WHITE PAPER

The Transformation to 4G: LTE for WiMAX Operators

- The similarities in the wireless interface make a seamless transition from WiMAX to LTE—or coexistence—possible.
- But can the WiMAX and the LTE core elements coexist? Can WiMAX operators keep their core network, without disrupting service, as they migrate to LTE?
- With a common control plane suite serving 3G, WiMAX, and LTE, Bridgewater makes it simpler for WiMAX operators to add LTE to their networks or switch to LTE

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THE MOBILE PERSONALIZATION COMPANY

Introduction

The pace of technology evolution in wireless telecommunications is exciting, but for Worldwide Interoperability for Microwave Access (WiMAX) operators, it can also be overwhelming. WiMAX operators have launched their networks and are busy signing up subscribers, as they expand network coverage and capacity and develop new service offerings. In the midst of all this activity, they are under pressure from boards, investors, and customers to investigate whether they should move to the next emerging 4G wireless broadband technology: Long Term Evolution (LTE).

Virtually all WiMAX operators today are exploring the opportunities that LTE offers—either as a complementary technology or as an alternative to WiMAX.

> "We are a 4G company. We believe that the next generation of mobility requires a low-latency and low-cost structure. And there are only a couple of technologies that offer that, WiMAX and LTE. The good news for us is that WiMAX and LTE have 80 percent overlap in terms of technology when you consider modulation schemes etc... And we are working with suppliers to make sure we can easily transition from one to the other. The fact is that consumers don't care which technology you use; they just want a fast, low-latency network at an affordable cost."
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> "The beauty of our architecture is that we have the ability to bolt on additional technologies, like LTE. This means that we could continue offering WiMAX to existing customers, while we add LTE."
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> Bill Marrow, CEO of the U.S. WiMAX operator Clearwire, quoted in CNET News, May 2010.

LTE and WiMAX provide comparable performance, because they both use an Internet Protocol (IP) core and an Orthogonal Frequency Division Multiple Access (OFDMA) air interface as their core technologies. However, in commercial networks in most countries, WiMAX has reached a more mature state that will take a few years for LTE to match.

Why move to LTE, then? It will be difficult for the market to support two 4G technologies with comparable services, cost, and performance. With a strong commitment from mobile operators worldwide that have deep pockets and a large subscriber base, LTE is set to dominate the mobile broadband market within a few years, with WiMAX likely to meet the requirements of niche market segments.

Initially, coexistence of the two technologies seemed appropriate for meeting the market demand, because LTE focused more on frequency division duplexing (FDD) spectrum and WiMAX on time division multiplexing (TDD) spectrum, given that spectrum allocations in many countries are made specifically for either TDD or FDD transmission.

Three developments have changed this, and have forced WiMAX operators to reevaluate their long-term plans.

First, the growing support for a TDD-version of LTE, known as time-division LTE (TD-LTE), has created a more direct competitor to WiMAX. Interest in TD-LTE originated in China, but it has spread worldwide, with many mobile operators attracted by the opportunities for international roaming and for using much less expensive TDD spectrum to boost capacity in their domestic markets. Further demand for TD-LTE is driven by WiMAX operators who have started to take a more active role in the TD-LTE standardization process. In the US, for instance, Clearwire has asked the Third Generation Partnership Project (3GPP) to create a TD-LTE profile for the 2.5 GHz band it uses for its WiMAX rollout.

Second, vendors have introduced platforms that support multiple air interfaces through software upgrades, and they plan to expand the selection of affordable multimode devices. The cost and complexity of migrating to a new air interface has dropped, making it more attractive for WiMAX operators to switch to LTE or to support both WiMAX and LTE.

Third, with a larger market size and commitment from most tier-one mobile operators, a powerful LTE ecosystem is rapidly building, with a wider choice of subscriber devices and competitive equipment prices.

As they evaluate whether to move to LTE or add LTE to their networks, WiMAX operators want to make sure they are prepared for the transition. They require the flexibility to transition to LTE at their own pace, without disrupting their services. They want to retain as many elements as possible from their current deployments, not only in their radio access network (RAN), but also in their control plane, where they manage traffic and subscribers, provision services, and handle billing. While control plane elements capture a smaller portion of operators' capital expenditures than RAN equipment does, they support multiple functions that are vital to the operators' management of the network and to customer satisfaction.

This paper is aimed at WiMAX operators that want to get a better understanding of how to integrate LTE into their existing control plane infrastructure, either as a gradual replacement to WiMAX or as a complementary technology. The first part of the paper describes different scenarios and the requirements for the transformation to LTE. The second part focuses on how operators can manage the control plane transition from WiMAX to LTE, while retaining service continuity and portability.

