Competence Management Systems in Organisations: a Literature Review

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Abstract—**This paper presents a literature review on competence management for organizations. It aims to find competence modelling research trends, reveal the difference between the terms «individual competence» and «core competence», examine competence management systems, identify the most common features and highlight main requirements for design and development of these systems.**

I. INTRODUCTION

The paper presents a literature review on competence management for organizations. Nowadays competence management is becoming a crucial process for organizations in economic instability, which allows recruiters, chief executives and other heads to manage human resources effectively. This review aims to identify competence modelling research trends (the first research question), analyze existing competence management systems for organizations, and find common use cases & requirements to this class of information systems (the second research question). This development would be useful for strategic partnership between industry and universities and providing chance for students to realize scientific, R&D, and career ambitions at the university through direct academia-to-industry cooperation [1], [2].

In this work the systematic literature review method, which is presented in [3] was used partly: the research questions, search process and including and excluding criteria have been identified without deep statistical analysis. The research questions are defined above. The search process was a manual search of specific journal papers over the past 15 years by following keywords: competence management, competence management system, competence modelling, and core competence. Each found papers were reviewed thoroughly and divided into groups in accordance with the main issue: paper, which considers working competence management system; paper, which considers competence model or system architecture; paper, which considers competence identification and assessment; and paper, which includes another information about competences (for example literature review). Inclusion and exclusion criteria were based on the research questions. The papers, which consider working management systems, competence model and system architecture have been chosen for analysis. The result of analysis allows answering to the first research question (identification of competence modelling research trends).

In the paper the competence management systems for the different kind of organizations have been analyzed (for private enterprise and for educational establishment). Each of them was designed to meet various users' needs: develop competences, find employee for task or find investors. This selection allows to answer the second research question and to find common use cases and requirements to competence management systems.

The paper consists of several parts: Section II is devoted to term *competence* and competence modelling. Section III covers the related works in the competence management field. In Section IV, the most common use cases of competence management systems are represented. Section V focuses on requirements for competence management system design. Conclusion summarizes the paper.

II. COMPETENCE MODELLING

Researchers distinguish between two types of competences: a competence of a person and a competence of an organization [4]. In this paper the competence of a person is called as an *individual competence* and the competence of an organization is a *core competence*. It should be noticed that there are several work [5], [6] where concepts of *competence (pl. competences)* and *competency (pl. competencies)* are different. The authors of the paper [5] consider the competency as a part of competence, while competence is an aggregation of competencies, proficiency level and context. In this work, we use these terms with the same meaning: *competence* is a set of *competencies*.

A. Individual competence

There are a lot of various definitions of the term *individual competence*:

- synergy, integration and interplay between technology, people, organizational systems, and culture [7];

- ability to apply knowledge during the process [7], [8];

- effective performance within a domain/context at different levels of proficiency [5];

- measurable human capabilities that are required for effective work performance demands [10];

- any form of knowledge, skill, attitude, ability, or learning objective that can be described in a context of learning, education or training [5];

- effective performance of an actor in a well defined domain [11];

- a combination of tacit and explicit knowledge, behavior, and skills, that gives someone the potential for effectiveness in task performance [10];

- a specific, identifiable, definable, and measurable knowledge, skill, ability, and/or other deployment related characteristic (e.g., attitude, behavior, physical ability), which a human resource may possess and which is necessary for, or material to, the performance of an activity within a specific business context [5], [10];

- the skills, knowledge, abilities, and other characteristics that someone needs to perform a job effectively [10];

- the effect of combining and implementing resources in a specific context (including physical, social, organizational, cultural, and/or economical aspects) for reaching an objective (or fulfilling a mission) [12];

- the ability of an actor to do actions for a situation in an effective and efficient way; it cannot be directly measurable, but estimated from the performance [6];

- it is an ability (or skill) at a certain level that is required to perform a task [13].

Based on the analysis of the described definition the term *individual competence* was defined in this work as an ability of a person to apply knowledge, skills and experience to performing tasks effectively.

B. Core competence

The most popular definitions of the term *core competence* include the following:

- a collective asset, resulting from the synergy of human resources [14];

- knowledge of the whole company that consists of procedural and technological skills used either singularly or in various combinations [10];

- it provides potential access to a wide variety of markets; make a significant contribution to the perceived customer benefits of the end product, difficult to be imitated by competitors [15].

