Increasing the Speed of a Wireless Network by Processing Indoor

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Abstract— **Usage of technology MIMO in standard 802.11n allows to increase data transmission to 300 Mbit/s. This network successful operation is necessary to send signals from transmitting antenna to receiving antenna in different ways, that is there is multibeam reflection an indoor. This research is suggested to obtain the optimal interflection time by special indoor treatment. The radio wave propagation statisctical theory is consider by Author an indoor, the time Interflection T defenition formula is derived. According to author conclusions the time T can be selected by indoor special treatment: disposing of surface with high reflection coefficient indoors. Time T increases from 210 ns (before indoor treatment) to 390 ns(after room treatment). Increasing time T more then 400 ns author doesn't recommended, as «guard time» may be exceeded and required result does not achive. Practical researches with standard 802.11n equipment using confirm the theoretical conclusions and show, that data transmission rate after treatment increases to 10-15% upon the average.**

Keywords - RadioEthernet; wireless, interference; disturbance; Wi-Fi, reflectance.

I. INTRODUCTION

In the modern communication system intercomputer channel bandwidth is need to increase. The bandwidth may be increased by frequency band expansion or radiating power rise. Nevertheless such methods have disadvantages because of human ecological safety and electromagnetic compatibility frequency band expansion or radiating power rise is limited. So, if the required data rate isn't provided by possible frequency band expansion or radiating power rise, one of the effective problem solution may be usage of adaptive antenna arrays with a weakly correlated antenna elements. Communication systems, which used such antenna, is named MIMO system (Multiple Input Multiple Output). Such system uses at making of wireless network of IEEE 802.11n standard, which was approved in September 11, 2009.

Standard 802.11n the data rate increases in almost four times compared to the 802.11g standard devices(which maximal rate is equal to 54 Mbps) on conditions that it uses in regime 802.11n with other with device 802.11n.

High date rate is provided by:

1. Large quantity of bearing usage: 802.11g with 48 bearing against 802.11n with 52 – increases bandwidth from 54 Mbps to 58.5 Mbps.
2. FEC (Forward Error Correction): 802.11g has maximal value FEC - 3/4, 802.11n — 5/6. Increased bandwidth from 58.5 Mbps to 65 Mbps.
3. Guard Interval: 802.11a guard interval between transmission is 800 ns. In 802.11n it is decreased to 400 ns, so bandwidth increases from Mbps to 72.2 Mbps.
4. MIMO: spatial multiplexing can support a linear increase in bandwidth depending on the number of antennas on each side. The standard maximum permitted number of antennas is four. This allows to increase the total bandwidth up to 288.9 Mbps the subject to 72.2 Mbps channel.
5. Channels 40 MHz: all previous versions of 802.11 have the bandwidth 20MHz. 802.11n has a mode for the bearing channel width of 40 MHz. Due to the increasing amount of data bandwidth per channel is increased from 52 to 108. This increases the overall throughput to 150 Mbps. Taking into account the 4 channels of MIMO technology can theoretically get the speed of 600 Mbps.

802.11n devices work in the range 2.4 - 2.5 or 5.0 GHz. In this case, you can use one of three modes:

1. HT Greenfield mode - means that the next device does not use the old standards on the same frequency. If they try to do this, they will not be able to connect at 802.11n.
2. Non-HT (Legacy) mode - 802.11n AP in a Non-HT mode sends all packets in the old format 802.11a/g, so all devices can understand it.
3. HT Mixed mode - as soon as the majority points 802.11n will work in device support 802.11b/g and 802.11a. HT Enhancements will be used at the same time with the mechanism of HT Protection, which will enable devices to work with old cards.

During the ten-year period of work the following problems is identified and partially solved:

1. The unpredictability of coverage. In previous versions of wireless coverage was close to spherical. In networks with 802.11n coverage area has a complex structure and difficult to calculation and planning.
2. In the range of 2.4 GHz can only use one channel of 40 MHz. The most perspective usage of such a regime is in the range of 5GHz.
3. Network performance 802.11n in the range of 2.4 - 2.5

GHz decreases due to the small value of signal to noise ratio (SNR) due to the presence of a large number of devices operating in the same range: Bluetooth, Microwave Ovens, Cordless phones, Wireless Cameras, Game controllers , Baby Monitors, Digital video devices and many more. It is recommended to use a range of 5.0 GHz, in which the noise is much less.

