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RADIO ACCESS NETWORK REQUIREMENT FOR NEW DEPLOYMENT OF WIMAX IN DHAKA

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Abstract - Mobile WiMAX is expected to be the next generation radio-interface, complementing WLAN and challenging EVDO/HSPA/LTE. High speed data rate, reduced latency, better Quality of service, and mobility can allow WiMAX to meet the rapidly growing demand of the users. A study of WiMAX Radio Network Planning (RNP) for an urban area like Dhaka city in Bangladesh is presented in this paper in order to help predetermine the radio access infrastructure requirements. A suitable radio planning tool has been used for this purpose. The simulation results of throughput and Carrier to Interference plus Noise Ratio (CINR) are provided.

Keywords *- WiMAX; Network Dimensioning; Radio Network Planning; CINR.*

I. INTRODUCTION

This paper addresses the radio access network requirement for new deployment of WiMAX in a metropolitan area like Dhaka in Bangladesh based on the IEEE 802.16e air interface standards. The most important technical and business goal of radio access network is efficiently providing coverage and capacity, while avoiding the build-out of a large number of new base stations. This paper will focus on radio planning issues for new deployment of a cost-effective WiMAX radio access infrastructure using spectrum in the 3.3 GHz frequency bands. Current WiMAX deployments operate at 2.3 GHz in Bangladesh but 3.3 GHz is a likely carrier frequency for future spectrum allocation for WiMAX in Bangladesh. The paper organization is as follows: network dimensioning is explained in Section II; the detailed radio network planning is described in Section III; the simulation results for radio network planning are presented in Section IV; finally, the conclusions are highlighted in Section V.

II. NETWORK DIMENSIONING

Network dimensioning is the initial step of radio network planning for deployment of any generation technology. The target of network dimensioning is to estimate the number of required Base Stations (BSs) for the area of interest. The network dimensioning activities include radio link budget and coverage analysis, cell capacity estimation, determination of hardware configuration and equipment at different interfaces. The link budget determines the maximum cell radius for a given level of reliability. The result of this step depends on the propagation model used. With a rough estimate of the cell size and BS count, verification of coverage analysis is carried out for the required capacity.

The area of Dhaka city is approximately 1463 sq-km. This includes some areas where there are no dwellers (e.g. ditches). Also, in some areas, the number of potential users is not significantly high (e.g. slum areas). The estimated total coverage area can be 70% of the whole area, which is 1028 sq-km.

The total population of Dhaka city is approximately 15 million. A great numbers of the dwellers in Dhaka do not require access to internet facilities. The estimated number of target subscribers in first few years for a new operator can be about 1% of the whole population in Dhaka. The current operators claim to support about 100 thousand subscribers. The subscribers can be grouped based on their locations around main roads, secondary roads, small streets, railways and airports. The subscribers can also be classified based on their predominant data transfer in downlink, in uplink or in both downlink and uplink. Thus, the target subscribers are estimated as shown in Table I**.** .

TABLE I**:** NUMBER OF SUBSCRIBERS FOR DIFFERENT CLASSES

Area	**No. of users**			
	DL	***UL***	***DL+UL***	***Total***
Main roads	2857	747	268	3872
Secondary roads	13804	3247	1393	18444
Small Streets	87628	21201	9157	118986
Airport	684	153	69	906
Railways	6	5	1	12
Total	**104979**	**25353**	**10888**	**142220**

The assumptions for link budget calculation are shown in Table III. Other assumptions are shown in Table II.

TABLE II : CERTAIN ASSUMED PARAMETER VALUES

Parameters	**Value**	**Parameters**	**Value**

Carrier frequency	3.3 GHz	Throughput per user	512 kbps
Bandwidth in a sector	10 MHz	Overbooking Factor	20
Frequency Reuse Ratio	1	No. of antennas at BS	2
Scheduling Algorithm	Proportional fair	No. of antennas at CPE	1
Propagation model	Sakagami extended model	DL:ULframe ratio	31:15

Rough estimates of the required number of BSs have been calculated to meet certain target capacity and target coverage for DHAKA city. The cell range and BS configurations have also been estimated. All these estimates have been later used as a baseline for detailed radio planning.

