Methods of Determining the Influence of Physical Obstructions on the Parameters of The Signal of Wireless Networks

Andriy Dudnik[a,d], Biljana Presnall[b], Maksym Tyshchenko[c] and Oleksander Trush[a]

[a] *Taras Shevchenko National University of Kyiv, 60 Volodymyrska Street, Kyiv, 01601, Ukraine*
[b] *Jefferson Institute, 160 N Carolina Ave SE, Washington DC, 20003, United States of America*
[c] *The National Defence University of Ukraine named after Ivan Cherniakhovskyi, 28 Povitroflotskyi Ave, Kyiv, 03049, Ukraine*
[d] *Interregional Academy of Personnel Management, 2 Frometivska str, Kyiv, 01601, Ukraine*

Abstract

Object of research: signal in wireless networks. Objective: to study the behaviour of electromagnetic waves in a wireless network in the event of a collision with a physical obstacle. Research methods: system approach, comparison methods, index method, structural analysis, correlation-regression analysis. The behaviour of electromagnetic waves and physical obstacles is analysed in the paper. Problem solving options at the user level are suggested. A local wireless network has been created as a mean of studying the signal level. The practical significance of the research is to study and analyse local networks and physical obstacles in the signal path in order to use these results in wireless networks designing. The results of these studies can be used to improve radio communication. Application scope – modern telecommunication systems of Ukraine.

Keywords1

wireless network, local network, electromagnetic waves, Wi-Fi, Bluetooth, router, access point, signal, diffraction, scattering, Cisco Packet Tracer, Wi-Fi Scanner v.21.03, mechanical interference.

1. Introduction

It is necessary to list the general logic of propagation of electromagnetic waves. The higher the frequency, the more the obstacles affect a signal. Low-frequency radio waves from the AM bands easily penetrate into a house, which allows you to use only one indoor antenna. A higher frequency television signal usually requires an external antenna. Infrared and visible light do not pass through the walls, limiting transmission to the line of sight (LOS). The higher the frequency, the faster the signal energy decreases with increasing distance to the source. When electromagnetic waves propagate in a free space (without reflections), the attenuation of the signal power is proportional to the square of the distance from the signal source and the square of the signal frequency. Low frequencies (up to 2 MHz) propagate on the Earth's surface. Therefore, AM radio signals can be transmitted over a distance of hundreds of kilometres.

Signals with a frequency of 2 to 30 MHz are reflected by the Earth's ionosphere, so they can propagate to even greater distances - several thousand kilometres (with sufficient transmission power). Signals in the range above 30 MHz propagate only in a straight line, i.e. they are signals of direct visibility. At frequencies above 4 GHz, there are problems: signals begin to be absorbed by water, which means that not only rain but also fog can cause a sharp deterioration in the transmission quality of microwave systems. To successfully use the microwave range, it is also necessary to take into account additional problems associated with the behaviour of signals that propagate within line of sight and encounter obstacles in their path [1-3].

When the signal encounters an obstacle that is partially transparent to a given wavelength and at the same time the size of which is much larger than the wavelength, part of the signal energy is reflected from such an obstacle. The waves of the microwave range are several centimetres long, so they are partially reflected from the walls of houses when the signals are transmitted in a city. If the signal encounters an obstacle (for example, a metal plate) much larger than the wavelength, then there is diffraction - the signal seems to bypass the obstacle, so such a signal can be received without even being in the line of sight. Finally, when encountering an obstacle whose dimensions are commensurate with the wavelength, the signal is scattered, propagating at

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EMAIL: a.s.dudnik@gmail.com (A. 1); bpresnall@jeffersoninst.org (A. 2); tishenkom1@gmail.com (A. 3); Trush.viti@gmail.com (A. 4);
ORCID: 0000-0003-1339-7820 (A. 1); Scopus ID: 57224233338 (A. 2); 0000-0003-1266-4106 (A. 3); 0000-0002-4188-2850 (A. 4)

different angles [1,5-7]. There is also another model - a model of absorption of electromagnetic waves. The signal from the access point passes through walls in other rooms or on other floors and each wall or floor 'takes in' some amount of signals efficiency.

The problem of high levels of wireless obstruction is solved in different ways. An important role is played by special coding methods that distribute signal energy over a wide range of frequencies. In addition, signal transmitters (and receivers, if possible) are to be preferably placed on high towers to avoid multiple reflections. Another technique is the use of protocols with connection establishment and retransmission of frames already at the channel level of the protocol stack. These protocols allow correcting errors faster because they work with lower timeout values than transport-level corrective protocols such as TCP.

2. Analysis of literature and problem statement

Reflection of electromagnetic waves. Not only the power of the transmitting station and the sensitivity of the receiver, but also the location of the antennas significantly affect a reliable connection between the transmitting and receiving antennas. This principle became the basis for both cellular communication [8-9, 10] and the development of wireless computer networks [6, 11]. When analysing the number of transmitting antennas that provide high-quality and reliable communication, as well as the geometry of their location, experts use the concept of coverage quality. When the network is indoors and in a small area, the geometric patterns of the reflection of a signal from an obstacle are important. These models comply with the IEEE 802.11 wireless network standard [10, 12-14]. The physical essence of such models is that the radio signal does not pass through the obstacle between the transmitter and receiver due to the high attenuation factor, but with the correct geometric location of the transmitting and receiving antennas in relation to the obstacle, you can get a strong reflected signal. It is necessary to take into account the geometric law of reflection, according to which the angle of incidence is always equal to the angle of reflection [11, 15-17]. Such models of radio wave propagation in the literature are called radial or geometric optical models [6, 19-21].

Diffraction of electromagnetic waves. When providing long-distance radio communication in the design of wireless computers in accordance with the WiMAX standard, it is necessary to take into account the impact on the propagation of electromagnetic waves from the Earth's surface, its topography and the atmospheric conditions. It is known from the theory of wave processes that the phenomenon of diffraction has a significant effect on the propagation of waves in space, the essence of which is to avoid a wave of obstructions if the size of an obstacle is close to the wavelength [11, 22-24]. Because both UHF and centimetre waves are used in wireless networks, small diffraction interference effects must be taken into account in beam models when analysing wave propagation in buildings and small areas.

Scattering of electromagnetic waves. When elastically bound charged particles are exposed to electromagnetic waves, they move in an electric field. If the frequency of the wave is equal to the natural frequency of oscillations of the particles, there is a resonance, accompanied by significant absorption. Scattering occurs at frequencies that do not correspond to the natural frequencies of the particles. Emerging oscillations are called forced oscillations. Usually this oscillation will have the same frequency and direction as the electric field strength of the incident wave. However, its amplitude will be much smaller than in the case of resonance. In addition, the phase of forced oscillations differs from the phase of the incident wave, because the speed of photons decreases when penetrating a denser medium above [16, 25-28].

Absorption of electromagnetic waves. Due to the absorption, the intensity of the incident electromagnetic wave decreases as it passes through the medium. The absorption of the medium is defined as the ratio between the absorbed and the intensity of the falling substance. Absorption is the result of the partial conversion of light energy into thermal motion or oscillations of absorbing molecules. A completely transparent medium does not absorb light, i.e. the total energy of light coming in and out of the specified medium is the same. Among biological tissues, the cornea and lens of the eye can be considered almost transparent to visible light. The terms 'transparent' and 'opaque' are relative, as they certainly depend on the wavelength. For example, the cornea and lens consist mainly of water, which strongly absorbs in the infrared region of the spectrum. Therefore, in this region of the spectrum, these tissues appear opaque [17, 29-31].