4. When the bandwidth of a cable connection wireless access points to the wired network is more than 100 Mbps, the trouble in the way of traffic becomes a wireless controller, a speed which is recommended to increase up to 1 Gbps.

5. Wireless network security: a large coverage area implies an increase in risk of unauthorized access, illegitimate passive devices can listen to the broadcast, unnoticed, Fluke Networks products can detect the device (including passive) connected to the network 802.11n; 40MHz channel scan takes twice as much time than scanning 20MHz channel mechanism of block confirmation of 802.11n is the vulnerability to DoS attacks.

6. One access point can connect up to 254 users. The bandwidth of a single half-duplex radio channel is divided into all simultaneously transmitting users. Given the numerous repetitions of data transmission because of conflicts with their simultaneous transmission of real bandwidth per user goes down to very small quantities. Therefore, the number of concurrent clients in terms of a single point of access must be in the range of 12 to 50. For example, this problem manifested itself during the Mobile World Congress [1].

MIMO enables omni-directional transmission on a lot of antenna pairs. This ensures they get the signal receiver and is called spatial streams. Data packet can be divided into several packets and sent on different streams. The receiver collects them back into a single data packet. 802.11n supports up to 4 threads. But more often considered the standard antenna configuration circuit for transmitting and receiving information, 3 × 3 or 2 × 3.

Many researchers engages, eg [2,3], to raise productivity wireless IEEE 802.11n standard. These works are devoted to the advancement of the antennas and radio devices. A distinctive feature of our work is that we are engaged in the advancement of the transmission medium, since the success of MIMO operation mode is necessary to establish such a regime under which the multipath propagation of radio waves. We limit the wireless network work in one room. This regime occurs when installing access points in places of public access: restaurants, libraries, hotel lobby, etc. The aim of this work - forming the best possible conditions of multibeam propagation in a room and experimental verification of the results.

II. THE STATISTICAL THEORY OF RADIOWAVES DISTRIBUTION IN INDOOR

With the standard 802.11 POP in an indoor the signal doesn't only reach to subscriber P on the right line, but also on the ways repeatedly broken through the signal reflections from walls, a ceiling and a floor indoors. At each signal‘s reflection from surfaces, limiting an indoor the some part of signal's energy is absorbed, in spite of all this the reflected signal level at the subscriber will be quite enough for creating a handicap, named interference, at the expense of a phase difference.

Let's examine a definition problem of time, during which the interferential handicaps level will reduced to the acceptable signal-to-noise ratio value. Let's name the time T as interflection time.

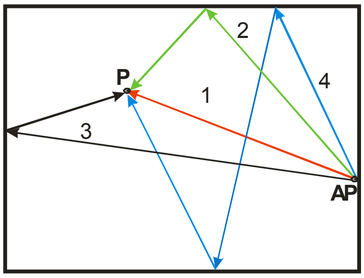

Figure 1. Repeated reflexion of radio-waves indoors

Through each point in indoor volume the great number of the reflected waves passes moving on various directions at a time. Field strength and vibrational speed vector in each point are determined by result of an interference of all these waves. In this case to calculate a signal level in each point is represented with difficulty sufficiently. However, the great number of interference waves suggests the problem to be solved by statistical treatment with usage of the mathematical probability theory basis at least in some cases. Assuming, that orientations, amplitudes and phases of waves superimposed on each other are distributed more or less chaotically, we can examine these waves as not coherent and consider the energy density in each point to be the sum of the energy density connected to each these waves. If wave movement in an indoor really has such indigested character without presence of oscillatory movement prevailing directions and symmetry in amplitudes distribution, research statistical methods are quite right and lead to the important practical results [4].

