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WiMAX Propagations

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Abstract: **The Worldwide Interoperability of Microwave Access (WiMAX) technology has become popular nowadays and has been receiving growing acceptance as a Broadband Wireless Access (BWA) system. Below 11 GHz frequency in its line-of-sight (LOS) and non line-of-sight (NLOS) conditions where it operates, WiMAX has potential success. For the deployment of WiMAX networks there are going to be a surge all over the world. In initial deployment of wireless network and cell planning estimation of path loss is very important. In this paper we explain the WiMAX propagation in LOS and NLOS environment.**

Keywords: WiMAX, LOS, NLOS propagation

I.INTRODUCTION

The latest broadband wireless technology for terrestrial broadcast services in Metropolitan Area Networks (MANs) is the Worldwide Interoperability for Microwave Access (WiMAX). To facilitate broadband services on areas where cable infrastructure is inadequate, it was introduced by the IEEE 802.16 working group. Installation is very easy and cheap. Voice, data and video for fixed, mobile and nomadic applications are the triple play applications that are provided by it. Higher bandwidth, wider range and area coverage, its robust flexibility on application and Quality of Services (QoS) that attract the investors for the business scenarios are the key features of WiMAX. For deploying this technology, nowadays millions of dollars are going to be invested all over the world.

In conditions operating below 11 GHz frequency, Broadband Wireless Access (BWA) systems have potential benefits in Line-of-sight (LOS) and Non-line-of-sight (NLOS)[1]. Propagation models are extensively used for conducting feasibility studies during the initial phase of network planning. To predict the path loss (e.g. Okumura Model, Hata Model) there are numerous propagation models available, but they are inclined to be limited to the lower frequency bands (up to 2 GHz).

II.BENEFITS

• Component Makers
• Creates a volume opportunity for silicon suppliers
• Equipment Makers
• Innovate more rapidly because there exists a standards-based, stable platform upon which to rapidly add new capabilities.
• No longer need to develop every piece of the end-to-end solution
• Operators
• A common platform which drives down the cost of equipment and accelerates price/performance improvements unachievable with proprietary approaches
• Generate revenue by filling broadband access gaps
• Quickly provision T1 / E1 level and "on demand" high margin broadband services
• Reduce the dollar risk associated with deployment as equipment will be less
expensive due to economies of scale
• No longer be locked into a single vendor since base stations will interoperate with multiple vendors' CPEs.
• Consumers
• More broadband access choices, especially in areas where there are gaps: worldwide urban centers where building access is difficult; in suburban areas where the subscriber is too far from the central office; and in rural and low population density areas where infrastructure is poor.
• More choices for broadband access will create competition which will result in lower monthly subscription prices.

III. NLOS VERSUS LOS PROPAGATION

A. NLOS versus LOS Propagation

Often the radio channel of a wireless communication system is differentiated into either LOS or NLOS. A signal travels over a direct and unobstructed path from the transmitter to the receiver in a LOS link[2]. Most of the first Fresnel zone should be free of any obstruction is the requirement of LOS link see Figure 2.4. There is a significant reduction in signal strength if this criterion is not met. The operating frequency and the distance between the transmitter and receiver locations are the factors on which the Fresnel clearance is dependent upon.

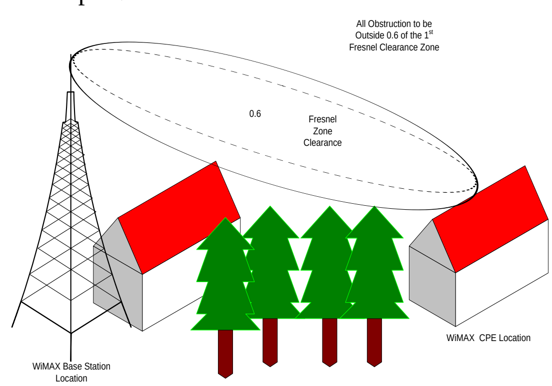

Figure.1 LOS Fresnel zone

A signal reaches the receiver through reflections, scattering, and diffractions in a NLOS link. The signals that arrive at the receiver end consist of components from the direct path, multiple reflected paths, scattered energy, and diffracted propagation paths. Different delay spreads, attenuation, polarizations, and stability relative to the direct path are there in these signals.