3. The purpose and objectives of the study of the influence of physical obstructions on the signal

The purpose of this article is to solve the problem of determining the characteristics and reducing the impact of physical obstructions on the operation of wireless networks. The following tasks were set:

Determination of the relevance of problems associated with physical obstructions. Analysis of the types of physical obstacles and the phenomena they cause, as well as a description of their models. Study of particular physical obstacles with Wi-Fi Scanner v.21.03.

Discussion of possible options to address the consequences of phenomena that physical obstructions may cause. The results can be useful for professionals in the field of wireless communication.

4. Models and methods of research of influence of physical obstructions by means of wireless networks

Synthesis of the model of reflection of electromagnetic waves. Geometric optical models are mainly used to design IEEE 802.11 wireless networks within buildings according to their architecture. It is necessary to distinguish between single-wall and multi-wall models of beam reflection. A simple single-wall reflection model is shown in Fig. 1 [6].

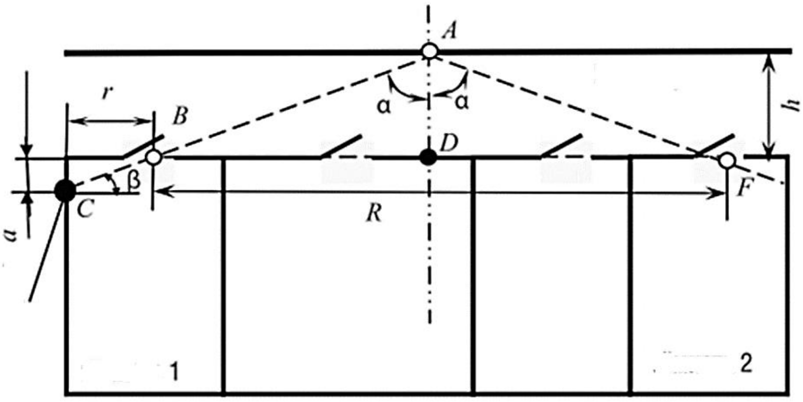

Figure 1: One-dimensional geometric reflection model for a section of wireless networks

The essence of the geometric model of reflection (Figure 1) is that it is necessary to provide wireless communication in rooms 1 and 2, and this can be done by reflecting the radio wave from the corridor wall. Assuming that the wireless access point is in room 1, knowing the distance between the doors of rooms *R* and the width of the corridor *h*, from the constructed isosceles triangle BAF you can easily find the location of access point *C* relative to the left corner of room 1 and the antenna angle β [6]:

$$a = \frac{2hr}{R} \tag{1}$$

$$\beta = \frac{\pi}{2} - arctg(\frac{R}{2h}) \tag{2}$$

In fig. 2 the dependences of the location of the access point *a* (Fig. 2, a) and the angle of the antenna β (Fig. 2, b) on the geometry of the floor of the building is given.

The obtained graphical dependencies can be directly used by designers of wireless networks in optimizing the location of access points in buildings.

Synthesis of electromagnetic wave diffraction model. Diffraction in the propagation of waves on the surface of the globe is not inherent in UHF and microwave frequencies, so radio communication in this frequency range can be carried out only within line of sight. In other words, the curvature of the Earth's surface limits the possible distance between the transmitting and receiving antennas of high-frequency radio signals.

It is possible to calculate the critical distance between the transmitting and receiving antennas *L*, which limits the zone of direct visibility, including the zone of penumbra, into which the waves penetrate due to interference, with a simple empirical equation [12]:

$$L[\text{км}] \cong 4{,}12\left(\sqrt{h_a[\text{м}]} + \sqrt{h_2[\text{м}]}\right) \tag{3}$$

where h_a, h_2 are the heights of the transmitting and receiving antennas.

Because of the obstacles in the area of propagation of electromagnetic waves, ensuring direct visibility is not a sufficient condition for stable signal reception; it is also necessary to take into account the first Fresnel diffraction zone [13]. According to Fresnel's law, the diffraction of a wave is insignificant if the first Fresnel zone through which the radio wave propagates is free of obstacles [14]. Any shielding of the first Fresnel zone will significantly impair the performance of the wireless network. The geometric illustration of the propagation of electromagnetic waves taking into account the Fresnel diffraction is shown in Fig. 3. The radius of the first Fresnel zone is calculated by the formula [15]:

$$H_0 = \sqrt{\frac{d_1 d_2 \lambda_0}{d_1 + d_2}} \quad (4)$$

where the geometric parameters d_1 and d_2 characterize the position of the obstacle, λ0 is the wavelength.

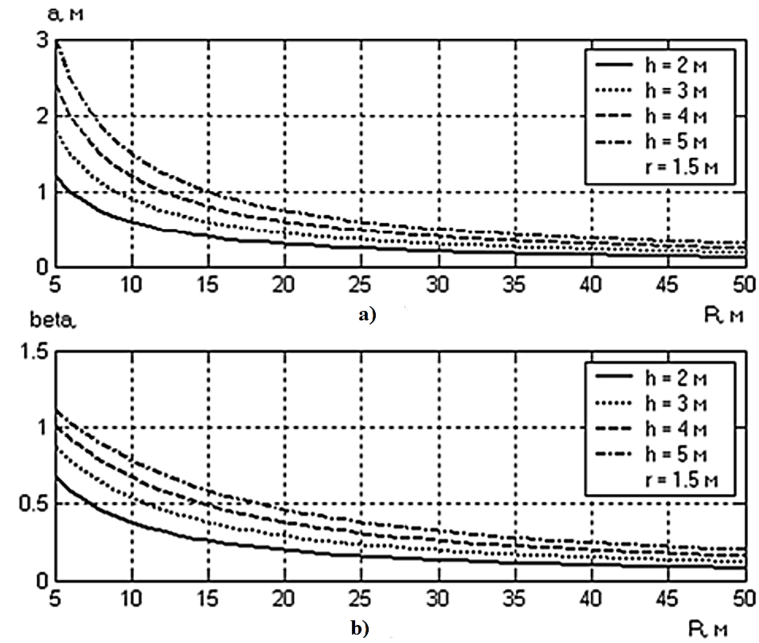

Figure 2: One-dimensional geometric reflection model for a section of wireless networks

If the value of the radius of the first Fresnel zone H_0 is known, the minimum heights of the transmitting and receiving antennas are easy to be calculated according to the formula:

$$h_a \geq h_n + H_0 \quad (5)$$

where h_a is the height of the antenna, h_n is the height of the obstacle.

In the theory of electromagnetic wave propagation, two more important types of diffraction are considered: diffraction on a wedge-shaped obstacle and on a spherical obstacle. Signal power losses with diffraction at a wedge-shaped obstacle are determined with the geometric parameter ν and are calculated as follows:

$$\nu = h * \sqrt{\frac{d_1 + d_2}{0{,}5\lambda d_1 d_2}} \quad (6)$$

where h, d_1, d_2 are the geometric parameters of the transceiver system.

From the given data it is possible to draw a conclusion that a significant attenuation of a signal is observed at a condition:

$$\lambda_0 \ll h \quad (7)$$

This case corresponds to the waves of the meter and decimetre ranges, which are used for wireless communication in computer networks. Thus, for the values of λ0=5.36 cm and λ0=12.5 cm used in Wi-Fi and WiMAX networks, the signal attenuation parameters are very significant and almost coincide. On the contrary, for the wavelength of the decametre range λ0=10 m the attenuation at diffraction at the obstacle is much smaller. Another important mathematical model of radio wave diffraction, which is widely used in practice, is diffraction on spheres [9]. First, determine the direct visibility of a sphere with a radius close to the heights of the transmitting and receiving antennas. Here you cannot use a simplified equation, it is necessary to take into account the complete geometry of the system and analyse the equation of visibility in the sphere as a whole [9]:

$$L = \sqrt{(R + h_1)^2 + R^2} + \sqrt{(R + h_2)^2 - R^2} \quad (8)$$

where R is the radius of the sphere, h_1 and h_2 are the heights of the antennas, L is the range of direct visibility. The results for the height of the transmitting antenna h_1=100 m and for different h_2 and R parameters are shown in Fig. 4.

