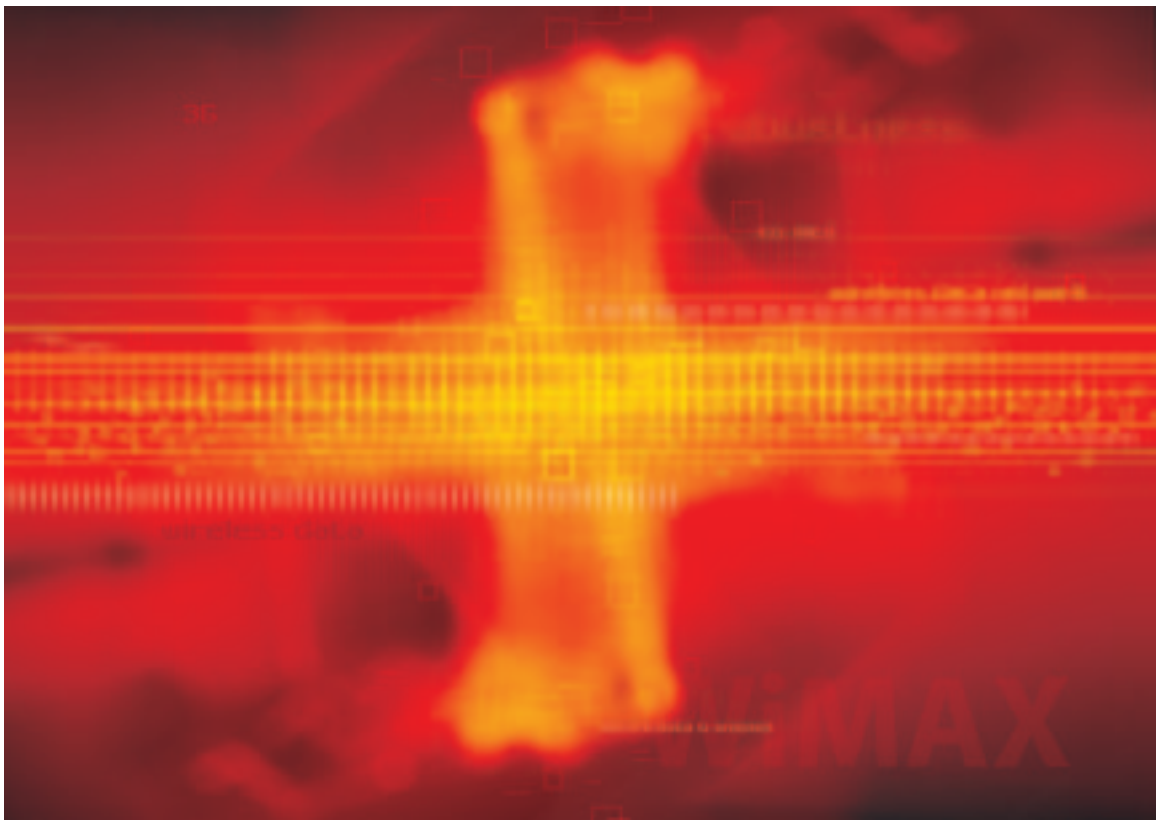
WiMAX and Synergies with Wireless Service Provider Networks



Introduction

The world has watched traditional land-line voice carriers rapidly lose business to mobile service providers during the last several years. We are poised to see the same in personal data networking. Wireless data solutions will play a major role in developing networks and create a challenge to data solutions that do not support at least portability, if not full mobility for the user. The American consumer is very interested in having a solution that moves with them. Having to maintain multiple points of access, each with its own complications, will have little support in a world where all data access needs can be met without wires.

As recently as five years ago, it seemed unreasonable to drop the connection to your land-line phone and subscribe exclusively to a wireless service. Early handsets were cumbersome, heavy and had short battery life. Coverage was weak, and roaming outside of the local area was problematic and expensive. These reasons also happen to be the same ones currently given by those with a negative view of WiMAX network deployments. The ability to develop technology to meet our requirements always trumps the difficulties when the advantages are clear.

There is room for competing technologies to each occupy their own range of niches. 3G, WiMAX and WiFi each have their place in the total wireless data network and offer unique advantages and challenges. The massive amount of wireless data that is required to meet the needs of an unwired population ensures that technology segmentation will be supported. As personal services become associated with an individual rather than a location, cost-effective use of our limited spectrum will determine who succeeds in this competitive marketplace.

