UDC 621.391

RESEARCH OF LOW-BANDWIDTH RADIONETWORKS QOS PARAMETERS

Irina V. Strelkovskaya , Roman V. Zolotukhin

O.S. Popov Odesa National Academy of Telecommunications, Odesa, Ukraine
Educational and Research Institute of Infocommunications and Software Engineering

Background. This article describes the research of QoS parameters in low-bandwidth communication networks based on VHF (Very High Frequency) radio stations produced by Aselsan (Turkey) and Harris (USA).

Objective. The aim of the paper is the research of data transfer delay, jitter of data transfer delay, packet losses and analysis of the possibility of different data traffic types to pass through VHF radio channels.

Methods. The program "iperf-v2.0.5", the system utility "ping" and the software "Packet Sender" were used to experimentally research the QoS parameters of low-bandwidth radio networks.

Results. The obtained data concerning the QoS parameters of low-bandwidth radio networks was applied to improve special software "DSS Telecard" of LLC «Telecard-Prilad». which resulted in the increase of maximum users number in the VHF radio networks by 60%.

Conclusions. The research of QoS parameters in VHF radio networks was performed and recommendations upon the operation in low-bandwidth radio networks were provided for the use in the “DSS Telecard” software of LLC «Telecard-Prilad».

Keywords: radio station; VHF; QoS; data transfer rate; jitter; packet loss; ping.

Introduction

The decrees of the President of Ukraine №555/2015 [1], №92/2016 [2], №240/2016 [3] state that the development of modern digital troop control systems in Ukraine is performed in the way of creating an automatic command and control system(C2) in accordance to NATO standards. Low-bandwidth radio communication networks based on VHF radio stations are the base part of the communication networks of the C2 system. Therefore, it is necessary to experimentally investigate the QoS of these radio networks and provide recommendations for their use.

The results of measurements of QoS in communication networks based on the VHF radio stations are considered in this article. It is also necessary to solve the main problems faced by the users and provide recommendations on the protocols and types of traffic that should be used in such communication networks.

Measurement and analysis of QoS parameters

The scheme shown in Fig. 1 was built to take the necessary measurements. It is valid for both the radio station VRC-9661 Aselsan and the radio station MHH-7850 Harris.

The program "iperf-v2.0.5" [4], the system utility "ping" [5] and the software "Packet Sender" [6] were used to check the performance of radio equipment. Radio stations were placed 100m apart, personal computers (PCs) and radio stations were connected to the routers via 100BASE-TX. Whip aerials were connected to radio stations. The power of radio stations was set to 1 W, the measurements were performed outdoors at a temperature of 14-15 °C, humidity 40% and a pressure of 756 mm Hg.

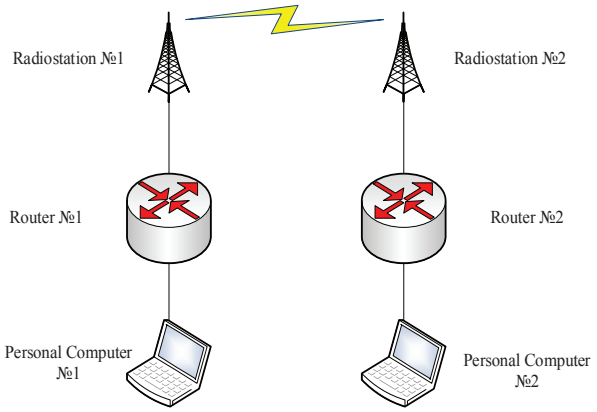

Fig. 1 Scheme of the communication network for measurement.

Radio stations support two similar modes of operation: narrowband and broadband.

In the first experiment the VRC-9661 radio station in the NBNR[7] narrowband mode is considered. The scheme for the experiment is shown in Fig.2. The client part of the software "iperf-v2.0.5" runs on PC-1, and the server part of "iperf-v2.0.5" runs on the PC-2. UDP datagrams [8] of 1470 bytes length were sent from PC-1 to PC-2. A fragment of the program with the results of measurements is shown in Fig.3. In order to measure losses in the channel from PC-1 to PC-2 "Packet Sender" was used. It transmitted UDP-datagrams of 200 bytes length every second during one hour. As a result, 22% of datagrams were lost.