A. Dimensioning for Target Capacity

The capacity of a given network is measured in terms of the subscribers or the traffic load that it can handle. The former requires knowledge of the number of the subscribers and the types of their usage.

The estimated cell throughput for 10MHz bandwidth is 15Mbps. The assumed throughput per user is 512 kbps. Then the cell size should be such that it supports 15Mbps/512 kbps=30 active users simultaneously. Thus, a BS supports 90 active users. For overbooking factor 20, the number of total users under a BS can be 90 × 20 = 1800. Thus, the required number BS can be estimated as 142220/1800 ≈ 79.

B. Dimensioning for Target Coverage

Dimensioning for target coverage includes radio link budget and coverage analysis in both downlink and uplink. A link budget is developed assuming potential values for different parameters as shown in Table 3. The Maximum Allowable Path Loss (MAPL) is calculated based on the required CINR level at the receiver. The minimum of the maximum path losses in uplink and downlink is converted into cell radius, by using a propagation model appropriate to the deployment area.

TABLE III **:** RADIO LINK BUDGET

Parameters	**Downlink**	**Uplink**	**Notes**
Transmit power	49 dBm	30 dBm	A1
No of transmitting antenna	2	1	A2
Transmitter antenna gain	18 dBi	0 dBi	A4
Transmitter losses	3.0 dB	0 dB	A5
Effective Isotropic Radiated Power (EIRP)	67 dB	30 dB	A6=A1 + 10 log10(A2)-A3+A4-A5
Channel bandwidth	10 MHz	10 MHz	A7
No of sub channels	16	16	A8
Receiver noise level	-104 dBm	-104 dBm	A9=-174+ 10 log10(A7*1e6)
CINR	8 dB	6 dB	A10
Macro diversity gain	0 dB	0 dB	A11
Sub channelization gain	0 dB	12 dB	A12 = 10 log10(A8)
Receiver sensitivity (dBm)	-96	-110	A13=A9+A10 +A11-A12
Receiver antenna gain	0 dBi	18 dBi	A14
System gain	163 dB	158 dB	A15=A6 – A13 +A14
Shadow - fade margin	8.5 dB	8.5 dB	A16
Building penetration losses	0 dB	0 dB	A17 ; Assuming single wall
Path Loss	154.5dB	149.5 dB	A18=A15-A16-A17
Coverage range, d	3.17 km (1.97 miles)	2.34 km (1.45 miles)	Assuming Sakagami extended model

The minimum between downlink and uplink coverage ranges, d = 2.34 km is considered as the cell radius. The hexagonal cell site area is then calculated as, $3d^2 \times \sin(\pi/3) = 14.22$ sq-km. The required number of BS can be estimated as, 1028/14.22 ≈ 72. As a densely populated city, it is thus found that Dhaka requires little more number of BSs to fulfill capacity requirements than what is required for coverage requirements.

III. DETAILED RADIO NETWORK PLANNING

ATOLL, a Radio Network Planning (RNP) tool from FORSK has been used in the detailed radio network planning step. A digital map for Dhaka city is used which incorporates the terrain properties. The results from network dimensioning have been taken into account as initial estimation for number of BSs in order to meet capacity and coverage requirements. The location of BS sites, transmit power, antenna height, number of sectors, azimuth and down tilt have been carefully chosen based on results from dimensioning, terrain, subscriber densities, building densities, typical building heights, foliage, interference from neighboring cells and so forth. The

number of BSs, their locations and BS configuration parameters are then adjusted through a good number of iterative simulations for optimum performance in terms of both coverage and throughput. This was a long manual process. This led to the establishment of 75 BSs in total in Dhaka with transmit power and antenna height configurations as shown in Fig.1. The frequencies of 10 MHz bandwidth have been allocated to sectors using automatic frequency planning feature. Preamble indexes have also been allocated using automatic allocation feature.

