WiMAX

By:
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What is WiMAX?

- Worldwide Interoperability for Microwave Access (WiMAX) is the common name associated to the IEEE 802.16a/REVd/e standards. These standards are issued by the IEEE 802.16 subgroup that originally covered the Wireless Local Loop (WLL) technologies with radio spectrum from 10 to 66 GHz. Recently, these specifications were extended below 10 GHz.

- The WiMAX Forum intends to do for 802.16 what the Wi-Fi Alliance did for 802.11:
  - harmonize standards and certify interoperability between equipment from different vendors. Standardized interoperable solutions will result in mass volume and bring down costs,
  - promote and establish a brand for the technology.
History

- WiMAX Forum was formed in April of 2001 as an industry group to promote conformance and Interoperability of IEEE 802.16-2001 Broadband Wireless Access products.

- Founding organizations: Ensemble, CrossSpan, Harris, and Nokia.

- The first version of the standard, 802.16, was published in April 2002 and addressed fixed, line of sight connections for the ‘first mile/last mile’ link. It focused on efficient use of various licensed frequencies in the 10-66GHz bandwidth.

- The next version of the standard, 802.16a, published in April 2003, is the one that has really kick-started WiMAX into being adopted as the dominant wireless broadband technology. This is also for fixed wireless but extends the range of WiMAX from 31 to 50 miles and operates in the low frequency 2-11GHz spectrum and so can be adopted by unlicensed operators.
In January 2003, the IEEE approved 802.16a as an amendment to IEEE 802.16-2001, defining (Near) Line-Of- Sight capability.

In July 2004, IEEE 802.16REVd, now published under the name IEEE 802.16-2004, introduces support for indoor CPE (NLOS) through additional radio capabilities such as antenna beam forming and OFDM sub-channeling.

In 2005, IEEE 802.16e, which adds mobility to the standard and really throws down the gauntlet to cellular.
Standards

IE 802.16-2004 is a fixed wireless access technology, meaning that it is designed to serve as a wireless DSL replacement technology, to compete with the DSL or broadband cable providers or to provide broadband access in underserved areas where no other access technology exists. It is also a viable solution for wireless backhaul for WiFi access points or potentially for cellular networks. Typically, the CPE (consumer premise equipment) consists of an outdoor unit (antenna, etc.) and an indoor modem.

EE 802.16e standard is intended to offer a key feature that 802.16-2004 lacks - portability and eventually full-scale mobility. This standard requires a new hardware/software solution since it is not backward compatible with 802.16-2004. The .16e standard tries to incorporate a wide variety of proposed technologies. Since there has been only modest justification of proposed features on the basis of performance data, and the final composition of these technologies has not been completely determined, it is difficult to know whether a given feature will enhance performance.
In Wi-Fi, the MAC uses contention access — all subscriber stations that wish to pass data through a wireless access point (AP) are competing for the AP's attention on a random interrupt basis. This can cause subscriber stations distant from the AP to be repeatedly interrupted by closer stations, greatly reducing their throughput and increases difficulty to maintain for more than a few simultaneous users.

In contrast, the 802.16 MAC uses a scheduling algorithm for which the subscriber station needs to compete only once (for initial entry into the network). After that it is allocated an access slot by the base station. The time slot can enlarge and contract, but remains assigned to the subscriber station, which means that other subscribers cannot use it.
(2) The three 2–11 GHz air interface (PHY) specifications in 802.16a are:

- WirelessMAN-SC2: This uses a single-carrier modulation format.
- WirelessMAN-OFDM: This uses orthogonal frequency-division multiplexing with a 256-point transform. Access is by TDMA. This air interface is mandatory for license-exempt bands.
- WirelessMAN-OFDMA: This uses orthogonal frequency-division multiple access with a 2048-point transform. In this system, multiple access is provided by addressing a subset of the multiple carriers to individual receivers.
**Fundamental technology: OFDM**

- OFDM is well established and is incorporated in some new generation carrier services as well as being fundamental to digital TV. It transmits multiple signals simultaneously across wireless transmission path, within separate frequencies, with the orthogonal element spacing these frequencies to avoid interference. It is also supported in the 802.11a WLAN standard.
Single carrier mode