Statistical research of electromagnetic fields in the closed indoors requires prior average time definition between two consecutive signal reflections from surfaces, limiting a indoors, and also an reflections average undergone by radio-waves in unit of time. Let's imagine the surface element dS, limiting volume V of an indoor and a radio-wave, moving at an angle of θ to an element dS normal (Fig.2). What probability that this wave will fall to platform dS per unit time from t to t+dt? We take notice, that during dt on platform dS only the electromagnetic wave energy, being contained in volume of the cylinder with basis dS and height $c_0dt\cos\theta$ (where c_0 - speed of distribution of a radio-wave), can fall at an angle of θ.

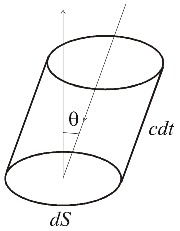

Figure 2. Cylinder

The cylinder volume is $dV = c_0 dt \cos\theta dS$

The required probability is determined by the relation volume dV to the indoor volume V:

$$W_1 = \frac{1}{2}\frac{dV}{V} = \frac{1}{2}\frac{c_0 dt \cos\theta dS}{V} \tag{1}$$

The multiplier ½ explains that a wave movement can be in the platform direction, or in an opposite direction with equal probability.

It is necessary to take into account, what probability will be that some wave chosen randomly pass at an angle of θ to dS. For probability definition we will surround a platform dS with a hemisphere of any radius r and allocate band on a hemisphere with the area 2πrsinθ·rdθ, on which the radius - vector r forms with a normal dS at an angle of θ (Fig.3).

The probability of falling wave at an angle between θ and θ+dθ is the correlation of the area band to a surface to a hemisphere 2πr^2:

$$W_2 = \frac{2\pi r \sin\theta \cdot r d\theta}{2\pi r^2} = \sin\theta d\theta \tag{2}$$

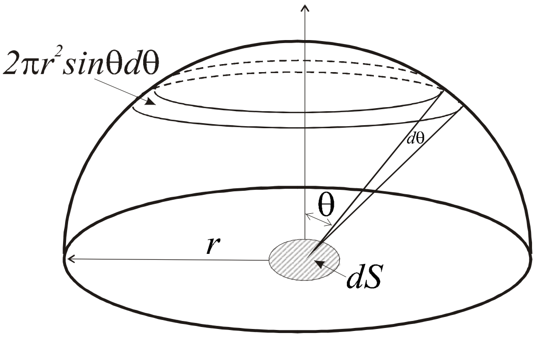

Figure 3. Hemisphere

Now it is possible noting, what probability of signal's falling on a platform dS per unit time dt at an angle between θ and θ+dθ is:

$$W_3 = W_1 W_2 = \frac{1}{2}\frac{c_0 dt dS}{V}\cos\theta \sin\theta d\theta \tag{3}$$

According to additive rule the probability of a signal falling on dS at an angle in the range [0,π], related to the same time interval dt, results by integration of this result on θ:

$$W_4 = \frac{1}{2}\frac{c_0 dt dS}{V}\int_0^{\frac{\pi}{2}} \cos\theta \sin\theta d\theta = \frac{c_0 dt dS}{4V} \tag{4}$$

The probability of a signal falling per unit time dt at an angle and on any element of a surface S, limiting volume Vof an indoor is:

$$W = \frac{c_0 dt}{4V}\int_S dS = \frac{c_0 S}{4V} dt \tag{5}$$

The found probability is proportional to any time interval dt. Increasing this interval, eventually, we will receive such time interval τ, within range of signal falling on any surface Spoint should be exactly. As the authentic event probability is equal to one, required interval τ, between two consecutive signal reflexions, will be defined from condition

$$\frac{c_0 S}{4V}\tau = 1 \quad . \ \Omega\eta\varepsilon\nu\chi\varepsilon \quad \tau = \frac{4V}{c_0 S} \tag{6}$$