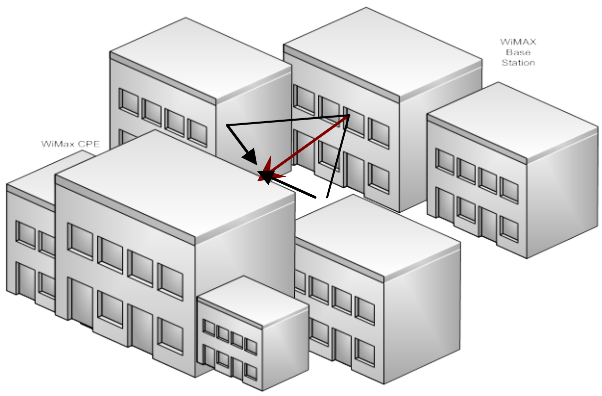

Figure 2 NLOS propagation

The polarization of the signal to be changed is caused by the multipath phenomena. Hence, by using polarization as a means of frequency re-use, it can be problematic in NLOS applications as is normally done in LOS deployments. The key to providing service in NLOS conditions is to how a radio system uses these multi path signals to an advantage. By increasing the power to penetrate obstructions (sometimes called "near line of sight") does not make a product to be of NLOS technology because this approach still relies on a strong direct path without using energy present in the indirect signals. Coverage conditions in both LOS and NLOS[3] are governed by the propagation characteristics of their path loss, environment and radio link budget. NLOS deployments are desirable because of several advantages: - strict planning requirements and antenna height restrictions often do not allow the antenna to be positioned for LOS is one of such instance. Lowering the antenna is advantageous to reduce the co channel interference between adjacent cell sites for large-scale contiguous cellular deployments, where frequency re-use is critical. The base stations are often forced by this to operate in NLOS condition. By reducing the antennae height of LOS systems this would impact the required direct view path from the CPE to the Base Station. By making under-the-eaves CPE installation a reality and easing the difficulty of locating adequate CPE mounting locations, NLOS technology also reduces installation expenses. The technology improves the accuracy of NLOS planning tools and also reduces the need for pre installation site surveys.

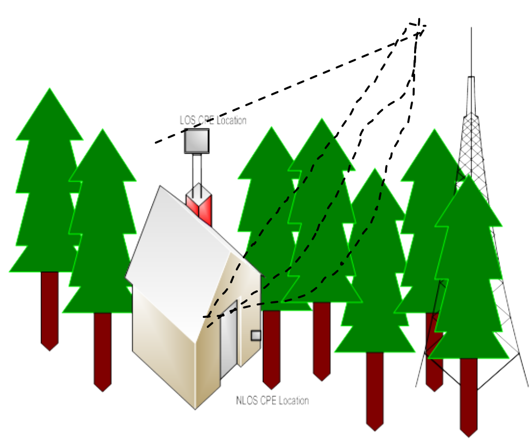

Figure.3 NLOS CPE locations

It is possible to use indoor customer premise equipment (CPE) because of the NLOS technology and the enhanced features in WiMAX. This leads to two main challenges: - overcoming the building penetration losses is the first and covering reasonable distances with the lower transmit powers and antenna gains that are usually associated with indoor CPEs is the second. This is made possible by WiMAX and by leveraging some of WiMAX's optional capabilities the NLOS coverage can be further improved. In the subsequent sections this is further elaborated.

B. NLOS Technology Solutions

WiMAX technology solves the problems resulting from NLOS conditions by using:

- OFDM technology.
- Sub-Channelization.
- Directional antennas.
- Transmit and receive diversity.
- Adaptive modulation.
- Error correction techniques.
- Power control.

(i) *OFDM Technology*

To overcome the challenges of NLOS propagation, orthogonal frequency division multiplexing (OFDM) technology provides operators with an efficient means. The advantage of being able to operate with the larger delay spread of the NLOS environment is offered by the WiMAX OFDM waveform. The OFDM waveform eliminates the inter-symbol interference (ISI) problems and the complexities of adaptive equalization by virtue of the OFDM symbol time and use of a cyclic prefix. Selective fading is localized to a subset of carriers that are relatively easy to equalize because the OFDM waveform is composed of multiple narrowband orthogonal carriers.

(ii) *Sub Channelization*

Within WiMAX in the uplink, sub Channelization is an option. Regulatory restrictions and the need for cost effective CPEs[4] without sub channelization typically cause the link budget to be asymmetrical. This causes the system range to be up link limited. For both the up and down links, sub channeling enables the link budget to be balanced such that the system gains are similar. Sub channeling increases the system gain that can either be used to extend the reach of the system, overcome the building penetration losses, and or reduce the power consumption of the CPE since it concentrates the transmit power into fewer OFDM carriers. To enable a more flexible use of resources that can support nomadic or mobile operation, the use of sub channeling is further expanded in OFDMA.

