Marmara University, **2021**

Wireless and Mobile Networks

Subject 6

WiMAX Technology

Mujdat Soyturk, **Ph.D.**
Associate Professor

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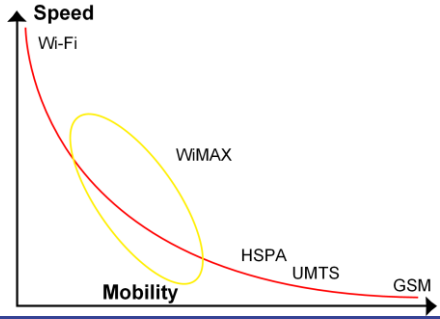
- Introduction to WiMAX Technology
- WiMAX Features and Services

WiMAX



INTRODUCTION TO WiMAX TECHNOLOGY

The WiMAX Technology

Worldwide Interoperability for Microwave Access

broadband access over long distances, based on the IEEE 802.16 standard

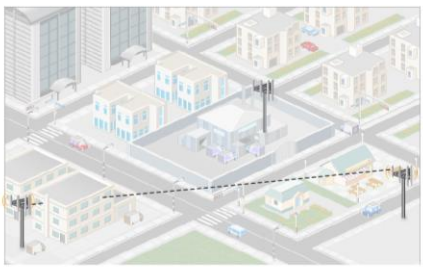
The WiMAX Technology

Provides access to fixed as well as mobile stations

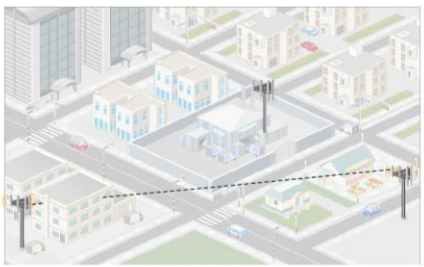
The WiMAX Technology

The WiMAX Technology

The WiMAX Technology



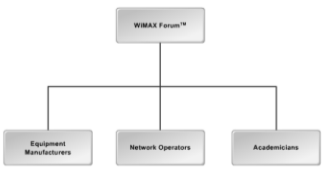
The WiMAX Technology



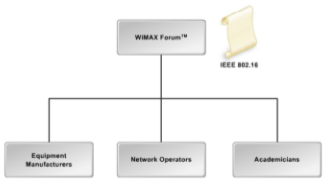
can handle a peak data rate of up to 70 Mbps

The WiMAX Forum

The WiMAX Forum



The WiMAX Forum



The WiMAX Forum

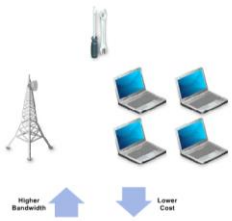
The WiMAX forum:

- Takes into account emerging trends in the industry, market demands, and international regulations for the development of WiMAX
- Provides guidelines for an end-to-end WiMAX architecture along with roaming and integration with other networks such as WI-FI and 3G

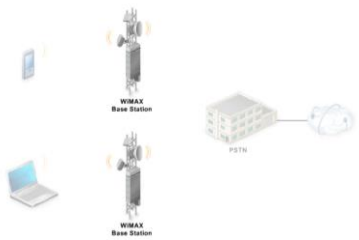
WiMAX as a Wireless MAN Technology

Large subscriber base but limited bandwidth availability

WiMAX as a Wireless MAN Technology



WiMAX as a Wireless MAN Technology



WiMAX as a Wireless MAN Technology

Mobile communication
Data services
Campus networks

Types of WiMAX

Type	Description
Fixed	
Mobile	

Types of WiMAX

Type	Description
Fixed	Developed based on the IEEE 802.16d standard, it is optimized for fixed applications in LOS and NLOS environments. Products based on 802.16d are available for fixed WiMAX. The main disadvantage of fixed WiMAX is that its access is limited to distances of up to 12 miles. It is also difficult for fixed WiMAX to compete with established wired technologies such as DSL in places where the wired telecommunication infrastructure is well developed.
Mobile	

