Advances in Databases and Information Systems at the University of Novi Sad

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Abstract. In this paper we will briefly present significant domains of current interest of most productive research groups from the Faculty of Sciences and Faculty of Technical Sciences, University of Novi Sad. We will concentrate on areas relevant to advances in databases and information systems (ADBIS). Some areas of presented research are more strongly related, while others are loosely connected to current ADBIS topics.

1 Introduction

The University of Novi Sad was founded on 28 June 1960. Today it is comprised of 14 faculties located in the four major towns of the Autonomous Province of Vojvodina: Novi Sad, Subotica, Zrenjanin, and Sombor. The University of Novi Sad is now the second largest university in Serbia. Having invested considerable efforts in intensifying international cooperation and participating in the process of university reforms in Europe, the University of Novi Sad has come to be recognized as a reform-oriented university in the region and on the map of universities in Europe.

The Faculty of Sciences was founded in 1969. Before its foundation, the development of higher education in its scientific disciplines started in 1954 when the Faculty of Philosophy was established. Since academic year 1961/1962, courses in Chemistry, Physics, Biology, Mathematics and Geography were taught at the Faculty of Philosophy. Nowadays, the Faculty of Sciences represents an educational and scientific institution in the fields of Biology, Chemistry, Physics, Mathematics, Computer Science, Geography, Tourism and Environmental Protection.

The Faculty of Technical Sciences was founded as the Faculty of Mechanical Engineering in 1960, and soon afterwards became an integral part of the University of Novi Sad. In 1974, when the Electrical and Civil Engineering Departments were established, the Faculty evolved into the Faculty of Technical Sciences. Nowadays, the Faculty of Technical Sciences represents an educational and scientific institution consisting of 13 departments.

Education in the domain of Informatics firstly started in 1979 at the Faculty of Sciences and a couple of years later also at the Faculty of Technical Sciences. Today these two faculties are among the leading Serbian educational and research institutions in the field of Informatics. Most significant research in different domains of Information and Communication Technologies (ICT) is conducted within the Department of Mathematics and Informatics (Chair of Computer Science, Chair of Information Systems), Faculty of Sciences and the Department of Computing and Control, Faculty of Technical Sciences (with chairs covering Applied Computer Science, Informatics, Geoinformatics, and Computer Engineering).

This paper will present significant domains of interest of most productive research groups from the Faculty of Sciences and Faculty of Technical Sciences, concentrating on areas relevant to advances in databases and information systems (ADBIS). The paper is organized as follows. In Section 2, most significant research at the Faculty of Sciences is presented including: agents, workflow management systems (WFMS), document management, high-dimensional data mining, fuzzy databases, part of the faculty information system, digital libraries and archives. In Section 3, most significant research at the Faculty of Technical Sciences is discussed, including: methods and tools for rapid development of enterprise information systems, and development of geospatial information systems. Section 4 gives concluding remarks.

2   Current Research at the Faculty of Sciences, Department of Mathematics and Informatics

At the Faculty of Sciences, research and development in the field of ICT started in 1984 when several of the best graduated students were employed as research assistants. Currently, research is conducted within two chairs: Chair of Computer Science and Chair of Information Systems. This section presents several research areas more or less connected to ADBIS topics.

2.1 Agents, WFMS, and Document Management

More then a decade ago at the Chair of Computer Science, research started in the domain of mobile agents and their implementation in workflow management systems – WFMS (Budimac et al., 1999). At that moment, the use of mobile agents in modeling and implementation of a workflow represented a novel approach. Several years later, a prototype infrastructure for realization of a workflow management system using mobile agents was implemented.

Meanwhile, it has been proven that the usage of mobile agents in modeling and implementation of a workflow simplifies workflow management. We therefore continued our research and developed special framework (Pešović, 2007; Pešović et al., 2008) which consisted of individual agents with autonomous behavior. Mobile agents carrying out workflow instances (so-called workers) have the ability to move to different users, where they can interact with them locally, autonomously taking

care of their current position, state, and further itinerary. The proposed framework completely relied on agents and has been fully distributed with autonomous agents. All important elements are implemented as plug-ins, which provides flexibility in both design and implementation.

