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Worldwide Interoperability for Microwave Access (WiMAX) networks: A Conceptual Viewpoint

Engineering

KEYWORDS :

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ABSTRACT

This paper covered the dimensioning and planning of Worldwide Interoperability for Microwave Access (WiMAX) networks. The main emphasis is to enlarge the coverage area of base station in terms of reduction of interference. Cluster order has extended and cluster orders twelve and nineteen are compared based on interference correction. Interference correction (intcor) for cluster order nineteen is calculated by assuming that BS is at centre of hexagonal cell but it is not a good assumption. So, interference correction is used to correct this wrong assumption. Basic calculus (Double Integration) has been used for calculation of interference correction (intcor) using Suburban C1 Metropol Pathloss model. With cluster order nineteen intcor is approaching near to one whereas in lower cluster orders this value is not as close to one. Achievable UL and DL Carrier to Interference Ratio (CINR) are observed.

1. Introduction

Every wireless system goes through radio propagation characteristics, so WiMAX also faces interference problem. Cell planning techniques and dimensioning has been studied. With an increase in link distance, the achievable Carrier to Interference and Noise Ratio (CINR) decreases. The most critical part sounds to be the Downlink (DL) broadcast phase in dimensioning. Thus the presented result shows only Uplink (UL) broadcast phase. Based on computed Signal to Interference plus Noise Ratio (SINR) values, the mean cell capacity of singlehop WiMAX networks has been derived [1].

For dimensioning WiMAX networks, the lowest CINR within a cellular 802.16 network is relevant. In Downlink (DL), the central Base Station (BS) transfers to the farthest Subscriber Station (SS), this placed at the cell border. In Uplink (UL), the SS at the cell border transfers to the central BS.

Interference is created by co-channel cells that utilize the identical frequency channel. In the analyzed network, DL and UL channels are assumed to be perfectly isolated either by a Frequency Division Duplex (FDD) or by a fully synchronized Time Division Duplex (TDD) scheme [2].

2. WiMAX Technology and Cell Planning Features

2.1 WiMAX Technology

2.1.1 OFDM

WiMAX uses Orthogonal Frequency-Division Multiplexing (OFDM). In an OFDM system, a very high rate data stream is splited into multiple parallel low rate data streams [4]. Using phase shift keying (PSK) or quadrature amplitude modulation (QAM), each small data stream is then mapped to distinctive data sub- carrier. OFDM systems effectively overcome the interference. The outcome of inter symbol interference (ISI) is suppressed because the parallel OFDM sub carriers have a longer symbol period carrier in a single carrier system. OFDM distributes better performance in NLOS urban environment. In the UL, a transmitter may be assigned one or more sub-channels. In the DL, a sub-channel may be intended for several receivers [4].

2.1.2 Sub-Channelization

Based on the channel conditions and data requirements, Sub–channelization describes sub channels that can be assigned to the subscriber stations (SSs). By using sub-channelization, a base station (BS) can assign more broadcast power to user devices (SS) with a lower Signal to Noise Ratio within the same time slot. Sub-channelization also allows the BS to assign higher power to sub-channel allocated to indoor SSs, this improves in-building coverage [4]. Sub-channelization in the UL rescue a user device to broadcast power because it can focus power to only sub-channels assigned to it. Inter-cell interference is decreased by using sub-channelization.

2.2 Cell planning features

2.2.1 Clustering

Clustering is used to avoid the interference in cellular networks. Clustering is a process to combine cells into clusters in which each cell has unique frequency channel. Cluster order k, D is the distance of co-channel cells and R is radius [5].

$$D = R\sqrt{3k}\sqrt{3k}$$

Neighboring SSs are presumed to be centrally placed in their cell and noise is disregarded. According to [5] the UL carrier to interference ratio (CIR) only relies upon cluster order. The CIR at a central BS gaining a signal from a SS at a cell border is rising. γ is the path loss component. The worst case CIR can be computed as:

$$\frac{C}{I} = \frac{1}{6}\left(\frac{D}{R}\right)^{\gamma} = \frac{1}{6}(3k)^{\frac{\gamma}{2}} \frac{C}{I} = \frac{1}{6}\left(\frac{D}{R}\right)^{\gamma} = \frac{1}{6}(3k)^{\frac{\gamma}{2}} \qquad (1)$$

2.2.2 Sectorization

For further reducing the interference level sectorization is done. Sectorization is a technique to divide the cells into sectors. This procedure is repeated all over the network. Adaptive antenna are used to suppress the transmit energy, so that the transmit energy limited to sector region and interference level is reduced [7].

