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Towards the Information System for Research Programmes of the Ministry of Education, Science and Technological Development of the Republic of Serbia

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Abstract

The work describes the phases of the development of the information system on scientific activities covered by the Ministry of Education, Science and Technological Development of the Republic of Serbia. The sequential phases of the project are: Recording data on scientific institutions, researchers, and research projects financed by the Ministry, Input and evaluation of the published results achieved in the research projects financed by the Ministry, Establishing electronic services for searching, presentation, and interoperability of data on scientific activity, and Generating various reports for the different needs related to scientific activities. The information requirements are listed and the system software architecture is described. The development of the system is based on the recommendations of the organization euroCRIS.

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1. Introduction

The Ministry of Education, Science and Technological Development (MESTD) has several sectors, among the others, *The Sector for Science, and The Sector for Technological Development, Transfer of Technologies, and Innovation System*. These two sectors are concerned with policies and realization of scientific research activities in the Republic of Serbia. The present work describes the phases of the development of an information system for these activities, entitled CRIS MESTD (Current Research Information System of MESTD).

At the end of 2015, the Government of Serbia passed *The Law on Scientific Research Activity*¹ and *The Strategy of Scientific and Technological Development of the Republic of Serbia for the Period 2016-2020*². This Strategy will be

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the basis for announcing the call for the new cycle of projects funded by the Ministry in the period of 2016-2020. The Law¹ contains Section VIII entitled *Keeping records of documentation*, which describes the way of recording data on Scientific institutions, Researchers, and Scientific projects.

The data from the *Records* will be open, publicly accessible on the internet presentation of the Ministry, available in machine treatable form for the use and further publication. It is also envisaged that the data on researchers will be publicly available, with the exception of data on gender, personal identity number, and passport number for foreign citizens. The first phase of the development of CRIS MESTD is the modelling and implementation of the processes for keeping these records in accordance with the legal regulations concerning electronic records and use of modern information technologies.

The second phase of the development of CRIS MESTD comprises the development of a module for entry and evaluation of different kinds of published scientific research results achieved within the projects. This module will be used for different needs such as categorization of researchers for the participation in the projects, evaluation of scientific results of the researchers for obtaining scientific titles, evaluation of the published results of scientific institutions, and the like.

The third phase of CRIS MESTD will be devoted to the development of different public electronic services: Service for search and presentation of data on scientific institutions and researchers., Service for taking up (interoperability) data on scientific institutions and researchers from other services in the Republic of Serbia or from the corresponding international services, Service for search and validation of published papers resulting from the project, Service for the interoperability of scientific results with other domestic and foreign portals, and the like.

The fourth phase of CRIS MESTD comprises the implementation of subsystems for generating reports of the different kind related to scientific activities both at the state and international levels.

2. Related work

The Common European Research Information Format (CERIF) is a standard recommended by the European Union to its member states for the development of information systems concerning scientific research activities³. It was developed under the support of the European Commission (<http://ec.europa.eu/>) in two main phases: 1987-1990 and 1997-1999. In 2000, the European Commission delivered up CERIF, euroCRIS⁴ to the non-profitable organization called Current Research Information Systems (CRIS). The CERIF data model contains information related to scientific research activities such as researchers, scientific projects, scientific research organizations, publications, patents, products, financed programs, equipment, as well as the relationships between them. Besides the data model, CERIF specifies also the XML scheme for data exchange. CRIS MESTD is developed based on a model which is compatible with the CERIF data model.

There are numerous information systems across Europe that are compatible with CERIF: IST World⁵, SICRIS⁶, CRIS⁷, Pure⁸, Converis⁹, etc. IST World is a portal that enables access to scientific research results from a number of countries of central and south-eastern Europe. This portal has been developed within an FP6 project. The data model created for the needs of this system is an expansion of the CERIF data model. SICRIS is the Slovenian CRIS system based on CERIF; CRIS⁷ is the information system of scientific institutions in Norway; Pure and Converis are commercial software packages that can be installed, configured and adapted to the needs of scientific institutions.

At the level of Serbia, there are systems for storing data on scientific research activities. They are different installation repositories, most often implemented using DSpace and EPrints software platforms, such as Digital library of doctoral dissertations, Records of scientific workers of Vojvodina¹⁰, Information system on scientific activities at the University in Novi Sad¹¹, etc.

