Cambium Networks™

Service enablement and growth using purpose-built non-3GPP fixed wireless broadband access as an alternative to Fixed LTE

How fixed wireless broadband can interwork with the EPC network to increase coverage and capacity to profitably drive revenue subscription growth.

NEED FOR SPEED

People want to access the Internet at home, work, hotel, airport, café and various other places. “Things” such as sensors that adjust the temperature in homes, smart appliances that track content and automatically order replenishment supply, and smart dust to monitor weather pattern in the forest to prevent spread of forest fires all connect to the network and drive bandwidth consumption higher and higher. There will be more and more ways to communicate, do business, do science and research, and entertain using voice, video, social networking, applications and collaboration tools. All of these things need to connect to the network. Governments, especially from emerging countries, are driving broadband network build-out initiatives to help improve lives of their people. We all benefit from this. The problem is that all of this data is putting ever-increasing demands on networks, especially where all of these things “on-ramp” to the network – the access network. Existing network assets are being strained which has a direct impact to Service Provider financial performance.

Service Providers are feeling the enormous pressure of trying to keep up with this broadband traffic phenomenon. Cost is going up, but Average Revenue Per User (ARPU) is flat. It is getting more difficult to find new sources to generate revenue due to more intense competition. In order to keep up with subscriber demands, Service Providers need to expand the network to new places and different applications. The challenge is that refurbishing existing copper or laying down new fiber optic strands may be next to impossible due to terrain and cost. There are also challenges with extending the network wirelessly – namely, licensed spectrum is expensive.

It is clear that there is a massive need for speed – speed and capacity of the network, speed of deploying differentiated services, speed of socio-economic uplift, and speed of change in our connected lives.

DIFFERENT WAYS TO CONNECT TO THE NETWORK

There are several ways to connect to the network. In this whitepaper, we will focus on the three wireless broadband access segments – unlicensed indoor wireless access, licensed mobile wireless access, and unlicensed and licensed fixed outdoor wireless access.

WIRELESS BROADBAND SEGMENTS

Wireless Broadband Segment	Access Technology	Market Growth
Unlicensed Fixed Indoor Wireless Access	WiFi: IEEE 802.11 a/b/g/n/ac	2012: 5.2 million hotspots 2018: 10.5 million hotspots 12% CAGR (2012-18) *Source: Wireless Broadband Alliance*
Licensed Mobile Wireless Access	GSM, WCDMA, TD-SCDMA, HDSPA, LTE	2012: 6.5 billion connections 2018: 8.1 billion connections 4% CAGR (2012-18) *Source: Ovum*
Unlicensed and licensed Fixed Outdoor Wireless Access	LMDS, WiMAX, Fixed LTE, non-3GPP FWA	2012: 29 million subscribers 2018: 41 million subscribers 6% CAGR (2012-18) *Source: Ovum*

As clearly shown in the table above, all three wireless broadband access segments are growing. What is even more important is that all three segments co-exist. This is indicative of the fact that depending on where people and things are located, there are different ways to best get connected to the network.

What is increasingly true is that regardless of the type of wireless access network, the trend is to migrate and evolve the network to be more packet-based – IP/Ethernet based. The economics of packet-based networks have been proven to be more compelling than circuit-switched based networks. And on the wireless front, LTE networks that are based on Third Generation Partnership Project (3GPP) have been the defacto standard for Service Providers for the radio access network (RAN) and packet core. The three wireless broadband segments described above need to somehow, somewhere connect to the System Architecture Evolution (SAE) LTE packet core - more widely known as Evolved Packet Core (EPC) - in order for Service Providers to maximize their investments on the assets they have deployed and maximize subscriber Quality of Experience (QoE).

Let us first take a look at licensed mobile wireless access. We all know and love (or hate) this. For most of us, we heavily rely on our smartphone or tablet to do what we need to do on a daily basis. With LTE, we are able to watch videos, stream music, download lots of content, check on security cameras at your house, start your car, and have a video call with people. Service Providers around the world have a love-hate relationship with this phenomenon. It certainly drives subscription revenue, but subscription revenue is being outpaced by network costs. Capital expenditure (CapEx) goes up due to investments to increase capacity. Operational expenditure (OpEx) also goes up in order to deploy and manage the ever expanding network. And with limited and expensive spectrum – which directly impacts coverage and capacity – Service Providers are constrained with what they can do with their macro-cellular networks.