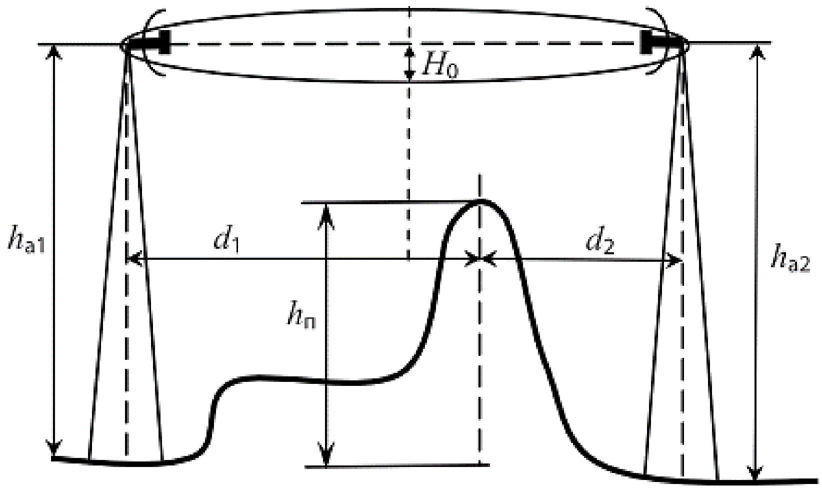

Figure 3: Geometric interpretation of the first Fresnel diffraction zone with an obstacle in the path of radio wave propagation

From the above results we may infer that with the increase of the radius of the sphere the range of direct visibility between the transmitting and receiving antennas significantly increases.

Synthesis of electromagnetic wave scattering model. In Fig. 5 a simple Rayleigh scattering geometry is shown.

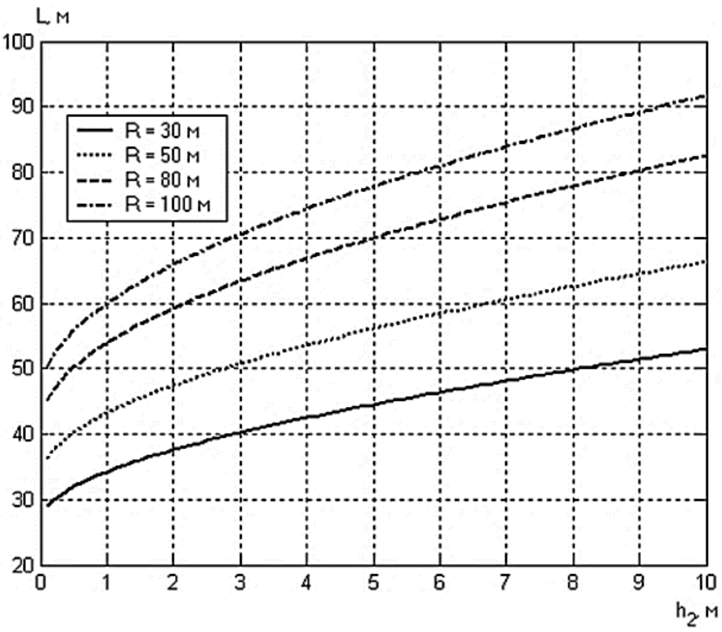

Figure 4: Calculations of the line of sight for a sphere whose size is close to the heights of the transmitting and receiving antennas

A plane electromagnetic wave falls on a thin scattering medium with a thickness of L. In an individual case, the electric field of the incident wave can be put down as:

$$E(z) = E_0 \exp(ikz), \tag{9}$$

where i is the amplitude of the incident electric field, k is the magnitude of the wave vector, and z denotes the optical axis. Intensity losses due to scattering are described by the equation (9):

$$I(z) = I_0 \exp(-\mu_S z), \tag{10}$$

where μ_S is the scattering coefficient. Differentiation (10) by z gives:

$$dI = -\mu_S I dz, \tag{11}$$

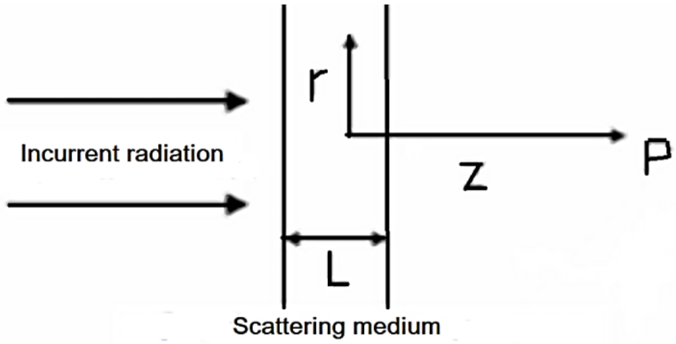

Figure 5: Rayleigh scattering geometry

The intensity scattered by a thin layer of a substance with a thickness resulting from (11) and is proportional to μ_S and L:

$$I \sim \mu_S. \tag{12}$$

We introduce the parameter - the density of scattering centres per unit of area. Thus the intensity scattered by one of these centres can be put down as follows:

$$I_S \sim \frac{\mu_S L}{NL} = \frac{\mu_S}{N}, \tag{13}$$

Thus, the amplitude of the corresponding electric field:

$$E_1 \sim \sqrt{\frac{\mu_S}{N}}, \tag{14}$$

due to the interference of all scattered waves, the total scattered amplitude can be put down as follows:

$$E_S \sim NL\sqrt{\frac{\mu_S}{N}} = L\sqrt{\mu_S N}, \tag{15}$$

The complex amplitude at a distance *z* on the optical axis consists of adding the amplitudes of all scattered spherical waves and the amplitude of the incident plane wave, i.e.:

$$E(z) = E_0(e^{ikz} + L\sqrt{\mu_S N}\int_Z^\infty \frac{e^{ikR}}{R} 2\pi r dr) \tag{16}$$

where $R^2 = z^2 + r^2$. For this *z* we obtain:$rdr = RdR$, and then equation (16) will take the form:

$$E(z) = E_0\left(e^{ikz} + L\sqrt{\mu_S N} 2\pi \int_z^\infty e^{ikr} dR\right), \tag{17}$$

Since the wave has a finite length, scattering can be neglected. Then equation (17) takes the form:

$$E(z) = E_0\left(e^{ikz} = L\sqrt{\mu_S N}\frac{2\pi}{ik} e^{ikz}\right), \tag{18}$$

and if we consider that the wavelength $\lambda = 2\pi/k$, then

$$E(z) = E_0 e^{ikz}\left(1 + i\lambda L\sqrt{\mu_S N}\right). \tag{19}$$

According to the assumption, the scattering contribution - i.e. the second term in parentheses in equation (19) - is small compared to the initial wave (first term). Thus, they can be considered as the first two members of the decomposition into a series of the equation

$$E(z) = E_0\left(i\left(kz + \lambda L\sqrt{\mu_S N}\right)\right). \tag{20}$$

Thus, the phase of the incident wave changes by $\lambda L\sqrt{\mu_S N}$ due to scattering. The value of the phase delay:

$$\Delta\varphi = \frac{2\pi}{\lambda}(n - 1)L, \tag{21}$$

which occurs when light enters from free space into a medium with a refractive index n. Thus

$$\lambda L\sqrt{\mu_S N} = \frac{2\pi}{\lambda}(n-1)L, \rightarrow n-1 = \frac{\lambda^2}{2\pi}\sqrt{\mu_S N} \quad (22)$$

From (13) and (22) we finally obtain the Rayleigh scattering law, neglecting the dependence of the refractive index on the wavelength [3]

$$I \sim \frac{1}{\lambda^4} \quad (23)$$

If we take into account the scattering angle θ, we obtain a more accurate formula:

$$I_S(\theta) \sim \frac{1+cos^2(\theta)}{\lambda^4}, \quad (24)$$

where $\theta = 0$ denotes forward scattering. Within the visible range, scattering always significantly reduces when comparing green and red light.

