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COMPUTER SCIENCE

MANAGEMENT OF RESEARCH ORGANIZATION: INFORMATIONAL SUPPORT

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We consider the conceptual approach to the system, providing scientific management of a research institution, and information support of scientific cooperation with similar institutions from other countries. This approach is partly tested at the Institute of Mathematics and Computer Science of Academy of Sciences of Moldova and is proposed for several other academic institutions. We believe that this approach will allow automated information management of cooperation with foreign scientific institutions.

Key words: information analytical system, database, scientific management of research institution, primary information, reports.

1. INTRODUCTION

Science is required to become an economic power and to have an influence on economic development of society, which imposes special requirements on decision making in this area. Management of a research institution consists of several aspects: financial (accounting, planning), logistics (equipment, maintenance and endowment of rooms, supply, security), informational support (library, Internet network), and the research itself. If for the first aspects there exist systems that assist in the management process or even completely automate some functions (such as accounting systems, inventory management methods, digital libraries, etc.), the last aspect – the research – presents a particular difficulty in acquisition and formalization of knowledge that characterizes this activity. So the question appears: how to manage unmanageable [4] - the creative research process?

Regardless of the type of domain – well or poorly structured (and in the case of research we have the latter) – possible solutions are grounded on technologies of information acquisition, storage and processing. So, as the first step to find the answer

to the question formulated above, it would be to determine indicators that characterize the work of a research institution and develop instruments for their monitoring.

Naturally, that various administrative bodies require information in accordance with their needs. It actually enforces to present the same data in different required forms.

Though the requirements for reports forms and documentation on scientific activities of research institutions are often modified, they always are based on the same primary information: researchers' scientific publications, detailed information about patents, developed software, scientific projects and forums, etc. This information is to be kept in an information analytical system (IAS) for support of the process of research institution scientific management.

The specific aspects of such system design and implementation are described in present paper. The analysis of how the system meets its main purpose is made. The possibilities to extend the system for its usage for international projects submission and management are described as well.

In section 2 the requirements for the system's functionality are described, including some specific features and technological solutions on its implementation, hardware and software prerequisites.

In section 3 the system's usability is analyzed on an example of person's CV preparation.

In section 4 it is shown how the system may be improved to meet the needs of informational support and management for inter-institutions' cooperation.

2. REQUIREMENTS FOR FUNCTIONALITY OF IAS OF SCIENTIFIC INSTITUTION

2.1. ABOUT THE IAS FOR RESEARCH INSTITUTION IN GENERAL

IAS for research institution scientific management has to provide the following:

- to assure constant accessibility to up-to-date information;
- to get solicited data promptly in the form needed at proper moment;
- to analyze current state of the institution according to calculation of certain indexes on the base of information stored in the system.

The system should be centralized, multi-user, public within the definite range of users, as simple as possible in administration, provide comprehensive information in convenient for user format (report form), and ensure data protection from undesirable effect in the case of carrying forth information to public domains. Not of less importance factor is also the usage of open source solutions, the license of which satisfies their usage in noncommercial purposes.

The system should be fairly complete (in terms of diversity of data filling it) and flexible (in terms of diversity of selection criteria and methods of combining them) in order to provide the user with necessary information even if the reporting forms are changed.

The final target consists in elaboration of an interactive processing system with informational and decision making functions. The main of these functions are listed below:

- accumulation and analysis in different aspects of the detailed information about state and dynamics of the scientific capacity both of the research institution as a whole, of its subdivisions apart, and different staff categories, and individual researchers as well;
- complete information storing about scientific capacity of the research institution: classification, concentration, tendencies of development;
- decision making support in the management process of the technical and scientific programs and research projects;
- automation of report creation (including those annual) about scientific activity of the entire institution and each researcher apart;
- automation of scientific projects drawing up;
- automation of researchers CV drawing up;
- information extraction for the research institution accreditation;
- information obtaining and report generation according to specified filtering criteria.

To enable users to access information from different places of the world, the access to DB will be provided through the global and/or local network for some categories of users with different rights of access.

Such type of the system "IAS IMCS" is under development and testing in the Institute of Mathematics and Computer Science of Moldova [1, 3].

The design of this system includes:

- The database "Scientific potential of the research institution",
- Analysis tools,
- Tools for reports drawing up.

Information Analytical System of scientific institution should serve the same purpose as the IAS of any other institution. However, because of specific features of scientific institutions, it must possess a number of peculiarities.

One can judge about the scientific activity of scientific institutions basing on the analysis of some indicators. The main ones, that can be formalized and accounted, are the following:

- personal data of scientific researcher (age, scientific degree, scientific title, scientific work experience, position, etc.);
- publications of institution's scientific researchers (author(s), title – perhaps in different languages, type of publication, date of publication, edition, publishing house, pages, language of publication, international identification number, etc.);
- scientific projects, executed by institution's scientific researchers (title, project manager, executors, project financing, project domain, project execution dates);
- theses defenses (title, place and date of defense, scientific leader and opponents, scientific speciality);
- participation in scientific forums (conferences, symposiums, congresses, workshops, exhibitions etc. – including reports, thesis and poster representation, participation in program committee, sections organization, etc.);
- participation in scientific journals editing;
- membership in scientific associations.

