Knowledge management in the HR sector of RD organizations

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Abstract: - This paper presents a solution for managing the specific HR assets in research organizations, i.e. the scientific track record of scientists and researchers. The solution has already been installed at the Mihajlo Pupin Institute (MPI) in Belgrade as a part of the knowledge management initiative started a few years ago. It is based on SAP Human Capital Management (HCM) solution that ensures standardized integration and automation of HR activities and provides a wide range of reporting options. However, as standard SAP HCM solution does not cover the specific aspects of the R&D business process, the additional functionalities were built upon the standard SAP system in order to keep an extensive record of the employee professional and scientific life including scientific and professional skills and expertise, degrees and certificates obtained, information about engagements in concrete projects with details about their roles and competences, scientific achievements (patents, technical solutions, scientific papers / books), other achievements / awards, etc. The new functionalities were build taking into consideration the recommendations of Serbian Ministry of Science for compilation of the Researchers file. The new HCM solution is used for analysis and reporting indoors, as well as towards Serbian Ministry of Science and Statistical Office of the Republic of Serbia. Moreover, CVs of researchers are also kept in several standard forms (European Commission, World Bank, Microsoft, etc), facilitating preparation of international project proposals and bidding material. In this paper we discuss the implementation aspects of the solution, as well as the lessons learned and the benefits gained.

Key-Words: - knowledge management, scientific track record, R&D organization, SAP HCM, ontology, integrated KM platform

1 Introduction

Many studies discuss the importance of intangibles as sources of competitive advantage, and in particular, the importance of human capital ([1], [2], [3], [4]). Human capital is of special importance for R&D organizations, because the vital business process, i.e. the process of research and innovation, depends on the effective management of scientific and technical knowledge of employees. Li-Hsia Ko, in his research carried out in more than 1500 high-tech companies from Taiwan, is reporting about the positive impact of human capital management, organization learning culture and knowledge management on R&D performance. His research has shown that investment in human capital management significantly improves R&D performance.

Having understood the role of knowledge, especially in R&D business activities, a few years ago the Mihajlo Pupin Institute (MPI) started a knowledge management initiative with the aims to create a knowledge sharing environment that will integrate and automate in-doors information flows, facilitate research work by providing a standard access to documentation and research results (publications, technical documentation, methods, prototypes, software products), as well as to help to protect the intellectual capital of the company [5]. Implementation of such an integrated knowledge management platform is a large, multifaceted project that is carried out in phases. The first phase was devoted to studying the knowledge management solutions and to designing the holistic KM infrastructure that suited the MPI R&D process. In the second phase the in-doors information flows were integrated, automated and standardized in accordance with the adopted ISO 9001 Quality Assurance standards. As a result, the knowledge sources are made explicit and ready for exploitation. In the third phase, based on the semantic technologies, a semantic platform would be established in order to provide a uniform user-centric access to the integrated knowledge resources.

In the presented paper we will look at the process of integration, automation, and standardization of data and processes in the human resources (HR) sector of an R&D organization. The process will be illustrated through the new system that is currently being

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introduced at the Mihajlo Pupin Institute (MPI). It is based upon SAP Human Capital Management (HCM) solution that is a part of the SAP Enterprise Resource Planning (ERP) system. Choosing SAP ERP system to integrate and automate in-doors information flows, MPI joined 21 universities in Austria and many other universities in Europe and elsewhere (University of Westminster, University of Leeds, University of Toronto) and others that use SAP® software for HCM [6]. However, because the standard SAP HCM solution does not completely suit the needs of an R&D environment such as MPI, a wide range of new functionalities were built upon the standard SAP system. The new reporting facilities were developed in accordance with the standards of Serbian Ministry of Science [7].

The paper is organized as follows. Section 2 defines the scientific track record management requirements. Section 3 discuss the implementation aspects of the solution, while Section 4 presents the ways of exploitation of the established HR knowledge pool. Section 5 introduces our future plans for semantical knowledge retriaval. At the end we conclude the paper with the lessons learned, the benefits gained and the plans for future work.