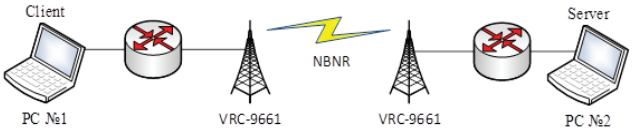

Fig. 2 Scheme of the experiment №1 with VRC-9661 radio stations in the "NBNR" mode.

After that, ICMP-requests were sent from PC-1 to PC-2 using the "ping" system utility during one hour. The following results were obtained: minimum response time to ICMP request - 1046 ms, maximum - 2627 ms, average - 1998 ms. The transmission of online video traffic was started from PC-1 to PC-2 with a bit rate of 400 kbit/s using the RTP protocol [9]. As a result, it was possible to trace only "frozen" images, which were updated once every few seconds. The next step was to try to exchange online voice messages using SIP [10] and RTP protocol with G711 and speex audio codecs. Voice messages could only be transmitted in one direction from PC-1 to PC-2 or vice versa. At the same time, there were long delays and losses of audio frames, which led to the impossibility of receiving some sentences.

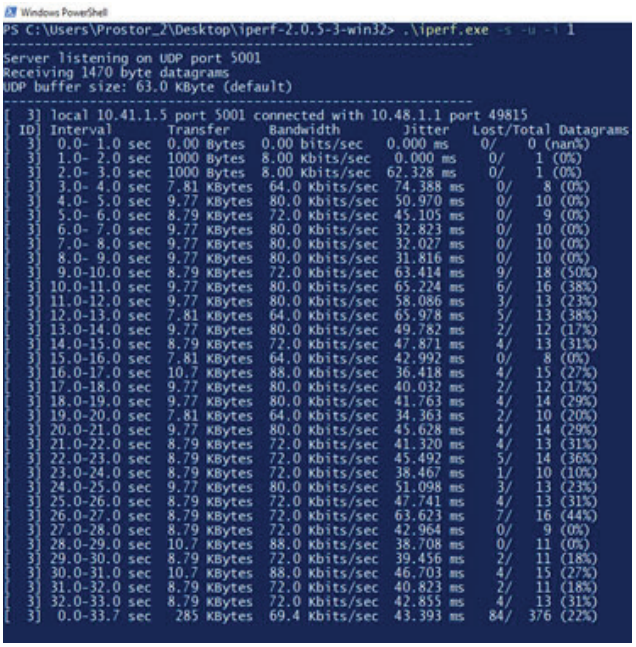

Fig. 3 The result of measuring the data transfer rate in the "NBNR" mode.

The attempt to transfer a 10 MB file using TCP [11] and UDP from PC-1 to PC-2 was made. File transfer failed due to the fact, that TCP has an excessive number of service messages. This fact along with the high probability of loss, delay in the channel and simplex mode of operation led to the fact that the TCP protocol service messages after some time occupied the entire bandwidth. UDP data transmission failed due to loss of datagrams in the channel and inability of the protocol to retransmit lost packets. Short text messages were sent from PC-1 to PC-2. The messages were transmitted using TCP and UDP protocols.

In the second experiment, VRC-9661 radio station in WBNR [12] broadband mode is considered. The scheme for the experiment is shown in Fig.4. UDP datagrams of 1470 bytes length were sent from PC-1 to PC-2 using "iperf-v2.0.5". A fragment of the program with the results of measurements is shown in Fig.5. ICMP-requests were sent from PC-1 to PC-2 using the system utility "ping" during one hour. The following results were obtained: the minimum response time is 93 ms, the maximum is 2912 ms, and the average is 851 ms. "Packet Sender" was used to measure the losses in the channel from PC-1 to PC-2. It transmitted UDP-datagrams of 200 bytes length every second during one hour. As a result, 24% of datagrams were lost.

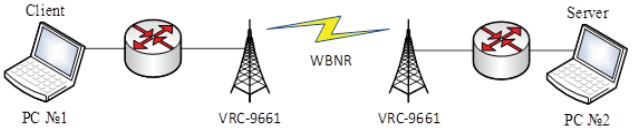

Fig. 4 Scheme of the experiment №2 with radio stations VRC-9661 in the mode "WBNR".

