Fibocom
PERFECT WIRELESS EXPERIENCE

Whitepaper

Unlocking Massive Data Capabilities With 5G and mmWave

Introduction

With the advent of 5G technology comes the promise of ubiquitous connectivity, low latency and high capacity across a wide range of use cases. As the Internet of Things (IoT) ushers in an era of up to a million connected devices per square kilometer, existing network architectures such as 4G, won't be able to keep up with increased data usage needs.

Enter 5G, primed to provide the capacity and speed required to power the IoT world but, to meet its full potential, providers must access new frequency bands beyond the Sub-6 GHz frequencies currently used. A promising step towards that goal is the use of New Radio (NR) mmWave frequencies.

mmWave opens the door for the massive IoT connectivity vital for future industry and automation. At the same time, it enables ultra-fast broadband across Fixed Wireless Access (FWA) networks, providing rich new data services to meet demands in both business and residential settings.

How will mmWave enable 5G's full potential?

What is mmWave?

Current services, delivered across Sub-6 (below 6 GHz) low- and mid-frequency bands, are constrained by limited bandwidth. The 5G offerings utilizing Sub-6, for example, could face serious capacity issues as early as 2023, accelerating the need for new spectrum allocations.

mmWave or "high band" frequencies offer a solution to this bottleneck, in the form of large new tracts of spectrum stretching from 24GHz to 100GHz. Figure 1 illustrates the spectrum available for Sub-6 and mmWave, including the bands identified for 5G usage.

Current Sub-6 spectrum usage and projected mmWave frequency range

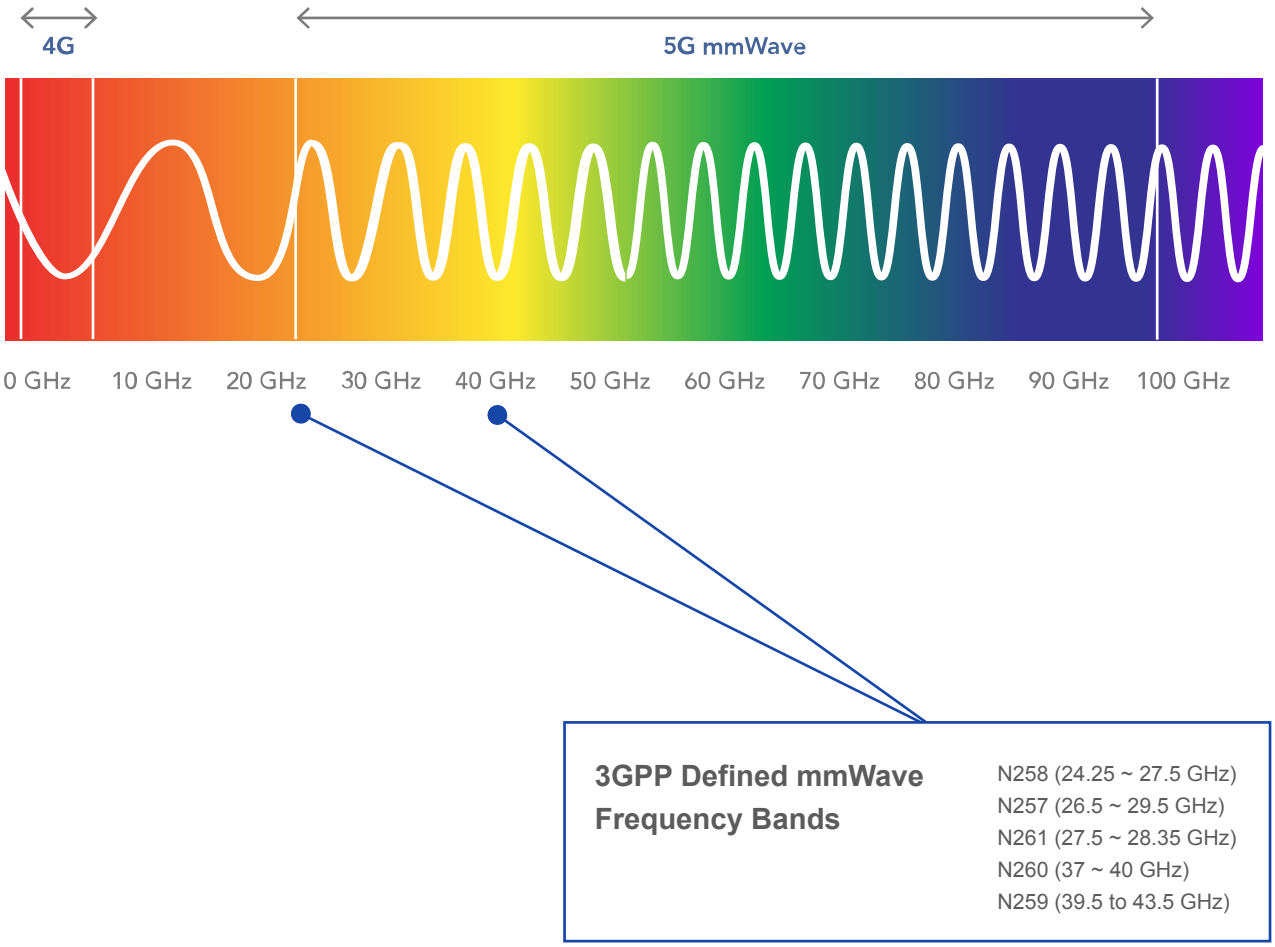


Figure 1.

