Wimax Networks

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Abstract:

New data services are increasing demand on a data rate in communication systems, the emerging technology, which allows high speed broadband wireless access, is Wimax. It is often thought that Wimax is one unique technology when in fact it is a trade name for a group of Institute of Electrical & Electronics Engineers (IEEE) wireless standards. IEEE 802.16 is an emerging wireless MAN technology. The IEEE 802.16 standard contains the specification of Physical (PHY) and Medium Access Control (MAC) layer for Broadband Wireless Access (BWA). In this paper, the development of IEEE 802.16 is presented, Wimax network architecture, physical layer fundamentals, medium access control operations, access types and finally some application is mentioned also.

1-Introduction

The explosive growth in broadband demand and wireless technologies have created a difficult environment for existing wireless standards and companies competing in this market. Consequently, in order to satisfy market needs a new approach needs to be introduced to unleash the mobile information and entertainment markets. A possible solution is the broadband wireless network like Wimax, which is a fast emerging technology developed as an alternative to cable and Digital Subscriber Line (DSL). The objectives of Wimax include: delivering service in the most cost-efficient way and lowering the expenditures for service providers as well as for users providing service in suburban and rural areas where other technologies are not presented; increasing coverage; increasing capacity; providing high security etc. [1].

WIMAX (Worldwide Interoperability for Microwave Access), is a cell-based technology aimed at providing last-mile wireless broadband access at a cheaper cost. The "last mile" is the final leg of delivering connectivity from the service provider to the customer. This leg is typically seen as an expensive undertaking because of the considerable costs of wires and cables. The core of Wimax technology is specified by the IEEE 802.16 standard that provides specifications for the Medium Access Control (MAC) and Physical (PHY) layers. The term WiMAX was created by the WiMAX forum that promotes conformance and interoperability of the standard. Wireless Broadband (WiBRO) is a technology developed by the Korean telecommunications industry that mirrors the specifications of the IEEE 802.16 standard [2].

In this paper a view on WIMAX network is presented to know its fundamentals and specifications to work with, it mentions its type and application.

2-Fundamentals of Wimax

Wimax technology is a worldwide wireless networking standard that addresses interoperability across IEEE 802.16 standard-based products. It offers greater range and bandwidth, the original Wimax system was designed to operate at 10-66 GHz and it had to change to offer Broadband Wireless Access (BWA) in the 2-11 GHz frequency range.

To do this, the Wimax standard includes variants that use different combinations of radio channel types (single carrier, multicarrier), modulation types and channel coding types to provide fixed, nomadic or portable services. Wimax protocols are designed to allow for Point to Point (PTP), Point to Multipoint (PMP) and mesh networks [3]. Fig (1) indicates Progression in Wimax standards.

The development of IEEE 802.16 was started by the IEEE in 2001. After that it was revised several times and ended in the final standard IEEE 802.16-2004 which corresponds to revision D and is often called Fixed Wimax. It defines Wireless Metropolitan Broadband access for stationary and nomadic use. This means end devices can not move between Base Stations (BS) but they can enter the network at different locations this specification was extended by the development of IEEE 802.16e which supports mobility, so Mobile Stations (MS) can handover between BS while communicating, IEEE 802.16e is often called Mobile Wimax and is an amendment to the IEEE 802.16-2004 standard, Fig (2) indicate IEEE 802.16 standard [4].

The IEEE 802.16 network standard applies the so-called Open Systems Interconnection (OSI) network reference seven-layer model, also called the OSI seven-layer model. This model is very often used to describe the different aspects of a network technology. It starts from the Application Layer on the top and ends with the PHYsical (PHY) Layer on the bottom. IEEE 802 splits the OSI Data Link Layer into two sublayers named Logical Link Control (LLC) and Medium Access Control (MAC) as shown in fig(3). The PHY layer creates the physical connection between the two communicating entities (the peer entities), while the MAC layer is responsible for the establishment and maintenance of the connection [5].

3- Understanding Wimax

The network architecture consists of a base station in the center of the city with the base station communicating with all the substations or access points each sector can provide broadband connectivity to dozens of businesses and hundreds of homes, the IEEE 802.16 networks are resembled to cellular phone network. Each cell consists of a Base Station (BS) and one or more Subscriber Station (SS), depending on the implementation of the topology. Therefore, the BS provides Point to Point (PTP) service or Point to Multipoint (PMP) service in order to serve multiple SSs. BSs provides connectivity to core networks.

