UDC 621.391 + 621.37

Determination of the Range of the Guaranteed Radio Communication in Wireless Telecommunication Networks of IEEE 802.11 Standard with the Use of Ping Program

Irina A. Gudkova*, Oksana N. Romashkova†, Vyacheslav E. Samoylov‡

* *Department of Applied Probability and Informatics*
Peoples' Friendship University of Russia (RUDN University)
6 Miklukho-Maklaya st., Moscow, 117198, Russian Federation

† *Department of Applied Informatics*
Moscow City University (MCU)
4/1, 2nd Selskokhozyajstvennyj passage, Moscow, 129226

‡ *Department of Automatic Equipment, Telemechanics and communication on railway transport*
Russian University of transport (MIIT)
9/9, Obraztsova str., Moscow, Russian Federation, 127994

Email: gudkova_ia@rudn.university, ox-rom@yandex.ru, samoilov.1992@list.ru

The article discusses the data transmission quality in wireless telecommunication networks developed according to IEEE 802.11 standard, which are important for design, installation and further operation of the networks. In particular, attention is paid to determining the range of guaranteed radio communication and the probability of packet loss. It is proposed to use the ping program as a method of determining the range of guaranteed radio communication and the probability of packet loss for IEEE 802.11 standard routers. The program allows to approximate the conditions of data transmission to real conditions, and, working for a long period of time, allows to determine the probability of packet loss. One of the advantages of the method proposed in the article is its availability in use, as no special equipment is required. In addition, the article presents the results of comparison of the quality of data transmission evaluation obtained by the proposed method with the data of technical documentation for equipment. This fact confirms the adequacy and accuracy of the proposed method. During the testing of the equipment, information about the number of sent, received and lost packets in the radio channel under study will be obtained, in addition, the average value of the delay in the transmission of data over the channel will be determined. The scope of application of the considered method for determining the range of guaranteed radio communication in wireless telecommunication networks of IEEE 802.11 standard is also proposed. An example of using the method is building a network coverage map or creating a database with the technical characteristics necessary for the design of local telecommunication networks with wireless access.

Key words and phrases: the range of guaranteed radio communication, wireless telecommunication networks, the probability of losing packets.

In: K. E. Samouylov, L. A. Sevastianov, D. S. Kulyabov (eds.): Selected Papers of the VIII Conference "Information and Telecommunication Technologies and Mathematical Modeling of High-Tech Systems", Moscow, Russia, 20-Apr-2018, published at http://ceur-ws.org

1. Introduction

It is often necessary to test the technique to determine the quality of network access services at a distance from the access point at the process of designing and operating IEEE 802.11 wireless LAN networks [1–5]. Testing of a wireless router can be either preliminary (on a laboratory stand) or current (during network operation) [4–9]. In both cases the most simple and quick solution is to use the built-in Windows ping utility.

2. The concept of guaranteed radio communication area for modern telecommunication networks with wireless access IEEE 802.11 standard

In the process of designing a new local telecommunication network with wireless access, an important issue is the exact location of wireless access points, since the quality of services provided by the network and the speed of the handler process depends on the fact whether the location of the wi-fi point is chosen correctly. This question is particularly relevant in the case of building a local wireless telecommunications network with a given speech transmission quality [6, 10–17]. In order to find the answer to these questions it is necessary to know the exact value of the range of the guaranteed radiocommunication of the equipment.

First of all, it is necessary to introduce the concept of guaranteed radio communication for IEEE 802.11 standard modern telecommunications networks with wireless access. It is well known, that multitraffic is passed in modern IP networks, which is usually "split" for video traffic, voice traffic and data transmission. Therefore, the area of guaranteed radio communication is limited to a line, each point of which is far away from the base station, and at the same time it meets the minimum required transmission quality requirements for all types of traffic. The requirements for the quality of transmission over communication channels for each type of traffic have their own characteristics. Accordingly, the area of guaranteed radio communication is limited to the most stringent requirements applicable to one of the three types of traffic. The most sensitive of these types of traffic is voice traffic, so we use the requirements for speech transmission over IP networks as a requirement to limit the area of guaranteed radio communication.

