REVIEW

of the official reviewer for dissertation work

Mukhit Zhanuzakov on the theme «Research of fault-tolerance algorithms for reliable information processing» presented for the degree of Doctor of Philosophy (PhD) in the specialty «8D06103 – Computer Science».

№	Criteria	Eligibility (one of the options must be checked)	Justification of the position of the official reviewer
1.	The topic of the thesis (as of the date of its approval) corresponds to the directions of development of science and/or state programs	1.1 Compliance with priority areas of science development or government programs:	
		1) The thesis was completed within the framework of a project or target program financed from the state budget (indicate the name and number of the project or program) 2) The thesis was completed within the framework of another state program (indicate the name of the program) 3) The dissertation corresponds to the priority direction of the development of science, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (indicate the direction)	1) The dissertation was completed within the framework of a scientific project financed from the state budget of the Republic of Kazakhstan — AP09259208 "Development of a scalable fault-tolerant information system for enterprise digitalization using Big Data technologies" (0121RK00369). The research results directly contribute to the objectives of this project, particularly in the development of fault-tolerant algorithms, scalable distributed systems, and digital enterprise solutions. 2) The dissertation was not carried out within the framework of other state programs. 3) The dissertation corresponds to the priority direction of the development of science approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan, namely: "Information, communication and digital technologies". The research aligns with this priority

			through: - development of fault-tolerant distributed systems, - application of artificial intelligence and Big Data technologies, - ensuring reliability and scalability of enterprise information systems in the context of digitalization.
2.	Importance for science	The work makes/does not make a significant contribution to science, and its importance is well disclosed/not disclosed	The work makes a significant contribution to science, and its importance is clearly and sufficiently disclosed. The dissertation addresses a relevant problem in the field of reliable information processing in distributed systems and proposes well-grounded approaches to optimizing checkpointing intervals in rollback-recovery algorithms. The scientific contribution is reflected in the development of both model-based and queuing-theory-based solutions, supported by experimental validation in simulated and real-world environments. The author consistently demonstrates the practical relevance and applicability of the obtained results, which confirms the overall significance of the research.
3.	The principle of independence	Self-reliance level: 1) High; 2) Medium; 3) Low; 4) No independence	Self-reliance level: High. The dissertation demonstrates a high degree of independence. The author has independently formulated the research objectives, developed theoretical models and algorithms, carried out their

			implementation, and performed experimental validation. The results presented in the work, as well as the publications on the topic, confirm the author's ability to conduct scientific research at a high level.
4.	The principle of inner unity	4.1 Justification of the relevance of the thesis: 1) Justified; 2) Partially justified; 3) Not justified.	The relevance of the dissertation topic is clearly substantiated. The work addresses current challenges related to ensuring reliability and fault tolerance in distributed enterprise systems, which are particularly important in the context of ongoing digitalization and the increasing complexity of information infrastructures. The author convincingly demonstrates the need for improving existing approaches, and the proposed solutions are well aligned with modern scientific and technological demands.
		4.2 The content of the thesis reflects the topic of the thesis: 1) Reflects; 2) Partially reflects; 3) Does not reflect	The structure and content of the dissertation are fully consistent with the stated topic. All sections of the work are logically interconnected and focused on solving the defined research problem. The theoretical analysis, methodological developments, and experimental results directly correspond to the objectives of the study and ensure comprehensive disclosure of the topic.
		4.3. The purpose and objectives correspond to the topic of the thesis: 1) correspond; 2) partially correspond;	The stated purpose and research objectives are fully consistent with the topic of the dissertation. They are clearly formulated and directly aimed at solving

		3) do not correspond	the identified scientific problem. The tasks logically follow from the goal and are successfully addressed throughout the work .
		4.4 All sections and provisions of the thesis are logically interconnected: 1) completely interconnected; 2) the interconnection is partial; 3) there is no interconnection	All sections of the dissertation are logically structured and interconnected. The theoretical foundations, methodological developments, and experimental results form a coherent and consistent narrative, ensuring a comprehensive and systematic disclosure of the research topic.
		4.5 The new solutions (principles, methods) proposed by the author are reasoned and evaluated in comparison with the known solutions: 1) there is a critical analysis; 2) partial analysis; 3) the analysis does not represent one's own opinions, but quotes from other authors 4) the analysis is absent.	The dissertation includes a comprehensive and critical analysis of existing approaches to fault tolerance and checkpointing methods. The author not only reviews known solutions, but also identifies their limitations and justifies the need for improved methods. The proposed models and algorithms are compared with existing approaches, and their advantages are substantiated through both theoretical reasoning and experimental evaluation.
5.	Scientific novelty principle	5.1 Are the scientific results and provisions new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The dissertation contains elements of scientific novelty, particularly in the development of approaches to optimizing checkpointing intervals. At the same time, the research builds upon existing theoretical foundations in the field of fault tolerance and distributed systems, which determines the partial nature of its novelty .

		5.2 Are the dissertation findings new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The conclusions obtained in the dissertation reflect both new results and the development of known approaches. The findings are substantiated and logically derived, although they are partly based on the extension and refinement of existing methods.
		5.3 Technical, technological, economic or management decisions are new and reasonable: 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The proposed technical and technological solutions demonstrate elements of novelty and are reasonably justified. They represent an improvement and adaptation of existing methods to specific conditions of enterprise distributed systems, confirmed by experimental evaluation.
6.	The validity of the main findings	All main conclusions are/are not based on scientifically significant evidence or well-grounded (for qualitative research and areas of training in the arts and humanities)	All main conclusions are based on scientifically significant evidence and are well-grounded. The conclusions presented in the dissertation are supported by a solid theoretical foundation, critical analysis of existing approaches, and results of experimental validation. The author consistently substantiates the findings through modeling, algorithm development, and testing in both simulated and real-world environments, which confirms their scientific validity and reliability.
7.	The main provisions for the defense	It is necessary to answer the following questions for each provision separately: 7.1 Is the provition proven? 1) proven; 2) rather proven;	7.1 Is the provision proven? – proven. The provision is supported by theoretical justification and confirmed through experimental validation.

