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Rapid application development for a research information system: a case study

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Abstract: *It can be argued that research is what makes science advance and that higher education institutions are in the frontline of developing and promoting research projects and making their results public by means of articles. But the projects and articles have to be managed at institutional and national level. This paper proposes an implementation case study: the first part makes a short introduction with an emphasis on the existing research, the second part presents the implementation objectives, while the third part details the development and the implementation process.*

Key-words: *research information system, application development, performance.*

1. Introduction

Quality in higher education represents a difficult and multidimensional concept, which explains why a single and all-encompassing definition of the term „quality" is lacking. Consequently, an agreement related to "the best way to define and measure service quality" (Clewes, 2003) does not exist as yet because there is no consensus on the exact objectives of higher education (HE): production of qualified manpower, training for a research career, the efficient management of teaching provision or a matter of extending life chances. This paper discusses quality from the point of view of research, debating it as research information management.

Studies related to research and research information management in higher education institutions (HEI) have been conducted since the wide-spread of HE. More than a decade ago, Kemp (1999) has defined a policy framework for research and research training in higher education, his proposals aiming at benefiting people who participate in the generation and application of research (Kemp, 1999). Another researcher has examined the applicability of the knowledge management concepts to higher education institutions in the United Kingdom (Rowley, 2000), as the research in HE is the base for advancing science. Rowley identifies a number of existing

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facilities, systems or projects which contribute to knowledge management in higher education (libraries, electronic collections of learning materials and others), although, from her point of view, while knowledge based organizations might seem to have the most to gain through knowledge management, effective knowledge management may require significant change in culture and values (Jennifer Rowley, 2000).

Cullen, Joyce, Hassall and Broadbent (2003) discuss concepts of accountable management in HE and their relation to performance measurement. More recently, Tight (2012) has made a meta-analysis on 567 articles published in 15 leading higher education journals in 2010, demonstrating both the high interest in higher education research across the academy and variations between disciplines in the themes researched, the methods and methodologies employed and the theoretical perspectives applied. More related to the practical aim of this paper, Waddingtona et al (2013) have found out that there is limited harmonization in reporting requests made on institutions and researchers, resulting in duplication of effort and limiting the potential for the reuse of the information, their paper describing the landscape for research reporting in the United Kingdom.

A European Union funded project entitled *euroCRIS* emerged first as a simple standard similar to a library catalogue card or the present DC (Dublin Core Metadata Standard). It provided CERIF, a data model intended as a data exchange format. It was based on records describing projects, with persons and organisational units as attributes, intending to answer questions similar to: How many articles has author X published in 2015 as a first author? / How many times have articles by author X been cited by the end of the previous year? / Did author X publish with institutionally external authors? / In how many FP7 projects does/did organisation Z participate? and many more. An open source project implementing euroCRIS was developed by *Cineca* and was published using various DSpace versions and the latest CERIF version. Also, according to Clements and McCutheon (2014), two research-intensive universities in the UK, St. Andrews and Glasgow, have worked together to develop their institutional research management systems, based on euroCRIS-CERIF, in order to deliver services to support the rapidly evolving needs of funders, institutional policy makers and management and of the researchers themselves.

2. Objectives

The necessity of implementing the software presented in the current case-study appeared as the need of implementing the methodology of allocation of budgetary funds for base and supplementary financing of state-funded higher education institutions for the year 2015 (CNFIS, 2015). For implementing this methodology, each HEI must provide a series of indicators related to its teaching, research and

administrative activities (e.g. teaching – number of students for each domain and program of study, research - quality indicators related to human resources and research, like the degree of fulfilment of the latest minimal CNATDCU requirements for conferring academic titles in higher education). According to this methodology, a criterion is considered fulfilled by an assistant/lecturer if one meets all the minimal required criteria for the academic title of associate professor, while an associate professor and a professor have to meet the current required minimal criteria for the academic title of professor. The difficulty of implementing this methodology consists in collecting the data, because each professor has to provide detailed, opera omnia data that might fit in the current CNATDCU standards. Currently there are 33 standards for the teaching staff part of *Transilvania* University of Brasov, divided and supervised by multiple consultancy-committees, with a total of over 950 possible items that could be filled. It should be noted that there are cases when certain professors met in the past that-time minimal requirements for acceding to the next academic degree, while they do not meet the current minimal requirements any longer.

