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5G Fixed Wireless Access for fixed-grade gigabit services

White paper

To address customer, competitor and regulatory pressures, broadband service providers need to increase both service speeds and coverage. They are adopting different technologies for different service areas, always balancing potential service speed, cost and time-to-market, in order to provide ubiquitous ultra-broadband.

Fixed wireless access (FWA) technologies are – at long last – a viable tool in the toolkit, thanks to a combination of technological advances and shifting market trends. Mobile and converged communications service providers can use their licensed 4G and 5G spectrum in a “to-the-home” FWA solution to deliver ultra-broadband services to subscribers not just on the go but as a fixed-grade service in their homes.

This paper outlines the developments that make FWA a compelling option for residential broadband and the technological and deployment considerations for 4G/5GTTH.

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Introduction

In the world today, there are 713 million[1] broadband[2] households. That may sound like a lot but it, in fact, represents only 32% of all households. The clear majority of the world's homes do not have a reliable fixed connection to the internet and the benefits it brings. There are, of course, significant regional variations. Around 85% of North American households have a broadband connection while the figure for Africa and the Middle East is only around 7%. Even in Western Europe, 25% of households still do not have a broadband connection.

Then there are the many locations that are crying out for higher speeds. Only 7% of households enjoy speeds of 10 Mb/s or above. So even in 2018, it was clear that there was still a huge untapped opportunity for ultra-broadband even in developed countries.

The primary reason for these unserved and under-served populations is economics. The coverage gaps in urban and suburban areas tend to be the hard-to-reach locations where it is too costly to deploy a new broadband connection or upgrade an existing one for the few households it will serve. In under-served rural areas, it is more the challenge of generating sufficient revenues to make ultra-broadband investment commercially viable.

Much of the economics comes down to upgrading an old or providing a new physical connection to a customer, whether it be an isolated farmstead far from the nearest network node, an old-style multiple-dwelling unit without cableways, or a dense urban environment that requires extensive civil works to lay new cables. In these situations, using a wireless technology to provide a fixed broadband connection is a very attractive option.

The need for fixed wireless access

The market drivers are familiar. Policy makers are becoming more demanding with both the minimum service levels and the coverage that must be provided by operators. Customers everywhere are also demanding higher speeds – and are ready, willing and able to switch providers to get it. It's no longer enough to offer 10, 20, 30 Mb/s. The new urban aspiration is Gigabit services, with 100 Mb/s peak now often seen as a minimum rather than maximum. A divide still exists between urban and rural areas with operators struggling to find ways to deliver 10 to 20 Mb/s to their rural subscribers.

Fixed operators have significant challenges providing ubiquitous broadband. If money were no object, and time were not a factor, fiber would already be used for every broadband connection. In reality, the economics of serving different groups of users mean that there's no "one size fits all" ultra-broadband technology.

Fixed wireless technologies have been talked about for many years as a promising alternative where it is too difficult, costly or time-consuming (or all three) to deploy a wired broadband connection. And for many years, fixed wireless technologies have failed to live up to the promise.