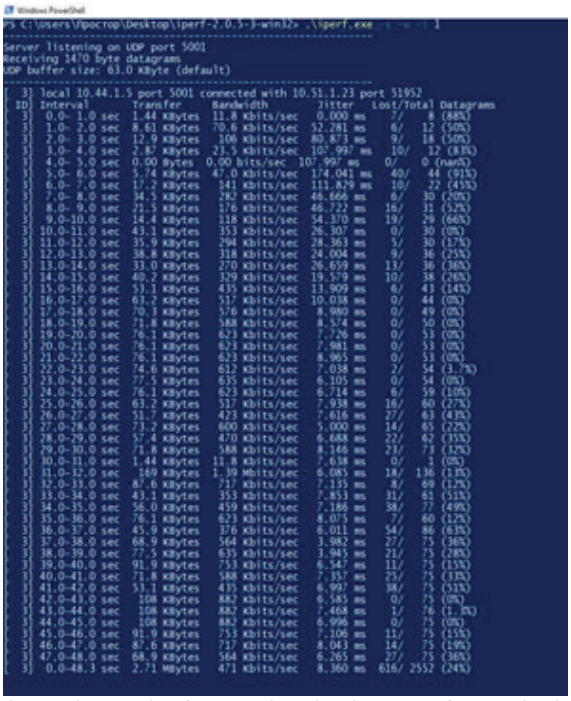

Fig. 5 The result of measuring the data transfer rate in the mode "WBNR".

The attempt to transmit online video traffic, voice messages, file and text messages as in experiment №1 was made. The transmission of video traffic in broadband mode showed the better image update, but there was digital noise and image fading. Voice messages were transmitted simultaneously between PC-1 and PC-2, but there were delays in transmission and loss of audio frames, which made it impossible to receive some words. The file could only be transferred using the TCP protocol. Short text messages were transmitted via TCP and UDP protocols.

In the third experiment, MHH-7850 radio station in Quicklook-Wide mode [13] is considered. The scheme for the experiment is shown in Fig.6. UDP datagrams of 1470 bytes length were sent from PC-1 to PC-2 using "iperf-v2.0.5". A fragment of the program with the results of measurements is shown in Fig.7. ICMP-requests were sent from PC-1 to PC-2 using the system utility "ping" during one hour. The following results were obtained: the minimum response time is 2130 ms, the maximum is 3927 ms, and the average is 2973 ms. "Packet Sender" was used to measure the losses in the channel from PC-1 to PC-2. It transmitted UDP datagrams of 200 bytes length every second during one hour. As a result, 1% of datagrams were lost.

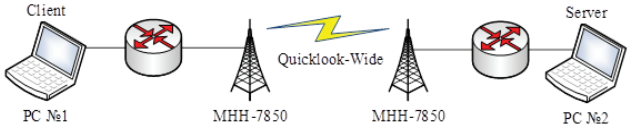

Fig. 6 Scheme of the experiment №3 with radio stations MHH-7850 in the Quicklook-Wide mode.

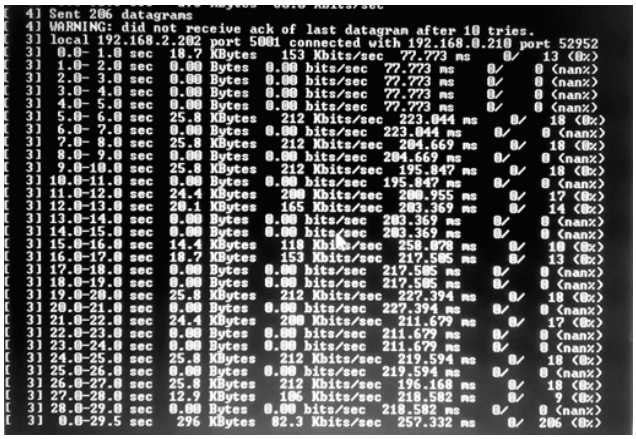

Fig. 7 The result of measuring the data transfer rate in the Quicklook-Wide mode.

The results of the transmission of online video, voice messages, files and short messages completely coincide with the results of experiment №1.

In the fourth experiment, MHH-7850 radio station in the M-TNW broadband mode [14] is considered. The scheme for the experiment is shown in Fig.8.

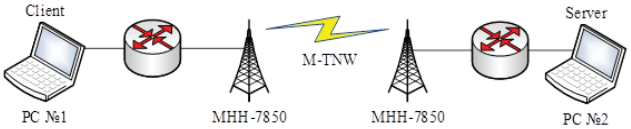

Fig. 8 Scheme of the experiment №3 with radio stations MHH-7850 in the «M-TNW» mode

UDP datagrams of 1470 bytes length were transmitted from PC-1 to PC-2 using "iperf-v2.0.5". A fragment of the program with the results of measurements is shown in Fig.9. From PC-1 to PC-2 send ICMP-requests using the system utility "ping" during one hour. The following results were obtained: the minimum response time is 284 ms, the maximum is 350 ms, and the average is 318 ms. "Packet Sender" was used to measure the losses in the channel from PC-1 to PC-2. It transmitted UDP-datagrams of 200 bytes

length every second during one hour. As a result, 4% of datagrams were lost.