Recently, we made efforts to continue research in the area of mobile agents and WFMS. To allow the exchange of process definitions with various workflow products (ranging from other workflow management systems to modeling and simulation tools), our framework needs to be made compliant with XML Process Definition Language – XPDL (Workflow Management Coalition, 2002), the proposed standard in the area of workflow definition languages. In order to comply with XPDL, we plan to modify developed framework to conform to the basic constructs of XPDL and the underlying meta-model. Moreover, a system-specific import layer needs to be provided to allow translation of XPDL process definitions, generated using a visual modeling tool, into worker execution contexts, their internal system representations.

At the Faculty of Technical Sciences some colleagues have been working in the similar area and they developed EXtensible Java-based Agent Framework – XJAF (Vidaković, 2004). XJAF is a pluggable architecture of a hierarchical intelligent agent system with communication based on KQML. This framework supports pluggable software managers that are dealing with a particular task.

To consolidate efforts of two research groups, we considered the possibility of application of agent technology in the domain of document management systems (DMS). One of the main motives for such research is that among DMS proposed over the years, there are only a few that are agent-based or agent-enhanced. However, none of them emphasize the benefits of agent mobility. Therefore, in the future we plan to apply the above-mentioned and implemented frameworks to the area of DMS. Our approach in the domain of workflow and DMS emphasizes the fact that mobile agents have wide range of advantages including organizational ones. Solutions are easier to program, understand, and maintain, if implemented using mobile agents.

The work in this direction has already been started (Pešović et al., forthcoming) and more significant results are expected in the future.

Currently we are applying for membership in COST Action IC0801 – Agreement Technologies (http://www.agreement-technologies.eu/). The main goal of the European project is to establish a new paradigm for distributed systems based on agreement between members of a special class of agents – computational agents. We are also taking appropriate steps to sign agreements of multilateral cooperation in the domain of agent technology with colleagues from the Polish Academy of Science and University of Craiova, Romania.

2.2 High-Dimensional Data Mining

Much of the incentive and motivation for research into the problems that high dimensionality poses to various data mining and machine learning tasks at the Chair of Computer Science stem from earlier research in text and Web mining (summarized by Radovanović et al., 2009a) and joint work with colleagues from the Jožef Stefan Institute, Ljubljana, Slovenia on the bilateral project "Using artificial intelligence in text and Web mining" (2005–2006). Research in the field of high-dimensional data

mining is conducted in cooperation with a colleague from the Information Systems and Machine Learning Lab (ISMLL), University of Hildesheim, Germany.

For numerous data mining and machine learning tasks, high dimensionality was shown to be able to pose significant problems, commonly referred to as different aspects of the *curse of dimensionality*. The primary focus of the research on high dimensionality conducted at the Chair of Computer Science is a novel aspect of the dimensionality curse called *hubness*, which is manifested by the tendency of some instances in a data set to become *hubs* by being included in a seemingly unexpectedly large number of k-nearest neighbor (k-NN) lists of other instances. In other words, the distribution of node in-degrees of a k-NN directed graph tends to become more skewed with increasing dimensionality, even exhibiting scale-free properties under some circumstances. In our work we demonstrate that phenomenon is relevant to all commonly used distance/similarity measures and types of data, and show that it is in fact an inherent property of data distributions in high-dimensional vector space. In addition, we explore how the phenomenon affects key data mining and machine learning tasks, including classification (k-NN, SVM, AdaBoost), semi-supervised learning, and clustering, demonstrate its profound impact on key techniques for information (text) retrieval, and also have preliminary results concerning outlier detection and collaborative filtering.

Hubness, which is a fundamental property of k-NN graphs in high-dimensional space, has been largely unexplored in data mining, machine learning, information retrieval, and many other communities for which it could be considered relevant. Most recent observations of the phenomenon come from the music retrieval community, e.g., the work by Aucouturier and Pachet (2007) where hubness is considered a problematic situation which hampers the precision of retrieval. Unlike all related work (to the best of our knowledge), we give a unified view of the causes and mechanics of the phenomenon through extensive theoretical and empirical investigation, explaining how the phenomenon originates from high *intrinsic* dimensionality of data, successfully generalizing the explanations to real data (determining that hubs tend to be located near the central parts of high-density regions), and demonstrating the effects of hubness on the aforementioned data mining, machine learning , and information retrieval tasks.