The IAS IMCS meets the goals and requirements described above owing to:

- flexible and convenient database structure, including at the present moment about 70 tables [1];
- chosen platform, tools for implementation and a number of reasonable technological solutions (see section 2.3, [2,3]);

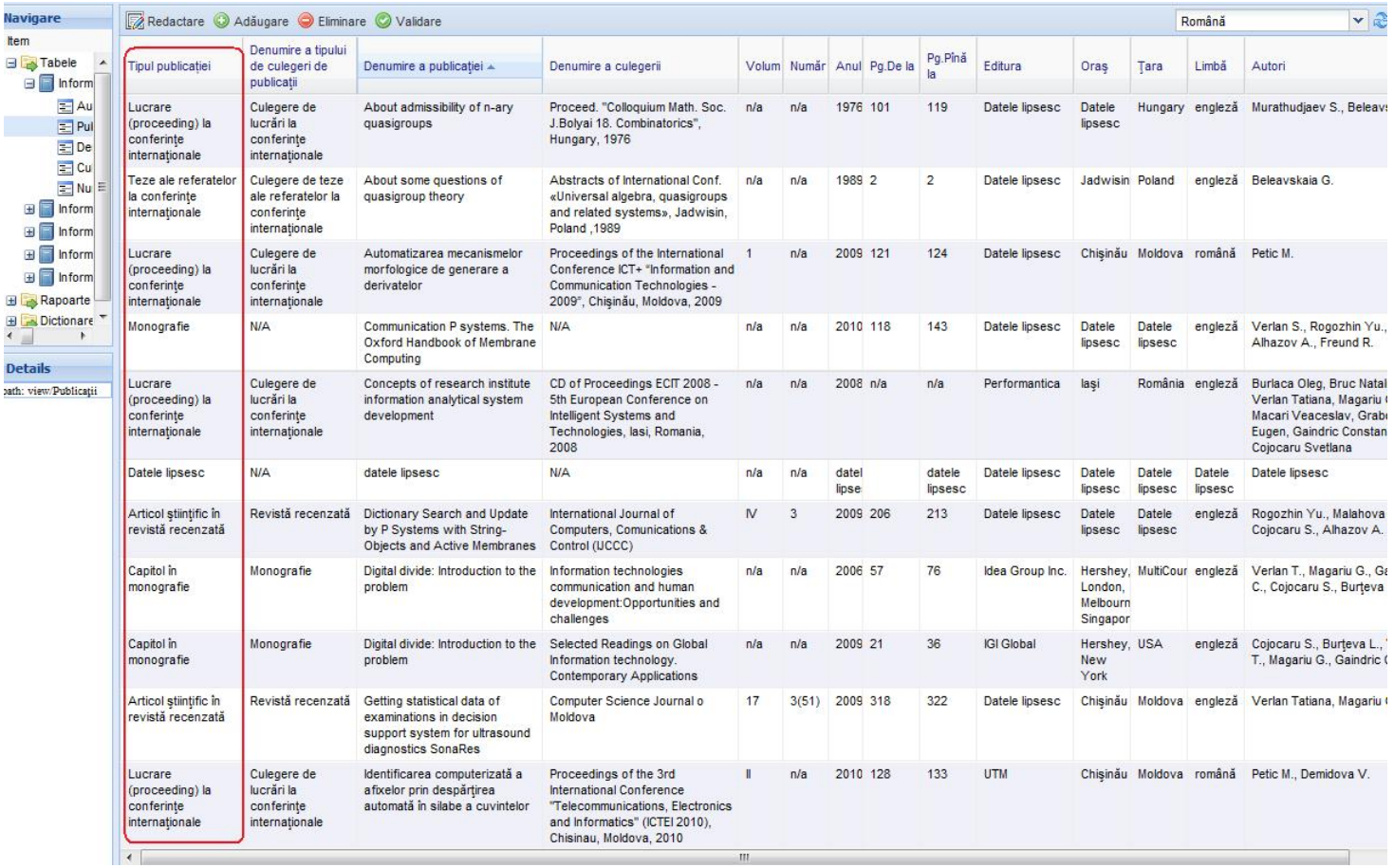
- specific solutions that effectively solve some particular problems caused by specificity of scientific institutions (see section 2.2, [3,5]).

2.2. SOME SPECIFIC FEATURES

Despite the seeming simplicity, on closer inspection, there occur many small-scale problems, from the successful solution of which the system usability, flexibility and vitality depends on. Let us consider some of them.

Types of publications. Besides the typical information, the specific one for a research institution is stored as well. Thus, for example, in the table about publications, besides the usual bibliographic data, type of publication is also stored (e.g. article in peer-reviewed journal, article in collection, thesis in Proceedings of national/international conference, monograph, chapter in monograph, manual, etc.) (see Fig. 1). The variety of types of publications existing at this stage in IAS IMCS agrees with terminology in library science and reporting requirements of scientific institution (see Fig. 2).

The type of publication allows us to some extent to judge the quality and scale of scientific work. Thus, one can get the answer to the question: How many monographs/articles in peer-reviewed journals are published?



