Design and Architecture of an Integrated E-learning Environment.Case Study on Babes-Bolyai University, Cluj-Napoca, Romania

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The paper focuses on the architecture and characteristics of an advanced e-learning environment that provides integration facilities with dedicated information systems for educational, administrative and research management software systems. The study reveals the design principles and the architecture of the system, the advantages of implementing a flexible system and a proficient system integration solution, as well as means of maintaining and developing e-learning facilities. We present the case study of Babes-Bolyai University, Cluj-Napoca, Romania, by analyzing the implemented system and highlighting its strong points in pace development, its impact in learning and first user feed-back opinions consequent to the implementation of the e-learning environment.

Keywords integrated e-learning environment; software system; system integration; e-learning facilities; system flexibility

1. Introduction

Information systems have important roles nowadays in increasing organization competitiveness [3] and require systematic implementation solutions, adapted to organizations' characteristics. The universities' case is quite complex, since their activity covers a wide range of areas: education and learning, research, administration. Therefore, an efficient system implementation has to pursue systematic design and goal-oriented principles. Moreover, organizations face today the challenges of integrating their systems in order to ensure advanced management facilities at a global organization level and integrated IT facilities for various user categories.
The paper deals with these topics and presents the case study of Babes-Bolyai University - BBU, Cluj-Napoca, Romania. We describe BBU's information systems in section 2 and its e-learning platform in section 3, section which also contains first implementation feed-backs consequent to launching the platform. Section 4 addresses advanced integration principles and describes the integrated architecture characteristics we are in train of implementing in order to create an integrated e-learning environment in our university. Conclusions reveal the most important directions and implementation principles stated in the paper.

2. BBU Information Systems

Taking into account its goals and resources, BBU adopted since 2003 the strategy of developing and implementing its own systems, with important autonomy and manageability characteristics in system development and extendibility. Three integrated information systems have been developed and implemented since, in order to manage the university's main activity directions: education – **AcademicInfo** system, research – **Research Management** system and administrative management – **ManageAsist** system. These systems are further described.

2.1 AcademicInfo System

AcademicInfo is an integrated information system dedicated to managing educational information, with dedicated processing facilities for secretariats, specific access facilities for students and teachers and relevant synthesis regarding the educational process. The systems models educational processes at BBU level, ensuring course selection from all faculties' curricula in study agreements, models in a flexible manner various types of educational activities at all study levels (BA, MA, PhD, continuous education, specific curricula), ensures multilingual support in processing and reporting, integrates various types of facilities, fee management, student documents and requests, on-line course evaluation.
AcademicInfo contains the following component modules – see figure 1:
Educational management – processes educational information in secretariats and generates all necessary reporting documents at faculty level;

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Web Acces for students, teachers, management – provides on-line access facilities to educational information for students (curricula, disciplines, grades), teachers (curricula, coordinated disciplines, grades), syntheses for academic management - http://academicinfo.ubbcluj.ro/Info ; additional facilities for students are related to on-line filling in student documents and course evaluation while academic management has on-line access facilities to relevant educational syntheses at various levels;

Fees – faculties – fee management at faculty level, cash operations and dedicated reporting facilities;

Fees - economic administration – fee management within administration, financial management for payment orders, payment operations and dedicated reporting facilities; the module is integrated with ManageAsist system – Finance module and departments' financial management – see next section;

Admission – on-line pre-registration and client modeling of the admission process: registration, uniform data processing for various admission criteria by expression modeling, admission reports, confirmations and re-locations in admission stages ;

Diplomas – automatic generation of graduation diplomas based on the stored educational information

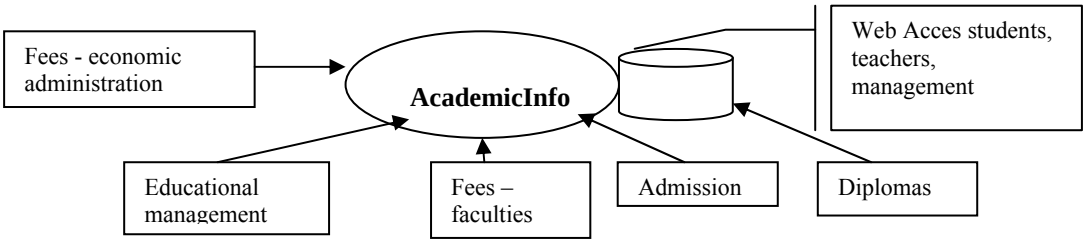

Fig. 1 AcademicInfo – functional structure

Architecture and development principles: the system was designed and implemented on systematic layer based architecture principles in order to ensure proficient implementation and flexible stage development; client modules are developed in C# and the web interface is constructed in ASP; the system uses and MS SQL database; hierarchical structures are used for modeling curricula information is efficiently processed by means of stored procedures.

