GIGAMEDIA

SMART BUILDING SOLUTIONS

SURFING THE WI-FI ERA
DEVELOPMENTS & PROSPECTS
IN WIRELESS CONNECTIVITY

INTRODUCTION

Developed in the 1990s through the IEEE 802.11 standards and the Wi-Fi Alliance, Wi-Fi technology has undergone a meteoric rise to become an essential form of connectivity for both personal and professional digital uses.

From the early days of the technology to today's standards, a look back at how wireless technology has evolved, how it works and what the future holds.

SUMMARY

ORIGINS AND DEVELOPMENT OF
WI-FI TECHNOLOGY

Wi-Fi has its roots in the work of pioneers such as Hedy Lamarr and George Antheil, who developed a frequency hopping technique to secure wireless communications in the 1940s.

However, it was not until the early 1990s that Wi-Fi technology began to take shape under the aegis of **802.11 standards**.
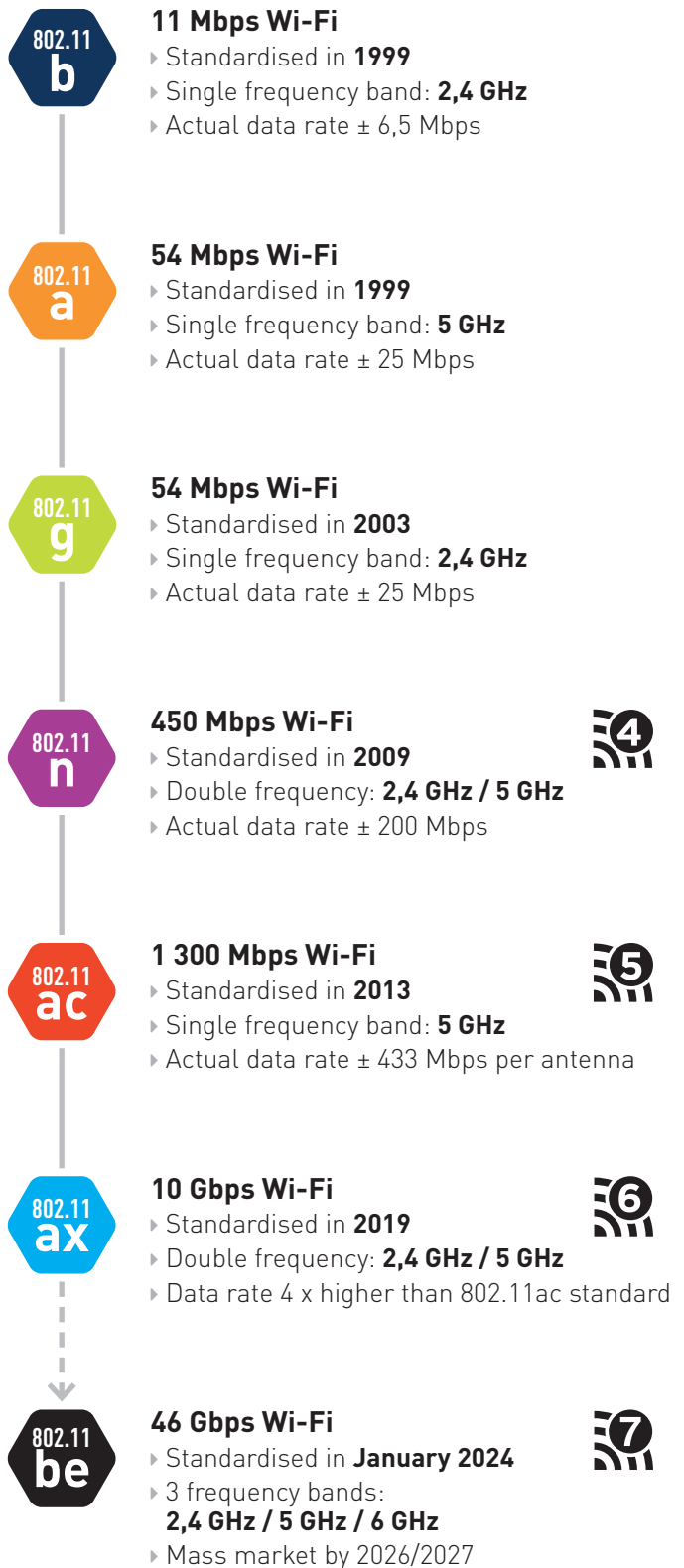
Ratified by the IEEE*, these standards define communication protocols, technical specifications for components and the implementation of wireless local area networks (WLANs).