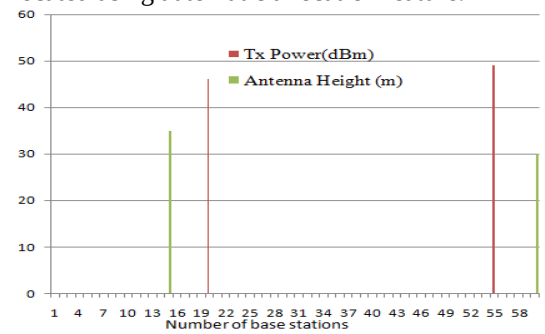


Fig. 1: Transmit power and antenna height vs. BS counts

IV. SIMULATION RESULTS

The simulation results from the radio planning for Dhaka using ATOLL are presented in this section. Coverage by Signal level and Downlink CINR distribution around BSs for a small area are shown in Fig.2 and Fig.3 respectively. As demonstrated, satisfactory coverage quality has been achieved for the presented network setup.

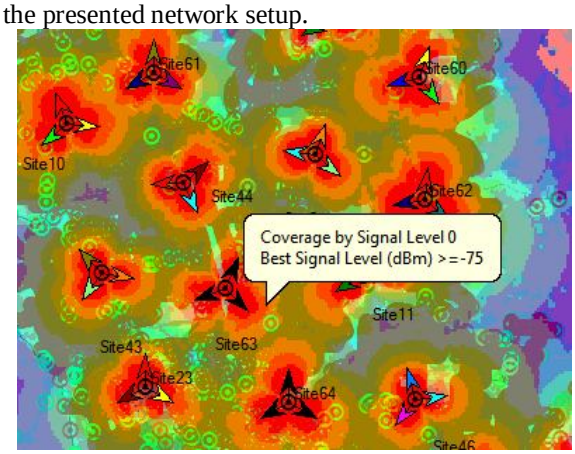


Fig. 2 : Coverage Signal level distribution around BS

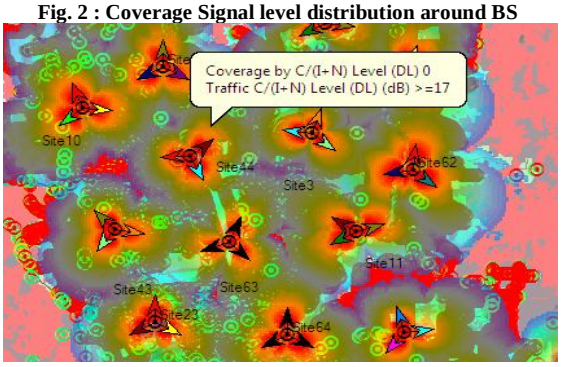


Fig. 3 : Downlink CINR distribution around BS

The Signal Level over the whole Dhaka city is demonstrated in Fig.4 using histogram. It may be noted that almost three-fourth of the whole Dhaka city have satisfactory coverage while subscribers are not available everywhere .This histogram depicts signal level exceeding -90 dBm for pretty large amount area as shown by the end portion of the histogram. This confirms the achievement of good coverage quality.

The CINR distribution over the whole Dhaka city is demonstrated in Fig.5 using histogram. Since almost one-fourth of the whole Dhaka city is left out of coverage based on the presence of very few or no subscribers, this histogram leaves low CINR for a good amount of area.

However, CINR exceeding 30 dBm exists for pretty large amount area as shown by the sharp rise at the end of the histogram. This confirms the achievement of good CINR quality.