1 Source: IHS Markit

2 Households with an internet connection of 1 Mb/s or faster.

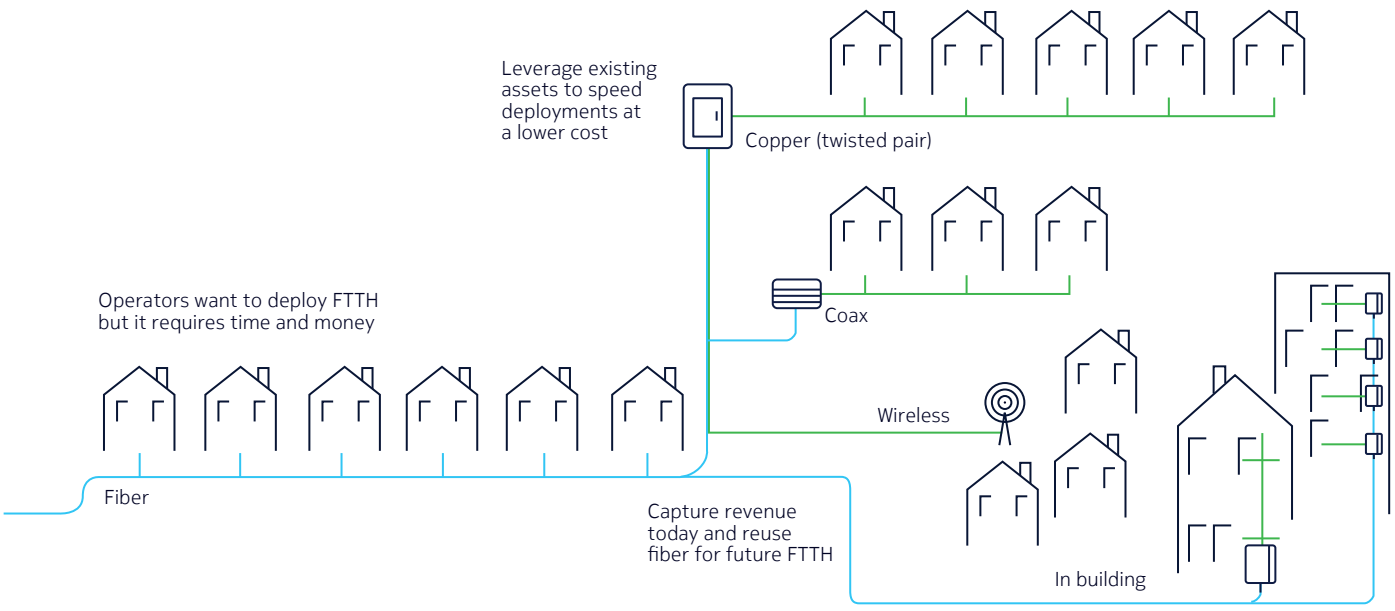
Now, however, things have changed.

- Firstly, the technology has finally caught up with the vision. Fixed wireless access as a concept has been around for a number of years, but only recent technological breakthroughs have taken it from being just a niche solution. Licensed spectrum for 4G can provide speeds in the 100s of Mb/s and now, with 5G, Gigabit and even multi-Gigabit speeds can be achieved.
- Second is that communication service providers themselves are converging. Consolidation has left us with more converged operators that can use either fixed or wireless infrastructure to serve residential subscribers. Fixed operators are deploying fiber wherever economically feasible but need solutions to serve areas where fiber is impractical. And mobile operators are looking for more ways to monetize their networks by entering new markets, including fixed residential access.
- Thirdly, most internet usage is through a mobile device and, ironically, much of that usage is over a fixed access connection via Wi-Fi©. These users move from a mobile connection outside the home to a fixed connection inside the home without a second thought. There is acceptance that wireless technology can provide home connectivity although consumer expectations for fixed and mobile services differ.
- Fourthly, consumer demand for broadband is at an unprecedented level. Broadband has changed the way people work, play and interact with the world around them. The need for ubiquitous broadband is upon us and consumers will take it however they can get it.

Fixed wireless access technologies are finally a viable addition to the toolkit of technologies that operators need to connect the unconnected.

From a converged operator's perspective, FWA plays a strategic role in completing coverage of a deployment area. Any under-served customers in a region are, of course, ideal prey for competitors. The longer they remain under-served, the more likely they are to churn. So, a key factor in any network deployment is time-to-market (TTM) for new services. FWA connections can generally be deployed more quickly and easily than fixed broadband, helping an operator trend to 100% coverage and increasing take-up-rates which, in turn, makes it a less attractive market for competitors.