Our approach is both theoretical and empirical. The theoretical side of the research relies in large part on related work concerning *distance concentration* (François et al., 2007). For the experimental parts of the research we employ large collections of data sets, where instead of "hand-picking" data sets to demonstrate superiority of a proposed algorithm we consider large numbers of data sets, enabling us to establish correlations of different measurements *across data sets*, and explore the relationships between properties of data and the success of a proposed method (e.g., for improving k-NN classification). The measurements include skewness (standardized third moment) of the distribution of k-NN graph node in-degrees, estimates of intrinsic dimensionality, measurements of the degree of violation of the cluster assumption, etc. The vast majority of data sets originate from well-known repositories, or are otherwise widely used. For the first part of the empirical research concerning general vector-space data, we use data sets mainly from the UCI Machine Learning Repository and the Kent Ridge Biomedical Data Repository. For the second part involving analysis of time series, we employ data sets from the UCR Time Series

Data Repository, including the extensions to the collection presented by Ding et al. (2008). In the third experimental part regarding information retrieval, we use the text data sets first introduced by Han and Karypis (2000), which include parts of the Reuters, OHSUMED, and TREC text data collections. For experiments in collaborative filtering, we use the popular Movielens data set.

Results of our analysis of the hubness phenomenon, its interaction with class labels (i.e., the violation of the cluster assumption), and effects on popular approaches to classification, clustering and information retrieval, have been presented by Radovanović et al. (2009b). In an extended version of this paper (Radovanović et al., forthcoming), we prove a property of distributions of pairwise Euclidean distances between points drawn from a multivariate Gaussian distribution, which effectively illustrates how points closer to the data distribution mean tend to become closer, on average, to all other points as dimensionality increases, giving points closer to the data center (in an analogous manner across dimensions) a greater chance to be included in k-NN lists of other points. Regarding cosine similarity, in order to show analogous behavior we prove its concentration property for data points whose components are drawn from arbitrary iid distributions, with the proof sketch given by Nanopoulos et al. (2009), along with an analysis of hubness in the context of collaborative filtering. The significance of the hubness phenomenon to time-series classification in the context of the 1-NN classifier and dynamic time warping (DTW) distance is detailed by Radovanović et al. (2010b). Finally, we explore hubness in the context of "persistent" results returned by information retrieval systems based on vector space models, showing its independence from the factor of document length, which is widely considered to be one of the principal causes of result "persistence" (Radovanović et al., 2010a).

In future work we plan to study the impact of hubness on various application fields, including outlier detection and image retrieval. Topics that could also be worth further study are the interplay of hubness with learned metrics and dimensionality reduction. Also, it would be interesting to see whether the hubness property can be used for estimation of the intrinsic dimensionality of data.

2.3   Fuzzy Databases

Relational model's inability to model uncertain and incomplete data can be viewed as a disadvantage in some applications. The idea to use fuzzy sets and fuzzy logic to extend existing database models to include these capabilities has been utilized since the 1980s. Although this area has been researched for a long time, concrete implementations are rare. Methodologies for fuzzy-relational database applications development are nonexistent.

Research related to usage of fuzzy logic in relational databases has been conducted at the Chair of Information Systems since 2005. Fuzzy logic and fuzzy sets have emerged as a natural solution for handling of uncertainty in relational databases. The main target of the research is the definition of methodology for development of fuzzy relational database applications and implementation of all necessary tools (Škrbić et al., forthcoming).

Researchers have studied the possibilities to extend the relational model with fuzzy logic capabilities. The subject was elaborated by Takači and Škrbić (2008), where a detailed model of Fuzzy Relational Databases (FRDB) was given. One of the main features of the model is that it allows any fuzzy subset of the domain to be the attribute value which was not the case in previous FRDB models. In addition, authors describe a CASE tool that allows development of fuzzy databases using the model. This appears to be the first implementation of such a CASE tool. The proposed fuzzy relational data model and the CASE tool that supports it provide a good foundation for development of the database part in fuzzy relational database applications.