An implementation of DSpace with euroCRIS-CERIF was not possible, although it was evaluated, due to the very short time span available to implement the software and to the time necessary for the teaching staff to fill in the data.

3. Methods and results

In order to develop the current requirement, the following possibilities have been considered:

- Collecting data manually: in this case, teachers would have to collect their data in Word documents, meaning that the data would be totally unstructured, and organizing and summarizing them would have been an administrative nightmare;
- Collecting data in Excel documents: for each standard multiple sheets should have been created, and each sheet should have had its validation features, so that only the required data could have been entered. Because Excel could be likened to a semi-structured database, this was one of the possibilities taken into account. What lead to the use of a centralized application was the fact that each sheet had to be designed and validated, while the data summarization from multiple files was not a strong point;
- Designing a centralized, web-based module with similarities to the currently implemented application was the best approach, because of the distributed data-entering capabilities of the web and data centralization.

The requirements for implementing this web-based application were: 1) rapid development; 2) fast implementation; 3) good performance and 4) resemblances with currently implemented applications for research reporting (Maican, 2009).

The fast/rapid application development (RAD) took places using commercial tools (Visual Studio) and ASP.NET Web Forms. Using them, we were able to design the modules in a reusable manner, also creating a framework inside another framework in the end (Figure 1).

The base framework consists of the open source content management system (CMS) DNN Software (DNN) from which we used its module development methodology, security and integration. Figure 1 shows that there are a lot of other modules and applications built over DNN, like the student management application, the students' and teachers' portal, modules for the university web site. The integration through authentication (similar to Single Sign On) with the e-learning (Moodle) platform is also based on DNN.

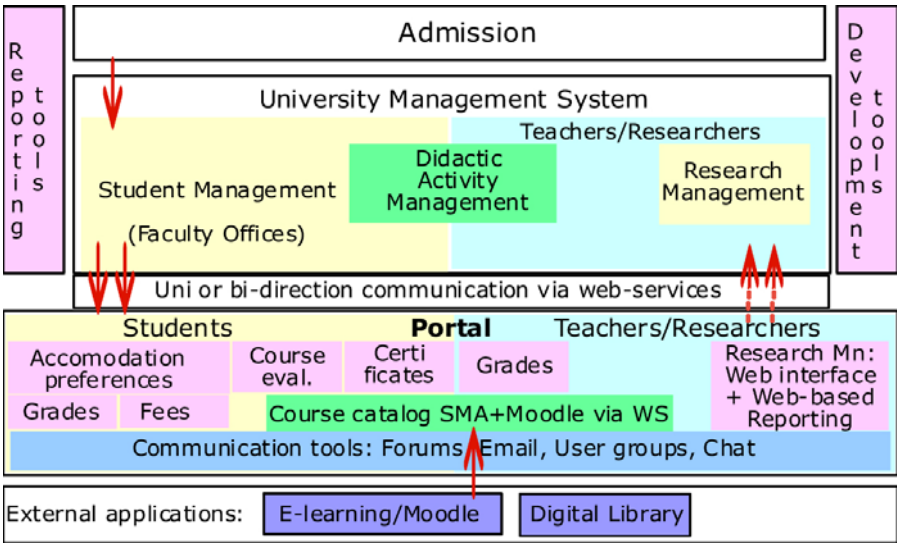

Fig.1 *The existing framework based on open source software.*

Because of the very different criteria from one CNATDCU standard to another, there was no possibility to develop separate modules for each standard. The approach we took was to build a data-editing module that generates its interface dynamically at runtime, based on configuration data. After an analysis, we took into consideration the following end-user controls: textbox with a required validator for regular strings (title of an article, title of a book etc.), a numeric textbox for numbers (it is able to accept only integers/decimals, rejecting other characters – e.g. number of authors for a certain item), a date picker for dates (when an article/book was published), a checkbox for Boolean typed data (e.g. the article/book was published after publicly defending the user's Ph.D.), a "masked" textbox for entering data in special-format fields (e.g. ISSN, ISBN etc.) and a list for the user to choose from predefined values (e.g. the database where a journal is indexed), as depicted in Figure 2.

