Wireless Broadband Alliance

WI-Fi 7 TRIALS FOR RESIDENTIAL DEPLOYMENTS

CableLabs® | intel®

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EXECUTIVE SUMMARY

Wi-Fi technology continues to evolve with Wi-Fi 7, building on Wi-Fi 6/6E and introducing significant advancements such as multi-link operation (MLO), 4K QAM, multi-user resource units (MU-RU), QoS and support for up to 320 MHz channels. These improvements enable higher throughput, lower latency, improved efficiency and greater reliability, addressing the needs of demanding applications and use cases like AR/VR, online gaming, working from home and IoT in residential settings.

Building on its initial initiatives with the report "Get Ready for Wi-Fi 7: Applying New Capabilities to Key Use Cases," the WBA highlights the transformative potential of Wi-Fi 7 for industries worldwide. To advance this vision, WBA is conducting Wi-Fi 7 field trials with its participating members to evaluate and validate the key capabilities of Wi-Fi in real-life various deployment scenarios.

As part of this initiative, CableLabs and Intel have collaborated to test Wi-Fi 7 in residential settings. This multi-phase project has completed Phase-1, focusing on performance and coverage testing of Wi-Fi 7, and evaluating its performance and benefits.

This report presents performance data gathered from testing Wi-Fi 7 and Wi-Fi 6E generations in a typical home environment, quantifying the performance improvements between two Wi-Fi generations. Our findings show that Wi-Fi 7 demonstrated significant performance improvements over Wi-Fi 6, delivering up to 3.5 Gbps TCP throughput.

Phase 2 will address MLO and QoS, further exploring the benefits of Wi-Fi 7 in residential deployments.

INTRODUCTION

Wi-Fi has become a cornerstone of residential internet connectivity, with 92% of U.S. internet households using Wi-Fi at home [8]. The types and number of devices connecting to home Wi-Fi networks – such as tablets, TVs, game consoles, computers, mobile phones, lights, cameras, switches, thermostats, IoT devices, and cars – are increasing and creating more demand on Wi-Fi networks. In 2023, the average U.S. home had 17 connected devices, and this number continues to increase each year [7].

Emerging use cases and proliferation of high-bandwidth applications, such as working from home, smart homes, video conferencing, security systems, 4/8K video streaming, automation, cloud connectivity, online gaming, AR/VR/XR, and AI are demanding high throughput, low latency and reliable Wi-Fi connection, further straining home Wi-Fi networks.

Furthermore, the increasing number of overlapping Wi-Fi networks in high-density neighborhoods or multi-dwelling units is causing co-channel and adjacent channel interference, resulting in poor performance, especially in the congested 2.4 GHz and 5 GHz bands.

Cable broadband speeds are continually increasing, with internet service providers enabling multi-Gbps backhaul connections for residential customers [5][6][10]. However, older Wi-Fi generations and limited bandwidth in the 2.4 GHz and 5 GHz are bottlenecks for delivering multi-Gbps connectivity throughout homes [9].

Wi-Fi 7 (IEEE 802.11be) also known as Extreme-High-Throughput (EHT) is the latest generation of Wi-Fi bringing support for Multi-Link-Operations, up to 320 MHz channels, MU-RU, scheduled based QoS, restricted Target Wait Time (r-TWT) and 4K QAM. It is designed to provide higher throughput, increased network capacity, reduced latency, and improved efficiency and reliability. Further details on Wi-Fi 7 capabilities for key use cases are provided in the WBA's report [4]. These new capabilities, along with the clean 1200 MHz spectrum[1] at 6 GHz, should address the growing needs of residential Wi-Fi deployments.

The WBA has been conducting Wi-Fi field trials over the past several years, including Wi-Fi 5, Wi-Fi 6, and Wi-Fi 6E and it is now executing Wi-Fi 7 trials with participating members to evaluate the key capabilities of Wi-Fi 7 in real-life deployments and share the findings with the industry, as it has done with the reports earlier [2][3][4].