In spite of all the commercial ready-made CRIS solutions and local systems for storing data on scientific research in Serbia, the MESTD decided to develop their own system for monitoring scientific research in the Republic of Serbia. This information system has its specificities related to the legal regulations in Serbia, and the adoption of any ready-made solution would require its significant alteration. The Information system on scientific activities at the University of Novi Sad (CRIS UNS, <http://dosird.uns.ac.rs>) has a supplementary part related to the legal regulations in Serbia, and because of that, the development of the national CRIS MESTD will be based on the development and experience gained in using the institutional CRIS UNS system. The development of the latter system has been described in the works^{12,13,14,15,16,17}.

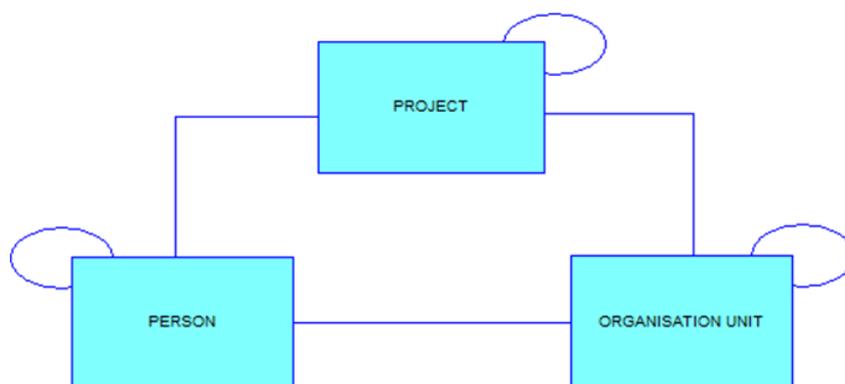


Fig. 1. Basic entities of the CERIF model and their relationships

3. Data model

According to the CERIF model, the basic entities of scientific research activities are PROJECT, PERSON, and ORGANISATION UNIT, designated as *cfProj*, *cfPers*, and *cfOrgUnit*. The relationship between these entities is depicted in Figure 1. The data model CRIS MESTD is compatible with CERIF, has also these three entities and a semantic layer, and it supports multilingual characteristics of certain attributes by using multilingual entities. Besides, it should be noticed that the model is expanded with the necessary data for the use of legal regulations of Serbia and keeping record of the project finances. For instance, the entity ORGANISATION UNIT is extended with the attributes Last scientific accreditation number, Last scientific accreditation date, Institution name from the accreditation, Founder, Foundation date, Number of founding rescript.

In accordance with the Law¹, the entity PROJECT keeps the following records: Name and surname, Identification number of the researcher and title of the project manager, Project coordinating institution, Project abstract, List of scientific institutions and researchers engaged on the project (name and surname, scientific/academic title, researcher's identification number), List of scientific publications, patents, technical solutions, and the like, realized in the frame of the project, and Record of the amount of money by which the project is financed at an annual level from the budget of the Republic of Serbia. The relation between the PERSON and PROJECT entities is additionally described by data on the number of months a person is engaged on the project, and by the category of the researcher, determining his/her salary.

According to the Law¹, the entity ORGANISATION UNIT keeps records about the following data: Name, Address, Identity number, Type, Ownership structure, Scientific area, Number and data of the Accreditation act, Date of registration in the Registry of scientific research organizations and remarks on the status changes, Overall amount by which the organization is financed annually from the budget of the Republic of Serbia. Organizations are classified according to their scientific activity, viz.: Institutes, Higher education institutions, Centres of excellence, Institutions of national importance. Institutes are classified as a Scientific institute, Research-development institute; Institute of national importance for the Republic of Serbia. Institutions of national importance are Serbian Academy of Science and Arts and Matica Srpska. Organizations are classified in accordance with the ownership structure as: State-owned, Private, and Mixed-owned. Records of scientific areas will be also kept in compliance with international classifications, such as CERIF and FRASCATI. This way ensures the generation of the reports per different classifications at the state and international levels.

According to the Law¹, the entity PERSON is related to the records of the following data: Name and surname of researcher, Name of one of the parents, Gender, Personal identity number, Passport number for foreign citizens, Researcher's identification number, Scientific/academic title, Date of obtaining the title and the institution in which it was earned, Scientific-research organization where the researcher is employed and the address, List of scientific publications, patents, and technical solutions of the researcher. The relationship between the entities PERSON and ORGANISATION UNIT is additionally described by the Function of the person in the given scientific institution.