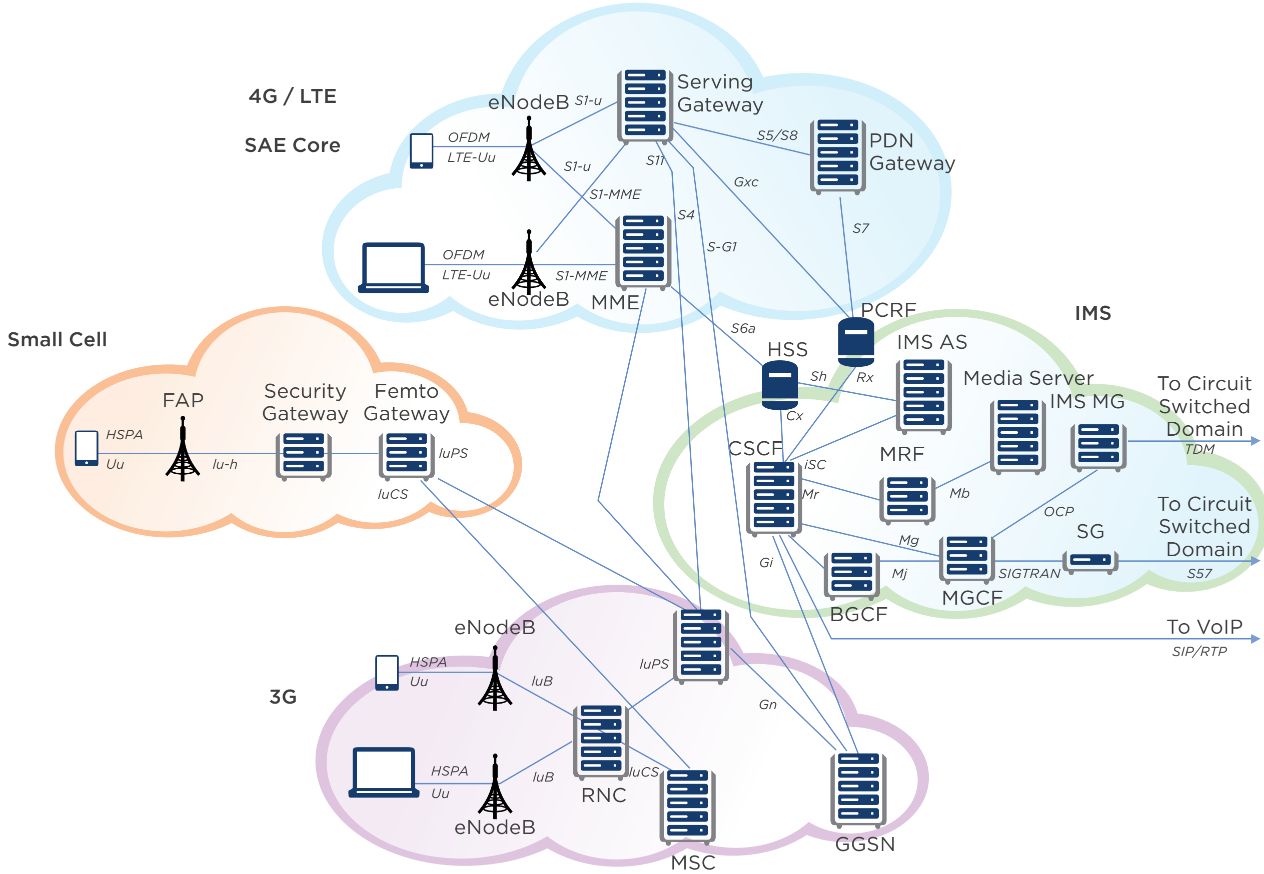
For emerging countries, there is still usage of 2G and 3G networks to provide low cost broadband connectivity. For 2G and 3G networks where voice is the primary traffic type of service, unlicensed fixed outdoor wireless access coupled with indoor WiFi can complement the 2G/3G mobile service. Service Providers in these emerging countries can save precious spectrum for voice services and extend the return on asset (ROA) of the 2G/3G network while using fixed outdoor wireless access for true broadband service that does not burden the 2G/3G network. The benefit for Service Providers is not just ROA extension but a new source of revenue growth as people in these emerging nations get used to higher capacity broadband services.