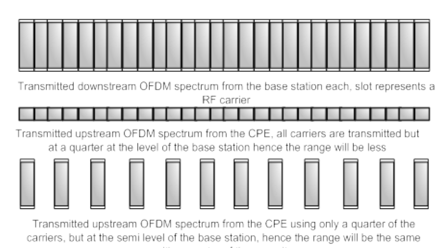

Figure.4 The effect of sub-channelization

(iii) *Antennas for Fixed Wireless Applications*

By adding more gain, directional antennas increase the fade margin. Between directional and uni-directional antennas this increases the link availability as shown by K-factor comparisons. By directional antennas at both the Base Station and CPE there is further reduction of delay spread. Any multi-path signal that arrive in the side lobes and back lobes is suppressed by the antenna pattern. The service operates under significant NLOS fading where the effectiveness of these methods has been proven and demonstrated in successful deployments. An optional part of the 802.16 standard is the adaptive antenna systems (AAS). They can steer their focus to a particular direction or directions since these have beam forming properties. Like a spotlight, this signal can be limited to the required direction of the receiver while transmitting. On the other hand, the AAS can be made to focus only in the direction from where the desired signal is coming from, when receiving. From other locations, they also have the property of suppressing co-channel interference. To improve the spectrum re-use and capacity of a WiMAX network, AASs are considered to be future developments.

(iv) *Transmit and Receive Diversity*

The multi-path and reflections signals that occur in NLOS conditions are taken advantage in the diversity scheme. An optional feature in WiMAX is diversity. In both the transmitter and receiver, the diversity algorithms offered by WiMAX increase the system availability. To provide transmit source independence, the WiMAX transmit diversity option uses space time coding. The fade margin requirement is reduced by this and this combats interference. Various combining techniques exist to improve the availability of the system for receive diversity. For example, to help overcome fading and reduce path loss maximum ratio combining (MRC) takes advantage of two separate receive chains. For coping with the challenges of NLOS propagation diversity has proven to be an effective tool.

(v) *Adaptive Modulation*

Depending on the signal to noise ratio (SNR)[5,6] condition of the radio link, adaptive modulation allows the WiMAX system to adjust the signal modulation scheme. The highest modulation scheme is used when the radio link is high in quality giving the system more capacity. To maintain the connection quality and link stability, the WiMAX system can shift to a lower modulation scheme during a signal fade. To overcome time-selective fading this feature is allowed in the system. The key feature of adaptive modulation is that it increases the range that a higher modulation scheme can be used over, since the system can flex to the actual fading conditions, as opposed to having a fixed scheme that is budgeted for the worst case conditions.

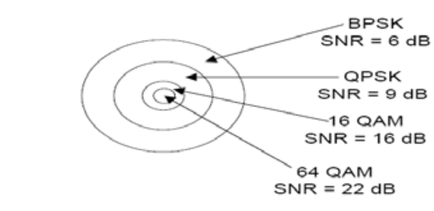

Figure.5 Cell radius

(vi) *Error Correction Techniques*

The system signal to noise ratio requirements is reduced to incorporate error correction techniques into WiMAX. Algorithms that are used to detect and correct errors to improve throughput are Strong Reed Solomon FEC[7,8], convolutional encoding, and interleaving. To recover errored frames that may have been lost due to frequency selective fading or burst errors, robust error correction techniques are used. By having the errored information resent, Automatic repeat request (ARQ) is used to correct errors that cannot be corrected by the FEC. For a similar threshold level, this significantly improves the bit error rate (BER)[9,10] performance.

(vii) *Power Control*

The overall performance of the system is improved by using power control algorithms. It is implemented by the base station sending power control information to each of the CPEs to regulate the transmit power level so that the level received at the base station is at a pre-determined level. This pre-determined performance level means that the CPE only transmits enough power to meet this requirement in a dynamical changing fading environment. The CPE transmit level is based on worst-case conditions is the converse of this. The overall power consumption of the CPE and the potential interference with other co-located base stations is reduced by the power control. For NLOS the transmit power of the CPE is heavily dependent on the clearance and obstructions and for LOS it is approximately proportional to its distance from the base station.

IV. SUMMARY

In both LOS and NLOS conditions, WiMAX technology can provide coverage. To deliver broadband data to a wide range of customers NLOS gives many implementation advantages to operators. With essential features such as OFDM technology, adaptive modulation and error correction, WiMAX technology has many advantages that allow it to provide NLOS solutions. In addition, to provide quality and performance that rivals wireline technology, WiMAX has many optional features, such as ARQ, sub-channeling, diversity, and space-time coding that will prove invaluable to operators wishing. For the first time, with the right balance of cost and performance, broadband wireless operators will be able to deploy standardized equipment; choosing the appropriate set of features for their particular business model.

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