The spatial size of the scattering particles was also not taken into consideration. If this size becomes of the same magnitude as the wavelength of the incident radiation, as in the case of blood cells, Rayleigh's law cannot be applied and another type of scattering occurs, called Mie scattering (2). However, it is necessary to note two important differences between Mie scattering and Rayleigh scattering. Mie scattering shows a weaker dependence on the wavelength $\sim\lambda^x, 0.4 \leq x \leq 0.5$ compared to Rayleigh scattering.

Synthesis of the model of absorption of electromagnetic waves. The ability of a substance to absorb electromagnetic radiation depends on certain factors, mainly on the electronic composition of its atoms and molecules, the length of the radiation wave, the thickness of the absorbing layer and internal parameters such as temperature or concentration of the absorption centres. [17].

The two laws are most often used to describe the effect of thickness or concentration on absorption, respectively. They are usually called Lambert's Law and Beer's Law, and they are put down as follows:

$$I(z) = I_o \exp(-\mu_a z), \quad (25)$$

and

$$II(z) = I_o \exp(-k'cz), \quad (26)$$

where *z* denotes the optical axis, (z) is the intensity at a *z* distance, I_0 is the incident intensity, μ_a is the absorption coefficient of the medium, *c* is the concentration of the absorption centres, *k′* depends on other internal parameters. From equation (25) we obtain:

$$z = \frac{1}{\mu_a} ln \frac{I_0}{I(z)}, \quad (27)$$

The inverse of the absorption coefficient is called the absorption length and is determined by the formula:

$$zLa = \frac{1}{\mu_a}, \quad (28)$$

The absorption length shows the distance at which the intensity *l(z)* decreases *e* times from its initial value l_0.

5. The results of the study of the influence of physical obstruction on signal quality in wireless sensor networks.

Designing a local network for further research. Cisco Packet Tracer computer network emulator from Cisco Systems was used for the network design. All devices were connected together, a smartphone was connected to a radio tower, a laptop and smart appliances were connected to the home access point, and all external devices were connected using a coaxial cable and a fibre optic cable. Figure 6 shows all device connections [27-30].

Measurement of signal parameters of the designed local network. The next step in wireless network research is to measure signal parameters with possible obstacles. Obstacles in this case will be such physical structures as walls and doors in the room.

Wi-Fi Scanner v.21.03 is used to measure signals. The application is used to analyse and study any IEEE 802.11 network. The application allows getting the required number of parameter graphs that are needed to study the Wi-Fi network.

To study the real network, the model of which is shown in Fig. 6, two charts will be used - of signal power and signal quality.

In order to measure the signal of this network, a laptop with a Wi-Fi module is used, and it is simply relocated to various available places on the local network. The first step is to measure the laptop signal quality near the transmitter (Fig. 7).

