THE BENEFITS OF IEEE 802.11AC STANDARD: COMPARISON WITH 802.11N WIRELESS NETWORK AND EXPERIMENTAL INVESTIGATIONS FOR REAL-TIME SERVICE TRANSMISSION

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Abstract

Today's users want to be connected to a wireless network not only at home, but in any place at any time. Due to this, the users' demands on the mobility, data security and the Quality of Services (QoS) are increasing rapidly. Wireless networks are good choice for the users' mobility, however it have a number of disadvantages, as the limited network's bandwidth, the problems of data security and the pollution of the radio ether. That is the reason for use a more flexible and more adaptable wireless network, based on a relatively new Wi-Fi standard - IEEE 802.11ac. The wireless network over 802.11ac standard is more advanced due to the extended coverage of the radio signals and improved network's bandwidth. According to this, the authors compared 802.11ac with 802.11n by the network's parameters of these standards (the throughput, the signal level) in different conditions. In order to evaluate the benefits of IEEE 802.11ac wireless network to the transmission of the telecommunication services the authors created an experimental wireless network over 802.11ac standard and investigated the quality parameters of Voice over Internet Protocol (VoIP) as a Real-time service. The impact of the transmission of Non Real-time services (video streaming, FTP and HTTP) as an additional network traffic during the transmission of VoIP service was investigated also. The results of these investigations and the conclusions, based on the simulation and experimental investigations in the wireless networks over different 802.11ac and 802.11n standards, are presented in this paper.

1. INTRODUCTION

Currently, the real-time services and the wireless networks (Wi-Fi) are very popular and widely used [1,2]. However, these real-time services have very strict requirements for their quality characteristics [3]. The latter are directly dependent on the channel bandwidth. This problem was solved with the new next generation 802.11ac standard [4-6]. IEEE 802.11ac wireless standard is able to provide a theoretical data rate of 3.5 Gbps with the channel width of 160 MHz for 4 streams at 256-QAM modulation. This is indeed an impressive speed compared to the 802.11n standard, which is currently widely in use now [7]. IEEE 802.11n standard provides a maximum theoretical data rate of 1.3 Gbps.

In order to compare the 802.11n and 802.11ac wireless standards in theoretical and practical view, the simulation and experiments of it throughput, the signal strength are presented in this paper. Then, to make sure that the 802.11ac standard is able to transmit multiple streams of a real-time service, the authors carried out the experiments, which investigate the quality of VoIP service, continuously increasing the number of active TCP sessions in the network. The results of these investigations and the conclusions are presented in this paper.

2. COMPARATIVE ANALYSIS OF SIMULATED PARAMETERS OVER IEEE 802.11N AND 802.11AC WIRELESS NETWORKS

In order to evaluate the possibility of the user as a mobile user of a wireless network, it is necessary to compare two different IEEE 802.11n and 802.11ac standards in accordance to their signal coverage and throughput. The authors used *Ekahau Site Survey* software tool for the simulation of throughput and received signal strength in the wireless networks based on 802.11n and 802.11ac standards. The selected access point (AP) is working on 802.11n and 802.11ac standards in 5GHz frequency band. The simulation was done in LOS (Line of Sight) and NLOS (Non-Line of Sight) conditions of the wireless networks. It has been used the wall of a 20 cm thick in NLOS conditions. The comparison of the throughput by using the different wireless standard is presented in Figures 1 and 2.

The average simulated throughput is 280 Mbps in LOS conditions (Fig. 1). The average simulated throughput is 150 Mbps in NLOS conditions, when the distance from access point to the user was 6 m. If the user is 40 m away from the AP (NLOS conditions), the average simulated throughput is 60 Mbps.