The average of reflections per unit time is

$$\nu = \frac{1}{\tau} = \frac{c_0 S}{4V} \tag{7}$$

The radiowave mean free path is

$$\lambda = c_0 \tau = \frac{4V}{S} \tag{8}$$

As mentioned above, some part of energy is absorbed at each signal reflection from surfaces limiting an indoor. It is necessary to specify an absorptivity quantitative measure of these surfaces for calculation of signal reflexions duration obviously. Let's designate symbol α as an average value of energy relative reduction at each separate absorption act of a signal

$$\alpha = \frac{\Delta E}{E}, \tag{9}$$

There is E - the general energy store of indoors before the absorption act, ΔE - average size of the energy absorbed by an indoor surface per the one act. It is clear, that the size, defined by the formula (9), has only statistical meaning: as separate signal's absorption acts occur place at falling of waves under different angles on the surfaces possessing, generally speaking, various absorbed ability, the energy ΔE absorbed per the one act, can actually have the various values being subject to statistical averaging at invariable size E. Last condition is satisfied, obviously, in a stationary conditions when the energy transmitted by a signal source, continuously fills up the losses, caused by signal absorption indoors. We consider the average energy to be absorbed per the one act is proportional to the general energy store indoors: ΔE =αE.

As absorption act occurs ν per unit time the average value of the signal absorbed energy per unit time, is

$$\delta E = \nu\Delta E = \alpha\nu E = \alpha\frac{c_0 S}{4V}E \qquad (10)$$

The formula (9) defines α as average relative reduction of signal energy indoors in the one absorption act. But, in addition to that, it is possible to give to coefficient α other interpretation.

Energy ΔE falling at small time Δt on surface S, limiting volume V of an indoor, it is possible to define, multiplying an energy stock E on the probability of its falling calculated on time Δt. According to (5), this probability is equal $\frac{c_0 S}{4V}\cdot\Delta t$. Therefore, let's write $\Delta' E = \frac{c_0 S}{4V}\cdot\Delta t\cdot E$. Energy $\delta' E$, falling on surface S per unit time, is equal

$$\delta' E = \frac{\Delta' E}{\Delta t} = \frac{c_0 S}{4V}E \qquad (11)$$

Comparing this result with (10), we have:

$$\alpha = \frac{\delta E}{\delta' E} \qquad (12)$$

If one see, that the indoor is limited by a homogeneous for the physical properties surface (12) defines factor α as the relation of the energy absorbed by this surface, to energy, diffusely falling on it. The term «diffusive falling» [5] concerns to ergodic process when all directions of carrying over energy signal are equiprobable. It is possible to define, therefore, α as signal absorption factor(in conditions diffusive fields) such homogeneous surface which, limiting an indoor, causes the same losses of signal energy, as well as actually cash non-uniform surface. So size α we name average absorption factor, and its product on surface S we name the general absorption of a premise

$$A = \alpha S \qquad (13)$$

If the indoor is limited by surfaces S_1, S_2… with absorption factors α_1, α_2… (measured in conditions diffusive an electromagnetic field) the general absorption is defined by the sum of absorption separate surface sites:

$$A = \sum_i \alpha_i S_i \qquad (14)$$

Considering that average radiowave absorption factor value

$$\alpha = \frac{A}{S} = \frac{1}{S}\sum_i \alpha_i S_i\,, \qquad (15)$$

where α_i- absorption factor of a homogeneous surfaces S_i, limiting an indoor.

The reasons developed above, give the chance of the a radio-waves distribution phenomena mode establishment statistical calculation in the closed indoor. Let at the moment of time t=0 in an indoor the signal source starts to do with capacity P per unit time τ, equal to average radiowave mean free path, the signal source gives energy Pτ indoor. As a result of the first reflection, that is by the moment 2τ, from this energy there will be a part Pτ(1-α according to 9. But a signal source again gives to an indoor energy Pτ per an time interval from τ up to 2τ. Thus, by the moment t=2τ indoor there will be an energy $P\tau + P\tau(1-\alpha) = P\tau\left[1+(1-\alpha)\right]$

Developing the idea further, we consider, that energy will be equal $P\tau + P\tau[1+(1-\alpha)](1-\alpha) = P\tau\left[1+(1-\alpha)+(1-\alpha)^2\right]$ per the time interval t=3τ indoors.

