номерным квантованием на 2^{16}= 65536 уровней.

Искажения СПМ речевого сообщения неизбежно приводят к уменьшению отношения сигнал/шум по мощности ОСШ, дБ.

На рис. 3 для тех же условий приведена зависимость ОСШ от дальности связи L, м.

ВЫВОДЫ

Увеличение дальности связи при пакетной передаче речи с использованием на канальном уровне технологии стандарта IEEE 802.11, как следует из нашего анализа, приводит к уменьшению отношения сигнал/шум воспроизведения речевого сообщения.

Представляется целесообразным провести отдельные исследования пакетной передачи речи с применением на канальном уровне технологии внедряемого на железнодорожном транспорте стандарта DMR, что позволило бы сделать аналогичные по целям заключения.

ЛИТЕРАТУРА

1. Современные телекоммуникационные технологии. Моделирование / Под ред. Г. В. Горелова. – М.: МИИТ, 2009. – 161с.

2. Телекоммуникационные технологии на железнодорожном транспорте / Под ред. Горелова Г. В. – М.: Желдориздат, 1999. – 576 с.

3. Цифровые телекоммуникационные сети / Под ред. Горелова Г. В. – Харьков. 2000. – 216 с.

4. Горелов Г. В., Чуриков В. Н., Ваванов К. Ю. Радиосети передачи данных в тоннелях с использованием излучающих кабелей // Проектирование и технология электронных средств. – 2009. – № 4. – С. 52–56.

5. Горелов Г. В., Ромашкова О. Н., Казанский Н. А. Многофункциональная единая цифровая сеть связи (МЦСС) для городской транспортной системы // Наука и техника транспорта. – 2003. – № 4. – С. 18–29.

6. Горелов Г. В., Ромашкова О. Н., Житнов А. А. Искажения энергетического спектра речевого сообщения при использовании технологии VOICE OVER WI FI // Телекоммуникации. – 2011. – № 1. – С. 10–12.

7. Горелов Г. В., Житнов А. А., Вин Хан. Пакетная передача речи с использованием динамической беспроводной сети AD-HOC NETWORK стандарта 802.11 // Проектирование и технология электронных средств. – 2011. – № 3. – С. 24–25.

8. Горелов Г. В., Казанский Н. А., Лукова О. Н. Оценка качества различных методов восстановления речи в цифровых сетях с коммутацией пакетов речи и данных // Автоматика и вычислительная техника. – 1993. – N4. – С.11–14.

9. Горелов Г. В., Ромашкова О. Н. Оценка качества обслуживания в сетях с пакетной передачей речи и данных // Вестник РУДН. Серия «Прикладная и компьютерная математика». Т. 2. – 2003. – № 1. – С. 23–31.

10. Горелов Г. В., Венедиктов М. Д., Шалимов И. А. Компьютерная телефония в вопросах и ответах. Учебное пособие. – М.: МИИТ, 2009. – 124 с.

11. Горелов Г. В., Ромашкова О. Н., Чан Туан Ань. Качество управления речевым трафиком в телекоммуникационных сетях / Под ред. Г. В. Горелова. – М.: Радио и связь, 2001. – 215 с.

12. Горелов Г. В., Пчелипцев А. В. Анализ кодеков G.711 с использованием распределения Парето длительности интервалов в потоке отсчетов //Телекоммуникации. – 2003. – № 5. – С. 7.

13. Горелов Г. В., Чуриков В. Н., Ваванов К. Ю. Имитационные оценки качества речепреобразования низкоскоростного кодека // Проектирование и технология электронных средств. – 2009. – № 3. – С. 62–64.

14. Горелов Г. В., Бахтиярова Е. А. Вероятностные характеристики сообщения устной казахской речи // Телекоммуникации. – 2007. – № 9. – С.8–10.

15. Gorelov Georgy V., Romashkova Oksana N. Influence of Russian, Spanish and Vietnamese speech characteristics on digital information transmission quality. Proceedings of the IEEE International Symposium on Industrial Electronics, ISIE'96. Part 1 (of 2). (Sponsors: IEEE, Warsaw University of Technology). Warsaw, Poland, 1996. – С. 311–313.

16. Горелов Г. В., Бахтиярова Е. А., Карпов А. В. Вероятностные характеристики речевого трафика // Мир транспорта. – 2007. – № 1. – С. 22–25.

17. Горелов Г. В., Ромашкова О. Н., Горелов Г. В., Житнов А. А., Вин Хан. Спектральная плотность мощности и корреляционная функция сообщения устной мьянманской речи // Проектирование и технология электронных средств. – 2010. – № 3. – С. 49–51.