The Path to 4G

WiMAX and LTE have comparable performance, prices, and requirements, and they will coexist side by side (Table 1). Key factors for WiMAX operators to consider when assessing their options include:

- **Services offered**. LTE will be more attractive to WiMAX operators that target—or intend to target—mobile broadband subscribers. LTE will give them access to a wider choice of mobile devices, and will facilitate domestic and international roaming.
- **Spectrum availability**. WiMAX operators have the flexibility to deploy LTE using TDD or FDD spectrum bands, while WiMAX equipment is limited to TDD.
- **Growth plans**. WiMAX operators may decide to roll out LTE as a replacement for WiMAX, or as a complementary technology that provides additional capacity and facilitates the introduction of new services.
- **Market size and ecosystem**. WiMAX operators will find a move to LTE more compelling if LTE keeps the momentum it now enjoys, and its ecosystem delivers the wide range of devices it promises.
- **Timeline**. The timeline for transition to LTE is still unclear. If the market for LTE takes off quickly and many of the large WiMAX operators switch to LTE, the overall WiMAX market might contract. If LTE deployments are delayed and WiMAX retains its edge, the move to LTE might be delayed. WiMAX operators may wait until the LTE ecosystem is at least as well developed as the WiMAX one to reap the full benefits of the transition and minimize its costs.

WiMAX	LTE
IP-based technology with OFDMA modulation used in the uplink and downlink.	IP-based technology with OFDMA modulation in the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) in the uplink.
WiMAX networks operated by 559 operators covering more than 620 million people in 147 countries and supporting a rapidly growing subscriber base.	Few commercial networks for FDD LTE with a limited number of subscribers, and none for TD-LTE to date Commercial FDD LTE deployments are expected to increase in early 2011.
Only TDD supported, in the 2.3 GHz, 2.5 GHz, and 3.5 GHz bands. Additional bands might be added in the future.	Supports both TDD and FDD. TD-LTE frequencies range from 1800 MHz to 2.6 GHz (with possible inclusion of the 3.5 GHz band in the future). LTE FDD bands range from 700 MHz to 2.6 GHz.
Less complex solution for regional/rural operators who don't need roaming with 3GPP networks.	Larger market share in the long term, with better opportunities for international and domestic roaming
Standardization driven by vendors, operators, and greenfield players at the Institute of Electrical and Electronics Engineers (IEEE) and the WiMAX Forum.	3GPP standardization process led by mobile operators and top vendors.
WiMAX Forum certification program supports interoperability across vendors, but smaller market size results in more limited choice of devices.	Powerful ecosystem with strong vendor and operator support to ensure affordability and choice among devices.
The next version of WiMAX—WiMAX 2, based on IEEE 802.16m—is expected to be commercially available by 2012.	Legacy support for Global System for Mobile Communications (GSM), and High Speed Packet Access (HSPA) gives LTE potential access to 4.6 billion mobile subscribers. LTE Advanced is the next version of LTE; the standard is still being developed.
Supports fixed, nomadic, and mobile usage scenarios.	Developed with mobility in mind, but could support fixed usage scenarios.
Comparable performance, spectrum requirements, and channel bandwidth for WiMAX 2 and LTE.	

Table 1: WiMAX and LTE: A Comparison

The assessment of LTE's advantages is likely to vary considerably among WiMAX operators. Table 2 shows the transition scenarios that are expected to prevail. A choice is still premature for most WiMAX operators. The market and ecosystem dynamics will have to settle, and LTE— especially in its TDD version— is behind WiMAX in terms of equipment and device availability. Many operators have let their vendors know that while they have not decided between the technologies, they continue to monitor both and want to be ready to move toward either LTE or WiMAX at the appropriate time. As long as WiMAX operators have a plan to transition to TD-LTE, they can confidently continue to expand their WiMAX networks, because the transition will not disrupt service and subscriber growth.

Yota, a Russian WiMAX operator, was the first to announce a plan to deploy an LTE network as an expansion of the existing WiMAX network. Yota intends to invest $100 million to cover new markets in 2010, and, in 2011, plans to build an overlay network in Moscow and St. Petersburg, where it already has 500,000 subscribers. At least initially, Yota will support both networks. "Yota is a services company; for us technology is an instrument. It's clear that the LTE standard is becoming the main trend in wireless communications," Denis Sverdlov, General Director of Yota, said in a statement on the company's website.