Act according to an induction, we will receive by the moment t=nτ:

$$E = P\tau\left[1+(1-\alpha)+(1-\alpha)^2+\ldots+(1-\alpha)^{n-1}\right] = \\ = P\tau\frac{1-(1-\alpha)^n}{1-(1-\alpha)} = \frac{P\tau}{\alpha}\left[1-(1-\alpha)^n\right] \qquad (16)$$

Supposing n=t/τ and substituting value τ from (6), we will receive:

$$E = \frac{4P}{c_0\alpha S}\left[1-(1-\alpha)^{\frac{c_0 S}{4V}t}\right] \qquad (17)$$

Using identity $(1-\alpha)^x = e^{x\ln(1-\alpha)}$, we will receive the formula of energy increase indoor after signal inclusion

$$E(t) = \frac{4P}{c_0\alpha S}V\left[1-e^{\frac{c_0 S\ln(1-\alpha)}{4V}t}\right] \qquad (18\alpha)$$

For signal energy average density increase we receive

$$\varpi(t)=\frac{E(t)}{V}=\frac{4P}{c_0\alpha S}\left[1-e^{\frac{c_0 S\ln(1-\alpha)}{4V}t}\right] \qquad (18\beta)$$

As α<1, that follows from definition of this size both as by the formula (9) and the formula (12) – ln(1-α) .So, an exponent is negative.

Thus,

$$\lim_{t\to\infty}\left[e^{\frac{c_0 S\ln(1-\alpha)}{4V}t}\right]=0$$

Therefore, for a stationary mode when energy losses due to absorption completely compensate the energy transmitted by a signal source, from (18) formulas follow

$$E_0=\frac{4P}{c_0\alpha S}V \quad (19\alpha) \qquad \varpi_0=\frac{4P}{c_0\alpha S} \quad (19\beta)$$

Now let's proceed to signal reflection process analysis after turning off signal's source. Let per the time interval t=0 when energy containing indoors has some size E_0, the signal source is switched off. Through time τ indoors there will be energy $E_0(1-\alpha)$, by the time interval 2τ the energy stock will decrease to size $E_0(1-\alpha)^2$ etc.

By the time interval t=nτ energy will be equal $E(t)=E_0(1-\alpha)^n=E_0(1-\alpha)^{\frac{t}{\tau}}$.

Replaced indicative function exponential and substituting average time value of free path τ according to (6), we will find reflection formulas indoors after source turning off:

$$E(t)=E_0 e^{\frac{c_0 S\ln(1-\alpha)}{4V}t} \quad (20\alpha) \qquad \varpi(t)=\varpi_0 e^{\frac{c_0 S\ln(1-\alpha)}{4V}t} \quad (20\beta)$$

Diagram signal change processes indoors, constructed on the equations (20), and are presented on Fig.4. Level of falling off process value to be presented in the form of a descending straight line, it is clear from picture. The this straight line dip to an abscissas axis defines level of falling off signal's speed in dB/sec. The formula for falling rate is easy receiving, noticed, that on the equations (20).

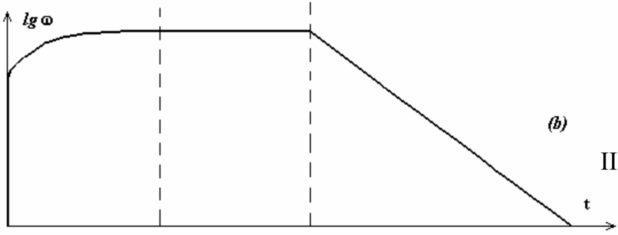

Figure 4. Process of change of a signal indoors at inclusion and source deenergizing

$$N=10\lg\frac{\varpi}{\varpi_0}=-\frac{c_0 S}{4V}\ln(1-\alpha)\cdot t(10\lg e)=\left(\frac{10c_0 S}{4V}\lg\frac{1}{1-\alpha}\right)t$$

From here it is clear, that level of falling rate is equal after turning off a signal's source

$$\beta=\frac{N}{t}=\frac{10c_0 S}{4V}\lg\frac{1}{1-\alpha} \qquad (21)$$

Let's find time necessary for reduction a signal level to noise level

$$T=\frac{N_{S/N}}{\beta}=\frac{N_{S/N}\cdot 4V}{10c_0 S\lg\frac{1}{1-\alpha}}=\frac{0{,}4N_{S/N}V}{c_0 S\lg\frac{1}{1-\alpha}} \qquad (22)$$

In indoor with small average absorption factor absorption (α<0.2) it is possible to time T by the simplified formula, which turns out as follows.

