The Evolution of Wimax – Features and Applications

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Abstract – Wimax is used for providing broadband using wireless medium mainly at 2.5GHz, 3.5GHz and 5.8GHz radio frequencies. It is also known as 4G technology. It delivers about 4 times fast internet compared to its 3G counterpart. OFDM technique has increased the speed as it carries multiple carriers, each carrying more than one data bits based on modulation techniques (QPSK, 16QAM). The carriers are concisely packed together to save bandwidth. Intel is behind the development and proliferation of Wimax throughout the world. This paper reviews the basic architecture, features, advantages, limitations and some of the applications also. The comparison of Wimax with edge technologies is also discussed.

Index Terms – fixed Wimax, mobile Wimax, IEEE 802.16, MIMO, CPE, QoS.

1. INTRODUCTION

Wimax, an acronym of Worldwide Interoperability for Microwave Access, is a telecommunications technology that provides for the wireless transmission of data using a variety of transmission modes, from point-to-point links to full mobile cellular-type access. The technology provides up to 70 Mb/sec symmetric broadband speed without the need for cables. The technology is based on the IEEE 802.16 standard (also called WirelessMAN). The name "Wimax" was created by the Wimax Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes Wimax as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL [1]. Wimax is a wireless digital communications system, also known as IEEE 802.16, which is intended for wireless "metropolitan area networks". Wimax can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations.

Wimax can be used for wireless networking in much the same way as the more common WiFi protocol. Wimax is a second-generation protocol that allows for more efficient bandwidth use, interference avoidance, and is intended to allow higher data rates over longer distances [5]. The IEEE 802.16 standard defines the technical features of the communications protocol. The Wimax Forum offers a means of testing manufacturer's equipment for compatibility, as well as an industry group dedicated to fostering the development and commercialization of the technology [2]. Wimax.com provides a focal point for consumers, service providers, manufacturers, analysts, and researchers who are interested in Wimax technology, services, and products.

1. 802.16-2004 is often called 802.16d, since that was the working party that developed the standard. It is also frequently referred to as "fixed Wimax" since it has no support for mobility.
2. 802.16e-2005 is an amendment to 802.16-2004 and is often referred as 802.16e. It introduced support for mobility, amongst other things and is therefore also known as "mobile Wimax".

2. ARCHITECTURE

Wimax is a term coined to describe standard, interoperable implementations of IEEE 802.16 wireless networks. Wimax architecture is described as:

2.1. MAC layer/data link layer

In Wi-Fi the media access controller (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 [2]. This makes services such as Voice over IP (VoIP) or IPTV, which depend on an essentially-constant Quality of Service (QoS) depending on data rate and interruptibility, difficult 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. In addition to being stable under overload and over-subscription (unlike 802.11), the 802.16 scheduling algorithm can also be more bandwidth efficient [3]. The scheduling algorithm also allows the base station to control QoS parameters by balancing the time-slot assignments among the application needs of the subscriber stations.

2.2. Physical layer

The original version of the standard on which Wimax is based (IEEE 802.16) specified a physical layer operating in the 10 to 66 GHz range. 802.16a updated in 2004 to 802.16-2004, added specifications for the 2 to 11 GHz range. 802.16-2004 was updated by 802.16e-2005 in 2005 and uses scalable orthogonal

frequency-division multiple access (SOFDMA) as opposed to the OFDM version with 256 sub-carriers (of which 200 are used) in 802.16d. More advanced versions, including 802.16e, also bring Multiple Antenna Support through Multiple-input multiple-output communications (MIMO) [4]. This brings potential benefits in terms of coverage, self installation, power consumption, frequency re-use and bandwidth efficiency. 802.16e also adds a capability for full mobility support.