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WiMAX Defined

Many vendors have claimed the title "WiMAX" for their products. WiMAX is a specific name owned by the WiMAX Forum™ (www.wimaxforum.org) for the certified implementation of the IEEE 802.16 set of standards. Standards are necessarily broad in their scope and require an industry alliance to make sure there is a smooth implementation of these standards and clean interoperation between multiple vendor products.

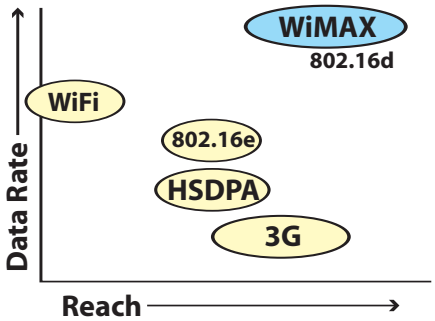
Current RF Data Standards

The WiFi Alliance has achieved great success in enforcing interoperability between the multiple vendors who supply solutions matched to the IEEE 802.11 set of standards. However, there are quite a few limitations to WiFi for public use. Several efforts have been made to address these limitations and produce a standard that supports a public network implementation.

Some experts have advocated an extension to the IEEE 802.11 standard to create a public WiFi network, but the required changes are quite drastic and the market space so different that this is considered a disingenuous effort that would be difficult to implement. This implementation would also be proprietary in nature.

There has also been a discussion about using 3G cellular types of networks to support wireless data. Another element affecting the standards and implementation of this technology is the premium placed on voice quality and reliability, which burdens the network with costs that data service consumers are unwilling to pay.

The target reach and data rate for each of the wireless technologies is reflected in Figure 1 below. Because each technology was defined for a specific segment of the market, there are technology and cost trade-offs that must be made to meet the demands of the consumers in each market.



Technology	*Standard*	*Frequency*	*Data Rate*	*Range*
WiFi	802.11g	2.4 GHz	<54 Mbps	<300 ft
WiMAX	802.16d	<11 GHz	<75 Mbps	4–6 mi
Mobile WiMAX	802.16e	2–6 GHz	<30 Mbps	1–3 mi
3G Wireless	UMTS/EVDO	Various 400–2100 MHz	<2.4 Mbps	1–5 mi
3.5G Wireless	HSDPA	Various 400–2100 MHz	<12 Mbps	1–3 mi

Figure 1: Wireless Technology Comparison – Reach vs. Data Rate

Another major implementation challenge is to balance cost with the robustness of the system. 3G architectures are developed around the absolute availability of service required by voice customers during hand-off procedures. WiMAX is designed to meet the needs of the data services user and service provider. Not all data networks require the level of mobility required by 3G. There is sufficient room in the implementation of WiMAX to allow for a balance between cost and control. It is up to the service provider to determine the best level of mobility and network capital and operational cost to best serve customers.

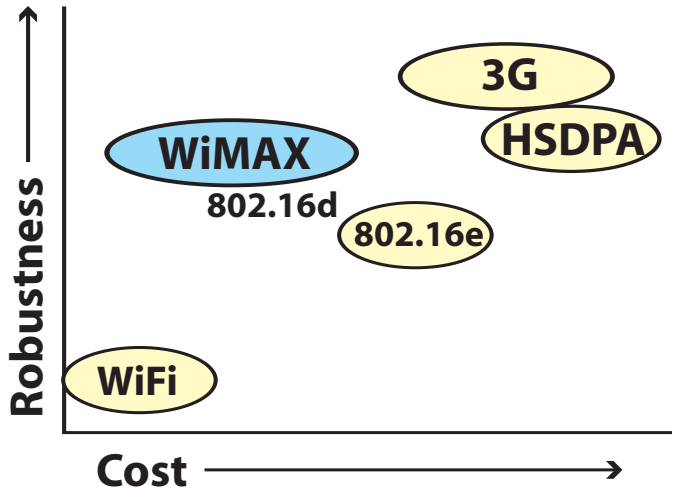


Figure 2: Wireless Tech - Mobility vs. Cost

Levels of Mobility Defined

There is considerable confusion in the various terms used when discussing the levels of mobility in wireless data networks. For the purposes of this paper, the following definitions apply:

Fixed

Fixed access data services support locations that remain stationary over time and are generally characterized by high data rates and low user density. The CPE is normally fixed in one location, powered by a commercial source and linked to a fixed antenna.

Enterprises, MDUs and business park applications typically fit into this deployment model. Home service currently fits into this model, but is likely to shift over time as personal data devices replace the existing business model.

Fixed users expect high service quality levels. Fixed high-gain antenna placement is possible and can be used to extend the throughput and reach of the wireless signal.