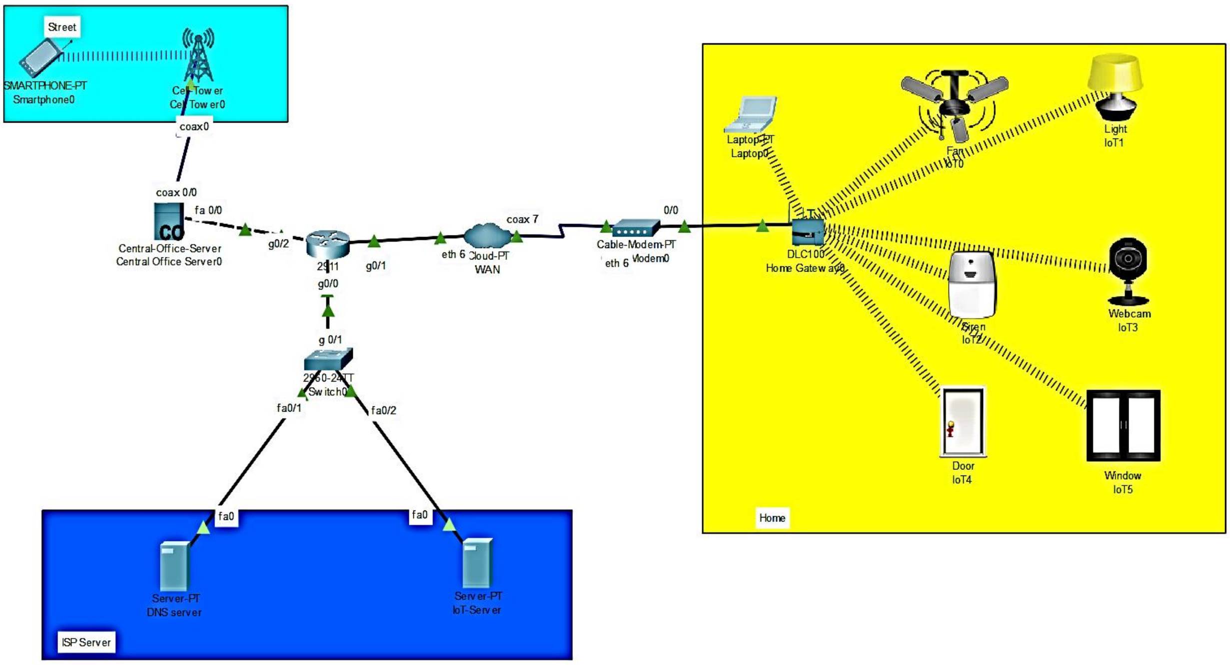

Figure 6: Distributed wireless sensor network

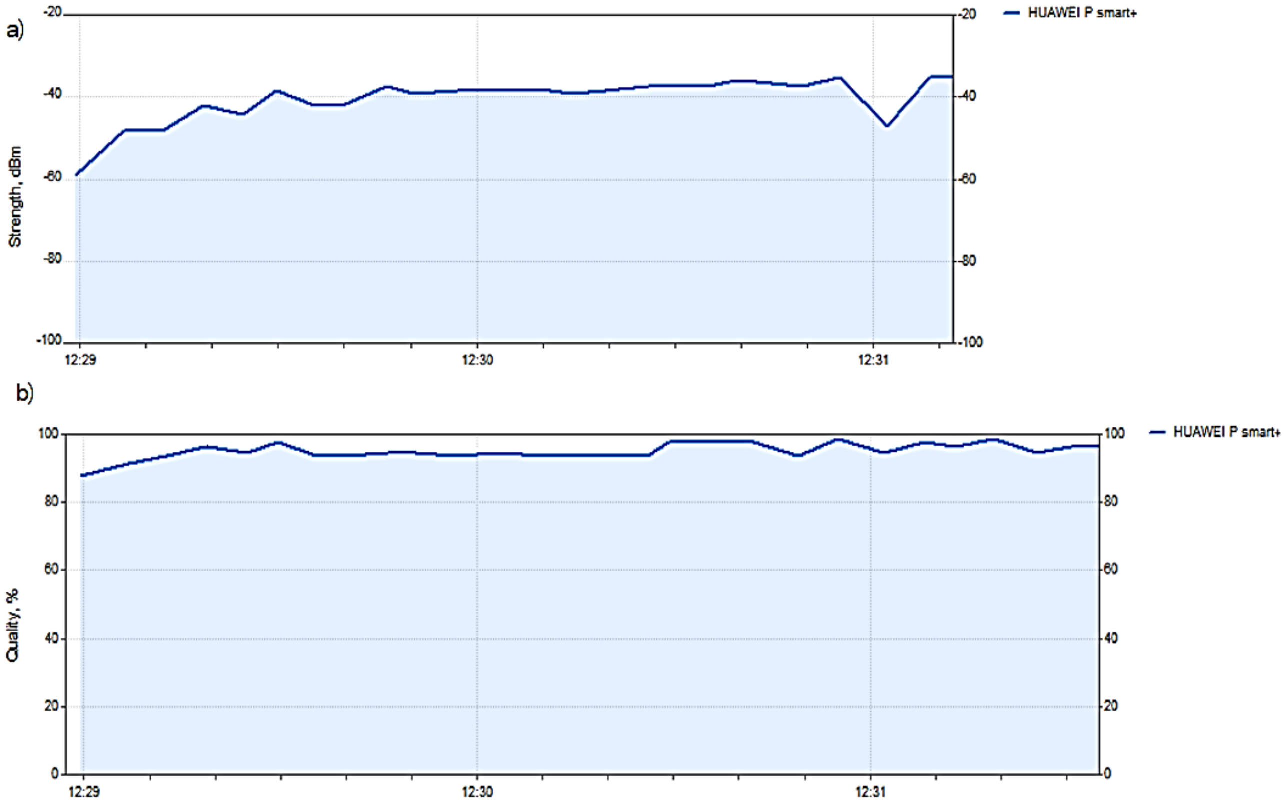

Figure 7: Chart of the signal strength near the router (a), Chart of the signal quality near the router (b)

From the two charts above we can conclude that there are no problems with signal transmission.

Now we need to move the laptop 2 meters from the router and we get the following results: the signal strength became -60 dBm, and the quality decreased by 6% (Fig. 8).

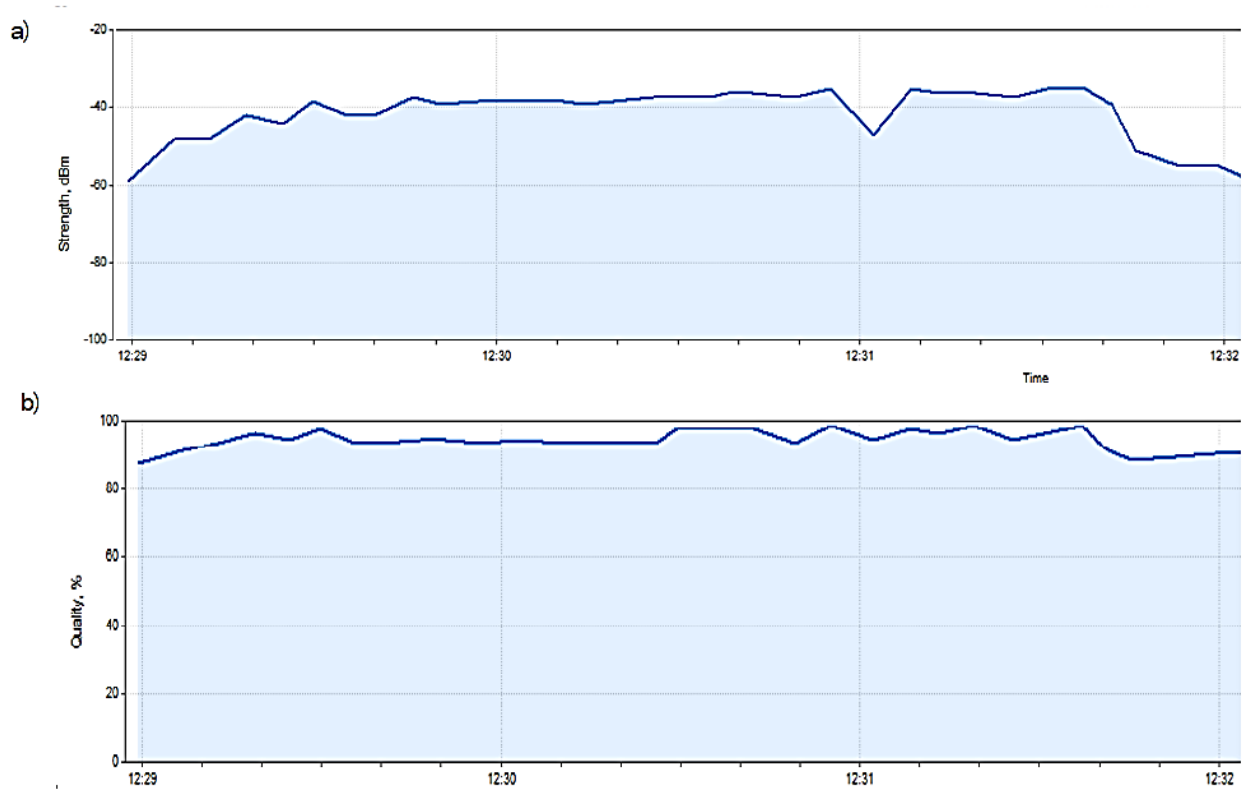

Figure 8: Chart of the signal strength two meters from the router(a), Chart of the signal quality two meters from the router (b)

Next is a study of signal reception through a wooden door (Fig. 9).

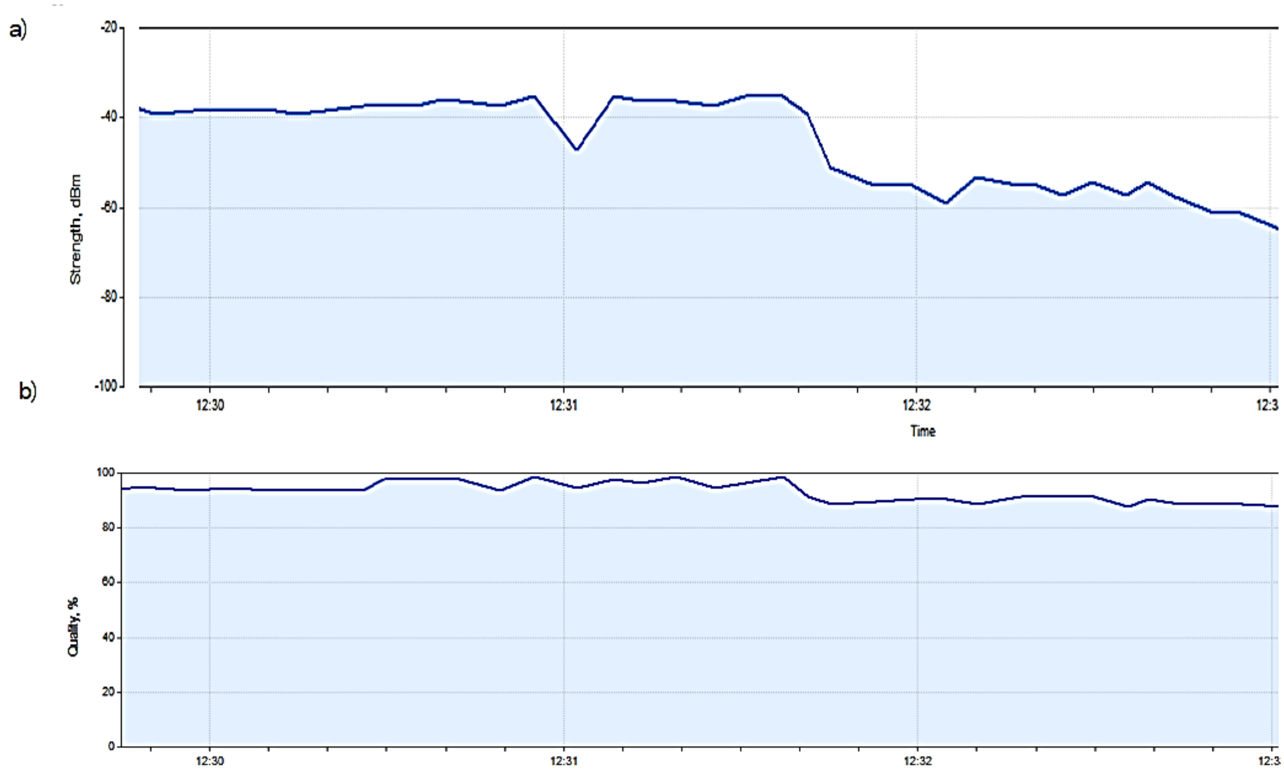

Figure 9: Chart of the signal strength through a wooden door (a), Chart of the signal quality through a wooden door (b).