Analog to earlier equation, the expected UL CIR in a sectorized and clustered cell is presented as:

$$\left(\frac{C}{I}\right)_{sector} = \frac{m}{6}\left(\frac{D}{R}\right)^{\gamma} = m\left(\frac{C}{I}\right)_{\gamma}$$

$$\left(\frac{C}{I}\right)_{sector} = \frac{m}{6}\left(\frac{D}{R}\right)^{\gamma} = m\left(\frac{C}{I}\right)_{\gamma} \qquad (2)$$

m is the number of sectors [6]. Here only UL CIR is computed. In further analysis, the effect of noise is studied and the position of SSs designed more accurately. This analysis is further expanded to compute the DL CINR as well [2].

3. Mean Interference of a Distant Cell

In UL transmission, interference is generated by SSs of co-channel cells. The generated interference by placing all SSs in center of the cell is not correct, due to the non-linear of pathloss. In order to model the influence of co-channel interference efficiently, the mean interference produced by a co-channel cell is computed by assuming a planar transmitter with the shape of the hexagonal cell. The broadcast power equally distributed all over the network. According to the method determined in [2] interference correction factors for distant cells were calculated. The factor relies upon the pathloss model and scenario type.

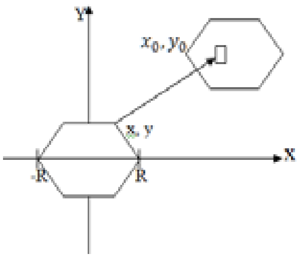

Figure 1: Interference from a co-channel cell

Figure1. Presents the on the right and a co-channel cell that produces interference on the left. The interference received by a central BS is located at x_0, y_0 x_0, y_0, can be computed by assuming that each area element of the hexagonal cell transfers with equal fractions of the transmit power.

The cell area and the Pathloss (PL) model (PL coefficient) are given below

$$\text{area} = \frac{3}{2}\sqrt{3}R^2 \frac{3}{2}\sqrt{3}R^2 \qquad (3)$$

$$\text{pl} = \beta\sqrt{(y-y_0)^2+(x-x_0)^2}^{\,-\gamma} \quad \beta\sqrt{(y-y_0)^2+(x-x_0)^2}^{\,-\gamma} \qquad (4)$$

For the PL, the suburban C1 Metropol PL Model from the IST-WINNER project was taken from [8].

Values of parameters γ and β:

$$\text{NLOS:} \quad \beta = 10^{\frac{-27.7}{10}} 10^{\frac{-27.7}{10}} \qquad \gamma = \frac{40.2 \quad 40.2}{10 \quad 10} \qquad (5)$$

$$\text{LOS:} \quad \beta = 10^{\frac{-41.9}{10}} 10^{\frac{-41.9}{10}} \qquad \gamma = \frac{23.8 \quad 23.8}{10 \quad 10} \qquad (6)$$

The coordinates x0, y0 depend on the cell radius and the cluster order. The relation between re-use distance D and cell radius R is given in Table1 [3].

Table 4: Values of coordinate

Cluster order	x_0	y_0	$\sqrt{x^2+y^2} = \sqrt{3k}\,R$
1	0	√3 R	√3
3	3R	0	3R
4	0	2√3 R	2√3 R
7	3R	2√3 R	√21 R
12	6R	0	6R
19	3R	4√3 R	√57 R

A factor (1+intcor) computes and result of 1+intcor corrects the wrong assumption of a centered source of interference.

$$1 + intcor = \frac{1}{pl(0,0)} \int_x \int_y \frac{pl(x,y)}{area}\, dy\, dx \quad \frac{1}{pl(0,0)} \int_x \int_y \frac{pl(x,y)}{area}\, dy\, dx \qquad (7)$$

It has to be noted that the correction factor is independent of the cell radius. The cell radius is part of the limits of the integral [2].

4. Analysis for order nineteen

Correction values depend on the number of sectors and on the cluster order. With an increasing cluster order, the reduction is approaching one. This is due to higher co-channel distances. With an increased number of sectors per cell, the shape of the sector narrows down so that the corrections become larger. Order number is calculated by using equation (8).

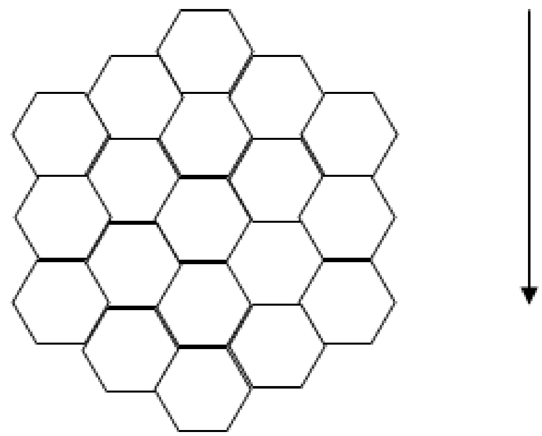

Figure 2: Cellular Network of order nineteen

$$N = i^2 + ij + j^2 \qquad (8)$$

Here N = number of order i = 3
j = 2

Table 2: Intcor for LOS scenarios for order 19 in [%]