Characteristics of mmWave

A primary characteristic of the spectrum in the high frequency range is the large bandwidths available for use, which enable massively increased capacity. As Figure 1 shows, wavelengths in the mmWave ranges are also shorter, driving rapid data transmission. Combined, these characteristics allow 5G mmWave services to offer users:

Low and ultra-low latency

5G mmWave improves on current 4G latency by a factor of 5 or more, reducing 4G's 40-50ms latency to ~10ms. For mission-critical use cases, such as self-driving cars, this may drop as low as ~1ms.

Higher data rates

5G mmWave promises speeds of up to 10Gbps, a 10-100X improvement on existing 4G and 4.5G network rates.

More bandwidth

5G mmWave provides 1,000X the bandwidth per unit area.

These capabilities offer up exciting new opportunities for products and services in the IoT space, and in the provision of next generation wireless network capabilities.

Setting the 5G standard

Unlocking the full potential of 5G mmWave requires globally-recognized technical specifications for 5G network infrastructure and 5G-enabled products.

The 3GPP (Third Generation Partnership Project) has made large strides towards accomplishing this with their most recent sets of 5G specifications (releases 15 and 16), and release 17 scheduled to follow in 2022.

These 3GPP releases address the technical specifications required to meet three main pillars of 5G capability, specifically:

- eMBB (enhanced Mobile Broadband)
- uRLLC (ultra-Reliable Low Latency Communications)
- mMTC (massive Machine Type Communications)

With these specifications in place, operators and manufacturers can develop products that are interoperable across the globe, an essential prerequisite in the deployment of IoT devices and infrastructure.

Fibocom is at the forefront of IoT product development, with 5G communication modules that are 3GPP-R16 compliant already, meeting diverse use cases from Industrial IoT (IIoT) to Telemedicine and Fixed Wireless Access (FWA) applications.

Setting the stage for mmWave

Beyond standardized technical specifications, mmWave functionality requires the development of key infrastructure components. Though 5G can, and does, currently run on existing 4G LTE architecture, unlocking the full potential of mmWave requires dedicated 5G architecture.

How will 5G mmWave be deployed as NSA and SA technology?

Non-standalone (NSA) 5G leverages the advantage of existing network infrastructure, such as base stations, to deliver a workable 5G product in the short term. In practical terms, this means operators can be early to market with offerings that realize some of the potential of 5G, without requiring costly infrastructure overhauls. This solution is suitable in the short term, but future massive data requirements are set to outstrip existing networks.

Advanced use cases for 5G will require standalone (SA) architecture, bringing into play the full capabilities of 5G mmWave – providing the basis for true uRLLC, eMMB and mMTC. Unlike 4G LTE, 5G mmWave technologies and networks are also designed to be cloud-native, providing speed and agility when upgrading, changing or adding services.

