5G Fixed Wireless Access

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01.

Introduction

Broadband access is vital to socio-economic development. However, deploying wireline broadband networks requires high capital expenditure and mid to long term investment. In particular, few hundred meters of last mile deployment has been a major obstacle for wireline broadband technologies. A solution to this time consuming and costly last mile deployment is Fixed Wireless Access (FWA). FWA is an innovative solution which enables easy and rapid deployment of broadband networks. It allows carriers to meet the increasing demand for high speed broadband services time to market and more cost-effectively.

FWA solution using LTE or WiMAX has been around for many years but its speed is not nearly as fast as other high speed broadband solutions such as fiber. Fortunately, with the introduction of 5G and abundant swaths of under-used, high frequency millimeter waves (mmWaves) above 6GHz, the speed of FWA is now comparable to fiber. In addition, technology advancement has made even below 6GHz spectrums more feasible for fixed wireless by applying massive MIMO technologies. Using below 6GHz band, wider coverage can be achieved which makes it suitable to cover rural areas.

Depending on each operator's spectrum assets, either or both below and above 6GHz spectrums can be utilized to provide 5G FWA service as a competitive solution for superfast broadband network.

[Concept of 5G Fixed Wireless Access]

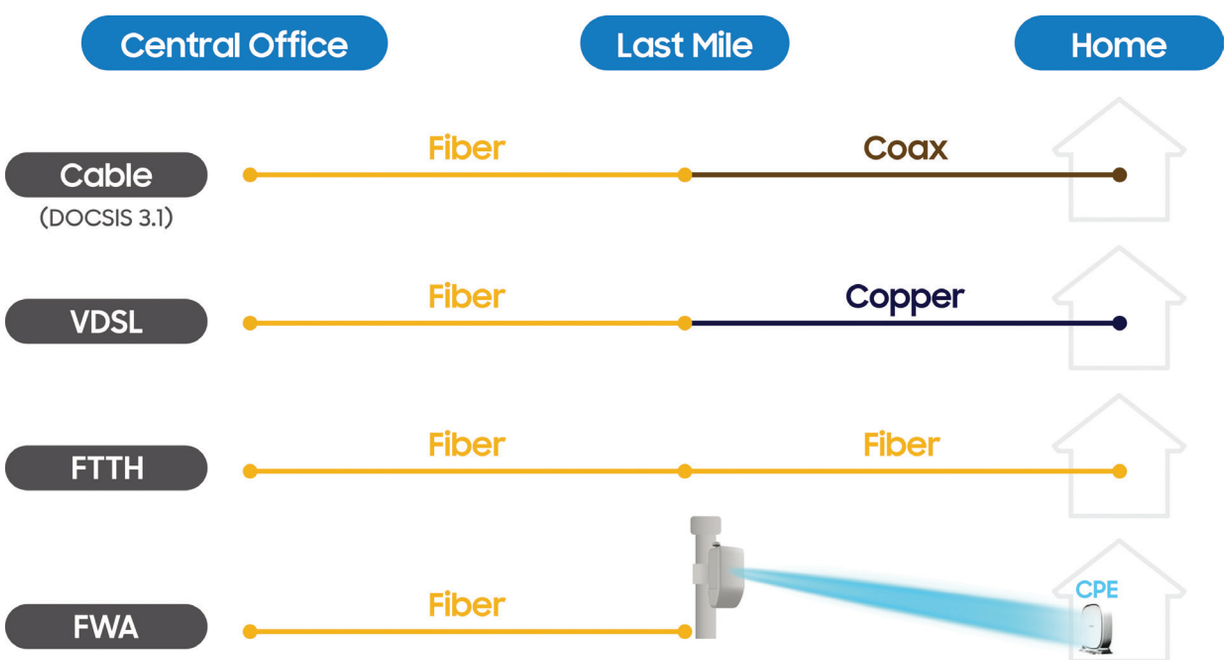
From a technology perspective: A cost-effective last mile solution

Perhaps the most compelling aspect of FWA is its potential to transform the last mile and greatly reduce the burden for Network Service Providers (NSPs) and subscribers alike.

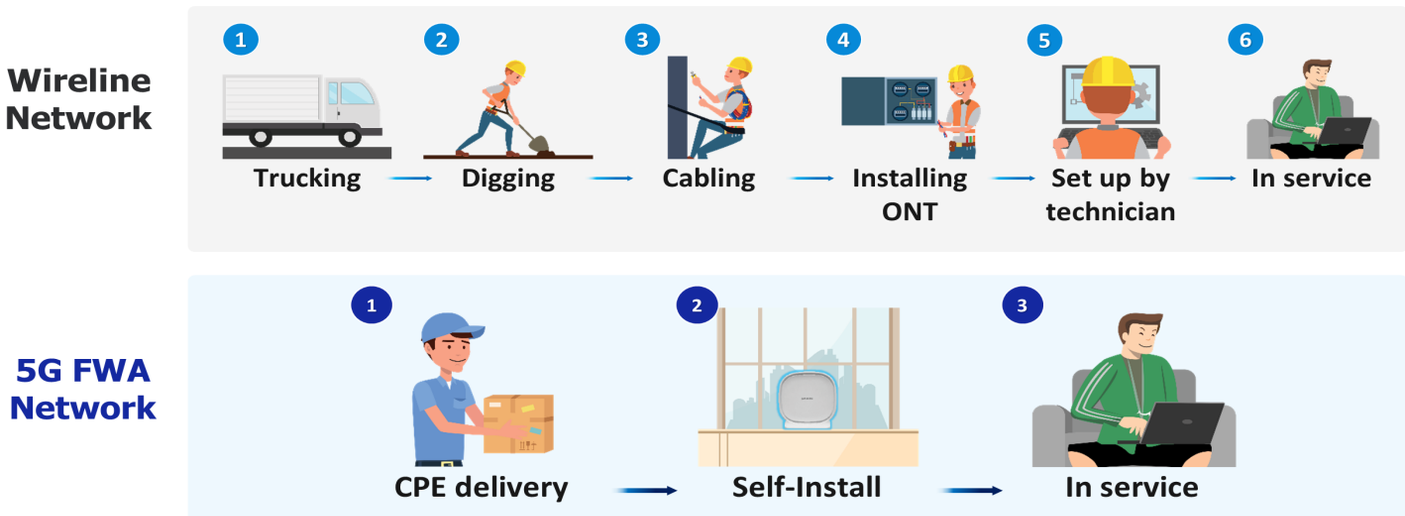
Deploying fibre is hard. It requires a significant outlay in terms of time and capital, as well as considerable strategic planning, understanding of legal frameworks at multiple levels of government and a considerable amount of available labour. Broadly speaking, there are two phases to any localized fibre deployment: the "pass" – in which fibre is laid through or nearby a target neighbourhood or district – and the "drop" – in which the fibre is laid down in the "last mile" connecting the "passing" fibre to the subscriber's home. Regardless of the delivery technology chosen – whether VDSL, DOCSIS 3.1 or FTTH – the "pass" is largely unavoidable. Due to the distances covered and capacities required for backhauling, fibre is really the only option.