Sectors \ Cluster order	12	19
1	1.68	.99
3	-8.82	-7.45
4	-15.33	-9.05
6	-19.51	-15.5

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Table 3: Intcor for NLOS scenarios for order 19 in [%]
Cluster order

Sectors	12	19
1	4.86	2.43
3	-13.37	-10.45
4	-24.16	-16.53
6	-30.45	-24.02

Table 2 and table 3 list the interference correction (intcor) in percent for line of sight (LOS) and non line of sight (NLOS) case. From the tables it can be seen that due to higher PL coefficient γ, the correction for NLOS scenarios is larger than the LOS scenarios. The higher PL coefficient causes non- linear behavior of the PL attenuation. The correction factor relies on the cluster order. The co-channel distance increases with increase in cluster order and interference level is also decreases. Both LOS and NLOS scenarios are shown in figure3 and figure4 respectively. The values for order twelve and nineteen are 1.68 and .99 in LOS, 4.86 and 2.43 in NLOS. So correction is lower in LOS scenarios. In nineteen the reduction is near to one. This is due to higher co-channel distance. Interference level is reduced in order nineteen as comparative to order twelve.

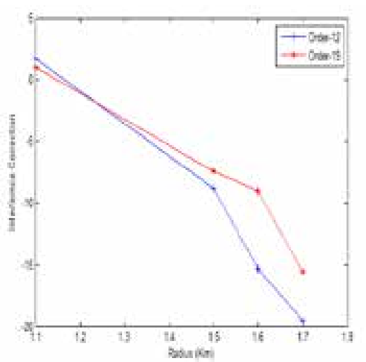

Figure3. LOS scenario for cluster order (12, 19)

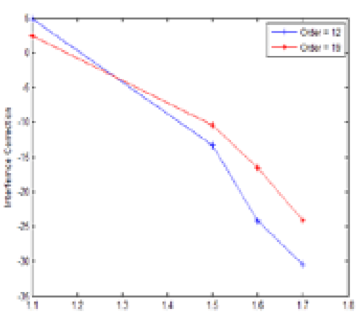

Figure4. NLOS scenario for cluster order (12, 19)

The correction for two or more sectors per cell is always negative because the sector is always far away than the center of the cell. The mean interference produced by planner sector is lower than the interference produced by a single source placed at the centre of the co-channel cell.

5. Cellular Scenario

The examined cellular scenario consists of a hexagonal cell with central BS. The network is clustered in groups of twelve and nineteen and the cell is covered by one to six sectors. The distance of co-channels in order nineteen is larger than order twelve. Interference level is lower in order nineteen. The BSs of the cell are centrally placed. In comparison to section (2), the unknown and varying locations of the interfering SSs are modeled by means of mean interference produced by a planner transmitter. Unlike in section (2), noise is taken in the analysis. Antenna gain is neglected at the transmitter as well as at the receiver. The modulation and coding scheme (Binary Phase Shift Keying) are used for dimensioning.

The cellular WiMAX network uses upper 5GHz frequency bands, which had been licensed for indoor and outdoor Wireless Local Area Network (WLAN). According to this, both BSs and SSs are transmitting at 1W. The suburban C1 Metropol PL model from IST-WINNER project was applied during analysis [8].

6. UPLINK Transmission

The following figures show the CINR at

the central BS and the most distant SS is transmitting. In UL, SSs broadcast to the central BS. The SSs of neighboring cells use the same frequency generated interference. For dimensioning, the most critical SS is placed at the cell border.

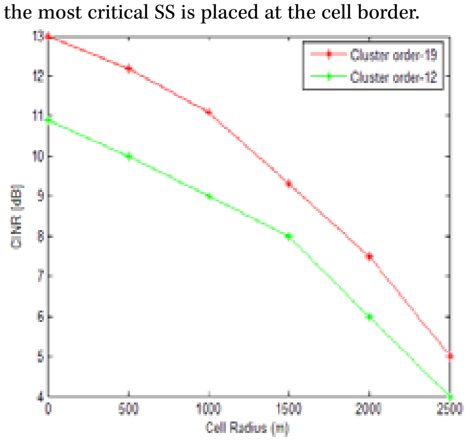

Figure5. UL CINR for cluster order (LOS, 12 and19)