Each standard within the 802.11 family corresponds to a specific version of Wi-Fi technology, identified by a series of letters.

Created in 1999, the Wi-Fi Alliance has also played a crucial role in establishing interoperability standards, guaranteeing total compatibility between equipment originating from different manufacturers. This initiative contributed to the popularity and worldwide expansion of Wi-Fi.

The development of the technology, and the successive standards associated with it, has been such that the Wi-Fi Alliance has decided to introduce a numbering system based on the generation of Wi-Fi in question. This numbering provides greater clarity and readability for consumers/users.

SUCCESSIVE GENERATIONS OF WI-FI STANDARDS:

802.11 b
11 Mbps Wi-Fi
▸ Standardised in **1999**
▸ Single frequency band: **2,4 GHz**
▸ Actual data rate ± 6,5 Mbps

802.11 a
54 Mbps Wi-Fi
▸ Standardised in **1999**
▸ Single frequency band: **5 GHz**
▸ Actual data rate ± 25 Mbps

802.11 g
54 Mbps Wi-Fi
▸ Standardised in **2003**
▸ Single frequency band: **2,4 GHz**
▸ Actual data rate ± 25 Mbps

802.11 n
450 Mbps Wi-Fi
▸ Standardised in **2009**
▸ Double frequency: **2,4 GHz / 5 GHz**
▸ Actual data rate ± 200 Mbps

802.11 ac
1 300 Mbps Wi-Fi
▸ Standardised in **2013**
▸ Single frequency band: **5 GHz**
▸ Actual data rate ± 433 Mbps per antenna

802.11 ax
10 Gbps Wi-Fi
▸ Standardised in **2019**
▸ Double frequency: **2,4 GHz / 5 GHz**
▸ Data rate 4 x higher than 802.11ac standard

802.11 be
46 Gbps Wi-Fi
▸ Standardised in **January 2024**
▸ 3 frequency bands: **2,4 GHz / 5 GHz / 6 GHz**
▸ Mass market by 2026/2027

*Institute of Electrical and Electronics Engineers. World organisation responsible for standardising wired and wireless communication protocols.

EVOLUTION, PERFORMANCE AND SECURITY

EVOLUTION AND PERFORMANCE

Each generation of Wi-Fi has been marked by significant advances in terms of performance, range, security and functionality, enabling a tailored response to the growing needs of users and applications.

ADVANCES IN SPEED

One of the most remarkable developments in Wi-Fi is the speed of data transmission. Early Wi-Fi standards, such as 802.11b and 802.11g, offered relatively low data rates. However, with the introduction of 802.11n, 802.11ac and 802.11ax, transmission speeds have increased dramatically, and today Wi-Fi networks can reach speeds of several gigabits per second, enabling smooth video streaming, fast downloads and an uninterrupted online experience.

EXTENDED RANGE

Another major development in Wi-Fi is the extension of the signal's range. Early Wi-Fi networks had a limited range, which meant that connectivity was often restricted to a small area, but thanks to improved antennas and transmission techniques, modern Wi-Fi networks can cover greater distances. In addition, the use of Wi-Fi repeaters and mesh technologies can significantly improve signal range, offering extended wireless connectivity.

ENHANCED SECURITY

The security of Wi-Fi networks has also evolved significantly. Early Wi-Fi networks were often vulnerable to attack and intrusion. However, with the introduction of security protocols such as WEP, WPA and WPA2, Wi-Fi networks have become much more secure. These protocols use advanced encryption methods to protect data and prevent unauthorised access. In addition, the latest Wi-Fi standards incorporate enhanced security features, such as WPA3, which further strengthen the protection of Wi-Fi networks.

SMART MANAGEMENT OF WI-FI NETWORKS

Modern Wi-Fi networks use technologies that enable intelligent, centralised network management, including:
→ **beamforming**, which directs the Wi-Fi signal to connected devices, improving connection quality.
→ **load balancing**, which allows the load / number of users connected per access point to be distributed and balanced.
→ **roaming**, which enables seamless connectivity.
In addition, the use of advanced algorithms on smart Wi-Fi networks optimises bandwidth, prioritises devices and efficiently manages network traffic, delivering an optimal user experience.

SECURITY

Ensuring security means guaranteeing the availability, integrity and confidentiality of data. This is why the Wi-Fi Alliance has developed encryption technologies such as WEP, WPA, WPA2, WPA3 and WPS, to secure connections to Wi-Fi networks.