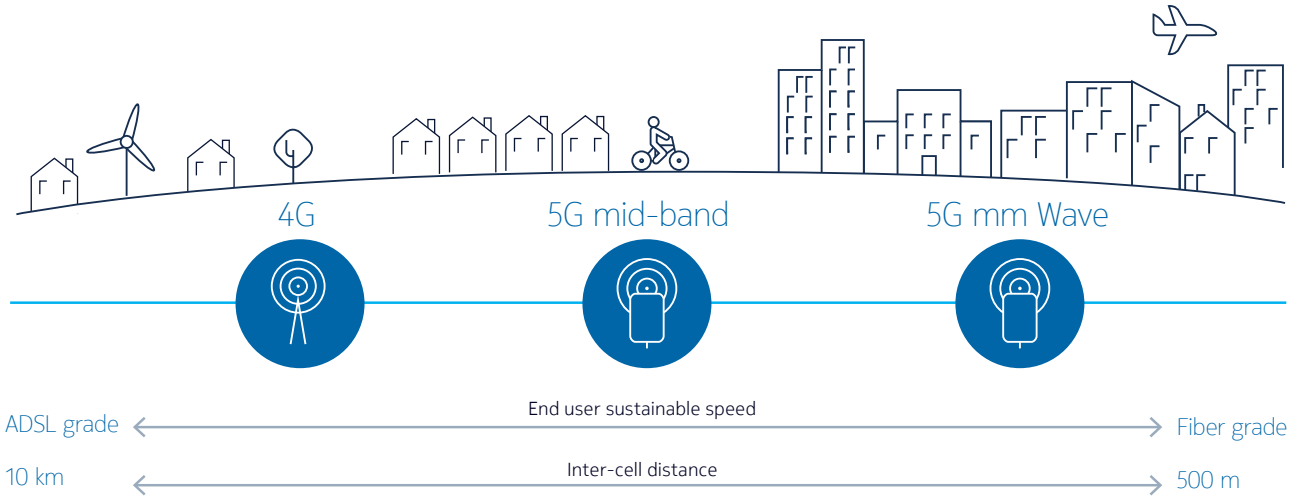
Figure 1. Combining fixed and wireless technologies for ubiquitous broadband coverage



Technology considerations

The evolution of radio access networks (RAN) gives us a lot to work with for fixed wireless access solutions. Traditional deployments used larger cell towers or macrocell. As speeds and subscriber density increased, small cells were introduced. Now with 5G, there is increased radio efficiency and greater spectrum with mid-band frequencies for increased capacity on the existing mobile footprint and mmWave to drive multi-Gigabit speeds with small cells.

Figure 2. 4G and 5G FWA technologies



Macrocell networks

Traditional cellular networks use macrocells serving a large number of users over multiple kilometers, typically using licensed spectrum up to 2.6 GHz. Operators with an LTE license and some spare capacity can consider using their existing network for fixed wireless broadband services. This is an attractive option in suburban and rural areas where end-user density is not too high. In this case, a converged or mobile operator can introduce fixed wireless services with a minimum investment in the RAN. In urban areas where competition and consumer expectations are higher, operators can invest in wider spectrum dedicated to fixed wireless access to ensure that high throughput with a guaranteed sustained rate is obtainable.

LTE in a “to-the-home” application (LTE-TTH) can offer good range – in the region of 10-15 km – and peak speeds of several hundred Mb/s. LTE radio access networks generate several hundred Mb/s at source but this obviously degrades over distance.

In field trials using LTE at 1.8 GHz, we have demonstrated LTE-TTH delivering 130 Mb/s downstream and 42 Mb/s upstream over 10 km, and 53/21 Mb/s over 15 km.

Mid-band 5G

5G operating in sub-6 GHz bands fuels the strongest early use cases for 5G, namely fixed wireless access and enhanced mobile broadband (eMBB). At these frequencies the coverage area per base station is comparable to LTE because of better signal propagation at lower bands especially in the case of non-line of sight (NLOS) scenarios. 5G at 3.5 GHz with beamforming antenna can provide similar or even better coverage than LTE at 1.8 GHz, thereby enabling reuse of existing base station sites, bringing major savings in deployment costs when compared to mmWave.