Then there is WiFi. One of the tools Service Providers have used lately and continue to use is to offload some of that heavy traffic onto WiFi hotspots or homespots. One of the biggest values of WiFi is that it can help alleviate traffic congestion on the macro-cell network precisely where people and things connect to the network. Your Youtube video session, Netflix movie watching, and other intensive broadband applications can be offloaded onto the WiFi network. By deploying carrier WiFi, the benefit to the Service Provider is that they can provide the same Quality of Service (QoS) over Wifi networks as over the macro-cell network. Nonetheless, QoS guarantees are not the same as over protected command-and-control eNodeB-to-UE (user equipment) model. For example, voice traffic can be offloaded to the WiFi network, providing a consistent voice over LTE (VoLTE) experience. The challenge is that most WiFi networks are “best effort” and not optimized for outdoor usage. WiFi also suffers from poor latency and spectral efficiency. Spectral efficiency is the measure of the information rate that can be transmitted over a given bandwidth measured in bps/Hz.

So if a Service Provider already has an EPC network and WiFi is not adequate for all fixed wireless access applications, then why not deploy Fixed LTE?

FIXED LTE

One of the benefits of fixed LTE is the fact that it shares the same architecture and systems as the mobile side of the network. It normally shares the same radio access network (RAN), evolved packet core (EPC), and IP multimedia system (IMS) core as shown in the picture below. In other words, there is quite a bit of reuse. But reuse is a double-edge sword. The side that cuts the most is spectrum. Spectrum usage should be maximized for the mobile side of the business due to mobility overhead bits and requirement for more channels due to higher device counts. Unfortunately, licensed spectrum is allocated for mobile and fixed services. The issue this introduces is capacity and throughput constraints. What further exacerbates this issue is that subscriber behavior is normally different between mobile and fixed where fixed broadband subscribers consume more capacity and stay on longer. This results in connectivity issues for mobile subscribers (and other fixed subscribers) and poor customer experience overall. And as bandwidth consumption grows, the contention in spectrum allocation between mobile and fixed LTE increases.



A solution that some Service Providers have considered and deployed to maximize the ROI on LTE spectrum is to use time-division (TD) LTE or TD-LTE also known as LTE-TDD (time division duplex). TD-LTE maximizes spectrum by using the same frequency band for transmission in both direction, a methodology formally known as “unpaired spectrum”. Unlike FD-LTE (frequency division duplex) where separate frequencies are needed for transmit channel and receive channel, TD-LTE divides the single frequency in time between transmit and receive. Typically, the time divisions are asymmetric where more time-slots are allocated to data going from the tower to the user device (downlink). Clearly, with TD-LTE, spectrum usage is maximized. Unfortunately, it does not solve the problem of reusing the same spectrum for both mobile and fixed. Furthermore, TD-LTE is asymmetric which limits the types of services, applications and SLA’s (Service Level Agreement) that Service Providers can offer (and generate revenue from) with it such as, for example, providing business services for a geographically dispersed enterprise and being able to do video conferencing which requires symmetric broadband where uplink and downlink need to be the same capacity and throughput.

What some Service Providers are doing is use FD-LTE for mobile and TD-LTE for fixed. The usage of TD-LTE for fixed certainly conserves spectrum for traditionally higher ARPU mobile service where mobile is metered and fixed is an “all you can eat” service. Why not save that entire LTE spectrum for mobile service instead and use another technology using unlicensed spectrum for fixed service that has RF interference mitigation techniques that make it on par with using licensed, dedicated spectrum?