WEP — **WIRED EQUIVALENT PRIVACY**
SIMPLE DATA ENCRYPTION MECHANISM

▸ Security key length: 64, 128 or 152 bits
▸ Light encryption

Used for encrypting **low-sensitivity** data

WPA — **WI-FI PROTECTED ACCESS**

▸ Dynamic configuration
▸ TKIP encryption (Temporal Key Integrity Protocol)
▸ Encryption requires more bandwidth than WEP

Used for encrypting **sensitive** data

WPA2 — **WI-FI PROTECTED ACCESS 2**

▸ Available in 2 versions: WPA2-Personal
  and WPA2-Enterprise
▸ AES encryption (Advanced Encryption Standard)

Improved security protocol compared to WPA (802.11i standard)

WPA3 — **WI-FI PROTECTED ACCESS 3**

▸ Available in 2 versions: WPA3-Personal
  and WPA3-Enterprise
▸ Improved data encryption
▸ Greater protection against attacks
▸ Session keys of up to 192 bits

WPS — **WI-FI PROTECTED SETUP**
THE WPS SYSTEM SIMPLIFIES THE CONFIGURATION OF WI-FI NETWORK SECURITY

▸ Simple Wi-Fi LAN standard.

It can be used to configure secure Wi-Fi access between two devices that support WPS.
The user presses a button (physical or virtual) on both the access point and the new device.
The two products interconnect without the user having to enter passwords.

TECHNOLOGICAL ADVANCES:
FOCUS ON WI-FI 6

Also known as the 802.11ax standard, Wi-Fi 6 offers a number of significant advantages over previous standards, including:
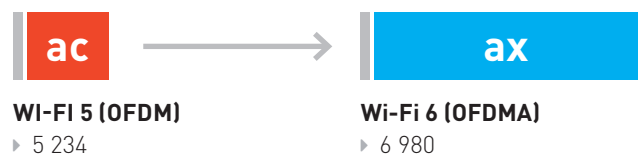
QAM MODULATION
IMPROVED WIRELESS
NETWORK BANDWIDTH

- ➡ **Multiplication of spatial flows**
- ➡ **More subcarriers in the signal**
- ➡ **4x faster signal transmission**
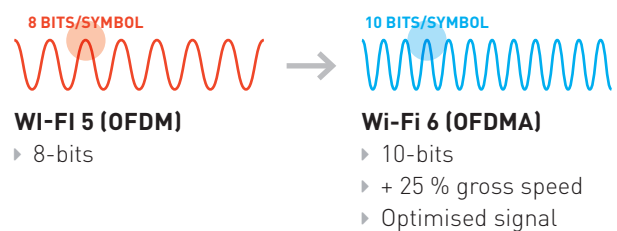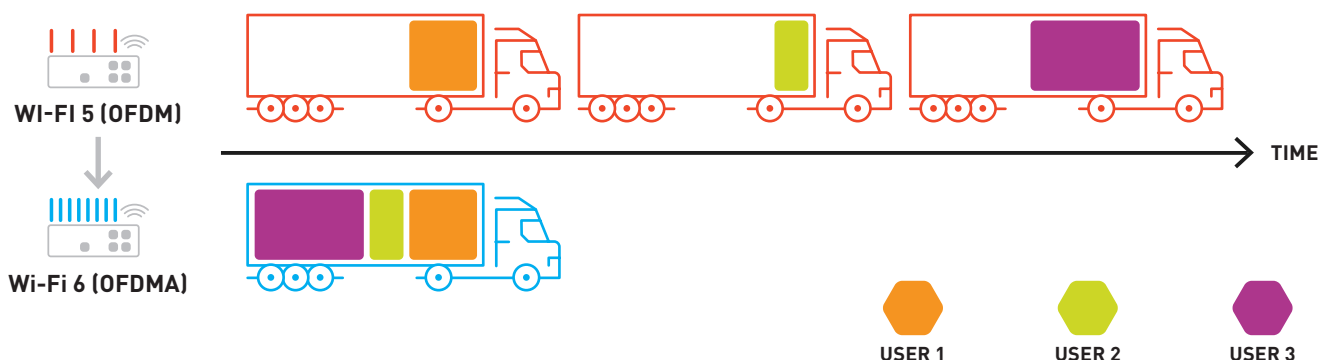- ➡ **More data transported per subcarrier**

INCREASED SPEED

Wi-Fi 6 offers much faster data transmission speeds than previous standards. It uses a technology called OFDMA (Orthogonal Frequency Division Multiple Access), inherited from mobile operator networks, which allows channels to be divided into smaller sub-channels, enabling several devices to transmit data simultaneously. The result is a significant increase in network capacity and higher data rates for each connected device.