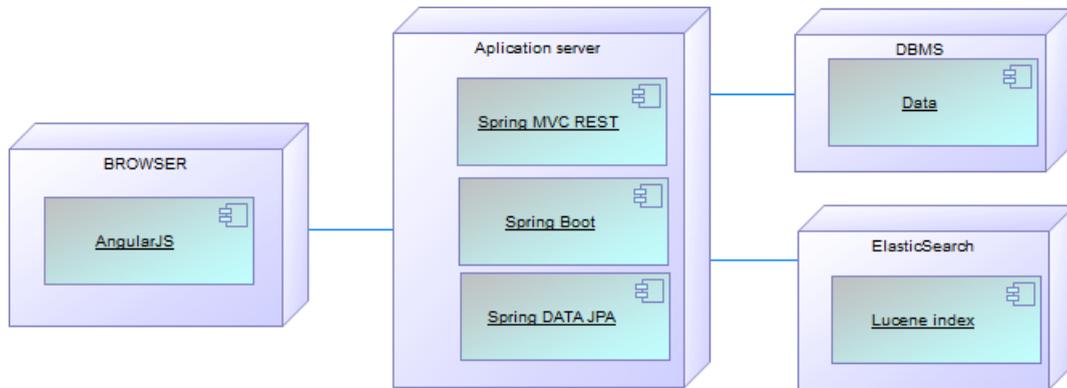


Fig. 2. System architecture

4. Software architecture

The system's architecture is presented by the *deployment diagram* in Figure 2. The system consists of the Server application, Client application, and Data layer. Part of the Server application is generated using *JHipster* tools. The Server application exposes services for the work with the basic entities, implements the program logic, enables work with users, and performs storing and indexing of data on the entities. The data are stored in the MySQL database which is accessed from the server application via the ORM tool (*Hibernate*). Indexing of entities (metadata and book contents) is performed by using the *ElasticSearch* server, which stores its index relying on the Lucene IR library. The main server application is accessible through the server which opens up the interaction with the accessible services via the REST service. The client application is implemented by using *AngularJS*, *Bootstrap*, and *HTML5*. *AngularJS* is a structural *framework* for dynamic web applications. The client application uses the discovered REST services of the server applications, and, on the user's request enters data on the new entity, searches the existing entities, alters the data, creates a new user account, etc.

5. Implementation

The user interface of the CRIS MESTD application is available in Serbian and English language. The application in the first phase is available only to authenticated users after providing user credentials (*username* and *password*). The registers of institutions (organisation units) and researchers are available at <http://minis.mpn.gov.rs/registri> while the subsystem for application of scientific projects is available at <http://minis.mpn.gov.rs/projekti/>. There are three types of users in the first implemented phase of CRIS MESTD. The first type of user is a *responsible institutional authority* which is connected to an institution and responsible for editing data about the certain institution, as well as for editing the list of researchers affiliated with the institution.

The form for editing data about an institution is divided into three sections. The first section containing basic institution data is shown in Figure 3. Besides those data, there are also specific data for Serbian register of scientific organisation unit in accordance with Serbian law (the second section entitled *INFORMATION FOR REGISTER* in Figure 3), and there are also data about engagements between the institution and projects (the third section entitled *INFORMATION FOR PROJECTS*).

As already mentioned, this type of user is also responsible for editing the list of researchers affiliated with the certain institution. The user can search, browse and export the list of researchers. Also, the list can be sorted by researchers' first names, last names and birth dates. Moreover, the list can be also filtered by verification status of previously migrated data. The list of researchers can be edited by adding a new researcher, and by editing data about existed researchers by selecting a researcher row in the list. Data about a researcher are grouped into four sections. The form for editing personal researcher data is shown in Figure 4. The system supports the consolidation of researchers' data by rejecting input of researchers with same personal identity numbers, and by warning the system user about the existence of researchers with the same name, surname and birth date.

BASIC INFORMATION
INFORMATION FOR REGISTER
INFORMATION FOR PROJECTS

Institution name *	<input type="text" value="Војногеографски институт"/>
Institution name in English *	<input type="text" value="Military Geographical Institute"/>
State *	<input style="border-bottom: 1px solid #ccc;" type="text" value="Србија"/>
City *	<input style="border-bottom: 1px solid #ccc;" type="text" value="11000 - Београд"/>
Township	<input style="border-bottom: 1px solid #ccc;" type="text" value="Палулула"/>
Street and number *	<input type="text" value="Мије Ковачевића 5"/>
Web adress *	<input type="text" value="http://www.vgi.mod.gov.rs/"/>
Email *	<input type="text" value="vgi@vs.rs"/>
Phone number *	<input type="text" value="011 3205 007"/>
Short name	<input type="text" value="ВГИ"/>
Super institution	<input type="text" value="Select a super institution"/>

* - mandatory fields

Fig. 3. Basic organisation unit data

Besides those data, there are also specific data for Serbian register of researchers in accordance with Serbian law (the second section entitled *INFORMATION FOR REGISTER* in Figure 4), there are also data about engagements between researchers and projects (the third section entitled *INFORMATION FOR PROJECTS*), and there are also data about engagements between researchers and organisation units (the fourth section entitled *ENGAGEMENTS*). The user can edit the list of the selected researcher engagements including data about the position, function, the percentage of employment in the organisation, start date, end date.

