REVIEW

by Prof. Dr. Radoslav Yoshinov
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of a dissertation on the award of the educational and scientific degree "**Doctor**" in the doctoral program "**Informatics**", professional field **4.6. Informatics and Computer Science**

with author: Tasho Dimitrov Tashev

on topic: ALGORITHMS FOR CONFLICT-FREE SCHEDULE OF A PACKET SWITCH WITH MATRIX SWITCH

By Order No 65/27.02.2023 of the Director of IICT, I was appointed as a member of the scientific jury in a dissertation procedure on "ALGORITHMS FOR CONFLICT-FREE SCHEDULING OF PACKET SWITCH WITH MATRIX SWITCH '" for awarding the educational and scientific degree "Doctor" under the doctoral program "Informatics", professional field 4.6. Informatics and Computer Science by Tasho Dimitrov Tashev.

As a member of the scientific jury, I have received:
1. Dissertation for awarding the educational and scientific degree "Doctor";
2. Dissertation autoreferate;
3. Copies of the articles included in the dissertation;
4. Reference for the implementation of the minimum requirements of IICT-BAS for acquiring the educational and scientific degree "Doctor".
5. Other documents supporting the procedure.

At the first meeting of the scientific jury held on 10.03.2023 I was selected as a reviewer under the procedure.

1. Timeliness of the dissertation

The need for research and application of innovative technological solutions, the increasing access to databases in recent years, as a result of the conscious and rational human activity related to the generation, storage, processing and use of information, leads to an increasing need to develop stable devices for the exchange of information. Currently, telecommunications flows are of a digital kind based on packet exchange. In computer networks, the devices for exchanging information between major nodes are switches also called routers and routers. Their central block is the switch representing. The control circuit implements a conflict-free transmission through the switching field following this schedule, which is calculated according to a corresponding algorithm. Such conflict-free scheduling algorithms are the subject of the proposed dissertation.

The dissertation presents a study in the field of computer networks by modeling existing algorithms for conflict-free scheduling in a packet switch with a matrix switch and proposes an OM model of a new algorithm called MiMa-Minimum of Maxima. Computer simulations of the switch's throughput with a MiMa-algorithm were conducted, allowing the determination of its positive sides and disadvantages. This makes it possible to identify future research to improve the MiMaalgorithm.

The main objective of the dissertation study is to gain methodological experience in the use of the Summary Networks apparatus in modeling algorithms for conflict-free timetable for a packet switch with matrix switcher with incoming buffering of the type "virtual output queues" and to propose a new algorithm and its formal OM model for conflict-free scheduling in a packet switch with matrix switch and to probe a methodology for large-scale computer simulations of its throughput ability to provide an unambiguous comparison of different algorithms.

The implementation of the set goal implies the solution of the following tasks:

Task 1. To specify models using the Summary Networks (OM) apparatus of classical conflict-free scheduling algorithms in a packet switch with a matrix switch, through which to obtain methodological experience from the application of the OM apparatus to running algorithms.

Task 2. To synthesize a new algorithm for conflict-free scheduling in a packet switch with matrix switch and obtain its specification in the form of an OM model.

Task 3. To propose inbound traffic templates realizing uniquely different workloads for computer simulations of the throughput (PS) of conflict-free timetable algorithms.

Task 4. To develop a procedure for calculating an accurate upper bound of the throughput (PS) of conflict-free timetable algorithms in a packet switch with a matrix switch, for uniquely adequate comparison of the PS of conflict-free timetable algorithms.

I find that the set goal and the tasks thus formulated are up to date, and the content proves the significance of the dissertation presented. I appreciate the topic and the research done in the dissertation.

2. Degree of knowledge of the state of the problem and general characteristics of the work

The dissertation study is the intersection of the fields of Informatics and Computer Networks. The subject of the dissertation are new technological solutions and modern tools (models, methods and tools) in the field of computer networks by modeling with the means of the formal apparatus of the Generalized Networks (OM) existing algorithms for conflict-free scheduling in a packet switch with a matrix switch. The subject of the study is the identification of opportunities to use a switching field and a control scheme to carry out the necessary transfer of data packets from the incoming to the

outgoing communication lines, by executing a calculated "schedule", offering an OM-model based on a new algorithm.

The dissertation is structured in content, a list of abbreviations used, an introduction, five chapters, a conclusion and summary of the results achieved, applications, prospects for future development, approbation, publications on the topic of a dissertation, noted citations, a list of used literature and a declaration of originality and authenticity.

The dissertation work has a volume of 138 pages, 42 figures, 4 tables and 130 literary sources. 7 publications of the author related to the dissertation presented

In the bibliography of the dissertation are cited 130 literary sources: books, scientific articles and Internet publications.

Chapter 1 provides an analytical overview of approaches and methods for the synthesis of models and information interactions and structure of complex systems. The Summary Networks (OM) apparatus was chosen to be used as a formal means of describing and calculating a conflict-free timetable in a packet switch.

In Chapter 2. the developed OM-models for the algorithms "Wavefront" and "Observation" and their three modifications are presented.

In Chapter 3. a method for sequential construction of an OM-model of the PIM-algorithm (Parallel Iterative Matchingjf, "rib" type) is described, which uses a parallel computation of a conflict-free timetable. As a result, the synchronization points of parallel processes are clearly displayed. Specified is an OM-model of a "weight" type of algorithm – LPF. The model allows easy determination of the most "severe" computational operation (sorting).

In Chapter 4. a new algorithm is described – MiMa. It is of the "weight" type with

consistent calculation based on a "hard" criterion of conflict formulated by us. The four options for selecting weighting factors have been investigated. Computer simulation confirms that the classical discipline "max-max" gives maximum throughput (PS) and "min-min" – minimum PS.