MORE
SUBCARRIERS

ac → **ax**

WI-FI 5 (OFDM)
▸ 5 234

Wi-Fi 6 (OFDMA)
▸ 6 980

DOUBLED
SPATIAL FLOWS

WI-FI 5 (OFDM)
▸ 4Tx / 4Rx

Wi-Fi 6 (OFDMA)
▸ 8Tx / 8Rx

MORE
TRANSPORTED DATA

8 BITS/SYMBOL

10 BITS/SYMBOL

WI-FI 5 (OFDM)
▸ 8-bits

Wi-Fi 6 (OFDMA)
▸ 10-bits
▸ + 25 % gross speed
▸ Optimised signal

DATA TRANSMISSION TIME
4X FASTER

WI-FI 5 (OFDM)

Wi-Fi 6 (OFDMA)

TIME

USER 1 **USER 2** **USER 3**

OFDMA TECHNIQUE
IMPROVED CONNECTION CAPACITY

- OFDMA = Orthogonal Frequency Division Multiple Access
- Frequency modulation technique used in mobile networks
- Optimised channel sharing for each user (benefit vs MU-MIMO)
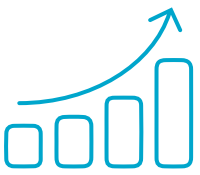
IMPROVED CAPACITY

Wi-Fi 6 is designed to efficiently manage a large number of devices connected simultaneously. Thanks to MU-MIMO (Multi-User Multiple Input Multiple Output) technology, standardised in 2016 (802.11ac Wave 2), Wi-Fi 6 can communicate with several devices at the same time, offering a smoother, latency-free experience, even in dense environments where many devices are connected.

BANDWIDTH

FRAME 1
FRAME 2
FRAME 3
FRAME 4

FREQUENCY

WI-FI 5 (OFDM)
Each user occupies the channel's resources exclusively.

TIME

SPECTRUM UTILISATION:
MORE THAN 30 TIMES HIGHER

FREQUENCY

Wi-Fi 6 (OFDMA)
Several users share the resources of each channel.

TIME

USER 1   USER 2   USER 3

REDUCED LATENCY

Wi-Fi 6 significantly reduces latency, which is essential for real-time applications such as online gaming, video conferencing and virtual reality. Thanks to Target Wake Time (TWT) technology, Wi-Fi 6 enables devices to synchronise their periods of activity and inactivity, reducing energy consumption and latency.

**30% LOWER
INTERFERENCE RATE**

←——→ **INTERFERENCE**

←– –→ **NO INTERFERENCE**

WI-FI 5 (OFDM)
Co-channel interference can easily occur.

Wi-Fi 6 (OFDMA)
Different users on the same channel are marked with different colours, without interference.

BSS COLORING
REDUCED OVERALL
WIRELESS NETWORK LATENCY

➲ **Optimised channel sharing for each user = reduced latency.**

➲ **BSS coloring to optimise frequency use by users, without interference.**

- **Previously, access points and peripherals communicated continuously, without standby.**
- **With TWT technology, devices can be idled at set times to optimise battery consumption.**
- **Fundamental technology for the IoT.**
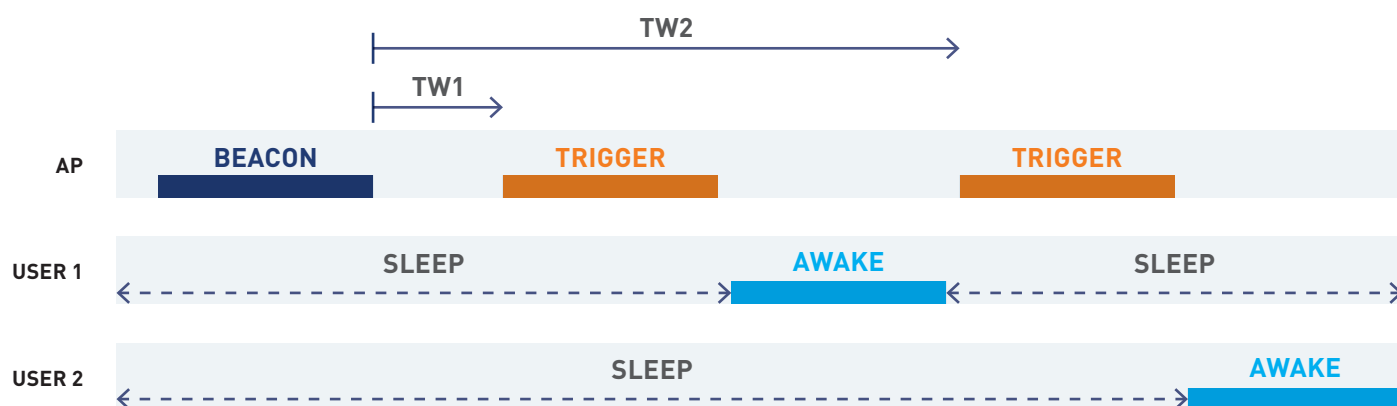
ENERGY EFFICIENCY