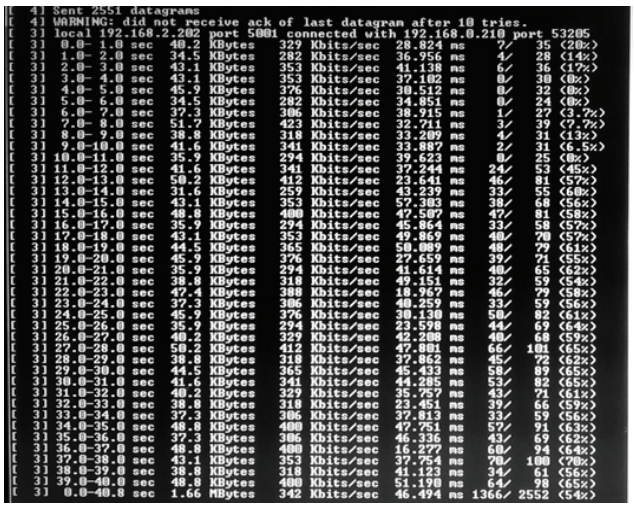

Fig. 9 The result of measuring the data rate in the "M-TNW" mode

The results of the transmission of online video, voice messages, files and short messages completely coincide with the results of experiment №2.

Summary of four experiments is shown in table 1.

Table 1 Measurement results

	VRC-9661 Aselsan		MHH-7850 Harris	
Radio mode	NBNR	WBNR	Quicklook-Wide	M-TNW
Bandwidth, kbit/s	69,4	471	82,3	342
Jitter, ms	43,39	8,36	257,3	46,494
Packet Loses	22%	24 %	1 %	4 %
Min Ping, ms	1046	93	2130	284
Max Ping, ms	2627	2912	3927	350
Mid Ping, ms	2000	851	2973	318

Based on these experiments, the following recommendations can be provided:

1. VHF radio networks have the following features: low data transfer rate, high data transfer latency, high jitter of data transfer latency, high probability of packet loss in the channel, which makes it impossible to use modern means and software designed for high-speed communication networks to transmit traffic.

2. To transmit online traffic, you have to use audio and video codecs that have the highest compression ratio.

3. It is better to use the UDP protocol with delivery control of packets at the application level of the OSI model for messages and files transmission. The use of TCP protocol leads to the occupation of the bandwidth by a large amount of service traffic.

Conclusion

1. The measurement of VHF radio networks QoS is a base part of the work for creation of the digital C2 system, which is being conducted at LLC «Telecard-Prilad».

2. This article demonstrates the analysis of different traffic type transmission possibility over low-bandwidth radio networks, including media and VoIp traffic, short messages and files.

3. Approbation of the research results allowed improving the mechanisms of traffic transmission in the special software "DSS Telecard" of LLC «Telecard-Prilad»., which increased the number of possible users of software in the VHF radio networks by 60%.

References

[1] Decree of the President of Ukraine № 555/2015: “On the decision of the National Security and Defense Council of Ukraine on September 2, 2015 "On the new version of the Military Doctrine of Ukraine"; https://zakon.rada.gov.ua/laws/show/555/2015, accessed May 2020

[2] Decree of the President of Ukraine № 92/2016: “On the decision of the National Security and Defense Council of Ukraine on March 4, 2016 "On the Concept of Security and Defense Sector Development of Ukraine"; https://zakon.rada.gov.ua/laws/show/92/20164, accessed May 2020

[3] Decree of the President of Ukraine №240/2016: «On the decision of the National Security and Defense Council of Ukraine on May 20, 2016 "On the Strategic Defense Bulletin of Ukraine"; https://www.president.gov.ua/documents/2402016-20137, accessed May 2020

[4] iPerf - The ultimate speed test tool for TCP, UDP and SCTP; https://iperf.fr/iperf-doc.php, accessed May 2020

[5] PING - utility for checking network connections TCP/IP; http://cmd4win.ru/administrirovanie-seti/diagnostika-sety/50-ping, accessed May 2020

[6] Packet Sender; https://packetsender.com/, accessed May 2020

[7] Narrow Band Networking Radio Waveform; https://www.aselsan.com.tr/en/capabilities/military-communication-systems/waveforms/narrow-band-networking-radio-waveform, accessed May 2020.