Swap	**How**: The operator upgrades all users within a market at the same time. **Why**: Operators will avoid this approach if possible, but those operators with limited spectrum allocations may be forced to choose it, as they cannot support a network that combines WiMAX and LTE for even a limited time. This approach works more effectively if a software upgrade is available for base stations and subscribers have multimode devices that support both WiMAX and LTE. If a subscriber device swap and hardware changes are needed, the transition is likely to cause service disruption.
Overlay	**How**: The operator rolls out LTE, and gradually migrates WiMAX subscribers to LTE. WiMAX and LTE will operate in parallel for a period determined by the operator. **Why**: This approach allows for greater flexibility and a lower risk of service disruption than the swap approach, but operators need to have access to sufficient spectrum to operate LTE and WiMAX networks concurrently.
Coexistence	**How**: The operator deploys an LTE network designed to complement the existing WiMAX network, leaving both active. **Why**: The operator can provide bundled services and dual-mode devices to increase the attractiveness of the service. However a coexistence approach requires sufficient spectrum and funding to operate two networks in the long term, and only a few operators can afford this.
Status quo	**How**: The operator chooses to remain focused on WiMAX and forgo LTE entirely. **Why**: The operator does not deem a transition to LTE advantageous. This is likely to be the case for many regional WiMAX operators that are focused on fixed services to well-targeted communities and do not have sufficient wide area coverage to promote mobile access either to their customers or to roamers.

Table 2: Transition Scenarios

The Emergence Of The 4G Operator

In the past, moving to a new air interface required significant efforts and investment. In many cases, operators found it more cost effective and less disruptive to keep operating old networks than to upgrade to new ones. This is one of the reasons GSM networks have been operating for almost 20 years and continue to support the majority of subscribers, despite the availability of technologies like 3G with better performance. This is rapidly changing. Devices can support multiple air interfaces in a cost-effective way, or can add support for a new interface through a software upgrade. This means that operators transitioning to a new interface can gradually move base stations to the new interface without having to replace subscriber devices, and at their own pace. With a software update, base stations can support a new interface as vendors increasingly use the same platform for multiple air interfaces, reducing the investment and effort required to upgrade the network.

Furthermore, new air interfaces are based on IP end-to-end networks. As operators move from one IP-based air interface to another, the upgrade effort is mostly directed toward developing the required new interfaces between core elements. The overall functionality and structure of many of the core network elements remains the same, and in fact some core elements may be shared by the two networks.

This streamlined upgrade process and the pressing need to upgrade quickly in response to steep traffic growth have made it possible for a new breed of radio-agnostic operators to emerge—and among them are the largest WiMAX operators, Clearwire and Yota. These operators are committed to providing the services that their customers want using the technology that is more appropriate and cost effective. Their subscribers demand a fast and reliable connection with low latency, but they do not care whether it is WiMAX, LTE, or a combination of the two that supports the service.

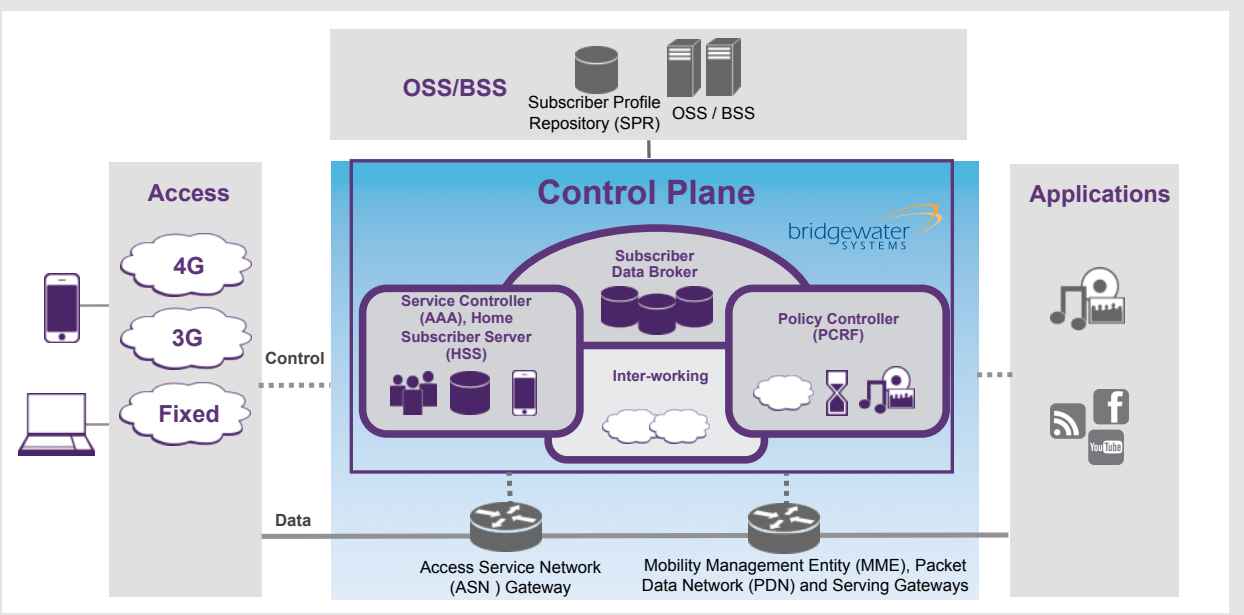
Service Continuity And Portability – The Importance Of The Control Plane

Multimode and software-upgradable devices and base stations will enable WiMAX operators to smoothly transition to LTE. Overlay networks with a paced migration will further reduce the risk of service interruption within the RAN.

