DESIGN, IMPLEMENTATION AND ANALYSIS OF A WIRELESS NETWORK COVERAGE USING A NANOSTATION

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ABSTRACT

Wireless networks are a popular technology offering great flexibility over traditional wired technology. This flexibility extends from increased convenience to customers and reduced construction costs to facilitating network installation. Wireless networks are also used to provide network access in places where there is no traditional network infrastructure. The radio devices providing the radio coverage of the network operate at a frequency of 2.4 or 5 GHz. At this high frequency, a high data rate is achieved, but there is also an important limitation - there must be direct visibility between the devices that communicate. The main objective of the report is the design, experimental study and analysis of IEEE 802.11b/g radio coverage in the 2.4GHz frequency band for a part of the territory of Gabrovo, realized using a nanostation.

Keywords: IEEE 802.11, wireless network coverage, nanostation, signal strength.

1. INTRODUCTION

The use of wireless Internet sharing technology has long been a novelty, but activity in this area is very large and constantly has innovations and improvements [1, 4, 5]. Wireless data transmission standards enable the introduction of many affordable wireless solutions, which has rapidly increased their popularity in many areas such as health, commerce, industry and education.

In these areas are used mobile terminals and computers to enable wireless real-time data transmission. The wireless communication technology (Wi-Fi), specified in the IEEE 802.11 family of standards, is designed to build Ethernet-compliant local wireless networks [8, 9]. Its main advantage is the ability to easily and economically implement small-scale, flexible network configurations that are able to complement traditional cable access networks.

Network topologies in wireless networks define how to build a particular network, as well as the operating modes of the communication equipment.

Depending on the type of the equipment, wireless equipment is divided into two main types - a client whose role is typically taken over by a computer with a wireless network interface board installed and an access point (AP). The design, implementation and analysis of radio coverage are based on specialized software products, different models for predicting the propagation of radio waves, traffic analyzes, assessment of the transfer medium, assessment of the specifics of the site, etc. [2, 3, 6, 7].

2. DESCRIPTION OF THE PROJECT

Planning of the experimental wireless coverage according to the IEEE 802.11b/g standard is realized on the territory of the town of Gabrovo and in particular for "Petkova niva" district.

The basic requirements for radio coverage are as follows:

- in the coverage area of the transmitting antenna (nanostation) the signal is strong, and when it is away from it, it does not dampen quickly or suddenly (depending on the relief)
- in the peripheral points of the coverage area, the signal does not attenuate to the level of impossible communication between the two devices.

In Figure-1 on the satellite map of the territory of the town of Gabrovo the radio coverage area is shown according to a conceptual design.

The Access Point (AP) is planned to be located in a Lab. 1403 on the 4-th floor of the Campus № 1 of the Technical University of Gabrovo (Camp. №1, TU-Gabrovo). The altitude at this point is 538 m. The main part of the area of "Petkova niva" district is situated at a height of 519 m opposite the location of Camp. №1, which implies very good direct visibility (i.e. line of sight) to the access point.

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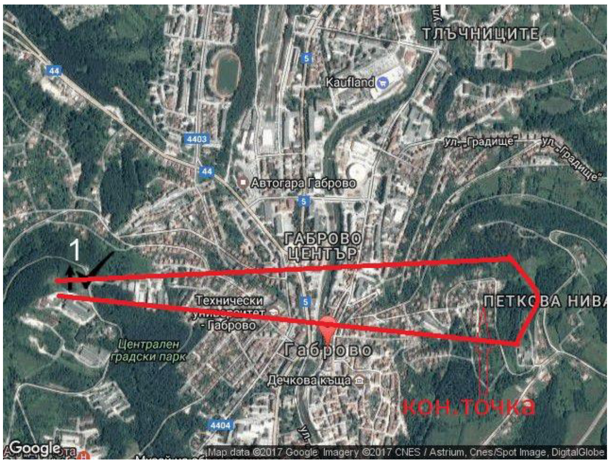

Figure-1. Conceptual design of the radio coverage area (Camp. №1 „Integral“ - "Petkova niva" District)

2.1 Radio coverage implementation

In Figure-2 is shown a cross-section of the relief between the location of the AP in Camp. №1 and the highest point of coverage area. It shows that there are no natural obstacles in the field of line of sight and that the first Fresnel zone is clean, which is an important condition for establishing radio communication. The cross section of the relief is displayed using the web-based product airLink Outdoor Wireless Link Calculator [10].