There are two methods, most common for assessing the quality of speech transmission in modern packet telecommunication networks: the method of subjective assessment of the quality of speech transmission MOS (Mean Opinion Score) and E-model. We would like to draw attention to the method of objective assessment of speech quality – E-model. This method is governed by ITU-t G. 107 recommendation. The E-model is a common model for assessing the quality of speech transmission in networks. The main task of the method is to find the values of the parameter called R-factor. R-factor is an integral index of speech transmission, calculated by the specified parameters of the speech path, taking into account its configuration [21].

The method of calculation of the R-factor takes into account the following features of speech:

1. the appearance of speech packets loss in the transmission of speech in the network with packet switching, due to the increase in the transmission delay time;
2. use of codecs of different types in the network. The use of low-speed codecs, such as G723, G729, etc., can result in packet loss and transmission delays. The use of low-speed codecs allows you to increase the bandwidth of the network, but it significantly reduces the quality of the voice signal compared to the case of high-speed codecs, such as G. 711, G. 726-32, etc.
3. speech transmission between two subscribers or group call support;
4. the use of voice activity detectors VAD (Voice Activity Detection) in the network, which allows to detect voice activity when a signal occurs and separate speech from noise [21].

These features have a different effect on the signal delay time, which creates inconvenience due to overlapping conversations and the occurrence of echo. The effect of delay becomes critical when its value in one transmission direction exceeds 250 ms [21].

When calculating the R-factor, it is possible to localize the following causes and places of delays in the formation, transmission and processing of speech packets in the conversation: in the codec (encoder or decoder), in the receive or transmit buffer, in the summator, in the adaptation module, in the IP network, in the switch [21]. Most of the coefficients used in the calculation are determined by tables, because they depend on the type of codec used or the type of technology used. However, you cannot use the table to determine the probability of packet loss in a speech path because this characteristic depends only on the properties of the communication channel. To sum it all up, it can be said that the boundary of guaranteed radio communication area will vary depending on the change in the probability of packets loss at different points.

3. Determination of the range of the guaranteed radio communication

It is proposed to use the following scheme of testing equipment to determine the range of the guaranteed radiocommunication using the ping program (see Fig. 1). You need to take two laptops (one used as a server, the other as a client) and a router supporting one of the IEEE 802.11 b/g/n wireless transmission standards.

Figure 1. Connection diagram of equipment for testing

The router configuring and a wireless LAN creating are done through the web interface of the router. In order to do this, you need to connect the router to the first laptop using a cable with a connector of standard RJ 45, called “twisted pair”, and then connect to the IP address of the router by default using a browser. In our case, Wi-Fi router Asus Rt-N12 with a standard IP address by default-192.168.1.1 is used. Then it is necessary to connect the second laptop to the created local network. In order to do this, it is required to check the operation of the PC2 wi-fi adapter, select the local wireless network created by the router, enter the appropriate username and password. The exchange of packages is checked after connecting the laptop to the network.

Afterwards, it is necessary to customize your ping on the first laptop: you should open the Execute task window using the win+r shortcut, enter the cmd command, and then open the command window. It is necessary to enter a command on the opened command window to start the ping utility. Ping program has several different parameters that affect the principle of its operation. In order to test wireless routers, you need to bring the transmission conditions closer to the real ones. Therefore, Ethernet packets with data must be sent to the router. Accordingly, the ping utility must constantly form a packet size of 1 kb. In our case, this command is as follows: `ping [router ip address] -l 1000 -t`. With this command we create a packet size of 1000 bytes that will be transmitted from PC1 to PC2 and back again until we enter the command `Ctrl+C`.

The program runs for a long period of time, sufficient to fully estimate the probability of losing packets. After that, the program is stopped by a certain combination of keys. In our case, the program has a sufficient duration of 20 minutes. In other words, the program must transfer 1000+ packets. At the end of the program work we will see information about the number of the packets sent, received and lost, in addition, we will know the average value of the delay in the transmission of data through the channel. After the end of the program and the probability of loss of packets for this point, the distance between the router and the receiving laptop increases. Testing is repeated for multiple points to obtain the average probability of packet loss. It is assumed to

start with a distance of 5 m between PC1 and PC2 and increase by 5 m for a more accurate result. In addition, a fundamental condition for this type of testing is to perform measurements in conditions of direct radio visibility, since various obstacles between PC1 and PC2 can lead to less accurate values.