The SS can be a roof mounted or wall mounted Customer Premises Equipment (CPE) or a stand alone hand held device like Mobile phone, Personal Digital Assistant (PDA) or Peripheral Component Interconnect (PCI) card for PC or Laptop. In case of a outside CPE, the users inside the building are connected to a conventional network like Ethernet Local Area Network (IEEE 802.3 for LAN) or Wireless LAN (IEEE 802.11b/g for WAN) which have access to the CPE. A group of cells can be grouped together to form a network, where BSs are connected through a core network. The IEEE 802.16 network also support mesh topology, where SSs are able to communicate among themselves without the need of a BS ,BSs typically employ one or more wide beam antennas that may be partitioned into several smaller sectors, where all sectors sum to a complete 360 degree coverage. CPEs typically employ highly directional antennas that are pointed towards the BS. Depending on the need, IEEE 802.16 network can be deployed in different forms [6].

Fig (4) Wimax network architectures: a) PMP mode; b) mesh mode.

Wimax can further be connected to one or more Wireless Fidelity (Wi-Fi) access points to connect with a Wi-Fi enabled Laptop, or a standard Ethernet cable attached to a computer or LAN. The various parameters of IEEE 802.16 standard in Wimax are related to the MAC and PHY layers. To ensure that resulting 802.16-based devices are in fact interoperable, an industry consortium called the WIMAX Forum was created. The WIMAX Forum develops guidelines known as profiles, which specify the frequency band of operation, the physical features to be used, and a number of other parameters. The WIMAX Forum has identified several frequency bands for the initial 802.16d products, in both licensed (2.5–2.69GHz and 3.4–3.6 GHz) and unlicensed spectrums (5.725–5.850 GHz) [7].Fig (5) show the Wimax Architecture.

In IEEE 802.16a-2001, the frequency is addressed from 10 to 66 GHZ, which is available all over the world. Due to higher frequency, Line-of-Sight (LOS) propagation is a necessity. For a residential application, roof tops may be too low for a clear sight line to a BS. We must consider the multipath propagation affection. Recently, more interest is in the 2-11GHz projector. Design of the 2-11 GHz PHY is driven by the need for Non-LOS (NLOS) operations.

The standard defines three different air interfaces that can be used to provide a reliable end-to-end link:

1-SC: A Single-Carrier modulated air interface.

2-OFDM: A 256-carrier Orthogonal-Frequency Division Multiplexing (OFDM).

Multiple accesses of different SSs are Time-Division Multiple Access (TDMA) -based.

3-OFDMA: A 2048-carrier OFDM scheme. But a subset of the carriers can be assigned to an individual user. It is referred to be OFD Multiple Accesses

3-1 Wimax Physical Layer

The primary function of PHY is the actually physical transport of data itself. A variety of technologies like OFDM, TDD, FDD, QAM and Adaptive Antenna Systems (AAS) are utilized to achieve maximum performance from the PHY itself, one of the essential components of WiMAX is OFDM.

Mathematical Process known as Fast Fourier Transform (FFT) is used in OFDM which enables 52 channels to overlap without losing their individual characteristics. This allows the channels to be processed at the receiver end more effectively. OFDM is known for its resistance to forms of interference and degradation and is widely used in Wireless applications [8].

OFDM belongs to a family of transmission schemes called multicarrier modulation, which is based on the idea of dividing a given high-bit-rate data stream into several parallel lower bit-rate streams and modulating each stream on separate carriers—often called subcarriers, or tones. Multicarrier modulation schemes eliminate or minimize Inter Symbol Interference (ISI) by making the symbol time large enough so that the channel-induced delays—delay spread being a good measure of this in wireless channels—are an insignificant (typically, <10 percent) fraction of the symbol duration.