Equally important for operators is service continuity within the core network and full service portability. The transition to LTE must be transparent to subscribers. Service plan features and options, billing settings, application and bandwidth management, and provisioning must be consistently available as subscribers move from WiMAX to LTE. This is even more important if WiMAX and LTE coexist, either for a short transition period or within multi-interface networks, because subscribers will frequently switch among interfaces and should be able to do so without noticing any change in their service.

Another consideration is the ability to have a common subscriber data management system to manage discreet WiMAX and LTE subscribers and services in a co-existence strategy. This reduces operating costs for the operator and avoids the creation of disparate subscriber databases.

A smooth upgrade to LTE is available to WiMAX operators that have adopted Bridgewater's control plane suite as shown in Table 3.



WiMAX and LTE are supported by an overlapping set of vendors. As a result, there is a great functional similarity of control plane elements in WiMAX and in LTE's Evolved Packet Core (EPC). Bridgewater's control plane suite for WiMAX and LTE was developed using the same platform and provides functionally equivalent elements that work within both networks.

In both WiMAX and LTE networks, Bridgewater's Subscriber Data Broker™ provides a common subscriber management platform to leverage subscriber information such as profile, usage and location, and deliver personalized services. The Bridgewater® Policy Controller, which supports the Policy and Charging Rules Function (PCRF) in LTE, manages network, application, and subscriber policies and is deployed today in WiMAX networks supporting dynamic metering services such as day passes, Quality of Service (QoS), fair usage, and over-the-air device management.

Some of the functionality of the Bridgewater® Service Controller (AAA) which provides authentication, authorization, and accounting in WiMAX is provided in the Bridgewater® Home Subscriber Server (HSS) and Mobility Management Entity (MME) in LTE.

A 3GPP AAA inter-working module in the LTE network ensures that the control plane elements in the 3GPP (LTE) network and non-3GPP (WiMAX) network share subscriber and policy information.

Table 3: In a Nutshell: Moving from WiMAX to LTE

Figure 1 shows the control plane functions that WiMAX operators need to preserve as they incorporate LTE.

