, December 3,2018
3. HUHGES SYSTIQUE-An Introduction to Wi-Fi 6 August 27,2019
4. https://www.cisco.com/c/en/us/solutions/enterprise-networks/benefits-wifi-6.html, Accessed on Feb,2020
5. https://wballiance.com/wp-content/uploads/2019/07/Wi-Fi-6-Deployment-Guidelines-and-Scenarios-V1.0.pdf, Accessed on Jan,2020
6. AirEngine Wi-Fi 6 Powered by Huawei 5G- https://e.huawei.com/, Accessed on Dec,2019
7. https://www.wi-fi.org/discover-wi-fi/wi-fi-certified-6
8. NETWORKWORLD- NETWORK INTELLIGENCE- By Zeus Kerravala, Network World - MAR 8, 2019
9. Insights & Events- 04 February 2020- https://ukconnect.com/
10. https://www.theverge.com/2019/2/21/18232026/wi-fi-6-speed-explained-router-wifi-how-does-work, Nov, 2018
11. GRANDMETRIC- Blog- How we ended up in WPA3 Wi-Fi Security Evolution - by Mateusz Buczkowski- 06.07.2018
12. https://www.androidauthority.com/wi-fi-6-910014/, Oct,2019
13. Community home-Wifi 6 Wi-Fi 6: Meet the 6th Generation of Wi-Fi Technology by Vincent 8th December 2019
14. https://www.ipass.com/blog/the-benefits-of-wi-fi-6/, Accessed on Jan,2020
15. Capacity- WiFi 6: is it just about speed- 09 March 2020 - Patrick Hirscher

16. https://www.netgear.com/landings/wifi-6-access-points/, Accessed on Jan,2020
17. http://finleyusa.com/new-wi-fi-6-chipsets-expected-to-have-strong-demand/, Accessed on Dec,2019
18. https://www.qualcomm.com/media/documents/files/wi-fi-6-industry-impact-report.pdf, Accessed on Oct,2019
19. https://www.transparencymarketresearch.com/wifi-6-devices-market.html, Feb 2020