

OPINION

by Prof. DSc. Ivan Ganchev Garvanov

member of the Scientific Jury, appointed by an Order of the Director of IICT-BAS
with No 179/01.07.2026

Subject: Dissertation of **Genka Ivanova Slavova-Torres** on the topic "Methods and Means for Optimizing Records in a Network Storage Environment", presented for the acquisition of the educational and scientific degree "DOCTOR" in scientific field 5. "Technical Sciences", professional field 5.3 "Communication and Computer Engineering" under the Doctoral Program "Computer Systems, Complexes and Networks", at the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences, with scientific supervisor: Assoc. prof. Phd Vladimir Ivanov.

1. Information about the procedure

At the first meeting of the Scientific Jury, I was selected to write an opinion and received the following documents:

- Dissertation in Bulgarian;
- abstract in Bulgarian and English;
- a list of published scientific publications on the topic of the dissertation;
- a copy of scientific publications on the topic of the dissertation;
- reference for the implementation of the EOM;
- other documents related to the defense of the dissertation.

2. Relevance, purpose and tasks of the dissertation

The dissertation is devoted to a topical and scientifically applied problem in the field of computer systems and storage networks (Storage Area Networks – SAN).

With the advent of high-speed technologies such as SSDs, NVMe, and NVMe-over-Fabrics (NVMe-oF), hardware latency has been reduced to microseconds. However, this has shifted critical bottlenecks to queue management and coordination between layers. The author correctly identifies that the optimization of modern systems cannot be considered in isolation at the component level, but requires a systems approach. The focus on "final latency", as measured by high percentiles, is extremely valuable for practice, where rare but large delays compromise the quality of service.

The purpose of this dissertation is to develop and validate a system model of the behavior of write operations in a SAN environment, which takes into account the interaction between the different layers of the write path and allows to identify the factors determining the final latency, as well as to formulate principles and guidelines for optimizing write operations under different load modes.

To achieve this goal, the dissertation addresses the following tasks:

Theoretical modeling of the software stack and components of the network storage environment. This task encompasses the detailed study and conceptualization of the recording path as a complex system of sequential hardware and software queues. By applying the theory of mass service, a mathematical model is built that makes it possible to analyze how the transition to high-speed NVMe technologies shifts critical delays from physical media to queue management.

Empirical study of the factors influencing latency. The task is aimed at designing a controlled test environment in a real SAN infrastructure, where only one parameter varies under fixed other conditions in order to ensure scientifically sound and reproducible results. A series of targeted experiments are being conducted to investigate the influence of tail depth, load profile (uniform or pulsating), request coordination, and the effect of the "noisy neighbor" on high latency percentiles.

Analysis of the results and formulation of an optimization framework for record management. This task involves collating and interpreting the collected

empirical data to reveal the nonlinear behavior of latency at a high level of parallelism. As a result, specific practical rules and methodological guidelines are defined for software optimization of write operations, which improve the stability of the system without the need to purchase new hardware.

3. General characteristics of the dissertation

The dissertation is structured in six chapters spanning 145 pages and contains a balanced relationship between theoretical modeling and experimental validation.

Chapter 1. Problem, goals and objectives: Clearly defines the motivation, practical applicability and research thesis. 9 specific tasks have been set, which consistently lead to the achievement of the main goal.

Chapter 2. System model of write operations in SAN: An in-depth analysis of the write path has been performed. The evolution of bottlenecks from the HDD era to NVMe-oF is traced here. A key contribution here is the interpretation of software and hardware queues through the Mass Service Theory and the definition of the empirical cumulative distribution function (ECDF).

Chapter 3. Experimental methodology: A controlled test environment using a real SAN infrastructure is described here. The research approach is scientifically sound - only one independent variable changes under fixed other conditions, which guarantees reproducibility of the results.

Chapter 4. Experimental results: The baseline scenario and 4 target experiments investigating: Queue Depth (QD) are presented. Load shape (uniform flow vs. pulsating mode). Coordination in the submission of applications (coordinated vs. non-coordinated regime). The Noisy Neighbor effect of shared data.

Chapter 5. Analytical synthesis and interpretation: A comparison of the scenarios was performed. A comprehensive optimization framework for managing record operations has been formulated.

Chapter 6. Conclusion: The contributions are summarised and guidelines for future research are outlined.

The results are illustrated in 24 figures and 16 tables. 61 literature sources were used.

4. Contributions

The dissertation contains contributions that I would classify both scientific and applied in nature.

I would summarize the contributions as:

A complete system model of the write path in the SAN has been developed as a circuit of autonomous, interacting queues and regulators.

An experimental framework has been created to isolate the factors affecting tail latency through controlled load and the application of ECDF analyses.

It has been empirically proven that layer-to-layer coordination and parallelism control are more important for latency stability than the rated speed of the hardware.

A practical framework and specific guidelines for optimizing SAN environments without the need for additional hardware resources have been formulated.

5. Abstract

The presented abstract reliably reflects the content of the dissertation and corresponds to the requirements of the Law on Abstract Abstract and Abstract. From the attached declaration of originality of the presented results, as well as from the presented publications on the dissertation, it can be judged that the described results are original and personal work of the doctoral student.

6. Assessment of compliance with minimum national requirements

PhD student Genka Ivanova Slavova-Torres has tested parts of her dissertation in six scientific publications. In four of the publications, she is an independent author. Two of the articles are indexed in Scopus. The presented publications on the dissertation form a total sum of the points for the indicators from Group G equal to 140 points, which exceeds the required minimum of 30 points.

7. Notes and recommendations

Some of the results presented in the dissertation have not been reflected in the publications of the dissertation and my recommendation is that they be published.

8. Final due diligence

I believe that the presented dissertation meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for the Implementation of the Law on the Implementation of the Law on Academic Studies and the Regulations for the Acquisition of Scientific Degrees at IICT-BAS. The results achieved give me grounds to give a positive assessment with full conviction and I recommend to the honorable Scientific Jury to award the educational and scientific degree "Doctor" to **Genka Ivanova Slavova-Torres** in the professional field 5.3 "Communication and Computer Equipment", PhD program "Computer Systems, Complexes and Networks".

20.07.2026

Sofia. Sofia