Therefore, in high-data-rate systems in which the symbol duration is small, being inversely proportional to the data rate, splitting the data stream into many parallel streams increases the symbol duration of each stream such that the delay spread is only a small fraction of the symbol duration. OFDM is a spectrally efficient version of multicarrier modulation, where the subcarriers are selected such that they are all orthogonal to one another over the symbol duration, thereby avoiding the need to have non overlapping subcarrier channels to eliminate intercarrier interference, in mobile Wimax, OFDMA-PHY, however, allows subchannelization in both the uplink and the downlink, and here, subchannels form the minimum frequency resource-unit allocated by the base station. Therefore, different subchannels may be allocated to different users as a multiple-access mechanism. This type of multiaccess scheme is called Orthogonal Frequency Division Multiple Access (OFDMA), which gives the mobile Wimax PHY its name ,some OFDM parameters used in Wimax can be shown in Table(1)[9]. Fig (6) illustrates the significance of OFDM. A focused beam delivering maximum bandwidth over maximum distance with minimum interference.

3-2 Wimax MAC Layer

The Medium Access Control (MAC) layer refers to the network layer immediately above the physical layer, which is the actual physical medium for conveying data. The access layer, as the name suggests, determines the way in which subscribers access the network and how network resources are assigned to them. The media access control layer described in the 802.16 standard is designed primarily to support Point-to-Multipoint (PTMP) network architectures, though it also supports the Point to-Point (PTP) and Point-to-Consecutive Point (PTCP) architectures. The lower-frequency bands also support mesh topologies [10].

The MAC layer is formed with three sublayers: Service Specific Convergence Sublayer (CS), MAC Common Part Sublayer (CPS) and Privacy Sublayer the MAC CS receives higher level data through CS Service Access Point (SAP) and provides transformation and mapping into MAC Service Data Unit (SDU). MAC SDUs are then received by MAC CPS through MAC SAP.

The specification targeted two types of traffic transported through IEEE 802.16 networks: Asynchronous Transfer Mode (ATM) and Packets. Thus, Multiple CS specifications are available for interfacing with various protocols. The MAC CPS is the core part of the MAC layer, the CPS provides functions related to duplexing and channelization, channel access, PDU framing, network entry and initialization.

This provides the rules and mechanism for system access, bandwidth allocation and connection maintenance. Quality of Service (QoS) decisions for transmission scheduling are also performed within the MAC CPS, the Privacy layer lies between the MAC CPS and the PHY layer [6].Fig (7) show IEEE 802.16 Protocol Stack.

4-Types of Access to a Wimax Network

In older version IEEE 802.16-2004 was defined only fixed and nomadic access. Fixed access allows no movement. The user device is assumed to be fixed in a single geographic location. Nomadic access provides movement among the cells. It means that moving user must establish a new network connection after each cell boarder overrun. IEEE 802.16e specifies portability feature, simple mobility and full mobility of the users. The moving speed is in the range of walking speed and low vehicular speed for portability and simple mobility [11], types of access are classified into:

- **Fixed access: Wireless access application in which the location of the end-user termination and the network access point to be connected to the end user are fixed.**
- **Nomadic wireless access: Wireless access application in which the location of the end-user termination may be in different places but it must be stationary while in use.**
- **Mobile wireless access: Wireless access application in which the location of the end-user termination is mobile [12].**
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Fig (8) show Technology rollout for wireless MAN services, Fig (9) show access types of Wimax Network.

5-Application of Wimax network

The Wimax network has been developed to address a wide range of applications, as summarized below:

<u>1-Private Networks</u>: it used exclusively by a single organization, institution or business, offer dedicated communication links for the secure and reliable transfer of voice, data and video. Quick and easy deployment is generally a high priority, and configurations are typically Point-to-Point or Point-to-Multipoint, in this type of network, application will be:

- **Cellular Backhaul**
- **Wireless Service Provider Backhaul**

- **Banking Networks**
- **Education Networks**
- **Public Safety**
- **Offshore Communications**
- **Campus Connectivity**
- **Temporary Construction Communications**
- **Theme Parks**

2-Public Networks: In public network, resources are accessed and shared by different users, including both businesses and private individuals. Public networks generally require a cost-effective means of providing ubiquitous coverage, since the location of the users is neither predictable nor fixed. The main applications of public networks are voice and data communication, although video communication is becoming increasingly popular. Security is a critical requirement, since many users share the network [13].