Here the term *core competence* is defined as a combination of skills, proficiency levels and context in which they are applies.

The competence management system, designed for Technopark of ITMO University works mainly with core competences of residents. However, the term *individual competence* would be helpful in recruiting employees for residents.

III. RELATED WORKS IN THE AREA OF COMPETENCE MANAGEMENT

In this section the systems DeCom [7], IMPAKT [14], [16], [17], KnoMe [18], [19], TENCompetence Personal Competence Manager [11], [20] and Competence management system of Technopark of ITMO University [13], [21] have been reviewed, their main features and principles of development have been identified.

A. DeCom

DeCom is a competence management system for organizations. It also supports learning activities within a company. The model of DeCom system is organized in three modules: profile, competence, and context. Profile module keeps general information about a user, interface, and personal security settings, acquired competences and projects in which the user is engaged. Competence module contains competence model, which has a competence tree structure and based on IEEE RCD (Reusable Competency Definitions) entities. Competence model was extended by proficiency level (the minimum level, which required for completing a task or joining in a project) and competence weight (weight defines a certain competence as more important for task or job). Competence model also has a description of a positions and projects within an organization linked with the required competences. Context module keeps information about the user's location, devices, which a user applies and details of available resources. It helps users to find people, resources, and future educational events, which can be useful for users to fill their competence gaps.

The model of DeCom has three agents and one administration site. Agents support users by showing messages with recommendations and notions to update their profile, delivering messages among another agents or modules, and searching opportunities for their personal development.

DeCom system can be used for different scenarios. The first scenario is an evaluation of the current competence proficiency level and competence gaps. A user can find information about competences, which should be evolved. The application sorts competences over: the top competence is with the minimum competence gap. The second one is to get a promotion. The application compares the list of user's competences and the list of required competences for the chosen position and shows the results of the evaluated competence gaps. The last scenario is a change in a job position. The application demonstrates the acquired competences of a user and the company positions rating according to the evaluated gaps between them in ascending order. Using this rating and information about the position a person is able to choose a new interesting professional sphere and develop their own competence.

The requirements to the system are:

1) user profile management (for example contacts, preferences in the system interface and security settings);
2) competence management (for example determination the required competences for a position or the company's projects);
3) competence gap identification;
4) proficiency level identification;
5) identification of a competence weight;
6) search for users (for example the user, who have the maximum levels of a certain competence);
7) mapping company's facilities (rooms, offices and even larger spaces, covering an entire branch.)

DeCom is written in C#. It runs on desktop and mobile devices as an ASP.NET web application, which allows the system to be independent from the operation systems. Interface adaptation to devices is provided by HTML and CSS.

B. IMPAKT

IMPAKT is an integrated human resources management system. It supports three business processes of a company: retrieval of the ranked referral lists, task and team composing, and core competence identification.

It is worth noting that IMPAKT provides graphical user's interface for the users' competence and curriculum vitae presentation; divides job requirements into mandatory and optional ones; searches information about users, company, competence etc. and range it; explains the ranged results. IMPAKT system stores curriculum vitae.

The system receives information about competence from a specifically developed modular ontology [17]. Ontology includes about 5000 technical and complementary user's skills. Technical skills mean knowledge about a certain technology or a tool, while complementary skills are understood here as communicative and collaborative ones.

IMPAKT is implemented as a JAVA application. The system uses JENA API to access the ontology, a Pellet reasoner to classify ontologies in the pre-processing phase and PostgreSQL to store the intermediate results, procedures and b-tree indexes on proper attributes to reduce retrieval times. It is worth noting, that if a query does not include implicit axioms, user can disable a reasoner to improve application performance.

This system allows a personnel officer to search for employees taking into account mandatory and optional requirements (matchmaking [17]). It is carried out in two steps: search for profiles fully satisfying mandatory requirements (strict match) and a choice of the profiles from the set returned by strict match, which approximately match optional requirements (soft match).

The requirements to the system are:
1) storage of information about the user's competences;
2) search for applicants to the position or employees considering mandatory and optional requirements;
3) search for applicants and ranking them by best match to the query;
4) browse the user's CV;
5) explanation of the ranging result;
6) team composing, which allow to allocate a set of tasks to group of users (many to many skill matching);
7) identification of the core competences.

