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WIMAX Performance Evaluation: OFDM (MIMO) Antenna for Base Station Applications with Space Diversity

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ABSTRACT

Like any technology, WIMAX (Worldwide Interoperability for Microwave Access) has taken years to become available. Even so, it took less time than most new wireless technologies. It developed quickly from an idea to a formal standard to real products and services in just a few years. Now a days it is an effective Technology and extremely available. This paper presents a new approach in the design of WIMAX base station antenna compatible with Space Diversity to evaluate multiple input multiple output (MIMO) antenna for base station applications.
In this paper we used MATLAB for simulation to measure transmitted, Received and loosed signal. Theory and methods are presented in details. The system model is designed for WIMAX IEEE 802.16 transceiver in MATLAB SIMULINK and the performances are evaluated using software MATLAB.

Keywords: *Adaptive modulation, Multipath Fading, Equalizer, OFDM, WIMAX*

1. INTRODUCTION

WIMAX refers to a broadband radio technology defined by IEEE standard 802.16-2004 and 802.16e-2005. This standard defines an IP-based (Internet Protocol) wireless technology using orthogonal frequency-division multiplexing (OFDM) and multiple-input multiple-output (MIMO) in the 2- to 6-GHz microwave range to provide high-speed Internet access, e-mail, video, and other services. Its potential speed ranges from 1 to 20 Mbits/s, depending upon the services offered by the provider. Using cell-phone-like base stations, coverage ranges over several miles._While Internet connectivity is the target application, WIMAX could carry Voice over IP (VoIP) phone calls, making WIMAX handsets or dual-mode cellular-WIMAX handsets a possibility. WIMAX also will be built into most new laptops, just like Wi-Fi. In fact, most laptops will probably have both wireless technologies.

2. METHODOLOGY

I describe the WIMAX studied waveform and diversity algorithms, present a single element antenna, and present a global analysis of the behavior of MIMO schemes, especially those with polarization diversity and cross-polarized antennas. Results for the various MIMO schemes, in terms of bit error rate (BER) at the output of the soft-combining Alamouti decoder and correlation between received signals, are given as a function of the antenna characteristics as S-parameters, radiated power, the polarization of the transmit and receive antennas, and the spacing between receive antennas.

3. DISCUSSION

The main objective of the AMIMO study is to define antenna specifications via a transmission performance analysis. The first step in the process was the development of a vectorial signal model to analyze industrial antenna networks for base stations.

3.1 WIMAX Network Characteristics

There are two scenarios for a wireless deployment: point-to-point and point-to multipoint.

3.1.1 Point to Point (P2P)

Point to point is used where there are two points of interest, one sender and one receiver.

3.1.2 Point-to-Multipoint (PMP)

One base station can serve hundreds of dissimilar subscribers in terms of bandwidth and services offered. .

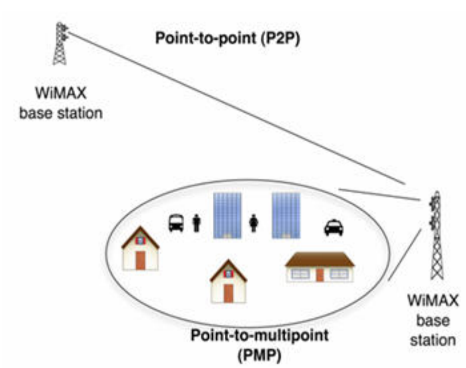

Fig 1: P2P & PMP wireless scenarios

3.1.3 Line of sight (LOS) or Non-line of sight (NLOS)

WIMAX functions best in line of sight situations. Buildings between the base station and the subscriber diminish the range and throughput, but in an urban environment, the signal will still be strong enough to deliver adequate service.

