WIMAX OR WIBRO

SIMILAR NAMES, YET DISSIMILAR TECHNOLOGIES

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1.0 Executive Summary

Later this year, Korea Telecom and SK Telecom will both launch WiBro (Wireless Broadband) services in South Korea. Although this launch will be heralded as the first commercial deployment of Mobile WiMAX (Worldwide Interoperability for Microwave Access), the underlying facts, based on a technical comparison between the two technologies, should be used to reach a somewhat different conclusion.

By all accounts, a successful launch and widespread adoption by the South Korean consumers bodes well for next-generation mobile broadband wireless services in general, and WiBro in particular. However, due to meaningful differences between the two technologies, WiBro and Mobile WiMAX are not presently compatible with each other. For the near-term, this lack of compatibility will limit the WiBro market opportunity primarily to South Korea, and possibly a small number of additional markets in Asia, while the more universally accepted Mobile WiMAX will be deployed in other parts of the world.

As discussed in this white paper, the non-compatibility between the two standards can best be explained by looking at the relationship between the WiMAX Forum, WiBro and the IEEE 802.16-2005 standard.

IEEE 802.16-2005 is an overarching standard that serves as the basis for Mobile WiMAX, and, more recently, WiBro. However, the IEEE standard is not sufficient in and of itself to define all of the requirements necessary to ensure an end-end network architecture and compatibility among multiple vendors since the standard is limited to the Physical and Medium Access Control (MAC) layers. Further, given the multi-faceted requirements of a global technology that can be deployed in multiple frequency bands of varying channel bandwidths, IEEE 802.16-2005 contains literally hundreds of options and features which vendors may not necessarily implement, depending on the market requirements.

The WiMAX Forum and its constituent members, therefore, are responsible for commercializing IEEE 802.16-2005. This process includes selecting the subset of options that all vendors must implement, ensuring interoperability across multiple vendor solutions through a rigorous testing procedure, and defining higher layer requirements, such as security and the network architecture, which are not addressed by the standard.

WiBro is beginning to align itself with Mobile WiMAX, but the two technologies will remain incompatible with each other for the next few years.

As of 2004, WiBro began to align itself with the WiMAX Forum's implementation of IEEE 802.16-2005 using a two-phased approach. Phase I of WiBro is now based in part on the IEEE standard; however, the WiBro community has selected a different set of options which results in WiBro Phase I equipment being different from, and non-compatible with, Mobile WiMAX. Over the next few years, the WiBro community will move to Phase II of WiBro, which will help harmonize WiBro and Mobile WiMAX. However, the migration to Phase II will likely require meaningful hardware and software changes to Phase I WiBro equipment which will make it an overly complex and expensive upgrade to complete.

Operators who are evaluating a mobile broadband wireless strategy need to carefully weigh the time-to-market advantage of WiBro with the long-term implications of deploying infrastructure and client devices that are not aligned with the WiMAX Forum's requirements. In the end, these operators should find that selecting WiMAX will result in a far greater choice of vendors, lower total cost of ownership, and a smooth migration to future Mobile WiMAX enhancements without the risk of technology obsolescence.

2.0 Introduction

In 2001, the WiMAX Forum was established to help promote and commercialize the IEEE 802.16 family of standards, which include a fixed and a mobile variant. Unlike other standards bodies, such as the 3GPP (Third Generation Partnership Project) which is responsible for developing UMTS (Universal Mobile Telecommunications System), the IEEE does not define all of the requirements necessary to fully implement its standard(s). Instead, organizations such as the WiMAX Forum and the Wi-Fi Alliance provide this important and very crucial task.

Separate from the IEEE and the WiMAX Forum, the South Korea Ministry of Communication (MIC) and the ETRI (Electronics and Telecommunications Research Institute), along with the TTA (Telecommunications Technology Association) were developing its own portable broadband wireless technology. This technology, which was originally called HPi, for High-speed Portable Internet, was largely exclusive to the domestic suppliers, which resulted in both political, as well as market, implications. Ultimately, TTA made the decision to harmonize its homegrown broadband wireless standard, which it renamed WiBro (Wireless Broadband), with the work being done in the IEEE 802.16-2005 standards body.