Moreover, using the concept of the Generalized Priority Constraint Satisfaction Problem (GPFCSP) by Takači (2005), authors have found a way to introduce priority queries into FRDB, which resulted in the Priority Fuzzy Structured Query Language (PFSQL). Takači and Škrbić (2007) introduce similarity relations to the fuzzy domain which are used to evaluate the FRDB conditions. The PFSQL allows the conditions in the WHERE clause of the query to have different priority, i.e., importance degree. It is the first language with such capabilities. The GPFCSP gives the theoretical background for the implementation of priority queries.

The idea to implement fuzzy extensions to a JDBC driver and incorporate the process of query execution inside it is also innovative. It makes the PFSQL querying mechanism database-independent.

Further research on this subject has taken the direction in which possibilities to incorporate fuzzy logic capabilities into XML technologies are investigated. There are two fields of interest in this area. The first one is defining an expansion to the XML Schema language that includes possibilities to store fuzzy values. The other one is the possibility to extend the XQuery language with known priority fuzzy logic concepts and to implement an interpreter for such a language.

2.4   Information Systems Development Laboratory

Information system of the Faculty of Sciences in Novi Sad is being developed and maintained by the Information Systems Development Laboratory of the Department of Mathematics and Informatics (http://www.is.pmf.uns.ac.rs/ris/). In the last eight years, the Laboratory members have designed, implemented and maintained the information system of the Faculty of Science. This information system has attracted attention of other institutions, and was therefore implemented at some other faculties of the University of Novi Sad as well.

The information system is segmented to following ten subsystems: student affairs, accounting, human resources, library information system, teaching and e-learning, fixed assets, research project management, document management and business intelligence (Škrbić et al., 2007).

The system serves three types of clients. The first type consists of Swing applications developed to be used by the staff at the Faculty. Clients that access the system using a Web browser fall into the second type. The third type is related to external SOAP clients – other information systems (especially the system in the Rectorate) that connect to the system using Web services.

Being a modern information system, it is based on the multi-tier architecture that allows all three types of clients to be served. Communication between individual subsystems is being implemented using secure Web services.

Every subsystem of the information system is a three-tier application for itself. It consists of a database management system, application server, and a set of client GUI applications. This construction is well known, although the one with Web clients is more popular. In this case, GUI clients are needed because of the complexity of processes conducted by the Faculty services and overall performance.

The application server in every subsystem of the system is divided in two layers. The first one is the business logic of a particular information system's subsystem, while the other is a Web container. GUI clients communicate directly with corresponding business logic layer, while external clients – Web browsers and SOAP clients communicate with the Web container.

It is also worth noting that individual subsystems also communicate with each other using Web services. This communication differs from the communication with SOAP clients in two ways (Bodroški and Škrbić, 2009). First of all, this is communication between business logic layers, and not between a SOAP client and Web container. In addition, business logic layers of other segments of the system are allowed access to a much larger set of services than external clients.

Moreover, modern AJAX Web applications running in Web containers are set as a requirement. Web clients communicate with a Web container using JavaScript, asynchronous calls and XML as a medium for data transport.

2.5   Innovation Centre for Academic Libraries and Archives

The main activity of the Innovation Centre is the development of the library information system BISIS. The system has been in the process of development since 1993. Up to now, four versions of the BISIS system have been developed.

From 2005 on, continual work has been done on the Library Network of Parent Libraries of Vojvodina project. This network comprises of five parent libraries and three specialized libraries from Vojvodina and 36 libraries in the rest of the Republic of Serbia.

The BISIS system stands on two pillars – MARC 21 standard and XML technology. The most important research papers describe different modalities of the use of these technologies in library information systems. Škrbić and Surla (2008) describe modeling and implementation of an editor designed for the processing of bibliographic matter in the form of UNIMARC XML bibliographic records. Tešendić et al. (2009) describe a software system for library circulation. The application of the system supports the work with the local database (intranet), as well as with the remote database (internet). In addition, the application supports the work with different library formats. The BISIS system features the application for retrieving bibliographic records following the Z39.50 standard. The library cataloguing editor is XML-based. It supports data input in the form of free text with interactive control of structure and content validity of records specified in the UNIMARC and MARC 21 formats.