Design and implementation principles are in train of being discussed and published in more details, together with run-time studies and approaches on processing hierarchical structures

2.2 ManageAsist System

ManageAsist system is the integrated software system for administrative management that has been developed for our university . The system can be viewed as an ERP system; within its design and implementation, we integrated systematic efficiency principles in software design: multi-layer architecture and layer autonomy [9], [12], advanced object oriented design based on systematic abstraction principles [8], design patterns [11], flexibility in module integration and communication, systematic workflow management, efficient database access and design [14], [7].

ManageAsist's principles and facilities are adapted for higher education institutions; the system contains the following modules: Document management, Assets, Warehouse, Cashier, Finance, Accountancy, Grants, Human Resources and Acquisitions, and decision assistance facilities. The first 7 modules are already in use; their implementation has pursued systematic and efficient principles [2]. Each module contains management reports for the corresponding compartment. Relevant synthesis from each compartment will be integrated, together with global management tools into a decision support module

In [6] we address the advantages of pursuing advanced design principles in the implementation stages of the system, and in designing a flexible framework for efficiently integrating the system's modules. We also deal with means of managing hierarchical data structures, and efficiency issues in respect with processing them.

We further describe module characteristics and functionalities. Each module includes levels [6] for specific document processing, operational facilities and reporting, level that provides management assistance information for the corresponding compartment.

ManageAsist system presently implements the following modules [6]:

The *log on module* – performs authentication and verifies user permissions. Data availability domains and user permissions are modelled at the database level, specific operations being granted according to user permissions. Permissions are managed in respect with the organization chart, as well as with data availability domains and operation types (operational, reporting, full access – including configuring facilities)

The *Acquisitions module* – models acquisitions according to public acquisition regulations. Primary documents are processed in a dedicated flow, containing order specifications, orders, invoices, receipt, payment orders (processed by the Finance module). Reporting facilities are available at different user levels. Acquisition operations are automatically pre-registered in order to be processed by the Accountancy module.

A dedicated module selects acquisition ordering facilities, *tracing and adequate reporting facilities* that are available for all system's users; management levels have available dedicated reporting facilities;

The *Warehouse module* – models warehouse activity: product delivery receipts, product registration, transfer operations, internal ownership. Products are retained in the integrated database

The *Assets module* – models asset management, specific input / output / transfer operations, internal ownership (compartment). Reporting facilities are available at different user levels. Specific operations are automatically pre-registered in order to be processed by the Accountancy module

The *Cashier module* – models the cashier activity based on: cash payment orders, cheques, cashier reports, etc. The module communicates with the Internal finance / accountancy processing module, which performs the internal finance operations for the corresponding internal account and adequate accountancy pre-registrations;

The *Finance module* – models the financial activity of the organization in respect with its bank accounts and internal compartment accounts (based on the organization's chart). The module processes payment orders, cheques, etc. and provides specific reporting facilities. The module communicates with the Internal finance / accountancy processing module, which performs the internal finance operations for the corresponding internal account and adequate accountancy pre-registration operations, for the Accountancy module. A dedicated module selects adequate *reporting facilities* available for all faculty / department *managers*;

The *Accountancy module* – models the accountancy activity of the organization: accountancy operations / registrations, ledger reports. The module uses an Accountancy plan management module. The Accountancy module is based on pre-registered accountancy operations performed by other modules. Reporting facilities are consistent and cover various documents required by accountancy regulations for public institutions

The *Internal finance / accountancy processing module* – belongs to the business layer and performs internal financial operations within compartment accounts and appropriate pre-registered accountancy operations

The *Document management* module – creates, retains, updates, erases and operates on documents in a uniform manner. Documents are further processed by other operational modules

The *Grants* module – processes financial operations on grants (research projects) and includes adequate reporting facilities; a dedicated module selects adequate reporting facilities for all grant coordinators

