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Link budget analysis in the network designed mobile WiMAX technology in the territory of the urban area of the city of Gjakova

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Abstract

Wireless communication has now entered the second century of its use and has valuable merits of improving the quality of life of all mankind. Technologies for wireless and mobile communications are replaced every 2-3 years. The current version of the Protocol provides Internet access up to 40 Mbps and this version is expected to increase the bandwidth. The telecommunications sector leaves much to be desired in improving service quality. This paper presents the possibilities of implementation of WiMAX technology in the territory of Gjakova. Also, here are discussed some aspects of mobile network on calculating the budget link of the mobile network with WiMAX technology. Calculating the link budget, the radius of cell to a base station in urban areas is about 0.6 km. In the planning area and the frequency band of 3.5GHz, with channel width of 5 MHz TDD and spectrum 30MHz. The link margin used in this case is 133.5 dB.

Keywords: *Link, Budget link, Mobile, WiMAX, Antenna,*

1. Introduction

In wireless environments, link budget (measured in dB) and spectral efficiency are the two primary parameters used for evaluating system performance.

Here we will deal with the link budget, which will be to study the link budget parameters for network expansion in the urban environment in the planning area of Gjakova [1], and the frequency band of 3.5GHz, with channel width of 5 MHz TDD and 30MHz spectrum.

2. What is a link

A link is an interconnecting circuit between two or more locations for the purpose of transmitting and receiving data. A link equation is given by: [2]

$P_{received}$= *Power of the transmitter + Gain of the transmitting antenna + Gain of the Receiving antenna – Sum of all losses*

3. Link Budget

Link budget analysis should be performed prior to entering the network [3].We discuss the calculation of the link budget, which indicates to what extent the signal may weaken (Figure 1). Then, a propagation model is proposed to determine the range, by taking into account the link budget. Based on this range, we illustrate the calculation of the cell coverage area [2]. In a next step, we calculate the bit rate per cell sector and finally, the cell areas and bit rates are combined to estimate the required number of base stations.

Link budget analysis takes into account 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.

The link budget is analyzed using the model of the waves spread known as Hata COST 231, taking the values of the parameters of the transmission system[4].

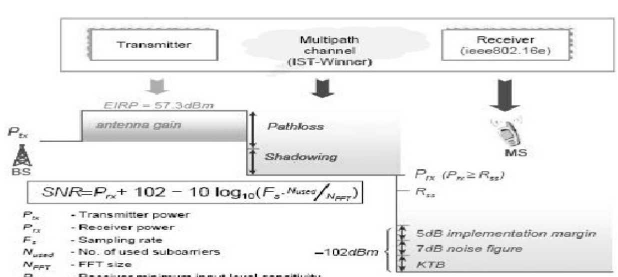


Fig. 1 Link-budget for downlink [2]

A link budget is the accounting of all of the gains and losses from the transmitter, through the medium (cable, free space, fiber, waveguide, etc.) to the receiver in a communication system (Figure 2). It accounts 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.

In this paper it is shown that the optimization of link budget parameters, such as the number of antennas, the number of sub-channels for uplink and downlink as well as the radius of cell determines the required number of base stations to cover the area of planned network expansion. This means that huge savings are made in the cost of the infrastructure of base stations, which greatly increase the total value of implementing this technology.

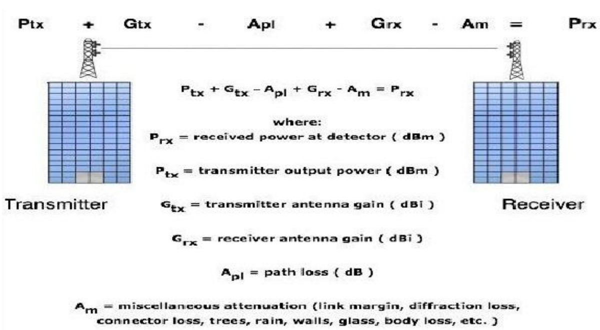


Fig. 2 Link budget illustration model [2]

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. Link budget 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 is sufficient 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 and contains two types of components. [5]:

● system-level components which include the sensitivity of the receiver, the power level and modulation efficiency. These components do not change so much when they are in different frequency bands.

