REVIEW

on the competitive procedure for the academic position of "associate professor" in the professional area 5.2 Electrical Engineering, Electronics, and Automatics for the needs of the "Information Technologies for Security" Department of the Institute of Information and Communication Technologies (IICT), announced in *State Gazette* no. 81 of 11 October 2022.

Candidate: **Dr. Georgi Ivanov Sharkov**

Member of the Scientific Jury: **Professor Dr. Todor Dimitrov Tagarev**, Institute of Information and Communication Technologies

The single candidate in the procedure holds a "master in mathematics" degree from the Faculty of Mathematics and Informatics of Sofia University "St. Kliment Ohridski" (1981-1986) with a specialization in computer science, informatics, and artificial intelligence. From 1987 to 1991 he is a PhD student in a programme provided jointly by the Sofia University and the Bulgarian Academy of Sciences. He defends his dissertation on "Providing and Interpreting Knowledge from the Area of Membrane Physics" and receives a diploma for "candidate of mathematical sciences" (currently "doctor" / PhD). From 1992-1993 he conducts post-doctoral studies at the University of Gent, Belgium, with applications of artificial intelligence methods in the fields of genetics and thermography. In this period, he is involved in research projects related to modelling and design of information and control systems with applications in diverse areas.

Since 2013, Dr. Sharkov holds the scientific title of "principal assistant" and teaches in the programmes of the "Computer Technologies" department of Plovdiv University "Paisiy Hilendarski". He also teaches at the Faculty of Mathematics and Informatics of Sofia University and at New Bulgarian University.

The information on the scientific degree and scientific title held by the candidate is confirmed by the information in the Register of Academic Positions and Dissertations of NACID, https://ras.nacid.bg/dissertation-preview/31620.

To participate in this competitive procedure, Dr. Sharkov has submitted 38 scientific publications, including 22 conference reports, 14 articles and 2 chapters in a collective monographic publication. Only two of those presented are in Bulgarian (chapters in a monographic edition in

Bulgarian), and the remaining 36 are in English. In 12 of these publications, the candidate is the lead (first) author, and in four of the publications he is the sole author.

The candidate has submitted a declaration on the absence of plagiarism in the works submitted for review. I find no reason to doubt his statement.

Ten of the publications submitted for review are indexed in Web of Science and/or Scopus. All but one of them were published in the last few years (2016 and later).

A total of 12 of his publications are indexed in Dr. Sharkov's Web of Science profile (of which five are not indexed in the Core Collection), and 11 publications – in his Scopus profile. The citations of these publications are 61 and 75, respectively (I have excluded self-citations of the author and his co-authors). I believe that his other publications are also cited in articles and reports indexed in Web of Science and/or Scopus. This is precisely what explains why the minimum requirements in group D are exceeded multiple times, and in particular those in group D12 for citations in scientific publications, referenced and indexed in world-renowned databases of scientific information.

In the self-assessment report for meeting the minimum requirements of IICT for an associate professor, Dr. Sharkov has provided information on participation in four research projects with European funding. I have information on many more projects that he has been involved in or led, including some that are currently underway. I assume that the applicant has included only selected projects that meet and exceed the institute's minimum requirements for an associate professorship.

Dr. Sharkov also has experience in the state administration as an advisor to the Minister of Defense and the Prime Minister, and in these functions, he also performed as a national cyber security coordinator. In this capacity, he led an expert group of over 20 senior representatives from relevant organizations with the task of developing the first national cyber security strategy (endorsed by the Council of Ministers in 2016).

He participates in expert groups at the European level (DG CONNECT, ENISA, etc.) on issues of cyber security and "trustworthy artificial intelligence".

