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Investigation of sensitivity impact of receiver to effective data transmission rate

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***Abstract*—This paper deals with the study of sensitivity impact of receiver to effective data transmission rate. The minimum signal level has been found out the equivalent, at which the receiver can decode the information with the set up and the level of noise and interference noise.**

Based on experimental studies the averaged values of input signal for all investigated consumer devices have been obtained below which the effective data transmission rate has been significantly reduced. To use a device with high sensitivity has also been found to be necessary for the broadband.

***Keywords*—802.11 wireless channel standard; receiver sensitivity; effective data transmission rate; signal strength; signal-to-noise ratio**

I. INTRODUCTION

It is known [1], the main indicators of quality of the 802.11x family of wireless standards are effective transmission rate and the signal strength at the receiver input, which are interrelated. But there are factors affecting these indicators, which can be divided into two categories [2]: change of the environmental parameters during the transmission from the effects of natural phenomena; noise that is independent radiation sources. In addition, the physical factors affecting the effective bandwidth of the 802.11x family of wireless standards are connected with two-way radio equipment which include: transmitter output capacity; factors of transmitting and receiving antennas; quality of conductors and connectors; selectivity of the receiver; sensitivity of receiver. Considering the radio, the advanced equipment for this standard has output capacity signal of 12 dB (thin) to 28 dB (high-performance). By the way, an antenna with a gain of 2 dB (built) and external 25 dB and more are also used [3]. Usually the radiation level of transmitters is standardized and the compatibility taking the legislation of different countries into account set the boundary at 100 mW for unlicensed frequency bands. One of the important factors that affect the basic criterion of the efficiency of the 802.11x family of wireless standards is the quality of the receiver, i.e. the ability to correctly allocate the necessary signal from the transmission medium to background noise and interference noise [3].

In turn, the factors with random variables have the greatest impact on noise level. Taking into consideration the above-mentioned information, we can conclude that wave propagation for the 802.11x family of wireless standards are quite heterogeneous in the room. This is confirmed by the results of studies of the wireless channels in [1], [4] and [5]. Based on this, in this paper, we select another important parameter – sensitivity of receiver. We are to try to assess the impact of this option on the effective rate information to develop effective methods of diagnosis and control of the 802.11x family of wireless standards.

II. THEORETICAL FUNDAMENTALS

It is known [6], the sensitivity for any digital receiver is the minimum acceptable signal level at which the receiver can decode the information with the set up or set level of signal / noise ratio. For such transmission system the signal / noise ratio is the ratio of signal energy E per 1 bit of information to noise capacity density P_n. Taking into consideration the general construction of the 802.11 wireless channel as described in [2], the signal/noise ratio can be written as follows:

$$E/N = \frac{P_{RX}}{(P_n + P_i)R}, \qquad (1)$$

where P_{RX} is the capacity level of the received signal at the receiver input; R is the information data rate; P_i is the capacity interference noise; P_n is the total output noise, which include a noise environment and radiation transmitters of other standards.

As seen from the formula (1) the real sensitivity of the 802.11 receiver depends on the capacity level of the input signal and noise and interference noise. As the 802.11x family of wireless standards are considered as an access point and the mobile subscribers, the access point of the transmitter capacity is directly related to the level of the signal at the receiver input. Then taking into account [6], we can write the following expression:

$$P_{RX} = \frac{P_{TX} G_1 G_2 \lambda^2}{(4\pi D)^2},$$

where P_{TX} is the output capacity of the transmitter; D is the distance from the transmitting to the receiving antenna; G_1, G_2 are the antenna gain factors of transmitter and receiver; L is the fading in wireless channel; λ is the wavelength.

To determine the maximum number of sources of noise and interference noise the expressions can be used for these components, which can be written as follows [2]:

$$P_n = kT\left(\frac{k_n}{k_f} + \frac{1}{P_0}\sum_{i=1}^{n} P_{n.i} - 2\right);$$

$$P_i = \frac{G_2}{L_{RX}}\sum_{i=1}^{m}\frac{P_{c.c.i}G_{c.c.i}}{G_{\varphi.i}L_{i.i}L_a}.$$

where k is the Boltzmann constant; T is the temperature of the receiver; k_n is the noise ratio of receiving channel; k_f is the transmission factor of capacity feeder; $P_{n.i}$ is the capacity of noise interference in transmission; n is the amount of noise in; P_0 is the level of thermal noise of the Earth; L_i is the relief in the interference channel; L_a is the attenuation in the antenna-feeder devices of interference transmitter; G_φ is the easing at the minimum angular distances between antennas; $G_{c.c}$ is the antenna gain of adjacent station interference; $P_{c.c}$ is the signal strength of a neighboring station; m is the number of interference stations within the coverage area of a base station.

