Coverage Planning of Mobile WiMAX for Urban and Suburban Environment using Power Scheduling Scheme

M. L. Palash, Masum Billah, M. J. Rashid

Abstract-This work presents thecoverageplanning of Mobile WiMAXforthe urbanand suburban environment. An effective coverageplanningis veryimportant to obtain the benefits over existing voice and datacommunication techniques.In thisrespectwe proposeacosteffective coverageplanning basedonthepower frequency schedulingtechnique.This techniqueisflexibletocapacity anddata speedvariance.Theefficiency ofpower schedulingscheme isfound higher compare toother scheme.Thisproposed planning canbe implemented in the urban andsuburbanareas without changing thestandardhardware equipment of MobileWiMAX.

Keywords: IEEE802.16e,coverageplanning,powerfrequency scheduling, Mobile WiMAX.

I. INTRODUCTION

Mobile WiMAX (IEEE 802.16e)is a wireless communication standardfor both data and voice communication. It ispromoted to support the mobility. This technique uses the concept of cellular system to cover a metropolitan area, where the base stations provide communication services with coverage radius up to several kilometers.

A usual problem in cellular system is interference. To avoid the interferences in cellular system the most widely used technique is frequency reuse technique. The 2G cellular system uses conventional seven segment reuse scheme to reduce interference [1]. Frequency hopping is another effective technique butit reduces the spectral efficiency. To increase the spectral efficiency, 802.16e uses fractional frequency reuse (FFR) planning [2]. But it also has a demerit of using less bandwidth ofwhat it has been allocated. Conversely, frequency reuse technique utilizes its allocated bandwidth depending on its reuse factor. Although the bandwidth utilization ofFFR planning is higher than the classical frequency reuse scheme, the FFR uses less of its allocated bandwidth. This low utilization of bandwidth reduces intercell- interferences [3].

In this workwe present a new technique known as power frequency scheduling. Using this technique, a coverage planning is proposed for both urban and suburban environments.

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II. METHODOLOGY

The coverage planning of any system basically focuses on the cell structure, frequency uses policies and network design.An appropriate design of a cell structure and suitable frequency reuse scheme can increasethe network efficiency: capacity enhancement and reduction of interference [4]-[6].

The essential part of a coverage planning is link budget. In this work the link budget calculation is performed using Power Frequency scheduling scheme.This scheme uses all the frequency bands at each cell with an intelligent power allocation to mitigate interference, achieves high cell throughput with an acceptable cell-edge performance. [7]

In our work four link-budget calculationsis performed for both urban and suburban cell structure. The most of the data required for these link budget calculationsare taken from the existed WiMAX networks and standard initialization [8]. The first two calculations are for finding the urban cell size and the later two are to find the suburban cell structure. Suburban and urban cell structures are designed considering the growing population of a country.

A.Selecting the best frequency reuse plan:

A mix of frequency-reuse one and three schemes has then been proposed to avoid interference at cell edges. This consists in dividing the frequency band into two sub-bands: a frequency-reuse one sub-band, allocated to users at cell center, and a frequency-reuse three sub-band, allocated to cell-edge users [9]. This scheme indeed decreases interference, but also reduces peak data rates as the entire frequency band is not allocated to each cell. When using this fractional frequency allocation and to overcome the loss of capacity caused by the partial use of the frequency band in each cell, some manufacturers propose to implement fractional reuse as part of the scheduling decision [10]. The idea is to allocate cell-edge frequencies in adjacent cells with lower power to limit the interference. This can be viewed as a power/frequency scheduling technique based on the path loss of the user. Even if the overall cell throughput is large in the hybrid frequency allocation scheme, there is still a loss of subchannels compared with the reuse one scenario. To overcome this problem, a proposed solution is to use a power control on some frequency bands to limit interference at the cell edges which is known as power frequency scheduling scheme [11]. This scheme has been selected here as it provides maximum channel use within a cell.