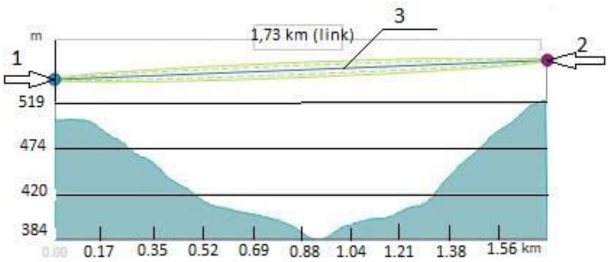

Figure-2. Cross section of the relief between the AP in the Camp. №1 and the central coverage area (1 - AP location, 2 - the highest point of the radio coverage area, 3 - first Fresnel zone)

The scheme of the experimental set-up, on which the radio coverage was implemented and the experimental studies was carried out, is shown in Figure-3.

The scheme of the experimental set-up includes the following elements:

a) Router for Internet access (ISP – Internet Service Provider);
b) POE an injector for nanostation power supply;
c) Nanostation Ubiquiti Nano Station M2;
d) Nanostation hookup and guiding stand;
e) NB - mobile terminals 1 and 2.

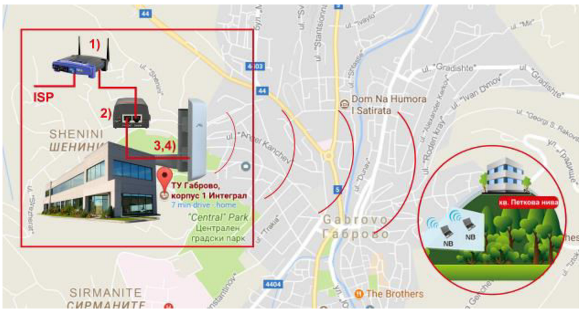

Figure-3. Scheme of the experimental setting

The built-in access point in Lab. 1403 of Camp. №1 is shown in Figure-4.

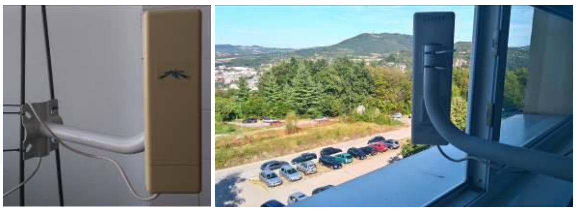

Figure-4. Overview of the built-in access point in Camp. №1

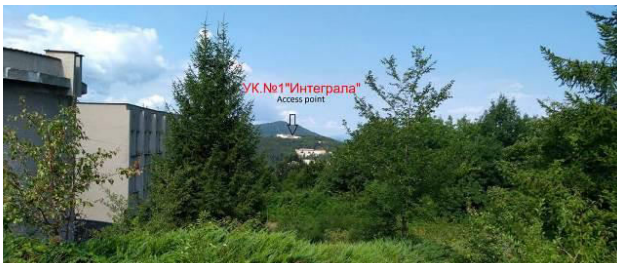

Figure-5. Zone of direct line of sight towards Camp. №1

In Figure-5 is shown the location of Camp. № 1 from the area of coverage and in particular from the National Observatory and Planetarium - Gabrovo.

2.2 Radio coverage study and analysis

In the analysis of the parameters of the realized radio coverage are defined 4 directions and 15 control points (CPs), also shown in Figure-6. These directions correspond to the central area of the radio coverage (Directions 1 and 2) and the two end zones of the area (Directions 3 and 4)

The beginning of these directions is in CP-0 (Camp. №1 of TU-Gabrovo).