FIXED LTE PROS AND CONS

Pros	Cons
Shares the same architecture and systems as the mobile side of the network	TD-LTE typically asymmetric which limits service types for symmetric applications like video conferencing, e-Learning, online gaming, etc.
Usage of licensed spectrum which maximizes ROI of expensive spectrum	Consumes licensed spectrum which reduces its usage for higher ARPU mobile services
TD-LTE conserves licensed spectrum in order to use more licensed spectrum for mobile services using FD-LTE	Still consumes licensed spectrum which reduces its usage for higher ARPU mobile services

The concept of being able to provide fixed wireless access services to complement mobility subscription is still a compelling business driver. Fixed wireless access helps generate additional subscription revenues from the same customer base. Fixed wireless access helps to offload traffic and reduce macro-cell congestion for when subscribers are stationary. It helps maximize the ROA (Return-on-Asset) on an already existing EPC for LTE networks.

So, is there another way to do all of this and solve the issues associated with using fixed LTE?

PURPOSE-BUILT FIXED WIRELESS ACCESS

The answer to the question above is a resounding “Yes”! A complementary non-3GPP fixed wireless broadband network can add significant value by interworking with the EPC of an LTE network. Non-3GPP fixed wireless broadband, which we will simply call FWB going forward, can be an alternative to AND co-exist with fixed LTE.

FWB AS AN ALTERNATIVE TO FIXED LTE

According to Heavy Reading in their special research report about TD-LTE services in the 3.5GHz bands, they highlight important drivers for TD-LTE based on what China Mobile and Softbank have done:

- Limited coverage, low mobility and isolation makes higher frequency attractive for outdoor rooftop and street level small cells in urban zones
- Higher frequency spectrum offers high throughput for both outdoor and indoor hot zones
- Large channel band is ideal as a dedicated large-bandwidth small cell band to boost hot zone capacity on top of the macro cell coverage layer
- Higher frequency spectrum using TD-LTE solutions is well suited for handling severe unbalance and fluctuation of downlink/uplink traffic in each hot zone area
- Higher frequency spectrum offers greater isolation to avoid interference, ensure QoS and enable frequency reuse

If you evaluate each one of those points more closely, the underlying theme for justifying TD-LTE is to use higher frequency bands, and in this case at 3.5GHz. But what it does not address are the two major issues: not being able to maximize usage of licensed spectrum for higher ARPU mobile services, and asymmetric transmission (more downlink than uplink) which limits growing service and application types requiring symmetric transmission.