- **Wireless Service Provider Access Network**
- **Rural Connectivity**

6 -Conclusion

Wimax is a wireless access technology for building networks with large coverage areas and high data rates, so-called Metropolitan Area Networks (MANs).It can provide coverage in both LOS and NLOS conditions. NLOS has many implementation advantages that enable operators to deliver broadband data to a wide range of customers. Wimax technology has many advantages that allow it to provide NLOS solutions, with essential features such as OFDM technology, adaptive modulation and error correction, it was designed to work for serving fixed, nomadic and mobile subscribers and incorporates a broad range of transmission and access technologies, high-speed wireless broadband technology based on the IEEE 802.16 standard promises to open new, economically viable market opportunities for operators, wireless Internet service providers, and equipment manufacturers. The flexibility of wireless technology, combined with the high throughput, scalability, long range and Quality of Service features of the IEEE 802.16 standard.

7-Future Work

1-Study a trail of connecting this type of networks in universities or in banking system by study its cost, equipment, no. of user and level of the land geographically.

2- Study the performance of OFDM technology in enabling all channels to overlap without losing their individual characteristics.

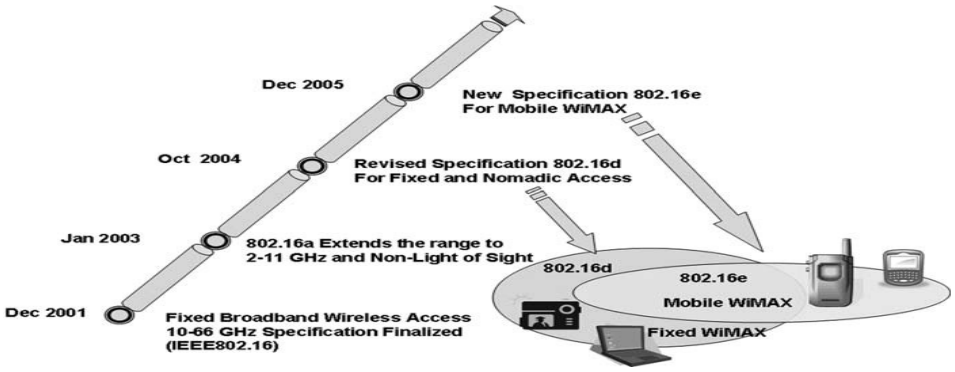


Fig (1) Progression in WiMAX standards

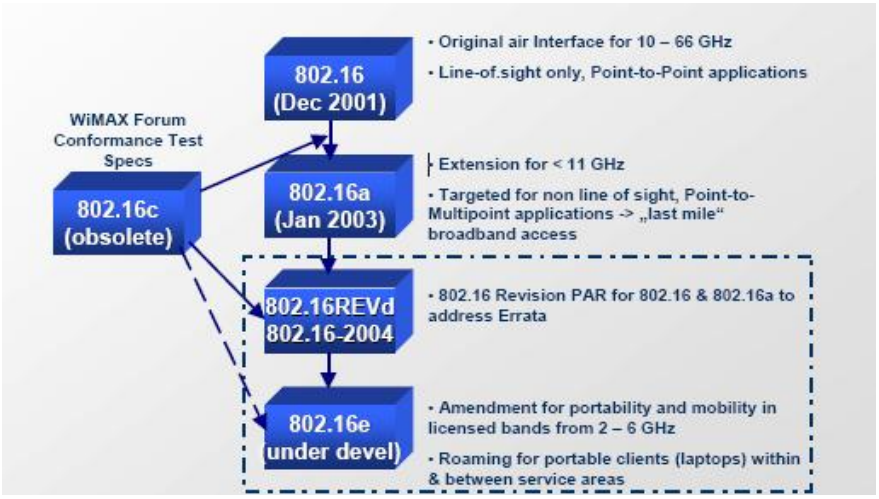


Fig (2)

IEEE 802.16 standard

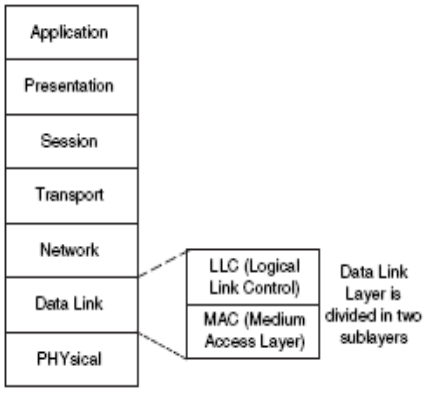


Fig (3)