Technological Developments Supporting 5G Deployment

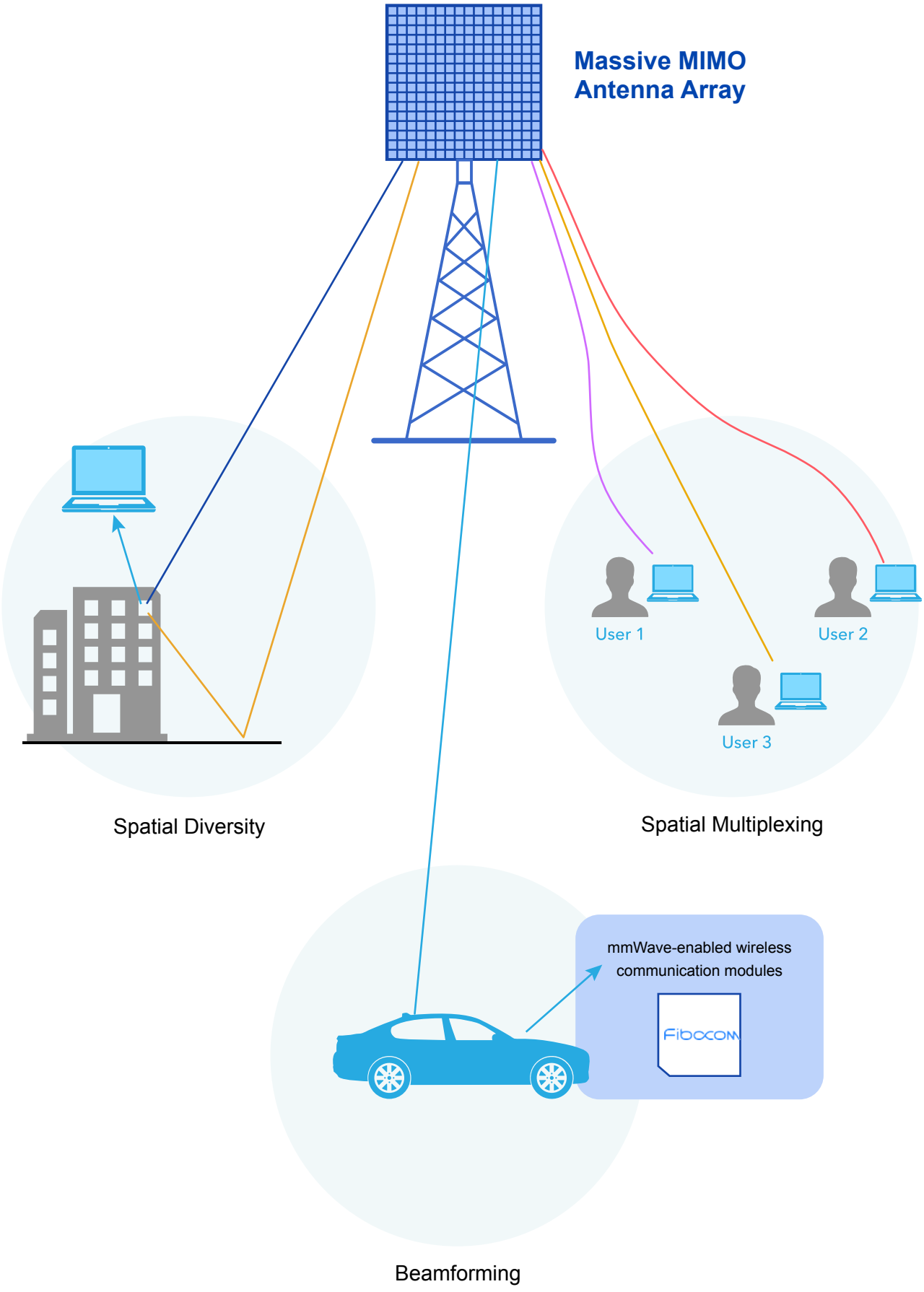


Figure 2.

Figure 2. highlights some of the key developments that support dedicated 5G architecture. These include:

Massive MIMO (multiple input, multiple output)

Using a larger array of small antennas on the base station, throughput and efficiency increase to true 5G capability. Smaller but more regularly spaced cells will add to these gains.

Spatial diversity, spatial multiplexing and beamforming

Spatial diversity (sending the same data by multiple paths), multiplexing (techniques for sending multiple packets of data in one signal without interference), and beamforming (focusing a wireless signal to reach one device or user), will be crucial aspects of future 5G functionality. Beamforming in particular can help track “moving targets”, such as vehicles, which require ongoing uRLLC in automated modes.

mmWave-enabled wireless communication modules

IoT devices, including cellular equipment, will also need to be equipped with 5G mmWave-enabled communication modules. For businesses, this will open up new possibilities for data usage on-the-go, with large file sizes and data-hungry applications no longer restricted by wireless usage.