Types of WiMAX

Type	Description
Fixed	Developed based on the IEEE 802.16e standard, it is optimized primarily for portable and mobile applications in an NLOS environment. Mobile WiMAX includes additional features crucial to mobile applications such as handoff, flexible power management, channel bandwidth scalability, frequency reuse, and better NLOS performance and indoor penetration.
Mobile	

WiMAX vs. Wi-Fi

Factor	Description
Standard	
Mode of communication	
Centralized vs. distributed control	
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: Is based on the 802.16 standard and is used on WMANs for wireless broadband access. Wi-Fi: Is based on the 802.11 standard and is used on WLANs. It is primarily used for close-range indoor applications.
Mode of communication	
Centralized vs. distributed control	
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: Primarily uses NLOS communication. Devices can locate a Base Station (BS). Wi-Fi: Primarily uses the LOS mode of communication. Devices are omni directional, and can locate the access points.
Mode of communication	
Centralized vs. distributed control	
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: Uses a scheduling protocol, with all the scheduling performed by the base station. Users transmit only when instructed to do so by the base station. This improves the reliability of the system.
Mode of communication	
Centralized vs. distributed control	Wi-Fi: Uses CSMA/CA to broadcast a signal on the network. Before broadcasting, a device informs all other devices on the network to stop transmission so as to avoid collision.
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: As WiMAX networks are built for a larger user base, the number of users accessing the network does not affect them.
Mode of communication	
Centralized vs. distributed control	Wi-Fi: In Wi-Fi networks, as the number of users increases, the efficiency of the network decreases.
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: Uses the licensed spectrum.
Mode of communication	Wi-Fi: Uses the unlicensed spectrum.
Centralized vs. distributed control	
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: Covers an area with a radius of about 30 miles with wireless access.
Mode of communication	
Centralized vs. distributed control	Wi-Fi: Covers an area of about 300 ft (~90 m).
Number of users	
Spectrum	
Coverage area	
Data rate	

WiMAX vs. Wi-Fi

Factor	Description
Standard	WiMAX: Supports a peak data rate of up to 70 Mbps. Even if it is split between various users, the throughput does not decrease.
Mode of communication	
Centralized vs. distributed control	Wi-Fi: Support a peak data rate of about 54 Mbps. As the number of users increases, this rate will be shared among the users thus reducing the throughput.
Number of users	
Spectrum	
Coverage area	
Data rate	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	This version was the first amendment of the standard. It uses LOS communication, and external antennas provide access to the network. This version, however, was not adequate for broadband wireless access.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	This version is the most important amendment of 802.16, and was published to standardize the Multichannel Multipoint Distribution Services (MMDS) solutions in the licensed and unlicensed 2 to 11 GHz frequency range. As it works on a lower range than 802.16-2001, 802.16a can provide NLOS communication. It additionally allows for the mesh mode of operation that facilitates communication between individual subscribers.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	This version provides the applications of both 802.16–2001 and 802.16a. Additionally, it also provides various enhancements to the protocol stack. This version is considered the base version for fixed broadband wireless.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	This version is an amendment to the 802.16d specification to provide explicit support for mobility. It is also referred to as 802.16-2005. This version incorporates the WiBRO specification of the 802.16 standard. It is considered the base 802.16 mobile broadband wireless specification.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	This version was an amendment to define a Management Information Base (MIB) for network management. It provides an MIB for fixed broadband wireless access systems.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16–2001	This version is an amendment to add procedures and service amendments to 802.16d and 802.16e. It defines network management procedures to enable interoperability and efficient management of network resources, mobility, spectrum usage, and standardize the management layer for both 802.16 fixed and mobile devices.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16-2001	This version was created to develop a standard that improves coexistence mechanisms for the operation of the license exempt spectrum. It allows for the interoperability between different devices and facilitates coexistence with other systems using the same band.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16-2001	This version provides mobility enhancements to the 802.16 MIB and other associated management procedures. It uses methodologies that are protocol-neutral for network management. It also provides specifications for the management of multivendor devices.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16-2001	This version is targeted to improve the legacy 802.16 network's coverage, throughput, and system capacity.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