CableLabs and Intel collaborated on this trial to evaluate Wi-Fi 7 capabilities in a residential setting and compare the results of Wi-Fi 7 with Wi-Fi 6E, as they have done with previous trials [3][4]. The trial settings, description of the environment, results and key takeaways are discussed in the following sections.

TRIAL SETTINGS

This is a multi-phase initiative, and the phase-1 of the testing focused on evaluating the performance of Wi-Fi 7 in a residential setting, analyzing its capacity, throughput and coverage capabilities in an everyday environment.

Devices:

- AP:
  - Wi-Fi 7 ASUS AP RTBE96U BE19000 for testing Wi-Fi 7
  - Wi-Fi 6E ASUS AP GT-AXE11000-6E for testing Wi-Fi 6E
- Client
  - DELL Latitude 5440 with an Intel Wi-Fi 7 chip BE200 and Windows 11
  - DELL Latitude 5440 with an Intel Wi-Fi 6E chip AX211 and Windows 11
  - Swapped the BE200 and AX211 on the same DELL latitude 5440 laptop to test Wi-Fi 7 and Wi-Fi 6E

We have used the devices with their default settings and no optimization tweaking was done to boost their performance. Multi-link operation was not enabled.

[1] 6 GHz availability depends on local regulations. 1200 MHz is available, for example, in U.S, Canada and Brazil.

Tools:

- IxChariot was used to generate TCP traffic and measure the downlink and uplink performances.
- Client RSSI recorded for each location in the house (e.g., RSSI reported by the client).
- Note that reported RSSIs are only a rough indication of the received signal strength.

RF environment and Channels:

- 6 GHz (channel 151) with 320 MHz and 160 MHz channel bandwidth with Low Power Indoor (LPI)
- 5 GHz (Channel 36) with 80 MHz channel bandwidth. Since the test house is further away from the other homes, there was no interference from the other nearby Wi-Fi networks.
- The trial was executed under Low Power Indoor (LPI) mode at 6 GHz.

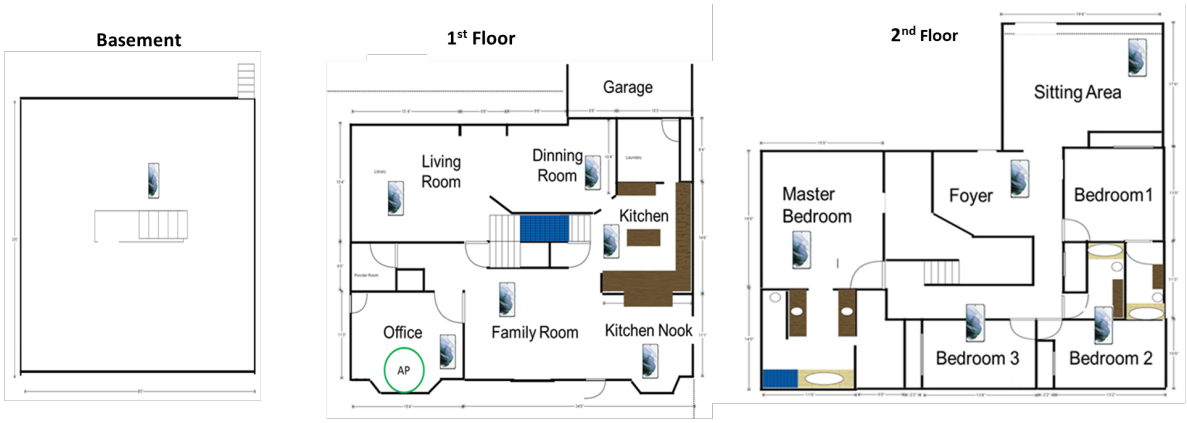
Figure 1. CableLab's test house

Test House:

The Wi-Fi 7 phase 1 trial was conducted in CableLab's 4,500+ sq. ft. single family test house, located on a 1.7-acre lot, free of most Wi-Fi interferences from surrounding neighbor homes. It is a large2-story furnished home with a basement and interior walls mainly made up of wood and drywall construction.