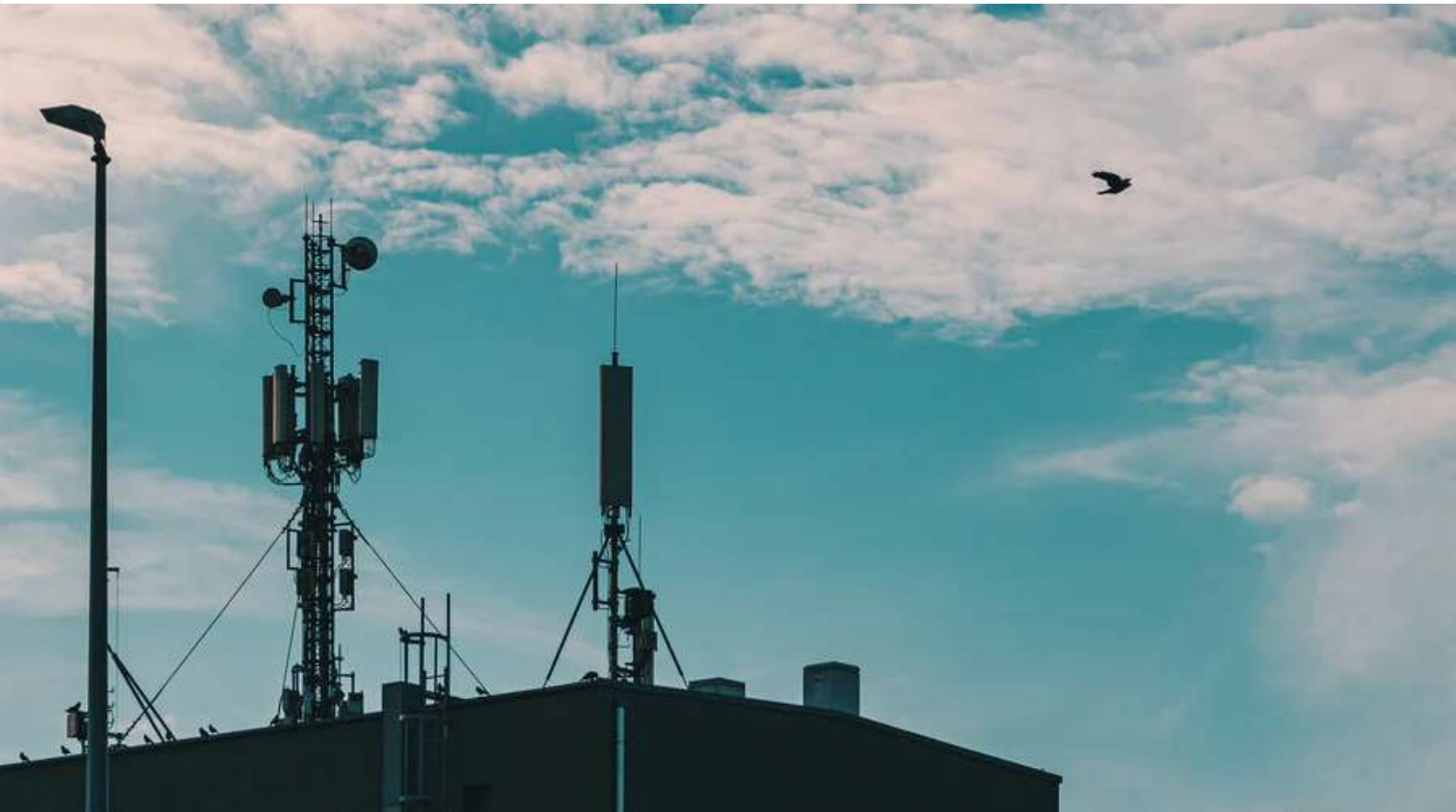
Limitations and challenges of mmWave

5G mmWave deployed at scale holds exciting new possibilities for wireless communications and the full spectrum of IoT use cases, but there are several limitations imposed by short wavelengths in high-frequency bands.

Most significantly, mmWave signals operate over very short ranges, typically around 500 meters, making it challenging to provide adequate coverage. mmWave also faces significant challenges in terms of line-of-sight, with common building materials and foliage blocking the signal.

These properties mean that cells are typically short-range and will need to be densely deployed to provide continuous coverage. There are also concerns around high energy usage by extensive, massive MIMO mmWave cells.

The increased infrastructure requirements make it challenging and costly for operators to install mmWave-exclusive networks, and represent one of the bigger obstacles in the way of full-scale deployment. Because of this, many networks currently integrate 5G into their existing 4G LTE infrastructure, but true SA 5G is still a necessity for many future IoT applications.



How are companies rising to the mmWave challenge?

Despite these challenges, several pioneering companies are investing significantly into the design of next-generation equipment and networks, working to make 5G mmWave a reality. These enterprises recognize the opportunity on offer and are positioning themselves to be first to market with true 5G capable offerings.

Telecom Operators

Several operators have already snapped up massive bandwidth in the mmWave range, with big players like Verizon and AT&T securing licenses for billions of dollars worth of spectrum. Both operators already offer limited 5G mmWave services. A synergistic approach, where low- and mid-band 5G offerings bolster mmWave's capabilities, is one way to overcome the trade-offs between bandwidth and signal propagation that occur in different portions of the spectrum.

Telecom equipment vendors

Major telecom equipment vendors have also been quick on the uptake. The December 2021 GSA report[1] indicates that 57 vendors are already producing 5G mmWave devices, with phones and Fixed Wireless Access (FWA) CPE making up the lion's share of offerings. Companies like Ericsson are also pushing the boundaries of this technology, with a recent trial by the company achieving high data speeds on the 26 GHz frequency over a distance of 7km.[2]

Chipset companies

A key component in the mix has been research and development partnerships between chipset companies like Qualcomm and MediaTek, industry giants like Intel, and IoT wireless module pioneers like Fibocom. In 2021, Fibocom released Sub-6 5G modules for PC in partnership with Intel and MediaTek, and dedicated 5G mmWave modules in partnership with Qualcomm.

Footnote:

1. December 2021 GSA report
2. Leveraging the potential of 5G mmWave

Fibocom's mmWave test systems

Fibocom also contributes expertise in terms of testing and calibration services and equipment for mmWave deployments. Unlike Sub-6 and LTE RF tests, which require conducted testing, mmWave RF testing is entirely OTA (Over-The-Air). Fibocom has already established a full set of test systems and calibration services that address this shift to the more demanding testing conditions of direct OTA antenna coupling, increasing the ease of mmWave deployment.

