WI-Fi 7 TRIALS FOR RESIDENTIAL SETTINGS

LG U+ | intel

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INTRODUCTION

LG U+ is a telecoms operator with over 5 million subscribers in South Korea, offering Wi-Fi based wireless internet services. The recent explosion of data-heavy applications and use cases, such as large-scale gaming, high-definition video streaming, AR/VR/XR, cloud access, AI/ML, working from home and IoT, has led to a growing demand for high-speed internet.

To meet this demand, LG U+ provides up to 10-gigabit internet connectivity to its residential customers. However, Wi-Fi limitations, including restricted channel size availability, congestion, and co-channel/adjacent channel interferences at the 2.4 GHz and 5 GHz bands, create bottlenecks in delivering gigabit speeds within residential buildings, especially in high-density multi-dwelling units common in Korea.

Wi-Fi 7 introduces significant improvements over Wi-Fi 6, including Multi-Link Operation (MLO), support for 320 MHz channels in the 6 GHz band, 4K-QAM, Quality of Service (QoS), preamble puncturing, r-TWT, MU RU, providing higher throughput, reduced latency, and improved efficiency and reliability.

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, LG U+ and Intel have collaborated to evaluate Wi-Fi 7 technology. LG U+ is developing its Wi-Fi 7 router to deliver a better home internet connectivity service to its customers.

TEST CASES AND SETTINGS

Wi-Fi 7 differs from its predecessor, Wi-Fi 6, in several ways. First, Wi-Fi 7 utilizes an additional 6 GHz band. Most legacy devices use 2.4GHz or 5GHz, so the 6GHz band is cleaner with less interference. Second, Wi-Fi 7 supports a 320 MHz bandwidth. Compared to the 80 MHz bandwidth of 5GHz, the 320 MHz bandwidth of 6GHz is theoretically 4 times faster.

Our tests evaluated Wi-Fi 7's new features including, 6 GHz 320 MHz channel, MLO, preamble puncturing and QoS as described below.

Test Coverages:

The following five test scenarios were covered within the tests:

1. Max TCP/UDP throughput testing
    1a. AP to AP backhaul throughput testing
    1b. Max throughput between STAs and APs
2. Multi-Link Operation (MLO) testing
    2a. AP to AP backhaul MLO testing

2b. MLO test between AP and STA

3. Downloading performance
4. Preamble puncturing analysis in an interference-prone environment
5. QoS testing to compare the delay with and without QoS Management

Test Equipment & Tools:

- APs:
  - Wi-Fi 7 AP to test Wi-Fi 7 cases
  - Wi-Fi 6 AP for testing Wi-Fi 6
- Clients:
  - Intel BE200 to test Wi-Fi 7
  - Intel AX201 to test Wi-Fi 6
- IxChariot for TCP
- iPerf2 for UDP

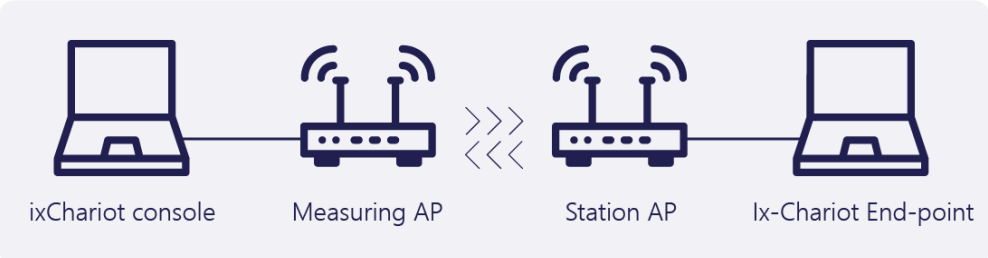
Spectrum:

LG U+ and Intel executed the test cases in 2.4, 5 and 6 GHz bands with different channel sizes as relevant to each test case. For 6 GHz, devices operated under Low-Power Indoor (LPI).