Portable

Portable data services support users who appear in several cells at different times. This kind of service is enabled through messaging to external databases that control the user account in QoS management. CPE tends to be small and must adhere to low power requirements because they tend to run on batteries. The antenna often has a far less clear line of sight to the base station. The number of users per base station is higher than the fixed model, but the data rate per user is lower.

Portable users are typically field workers, such as real estate agents, insurance adjusters, construction workers, etc. They can also be workers provided with high-speed data at the office who are extending their services to home or accessing data services while traveling on business.

Portable users are more tolerant of mixed service quality. Fixed high-gain antenna placement is possible in SOHO and office extension environments, but will not be tolerated by a field user. This drives a requirement for a more dense base station deployment and robust network performance monitoring support system.

Nomadic

Nomadic data services are an extension of the portable network that supports per user power management and modulation control. These features allow a user to move within a cell and expect the best level of service while still maintaining the best spectral performance for the service provider.

Nomadic users will expect to be able to move around with their data devices while experiencing minimal data interruption. CPE will often be small and run on batteries and there will be no tolerance for fixed antenna deployment.

Mobile

Mobile data services supply high-speed connectivity while users are moving through the service area, both within a cell and between cells. CPE tends to be quite small, typically a personal appliance with a size that is comparable to current cell phones, but can also be configured with higher power and more sophisticated antennas in vehicular applications. Coverage models must be very dense to limit dead spots and ensure continuous coverage.

Typical applications include mass-market mobile appliances (e.g. next-generation smart phones), public safety, commercial transportation, maintenance fleets and mobile VOD.

The market is still determining how much revenue will be supported by such services. There are several competing methods for delivering these services, and mass consumers gravitate to the lowest cost alternative. Indications are that the first drivers to a ubiquitous mobile data network will be public safety and commercial fleets that are less cost-sensitive. The incremental capacity required for mass-market services can then be layered onto the base network already deployed.

Why WiMAX Works

WiMAX addresses the weakness of IEEE 802.11-based networks without the burdensome requirements imposed by 3G standards. This section explores the differences between IEEE 802.11, WiMAX and 3G networks and the impacts of these differences.

For a public network provider to implement a wireless data service, there must be a way to support and enforce SLAs. WiMAX systems offer the ability for a carrier to support such functionality.

Certified Implementation of the IEEE 802.16x Standards

The biggest challenge to successful implementation of a new technology is controlling the cost of the deployment. Low cost comes through volume of deployment and the competition that a multi-vendor environment brings. In order to ensure an economy of scale not enjoyed by prior versions of wireless data services, the industry must support an implementation with sufficient commonality. This is only done through control by an industry alliance such as the WiMAX Forum.

Adds Non-Line of Sight

WiMAX systems implement a 256 OFDM scheme, which breaks the available spectrum into 256 separate slices. This greatly reduces the effects of any one section of the spectrum dropping out due to physical or EM interference. This also provides for a rapid upstream response for delay-sensitive traffic such as gaming.

