IEEE 802.16 WIMAX

1st Gülsüm İrem Baş
19011502
gulsum.bas@std.yildiz.edu.tr

2nd Alperen Oğuz Demir
20011029
oguz.demir@std.yildiz.edu.tr

3rd Furkan Salman
20011021
furkan.salman1@std.yildiz.edu.tr

4th Onur Eray Bölük
20011028
eray.boluk@std.yildiz.edu.tr

5th Onat Duman
20011619
onat.duman@std.yildiz.edu.tr

I. WIMAX Overview

A. What is Wimax

WiMAX (Worldwide Interoperability for Microwave Access) is a telecommunications standard that provides wireless high-speed internet and other digital communication services over a wide area. It is a type of wireless broadband technology that uses microwaves to transmit data over long distances.It is based on the IEEE 802.16 standard which is known as WMAN(Wireless Metropolitan Area Network). [1]

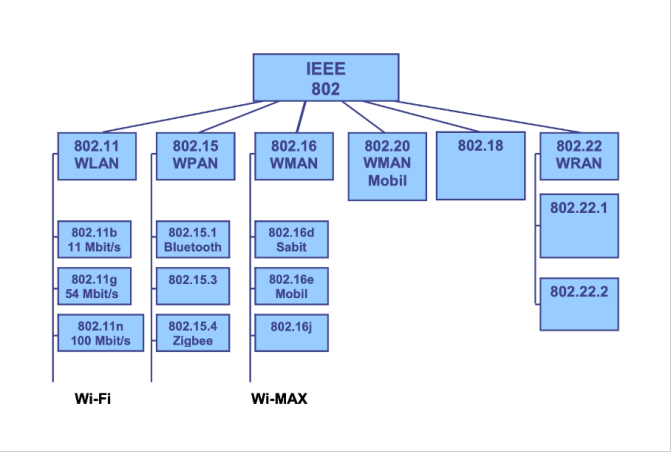

Fig. 1. IEEE 802

WiMAX was developed to provide high-speed internet access to areas that are underserved or not served by traditional broadband infrastructure, such as cable or DSL. It can be used to provide internet access to fixed locations, such as homes and businesses, as well as to mobile devices, such as laptops and smartphones. WiMAX offers high-speed data rates and can support multiple users simultaneously, making it an attractive option for providing internet access in a variety of settings.

B. Purpose of Wimax

The main purpose of WiMAX is to provide high-speed wireless internet access to a wide area. It is particularly useful in areas where traditional broadband infrastructure, such as cable or DSL, is not available or is not sufficient to meet the demand for high-speed internet access.

C. Overview

WiMAX can be used for a variety of applications, including internet access, video conferencing, and other types of data transmission. It is a broadband technology that can support a wide range of data rates and can be used to connect devices over long distances, making it suitable for a variety of applications. WiMAX is also designed to be interoperable with other wireless technologies, such as Wi-Fi, which allows it to be used in conjunction with other wireless systems to provide enhanced coverage and connectivity.Initially designed to service in the 10-66 GHz frequency range, WiMAX requires line of sight, LOS (Line of Sight). [2]

In an area, computer networks, as well as cell phone base stations, have their own wideband internet and phone network structures. With the development of metropol network connection, MAN (Metropol Area Network), using WiMAX technology, all of these services can be provided on a single network. Efforts to establish a telephone, internet, and television infrastructure on the same line using WIMAX are accelerated.

D. History of Wimax

The development of WiMAX began in the late 1990s, when the Institute of Electrical and Electronics Engineers (IEEE) started working on a standard for wireless broadband access. The first version of the WiMAX standard, called 802.16, was released in 2001. This standard was later revised and expanded to include additional features and capabilities, resulting in the release of the 802.16a and 802.16d standards in 2004 and 2005, respectively. Initially designed to service in the 10-66 GHz frequency range, WiMAX requires line of sight, LOS (Line of Sight). With the IEEE 802.16a standard, the frequency range of 2-11 GHz was also added. The addition of these frequencies and the performance of none line of sight, NLOS, also allows WiMAX stations to be installed on building tops instead of high structures or towers, providing the same convenience as wired internet. [3]

II. Versions Of WiMAX

A. WiMAX Release 1.0 (IEEE 802.16-2001)

The first version of the IEEE Standard 802.16-2001, completed in October 2001 and published on 8 April 2002, defined

the WirelessMAN™ air interface specification for wireless metropolitan area networks (MANs). The intention behind the first release of the standard was to define a technology for broadband wireless access (BWA) for fixed users, as an alternative to cabled access networks, such as a digital subscriber line (DSL) links. The standard, as approved in 2001, addresses frequencies from 10 to 66 GHz in line-of-sight (LOS) operations using single carrier transmission only [4]. This version supports up to 75 Mbps data rate.