Wi-Fi 6 is designed to be more energy efficient, which is beneficial for mobile devices such as smartphones, tablets and connected objects.
With features such as TWT and enhanced sleep mode, Wi-Fi 6 allows devices to reduce power consumption when not actively in use, thus extending battery life.

Target Wake Time (TWT) technology

ALLOWS DEVICES
TO REMAIN INACTIVE UNTIL THEIR TURN

ACCESS POINTS
SEND A SCHEDULED «WAKE-UP» SIGNAL

ONCE THE SIGNAL HAS BEEN TRANSMITTED,
THE DEVICE GOES INTO STANDBY MODE

BATTERY OPTIMISATION
THROUGH STANDBY MODE

ENHANCED SECURITY

Wi-Fi 6 also incorporates improvements in terms of security. It supports the WPA3 protocol, which offers more robust encryption and stronger protection against attacks and intrusions, guaranteeing greater confidentiality and security for the data of wireless users. WPA3 benefits include:

CONFIDENTIALITY

The WPA3 protocol incorporates additional protections such as mutual authentication of devices and encryption of exchanged data, to prevent attacks and data interception. What's more, during a session, each connection between a device and the router is encrypted separately, further strengthening the confidentiality of information exchanged over the network, and reducing the risk of IDs and passwords being compromised.

PROTECTING OPEN NETWORKS

WPA3 offers enhanced security features for public or open Wi-Fi networks, including the Enhanced Open™ protocol, which uses techniques such as Opportunistic Wireless Encryption to encrypt exchanged data, even in the absence of pre-shared encryption keys. This ensures the confidentiality of communications and protects users from attacks on Wi-Fi networks with little or no security.

STRONGER ENCRYPTION

WPA3 uses 192-bit encryption (compared with 128-bit encryption in WPA2) in WPA3-Enterprise mode, strengthening data encryption and providing enhanced protection for networks requiring a high level of security.

SAE AUTHENTICATION

SAE (Simultaneous Authentication of Equals) is a secure authentication method that replaces the previously used WPA2-PSK (Pre-Shared Key) security protocol. SAE is a key component of the WPA3 security protocol. It provides more robust authentication and ensures a secure Wi-Fi connection, notably by protecting against brute force attacks*.

*The technique of cracking a password or encryption key by systematically and exhaustively trying all possible combinations.