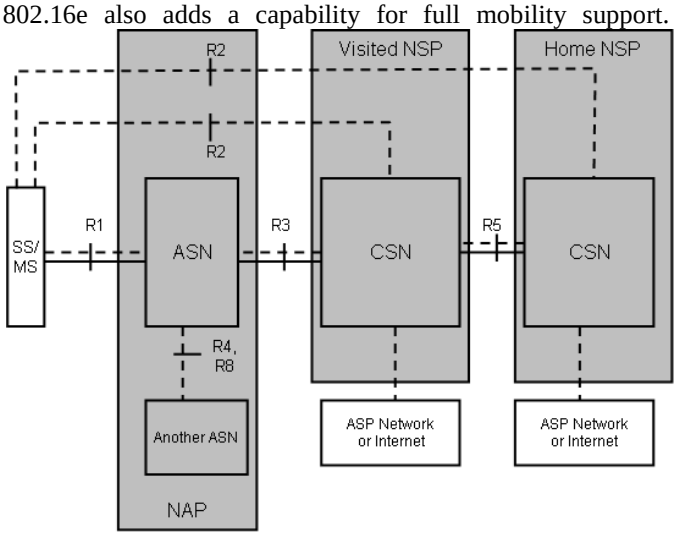

Figure-1 Architecture of Wimax [5]

The Wimax certification allows vendors with 802.16d products to sell their equipment as Wimax certified, thus ensuring a level of interoperability with other certified products, as long as they fit the same profile.

Most commercial interest is in the 802.16d and .16e standards, since the lower frequencies used in these variants suffer less from inherent signal attenuation and therefore give improved range and in-building penetration [4]. Already today, a number of networks throughout the world are in commercial operation using certified Wimax equipment compliant with the 802.16d standard.The Wimax Forum has defined an architecture that defines how a Wimax network connects with other networks, and a variety of other aspects of operating such a network, including address allocation, authentication, etc. This defines the following components:

- SS/MS: the Subscriber Station/Mobile Station
- ASN: the Access Service Network
- BS: Base station, part of the ASN
- ASN-GW: the ASN Gateway, part of the ASN
- CSN: the Connectivity Service Network
- HA: Home Agent, part of the CSN
- NAP: a Network Access Provider
- NSP: a Network Service Provider

It's important to note that the functional architecture can be designed into various hardware configurations rather than fixed configurations. For example, the architecture is flexible enough to allow remote/mobile stations of varying scale and functionality and Base Stations of varying size - e.g. femto, pico, and mini BS as well as macros.

2.3. Functional units of Wimax

A WIMAX system consists of

1. A Wimax tower, similar in concept to a cell-phone tower - A single Wimax tower can provide coverage to a very large area as big as 3,000 square miles (~8,000 square km).

Figure-2 Wimax tower

2. A Wimax receiver - The receiver and antenna could be a small box or Personal Computer Memory card, or they could be built into a laptop the way WiFi is accessed.

Figure-3 Wimax receiver

2.4. Subscriber units

Wimax subscriber units are available in both indoor and outdoor versions from several manufacturers. Self-install indoor units are convenient, but radio losses mean that the subscriber must be significantly closer to the Wimax base station than with professionally-installed external units [5]. As

such, indoor-installed units require a much higher infrastructure investment as well as operational cost (site lease, backhaul, maintenance) due to the high number of base stations required to cover a given area. Indoor units are comparable in size to a cable modem or DSL modem. Outdoor units are roughly the size of a laptop PC, and their installation is comparable to a residential satellite dish. With the potential of mobile Wimax, there is an increasing focus on portable units. This includes handsets (similar to cellular smartphones) and PC peripherals (PC Cards or USB dongles).

Figure-4 Intel's first WIMAX chip [6]

3. WORKING OF WIMAX

A Wimax tower station can connect directly to the Internet using a high-bandwidth, wired connection (for example, a T3 line). It can also connect to another Wimax tower using a line-of-sight, microwave link [6]. This connection to a second tower (often referred to as a backhaul), along with the ability of a single tower to cover up to 3,000 square miles, is what allows Wimax to provide coverage to remote rural areas.