B. WiMAX Release 1.0 (IEEE 802.16a-2004)

In 2003, a new version of the standard, IEEE 802.16a-2003, was published with support for non-LOS operations in frequencies from 2 to 11 GHz. Then in 2004, IEEE 802.16-2004 was developed, which introduced support for two additional physical layers: orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA). [4]

C. WiMAX Release 1.5 (IEEE 802.16e-2005)

In 2005, a new version of the standard was released to enable combined fixed and mobile operations in licensed bands. The aforementioned standard, IEEE 802.16e-2005. [4] Same as it's predecessor version this version supports up to 75 Mbps data rate.

D. WiMAX Release 2.0 (IEEE 802.16m-2009)

After the 2005 release, the standard development continued to define the management information base (MIB) for MAC and PHY (IEEE 802.16f) and the management plane and procedures (IEEE 802.16g), to improve the co-existence for license exempt operation (IEEE 802.16h), to introduce relay capabilities (IEEE 802.16j-2009), and to refine the MAC and PHY procedures for mobile operations (IEEE 802.16-2009). The latter is also known as the 2009 release, and brings the following major changes: half-duplex mobile terminal operations in OFDMA frequency division duplexing (FDD), load balancing, robust header compression (ROHC), enhanced mechanism for resource allocation (e.g., persistent allocation), support for location based services (LBSs) and multicast and broadcast services (MBSs) [4].

E. WiMAX Release 2.1 (IEEE 802.16m-2011)

WiMAX Release 2.1 was released in early-2010s which have broken compatibility with earlier WiMAX networks. Significant number of operators have migrated to the new standard that is compatible with TD-LTE by the end of 2010s. This version of WiMAX, added support for carrier aggregation, which allows for even faster data rates by combining multiple channels of spectrum. It also added support for high-definition (HD) video and improved support for MIMO technology.

F. WiMAX Release 2.5 (IEEE 802.16m-2014)

This version of WiMAX, released in 2014, added support for higher frequency bands, such as the 5 GHz band, which allows for faster data rates. It also added support for advanced modulation schemes and improved support for MIMO technology. In 2020, IEEE 802.16s-2020 is released which added support for very high frequency bands, such as the 60 GHz band, which allows for even faster data rates. It also added support for advanced multiple-input multiple-output (MIMO) technology and improved support for carrier aggregation.

III. Features of Wimax

A. High Speed

Wimax can provide broadband speeds of up to 75 Mbps for stationary devices and up to 20 Mbps for mobile devices, making it suitable for a wide range of applications including high-definition video streaming, voice over IP (VoIP), and online gaming. [5]

B. Long Range

Wimax can cover distances of up to 50 kilometers (30 miles) in non-line-of-sight (NLOS) environments and up to 10 kilometers (6 miles) in line-of-sight (LOS) environments, making it suitable for both urban and rural areas. [6]

C. Frequency Bands

Wimax operates in various frequency bands including 2.3 GHz, 2.5 GHz, and 3.5 GHz, which are suitable for deployment in different regions around the world. [6]

D. Multiple Access Methods

Wimax supports both time-division multiple access (TDMA) and orthogonal frequency-division multiple access (OFDMA), which allows for efficient use of the available spectrum and support for a large number of users.