SECURITY LEVEL

HIGH

MEDIUM

LOW

VERY LOW

WEP

WPA

WPA 2

WPA 3

TIME

1999   2003   2004   2018
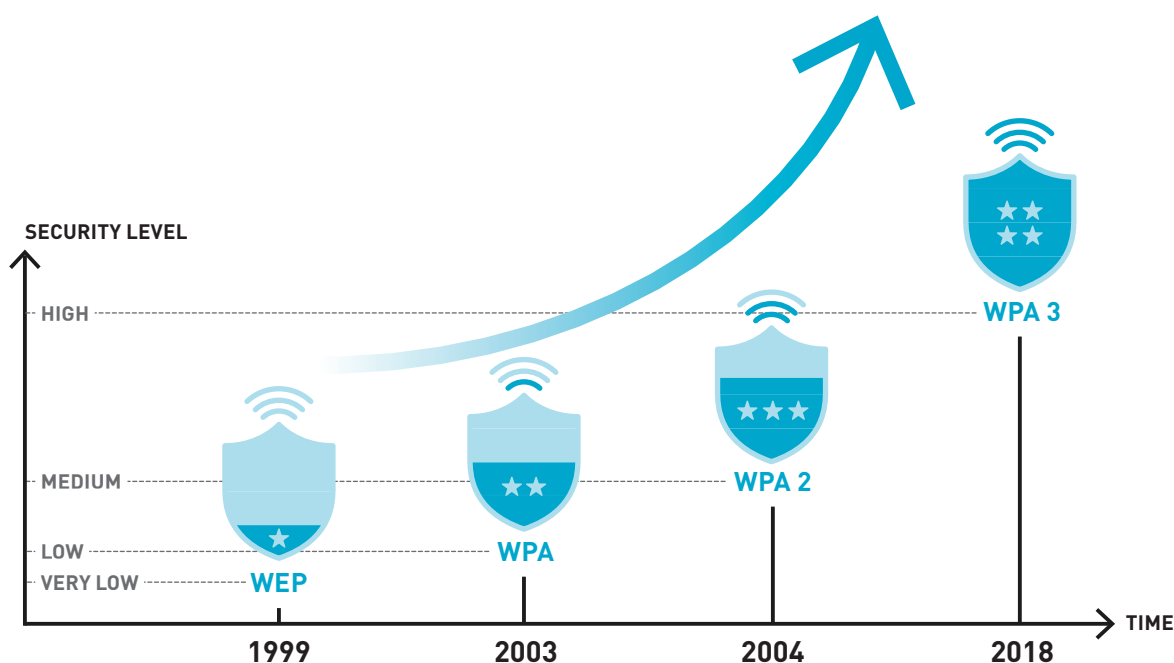
Advances in the speed, range, security and management of Wi-Fi networks have dramatically improved our wireless connectivity experience.

With the emergence of new standards such as Wi-Fi 6 (802.11ax) and Wi-Fi 6E, we can expect continued improvements to Wi-Fi, offering even faster, more reliable and more secure connectivity in the years to come.

The advantages of Wi-Fi 6 over previous generations

IMPROVED
WIRELESS NETWORK BANDWIDTH

IMPROVED
SIMULTANEOUS CONNECTION CAPACITY

REDUCES
**OVERALL WIRELESS NETWORK LATENCY**

REDUCES
THE POWER CONSUMPTION OF WIRELESS DEVICES

APPLICATIONS AND USES

Wi-Fi has made some spectacular advances with the introduction of the 802.11g, 802.11n, 802.11ac and, more recently, 802.11ax (Wi-Fi 6) standards. These developments have brought significant improvements in terms of speed, capacity, traffic management and connection stability, making Wi-Fi an essential part of our daily lives by helping to meet the growing need for wireless connectivity in domestic, professional and public environments.

Applications such as ultra high definition video (4K/8K UHD), virtual and augmented reality, and real-time applications harness the power of Wi-Fi to create immersive experiences and connected environments.