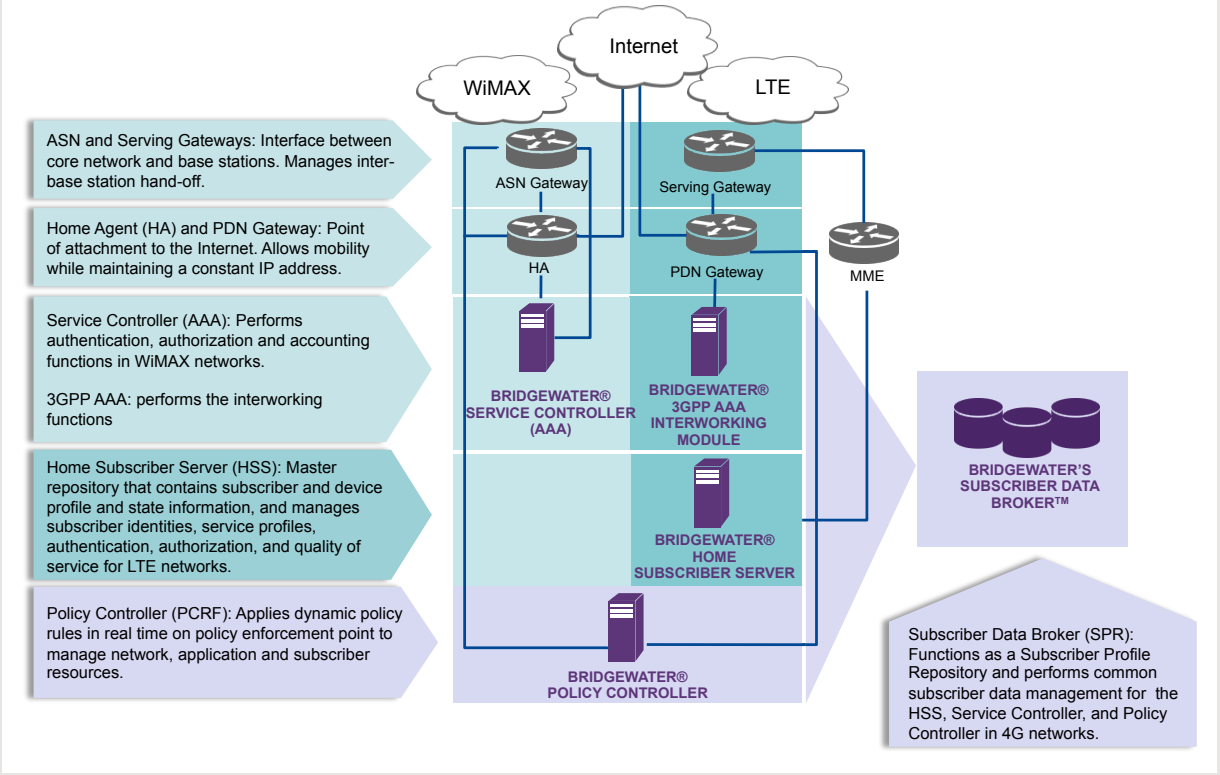


Figure 1: Evolution of the Core Network

Coexistence and Evolution Within The LTE Core

WiMAX and LTE have different core networks, but they share a flat IP structure that consists of largely equivalent elements. The WiMAX ASN Gateway corresponds to the MME and Serving Gateway in LTE; they each manage the RAN. The MME is responsible for mobility and session management, resource allocation, and bearer control, and the Serving Gateway routes packets through the access network. The WiMAX HA corresponds to the LTE PDN Gateway; both manage connectivity between the subscriber device and the Internet, plus interworking with other networks. While these core elements perform similar functions, they are specific to the air interface and cannot be shared by WiMAX and LTE networks.

As mentioned above, Bridgewater's control plane suite for WiMAX and LTE is built on the same platforms and is air interface-agnostic. Elements like the Subscriber Data Broker and the Policy Controller can be shared by a WiMAX and an LTE network, provided relevant interfaces, which are different for WiMAX and the LTE EPC, are used to connect the Subscriber Data Broker and the Policy Controller to the other core elements. The Service Controller in WiMAX can be upgraded to the Home Subscriber Server in LTE.

Operators using different transition models will follow different paths from the WiMAX to the LTE control plane (Table 4). For a swap of WiMAX for LTE, a software upgrade of common modules will suffice. If the two networks need to coexist, two core networks have to be established, but some elements can be shared.

Swap	**During the swap, common WiMAX core elements such as the Subscriber Data Broker and the Policy Controller only require a software upgrade to LTE and existing subscriber data is preserved. The Service Controller is migrated to the Home Subscriber Server in LTE.**
Overlay	**During the initial phase, the operator will maintain two overlapping sets of core elements, one for WiMAX, and one for LTE. When the transition is completed, the operator can remove the WiMAX core network elements.**
Coexistence	**The operator establishes and maintains two separate but communicating core networks, connected through the 3GPP AAA interworking module. The operator can leverage common elements by sharing information across them or by using the same elements for both networks.**

Table 4. Service Continuity and Portability during the Transition to the LTE Control Plane

Operators can choose different approaches to benefit from commonalities in the control plane:

- **Separate Core Networks** (Figure 2). Two parallel core networks are established and maintained—one for WiMAX and one for LTE. Common control plane elements (i.e., the Subscriber Data Broker and the Policy Controller) share some information, but they are kept mostly distinct. This approach allows the operator to offer different services over each network and to maintain separate subscriber databases and profiles. Operators that see LTE and WiMAX as complementary but fundamentally different networks that support different types of services and devices (e.g., wireline broadband replacement with WiMAX, and mobile broadband access with LTE) may find this approach well suited to their needs.