Mid-band 5G also provides the speed needed for most fixed wireless access cases supporting sustained speeds in the hundreds of Mb/s and peak speeds of 1 Gb/s. This is achieved with the help of increased spectral efficiency with massive MIMO, beamforming, increased channel bandwidth and other factors resulting in a 10-15 fold increase in capacity when compared to LTE. This also translates into an increased base station capacity which, in practice, could allow a few hundred FWA users to connect to a single base station when sufficient spectrum is available.

mmWave technology

5G mmWave operates at 24-39 GHz making up to 800 MHz of bandwidth available to an operator and thus supporting multi-Gigabit services.

Basic physics tell us that the higher the frequency of a signal, the shorter the distance it can travel. 5G mmWave can propagate multi-Gigabit broadband services up to 500 meters. This can impact the FWA business case as small cells along with the additional infrastructure, power and mobile transport required to support this network densification. These costs need to be weighed against the significantly greater speeds and potentially high ARPU services that it brings to a service area.

Another consideration is that mmWave requires line of sight; any obstructions between transmitter and receiver degrades the signal quality significantly. For this reason, line of sight planning is required to ensure that a service area can support mmWave services. While field research has shown that there are plenty of addressable areas, both in suburban and urban environments, mmWave signal degradation when penetrating windows and walls is still significant. In most cases this creates a need for external antenna designs to avoid losses.

Figure 3. 5G FWA options

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The importance of antenna gain

Antenna gain is a critical aspect to consider when choosing a FWA solution. It's one of the factors that can transform a service from a me-too MiFi grade (0 dBi) to a competitive differentiated service. The level of gain needed is application dependent. In rural areas, where signal strengths are weak, an outdoor high gain antenna can avoid first wall penetration loss and bring a 50 Mb/s service to a home that can't connect with MiFi.

In suburban and urban areas where base station densities are higher and more spectrum is typically utilized, indoor gateways with high gain antennas are a good option. Indoor gateways can be easily installed by customers which reduces deployment costs while still making the most of the signals that penetrate the home. Network simulations for suburban and rural morphologies shows that using high-gain compared to low-gain indoor antennas can double the number of households that can be served, triples the download speed delivered and increases upload capacity by a factor of five. This translates into considerable cost savings per household connected.

FWA in practice

Using an existing mobile network for fixed wireless access is both a unique opportunity and challenge.

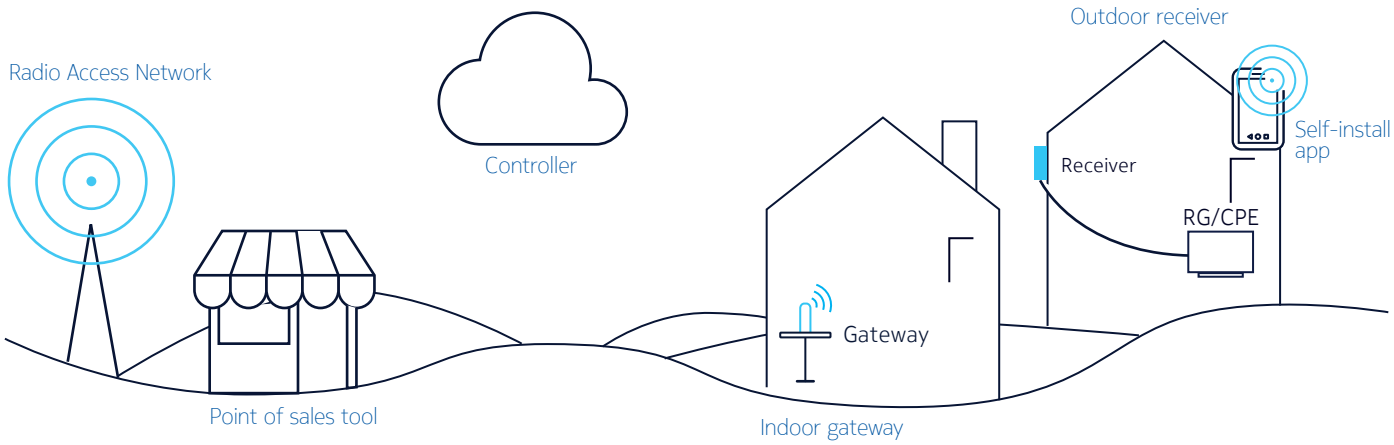
Assuming there is sufficient network capacity, no upgrade to the RAN is required to start offering FWA services. This means FWA Services can be quickly rolled out, abating customer churn and increasing ARPU from the subscriber base while attracting new subscribers with a complete fixed and mobile bundle.