The second type of user is a *ministry officer* which can edit data about any institution and researcher in the database. The user can search, browse and export the list of institutions. Also, the list can be sorted by institutions' names, city, and official Internet address. Moreover, the list can be also filtered by verification status of previously migrated data, i.e. the user can browse the list of institutions which data are not verified by responsible institutional authority. The list of institutions can be edited by adding a new institution using, and by editing data about existed institutions by selecting an institution row in the list and using the same form shown in Figure 3. Also, a ministry officer can edit a list of all researchers stored in the system database using the form shown in Figure 4. Moreover, this type of user can edit the list of system users, registers of cities, states, institution types, researcher types, etc.

The third type of user is a *project coordinator* which can submit a project proposal for funding by MESTD. There is a call for projects funded by MESTD which is in accordance with The Strategy of Scientific and Technological

PERSONAL INFORMATION	INFORMATION FOR REGISTER	INFORMATION FOR PROJECTS	ENGAGEMENTS
First name *	<input type="text" value="Лидија"/>		
Last name *	<input type="text" value="Ивановић"/>		
Name of one parent	<input type="text" value="Славко"/>		
Person title	<input type="text" value="Dr"/>		
Birth date	<input type="text" value="23.07.1982"/>		
State of birth	<input type="text" value="Србија"/>		
City of birth	<input type="text" value="Врбас"/>		
Township of birth	<input type="text" value="Врбас"/>		
State of residence	<input type="text" value="Србија"/>		
City of residence	<input type="text" value="Нови Сад"/>		

Fig. 4. Researcher personal data

Development of the Republic of Serbia for the Period 2016-2020 [2]. The call has been announced for the following program areas:

- Fundamental research,
- Applied fundamental research,
- Technological development.

A project coordinator submits a project proposal in the following way. The first step is to register him/her as a potential project coordinator of a program area. A ministry officer responsible for that program area checks whether registered researcher fulfils all requirements for coordinating a project prescribed by the program call. If does, the project identification code is generated as well as the user account for the registered project coordinator, and registered researcher is notified via email. After that, the project coordinator can start application of project proposal which besides basic application data about the project also includes a selection of consortium. The consortium includes scientific institutions and researchers which data are stored in the previously described registers of institutions and researchers.

6. Further development

The other phases of the development will be related to the input of published scientific research outputs, the introduction of electronic search services, presentation and interoperability of data on scientific activities and providing reports about them.

Further development of CRIS MESTD and its phases will be based on the CRIS UNS development and users experience. Two faculties, Faculty of Sciences and Faculty of Technology, are using the CRIS UNS system for cataloguing scientific research outputs. The CRIS UNS system provides cataloguing of all types of scientific research outputs by researchers and librarians. Moreover, evaluation of published scientific results has been implemented in order to enable automatic evaluation of journal articles using journals bibliometric indicators in accordance with Serbian research evaluation rule book, while special faculties' boards individually evaluate scientific conferences papers and monographs. Digital library of Ph.D. dissertations used by all 14 faculties of the University of Novi Sad was implemented within CRIS UNS. Moreover, the server side of the OAI-PMH protocol has been implemented. It enables interoperability with other digital repositories: NaRDuS - a national digital repository of the Republic of Serbia, OATD, DART-Europe, OPENAire+. Furthermore, a search of scientific research outputs is available at <http://cris.uns.ac.rs/search.jsf>, and search of the Ph.D. digital library is available at <http://cris.uns.ac.rs/searchDissertations.jsf>.

The quality and development of scientific research in the Republic of Serbia are in charge of the following bodies:

- National Council for Scientific and Technological Development;
- National Board for Accreditation of Research Organizations;
- The Commission for Researchers' Promotion into Scientific and Teaching Positions;
- Main Scientific Boards (MSBs)
- Serbian Association of Scientific Research Organizations;
- The Ministry of Education, Science and Technological Development (MESTD).