Another feature of the distribution of signals in the room turned during the analysis of research results [5]. It can be argued that variation in capacity distribution options may be more than 10 dB for a receiver with its work in standards 802.11b, 802.11g and 802.11n. Besides the presence of architectural barriers in a room with high reflective, non-uniformity of distribution increase with the number of active emitting devices.

III. RESEARCH METHODOLOGY

The methodology of research is as follows. As noted above, one of the key parameters of receivers is the sensitivity, which may be defined with signal/noise ratio. Based on the formula (1) the primary evaluation criterion can install the capacity of signal P_{RX}, which in turn will differ for each receiver depending on the external environment and the number of active devices in the network. Another parameter directly related to capacity is effective data transmission rate V, which is the equivalent effectiveness characteristics of software and hardware information of the receiver to decode the required accuracy. By analogy to [5] we may suppose that the different types of receivers would allocate the signal from the environment in different ways because of the deviation values of sensitivity. Therefore a large number of consumer devices that can work in standards 802.11b, 802.11g, 802.11n. Have been selected for research, and a network through an access point (AP) has been built, the scheme is shown in Fig. 1.

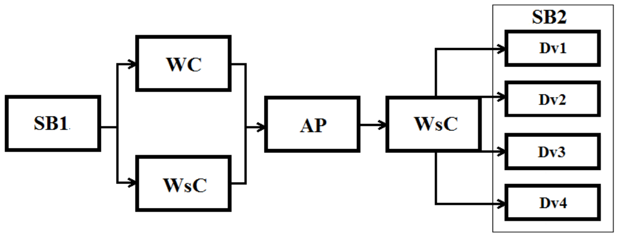

Figure 1. Scheme of investigated network

There are a subscriber (SB1) in this network for which wire channel (WC) or wireless channel (WsC) can be installed to AP. Between AP and second subscriber (AB2) involving the change of receivers, there is only the wireless channel (WsC) whose length can be up to thirteen meters. While increasing of bandwidth the capacity level of transmitter emitting decreases, the research of the 802.11n standard has been conducted for Channel 20 MHz and 40 MHz. To determine the conditions of the network the Fig. 2 demonstrated a typical piece of monitoring the transmission medium.

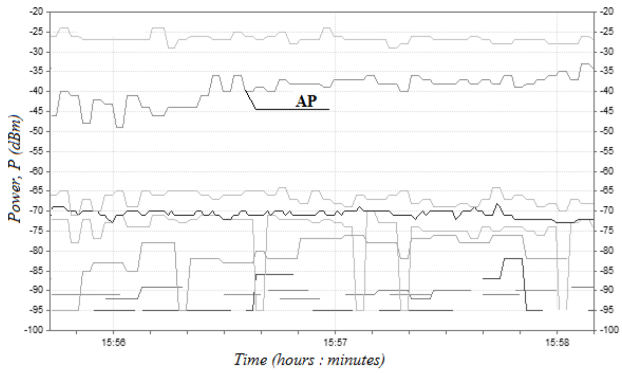

Figure 2. Detail of monitoring of transmission medium

IV. RESULTS

Based on the proposed wireless network experimental research has been conducted under the same conditions of receivers.

Two typical devices Dv1, Dv2 have been selected for the analysis of the results marked with curve 1 and curve 2; curve 3 is of the highest sensitivity (Dv3); curve 4 is the high-sensitivity device with additional external antenna (Dv4).

The distribution of the importance of signal capacity at the receiver input in the room is represented in Fig. 3.

The following characteristics demonstrate the highs and lows of deviation from the mid-point of 10 dBm for

Dv1 and Dv2, confirming the obtained results in [5]. For highly sensitive devices the rejection is twice smaller.