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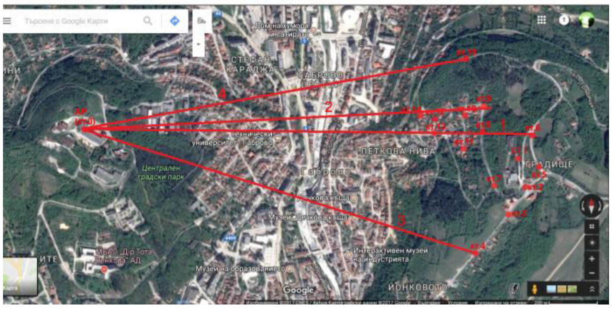

Figure-6. Control points and directions for radio coverage study and analysis.

The power level of the radio signals is measured and tested for the reliability and stability of the radio link, the frequency distribution of the radio signals and the impact of other wireless networks available.

For the control points so defined, using selected test devices with software products installed on them Acrylic Wi-Fi Home and Network Analyzer [11] have been made the measurements of the power level of the radio signal. The measurement results are summarized in a Table-1.

Table-1. Experimentally measured levels of radio signals at selected control points.

CP №	Measured level, dBm		Distance, km
	Mobile terminal 1 (laptop Asus x55v)	Mobile terminal 2 (smartphone Lenovo P2)	
0	-30	-30	0
1	-84	-82	1,73
2	-79	-74	-
3	-86	-84	-
4	-85	-85	1,63
5	-80	-75	-
6	-82	-78	1,77
7	-85	-83	-
8	-77	-79	1,58
9	-81	-80	1,58
10	-78	75	-
11	-76	-75	-
12	-76	-77	1,47
13	-82	-78	1,41
14	-80	-79	1,35
15	-84	-74	1,54

Note: The indicated distances are from CT-0 to the relevant CT by air and are reported only in Directions 1, 2, 3 and 4.

Using the information for the measured signal levels in Table-1, there are presented graphs of variation of the signal levels depending on the relief according to data from the control points for Names 1, 2, 3 and 4. In the analysis of the obtained results are also calculated the values of Free Space Path Loss (FSPL), which are derived with the following analytical dependence:

$$FSPL_{dB} = 20\lg(d) + 20\lg(f) + 32{,}44 \qquad (1)$$

where d is the distance from the access point in km and *f* is the operating frequency in MHz (i.e. 2400 MHz).

Determination of the theoretical free space path losses for analysis purposes is based on the output signal level in CP-0 (i.e., immediately up to the access point) equal –30 dBm

As can be seen from Figure-7 to Figure-10, the actual signal attenuation is greater than the theoretical attenuation in the free space but the results are comparatively close in value due to the presence of direct line of sight between the access point and the control points.

The measured higher signal attenuation is due, on the one hand, to the influence of the relief of the covered area, regardless of direct line of sight, and on the other hand depends on the sensitivity and size of the antennas of the mobile terminals used for measurement.