2 Problem Formulation

The Mihajlo Pupin Institute is in the process of the implementation of the knowledge infrastructure that suits the MPI R&D process. The implementation of this infrastructure is a large, multifaceted project, and hence, it is carried out in phases (by turns) in both bottom-up and top-down manners. Bottom-up approach aims at building an inventory of existing knowledge artifacts, while top-down approach include design and implementation of semantic web applications for knowledge retrieval and exploitation. As highly educated and skilled employees with their business activities and results are one of the main assets of the company, special attention in design and implementation of the knowledge infrastructure was paid to integration of human resource (HR) data and processes, as well as the establishment of knowledge repository where up-to-date information about the researchers' professional skills, experience and expertise is kept.

To clarify the specifics of management the scientific track record of employees at Mihajlo Pupin Institute, we will first look closely at its organizational structure.

2.1 The specifics of the MPI organizational structure

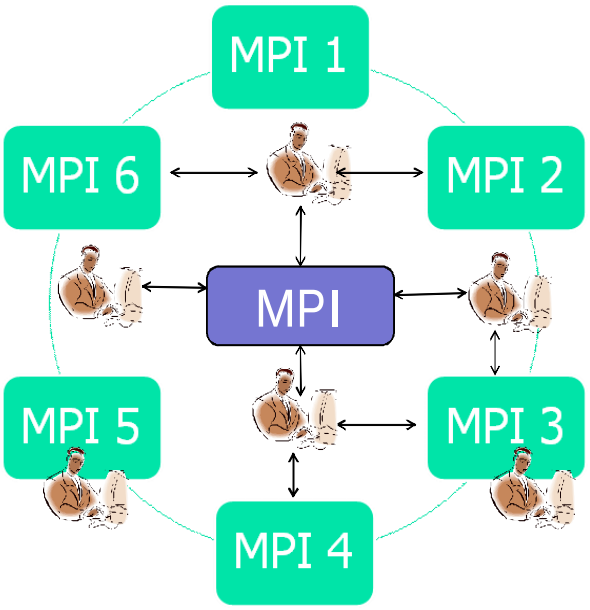


Figure 1. The specifics of the MPI organizational structure.

The business process of an R&D organization in hi-tech sector (information and communication technologies – ICT), such as the MPI is a very complex one that is driven, on one hand, by market needs and relations with industry (both public and private sector), and, on the other hand, by science, societal needs and expectations (public sector). Since MPI performs research with outcome directly applicable in industry, it takes advantage of it and successfully performs technology transfer from academia to industry. Indeed, more than 90% of its turnover comes from market and only 10% is accounted to research funds, coming predominantly from Serbian Ministry of Science and European Commission (Framework Program Projects). This dual nature of business activities in modern R&D environments, especially in ICT sector, requires a flexible organizational structure where human resources are shared by different processes / projects. Therefore, on one end, an R&D organization has to act as a profit oriented organization and integrate functions such as marketing, sales, technical support and services. In this type of organization, human work results in valuable final products and services. And on the other, operating in research sector and having links with universities and other research institutions, an R&D organization has to act as learning environment where employees can easier and faster develop their professional skills, and expertise and where their work results in scientific papers, prototypes or innovations. Managing human resources in such a R&D environment thus demands planning and tracking professional career of employees and efficient management of knowledge about employees for better utilization of scientific competence and experience in

practice and more efficient knowledge transfer from academia to industry.

Taking into consideration the dual nature of R&D business process, the Mihailo Pupin Institute, the leading Serbian R&D institution in information and communication technologies is organized as a holding company (see Fig. 1), with one mother company, dealing with research and innovation (e.g. illustrated as a box in the center), and seven daughter companies that operate as independent departments of the parent holding company, dealing mainly with implementation of research results and technology transfer towards industry (e.g. illustrated as boxes that surround the central box). Each daughter company is partly independent and responsible for its policy (both technical and financial), and partly integrated into a unified system (general vision, mission, policy, strategy, integral planning and resource management, marketing strategy, etc.).