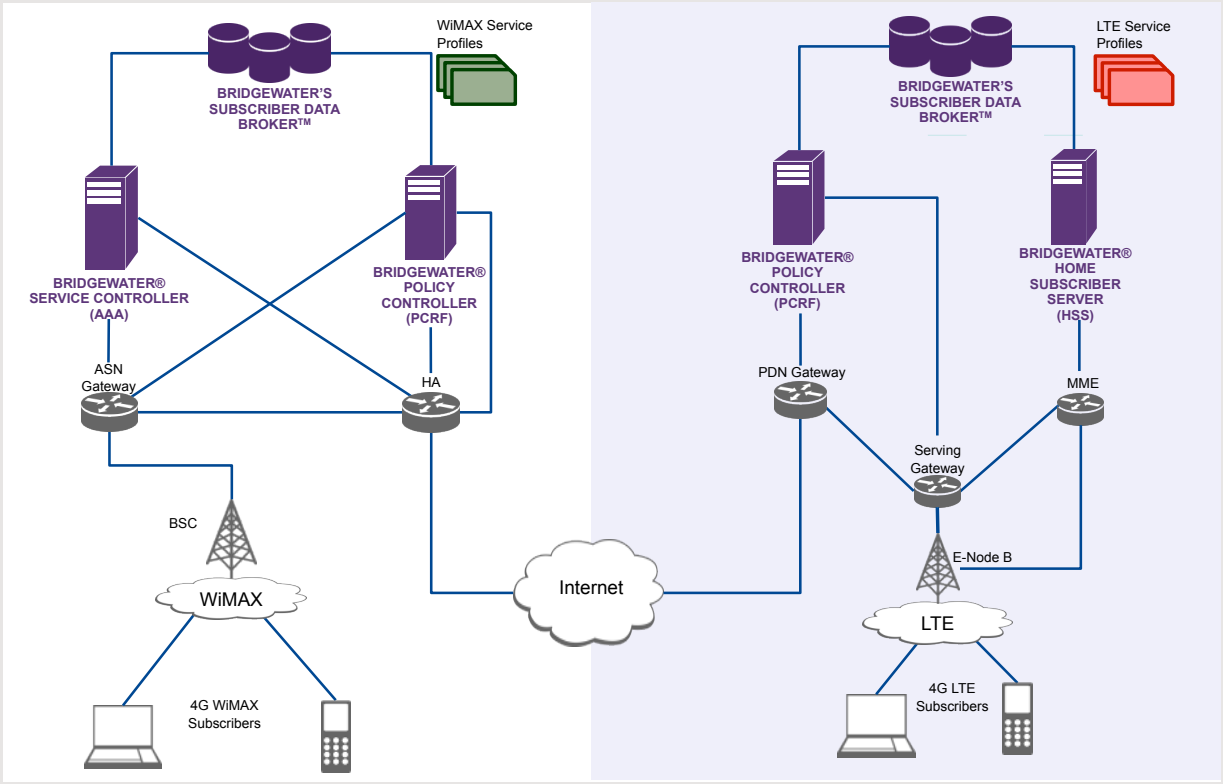


Figure 2: Separate Core Networks

- **Co-existence with Common Subscriber Management** (Figure 3). Two separate core networks are maintained, with the Subscriber Data Broker (SPR) shared between them. With a common repository of subscriber data, this approach will appeal to operators that intend to manage the two networks differently but expect many subscribers to have service plans that include both WiMAX and LTE. By sharing subscriber profiles across networks, operators can keep their current processes for provisioning, modeling, and billing, while retaining the ability to manage subscribers and services differently in the two networks (i.e., subscribers may be charged differently, or be subject to different policy settings or traffic caps depending on the network they use).