Tipul publicaţiei	Denumire a tipului de culegeri de publicaţii	Denumire a publicaţiei	Denumire a culegerii	Volum	Număr	Anul	Pg.De la	Pg.Pînă la	Editura	Oraş	Ţara	Limbă	Autori
Lucrare (proceeding) la conferinţe internaţionale	Culegere de lucrări la conferinţe internaţionale	About admissibility of n-ary quasigroups	Proceed. "Colloquium Math. Soc. J.Bolyai 18. Combinatorics", Hungary, 1976	n/a	n/a	1976	101	119	Datele lipsesc	Datele lipsesc	Hungary	engleză	Murathudjaev S., Beleav
Teze ale referatelor la conferinţe internaţionale	Culegere de teze ale referatelor la conferinţe internaţionale	About some questions of quasigroup theory	Abstracts of International Conf. «Universal algebra, quasigroups and related systems», Jadwisin, Poland ,1989	n/a	n/a	1989	2	2	Datele lipsesc	Jadwisin	Poland	engleză	Beleavskaia G.
Lucrare (proceeding) la conferinţe internaţionale	Culegere de lucrări la conferinţe internaţionale	Automatizarea mecanismelor morfologice de generare a derivatelor	Proceedings of the International Conference ICT+ "Information and Communication Technologies - 2009", Chişinău, Moldova, 2009	1	n/a	2009	121	124	Datele lipsesc	Chişinău	Moldova	română	Petic M.
Monografie	N/A	Communication P systems. The Oxford Handbook of Membrane Computing	N/A	n/a	n/a	2010	118	143	Datele lipsesc	Datele lipsesc	Datele lipsesc	engleză	Verlan S., Rogozhin Yu., Alhazov A., Freund R.
Lucrare (proceeding) la conferinţe internaţionale	Culegere de lucrări la conferinţe internaţionale	Concepts of research institute information analytical system development	CD of Proceedings ECIT 2008 - 5th European Conference on Intelligent Systems and Technologies, Iasi, Romania, 2008	n/a	n/a	2008	n/a	n/a	Performantica	Iaşi	România	engleză	Burlaca Oleg, Bruc Natal Verlan Tatiana, Magariu Macari Veaceslav, Grab Eugen, Gaindric Constan Cojocaru Svetlana
Datele lipsesc	N/A	datele lipsesc	N/A	n/a	n/a	datel lipse		datele lipsesc	Datele lipsesc	Datele lipsesc	Datele lipsesc	Datele lipsesc	Datele lipsesc
Articol ştiinţific în revistă recenzată	Revistă recenzată	Dictionary Search and Update by P Systems with String-Objects and Active Membranes	International Journal of Computers, Comunications & Control (IJCCC)	IV	3	2009	206	213	Datele lipsesc	Datele lipsesc	Datele lipsesc	engleză	Rogozhin Yu., Malahova Cojocaru S., Alhazov A.
Capitol în monografie	Monografie	Digital divide: Introduction to the problem	Information technologies communication and human development:Opportunities and challenges	n/a	n/a	2006	57	76	Idea Group Inc.	Hershey, London, Melbourn Singapor	MultiCour	engleză	Verlan T., Magariu G., G C., Cojocaru S., Burţeva
Capitol în monografie	Monografie	Digital divide: Introduction to the problem	Selected Readings on Global Information technology. Contemporary Applications	n/a	n/a	2009	21	36	IGI Global	Hershey, New York	USA	engleză	Cojocaru S., Burţeva L., T., Magariu G., Gaindric
Articol ştiinţific în revistă recenzată	Revistă recenzată	Getting statistical data of examinations in decision support system for ultrasound diagnostics SonaRes	Computer Science Journal o Moldova	17	3(51)	2009	318	322	Datele lipsesc	Chişinău	Moldova	engleză	Verlan Tatiana, Magariu
Lucrare (proceeding) la conferinţe internaţionale	Culegere de lucrări la conferinţe internaţionale	Identificarea computerizată a afixelor prin despărţirea automată în silabe a cuvintelor	Proceedings of the 3rd International Conference "Telecommunications, Electronics and Informatics" (ICTEI 2010), Chisinau, Moldova, 2010	II	n/a	2010	128	133	UTM	Chişinău	Moldova	română	Petic M., Demidova V.

Fig. 1 - Appearance of IAS interface showing the information about publications indicating the type of publication

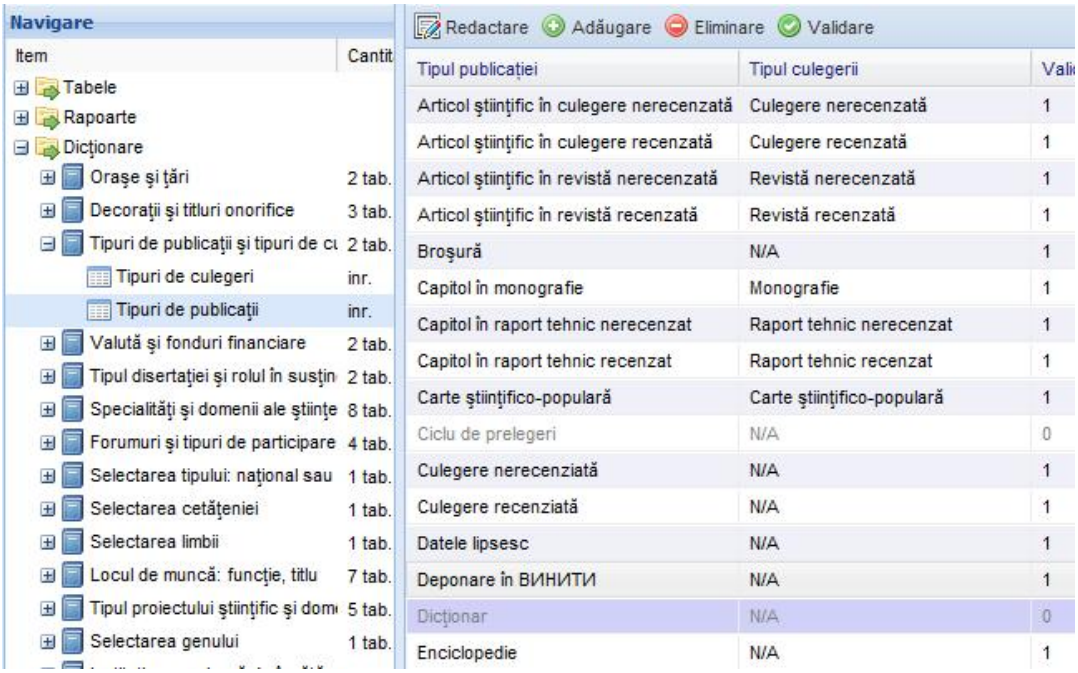


Fig. 2 - Appearance of IAS interface showing the variety of types of publications