At first glance, this realignment suggests that WiBro and Mobile WiMAX are synonymous and that WiBro equipment being deployed today in South Korea could be used to meet the requirements of operators who have adopted a Mobile WiMAX strategy. This assumption, however, is not correct.

WiBro is now based on IEEE 802.16-2005, but its implementation of the standard differs from the implementation being mandated by the WiMAX Forum.

In addition to WiBro limiting an operator to a specific frequency band, channel bandwidth and duplex scheme, the WiBro compliance with IEEE 802.16-2005 does not imply that WiBro is compatible with Mobile WiMAX. Instead, although WiBro and Mobile WiMAX have similar features and are based on the overarching IEEE 802.16-2005 standard, the two technologies also have enough dissimilar characteristics that compatibility between the two systems is impossible to achieve. Over the next few years, WiBro could become synonymous with Mobile WiMAX, at which point WiBro and Mobile WiMAX equipment will be compatible. In order for this to be achieved with existing WiBro infrastructure it will likely require significant amounts of new hardware and software upgrades for current WiBro mobile devices to attain Mobile WiMAX compatibility.

This paper will explain the relationships between the WiMAX Forum, WiBro and IEEE 802.16-2005. Once these relationships are understood, the paper will discuss in relatively simple terms some of the technical differences which result in Mobile WiMAX and WiBro being incompatible with each other. Finally, the paper will examine the market opportunities for Mobile WiMAX versus WiBro.

3.0 WiMAX Background

To better understand how WiBro relates to Mobile WiMAX and why the two broadband solutions are largely dissimilar at the moment, it is first important to take a step back and understand the relationship between IEEE 802.16 and Mobile WiMAX.

3.1 Understanding the role of an IEEE standards body

A PAR (Project Authorization Request) is required prior to any work commencing with a new IEEE standards body. Among other things, a PAR defines the objectives and scope that the requisite standards body is hoping to achieve.

Within the context of the IEEE, a PAR somewhat limits the final contents of the standard since the PAR restricts the standards work to only the definition of the Physical and Medium Access and Control layers (MAC) of the technology. For comparison purposes, standards bodies, such as the 3GPP, which is responsible for defining one of the 3G cellular standards (UMTS), have an all-encompassing task, including developing applications and services, establishing inter-operability testing procedures, and defining the network architecture.

Since the task of an IEEE body is somewhat limited, efforts that reside outside of IEEE are required to bring an IEEE standard to a commercial reality. For example, the Wi-Fi Alliance was formed to commercialize the IEEE 802.11a/b/g/n family of standards, while other examples include the Bluetooth SIG (IEEE 802.15.1) and ZigBee (IEEE 802.15.4). In the case of IEEE 802.16d and 802.16e, the WiMAX Forum is the responsible organization.

3.2 IEEE 802.16 family of standards

For simplicity purposes, WiMAX is generally considered to be synonymous with IEEE 802.16, especially since the latter lacks the marketing appeal of what could become a widely-adopted broadband wireless service. However, there are also several important nuances that must also be taken into consideration.

IEEE 802.16 was first organized in the late 1990s, and according to its PAR, its task was to develop a broadband wireless technology that could be deployed in the 10-66GHz frequency bands. After further consideration, the standards body was divided into two separate groups. IEEE 802.16 continued to develop a solution for 10-66GHz while the newly-formed 802.16a began development of a solution for the 2-11GHz bands. Due to the lack of an external body, such as the Wi-Fi Alliance or the Bluetooth SIG, both of these standards failed to achieve commercial success.

While the 802.16a standard failed to achieve commercial success, some of the initial work later formed the basis of a "reborn" standards body, IEEE 802.16d. This IEEE body subsequently published IEEE 802.16-2004, which is commonly referred to as Fixed WiMAX, since its feature set limits the technology to fixed and portable usage models. With the focus of this paper on the mobility capability of the IEEE 802.16 standard, the WiMAX Forum's involvement with IEEE 802.16-2004 is outside the scope of this paper.

3.2.1 IEEE 802.16-2005

The mobile variant of the IEEE 802.16 standard is IEEE 802.16-2005, which, as of February 28, 2006, is a published standard. This standard, which is now referred to as IEEE 802.16-2005, defines the Physical and MAC requirements for a mobile broadband wireless technology that operates in licensed spectrum below 5GHz.