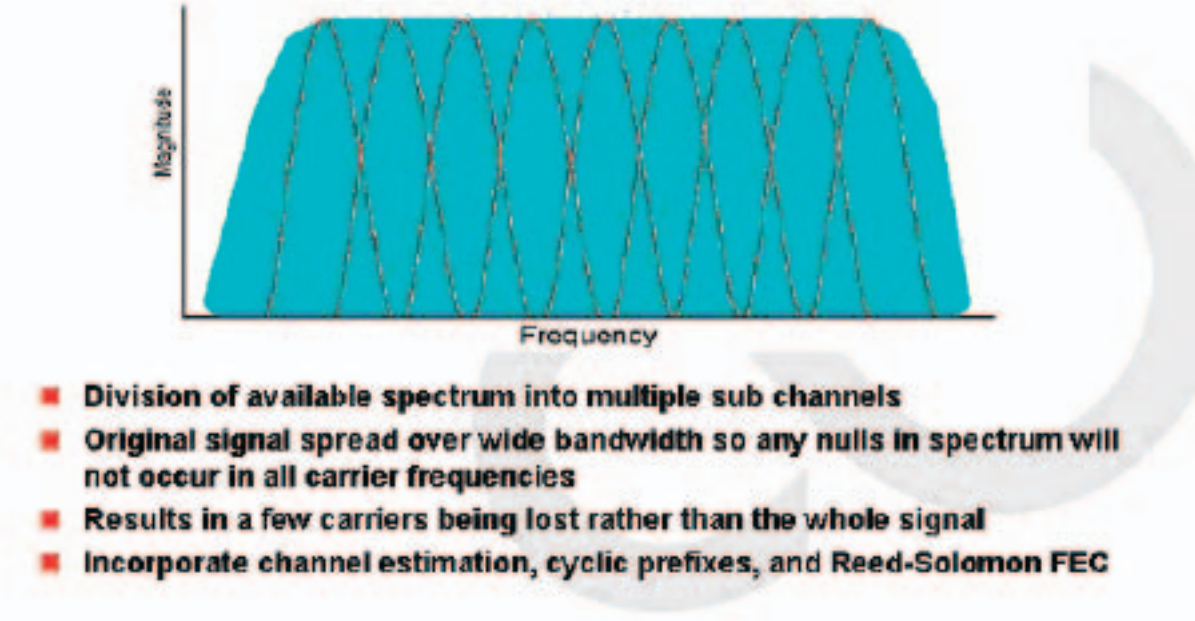


Figure 3: OFDM Waveform

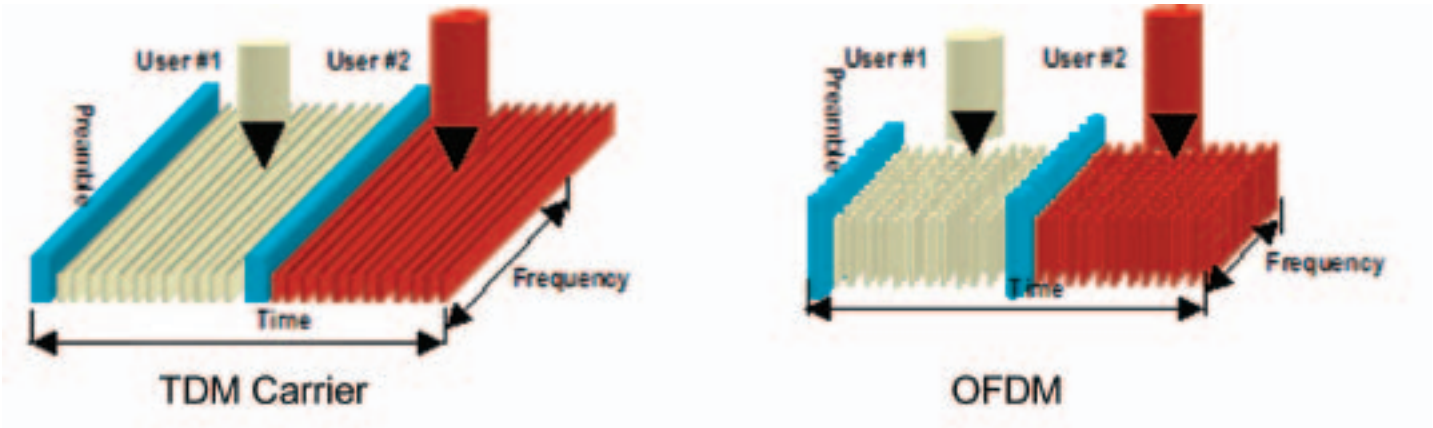


Figure 4: TDM vs. OFDM Structure

Enables Efficient Data Transport over the Air

Compared to other wireless technologies, WiMAX is especially processor-efficient. Current studies indicate that an IEEE 802.16 system will require up to 75% fewer MIPS than an equivalent UMTS 3G service. Simpler software and higher levels of integration enable this processing efficiency. The reduction in computing resource requirements allows for less expensive parts that use less power and space.

Modulation is determined per OFDM sub-carrier, allowing for the best possible spectral efficiency. For each user, the spectral conditions are assessed and the modulation format is adjusted to ensure the maximum data transfer rate. This allocation scheme is well suited for point-to-multipoint data service networks.

Enables Secure Data Transport over the Air

The IEEE 802.16x standard supports both the 3DES and AES encryption standards. Implementation of a public network requires the implementation of a strong security protocol. Many corporations have placed severe restrictions on the deployment of IEEE 802.11 networks because of the security risks, and often require VPN access even through their own wireless access points. This issue is magnified on a network that is reachable through a much larger footprint.

Adds Nomadic Data Transport over the Air

The OFDM system of user bandwidth allocation also allows WiMAX systems to provide per-user power control and sub-carrier modulation. This control of modulation format for each user is constantly adjusted in the cell. This allows for nomadic patterns of usage as users move throughout a cell's coverage area.

Implements a Demand Request Bandwidth Allocation Scheme

WiFi is a collision-based bandwidth allocation system. Each user on the network sends data whenever they want and then waits for collisions to occur. This inefficiency has been well studied and indicates that a considerable amount of traffic on a collision-based system is dedicated to the resolution of these collisions.

WiMAX requires individual users to request the amount of data they would like. The base station then determines the amount of bandwidth to allocate to each user. This limits the time that packets are fighting for capacity and allows for the most efficient use of the spectrum available.