Ivanović et al. (forthcoming) present a proposal of CERIF data model extension for evaluation of scientific research results. The data model extension is based on the

CERIF semantic layer which enables classification of entities and relations between entities according to some classification scheme. The model is represented using a physical data model in the conceptual notation that is adopted in literature for representing the CERIF data model. This model is verified using the rule book for evaluation and quantitative expression of scientific research results of researchers employed at the University of Novi Sad.

3   Current Research at the Faculty of Technical Sciences

At the Faculty of Technical Sciences, research and development in the field of ICT is conducted in a number of chairs and laboratories. Due to space constraints, this paper will present only the topics dealing with the subject of ADBIS conference: research in the domain of methods and tools for rapid development of enterprise information systems, and in the domain of development of geospatial information systems.

3.1   A Tool and Method for Development of Integrated Information Systems

Until now, over 20 researchers, PhD and MSc students have contributed to the development of IIS*Case, a model-driven software development tool. They come mostly from two departments of the Faculty of Technical Sciences, one being the Department of Computing and Control and the other the Department of Industrial Engineering and Management. One researcher has moved to Victoria University of Wellington, New Zealand. Three researchers are from the Faculty of Science, University of Montenegro. Recently, we have also established research collaboration with the University of Minho from Braga, Portugal.

Integrated Information Systems CASE Tool (IIS*Case) is a software tool aimed to provide information system (IS) design and generate executable application prototypes. Its development has spanned through a number of research projects lasting over 20 years. Currently, IIS*Case provides:

- Conceptual modeling of database schemas, transaction programs, and business applications of an IS,
- Automated design of relational database subschemas in the 3rd normal form (3NF),
- Automated integration of subscehmas into a unified database schema in the 3NF,
- Automated generation of SQL/DDL code for various database management systems (DBMSs),
- Conceptual design of common user-interface (UI) models, and
- Automated generation of executable prototypes of business applications.

IIS*Case may support an intensive and efficient communication among designers and end-users of an application domain, throughout the software development process. We also defined a methodological approach to the application of IIS*Case in the software development process. Through this approach, the software development

process provided by IIS*Case is, in general, evaluative and incremental. Besides, it is based on the concepts that are very close to the perception power of an average user. Therefore, it enables an efficient and continuous development of a software system, as well as an early delivery of software prototypes that can be easily upgraded or amended according to the new or changed users' requirements. Consequently, it is a tool suitable for application to agile software development.

Our research efforts for improvements to IIS*Case have lead to the development of a code generator for transaction programs and applications that are executed over a database. One of the important expectations was to create a code generator that produces executable program code for target program environments, starting from a technology-independent IS model designed in IIS*Case. Therefore, IIS*Case was improved by introducing new PIM concepts and features that provide the specifications of: (i) visual properties of transaction program screen forms; (ii) functionality of transaction programs; and (iii) business applications comprising calling structures. Former versions of IIS*Case did not provide a possibility to formally specify functionalities concerning relationships (so called "calls") between generated screen forms, i.e., transaction programs. In order to make an adequate basis for the development of a code generator, IIS*Case enriched by new concepts enabling the design of such specifications. Therefore, we introduced a new concept, called *business application*. In our approach, a *business application* is a named structure of interrelated transaction programs aimed at supporting business activities at an organization (business) unit. End-user perception of the future IS highly depends on the way how business applications of the IS are structured. We consider it important for a tool providing the IS design and generation of executable application prototypes, to also provide the creation of business application specifications in the design phase.

Detailed information about IIS*Case and its main concepts may be found in several references. Some of them are publications by Pavićević et al. (2006), Aleksić et al. (2007), Luković et al. (2010), and Banović (forthcoming). A case study illustrating the main features of IIS*Case and the methodological aspects of its usage is provided by Luković et al. (2007). In the paper by Luković et al. (2008) we considered the application of the model-driven software engineering (MDSE) principles in IIS*Case.