Test Locations:

The AP was placed in the office on the first floor, situated in the corner of the house. The client was placed in various locations throughout the house.



RSSI on client (dBm)	Office	Family Room	Kitchen Nook	Kitchen	Dining Room	Living Room	Master Bedroom	Bedroom1	Bedroom2	Bedroom3	Upper Foyer	Sitting Room	Basement
6 GHz - 320 MHz	-37	-44	-58	-62	-56	-52	-57	-82	-79	-59	-80	-87	-77

Figure 2. Test locations

Measurements:

For each measurement, the laptop was positioned at various fixed locations throughout the house to compare Wi-Fi 7 and Wi-Fi 6E for different bands and channel bandwidths. IxChariot generated uplink and downlink TCP traffic, and throughput measurements were recorded for each scenario. The diagrams in the next section report the average throughput recorded over 3 identical test conditions.

RESULTS AND KEY TAKEAWAYS

The performance results shown in Figures, 3, 4 and 5 compare Wi-Fi 7 and Wi-Fi 6 across different channel sizes in the 5 GHz and 6 GHz bands. The Wi-Fi 7 trial results highlight several key benefits for the residential Wi-Fi market as discussed in the following key takeaways.

Improved Throughput: Wi-Fi 7 demonstrated a clear throughput advantage over Wi-Fi 6E. It can deliver up to 3.7 Gbps downlink throughput with a 320 MHz channel in the office where the client is located within a 3-foot range of the AP. As the client moves to other rooms away from the AP, and the range increases, the throughput decreases due to lower modulation but still exceeds 2 Gbps on most of the first floor where the AP is located.

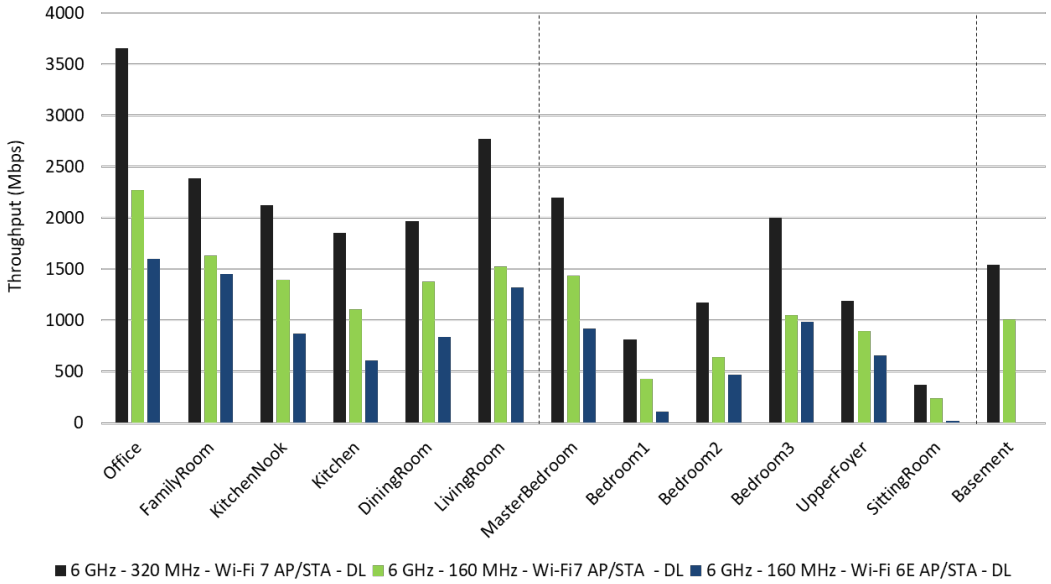


Figure 3. 6 GHz Wi-Fi 7 versus Wi-Fi 6E downlink (DL) throughput

Comparing the 160 MHz performance between Wi-Fi 7 and Wi-Fi 6E, Wi-Fi 7 achieves close to or over 1.5 Gbps TCP throughput across most of the first floor versus less than 1 Gbps with Wi-Fi 6E. This significant increase in speed ensures that households can support multiple high-bandwidth applications simultaneously, such as online gaming, streaming videos, downloading, and video conferencing, without experiencing lag or buffering. It also addresses Wi-Fi bottleneck issues where multi-Gbps internet connections are available but not deliverable inside homes due to the 2.4 GHz and 5 GHz throughput limitations.

