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Design of Cell Property based on Fixed WiMAX Access System for Different Terrain Types

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Abstract

This paper focuses on a detailed mathematical analysis of cell coverage, effective bandwidth analysis and performance for fixed WiMAX. The calculation is based on propagation model suitable for 802.16d fixed WiMAX. The estimation is done for different terrain types. Based on the above approach, coverage and performance are estimated under some real world application for Republic of Bangladesh as per licensed spectrum. As WiMAX is low cost for both implementation and ongoing charges, it will be the best candidate for Bangladesh to provide high-speed broadband wireless Internet access technology.

Keywords: WiMAX IEEE 802.16, Fixed WiMAX, CellCoverage Analysis, Terrain Type, Effective Bandwidth.

1. INTRODUCTION

WiMAX is a broadband wireless access technology that provides wireless transmission of data using a variety of transmission modes, from point-to-multipoint links to portable and fully mobile Internet access. The technology is based on the IEEE 802.16 standard. The earlier IEEE 802.16.1 standard is for a point to multipoint broadband wireless transmission in the 10 – 66 GHz band, with only a line-of-sight capability [1]. However, IEEE 802.16a standard can support non-line-of-sight transmission in the 2 – 11 GHz band. In 2004 and 2005 another two standards IEEE 802.16d and IEEE 802.16e, respectively are ratified. The IEEE 802.16d is frequently referred to as "fixed WiMAX" and IEEE 802.16e is "mobile WiMAX". The main goal of IEEE 802.16d is the connectivity for end-to-end network without direct link of sight in some circumstances [2].

WiMAX is an introducing and emerging technology in Bangladesh. Three national licenses of 30 MHz each are awarded, comprised of two licenses in the 2.3 GHz frequency, and one license in the 2.5 GHz band [3]. In this paper we theoretically calculate the area coverage i.e. cell radius, number of cells, coverage prediction and performance analysis for different terrain types. The IEEE 802.16 covers three most common terrain types such as i) Terrain type A, hilly terrain with moderate-to-heavy tree densities, ii) Terrain type B, intermediate path loss conditions and, iii) Terrain type C, mostly flat terrain with light tree densities [4]. As for example we applied our theory for different terrain types suitable for Bangladesh. The land of capital city Dhaka is flat with intermediate path loss conditions. So it is under the terrain type B. On the other hand, Chittagong is a hilly area and it is under the terrain type A. Similarly, other divisions of Bangladesh can be classified under different terrain types as shown in Table 3 (which is shown in Section 3).

2. COVERAGE ANALYSIS

Coverage analysis mainly depends on selection of propagation model and fade margin for area coverage [5]. The link budget analysis is a prerequisite to any type of cell plan. The link budget serves to look at the system at a whole and attempts to represent the system as an average providing the engineers guideline to begin cell layout and design. Here we give Table1 of link budget analysis for our calculation. For this calculation we used typically values of the commercial WiMAX system and equipment [4,8].

Table1: Basic parameters for link budget evaluation

Model Parameters	
Propagation Model	COST231HATA
Operating frequency f (MHz)	2300
Modulation technique	64 QAM3/4
BS antenna height h_{BTS} *(m)*	100
Transmitting antenna height h_{TS} *(m)*	10
Transmitted power P_t *(dBm)*	23
Transmitting antenna gain G_t (dBi)	18
Transmitter feeder loss L_t *(dB)*	0.5
Receiving antenna gain G_r *(dBi)*	14
Receiver feeder loss L_r *(dB)*	0.5
Receiver sensitivity, S_r (dBm)	-80
Nominal distance d_o (m)	1km (far field calculation)
Shadow margin s (dB)	10

All the parameters are considered for better performance and from point of practical view, available for these areas.

COST231, the extended version of HATA model is useful for fixed wireless access (FWA) below 6 GHz. Among the different types of terrain supported by IEEE802.16d model, we consider the intermediate path loss condition i.e. terrain type B for Dhaka division. For WiMAX fixed wireless access system, the cell diameter is given by the following equation [4].

$$d_{max} = d_0 . 10\ (M\text{-}N)/\ 10^{\ L} \quad \text{----------}\ (1)$$

where

$$M = (P_t - L_t + G_t + G_r - L_r) - S_r$$

$N = \{20 \log (4\pi d_0/\lambda) + 6\log (f_{Ghz}/2) - 10.8\log(h_{TS}/2) + s\}$

$L = 10(a - b h_{BTS} + c / h_{BTS})$

In the above equation: a, b and c are the co-efficients for different terrain types. As Dhaka division is of terrain type B, the values of coefficients are $a = 4$, $b = 0.0065$, $c = 17.1$ [4,6]. Using above values in equation (1) we get d_{max} = 13.5 km. So, for Dhaka division, the cell radius $r = d_{max} / 2 = 13.5 / 2 = 6.75$ km.