Industry partnerships and technical deployments that rise to the mmWave challenge will be a key part of the process of building out 5G mmWave infrastructure and capabilities and powering future IoT developments.

Powering up IoT functionality

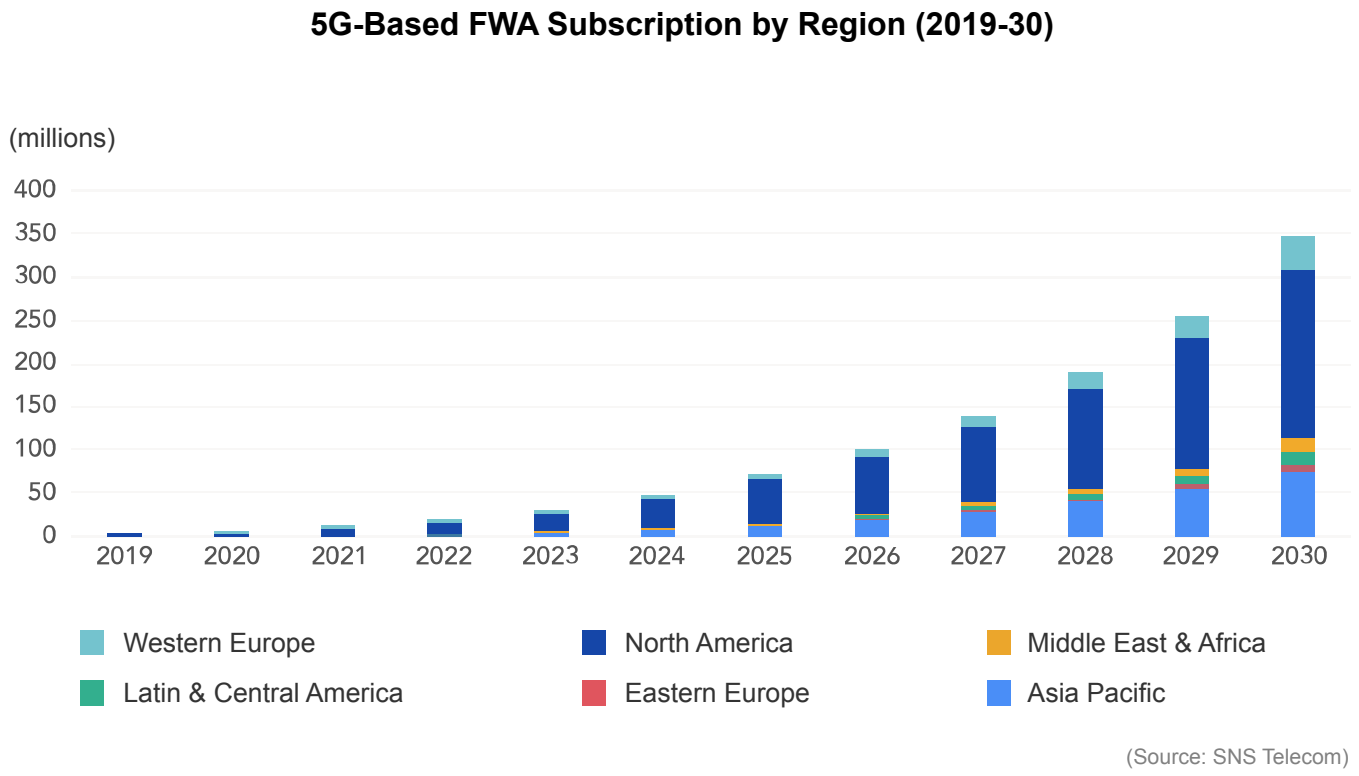
The speed and reliability of 5G connections enables IoT devices to communicate and share real-time data in ways previous network generations have never been able to. This pivotal shift is set to become the backbone of the IoT, powering up a range of new applications and use cases.
From how we do business, to automation in industry and online gaming, IoT will be ubiquitous, powering never-before-seen connectivity and massive data consumption. Ultra-fast, ultra-low latency 5G mmWave bandwidth presents an exciting opportunity to realize the potential of IoT and unlock a multitude of new use cases.

5G FWA market trajectory

The market for these new data services is growing rapidly. Current estimates project a total value for 5G FWA of US$46 billion by 2026[3], placing 5G services in pole position to disrupt existing broadband offerings.