18. Горелов Г. В., Житнов А. А., Вин Хан. Сопоставление оценок энергетического спектра устной русской и мьянманской речи// Телекоммуникации. – 2010. – № 8. – С. 8–11.

19. Горелов Г. В., Вин Хан, Житнов А. А. Мощность речевого сопровождения. Проверка расстоянием // Мир транспорта. – 2010. – № 3. – С. 46–49.

20. Чивилев С. В. DMR – новый стандарт радиосвязи // Специальная техника. – 2008. – № 2. – С. 72–73. ●

PACKET VOICE TRANSMISSION IN MOBILE NETWORKS

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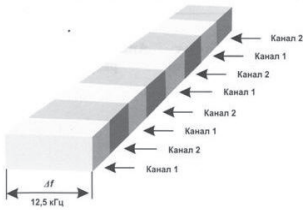
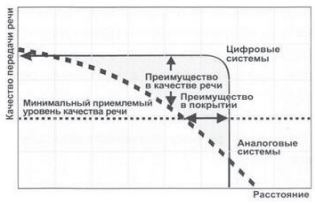
ABSTRACT

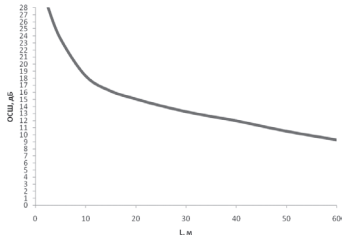
In the article the authors represent problems and resources of packet voice transmission in mobile networks on rail transport. It is proposed to extend the research methods of transmission quality by using the data link layer of IEEE 802.11 standard for analysis of systems introduced in railways with DMR standard.



Pic. 1. The structure of air interface of DMR standard.



Pic. 2. Dependence of voice transmission quality from communication range.



Pic.3. Dependence of signal/noise ratio from communication range L.

ENGLISH SUMMARY

Background. *Integrated (combining different kinds of traffic and different access methods) telecommunications networks have proven themselves to be quite effective means of communication for the needs of railways [1–4], metropolitan cities (subways, monorail transport systems [5]).*

Concurrently it is rational to use wireless networks for access of mobile subscribers to resources of stationary networks, applying rapidly developing technologies of standards IEEE Radio Ethernet 802.11 (WI FI) and 802.16 (WI MAX) in the 2.4 GHz band and other high-frequency bands [6,7].

Broadband access technologies (both wired and wireless) became the fastest growing and modificatory telecommunications technology on rail transport and should provide the user with the proper quality of service (QoS) [8, 9].

Virtually all modern wireless access networks of mobile subscribers to resources of stationary networks (mobile network) apply the technology of packet voice transmission.

Objective. *The authors' goal is to demonstrate the most important aspects of packet voice transmission systems, which are applied on rail transport.*

Methods. *In the article the authors use descriptive method and the method of analysis.*

Results. *The most significant example of packet voice telecommunication is CTI technology (Computer-Telephony Integration) – computer telephony, which arose at the intersection of computer data processing and telephony technologies in the mid 80 – ies of the last century [10].*

Computer telephony technology (Vo IP, IP- telephony) is based on the use for voice transmission networks, which were originally designed for transmission of data. Voice is digitized, divided into packets, used to work with data, and sent over the network. On the receiving side, packets are collected, voice signal is restored, and telephone conversations between two devices connected to the data network are provided.

Since voice packets are not repeated, in case of loss (or distortion) at the receiving side a brief pause in speech occurs. Frequent loss of voice packets due to poor quality of communication channels and congestion in the network can lead to a deterioration of speech, and sometimes to the complete inability to communicate [11]. Distortion from packet loss are also dependent from codecs, used in network gateways. Voice quality when using low-rate codecs G.729 and G.723.1 type is to a greater extent influenced by packet losses as compared with high-speed codecs such as G.711 [12, 13]. It can be approximately assumed that for IP- telephony of good quality allowable packet loss rate should be 1–3%, where a smaller value refers to the low-speed codecs, and a larger one – to high-speed.

The emergence of mobile networks with packet voice transmission can also be attributed to the 80-ies years of the last century. In 1982, the CEPT (Conference of European Posts and Telegraphs) formed a workgroup for development of pan-European cellular mobile communication system- GSM (Groupe Special Mobile), and in 1989 ETSI (European Telecommunication Standards Institute) began to perform the task.