B.Design of urban and suburban cell:

Link budget analysis deals with the factors such as path loss, receiver sensitivity, noise, enforcement and losses from the antennas and cables. Link budget analysis results in a power transmission required to achieve a given

BER advance. A link budget is the accounting of all of the gains and losses from the transmitter, through the medium to the receiver in a communication system (Fig-1). It is a calculation for the attenuation of the transmitted signal due to propagation, as well as the antenna gains, feed line and miscellaneous losses. Randomly varying channel gains such as fading are taken into account by adding some margin depending on the anticipated severity of its effects.

$$P_{tx} + G_{tx} - A_{pl} + G_{rx} - A_m = P_{rx}$$

P_{rx} = Received Power at Detector (dBm)
P_{tx} = Transmitter Output Power (dBm)
G_{tx} = Transmitter Antenna Gain (dBi)
G_{rx} = Received Antenna Gain(dBi)
A_{pl} = Path loss (dB)
Am= Miscellaneous Attenuation(link margin, diffraction loss, connection loss, trees rain, walls glass, body loss etc.)

Fig 1: Link budget illustration model. [8]

The link budget is the amount of losses and strengthening the power of the signal while it is passing through the different elements to the path from transmitter to receiver. It allows determining the required transmission power which is able to overcome them in the media transmission losses so that the recipient has adequate power for receiving the signal.
As a result of the link budget, receiving power issufficiently greater than the power of noise and that is the target of the transmission speed can be achieved. The link budget determines the theoretical maximum value for each cell range of base station. [11].
Here in this paper we have used multiple link budget calculation for finding a suitable urban and suburban cell design. The procedure is illustrated in the Fig-2.

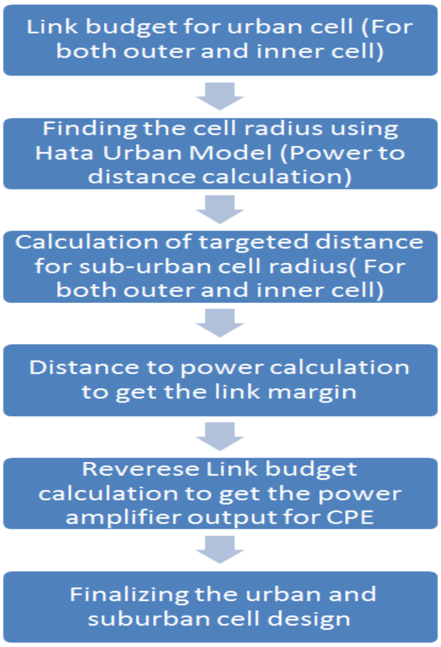

Fig-2: Working procedure for designing combined urban and sub-urban cell.

Link budget for the channel having EIRP +40dBm:
In Bangladesh BTRC specification (max EIRP +40dBm) urban cell has been designed [12]. To get +40dBm EIRP the Power Amplifier output is taken as 27dB.Taking this value the first link budget calculation is shown in Table I.

Table I:Link budget calculation for urban cell

Parameter	**mobile hand set outdoor**		**Fixed Desktop**	
	DL	UL	DL	UL
Power amplifier output power(dB)	27	15	27	15
Number of tx antennas(dB)	2	1	2	1
Power amplifier back off(dB)	0	0	0	0
Transmit antenna gain(dB)	16	0	16	6
Transmitter losses(dB)	3	0	3	0
EIRP(dB)	40	15	40	21
Channel BW(MHz)	30	30	30	30
Number of sub-channels	90	90	90	90
Receiver noise level(dB)	-99.22	-104	-99.22	-104
Receiver noise figure(dB)	3	4	3	3
Required SNR	0.8	1.8	0.8	1.8
Sub-channelization gain(dB)	0	19.54	0	19.54
Macro diversity gain(dB)	0	0	0	0
Receiver sensitivity(dB)	-95.42	-117.74	-95.42	-118.74
Receiver antenna gain(dB)	10	15	15	15
System gain(dB)	145.43	147.74	150.43	154.74
shadow fade margin(dB)	5	5	5	5
building Penetration loss (dB)	0	0	5	5
Link margin(dB)	140.43	142.74	140.43	144.74
Operating frequency(MHz)	2300	2300	2300	2300

The distance covered by the calculated link margin is obtained by Hata (Urban) Path loss model which is specified in Fig-3.[13]

$$L_u = 69.55 + 26.16\log_{10} f - 13.82\log_{10} h_B - C_H + [44.9 - 6.55\log_{10} h_B]\log_{10} d$$

$$C_H = 0.8 + (1.1\log_{10} f - 0.7)h_M - 1.56\log_{10} f \quad (\textit{for medium sized city})$$

L_u = Path loss in Urban Areas.(dB)

f = Frequency of Transmission.(Mhz)

h_B = Height of base station Antenna.(meter)

C_H = Antenna Height Correction factor.

