

# Competency Management System for Technopark Residents: Smart Space-Based Approach

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**Abstract.** Technopark is a union of companies called residents that implement innovation activities. Development of the competence management system for technoparks is currently a relevant task. Such system allows automating the process of resident's search that can satisfy potential customer tasks. The paper presents a smart space-based approach for competence management system development and implementation. Every resident is described by a profile that is shared with the smart space and becomes accessible for other competence management system users. The profile consists of several competencies and evidences with skills levels characterized their degree of possession.

**Keywords:** Competence management · Skills · Smart space · Technopark residents

## 1 Introduction

Technopark is a union of companies called residents that implement innovation activities. For joint collaboration of residents and for finding of potential customers for a resident or for a group of residents it is useful to acquire resident competencies and use it to represent them. Last years, competency management of companies is a popular research and development topic (see [1, 2]). At the moment, advantages in a global competition is determined by learning and deployment speed of new knowledge into modern technologies and production. In accordance with [3], the main aspects involved in competence management are related to: development of concepts, skills and attitudes (formation); work practices, ability to mobilize resources, which distinguishes it from others; combination of resources; search for better performances; permanent questioning; individual learning process in which the higher responsibility should be attributed to the individual him/herself; relationship to other people. Such system allows automating the process of residents searching that satisfy potential customer tasks. Competence management of employee and companies at all is a popular research

direction in the last years. The paper presents a relate work of modern competence management systems. Main requirements for such systems are formulated based on this related work. An approach for competence management system and its implementation were developed and described based on smart space technology that provides possibilities to organize semantic based information exchange among technopark residents and other competence management system customers.

At the moment, the system is developed and deployed for ITMO University Technopark. This technopart is a member of international association of technoparks and presents residents for potential customers. Thereby, development of the competence management system for ITMO University Technopark is the actual at the moment task.

The rest of the paper is structured as follows. Related work is presented in Sect. 2. Section 3 describes a reference model of the competence management system. Section 4 presents the approach evaluation. The results are summarized in Conclusion.

## 2 Related Work

The article [4] presents the outcomes of studies, which resulted the creation of the information system for the storage and evaluation of competencies of university students. The system is based on fine-grained representation of the skills and competencies through ontologies. The system supports students in planning their courses, fills a gap in the analysis of competencies and creates profiles for application forms when applying for a job. Presentation profiles based on XML HR for data exchange. For example, if students give the access to their profiles to recruitment companies, it allows recruiters to find the desired employee faster. Due to the high accuracy of stored data, encrypted XML data store is used.

As part of a university course, it was selected about 60 students with relevant competences in the field of computers to work with economic tasks/information systems. Each student has three courses for himself/herself, which he/she later takes. For each course there is a number of competencies, which are prerequisites for the taking of a course and a number of competencies (postconditions), which were obtained during the course of implementation.

The proposed system can only be regarded as the first prototype, as it considered only certain important competences. For example, the competence “programming” was developed in parallel courses and was not represented in the system. Profile was considering only the post-conditions, without taking into account the student’s competence in programming.

The article [5] presented the results of studies, conducted over 10 years, which led to the creation of applications for ontology learning, based on competencies and knowledge management. Based on this ontology, the structure of the software for e-learning systems managed by ontology is presented. The researchers concluded, that in order to meet the challenges of the information society, it is necessary to maintain process of competence development in the context of lifelong learning. More flexible, adaptive learning systems are required. The article tells about the experience, of using MISA method (Instructional Engineering Method) - training engineering development

method. It was first used in 1992 with the aim of integrating the knowledge of modeling and competence within the framework of this method.

Also, researchers present TELOS system (TeleLearning Operating System), which is a teaching operating system with an ontologically-driven architecture. The system integrates computer and human agents using two basic processes: semantic representation of resources and resource aggregation. Acquisition of new competencies is the important task of competence management. This process should be integrated into the software system as an educational engineering tool, allowing to inform the operational tools of the new acquired qualities and their position in relation to the achievement of the objective of acquired new competencies.