3.2.1.1 Flexibility versus Compatibility

The availability of a wide spectrum band gives the standard a high degree of flexibility with respect to the spectrum in which the technology can be deployed. For example, 3.5GHz is widely available across the globe so the standard defines the requirements for that particular frequency band. However, in the United States 3.5GHz is not currently available so other frequencies, such as 2.5GHz have to be used instead. As discussed later in this paper, 2.3GHz spectrum is another viable band, although outside of South Korea, and a few other countries, such as Australia and New Zealand, it is already been used for other services or, as is the case in North America, only a few channels are available in the spectrum.

The IEEE 802.16-2005 standard is comprised of a number of options in order to meet the numerous requirements of operators around the world.

In addition to the wide range of potential spectrum, there are also other factors that must be taken into consideration, and are therefore included in the IEEE 802.16-2005 standard. For example, different deployment scenarios may dictate the requirement for different technical features of the underlying broadband wireless standard. In some cases, the limitations of the available spectrum or an operator's preference could result in a TDD (Time Division Duplex) scheme being selected in which the forward link and reverse link traffic uses the same radio channel, albeit with a short time guard band separating the traffic. In other cases, an FDD (Frequency Division Duplex) scheme might be preferred in which the forward link and reverse link traffic are assigned to their own radio channel. One final example is the width of the radio channel that is used to carry the traffic, which could be as narrow as 1.25MHz or as wide as 20MHz, depending on the spectrum that is available and the requirements of the service.

The IEEE 802.16-2005 standard is designed with this flexibility in mind, but this flexibility can also result in incompatibility if vendors do not agree and work toward a common set of features.

3.2.1.2 Other Requirements

As discussed in Section 3.1, the IEEE 802.16 PAR limits the work in the standards body to the Physical and MAC layers. For IEEE 802.16-2005, this means that the standard does not define security mechanisms, as well as other higher layer features, such as the network architecture. With mobility being a key criteria of the standard, the definitions of how a mobile device authenticates onto a network, how it moves throughout the network, and the network elements and protocols responsible for ensuring the seamless handoffs between cell sites, need to be agreed upon by all vendors; otherwise, compatibility would be impossible to achieve.

IEEE 802.16-2005 does not define all of the technical specifications that are required to commercialize the standard.

Even after a specification is fully defined, there is a need to test each vendor's solution against that specification to ensure that the solutions comply with the standard and that multi-vendor interoperability is achieved. As has been the case with a number of wireless technologies,

multi-vendor interoperability is never as easy as it seems, yet without it, the advantages of having a universally-adopted standard in place cannot be achieved.

3.2.2 Profiles

In some respects, IEEE 802.16-2005 lacks sufficient requirements that are necessary for commercializing a multi-vendor standard while in other respects the standard has so many built-in options, that there are actually incompatibilities within the standard itself. In order to commercialize the IEEE standard, the WiMAX Forum establishes profiles, which define the specific options that vendors have to implement and then successfully demonstrate through interoperability testing in order to receive a WiMAX certification.

At a macro level, a Mobile WiMAX profile defines the frequency band, duplex scheme, and channel bandwidth that vendors must implement, with the exact requirements of the profile based in large part on the market demand from potential customers. Additionally, a profile defines very technical aspects that are not fully characterized in the IEEE standard.

A profile defines the specific options and other technical parameters that vendors must implement in order to ensure multi-vendor interoperability of the IEEE 802.16-2005 standard.

For example, Mobile WiMAX uses S-OFDMA (Scalable Orthogonal Frequency Division Multiple Access), which means that the number of tones, or sub-carriers, used to transport the data and signaling traffic scales with the channel bandwidth. The IEEE standard, however, does not specify the exact number of tones required for a given channel bandwidth nor does it specify how many tones are assigned to carry data traffic versus carry signaling traffic. Other examples include how mobile devices are able to move throughout a network while remaining connected with the network (e.g., handoffs), as well as more detailed specifications on how the individual data bits, or symbols, are structured on each OFDM sub-carrier.

Without this detailed information contained in the profile(s), vendors would inevitably use different approaches. Each approach could deliver a similar performance outcome, but it would also result in a number of proprietary solutions, thus negating one of the biggest advantageous of using a standards-based solution.