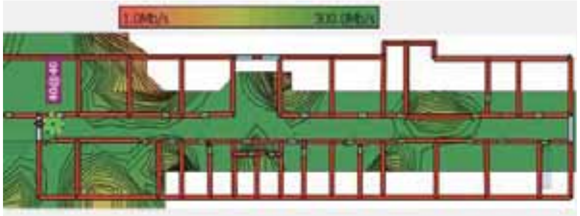

Fig. 1. The simulated throughput in the 802.11n wireless network

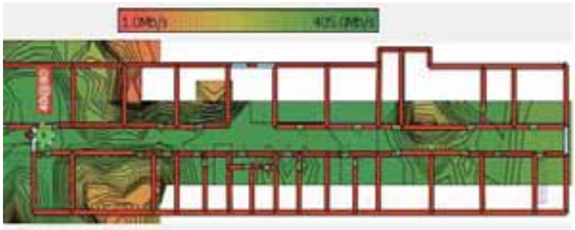

Fig. 2. The simulated throughput in the 802.11ac wireless network

The results from the 802.11ac throughput simulation (Fig. 2) showed that the average throughput is 350 Mbps in LOS (Line of Sight) conditions. In this case, the distance from AP to the user was 1 m. Due to this the simulated throughput in the 802.11ac wireless network is 43% bigger than the throughput in the 802.11n network.

As the user quite often uses Wi-Fi in NLOS conditions, the 802.11ac standard is more effective in this way also. The average throughput is 250 Mbps in NLOS (Non-Line of Sight) conditions, when the distance from access point to the user was 6 m, and 65 Mbps, when the distance was 40 m. That means the simulated throughput in 802.11ac network differences in 120 Mbps, when the distance is 6 m, and in 5 Mbps, when the distance is 40 m.

The signal strength is the most basic requirement for a wireless network, because low signal strength means unreliable connection and/or low data throughput. The simulated signal strength in 802.11n and in 802.11ac wireless networks is presented in Figures 3 – 4.

According to the results in Figures 3, 4 it can be stated, that the signal strength in 802.11ac wireless network is more influenced by the obstacles (walls, partitions, etc.) than in 802.11n. This is because of the channel bandwidth, used in 802.11n [8].

Due to the results from the simulations, the 802.11ac wireless network provides 3 times faster connection than 802.11n, but its signal strength is more influenced by the obstacles.

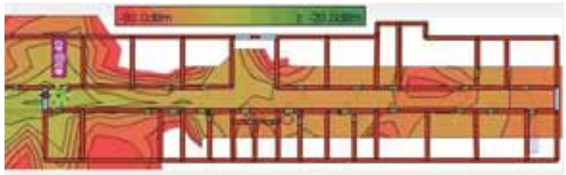

Fig. 3. The simulated signal strength in the 802.11n wireless network

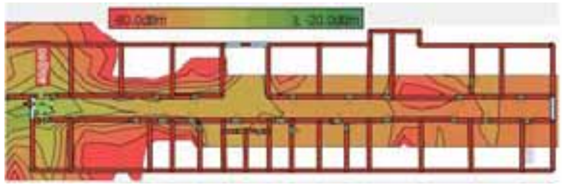

Fig. 4. The simulated signal strength in the 802.11ac wireless network

3. EXPERIMENTAL INVESTIGATIONS FOR THE THROUGHPUT EVALUATION OVER IEEE 802.11N AND 802.11AC WIRELESS NETWORKS

After the simulations, it is necessary to investigate the parameters of the wireless networks based on 802.11n and 802.11ac standards. The experiments were carried out in the 4th floor of the building at Kaunas university of technology, Department of Telecommunications. Its layout corresponds to the scheme, used during the simulations. The structure of the experimental network and LOS/NLOS conditions is presented in Figure 5. The parameters, which were investigated: the throughput and the signal strength. The results of the investigated throughput of 802.11n and 802.11ac wireless networks in NLOS conditions are presented in Figures 6, 7. The results in Figure 8 show the ratio of the throughput between the different standards in accordance to the signal strength.

According to the results of the investigated throughput in NLOS conditions, it can be seen, that the distance between the AP and the user influences the throughput of 802.11ac wireless network. In this case, the average throughput of 802.11ac wireless network is 281 Mbps in 6 m distance and only 45 Mbps in 40 m distance. The average throughput of 802.11n wireless network is only 7% less in the distance of 40 m from AP.

The ratio of the investigated throughput between the different standards shows that the investigated throughput differences in ~ 4 times if the received signal strength indication (RSSI) is -65 dBm. In this case, the signal strength of 802.11n wireless network in NLOS conditions is more appropriate for the wireless connections.