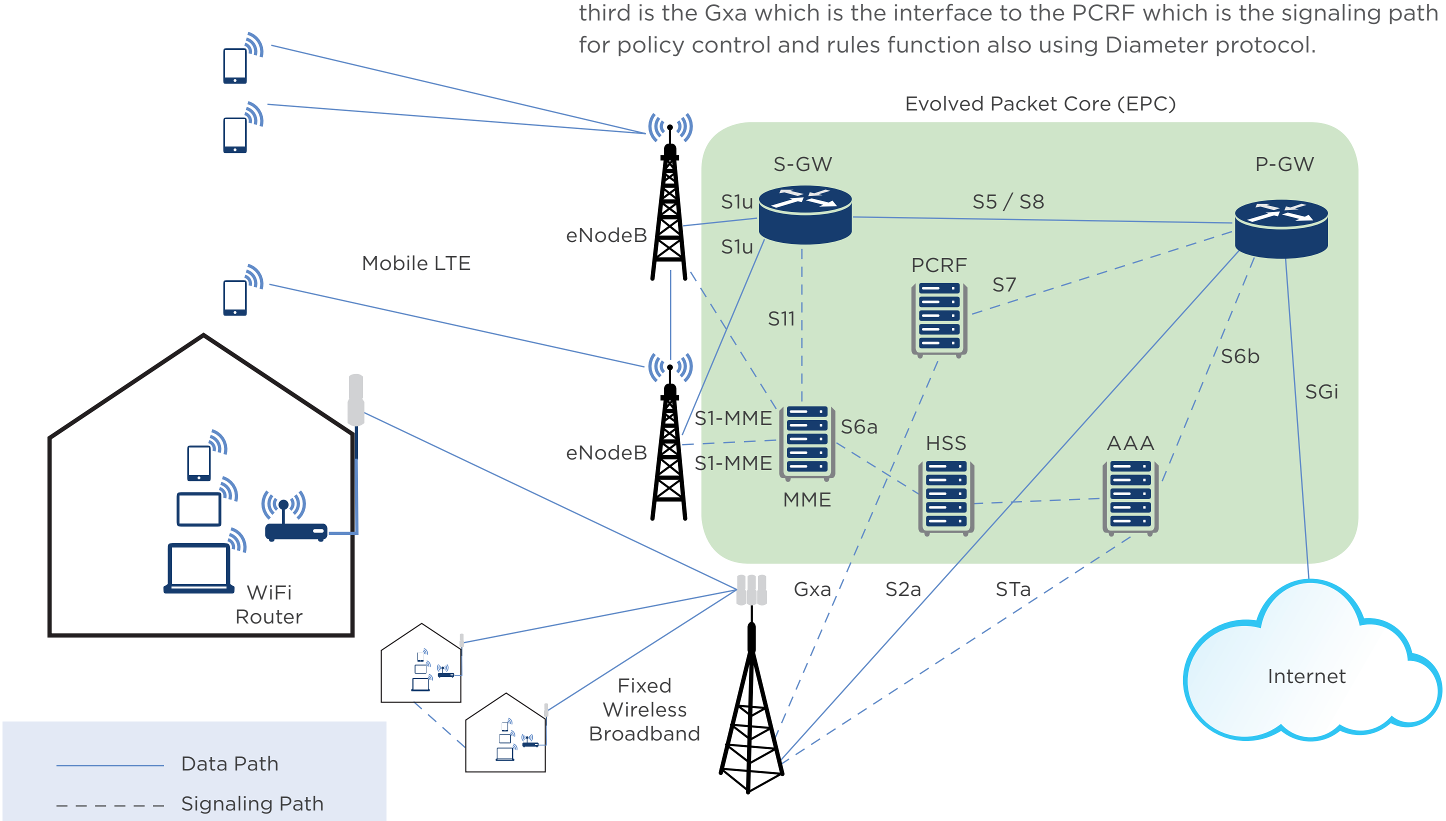
Unlicensed FWB can be and has been a proven alternative as a reliable and profitable fixed wireless service. The key is to provide equal or better radio frequency (RF) interference protection and link quality maximization algorithms when using unlicensed FWB. Please note that using unlicensed FWB is not the end-all-be-all solution for everything fixed wireless access. Unlicensed FWB is to help expand the network in new places and different applications that fixed LTE cannot address.

Similar to fixed LTE, unlicensed FWB can leverage the existing EPC network which extends the benefits of reusing the same architecture and systems. Given that FWB can be in a different spectrum than licensed spectrum, the precious, expensive LTE spectrum can be focused and used more for the mobility side of the business. And with purpose-built FWB, asymmetric AND symmetric broadband transmissions can be supported which expands the service enablement capability of Service Providers.

The diagrams below show the interworking of non-3GPP FWB with the EPC network.

The first diagram depicts a trusted non-3GPP access network where the Service Provider – who owns the Packet Data Networking Gateway (P-GW) and the Home Subscriber Server (HSS) – trusts the security of the non-3GPP access network. This is where the user equipment (or client equipment) such as a WiFi router is provided by the Service Provider. That client equipment contains the Mobile IP client configuration that provides the security information to interface to the network. This function can be used totally transparent to the functionality in the access network such as the FWB access network.