Based on a careful engineering analysis of the requirements, the WiMAX Forum determines this critical information. More importantly, without adhering to the WiMAX Forum profiles, it is actually possible to have a solution that is compatible with the IEEE 802.16-2005 standard, yet require meaningful hardware and software changes in order to be compliant with Mobile WiMAX.

4.0 WiBro Background

In February 2002 the South Korean government assigned 100MHz in the 2.3GHz spectrum for a portable Internet service. At the time, the operators, such as Hanaro Telecom, SK Telecom and Korea Telecom were also field testing a number of potential broadband wireless solutions, albeit solutions that were largely proprietary in nature.

Eventually, the decision was made to create a new solution that would best meet the needs of the South Korean market. ETRI, which is a South Korean research institute that is focused on telecommunications, along with Samsung and the aforementioned operators formed the HPi (High-speed Portable Internet) Project. In this project, ETRI was responsible for defining the HPi requirements and prototype development while Samsung was responsible for developing a commercial system.

4.1 HPi is the precursor to WiBro

At a macro level, the goals of the HPi Project were very similar to the present day objectives of the WiMAX Forum. In particular, members of the HPi Project were designing a service which supported high bandwidth connectivity at a low delivery cost to consumers in a mobile environment. However, since HPi was specific to the South Korean market it did not have to include the optional features which are necessary to meet a wide range of unique requirements that can arise when a technology is being considered for a global deployment.

For example, HPi was, and still is, only defined for the 2.3GHz spectrum band with 8.75MHz radio channels and a TDD duplex scheme. Given that this spectrum band was already reserved in South Korea for the technology, there was little need to define the technical specifications required to deploy HPi in other spectrum bands or channel bandwidths. Additionally, HPi was also considered to be a portable solution versus a truly mobile solution. HPi documents, which can still be found on the Internet, indicate that the solution was being designed for sub-60km/h with sub-150ms intra-cell handoffs versus the more stringent Mobile WiMAX requirements of 120km/h and sub-50ms, respectively.

At its inception, the HPi Project members were not even designing HPi to be compatible with the IEEE 802.16-2005 standard.

At its inception, the HPi Project members were not even designing HPi to be compatible with the IEEE 802.16-2005 standard. However, political maneuvering and a willing/desire to comply with a universally-accepted standard resulted in the HPi Project realigning its efforts with the work being done in the IEEE. In April 2004, the HPi moniker was replaced with the more commonly known WiBro marketing name.

4.2 WiBro Phase I and Phase II

WiBro is comprised of two phases. WiBro Phase I, which was completed in March 2005, retains many of the "proprietary" elements of the original HPi standard with the network deployments taking place today in South Korea based on this earlier phase. WiBro Phase II, which was largely completed late in 2005, more closely aligns WiBro with the Physical and MAC layer requirements defined in IEEE 802.16-2005.

As discussed in previous sections, adherence to the IEEE 802.16-2005 standard does not ensure compatibility with Mobile WiMAX, although it is now more likely that full convergence between WiBro and Mobile WiMAX will be achieved in future WiBro Phase II products that have yet to be introduced. In a presentation the South Korean Ministry of Information and Communications indicates that WiBro Phase II products will be available for commercial deployments in the second quarter of 2008.

It isn't entirely clear how South Korean operators will handle the migration from WiBro Phase I to WiBro Phase II or even when they will begin the migration. Given the incompatibility between the two phases, multi-mode devices that support both phases will likely be used, while in the network the operators will have to deploy new hardware and software in order to dedicate resources to Phase I and Phase II devices.

5.0 Technical Differences

While it might suffice to just point out that Mobile WiMAX and WiBro are not compatible with each other, it is also helpful to identify a few specific examples where the two technologies differ. Additionally, by understanding some of these differences, it is then possible to better appreciate why the migration from WiBro to Mobile WiMAX will require a fair amount of hardware replacement and software upgrades.

5.1 Physical Layer Differences

5.1.1 S-OFDMA

IEEE 802.16-2005 outlines the concept of S-OFDMA in which the number of tones scales with the width of the radio channel. The standard does not, however, define the number of tones for each bandwidth nor does it define how these tones are used.

Working outside the auspices of the IEEE, the WiMAX Forum has determined the number of tones that are required for each channel bandwidth. For example, the WiMAX Forum has determined that 1,024 tones, or sub-carriers, are assigned to a system bandwidth of 10MHz and that 512 tones are used when the system bandwidth is 5MHz. Further, the WiMAX Forum has designated a certain number of tones for carrying data traffic, as well as pilot tones and null tones, which are used to limit interference in the system.