Expanding logarithm into a series, we write

$$\lg\frac{1}{1-\alpha}=-\lg(1-\alpha)=-0{,}434\ln(1-\alpha)=0{,}434\left(\alpha+\frac{\alpha^2}{2}+\frac{\alpha^3}{3}+\ldots\right)$$

At small α it is possible to be limited to the first member of the series, which substitution in (22) leads to result:

$$T=\frac{N_{S/N}\cdot 4V}{4{,}34c_0 S\alpha} \qquad (23)$$

The average coefficient of radio wave indoor absorption is determined by the following formula:

$$\alpha=\frac{1}{S}\sum_i \alpha_i S_i, \qquad (24)$$

where α_i – absorption coefficient of one of the conspecific indoor surface S_i.

The problem is that up to date the data on absorption coefficient of radio waves of range 2.4 and 5 for materials used in modern buildings are quite limited.

To determine radio wave absorption coefficient we suggest applying the method described in [6], which refers to radio wave of range 2.4 GHz reflection coefficient for three-layered environment in this work.

III. THE METHOD OF MEASURING DIELECTRIC CAPACITIVITY

To explore the dielectric properties of the materials the waveguide method of short-circuit contact and free running [6] is the optimal one. The method is based on defining the standing wave ratio (SWR) and the phase of a microwave signal passing though a sample. First the microwave path is calibrated by choosing the reference plane while measuring wave phase. To be able to do that we should define the standing wave short-circuited line minimum position. After that the shorted waveguide section without sample is connected to the line end. The shorted plane shifts a bit, as the section length isn't equal to the integer number of radiation half-waves in the waveguide.

After calibration the waveguide section with a sample is set on the microwave path which results in shifting the standing wave minimum as the minimum depends on dielectric in question properties. The standing wave minimum / dielectric properties ratio is calculated on the basis of the respective electrodynamic problem which is reduced to a complex transcendental equationequation. The usage of waveguide method of short and free running [7] allows to avoid the solution of this equation. This method provides reliable results and consists in SWR measurement and shifting standing wave minimum with regard to the chosen reference plane for a given sample, at the end of which the shorted and free running conditions are created. Skipping the derivation, we only give the final formula to calculate the imaginary and real part of complex dielectric capacitivity ε′ and ε″:

$$\varepsilon' = \frac{AC + BD}{A^2 + B^2} \cdot \left\{ 1 - \left(\frac{\lambda_0}{2a} \right)^2 \right\} + \left(\frac{\lambda_0}{2a} \right)^2 \tag{33}$$

$$\varepsilon'' = \frac{BC - AD}{A^2 + B^2} \cdot \left\{ 1 - \left(\frac{\lambda_0}{2a} \right)^2 \right\}, \tag{34}$$

where:

$A = 1 - S_1 S_2 tg(\beta \Delta x_1) tg(\beta \Delta x_2)$,

$B = S_1 tg(\beta \Delta x_1) + S_2 tg(\beta \Delta x_2)$,

$C = S_1 S_2 - tg(\beta \Delta x_1) tg(\beta \Delta x_2)$,

$D = S_1 tg(\beta \Delta x_2) \cdot S_2 tg(\beta \Delta x_1)$,

S_1, S_2 – SWR under short and free running conditions respectively;

$\beta = \frac{2\pi}{\lambda_w}$ – propagation constant in air-filled waveguide (λ_w — waveguide wavelength);

Δx_1, $\Delta x2$ – standing wave minimum shift with regard to the chosen reference plane at short and free running resepectively; in case of "half-infinite" layer $\Delta x_1 = \Delta x2$ and $S_1 = S_2$;

λ_0 – wavelength in free space;

$2a = \lambda_{cr}$ – critical wave length, where a – the waveguide width (the bigger cross-section side).