This points out that Wimax actually can provide two forms of wireless service:

1. There is the non-line-of-sight, where a small antenna on your computer connects to the tower. In this mode, Wimax uses a lower frequency range -- 2 GHz to 11 GHz (similar to WiFi). Lower-wavelength transmissions are not as easily disrupted by physical obstructions -- they are better able to diffract, or bend, around obstacles [4].
2. There is line-of-sight service, where a fixed dish antenna points straight at the Wimax tower from a rooftop or pole. The line-of-sight connection is stronger and more stable, so it's able to send a lot of data with fewer errors. Line-of-sight transmissions use higher frequencies, with ranges reaching a possible 66 GHz [4]. At higher frequencies, there is less interference and lots more bandwidth.

Through the stronger line-of-sight antennas, the Wimax transmitting station would send data to Wimax-enabled computers or routers set up within the transmitter's 30-mile radius (2,800 square miles or 9,300 square km of coverage). This is what allows Wimax to achieve its maximum range [10].

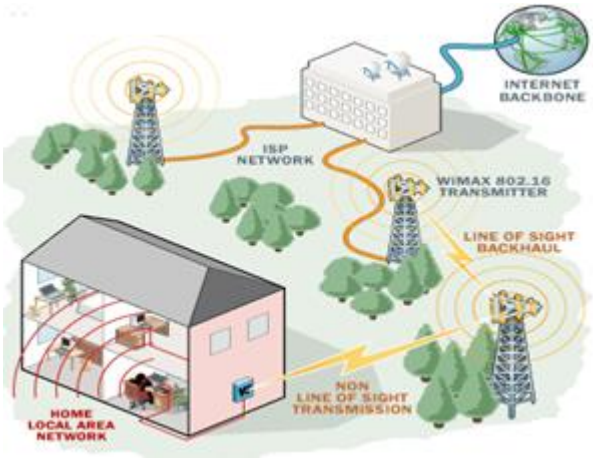

Figure-5 Working of wimax [4]

4. FEATURES OF WIMAX

1. Scalability
   (a). The 802.16 standard supports flexible radio frequency (RF) channel bandwidths.
   (b). The standard supports hundreds or even thousands of users within one RF channel [5].
   (c). As the number of subscribers grows the spectrum can be reallocated with process of sectoring.
2. Quality of Service
   (a). Primary purpose of QoS feature is to define transmission ordering and scheduling on the air interface
   (b). 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
   (a). Optimized for up to 50 Km.
   (b). Designed to handle many users spread out over kilometres [7].
   (c). Designed to tolerate greater multi-path delay spread (signal reflections) up to 10.0μ seconds
   (d). PHY and MAC designed with multi-mile range in mind
4. Coverage
   (a). Standard supports mesh network topology
   (b). Optimized for outdoor NLOS performance
   (c). Standard supports advanced antenna techniques

4.1 Advantages

1. Allow service providers to deliver high throughput broadband based services like VoIP, high-speed Internet and Video.

2. Facilitate equipment compatibility [8].
3. Reduce the capital expenditures required for network expansion.
4. Provide improved performance and extended range.
5. Range of technology and service level choices from both fixed and wireless broadband operators.
6. DSL-like services at DSL prices but with portability.
7. Rapidly declining fixed broadband prices.