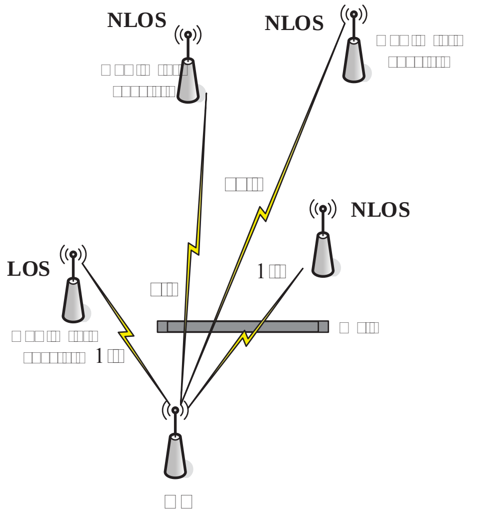

Fig. 5. The structure of the experimental network and its LOS/NLOS conditions

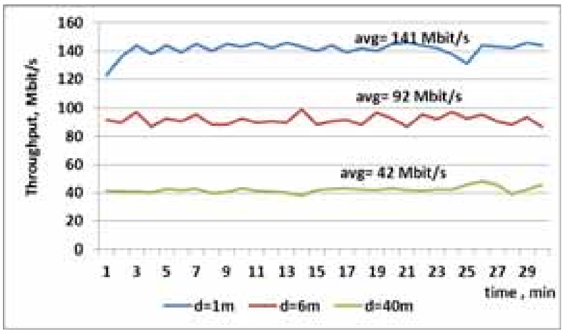

Fig. 6. The investigated throughput of 802.11n wireless network in NLOS conditions

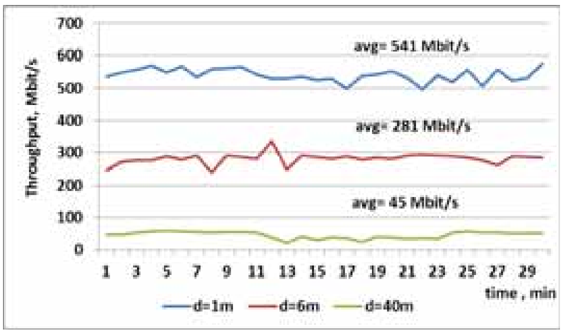

Fig. 7. The investigated throughput of 802.11ac wireless network in NLOS conditions

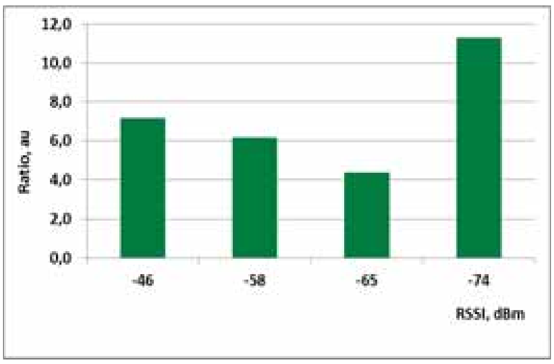

Fig. 8. The ratio of the investigated throughput between the different standards

The investigated throughput of 802.11ac wireless network in LOS conditions is presented in Figure 9.

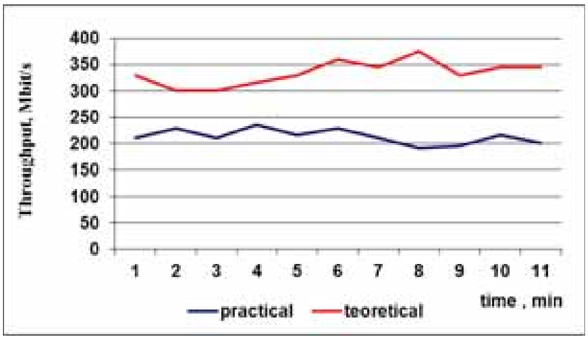

Fig. 9. The comparison of 802.11ac throughput in LOS conditions

Its comparison with the results from the simulations is presented also in this Figure. It can be seen, that the investigated 802.11ac wireless connection is 1.5 times faster than the simulated.

In order to evaluate the 802.11ac throughput in realistic conditions, it is necessary to investigate the impact of traffic load on it (Fig. 10).