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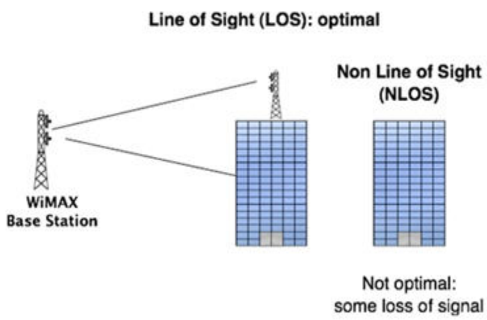

Fig 2: WIMAX Function in LOS & NLOS

WIMAX ability to deliver services non-line-of-sight, the WIMAX service provider can reach many customers in high-rise office buildings to achieve a low cost per subscriber because so many subscribers can be reached from one base station.

3.1.4 Base Station

It provides connectivity to the consumer equipments Base station consist of wireless electronic tower, Coverage area theoretically up to 50km but practically 10 km

3.1.5 Additional functions

Additional functions are handoff triggering, QoS policy enforcement, DHCP etc, BS can be point-to point or point-to-multipoint also, BS are LOS as well as NLOS.

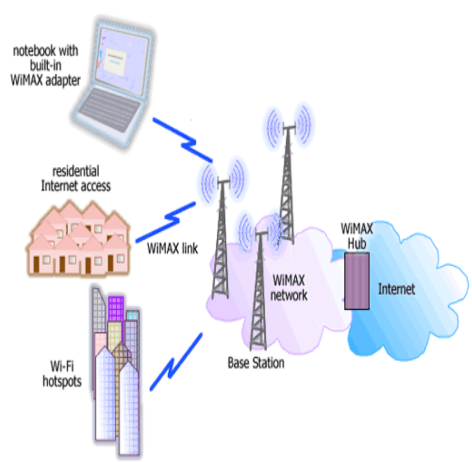

Fig 3: WIMAX Network Sample

4. MULTIPLEXING TECHNIQUES

4.1 OFDM

OFDM divides the bandwidth into multiple frequency sub-carriers, In OFDM sub-carriers are orthogonal to each other, also uses multiple sub-carriers but the sub-carriers are closely spaced to each other without causing interference.

For fixed devices Orthogonal sub carriers produce no signal power in adjacent sub carriers.

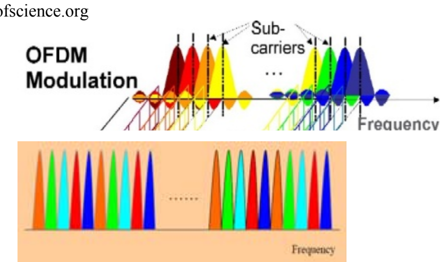

Fig 4: OFDM Modulation

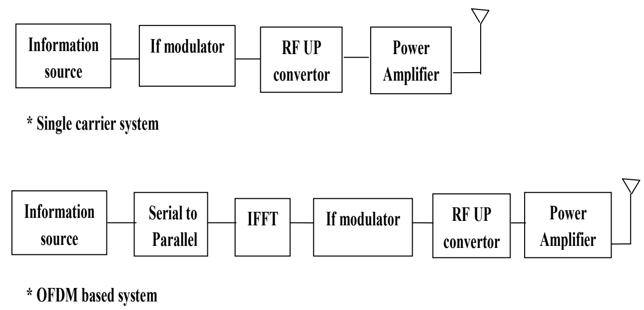

Fig 5: Baseband OFDM system

As a reminder, IFFT (Inverse Fast Fourier Transform) is used in a WIMAX transmitter to create an OFDM waveform from modulated data streams, while FFT (Fast Fourier Transform) is used in a WIMAX receiver to demodulate the data streams.

4.2 OFDMA

OFDMA employs multiple closely spaced sub-carriers, which are divided into groups of sub-carriers.
For mobile services, Point-to-point systems are OFDM, and do not support OFDMA and Point-to-multipoint fixed and mobile systems use OFDMA.