The signal quality remained at the previous level, and the signal strength is 62 dBm.

Let’s compare these values with the values obtained through the iron door: the signal strength is -75 dBm, and the quality is 80% (Fig. 10).

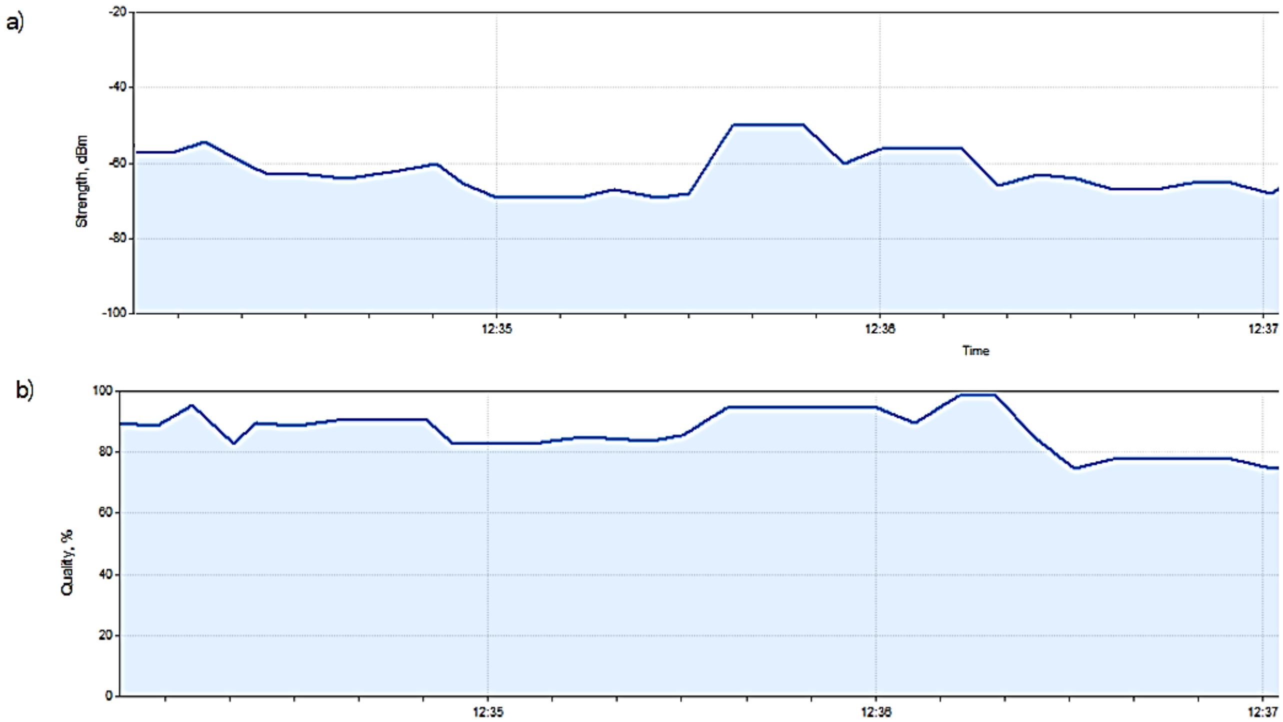

Figure 10: Chart of the signal strength through an iron door (a), Chart of the signal quality through an iron door (b).

Next, a study of signal reception through walls was performed (Fig. 11).

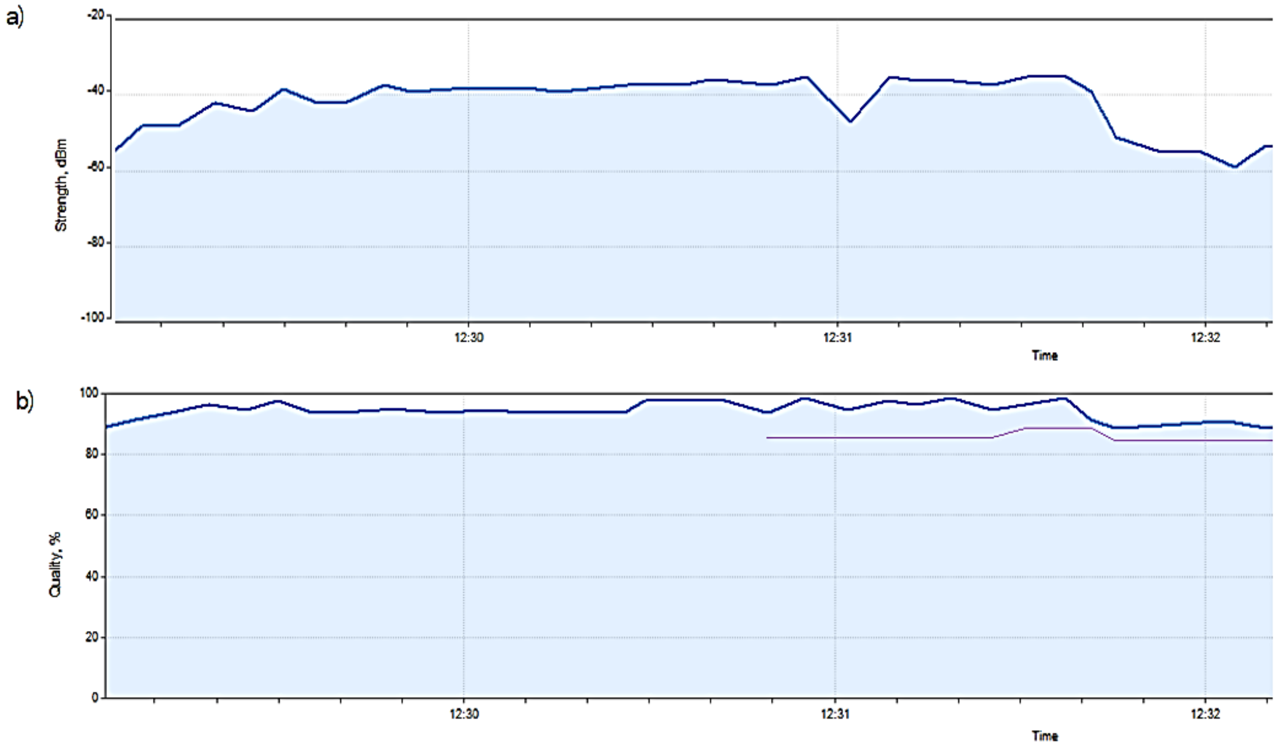

Figure 11: Chart of the signal strength through a brick wall (a), Chart of the signal quality through a brick wall (b).

From the charts above, it is possible to draw conclusions about the deterioration of the signal with indicators of signal quality and strength of 90% and -57 dBM, respectively.

When studying the signal parameters through 2 brick walls, the obtained values were: -66 dBm and 78% (Fig. 12).

