Key Advantages of Wi-Fi 7:

Performance, MRU & MLO

White Paper

Key Insights

Wi-Fi 7 advantages over Wi-Fi 6:

- **Faster:** Close to 4X the wireless datalink performance, delivering over 36Gbps
- **More Reliable:** New Multiple Resource Unit (MRU) lowers multiple user latency by 25%
- **Always-on Connected:** New Multi-Link Operation (MLO) improves single user latency by 80% and throughput gains of up to 300%

As Wi-Fi technologies advance, MediaTek's innovations and products platforms will continue to emerge to deliver fast, reliable and always-on connected solutions to meet user's needs.

Foreword: MediaTek in the Wi-Fi Industry

MediaTek is the world's larger supplier of Wi-Fi solutions. This includes not just products built expressly for Wi-Fi, such as routers, repeaters and mesh networking equipment, but also Wi-Fi that serves as a principal connectivity factor within other devices such as smartphones, tablets, TVs, IoT, smart home devices, PCs, laptops, games consoles, and much more.

MediaTek has worked closely with the Wi-Fi Alliance, most recently providing it with test beds for its Wi-Fi 6E certification programs. Our latest Filogic platforms are also among one of the first to market with Wi-Fi 6 Release 2 readiness. All this reinforces MediaTek's technical prowess and industry leadership as we head into the Wi-Fi 7 era, which will once again revolutionize wireless connectivity for a wide range of products in our daily lives. MediaTek's first Wi-Fi 7 silicon has already demonstrated over 10Gbps data rate using just the 6GHz band, and we base some of the findings in this white paper on this establishing platform.

Introduction

Wi-Fi has become the standard of unlicensed wireless internet connectivity in consumer products. After twenty five years of Wi-Fi technologies being widely deployed worldwide, it has become ubiquitous. The demand for Wi-Fi continues to grow in line with the growth of devices, internet speeds, and internet-based applications and services. The recent introduction of the latest standard, Wi-Fi 6E, and the adoption of the 6GHz band into its unlicensed remit; it allows Wi-Fi devices to operate in a dense environment, and still achieve up to 9.6Gbps peak data rate to provide incredible wireless throughput performance for even the most bandwidth-demanding applications (video streaming, gaming, etc).

However, seamless connectivity demand for emerging real-time applications, such as 4K/8K streaming, anticipated AR/VR and Metaverse developments, remote collaboration, Cloud gaming and much more, is rapidly growing across various network environments, including the home, business environments, public spaces, and industrial applications. Wi-Fi technology must evolve continuously to meet the new requirements of forthcoming applications, as well as the expected density growth of wireless devices, all without further increase in the available unlicensed spectrum.

The IEEE 802.11be EHT (Extremely High Throughput) working group is developing the amendment to define the next generation. Its target is to provide super high-bandwidth, lower latency and higher reliability to make the user experience even better, especially in heavily trafficked network environments. The final version of the 802.11be standard is expected to be published by late 2023, and to complete approval by early 2024. Meanwhile, the WFA (Wi-Fi Alliance) is also working on Wi-Fi 7 program based on IEEE802.11be SPEC Draft 1.3.

The evolution of recent Wi-Fi generations is summarized in Figure 1.