Symbols have wide frequency short symbol time

Serial symbol stream used to modulate a single wide band carrier

Serial datastream converted to symbols, (each symbol can represent 1 or more data bits)

Orthogonal frequency division multiplex mode

Symbols have narrow frequency long symbol time

Each of the symbols is used to modulate a separate carrier

The dotted area represents the transmitted spectrum. The solid area is the receiver input.
Transmitted downstream OFDM spectrum from the base station, each slot represents a RF carrier

Transmitted upstream OFDM spectrum from the CPE, all carriers are transmitted but at a quarter of the level of the base station, hence the range will be less

Transmitted upstream OFDM spectrum from the CPE using only a quarter of the carriers, but at the same level as the base station, hence the range will be the same with a quarter of the capacity
Unlicensed:

In most markets, the unlicensed spectrum that could be used for WiMAX is **2.4GHz** and **5.8GHz**. Since the spectrum is unlicensed, the barrier to entry is low, thus making it easier for a potential operator to begin offering services using the spectrum.

Unfortunately, there are also several disadvantages:

1. Interference
2. Increased Competition
3. Limited Power
4. Availability
**Licensed**: The advantage of having licensed spectrum is that the licensee has exclusive use of the spectrum. It is protected from outside interference.

The licensed spectrum is found at 700MHz, 2.3GHz, 2.5GHz and 3.5GHz, with the latter two frequency bands currently receiving the most attention.

1. **2.5 GHz** - The 2.5GHz spectrum band is more interesting since it is available for terrestrial use in North America, Latin America.

2. **3.5 GHz** - The 3.5GHz frequency band is currently available for use in virtually every country except the United States. WiMAX proponents also believe that 3.5GHz is not suitable for mobility, largely because of the RF propagation at this frequency.
3. **700 MHz** - At this time there isn't a WiMAX profile for the 700MHz spectrum, however there is at least some interest within the WiMAX community to introduce WiMAX in this frequency band. Currently, this spectrum is being used by analog TV broadcasters. 700MHz is a very attractive spectrum band in remote regions due to the favorable propagation conditions that exist at this lower frequency (the lower the frequency the farther the signal can be propagated, all things being equal).

4. **2.3 GHz** - The use of the 2.3GHz spectrum band is largely limited at this time to certain applications in South Korea (WiBro), Australia, New Zealan. While there is 2.3GHz spectrum available in the United States, it is not attractive for WiMAX, namely because usage in adjacent channels limits the amount of available bandwidth.
1 Scalability
- The 802.16 standard supports flexible radio frequency (RF) channel bandwidths.
- The standard supports hundreds or even thousands of users within one RF channel.
- As the number of subscribers grow the spectrum can be reallocated with the process of sectoring.

2 Quality of Service
- Primary purpose of QoS feature is to define transmission ordering and scheduling on the air interface.
- These features often need to work in conjunction with mechanisms beyond the air interface in order to provide end to end QoS or to police the behaviour or SS.
3 Range
- Optimized for up to 50 Km.
- Designed to tolerate greater multi-path delay spread (signal reflections) up to 10.0μs seconds.
- PHY and MAC designed with multi-mile range in mind.

4 Coverage
- Standard supports mesh network topology.
- Optimized for outdoor NLOS performance.
- Standard supports advanced antenna techniques.
Applications

(1) Developing and Underserved Markets:
In several regions of the world, copper wire to the home or business just doesn't exist. In these situations, a fixed wireless offering that is based upon an open standard may make more economic sense than deploying copper wire.

(2) DSL and cable modem replacement:
Even in developed markets, such as the U.S. and Canada, there are regions of the country where the economics of running cable or putting in DSLAMs does not make sense. In these cases, a fixed broadband wireless access technology might be more appropriate.