The MPI organizational structure is flexible, meaning that human resources are shared among the companies, and complex multidisciplinary projects are undertaken by ad-hoc assembling of the project team the most suitable to the problem at hand. Most often an employee is officially hired by two companies, by the mother company and one daughter company, therefore involved both in research and in implementation of the research results and technology transfer towards industry. However, in order to reuse the employee's experience, an employee (a researcher) could be lent/borrowed by third company (as is illustrated in Figure 1). Because there are a lot of changes in the organizational structure through one year i.e. a lot of employees change their positions, we can conclude that the Mihajlo Pupin Institute has dynamic and rather complex organizational structure, especially regarding HR sector.

2.2 The problem of integration of the knowledge resources from HR perspective

The business process of an R&D organization is a very complex one that is influenced by the relations of the R&D organization with the other actors in the society (universities, industry, government and other financers). The main innovation driving forces are: science, market needs, as well as the societal needs and expectations. In a very simplified way, the innovation process of an R&D organization can be presented as follows. The process can be roughly divided into three phases: research phase, development phase, and deployment phase. The results of research phase are either published and stored in publication database or kept strictly confidential in paper or electronic form for later use in patent, technical or project documentation. The result of development phase is a prototyped solution that is sooner or later put in practice and as such is accompanied with different kinds of documentation e.g. marketing leaflets, technical white paper, user guide, etc. Keeping the documentation that is created in different time periods in different databases or document management systems makes difficulties in tracking the activities in the business process. Therefore, an R&D organization, like any profit oriented organization, needs an infrastructure for integration of the business activities. Such business integration infrastructure should: provide uniform user-centric access to integrated knowledge resources, facilitate reusability, and automate the tasks defined by the adopted Quality Assurance standard.

The adopted ISO 9001 Quality Assurance standard envisages the existence of Research files for each researcher taking part in scientific projects. A file reports about the scientific and professional work of researchers on an individual basis. The compilation of the Researchers file requires integration of data from different sources. The structure of the Researcher file and the identified data sources are given in Table 1.

Table 1. Structure of the scientific and professional file.

Section	*Data source*
Personal data, Employment, Studies, Educations	old HRM system (ORACLE)
Key qualifications – Skills, Fellowships, Memberships/Associations, Languages	Weakly-structured documents
Participation in Projects	Publication DB (ORACLE) Weakly-structured documents
References	Publication DB (ORACLE) Weakly-structured documents

2.3 The required functionalities for scientific track record management

From the short overview of the MPI business process and organizational structure, we can summarize the required functionalities for scientific data management in the framework of a Human Capital management (HCM) solution for R&D organizations as follows:

- Basic requirements are related with the integration of HR data and automation of HR processes. In this context, the system should keep information up to date and enable tracking of frequent employee movements indoors, as well as occasional departures of scientific workers

abroad (scholarships, fellowships, sabbaticals, etc.).

- Advanced functionalities should address the knowledge management needs. In this sense, the system should serve as an inventory of employees' qualifications and competences, as well as knowledge pool of employees' professional and scientific results and achievements.

Reporting possibilities should meet the needs of all the indoor users, as well as to support the reporting process towards Serbian Ministry of Science and European Commission (time sheets, payroll, publications, etc.) . In order to enhance visibility and decision making, the system should be accessible, user friendly, and enable efficient knowledge retrieval. Following the recommendations of the Serbian Ministry of Science, the scientific track record should be exported and kept in electronic form for further usage.

3 The implementation aspects of the HCM solution

Herein, we will describe the integration processes in HR sector, concentrating on the processes that are specific for R&D organizations.

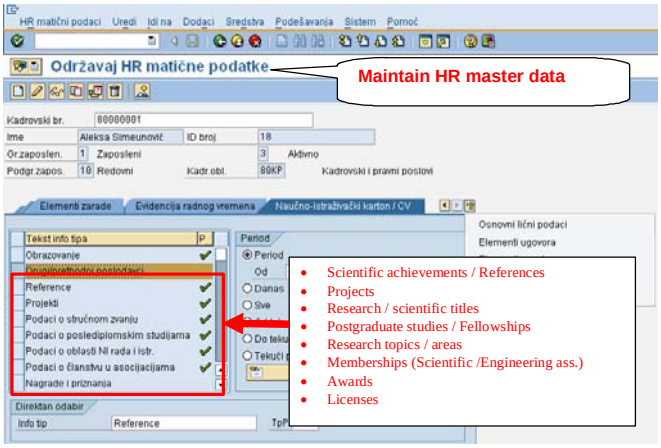


Figure 2. Data stores for keeping the scientific data.