This requirement is very important for a wireless network, as it is difficult to control the number of users who appear in any given cell that are trying to vie for the same network resources. Wireline networks can control the number of users simply by limiting the number of connections, which is not possible when the users are not controlled by physical connectivity.

Specified Over a Wide Range of the Spectrum

The limitation of available spectrum all over the world has driven IEEE 802.16x to support a wide range of frequencies in both the public and licensed bands. IEEE 802.16-2004 has defined the applicable spectrum as less than 6 GHz. Figure 5 shows the spectrum allocation in the US and indicates the target spectrum for WiMAX implementation worldwide.

The WiMAX Forum has scheduled compliance and interoperability testing for two parts of the spectrum. 3.5 GHz is available in many parts of the world for BWA, and 5.8 GHz is used for the public spectrum in the US and other parts of the world. Additional slices of spectrum will be profiled and scheduled for interoperability testing as driven by the carrier members of the WiMAX Forum.

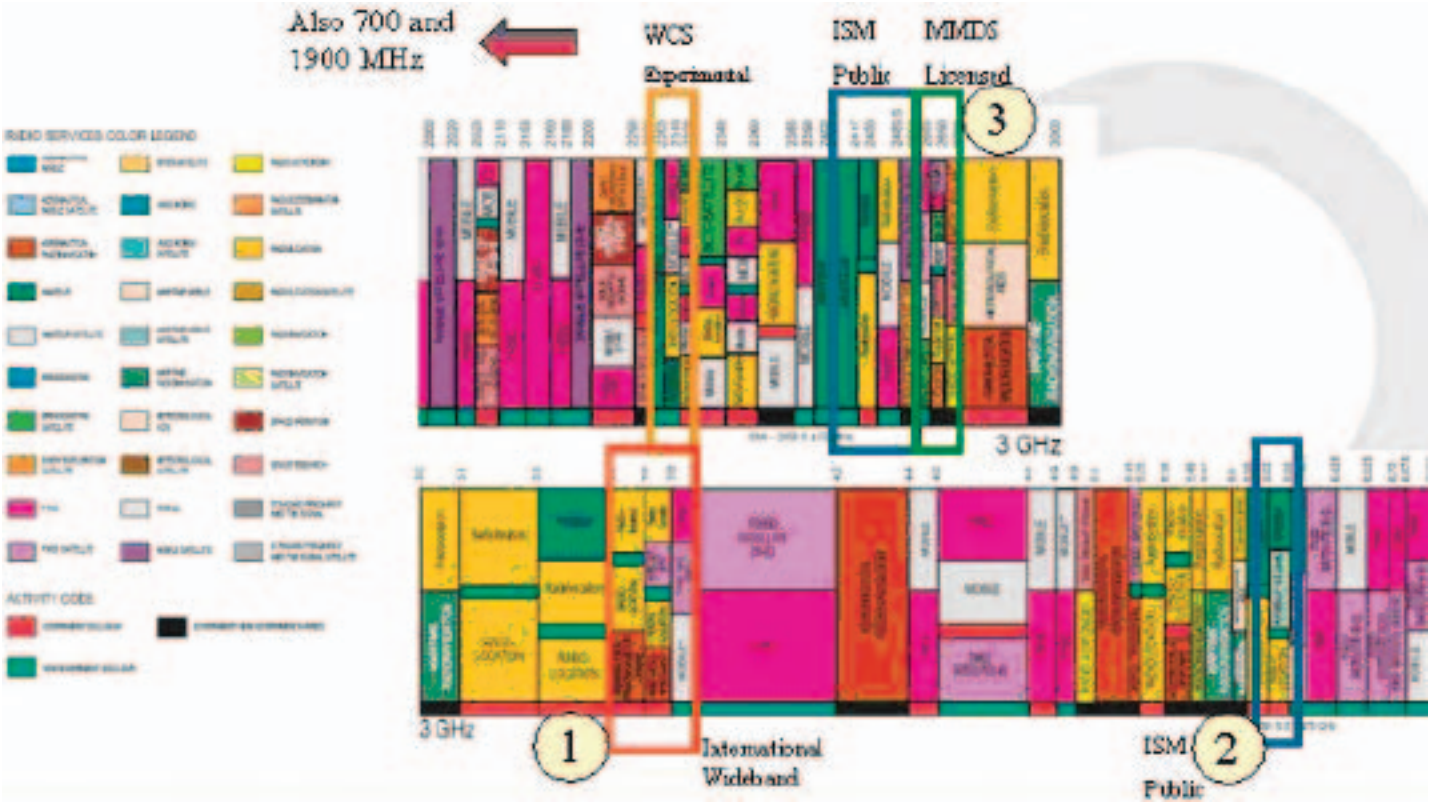


Figure 5: WiMAX Spectrum Allocation in the Unites States

Adds QoS Management to WiFi

Hooks for scheduling algorithms enforce QoS that is optionally implemented on each vendor solution. These hooks control several parameters, including packet loss, minimum and maximum bandwidth jitter and latency.