The seven-layer OSI model for networks

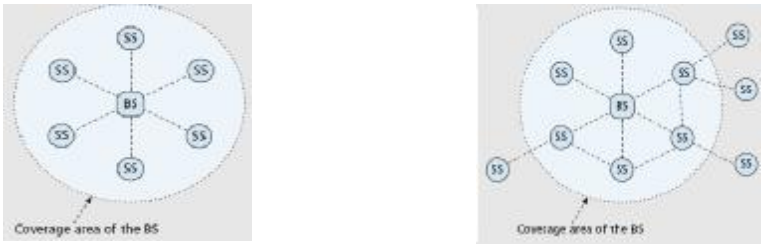


Fig (4) ***WiMAX network architectures: a) PMP mode; b) mesh mode.***

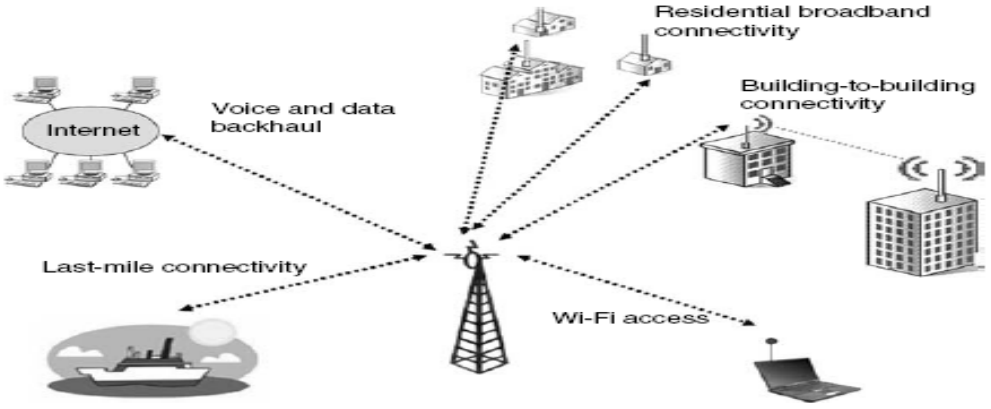


Fig (5) WIMAX Architecture

Fig (6)

The significance of OFDM

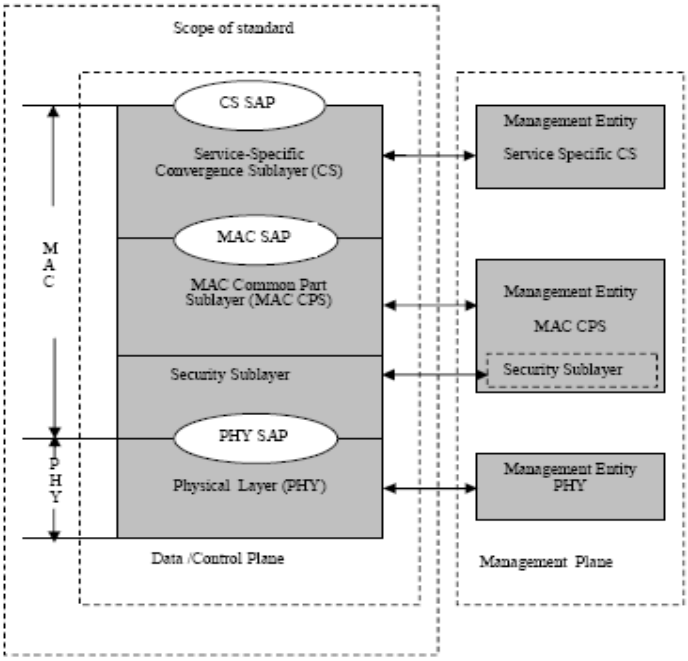


Fig (7)