3.1 Standard HCM processes

The core processes required to manage a workforce are: employee administration, organizational management, time management, benefits, payroll, and legal reporting. SAP HCM covers the whole life-circle of an employee from her/his recruitment, training, development, deployment to retirement. SAP HCM enables tracking of employee movements and adequate tracking of changes in organizational structure. It supports skill management and gives managers and HR professionals reporting and analysis options that provide a real-time insight into employee qualifications. With SAP HCM it is possible to plan the employees' career and deploy the right people with the right skills to the right positions at the right time. Figure 2 shows the user interface for managing the employee's master data. The red rectangle denotes the data structures that have been implemented in addition in order to fulfill the needs of the MPI.

3.2 Specific HCM processes

After a thorough analysis of the MPI HR requirements in blueprint design phase it was concluded that considerable modifications have to be made in SAP HCM solution in order to meet the MPI requirements and the adopted ISO 9001 Quality Assurance standards [8]. Modifications concern, first, the specifics of the MPI organizational structure, and second, the specifics of human resource data in the research sector. The following subsections overview the standard SAP HCM features and then the add-value functionalities for the MPI. In order to cover the specific organizational aspects of the MPI and the need to organize and keep an extensive record of employee professional and scientific life, SAP HCM solution was configured /changed as follows:

- From a financial point of view the MPI is organized as one controlling area with nine companies,
- On a global level, an employee is identified with one ID number,
- A person has as many files as there are companies he is / was hired from. In one company, a person has a unique file number as an employee and a unique file number as an outer collaborator. Therefore, a person's history of employment is different for each company, while her/his personal data is unique.
- Taking into consideration the recommendations of Serbian Ministry of Science for compilation of the Researchers files, SAP employee master data was supplemented by data specific for scientific research environments including: scientific and professional skills and expertise, information about engagements in projects with details about roles and competences, scientific achievements (patents, technical solutions, scientific papers / books), other achievements / awards, etc. The process of compilation of the Researchers file is discussed in subsequent subsection.

It is worth mentioning here that HR business processes were integrated and automated in accordance with the adopted ISO 9001 Quality Assurance standard in the MPI. Scientific data is organized and classified in accordance with the Serbian Ministry of Science

standards, which themselves reflect SCI, ISI and IEEE standards. Each employee is assigned a profession code in accordance with Serbian system of classification of professions.

3.3 Project details

In March 2007 a project was initiated with the aim to replace the old ERP system with a new SAP ERP delivered by the SAP partner S&T [9]. The SAP ERP system includes a solution for managing human resources data named SAP Human Capital Management (HCM) solution. However, due to the specifics of the MPI organizational structure, the specifics of the management of scientific track record and the requirements and the recommendations of the Serbian Ministry of Science, the standard SAP HCM solution poorly matched the need of MPI in HR sector. The SAP consultancy efforts were used not just for customizing the SAP system, but mainly for implementing the new functionalities that required SAP ABAP programming. The MPI HCM solution was implemented following the AcceleratedSAP (ASAP) methodology (see Fig. 3).

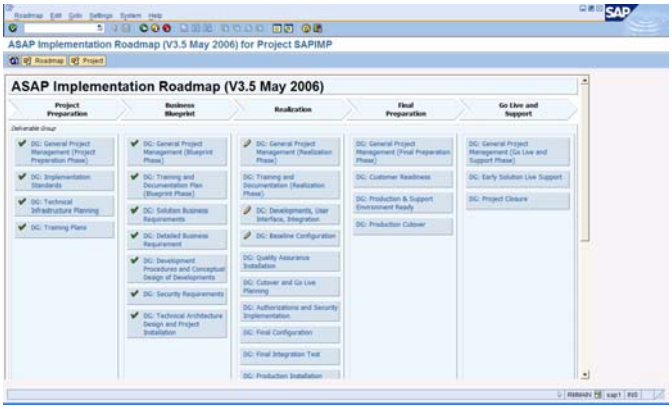


Figure 3. ASAP Implementation Roadmap.