This picture shows that, for the given example, we use multiple reusable elements, the case of Citations being the most obvious one. In this case we use references from both journals and books, the requirements and some of the standards not making differences between the types of the material where the citing article appears. However, there are criteria that explicitly state the differences, and in this case, the implementation is different for citations in books vs. citations in various kinds of journals.

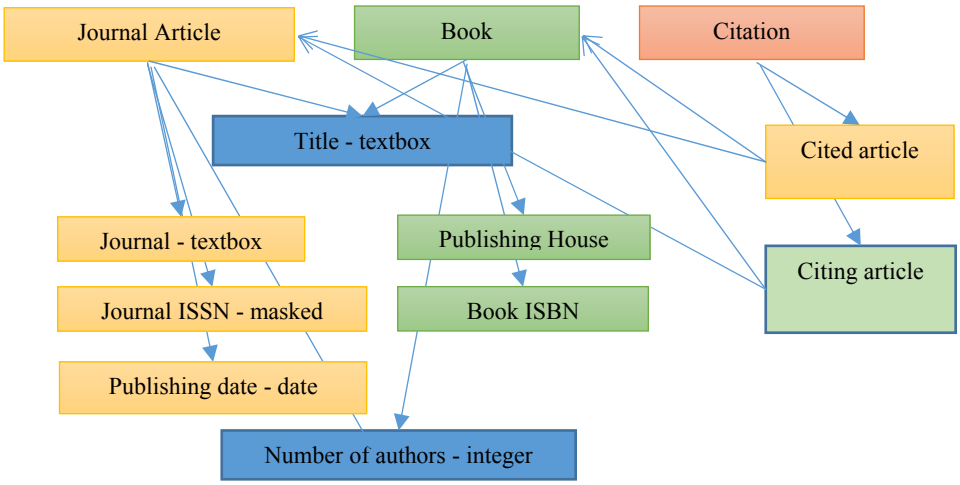

Fig.2. *Example of criteria and their corresponding user-interface objects*

A minimal algorithm for implementing this is presented below:

```
Page initialization (Page_Init):
get calculation formula from CriteriaConfig root
foreach element in CriteriaConfig
  get element type (textbox, numeric textbox, date picker,
checkbox, list)
  create element dynamically
  add validation according to configuration for the current
element
  add help tooltips
end foreach
cache the element for faster creation, so that for the same
element the data is retrieved from cache and not from database
```

Another requirement that had to be met was the **fast implementation**. There were over 950 criteria to be implemented: they had to be written in a structured manner so that they could be read by the application. The decision to choose

between JSON and XML as data configuration fields was led by the human factor, as the implementers had to write the configuration manually. As JSON is more verbose than XML and not very user-friendly (Figure 3), the entire configuration was written using XML. The entire configuration and formula validation for all the criteria lasted 48 hours, with an average of 18 criteria/hour. Based on this data, we consider that the implementation was accomplished in a reasonable amount of time, so that the teachers could fill in the data for the appropriate criteria.

XML

```
<root formula="(25+20 * [fi]/[ Autori])">
<field id="titlu" title="Title" type="string" required="true" width="500px"/>
<field id="revista" title="Publishing Journal" type="string" required="true" w
<field id="link" title="Proof as hyperlink" type="string" regex="OMITTED FOR B
<field id="issn" title="Journal ISSN" type="masked" mask="aaaa-aaaa" required=
<field id="fi" title="Implact factor" type="float" decimals="5" required="true
<field id="AnAparitie" title="Publishing year" type="integer" required="true"
<field id="Autori" title="Number of authors" type="integer" required="true" wi
</root>
```