Publications and collections of publications. As usually the information about publication is stored in specific tables. But articles are published in scientific journals, conference proceedings and other collections of publications. The structure of information for collections of publications is much similar to the one for a single publication (as, for example, for an article or a monograph). It would seem that for economy-size information storing this information needs only one table in DB. However, it became reasonable to design two tables apart in the DB: one for information about collections of publications, and another – for information about single publications (see Fig. 3). Such design made it easier the information input, and query construction as well.

Using this approach the information about a monograph can be input into the table about publications, or into the table about collections of publications, depending on situation. For example, if a monograph has one list of authors, then the information about it is input into the table about publications. If a monograph has several chapters and each chapter has different list of authors, then the information about it is input into the table about collections of publications.

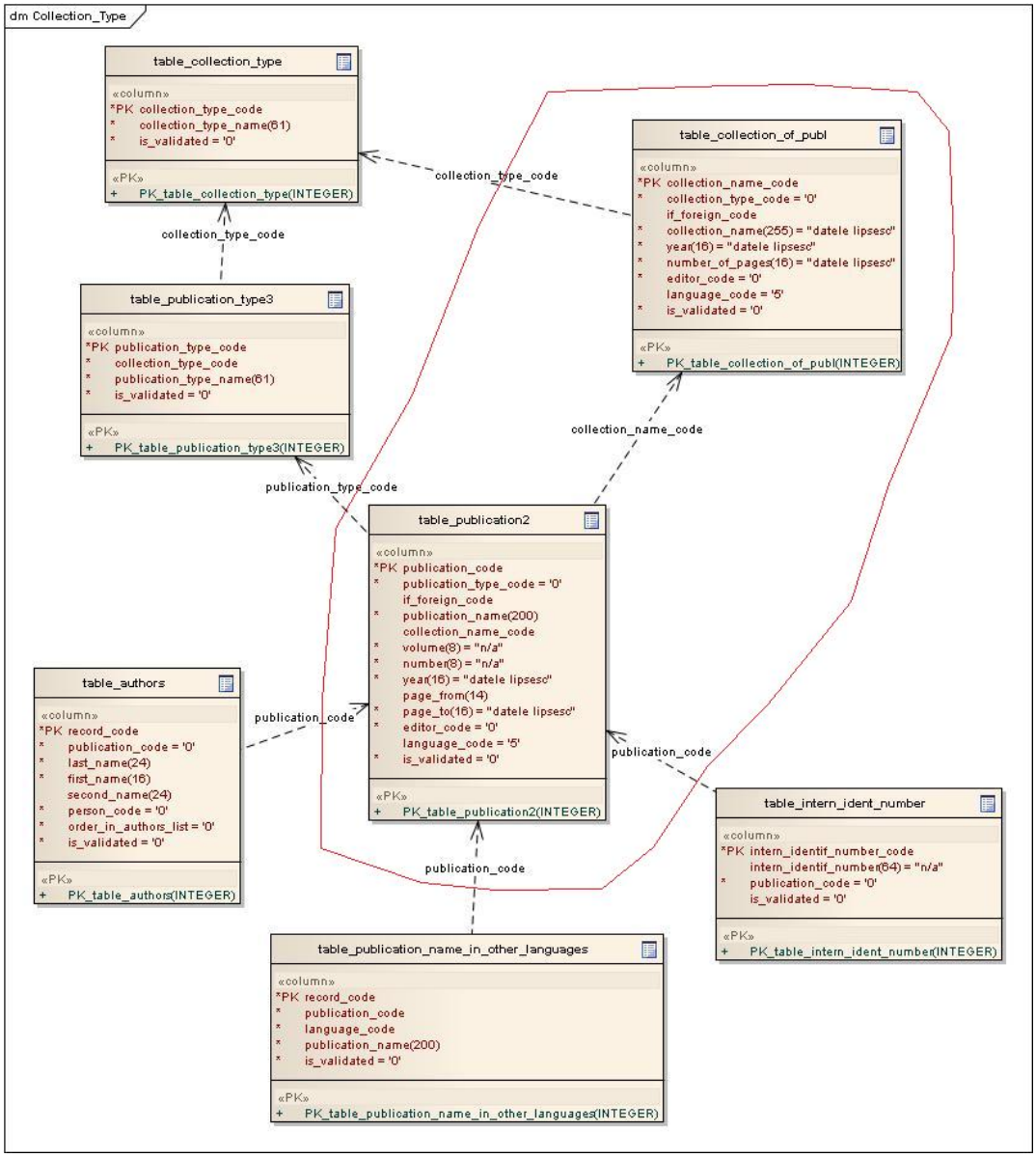


Fig. 3 - Interconnection between table on publications and collections of publications

Author's multiname. Because of publishing in different languages, legal name changing, etc., a person can have publications with various name spellings. To solve this problem, the author name, as it is originally written in a publication, is kept in the table about (co-)authors linked to the table about publications (see Fig. 4). Owing to the relation between the table about persons and the table about publications, the query by the name of the researcher (as it is written in his passport) generates the list of all his

publications regardless of how and in what language his name is written originally in the publication.