This is also where the challenge comes in. Success with FWA can put a strain on parts of the network, which may impact mobile broadband performance. This is especially important when considering the fact that FWA users are likely to consume 10 time more data than mobile users due to big screen video streaming and all of the other IoT applications that are present in homes today. Network management can help with this. The OSS needs to support these new services and provide sufficient insight into network performance so that the right level of service can be offered in each area. This insight can also help with deployment and installation planning. A detailed understanding of radio cell sites and local morphology will help determine where excess capacity exists in the radio access network, allowing operators to selectively deploy home services without upgrading the RAN. Rules can be set to allow only a certain number of FWA subscribers to connect to a given base station.

Consideration also needs to be given to the grade of service offered. Customer expectations are much higher for fixed than mobile broadband while mobile broadband customers accept giving up some level of performance and predictability for the convenience of mobility. That is not the case for fixed-grade services. For example, there are usually multiple streaming devices in a household often connecting at the same time, and larger screens as well; all must get good service. A mobile operator looking to provide a competitive fixed-grade service must provide a quality of service at least on a par with a wireline service. This means significant differences in reliability, latency, minimum, sustained and peak speeds.

Nokia FastMile for 4G/5GTTH

Figure 4. FastMile in the network



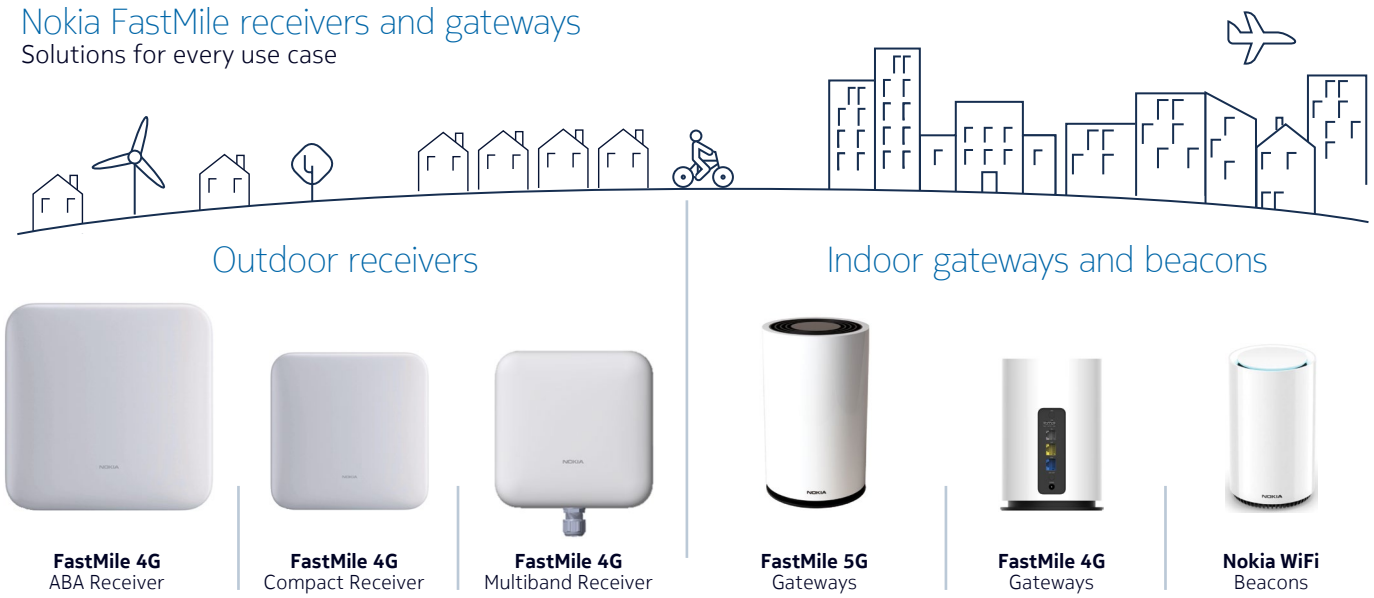
Nokia FastMile is a broad portfolio of 4G- and 5G-TTH FWA products for mobile and converged operators with solutions for every target use case, morphology and market segment that operators need to address. FastMile lets operators build profitably on their existing installed base and idle rural spectrum to offer fixed wireless broadband with guaranteed throughput to urban, suburban, rural, and deep rural users. As a fully 3GPP compliant solution, FastMile works with any radio access network while still being a part of Nokia's end-to-end solution for 4G and 5G with industry-leading performance and ease of deployment.