JSON

```
{
  "root": {
    "-formula": "(25+20 * [fi]/[ Autori])",
    "field": [
      {
        "-id": "titlu",
        "-title": "Title",
        "-type": "string",
        "-required": "true",
        "-width": "500px"
      },
      {
        "-id": "revista",
        "-title": "Publishing Journal",
        "-type": "string",
        "-required": "true",
        "-width": "500px"
      },
      {
        "-id": "link",
        "-title": "Proof as hyperlink",
```

Fig.3. *XML and JSON for criterion definition.*

We may also note the *formula* attribute of the *root* element. A value, based on this formula and on the data entered by the end-user, is calculated using *ciloci FormulaEngine* open source tool.

The requirement referring to **good performance** was accomplished by using two methods (Meier et al, 2004): application caching and compressing the web page before its way to the client, at the same time moving the *ViewState* to *Session*. We implemented the application caching by adding the criteria configuration to cache, and reading it from that collection, if it still existed there, so that we avoided additional reading from the underlying data layer, according to the following algorithm.

```
on Insert/Update to database
  > set Cache for criterion X

get X=criteria X from Cache
if X == null
  read from database
  set Cache for criterion X

additional processing for criterion X
```

Moving the ASP.NET WebForms ViewState to the session variable was accomplished by using a `PageStatePersister` that could move the ViewState to

either Session or (NO/SQL) database, with various performances, the best performance being obtained by using in-memory Session state. By moving the ViewState, we reduced the page size sent to the client to about 50% from the original size, especially when editing items, because the ViewState was not required on read-only (display-only) operations.

We acquired **resemblance** with the existing research management application by keeping the same user interface on display-only operations and reusing the proofs already uploaded by users for the yearly research reporting, with the differences stated above, differences appeared due to specific requirements for this application. We may observe this resemblance in Figure 4.

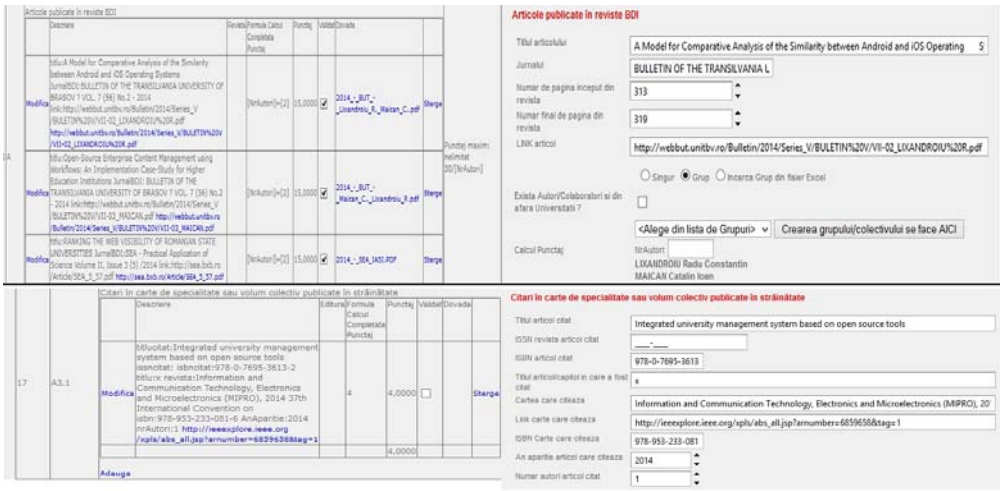

Fig. 4. *The existing application for research reporting (up) and the new application (down).*

This picture shows the resemblance in styling the user interface, how the items/criteria are displayed.

4. Conclusion

Developing a module for research management is possible with RAD tools, also taking performance and existing applications into consideration. The existence of important projects like *euroCRIS* is important for HEIs, as they could be seen as a base for policy making, evaluation of research based on outputs, documenting research activities and output and assistance in project planning. Also, they constitute a formal log of research in progress (euroCRIS). The integration between the application we

presented with tools developed in such projects would benefit both the users using the software and the HEI management.

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