		3) rather not proven; 4) not proven 5) in its current wording, it is impossible to verify whether the statement has been proven. 7.2 Is it trivial? 1) yes; 2) no 3) in its current wording, it is impossible to verify whether the statement is trivial. 7.3 Is it new? 1) yes; 2) no 3) in its current wording, it is impossible to verify the novelty of the statement. 7.4 Application level: 1) narrow; 2) medium; 3) wide 4) in its current wording, it is impossible to determine the scope of application of the statement. 7.5 Is it proven in the article? 1) yes; 2) no 3) in its current wording, it is impossible to verify whether the statement has been proven in the article.	7.2 Is it trivial? – no. The proposed solution goes beyond standard approaches and addresses a non-trivial optimization problem. 7.3 Is it new? – yes. The method introduces an original approach to calculating checkpointing intervals based on system parameters . 7.4 Application level: – medium. The solution is applicable to enterprise distributed systems and can be adapted to similar environments. 7.5 Is it proven in the article? – yes. The results are reflected in the author's publications in peer-reviewed journals
8.	The principle of reliability Reliability of sources and information provided	8.1 Choice of methodology - is justified or the methodology is described in sufficient detail 1) yes; 2) no	The selected research methodology is justified and described in sufficient detail. The author clearly explains the use of theoretical analysis, modeling, and experimental validation appropriate to the research objectives .

		8.2 The results of the thesis were obtained using modern methods of scientific research and methods of processing and interpreting data using computer technologies: 1) yes; 2) no	The study employs contemporary scientific methods, including algorithm design, simulation, and data processing using modern computational tools and technologies .
		8.3 Theoretical conclusions, models, identified relationships and patterns have been proven and confirmed by experimental research (for areas of training in pedagogical sciences, the results have been proven on the basis of a pedagogical experiment): 1) yes; 2) no	The proposed models and theoretical conclusions are supported by experimental research conducted in both simulated and real-world environments, confirming their validity .
		8.4 Important statements are confirmed / partially confirmed / not confirmed by references to current and reliable scientific literature	The key provisions of the dissertation are supported by references to relevant and reliable scientific literature, reflecting the current state of research in the field.
		8.5 Used literature sources are sufficient/not sufficient for a literature review	The number and quality of literature sources are adequate for a comprehensive review and demonstrate a good understanding of the research area .
9	Practical value principle	9.1 The thesis has theoretical value: 1) yes; 2) no	The work contributes to the development of theoretical approaches in the field of fault tolerance and distributed systems, particularly in optimizing checkpointing mechanisms.
		9.2 The thesis is of practical importance and there is a high probability of applying the results obtained in practice: 1) yes; 2) no	The results have practical significance, and there is a high probability of their application in real enterprise distributed systems, as demonstrated by implementation and testing .
		9.3 Are the practice suggestions new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The practical recommendations are based on both original developments and adaptation of existing approaches, demonstrating a reasonable level of

			novelty and applicability .
10.	The quality of writing and design	Academic writing quality: 1) high; 2) average; 3) below average; 4) low.	The dissertation is written in a clear and consistent academic style. The material is logically structured, the arguments are presented coherently, and the terminology is used correctly. The text demonstrates a good level of scientific language proficiency and meets the requirements for academic writing
11.	Notes on a thesis		The dissertation is a complete and well-structured scientific work devoted to a relevant problem in the field of distributed systems and fault tolerance. The author demonstrates a solid theoretical background and the ability to apply modern research methods. The results obtained are substantiated and supported by experimental validation. At the same time, certain aspects, such as broader generalization of the proposed methods and comparison with a wider range of alternative approaches, could be further elaborated.
12.	Scientific level of the doctoral student's articles on the topic of research (in case of defense of the dissertation in the form of a series of articles, the official reviewers comment on the scientific level of each article of the doctoral student on the topic of research)		The publications of the doctoral student correspond to the topic of the dissertation and reflect its main results. The articles are published in journals recommended by the authorized body and in international journals indexed in recognized databases, which indicates their scientific relevance and quality. The works demonstrate a sufficient level of originality, methodological soundness, and practical significance. Overall, the scientific level of the publications can be assessed as high.

13.	Decision of the official reviewer (pursuant to paragraph 28 of the present Model Regulations)		Based on the analysis of the dissertation, its scientific results, publications, and the level of their substantiation, it can be concluded that the work meets the requirements for doctoral dissertations established by the current regulations. The dissertation makes a meaningful contribution to the development of the field of distributed systems and fault-tolerant computing. I consider Mukhit Zhanuzakov to be worthy of the degree of Doctor of Philosophy (PhD) in the specialty "8D06103 – Computer Science".

In reviews, official reviewers indicate one of the following solutions:

1) to award the degree of Doctor of Philosophy (PhD);

2) send the thesis for revision (except for cases of thesis defense in the form of a series of articles);

3) refuse to award the degree of Doctor of Philosophy (PhD).

HR Қызметі

Official Reviewer:
Kazakh National Research Technical University named after K.I. Satpayev
Candidate of Physics and Mathematics
Associate Professor

Aiman N. Moldagulova