

OPINION

**of a dissertation
for awarding an educational and scientific degree of "Doctor" in**

**in the field of higher education – 5. Technical Sciences
the professional field – 5.3 “Communication and Computer Engineering”
doctoral program – "Communication Networks and Systems"**

Author: M.Eng. Boris Blagoy Arsov

Topic of the dissertation: “Performance Management and Quality of Service in Mobile Broadband Networks”

Member of the scientific jury: Assoc. Prof. Krasen Kirov Angelov, PhD

1. Topic and relevance of the dissertation work

The dissertation work of M.Eng. Boris Arsov is dedicated to the mechanisms, methods and means of regulation and implementation of the main parameters that broadband mobile operators must meet for their communication network, in the direction of realizing the broadband access strategy itself and ensuring quality of services over the mobile networks. This is a process with continuous development, a definite guarantee of the relevance of the work and a real challenge for in-depth dissertation research.

The object of research in the dissertation is the performance management and quality of service in broadband mobile networks, with the main focus on the evaluation of the parameters of the wireless transmission channel as well as the dependencies between them determining the quality of the transmitted signals and the efficiency of the radio access network.

The structure of the dissertation includes an introduction, five chapters, a conclusion, a list of abbreviations used, a list of publications on the dissertation, and a reference list. The dissertation, with a volume of 171 pages, was developed on the basis of an analytical review of 184 literary sources, including 25 in Bulgarian, Russian and Macedonian, 117 in English and 42 Internet-based sources. Not all listed sources are cited in the dissertation.

The introduction in the first chapter of the dissertation shows a good knowledge of the good knowledge of the status and regulations regarding mobile broadband networks, the broadband access they provide, as well as their deployment and use in the Balkan region. This knowledge has allowed the author to correctly assess the current state of the problem and formulate research goals in the dissertation work.

2. Research methodology

The research methods in the dissertation work are analytical, simulation and practical. The MATLAB/Simulink programming environment with specialized modules Communications System Toolbox and DSP System Toolbox was used as a tool for the simulation studies. As instruments for the experimental measurements, specialized measuring

devices were used to evaluate the network efficiency and measure the emission of non-ionizing radiation from the base stations of the mobile operators: universal radio network analyzer, hybrid platform TEMS Investigation, software application Network Cell Info, broadband electromagnetic field meter and frequency selective electromagnetic field meter. The chosen research methodology is adequate.

The purpose of the research is real-time analysis and assessment of quality indicators, maintaining a high level of quality of the services provided, identifying the causes of problems that have arisen and preventing future ones. This is related to determining optimal ranges of variation of specific technical parameters and criteria related to the effective operation and setting of transmission channels in broadband mobile networks.

3. Contributions of the dissertation work

The contributions of the dissertation work can be classified as scientific-applied and applied, which can generally be summarized as follows:

A) Scientific-applied contributions:

– An analytical methodology for designing and calculating the parameters of a broadband mobile network is presented.

– Mathematical dependencies related to network load factors in the uplink and downlink channel, with determination of radio coverage, radio propagation losses, and antenna gain are derived.

– A simulation model of the WCDMA End-to-End Physical Layer has been developed, based on which studies have been carried out and graphical results have been derived for three different cases of the environment and the user mobility. Based on this, the effective BER values can be determined depending on the SNR, related to ensuring the quality of services under the different conditions.

B) Applied contributions:

– It is found that the power control algorithm has limits and when the power control reserve resource is exhausted, it switches to channel switching (handover). Very high power transmission leads to a decrease in the sensitivity of the system, so the BPC power control reserve parameter is introduced, the value of which is 0.7 at a subscriber movement speed of 3 km/h and 0 at a subscriber movement speed of 50 km/h.