802.11 b	802.11 a/g	802.11 n	802.11 ac	802.11 ax
1999	2003	2009	2013	2019
		4	5	6
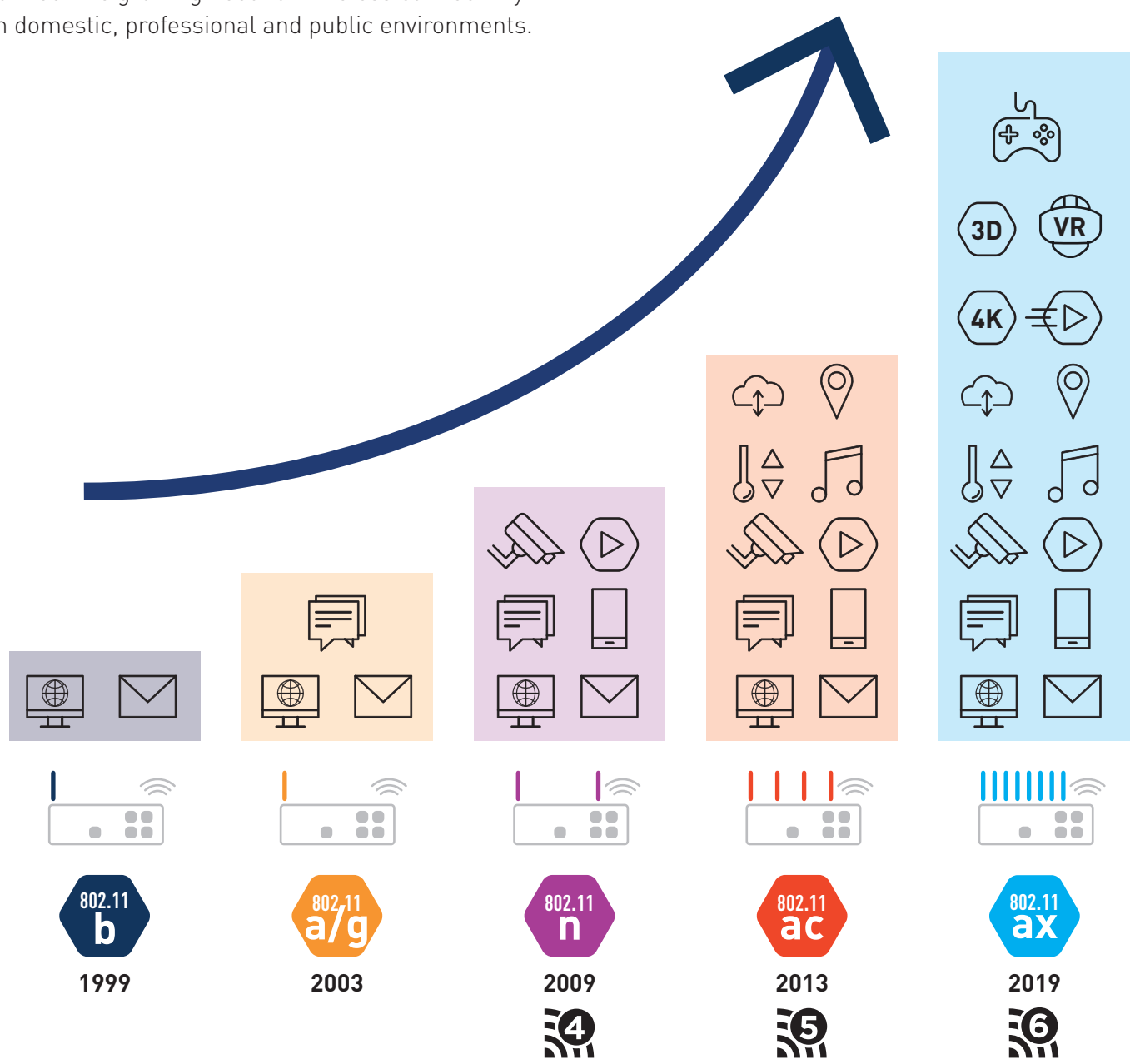
THE FUTURE
OF WI-FI

Wi-Fi connectivity continues to evolve, with standards such as Wi-Fi 7 (IEEE 802.11be) on the horizon, newly standardised in January 2024, promising even faster performance and more robust connectivity.

With speeds of up to 30 Gbps, or around 3x faster than Wi-Fi 6, Wi-Fi 7 looks set to be a promising development, thanks in particular to :

⊙ The use of 3 frequency bands

▸ 2,4 GHz, 5 GHz, and 6 GHz
▸ Increased capacity
▸ Reduced congestion

⊙ Wider channels

▸ Up to 320 MHz bandwidth
▸ Double the transmission capacity compared with Wi-Fi 6
▸ Improved overall performance

⊙ Even more effective modulation

▸ 4096-QAM modulation
▸ Improved spectral efficiency
▸ Increased throughput

⊙ New features

▸ Exploiting frequency bands
▸ Optimising transmissions
▸ Reducing latency

These developments pave the way for new technological opportunities and applications in areas such as virtual reality, IoT and real-time communications, as well as new opportunities in the healthcare, education and mobility verticals. From an industrial point of view, however, the development of this brand new generation is still limited, and is not expected to see mass adoption until 2026/2027.

CONCLUSION

Wi-Fi technology has evolved spectacularly, constantly adapting to users' needs and becoming indispensable in our everyday digital lives. Responding to growing needs in terms of performance and security, it has become an essential catalyst for innovation, supporting ever more demanding applications.

In this respect, Wi-Fi 6 is today the wisest choice, offering :

⊙ very high data rates
⊙ reduced latency
⊙ improved connection capacity
⊙ increased energy efficiency
⊙ enhanced security

These benefits make Wi-Fi 6 a must-have technology, meeting today's and tomorrow's connectivity needs and technological requirements.

GIGAMEDIA
SUPPORTS YOU!
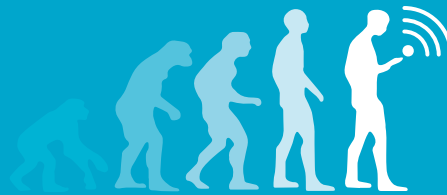
GIGAMEDIA supports your Wi-Fi projects through a comprehensive range of products and services tailored to the constraints of your sites in residential and commercial environments.