Settings for the test cases:

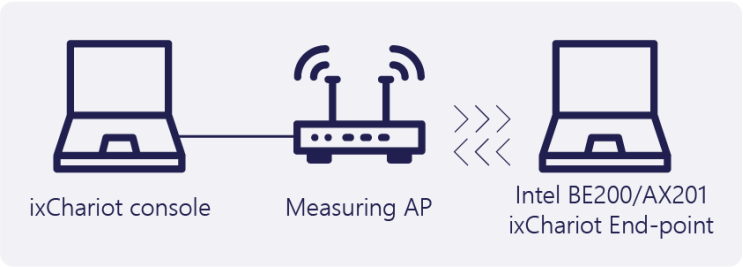
1. Max TCP/UDP throughput testing

1a. Max mesh backhaul throughput between two APs



Connect the PCs to both APs with wires and change one AP to Station mode/Bridge mode to wirelessly connect to the other AP (default mode). The PCs on both sides act as end points to send and receive data and measure the speed on the PC connected to the AP in Station mode/Bridge mode. Measure the speed of the wireless section between the APs, assuming that there is very little slowdown due to wires. To test Wi-Fi 7, both APs were Wi-Fi 7 APs, and for testing Wi-Fi 6, both APs were Wi-Fi 6 APs.

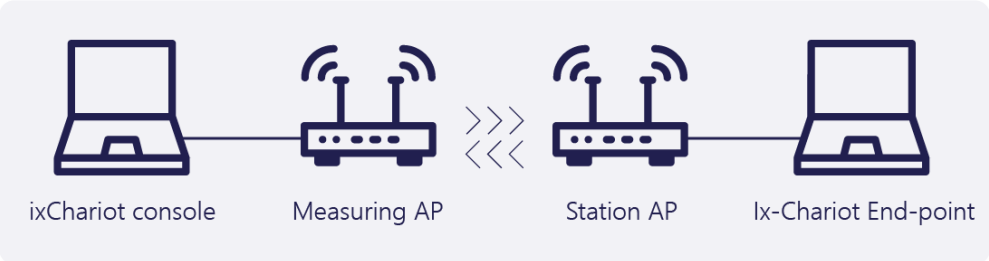
1b Max throughput between STA and AP



For testing Wi-Fi 7, we used Intel BE200 clients with Wi-Fi 7 AP. For testing Wi-Fi 6, we used Intel AX201 and Wi-Fi 6 AP. The testing computer was wirelessly connected as shown above. The throughput was measured for Wi-Fi 7 and Wi-Fi 6 separately.

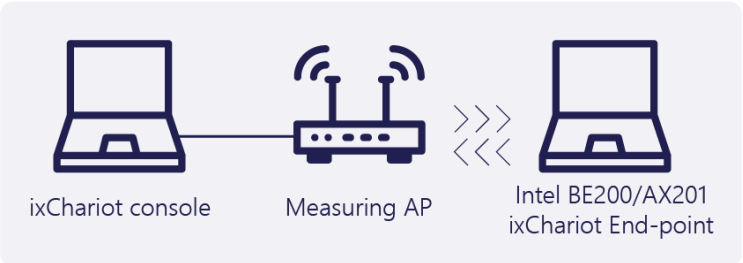
2. Multi-Link Operation (MLO) testing

2a. AP to AP MLO testing



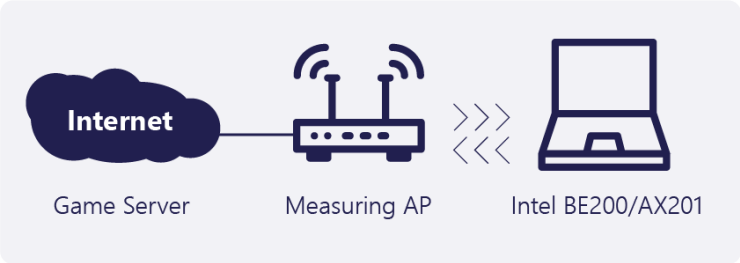
In the same configuration as Test 1a, the wireless connection is the MLO.

2b. AP to STA MLO testing



In the same configuration as Test 1b, the wireless connection is the MLO.