The authors [6] address the problem of knowledge modeling in multi-agent systems that allow agents and users, to perceive alike and accept the concept of a domain. Ontologies are offered as a solution that allows to develop a coherent rules for specific domains. The researchers presented a multi-agent system that allows to manage, search and map existing competences of the user with represented ones, on the basis of relevant ontologies identified by specific domain. The authors examined examples for using the competencies in the relationship between universities and prospective students, between companies and future employees. The model considered in the framework of the article allowed universities, students and employees of companies to build and maintain their own competence to assess their knowledge to comply with their mandates and to search for the desired competencies in the respective areas. The direction that the researchers plan to expand within the next scientific work - refinement of quantitative ontologies of the component. It is important for requests and offers matching. Long-term studies will be focused on the model's ability to match two different ontologies of the domain.

Authors of the article [7] pay attention to the lack at the moment of successful indicators in the field of competence management, which could provide promising tools for a more efficient allocation of resources, knowledge management, support for training and human resources development in general, especially in the individual entrepreneurs level. Pilot applications, such as detection of an expert often fail in the long run, because of the incomplete or outdated databases. In order to overcome this problem, scientists have proposed an approach of joint management competencies. In this approach, they have joined in the Web 2.0 technology processes, running from the bottom up with the organizational processes that run from top to bottom. They solved this problem as the task of constructing a joint ontology, which is the basis for the model of ontology aging process. In order to implement model of ontology aging process for competence management, the researchers have built a semantically-social application SOBOLEO that offers competence ontology aging and easy to use interface. Thus, in the article the researchers show how ontology competencies can be developed to cover less formal tag topics. It was proved that it guarantees value and timeliness during application. Easy to use in everyday activities SOBOLEO motivates employees to fill the data into the system.

The article [8] presents a common framework for intelligent competence management system based on ontologies for an information technology company. In the first phase, it was tested in small enterprises working in the field of information technology, and then it applied for other organizations of the same type. Competence

management system according to the authors has to achieve the following key objectives: (a) maintain complete and systematic acquisition of knowledge about the competencies of employees of the enterprise; (b) ensure knowledge about the competencies and their owners; (c) apply existing knowledge to achieve the goal.

The core competencies of information management system is an ontology, which plays the role of declarative knowledge base repository, containing the basic concepts (such as company work, competence, domain, group, person, etc.) and their relationship to other concepts, examples and properties. Protégé framework was used to create such ontology. Ontology structure is conceived in such a way that the logic description can be used to represent the concept of determining the subject area in a structured and widespread form. Acquiring knowledge in this approach is performed by enriching ontology, in accordance with IT-company requirements. According to the authors, the advantage of using the system on the basis of ontology, is the ability to identify new relationships among concepts, based on logical conclusions, starting from existing knowledge. The user may choose for request examples of one type concept. The article also provides some examples of using such system.

Authors of the article [9] have focused on the analysis of dynamic competence management system. The system takes into account the changes of competences with the time, caused by diffuse processes in project groups. Authors emphasize that the management and control of knowledge and skills, and, more recently, the companies competence, have become an essential factor of the production process in terms of the strategic human capital management purposes. Knowledge and competence management is becoming increasingly important subject of research for educational institutions. It is necessary to focus on a detailed description of the achievements of the student in the form of their competences, as well as the analysis of competences of companies employees where intellectual capital is equal to the investment to the competence, that allows the employer to make decision regarding trainings, attracting to new projects and recruitment.

Considered article describes the concept of dynamic competence management system, which contributes to a better dynamic nature competences guidance. The authors cite several arguments in favor of use of this system in the organization: (1) the system provides the identification of skills, knowledge, behaviors and capabilities needed to meet current and future staffing needs, (2) it can focus on the individual and group development plans.

Offering the formal approach in building a competence management system, the author of the paper [10] addresses the problem of competence profiles management. Competence management in recent years has become very topical, because it contributes to the achievement of organizational goals and solves problems such as improving the information flow or the competences generation. In the paper were proposed a lot of competence modeling approaches and the use of competency models.