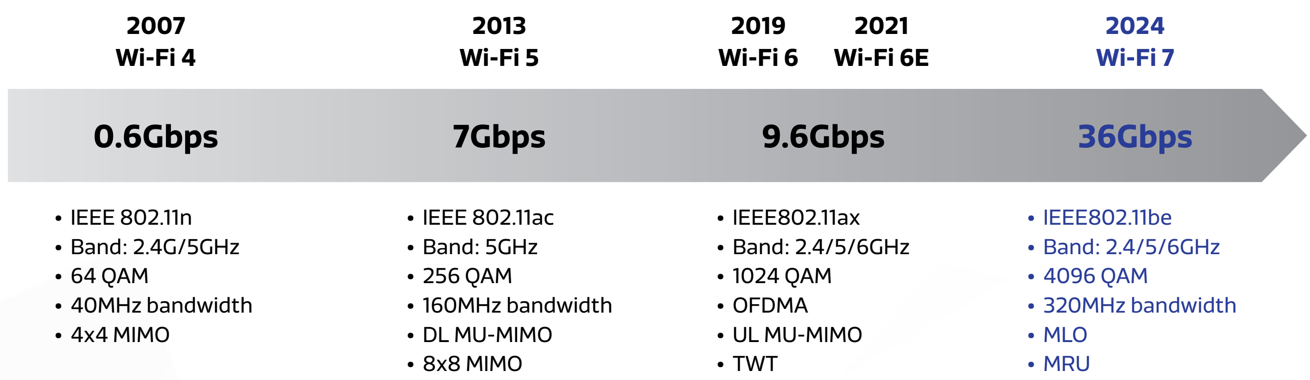

Figure 1. Key evolutions of different Wi-Fi generations

Key New Wi-Fi 7 Technologies

There are many core improvements in Wi-Fi 7 that enhance the wireless experience by handling wireless connections more efficiently. This greatly increases speeds, allows more effective mesh networks, and provides the very latest interference mitigation techniques to ensure wireless devices are always connected fast and reliably, even in dense network environments.

Figure 2 shows an overview of Wi-Fi 7's key new technologies that improve throughput most significantly.

1) The next generation of advanced modulation scheme: 4K QAM (Quadrature Amplitude Modulation), increases throughput by 20%. 4K QAM is capable of carrying 2^{12} symbols (12 bits), compared to 1K QAM used in Wi-Fi 6, which only carries 2^{10} symbols (10 bits).
2) Doubling the maximum channel bandwidth available to each device to 320MHz in the 6GHz band effectively doubles the throughput.
3) The newly introduced MLO (Multi-Link Operation) in the MAC layer enables link aggregation across different bands and channels with considerably lower latency.

Working together, these technologies deliver effective speeds close to 4X times faster than Wi-Fi 6/6E.

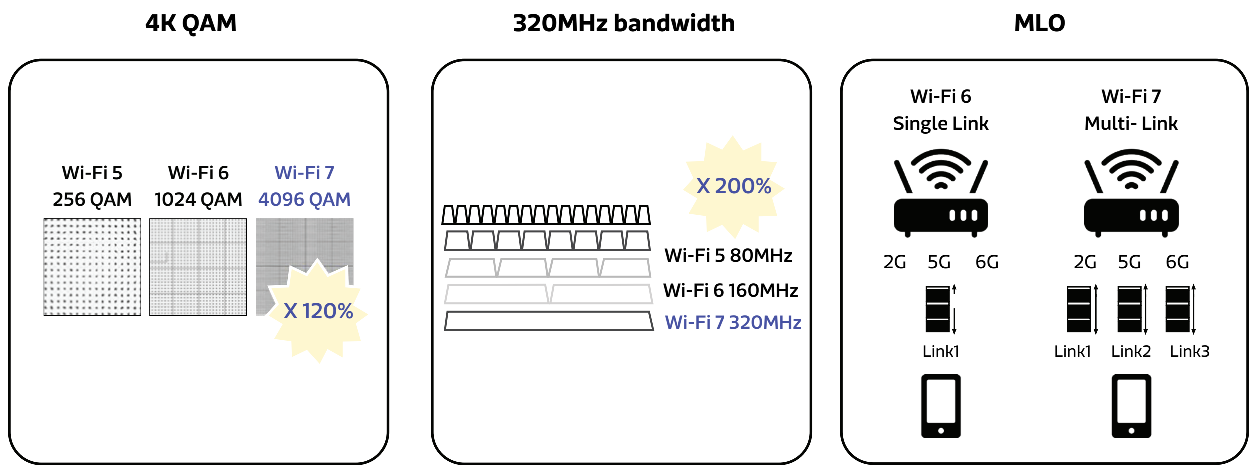

Figure 2. Key Wi-Fi 7 technologies and their performance enhancements

MRU

OFDMA (Orthogonal Frequency Division Multiple Access) was introduced in Wi-Fi 6. It divides the radio channel into smaller frequency allocations called RU (Resource Units). By partitioning the channel, smaller data packets can be transmitted to multiple users simultaneously, which increases throughput and reduces latency in a dense environment. Wi-Fi 7 builds on this foundation with a new MRU (Multiple RU) feature supported in the EHT PHY. A MRU consists of combinations of either 26-, 52-, 106-, 242-, 484-, 996-, 2x996-, or 4x996-tone RU. RUs under 242-tone RU are defined as small size RUs, while those that are equal to or larger than 242-tone RUs are defined as large size RUs, and they can only be combined with other large size RUs to form large size MRUs.