There are three entities for task description: knowledge for tasks perfomance, set of temporal limits and number of team participants. The process of team composing process considers all alternatives to team creation as equivalent ones. In case it is impossible to build a team, which fully corresponds to personnel officer's requirements, the system shows the best result matching a query.

C. KnoMe

Competence management system KnoMe [18] is an easy scalable system, which has both mobile and web versions that can be helpful in customer demands and current or future employee competences matching. KnoMe is based on hedgehog concept [18], [19], which includes the following ideas: it is important to concentrate on the strength of a company, it is important to maximize profit and it is important to take into account interests of the company staff. The hedgehog concept was implemented in the system as:

Strength of a company (competences) – storage of profiles with information about employees and customers: personal data, courses completed, procedural and technological skills.

Maximization of profit (customer's demand) – storage of information about clients and related internal projects. Data includes description of completed projects: participants, their duties, required technological skills for tasks execution.

Company staff interests (enthusiasm) – report creation and data visualization as a skill cloud on either employee groups (tribes) or company levels. Every employee is able to rate his/her skills using «skill level» and «interest to use it» scales.

The requirements to the system are:
1) data editing (personal details, certificates, training and methodology, and technological skills);
2) staff or competence search;
3) competence or tribes report creation;
4) authentication for external users (for example via LinkedIn);
5) search for information about business partners.

The system uses CoachDB and ElasticSearch search engine for the database layer, Node.js and REST for the application layer, and Angular.js for the user interface [19].

D. TENCompetence personal competence manager

The aim of the TENCompetence project is creation of competence management system, which would be useful for an individual user along with groups of users or the whole organization. This system is mostly oriented to lifelong competence development.

The conceptual model of this system includes four concepts: actor performance, learning networks (or community of practice as a container for the rest concepts), competence model, and learning materials.

Actors perform actions to reach their goals: to keep up-to-date information in professional sphere, develop actor competences, and compare them with the competences of other actors. The last objective encourages users to help and stimulate each other during training session. The actions are performed in the community of practice, represented by learning networks. Competence model concept is a collection of competences, required proficiency levels to perform a task or solve a problem and competence maps (the set of competences of certain learning network). Learning materials are represented as knowledge resources, activities (assessment, learning, and support activities), units of learning, and competence development programs (plans).

The requirements to the system are:

1) definition of a target competence profile (users are able to create a profile, evolve it, and use for competence development programs);

2) mapping the acquired user's competences to a target competence profile (users are able to assess the acquired competences and map them onto the set of competences, which they want to develop);

3) identification of competence development opportunity (users can find or create resources, which could be useful in the competence development process);

4) creation of a competence profile (users are able to collect information about the acquired competences from different sources);

5) sharing development plans with other users. (users are able to improve competence via experience of other users);

6) feedback in a form of questions and comments (users can share opinions and find the answers to questions).

TENCompetence is a desktop client-server application. The client application is designed with Eclipse Rich Client Platform, which allows it to be run on different platforms. The server is deployed on a Tomcat application server. The application uses MySQL database server.

E. Competence management system of ITMO University Technopark

Technopark of ITMO University is a community of separate companies, which supports young scientists, entrepreneurs, and students to develop their own projects and ideas. These companies are called as *residents [21]*.

The competence management system of ITMO University Technopark system was designed for competence representation to investors and customers. This system allows residents to store general information about them and create the residents' competence profile. Residents are able to describe the acquired skills, their proficiency level, and evidence of the acquired qualification. Skill lexicon is represented by a skill tree. Customers are able to define a task via the required skills and proficiency level and search for an appropriate resident to perform it.

The requirements to the system are:

1) competence search by task, which returns appropriate residents' profiles based on the list of competencies determined for a task;

2) aggregation of possibilities, which finds the list of the tasks a resident can perform;

3) comparison of a resident profile with a task or with an another resident profile;

4) resident profiles' ranging based on matching with a customer task.

The system is a client server application. The server layer is based on JAVA and Spring Framework. The database server layer uses MySQL. Application layer was designed using Spring Data JPA and Hibernate for data extracting and Spring MVC for the user interface.

IV. USE CASES AND REQUIREMENTS FOR COMPETENCE MANAGEMENT SYSTEM DESIGN

Based on the analysis of related works (section III) the common use cases, which could be found in almost all competence management systems have been identified. There are several use cases, which are unique to certain systems (for example competence gap identification in the focused on personal competence development systems, such as DeCom or TENCompetence). The defined use cases are the basis for identification of the requirements to competence management systems. The use cases and requirements are given below in details.