Fig-3: Hata model for urban areas.

Table II: Power to distance calculation for urban cell (outer)

CPE	DL/UL	Power	Distance cover
Mobile handset outdoor	Download	140.4390874	2310m
	Upload	142.7424251	2710m
Indoor Fixed	Download	140.4390874	2310m
	Upload	144.7424251	3100m

So if the lowest value is taken then the coverage range is = 2310m ≈ 2300m

Link budget for the channel having EIRP +30dBm:

Table III: Link budget calculation for urban cell (inner)

Parameter	mobile hand set outdoor		Fixed Desktop	
	DL	UL	DL	UL
Power amplifier output power(dB)	20	10	20	10
Number of tx antennas(dB)	2	1	2	1
Power amplifier back off(dB)	0	0	0	0
Transmit antenna gain(dB)	16	0	16	6
Transmitter losses(dB)	3	0	3	0
EIRP(dB)	36.01	10	36.01	16
Channel BW(MHz)	30	30	30	30
Number of subchannels	90	90	90	90
Receiver noise level(dB)	-99.22	-104	-99.22	-104
Receiver noise figure(dB)	3	4	3	3
Required SNR	0.8	1.8	0.8	1.8
Sub-channelization gain(dB)	0	19.54	0	19.54
Macro diversity gain(dB)	0	0	0	0
Receiver sensitivity(dB)	-95.42	-117.74	-95.42	-118.74
Receiver antenna gain(dB)	10	15	15	15
System gain(dB)	141.43	142.74	146.43	149.74
shadow fade margin(dB)	5	5	5	5
building Penetration loss (dB)	0	0	5	5
Link margin(dB)	136.43	137.74	136.43	139.74
Operating frequency(MHz)	2300	2300	2300	2300

Similarly usingHata (Urban) Path loss model the calculation of inner cell radius is shown in the table IV.

Table IV: Power to distance calculation for urban cell (inner)

CPE	DL/UL	Power	Distance cover
Mobile handset outdoor	Download	136.4390874	1810m
	Upload	137.7424251	1970m
Indoor Fixed	Download	130.4390874	1810m
	Upload	139.7424251	2260m

If the lowest value is considered then the coverage range is = 1810m ≈ 1800m

For sub urban environment cell in the first tier can form up an entire cell. Here power in the base stations can be controlled to make a desired coverage range. For this purpose the following Value is taken. Fig-4 illustrates the desired coverage range for sub-urban cell.

$$Cell\ Maximum\ range = 2300 \times \frac{\sqrt{3}}{2} \times 3 = 5975 \approx 6000m$$

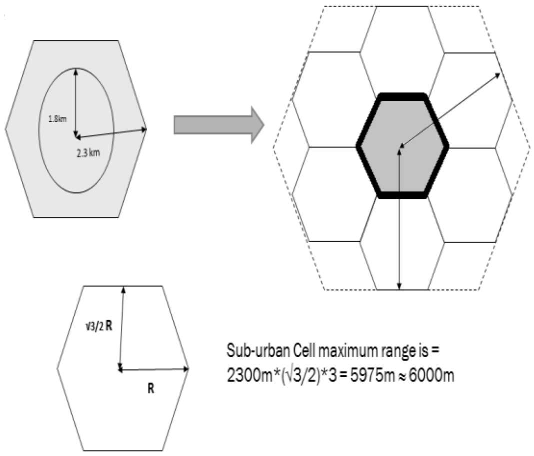

Fig- 4: Suburban Cell maximum range based on Urban Cell.

This sub-urban range can be used to find the suitable output power of CPE. To do this firstly the desired link margin calculated by distance to power calculation using Hatamodel(shown in table V and table VII). Then this calculated link margin is used to find the power amplifier output power of CPE using Link-budget calculation (table 6 and table 8).