A significant benefit of FastMile is performance. With best-in-class gain both in outdoor receivers and indoor gateways, FastMile makes the most of radio resources, reducing RAN costs and providing the greatest speed possible in any deployment scenario.

FastMile gateways and receivers can be managed through an access control system with TR-069 or, if additional insight is needed, the Nokia Altiplano FastMile Controller can be used to manage the overall solution. The controller helps avoid the traps of treating fixed wireless services like mobile broadband, providing visibility to where mobile capacity exists in the network and empowering sales and marketing with the information needed to serve fixed subscribers without impacting mobile broadband. Capacity can be managed without upgrading the RAN by setting rules to connect to specific primary and alternative cell sites.

Our FastMile 5G gateway helps optimize the business case for mid-band 5G RAN upgrades with true fixed-grade services. Directional high gain 5G antennas make the most of the signals that penetrate the home. These antennas also facilitate self-installation through a series of LEDs that indicate the direction of the best signal received and strength. Subscribers are then able to find the ideal location within the home for optimum 5G performance. That location may not be ideal for in-home Wi-Fi so the 5G gateway supports Nokia whole home WiFi beacons to create a true mesh network bringing 5G speeds to every corner of the home.

Figure 5. Nokia FastMile 4G/5G portfolio



Conclusion

Fixed wireless access has been around for some time but never have there been so many options for serving rural suburban and urban subscribers. As 5G networks become a reality we have the opportunity to move FWA from 100s of Mb/s to Gigabits. With either case, with the proper network planning and the FastMile solution set, true fixed-grade services can be offered.

Nokia is the only equipment vendor with a leading position in both fixed and mobile technologies in every region of the globe. The combination of our wireless and fixed access solutions and services creates a world-class value proposition for operators providing fixed ultra-broadband services. With Nokia fixed wireless access solutions, operators can:

- Differentiate in a competitive marketplace
- Vastly improve TCOs and maximize ROI
- Accelerate ultra-broadband deployments.

Acronyms

5G	5th generation mobile
ARPU	Average revenue per user
dBi	Decibels relative to isotropic radiator
CAPEX	Capital expenditure
FTTH	Fiber-to-the-home
FTTx	Fiber-to-the-curb/building/distribution point, etc.
FWA	Fixed wireless access
IoT	Internet of Things
LED	Light emitting diode
LTE	Long-term evolution
MCS	Modulation and Coding Scheme
MIMO	Multiple-input and multiple-output
NLOS	Non-line of sight
OPEX	Operational expenditure
OSS	Operations support system
RAN	Radio access network
ROI	Return on investment
TCO	Total cost of ownership

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