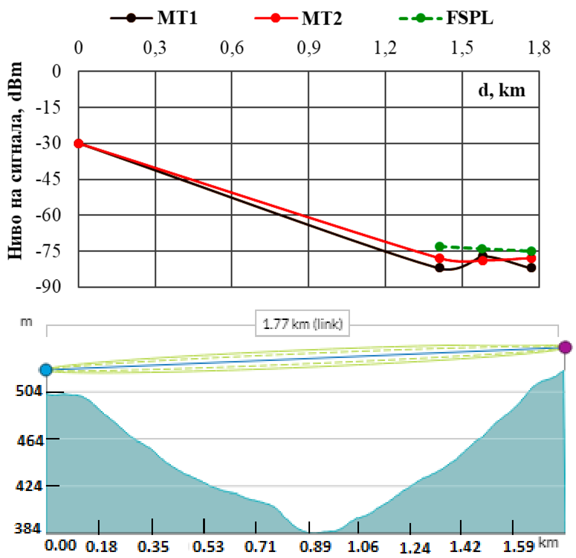

Figure-7. Level of the radio signal in Direction 1

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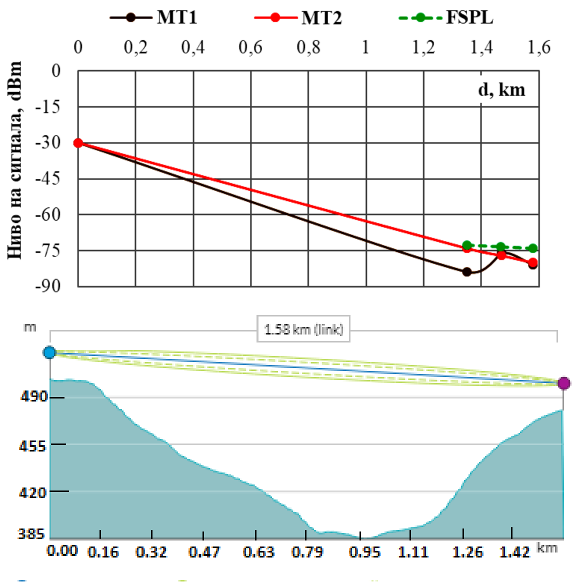

Figure-8. Level of the radio signal in Direction 2

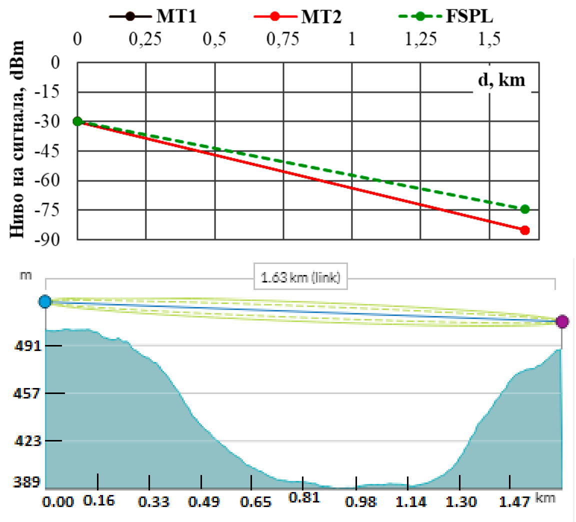

Figure-9. Level of the radio signal in Direction 3.

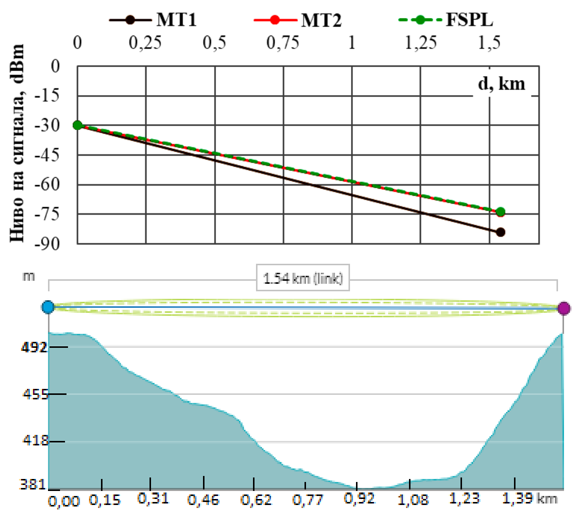

Figure-10. Level of the radio signal in Direction 4.

A direct comparison in reception quality between the two mobile terminals makes it difficult to account for the small number of control points on a given direction (depending on the size of the coverage area itself), as well as the constructive differences and the way of using the terminals (i.e. their mobility in the way of hookup and guiding or handling). Nevertheless, the results differ with a value of up to a maximum of 5dBm (for CP-2 and CP-5).

3. CONCLUSIONS

The presented experimental results show that using the Ubiquiti Nano Station M2 nanostation, it is easy to realize quality radio coverage, but only when we have excellent direct line of sight.

An important problem is access to the created wireless network indoors as signal attenuation increases significantly. This necessitates the use of additional antenna equipment to provide connectivity in individual residential buildings. For this purpose, a mast and the same nano-station model can be suggested as a good option for locally receiving, amplifying and providing stable signal parameters and reliability (i.e. realizing a point-to-point connection between the access point and the corresponding receiving antenna).

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