4.2 Limitations

1. A commonly-held misconception is that Wimax will deliver 70 Mbit/s over 31 miles/50 kilometers. In reality, Wimax can only do one or the other — operating over maximum range (31 miles/50 km) increases bit error rate and thus must use a lower bit-rate. Lowering the range allows a device to operate at higher bit-rates [4].
2. Typically, fixed Wimax networks have a higher-gain directional antenna installed near the client, which results in greatly increased range and throughput. Mobile Wimax networks are usually made of indoor "customer premises equipment" (CPE) such as desktop modems, laptops with integrated Mobile Wimax or other Mobile Wimax devices. Mobile Wimax devices typically have an omni-directional antenna which is of lower-gain compared to directional antennas but are more portable. In practice, this means that in a line-of-sight environment with a portable Mobile Wimax CPE, speeds of 10 Mbit/s at 6 miles/10 km could be delivered [9]. However, in urban environments they may not have line-of-sight and therefore users may only receive 10 Mbit/s over 2 km. In current deployments, throughputs are often closer to 2 Mbit/s symmetric at 10 km with fixed Wimax and a high gain antenna [5]. It is also important to consider that a throughput of 2 Mbit/s can mean 2 Mbit/s, symmetric simultaneously, 1 Mbit/s symmetric or some asymmetric mix (e.g. 0.5 Mbit/s downlink and 1.5 Mbit/s uplink or 1.5 Mbit/s downlink and 0.5 Mbit/s uplink), each of which required slightly different network equipment and configurations. Higher-gain directional antennas can be used with a Mobile Wimax network with range and throughput benefits but the obvious loss of practical mobility.
3. Like most wireless systems, available bandwidth is shared between users in a given radio sector, so performance could deteriorate in the case of many active users in a single sector. In practice, many users will have a range of 2-, 4-, 6-, 8-, 10- or 12 Mbit/s services and additional radio cards will be added to the base station to increase the capacity as required [8].
4. Because of this, various granular and distributed network architectures are being incorporated into Wimax through independent development and within the 802.16j mobile multi-hop relay (MMR) task group. This includes wireless mesh, grids, network remote station repeaters which can extend networks and connect to backhaul.

4.3. Applications

The bandwidth and range of Wimax make it suitable for the following potential applications:

1. Connecting Wi-Fi hotspots to the Internet.
2. Providing a wireless alternative to cable and DSL for "last mile" broadband access [8].
3. Providing data and telecommunications services.
4. Providing a source of Internet connectivity as part of a business continuity plan. That is, if a business has a fixed and a wireless Internet connection, especially from unrelated providers, they are unlikely to be affected by the same service outage.
5. Providing portable connectivity.
6. Backhaul/access network applications

5. COMPETING TECHNOLOGIES

The main competition to Wimax comes from existing widely used wireless systems such as UMTS and CDMA2000, as well as a number of Internet oriented systems such as HIPERMAN. 3G cellular phone systems usually benefit from already having enhanced infrastructure, being upgraded from earlier systems. Users can usually fall back to older systems when they move out of range of upgraded equipment, often relatively seamlessly [4].

The major cellular standards are being evolved to so-called 4G, high bandwidth, low latency, all-IP networks with voice services built on top. With GSM/UMTS, the move to 4G is the 3GPP Long Term Evolution effort. For AMPS derived standards such as CDMA2000, a replacement called Ultra Mobile Broadband is under development. In both cases, existing air interfaces are being discarded, in favor of OFDMA for the downlink and a variety of OFDM based techniques for the uplink [5].

In some areas of the world the wide availability of UMTS and a general desire for standardization has meant spectrum has not been allocated for Wimax in July 2005, wide frequency allocation for Wimax was blocked. The comparison of Wimax with edge technologies such as Wi-Fi and 3G is summarized in Table – 1.

	3G	Wi-Fi	Wimax
Max. Speed (in Mbps)	2	54	100

Coverage (in miles)	Several	˜1	50
Airwave	Licensed	Unlicensed	Licensed/ unlicensed
Advantages	Range, distance	Speed, price	Speed, price
Disadvantages	Slow, expensive	Range	Interference

Table-1 Comparison of various wireless technologies

6. CONCLUSION

Wimax provides vehicular mobility, high service areas and data rates. It is a standardized wireless version of Ethernet intended primarily as an alternative to wired technologies such as Cable Modems, DSL, and T1/E1 links to provide broadband access to customer premises equipments. The paper summarizes the various features and working of Wimax.

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