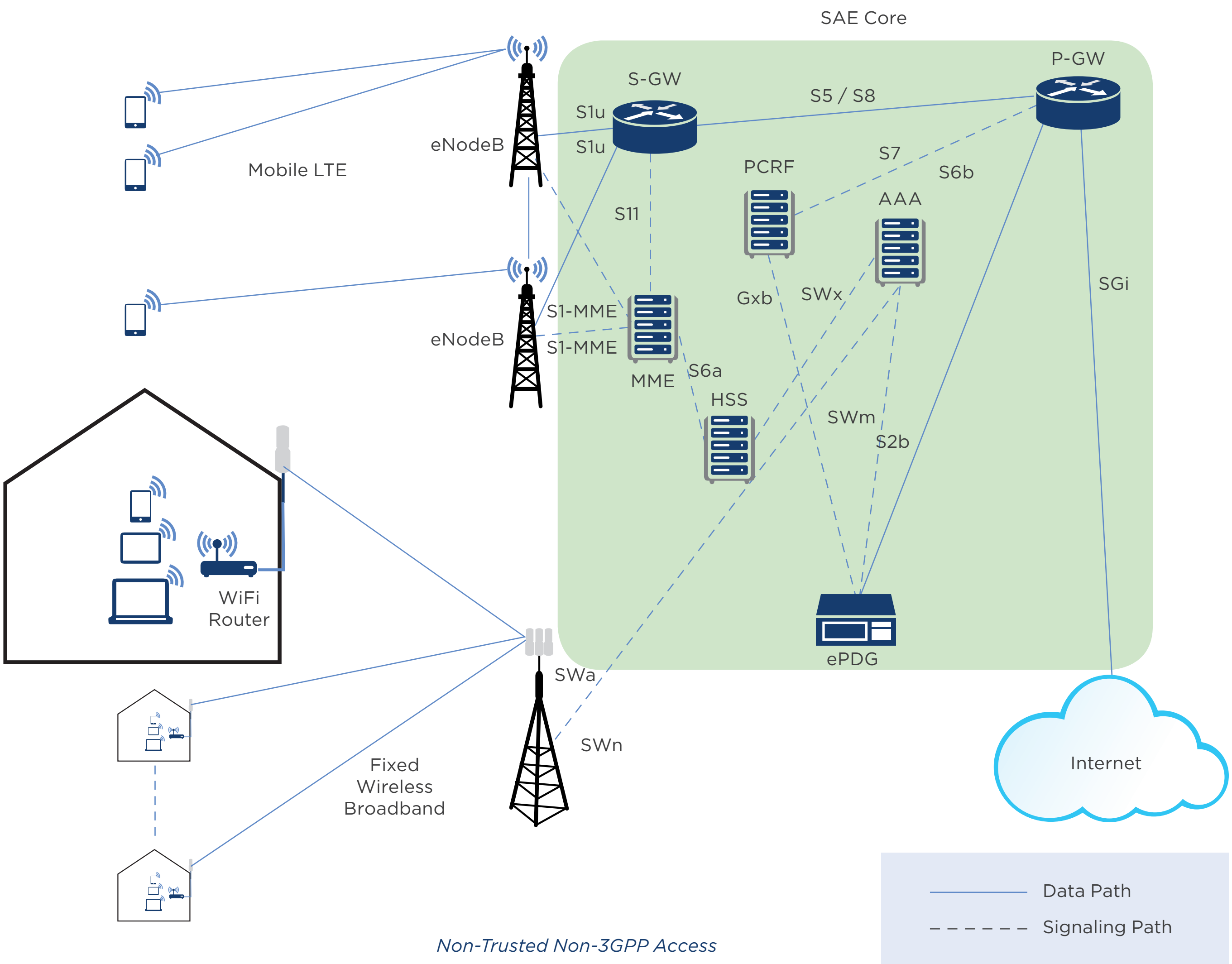
As shown in the network diagram below, the FWB access network connects with the EPC on three interfaces. The first is the S2a interface which is the interface to the P-GW for the data path to and from the internet. The second is the STa which is the interface to the AAA which is the signaling path for authentication, authorization and accounting using Diameter protocol. The third is the Gxa which is the interface to the PCRF which is the signaling path for policy control and rules function also using Diameter protocol.



Trusted Non-3GPP Access

The second diagram depicts a non-trusted non-3GPP access network where the Service Provider is providing access to user equipment that on-ramps to the Internet from a Wireless LAN such as a public café. The difference with this architecture is that it involves an evolved Packet Data Gateway (ePDG) for the access network to connect to the EPC network. An ePDG is normally used with WiFi networks deployed in public cafes, airports, hotels, etc. Therefore, a FWB access network can leverage an already existing ePDG that a Service Provider normally has as part of their EPC network.