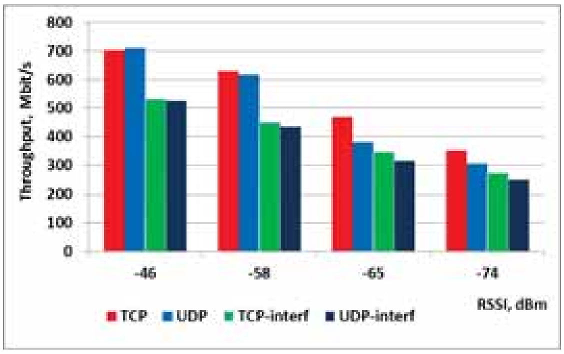

Fig. 10. The influence of the traffic load to the 802.11ac throughput

According to the results in Figure 10, if the signal strength is falling and there are the additional loads in the network TCP (*Transmission Control Protocol*), UDP (*User Datagram Protocol*) sessions) the throughput of 802.11ac wireless network can be reduced in 2 times. However, even the throughput can be reduced the wireless network of 802.11ac standard provides access to a faster Wi-Fi connection than 802.11n.

4. THE EXPERIMENTAL EVALUATION OF VOIP QOS OVER IEEE 802.11AC WIRELESS NETWORK

The broadcasting of Real-time services, such as VoIP, depends on the quality of the communication process over wireless connection and its continuity.

The throughput, the packets' delay and loss, the signal level are the main QoS parameters for VoIP service transmission over wireless network. Due to this, the experimental investigations were carried out in order to evaluate the QoS parameters of VoIP service transmission over 802.11ac wireless network. The structure of the experimental 802.11ac wireless network is presented in Figure 11.

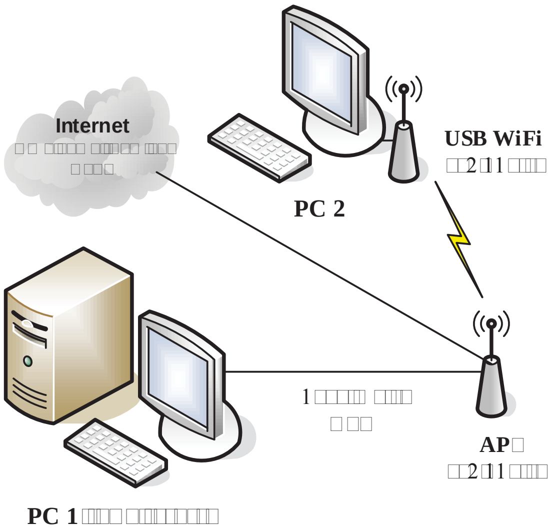

Fig. 11. The structure of the experimental network

This experimental 802.11ac wireless network consists of two computers, both of them were working as a VoIP users, and the wireless access point (AP). The model of the access point was D-Link DIR 850L, which is working on 802.11n and 802.11ac standards. It has four MIMO antennas and dual band (2.4 GHz; 5 GHz) performance up to 1167 Mbps. The measurements were made using *Jperf 2.0.2v, InSSIDer, SJ Phone, Wireshark 1.12.0 Network Analyzer software*. G.711 voice codec was used for VoIP service transmission. The distance from AP to the user was 1 m.

The experimental investigations have been carried out for three different scenarios. At first, only VoIP calls were made in the experimental 802.11ac network without any additional traffic in the network. The results for the delay and the jitter of VoIP service transmission over IEEE 802.11ac wireless network are presented in Figure 12 and Figure 13. According to the results in these Figures, it can be stated, that Voice over IP transmission in 802.11ac wireless network is performed with a high quality, if there is no any additional traffic in the network.

The average delay of VoIP packets was 45.56 ms and the average jitter – 13.44 ms, the loss of VoIP packets – 0 %.