3. Downloading Performance



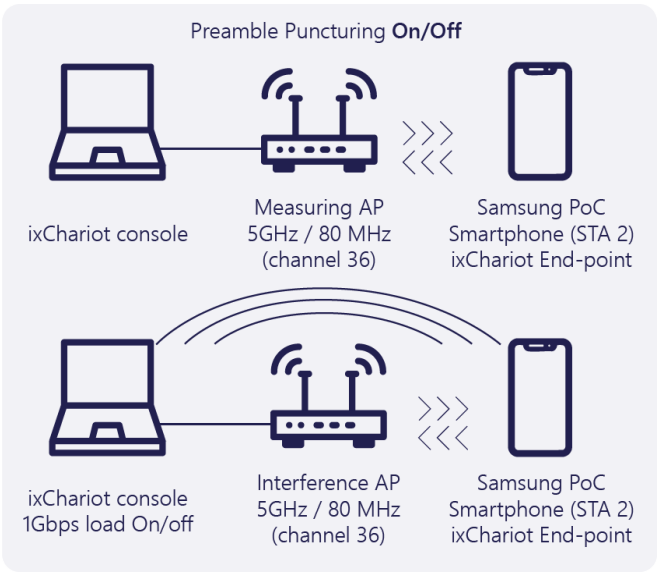
Connect the PC wirelessly (6 GHz) to the router connected to the internet to measure game download speeds.

4. Preamble puncturing analysis in an interference-prone environment

Measure the speed of the preamble puncturing function in an interference environment

Equipment & Tools:

- Wi-Fi 7 Router 2 units,
- Samsung PoC smartphone 2 units,
- IxChariot



Connect a PC and a smartphone to the main router and measure the speed on the PC when the PC and smartphone are exchanging data as end points. In this case, the smartphone is connected to channel 36 with 80MHz bandwidth in the 5GHz frequency band. On the Sub Router, the PC and Smartphone are connected to each other in the

same way, and the Smartphone is connected to channel 44 with a bandwidth of 20MHz in the 5GHz frequency band to interfere with the main router.

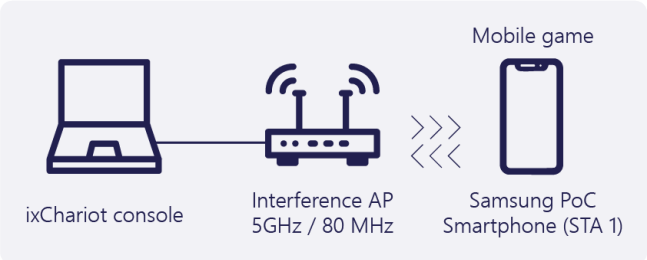
5. QoS testing to compare the delay with and without QoS Management

Measuring Latency when QoS management feature, MSCS (Mirrored Stream Classification Service), runs in an interference environment.

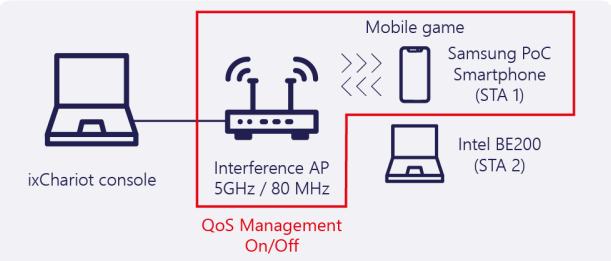
Equipment/Tools:

- Wi-Fi 7 Router,
- Intel BE200 Wi-Fi 7 chip,
- Samsung PoC smartphone,
- IxChariot

Settings:



Measure latency in a clean, interference-free environment using only a single smartphone device. This is a control to verify the performance of the QoS Management feature.



Connect additional PCs to the same router to create an interfering environment, and measure latency while turning on and off the QoS Management feature on your AP and smartphone.

RESULTS AND KEY TAKEAWAYS

For all test cases, we measured the max throughput with the link rate as shown in the table below.