As shown in the network diagram below, the FWB access network connects with the EPC on five interfaces, two of which are direct and the other three via the ePDG. The first is the SWn interface to the ePDG. The ePDG provides connectivity to P-GW via the second interface called S2b for the data path. The ePDG also provides connectivity to the AAA via the third interface called SWm. Finally, the ePDG also provides connectivity to the PCRF via the Gxb interface. Both SWm and Gxb use Diameter protocol. The fifth interface is the SWa which provides an additional authentication mechanism with the AAA server. This interface is optional because the client equipment is already getting authenticated via the SWn-to-SWm interfaces.



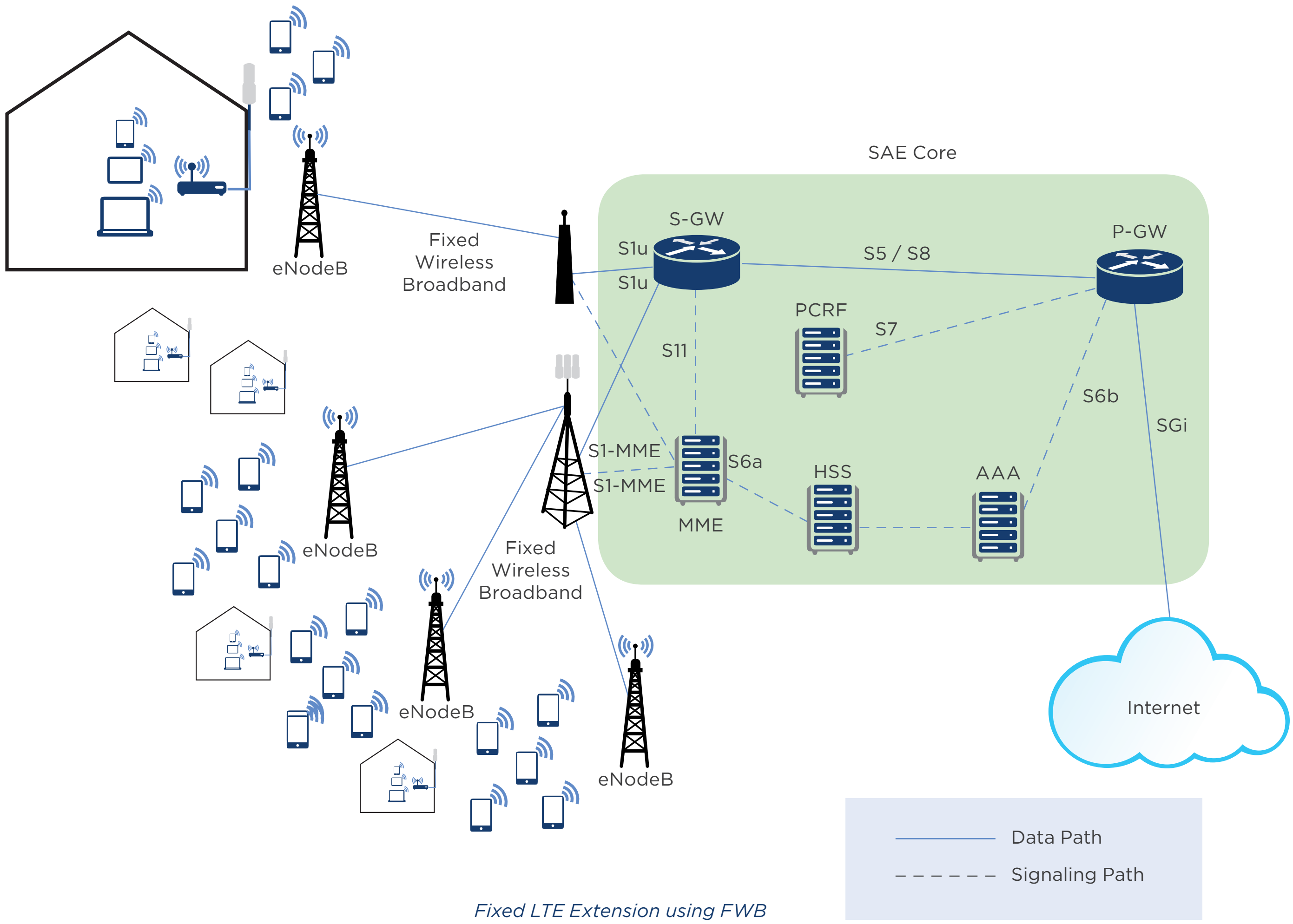
Non-Trusted Non-3GPP Access

The value to Service Providers with FWB interworking with the SAE core is to enable the same level of QoS as over macro networks. For example, voice traffic can be offloaded to the FWB-delivered WiFi network, thus providing a consistent voice of LTE (VoLTE) experience. Other essential components of the solution supporting the user's quality of experience with FWB interworking with the SAE core are the following:

- Policy-controlled access selection
- Transparent user authentication
- Service Provider control over traffic routing
- New services enablement

FWB CO-EXISTING WITH FIXED LTE

FWB can also co-exist with fixed LTE. For topologies where fixed LTE is deployed in the far-edges of the network where spectrum reuse is not a major concern for congestion and contention with the mobile side, FWB can help extend the LTE network as depicted below.



Fixed LTE Extension using FWB

From an RF link connectivity perspective, there are a few similarities and differences between LTE and a couple of best-in-class purpose-built FWB techniques. The table below summarizes a few key items.

RF LINK CONNECTIVITY TECHNIQUES OF LTE AND PURPOSE-BUILT FWB

RF Techniques	LTE	Purpose-built FWB
MIMO (Multiple Input, Multiple Output)	✓	✓
OFDM (Orthogonal Frequency Division Multiplexing)	✓	✓
TDD (Time Division Duplex)	✓	✓
HOM (Higher Order Modulation)	✓	✓
Adaptive Modulation Rate	✓	✓
Spatial Diverse Antennas	✓	✓
Dynamic Flexible Frame Ratio for DL/UL		✓
Asymmetric and Symmetric DL/UL		✓
Dynamic Spectrum Optimization		✓