The block-diagram of proposed measuring stand is shown on Figure 6. The stand includes signal generator 1 (G4-79 (1,78-2,56 GHz) or G4-81 (4-5,6 GHz)), ferrite isolator 2, providing isolation ~ 20 dB, attenuator 3, waveguide measuring line 4, selective voltmeter 5 and waveguide section with the sample under analysis 6, at the end of which conditions of short and free running can be created with the help of piston 7 in turn. The voltage of SWR of such short is not worse than 30.

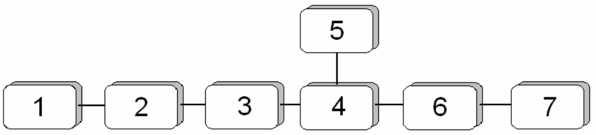

Figure 5. Block-diagram of the measuring stand for complex capacitivity research

Absolute measurement error ε′ is not more than 0.5.

The above-given measurements allow to obtain ε′ and ε″ value for different materials used indoor. In turn this allows to define the average absorption coefficient α value for such materials applying formulas (28-33). The resultant value allows to calculate time T (time Interflection) for the indoor processes.

IV. APPLICATION OF THE STATISTICAL THEORY AT CONSTRUCTION OF WIRELESS NETWORKS

The network using technology MIMO is required to optimize the magnitude T. Time T is calculated for given indoor by (22). Having received theoretical calculation results the wireless network practical research in indoor is carried out. We used the wireless network Radio Ethernet, making with standard equipment IEEE 802.11n usage. Router Linksys WRT610N, Netgear WNDR3700 and TRENDnet TEW-671BR are used as POP.

The research was carried out with method [8] and rate was measured by IxChariot (http://www.ixiacom.com).

TCP-traffic (with max size package mainly) is generated by the program and different situation as receiving, transmission and both synchronous(direction to adapter in PC) is modeling.

POP (Depending from model no all point was available) is set to operate with 802.11n range on channel 1(5) in regime «40 MHz», previous generation network security regime was switched off, ciphering WPA2-PSK whit c AES algorithm was switched on. Others setting were standart.

That network works sufficiently stable should take into account, as data transmission rate negligible changed during all test. After first examination cycle we did indoor treatment, placed supplementary elements with high reflection property. These elements placed behind POP and along radio wave diffusion trace. To avoid the standing wave reflection element planes placed by different angle to each other. Time T increased from 210 ns to 390 ns according to calculation results. Increase time T more 400 ns isn't recommended, as "guard time" can by overdraw and require result isn't archived.

Test results are shown on Figures 6, 7, 8, 9.

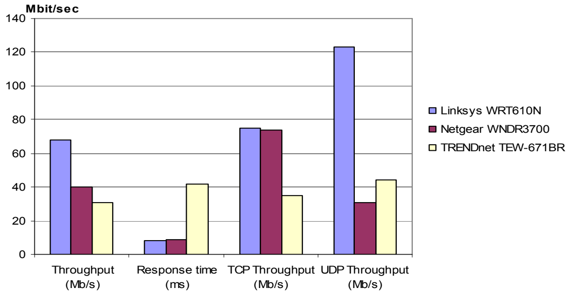

Figure 6. 2.4 GGz before processing

In the range 2.4GGz we received max rate in transmission regime UDP (about 123 Mbit/s) for POP Linksys WRT610N. Throughput is a twice less – on the order of 68 Mbit/s.

The second indicator in the POP Netgear WNDR3700. Worst performance in terms of in the POP TRENDnet TEW-671BR.