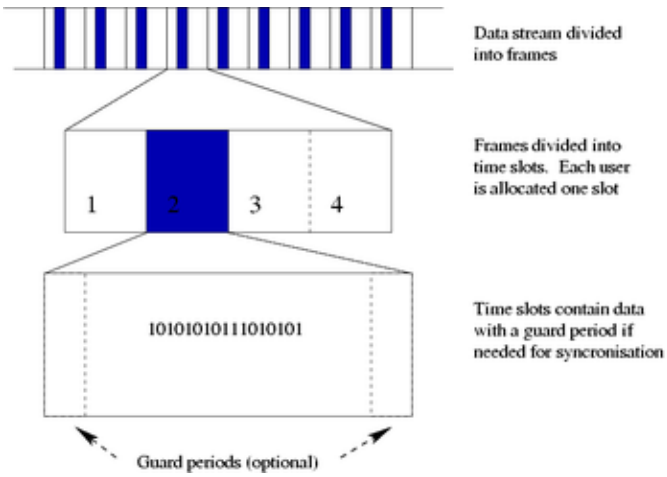

Fig. 2. TDMA (Time Division Multiplexing Access) [7]

E. Security

Wimax supports various security protocols including AES (Advanced Encryption Standard) and TKIP (Temporal Key Integrity Protocol) to protect against unauthorized access and ensure the confidentiality of transmitted data.

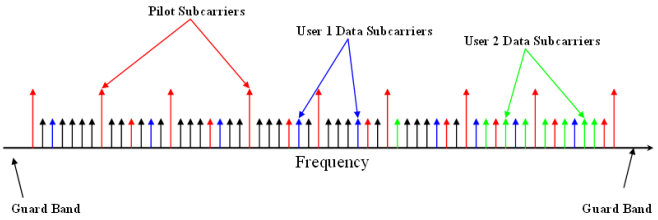

Fig. 3. OFDMA (Orthogonal Frequency Division Multiplexing Access) [8]

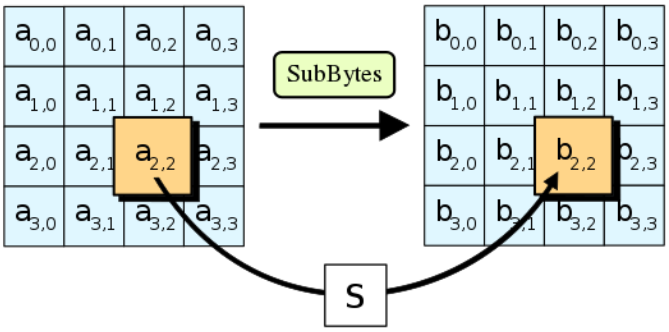

Fig. 4. AES Matrix Representation [9]

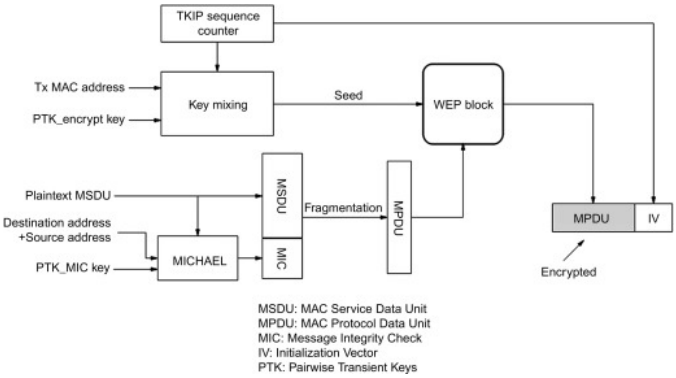

Fig. 5. TKIP Encryption Diagram [10]

F. Quality Of Service (QoS)

Wimax supports QoS mechanisms such as prioritization of different types of traffic and resource allocation to ensure that critical applications such as voice and video receive adequate bandwidth.

G. Mobility

Wimax supports handover, which allows mobile devices to maintain a connection as they move between different base stations. This enables Wimax to provide continuous connectivity to mobile devices as they move within the coverage area.

H. Interoperability

Wimax is an international standard and is interoperable with other wireless communication technologies such as 3G and 4G cellular networks, allowing for seamless integration with existing infrastructure.

IV. Comparison With Other Technologies

A. WiMAX And LTE

One difference between LTE and WiMAX is that they function on different frequencies, making their deployment slightly different. WiMAX is made to work with new deployments, while LTE is made for existing mobile and broadband deployments. Between LTE and WiMAX, LTE is slightly faster and WiMAX is slightly easier to set up. The number of simultaneous users affects any carrier, because more users need more bandwidth; LTE is slightly more affected by the number of users than WiMAX.