It was revealed that there was no examination of the structures and the use of competence profiles in competence management system. The author has represented the ontological realization of the abstract model, including software architecture of competence profile management system. The main contribution of this work is that the authors consider the formalization of competency profiles operations and ontological implementation of these operations.

The authors of the paper [11] focuses on the role of user behavior modeling and semantically enhanced submissions for personalization of its interaction with the system. The work represents the general ontological foundations of user modeling OntobUMf (Ontology-based User Modeling framework) its components and processes, associated with the user behavior modeling. The authors present them as wireframes, shaping user behavior and classifying people according to their behavior. The basis of OntobUMf is user ontology, which was developed in accordance with the information system management, information package IMS LIP (Information Management System Learning Information Package). Custom ontology includes behavioral concept, extends to IMS LIP specification, defines the users characteristics, interacting with the system. The paper gives examples of OntobUMf in the context of a knowledge management system. Also, in the scientific work, the background of the ontological modeling creation, user behavior for semantically enhanced knowledge management systems are discussed. According to the authors of this article, the results of presented research, may contribute to the development of other frameworks of user behavior, other semantically enhanced user modeling systems or other semantically enhanced information systems.

According to the authors of the paper [12] learning management system Moodle (Modular Object - Oriented Dynamic Learning Environment) is currently the most popular software solution that provides a variety of modules for various educational purposes. However, there are some aspects related to competence management, which are missing in Moodle. Article [10] offers an application that is designed as an extension of Moodle to support the development and evaluation of competences within the course. The article provides detailed information about the competence ontology, adopted for course structure development, based on competence, as well as competence management features built into Moodle. The authors show how these functions, embedded in the learning management system, allow the controlling of the target competencies together with associated elements and evaluate the level of skills, achieved by students within each of the target competencies. In addition, it becomes possible to generate different types of competency reports, depending on the target role (teacher, student or administrator). The application, offered by authors, satisfies the need for practical and convenient way to manage and evaluate the competencies, associated with learning management system Moodle.

In the paper [13] authors analyze the various approaches, presented in the literature, related to the competence modeling and offers a competence ontology as a formal description of the competence characteristics, agents, and educational resources in the educational networks. The proposed by authors ontology also seeks to simulate aspects, related to competence management and tracking to support the development of competences in educational networks throughout life. The authors believe that with the introduction of a paradigm of continuous education and dissemination of the terms “knowledge society”, “civil mobility”, “globalization”, competence based learning and training, interest in technologies, improving the quality of education is growing, as it provides an important advantage for individuals and organizations, supporting the transformation of learning outcomes into permanent and valuable asset - knowledge.

In this context, in order to facilitate the acquisition and ongoing development of new competencies, educational networks have revealed the need to provide a variety of learning opportunities throughout life.

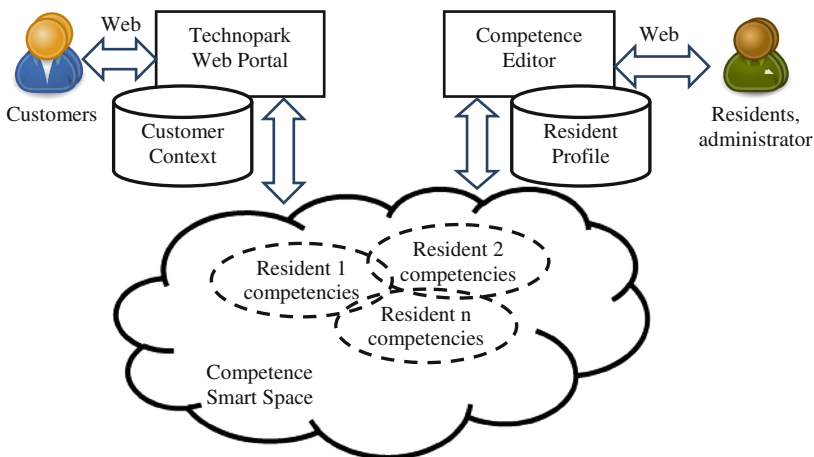
Based on the presented related work the following basic requirements for the competence management system of the technopark residents were highlighted:

- competence management system has to be based on smart space that contains residents competencies modelled in terms of ontology;
- storing residents profiles, information about customer tasks and the ability to handle them in competencies management system;
- separation of user rights to the following key roles: user, administrator and resident;
- web interface support;
- comparison between the residents competence profiles;
- comparison of a task with a profile.