Author's order. The number of authors of publication is not predetermined. And the requirements for order in (co-)authors list are different for different publishers. The table about (co-)authors contains as many records for a publication, as the number of (co-)authors of this publication. Information about (co-)author includes his order in the list of (co-)authors of this publication (see Fig. 4). Such solution permits to represent the (co-)authors list as it is in the publication.

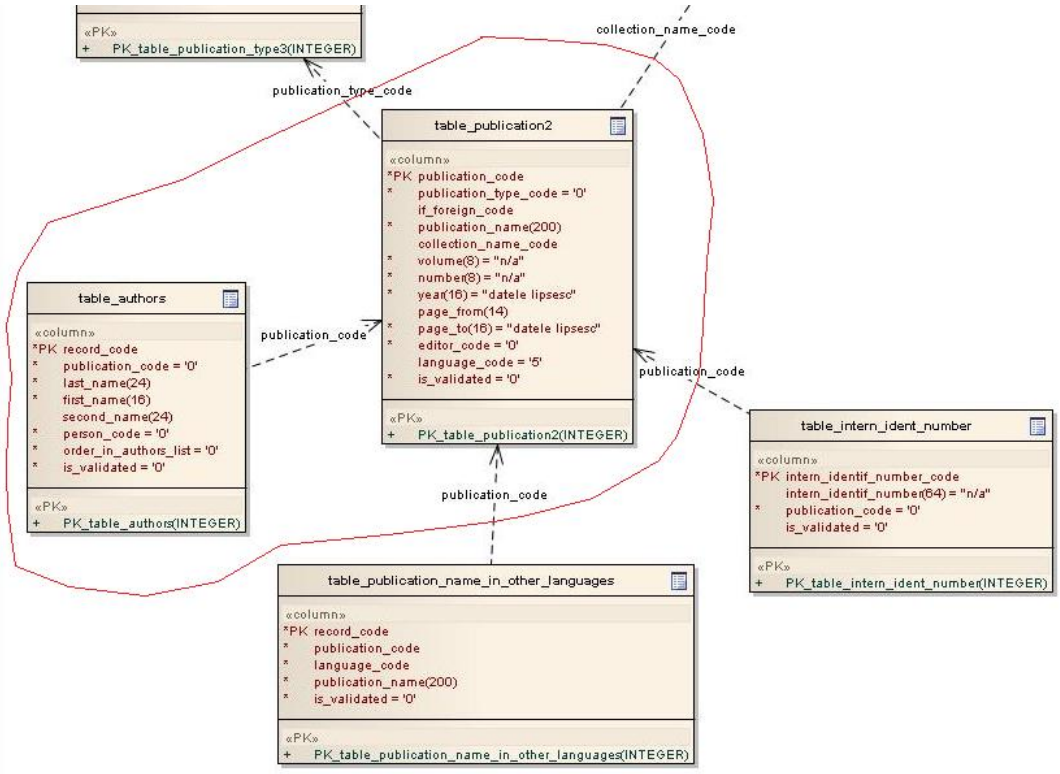


Fig. 4 - Solution of the problems of author's multiname, author's order and publication title in different languages.

Publication title multilanguage. Very often the researcher needs to translate his list of publications into different languages. That is why the relevant table is foreseen in the DB. This table contains the name of the publication in languages other than the original one (if exists) (see Fig. 4). This allows one to easily prepare information for documents in different languages and not to spend precious time in translating. Transliteration is considered as one of the languages too.

Dates. In due course, many important indicators of a scientific institution (e.g., its structure) or an individual employee (e.g., position, scientific title, etc.) may vary. Therefore, the information in the IAS is connected to the dates: there are date fields in all relevant tables. Thus, any record in each of the tables, describing the structure of the institution, contains also the information on the date of creation and date of liquidation of respective structural unit. In addition, there is a table that links up each institution collaborator with a structural unit of the institution to which it relates, indicating the post and the date of taking office. This allows us, for example, to consider the dynamics of institutions indicating the number of researchers with scientific degree.

Such organization allows one to track evolution of scientific activities of the institution as a whole, its subdivisions, and of each its collaborator.

User roles. User role is one of the most important features of the system. The IAS users are divided into simple users with no rights, limited users with restricted permissions, and administrator users with full access rights. The access rights of each registered user are defined in specific database table. They can be changed by the system administrator.

Data validity. To monitor the reliability of data in each table there is the field "is validated". When the usual user inputs the information, the value "false" is automatically assigned to this field. Only the person with corresponding access rights can change it to "true" (see Fig. 5). However, information is available. This simplifies the DB populating, as well as allows maximum use of existing information.

Workflow. Application workflow is ergonomic and user friendly. Special investigations were performed about user preferences and commonly used actions.

The possibilities provided to user can be divided into four basic actions: login, looking through the data, data editing and/or adding, and reports generation.

The interface is tailored according to the user's rights of access. On user login the view of interface is configured - the set of available buttons (and respectively the possibilities) is changed:

- for simple users, the function of looking through the data is available but buttons for data editing and adding are absent;

- for selected users, buttons for data editing and adding are present, but button for changing data validity is absent;

- for administrating users, all the buttons are present.