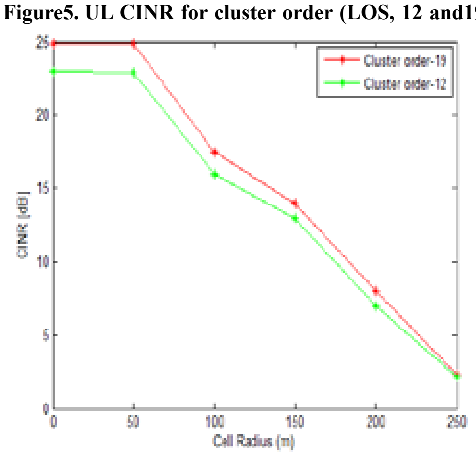

Figure6. UL CINR for cluster order (NLOS, 12 and 19)

Figure5 shows the influence of clustering in a LOS scenario. Lower cluster orders are not leading to sufficient CINR. Cluster orders twelve and nineteen allow for cell radii of 1500m and 1700m respectively. The system is interference-limited here.

With the smaller radii than 200m, CINR is increased in case of NLOS (shown in figure6) and proper signal quality has been achieved for cluster orders twelve and nineteen. The CINR decreases due to high coefficient for larger radius. In NLOS case, the level of interference is very low between cell radius 200 to 250m and system is noise limited here.

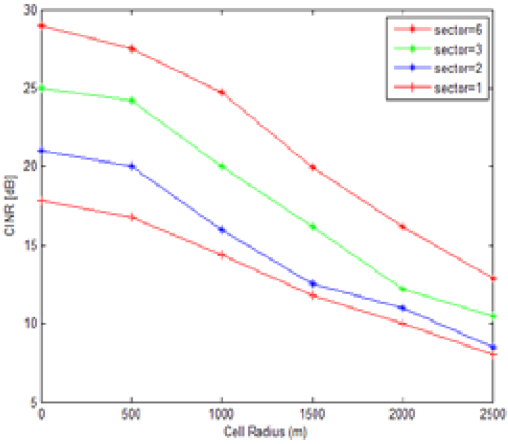

Figure7. UL CINR with sectorization (LOS, cluster order 19)

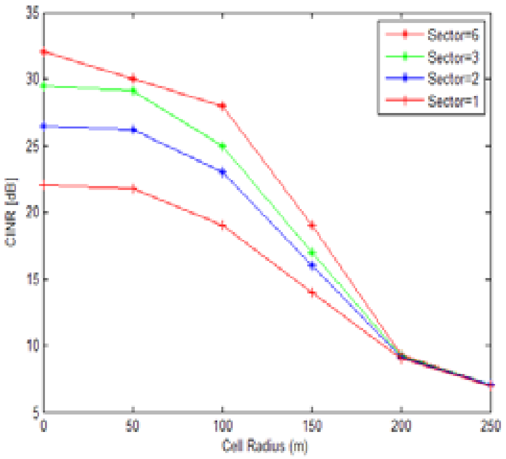

Figure8. UL CINR with sectorization (NLOS, cluster order 19)

Figure7 shows UL CINR in LOS scenario with cluster order nineteen and sectorization. The radius can be extended from 2000 to 2500m for cluster order nineteen.

Figure8 shows UL CINR in NLOS scenario with cluster order nineteen and sectorization. CINR has been increased for small radii but it has no effect for larger radii. As system is noise limited, so reduction in interference is not effective. For small sector interference increases but for larger sector it remains constant.

Some features to raise the CINR are relevant during the scheduled UL data transmission, else during the contention based access. The BS can target its receive antenna to the transmitting SS during the scheduled part of the UL subframe, in this way BS receive gain boost the signal quality [9]. Subchannelization during ranging and request procedures allows targeting the transfer power onto a subset of subcarriers. This raises the spectral density and enlarges the transmission range significantly [10]

7. Conclusion

For enhancing the coverage area of network in terms of reduction of interference, various performance parameters are used. Since, correction factor depend on the cluster order, with increasing cluster order, the co-channel distance also increasing and therefore interference has reduced. Interference correction approaches to one that was not in the previous cluster orders. This is due to higher co-channel distances. Influence of clustering for LOS (Line of Sight) and NLOS (Non-line of Sight) scenarios have analyzed. And performance under LOS scenario resulted to be better than NLOS. In DL, the interference level analyzed to be slight greater that has reduced in UL because of location of receiver at the centre of the cell not at the cell border and the CINR also reduced because SSs generate interference not the central BSs. Here, the system is interference –limited.

Interference correction for UL has done in this dissertation and same scenario for DL will be analyzed in future. And the most critical part of cellular WiMAX network seems to be the DL broadcast phase. During this phase, neither subchannelization nor antenna gain can be applied. Hence, work for DL in future will have to be done for improving performance and to reduce interference level.

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