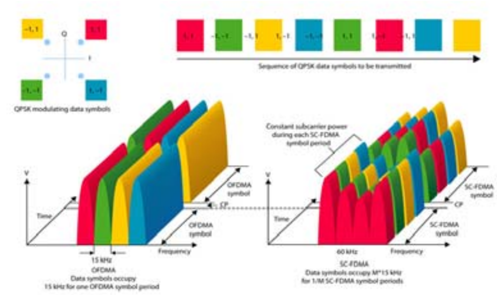

Fig 6: OFDMA in mobile services

4.3 OFDMA

OFDMA is a multi-user version of the popular (OFDM) digital modulation scheme Assigns different subset of sub-carriers to individual user, Bandwidth options 1.25, 5, 10, or 20 MHz, Entire bandwidth divided into 128, 512, 1024 or2048 sub carriers

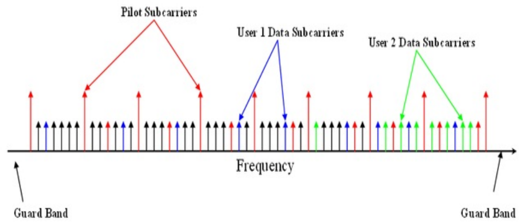

Fig 7: OFDMA as multi-users

4.4 SOFDMA

SOFDMA is used for mobile WIMAX mode, Smaller FFT size is given to lower bandwidth channels, while larger FFT size to wider channels, Capacity of each individual sub-channel remain constant, By making the sub-carrier frequency spacing constant, SOFDMA reduces system complexity of smaller channels and improves performance of wider channels.

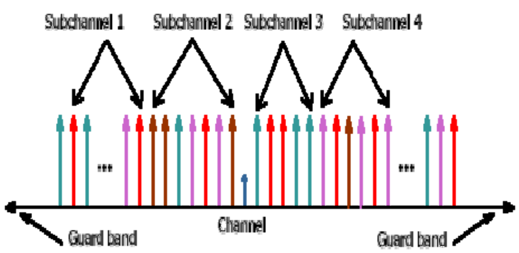

Fig 8: SOFDMA for mobile WIMAX mode with FFT size

4.5 Sub-channelization

Like OFDM, OFDMA employs multiple closely spaced sub-carriers, but the sub-carriers are divided into groups of sub-carriers. Each group is named a sub-channel. The sub-carriers that form a sub-channel need not be adjacent. In the downlink, a sub-channel may be intended for different receivers. In the uplink, a transmitter may be assigned one or more sub-channels.

The figure below considered that: In OFDM, only one SS transmits in one time slot.

In OFDMA, several SS's can transmit at the same time slot over several sub-channels.

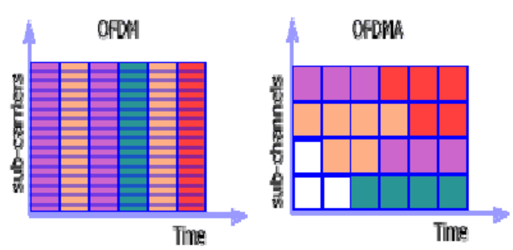

Fig 9: Sub-carrier VS Time in (OFDMA&OFDM).

5. WIMAX ANTENNAS

WIMAX antennas, just like the antennas for car radio, cell phone, FM radio, or TV, is designed to optimize performance for a given application.

WIMAX Radios: A radio contains both a transmitter (sends) and a receiver (receives).

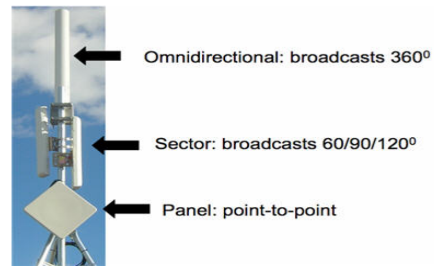

Fig 10: WIMAX Antennas

5.1 Omni Directional Antennas

Omni directional antennas are used for point-to-multipoint configurations.

Omni directional antenna broadcasts 360 degree from the base station.

Omni directional antennas are good for situations where there are a lot of subscribers located very close to the base station.