GSM technology is based on the multiple accesses with time division of TDMA (Time Division Multiple Access) [2] that provides organization of several timeslots at the same carrier frequency. In the GSM the following technologies are applied: HSCSD (High-Speed Circuit-Switched Data) – high speed data transfer in mobile radio networks with channel switching; GPRS (General Packet Radio Service) – packet switching in mobile radio networks at speeds up to 115 kbit / s; Packet GSM – for packet voice transmission using VoGPRS (Voice over GPRS) technology and data.

Russian rail transport in the organization of technological radiotelephone communications and data links for motion control systems uses systems with packet voice transmission: cellular system of GSM-R standard and trunked system of TETRA (Terrestrial Trunked Radio) standard, which uses the basic principles of its construction (primarily- TDMA), and systems of a wireless access of standard IEEE Radio Ethernet modifications [2,4,6,7,19].

System of DMR (Digital Mobile Radio) standard, developed by ETSI in 2005 as the single European digital radio standard, starts to intrude and has good prospects. The basis of DMR is again TDMA technology (Pic. 1) [20].

The specifics of the language of speech [14–18] and the impact of the communication range [19] should be considered primarily in assessing voice transmission quality in mobile networks.

Pic. 2 shows the dependence of voice transmission quality from communication range (distance) for analog and digital systems [20].

The shown dependence is purely illustrative and reflects the qualitative aspect of the question (a criterion for assessing the voice transmission quality and its values and distance values are not given). Actually, by the application of digital systems communication threshold-range appears, overcoming of which reduces the voice transmission quality to an unacceptable level. Studies on quality deterioration as a function of this threshold are worth noticing.

With increasing distance, power spectral density (PSD) of voice message starts to distort. Proportions of power in the band Δf for PSD are 300–3400 Hz*

and the absolute and relative values of its distortion for its central frequency is $\Delta f^*=1/3$octave with a communication range of L=0 and 35 m are shown in Table 1 [6]. The data therein are for the standard IEEE 802.11 (WI FI). Verbal communication of Russian oral speech was used with duration of 35 minutes in the format wav (wave), with a sampling frequency of 44100 Hz and uniform quantization at 216= 65536 levels.

PSD distortion of voice message inevitably leads to a reduction of the ratio signal/noise according to capacity of ratio signal-noise, dB.

Pic. 3. shows the dependence of ratio signal-noise from communication range L, m for the same conditions.

Conclusion. *Increase in communication range in packet voice transmission using at the data link-layer technology of IEEE 802.11 standard, as the present analysis shows, reduces signal/noise ratio of a voice message.*

It appears appropriate to conduct individual researches of packet voice transmission using at the data link -layer technologies of DMR standard, which are being introduced to the railway transport.

Keywords: rail transport, mobile networks, packet voice transmission, transmission quality, process standards, analog system, digital system, the communication range.

REFERENCES

1. Modern telecommunication technologies. Modeling [*Sovremennye telekommunikatsionnye tehnologii. Modelirovanie*]. Ed.by G. V. Gorelov. Moscow, MIIT publ., 2009, 161 p.

2. Telecommunication technologies at the rail transport [*Telekommunikatsionnye tehnologii na zheleznodorozhnom transporte*]. Ed. by Gorelov G. V. Moscow, Zheldorizdat publ., 1999, 576 p.

3. Digital telecommunication networks [*Tsifrovye telekommunikatsionnye seti*]. Ed. by Gorelov G. V. Har'kov, 2000, 216 p.

4. Gorelov, G.V., Churikov, B.H., Vavanov, K. Yu. Radio data transmission tunnels with the use of leaky cables [*Radioseti peredachi dannyh v tonnelyah s ispol'zovaniem izluchayuschih kabeley*]. *Proektirovanie i tehnologiya elektronnyh sredstv,* 2009, Iss.4, pp. 52–56.

5. Gorelov, G.V., Romashkova, O.N., Kazanskiy, N. A. Multifunction uniform digital network for urban transport system [*Mnogofunktsional'naya edinaya tsifrovaya set» svyazi (MTsSS) dlya gorodskoy transportnoy sistemy*]. *Nauka i tehnika transporta*, 2003, Iss. 4, pp. 18–29.

6. Gorelov, G.V., Romashkova, O.N., Zhitnov, A. A. Distortion of the energy spectrum of the voice message using VOICE OVER WI FI technology [*Iskazheniya energeticheskogo spektra rechevogo soobscheniya pri ispol'zovanii tehnologii VOICE OVER WI FI*]. *Telekommunikatsii*, 2011, Iss. 1, pp. 10–12.