Any wave-based technology, such as LTE and WiMAX, needs to run on a certain frequency to be deployed. This frequency does not affect speed, functionality or dependability, but it does change how the systems are set up and deployed. LTE is made to work on 700 megahertz (MHz), WiMAX is made to work on 2.3 gigahertz (GHz) and 3.5 GHz, and both are able to work on 2.1 GHz and 2.5 GHz.

LTE and WiMAX are both capable of working with new and existing broadband and mobile deployments. At the same time, LTE is meant to work with existing systems and tends to be better at integrating existing networks. WiMAX is meant more for new deployments and networks. For common users, this will not mean much but, for business users, this means new businesses will tend to find WiMAX more useful, while LTE will help existing business upgrade and integrate their systems with the new technology.

Speed and ease of use are two common factors that users look at when choosing any type of technology. While LTE and WiMAX are similar in both aspects, each shows its strength in a certain facet. Transfer rates are slightly higher with LTE, especially in the mobile department; the difference is not as pronounced with fixed deployments or routers. Setting up is relatively easy for both standards, but WiMAX is slightly easier to set up.

It is rare for only one person in an immediate area to use a 4G device. More commonly there are tens or hundreds of people using similar devices at once. With so many users in the same area, the 4G data stream slows down to meet the demands of every user. While both LTE and WiMAX are adversely affected by the number of users, LTE tends to be slightly more affected. At the same time, LTE is faster, which tends to balance out the two.

B. WiMAX And Wi-Fi

The main difference between Wi-Fi and WiMAX is range. Wi-Fi is typically used for short-range connections, such as within homes and offices, while WiMAX is used for much longer-range connections, such as across cities and even countries. Wi-Fi also typically has a lower data rate than WiMAX. Wi-Fi is a good choice for local networking, while WiMAX is better for wide area networking.

C. WiMAX And Bluetooth

The main difference between WiMAX and Bluetooth is the distance over which they can operate and the types of devices

S.No.	WIMAX	LTE
01.	Worldwide Interoperability for Microwave Access, in short, is referred to as WiMAX.	Long Term Evolution in short is referred to as LTE.
02.	WiMAX is a wireless communication standard based on IEEE 802.16 and it is a newer technology for point to multipoint wireless networking means it specifies how wireless devices communicate over the air in a wide area.	LTE is not a technology rather it is a path followed to achieve 4G speed and a standard for wireless data transmission means it is behind 4G which is used worldwide for transferring data over cellular networks.
03.	Its network architecture is Flat and IP-based, Access Service Network Gateway (ASN-GW).	Its network architecture is Very flat and IP-based, Evolved Node B (ENode B).
04.	The subscriber is identified using EAP (Extensible Authentication Protocol) protocol.	The subscriber is identified using the SIM (Subscriber Identity Module) card.
05.	The range of frequency bands: 700 MHz – 2.2 GHz.	The range of frequency bands: 2-11 GHz
06.	It provides mobility with a target of up to 120km/h.	It provides mobility with a target of up to 350km/h.
07.	Modulation Schemes: Downlink: BPSK (optional for OFDMA-PHY) QPSK 16QAM 64QAM Uplink: BPSK QPSK 16QAM 64QAM(optional)	Modulation Schemes: Downlink: QPSK 16QAM 64QAM Uplink: QPSK 16QAM 64QAM (optional)
08.	The subcarrier spacing can be variable due to which capacity can be varied.	Subcarrier spacing constant at 15Khz.
09.	In this due to high channel utilization, processing that much information requires 1000 point Fast Fourier Transform (FFT).	In this due to organization of data into smaller chunks makes it process the information by lower point Fast Fourier Transform (FFT) like 16 point FFT.
10.	Duplex mode mostly focus on Time Division Duplex (TDD).	Duplex mode mostly focus on Frequency Division Duplex (FDD).
11.	It mostly provides fixed bandwidth.	It mostly provides flexible bandwidth.
12.	The technology used to access is OFDMA (Orthogonal Frequency-division Multiple Access) for both downlink and uplink.	The technology used to access for downlink is OFDMA and for uplink is SC-FDMA (Single Carrier Frequency Division Multiple Access).
13.	Multiple Antenna Techniques- DL: 2X2 MIMO UL: 2X2 MIMO	Multiple Antenna Techniques- DL: 2X2 MIMO 4X4 MIMO UL: 2X2 MIMO DL: Downlink, UL: Uplink
14.	WiMAX does not provide backward compatibility.	LTE provides full backward compatibility with full 3GPP interoperability.