The *Human Resources* module is continuously being developed

Design and architecture principles of the system, as well as workflow management characteristics are presented in [6]. The system's functional scheme is presented in figure 2

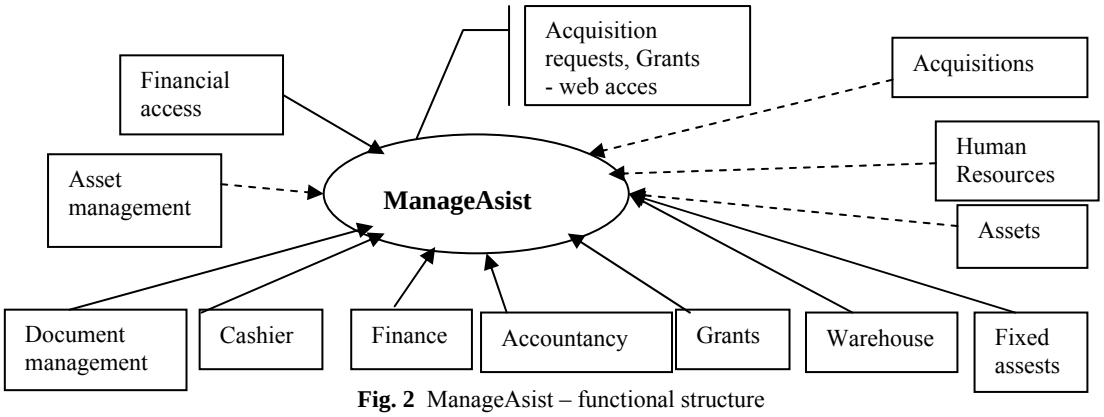

Fig. 2 ManageAsist – functional structure

2.3 Research Management System

Our university's management decided to develop and implement a dedicated software system for managing Babes-Bolyai University's (BBU) research activities, by offering accessible and user-friendly means of collecting specific information, and automatically performing quantitative analyses, syntheses and evaluations based on the collected information. The system may be viewed as a tool for quantitative research evaluation and its more general aim is to ensure proficient management of the research activity within BBU and to support the design of competitive strategies in the field by means of this dedicated software system.

The design and implementation principles of the Research Management software system, its architecture features and its impact in research activity management are described in [5]. The system's impact on managing research activities is important not only for the members of the academic & research staff, but especially for research management levels: chairs, institutes, departments, faculties, university

The implementation of the system complied structured efficiency principles and stages [2], [3] in order to ensure best design and impact features.

The system that was designed and implemented in this respect – **BBU Research Management System** – is accessible my means of a user-friendly web interface – the address is http://infocercetare.ubbcluj.ro and provides the following facilities:

efficient collection of the research activity for each member of the academic staff – from any Internet location, by means of a web interface and dedicated user accounts;
proficient synthesis & reporting facilities for each staff member, as well as for various management levels – chairs, institutes, departments, faculties, university – based on managers' accounts and corresponding access facilities

The system's user categories are: teaching & research staff (including PhD candidates); chairs / departments / institutes' managers; BBU research activity managers.
From a technical point of view, the system's architecture comprises a Postgresql database accessible on a web server and dedicated php [15] interfaces (including some Java script modules) which perform the dedicated information processing. Design and architecture principles of the system are presented in [5]

The system's facilities are consistent with *the university's organization's chart* since the research database is integrated into the human resources one. Therefore, management level facilities are based on managerial information collected from the organization's chart & human resources database and related to user account permissions (user categories & management levels), also based on the organization chart. The system's functional scheme is described in figure 3