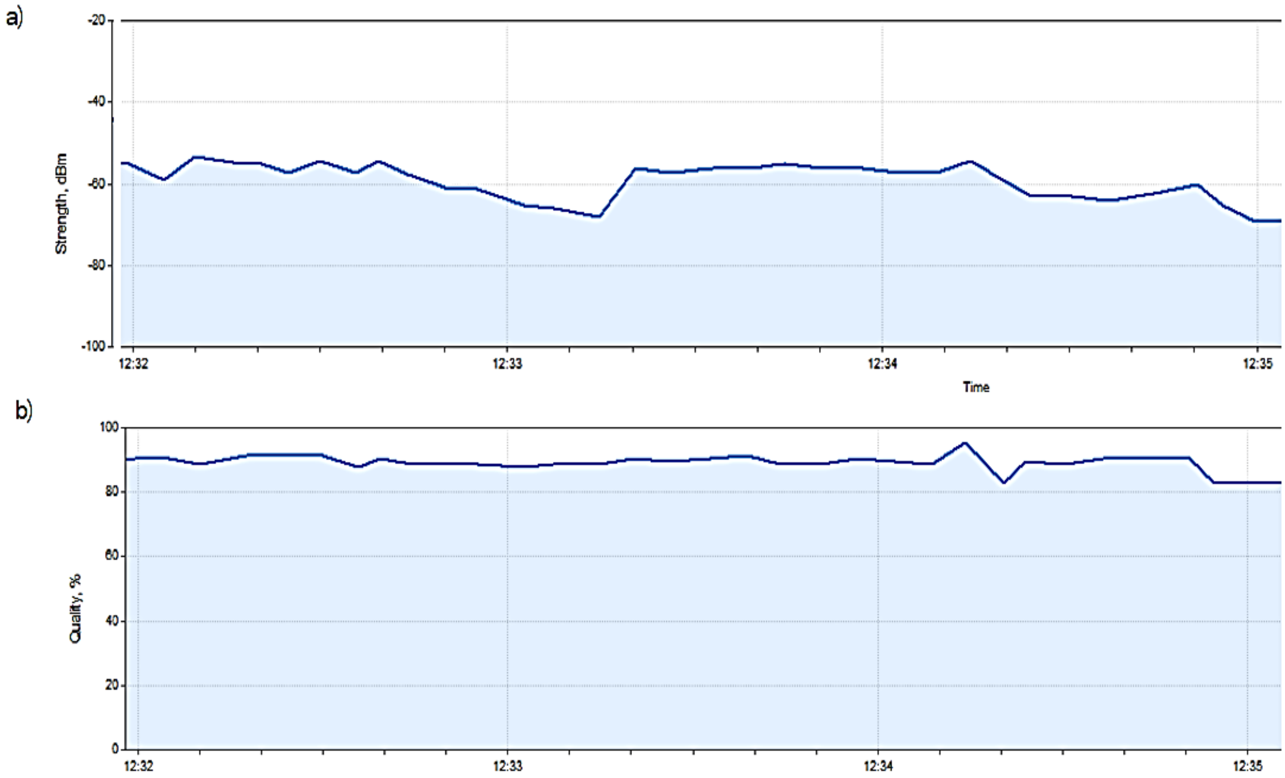

Figure 12: Chart of the signal strength through 2 brick walls (a), Chart of the signal quality through 2 brick walls (b).

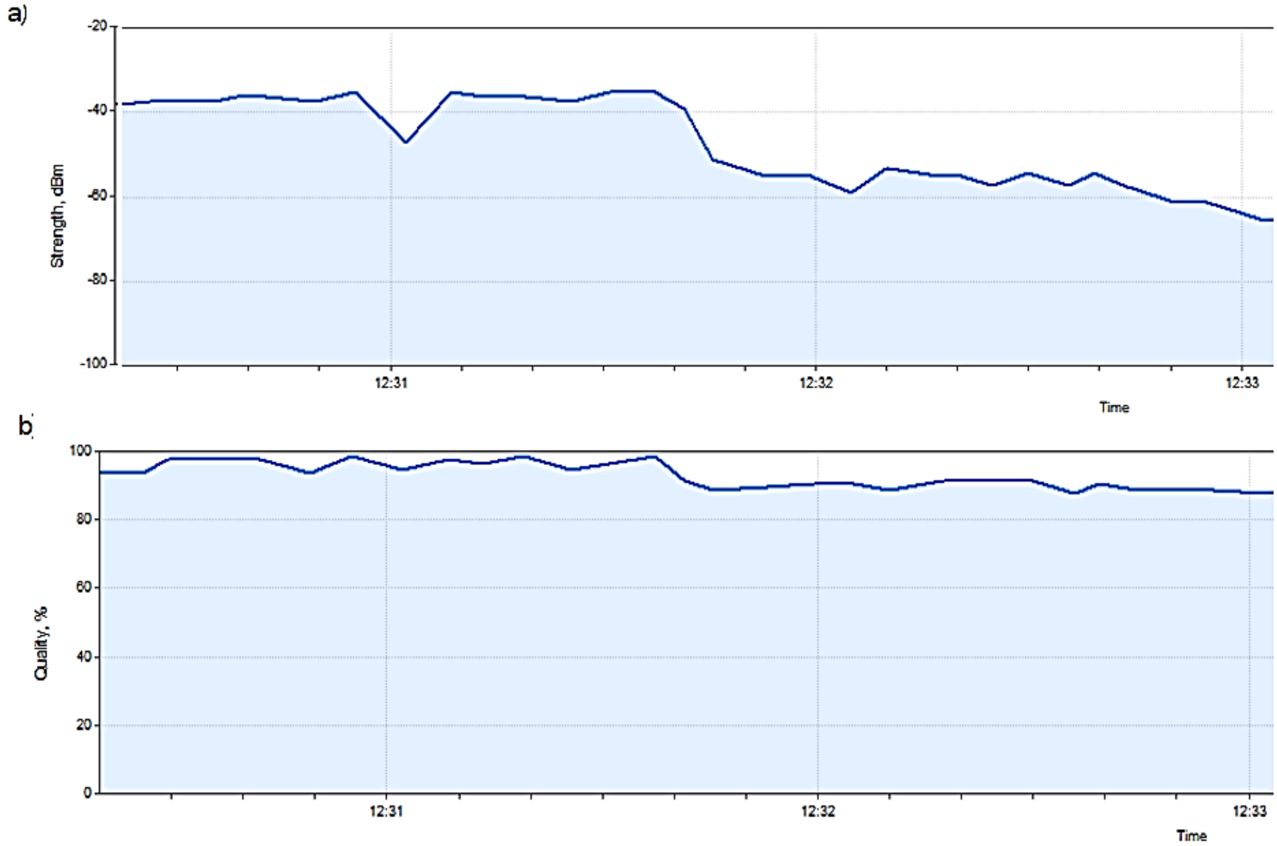

Figure 13: Chart of the signal strength through a plasterboard wall (a), Chart of the signal quality through a plasterboard wall (b).

The signal through the plasterboard wall has improved compared to the signal through the brick wall and is 64 dBm of signal strength and 84% of signal quality. The last experiment will be an experiment through a reinforced concrete wall. The figures are -71 dBm and 81% (Fig. 14).