In reality, it is the "drop" where deployment challenges really take shape. Construction permits, contracted labour and trench digging need to be arranged on a per sub-scriber basis in order to physically deliver service at subscriber homes, and thus these costs cannot be shared.

In many markets, operators need to work with national, regional and municipal government at different stages in order to obtain necessary construction and deployment permits for equipment along the way. This whole process can take days to weeks whereas for FWA it takes only several minutes.



By deploying Access Units (AUs – the 5G base station) on utility poles or building rooftops in close proximity to the passing fibre backhaul, a neighbourhood or district can be blanketed with high-density, high-capacity (multi-Gbps) wireless coverage. After activating a subscription, users simply place a 5G customer premises equipment (CPE, analogous to a DSL or cable modem) in a window near the AU, and they are online instantly. Subscribers can enjoy a broadband experience just as they would with FTTH, without the hassle of paying (and waiting) for a contractor to dig up their front lawn to bury a physical fibre line to their home.



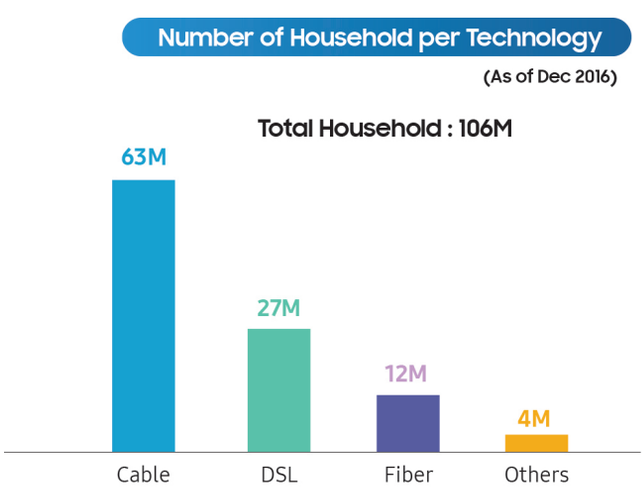
Greatly Reduces CAPEX/OPEX, Deployment Times (Weeks → Days)

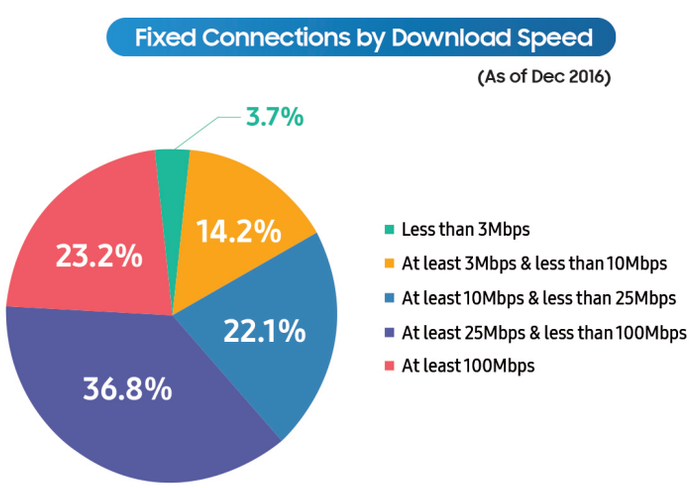
Additionally, as will be explored later in this paper, this opens up significant new opportunities for operators to expand their FWA infrastructure deployments into additional new use cases, by leveraging additional, unused wireless capacity for new services and new devices.

Broadly speaking, FWA provides significantly lower barriers to entry into the broadband market as compared to FTTH, while providing a robust and flexible network access layer to jumpstart future service opportunities.

From a market perspective: accelerating the pace of innovation in the wireline broadband market

The main interest in current 5G FWA has come from the USA. Major US operators such as Verizon and AT&T have particular reasons to be interested in 5G FWA. About 80% (106M) of the 134M housings units in the US have access to broadband internet however only 23% of US housings units have access to superfast broadband networks with speeds over 100Mbps. It implies there is a growing needs for higher speed broadband networks and opens the door for new players. With 5G FWA, the high cost of entry into the market would no longer be an obstacle for new entrants and the technology could help bridging the digital divide.