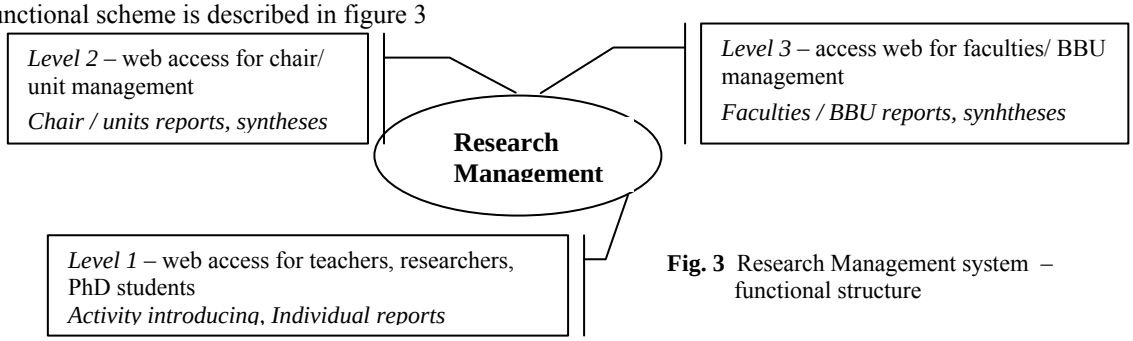

Fig. 3 Research Management system – functional structure

3. The E-learning System

3.1 Strategies and Requirements

The implementation of e-learning systems should pursue similar rules and stages to the implementation of other information systems [2], user role being crucial in the specification, verification, system installation and exploiting phases. In this respect, specific requirements should be taken into account for each user category: students, teachers, administrators, secretaries. It should be verified that these roles and their corresponding permissions are appropriately implemented and that specific facilities are available to each of these user categories.

Though e-learning capabilities are quite well defined, it is often useful that adaptive characteristics are also possible to be implemented and stage development is ensured in respect with user needs (as further detailed). In this respect, system maintenance has to be taken into account both by the user side and by the system provider in order to ensure that adequate system use and current exploiting issues are appropriately managed.

Though not at its first e-learning implementation, "Babes-Bolyai" University decided in 2006 to upgrade its e-learning system since the existing one did not meet all necessary requirements, mostly regarding de-centralized administration and complete integration of different e-learning facilities. The upgrading necessity became clear as the number of students enrolled in distance leaning programs significantly increased in the last years and the university expanded in the region.

In this framework, the goal was to implement a more complex e-learning system, aiming at sustaining the more ambitious distance learning programs launched by the university. The system should be efficiently accessible from a wide geographical area, by 5000-8000 students, who should have available advanced e-learning facilities, integrated into a user-friendly e-learning system, in order to sustain their educational path in an efficient manner.

Supplemental to usual e-learning requirements, the following specifications were considered very important [4]: increased flexibility; adaptability to future requirements; adaptive stage development, flexibility in upgrades; adaptability in curricula organization based on studied courses; increased user accessibility; administrator accessibility, development potential; de-centralized system administration facilities; multi-language support, capable of sustaining the strong multicultural profile of the university; integration with a dedicated videoconferencing system; natural customization in respect with our university's organization culture.

3.2 E-learning system implementation

Taking into account these requirements, mainly oriented on flexibility specifications, we decided to implement Microsoft Learning Gateway [16] – https://portal.portalid.ubbcluj.ro , based on dedicated Microsoft Internet servers, which ensure not only the integration of various e-learning facilities in a very user-friendly manner (facilities with design permissions), but also system development in respect with different specifications and adaptability in stage development according to the university's needs. Examples of such facilities that were already added into the system regard manageability of educational resources and certain document workflows – customized in respect with the user category. One of the main advantages of the implemented system is flexibility in administration levels (which lacks in other e-learning systems). Further implementation details are presented in [4]

We note that the public-private aspects of published information are also very well managed by the permission system, customized for different users and user categories.

MS Learning Gateway is complemented by dedicated videoconferencing facilities, mostly used in order to broadcast lectures in the university's regional branches, at a high technical quality.

The first implementation stages relied on de-centralized system administration by faculties' administrators and continued with 'filling-in' the system with the necessary learning information: curricula, courses and feed-back material, schedules, contact information, additional shared information. Administrators may delegate design permissions for teachers on corresponding educational content (courses). Student and teacher categories have just passed the first stages of using the new e-learning system.

Until now, feed-backs are positive and the flexibility specifications that were pursued in choosing the system have proved their accuracy both for user categories, and administrators, while system adaptability supported the desired "add-ons".

3.3 Portal evaluation

Regarding the *system assessment*, we developed dedicated questionnaires for administrators, students and teachers, in order to obtain a general feed-back regarding existing facilities, platform functionalities and to ensure future developments

The questionnaire has been created and interpreted using the survey functionality built-un in the platform (Share Point Portal); we underline in this respect the flexibility of the platform's tools.