Take advantage of the latest technological advances and benefit from an ultra-fast wireless connection and advanced functionalities on your network with GIGAMEDIA's **Wi-Fi 6 ranges**.

Among the solutions on offer:

RESIDENTIAL SOLUTIONS

GGM WMESH1800KIT

GGM WAPRAX

⊙ Wi-Fi 6 Mesh kits
Take advantage of cutting-edge performance and extensive Wi-Fi coverage, with speeds of up to 1.8 Gbps.

⊙ Wi-Fi 6 repeaters
To increase the Wi-Fi router's range and optimise wireless coverage.

WI-FI 6 PRO SOLUTIONS
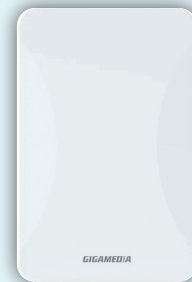
⊙ Wi-Fi 6 pro indoor access points
Benefit from advanced features and an ultra-fast wireless connection of up to 3.6 Gbps (depending on model).

⊙ Wi-Fi 6 pro IP67 outdoor access points
Enjoy a high-performance Wi-Fi connection wherever you are.

GGM WAPAX3600

GGM WAPEXT1800

CENTRALISED SOLUTIONS

GGM WCAP100

⊙ Centralised Wi-Fi controllers
For greater convenience and simplicity in setting up and managing your Wi-Fi access points.

⊙ Log servers
For filtering, data protection and securing public Internet access.
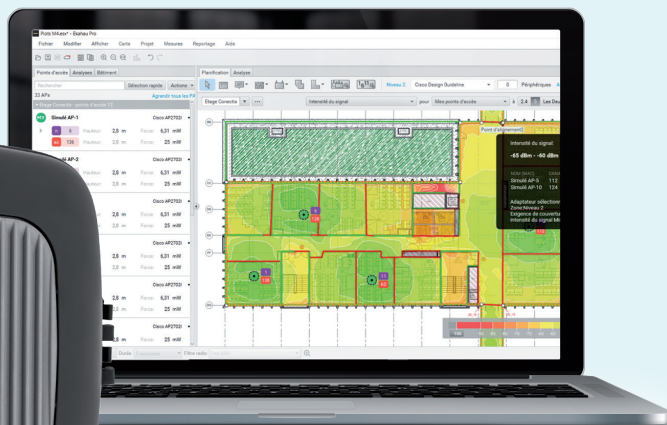
GGM AB2BOX0100

CUSTOMER LOYALTY

TIME SAVING

QUALITY OF SERVICE

NEW OPPORTUNITIES

CUSTOMISED SERVICES

Thanks to its team of technical experts in security and network equipment, GIGAMEDIA can help you successfully implement all your Wi-Fi projects through:

▸ **Pre-sales feasibility studies**
▸ **Technical and practical advice**
▸ **Technical audits and Wi-Fi coverage studies**
▸ **Parameterisation / pre-configuration services**
▸ **On-site installations and training**
▸ **Dedicated online portal and hotline**

...and further more!

By combining GIGAMEDIA's product ranges with the expertise of our technicians, you are assured of a high-quality, state-of-the-art installation. We also transfer skills so that you gain greater autonomy for your future projects.

Visit the online portal

support.gigamedia.net

And find out:

▸ **Tutorials**
▸ **How-to videos**
▸ **A knowledge base**

You can also open a support ticket directly, which will be handled by our expert technicians.

DID YOU KNOW?

GIGAMEDIA also offers an after-sales technical support service.

▸ Access the online technical self-service portal here
▸ Available 24 hours a day, 7 days a week

GIGAMEDIA PROVIDES A FULL RANGE OF INNOVATIVE SOLUTIONS for installers, integrators and engineering departments, dedicated to the distribution of structured cabling systems, IT and telecommunication networks.

FOR OVER 25 YEARS, WE HAVE BEEN SUPPORTING EXPERTS AND PROFESSIONALS in the Commercial, Industrial and Residential sectors through hardware solutions, expertise and additional services.

THE SOLUTIONS OFFERED BY GIGAMEDIA ARE KEY ELEMENTS OF SMART BUILDING INFRASTRUCTURES, with comprehensive product ranges providing customers with a full solution for their **DATACOM** projects.

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