The IEEE 802.16 Family of Standards

Version	Description
802.16-2001	This version was introduced to define the necessary procedures and enhancements to allow for the bridge functionality. Bridges allow all nodes on the network to receive the transmission.
802.16a	
802.16d	
802.16e	
802.16f	
802.16g	
802.16h	
802.16i	
802.16j	
802.16k	

Version Comparison of 802.16

Version	Description
802.16-2001	
802.16a	
802.16d	
802.16e	

Version Comparison of 802.16

Version	Description
802.16-2001	• **Mode of operation**: LOS. • **Frequency range**: 10 to 66 GHz. • **Modulation scheme(s)**: QPSK. • **Network architectures supported**: point-to-point, and point-to-multipoint. • **Support for mobility**: fixed. • **Cell radius**: 1 to 3 miles. • **Bit-rate**: 32 to 134 Mbps. • **Applications**: backhaul for Wi-Fi hotspots, residential broadband access, SOHO applications, and replacement of T1 or E1 services.
802.16a	
802.16d	
802.16e	

Version Comparison of 802.16

Version	Description
802.16-2001	• Mode of operation: NLOS. • Frequency range: 2 to 11 GHz. • Modulation scheme(s): QPSK and OFDM. • Network architectures supported: point-to-point, point-to-multipoint, and mesh. • Support for mobility: fixed. • Cell radius: up to 30 miles. • Bit-rate: up to 75 Mbps. • Applications: an alternative to T1 or E1, DSL, cellular services, Wi-Fi, VoIP and connections to the Internet.
802.16a	
802.16d	
802.16e	

Version Comparison of 802.16

Version	Description
802.16-2001	• Mode of operation: NLOS. • Frequency range: 2 to 11 GHz, 10 to 66 GHz. • Modulation scheme(s): QAM, QPSK, and OFDM. • Network architectures supported: point-to-point, point-to-multipoint, and mesh. • Support for mobility: fixed. • Cell radius: up to 30 miles. • Bit-rate: up to 75 Mbps. • Applications: Supports applications of both 802.16 and 802.16a.
802.16a	
802.16d	
802.16e	

Version Comparison of 802.16

Version	Description
802.16-2001	• Mode of operation: NLOS. • Frequency range: 2 to 6 GHz. • Modulation scheme(s): QPSK and SOFDMA. • Network architectures supported: point-to-point, point-to-multipoint, and mesh. • Support for mobility: mobility with regional roaming. • Cell radius: 1 to 3 miles. • Bit-rate: up to 15 Mbps. • Applications: applications supported by 802.16d along with fixed VoIP, QoS applications, and enterprise networking.
802.16a	
802.16d	
802.16e	

WiMAX FEATURES AND SERVICES

WiMAX Features

Feature	Description
Based on OFDM	
Very high peak data rates	
Support for scalability of bandwidth and data rate	
Support for mobility	
Support for advanced antenna techniques	

WiMAX Features

Feature	Description
Based on OFDM	The use of OFDM allows WiMAX to operate in NLOS conditions.
Very high peak data rates	
Support for scalability of bandwidth and data rate	
Support for mobility	
Support for advanced antenna techniques	

WiMAX Features

Feature	Description
Based on OFDM	WiMAX supports very high peak data rates of up to 70 Mbps. If the signal conditions are good, even higher rates can be achieved with the use of multiple antennas and spatial multiplexing.
Very high peak data rates	
Support for scalability of bandwidth and data rate	
Support for mobility	
Support for advanced antenna techniques	