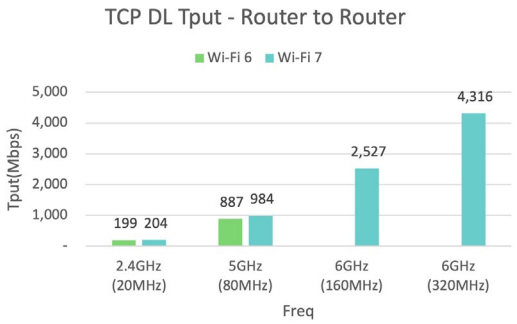
Linkrate by radio and bandwidth

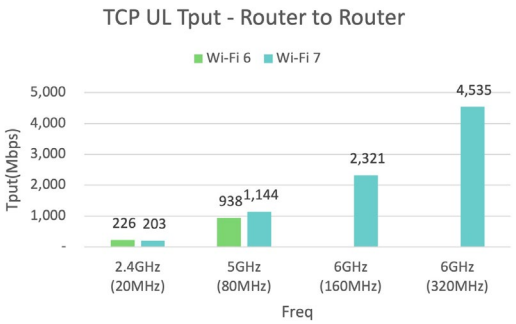
Radio / Bandwidth	Wi-Fi 6	Wi-Fi 7
2.4GHz / 20MHz	286Mps	344Mbps
5GHz / 80MHz	1.201Gbps	1.441Gbps
6GHz / 160MHz	-	2.882Gbps
6GHz / 320MHz	-	5.764Gbps

1. Max throughput on TCP and UDP Measurements

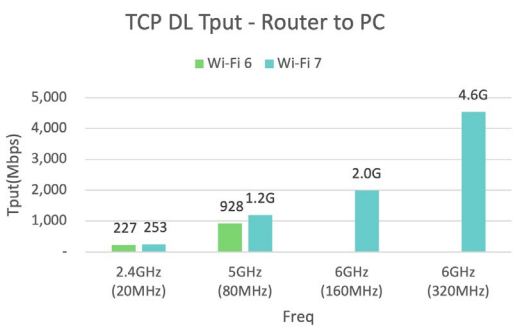
We compared download and upload speeds when using TCP and UDP protocols based on Wi-Fi version. Since Wi-Fi 7 has a higher max link rate than Wi-Fi 6, the actual speeds were similar or higher across all frequency bands. We saw very little difference in speed between TCP and UDP on the same Wi-Fi version, and very little difference between upload and download. Depending on the performance of the device, peak speeds are about 4x or faster on Wi-Fi 7 compared to Wi-Fi 6 on high-performance for router and Intel BE200 devices.

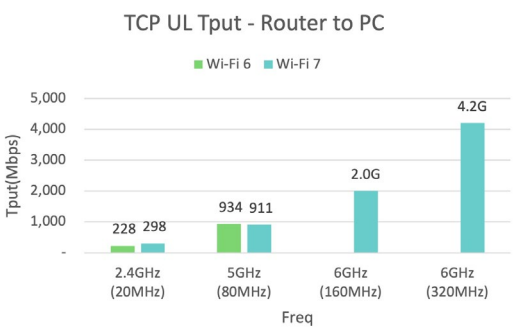
TCP Download/Upload Throughput – Router to Router