(Feb 2018, Internet Access Services report, FCC)

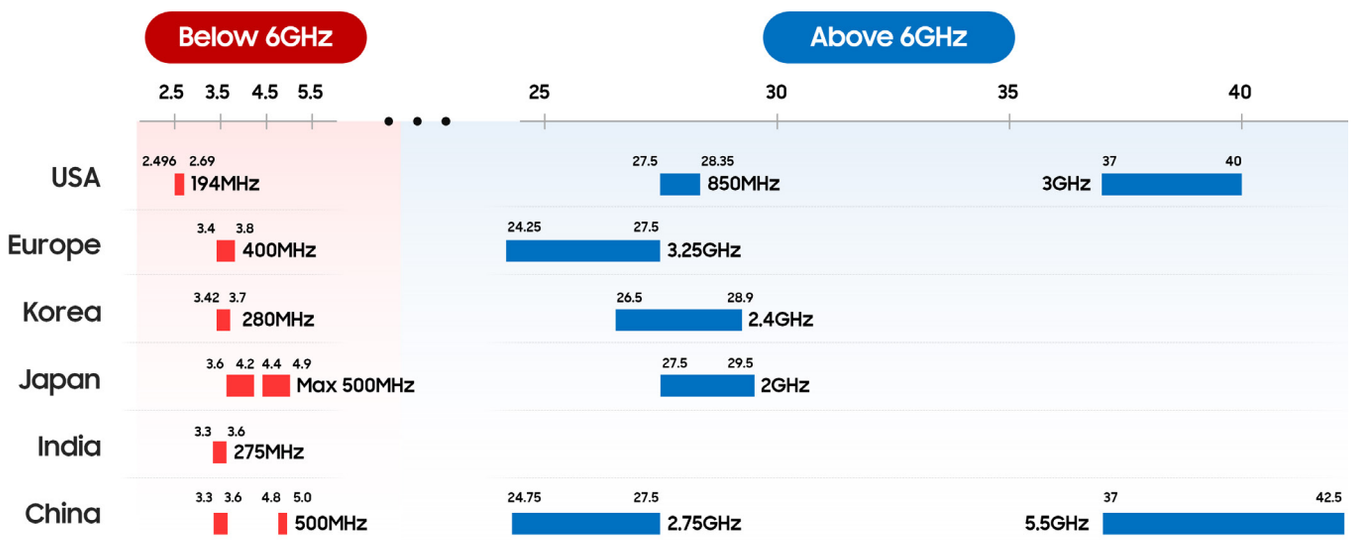
02.

FWA Spectrum and Standards

28 GHz Spectrum to Lead Early FWA Deployments

For decades mobile networks had been confined to a relatively narrow band of the radio spectrum generally between 600MHz and 2600MHz – a total space of about 2GHz.

Hence at least for the short-term, sub-6 GHz spectrum deployment remains an unfeasible concept for FWA due to bandwidth insufficiency. The mobile industry has turned its head to find a new territory and the most discussed "above 6 GHz band" for 5G today is 28GHz – which has been permitted for use in the US and South Korea. The spectrum has emerged as the preferred band for the very first deployments of 5G-based FWA networks. However, other options such as 26 GHz and 39GHz that are discussed primarily in Europe and the US respectively – are also being actively explored.



Many countries such as the US, Europe, Korea, and Japan have recently announced their 5G spectrum strategies, showing that the year 2018-2020 is the right time for 5G commercial systems deployments using mmWave bands. In line with this, it is expected that 5G commercial services be initiated with FWA in the US.

In the US, it has been announced by FCC that its policy and technical regulation (July 2016) outline the use of 28 GHz (27.5-28.35GHz), 37GHz (37-38.6 GHz) and 39GHz (38.6-40 GHz) for 5G. FCC Chairman Ajit Pai said he wants to hold an auction for 28 GHz spectrum in November 2018.

On the other hand, in Europe, EC has announced that the 26GHz (24.25-27.5 GHz) band is to be labeled as the "pioneer bands" for 5G in November 2016. In particular, UK's Ofcom has proposed that it will release its upper band (26.5~27.5GHz) prior to WRC'19, during their Call for Input 2017. Ofcom confirmed that it will commence an auction of 150 MHz of spectrum in the 3.4 GHz band for future 5G mobile services on Mar 20, 2018.

South Korea has completed auctioning off 5G spectrums on June 18, 2018. 280MHz bandwidth of 3.5GHz spectrum and 2400MHz of 28GHz spectrum were given to three operators. SK Telecom and KT each won 100MHz of the 3.5GHz spectrum, while LG Uplus clinched 80MHz. All three telcos secured 800MHz of the 28GHz spectrum. In Japan, MIC has published its final report on the 2020 Japan Radio Policy in July 2016 with a specific regard to their 5G candidate spectrum bands, including the 28 GHz band to be used for 5G commercial services realization in 2020.

As for other parts of the world, IMDA of Singapore, MIIT of China and ISED of Canada have all released their public consultation papers in 2017 to acquire industry perspectives on 5G spectrums, including 28 GHz.