The jurisdiction of MSBs is preparing materials to other bodies to take decisions. About 30 MSBs are divided into scientific fields: Physics, Chemistry; Electronics and Telecommunications, Social and Humanities, Literature and Language, etc. Each MSB has the following jurisdiction within its scientific field:

- Evaluation of the published scientific research outputs and other requirements for the promotion of candidates into scientific positions;
- Evaluation of the scientific competence of researchers, teachers, and higher education institutions to implement study programs and research projects;
- Evaluation of project proposals and proposing a ranking list of projects for funding;
- Evaluation of the funding projects reports;
- Assessment of the Act for categorization and ranking scientific journals;
- Assessment of the Act for evaluation and quantitative expression of scientific research outputs of researchers.

MSBs will play a crucial role in the development CRIS MESTD segments related to the input and evaluation of published scientific research outputs. MSBs will verify whether the data input is provided for all categories of individual scientific and research outputs including the specific characteristics of particular scientific fields. For example, in the field of architecture and urban planning, there are categories such as Award in the competition, participation in the exhibition, etc. Evaluation of published scientific research outputs is grouped into journal articles, conference articles, monographs, and the other scientific research outputs.

Moreover, MSBs will adopt rules for the evaluation of journal articles in accordance with MESTD rule book for evaluation and their own previous experience in evaluation. An automatic application of the adopted rules will be implemented. Furthermore, MSBs evaluate individually each conference and monograph publication. An electronic public service for search and browse of evaluated scientific outputs will be also implemented. Therefore, each researcher will have access to the results of MSBs' evaluation process of their own published scientific research outputs. MSBs have an obligation to publish an explanation for each of its evaluation decisions not supported by bibliometric indicators and rule book. For instance, if an MSB assigned an evaluation category to a journal which is not in accordance with adopted rules, the MSB has to publish an explanation for that evaluation decision. Moreover, evaluation of a monograph is accompanied by an evaluation decision report with an MSB name, an MSB meeting number and date and the obtained publication rank. In this way, a Serbian national repository of published and evaluated scientific research outputs for all researchers and scientific institutions will be established.

The Serbian national repository of published and evaluated scientific research outputs will be used in order to fulfil various needs of MESTD and scientific institutions. The Serbian scientific institutions have to submit a periodic application for accreditation and annual self-evaluation report to MESTD. A part of application documentation for self-evaluation and accreditation regarding published scientific research outputs will be generated automatically by CRIS MESTD:

- List of teachers which fulfil requirements to be Ph.D. advisors, as well as the ratio of the number of advisors and the total number of teachers
- The number and list of SCI-indexed journal papers by years
- Summary overview of scientific research outputs (publications) by years

Promotions to scientific positions are conducted by MESTD while promotions to teaching positions are conducted by universities. The main document for a promotion process is a report of the selection committee. The promotion process will be supported by CRIS MESTD and part of the report regarding the scientific activity of a candidate for promotion will be generated automatically by CRIS MESTD. In a similar way, the project application and monitoring processes will be supported by CRIS MESTD generating scientific activities of project participants. Moreover, there are other activities that will be supported by this information system: analysis of published scientific research outputs; applications for internationally project calls, etc.

The CRIS MESTD data model will be modified, functionality will be extended, but all extensions and modifications will be implemented in the adopted software architecture for the development of CRIS MESTD.

7. Conclusion

This paper is a short description of the development of the software architecture of the Information System on Scientific Research Activity of the Ministry of Education, Science and Technological Development of the Republic of Serbia (CRIS MESTD). The development of the system complies with the guidelines of the euroCRIS organization, good practice of the known CRIS systems, and on the development of the Information System of Scientific Activity at the University of Novi Sad (CRIS UNS). The aim of the development of CRIS MESTD is the informatization of the processes of the Ministry concerning scientific activities. The first phase deals with the implementation of the processes of keeping records related to scientific institutions, researchers, and projects funded by the Ministry.

The central part of CRIS MESTD will be devoted to the implementation of a national repository of published and evaluated scientific research results. The institutions are obliged to regularly update data about themselves and data about employed researchers. Every researcher is obliged to record his/her published scientific research results. These results are evaluated by the Main Scientific Boards (MSBs) of the Ministry. Evaluation of the papers published in journals will be automated based on the adopted evaluation rules. In the beginning, the MSBs will evaluate individually scientific meetings and monograph publications. Based on this experience, the corresponding rules will be established (expert system) so that all the results will be evaluated automatically. Therefore, the aim is to ensure that the MSBs have at their disposal a software support for an efficient and transparent evaluation of all scientific research results.

The Repository of published and evaluated scientific research results will be used for the different purposes of the Ministry and scientific institutions such as Accreditation and self-evaluation of scientific research results. Obtaining scientific/academic titles, Application and monitoring of the projects, Analysis of published scientific research results, Application for international projects, and the like.

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