

REVIEW

on the dissertation for the acquisition of the educational and scientific degree "DOCTOR", field of higher education 5. Technical sciences, professional field 5.3. Communication and computer technology, doctoral program "Computer systems, complexes and networks"

Author of the dissertation: Genka Ivanova Slavova - Torres

Topic of the dissertation: "Methods and tools for optimizing records in a network storage environment"

Reviewer: Prof. Dr. Eng. Kosta Boshnakov, appointed as a member of the scientific jury by order 179/01.07.2026 of the Director of IICT-BAS

1.Relevance of the problem developed in the dissertation in scientific and applied terms.

The dissertation is dedicated to a current and significant problem related to the analysis and optimization of write operations in modern networked data storage environments - Storage Area Networks (SAN).

The relevance of the topic stems from the increasingly widespread use of SAN infrastructures in virtualized environments, cloud platforms, database management systems and other applications with high performance and reliability requirements.

The following goal of the dissertation work has been formulated: 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 individual layers of the write path and allows for the identification of the factors determining the ultimate latency, as well as the formulation of principles and guidelines for the optimization of write operations under different load modes.

Nine tasks have been formulated to achieve the set goal.

2.Degree of knowledge of the state of the problem and creative interpretation of the literary material.

61 literary sources in English are attached to the dissertation. 62% of them are from after 2010, which gives me confidence that the literary sources used are up-to-date.

A glossary of terms and abbreviations is included at the beginning of the dissertation, which makes the presentation easier to read. References to literary sources are found in the first three chapters throughout the dissertation.

It is very impressive that the literary sources were used not only for the purposes of the literature review, but also as a basis for the research conducted in the dissertation.

The main scientific problem of the research in the dissertation paper is that the latency of write operations in a SAN environment is a system property that arises as a result of the interaction between load characteristics, coordination mechanisms, and input-output queues along the write path.

3. Brief overview of the dissertation work

The first chapter is dedicated to the problems, goals and objectives of the dissertation. The practical significance and applicability of the research are presented, why write operations remain difficult to optimize are analyzed and the optimization problem is formulated as a task to maintain stable and predictable latency behavior (delay) by managing parallelism, limiting queuing effects, and controlling the final percentiles (percentages) of latency. The methodology, limitations, and scope of the study are presented.

In the second chapter, a system model of write operations in storage area network environments (SAN) is considered, which covers the main elements of the system - host environment, transport layer and storage system - and considers the interaction between them as a determining factor in the formation of latency.

The main focus is on the queues and control mechanisms that appear along the path of the records. The total execution time of the write operations is presented according to the principles of the mass service theory.

It is shown that the latency behavior of recordings cannot be adequately described by a single average value. The meaning and interpretation of the percentiles p50, p95, p99 are introduced.

The third chapter is entitled "Experimental Methodology". A controlled experimental environment has been created that covers the host layer, the SAN transport infrastructure and the storage system, which are considered as a functionally connected circuit forming the recording path.

Five main experimental scenarios have been developed, which are implemented and analyzed in the fourth chapter.

Chapter four presents the results of the series of controlled experiments conducted within the experimental environment and methodology defined in chapter three.

Experiments were conducted and the results analyzed as follows: (0) Baseline experimental scenario (reference behavior); (1) Effect of queue depth (QD) on

write latency; (2) Impact of workload shape on write latency; (3) Impact of system request rate; (4) Impact of a competing host on write latency on a shared volume.

In the fifth chapter, an analysis and interpretation of the experimental results presented in the fourth chapter are made. The results of the experimental scenarios are compared.

Recommendations for optimization of SAN write operations are formulated based on the research conducted for five emerging precedents depending on observed effect.

A framework has been developed that enables experimental observations to be used as specific recommendations for optimizing the SAN write process. Practical interpretations have been made for the purposes of designing, configuring, and operating SAN-based systems.

The sixth chapter summarizes the main results obtained in the research conducted in the dissertation and outlines directions for future research.

The dissertation work concludes with contributions, literature used, author's publications on the dissertation, a declaration of originality of the results, and an appendix.

4. Correspondence of the chosen research methodology and the set goal and objectives of the dissertation work with the achieved contributions.