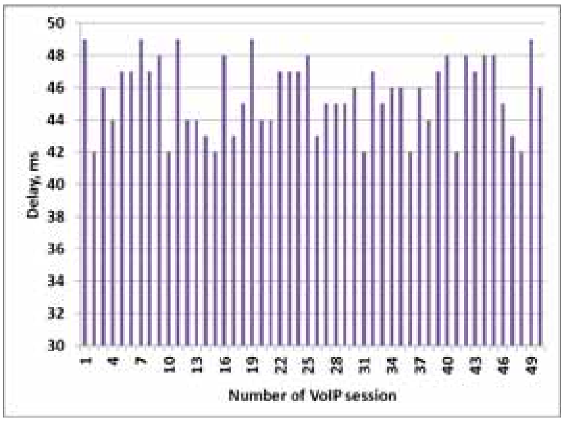

Fig. 12. The delay of VoIP packets transmission over 802.11ac network

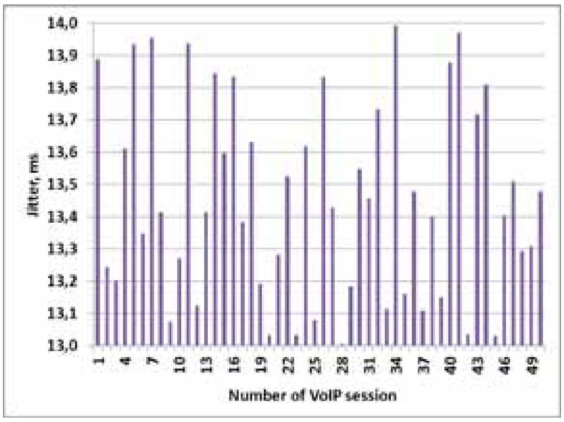

Fig. 13. The jitter of VoIP packets transmission over 802.11ac network

The transmission of VoIP service with the additional traffic over the 802.11ac network was done during the second and the third scenarios. The additional traffic (for the second scenario) was created from the HD (High Definition) video and FTP (File Transfer Protocol) transmissions to the VoIP user (PC2 in Figure 11) at the same time, when VoIP calls were made.

The results of the QoS parameters for VoIP service during the second scenario are presented in Figures 14 - 16.

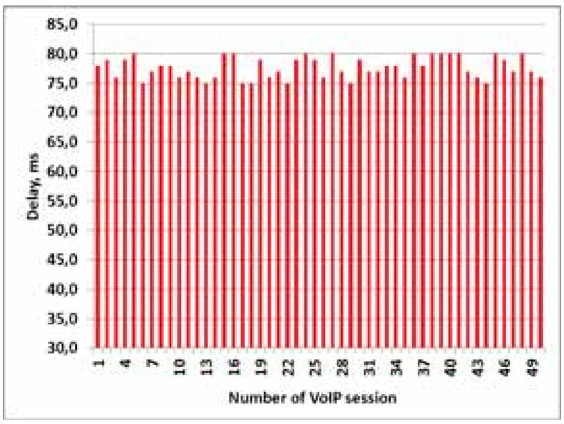

Fig. 14. The delay of VoIP packets transmission with the additional video/FTP traffic over 802.11ac network

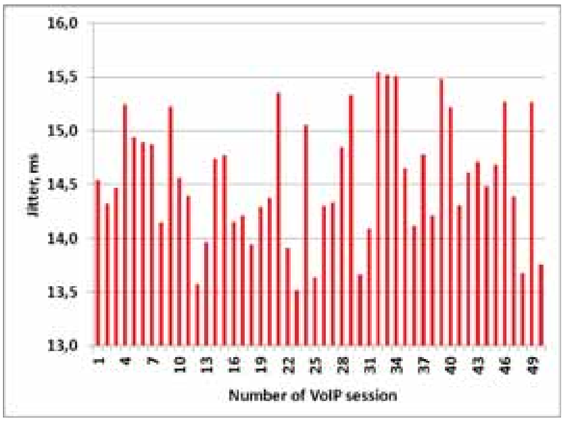

Fig. 15. The jitter of VoIP packets transmission with the additional video/FTP traffic over 802.11ac network

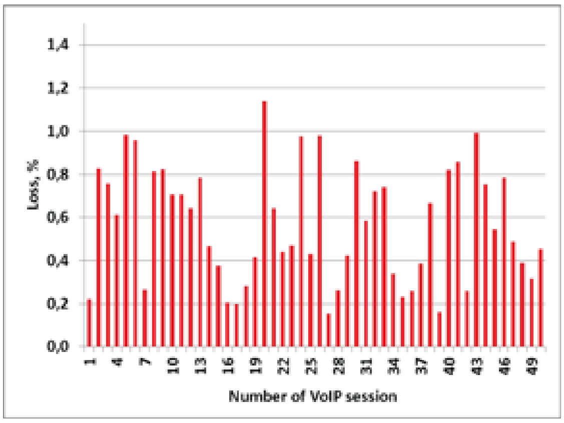

Fig. 16. The loss of VoIP packets transmission with the additional video/FTP traffic over 802.11ac network

The results of the investigations during the second scenario showed, that the additional traffic over 802.11ac wireless network influences the quality of VoIP service. However, such influence was observed only to minor changes in the voice calls, which the user felt as a voice jerking. In this case the average delay of VoIP packets was 77.6 ms and the average jitter – 14.7 ms. The loss of VoIP packets was 0.7 %.