Other technologies chosen to build the solution are listed in Table 2.

Table 2. Technologies and tools.

Aim	*Tool/ Technology*
Project management	SAP Solution Manager
Solution	SAP HCM
Programming language	SAP ABAP
Testing	SAP Solution Manager
Database	ORACLE 10g
OS	Linux Red Hat 9

The new SAP HCM solution was put into production in January 2008. Currently, it is used by HR department staff on everyday basis and occasionally it is used by additional users, mainly project managers, for reporting purposes. Additional information about the implemented security model is listed in Table 2

Table 2. User roles and access possibilities.

Role	*Posibilities*
HR administrator	Customize SAP and develop new functionalities
HR key user	Full access (read/write) to employee master data Read access to all reporting options
HR secretary	Restricted access (read/write) to employee master data: - Write acess to limited number of data structures - Read access limited to employee data from one company
User	Read access to some reporting options
Project manager	Read access limited to employee data from one company Read access to some reporting options

The new SAP HCM solution keeps information on about 450 current MPI employees and the complete employment history of 900 past MPI employees from 1960 until now. Half of the current MPI employees are scientists registered by Serbian Ministry of Science and hence have their own Researcher files. The data from the old HRM system as well as the data from the weakly structured documents that was possible to transfer to Microsoft Excel was imported into SAP using the SAP SECATT transaction. The process of manual import of data from weakly structured legacy documents is still in progress.

4 Exploitation of the HR knowledge pool

As was pointed out earlier, the Mihailo Pupin Institute has a complex organizational and operational structure. It is organized as a holding company, with one mother company, dealing with research and innovation, and seven daughter companies that operate as independent departments of the parent holding company. One daughter company deals with the operational activities that are common to the whole company such as human resource management, finance, marketing, technical support, security, etc. The other daughter companies deal with engineering activities and carry on projects that transfer the research and innovation results to industry. In such organizational structure we could distinguish three types of exploitation of the HR knowledge pool (see Fig. 4): reporting/analysis on a global level,

reporting/analysis on a company level and reporting to public that is part of our future work. We discuss these activities as follows.

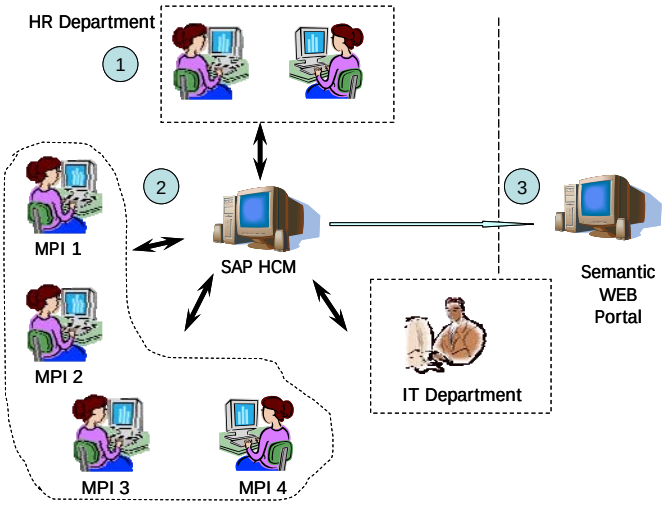
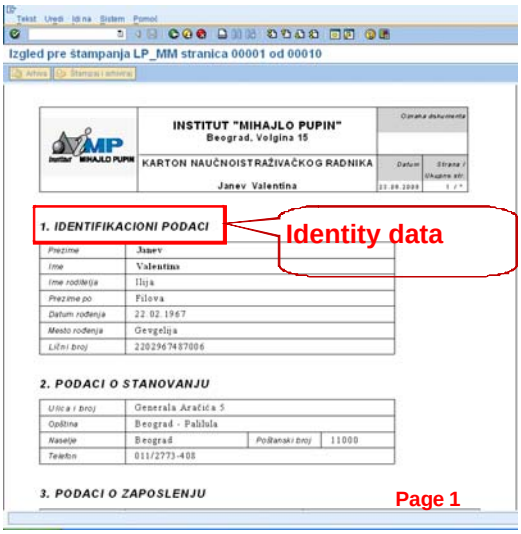
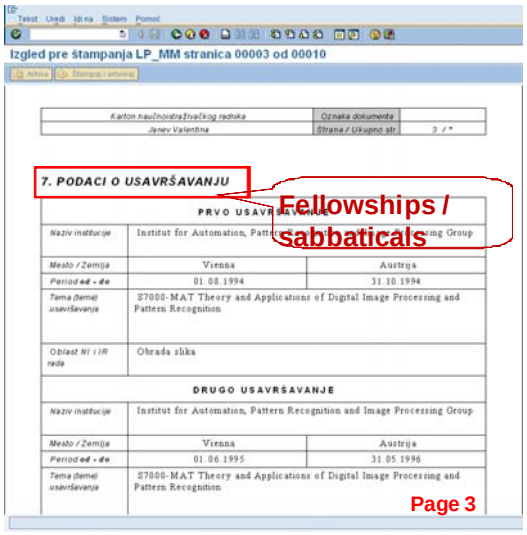