6 GHz Band Advantage: Utilizing a 320 MHz channel on the 6 GHz band provides substantial performance benefits, significantly enhancing data rates, achieving up to 3.7 Gbps downlink speeds compared to 1.6 Gbps with the 160 MHz in Wi-Fi 6E. The 6 GHz band offers more spectrum and less interference, leading to higher data rates and better performance. The 6 GHz band with 1200 MHz spectrum provides three 320 MHz channels, seven 160 MHz or 14 80 MHz channels.

Even if there are more Wi-Fi networks around the neighborhoods, APs will have more choices to select different channels to avoid interference from overlapping basic service sets BSSs and adjacent channel interference. Choosing the right channel size depends on the environment. If there are not many other nearby Wi-Fi networks, 320 MHz can be enabled, whereas in high-density areas with many Wi-Fi networks, such as multi-dwelling units, 160 or 80 MHz channels could help with better channel reuse and avoid interference from overlapping BSSs. The 6 GHz band also means less interference and congestion in the lower 2.4 GHz and 5 GHz bands. Wi-Fi 7 with 6 GHz is ideal for homes with many connected devices, ensuring each device gets the bandwidth it needs.

Improved Coverage: Although the AP was deliberately located at the corner of the house rather than in an ideal central location, Wi-Fi 7 still provided a robust coverage throughout the 4,500+ sq. ft. home. This improved coverage means fewer dead zones, offering a more consistent and reliable internet experience in every room, which is particularly beneficial for larger homes or those with complex layouts.