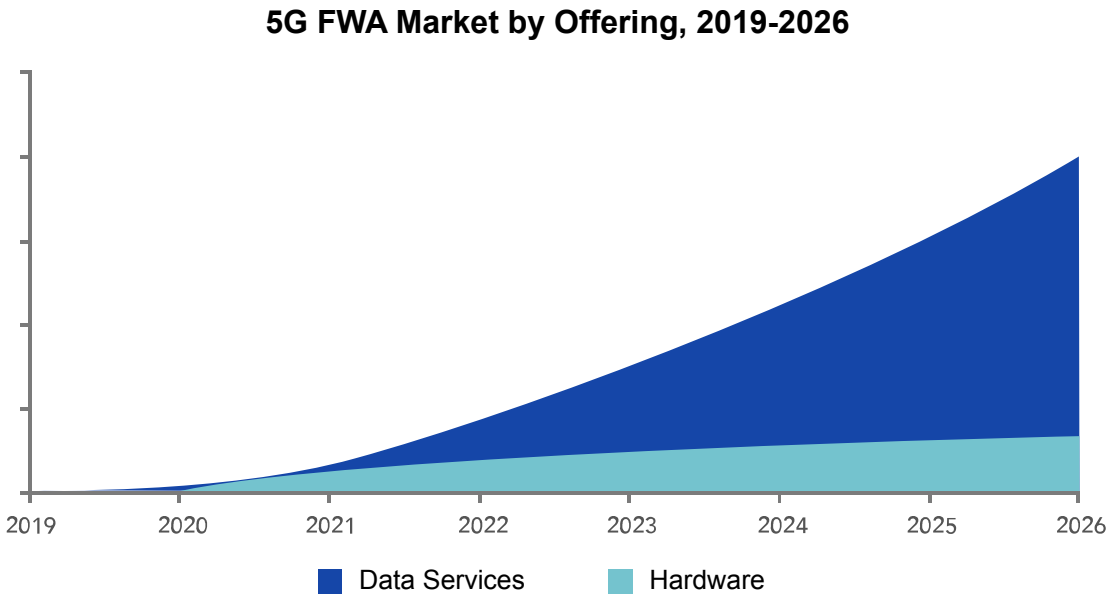
Footnote:

3. Bloomberg press release



(Source: SNS Telecom)

Figure 3.



(Source: Mircowave Journal)

Figure 4.

Figures 3 and 4 show the massive growth predicted for 5G FWA services in each region, with data services generating most of this value.

Fixed Wireless Access (FWA)

5G fixed wireless access broadband, for home and business, is a frontrunner in the application of mmWave technology. Current FWA solutions, using 4G LTE, are unable to provide the speed and experience of a wired connection, leaving users reliant on traditional fiber or DSL. 5G mmWave offers another solution, utilizing spectrum currently free of potentially conflicting traffic.

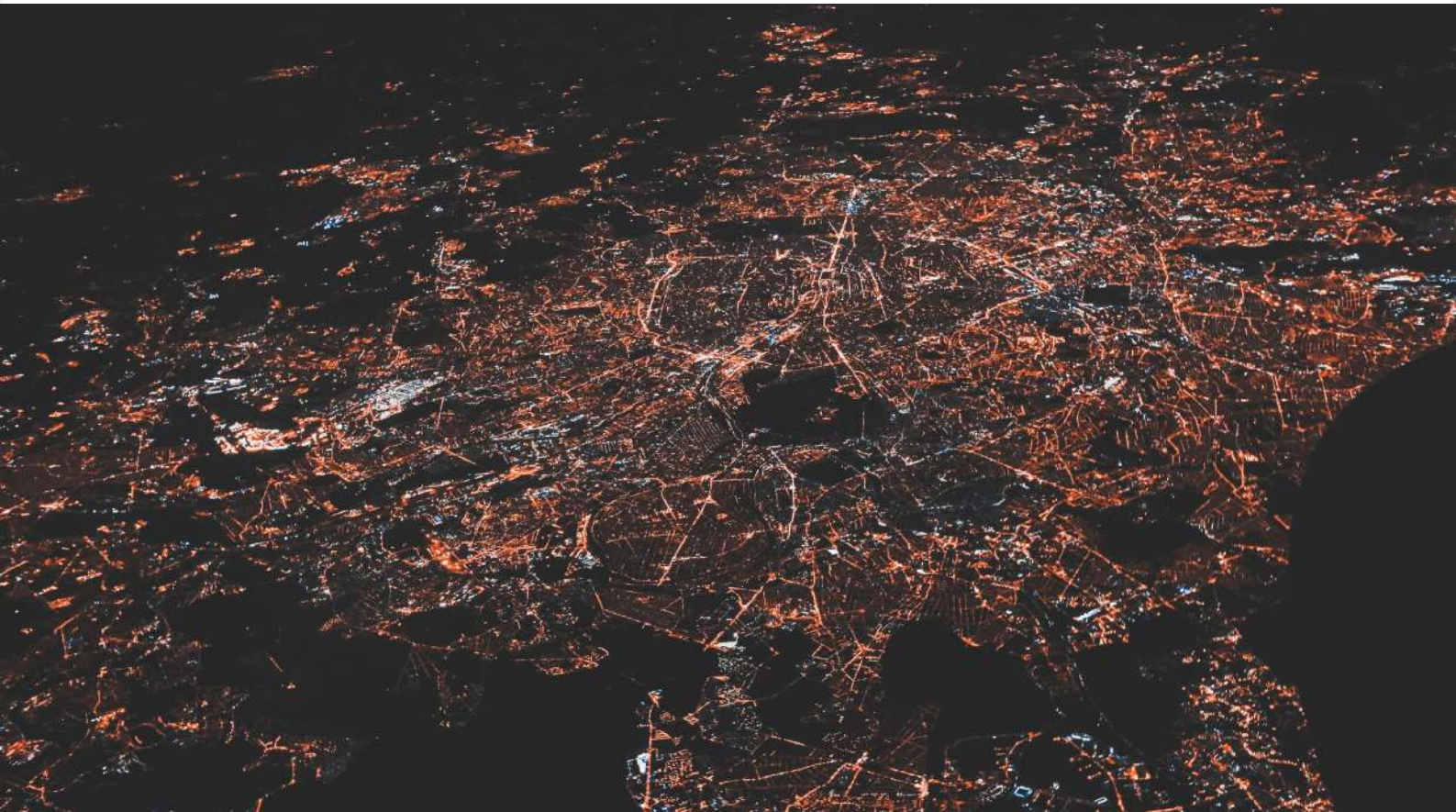
Thanks to the large bandwidth available, 5G users can expect high-speed services and low-latency, even when sharing the network with data-heavy devices and users. This places the value add of 5G FWA in sharp contrast to the low bandwidth, low-latency scenarios 4G FWA users often experience.