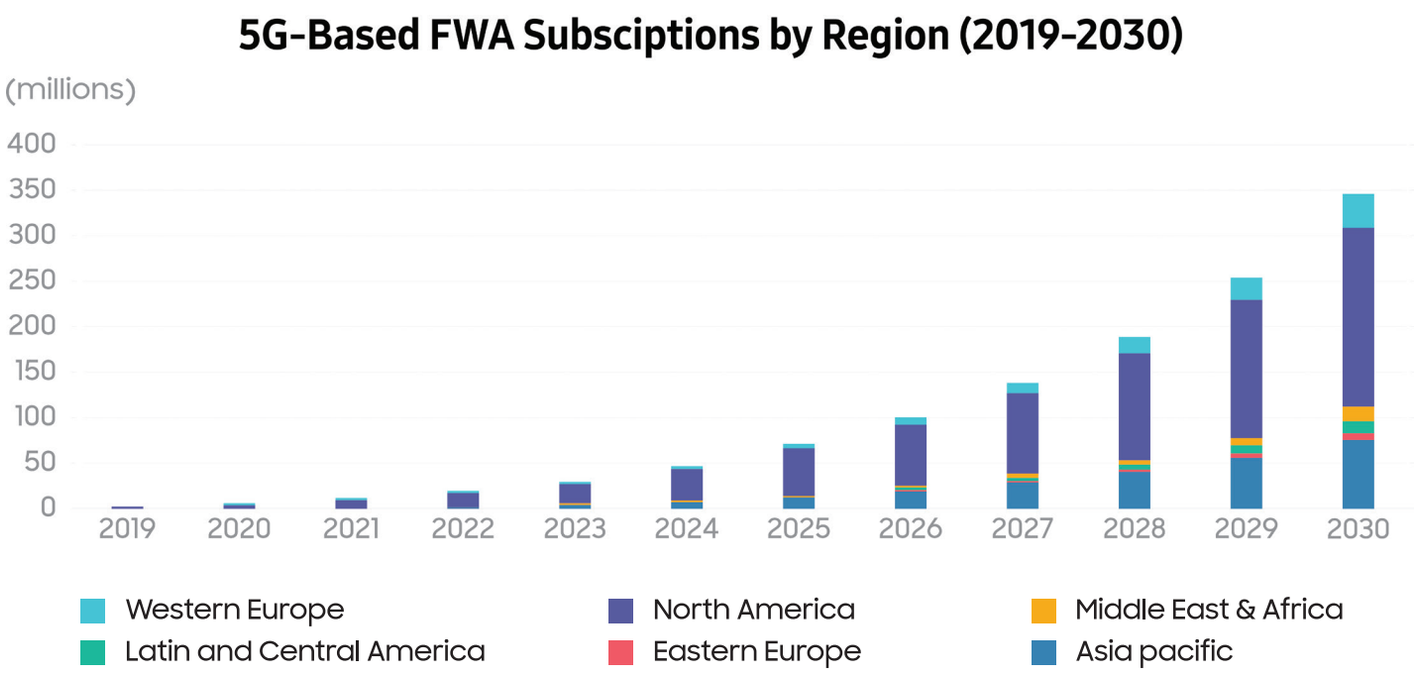
FCC : Federal Communications Commission, EC : European Commission, MSIP : Ministry of Science and ICT
MIC : Ministry of Internal Affairs and Communications, IMDA : Info-communications Media Development Authority
MIIT : Ministry of Industry and Information Technology, ISED : Innovation, Science and Economic Development

03.

3. Global Outlook for 5G FWA Services

5G FWA Subscriptions and CPE unit shipments by region

According to SNS Telecom, North America will be a benchmark for fast growing 5G FWA market in aspects of subscriptions and unit shipments. In 2030, the total number of 5G FWA subscriber will be almost 345 million and there will be 200 million subscriptions in North America.



(Source : SNS Telecom)

In the U.S., Verizon has rolled out its pre-standards 5G network footprint across 11 cities for trials of a FWA service. Verizon has announced its intentions to fully commercialize this offering as early as 2018. AT&T, also, is offering a 5G-based FWA service to select participants in residential, small business and enterprise locations, initially in Austin, Texas. As of Q3'2017, AT&T is expanding its trials to target both fixed and mobile applications, intended to track closely with the first 3GPP 5G NR specification. To help speed up its 5G rollout plans, the operator has successfully lobbied the 3GPP to finalize part of the 5G NR standard earlier in Q4'2017, instead of Q2'2018. While many industry analysts believe that 5G FWA is only suitable for densely populated urban areas, a number of rural carriers – including C Spire and U.S. Cellular – are beginning to view 5G as a means to deliver last-mile broadband connectivity to underserved rural communities. SNS Research expects that 5G-based FWA CPE unit shipments will grow at a CAGR of more than 57% between 2019 and 2025, eventually accounting for over 25 million unit shipments by the end of 2025. They expect these device unit shipments to generate nearly $4 billion in sales revenue. Broadband internet access for both residential and business environments is the primary application scenario for 5G-based FWA.