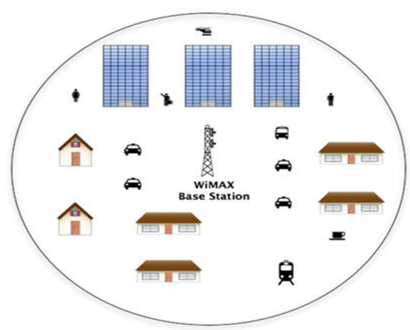

Fig 11: Omni directional Antenna for PMP Configurations.

5.2 Sector Antennas

A sector antenna, by focusing the beam in a more focused area, offers greater range and throughput with less energy.

Many operators will use sector antennas to cover a 360-degree service area rather than use an Omni-directional antenna due to the superior performance of sector antennas over an Omni-directional antenna.

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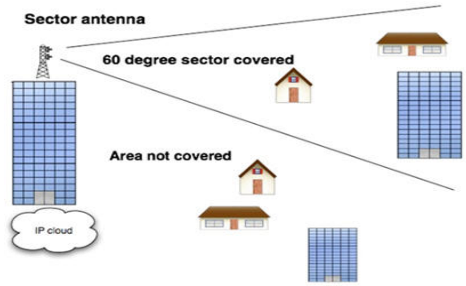

Fig 12: Sector Antenna coverage

5.3 Panel Antennas

Panel antennas are most often used for point-to-point applications.

Panel antennas are usually a flat panel of about one foot square.

Fig 13: Panel Antenna shapes & Type

6. SOME OF WIMAX APPLICATION

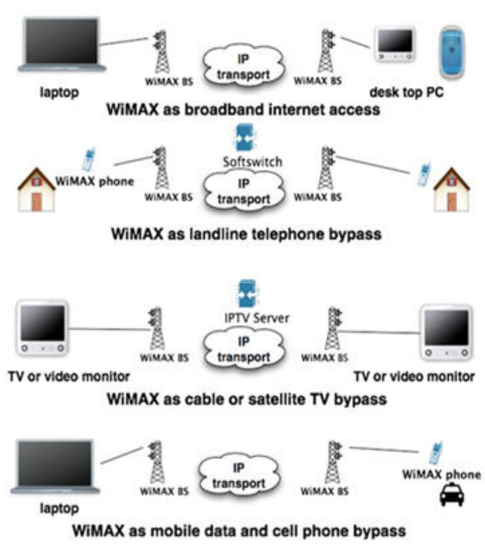

Fig 14: WIMAX Applications

7. MATHEMATICAL MODELING

FFT & IFFT: Fast & inverse Fourier transfer

7.1 Definition

The functions Y=FFT(x) and y=IFFT (X) implement the transform and inverse transform pair given for vectors of length N by:

$$X(k) = \sum_{j}^{N} 1\, x(j)\,\omega_n^{-(j-1)(k-1)}$$

$$x(j) = \sum_{j}^{N} 1\, x(j)\,\omega_n^{-(j-1)(k-1)}$$

$$\omega_n = e^{(2\pi i)/n}$$

Is an Nth root of unity.

Example for that, signal corrupted with zero-mean random noise.

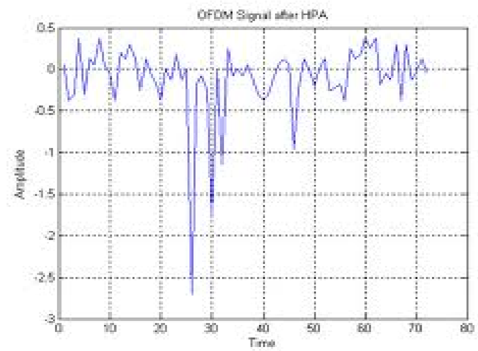

Fig 15: signal corrupted with zero-mean random noise.

8. SYSTEM ANALYSIS

In the section below, we will present the study realized during the AMIMO project. We begin by describing the waveform type and antenna characteristics to analyze the impact of antenna parameters on transmission performance.

