International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 34, Issue 01) and (Publishing Month: September 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

Overview of Wireless Metropolitan Area Network (WMAN) Physical Layer

Hibtallah Kamal Mohammed[1], Dr. Khaled Hamid Bilal[2] and Dr. Hala Eldaw Idris[3]

[1]Department of Communication, Faculty of Engineering, Al-Neelain University, Khartoum, Sudan
hibakamal294893@gmail.com

[2]Department of Communication, Faculty of Engineering, University of Science and Technology, Khartoum, Sudan
khalidhamidk9@gmail.com

[3]Department of Communication, Faculty of Engineering, Al-Neelain University, Khartoum, Sudan
haldaw@hotmail.com

Publishing Date: September 03, 2016

Abstract

The aims of this paper are to study, analyze and investigate general overview for WMAN physical layer such as specifications, architecture, applications and consider previous studies which contribute the research in this field with different objectives and methodologies.

Keywords: *OFDM, IEEE 802.16, WMAN, ISI, WIMAX, LOS.*

1. Introduction

OFDM "Orthogonal Frequency Division Multiplexing" divides the wide carrier into numerous narrowband subcarrier and handles them (almost) individually. These subcarriers are so narrow that the channel response is frequency nonselective (frequency flat). [1]

The orthogonality aims to address the Inter-Symbol Interference (ISI) while bringing better data rates with increased numbers of sub-carriers. If the modulated carrier is represented by a sin x function, then the subchannels peak at the zero crossings where modulation/demodulation occurs. [2]

OFDM systems provide amongst other advantages robustness to multi-path and frequency selective fading, simple equalization and a better spectral efficiency due to enhanced modulation techniques, optimized capacity due to flexibility in time and frequency domains, an expanded coverage provided by sub-channelization and a scalable design to support extra demand giving preserved radio performance.[2]

The objective of this paper is to overview the physical layer of a Wireless Metropolitan Area Network (WMAN), according to the IEEE® 802.16-2004 standard.

2. OFDM Principles

Since the OFDM scheme transmits the data via several narrowband subcarriers, the data bits have to first undergo a serial-to-parallel conversion, one parallel stream for each subcarrier. Next an inverse-FFT (IFFT) algorithm transforms the modulated subcarriers from frequency domain to time domain samples. FFT transforms the signal representation from the time domain to frequency domain, and IFFT does the opposite. In case of OFDM, IFFT is used at the transmitter and FFT at the receiver. After the IFFT function, the cyclic prefix is added. [1]

3. OFDM Physical Layer

OFDM-PHY is the first standard of WiMAX PHY layer which uses orthogonal frequency division multiplexing technique for data transmission and it is being implemented worldwide in the area of fixed applications. It uses 256 fixed sub-carriers where 192 subcarriers are for carrying data, for channel estimation and synchronization purpose 8 subcarriers are used called pilot subcarrier and the rest of the subcarrier are reserved for guard band. To overcome delay spread due to multipath and maintain frequency orthogonality it allows accepting variable guard time value 4, 8, 16, 32. If the channel is bad a high value of guard time is used otherwise the opposite will be considered. [3]

4. Wireless MAN-OFDM

WirelessMAN-OFDM air interface is based on OFDM (orthogonal frequency division multiplexing) modulation technique which supports point-to-multipoint communication. This multicarrier modulation technique uses 256-subcarrier which operates within 2-11GHz frequency band in a NLOS environment. Access is done by TDMA. Like other air interface, it implements TDD and FDD. Finally, as an optional support like transmit diversity and AAS (advanced antenna system) are also included here. Because of orthogonality between subcarriers, it saves almost half bandwidth than single carrier technique. This air interface is the most suitable candidate to support fixed SS related applications. [3]

Table 1: Basic Characteristics of Various Standards of IEEE 802.16 [5]

	802.16(2001)	**802.16 2004**	**802.16-2005**
Frequency band	10GHz–66GHz	2GHz–11GHz	2GHz–11GHz for fixed 2GHz–6GHz for mobile
Application	Fixed LOS	Fixed NLOS	Fixed and mobile NLOS
MAC architecture	Point-to-multipoint	Point-to-multipoint	Point-to-multipoint
Transmission scheme	Single carrier only	Single carrier, 256 OFDM or 2,048 OFDM	Single carrier, 256 OFDM or scalable OFDM with 128, 512, 1,024, or 2,048 Subcarriers
Modulation	QPSK, 16 QAM, 64 QAM		
Gross Data rate	32Mbps–134.4Mbps	1Mbps–75Mbps	1Mbps–75Mbps
Multiplexing	TDMA	OFDMA	
Duplexing	TDD-FDD		
Channel BW's	20-25-28Mhz	1.7, 3.5, 7, 14, 1.25, 5, 10, 15, 8.75 Mhz	1.7, 3.5, 7, 14, 1.25, 5, 10, 15, 8.75 Mhz