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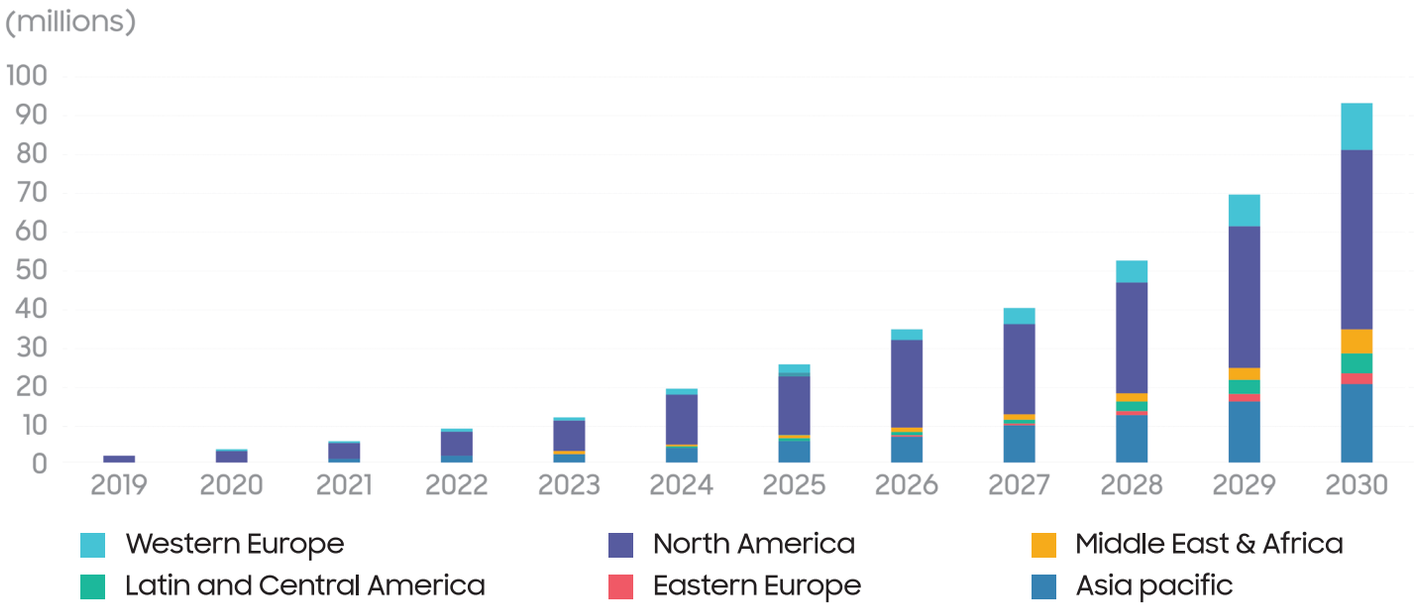
5G-Based FWA CPE Unit Shipments by Region (2019-2030)

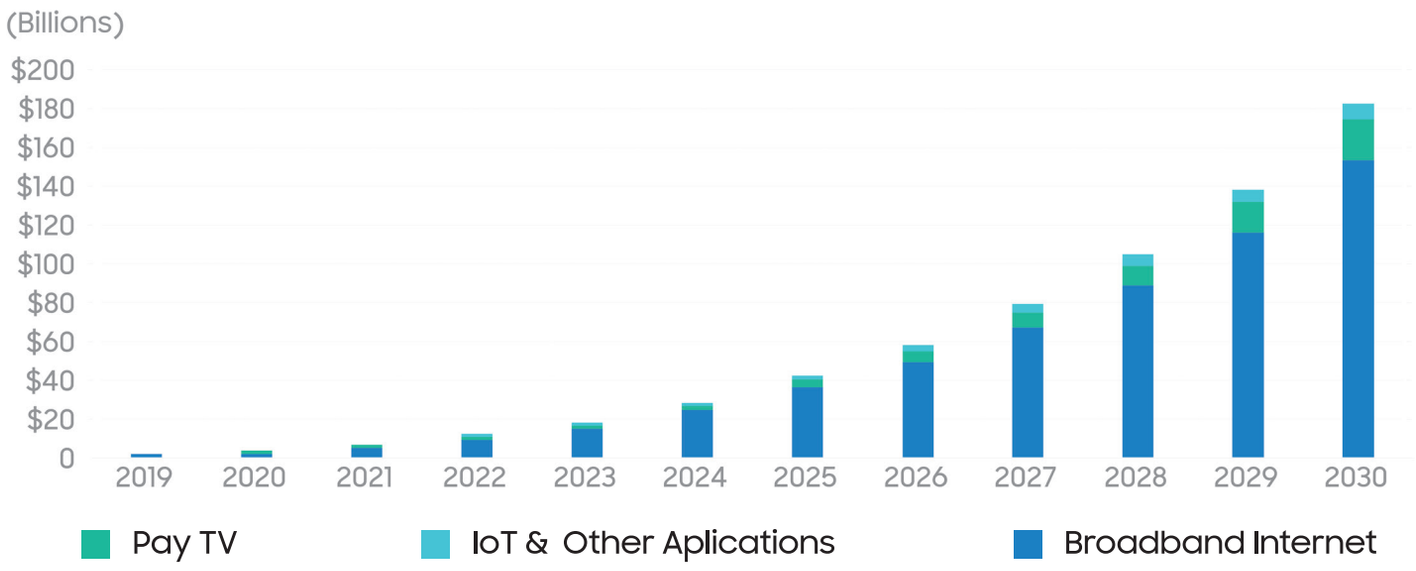


(Source : SNS Telecom)

Service Revenue

Broadband internet access for both residential and business environments is the primary application scenario for 5G-based FWA.

5G-Based FWA Service Revenue by Application Scenario (2019-2030)



(Source : SNS Telecom)

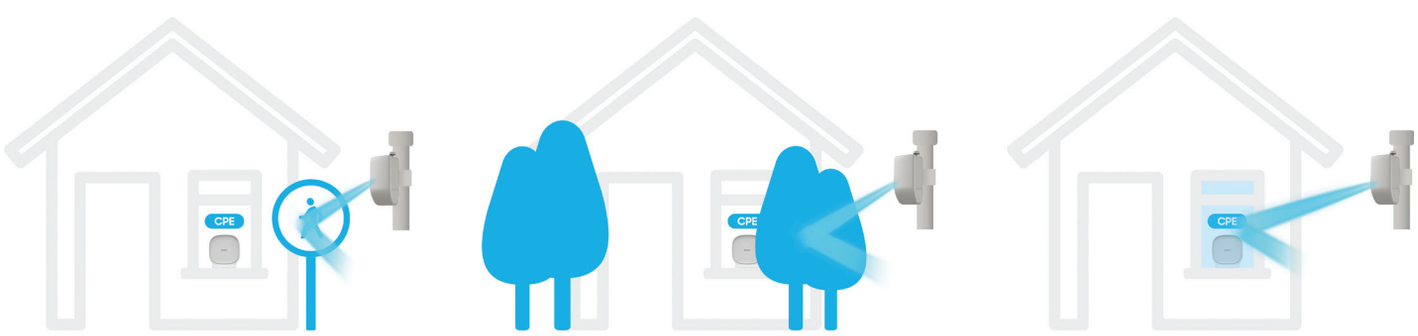
04.