A. Common use cases and requirements

The list below describes common use cases, which are typical for this type of systems:

- competence and user/organization profile management (creation and edition general information. For example, a description and proficiency level for competences and name, contacts, linking to competences for user etc. [7], [13], [22], [23]);

- search for appropriate users/organizations for certain tasks and projects [11], [23];

- creation of the ranged lists of users/organizations that best match a query result [13], [23];

- comparison of a user/organization profile with a task or with other profiles [21].

Common requirements to competence-based systems were revealed based on the use cases. The requirements are specified below.

Storage of information about users/organizations and competences [24], [25]: general information (first and last name, position and contacts), competences (proficiency level, behavioral traits, communication skills etc.), completed training programs and data about finished projects. Depending on the purpose the system is designed, the listed set of entities could be expanded or contracted. For example, if the main aim is to create competence management learning system, the information about competences might be extended by competence gaps and completed training program data. If developers want to create a system, which helps to define core competences and strategical choices, it would be better to add information about knowledge classes (a set of typical knowledge, which is used in certain business area).

Support for the search of users/organizations and tasks by competences [17], [23]. This requirement is a crucial one, because the most common use case is a search for an appropriate staff for an organization. Here search engine deals with competences, users, tasks or projects.

Support user profile management [7], [16], [17], [23]. Users should be able to create and edit general information such the first or last name, link to competences and etc.

Provide access rights [18]. Information in a user profile should be protected: users can restrict access to their personal

data. It is also essential to provide a privacy policy in order to prevent the system failures and unauthorized access to data.

Storage of the competence standard [25]. The system should keep information about a minimum competence set, required for a certain position, tasks or a working group. This kind of information could support such processes as a search for an appropriate applicant for a position/task or creation a development plan.

Storage of the required competences to complete a task and competence description in the same ontology [26]. It is necessary to avoid mess in terminology. The usage of the same vocabulary during human resource allocation processes guarantees that employees and a personnel officer mean the same thing.

B. Unique use cases and requirements

Unique or nonstandard use cases to this kind of systems have been identified. These use cases vary from system to system. The system, which was developed to help user to get a promotion would have a set of use cases and requirements, which are focused on personal development. Nevertheless, if the system is designed or meant for the whole company in order to help top-managers to make strategical choices, the system would have another set of use cases and requirements, which serve to reveal core competences, make the short-term or long-term plans, etc. The list below describes unique use cases for this kind of systems:

- periodic proficiency level review of a particular user [27], [28];

- tracking personal user's development [22], [28];

- project management in organization (addition, edition, removal, link with competences) [23];

- identification of competence gaps [7], [11], [20];

- creation of personal development plan for employee [14], [22], [23];

- search for information for promotion or changing a job [7]. Employees are able to find a new interesting sphere of activity or just broad his/her mind due to it;

- online training, which grant access to learning material (books, online magazines, audio files, video courses, webinars, professional advices etc.) and to online tests [22];

- search for an employee, taking into account mandatory and optional requirements [17], [29];

- search for similar competences if relevant resources (experts or learning objects) for personal development are not found [23];

- personnel allocation depending on tasks. There are several types of human resource allocation. The first one is the most common: the assignment of one individual to one task (single task assignment). The second one is the contemporary choice of more than one single assignments (multiple task single assignment); it is necessary in case, then the output of one task is input for another one. And the third allocation is the creation of an ad-hoc team (team creation) [14];

- reorganization of the personnel structure considering recourse limitations [28], [30];

- long-term personnel structure planning, which allows personnel officer to determine the number of employees and the required proficiency level in future [28], [30];

- short-term planning. It could be useful in case when an employee has certain responsibilities, but they should be engaged in another future project [28], [30];

- personnel behavioral modelling. Modelling is necessary in order to determine the impact of different external factors on employee reliability during work. Factors could be measured on a different scales as a monotony, task diversity, fatigue or time stress [30];

- core competence determination and assortment by knowledge clusters (a set of typical knowledge, which is used in certain business area). Organization would be able to make right strategical choices due to it [16].

Unique requirement to competence management systems were revealed based on use cases and are specified below.