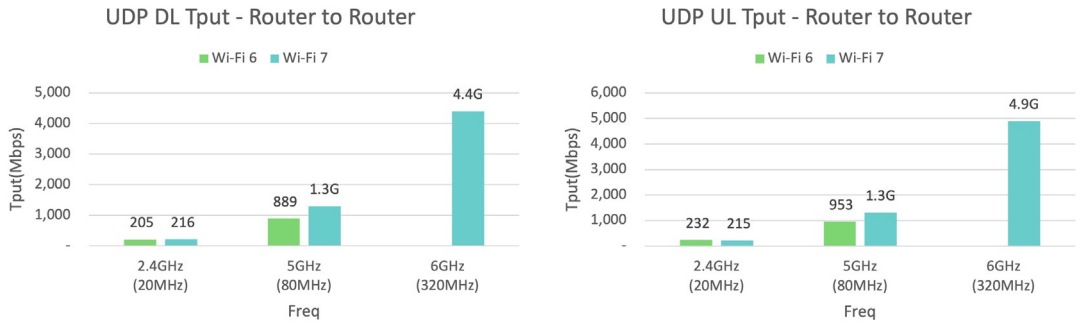


TCP Download/Upload Throughput – Router to PC

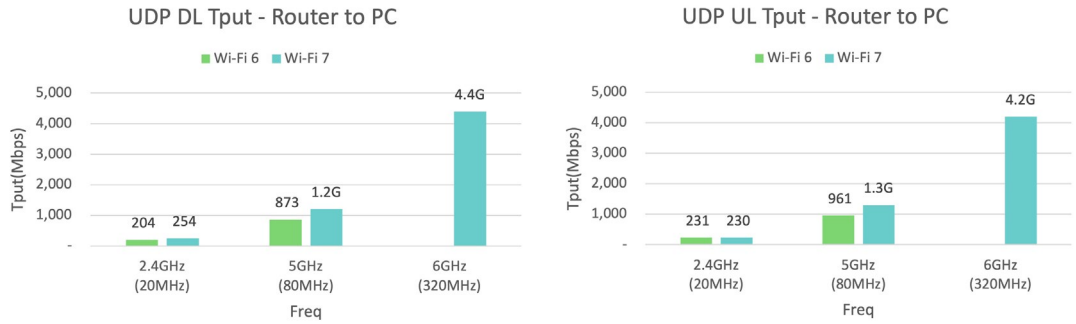




UDP Download/Upload Throughput – Router to Router



UDP Download/Upload Throughput – Router to PC



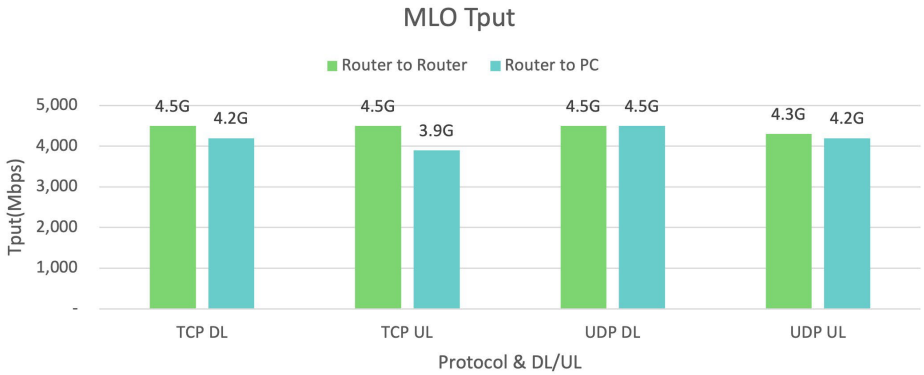
2. MLO Speed Measurement

Multi-Link Operation (MLO) utilizes multiple links to communicate, making it more reliable than traditional single-link-based communication. We measured the performance of MLO, a new feature of Wi-Fi 7. The way MLO works depends on the device: the router operates in MLMR (Multi Link Multi Radio) mode, and the PC (intel BE200 chip) operates in EMLSR (Extended Multi Link Single Radio) mode, which we used in our test environment. Since all of them use dual band, we set the 5GHz + 6GHz dual band, which has the highest performance among the dual bands of 2.4GHz + 5GHz / 2.4GHz + 6GHz / 5GHz + 6GHz. In the Router-to-Router test case, the speed was about 4.5 Gbps regardless of TCP and UDP, and in the Router to PC test case, the speed was slightly lower than 4.5 Gbps. This difference is likely caused by the performance of the equipment measuring the speed. MLO speed measurements showed performance comparable to 6 GHz single-band speeds.

MLO mode based on testcase

Testcase	Mode	Radio	Bandwidth
Router to Router	MLMR	5GHz + 6GHz	80M +320M
Router to PC	EMLSR	5GHz + 6GHz	80M +320M