FWA Technical Challenges and Solutions

Technical Challenges

The primary challenges with Fixed Wireless Access lie predominantly within the spectrum being used. In order to deliver a compelling alternative to today's wireline broadband, wireless solutions need to be able to meet capacity and throughput demands in line with common expectations for FTTH-type services. Due to the very limited availability of spectrum below 3GHz, mmWave (above 20GHz) remains the ideal target for FWA-type solution, and in turn, this means that we need new technology and tools to plan and deploy around the limitations of high frequency radio signals.

From Samsung's trial efforts throughout 2016 and 2017, the primary challenges identified include deployments with non-ideal line of sight conditions, high density tree foliage and certain types of glass designed to reduce thermal radiation (often referred to as low-emissivity, or low-e glass). In all cases, the primary consequence is greatly reduced signal quality, leading to significantly lower-than-expected throughputs and consequently a poor user experience.



Non-ideal line of sight conditions

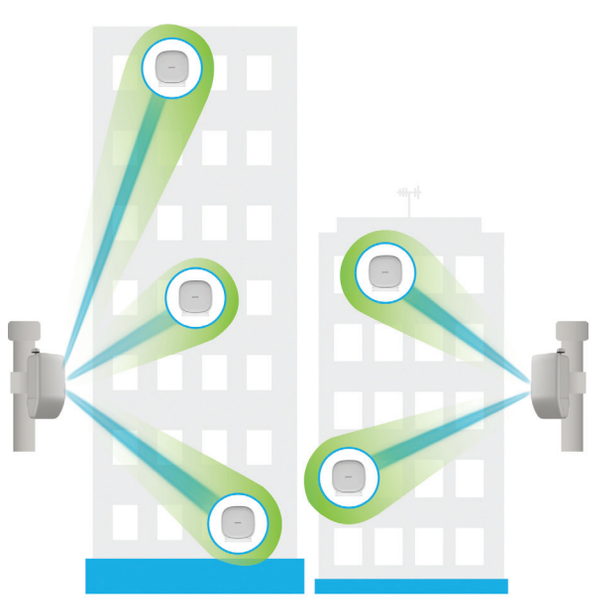
High density tree foliage

Glass designed to reduce thermal radiation

Technical Solutions

In order to overcome these challenges, Samsung has developed several key solutions that have demonstrated a high degree of success, greatly improving the viability of mmWave for high-throughput FWA applications.

First, Samsung has developed a technology called 'beamforming', in which we use advanced signal processing to physically shape the radio signal into a tight, flashlight-like beam that accurately targets each individual device. This allows us to confine the radio output energy into a small area, significantly extending the range and penetration capability of mmWavesignals. A stronger, confined signal can better penetrate foliage, and allows for clever manipulation of the beam, such as bouncing it off of surfaces in the environment to reach devices that don't have direct line-of-sight with the AU.



Beamforming

Second, in order to accurately simulate beam patterns in complex environments, Samsung has developed a specialized RF Planning software tool. The RF Planing tool is especially important in Fixed Wireless Access service because operators can easily identify 5G service availability in each geographic area. This can potentially save costs associated with dispatching technicians to areas with poor service availability by not subscribing customers in those areas and avoid customer disappointment.

Samsung will take map data of an environment from multiple sources including overhead satellite maps, 3D building maps and 360° street-level photography, stitch them together into a unified 'semantic map', and then use artificial intelligence to accurately simulate how mmWave radio signals perform and react with the environment.

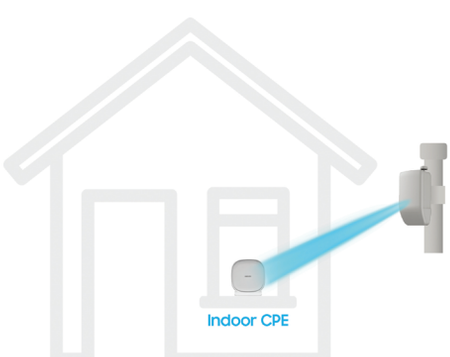
The tool uses machine learning to identify trees in the environment, building geometry and construction materials, and then uses ray tracing technology to simulate within a matter of minutes how radio beams bounce around the environment and reach potential devices.

3D RF planing tool

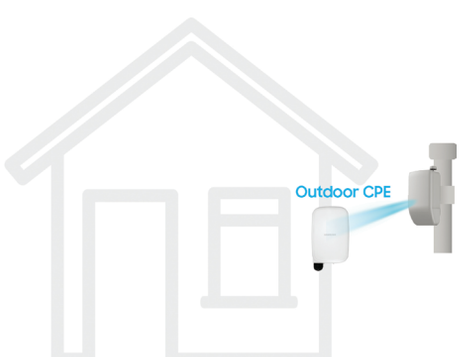
The tool replaces traditional drive testing methods, in which network planners physically drive through each neighborhood with expensive radio testing equipment – a labor-intensive process that can take days for a given neighborhood.

