SOFTWARE AND SERVICES - RESEARCH AND EDUCATION IN BULGARIA

A. Dimov [(1)], S. Ilieva [(1)], I. Pavlova [(1)], A. Eskenazi [(2)]

[(1)] Faculty of Mathematics and Informatics, Sofia University "St. Kl. Ohridski"
Sofia 1164, J. Bouchier str., No. 5
e-mail: sylvia@acad.bg, aldi@fmi.uni-sofia.bg, irena_pavlova@fmi.uni-sofia.bg

[(2)] Institute of Mathematics and Informatics, Bulgarian Academy of Sciences
Sofia 1113, Acad G. Bonchev str., bl.8
e-mail: eskenazi@math.bas.bg

***Abstract**: The starting point of this paper is the conviction that research and university education are tightly connected. It presents the main research directions carried out in Bulgaria in the recent years in the area of software and services. Following the ACM Computing Classification and taking into account the IEEE's Software Engineering Body of Knowledge (SWEBOK), the authors classify the topics of the research efforts in the area. Then the research activities of the academic community are analyzed and discussed[1].*

***Key words**: software and services, research, education*

1. Introduction

There are many evidences around the world demonstrating that the higher the level of research in a university - the better the quality of education. One of the most brilliant examples comes from our area of interest and is the Carnegie-Melon University and the SEI - the Software Engineering Institute belonging to it. No doubt that this university offers highly rated programs and education of very good quality in computing and particularly in Software engineering. Simultaneously, SEI is considered as the world leading research and innovation institution in Software engineering.

The main goal of the SISTER EC FP7 project ("Strengthening the IST Research Capacity of Sofia University") is to develop the Faculty of Mathematics and Informatics (FMI) as a Leading Center in South Eastern Europe (SEE) in research, innovation and training in the area of ICT and more specifically in **Software and Services (S&S)**, as well as in a few other close areas. One of the main tasks in this context is "**Determining joint research agenda in S&S"**. The purpose of this task is to enable the FMI research group in S&S to capitalize on existing research capacities, while providing a strategy for harmonization of research focus. It will identify topics of S&S research that (i) constitute research urgencies at European levels (ii) map on local and regional interests and capacities, and (iii) are in the research focus of FMI research group.

For the purposes of this paper we assume that "Software services" are distributed software components and integrated open software packages offering their functionality through a network. "Software" and "Software engineering" have the standard and well-known meaning. In this sense as a working hypothesis S&S is considered as a superset of software engineering (SE). This is because (among other arguments) some problems of the software services have a purely business character.

2. Background

We identified different sources of existing classifications, which try to structure the knowledge and research in S&S.

ACM classification system. The ACM Computing Classification System (CCS) [1] is the most popular system for classification and indexing of the published literature on computing. The full classification scheme involves three concepts: the four-level tree (containing three coded levels and a fourth non-coded one), General Terms, and implicit subject descriptors. After having examined the tree we consider the following topics as related to S&S:

D. Software
D.2 SOFTWARE ENGINEERING (K.6.3)
- D.2.0 General (K.5.1)
- D.2.1 Requirements/Specifications (D.3.1)
- D.2.2 Design Tools and Techniques
- D.2.3 Coding Tools and Techniques
- D.2.4 Software/Program Verification (F.3.1)
- D.2.5 Testing and Debugging

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D.2.6 Programming Environments
D.2.7 Distribution, Maintenance, and Enhancement
D.2.8 Metrics (D.4.8)
D.2.9 Management (K.6.3, K.6.4)
D.2.10 Design (D.2.2)
D.2.11 Software Architectures
D.2.12 Interoperability
D.2.13 Reusable Software
D.2.m Miscellaneous
H. Information Systems
H.3 INFORMATION STORAGE AND RETRIEVAL
H.3.5 Online Information Services
Commercial services
Data sharing
Web-based services

Guide to the Software Engineering Body of Knowledge (SWEBOK). The purpose of SWEBOK [4] is to provide a consensually validated characterization of the bounds of the software engineering discipline.