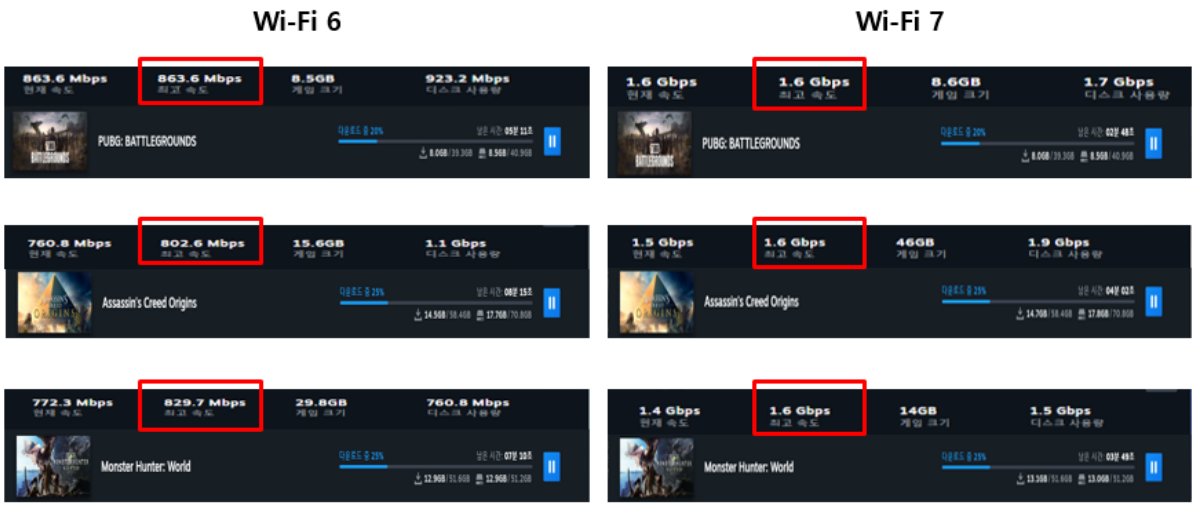
Troughput measurement results



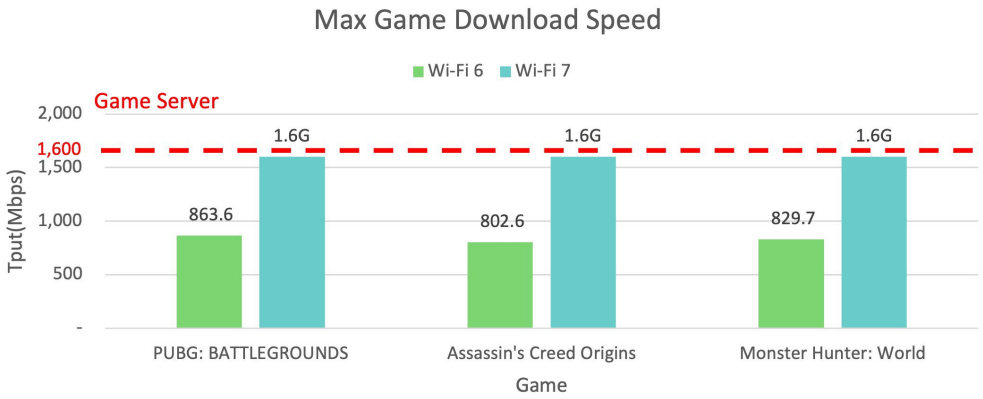
3. Downloading Performance

We measured max throughput and remaining time to compare the difference between Wi-Fi 6 and Wi-Fi 7 in a real-world customer environment using wireless internet. We measured game download speeds on Steam and used 5 GHz for Wi-Fi 6 and 6 GHz for Wi-Fi 7 to maximize the speed of each Wi-Fi version. As shown in test scenario 1, we expected the game to download four times faster on Wi-Fi 7 at 6 GHz than on Wi-Fi 6 at 5 GHz, but the difference was only about two times. This is likely since the maximum speed allowed by the game server is only 1.6 Gbps. If there were no speed limits in place, Wi-Fi 7 would download games 4x faster.