For network operators, 5G FWA presents an opportunity to launch offerings largely free of the data constraints of previous services, in tune with the new requirements of a work-from-home workforce.

Where can 5G mmWave FWA be deployed?

Using consumer or industrial 5G CPE (Customer Premises Equipment), mmWave-based FWA services can be deployed for both home and business usage. 5G mmWave also holds the potential to solve many Last Mile challenges, providing data connectivity to underserved markets in suburban and even rural areas. This circumvents the need for costly fiber installations, making 5G FWA an attractive proposition for both users and operators.

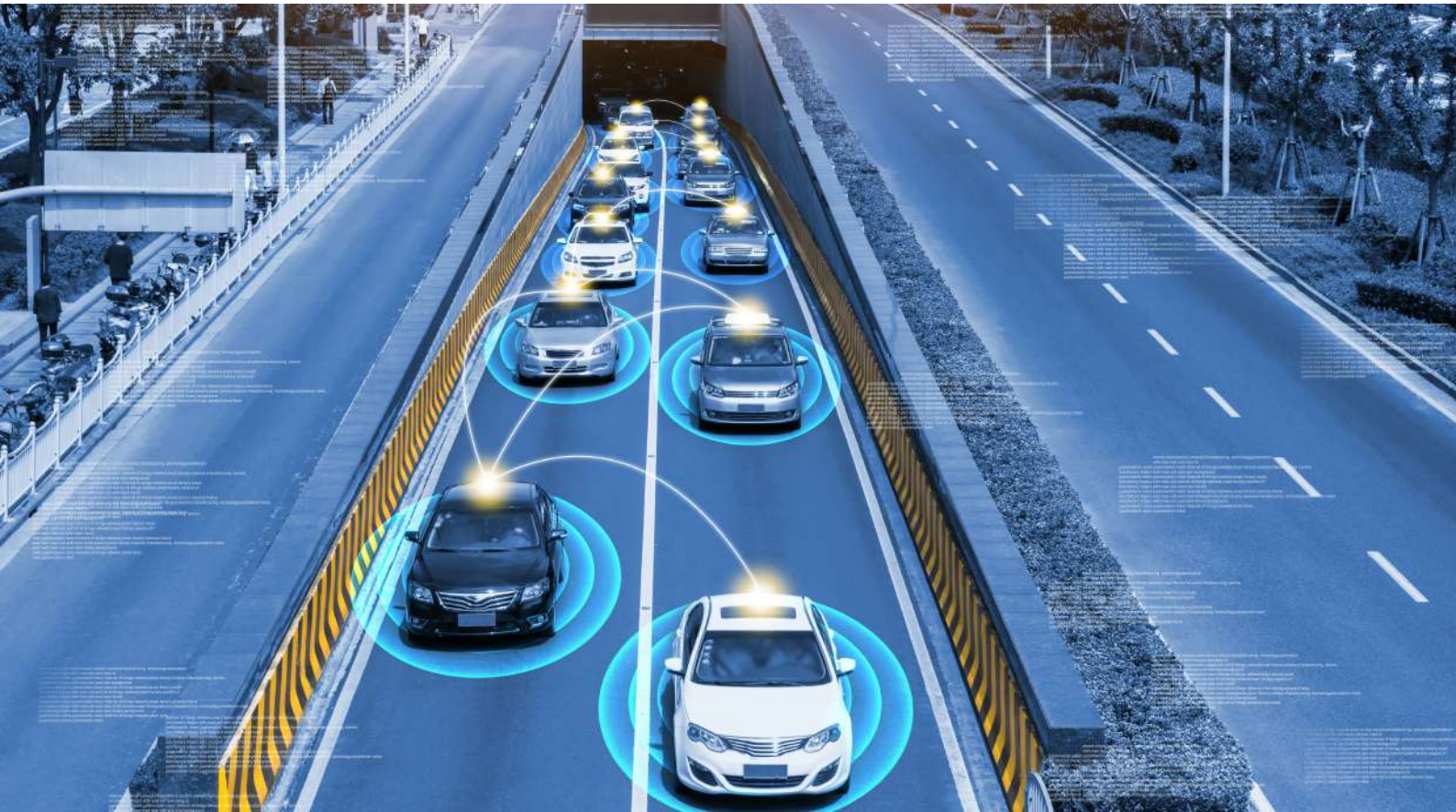
Fibocom's 5G modules are a key player in this deployment, enabling excellent indoor coverage, while delivering on the promise of high-speed, low-latency services.