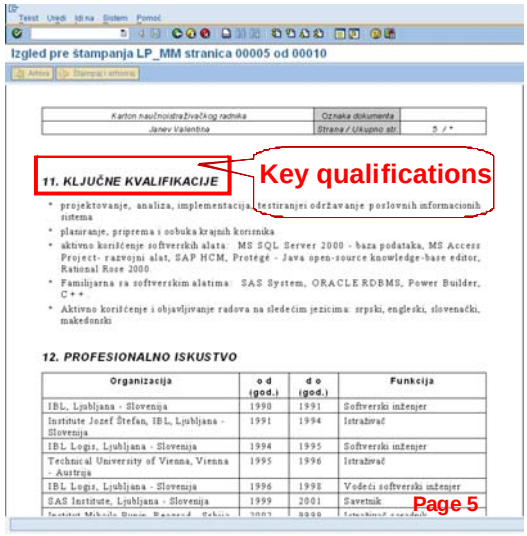
Figure 4. Exploitation of the HR knowledge pool.

4.1 Reporting on global level

The key users from HR department have full access to the MPI human resources data. They are the only category of users authorized to enter and change data. Most of the data that is entered or changed is based on signed documents (e.g. employee contracts and agreements), as well as documents issued by authorized bodies (e.g. degree certificates, licenses by engineering accreditation board or awards from engineering societies).







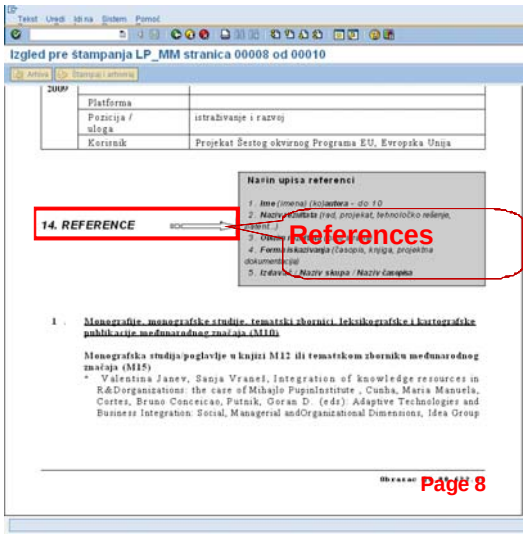


Figure 5. Compilaion of the Researcher files.

Scientific results (publications, patents) are valuated in accordance with the governmental guidance for valuating and quantitification of the scientific results of the researcher, defined by the National Scientific

Council [10]. Using the SAP Smart Form print solution, the Researcher files could be exported from SAP as PDF documents as is shown in Figure 5.

HR department reports to MPI management, Ministry of Science and Statistical Office of the Republic of Serbia.

4.2 Reporting on company level

On company level, the person responsible for HR reporting has full read access only to data of employees from the actual company and restrictive access to reporting functionalities on global level. Thus he/she has an overview of the qualification structure of the researchers in the whole MPI (e.g. for marketing purposes), however could not read the detailed researcher scientific record, nor look at his personal, employment or financial data.