And last, in order to resolve situations where coverage cannot suitably be provided to a user's in-home 5G CPCPE (for example, if the only suitable window is not facing to the Access Unit, or a building or street furniture blocks ideal beam pathing), additional form-factor options are available, including an outdoor 5G CPE. A ruggedized, all-weather outdoor CPE can be flexibly deployed on a building roof or mounted to external facia, ensuring an ideal deployment location, and requiring only a short on-premises run of cable to connect to indoor Ethernet or Wi-Fi routing equipment.

Used in conjunction with one another, these innovative solutions are time and cost effective in resolving the inherent challenges of mmWave deployments. Additionally they help streamline the deployment process for Network Service Providers improving the economics of deploying fixed wireless access broadband service and enabling those consumers or business with limited or no service options with the latest ultra broadband capabilities.



Indoor CPE for Normal glass

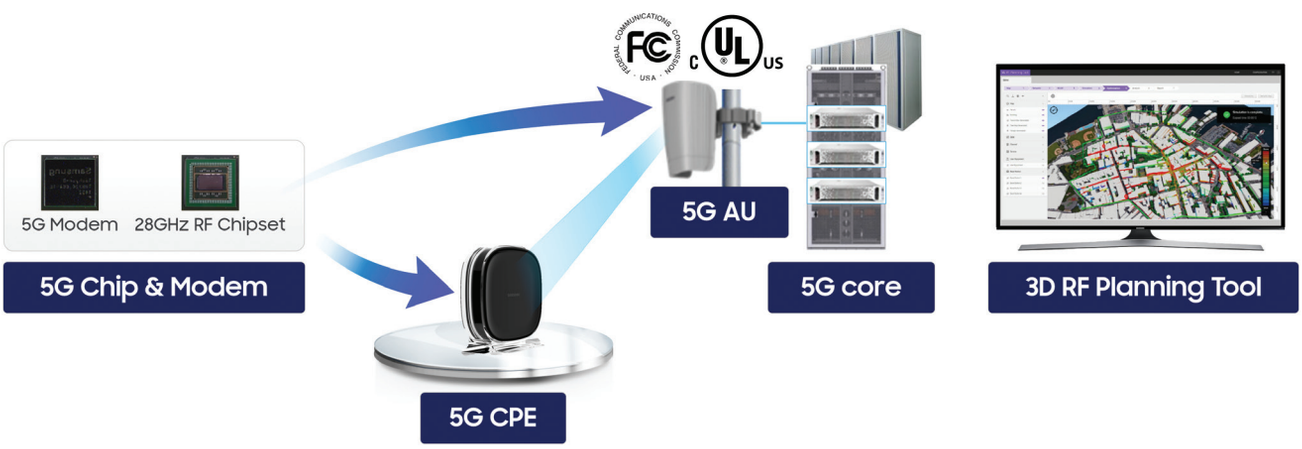


Outdoor CPE for Low-e glass

05.

Samsung End-to-end 5G FWA Solutions

includes: commercial form-factor 5G home CPEs for both indoors and outdoors, 5G Radio Access Network (RAN) comprised of a radio access unit and virtualized RAN, a next-generation core, as well as AI-powered 3D radio frequency planning tools and services. Using in-house technology and assets, Samsung has managed to develop the first commercial ASIC-based 5G modems and mmWave RFICs, enabling the design of compact access units and CPEs.



These products have already been proven through months of field trials in multiple markets. On February 23rd, the US Federal Communications Commission (FCC) granted authorization of Samsung's 5G access units. These are the first 5G millimeter-wave products in the world to secure government regulatory approval—a milestone achieved through close collaboration with the FCC's Office of Engineering and Technology

Radio Access

The key component of 5G radio access is the aptly named Access Unit (AU). Designed to be compact (11.6 litres, 9kg), yet robust, Samsung's AU aggregates the traditional Radio Unit (RU) and some of the lower layer MAC functions traditionally assigned to the Digital Unit (DU) into a single entity that can be easily mounted on a utility pole or installed on a building rooftop.

Each AU can leverage up to 800MHz of bandwidth simultaneously across eight 100MHz carriers, providing total peak capacity of up to 10Gbps. And due to the modified functional split between the AU and core network, backhaul bandwidth requirements match the radio link throughput – in other words, an AU set up to deliver the full 10Gbps requires only 10Gbps in fibre or copper backhaul to the unit.

In addition to implementing 4x4 MIMO, the AU takes advantage of Samsung's Hybrid Adaptive Beamforming technology, which uses a grid array of antenna elements, combined with specialized computer processing, in order to physically shape the radio wave into a flashlight-like beam that individual targets each device. This allows output power to be focused into a small area, overcoming the range challenges inherent with higher frequencies, and allowing individual beams to bounce off different surface in the environment to reach devices that are out of line of sight. Samsung has demonstrated gigabit throughputs at ranges of up to 2km in good conditions, with residential deployments more commonly dimensioned around densities of about four to six AUs per square kilometre, though this will depend on a wide variety of factors, including target service levels, building densities, tree foliage and environment topologies.

FWA Devices

With FWA serving as the pilot use case for the first 5G deployments, the device options centre primarily on Customer Premise Equipment (CPE). The CPE serves as the user terminal, receiving the 5G signal from the AU and providing Ethernet connectivity to the Local Access Network (LAN), thus the CPE represents the 5G equivalent of a cable or DSL modem.

Samsung's first generation commercial 5G CPE targets the same frequency band as the 5G AU (28GHz), implements 2x2 MIMO and supports up to 1Gbps peak throughput. As with the AU, a compact form factor was a key priority for product development. As observed in the earlier chapter, Samsung has developed a ruggedized, all-weather outdoor CPE for a low-e glass case or a case with poor window facing to the AU. Customers have a choice of deploying either indoor or outdoor CPE depending on their house environment.