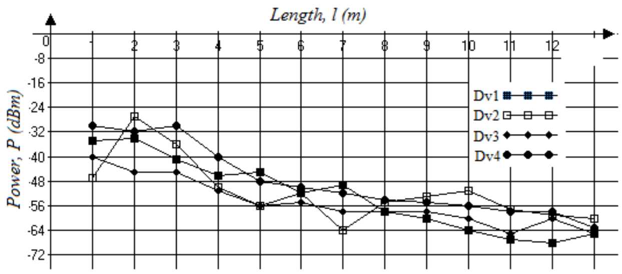

Figure 3. Dependence of signal strength on distance

Next, we are to consider the impact of capacity distribution for effective data transmission rate in the presence of a wireless channel between SB1 and SB2. The research results are represented in Fig. 4.

The graphs shows the operating mode in the 802.11b standard where the characteristics stability has been observed. The difference between the devices Dv1 and Dv2 is up to 1.5 times. Another picture of prevailing mode is in 802.11g standard. There is a significant variation in performance and an increase in the difference between the characteristics of the devices more than doubled.

Due to the existence of significant interference noise, the signal energy efficiency should be enhanced using a broadband channel. According to the research for the 802.11n standard, we may see that this is true for devices with high sensitivity of Dv3 and Dv4.

Next, we are to consider the presence of a wireless network of two channels when there is a mechanism for combating frequency resource [8]. The research results have been represented in Fig. 5. In this case, there are the higher uniformity characteristics and generally the reducing of the effective rate for the least highly devices. But the general character of remains is similar to the previous case.

Finally, based on the schedules we can set that for each receiver there is marginal limit input signal below which the characteristic of the effective rate is a significant decreasing factor. For example, for the following devices the borders are from 56 dBm for Dv1 and Dv2 and 60..65 dBm for Dv3 and Dv4; they also contain the deviations from these values from the midpoint 5..10 dBm.

CONCLUSIONS

Thus, based on experimental studies the impact of sensitivity of the 802.11 standard receivers to effective information rate has been identified. The results having a lot of random elements have been obtained, but based on transactions averaging the main laws have been identified that must be considered in the development of new methods of diagnosis and control of wireless networks of the 802.11x family of standards:

1. For each investigational device threshold value of the average capacity input has been set below which there is a significant decrease in the effective rate;
2. The average limit value of input signal affects the number of simultaneously existing subscriber wireless channels in the network;
3. The sensitivity of receivers can have both positive effect in the absence of interference and noise interference and negative increasing their level when they are present, but when broadband channels such as 40 MHz are used, the most preferred is the use of high sensitivity of receivers.

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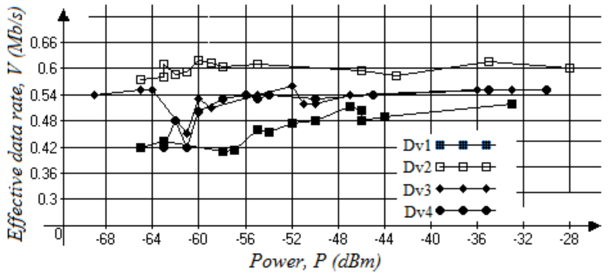

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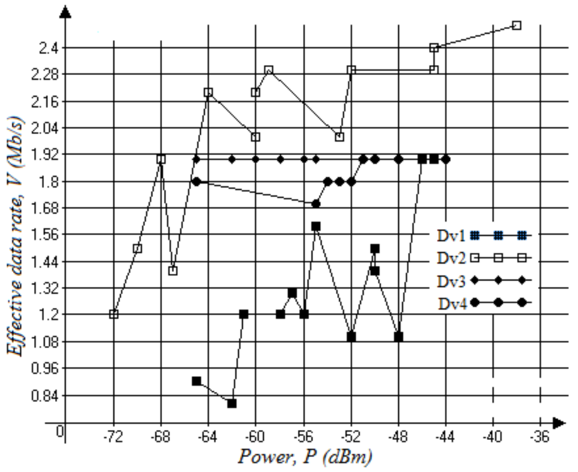

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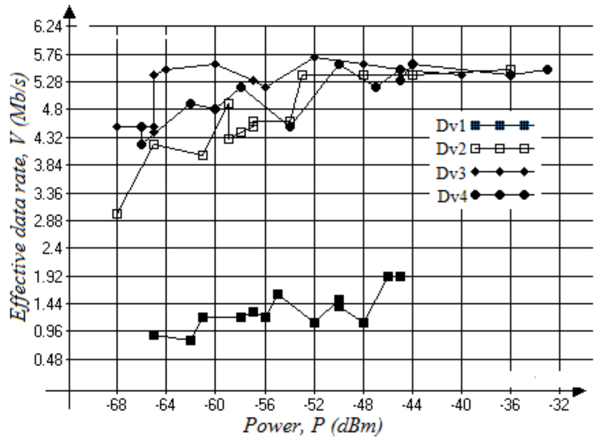