The MRU provides enhanced interference mitigation and OFDMA efficiency. The enhancement is achieved by assigning punctured RUs per STA (puncturing granularity is 20MHz) to provide more variety of RU sizes to enhance OFDMA efficiency, while new RUs with non-continuous spectrum also support preamble puncturing. Figure 3 shows that MRU can mitigate interference losses from 75% to just 25%. This is how a Wi-Fi 7 MRU STA can offer 3X effective data bandwidth availability than a Wi-Fi 6 STA in a dense network environment.

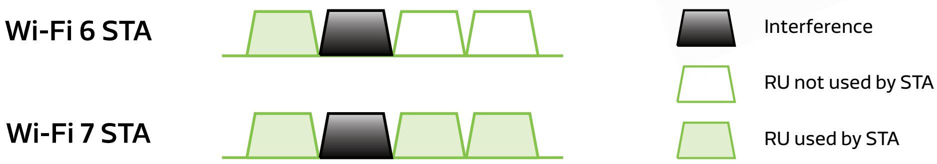

Figure 3. Spectral efficiency gain from using MRU improving data bandwidth

Moreover, an AP featuring MRU also significantly reduces the latency when multiple users try to transmit data simultaneously. For example, four different users transmit different data lengths: the proportion of data length for users 1 to 2 to 3 to 4 is 2:2:3:1, respectively. Figure 4 shows how a Wi-Fi 7 AP with MRU can allocate RU in a more efficient way, achieving the shortest end-to-end latency versus Wi-Fi 5 and Wi-Fi 6 APs with a 33% and 25% latency reduction, respectively.

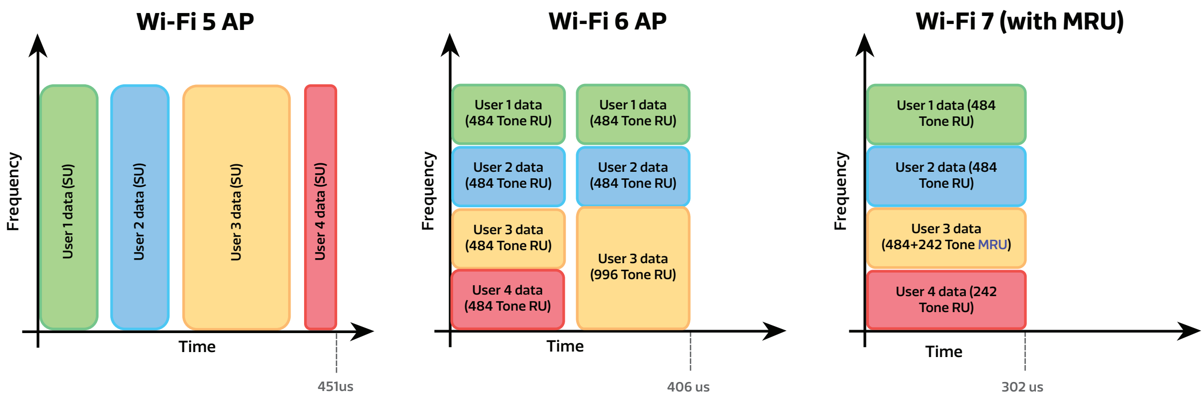

Figure 4. End-to-end latency comparison with four simultaneous users over the last three Wi-Fi generations

MLO

Multi-Link Operation (MLO) is an aggregation of multiple bands or channels. With MLO, Multi-Link Devices (MLDs) can simultaneously use the 2.4GHz, 5GHz and 6GHz bands under different circumstances, including load balancing according to traffic needs, or data aggregation across multiple bands, which significantly improves overall speeds and greatly reduces connection latency for all connected users. Whereas existing Wi-Fi technologies allow a device to connect and jump between either 2.4GHz, 5GHz and 6GHz bands, it can only send data via one band at a time. The current switching overhead as it hops frequencies can lead to delays of up to 100msec, whereas with an aggregated connection that's expected to drop as low as 1ms. This is obviously a huge benefit for things like game ping, wireless VR headsets, Cloud gaming and anything else latency sensitive. Figure 6 below shows the difference of data transmission between Wi-Fi 7 with MLO, and Wi-Fi 6 without. We can see that Wi-Fi 7 MLO STA can get more throughput from bandwidth aggregation and gain more data transmission opportunities to lower latency.