The proposed SWEBOK Knowledge Areas (KA) are:

1. Software requirements
2. Software design
3. Software construction
4. Software testing
5. Software maintenance
6. Software configuration management
7. Software engineering management
8. Software engineering process
9. Software engineering tools and methods
10. Software quality

Further, the description of each of the listed 10 KA consists of an introduction, the core of each KA description, a decomposition of the KA into sub-areas, topics and sub-topics, as well as references.

Standards. Areas of knowledge/research are closely related to various standards. The most widely used are those produced by IEEE Computer Society Software and Systems Engineering Standards Committee and ISO/IEC JTC1/SC7.

Software services. To identify the research priorities in software services we analyzed:

- Research projects funded by FP6 and FP7 programs.
- 3S European project for roadmaping
- Strategic Research Agenda (SRA) of NESSI (Networked European S&S Initiative) - European S&S technology platform.

We also took into account the research areas in the FP7 work program 2009-2010:

1. Service Architectures and Platforms for the Future Internet
   1.1 Service front ends
   1.2 Open, scalable, dependable service platforms, architectures, and specific platform components
   1.3 Virtualized infrastructures
2. Highly Innovative Service / Software Engineering
   2.1 Service / Software engineering methods and tools
   2.2 Verification and validation methods, tools and techniques
   2.3 Open source software

Based on those various sources of information we tried to identify and summarize the Bulgarian community strengths and achievements in the area of S&S.

3. Methodology

As already stated above, our main goal is to **select areas of research priority** in S&S. We believe that the main determining factors are:

- current state and trends of the research in the world,
- capabilities, traditions and trends in Bulgaria in S & S research
- needs of the employers in Bulgaria,
- needs of the Sofia University, respectively FMI.

One possible approach to solving the problem of the recognition of development trends in scientific fields may consist in analyzing the dynamics of various sources of information. This is a modification of the basic idea of [5]

investigating the vocabulary dynamics in documentary databases. The theoretical basis of the latter was provided by elements of the Prigojin theory of non-equilibrium thermodynamics in open systems [6], [7], the main points of which were projected on the field of information science and the science of science. The method is based on the principle of isolating monotonous and fluctuating sections in the dynamics of information sources under investigation.

Hence, first we have to gather the appropriate information. More specifically this is:

- at FMI level – areas and numbers of scientific publications, as well as research projects, authored or with the participation of FMI members/PhDs, number of PhDs and theses defended
- at national level - areas and numbers of scientific publications, PhDs and theses defended
- at global - areas and numbers of scientific publications, trends, particularly taking into account research priorities of relevant EU bodies
- the opinion on priorities and more generally on the methodology proposed of the foreign partners. They are asked trough a questionnaire to provide their views on the current state and current trends according to the experience of their institutions
- the opinion of representatives of Bulgarian software industry and trade.

The number and importance of citations would be also a valuable source of information, but our efforts proved to be quite difficult and expensive to obtain full and reliable data.

A very tempting instrument is to consider and compare the number of appearances of the candidate areas when searching with Google (or another engine). However such an approach would contain a high degree of noise.

Another possibility is to compare the number of queries made in Google within a given period.

Unfortunately this is difficult to implement for the moment.

4. Results on research and PhD activities In this section we present the results of research on various sources of information reflecting the activity of Bulgarian authors in the area of S&S between 2004-2008.

More specifically we classified those sources as follows.

- Publications of BG authors in BG (conferences + journals)
- Publications of BG authors in the world (conferences + journals)
- PhD theses defended in BG
- PhD students in BG
- Research projects with Bulgarian teams involvement (national + international)

We categorized them according to the aforesaid ACM classification.

We consider a *Bulgarian author* to be one working for a research organization established on Bulgarian territory, regardless of his/her nationality. We only focused on events organized and journals published by Bulgarian organizations. We examined the following conferences:

- International Conference on Computer Systems and Technologies CompSysTech (CompSysTech), 2004-2008
- International Conference on Information Research and Applications (i.TECH), 2004-2008.
- Balkan Conference in Informatics (BCI), held in Sofia in 2007.
- SAER, now International Conference on Information Technologies (InfoTech), 2004-2008
- SAI Automatics and Informatics conf – 2005-2008
- "John Attanasof Days" conference - 2006
- International Journal “Information Theories & Applications”, volumes – 14/2007 and 15/2008, edited by the Institute of Information Theories and Applications FOI ITHEA, Bulgaria.
- Journal of Information Technologies and Control, published by the Union of Automatics and Informatics in Bulgaria.
- Serdica Journal of Computing, published by the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences.
- Cybernetics and Information Technologies, published by the Institute of Information Technologies, Bulgarian Academy of Sciences.
- Journal of Computer Engineering

The results of the analysis of these "internal" Bulgarian activities are presented in the following table.