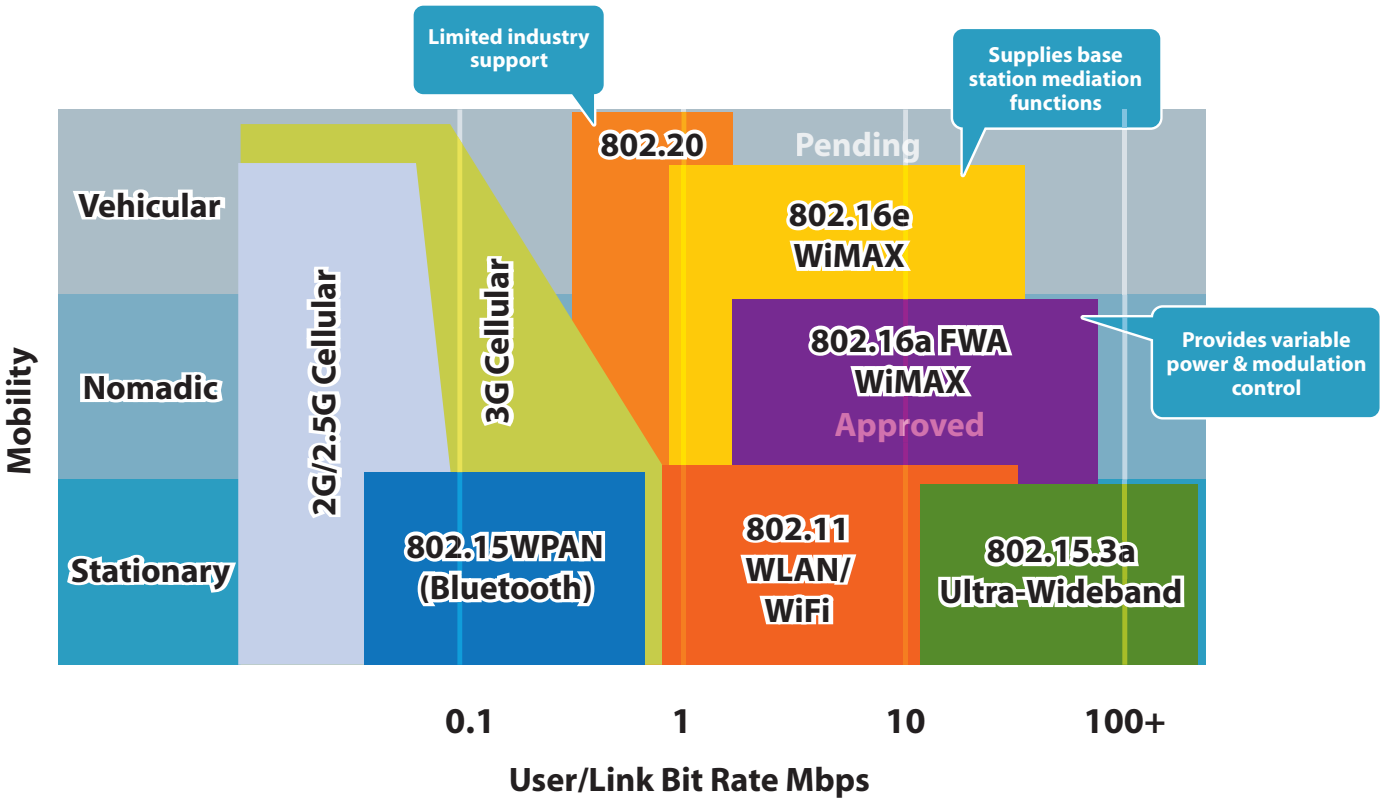


Figure 6: Comparison of Wireless Data Standards

WiMAX Market

The biggest concern among the various parties to the WiMAX marketplace is the true potential of the technology to attract customers and generate revenue. Even the best technology holds little promise if users do not adopt it.

Market Drivers

Many pundits comment that we already have multiple methods of last mile access. xDSL, cable, satellite, and various proprietary wireless solutions all offer an alternative to WiMAX-based systems. WiMAX is incrementally better than any of the wireless alternatives for high-bit-rate distributed data services. Every segment of the marketplace has a need for this kind of technology.