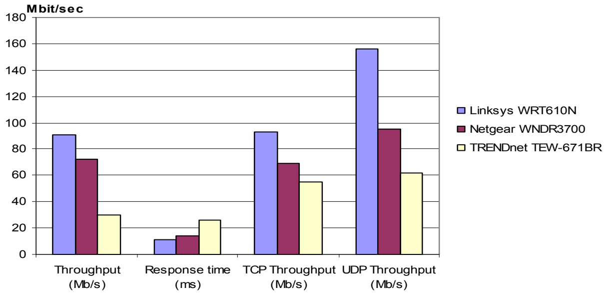

Figure 7. 5 GGz before processing

In the range 5GGz we received max rate (about 156 Mbit/s) for POP Linksys WRT610N. Response time of less is better, 11 ms for POP Linksys WRT610N.

After processing premises speed increased by 10-15%.

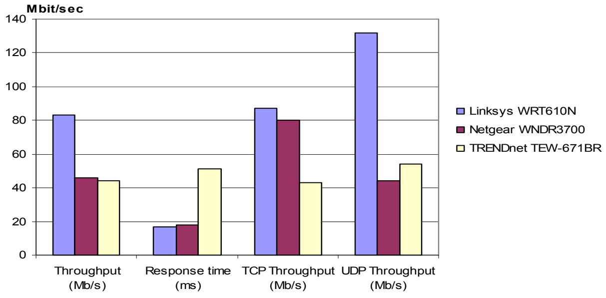

Figure 8. 2.4 GGz after processing

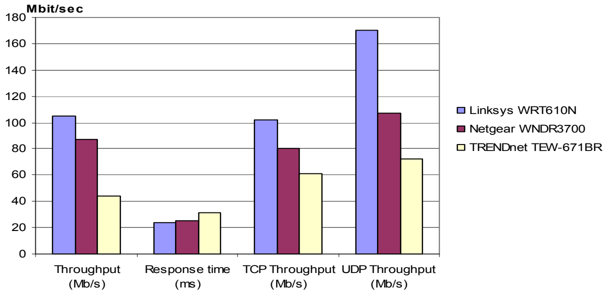

Figure 9. 5 GGz after processing

CONCLUSIONS

In section 2 we developed a statistical theory in result of the mathematical analysis of radio wave propagation in a room. Statistical theory of propagation in a room to determine interfleksion time during which the level of interference noise is reduced to the permissible ratio of NSR values. In Section 3 we proposed a method for finding the dielectric constant materials. Using the theory [6] we were able to find the various materials radio waves absorption coefficients used in buildings. Knowing these values by (23,24), we calculated the interfleksion time for a particular room. . a special treatment, which increases the value with the value 210 ns to a value of 390 ns, is held to ensure the regime of radio waves multiple reflection from the surfaces of the room. Treatment included the location of the additional elements with high reflective properties. Such elements are located beyond the access point and along the propagation. In order not to set up standing waves, the plane of the reflecting elements have not been parallel, they was at various angles to each other. Increased time interflection to 400 ns, we do not recommend, since it can lead to problems with the guard interval.

With this program IxChariot we simulated different situations: reception, transfer, simultaneous transmission and reception (direction - with respect to the adapter to a PC) with the packages mainly the maximum size. The comparison was performed on 4 basic parameters: Throughput (Mbs), Response time (ms), TCP Throughput (Mbs), UDP Throughput (Mbs). Speed was estimated by the maximum value, Response time -to the minimum value. The maximum speed of 170 Mbs was reached at a frequency of 5GHz mode UDP Throughput with using a router Linksys WRT610N. In the 5GHz range devices creating noise is less than in the 2.4 GHz range, so a top speed is managed to achieve only in 123 Mbs in this range. In general, the increase in the rate was 10-15% compared with the rate in the room, not being processed.

The experimental results are consistent with the developed theory. The theory may be used to improve the performance of a wireless network for 802.11n in the room.

Further, our work will focus on establishing a program to perform calculations according to advanced theories and experimental works on the transfer of video and audio wireless client.

The statistical theory of radio-waves distribution in indoor allows to define time interflection T achievements of demanded parity SNR. The Indoor after-treatment processing is carried out by selection in large area extent indoors with small factor of absorption for demanded technology MIMO interference noise level achievement. These surfaces are placed to increase T in wireless clients place.

Mentioned above method usage allows to increase data transmission rate in the indoor at wireless network design.

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