I believe that there is a very good correspondence between the goal, the set objectives, the chosen methodology and the formulated contributions. The objective is decomposed into logically related tasks – from SAN architecture analysis, through model building and experimental methodology, to analytical synthesis and development of a framework for optimization purposes.

5. Scientific-applied and applied contributions of the dissertation work

The dissertation work contains the following more important scientific-applied and applied contributions:

1. An approach for latency analysis using the empirical distribution function (ECDF) and the p95 and p99 indicators is proposed, which allows for the detection of effects invisible when using only average indicators.
2. An experimental methodology has been developed, based on a real SAN infrastructure, which allows for controlled variation of load parameters with a fixed system configuration.
3. On the basis of experiments conducted in a controlled environment and analysis, regularities in the behavior of latency have been established.

4.The results of five main experimental scenarios have been developed, implemented and analyzed.

5.The results of the conducted research confirm that the behavior of write operations in a SAN environment is determined to a greater extent by the interaction between load management mechanisms, input-output queues, and coordination between individual system layers.

6.It has been experimentally established that increasing parallelism beyond a certain threshold can lead to a disproportionate increase in the final percentiles.

7.A methodology and optimization framework has been developed that can assist in the design, configuration and operation of SAN systems.

6.Evaluation of the publications in the dissertation

6 scientific publications are attached to the dissertation. In four of them the doctoral student is an independent author, and in two he is a co-author with his scientific supervisor. Four of the publications are in English and two in Bulgarian. One of the publications is in an international journal, and the rest are in conference proceedings.

Two of the attached scientific publications are in editions that are referenced and indexed in world-renowned databases of scientific information, and the other four are in non-refereed journals with scientific review or in edited collective volumes.

The publications are thematically related to the storage environments (SAN) considered in the dissertation. The results obtained and analyses of the conducted research are published.

7.Assessment of the compliance of the abstract with the requirements for its preparation, as well as the adequacy of reflecting the main points and contributions of the dissertation work.

At the beginning, the abstract begins with a general description of the dissertation, including: relevance of the problem, purpose of the research, research objectives, object and subject of the research, research thesis, research methodology, limitations of the research, and practical applicability of the results.

After the general characteristics, the structure of the dissertation and the essentials of the chapters in the dissertation are presented. The main results of the dissertation, contributions, publications on the dissertation and used literature are published.

I believe that in this form the abstract can be printed.

8. Opinions, recommendations and notes.

1. Couldn't the foreign terms used, such as latency and percentiles, be replaced with the Bulgarian terms delay (in data transfer) and percentages, respectively?
2. The pages in the dissertation I have are not numbered.
3. Much of the experiments and results are presented in an extended verbal form, but could be presented in a much more concise form.
4. It is possible to derive a multidimensional mathematical model that would allow the optimization problem to be reduced to solving a classical optimization problem.
5. There are results obtained, conclusions drawn and recommendations formulated for optimization of SAN write operations, which should be published in the future.

9. Conclusion with a clear positive or negative assessment of the dissertation work

My overall assessment of Genka Slavova-Torres' dissertation work is positive.

The analysis of the implementation of the minimum national requirements for acquiring the educational and scientific degree "doctor" in the professional field 5.3. Communication and computer technology and the requirements of the Regulations on the specific conditions for acquiring scientific degrees and for occupying academic positions in the Institute of Information and Communication Technologies shows that under the group of indicators A, with a required score of 50 points, with the presented dissertation the doctoral student achieves these points and under the group of indicators G, with a required minimum score of 30 points, G. Slavova-Torres achieved 140 points. These points are formed from 80 points under indicator G7 (two of the applied scientific publications are in publications that are referenced and indexed in world-renowned databases of scientific information) and 60 points under indicator G8 (four publications are in non-refereed journals with scientific review or in edited collective volumes).

Based on my positive assessment of the dissertation work and the information presented in this review, I propose to the esteemed Scientific Jury **to award Genka Ivanova Slavova - Torres the educational and scientific degree "Doctor"**, in the scientific field 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, doctoral program "Computer Systems, Complexes and Networks".

Date: 3.09.2026

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