Wide Range of Applications

The biggest driver toward the success of WiMAX is its large array of applications across the entire globe. Regardless of the industry, the applications fall into four major groups, represented in Figure 7.

Point-to-Multipoint Backhaul

Cell towers can be remote, making them difficult and expensive to reach terrestrially. Statistical multiplexing can offer a cost savings for distributed base stations. This is especially true when smaller base stations with distinct time of day traffic patterns are deployed and with 3G base stations offering bursty data traffic.

Business Access
Backhaul of hot-spot traffic is problematic. DSL or leased-line is not always the best solution as the costs are recurring regardless of the traffic patterns. WiMAX can offer an excellent alternative as a shared cost backhaul solution.

Individual businesses are searching for a good way to provision survivable data links, but they are concerned about the cost. WiMAX has strong potential to serve a role in a shared survivability network.

Neighborhood Access
As the data consumer moves toward a personal data solution and away from today's location-based solutions, there is a need to supply these users with coverage where they work and live.

It is estimated that as much as 35% of the homes in the US are not reachable by DSL because of a combination of poor copper facilities and a limitation on the number of high-speed users supported by a common copper plant.

Ubiquitous Mobile Access
As the deployment of WiMAX networks progress, the coverage will become sufficient to support the consumers' expectations of availability. Users will naturally migrate to mobile usage as the carriers implement their determined levels of data mobility.

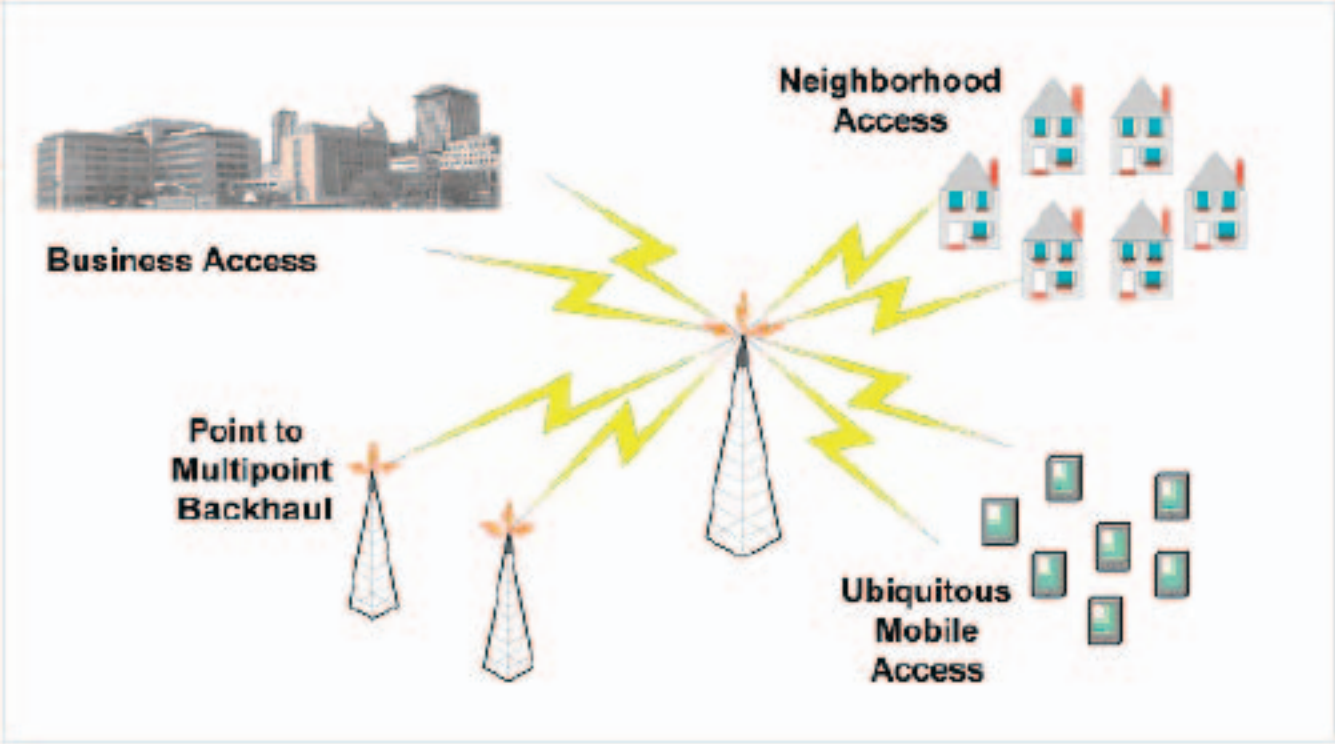


Figure 7: WiMAX has a Wide Variety of Applications across the World

Developing Nations Market
Developing countries need to deploy broadband services without having to carry the high cost of infrastructure deployments. Governments and NGOs are searching for a method of reaching consumers in these developing countries and have been extremely interested in WiMAX. Projects that have been funded for 2005 deployment will spur the development of reliable products. This will jumpstart the economies of scale in the worldwide market, resulting in an overall drop in deployment cost in all markets.