Indoor CPE

Outdoor CPE

5G Core Network

Virtualization represents one of the most transformational aspects of next-generation networks: proprietary, fixed-use hardware is being replaced by individual software components designed to run on generalized IT server hardware. This separation of network functions and network hardware resources promises to change the way the industry approaches network architecture design and use case implementation.

It is important to recognize that this process is not exclusive to 5G itself, and the concept of a "5G Core Network" is somewhat fuzzy. It is more useful to think in terms of a virtualized Next-Generation Core Network that runs various network functions as individual applications, some of which are specific to managing the 5G radionetwork. In the same way, the traditional LTE core is in the process of virtualization in some advanced networks (including Samsung's own virtual Evolved Packet Core solution), and it's generally expected that these LTE and 5G core components will be deployed in parallel in many cases, in the same data centre.

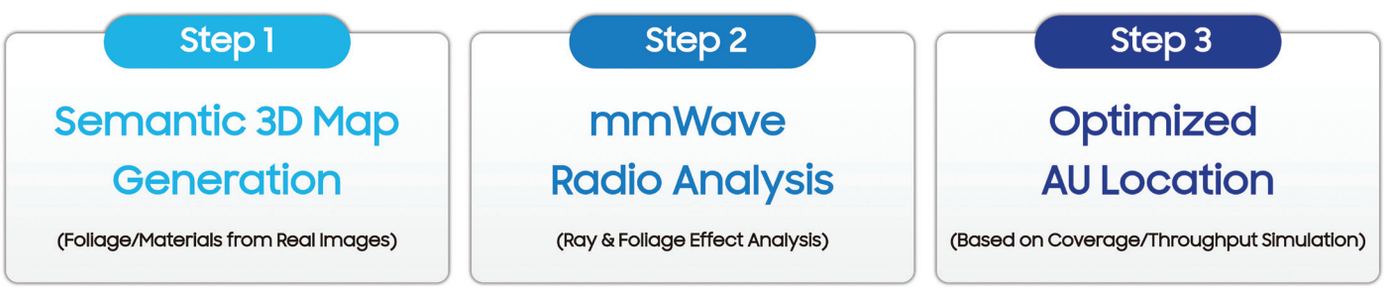
3D RF Planning tool

Network planning has traditionally been a challenging task, requiring countless man-hours, expensive in-field test equipment and physical access to deployment sites over periods of time measured in weeks. Poor network planning can easily lead to areas with poor quality coverage and even black spots where no coverage is available at all. This can be both time-consuming and costly to resolve, yet isn't always easy to foresee.

With mmWave and beamforming technologies, however, there are significant opportunities to drastically improve network planning processes using new approaches.

In order to leverage this, Samsung has developed a specialized 3D RF Planning tool which uses advanced radio propagation models, combined with detailed map data and extremely fast Graphical Processing Units (GPUs) to accurately simulate mmWave beamforming coverage in a given area on a scale of minutes to hours.

Starting with a Semantic Map, which stitches together map data from various sources (satellite overhead, 3D building and street view photography), the RF Planning Tool has been trained using machine learning techniques to build an accurate internal model of a neighbourhood that includes the location and geometries of buildings, trees, street furniture and windows. Using the Semantic Map, potential base station sites can be assigned and a process called Ray Tracing is then used to simulate RF beam patterns from each potential site throughout the environment. Ray Tracing, which involves calculating the paths of millions of different lines as they bounce off or penetrate different objects in the environment, is computationally very expensive – involving a type of mathematics that modern computer graphics cards are well-suited to handle.



Within a matter of minutes, an entire neighbourhood can be accurately simulated and ideal base station sites can be selected. From there additional tweaking can be carried out within the tool by experts in order to optimize the deployment based on individual service needs.

Today, the tool is designed to target FWA deployments that use mmWave radio access, but future development on the tool will explore applications for future mobility- and IoT-based service deployments, as well as sub-6GHz spectrum usage.

06.

Expanding Beyond FWA

True to the foundational goal of 5G, Samsung places significant emphasis on the ability to adapt early 5G FWA deployments for additional use cases with minimal additional infrastructure outlays.

One early concept that is now being examined is the implementation of a special type of device called a 5G Connectivity Node (CN). This device would function similarly to in-home CPEs in that it would provide a fixed wireless access point, but is being designed for deployment on street furniture such as utility poles. From there, the 5G CN would provide a wide variety of radio access technologies, such as WiFi, Bluetooth, Zigbee, etc., to local devices in the environment. These could include digital billboards, CCTV security cameras, public information displays and more. Essentially, the 5G FWA network evolves to additionally provide backhaul support to a wide array of commercial devices and third party services, without the need for LTE or 5G connectivity in the devices themselves.

5G will play a significantly greater role in services such as V2X, smart cities and commercial IoT. Many of the more advanced 5G use cases involve connecting previously unconnected or under-connected industries, and thus 5G is closely dependent on the progress of new, connected use cases in these industries. Operators will thus need to pace their 5G deployments in step with ongoing development and service/device evolution in these industries.

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About Samsung

Samsung is recognised as one of the leading and most enduring names in the world of mobile technology. For more than 3 decades we have championeddevelopments in the industry and played an integral part in the evolution of the mobile telecom sector. Our strong track record in innovation and manufacturing is matched with a history of financial stability, and an extensive globally-distribyted, skilled employee base. This combination of factors has lead to Samsung being the preferred partner of top-tier operators around the world. We are committed and active participants in key leadership bodies, helping to shape and regulate the industry.

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