C-V2X (Vehicle-to-everything)

Mission-critical applications, like automated and safety-assisted vehicles, will rely on 5G FWA to provide ultra-reliable, low-latency connections. Beamformed communications in the mmWave range support even the most demanding uRLLC requirements, where devices are required to provide millisecond latency. C-V2X enabled vehicles will therefore be able to communicate in real-time with virtually everything in their environment, from other vehicles (V2V), to road-side infrastructure (V2I), cloud services (V2C) and even pedestrian devices. Global Navigation Satellite Systems (GNSS) are also enhanced by this technology, with vehicles able to communicate with each other for safer, cooperative positioning.

These developments pave the way for the fully integrated Internet-of-Vehicles (IoV), with smart cars and smart roads providing an overall safer commuting experience.



Industry 4.0 and Industrial AR

Industrial IoT will revolutionize the manufacturing process, introducing enhanced automation and the benefits of uRLLC and mMTC to power Industry 4.0. Streamlined operations, real-time remote control, energy efficiency and flexibility are just some of the benefits 5G mmWave is set to bring to this sector.

Detailed Digital Twin models of buildings, production processes and workflow will provide operational data that businesses can use to trouble-shoot solutions long before physical infrastructure is built out.

With physical infrastructure in place, the industrial inspection process is also supported through Augmented Reality (AR). AR documentation, data-capture and imaging during construction inspections allow information to be rapidly shared between stakeholders, pre-empting costly structural and safety errors.

Entertainment and hyper-connected environments

Immersive AR and VR experiences

mmWave will enable transformative AR and VR applications for Cloud Gaming and 3D Virtual Worlds, opening up rich new streams of revenue in virtual space. As we launch into the era of metaverse-type environments, users will benefit from instant connectivity – providing a smoother experience while working or playing in virtual space.

Seamless wireless in massive venues

Another important use case is public spaces with thousands of connected users and devices, like airports and stadiums. The data demands and massive bandwidth needed in these venues will be easily met with 5G eMBB, allowing users to freely stream and access information, and supporting the event experience with on-demand data and services.

Fibocom's 5G communication modules

Fibocom's 5G modules enable the full suite of advanced IoT solutions, from industrial monitoring to AR/VR, smart cities and FWA PC and cellular connectivity. Our 3GPP-R16 compliant 5G modules tap into the possibilities of mmWave for faster, seamless connectivity up to 10Gbps.

FM160 and FG160

- Air Interface: 5G, 4G, 3G
- 5G NR Sub-6 band compliant with 3GPP release 16
- High data throughput for use with cellular terminals such as CPE, STB, IPC and ODU
- Supports multi-constellation GNSS receiver for high-performance positioning and navigation
- eMBB and low-latency service for IoT, FWA and other massive data requirement scenarios

FG360

- Air Interface: 5G, 4G, 3G
- Supports 5G SA and NSA network architectures
- 5G NR Sub-6 band, compatible with LTE and WCDMA standards
- High-speed performance designed for gateway, industrial monitoring, VR/AR and drone control

FM350

- Air Interface: 5G, 4G, 3G
- Multimode 5G NR Sub-6, with fallback to LTE and WCDMA
- Ideal for use with PCs, IoT gateway and routers

FM150 and FG150

- Air Interface: 5G, 4G, 3G
- Supports 5G SA and NSA network architectures
- 5G NR Sub-6 band, compatible with LTE and WCDMA standards
- High-speed performance designed for gateway, industrial monitoring, VR/AR and drone control

A perfect wireless experience with mmWave for IoT

Fibocom, in partnership with other industry innovators across the globe, is dedicated to the continued development of innovative IoT technologies. Fibocom's 5G communication modules are on the forefront of this new frontier, delivering the speed and low-latency that are prerequisites for a truly IoT-enabled world and a smart, sustainable, interconnected future.

Get started with Fibocom

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