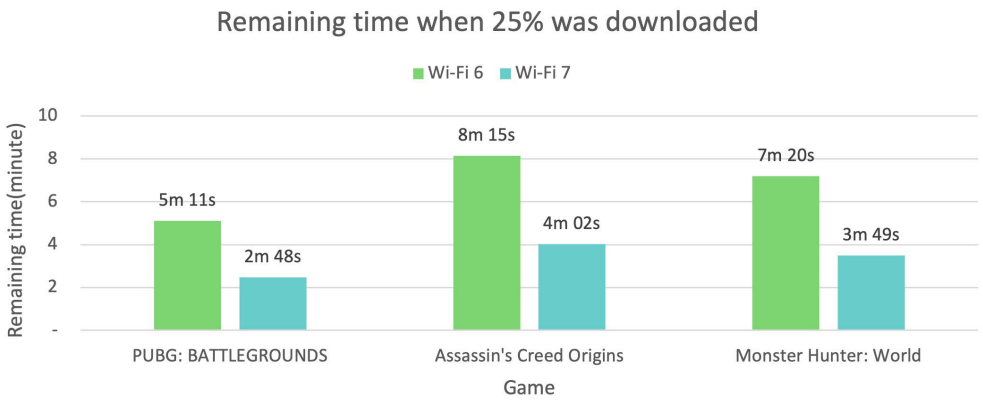
Max throughput checked while downloading the game



Max Game Download Speed



Remaining time when 25% was downloaded

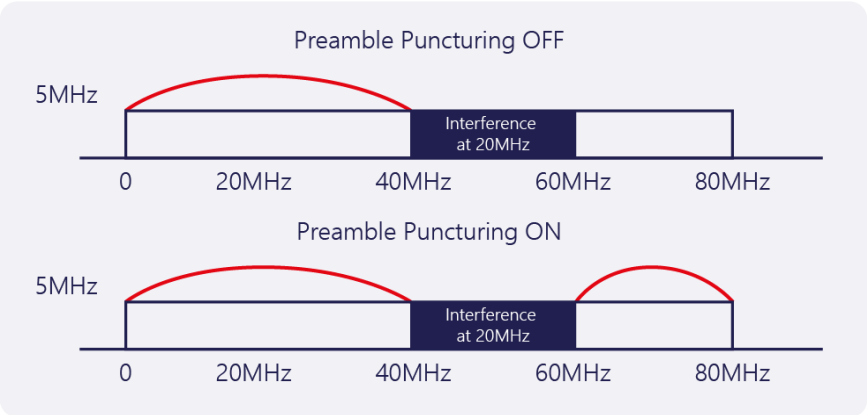


4. Preamble puncturing analysis in an interference-prone environment

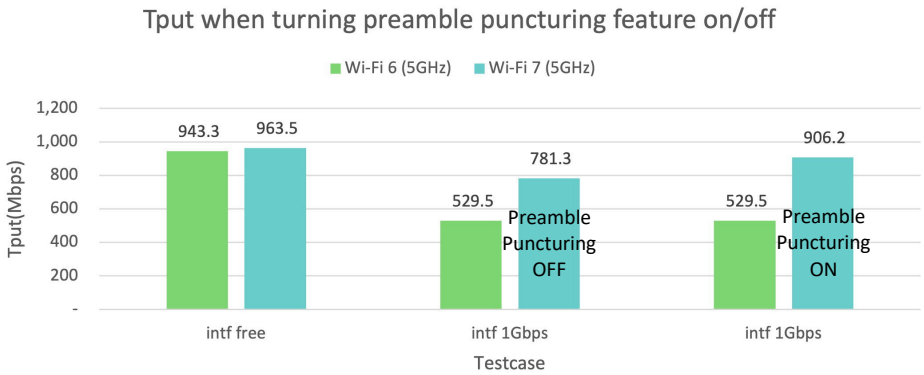
Preamble Puncturing is a feature that if there is interference on a particular channel, it will exclude that part of the communication when communicating. As with MLO, we measured the performance of preamble puncturing, a new feature of Wi-Fi 7. When there is interference on a channel, it can cause channel fallback to a lower bandwidth or channel reset, which can cause inconvenience to the user's media experience. Preamble puncturing is a solution to this problem, and we tested how well preamble puncturing can guarantee performance in real-world interference. The results showed that preamble puncturing guarantees excellent speeds that are close to those of an interference-free environment. The 6 GHz band is supported by Wi-Fi 7, so it is expected that there will be little interference in real life, but since 5 GHz is a frequency band is congested and often affected by interference, and the preamble puncturing may contribute to minimizing the impact of interference in this environment.