Air-Interface Design	WirelessMAN-SC	WirelessMAN-SCa WirelessMAN-OFDM WirelessMAN-OFDMA WirelessHUMANa	WirelessMAN-SCa WirelessMAN-OFDM WirelessMAN-OFDMA WirelessHUMANa
Implementation	None	256-OFDM as fixed Wimax	Scalable OFDMA as MobileWiMAX

5. Applications

- **Cellular Backhaul:** IEEE 802.16 wireless technology can be an excellent choice for back haul for commercial enterprises such as hotspots as well as point to point back haul applications due to its robust bandwidth and long range.
- **Residential Broadband:** Practical limitations like long distance and lack off return channel prohibit many potential broadband customers reaching DSL and cable technologies. IEEE 802.16 can fill the gaps in cable and DSL coverage.
- **Underserved areas:** In many rural areas, especially in developing countries, there is no existence of wired infrastructure. IEEE 802.16 can be a better solution to provide communication services to those areas using fixed CPE and high gained antenna.
- **Always Best Connected:** As IEEE 802.16e supports mobility, so the mobile user in the business areas can access high speed services through their IEEE 802.16/WiMAX enabled handheld devices like PDA, Pocket PC and smart phone. [4]

6. Previous study

In [3] the author was analyze and explore the resource allocation algorithms for the downlink of a WiMAX system focusing on certain allocation objectives and bridging between theoretical and practical aspects through several simulations. Then in [4] and [5] the objective was to implement and simulate the IEEE 802.16 OFDM physical layer using Matlab in [4] and making analysis of different existing high data rate wireless broadband technologies in [5]. Author in [6] investigating the effects of system impairments on OFDM systems, deriving bit error rate (BER) expressions for systems that employ a single antenna at both the transmitter and receiver, then he was comparing the analytical results with simulations that makes use of system parameters of IEEE 802.16 standard. The researcher in [7] had focused on physical layer parameters and baseband algorithms design for OFDM in a downlink LTE context, using an accurate baseband model of the received signal. In [8] author presented novel algorithms that address several problems that arise when OFDM is used as the physical layer in BFWA system.

7. Conclusion

The physical layer for the WirelessMAN-OFDM had been analyzed. First, we had given an introduction to OFDM and its principles. Then, we had discussed the OFDM physical layer and WirelessMAN-OFDM in details. We had also shown some applications of IEEE 802.16 such as: cellular backhaul. Finally, we had discussed some previous studies which are related to WMAN-OFDM.

References

[1] Juha Korhonen, “Introduction to 4G mobile communications”, Artech House-Boston London, 2014
[2] Marcel O. Odhiambo and Amimo P.O. Rayolla, “The WiMAX PHY Layer” University of South Africa, Department of Electrical and Mining Engineering, Florida, South Africa, 2012

[3] Md. Syedul Arif, "Subcarrier and Power Allocation in WiMAX", University Of VAASA, Faculty OF Technology, Telecommunication Engineering, 2010
[4] Mohammad Azizul Hasan, "Performance Evaluation of WiMAX/IEEE 802.16 OFDM Physical Layer", Helsinki University of Technology, Department of Electrical and Communications Engineering, Communications Laboratory, 2007
[5] Seyhun Barbaros YABACI, "Analysis and Comparison of Existing High Data-Rate Mobile Technologies (HSPA - WIMAX AND WI-FI)", 2010
[6] Mohamed Jalloh, "Performance Analysis of Multi-Antenna OFDM Systems with Phase Noise and Imperfect Channel Estimation", University of California San Diego, 2009
[7] Christian Rom, "Physical Layer Parameter and Algorithm Study in a Downlink OFDM-LTE Context", Aalborg University Denmark, 2008
[8] V. S. Abhayawardhana, "Investigation of OFDM as a Modulation Technique for Broadband Fixed Wireless Access Systems", University of Cambridge, 2003.