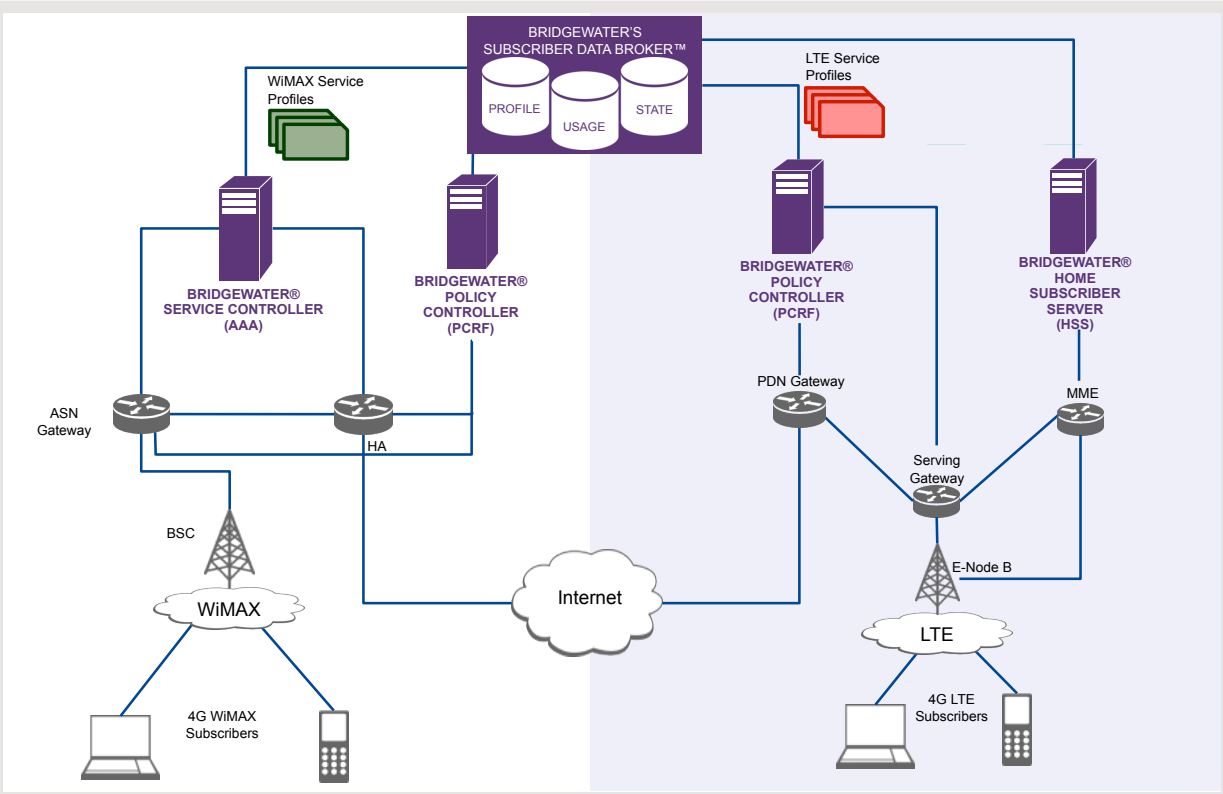


Figure 3: Co-existence with Common Subscriber Management

- **LTE/WiMAX Interworking** (Figure 4). All common control plane elements (i.e., Subscriber Data Broker and the Policy Controller) are shared between the WiMAX and LTE networks. This approach allows the operator to eliminate duplication and complexity in the core, and relies on deep interconnection between the two networks. It follows the 3GPP Evolved Packet System (EPS) WiMAX Interworking Specification which is based on the 3GPP architecture enhancements for non-3GPP accesses. This is an approach well suited to operators that have a temporary overlay network or that intend to use similar tools to manage the WiMAX and LTE networks. Of course, the operator will still be able to set different policies, apply different subscriber profiles, or choose different billing models for the two networks, and will be able to define how the two networks will interact with each other.