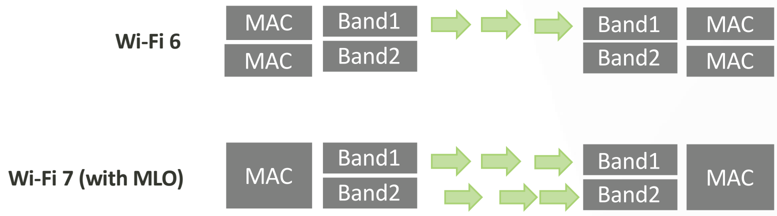

Figure 5. Wi-Fi 7 with MLO vs. Wi-Fi 6

Figure 6 illustrates that the effective throughput of Wi-Fi 7 Multi Link (MLO) STA speeds are up to 3X greater than Wi-Fi 6 Single Link (SL) STA based on the same MCS rate (MCS11).

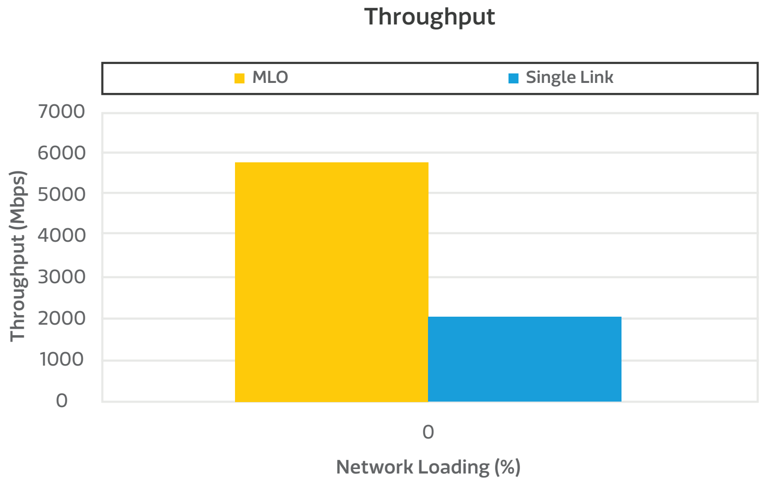

Figure 6. MLO benefit on bandwidth aggregation

Wi-Fi 7 MLO (2x2 BW160 + 2x2 BW320) vs. Wi-Fi 6 SL (2x2 BW160)

Figure 7 demonstrates latency benefit on Transmission Opportunity when subject to different dense environments. The result is up to 80% lower latency with a Wi-Fi 7 MLO STA compared to a Wi-Fi 6 SL STA when network loading is between 40~70%.

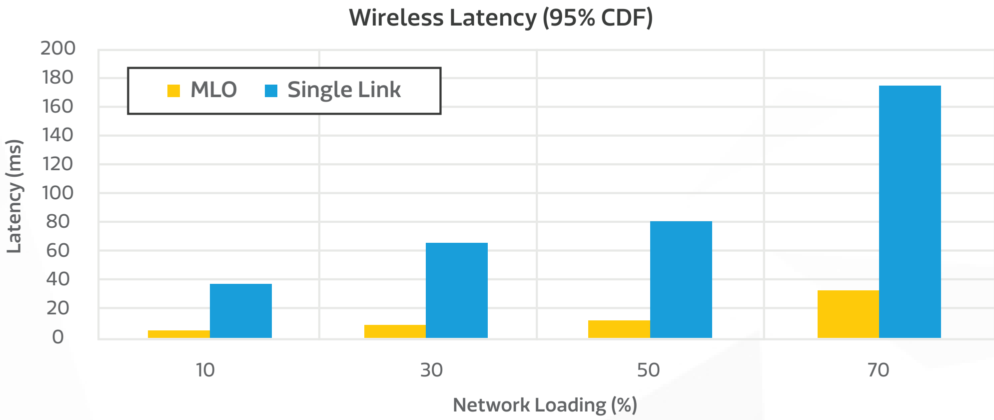

Figure 7. MLO benefit on Transmission Opportunity in Wi-Fi 7

Wi-Fi 7 MLO (2x2 BW40 + 2x2 BW160) vs. Wi-Fi 6 SL (2x2 BW160)