● components which are not directly related to the system, which are expected to vary over different frequencies. These components include:

- *path losses*: are losses in the process of spreading of radio frequency signals in the environment and which are dependent on frequency. The smaller is the operating frequency, the smaller will be the path losses and further away can spread the signal. While, the higher is the frequency, the greater are losses and less signal can be transmitted.
With the presence of obstacles, high frequency signals cannot penetrate the barrier and require the type LOS for efficient operation.
- *The physical environment*: the presence of buildings and other structures have made a significant effect on the appearance of losses in the frequency band used. For example, high frequency signals have substantial losses under the influence of concrete surfaces and metal ones. It also increases the need to take into account of losses that cause these structures in the link budget.

- *Cable losses:* have an impact when base stations are mounted around the bar. In this case, the cable losses increase with frequency.

-*Shadow*: field and buildings, have a significant impact on the variation of signal strength, and hence additional margin required to achieve the desired coverage.

Table1, presents the link budget parameters for network expansion in the urban environment in the planning area and the frequency band of 3.5GHz, with channel width of 5 MHz TDD and spectrum 30MHz.

Table 1: Link Budget – Urban area of Gjakova [6]

Parameters	Values on Downlink and Uplink		Data
	Downlink	Uplink	
Output power of power amplifier	43.0 dB	27.0 dB	A1
Number of antennas (assuming 2x2 MIMO base station).	2	2	A2
Strengthening of the transmitted antenna	15 dBi	0 dBi	A3
Losses in transmission	3. 0dB	0 dB	A4
EIRP	57 dB	30 dB	A5 = A1 + $10\log_{10}$(A2) + A3 + A4
The width of the channel	5 MHz	5 MHz	A6
Number of sub-channels	15	17	A7
Receiver noise level	-107 dBm	-107 dBm	A8 = -174 +10 $\log_{10}$(A6x1e6)
The receiver noise factor	8 dB	4 dB	A9
SNR	0.8 dB	1.8 dB	A10
Strengthening of sub-channels.	11.7 dB	12.3 dB	A11 = $10\log_{10}$(A7)
Speed for sub-channel (kbps)	151.2	34.6	A12
The sensitivity of the receiver (dBm).	-86.5	-88.9	A13 = A8 + A9 + A10 + A11
Strengthening receiving antenna	0 dBi	15 dBi	A14
Strengthening the system	143.5 dB	133.9 dB	A15 = A5 - A13 + A14
Shadow-fade margin	10 dB	10 dB	A16
Building penetration losses	0 dB	0 dB	A17
Link margin	133.5 dB	123.9 dB	A18 = A15 – A16 – A17
Cell radius	0.6 km		Taking into account the pattern of waves spread known as Hata Cost 231.

Number of sub-channels (15 and 17) is based on the initial profile of WiMAX with channel width of 5 MHz, which is defined to have 15 channels to 17 channels for downlink and uplink. Radius of coverage shown in Table 1 is determined based on the model of the spread of waves Hata COST-231 [6]. Link margin used is 133.5 dB.

Although the model Hata COST-231 model, applied to mobile applications in 1900MHz band, also it is admitted to be used for generation 2.5 GHz and 3.5 GHz. [6].
Coverage area, which is given in Table 2, is determined by taking the height of the base station, which is 30 m and height of the mobile station is 1m.