5 Semantic knowledge retrieval

Our knowledge architecture model defined in [5] envisions establishment of a semantic portal where relevant scientific information will be put for internal as well as for public use. The semantic portal will provides user-centric access to knowledge resources (reports, documents, studies etc.) based on intelligent search and retrieval techniques using ontologies [11],[12],[13],[14]. It will consist of business rules, logic, processes, and knowledge models that are common to the software application used in the R&D process, however, unlocked from any particular application. Decoupling the knowledge from software application will enable design of generic services that can be reused without regard to the type of business content passing through them or diversity of software environments/platforms. As ontologies are standard for knowledge representation in semantic Web applications, the semantic layer will be based on modular ontologies ([15], [16],[17]). In general, the semantic portal will be composed of (see Fig. 6):

- Access control and personalization services (APS) responsible for authorization, authentication, and composition of the user environments. Access should be determined on group/role level, service level or resource level (access to knowledge artifacts).
- Process modeling and execution services (PMES) responsible for matching the user requests to specific business application and invocation of other services.
- Modular ontology layer.

5.1 Process modeling and execution

The central part of the semantic layer is process modeling and execution sub layer (PMES). PMES is planned to be implemented as orchestrated Web services. Its objectives are to compose and automate business processes (module Process Builder) and invoke the binding services to specific business applications. Services will be described in common Web Services Description Language (WSDL). Common services to all business processes are: search service, crawl service, publication service, ontology repository, etc. The services will be orchestrated by a service manager that will control the service registration, and running. Working in a domain, e.g. an R&D organization, web-services will use the same knowledge models that represent the agreed domain semantics. Therefore, prior to defining Web-services that will be used for business integration in the MPI, ontology as a common knowledge model for all knowledge resources in the MPI had to be developed.

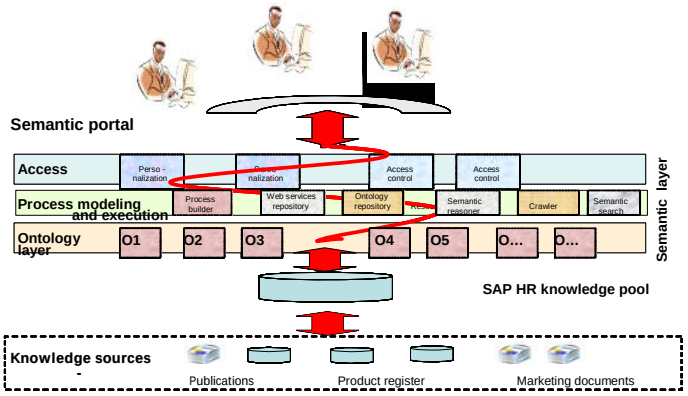


Figure 6. Semantic knowledge retriaval.

5.2 The core MPI ontology

Ontologies abstract from the physical representation of a domain. The purpose of the ontology is to define a shared conceptualization that can mediate between different storage concepts and business applications. The MPI ontology defines the common vocabulary and semantics for all knowledge resources in a top-down manner. Besides its applicability in Web-services implementation, it could be used to provide personalized access to knowledge resources or optimize the search and retrieval process. The core MPI ontology has been developed manually using Protégé 3.3 Ontology Editor and Knowledge Acquisition System [18]. Protégé is an open-source, Java tool that provides an extensible architecture for the creation of customized knowledge-based applications. In Protégé, concepts are named classes and they are described by properties.

The core MPI ontology is designed having in mind the nature of processes in R&D organizations, e.g.,

reporting to the Ministry of Science, as well as the adopted Quality Assurance standards. Things that are described with the MPI ontology are named concepts or classes. Classes are either abstract or concrete, linked to instances. Abstract classes are super classes of concrete classes that represent concrete objects (documents, software items, and hardware items), terms, individuals or group of individuals. Among the main concepts, we point out the following abstract concepts: Product database, Document database, Person, Reference, Community of Practice, Research Area, Events, Project, Business Process, Semantic Web Service, Computer Domain, and Organizational Structure. The core MPI ontology currently has 92 classes and 167 different attributes. Instances of the concrete classes will be imported via DataMaster v1.2 add-in for Protégé 3.3.