– Experimental results of the parameters of a broadband mobile network in urban environment are presented, by using specialized software applications installed on a mobile station. The signals from 2 operators in an urban environment in 2G/3G/4G and 5G modes of operation along defined routes are investigated by varying the movement speed of the mobile measuring station. From the statistics and the analysis of the obtained results, 12 specific conclusions are found, related to improving the performance management and ensuring a better quality of services in an urban environment.

– An experimental setup are proposed and practical studies are carried out by the regulatory body for the Republic of S. Macedonia – the Electronic Communications Agency (AEC). Statistics, processing and analysis of the practical results for voice services and data transfer of the most important operators for the country of Macedonia have been carried out.

A process has been developed that includes network monitoring, measurements of key performance parameters and cell optimization to improve efficiency and quality of service.

– Real measurements related to the emission of non-ionizing radiation from the base stations of mobile operators related to the commissioning of the new 5G technology are made. Diagnostics and evaluation of the operating characteristics related to ensuring the quality of service in urban areas have been carried out, problem areas have been localized and basic technical and technological solutions for its improvement have been defined.

4. Publications and citations of publications on the dissertation work

The results of the dissertation have been published in 5 publications: 4 in Bulgarian language and 1 in English language. Two of the publications are independent. The remaining 4 are co-authored with the scientific supervisor and colleagues from the university. One of the presented publications was presented at the International Conference on Electronics, Engineering Physics and Earth Science (EEPES 2023), refereed and indexed in world-famous database Scopus. The other 4 publications are reports at scientific conferences, referenced in the National reference list of modern Bulgarian scientific publications with scientific peer review – 2 of them were presented at the international scientific conference UNITECH in 2023 and 2 of them – at the national scientific conference TechCo in 2023. The publications promulgate the research carried out and present the main conclusions of the dissertation work. There is no information about known citations of the dissertation's publications.

The publication activity of the PhD student covers the minimum national requirements and the requirements of the regulations for awarding of the educational and scientific degree “Doctor”.

5. Authorship of the obtained results

From the presented publications, as well as from the dissertation work, it can be seen that a significant amount of research and experimental activity was carried out by the PhD student under the guidance of his scientific supervisor. The presented results build on existing research on quality-of-service improvement processes and performance management in mobile broadband networks based on: network monitoring, key performance measurements and cell optimization; statistical processing and analysis of practical results for voice services and data transfer; diagnostics and evaluation of operational characteristics related to ensuring the quality of service in urban areas.

I believe that the main part of the conducted research and compiled analyzes of the results are entirely the personal contribution of the PhD student.

6. Comments, recommendations and remarks on the dissertation work

The topic of the dissertation is relevant and interesting. My personal opinion is that the work has a sufficient volume and the necessary depth of research. The obtained results are significant enough for the educational and scientific degree “doctor”. The publicity of the work is ensured and proven by publications at refereed scientific conferences.

I have the following important remarks and recommendations regarding the dissertation work:

- 1) The large volume of variable and value symbols in Chapter 2 suggests as a recommendation the addition of a list of used symbols.
- 2) Part of the conclusions in Chapter 4 have a conclusive and generally applied nature and should be specified in relation specifically to the performance management and quality of service in mobile broadband networks.
- 3) I recommend the doctoral student to publicize his research and achieved results not only at scientific conferences in Bulgaria, but also in prestigious scientific journals and international scientific conferences indexed in the world-famous Scopus and Web of Science databases.

The presented remarks and recommendations do not detract from the results achieved by the PhD student on the scientific subject in the dissertation

7. Conclusion

My personal opinion is that the submitted dissertation work **meets the requirements** of the Law on the Development of the Academic Staff in the Republic of Bulgaria. The achieved results give me reason **to propose** that the educational and scientific degree "Doctor" be acquired from M.Eng. Boris Blagoy Arsov in the field of higher education – 5. Technical Sciences, professional field – 5.3 “Communication and Computer Engineering”, doctoral program – “Communication Networks and Systems”.

19.03.2024

Member of the scientific jury: /signature/
/Assoc. Prof. Krasen Angelov, PhD/