WiBro has also adopted S-OFDMA, but the channel bandwidths and the number of associated tones, including the number of tones for carrying data, pilot and null traffic, is not consistent with the WiMAX Forum. Worth noting, outside of South Korea WiBro will eventually support 7MHz (1,024 tones) and 14MHz (2,048 tones).

Taking it one step further, each sub-carrier is also divided into frames and it is these frames that carry the symbols, or bits of data. In this case, WiBro and Mobile WiMAX both use 5ms frames, but the number of symbols in each frame differs by technology. WiBro assigns 42 OFDM symbols and Mobile WiMAX assigns 48 OFDM symbols.

WiBro and Mobile WiMAX use OFDMA, but the number of tones and the frame structure within a given tone, or sub-carrier, differs between the two standards.

Since these tones, or sub-carriers, serve as the basis for transporting traffic in an OFDMA-based system, it is paramount to interoperability that each solution is implemented the same way. In the case of Mobile WiMAX and WiBro it is very evident that this is not the case. Further, since this is a Physical layer implementation, meaningful hardware changes (e.g., new ASICs in the devices, new channel cards in the base stations) will likely be required to bring the WiBro solution in line with Mobile WiMAX.

5.1.2 Multiple Input Multiple Output (MIMO) Antennas

The WiMAX Forum has also mandated that mobile devices support MIMO antenna schemes, while base transceiver station (BTS) support for MIMO is optional. Typically, the standards body would mandate that the terminal devices support the advanced feature set while making it optional in the base station for backward compatibility purposes. MIMO uses multiple antennas to transmit and multiple antennas to receive information, and is therefore a critical

element to achieve the required throughput in a mobile environment that is more sensitive to varying radio frequency conditions. In the case of Mobile WiMAX, the WiMAX Forum has specified that mobile devices support one transmit and two receive chains while MIMO is optional in WiMAX base stations in order to receive WiMAX certification.

Although this requirement is not mandatory until the next wave of WiMAX certification, most Mobile WiMAX solutions will support MIMO functionality by sometime in 2007. WiBro Phase I, however, does not include MIMO, which implies that additional hardware changes will be required to existing solutions in order to implement the feature.

5.1.3 Hybrid Automatic Repeat ReQuest (HARQ)

HARQ is another layer one/layer two feature that is supported by Mobile WiMAX and WiBro; however, with different implementations. HARQ is an advanced retransmission scheme that allows a more aggressive coding scheme for a given channel condition. Put simply, with HARQ the system takes more risks with the amount of data that it tries to transmit for a given radio condition. In the event that the transmitted data fails to reach its destination, the data is quickly retransmitted since the data is also being stored in buffers that exist in the hardware.

WiBro supports incremental redundancy HARQ while Mobile WiMAX supports Chase combine HARQ, the implementation of theses two different types of HARQ technologies requires different hardware arrangements, e.g. very different memory requirements.

5.1.4 Duplex Schemes

The IEEE 802.16e-2005 standard supports three different duplex schemes: TDD, FDD and half-duplex FDD. TDD means that the mobile device is transmitting and receiving data on the same radio channel with a very short time guard band separating the uplink (transmitting) from the downlink (receiving) traffic. FDD means that the mobile device can transmit and receive data at the same time with the transmitted data using one radio channel and the received data being sent on a different radio channel – a frequency guard band is used to separate the traffic. Half-duplex FDD is very similar to FDD except that the mobile device can only transmit or receive data at any given moment versus simultaneously as is the case with FDD, which is also referred to as full-duplex FDD.

Both Mobile WiMAX and WiBro presently support TDD, however, the DL and UL switching time gap is different, this means that the RF co-existence of the Mobile WiMAX and WiBro is not possible if they are deployed in same geographical region. More specifically, since the time gaps are different, the WiBro system cannot be easily modified to Mobile WiMAX, since the two systems have different RF requirements.

As discussed in Section 4, WiBro is only required to support TDD so hardware elements such as a duplexer are not required. Conversely, Mobile WiMAX profiles will likely include all three duplex schemes in order to provide greater flexibility across a diverse customer base with

different needs and spectrum limitations. In that regard, even if WiBro incorporated all of the other elements of the WiMAX Physical layer, it would still be limited to TDD.