[8] User Datagram Protocol; https://tools.ietf.org/html/rfc768, accessed May 2020.

[9] RTP: A Transport Protocol for Real-Time Applications; https://tools.ietf.org/html/rfc3550, accessed May 2020.
[10] SIP: Session Initiation Protocol; https://tools.ietf.org/html/rfc3261, accessed May 2020.
[11] Transmission Control Protocol; https://tools.ietf.org/html/rfc793, accessed May 2020.
[12] Wide Band Networking Radio Waveform (WBNR); https://www.aselsan.com.tr/Wide_Band_Networking_Radio_Waveform_2166.pdf, accessed May 2020.
[13] Harris Corporation Introduces New Frequency-Hopping Waveforms in International Markets for Enhanced Information Security and Tactical Communications; https://www.harris.com/press-releases/2012/02/harris-corporation-introduces-new-frequency-hopping-waveforms-in, accessed May 2020.
[14] Wideband Networking Manpack Radio; https://www.harris.com/sites/default/files/downloads/solutions/harris-falcon-iii-rf-7800m-mp-multiband-networking-manpack-radio_2.pdf, accessed May 2020.

Стрелковска ***І.В.,*** *Золотухін* ***Р.В.***

Дослідження показників якості функціонування в низькошвидкісних мережах зв'язку

Проблематика. У даній статті проводиться дослідження показників якості функціонування в низькошвидкісних мережах зв'язку, побудованих на базі ультракороткохвильових(УКХ) радіостанціях, виробництва компанії Aselsan(Туреччина) та компанії Harris(США).

Мета дослідження. Метою цієї роботи є дослідження швидкості передачі даних, затримки передачі даних, джитеру затримки передачі даних, втрат в каналі і аналіз можливостей проходження по УКХ радіоканалам різного типу трафіку.

Методика реалізації. Для експериментального дослідження показників якості функціонування низькошвидкісних радіомереж зв'язку використовувалась програма «iperf-v2.0.5», системна утиліта «ping» та програмне забезпечення «Packet Sender».

Результати досліджень. Отримані дані за показниками якості функціонування низькошвидкісних радіомереж зв'язку було апробовано в спеціальному програмному забезпеченні ТОВ «Телекарт-Прилад», що дозволило збільшити кількість можливих користувачів в УКХ радіомережі на 60%.

Висновки. Проведено вимірювання якості функціонування УКХ радіомереж на ТОВ «Телекарт-Прилад» та надано рекомендації по експлуатації низькошвидкісних радіомереж, які були застосовані в програмному забезпеченні «DSS Telecard» ТОВ «Телекарт-Прилад».

Ключові слова: радіостанція; УКХ; показники якості функціонування; швидкість передачі даних; джитер; втрати в каналі; ping.

Стрелковская И.В., Золотухин Р.В.

Исследование показателей качества функционирования в низкоскоростных сетях связи

Проблематика. В данной статье проводится исследование показателей качества функционирования в низкоскоростных сетях связи, построенных на базе ультракоротковолновых (УКВ) радиостанциях, производства компании Aselsan (Турция) и компании Harris (США).

Цель исследования. Целью настоящей работы является исследование скорости передачи данных, задержки передачи данных, джиттера задержки передачи данных, потерь в канале и анализ возможностей прохождения по УКВ радиоканалам разного типа трафика.

Методика реализации. Для экспериментального исследования показателей качества функционирования низкоскоростных радиосетей связи использовалась программа «iperf-v2.0.5», системная утилита «ping» и программное обеспечение «Packet Sender».

Результаты исследований. Полученные данные по показателям качества функционирования низкоскоростных радиосетей связи были апробированы в специальном программном обеспечении ООО «Телекарт-Прибор», что позволило увеличить количество возможных пользователей в УКВ радиосети на 60%.

Выводы. Проведены измерения качества функционирования УКВ радиосетей на ООО «Телекарт-Прибор» и даны рекомендации по эксплуатации низкоскоростных радиосетей, которые были применены в программном обеспечении «DSS Telecard» ООО «Телекарт-Прибор».

Ключевые слова: радиостанция; УКВ; показатели качества функционирования; скорость передачи данных; джиттер; потери в канале; ping.