Provision for the Deployment of a WiMAX Solution

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***Abstract:* - .Network planning determines the best placement of Base Stations (BSs) which satisfies the capacity requirements and minimizes the deployment costs. This process has to consider geographical information which varies from place to place. However, the optimization and verification stages of network planning are time-consuming. We propose a new methodology with which a provider will be able to assess the investment cost associated to the vendor's WiMAX offered solutions. Hypothetical model networks are examined with the purpose to illuminate our methodology in a given environment.**

I. INTRODUCTION

Network planning is the primary stage before any system deployment. It provides the necessary estimates for capacity and coverage with the most cost-effective set of sites. However, network planning is an on-going process during the whole lifecycle of the network for determining the best placement of the BSs and assigning the frequency channels. The number of BSs determines the installation cost. Besides, the planning process for a WiMAX system has more parameters to configure than a traditional system.

In this work, we define a novel methodology, based on the dynamic nature of the WiMAX network for the estimation of the number of sites. We compare different hypothetical vendor solutions by specifying how many BSs will be covering a given area under the same propagation parameters (propagation model, antenna height, etc), margins (building penetration, interference margin, etc) and cell throughput requirements. The main contribution of this paper is that it proposes a simple method for a WiMAX provider to compare the technical solutions offered by the vendors and demonstrates how the promised mandatory and optional features affect the cost of infrastructure. Since WiMAX demands a guaranteed Quality of Service (QoS), careful dimensioning ensures that the deployment for coverage does not sacrifice capacity and vice versa. The number of BSs and the data density required form the key elements in a mobile WiMAX network. The case study for selected regions of deployment with three WiMAX technical solutions aims to help understanding the benefits that WiMAX technology brings, its architecture and shows how to dimension the access network.

II. METHODOLOGY

At the beginning, the PHY throughput is calculated for ring boundaries, which are determined from eight MCS combinations. The inner ring corresponds to 64 QAM with code rate 5/6 mode while the outer ring to QPSK with ½ code rate. Path loss is estimated for each mode $M \in \{1,2,\cdots 8\}$.

$$PL(M) = EIRP(BS) - RXsensitivity(M) - FM \qquad (1)$$

Where the *EIRP(BS)* the effective isotropic radiated power measured at the BS. Tx beamforming gain and diversity gain for MIMO A scheme are added to the *EIRP(BS).* The *RXsensitivity(M)* consists of the receiver sensitivity for all the AMC schemes obtained from the equipment vendor's datasheet. The extra gain by macro diversity handover, subchannelization gain and receiver diversity gain are included. *FM* is the link margin which is the sum of building penetration loss, repetition coding gain, HARQ gain and interference margin. The COST-231 Hata propagation model uses an expression for the median path loss *PL(M)* as a function of carrier frequency, antenna heights and the distance between the BS and mobile. If $R_M = d$ is the ring radius that corresponds to different AMC modes ($R_9 = 0$) and is calculated from Hata propagation model we introduce

$$Q_M = \frac{\pi R_M^{\ 2} - \pi R_{M+1}^{\ 2}}{\pi(\max R_M)^2} \qquad (2)$$

This factor expresses the percentage of each ring area to cell area. The cell throughput is equal to *Throughput_cell* $(R_M) = \boldsymbol{\Sigma}$ *{Rx_throughput(M)* * Q_M *}* (3)

Rx_throughput(M) is the receiver throughput of the equipment for each MCS mode given from vendor's datasheets. An interpolation technique between calculated data points *Throughput_cell* (R_M) is applied for calculating the PHY cell throughput as a function of cell radius R_i. Our method was based on a circular grid pattern. We replace in equation (2) the circular area $\pi R_M^{\ 2}$ with the area of hexagon $3\sqrt{3}/2\, R_M^{\ 2}$ which is inscribed inside the circle radius R_M. So, we transform a circular cell into a hexagonal one. Then we estimate the number of BSs in the following way:**1**.We make an effort to fit the service area with hexagon cells, all with maximum radius R_1 (QPSK ½ mode). **2**. If the capacity requirements can be handled by that radius then the final number of BS is calculated **3**. If the capacity requirements are bigger than the calculated throughput then we reduce the radius by a small quantity ΔR and go back to step 2.

III. SIMULATION RESULTS

Simulation results are based on information from three typical and hypothetical vendors I, II and III. The system Gain for the three vendors after analytical calculations has been produced and is presented in Table I. Simulation results are presented in Table II. Table II depicts the capacity requirements (Mbps) for subscribers/business in DL and UL direction and the required area of service (square Km).We remark that the number of sites is approximately the same for vendor III and II. If 4-sector solution of vendor I is chosen, it needs 33% and 27% more sites than vendor's III solution for the 1st and 2nd year of deployment in the service area I. For service area II, it needs 19% and 20% more number of sites respectively. If a 3-sector solution of vendor I is chosen, 62% and 56% more sites than those for the vendors III solution are required for 1st and 2nd year at service area I. For service area II, the corresponding increase in the number of sites is 44% and 50%.Regarding vendor's I solution, due to the low link budget, the coverage area is smaller and the calculating throughput is substantially bigger than the throughput required. In this case, there is no need for additional Base Station to be deployed if more capacity is demanded.

IV. CONCLUSIONS

We introduced a dimensioning method that allows a straightforward estimate of the deployment cost associated with the vendor's offered solutions. Our dimensioning method reduces the necessary time and cost for the cell design and assists in the decision of WiMAX vendors for the required network infrastructure investment.

TABLE I. COMPARISON OF THREE VENDORS RADIO SOLUTION

	VENDOR I	
	Uplink	Downlink
EIRP(dBm)	34	50
Minimum receiver sensitivity(dBm)	-98	-96
System Gain (dB)	**132**	**146**
	VENDOR II	
	Uplink	Downlink
EIRP(dBm)	23	64
Minimum receiver sensitivity(dBm)	-123	-98
System Gain (dB)	**146**	**162**
	VENDOR III	
	Uplink	Downlink
EIRP(dBm)	32	56
Minimum receiver sensitivity(dBm)	-96	-94
System Gain (dB)	**128**	**150**

TABLE II. CAPACITY REQUIREMENTS & SERVICE AREA

Mbps	**Year 1**	**Year 2**
Service Area I	1470	1980
Service Area II	165	220

Sq Km	**Year 1**	**Year 2**
Service Area I	130	350
Service Area II	85	85

TABLE III. SIMULATION RESULTS

	Vendor III		
year 1	**Sites**	**Throughput (Mbps)**	**Area**
	100	1775	**I**
	16	211	**II**
year 2	**Sites**	**Throughput (Mbps)**	**Area**
	156	2454	**I**
	20	280	**II**
	Vendor I		
year 1	**Sites**	**Throughput (Mbps)**	**Area**
	133	2200	**I**
	19	237	**II**
year 2	**Sites**	**Throughput (Mbps)**	**Area**
	198	2911	**I**
	24	318	**II**
year 1	**Sites**	**Throughput (Mbps)**	**Area**
	162	2108	**I**
	23	227	**II**
year 2	**Sites**	**Throughput (Mbps)**	**Area**
	243	2786	**I**
	30	303	**II**
	Vendor II		
year 1	**Sites**	**Throughput (Mbps)**	**Area**
	104	1933	**I**
	17	199	**II**
year 2	**Sites**	**Throughput (Mbps)**	**Area**
	166	2628	**I**
	22	274	**II**