Path loss and received power can be calculated from the following equations [4]

$L_{tot\ (max)} = (P_r - L_t + G_t + G_r - L_r) - S_r$ -------(2)

$P_r = P_t - L_t + G_t \; L_{tot} + G_r - L_r) - S_r$ ---------- (3)

And finally we get the results in tabular form for six divisions of Bangladesh. We get the information of area of six divisions of Bangladesh from Bangladesh Bureau of Statistics [7]. Table 2 represents received power, maximum total path loss and cell radius with respect to various modulation techniques for different terrain types. On the other hand, Table 3 shows the final results i.e. cell radius, and cell number for six divisions of Bangladesh.

Table 2: Received power, maximum total path loss and cell radius with respect to various modulation techniques for different terrain types

Parameters		½ BPSK	½ QPSK	¾ QPSK	½ 16 QAM	¾ 16 QAM	2/3 64QAM	¾ 64QAM
L_{tot} (max (dBm)		153	150	148	144	141	136	134
Terrain Types		Cell Radius r (km)						
	A	9.3	7.823	6.96	5.526	4.645	3.477	3.1
	B	13.51	11.16	9.8	7.53	6.2	4.5	4
	C	18.16	13.74	11.95	9.04	7.3	5.17	4.5

Table 3: Cell radius, and cell number for six divisions of Bangladesh

Division	Area (sq Km)	Terrain Type	Cell radius	Area of Cell	No. of Cells
Dhaka	31,119.97	B	4	50.26	619
Rajshahi	35,513	B	4	50.26	706
Chittagong	33,771	A	3.1	30.19	1118
Khulna	22,274	C	4.5	63.6	350
Barishal	13,297	C	4.5	63.6	209
Sylhet	12,596	A	3.1	30.19	417

3. EFFECTIVE BANDWIDTH ANALYSIS

We consider, OFDM PHY Parameter according to IEEE 802.16d [8].

Sampling frequency $Fs = \frac{8000n\ BW}{8000}$ -------(4)

Bandwidth efficiency

$BW_{efficiency} = U / V$ ------------------- –(5)

where

$U = (F_s \times N_{used} \times N_{sub\ channels})$

$V = (BW \times N_{FFT} \times 16)$

Effective bandwidth

$W = BW_{efficiency} \cdot BW$ -------------------- (6)

where n is the sampling factor ; BW is the channel bandwidth in Hz ; N_{used} is the number . of sub carries used and N_{FFT} is the length of FFT in OFDM PHY. According to IEEE802.16d standard typical value of n is 8/7, $N_{used} = 192$, $N_{FFT} = 256$, $N_{sub\ channels} = 16$, $BW = 30$ MHz for this purpose[8]. So we get from equation (4), (5) and (6)

$Fs = (8/7) \times 30 \times 10^6$,

$BW_{efficiency} = 0.857$ and

W=25MHz

4. PERFORMANCE ANALYSIS

We consider, OFDM PHY Parameter according to IEEE 802C.16d [8]. In OFDM PHY, maximum transmission data rate

$R = N_{used} \cdot b_m \cdot c_r / T_s$ ----------------------(7)

where b_m is the no. of bits per modulation symbol, c_r is the coding ratio and T_S is the symbol duration.

Again $T_s = T_g + T_b = [G+I]\ T_b$ ----------- (8)

According to IEEE802.16d standard, for 64-QAM, typical values are $b_m = 6$, $c_r = ¾$,

$G = 1/32$, $T_b = 1/D_f$ with subscriber

$D_f = F_S / N_{FFT}$, So we get $Tb = 7.733 \times 10^{-6}$ and

$T_S = 122$ Mbps.

5. CONCLUSION

By using proposed path loss model of the IEEE for 2.3 GHz, we have made mathematical calculation model of the cell size and cell number. We calculated cell radius for different levels of adaptive modulation as specified by WiMAX forum like modo 0 -BPSK1/2, modo1 - QPSK1/2, modo2 - QPSK3/4, modo3 -16QAM1/2, modo4 - 16QAM3/4, modo5 - 64QAM2/3 and modo6 - 64QAM3/4.But the results are not satisfactory. For example we get cell radius for modo3 - 16QAM1/2 and modo5 - 64QAM2/3 13 and 8.6 km respectively. The radius is higher, which will make the signal weak at the border area of the cell. A way to overcome this problem is to increase the transmitted power. But this is not cost effective. So we consider 64QAM3/4 as a better option. Moreover using optical fiber cable can also reduce feeder cable loss.

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