4. The results of a wireless LAN standard IEEE 802.11 testing

The following results were obtained during the testing of the section of the experimental telecommunications network with wireless access of IEEE 802.11 standard (see Tab. 1).

Table 1

The results of a wireless LAN standard IEEE 802.11 testing

The distance between PC1 and PC2, m	The number of packets sent	The number of packets lost	The average latency of transfer and acceptance, ms
5	1168	19	330
10	1219	12	323
15	1306	3	338
20	1167	23	330
25	1179	3	334
30	1203	7	339

Measurements were carried out at 6 different points at a distance between PC1 and PC2 – 5 m, 10 m, 15 m, 20 m, 25 m and 30 m. In the following, as an example, we present the result of one point processing using the ping program (see Fig. 2). Figure 2 shows the statistics that are generated after the test packets are transmitted. You can see the number of packets sent, the number of packets received, the number of packets lost, the minimum time for receiving and transmitting one test packet, the maximum time for receiving and transmitting one test packet, and, accordingly, the average time for one test packet receiving and transmitting.

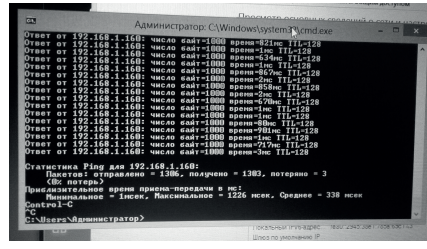

Figure 2. Test results at one point

In order to generate the guaranteed radiocommunication segment parameter value let's carry out the averages calculation: the average latency of transfer and acceptance transmission for 6 experiments — 332,33 ms; the average number of packets sent – 1207 PCs; the average number of packets lost for 6 experiments — 11; the percentage of

losses for 6 experiments is 0.91%.You should pay attention to the fact that the average value of the transmission delay in one direction is 165 ms. Estimation the probability of packet loss in the range of 1-3% and the average value of the transmission delay in one direction within 250 ms, indicates a good quality of speech transmission over the channel.

5. The scope of application of the proposed method

Considering the fact that the proposed method is simple and requires no special equipment, there are other areas of potential use.

1. The use of the proposed method makes it possible to obtain not only a zone of guaranteed radio communication for a particular equipment, but also the correspondence of the probability of packet loss on distance.
2. Testing a large amount of equipment for wireless access will allow you to create a database with the technical characteristics required for the design of local telecommunications networks with Wi-Fi access and a given speech transmission quality [1–5].
3. The use of additional software will provide additional information about the network, for example the use of such software as Acrylic Wi-Fi Home allows you to receive the level of received signal in dB, which allows you to build a sheet of the real radio network coverage, which is largely different from the calculated radio coverage obtained by statistical design methods [18].
4. Using this method in real conditions allows to get a picture of real radio coverage based not on the level of transmitted signal, but on the quality of services, which in turn carries more information load, because, for example, the construction of networks with a specified quality of speech transmission requires the following – the probability of packet loss does not exceed a certain value at each point of the network [6–8, 15–20].

In addition, the use of laptops as a server and client brings test conditions closer to the real conditions in which computers or smartphones usually act as network subscribers.

6. Conclusions

Summing it all up, it is necessary to mention that the method proposed in the article is effective and adequate. The comparison of technical parameters of the router given in technical documentation with the parameters received in the conditions of testing can serve as the certificate of its adequacy. According to the data stated in the router technical documentation, under the conditions of direct radio visibility, wi-fi router Asus Rt-N12 provides data transmission to a distance of 30 m with a probability of packet loss of 1-3%. As shown earlier at a distance of 30 m between PC1 and PC2, the probability of packet loss does not exceed 1%. In turn, the effectiveness of the method is confirmed by its simplicity, reliability and a wide range of possible applications.

References

1. G. V. Gorelov, V. E. Samoylov, S. A. Markachev, I. L. Popov, Measurement of the parameters of the 2.4 GHz band radio channel with the exception of the influence of multipath propagation, Modern problems of science and education, no. 1 (2015), in Russian.
2. O. N. Romashkova, V. E. Samoylov, To the definition of the quality of packet speech in mobile communication networks, High-Tech technologies in space exploration of the Earth **9** (3) (2017) 39–44, in Russian.
3. O. N. Romashkova, E. V. Dedova, The survivability of wireless networks in an emergency situation, T-Comm **8** (6) (2014) 40–43, in Russian.