### 3 Reference Model

Proposed competence management system is based on smart space technology that provides possibilities to share the semantic information among technopark residents and potential customers. Residents share with the smart space their competence profiles that represents main information about a resident and list of references to the resident competencies represented by ontologies (see Fig. 1). A competence profile of a resident is the set of skills with associated levels. A resident is used the competence editor to transfer their competencies into ontological representation. This ontology is shared with the smart space and describes the model of the resident in the smart space.

When a customer would like to collaborate with the technopark he/she opens technopark web portal and search for resident models in smart space who have required



**Fig. 1.** Reference model of the proposed competence management system

competence or describe his/her context to implement this searching automatically. Context is a set of customer competencies that are required at the moment to solve for him/her task.

Competence editor module supports the following main operations:

- skill lexicon management;
- residents management;
- competence profile management.

Skill lexicon management provides possibilities for a resident/administrator to add new, remove, update items in the technopark skill tree. These skills can be added by a resident to the competence profile. Every skill is characterized by levels that represent degree of possession of the skill. A resident/administrator can specify count of levels and title for every level. Resident management operation provides possibilities for administrator to add, remove and edit a resident profile. The resident profile includes: company name, web site, address, short description, and contact e-mail. Competence management operation provides possibilities for residents to add and remove skills from a resident profile and determine degree of possession by choosing the skill level.

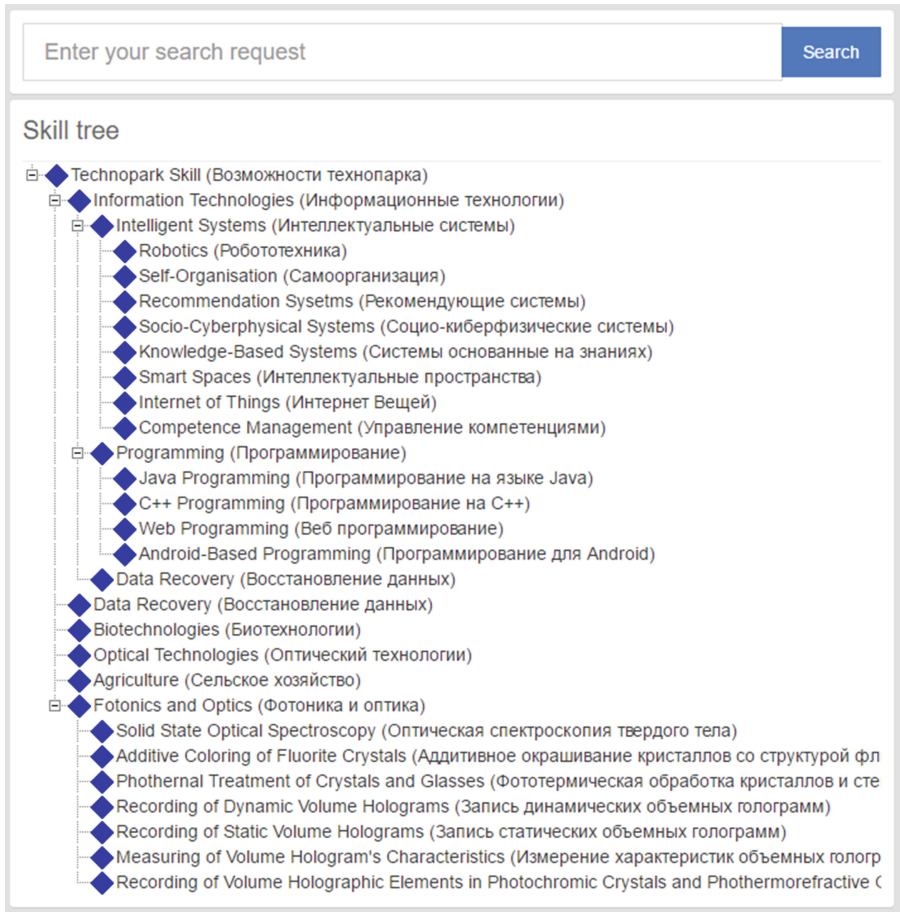
Technopark web portal supports the following main operations:

- determine a customer task;
- compare the customer task with resident profiles;
- compare profiles of different residents;
- range resident profiles based on similarity to the customer task.

A customer can determine a task and specify requirements that a company has to have for implement the task. Compare the customer task with resident competence profiles is used to determine if the resident can perform the selected task or not. For each requirement, the competency that implements the same skill is extracted from the competence profiles. If this skill level is less than the according skill level for the task requirement or profile does not have any competence with required skill, then selected profile cannot perform selected task, otherwise it can.

## 4 Implementation

Application has been implemented using Java programming language and Spring Framework technology stack for Technopark of ITMO University. Customers, residents, and administrator are working with competence management system through the web interface. Skills tree is shown in Fig. 2. It covers all ITMO University Technopark resident skills. Example of a resident profile is shown in Fig. 3. It includes the resident name, web site, address, resident description and set of competence linked to the resident profile. Implementation of the competence management system in details is described in [14].



**Fig. 2.** Skills tree for ITMO Univerisy Technopark residents

The following main scenarios are supported by application:

- User knows what competencies he/she needs. In this scenario user uses the search a resident by needed competencies.
- User knows the resident but should know it possibilities. In this scenario user can aggregate all tasks the resident can implement.
- User knows of two residents and he/she would like to compare their profiles. Which company can better implement the needed task.
- User knows the resident and and task and he/she would like to compare the resident and the task to understand if this resident can implement this task.

## International Research Laboratory «Intelligent Technologies for Socio-Cyberphysical Systems» (МНЛ «Интеллектуальные технологии для социо-киберфизических систем»)

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The international laboratory «Intelligent technologies for socio-cyberphysical systems» was founded based on the ITMO's faculty of information technologies and programming in 2014. The laboratory unites researches from St. Petersburg Institute of Informatics and Automation of the Russian Academy of Sciences, The University of Rostock (Germany), and St. Petersburg National Research University of Information Technologies, Mechanics & Optics. The laboratory carries out research on intelligent technologies for socio-cyberphysical systems. This direction of the investigations corresponds to the priority research direction "Information technologies in economic, social sphere, and art", which is the one of the ITMO's research areas.

Международная научная лаборатория социо-киберфизических систем основана в 2014 году на базе факультета информационных технологий и программирования ИТМО. Лаборатория объединяет ученых Федерального государственного бюджетного учреждения науки Санкт-Петербургского института информатики и автоматизации Российской академии наук, Университета г. Росток (Германия) и Федерального государственного бюджетного учреждения высшего профессионального образования Санкт-Петербургского национального исследовательского университета информационных технологий, механики и оптики. В лаборатории проводятся исследования в области интеллектуальных технологий для социо-киберфизических систем. Данное направление исследований соответствует приоритетному направлению исследований НИУ ИТМО «информационные технологии в экономике, социальной сфере и искусстве»

### Competencies:

Internet of Things (Интернет Вещей) - 1	Evidence:
Competence Management (Управление компетенциями) - 1	Evidence:
C++ Programming (Программирование на C++) - 1	Evidence:

**Fig. 3.** Example of a resident profile

## 5 Conclusion

The paper presents an approach and implementation for competency management system for technopark residents. The system has been implemented for Technopark of ITMO University and accessible by the following link: <http://77.234.220.70:8080/>. At the moment, the system is being filled by the information about Technopark residents and then this information will be used to generate information pages for Technopark residents in web portal: <http://technopark.ifmo.ru/en/>.

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