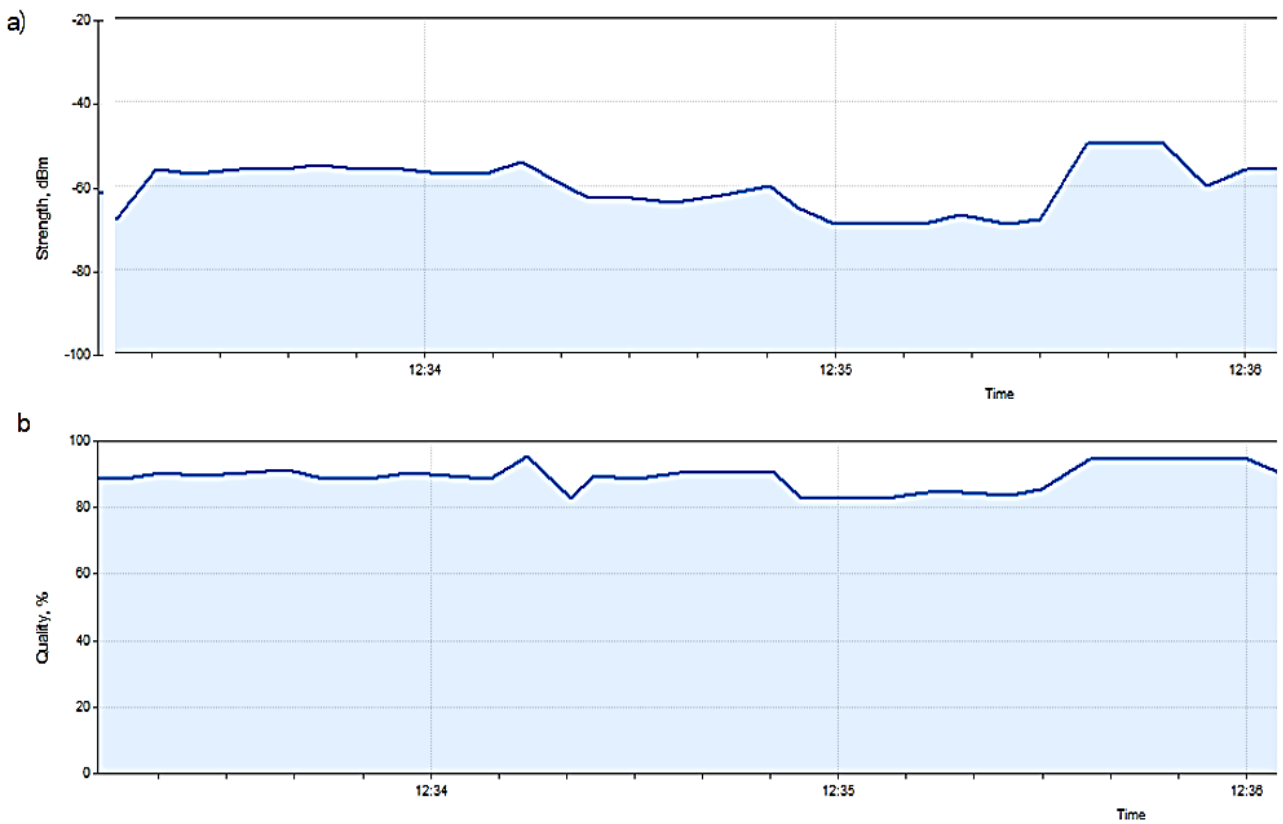

Figure 14: Chart of the signal strength through a reinforced concrete wall (a), Chart of the signal quality through a reinforced concrete wall (b).

Therefore, all the data are obtained, and it is necessary to draw conclusions about how physical structures affect the strength and quality of the signal in the local wireless network.

All received data are transferred to table 1.

Table 1

Dependence of wireless network signal parameters on physical obstruction

Parameter	Near the router	2 meters from the router	Wooden door	Iron doors	2 brick walls	Reinforced concrete wall
Signal strength, dBm	-37	-60	-62	-75	-66	-71
Signal quality, %	99	90	90	80	78	81

6. Discussion of the results of research on the influence of physical obstruction on the parameters of the signal of wireless networks

Most problems with wireless networks are caused by physical obstruction. Therefore, before designing a wireless network, it is necessary to consider all the physical phenomena that affect signal quality. This section discusses possible ways to solve wireless network problems for users.

First, it should be noted that the access point is the centre of the sphere, and signals from it are sent in all directions like rays. So, the wireless network is a sphere. That is, a typical home wireless network will cover the floor where the access point is installed and the edges of the upper and lower floors. But in reality this is not the case. The Wi-Fi coverage area is a toroidal field. In shape, this field resembles a torus, the axis of which is an antenna directed in any direction. The angle of the wireless signal propagation depends on the direction of the antenna. To ensure the best propagation of electromagnetic waves in a wireless network, the antenna should be installed perpendicularly to the ground. As a result, the waves will move parallel with the ground. Due to this, the waves will be able to cover the entire local network.

You also have to pay attention to where the wireless access point is. Since the antennas propagate the signal around them, the best signal will be near the access point, and the farther from it, the worse.

The position of the router in the corner of the premises is not effective, as the signal no longer reaches another corner. And if you place the access point in the centre, the signal will reach all corners. That is, we can conclude that you need to place the access point as close as it is possible to the centre of the premises where the wireless network is installed. It is also effective to ensure the direct visibility of the signal. Studies performed have shown that physical obstacles attenuate the wireless signal greatly. Therefore, providing direct signal visibility will be very effective for all users on the network.

As mentioned in the first section of this paper, there are a lot of Wi-Fi standards. Therefore, in the router settings, we can select the modes with which the created access point will work. Wi-Fi standards *b* and *g* give a slower rate for receiving or transmitting data and a shorter range. A slightly more modern mode of operation of routers - *n* - is able to provide data rates up to 150 Mbps, and in *ac* mode, the router can transmit up to several Gbps. Of course, they also cover a greater distance. You can switch the router to a faster mode, but only if the router and other devices connected to the wireless network support high-speed standards.

Also, another option to solve the problem with the signal in the wireless network is to install repeaters. Installing repeaters requires additional financial investment, but it is a great option to expand coverage. It is almost indispensable for places with a large area. It will also be useful for buildings with complex design. A special device, which may be used as a repeater and which is able to expand the coverage area of the local wireless network is not the only option. The role of such a Wi-Fi network extender can be taken over by a second router that supports WDS technology. Each option has its own characteristics. Yes, if you use a special repeater, this device connects to the access point and repeats its data. The device then creates a new access point with a different radio signal. The Wi-Fi signal will be strong and stable throughout the premises.

If a router operating in WDS mode appears in the local network, it will be possible to generate ‘seamless’ Wi-Fi. There will be one access point in this case for the entire coverage area. This option has a disadvantage: the speed of data exchange will decrease a couple of times. So if speed is a priority, it is better to buy a repeater.

There is another way to improve the wireless network - the transition to 5 GHz. To switch to such a range, you need a router that supports it. With this method, you can increase the speed of reception and transmission. The new frequency is a real lifesaver for offices and apartments, where the air is jammed with neighbouring radio waves on a more standard band of 2.4 GHz.

7. Conclusions

1. In the course of this study, the design of the local wireless network, its study and analysis were performed. Problems related to physical obstacles were identified and solutions were suggested. With the help of field experiments with the designed real network, it was shown what physical obstruction may actually affect the quality of the wireless signal. In addition, we found out which material has the worst effect on the wireless network.
2. Based on the indicators of the field experiment, it was found out that the walls and floors of wood and plasterboard have a low impact on the propagation of radio waves (-64 dBm signal strength and 84% signal quality), obstacles of brick, glass, concrete - medium (values: 66 dBm and 78%), of reinforced concrete and iron - high (-71 dBm and 81%).
3. To achieve the goal of the research the following tasks were performed:

- Models of physical phenomena that create obstruction for wireless network signals are suggested;
- The parameters of wireless networks signals at different types of physical obstruction are studied;
- Solutions to the problems associated with the negative impact of physical obstruction on the signal of wireless networks are suggested.

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