We further discuss the results obtained consequent to monitoring the administrators' survey, since students and teachers are still filling in responses. Preliminary results reveal that users a not fully aware of the platform functionalities and we still have to organize more trainings in this respect.

Administrators were requested to evaluate, on a 1 – 5 scale (1=very weak, 2=weak, 3=moderate, 4=good, 5=very good), the following platform characteristics: *administration functionalities*; the average weighted grade was 4.25; *communication functionalities*; the average weighted grade was 3.5; *functionalities for administering educational content*; the average weighted grade was 4.25; *functionalities for developing educational content*; the average weighted grade was 3.5; *functionalities for platform development* - the average weighted grade was 4.75; *platform adaptability / flexibility characteristics* - the average weighted grade was 3.75; *reporting facilities* - the average weighted grade was 4 .

We can notice that all characteristics are positively rated, some of them being qualified above 'good' (weighted grades >=4).

Administrators were also requested to evaluate the percentage of teachers who requested / were granted permissions for administering their courses / educational resources – results are displayed in figure7: we can notice that most of the faculties (75%) did not grant for most of their teachers permissions for administering their own educational content, which reveals the fact that users are still in initial phases of platform use

Regarding the experience of our administrator respondents, most of them - 75% didn't have the experience of using other platforms.

We further discuss some of the most relevant responses in respect with the platform characteristics: *administration functionalities* are very well rated: 75% very good, 25% good – see fig. 4; *functionalities for developing educational content* are positively rated: 75% good, 25% very good –fig.5; *functionalities for platform development are very well rated*: 75% very good, 25% good – see fig. 6

We may conclude that the adaptability and flexibility characteristics of the platform that were mainly aimed are actually implemented and we have a very good feed-back in this respect.

We also note that guided e-learning facilities are still being developed and further have to be evaluated.

We shall continue monitoring the system and completing the survey evaluations in order to ensure its most appropriate use and development; in this respect, we are confident that our prerequisites regarding adaptability specifications in system upgrades will also prove to be very useful in the future