IEEE 802.16 Protocol Stack

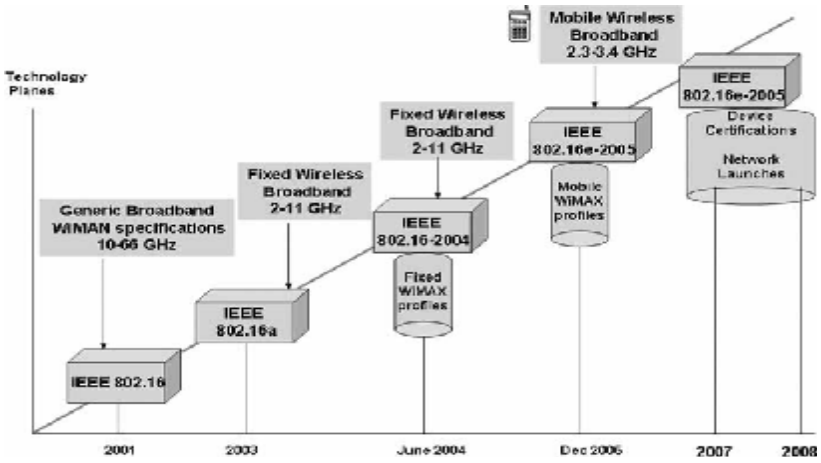
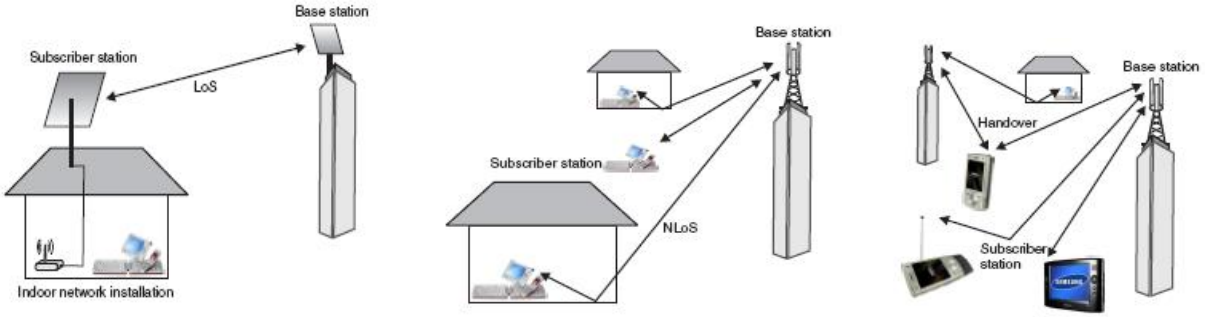


Fig (8)

Technology rollout for wireless MAN services



Fixed Wimax Nomadic WiMax Mobile WiMax

Fig (9)

Access Types of Wimax Network

Table (1)

OFDM parameters used in WIMAX

Parameter	Fixed WiMAX OFDM-PHY	Mobile WiMAX Scalable OFDMA-PHY			
FFT size	256	128	512	1,024	2,048
Number of used data subcarriers	192	72	360	720	1,440
Number of pilot subcarriers	8	12	60	120	240
Number of null/guardband subcarriers	56	44	92	184	368
Cyclic prefix or guard time (Tg/Tb)	1/32, 1/16, 1/8, 1/4				
Oversampling rate (Fs/BW)	Depends on bandwidth: 7/6 for 256 OFDM, 8/7 for multiples of 1.75MHz, and 28/25 for multiples of 1.25MHz, 1.5MHz, 2MHz, or 2.75MHz.				
Channel bandwidth (MHz)	3.5	1.25	5	10	20
Subcarrier frequency spacing (kHz)	15.625	10.94			
Useful symbol time (μs)	64	91.4			
Guard time assuming 12.5% (μs)	8	11.4			
OFDM symbol duration (μs)	72	102.9			
Number of OFDM symbols in 5 ms frame	69	48.0			

6. References

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شبكات ال WIMAX

ليلى حاتم عبود

الجامعة التكنولوجيا

المستخلص :

في انظمة الاتصالات الحديثة ظهرت خدمات لتناقل البيانات تتطلب وبشكل متزايدالتركيز على سعة نقل البيانات حيث ظهرت تكنولوجيا تسمح بايصال البيانات لاسلكيا وبسرعة عالية وتسمى شبكات الـ (Wimax), غالبا مايعتقد انها تكنولوجيا متفردة ولكنها في الحقيقة هي الاسم التجاري لمجموعة الـ (IEEE) والتي تعتبر المقياس العالمي لانظمة الشبكات اللاسلكية, وهذا المقياس يتضمن مواصفات محددة للـ (PHY) و الـ (MAC) لانظمة الشبكات ذات الترددات العالية والواسعة النطاق. في هذا البحث تم تقديم مراحل تطور المقياس العالي الخاص بهذا النوع من الشبكات ودراسة لمعمارية هذه الشبكة واساسيات المستوى الفيزيائي وعمليات السيطرة على نقل البيانات وانواع هذه الشبكات واخيرا تم ذكر بعض تطبيقاتها.