LANCOM SYSTEMS

White Paper

Wi-Fi 7 – The Future of Wireless Connectivity

Wi-Fi technology has continued to evolve over the last two decades to meet the growing demands of ever-increasing numbers of clients, increasing bandwidth requirements, and low latency. The introduction of the 6-GHz frequency band with Wi-Fi 6E marked a real milestone for Wi-Fi technology. It provided a frequency band exclusively for Wi-Fi and delivered interference-free and high-performance wireless communications. Now in the starting blocks is the next generation of wireless LAN: Wi-Fi 7 promises not only even faster speeds, but also dramatically improved responsiveness and reliability for immersive user experiences and demanding future technologies.

Wi-Fi evolution

The overview below presents the main differences between Wi-Fi 6 and Wi-Fi 7:

	Wi-Fi 6	Wi-Fi 6E	Wi-Fi 7
Max. throughput (gross)*	9.6 Gbps	9.6 Gbps	46 Gbps
Frequency bands	2.4 GHz 5 GHz	2.4 GHz 5 GHz 6 GHz	2.4 GHz 5 GHz 6 GHz
Modulation	QAM-1024	QAM-1024	QAM-4096
Supported channel bandwidth	20 MHz 40 MHz 80 MHz 160 MHz	20 MHz 40 MHz 80 MHz 160 MHz	20 MHz 40 MHz 80 MHz 160 MHz 320 MHz
MIMO	8×8 MU-MIMO	8×8 MU-MIMO	8×8 MU-MIMO
Multi-link operation	–	–	Yes
Resource units	One RU per client	One RU per client	Multiple RUs per client

* When operating the top equipment levels provided for by the standard.

This white paper outlines the main advances and their technical background.

6 GHz

The 6-GHz frequency band was introduced with Wi-Fi 6E. The advantage: The 6-GHz band is intended solely for Wi-Fi transmissions, making it interference-free and offering minimal latency and maximum data throughput. These are particularly important for time-critical applications and responsive connections. In contrast, the limited spectrum available in the 2.4- and 5-GHz bands can represent a bottleneck in the face of other radio technologies or higher-priority users. For example, the 2.4-GHz frequency band is overcrowded with high numbers of sources such as baby monitors and microwaves. The number of users is also steadily increasing in the 5-GHz band, with DFS (radar detection) posing an additional problem here.

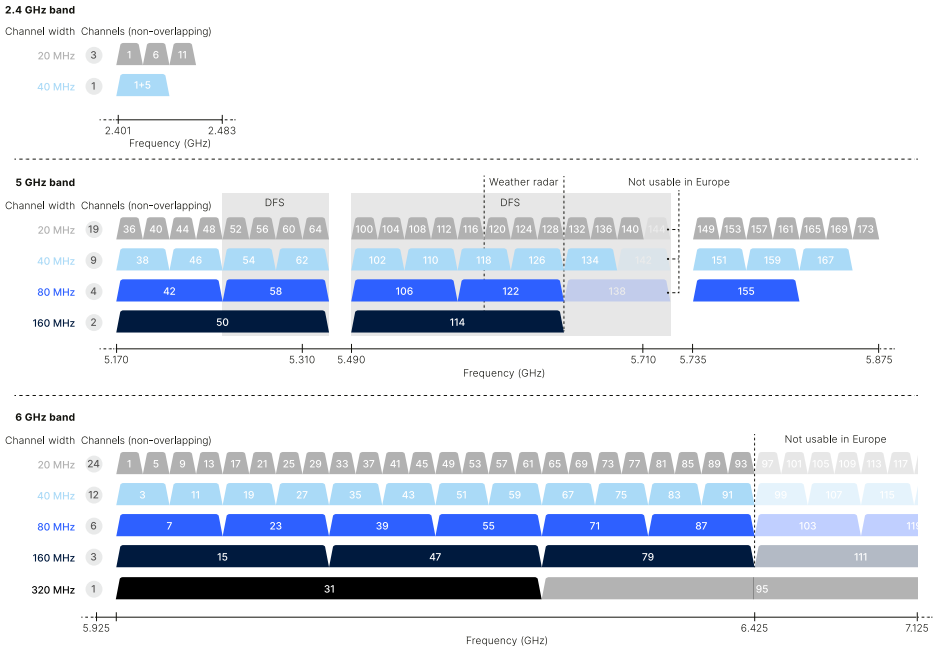

Figure 1:
Frequency scheme
2.4 GHz, 5 GHz, and 6 GHz

Consequently, Wi-Fi 7 uses not only the 2.4- and 5-GHz frequency bands but also the 6-GHz band, which in Europe is exclusively reserved for Wi-Fi. This in turn promises a rapidly increasing market presence of 6 GHz-capable Wi-Fi devices.