No	Classifiers	Number of papers
1	D.1.3 Concurrent Programming	3
2	D.1.5 Object-oriented Programming	1
3	D.2.1 Requirements/Specifications	1
4	D.2.2 Design Tools and Techniques	29
5	D.2.4 Software/Program Verification	1
6	D.2.5 Testing and Debugging	5
7	D.2.9 Management	10
8	D.2.11 Software Architectures	15
9	D.2.13 Reusable Software	4
10	D.3.4 (Software) Processors	1
11	D.4.6 Security and Protection	12
12	H.2.4 Systems	22
13	H.3.5 Online Information Services	46

The most active research area in S&S is the so-called Service Oriented Architecture (SOA), which as outlined in [3] *represents a distinct form of technology architecture designed in support of service oriented solution logic, which is comprised of services and service compositions, shaped by and designed in accordance with a specific design paradigm. This paradigm is comprised of principles that when applied to units of solution logic, create services with distinct design characteristics.* Bulgarian authors have focused their research in the areas of business process modeling and SOA for GRID environments. Additionally some aspects of Quality of Service in distributed systems were discussed. More generally - most of the research in Bulgaria is focused on study and practical application of technologies for general-purpose and desktop software systems (see D2.2).

As far as PhD activities are concerned, they are summarized in the following table.

No	Classifiers	Number of PhD theses	Number of papers
1	C.2.4 Distributed Systems		2
2	D.1.5 Object-oriented Programming		2
3	D.2.2 Design Tools and Techniques	2	4
4	D.2.5 Testing and Debugging	1	1
5	D.2.9 Management	1	1
6	D.2.11 Software Architectures	1	
7	D.4.6 Security and Protection	4	1
8	H.2.4 Information Systems		2

5. Discussion

As already said, the final aim of one of the SISTER's subtasks is to propose to FMI research priority areas in S&S. The methodology for solving this problem, as already mentioned, consists of a preliminary systematic accumulation of information concerning the current state and current trends at three levels - FMI, national and global. In the previous section we described part of the results obtained.

It seems however that additional factors have to be taken into account before the final conclusions. Good example for such a factor are the arguments to be found in [8] and [9]. Whilst those two papers are discussing the problems mostly from an educational point of view, it is obvious that they equally affect the research aspect. The main point of the discussion is to what extent are and should purely practical issues be a subject of university education/research. Our decision to consider S&S as a superset of Software Engineering urges us to address such areas as Business strategy, Business applications, Enterprise architecture, Technology infrastructure, Technology support, Technology acquisition, Organization and management. This also raises the question to what extent these areas belong to S&S and in case the answer is negative, should they nevertheless remain within our/FMI scope of interest.

As far as our concrete findings at the local (FMI) and national level (as reflected in 4. above) are concerned, they approximately match our initial expectations. Due to various factors neither the number of "active" S&S areas found is considerable, nor the activities within each of them is very rich. A happy exception is Bulgarian participation in international projects, mainly within FP5, FP6 and FP7. A particular attention should be paid to the fact that 65% of all ICT projects in FP6 and 70% in FP7 belong to S&S. This sounds very promising and

substantially guarantees that the level of Bulgarian researchers and their results at least matches that of their European colleagues.

6. Conclusion

Besides our methodology, we exposed in this paper part of the results obtained, particularly concerning the academic Bulgarian research interests and PhD development in the S&S area. Other results, encompassing the interests and priorities of Bulgarian business, foreign experts opinion about research priorities, as well as a specific application of the AHP method in order to aggregate experts opinions on those priorities will be published elsewhere. We expect that after completing all elements of the methodology described we will be in a position to draw final conclusions and make well-grounded recommendations on what research priorities in S&S should concentrate FMI in the years to come. On one hand this should contribute to the overall improvement of the quality of education FMI offers. On the other hand we hope that those recommendations will have a wider scope of validity and application in Bulgaria.

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