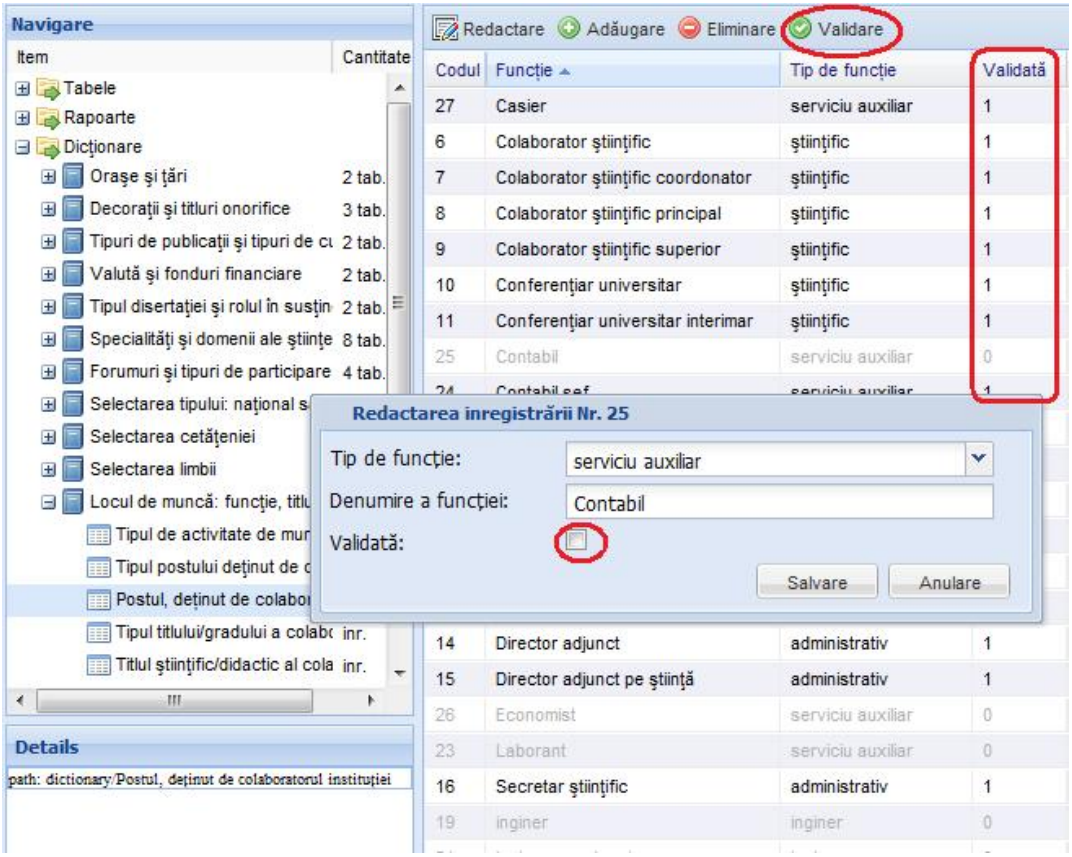


Fig. 5 - Solution of the problem of data validation.

The control of the interface appearance (its configuration) is realized simply and effectively through the special tables, where different interface elements correspond to respective user roles.

Incomplete data. The problem of incomplete data is solved as following. For example, information about publication lacks information about editor or about pages of publications. Then this publication can be placed in DB indicating the appropriate fields as “Data are absent”. It permits in simple way to require respectively in the query only complete data or, on the contrary, given the incomplete data. At the same time, the already introduced data are not lost and can be updated when the lacking information appears.

Taking this into consideration, for some fields in the DB tables the default value "Data are absent" is provided. So, if the user has no information for these fields, he does not take care on this question.

Another situation is when the matter is not in the lack of information, but the information has not to be for some case (for example, some journal has no volume). For such cases the value "N/A" is provided. When the user selects the value "N/A", it means that the data are complete.

2.3. SOME TECHNOLOGICAL SOLUTIONS ON IMPLEMENTATION

The IAS is implemented as a web application, and is intended to be used remotely in a multi-user environment. This fact requires that the amount of data which are transferred between server and web browser should be minimized and cached when possible.

For time delay reducing, at page opening it needs:

1. to reduce quantity of queries to DB as far as possible;

2. to optimize the queries in order to spend as low time as possible on their execution;

3. to reduce quantity of transmitted data from the application to the server and vice versa.

If the first two items are solved at the level of queries writing and programming of part responsible for dynamic data representation (Model), then the third item is solved by sending-receiving data needed to modify. It is realized with the help of AJAX technology, which is well realized in JavaScript Framework ExtJS [8].

The originality of the proposed concept is based on the design methodology which offers the possibility to clone existing system by the other research institutions. Another important aspect represents the possibility to interconnect this application with other databases (or web sites). During the concept elaboration the accent is put not only at reports generation but also at their analytical interpretation.

The success of the proposed solution is guaranteed by the combination of the latest modern technologies in realization of Model-View-Controller (MVC) design pattern. The **Model** is implemented using MySql database server [9]. Thus the Model is a

MySql DB which supports such features as transactions and tables lock. The **Controller** is realized using PHP language [10], as a set of routines which allow controlled access to database (DB). The **View** is implemented in Java Script & HTML using ExtJS open source library [8]. ExtJs proposes a lot of visual components, which allow interaction with user and data presentation. This design pattern simplifies development, debugging, and maintenance of the project.

Combination of PHP and MySQL forms back-end of the proposed system. Both of them proved their capabilities to handle complex system as well as the small one. The back-end implementation follows the same design concepts as the front-end. Few basic classes which implement main behavior are created and treated as “read-only” (which will not be changed during normal development process). The derived child classes define the configuration and behavior of the current application back-end.