WiMAX Features

Feature	Description
Based on OFDM	The WiMAX protocol stack allows for the data rate to scale to the available channel's bandwidth. As this scaling can be dynamic, it can support user roaming in different networks, each with different channel bandwidths allocated.
Very high peak data rates	
Support for scalability of bandwidth and data rate	
Support for mobility	
Support for advanced antenna techniques	

WiMAX Features

Feature	Description
Based on OFDM	WiMAX provides support for mobility to ensure secure, seamless handovers for applications that require full-mobility. It also has built-in mechanisms for saving power for subscriber devices.
Very high peak data rates	
Support for scalability of bandwidth and data rate	
Support for mobility	
Support for advanced antenna techniques	

WiMAX Features

Feature	Description
Based on OFDM	The design of the WiMAX protocol stack allows for the use of multiple-antenna techniques, such as beamforming, space-time coding, and spatial multiplexing.
Very high peak data rates	
Support for scalability of bandwidth and data rate	
Support for mobility	
Support for advanced antenna techniques	

WiMAX Features

Feature	Description
AMC	
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

WiMAX Features

Feature	Description
AMC	WiMAX provides support for a number of modulation and coding schemes that can be modified based on the channel conditions and user requirements. AMC is used to maximize the throughput in a variable channel.
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

WiMAX Features

Feature	Description
AMC	WiMAX supports methods such as ARQ that enhance the reliability of the connection. It requires that the receiver acknowledge the receipt of a data packet. If an acknowledgment is not received, the packet is retransmitted to ensure delivery.
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

WiMAX Features

Feature	Description
AMC	As the base station controls the allocation of resources, the capacity of a channel is allocated dynamically and shared among multiple users.
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

WiMAX Features

Feature	Description
AMC	The WiMAX protocol stack is designed to support multiple users with different QoS requirements. It provides support for constant and variable bit rates, real-time, and non-real-time traffic flows, and best-effort data traffic. This allows real-time multimedia services to be provided to users.
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

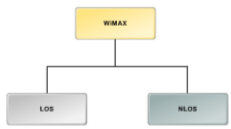
WiMAX Features

Feature	Description
AMC	WiMAX uses the Privacy Key Management (PKM) protocol along with strong encryption using the Advanced Encryption Standard (AES). Authentication is done using the Extensible Authentication Protocol (EAP), which allows for a variety of user credentials, including the username and password, digital certificates, and smart cards.
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

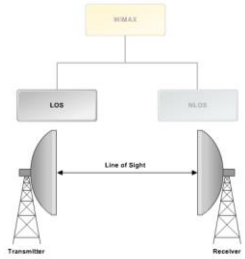
WiMAX Features

Feature	Description
AMC	The WiMAX reference network architecture defined by the WiMAX Forum is based on an all-IP platform. This reduces operation costs and allows for convergence with other networks.
Reliability	
Dynamic allocation of resources	
QoS support	
Robust security	
IP-based network architecture	

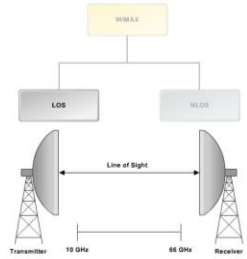
WiMAX Operational Modes



WiMAX Operational Modes



WiMAX Operational Modes

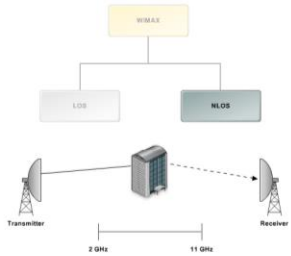


WiMAX Operational Modes

In an LOS environment a signal:

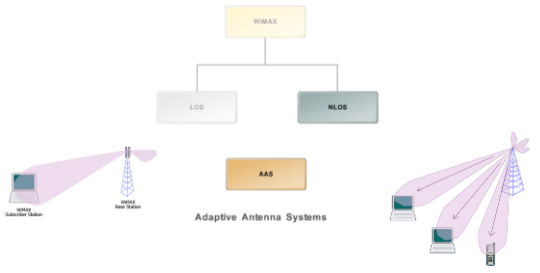
- Has better strength
- Is more stable
- Can be transmitted over longer distances
- Has a higher throughput