Faster speeds

Wi-Fi 7 is particularly impressive due to the significant increase in speeds of around 480% over Wi-Fi 6 and Wi-Fi 6E. However, this only applies when operating the top equipment levels provided for by the standard, such as 16×16 MU-MIMO, which is rarely used in practice. But even with 4×4 MIMO systems, bandwidth improvements of up to 240% are possible.

This gain in speed is due to two major upgrades:

320-MHz channel width

Wi-Fi 5 introduced a maximum channel width of 160 MHz in the 5-GHz band for connecting individual devices. Wi-Fi 7 doubles this channel width to 320 MHz, doubling the transmission speed for individual devices. This is where the 6-GHz frequency band comes into play: It is the only one with sufficient capacity to support this channel width.

However, within the European Union an important aspect has to be considered: In the EU, only 480 MHz of the total 1,200 MHz spectrum has so far been approved for use in the 6-GHz frequency band. This means that the radio field can only accommodate a single 320-MHz channel that is free of interference.

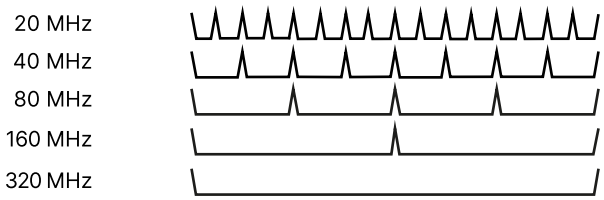

Figure 2:
Channel widths

4k QAM

QAM (quadrature amplitude modulation) increases data throughput by increasing the information density during transmission. The following applies: The higher the QAM level, the higher the data throughput. For example, Wi-Fi 5 uses QAM-256 (8 bits/symbol) and Wi-Fi 6 used QAM-1024 (10 bits/symbol). Wi-Fi 7 now supports the transmission of 4096 different data values per symbol (QAM-4096 / 4k QAM). With 12 bits transmitted per symbol, the transmission speed increases by a further 20%.

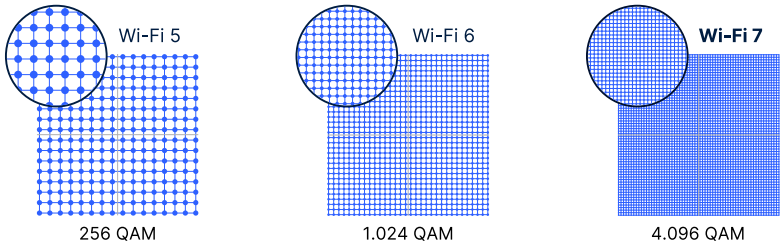

Figure 3:
QAM
(quadrature amplitude
modulation)

The increased channel width of 320 MHz and the higher data density (4k QAM) result in the 2.4x increase in maximum speed of Wi-Fi 7 over Wi-Fi 6.

More stable connections

In an environment with an ever-growing number of radio signals and devices, the key innovations with Wi-Fi 7 are two technologies that improve the stability of Wi-Fi connections.

Multi-link operation (MLO)

Previous Wi-Fi standards provided connections on several frequency bands, but any one end device can only use a single band to transmit. The frequency is only changed if there is a change of conditions. Multi-link operation (MLO) allows Wi-Fi 7 devices to connect on two frequency bands simultaneously.

Wi-Fi clients with a single integrated radio module benefit from improved connection stability, especially in radio environments with high signal densities: Without connection interruptions, packets are transferred over the frequency band offering the best quality (enhanced multi-link single radio).

However, Wi-Fi clients with more than one radio module can aggregate the two bands and benefit from faster speeds. Also, the connection is maintained if one of the frequency bands should become unavailable. Alternatively, the two frequency bands can be used concurrently to send redundant data packets, which increases stability and reduces connection latency (multi-link multi-radio).