Report facilities are the output of the system. New reports can be created at any time. It is a technical aspect of the system and it is not important when compared to organizational problems: who have the right to modify the information in the system's DB, where the data comes from, who approves it etc.

Web **security** is the most overlooked aspect of securing data which is shared over Internet. That is why in this project we paid special attention to security, meaning here not only data consistency but also safety of the data transmission and storage.

Input data is validated by the ExtJS routines in order to maintain data integrity. Database access is assured by PHP routines which perform additional verification to exclude data duplication. To avoid SQL injection, each query is processed before its execution.

Due to the fact that the project is targeting a multilingual society, the support for multiple and dynamically changeable language has been implemented starting from early stages of the project design. The languages are defined as a translation table. Current language is defined by an indexing variable, the value of which can be changed during program execution, and needs only page reloading to become active. Hence, no additional recompilation, or server restart is required, just page reload.

2.4. HARDWARE PREREQUISITES

For a proper functionality and reasonable response time, the presented system requires some relevant resources. Main resource consumers are database size and concurrent clients which are processed by apache web server. These resources represent not only disk size (for MySQL storage), but RAM memory and CPU speed for Apache and PHP back-end processing.

The GUI processing is fully transferred to client side. This approach makes the system a true cross-platform application and saves some resources due to client side user interface rendering.

The amount of data transferred across client's browser and web server is minimal, and speaking about clients' machines, it includes only query results on download and few bytes of information on upload. This architecture will require a low download speed and even lower upload speed for clients.

2.5. SOFTWARE PREREQUISITES

As it was told, the system is built on well tested open source solutions. The core is based on php-enabled Apache web server closely tied with MySQL database free edition which is well suitable for a medium size database. These applications suite provides a huge number of customization options which allow system tuning for a maximal productivity.

Client side is driven by open source solution - ExtJS, which implements AJAX technology, and it is capable to handle many existing html browsers of different versions. These libraries are tested for proper functioning and are stored on a server.

3. WHAT DATA FOR CV MAY BE OBTAINED FROM IAS

Equations should be aligned according to the pattern:

As an illustration for the system usage let us consider the example of person's CV preparation.

The database of IAS IMCS contains the majority of information necessary for person's CV preparation. It is supposed that the user to be afforded an opportunity to get all the information available in the database and useful for the CV by pressing just one

button "For CV", which will provide the user with the information in some standard form, for example, in XLS format. Then the user can use, complete and edit this information to form a CV in the needed format. For this feature implementation a variety of relevant queries has to be activated automatically:

- personal information (name, date of birth, gender, e-mail, work phone number, etc.);
- information about the current place of work and history of professional advancement within a given research institution;
- information about higher education;
- information about thesis defense;
- information about scientific publications;
- information on participation in research projects;
- information on participation in scientific conferences;
- information on participation in scientific societies;
- information on scientific prizes, titles and awards.

This information is rather detailed. So, the user can delete a part of it, depending on the situation. At the same time, the user can easily add by himself the missing information on language skills and on work in other institutions.

4. WHAT THE IAS SHALL CONTAIN TO BE USEFUL FOR SCIENTIFIC PROJECTS SUBMISSION AND MANAGEMENT

Traditional cooperation agreements between institutions of different countries, as a rule, do not contain any formal, in particular, quantitative indicators of cooperation effectiveness. It seems to us that the proposed approach allows making the first steps in formalization of assessment of informational and the conceptual interaction of this cooperation. Ipso facto, it allows contributing to its effectiveness.

The IAS will provide support to cooperation agreements, including bilateral projects between the parties and international projects in which they jointly participate.

In the IAS DB there is the majority of information about the scientific institution and its staff needed to prepare the documents for these projects (submission and management):

- personal information about prospective project participants (name, surname, gender, age, phone, e-mail);
- position, title of the prospective project participants;
- selected papers of the prospective project participants on domain of the project;
- list of projects (including international), in which the prospective project participants took part;
- general characteristics of scientific institutions, including number of researchers in the whole and ones with scientific degree, list of projects, potential's characteristics, etc.;
- joint publications and joint participation of the parties in other projects.

Also, there are the means for this information extracting.

However, to make the selection of information, which is required for project submission and management, more focused, it is necessary to provide it with additional features. One of these characteristics is "scientific domain". It should be applied to activities domain of scientific institutions in general and to the domain of each researcher, and to each publication, and to each project. To this end, it is appropriate to use international and national classifiers to determine the domain of science [6,7].

As the other feature one can take a set of keywords describing publication, project, the activities of institution or person.

This information will be useful when searching in the DB for a person-expert (specialist) or publication in required domain by international standards.

To this end, the classifiers for science domains are introduced into the DB. There can be several classifiers (both international and national). Also, the classifiers can be modified in the course of time. Publication's author may express a wish to indicate the codes for his publications from different classifiers and from different versions of one and the same classifier. Classifier modification is considered as appearance of the new one. That is why the classifier title contains the date. For example, "2000 Mathematics Subject Classification" and "2010 Mathematics Subject Classification" are considered

in the DB as two different classifiers. If to keep the single structure for all classifiers, then one can work with them in the IAS uniformly: the system proposes the user to select the classifier title at first, and then the codes of respective classifier will be accessible for him.

For this ideology realization some changes are proposed to be made in the structure of the existing DB.

At present in the IAS DB there are the means describing national classifier, which has three-level structure: science domain, subdomain, speciality. It is used for theses description. It is supposed that there will be a number of classifiers, which have the same three-level structure (or brought to it). Therefore, the four-level structure is to be created. The first level is for the table with classifiers titles. The other 3 levels are the levels of the classifier itself (see Fig. 6).