7. Gorelov, G.V., Zhitnov, A.A., Vin Han. Packet voice transmission with the use of dynamic wireless network AD-HOC NETWORK 802.11 [*Paketnaya peredacha rechi s ispol'zovaniem dinamicheskoy besprovodnoy seti AD-HOC NETWORK standarta 802.11*]. *Proektirovanie i tehnologiya elektronnyh sredstv*, 2011, № 3, pp. 24–25.

8. Gorelov, G.V., Kazanskiy, H.A., Lukova, O. N. Quality assessment of different speech reconstruction techniques in digital networks with switching of voice and data packets [*Otsenka kachestva razlichnyh metodov vosstanovleniya rechi v tsifrovyh setyah s kommutatsiey paketov rechi i dannyh*]. *Avtomatika i vychislitel'naya tehnika*, 1993, Iss.4. pp.11–14.

9. Gorelov, G.V., Romashkova, O. N. Quality of service assessment in networks with packet voice and data transmission [*Otsenka kachestva obsluzhivaniya v setyah s paketnoy peredachey rechi i dannyh*]. Vestnik RUDN. Seriya «Prikladnaya i komp'yuternaya matematika». V. 2, 2003, Iss. 1. pp. 23–31.

10. Gorelov, G.V., Venediktov, M.D,, Shalimov, I. A. Computer telephony integration in questions and answers. Textbook [*Komp'yuternaya telefoniya v voprosah i otvetah. Uchebnik*]. Moscow, MIIT publ., 2009, 124 p.

11. Gorelov, G. V., Romashkova, O.N., Chan Tuan An. Quality of voice traffic control in telecommunication networks [*Kachestvo upravleniya rechevym trafikom v telekommunikatsionnyh setyah*]. Ed.by G. V. Gorelov. Moscow, Radio i svyaz' publ., 2001, 215 p.

12. Gorelov, G.V., Pcheliptsev, A.B. G.711 codecs analysis with the use of Pareto distribution of interval duration in the flow of samples [*Analiz kodekov G.711 s ispol'zovaniem raspredeleniya Pareto dlitel'nosti intervalov v potoke otschetov*]. *Telekommunikatsii*, 2003, Iss.5, pp. 7.

13. Gorelov, G.V., Churikov, V.N., Vavanov, K. Yu. Simulation quality assessment of speech transformation of a low bandwidth codec [*Imitatsionnye otsenki kachestva rechepreobrazovaniya nizkoskorostnogo kodeka*]. *Proektirovanie i tehnologiya elektronnyh sredstv*, 2009, Iss.3, pp. 62–64.

14. Gorelov, G.V., Bahtiyarova, E. A. Probabilistic characteristics of Kazakh oral speech messages [*Veroyatnostnye harakteristiki soobscheniya ustnoy kazahskoy rechi*]. *Telekommunikatsii*, 2007, Iss.9, pp.8–10.

15. Gorelov, Georgy V., Romashkova, Oksana N. Influence of Russian, Spanish and Vietnamese speech characteristics on digital information transmission quality. Proceedings of the IEEE International Symposium on Industrial Electronics, ISIE'96. Part 1 (of 2). (Sponsors: IEEE, Warsaw University of Technology). Warsaw, Poland, 1996, pp. 311–313.

16. Gorelov, G.V., Bahtiyarova, E.A., Karpov, A. V. Probability Features of Speech Traffic. *Mir Transporta* [World of Transport and Transportation] *Journal*, 2007, Vol. 17, Iss. 1, pp. 22–25.

17. Gorelov, G.V., Romashkova, O.N., Gorelov, G.V., Zhitnov, A.A., Vin Han. Power spectral density and the correlation function of the Myanmar oral speech messages [*Spektral'naya plotnost' moschnosti i korrelyatsionnaya funktsiya soobscheniya ustnoy m'yanmanskoy rechi*]. *Proektirovanie i tehnologiya elektronnyh sredstv*, 2010, Iss. 3, pp. 49–51.

18. Gorelov, G.V., Zhitnov, A.A., Vin Han. Comparison of estimates of the energy spectrum of Russian and the Myanmar oral speech [*Sopostavlenie otsenok energeticheskogo spektra ustnoy russkoy i m'yanmanskoy rech*]. *Telekommunikatsii*, 2010, Iss. 8, pp. 8–11.

19. Gorelov, G.V., Vin Han, Zhitnov, A. A. Capacity of Vocal Tracking: A Remote Test. *Mir Transporta* [World of Transport and Transportation] *Journal*, 2010, Vol. 31, Iss. 3, pp. 46–49.

20. Chivilev, C.V. DMR – new radio standard [*DMR – novyj standart radiosvyazi*]. *Spetsial'naya tehnika*, 2008, Iss. 2. – pp. 72–73.

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