WiMAX Operational Modes



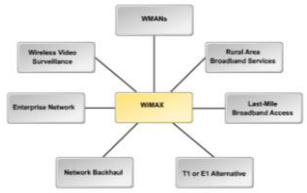
WiMAX Operational Modes

WiMAX Operational Modes

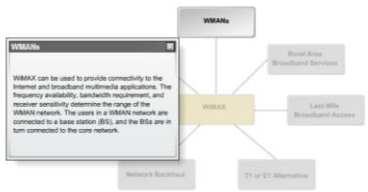


WiMAX Operational Modes

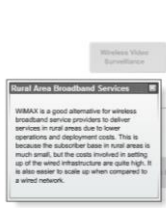
WiMAX Applications



WiMAX Applications

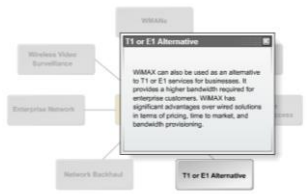


WiMAX Applications

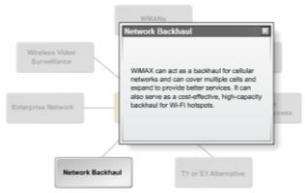


WiMAX Applications

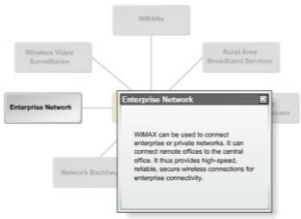
WiMAX Applications



WiMAX Applications



WiMAX Applications

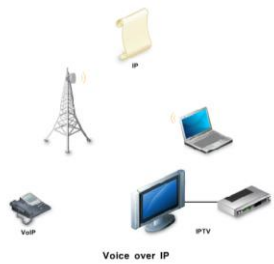


WiMAX Applications

WiMAX Triple and Quadruple Play

WiMAX Triple and Quadruple Play

WiMAX Triple and Quadruple Play



WiMAX Triple and Quadruple Play

WiMAX networks currently do not offer quadruple play services

Advantages of WiMAX

Advantage	Description
High capacity	
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	A single WiMAX BS can serve hundreds of users. It has a range of up to 30 miles with a target transmission rate exceeding 70 Mbps. Bandwidth can be increased by using a higher modulation scheme.
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	
QoS	Provides QoS on the network that ensures better services to customers. The use of subchannelization and different coding schemes allow for end-to-end QoS. A higher data rate and flexible scheduling can enhance the QoS. WiMAX supports optimized handover schemes to ensure QoS for real-time applications.
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	
QoS	
Flexible architecture	The architecture of WiMAX is highly flexible. WiMAX stations can be connected either in the point-to-point or point-to-multipoint architecture.
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	
QoS	
Flexible architecture	
Mobility	Using WiMAX, a subscriber can maintain the data service session for real-time applications because it allows movement at vehicular speeds within the network coverage area.
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	WiMAX allows users to stay connected using flexible channel bandwidths and adaptive modulation schemes. Using adaptive modulation enables them to stay connected even in noisy or low signal strength conditions.
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	WiMAX can work in the NLOS mode as it is based on OFDM technology. It can thus communicate in an NLOS environment, something other wireless systems cannot. The NLOS coverage can be increased using directional antennas or adaptive modulation.
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	The costs involved in device manufacturing will reduce with the mass production of devices and wider adoption of the standard. This competitive pricing will provide considerable cost-savings for subscribers and customers.
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	WiMAX can provide both fixed and mobile broadband access to customers. This allows for a wider range of applications to be supported.
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Advantages of WiMAX

Advantage	Description
High capacity	WiMAX is the first mobile standard to offer IP-based services. This reduces capital and operating expenses, allows multiple services to be provided over the same platform, and allows for the rapid development and deployment of applications.
QoS	
Flexible architecture	
Mobility	
Connectivity	
NLOS mode of working	
Cost savings	
Fixed and nomadic access	
Integration with IP	