5.2 MAC Layer Differences – the handoff

Although IEEE 802.16-2005 defines the Physical and MAC, the standard also includes a number of options for how it can be implemented. In addition to the scheduler which decides how bandwidth is allocated among a number of requesting users with different priorities, the MAC layer is also partly responsible for handing off the mobile devices between two base stations. Mobile WiMAX and WiBro, however, use different [incompatible] methods for completing handoffs.

IEEE 802.16-2005 defines three different handoff techniques with Mobile WiMAX selecting Hard Handoff (HHO) and WiBro using Fast Base Station Switching (FBSS).

IEEE 802.16-2005 defines three types of handoff techniques: Hard Handoff (HHO), Macro Diversity Handover (MDHO), and Fast Base Station Switching (FBSS), which is very similar to the mechanism used by EV-DO and HSDPA.

FBSS is somewhat similar to HHO since the mobile device is only communicating with one base station at any given moment, with some very key differences. Unlike HHO, FBSS uses the concept of an active list, which is a list of available base stations and the quality of each base station's signal that a mobile device maintains. In the event that the mobile device has to handoff to a new base station, it first negotiates the handoff request with the transmitting base station and the targeted base station. Additionally, with FBSS, each base station on the active list is actually receiving data transmissions that are targeted for that particular mobile device. However, only one base station actually transmits that data over the air – the rest of the base stations essentially drop the data packets.

MDHO uses the concept of soft handovers in which multiple base stations are transmitting the same data bits to a mobile device with the mobile device responsible for combining the separate, albeit synchronized, transmission streams coming from multiple base stations. In the uplink, the mobile device sends its transmission to multiple base stations, although there is no combining of information from multiple base stations. Instead, only the best transmission is used. MDHO is also used in WCDMA and CDMA2000.

In this case the WiMAX Forum has selected HHO while WiBro is using FBSS. These two handoff mechanisms are not compatible with implications on the devices as well as the overall network architecture of the two systems.

5.3 Network Architecture Differences

Since the IEEE standard only defines the Physical and MAC layers, the WiMAX Forum is now developing the network architecture, which it refers to as the WiMAX Network Reference Model (NRM). At the moment, the WiMAX Network Working Group is finishing up the first release of the architecture, which includes further definitions of certain key network interfaces with this work scheduled to be completed later this year. Conversely, the WiBro network architecture is already completed, which is a good indication that the two network architectures are different and largely incompatible.

Both architectures are comprised of the same basic elements and both networks take advantages of the efficiencies associated with an all-IP network, but even if one ignores the unique naming conventions, the two systems remain different. For example, the Mobile WiMAX architecture uses "base stations" while WiBro uses Radio Access Stations (RAS) with WiMAX "base stations" connecting to an Access Services Network – Gateway (ASN-GW) and WiBro RAS's connecting to an Access Control Router (ACR).

The WiMAX NRM defines at least eight interfaces throughout the Mobile WiMAX network which are not included in IEEE 802.16-2005.

In the previous section, the different handoff mechanisms used by the two systems was discussed, which in addition to impacting the MAC layer also has a direct impact on the network architecture. Specifically, since WiBro uses FBSS and Mobile WiMAX uses HHO the inherent functionality of the RAS and the ACR is different and likely more complex than the functionality of the Mobile WiMAX base station and ASN-GW.

Separate from the hardware elements of the network, the WiMAX NRM defines at least eight interfaces throughout the network. These interfaces define how the mobile devices connect with the ASN, how base stations connect with the ASN, how base stations connect to other base stations, and how networks from different service providers are connected, to name a few. These interfaces are unique to Mobile WiMAX and would also have to be implemented by a WiBro vendor in order to ensure interoperability.

6.0 Market Implications

The objective of this white paper is not to compare and contrast the performance characteristics of Mobile WiMAX and WiBro, but to demonstrate that despite these two technologies being based on IEEE 802.16-2005, Mobile WiMAX and WiBro are not compatible with each other. This current lack of compatibility, in turn, is a critical factor that an operator must take into consideration when evaluating its mobile broadband wireless strategy.