Personal impressions of the candidate

I have known the candidate for about 10 years. For the first time, we worked more closely together in the period 2014-2015 in the interagency working group for the creation of the first national cyber security strategy of Bulgaria, headed by Dr. Sharkov, in which I was a representative of the

Bulgarian Academy of Sciences. In 2016, we worked on the preparation of the large-scale exercise RACE (Parallel and Coordinate Exercise) of the European Union with the participation of NATO. In the period February 2019 – January 2023, we were partners in the ECHO project aiming to create a European cybersecurity competence network, financed under the Horizon 2020 program. On his invitation, in recent years I have been involved three times in providing methodological guidance in the preparation of annual cyber security exercises in hybrid scenarios, organized by the Cyber Security and Resilience Laboratory at Sofia Tech Park. Dr. Sharkov participates in the organization of the series of annual scientific conferences "Digital Transformation, Cyber Security and Resilience" (DIGILIENCE) with a leading role of IICT and is one of the editors of the collection of pre-published reports accepted for presentation at DIGILIENCE 2022 (Enhanced Collaboration for Cyber Security and Resilience, Information & Security: An International Journal, vol. 53, 2022), as well as the forthcoming volume in the "Communications in Computer and Information Science" series of Springer Nature.

In all these joint activities, Dr. Sharkov demonstrated a high level of professionalism, excellent communication skills and willingness to debate different ideas. In the preparation of official documents, such as the national cybersecurity strategy, he manages to combine requirements at the political and organizational level with the possibility to incorporate the latest concepts and technological capabilities. Putting the focus of the first Bulgarian cybersecurity strategy on resilience is entirely his merit. As a result, the very name of the concept was chosen – "Cyber Resilient Bulgaria 2020".

According to my personal observations, in national and international forums, the expert community demonstrates professional respect for the experience, knowledge and the ideas of Dr. Sharkov.

Assessment of the scientific results of the candidate

Papers submitted for review cover four areas:

- Security and resilience of complex systems of systems;
- Structuring knowledge and models for analysis of processes and phenomena in cyberspace and as a result of interactions in cyber-physical systems;
- Architectures for presenting cyber-physical systems and environments;
- Conceptual model for the analysis of organizational and organizational-technical systems for cyber security and resilience.

Below, I present my quantitative assessment on the compliance with the requirements of the Law on the Development of the Academic Personnel in the Republic of Bulgaria and the regulations for its application, followed by an assessment of the applicant's scientific and scientific-applied contributions.

Quantitative assessment on the compliance with the minimal requirements

According to the Regulations on the specific conditions for acquiring academic degrees and for holding academic positions at the Institute of Information and Communication Technologies, a candidate for associate professor in the professional area "5.2. Electrical Engineering, Electronics and Automation" must have not less than 50 points in group A, 100 points in group B, 220 points in group D, 60 points in group D and 20 points in group E.

The candidate has defended a dissertation for the scientific degree "Candidate of Mathematical Sciences" and thus fulfils the requirement in group A. In group B, the candidate has presented ten publications indexed in Scopus and/or Web of Science, which according to my calculations carry 269.5 (of the required 100) points. In group D, the candidate has included two publications indexed respectively in Scopus and Web of Science, which earn him 40 points. The remaining publications in this group carry another 198.67 (in the publication points from page 7 down to page 9 of the self-assessment report provided by the candidate, they differ from the relevant publications). Thus, the candidate meets the minimum requirements for group D.

As noted above, Scopus lists 75 citations of the candidate's publications indexed in Scopus. They alone are sufficient to exceed the minimum requirements in group D more than tenfold. Analogously, only Dr. Sharkov's participation in the ECHO project covers the minimum requirements in group E, while he referred to his participation in four international projects.

Evaluation of the claimed scientific and scientific-applied contributions

The candidate claims two scientific and four scientific-applied contributions on the basis of the 38 publications submitted for review. In analysing these claims, I exclude from consideration the four publications which I co-authored with the applicant (B04, B05, G15 and G19).

The first claimed scientific contribution is for developing theoretical models and concepts to investigate the security, resilience and risks of complex interconnected systems, designated as "systems of systems"

(SoS). The main publication supporting this claim is the paper "A System-of-Systems Approach to Cyber Security and Resilience" [G16] with sole author Dr. Sharkov. In the article, the candidate makes an extensive review of models of organizational-technical systems and their interaction. Its main focus is on expanding traditional models of the so-called "cyber terrain" focused on the physical and logical levels of interaction, with the inclusion of "layers" representing cyber personas, real people with their functions, organizational and governmental levels. It is this extension that allows the applicant to more fully account for the human factor and the role of organizational and governmental norms, policies, strategies and procedures on the security and resilience of complex systems. This expanded conceptual model enables a more holistic treatment and understanding of cyber threats, risk assessment, increased level of situational awareness [G09], analysis of cyber security and resilience of supply chains and, as the ultimate goal, to design and shape adequate policies common to public and private organizations at sectoral [G12], cross-sectoral, national [B01, G12] and international levels, as well as on adequate approaches to training [G07]. On these issues, the author has individual publications or is a lead author, and his role in achieving significant scientific results is indisputable.