Among all, our current or future research and development efforts are oriented towards the following:

- Introducing new concepts and tools in IIS*Case that will provide business process modeling, as well as system architecture modeling,
- Development of a DSL for an equivalent representation of the current repository-based function specifications at the level of PIMs,
- Development of algorithms providing transformations of check constraint specifications created at the level of form types as PIMs, to the equivalent specifications at the level of an implementation database schema (usually expressed by the relational data model), and then to the executable PSM specifications expressed as SQL/DDL program code,
- Extensions of the IIS*Case repository definition and the appropriate specifications (like event specifications) by new concepts, so as to make better foundation for (i) semantic analysis of check constraint expressions; and

(ii) using function specifications in specifying business application logic, as well as their syntax and semantic analysis,

- Development of algorithms providing transformations of function specifications created at the level of PIMs, to the equivalent executable PSM specifications expressed in a target programming environment and in the context of generated business applications,
- Providing for generation of complex transaction program functionalities concerning not only "standard" data operations (retrieve, insert, update and delete) expressed by the designed form types,
- Using the Meta-Object Facility Specification (MOF) in order to raise our repository based DSL specifications at meta-meta abstraction level,
- Developing a textual DSL, named IIS*DesLang and aimed at creating textual PIM specifications of IIS*Case repository objects. Then, we plan to use a compiler generator to produce a compiler for IIS*DesLang. On the basis of the grammar specifications and the problem domain knowledge, it is possible to design tools providing some semantic analyses of the designed specifications and further assist designers in raising the quality of their work. Finally, we plan to embed a textual editor for IIS*DesLang into IIS*Case and couple the language and generated compiler with IIS*Case repository.

3.2   A Method for Rapid Development of Large-Scale Information Systems

A method and tools for rapid development of large-scale information systems are being developed for the last 20 years at the Chair of Informatics. This method enables a small development team to develop and deploy large-scale information systems in a relatively short period of time. It is based on appropriate team organization, brainstorming techniques, simple and highly efficient application generator, and adaptive application architecture (Milosavljević and Perišić, 2004). The application generator is based on our internal Human-Computer Interaction (HCI) and programming standards, a library of high-level, coarse-grained components, and a set of rules for model-to-application mapping with embedded expert knowledge. Internal HCI standard defines functional and visual features of application components. Its goals include the following: simplicity of use, quick user training, and the automation of user interface construction.

In order to obtain quality program code and shorten the time needed to implement the software product, it is necessary to avoid redundancy in the program code. Rather than implement an application element for every situation that occurs during a software product lifetime, we strive to develop a generic application composed of adaptable components that can be customized for particular requirements with the minimal number of lines of code written (ideally, without changes to the program code at all). This way, the development team implements application components as "raw material," and specific application subsystems and user roles are defined (administered) as different views on a generic application.

Our previously implemented tools for various platforms are presented in papers by Milosavljević et al. (2003), Milosavljević and Perišić (2003), Milosavljević and Perišić (2004), and Komazec et al. (2007). They are used for the implementation of

more than 70 projects of business information systems (including the information system of the Faculty of Technical Sciences) by several different development teams. The percentage of the generated code in the overall code base (database, middle tier, UI) ranged from 81.8% to 98.2%, depending on the type of application.

Development of a new tools generation is based on the model-driven engineering (MDE) approach. We have developed two DSLs for application modeling:

- DOMMLite – realized in the form of a custom-made language which ensures more freedom during modeling and simplifies the solution, and
- EUIS (Enterprise User Interface Specification) – realized as a standard UML extension (a UML profile) facilitating the use of existing modeling tools.

DOMMLite (Dejanović et al., 2010) is an extensible DSL for static structure definition of database-oriented applications. The language structure is defined by a metamodel supplemented with validation rules based on Check language and extensions based on Extend language, which are parts of the openArchitectureWare framework. The metamodel has been defined along with the textual syntax, which enables creation, update and persistence of DOMMLite models using a common text editor. DSL execution semantics have been defined by the specification and implementation of the source code generator for a target platform with already defined execution semantics. In order to enable model editing, a textual Eclipse editor and stand-alone graphical editor have been developed. DSL, defined in this way, has the capability of generating complete source code for GUI forms with Create-Read-Update-Delete-Search (CRUDS) and navigation operations, according to the internal HCI standard.