How preamble puncturing works

Without preamble puncturing, you may not be able to fully utilize the 80 MHz bandwidth in an interfering environment and may only be able to use 40 MHz or 20 MHz of bandwidth. However, with preamble puncturing, the remaining bandwidth can be fully utilized, except for the interference, resulting in higher performance.



Throughput when turning preamble puncturing feature on/off



5. QoS testing to compare the delay with and without QoS Management

The QoS Management feature prioritizes traffic to ensure optimal performance for critical applications like video calls, streaming, and gaming. These tests were conducted to measure the performance differences experienced by customers in real-world environments. We checked the performance of QoS Management by measuring the latency in real-time gaming when QoS Management is enabled and disabled. In a multi-use situation, the latency without QoS Management is 88ms, which is slightly worse for real-time gaming, but when QoS Management is enabled, the latency is 20ms, which is the same as the single-use situation. It seems that the QoS Management feature can ensure consistently high performance when using real-time gaming, streaming, and AR/VR.

Latency observed in-game with QoS Management turned on and off

CONCLUSIONS

Wi-Fi 7 has demonstrated remarkable performance improvements over Wi-Fi 6 in our real-world testing of residential scenarios. It delivered up to 4.9 Gbps throughput for the entire apartment unit and enabled faster connectivity experience for LG U+ customers.

The trial's findings confirmed the many enhancements and superior performance of Wi-Fi 7. It supports speeds up to four times faster than Wi-Fi 6, which is very beneficial in environments that require large data transfers. We observed the Multi-Link Operation (MLO) feature greatly improved reliability of the network, maintaining stable connections even in complex environments with multiple devices in use simultaneously. In addition, the preamble puncturing feature enables efficient channel utilization in high-interference environments, minimizing performance degradation, and the QoS Management feature ensures low latency for real-time online gaming and streaming services, providing a seamless, high-quality user experience. These Wi-Fi 7 features are expected to help customers enjoy a more comfortable and enriched digital life.

Wi-Fi 7 offers advancements in transmission speed, connection capacity, and latency. These improvements ensure seamless connections in larger home environments, enhancing the user experience for data-intensive applications like streaming, online gaming, and video conferencing.

The enhanced data transfer speeds and network reliability improve customers' day-to-day network usage and also increase overall customer satisfaction. Reliable and fast connections are more than just a convenience for users; they are essential in strengthening a company's credibility. As a result, Wi-Fi 7 will contribute to a positive brand image and increase customer loyalty.

Furthermore, the expanded bandwidth and efficiency of Wi-Fi 7 will be an important catalyst for business expansion into a variety of wireless Internet-based services, especially when combined with high-tech areas such as smart homes, Internet of Things (IoT) devices, and smart cities. Wi-Fi 7 presents opportunities to compete in new markets and deliver innovative solutions to customers.

LG U+ plans to offer Wi-Fi 7 service to high-end internet subscribers in 2025. Wi-Fi 7 routers offer ultra-fast internet speeds, low latency, and a wide range of connectivity features. Wi-Fi 7's improved performance is essential for high-capacity, real-time applications such as high-

definition 8K streaming and high-quality gaming. With this latest Wi-Fi technology, we plan to provide a step-up in home internet service and deliver better Wi-Fi connectivity experience to LG U+ customers.

LG U+ and Intel remain committed to conducting further in-depth testing of these additional features to verify their performance. We will be working to revitalize the 6 GHz band, and in support of this, we will explore ways to maximize the potential of 6 GHz through discussions on power regulation. These efforts will focus not only on technological advances but also on providing our customers with the best quality and speed by reflecting trends in our home internet services.

By embracing Wi-Fi 7, LG U+ continues to position us as a more advanced internet service provider and deliver an innovative network environment that exceeds customers' expectations. With Wi-Fi 7, we are committed to providing even richer digital life with faster, more reliable, and smarter connectivity solutions.

JOIN THE WBA WI-FI 7 TRIAL PROJECT

PARTICIPANT LIST

We would like to express our sincere gratitude to all Project Leaders and the Editorial Team for their invaluable contributions, which played a crucial role in the success of this initiative.

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