4. G. V. Gorelov, O. N. Romashkova, A. A. Gitnov, Distortions of the energy spectrum of speech message using the Voice Over Wi Fi technology, Telecommunications, no. 1 (2011) 10–12, in Russian.
5. O. N. Romashkova, R. I. Yakovlev, The analysis of models and methods for an assessment of survivability of infokommunication networks in the conditions of emergency situations, T-Comm **6** (7) (2012) 165–170, in Russian.
6. Y. Orlov, D. Zenyuk, A. Samuylov, D. Moltchanov, Y. Gaidamaka, K. Samouylov, S. Andreev, O Romashkova. Time-dependent sir modeling for D2D communications in indoor deployments, Proceedings — 31st European Conference on Modelling and Simulation, ECMS, 2017, 726–731.
7. G. V. Gorelov, N. A. Kazanskii, O. N. Lukova, Communication quality assessment in speech packet transmission networks with random service interrupts, Automatic Control and Computer Sciences **27** (1) (1993) P. 62.
8. G. V. Gorelov, O. N. Romashkova, Influence of russian, spanish and vietnamese speech characteristics on digital information transmission quality, IEEE International Symposium on Industrial Electronics Proceedings of the IEEE International Symposium on Industrial Electronics, ISIE'96. Part 1 (of 2). sponsors: IEEE, Warsaw University of Technology. Warsaw, Poland, 1996, 311–313.
9. A. A. Drozdova, A. I. Guseva, Modern Technologies of E-learning and its Evaluation of Efficiency, Procedia — Social and Behavioral Sciences **237** (2017) 1032–1038.
10. V. S. Kireev, Development of fuzzy cognitive map for optimizing e-learning course, Communications in Computer and Information Science **706** (2017) 47–56.
11. V. Kireev, A. Silenko, A. Guseva, Cognitive competence of graduates, oriented to work in the knowledge management system in the state corporation "Rosatom", Journal of Physics: Conference Series **781** (1) (2017) 012060.
12. A. Adamu, Y. Gaidamaka, A. Samuylov, Discrete Markov chain model for analyzing probability measures of P2P streaming network, Lecture Notes in Computer Science **6869** (2011) 428–439.
13. V. Y. Borodakiy, K. E. Samouylov, I. A. Gudkova, P. O. Abaev, I. A. Buturlin, Sh. A. Etezov, Modelling a random access channel with collisions for M2M traffic in LTE networks, Lecture Notes in Computer Science **8638** (2014) P. 301.
14. D. Danaiata, A. Negovan, L. Hurbean, Accepting information technology changes in universities — A research framework, 15th International Conference on Informatics in Economy **273** (2016) 55–69.
15. O. N. Romashkova, S. V. Cheskidov, P. A. Frolov, Improvement of information technologies of the decision of problems of management in economic systems, Modern high technologies no. 10 (2017) 63–67, in Russian.
16. O. N. Romashkova, G. V. Gorelov, V. I. Osnitsky, K. S. Trusov, Compounding of speech communication on the recommendation of ITU-T G.711 of the International Telecommunication Union, Modern problems of science and education, no. 1 (2015), in Russian.
17. O. N. Romashkova, I. L. Popov, Methods of ensuring survivability of mobile radio networks in emergency situations on railway transport, Science and technology of transport, no. 3 (2016) 67–73, in Russian.
18. O. N. Romashkova, T. N. Ermakova, Improving the data flows management in the educational complex, Ryazan, Vestnik of RSTU, no. 57 (2016) 82–86, ISSN 1995-4565, in Russian.
19. O. N. Romashkova, V. I. Zykov, I. L. Popov, Secure location of base stations of mobile communication network. Determination of the handover zone in cellular communication networks in emergency situations, Fires and emergencies: prevention, elimination, no. 1 (2017) 25–29, in Russian.
20. T. Kryshtab, R. K. Savkina, A. B. Smirnov, M. Kladkevich, V. Samoylov, Multi-band radiation detector based on hgcdte heterostructure, Physical Status Solidi (C) Current Topics in Solid State Physics, no. 7–9 (2016) 639–642.
21. Recommendation ITU-T G.107 – 2011 The E-model: a computational model for use in transmission planning. – 18 p. [Electronic resource].