Ease of such implementation is that when the new classifier appears, the IAS DB needs only the name of the new classifier and the information from it (having structured it beforehand in accordance with three-level hierarchy if needed). Moreover, there is no need to immediately input the full contents of the new classifier into the IAS DB. It can be replenished as needed. At that, just IAS users take part in the process of the replenishment: when one inputs a record about his own publication, if the author does not find the necessary classifier or code in the database, he will input necessary information into the appropriate guides with status “is validated”=“false”. A person, who has the authority to change the status value to “true”, will check the correctness of the entered information and set the appropriate status. That is, the IAS treats the information from the classifiers for science domains in the same way as with any other guide information in the database (countries, cities, types of publications, etc.).

References to the classifiers are supposed to be for:

- research institution to indicate its activities domain;
- each researcher of scientific institution to indicate his activities domain;
- publication;
- defended thesis;
- scientific project.

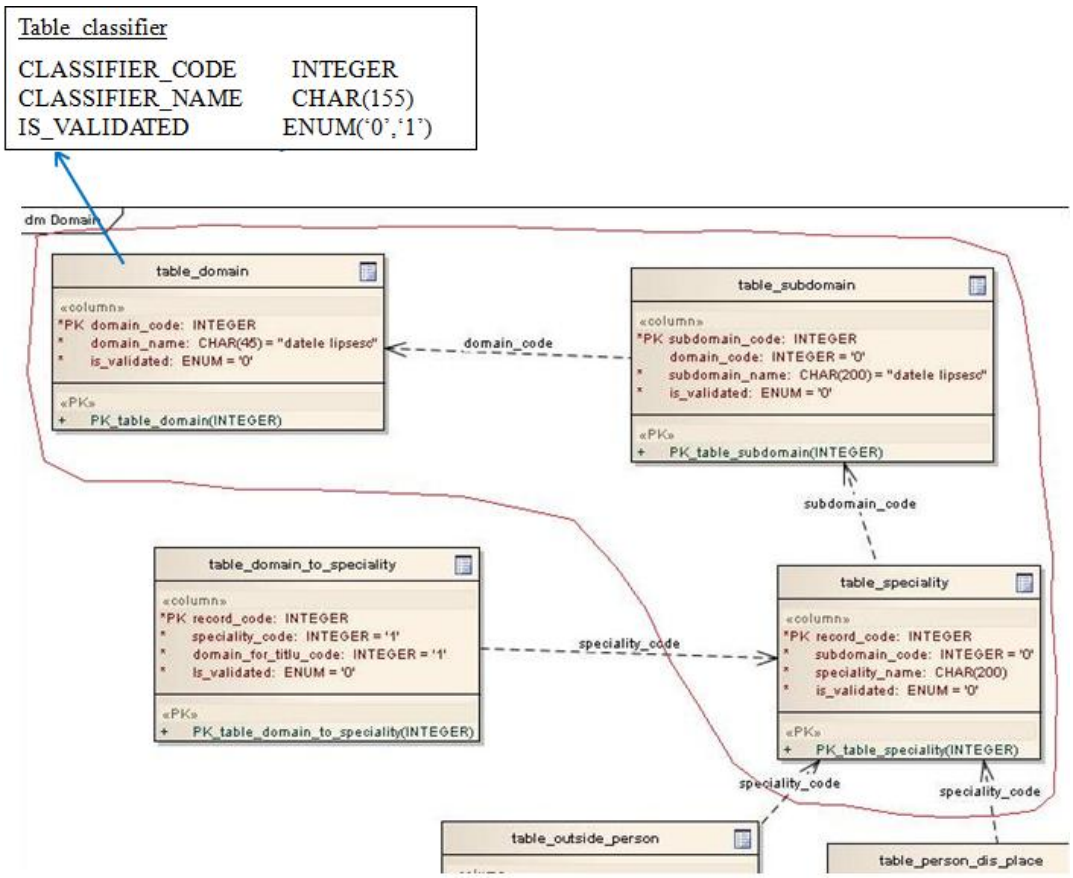


Fig. 6 - Four-level structure of classifier for scientific domains.

At that for one object there may be several references to one classifier, and references to different classifiers. For example, an employee during one period of time was active in some domain, subsequently his domain of interest has changed: in the DB both domains can be indicated as his domains of interest. Another example: when one had published some article, he indicated the domain of science according to the classifier 2000. In 2010, the classifier has changed. One can add the domain of science for this article in accordance with the new classifier. The old references can be left or removed optionally.

As the number of references with the classifiers for one object is not predetermined, it is not reasonable to keep these references in main tables, characterizing these objects. Five relevant tables are created to store these references: for research institution, for staff, for publications, for defended theses, and for research projects.

A similar solution can be proposed for the implementation of possibility to work with key words to describe the publications, theses defenses, projects, activities domains of the institution and staff.

5. CONCLUSIONS

In the basis of the proposed approach there is the principle of storage of primary information that characterizes activity of a researcher or a research institution. It is this information that represents those resources, on the ground of which the research evaluation and monitoring is carried out. The efficiency of support system for research management significantly depends on the fact, which ways of data acquisition, storage, retrieving and analysis are used, which methods for information structuring, organization and transfer are applied.

The first experience of IAS IMCS usage has demonstrated that it provides the reporting functionality for national authorities. It turned out that by extending slightly the DB structure and to add some new types of primary information, the system may be successfully used to support documentation for inter-institutional cooperation as well.

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