Competence gap identification based on competence standard [7], [22], [25]. Due to this function user would be able to evaluate and get information about his/her knowledge and their skills gaps. The result of this evaluation is the input data for generating development plan process.

Creation of personal development plan for each user [10], [25]. It would help to eliminate competence gaps of an employee applying an individual approach to him/her.

Reassessment of individual competences and monitoring user's progress in the personal development [22], [27], [28]. Information about competences needs to be reviewed regularly, because employee could acquire or lose skills during work. The employee progress report would be created based on this information. Report could be useful in human resource allocation processes (for example, there are two interns in a company, who lay claim to a position. The first intern shows rapid progress, while another one demonstrates modest success. Personnel officer or immediate supervisor would be able to use this information and make decision who is more suitable for this position).

Search for external users (potential employees) [5]. This feature would facilitate searching candidates for a position, if the competence management system is interoperable with the systems such as LinkedIn.

Competence model, which is complied with IEEE RCD standard [6]. It would guarantee a high level of interoperability with other information systems (for example HRM system).

Storage of users' competences and information about processes and data flows of a company in the same ontology [26]. To carry out business processes or support dataflow of a company employee should have a certain range of competences (or acquire them) [27]. Description of processes and competences in the same ontology could become a basis for creation of competence standard and keeping it up-to-date.

TABLE I. COMPARATIVE STUDY OF COMPETENCE MANAGEMENT SYSTEMS

Criteria	DeCom	KnoMe	IMPAKT	TENCompetence	Technopark system
Functions for individual competences					
Storage of information about users and their competences	+	+	+	+	-
Creation of personal development plan for each user	+	-	-	+	-
Reassessment of individual competences and monitoring user's progress in the personal development	+	-	-	+	-
Storage of the users' competences and information about processes and data flows of a company in the same ontology	-	-	-	-	-
Identification of user's competences through information about completed projects	+	+	-	+	-
Formation of personnel reserve using information about future needs for employees or competences	-	-	-	-	-
Functions for core competences					
Storage of information about organizations and their competences	-	-	+	-	+
Revealing core competences	-	-	+	-	+
Common functions					
Support for the search of users/organizations and tasks by competences	+	+	+	+	+
Support user profile management	+	+	+	+	+
Provide access rights	+	+	+	+	+
Storage of the competence standard	+	+	-	-	-
Storage of the required competences to complete a task and competence description in the same ontology	+	+	+	-	+
Competence gap identification based on competence standard	+	-	-	+	-
Search for external user (potential employee)	-	+	-	-	-
Competence model, which is complied with IEEE RCD standard	+	-	-	-	-

Identification of user's competences through information about completed projects [26]. Similarly, business processes and dataflow information about the completed projects by user could be described in a competence management system by means of the used competences. It would be possible to identify the acquired competences by user.

Formation of personnel reserve using information about future needs for employees or competences [24]. It is necessary to consider the future company needs and development strategy, which cause personnel changes. Company should have a candidate pool to meet these needs.

Revealing core competences [14], [16], [17]. It would show the strength and weaknesses of the organization and could be a key information for strategic development.

A comparative study of the described in Section III competence management systems is presented in the Table 1. The comparative study is based on revealed requirements revealed in this paper.

VII. CONCLUSION

The term *competence* has many different meanings. There are few standards, which were designed for competence modelling: IEEE RCD and HR-XML Consortium Competencies Schema. However, these standards do not consider such important elements as proficiency level and context, as it mentioned in [6], [8], [13], [29].

There are most common use cases in the competence management: search for an appropriate employee; core competence revealing; assessment of the acquired individual competences; acquired competence identification; competence gap identification; creation of a personal development plan; required competence identification; storage of descriptions of employees and tasks in the same ontology (using the same terminology). These use cases are the basis for specifying requirements to competence management systems. This kind of systems should store information about users/organizations, competences and competence standards provide search for the users/organizations, which could perform the task successfully and use the ontology for both task and users' description.

The competence management system design is aim-based. Some of the systems enable users to manage their individual competences, assess it and create personal development plan (DeCom, KnoMe, TENCompetence). Other systems focus on core competences and provide the functions, which help to compose team for tasks or projects and reveal the competences of an organization (IMPAKT, Technopark ITMO).

Competence modelling is a crucial task in the competence management sphere, because the competence model is a core of the competence management system, which could meet all needs of an organization.

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