6.1 The "WiBro Profile"

As discussed earlier in this paper, the WiMAX Forum is the organization responsible for defining profiles based on the over-arching IEEE 802.16-2005 standard. These profiles contain very specific requirements and performance parameters, such as the frequency, channel bandwidth, and duplex scheme, as well as the more detailed technical specifications such as the number of OFDM tones and frame structure that are otherwise not defined by the standard. Further, these profiles also allow vendors to introduce commercial products which can ultimately receive WiMAX certification, a key requirement that is essential for ensuring multi-vendor interoperability.

"WiBro solutions" that are deployed outside of 2.3GHz are nothing more than proprietary solutions that incorporate certain aspects of WiBro and/or Mobile WiMAX.

Conversely, WiBro equipment that is available today or in the very near future is targeted for a very specific application, namely the 2-3 commercial networks that are being deployed in South Korea. Operators in other regions of the world where 2.3GHz is available could also consider WiBro, but the near-term availability of equipment will likely be offset by the longer term implications of deploying a quasi-proprietary technology.

Additionally, if vendors offer "WiBro equipment" in other frequency bands, by definition the deployed solution would not be WiBro nor would it be Mobile WiMAX. There is, in effect, only one "WiBro profile" and that "profile" is entirely incompatible with WiMAX Forum profiles. Instead, these solutions would be nothing more than proprietary solutions that incorporate certain aspects of WiBro and/or Mobile WiMAX,

As an analogy, NTT DoCoMo launched its FOMA service in Japan using a solution that was based on UMTS, but not fully compatible with it. The operator had the advantage of having the first commercial WCDMA network in the world while its suppliers likewise benefited by having a captive customer. However, since UMTS has taken off around the world, NTT DoCoMo doesn't have the purchasing leverage that other operators have since any equipment that NTT DoCoMo requires must be customized to work on its network. The Japanese operator is now moving to adopt the more universally-accepted UMTS standard at which point it will reap the cost benefits that its peers possess, but this network migration will also come at a price.

6.2 The Convergence of Mobile WiMAX and WiBro

Mobile WiMAX and WiBro are moving toward convergence, but this migration will not happen over night, nor will it happen without meaningful consequences, both good and bad, for operators that initially adopt a WiBro strategy.

At the moment SK Telecom and Korea Telecom are the only operators that are committed to WiBro following Hanaro Telecom's decision to not deploy its WiBro network. Over the course of the next few years, these operators will need to upgrade their WiBro network with new hardware and software that is compatible with the Mobile WiMAX profile that is being defined for 2.3GHz. Further, these operators will need to offer their subscribers multi-mode devices that support the legacy WiBro network as well as the newly-introduced Mobile WiMAX solution.

While it is difficult to estimate the total cost required to complete this migration, it is fair to say that the cost can at least be described as meaningful. The migration to Mobile WiMAX, however, will have its advantages for these operators.

First, by adopting the universally-accepted Mobile WiMAX solution, the South Korean operators will have access to a much larger base of potential suppliers for infrastructure, handset and chipset solutions. Further, with Mobile WiMAX, certain network performance characteristics, such as sector capacity, cell coverage, and mobility should improve over what is possible with WiBro. Finally, from a subscriber's perspective, international roaming on other Mobile WiMAX networks would be possible, thus removing the island concept that existed with WiBro, and which is slowing diminishing with FOMA.

7.0 Conclusions

The work being done by the WiMAX Forum is resulting in the commercialization of the IEEE 802.16-2005 standard. When this work is fully completed and profiles are fully defined, potential operators around the world will have the ability to deploy a universally-accepted solution that benefits from having a large base of suppliers and flexibility to support a wide-range of operator requirements.

At the same time, WiBro, which is also based on IEEE 802.16-2005, is moving to harmonize with Mobile WiMAX. When this is achieved in the next few years, the economies of scale associated with the WiBro community will merge with the much larger Mobile WiMAX community, thus benefiting all operators, regardless of which technology path they initially followed.

In the interim, operators who are evaluating the mobile broadband wireless strategies need to consider more than the time-to-market advantages of WiBro. Instead, these operators must also take into consideration the migration costs that will result when they must upgrade their network with new hardware and software that is compatible with Mobile WiMAX, as well as the implications associated with only having a limited base of WiBro suppliers. For most operators, it appears that Mobile WiMAX represents the better choice.