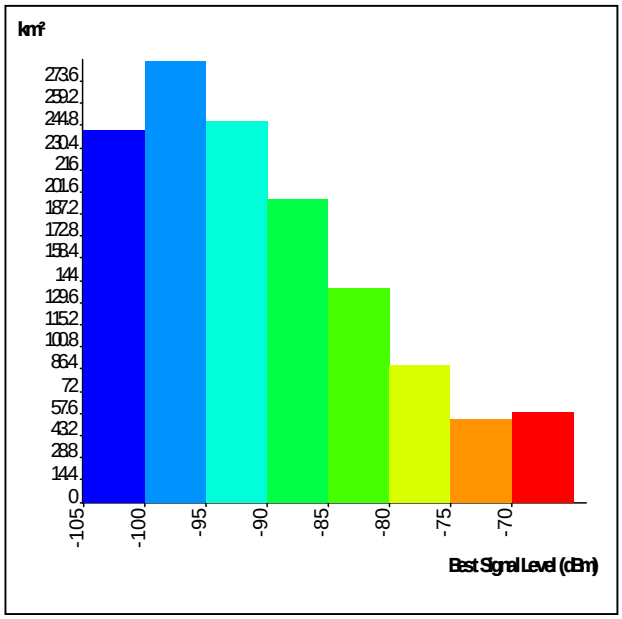


Fig. 4: Histogram showing area versus DL Signal Level

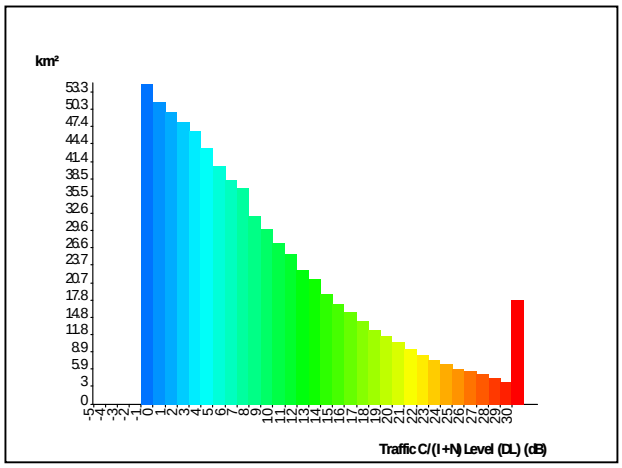


Fig. 5 : Histogram showing area versus DL CINR

The downlink throughput distribution around BSs over the whole Dhaka city area is shown in Fig.6. As demonstrated, satisfactory data rate has been achieved for the presented network setup.