(3) Wireless backhaul in a cellular network:
Microwave radios have been used since virtually the beginning of the cellular industry to provide backhaul, or transport, of voice and data traffic from outlying cell sites to the operator's core network. But it depends upon the availability of sufficient spectrum to meet their backhaul requirements, in particular with the increased requirements as the result of 3G data services.
A more likely scenario is that WiMAX will be used to provide backhaul in a Wi-Fi network. One of the biggest limitations with public Wi-Fi service is the backhaul constraint in which an 11Mbps or 54Mbps air interface is fed into a 500kbps or 1.5Mbps T-1 line.

Another limitation with public Wi-Fi is the cost and inconvenience associated with the wireline backhaul. Currently, a Wi-Fi access point can only be located where there is already wireline access, or where wireline access can be installed. Further, although DSL or cable broadband service is relatively inexpensive
(5) Portable or Mobile coverage:

- Much of the focus and interest of the WiMAX community is the scenario in which the subscriber has a seemingly ubiquitous broadband wireless connection that can provide connectivity in a portable environment and even mobile environment. This service offering would require WiMAX enabled data cards for PCs and potentially lead to embedded solutions and new types of devices.

- This usage scenario is the most appealing, since it implies broadband access and other voice/data services anytime and anywhere. At the same time, a portable/mobile solution is also more challenging to implement.
Technical and Market Challenges

All emerging technologies face their own set of challenges that they must overcome in order to become a technical and market success. WiMAX is no different. For WiMAX, its challenges include unfavorable radio frequency (RF) propagation in the relatively high spectrum being considered in some situations, the amount of unfinished work that must take place outside of the IEEE standards body for equipment to be WiMAX certified, and its economic merits relative to 3G and other broadband wireless services that currently exist.
RF propagation at higher frequencies is more challenging:

The effective cell radius at 700/800MHz is twice the size as it would be at 1.9GHz, meaning that four times as many base stations are required at 1.9GHz versus 700/800MHz. Between 1.9GHz and 2.5GHz the same multiples apply, as it does between 2.5GHz and 3.5GHz. Interpolating these numbers, a network deployed at 3.5GHz could require roughly sixty to eighty percent more cell sites as it would at 2.1GHz (UMTS spectrum) - all things being equal. WiMAX could include the use of smart antenna technologies, but this will probably not be enough to compensate for the loss. Smart antenna technologies can also prove to be costly and may not be well-suited to support a vehicular user that is moving at 120km/h, or even much slower.
(2) Deployment costs are not trivial.

The increased number of cell sites, as a result of using higher frequency bands, raises site acquisition/leasing and construction costs, regardless of the technology being deployed. This is one of the reasons why potential WiMAX operators want to use lower frequency bands (e.g., 2.5GHz and below).

(3) Incomplete network architecture:

The .16e standard only addresses PHY and MAC layers, leaving it to the WiMAX Forum to tackle issues such as call control, session management, security, the network architecture, roaming, etc. To put things in perspective, as the standard is currently written, each WiMAX base station is virtually unaware of its surrounding base stations while the MAC layer only has placeholders for the messaging traffic associated with implementing a handover. As a consequence, the notion of seamless mobility doesn't exist while power management issues could result in reduced performance.
(4) WiMAX chipset availability:

Another major uncertainty is the availability of chipsets. The initial profiles have not been selected yet, meaning that while some work can currently be done, the fine technical details cannot be implemented until after the standard is fully ratified.
WiMAX is often compared to Wi-Fi. Wi-Fi took years to achieve its recent popularity even though the same frequency band was available in virtually all countries (2.4GHz). Further, its success hasn't been dependent upon an operator-driven business model since most Wi-Fi users seldom, if ever, subscribe to use a public Wi-Fi service. Those that do pay to use public APs first purchased Wi-Fi and used it at home and then in the office before eventually migrating to the pay-for-use service.

More recently 802.11a (5.8GHz) has been gaining some traction, but it isn't a universal phenomenon and its success is nowhere near the success of 802.11b/g. One also cannot ignore that when the 54Mbps 802.11g was introduced as an enhancement to the 11Mbps 802.11b solution, it also included a mode that made it backwards compatible with 802.11b. No such compatibility exists at the moment between the fixed and mobile versions of WiMAX.
(6) WiMAX in a 3G world:

A number of operators are currently considering WiMAX, but most indicated that while they are not ruling out the portable/mobility potential of WiMAX; their main interest at this time is the potential that WiMAX offers with respect to backhaul (Wi-Fi and cellular) and fixed wireless service.