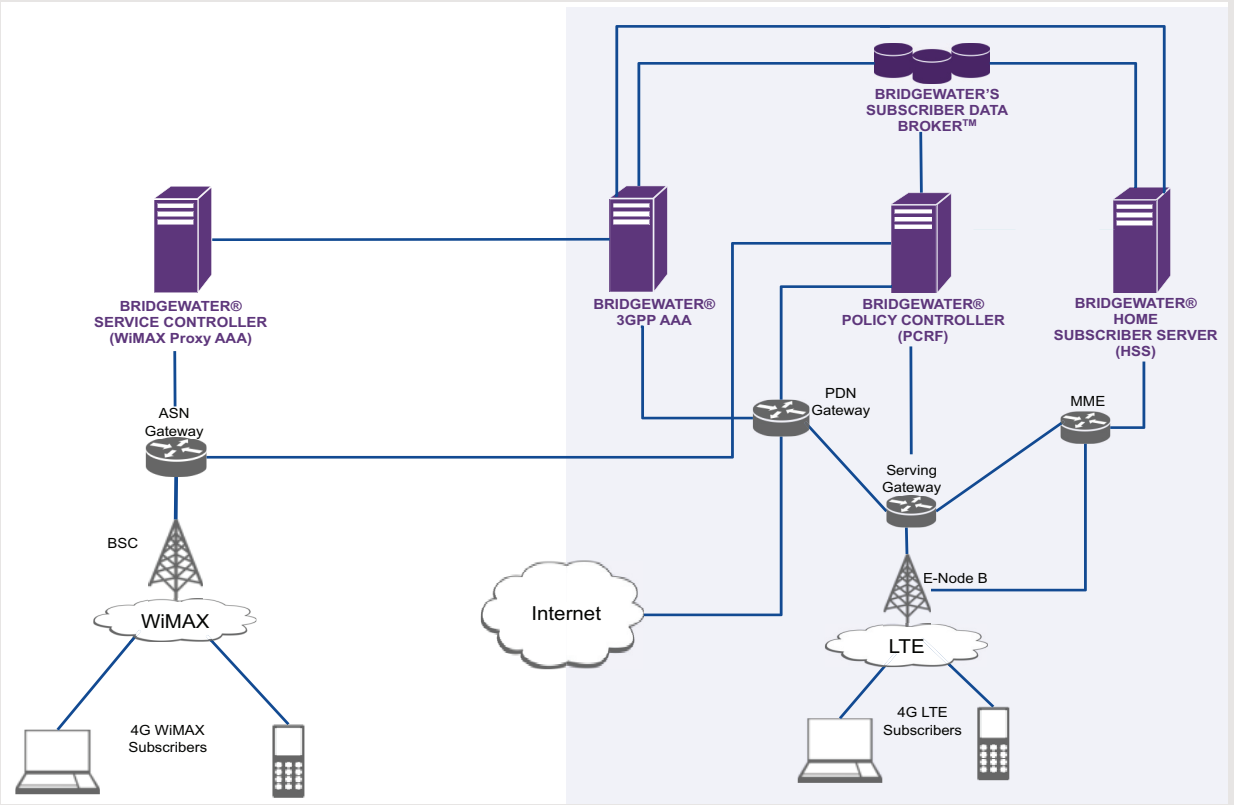


Figure 4: LTE/WiMAX Interworking

Transforming to 4G With Bridgewater

Bridgewater's 4G control plane suite enables service providers to efficiently manage and maximize revenues from wireless broadband services and applications. It has been developed through work with operators using a variety of interfaces (CDMA/EVDO, GSM/HSPA, WiMAX, Wi-Fi, LTE)—assisting operators in the transition from one interface to another, in integrating multiple interfaces within the same network, or in interworking across different networks and interfaces. The experience developed through many years and global engagements with more than 150 service providers has led Bridgewater to develop a widely adopted platform that is air interface–agnostic and that is optimized for the IP core architecture that defines 4G networks.

Why Bridgewater	
WiMAX Credentials	**Bridgewater has worked with over 40 WiMAX operators worldwide.**
Mobile data expertise	**Bridgewater's roots are in mobile data networks, and the company has extensive experience in helping operators make the control plane transition from 2G to 3G, and from 3G to 4G.**
LTE experience	**Bridgewater is helping operators manage their control plane as they roll out LTE service. Deployment is under way with one North American operator, and trials are in the planning and implementation stages with several global mobile operators.**
Interworking and Multi-Access Pedigree	**Wireless networks are rapidly becoming networks of networks, with traffic managed in real time across interfaces. Bridgewater helps operators build a control plane that is air interface–agnostic and can flexibly adapt to multiple technologies. Wi-Fi offload traffic management is one of the more recent areas of activity at Bridgewater.**

Bridgewater's portfolio of products has been widely deployed in WiMAX networks, and is being deployed in LTE trials and commercial networks. The key elements with common functionality include:

- Bridgewater's Subscriber Data Broker (WiMAX and LTE)
- Bridgewater Service Controller (WiMAX) and Bridgewater Home Subscriber Server (LTE)
- Bridgewater Policy Controller (WiMAX and LTE; includes PCRF support for LTE)

Bridgewater's approach is ideally suited to WiMAX operators that want to focus on expanding their WiMAX network today and be ready for a possible transition to LTE in the future. Bridgewater's WiMAX solution gives operators the confidence that they will be able to upgrade seamlessly to LTE, if they decide to do so. WiMAX operators that select Bridgewater enjoy the flexibility to choose their level of integration between networks—from a complete separation of the control plane to a deep integration in which multiple elements are shared—while retaining service continuity and portability. Bridgewater's future-proof control plane suite is designed to meet WiMAX operators' needs to maximize the benefits from any technology they choose, keep full control over their transformation to 4G, and make it transparent to their subscribers.

Acronyms

3G	Third generation. It includes UMTS, HSPA, HSPA+, and EV-DO	HSS	Home Subscriber Server
3GPP	Third Generation Partnership Project	IEEE	Institute of Electrical and Electronics Engineers
4G	Fourth generation. It includes WiMAX and LTE	IP	Internet Protocol
AAA	Authentication, authorization and accounting	LTE	Long Term Evolution
ASN	Access Service Network	MME	Mobility Management Entity
BSC	Base station controller	OFDMA	Orthogonal Frequency Division Multiple Access
CDMA	Code Division Multiple Access	OTA	Over-the-air
EPC	Evolved Packet Core	PCRF	Policy and Charging Rules Function
EPS	Evolved Packet System	PDN	Packet Data Network
EV-DO	Evolution Data Optimized	RAN	Radio access network
FDD	Frequency division duplexing	SPR	Subscriber Profile Repository
GSM	Global System for Mobile Communications	TDD	Time-division multiplexing
HA	Home agent	TD-LTE	Time-division LTE
HSPA	High Speed Packet Access	UMTS	Universal Mobile Telecommunications Service
HSPA+	Evolved HSPA	WiMAX	Worldwide Interoperability for Microwave Access

Bridgewater Systems, the mobile personalization company, enables service providers to efficiently manage and profit from mobile data services, content and commerce. The company's market leading mobile personalization portfolio provides a real-time, unified view of subscribers including entitlements, devices, networks, billing profiles, preferences and context. Anchored by Bridgewater's Subscriber Data Broker™, the portfolio of carrier-grade and standards-based products includes the Bridgewater® Service Controller (AAA), the Bridgewater® Policy Controller (PCRF) and the Bridgewater® Home Subscriber Server (HSS). More than 140 leading service providers including America Movil, Bell Canada, Clearwire, Cox, Hutchison Telecom, Iusacell, Scartel, SmarTone-Vodafone, Sprint, Tata Teleservices, Tatung, Telmex, Telstra, and Verizon Wireless use Bridgewater's solutions to rapidly deliver innovative mobile services to over 150 million subscribers. For more information, visit us at **www.bridgewatersystems.com.**

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