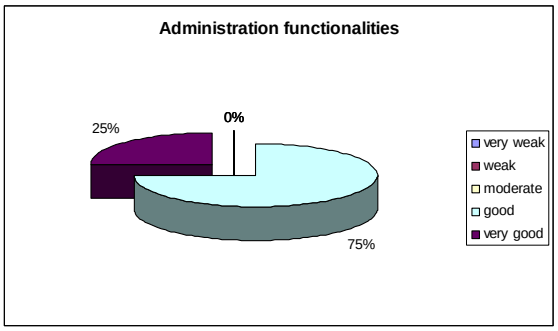

Fig. 4 Administration functionalities

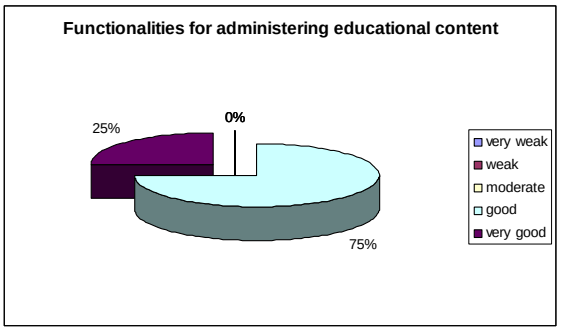

Fig. 5 Administering educational content

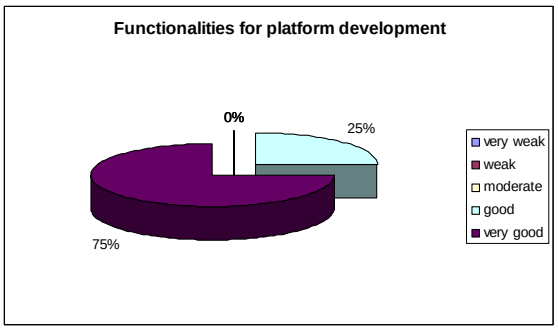

Fig. 6 Functionalities for platform development

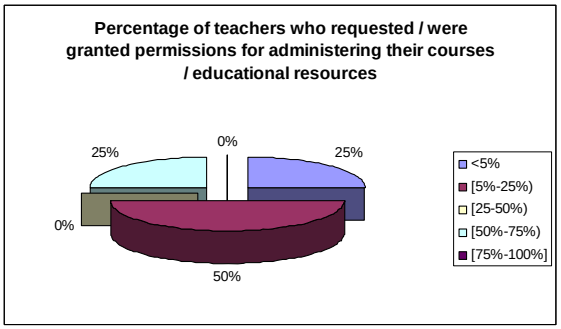

Fig. 7 Teachers who administer their courses

3.4 Implementation overview and perspectives

E-learning systems [13] may be viewed as advanced tools which assist teachers in creating a cooperative, multidisciplinary and explorative learning environment and students in accessing these learning facilities and developing learning interactions within this environment. The implementation of e-learning facilities strongly contributed to the development of the student and goal centered learning model [1].

E-learning implementations should pursue systematic implementation principles and stages [2] - user involvement within the stages of system requirements, verification and implementation being of outmost importance for a successful implementation. Though e-learning facilities are fairly standardized, it is important to take into account future upgrades of the implemented system

The implementation of the e-learning system within "Babes-Bolyai" University of Cluj-Napoca, systematically applied the above described principles. The system's flexibility and de-centralized administration are expected to prove their efficiency in the future developments of the system

4. Advanced System Integration Principles

We are currently working on an advanced system integration framework, in order to ensure the integration of the e-learning portal (see 3) with BBU's dedicated information systems (see 2) AcademicInfo, ManageAsist, Research Management System. Integration principles are based on an integrated authentication solution, which is going to map the facilities from the dedicated information systems into the portal, for each user category. The authentication server will associate, to each user group, the facilities that correspond to their logon in each of the dedicated information systems AcademicInfo, ManageAsist, Research Management System, in order to make them available within the portal – see figure 8

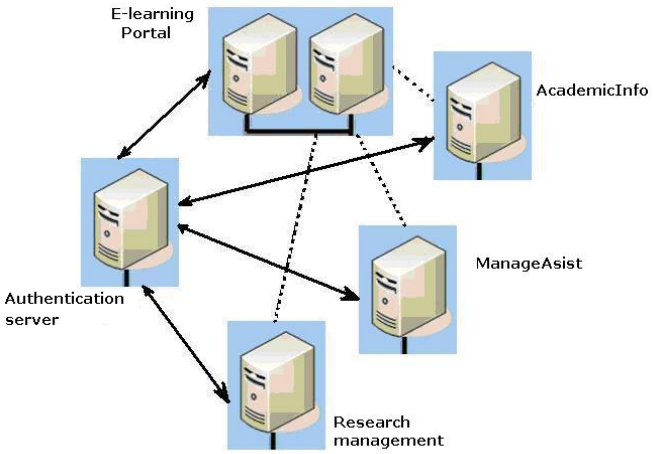

Fig. 8 Framework for advanced system integration

The integration solution will also ensure database synchronisation among AcademicInfo, ManageAsist, Research Management System and Portal databases based on the following principles / entities: *portal – AcademicInfo*: users (all categories), curricula, study contracts, grades, fees; *portal – AcademicInfo – ManageAsist*: organisation chart, units, human resources, managers, financial information; *portal – AcademicInfo – Research Management System*: research activities, PhD Students ; *portal – ManageAsist– Research Management System*: organisation chart, units, human resources, grants & corresponding financial information

In order to implement the authentication server it is very likely we are going to use MS Identity Lifecycle Management server, which has advanced integration facilities with our e-learning portal

Such an integration solution may be applied in different organizations, for integrating their dedicated information systems

5. Conclusions

The paper focuses on information system development and implementation as tools for increasing organization competitiveness. Organizations face nowadays the phase of system integration, in order to ensure advanced management facilities at a global organization level and integrated IT facilities for various user categories. The universities' case is quite complex, since their activity covers a wide range of areas: education and learning, research, administration.

We present the case of Babes-Bolyai University, Cluj-Napoca, Romania, by describing its dedicated information systems for educational, research and administrative management and its e-learning portal, which has been implemented as a flexible and extendable framework with e-learning facilities and a high integration potential. We present first feed-back results consequent to the portal implementation; results are positive and reveal the adaptability and flexibility characteristics of the solution.

We describe an efficient integration solution by implementing a single authentication server and mapping the facilities from the dedicated information systems into the portal, for each user category. This solution has a good extensibility degree and may be applied in various organization cases.

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