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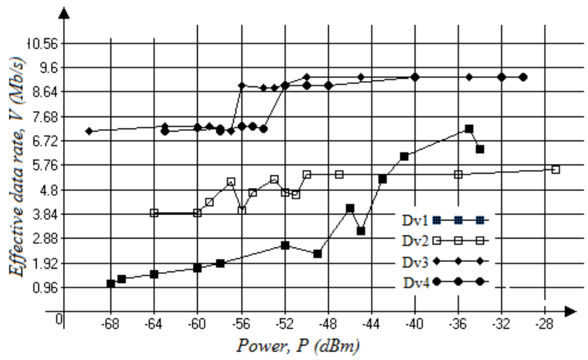
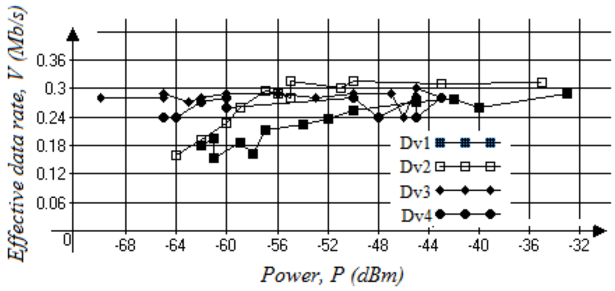


d

Figure 4. Dependency of effective data transfer from the power of signal at the receiver's input with the single wireless channel for: 802.11b standard (a); 802.11g standard (b); 802.11n standard 20 MHz (c); 802.11n standard 40 MHz (d)



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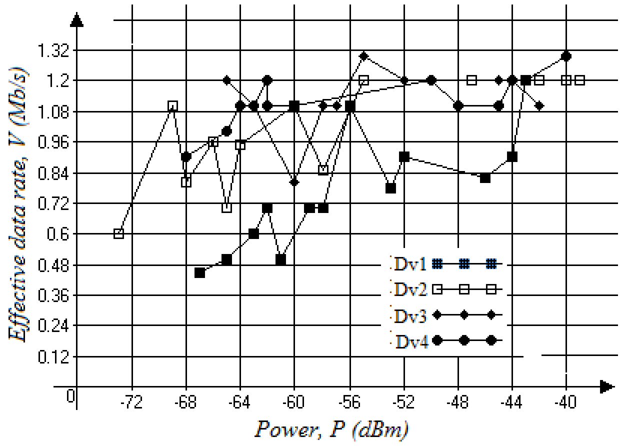

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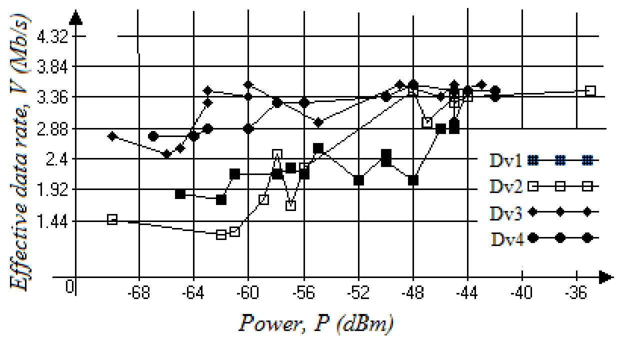

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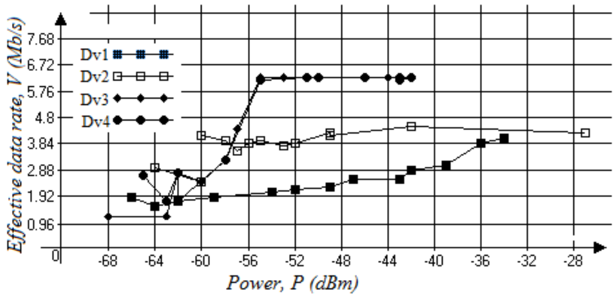

d

Figure 5. Dependency of effective data transfer from the power of signal at the receiver's input with double wireless channel for: 802.11b standard (a); 802.11g standard (b); 802.11n standard 20 MHz (c); 802.11n standard 40 MHz (d)