Challenges of WiMAX

Business Challenge	Description
Competition and growth of traditional broadband	
Spectrum availability	
Competing mobile technologies	
Device development	

Challenges of WiMAX

Business Challenge	Description
Competition and growth of traditional broadband	Traditional broadband wired alternatives such as DSL and cable modem are evolving rapidly and providing higher data rates to customers. These high data rates allow service providers to provide rich multimedia applications along with data and voice services. WiMAX may find it difficult to match these higher data rates provided.
Spectrum availability	
Competing mobile technologies	
Device development	

Challenges of WiMAX

Business Challenge	Description
Competition and growth of traditional broadband	The global allocation of the broadband spectrum varies considerably. It will be a challenge to achieve a standardized spectrum adoption for WiMAX. Also, the services offered in the different spectrum bands need to be flexible for WiMAX to be a global success.
Spectrum availability	
Competing mobile technologies	
Device development	

Challenges of WiMAX

Business Challenge	Description
Competition and growth of traditional broadband	The biggest challenge that WiMAX should overcome is the wide deployment of 3G technologies. Service providers may prefer to adopt performance enhancements using 3G than adopt WiMAX. WiMAX should thus come up with innovative ways for promoting itself to compete with 3G.
Spectrum availability	
Competing mobile technologies	
Device development	

Challenges of WiMAX

Business Challenge	Description
Competition and growth of traditional broadband	Mobile WiMAX requires a wide choice of devices and this could act as a distinction from 3G. These devices also need to be compatible with the different broadband systems that will be used for deployment so that broadband services can be personalized.
Spectrum availability	
Competing mobile technologies	
Device development	

Challenges of WiMAX

Technical Challenge	Description
Decrease in signal strength	
Interference	
QoS requirements	
Supporting IP in WiMAX	

Challenges of WiMAX

Technical Challenge	Description
Decrease in signal strength	In NLOS conditions that WiMAX works in, the signal strength decreases with the increase in distance. This phenomenon is called *pathloss*. Pathloss is directly proportional to the carrier frequency. As WiMAX systems will be deployed in frequency bands above 2 GHz in NLOS conditions, they need to overcome a significant amount of pathloss.
Interference	
QoS requirements	
Supporting IP in WiMAX	

Challenges of WiMAX

Technical Challenge	Description
Decrease in signal strength	As there is a limitation in spectrum availability, it requires users to share the available bandwidth. This can cause an interference of signals from different users. Interference needs to be addressed to improve the quality of the signal.
Interference	
QoS requirements	
Supporting IP in WiMAX	

Challenges of WiMAX

Technical Challenge	Description
Decrease in signal strength	WiMAX supports different applications that have differing QoS requirements. QoS also needs to be differentiated based on the service plans that have opted been by subscribers. The variability in the QoS requirements thus makes it hard for its implementation on the same network. For mobile WiMAX services, the channel also adds unpredictability, as it requires sessions to be handed over from one cell to another.
Interference	
QoS requirements	
Supporting IP in WiMAX	

Challenges of WiMAX

Technical Challenge	Description
Decrease in signal strength	Implementing IP in a WiMAX network is a challenge as IP-based protocols are not efficient or robust. In a wired environment, the media offers high reliability and bandwidth, and therefore counters some of these effects.
Interference	Implementing IP in WiMAX networks poses challenges such as: • Making it more bandwidth efficient. • Providing the required QoS levels. • Adapting them on a mobile WiMAX network.
QoS requirements	
Supporting IP in WiMAX	

The Future of WiMAX

IEEE 802.16m

The Future of WiMAX

4G Systems

The Future of WiMAX

The next generation of mobile WiMAX will:

- Allow for data rates of over 1 Gbps
- Support a wide range of IP-based applications and services
- Be backward compatible with existing mobile WiMAX systems