EUIS profile is developed in order to enable rapid user interface modeling at a high level of abstraction using general-purpose modeling tools. EUIS is based on our internal HCI standard of a business application that defines functional and presentational features of coarse-grained building blocks, thus enabling the generation of a fully functional UI, without the need for defining a multitude of models used for developing UIs in the general case. Case study using EUIS profile is presented by Milosavljević et al. (forthcoming).

Our current and future development efforts are oriented towards the following:

- Implementation of the adaptive application architecture based on aspect-oriented languages,
- A DSL development platform that features the following:
  - Defining new DSLs based on the MDE paradigm with the possibility of instantiating models according to the given DSL,
  - Defining DSL semantics by transforming it to a GPL or another DSL supplied with execution semantics, based on construction of program code generators,
  - Support for automatic propagation of changes from higher meta-levels to lower ones,
  - Support for concurrent model development.

3.3   Center for Geoinformation Technologies and Systems

The Center for Geoinformation Technologies and Systems was established at the Faculty of Technical Sciences in 2004. Activities of the Centre for Geoinformation Technologies and Systems include: geodetic terrain survey using GPS technology; map-making using photogrammetry concepts, remote sensing and cartography; terrestrial and aerial laser scanning; underground installations scanning; mobile objects tracking; consultancy in the field of geoinformation technologies and systems; designing and implementing GIS systems and designing and implementing infrastructure in the field of spatial resources management. The study program has been accredited for undergraduate studies of geodesy and geomatics engineering in the field of geodesy since 2007. It is also accredited for study programs of graduate academic studies in geodesy and geomatics in two main areas of technology: Geodesy and Geoinformatics.

One of the main activities in the Center is the application of GNSS technology in practice. The Center has designed, installed, and maintained the communication, computer, and software segments of the network of permanent GPS stations in the Republic of Serbia. The network comprises of 32 stations covering the whole territory of Serbia and provides correction and distribution of precise positions (centimeter-level precision) both in real time (over GPRS connections) and later off-line processing (distribution via the Web). The network also provides nanosecond-level precise time service. This is the first network designed and implemented in this part of Europe, and among the first in Europe as well. The Center is an active member of the European Position Determination System (EUPOS).

Another important activity of the Centre is discovery of underground objects (installations), as well as analysis of soil characteristics using remote sensing. The sensing process employs a georadar, combined with GPS and cartographic material, giving the user complete information on underground installations in a particular area.

The Center employs experts in various GIS technologies, who possess considerable experience in application of GIS in various domains. A significant part of the expertise is based on the application of ISO and OGC standards and the development of spatial infrastructures.

Selected recent results of the Center are presented in papers by Popov et al. (2007), Ristić et al. (2008), and Ristić et al. (2009).

4   Conclusion

Academic staff from the University of Novi Sad, like staff from most of other universities, has two significant obligations in their academic and professional life: to teach students and actively participate in various educational processes, and to conduct research in different scientific fields. Despite having, in general terms, more teaching responsibilities than their colleagues from Western Europe, professors and assistants from the Faculty of Sciences and the Faculty of Technical Sciences are active and successful in following the current trends, emerging technologies and contemporary scientific research, and also find time to actively do research and

publish research papers. Significant efforts are also devoted to supervision and leading young colleagues and PhD students.

According to such trends and attitude, we expect our younger colleagues to follow and even overcome the results of their supervisors and older colleagues. The goal of this paper was to illustrate the breadth and diversity of scientific work and research performed at our respective institutions, into which we invested significant amounts of time and effort. We believe that the overview given in this paper can be beneficial to all our current and potential future research collaborators. We are convinced that our research activities closely follow current scientific trends, and are open for active international cooperation with the goal of further exchange of ideas and results. To this end, a significant contribution is provided by the East-European Conference on Advances in Databases and Information Systems.

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