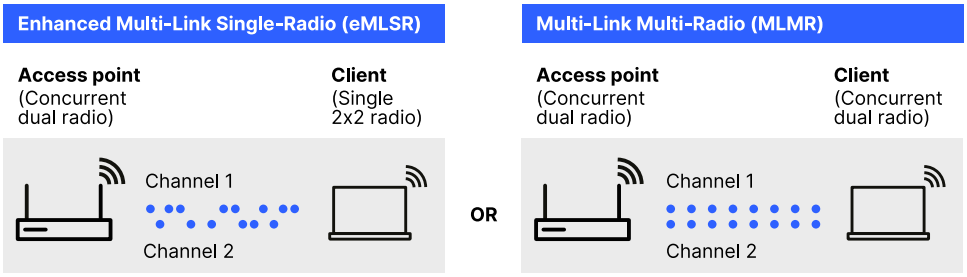

Figure 4:
Multi-link operation (MLO)

Multi-RU & puncturing

Previous generations of Wi-Fi had significant problems with interference and the resulting bandwidth limitations. A particular problem is narrow-band interference sources that cause channels to be impaired. Although these interference sources may occupy only a fraction of the channel width, they can put the entire channel out of service, so wasting valuable spectrum. Wi-Fi 7 addresses this issue with the concepts of Multi-RU (multiple resource units) and puncturing. Narrow-band interference is now viewed as a mere puncturing of the spectrum. In this situation, the channel is divided into smaller sub-channels (“resource units” or “RU”), as previously implemented with the OFDMA technology introduced with Wi-Fi 6. Puncturing excludes that spectrum or portion of the channel with the interference, which enables the use of the unaffected spectrum surrounding it. This means that, for the first time, even very wide Wi-Fi channels (160 MHz or even 320 MHz) can be used productively under normal environmental conditions.

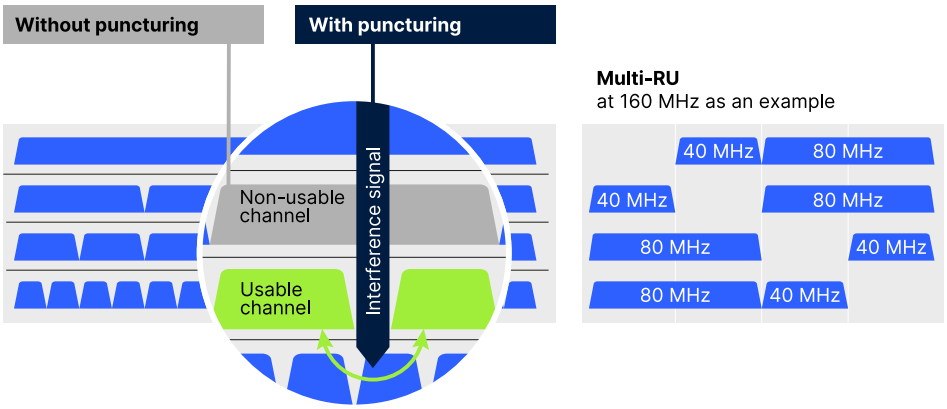

Figure 5:
Multi-RU & puncturing

What is there to consider before implementation?

In the context of Wi-Fi 7 implementation, apart from installing Wi-Fi 7 access points, there are other critical factors to consider to ensure optimal network performance and reliability.

Range

The 6-GHz band offers a lower wireless range than 5 GHz or even 2.4 GHz. This must be taken into account when it comes to planning Wi-Fi coverage and the number of access points to be installed. A professional service for planning the coverage may be a worthwhile investment here.

End devices

Even though Wi-Fi 7 is fully backwards compatible with earlier standards, the full potential of this standard can only be achieved with end devices that also support Wi-Fi 7. This should be considered when purchasing new notebooks or smartphones, for example.

LAN

Another important aspect concerns the network infrastructure itself, in particular the LAN components. The large bandwidths available with Wi-Fi 7 require switches with sufficient port capacity to effectively support the transfer speeds, including 10-GE and 2.5-GE ports. If the access points operate with Power over Ethernet, the switches must also provide PoE power in accordance with IEEE 802.3bt to meet the demanding power requirements of the Wi-Fi 7 access points.

Summary

Wi-Fi 7 represents a significant advancement in wireless connectivity, which goes well with the growing need for high-performance and reliable networks. Offering impressive speeds, greater channel width, higher data density, and innovative features such as multi-link operation and multi-RU & puncturing, Wi-Fi 7 provides the basis for immersive user experiences and demanding future technologies. Wi-Fi 7 is also expected to boost the widespread use of the 6-GHz band, which in Europe is exclusively reserved for Wi-Fi.

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