Table 2: Geographic factors affecting the mobile network

Elements	Data
City	Gjakova
Market segmentation	Residential/urban
Size	4.91 km2
Population	105.000 inhabitants
Density of population	196 per km2

4. Base Stations

Base station executes the allocation of resources based on QoS requirements and parameters for the connection. Figure 26 will illustrate one of SB's WiMax, which is connected to Femto cells and SBS for Internet connections [6]. Each Femto cell is covered by a SB. WiMAX technology is used between the SB and SB WiMAX Femto cell. Within Femto cell can be used any other technology. Base stations can vary by a single independent channel in the base station. In our case we used cells in a three-sector base station, because they are more preferred for more precise coverage, the expansion of mobile network with WiMax technology. A cell coverage area of a base station with three sectors defined by the following formula. [7]:

$$A_{cell} = 1.95 R^2 \qquad (2)$$

A_{cell} - Coverage area of a base station
R- radius of the cell's base station

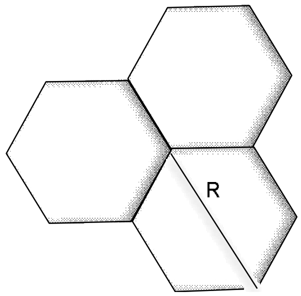


Fig. 3 Base station with three sectors [6]

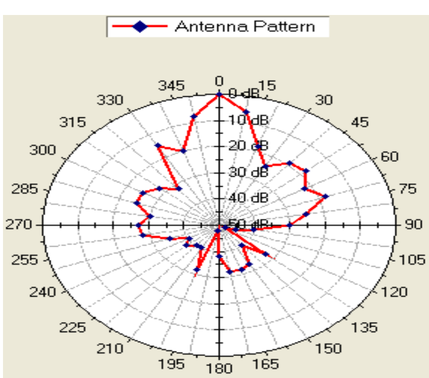
In order to determine the number of base stations, K, which are necessary to cover the area planned to extend a network, it is used the following formula [6]:

$$K = A/A_{cell} \qquad (3)$$

Using the equation 2 and 3 given above, it appears that the coverage of the planned network expansion needed for base stations is seven (7). In the territory of Gjakova is scheduled Network mobile with WiMAX technology based on IEEE 802.16e standard, which uses standard OFDM WiMAX TDD technology, channel width of 5 MHz, with respective values of input parameters: number of base stations and the range of cells[8]. The link budget is analyzed using the model of the spread of waves known as Hata COST 231, taking into account the of transmission system [4].

Base stations are simulated with isotropic radiant power (EIRP = 57 DBM), and sectors are displaced from each other to 120 º. Given the above parameters, it appears that the radius of cell to a base station in urban areas is about 0.6 km. Diagram of radiation of antennas used in this case is given in Figure 4, where these antennas have amplification of 15 dB.

Based on the results of the analysis, network dimensioning for coverage showed that the 4.91 km2 of the urban part of Gjakova are needed 7 base stations with three sectors in each of them.



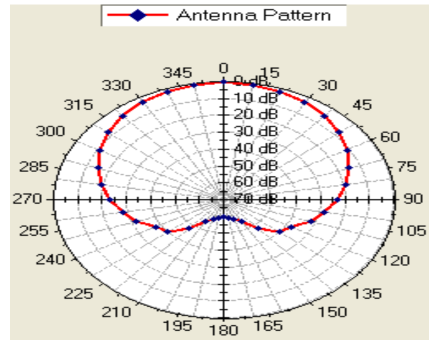


Fig. 4 Antenna Model

5 Conclusion

By planning this comes to mobile networks for a full coverage of the urban part of city are needed 7 (seven) base stations. This network is being planned in complete cohesion with the guidelines of the Kosovo Telecommunications Regulatory Authority in our country for the city's urban planning is done in the 3.5 GHz frequency band with a width of 5 MHz channel and using 6 frequency channels. From the calculation made above it appears that the radius of cell to a base station in urban areas is about 0.6 km. Link budget parameters for network expansion in the urban environment in the planning area and the frequency band of 3.5GHz, with channel width of 5 MHz TDD and spectrum 30MHz. What makes this calculation important and makes this paper important too is the results that came from the budget link, which is 133.5 dB.

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