Table V: Distance to power calculation for suburban cell radius (outer)

CPE	DL/UL	Distance cover	power
Mobile handset outdoor	Download	6000m	143.01db
	Upload	6000m	143.01db
Indoor Fixed	Download	6000m	143.01db
	Upload	6000m	143.01db

Link budget for the channel having maximum path loss 143.01dbm:

Table VI: Link budget (back) calculation for Suburban cell radius (outer)

Parameter	mobile hand set outdoor		Fixed Desktop	
	DL	UL	DL	UL
Power amplifier output power(dB)	29.6	15.3	29.6	13.3
Number of tx antennas(dB)	2	1	2	1
Power amplifier back off(dB)	0	0	0	0
Transmit antenna gain(dB)	16	0	16	6
Transmitter losses(dB)	3	0	3	0
EIRP(dB)	42.61	15.3	42.61	19.3
Channel BW(MHz)	30	30	30	30
Number of subchannels	90	90	90	90
Receiver noise level(dB)	-99.22	-104	-99.22	-104
Receiver noise figure(dB)	3	4	3	3
Required SNR	0.8	1.8	0.8	1.8
Sub-channelization gain(dB)	0	19.54	0	19.54
Macrodiversity gain(dB)	0	0	0	0
Receiver sensitivity(dB)	-95.42	-117.74	-95.42	-118.74
Receiver antenna gain(dB)	10	15	15	15
System gain(dB)	148.039	148.04	153.039	153.04
shadow fade margin(dB)	5	5	5	5
building Penetration loss (dB)	0	0	5	5
Link margin(dB)	143.03	143.04	143.03	143.04
Operating frequency(MHz)	2300	2300	2300	2300

Similar to suburban outer cell the inner cell radius can be calculated.

$$Maximum\ inner\ cell\ radius = 2300 \times \frac{\sqrt{3}}{2} \times 2 = 3983 \approx 4000m$$

Table VII: Distance to power calculation for suburban cell radius (inner)

CPE	**DL/UL**	**Distance cover**	**power**
Mobile handset outdoor	Download	4000m	137.07dBm
	Upload	4000m	137.07dBm
Indoor Fixed	Download	4000m	137.07dBm
	Upload	4000m	137.07dBm

Link budget for the channel having maximum path loss 137.07 dbm:

Table VIII: Link budget back calculation for suburban cell (inner)

Parameter	mobile hand set outdoor		Fixed Desktop	
	DL	UL	DL	UL
Power amplifier output power(dB)	23.6	9.3	23.6	7.3
Number of tx antennas(dB)	2	1	2	1
Power amplifier back off(dB)	0	0	0	0
Transmit antenna gain(dB)	18	0	18	6
Transmitter losses(dB)	3	0	3	0
EIRP(dB)	36.61	9.3	36.61	13.3
Channel BW(MHz)	30	30	30	30
Number of subchannels	90	90	90	90
Receiver noise level(dB)	-99.22	-104	-99.22	-104
Receiver noise figure(dB)	3	4	3	3
Required SNR	0.8	1.8	0.8	1.8
Sub-channelization gain(dB)	0	19.54	0	19.54
Macro diversity gain(dB)	0	0	0	0
Receiver sensitivity(dB)	-95.42	-117.74	-95.42	-118.74
Receiver antenna gain(dB)	10	15	15	15
System gain(dB)	142.03	142.04	147.03	147.04
shadow fade margin(dB)	5	5	5	5
building Penetration loss (dB)	0	0	5	5
Link margin(dB)	137.03	137.04	137.03	137.04
Operating frequency(MHz)	2300	2300	2300	2300

III. RESULTS AND DISCUSSION

The urban cell has smaller radius then the suburban cell. From the above calculation the design is taken in such a way that seven urban cells can form a suburban cell. The advantage of using this is if a suburban area converted to a urban area or in other words data speed demand increases then just converting the suburban cell to seven urban cells it will highly achievable . The central cell location will remain unchanged. This is shown in Fig-4.

Besides this a suburban cell can be partially converted to urban cells based on demand. The following Fig-5 shows an example of converting a suburban cell into one partially suburban and three urban cells. The shaded area represents the suburban transmission.

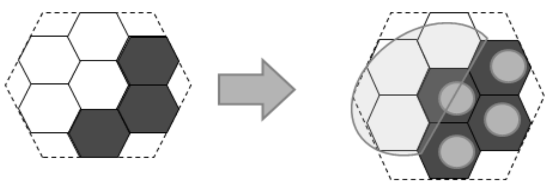

Fig-5: Partially suburban cell

IV. CONCLUSION

In this work we have proposed a power frequency scheduling reuse plan for urban and suburban environment. A flexible design is proposed for sub-urban cell base station and it is not required to relocate while necessary to increase the urban cell size. This design is also suitable for increasing capacity. By converting suburban cell to urban cell, structure capacity can be increased to 700 percent. Here a suitable algorithm is needed to control the transmission power for both base station antenna and CPE to vary based on the location of CPE.

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