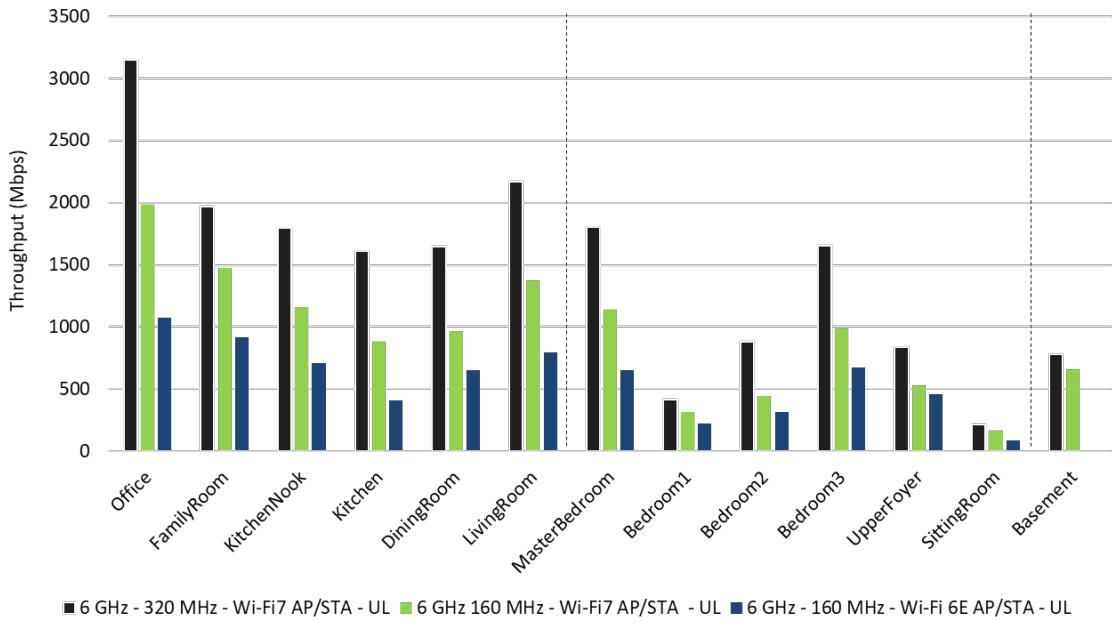


Figure 4. 6 GHz Wi-Fi 7 versus Wi-Fi 6E uplink (UL) throughput

It is important to note that our tests were conducted with LPI settings, which restrict APs to indoor use and limits the power spectral density to 5 dBm/MHz and EIRP (Equivalent isotropic radiated power) to 30 dBm on a 320 MHz channel. With LPI, mobile devices are also restricted to a maximum power 6 dB below the AP's allowed maximum EIRP, contributing to the throughput drop around 35 feet.

Standard Power 6 GHz, supported by Automated Frequency Coordination (AFC), enables access points to operate at up to 36 dBm EIRP, a 6 dB power increase compared to Low Power Indoor. This increase in power significantly enhances throughput and range in residential settings.

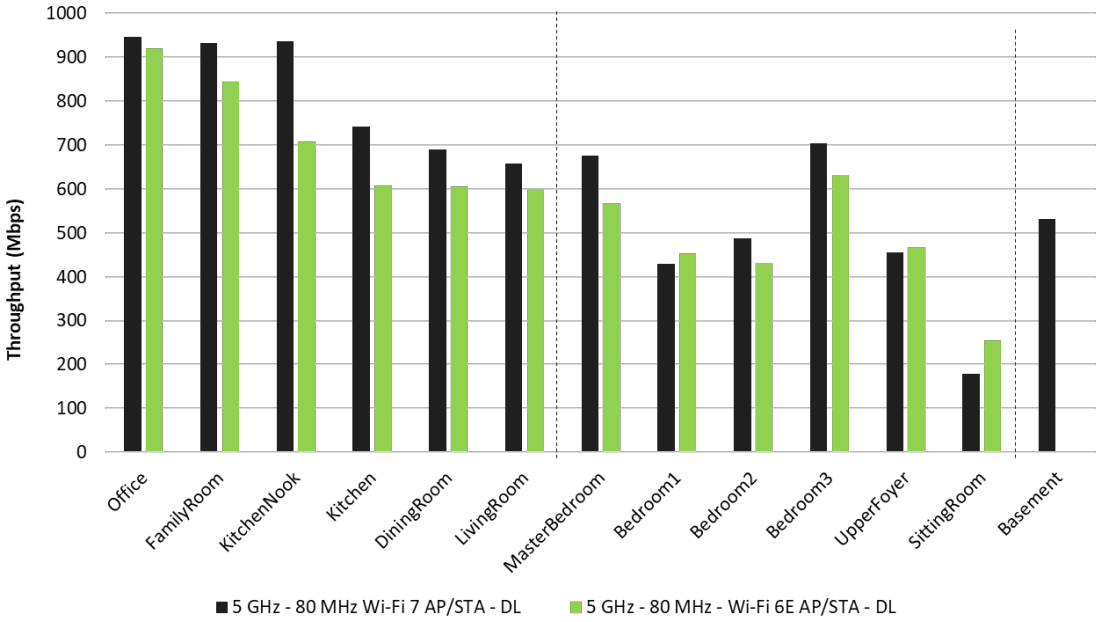


Figure 5. 5 GHz 80 MHz downlink throughput Wi-Fi 7 versus Wi-Fi 6E

Wi-Fi 7 also provides higher throughputs at 5 GHz with 80 MHz channels comparing to Wi-Fi 6E. The gains seemed more significant for the uplink compared to the downlink most likely due to the improved efficiency of the BE200 implementation.