Fig. 6. LTE and WiMAX

[11]

they are used to connect. WiMAX is a long-range technology that is used to provide internet access, while Bluetooth is a short-range technology that is used to connect devices.

BASIS OF COMPARISON	Wi-Fi	WiMAX	Bluetooth
Technology	Radio waves	Microwave.	Radio waves.
Multiplexing	OFDM	FDD, TDD.	FHSS, OFDM, DSSS.
Range	30 meters for indoor and 100 meters outdoor.	10 kilometers in air.	10 meters range.
Frame Size	0 to 2404 bytes.	5 to 20 ms	350 bytes.
Speed	Up to 60 Mbps.	Up to 75 Mbps.	1 to 4 Mbps.
Frequency Range	20 MHz	2 to 66 GHz.	2.4 GHz.
Media Access	CSMA/CD, CDMA	OFDMA.	Distributed/central CSMA/CA, MACAW.
Application Using The Technology	Video game consoles, PDAs, mobile phones, consumer electronics.	Healthcare, small business, wireless ISP, home/residential areas etc.	Microwave ovens, DVD players, Cameras, banking, office, etc.

Fig. 7. Wi-Fi, WiMAX and Bluetooth

[12]

V. Areas Of Use

A. Potential Applications

1. Providing portable mobile broadband connectivity across cities and countries through various devices.
2. Providing a wireless alternative to cable and digital subscriber line (DSL) for ”last mile” broadband access.
3. Providing data, telecommunications (VoIP) and IPTV services (triple play).
4. Providing Internet connectivity as part of a business continuity plan.
5. Smart grids and metering. [13]

B. Real Life Applications

Wireless Internet Service Providers (WISPs) – WiMAX is a major technology used by WISPs throughout the U.S. As a high-speed, fixed, wireless, point-to-point link technology, it is perfectly suited for what it was originally designed for. In this way it competes directly with technologies such as xDSL, cable, and even fiber, to connect customer premises to the internet. Its comparatively low cost and ease of implementation, especially in rural areas, makes it an ideal choice.

Middle-mile backhaul to fiber networks – Thought of as “middle of the road,” WiMAX is ideal for use as a middle-mile technology; that is, as part of the backhaul of a network for connecting more remote areas to higher-speed fiber networks. As such, WiMAX can be used as a backhaul network for cellular networks, especially in developing nations, but also in rural areas where backhauling can be quite expensive.

LTE Interoperability – The latest WiMAX release, 2.1, also branded as WiMAX 2+, is compatible and interoperable with LTE and can be used by cellular network providers to supplement their networks, especially when delivering fixed wireless over their own infrastructure.

Smart metering and IoT applications – WiMAX’s available channel bandwidth and capabilities of covering large distances make it ideal for use with applications that involve the Internet of Things (IoT), including smart metering and smart grids. Using WiMAX with time-sensitive applications

Wireless technologies are often responsible for poor network quality when it comes to implementing time-sensitive applications like video and voice. WiMAX inherently supports network features, including quality of service and multicast, that are necessary to successfully disseminate such services. This means that time-sensitive services can be sent over a WiMAX link without concern that the network capabilities would be unable to support the required performance. Thus, WiMAX can be part of a package service supplying voice, data and other services, such as video on demand, IPTV, and teleconferencing. [14]

Conclusion

WiMAX is currently being supported by the nonprofit WiMAX Forum, which has been formed to promote the adoption of WiMAX-compatible products and services while further developing it as a technological standard. As such, WiMAX is alive and well but is currently living in the shadow of Wi-Fi and modern cellular networks. Even so, it has been able to find its niche market and thrive as it delivers services that are ideal for last-mile, middle-mile, and even time-sensitive network services such as VoIP. [14]

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