The second claimed scientific contribution is structuring the knowledge of the "cyber terrain" through the development of adequate taxonomies and ontologies and the associated research apparatus. The main publication in this area [G03] was developed with co-authors in the format (research study or a group) of the European Union for Cybersecurity (ENISA). The remaining publications mainly present results from the application of this scientific apparatus. Based on the presented materials, it is difficult to assess what the individual contribution of the author is to the development of taxonomies and ontologies.

The first scientific-applied contribution is in the development of a flexible architecture of a research cyber-physical environment for simulating the behaviour of complex systems, that provides opportunities for automated analysis and tracking of vulnerabilities and cyberattacks in a closed and/or Internet environment, the application of intelligent autonomous agents in the creation and operation of platforms for monitoring the Internet space, ranges for conducting cyber exercises and others. Here I combine the claimed scientific-applied contributions 1 and 3 into one. In my view, the results in the candidate's publications give sufficient grounds to recognize such a contribution.

The above-cited conceptual model for presenting, studying and protecting "systems of systems" has been applied for the purposes of devel-

oping policies and strategies for cyber security and resilience at the organizational and national level, in particular, in the development of the first Bulgarian national strategy for cyber security. This model finds application in the design of a national cyber situation centre and network to coordinate cyber surveillance, increase the level of situational awareness and the effectiveness of the overall response to cyberattacks. I find this to be one of the most important scientific-applied contributions in Dr. Sharkov's overall work so far.

I already noted above that Dr. Sharkov contributed to the preparation and development of international standards and models for the design and development of reliable software and IT systems and their practical implementation. These include standards for "security by design" and "resilience by design", approaches and methodological apparatus for assessing the degree of maturity of systems for managing the resilience of organizations in relation to cyber impacts, models and standards of competences in the ICT area and in the area of cyber security. In recent years, this type of the candidate's activities has also included the development of policies and strategies for trustworthy artificial intelligence. The results are presented in a large number of publications submitted in this competitive procedure and defend the candidate's claim.

Critical remarks

I have no critical remarks on the candidate's publications presented in this competitive procedure. In his publication activity, however, a big gap is noticeable from the mid-1990s and for about twenty years. I would recommend the candidate after the (I presume successful) completion of this procedure to continue on the trend of his intensive research and publication activity from the last few years.

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Dr. Sharkov's research profile is aligned to the maximum possible extent to the research thematic of the "Information Technologies for Security" department of IICT. Including him in the department will contribute to a significant increase in research capacity on problems of cyber security and resilience of complex systems, including through application of artificial intelligence methods, as well as in the prospective scientific topic of security and safety of artificial intelligence systems. His experience in developing strategic documents in the field of cyber security and artificial intelligence will allow more effective inclusion of IICT in national and international expert forums on issues of cybersecurity and artificial intelligence. His practical experience in organizing and managing complex software

projects will be valuable in various formats aiming to transfer scientific results into business solutions and in supporting innovation.

CONCLUSION

My overall evaluation of the scientific and applied activities of Dr. Sharkov is positive. My assessment is that the requirements of the Law on the Development of the Academic Personnel in the Republic of Bulgaria, the national regulations for its implementation, and the regulations the Bulgarian Academy of Sciences and the Institute of Information and Communication Technologies are fully met. On that basis I am recommending that the Scientific Jury makes a proposal to the IICT Scientific Council to elect Dr. Georgi Ivanov Sharkov for the academic position of "Associate Professor" in the area of higher education "Technical Sciences", sub-area 5.2 Electrical Engineering, Electronics and Automatics.

Member of the Scientific J

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