From the view of the consumer, in order for there to be a compelling need to purchase a WiMAX-enabled device and to then subscribe to the service offering, the WiMAX service must offer something that existing services cannot offer or deliver the same level of service for a more attractive price.
Embedding WiMAX in devices isn't trivial:

- In the event that demand develops for WiMAX, these notebook computer manufacturers will likely offer an embedded WiMAX solution. The challenge, however, is that notebook computers can only contain so many RF solutions. Wi-Fi is virtually ubiquitous in all of the notebook computers that are shipped, and other RF solutions, including UWB, Bluetooth and 802.11x, are either currently available or will be available in advance of WiMAX.

- In order for WiMAX to be included in this list, the technology would need to replace one of the embedded solutions in order to free up enough space.
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| **Range**      | - Optimized for users within a 100 meter radius  
                 - Add access points or high gain antenna for greater coverage | - Optimized for typical cell size of 7-10 km      
                  - Up to 50 km range  
                  - No “hidden node” problem                  | - 802.16 PHY tolerates 10 more multi-path delay spread than 802.11 |
| **Coverage**   | - Optimized for indoor environments          | - Optimized for outdoor environments         
                  (trees, buildings, users spread out over distance)  
                  - Standard support for advanced antenna techniques & mesh | - 802.18: 256 OFDM (vs. 64 OFDM)  
                  - Adaptive modulation                      |
| **Scalability**| - Channel bandwidth for 20 MHz is fixed    | - Channel b/w is flexible from 1.5 MHz to 20 MHz for both licensed and license exempt bands  
                  - Frequency re-use  
                  - Enables cell planning for commercial service providers | - Only 3 non-overlapping 802.11b channels; 5 for 802.11a  
                  - 802.18: limited only by available spectrum |
| **Bit rate**   | - 2.7 bps/Hz peak data rate; Up to 54 Mbps in 20 MHz channel | - 3.8 bps/Hz peak data rate; Up to 75 Mbps in a 20 MHz  
                  - 5 bps/Hz bit rate; 100 Mbps in 20 MHz channel | - 802.18: 256 OFDM (vs. 64 OFDM) |
| **QoS**        | - No QoS support today \( \rightarrow 802.11e \) working to standardize | - QoS designed in for voice/ video, differentiated services | - 802.11: contention-based MAC (CSMA)  
                  - 802.18: grant request MAC |
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Mobile phone radiation and health concerns have been raised, especially following the enormous increase in the use of wireless mobile telephony throughout the world. This is because mobile phones use electromagnetic radiation in the microwave range. These concerns have induced a large body of research (both epidemiological and experimental, in non-human as well as in humans). Concerns about effects on health have also been raised regarding other digital wireless systems, such as data communication networks.

**HEALTH HAZARDS OF HANDSETS**

- Calculated specific absorbed radiation (SAR) distribution in an anatomical model of head next to a 125 mW dipole antenna. Peak SAR is 9.5 W/kg over 1 mg. (USAF/AFRL).
- Part of the radio waves emitted by a mobile telephone handset are absorbed by the human head. The radio waves emitted by a GSM handset, can have a peak power of 2 watts, and a US analogue phone had a maximum transmit power of 3.6 watts.
Thermal Effects:
Microscope photographs of lenses incubated in organ culture conditions for 12 days. Right frame shows Control lens with no damage. Bottom frame demonstrates the effect of microwave radiation on bovine lens sutures for a total exposure of 192 cycles (1.1 GHz, 2.22 mW). Each cycle lasts 50 min followed by 10 min pause. In the absence of microwave radiation, the bubbles are generated by temperature increase to 39.5 °C during 4 h; see left frame.
References:

- www.en.wikipedia.org/wiki/wimax
- http://www.cdg.org/resources/white_papers/files/wimax%20july%202005.pdf