Group of Niches
Making a case for market scale for any one of these applications for any individual service provider is difficult. However, all of the cases together have driven the silicon and systems providers to calculate a large market for wireless data services. This aggregate network demand has created the anticipation of a large market for WiMAX products.

This "group of niches" phenomenon has allowed for forward development and pricing models that bring base station costs toward an anticipated $10–15K per sector. This phenomenon will have an even more dramatic effect on the CPE market as unit pricing will drop far in advance of the target market volume due to the derived promise of the technology. As silicon solutions mature, CPE is anticipated to be near $200 by the end of 2006 and "nearly-free" in 2007 as it is integrated into laptops and other appliances.

Mass Market Take Up Drives WiMAX Model
With all of the stated reasons, the level of market anticipation has created the environment for systems vendors to increase their willingness to negotiate volume pricing contracts. The anticipated market is large enough to attract new and established vendors into the market. This combination has stirred competition, yet maintained the promise of network reliability, creating even greater interest from the large-scale service providers.

The increasing confidence in WiMAX becoming a fully deployable and operable standard feeds the cycle of support for WiMAX Certified systems.

WiMAX Applications for Wireless Service Providers

With the understanding that the overall market will drive the equipment volume to the required levels, there are several ways that the WSPs can take advantage of this volume market to cost-effectively deploy several applications.

WSPs have an obvious advantage because they have experience in planning, engineering, deploying and operating wireless networks. RF planning, while becoming more accurate, is still quite a bit of art on top of the science. This expertise does not come easy and will be an advantage to the WSP as the battle for space in the high-speed wireless data market begins.

Summary

The IEEE 802.16 has been developed to fill in the shortcomings of previous wireless data standards. The WiMAX Forum was formed to define the implementation of this set of standards to ensure common and interoperable equipment. There are many applications throughout the world for the robust wireless data services supported by WiMAX Certified systems including fixed, portable, nomadic and mobile. The combination of the breadth of applications and the availability of multi-vendor solutions drives volume and brings the cost of network deployment down to a level that can pass the business planning process.

WiMAX technology offers solutions to issues that face WSPs today and in the future. It is critical to participate in the rapidly maturing wireless data services market and battle the incursion into this market segment by traditional wireline companies.

WSPs have significant synergies in place that can be leveraged to deploy a cost-effective WiMAX network in the rapidly maturing wireless data services market. The existing experience in RF engineering and operations positions the WSP well for a cost-effective deployment of WiMAX-certified networks.

Acronym	Descriptor
3DES	Triple Data Encryption Standard
AES	Advanced Encryption Standard
BWA	Broadband Wireless Access
CPE	Customer Premises Equipment
EM	Electro-Magnetic
IEEE	Institute of Electrical and Electronics Engineers
MDU	Multiple Dwelling Unit
MIPS	Million Instructions Per Second
MVOD	Mobile Video on Demand
OFDM	Orthogonal Frequency Division Multiplexing
P2MP	Point-to-Multipoint
PDA	Personal Data Assistant
PHY	Physical
PM	Performance Monitoring
QoS	Quality of Service
PON	Passive Optical Network
POP	Point of Presence
POS	Packet Over SONET
PVR	Personal Video Recorder
QoS	Quality of Service
RF	Radio Frequency

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Acronyms	
ROI	Return on Investment
SAN	Storage Area Network
SLA	Service Level Agreement
SOHO	Small Office, Home Office
SONET	Synchronous Optical Network
TDM	Time Division Multiplexing
TLS	Transparent LAN Service
UMTS	Universal Mobile Telecommunication System
VCI	Virtual Channel Identifier
VOD	Video On Demand
VoIP	Voice over Internet Protocol
VPI	Virtual Path Identifier
VPLL	Virtual Private Leased Lines
VPN	Virtual Private Network
VSI	Virtual Switch Interface
WDM	Wavelength Division Multiplexing
Wi-Fi	Wireless Fidelity
WLL	Wireless Local Loop
WSP	Wireless Service Provider
xDSL	A generic form of DSL. Could include ADSL, HDSL, IDSL, SDSL and VDSL.

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