The additional traffic from the HD video, FTP and HTTP (Hyper Text Transfer Protocol) transmissions was created to the VoIP user at the same time, when VoIP calls were made during the third scenario. The results of these investigations are presented in Figures 17 – 19.

As it seen from the results in Figures 17–19, the transmission of VoIP service is affected by the additional video/FTP/HTTP traffic, because the average loss of VoIP packets is 2 %. Such loss of VoIP packets value exceeds the recommended limit of 1 % accord to the ITU-T G.711 recommendation. The average delay of VoIP packets was 229 ms and the average jitter – 16.23 ms. In this way, the user felt many negative things, like voice jerking or echo, however the transmission of VoIP service was not braked. So generally, the IEEE 802.11ac standard allows the transmission of VoIP service over the wireless network.

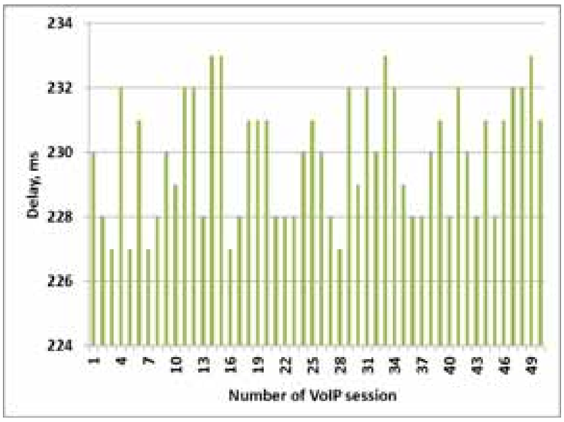

Fig. 17. The delay of VoIP packets transmission with the additional video/FTP/HTTP traffic over 802.11ac network

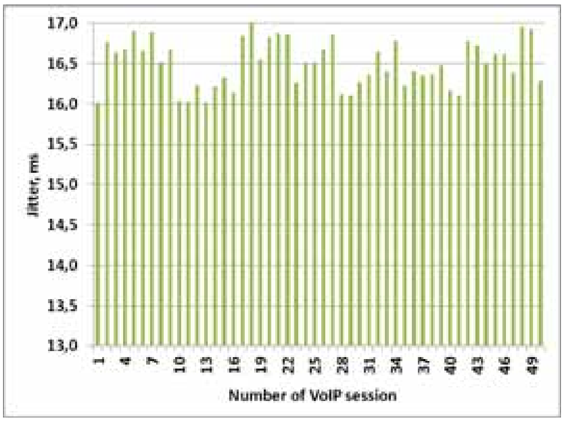

Fig. 18. The jitter of VoIP packets transmission with the additional video/FTP/HTTP traffic over 802.11ac network

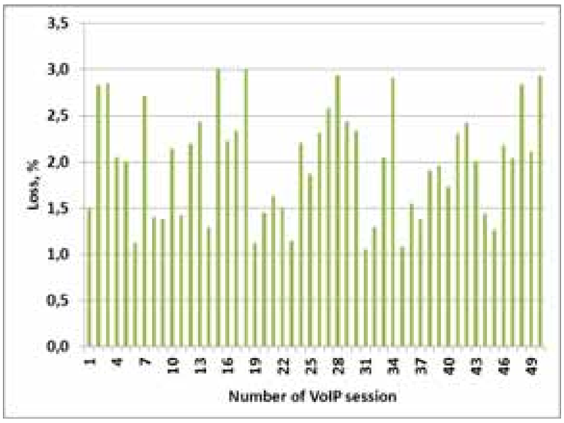

Fig. 19. The loss of VoIP packets transmission with the additional video/FTP/HTTP traffic over 802.11ac network

5. CONCLUSIONS

In this paper, the authors investigated the IEEE 802.11ac wireless network and compared it with IEEE 802.11n. According to the obtained results, it can be stated, that the 802.11ac wireless network provides 3 times faster connection than 802.11n, but its signal strength is more influenced by the obstacles.

The investigation of the VoIP QoS over 802.11ac showed that VoIP transmission is performed with a high quality, if there is no additional traffic in the network. The additional traffic as HD video, FTP and HTTP in the 802.11ac network influences the average loss in 2 % for VoIP packets.

References

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