

STATEMENT REPORT

**on the procedure for defense of a dissertation thesis entitled:
“Porous Medium Flow Simulations using Massively Parallel MLMC algorithm”
for obtaining the educational and scientific degree “Doctor”**

by

Candidate: **Nikolay Georgiev Shegunov**

Scientific field: **4. Natural Sciences, Mathematics and Informatics,**

Professional field: **4.6. Informatics and Computer Science,**

Ph. D. Program: **“Information systems”, Department of Computer Informatics,**

Faculty of Mathematics and Informatics (FMI),

Sofia University “St. Kliment Ohridski” (SU),

The statement report has been prepared by: Associate Professor **Radoslava Danailova Hristova**, Ph. D., in my capacity as a member of the scientific jury for the defence of this dissertation according to Order № 38-258/07.06.2021 of the Rector of the Sofia University.

1. General characteristics of the dissertation thesis and of the presented materials

The dissertation is written in English and has a volume of 129 pages, which include six chapters, three appendices and a list of references. The bibliography consists of 62 literature sources, all in English, most of which are either articles from recent years or fundamental publications in the subject area.

The aim of the dissertation is "to provide an efficient general purpose parallel variant of the Multilevel Monte Carlo algorithm for porous medium flow simulations" which to be used on high-performance systems.

The dissertation has a multidisciplinary nature. The problem addressed in it, namely the simulation of porous medium flows using the Multilevel Monte Carlo algorithm is relevant, and finding a solution to this problem would find application in other areas, such as in the development of metal composite materials, in simulation of filtration processes and many more.

The doctoral student has well motivated the purpose of the dissertation, has shown the need for and importance of finding solutions for this problem. He examined the mathematical models used to simulate flows in porous media, paying more attention to two models used for this

purpose, namely the stochastic Laplace equation and the stochastic convection-reaction-diffusion equation.

The main contribution of the doctoral student in the dissertation is the developed strategy for effective parallel calculation of the Multilevel Monte Carlo algorithm for simulation of flows in porous media.

2. Data and personal impressions of the candidate

I have known the doctoral student since April 2018, when he joined in the Department of Computer Informatics at the Faculty of Mathematics and Informatics at Sofia University “St. Kliment Ohridski” as a researcher. My personal impressions of him as a colleague are excellent.

3. Content analysis of the scientific and scientific-applied achievements of the candidate, contained in the presented dissertation thesis and the publications to it, included in the procedure

My overall impression of the text is that the work contains significant contributions, both scientific and scientific-applied. An analysis of the existing algorithms for solving two model problems is made, namely the stochastic Laplace equation and the stochastic convection-reaction-diffusion equation, considering the shortcomings of the classical Monte Carlo algorithm for solving this type of problems and the advantages of the application. of the Multilevel Monte Carlo algorithm.

The general structure of the theoretical construction of the Multilevel Monte Carlo algorithm is considered, as well as the difficulties for its practical application. A multilevel Monte Carlo algorithm for the Laplace model stochastic equation is constructed and applied. Various ways to renormalize the stochastic field are considered and simulation results are shown. The Multilevel Monte Carlo algorithm for the convection-reaction-diffusion equation has been developed and applied. A comparison is made with the classical Monte Carlo algorithm.

The fifth chapter of the dissertation contains the main contributions of the doctoral student. It sets out and analyzes in detail the algorithmic approach and the peculiarities of its program implementation. Difficulties in constructing the parallel calculation scheme are shown and analyzed. Different approaches to overcoming them are considered. An author's modification of the algorithm is proposed, aimed at massively parallel systems. Experiments have been performed and their results have been presented and analyzed.

4. Approbation of the results

The doctoral student has presented 5 publications in peer-reviewed and peer-reviewed editions. Four of the publications are with SJR, three of them are in Springer, one in CEUR Workshop Proceedings and one in Cybernetics and Information Technologies. All presented publications are in publications that are referenced and indexed in world-famous databases of scientific information (Web of Science and Scopus).

All publications are co-authored, and for two of them the doctoral student is the first author. For publication under number [2] in the abstract, the doctoral student has submitted a declaration of co-authorship, according to which the doctoral student's contribution to the publication is 80%. No declarations have been submitted for the other publications and it can be assumed that the contributions there are equal. The publications cover most of the doctoral student's work presented in the text of the dissertation.

The scientific works meet the minimum national requirements (under Art. 2b, para. 2 and 3 of ZRASRB) and respectively the additional requirements of Sofia University "St. Kliment Ohridski" for acquiring the educational and scientific degree "Doctor" in 4.6. Informatics and computer science.

The results presented by the candidate in the dissertation work and scientific works to it do not repeat those of previous procedures for acquiring a scientific title and academic position. There is no legally proven plagiarism in the submitted dissertation and scientific papers on this procedure.

5. Qualities of the abstract

The abstract to the dissertation is presented in both Bulgarian and English. The volume of the Bulgarian version is 39 pages, and of the English version 38. The two versions are identical. The abstract meets the requirements and correctly presents the results and content of the dissertation.

6. Conclusion

After getting acquainted with the dissertation presented in the procedure and the accompanying scientific papers and based on the analysis of their significance and the scientific and scientific-

applied contributions contained in them, I confirm that the presented dissertation and scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of ZRASRB, the Regulations for its application and the respective Regulations of Sofia University “St. Kliment Ohridski ”for acquisition by the candidate of the educational and scientific degree “Doctor” in the scientific field 4. Natural sciences, mathematics and informatics and professional field 4.6. Informatics and computer science. In particular, the candidate satisfies the minimum national requirements in the professional field and no plagiarism has been established in the scientific papers submitted at the competition.

Based on the above, I recommend the scientific jury to award Nikolai Georgiev Shegunov educational and scientific degree "Doctor" in scientific field 4. Natural Sciences, Mathematics and Informatics, professional field 4.6. Informatics and computer science (Information systems).

12.08.2021г.

Reviewer: Assoc. prof. Radoslava Hristova, Ph. D.