In Chapter 5 a numerical procedure is presented for an exact upper limit of the PS of the algorithms in a given range of dimension of the switching field

The Conclusion summarizes the results obtained on the tasks. The main scientific, applied and scientific-applied contributions of the dissertation are indicated. Prospects for future development are formulated

With the solution of these tasks, the main purpose of the dissertation is achieved. A list of scientific publications on the topic and noted citations are presented.

All this proves that the doctoral student has in-depth knowledge in the subject of the conducted research.

3. Compliance of the proposed methodology of research and the set objective and tasks of the dissertation

In the dissertation, a study was made in the field of computer networks by modeling existing algorithms for conflict-free scheduling in a packet switch with a matrix switch with a means of the formal apparatus of Summary Networks (OMs) and an OM-model of a new algorithm called MiMa-Minimum of Maxima was proposed. Computer simulations of the switch's bandwidth with MiMa-algorithm were conducted, allowing the identification of its positive sides and shortcomings. Directions for future research and development have been defined.

The chosen methods and means correspond to the main goal and tasks set for solution by the doctoral student.

4. Characterization of the nature and assessment of the credibility of the material on which the contributions of the dissertation are built

The methods and models that are created and used correspond to the target task. An OM-model of a new algorithm called MiMa-Minimum of Maxima is proposed. Computer simulations of the switch's throughput with a MiMa-algorithm were conducted.

For some statistical results of their application have been obtained and for others solution concepts are presented and directions for future research are given.

I have not noticed any errors in either the specific or conceptual models. I also find that the strategies proposed are well founded.

5. Contributions of the dissertation

The more substantial results obtained in the dissertation work are summarized in author's claims for the following scientific, scientific-applied and applied contributions.

1. A new MiMa algorithm (MinimumofMaxima) for conflict-free scheduling in a packet switch with matrix switch has been synthesized and investigated. The throughput of the algorithm tends to 100 %, and its time complexity for execution is (O(n2.6)).The theoretical limit for the class of "weight" algorithms to which MiMa belongs is (O(n2.5)).

2. They are modeled with the Summary Networks (OM) apparatus and OMmodels of 4 classical conflict-free scheduling algorithms in a packet switch with matrix switch are studied.

3. 4 families of templates for 4 classical (uniform, Chang, Chao, Rojas-Chessa) types (i.i.d. Bernoulli) incoming traffic are synthesized, designed for large-scale computer simulations of the bandwidth of conflict-free timetable algorithms, at 100% load on the incoming lines.

4. A numerical procedure has been developed to calculate an accurate upper bound of the throughput (PS) of conflict-free scheduling algorithms in a packet

switch with matrix switch. The limit is calculated as the specified switching field operating range (n) in large-scale computer simulations of the PC with the synthetic incoming traffic templates. The procedure is resistive to asymptotically attenuating disturbances. The procedure has been applied on the results of PC simulations of the synthesized OM-models.

The reviewer accepts the contributions thus described

6. Extent of the dissertant's personal involvement in contributions

The personal participation of the doctoral student is judged by the publication activity of the doctoral student reflected in the materials published on the dissertation. The PhD student convincingly presents the achieved results with a very good and thorough argumentation, as well as uses professional graphic design of the materials.

The nature of the study implies a very good and broad preparation in the field of innovative methods and applications through the means of information and communication technologies in computer networks. A positive assessment of the doctoral student is given, highlighting the overachievement of the required criteria for admission to the defense.

I believe that the PhD student has done well and I do not question her personal participation in the development of the dissertation material.

7. Evaluation of publications on the dissertation

The attached list of publications contains 7 titles. Six of the publications are co-authored with the supervisor and one is independent. One is in Bulgarian in collections of works from Bulgarian conferences. One is in Russian, the other five are in English in specialized journals and international conferences. Five of the publications are indexed in international databases Scopus, Web of Science, four of which have been published in issues with SJR.

This shows the ability of the doctoral student to conduct research in a team as well as independently.

The publications reflect the more substantial results achieved in the dissertation. They are reported at reputable scientific forums, which I take as approbation in the scientific community.

8. Compliance of the AUTOREFERATE with the requirements for its preparation and adequacy of reflection of the main points and contributions of the dissertation

The presented draft autoreferate is in accordance with the rules for the preparation of the dissertation dissertations, specified on the IICT-BAS website. The autoreferee in a volume of 51 pages reflects the essence and results achieved, as well

as the contributions of the author. It is graphically shaped very well and includes the necessary information describing in summary the dissertation.

9. Opinions, recommendations and remarks

The dissertation deals with a very complex, dynamically developing and promising field. Significant results have been achieved. You can see the work of a built scientist. I have no critical remarks on the dissertation, except for noticed spelling errors that do not diminish its value.

I have made some of the non-essential (linguistic) remarks on the copy that has been submitted to me.

10. CONCLUSION

The content and contributions of Tasho Dimitrov Tashev's dissertation fully meet the requirements of the Law on the Development of the Academic Staff of the Republic of Bulgaria, the Regulations for its application and the Rules on the Terms and Conditions for Acquiring Scientific Degrees at IICT-BAS. A significant amount and content of research work has been carried out. There is a sufficient number of scientificscientific, applied and applied contributions. A sufficient number of publications on the dissertation published at prestigious scientific forums have been presented. The educational doctoral minimum set in the individual plan is covered. Undoubtedly is the personal participation of the doctoral student in the development and contributions received. Expressing my categorical positive attitude towards the presented materials, this gives me reason to strongly recommend to the Honorable Scientific Jury to award to Tasho Dimitrov Tashev the educational and scientific degree **"Doctor"** in professional field 4.6 "Informatics and Computer Science", specialty "Informatics"

REVI

На основание

ЗЗЛД

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