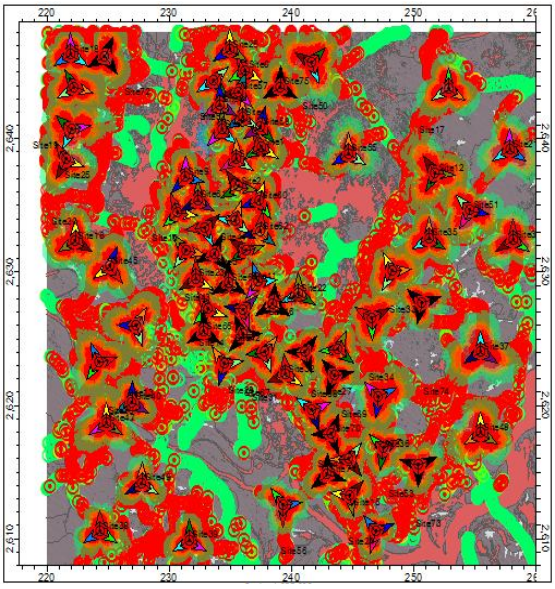


Fig. 6 : Overall throughput variation around BSs and distribution of subscribers

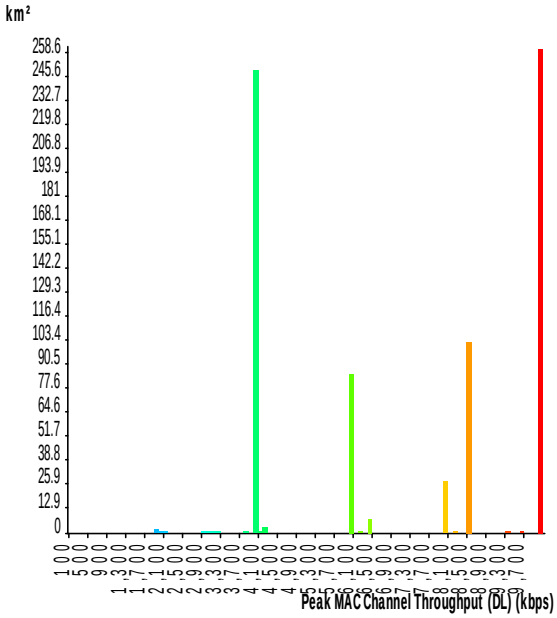
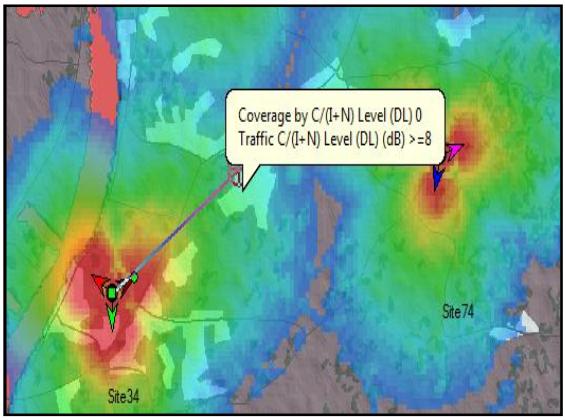


Fig. 7 : Histogram showing area versus downlink throughput

The downlink throughput distribution over the whole Dhaka city is demonstrated in Fig.7 using histogram. It may be noted that the data rate is higher than 4 Mbps for most areas and it is higher than 9 Mbps for a large amount of area. This depicts the achievement of a satisfactory data rate for the users.

A sample downlink link budget at a cell edge location, generated by Atoll, is shown in Fig.8. This demonstrates that the presumed or target link budget condition shown in Table III conforms pretty well to the simulated results.



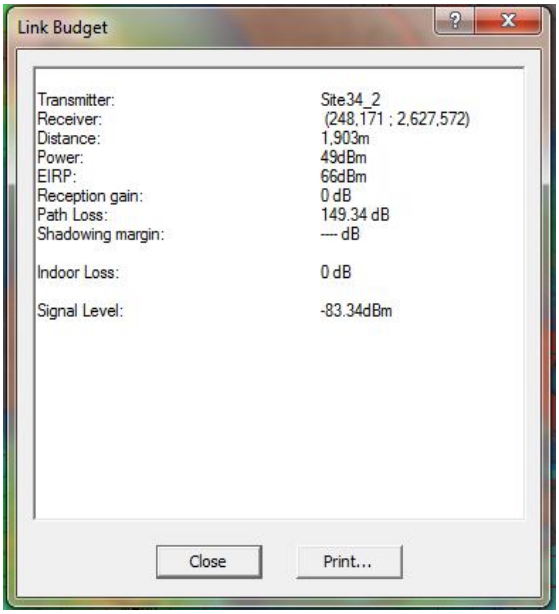


Fig. 8 : Sample link budget at a cell edge location for downlink

V. CONCLUSION

Radio network planning for new WiMAX deployment in Dhaka, Bangladesh has been performed. The simulation results show that satisfactory performance has been achieved in terms of coverage and throughput. The BS configurations presented in Section II and Fig.1 indicate radio access requirement for such a WiMAX deployment. This requirement analysis can function as a guideline for a new operator to meet the demand of the subscribers. It can help perform cost analysis and consider relevant issues at the outset. Of course, the operator can consider significant variations from the radio access infrastructure presented in this paper in order to support different number of subscribers or to bring about variations in target KPIs or configurations, but nevertheless, this analysis can help as a baseline.

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