9. SIMULATION

In this simulation used OFDM (MIMO) Technique, its Diversity for good signal.

Make simulation in two Statuses:

a. Before diversity
b. After diversity

Benefits

- Higher capacity (bits/s/Hz):
  - Spectrum is expensive; number of BS is limited
- Better transmission quality
- Increased coverage
- Improved user position estimation

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10. SIMULATION RESULTS

10.1 OFDM without Diversity

10.2 After Matlab Simulation Run

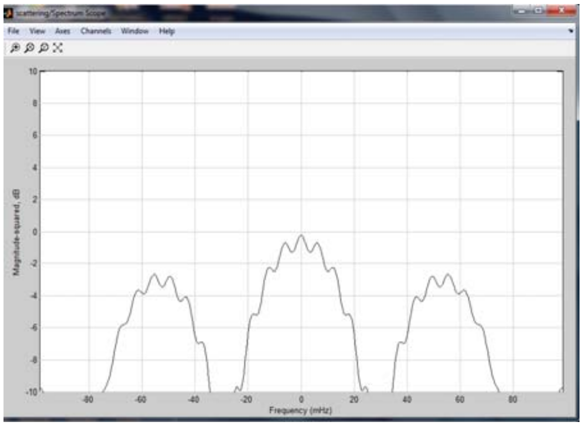

Fig 16: OFDM result without diversity in Matlab Simulink after run procedure.

10.3 OFDM with Diversity

10.4 After Matlab Simulation Run

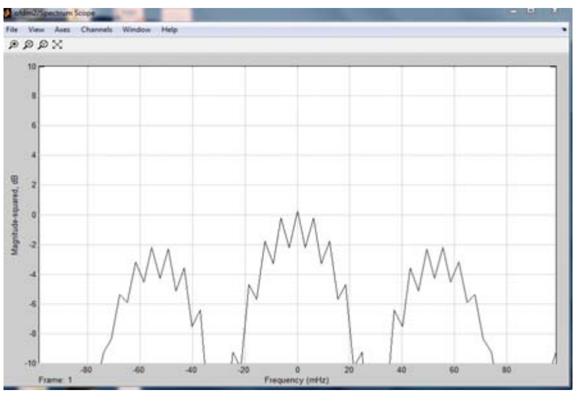

Fig 17: OFDM result with diversity in Matlab Simulink after run procedure.

11. CONCLUSION

An OFDM system is successfully simulated using MATLAB in this project; all major components of an OFDM system are covered. This has demonstrated the basic concept and feasibility of OFDM, Some of the challenges in developing this OFDM simulation program were carefully matching steps in modulator and demodulator, keeping track of data format and data size throughout all the processes of the whole simulation, designing an appropriate frame detector for the receiver, and debugging the MATLAB codes. Also showed and explained some analyses of the performance and characteristics of this simulated OFDM system. Also, there is other possible future works to enhance this simulation program include adding ability to accept input source data in a word size other than 8-bit, adding an option to use QAM (Quadrature amplitude modulation) instead of M-DPSK as the modulation method. Finally, changed in received signal depends on transmitted signal.

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APPENDICES

Panel 1: Abbreviations, Acronyms, and Terms:

Space diversity - also known as Antenna diversity, is any one of several wireless diversity schemes that uses two or more antennas to improve the quality.

33GPP—3rd Generation Partnership Project.
AMIMO—Antenna MIMO.
BER - Bit error rate.
COFDM - Coded Orthogonal Frequency Division Multiplexing.
COFDMA - Coded Orthogonal Frequency Division Multiple Access..
LTE - Long Term Evolution.
MIMO - Multiple Input Multiple Output.
QAM - Quadrature Amplitude Modulation.
RF - Radio Frequency.
RFS - Radio Frequency Systems.
SISO - Single Input Single Output.
SNR - Signal-To-Noise Ratio.
WIMAX - Worldwide Interoperability for Microwave Access.