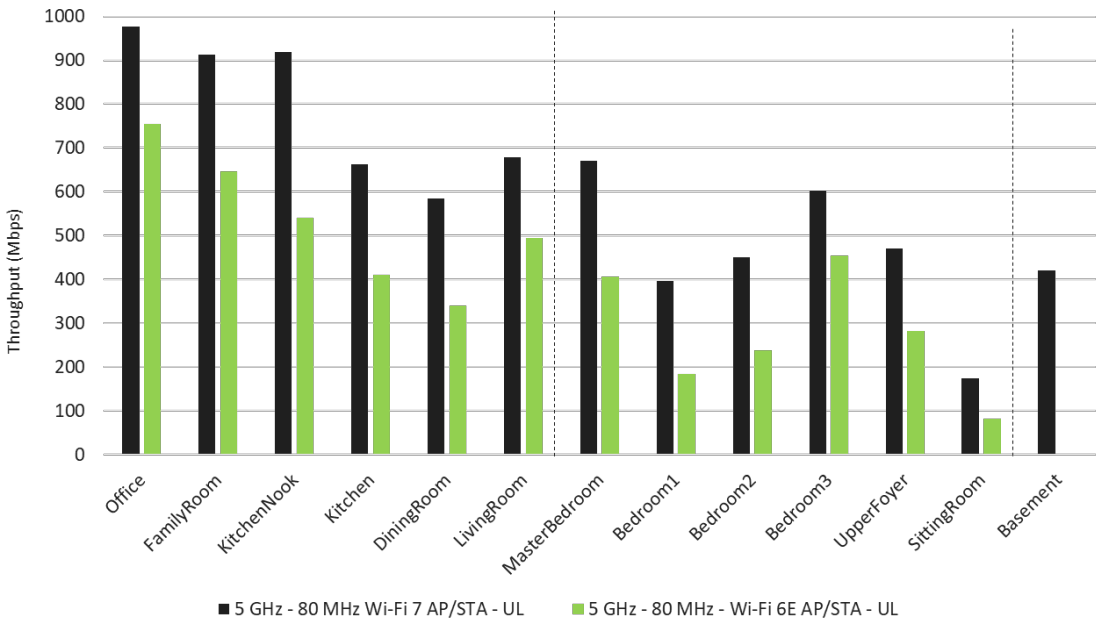


Figure 6. 5 GHz 80 MHz uplink throughput Wi-Fi 7 versus Wi-Fi 6E

Support for High-Demand Applications: Wi-Fi 7 has proven to be effective in supporting high-throughput and low-latency applications such as like AR/VR/XR, online gaming, working from home, IoT and making Wi-Fi 7 ideal for homes where multiple users simultaneously engage in demanding activities.

Market Readiness: The trial highlights Wi-Fi 7's outstanding performance in typical household settings and establishes Wi-Fi 7 as a dependable, high-performance solution, encouraging adoption by both service providers and consumers. The results confirm Wi-Fi 7's readiness for widespread residential deployments.

Futureproofing: The improvements in Wi-Fi 7 make it appealing for those wanting to future-proof their networks. Investing in Wi-Fi 7 ensures that homes are equipped to handle future technological advancements and increasing data demands for future applications.

CONCLUSIONS

Wi-Fi 7 offers a significant advancement in wireless technology, enabling higher throughput, reduced latency, increased network capacity, and improved efficiency and reliability. Our real-life Wi-Fi 7 trials in residential settings clearly demonstrate remarkable performance improvements over Wi-Fi 6E at 6 GHz, delivering up to 3.5 Gbps throughput and removing the bottlenecks to support gigabit internet connectivity in residential settings.

The trial's findings confirm that Wi-Fi 7 is well-suited for home environments, providing users with the best possible wireless internet connectivity experience, and demonstrate the readiness of Wi-Fi 7 for large scale residential deployments.

Enabling Wi-Fi 7 in residential environments is more than just an upgrade - it's a strategic investment in future-ready networks that will continue to meet the growing demands of massive number of devices, emerging applications, and use cases in home connectivity.

This Phase 1 trial demonstrated Wi-Fi 7's higher throughput and improved coverage at 6 GHz, laying the groundwork for future home networking solutions.

The Phase 2 Wi-Fi 7 trials will further explore the benefits of MLO, focusing on latency, coverage, and additional throughput improvements.

JOIN THE WBA WI-FI 7 TRIAL PROJECT

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