There are different types of MLO, for example, Simultaneous Transmit and Receive (STR) and Enhanced Multi-Link Single Radio (EMLSR). For small form factor STA, such as smart-phones, EMLSR is preferred due to improved RF isolation. In Figure 8 and Figure 9, we can see that when a network becomes more congested (i.e., loading over 10%), Hybrid EMLSR can have better throughput and latency than STR because it offers more opportunities to send data via three links rather than two.

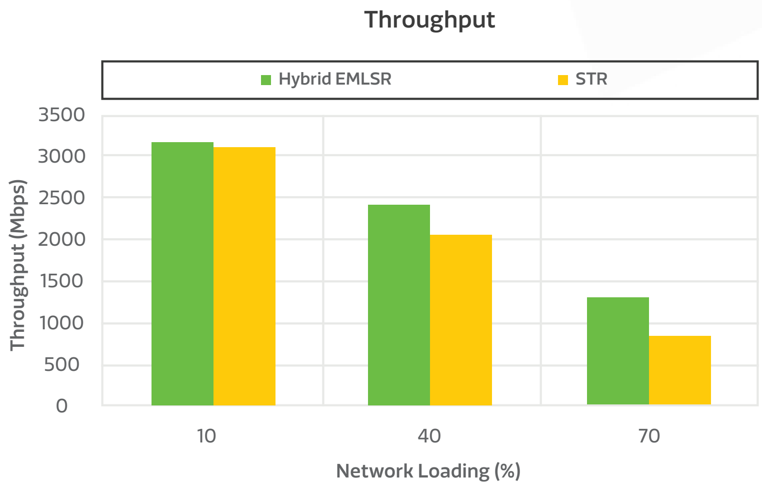

Figure 8. EMLSR benefit – throughput
Hybrid EMLSR 2x2 BW40 + (1x1 BW160 + 1x1 BW320) vs. STR 2x2 BW40 + 2x2 BW320

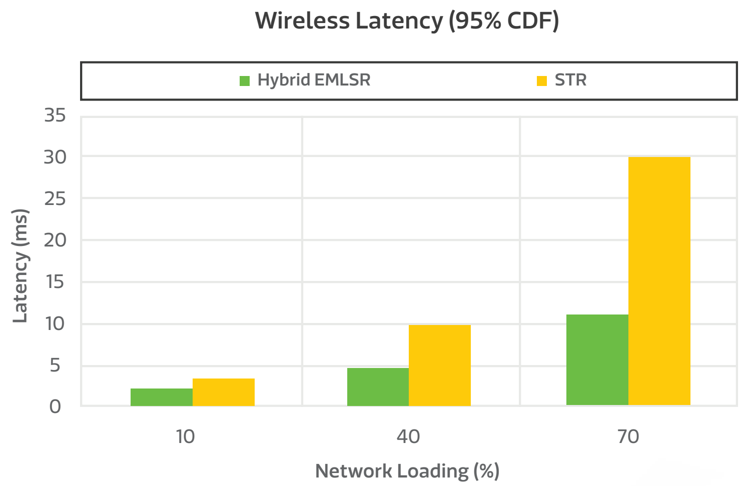

Figure 9. EMLSR Benefit – Wireless Latency
Hybrid EMLSR 2x2 BW40 + (1x1 BW160 + 1x1 BW320) vs. STR 2x2 BW40 + 2x2 BW320

Conclusions

This white paper brief has introduced the key new technologies in Wi-Fi 7, however it is not an exhaustive list of all its new features. Through different simulations, we demonstrate the significant enhancements achievable to throughput and latency, even in dense network environments that are expected to become increasingly more common. Wi-Fi 7 offers up to 4X greater wireless datalink performance potential, while new MRU and MLO technologies delivers 25% and 80% latency reductions respectively in their unique scenarios. These enhancements will allow Wi-Fi to retain the scalability required for the future, increasing adoption of use cases, even when there are strict latency and reliability requirements.

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