GPS Synchronization for Frequency Reuse		✓
Small 2.5ms Frame Size for Inteference Mitigation		✓

As shown in the table above, purpose-built FWB is similar in many ways to LTE where they both use standard techniques to improve RF link connectivity. For some purpose-built FWB solutions, there are best-in-class techniques that significantly augment RF link connectivity quality and reliability which enables usage of unlicensed spectrum AND augments RF link reliability for licensed spectrum.

CONCLUSION

The "Internet of Everything" will continue to drive the number of broadband connections and bandwidth consumption of each one of those connections. Unlicensed fixed indoor wireless broadband such as WiFi is valuable to Service Providers to help provide a consistent experience for their subscribers while reducing the congestion in the macro-cellular network due to limited spectrum. Mobile wireless access is an ever important part of people's daily lives and a major revenue driver for Service Providers. But with limited and expensive spectrum, mobile wireless access can only address certain network connectivity needs of people, businesses and things.

Fixed wireless broadband is an important component for Service Providers who need to deliver essential and innovative services but do not have the option to deploy wireline infrastructure based on copper and fiber optics or the option to acquire more spectrum. Certain purpose-built fixed wireless broadband solutions address the issues associated with Fixed LTE such as sharing expensive licensed spectrum with mobile service and asymmetric-only transmission. Purpose-built fixed wireless broadband solutions can be an alternative to Fixed LTE and can also co-exist with it by extending LTE to the far edges of the network. Service Providers can dedicate expensive licensed spectrum for higher ARPU mobile services while allowing a complementary purpose-built FWB to address fixed services using unlicensed spectrum with the same high reliable RF link connectivity.

Service Providers should consider different tools for service enablement to help generate profitable revenue growth. A purpose-built fixed wireless broadband solution is an important tool to help extend the network to new places and deliver new, innovative applications.

Cambium Networks™