5.3 The use of ontology in reasoning, searching and retrieval

As has been shown above, ontology is not only a database scheme for storing metadata but rather to specify semantics to a set of knowledge sources (documents) to define rules that are both processable by machines and understandable for humans. Hence, the purpose of the ontology repository that will store and maintain the developed ontologies is to make the search and retrieval meaningful. Integration of Semantic Reasoner and Semantic Search engine is part of our future work.

6 Concluding remarks

In this paper, we presented a solution for managing the scientific track record of scientists and researchers that is being introduced at the Mihajlo Pupin Institute (MPI) as a part of the knowledge management initiative started a few years ago with the aim of implementation of an integrated knowledge management platform. The solution is based on the SAP Human Capital Management (HCM) system. However, as standard SAP HCM solution does not cover the specific aspects of the MPI R&D process, additional functionalities and reporting options were implemented using the SAP ABAP programming language. The new system ensures standardized integration and automation of HR activities, provides wide range of reporting options, supports skill management and meets other requirements of MPI business environment. The new functionalities address two aspects:

- the requirements to support the MPI flexible organizational structure where human resources could be shared by two or more organizational units depending on participations of people in projects. The new HCM solution supports tracking of the frequent changes in MPI organizational structure on organizational level, as well as on individual level. Although engagement of people on projects is managed through SAP ERP Project System, the new HCM solution keeps track of this information and stores other data that describe the employee's roles and competences in projects and achieved results (patents, technical solutions, scientific papers / books, and other achievements / awards).
- the recommendations of Serbian Ministry of Science for storing of HR data and compilation of the Researchers file. MPI as a research organization partly financed by Serbian Ministry of Science is obliged to organize the human resource data in a form of a Researcher file. Therefore, the SAP employee master data was supplemented by data specific for scientific research environments and , in that way, the new HCM solution serves as a knowledge pool of employees' qualifications and competences, professional and scientific results and achievements, as well as a tool for Human Resource development and career planning, and efficient knowledge deployment and reusability. In this paper, we have shown that human resources processes, such as identification and deployment of right person on the right position, replication of innovations through faster movement of knowledge through the organization i.e. utilization of employees' knowledge wherever is necessary without being constrained by a rigid formal structure, have a key role in the development of MPI as a knowledge-based enterprise.

The implementation of an integrated knowledge management platform is a large, multifaceted project that is carried on by turns in a bottom-up and top-down manner. Successful design, implementation and introduction of such system in practice require several prerequisites. We would like to point out the most important ones here:

- *Project management prerequisite.* The project success depends on the involvement and contribution of senior executive leaders who provide the governance necessary to ensure that goals are achieved, as well as availability of human resources in a project team. Essential for successful project management is to follow a proven methodology. The new HCM solution was implemented using the AcceleratedSAP (ASAP) methodology.

- *Project definition prerequisite.* Implementation of a knowledge management initiative in practice requires time. Setting unrealistic goals that require drastic changes in business practice and organizational culture could result in fiasco. Therefore, project scope has to address so many design and implementation activities that could be realized in planned time scope.
- *Quality of information sources prerequisite.* Data integration and establisment of knowledge pool depend on availability of data sources. It is difficult to analyze and search for right information when it is stored in an unstructured way. Therefore, in the framework of establishment of the HR knowledge pool we automatically integrated data that was stored in a structured way (e.g. data bases, Excel format). However, there is a lot of information that is kept in .doc format that unfortunately requires a lot of semi-automatic and manual work.

In this paper we discussed three types of exploitation of the HR knowledge pool: reporting/analysis on a global level, reporting/analysis on a company level and reporting to public. While the first two types of reporting/analysis options are used in practice, our future work will be dedicated to presenting the scientific information on a semantic web portal. The semantic web portal is based on the MPI core ontology that has been earlier developed and tested in the framework of Protégé 3.3 Ontology Editor and Knowledge Acquisition System. However, as the process of importing the scientific results data is still going on, the MPI core ontology incorporates just testing data. The process of exporting/importing the scientific information from SAP into RDF/OWL format will be carried on via DataMaster v1.2 add-in for Protégé 3.3.

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