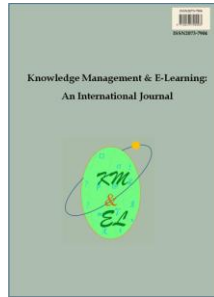


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### **Competences and knowledge: Key-factors in the smart city of the future**

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## **Competences and knowledge: Key-factors in the smart city of the future**

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**Abstract:** The effective and modern management of competence development, which represents a distinguishing key-factor in future Smart Cities, cannot be limited to the Learning Management exclusively, but rather be inclusive of aspects pertaining to Human Capital and Performance Management in a holistic vision that encompasses not only the sphere of operations but also the tactical and strategic levels. In particular, organizations need solutions that especially integrate Learning Management, Performance Management, and Human Resource Management (HRM). We propose an approach considering the competences as key-factors in the management and valorization of Human Capital and making use of a socio-constructivist learning model, based on the explicit (ontological) modeling of domain competences as well as a learner and didactic oriented approach. Unlike most of the current solutions, far from the proposed vision and concentrated on specific functionalities and not on the processes as a whole, the solution offered by MOMA, spin-off of the Research Group of the University of Salerno led by Prof. Salerno, is here presented as a demonstrative case of the proposed methodology and approach. A distinctive feature of our proposal, supported by the MOMA solution is the adoption of semantic technologies that for instance allows for the discovery of unpredictable paths linking them in the Knowledge Graph. Finally, we discuss how this framework can be applied in the context of the Smart Cities of the future, taking advantage of the features, enabled especially by semantics, of researching, creating, combining, delivering and using in a creative manner the resources of superior quality offered by Smart Cities.

**Keywords:** Competence management; Knowledge management; Learning management; Talent management; Semantics; Smart cities

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Antonio Nunziante graduated with honors in Electronic Engineering from the University of Salerno in 2008. He is involved in activity related to Intelligent Transport Systems and models and methodologies for Knowledge Representation and Management using languages and technologies specific to the Semantic Web, in particular as responsible for MOMA and MIA Semantic Technologies

Gabriella Santoro is since 2013 CEO of two companies operating in the fields of Knowledge & Competence Management Learning System and Semantic Technologies including the spin-off MOMA. She deals with Business Development and Sales & Communication Management, and carries out an extensive research activities covering both management and senior researcher roles for European, National and Regional projects.

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## 1. Introduction

The War for Talent sees an increasing attention towards approaches that take into account profound relationships intervening in the management of Human Capital, corporate strategies and quality control of the competence development process (Klett & Wang, 2013). As part of the Smart City, learning takes a key role for the territory development, while the traditional approaches need to be revised in response to new modes of interaction between Smart Citizens and Smart City (Giovannella et al., 2013). New e-Learning approaches can also take advantage from the availability of Information and Communication Technology (ICT) services and advanced services offered to citizens, and from new communication and collaboration paradigms.

The effective and modern management of competence development cannot be limited to the Learning Management exclusively, but rather be inclusive of aspects pertaining to Human Capital and Performance Management in a holistic vision (Klett, 2010) that encompasses not only the sphere of operations but also the tactical and strategic levels. In particular, organizations need solutions that especially integrate Learning Management, Performance Management, and Human Resource Management.

Moreover, in the context of the Smart City of the Future, Knowledge Management is seen as a core element, enabling the development of different application scenarios. The utilization of semantic techniques for Knowledge Management allows for example to tackle, in line with the Semantic Web vision (Shadbolt, Hall, & Berners-Lee, 2006), problems that are not only concerned with formal and non formal intentional learning (as in traditional e-Learning systems), but also related to informal learning using a mechanism of “unpredictable” resource links through possible paths on the Knowledge Graph. The approach proposed in this paper and adopted by MOMA ([www.momanet.it](http://www.momanet.it)) strongly focuses on the use of an ontological modeling of competences that, as underlined in (Malzahn, Ziebarth, & Hoppe, 2013), demands for the participation of domain experts in defining both, competences and their relationships. The experts are supported by tools for the management of ontologies (that foster the collaborative editing) featured in the

MOMA platform and based on a Common Sense Knowledge. MOMA is a spin-off of the Research Group of the University of Salerno, envisioning an optimal combination between market and research (Mukhopadhyay et al., 2013).

After referring to competences and presenting a State of the Art of Human Capital and e-Learning systems in Section 2, we describe the proposed approach, including an ontological model of competences in Section 3. This model is adopted for the definition of training paths and supporting corporate processes, such as staff recruitment, tailored and targeted training, performance assessment, definition and application of employee reward systems, career path development, skills inventory management, and know-how protection. The competence model also allows defining a methodology for the competence matchmaking that is explained in Section 3 providing a basis for various scenarios of use. Also a Semantic Framework and learning are discussed in this context. Afterwards, some MOMA technologies and solutions are presented in Section 4 as a demonstrative case of the examined methodology, highlighting main features of the MOMA solutions for e-Learning and Human Resource Management, and particularly focusing on enabling virtuous mechanisms for achieving new competences as illustrated in Section 5, where some possible applications to Smart Cities, based on the Semantics, are described.

## **2. The key-role of competences in human capital and e-Learning systems: state of the art and open challenges**

Competences and knowledge exchange are crucial aspects in all organizations processes and their management is shared by Human Capital and e-Learning systems. The Smart City concept allows new ways to learn, especially in social and collaborative way as transposed in suite that includes Human Resource Management, Performance Management and e-Learning.

### *2.1. Definition of competence*

There is not a univocal definition of competence in literature since, being it generally adopted by different disciplines (linguistics, psychology, educational sciences, Human Resource Management, etc.), its definitions are manifold. Regarding both educational sciences and Human Resource Management, a very commonly cited definition refers to competences as “a recognized and proven set of representations, knowledge, skills and attitudes pertinently mobilized and combined in a given context” (Le Boterf, 1994). The competences, as professionally relevant abstractions of human behavior, are becoming increasingly important in managing, in a wide range of application domains, personal skills and workers’ knowledge. In the Human Resource Management, the skills are used as criteria to select the most appropriate employee to accomplish a given task.

In the vocational training, moreover, the competences can guide the design of appropriate activities and didactic resources, the selection of due learning material and the creation of possible curricula aiming at cancelling or reducing the detected gap between available and needed competences.

Sampson and Fytros (2008) identify three basic dimensions related to the term “competence”. The first dimension refers to an amount of personal characteristics including concepts of knowledge, skill, attitudes, capabilities, behaviors, peculiarities, values, motivations, social role, etc. The second dimension is on the proficiency level that allows classifying the skills demonstrated by individuals in performing actions. Finally,

the third dimension concerns the context in which the individual must apply his/her skills, e.g. a particular area of work or a specific situation. Other authors (Clark, 2010) consider the competences as consisting of three distinct dimensions called Knowledge, Skills and Attitudes (KSA model), in which:

- The word Knowledge indicates all pieces of information owned by an individual that may be straightly applied to a given task and the ability to apply them.
- The Skills are defined as experience, practical ability and the ease of carrying out a task; the acquisition of skills increases the ability to perform actions effectively, automatically and unconsciously. The skills are supported by knowledge and attitudes as, for example, a skilled person may not be able to react successfully to external phenomena that deviate from the normal conditions in which they apply their skills.
- The Attitude is interpreted as the tendency to act in a consistent manner in response to a particular situation (Fishbein & Ajzen, 1975). The concept of attitude includes affective, cognitive and behavioral components that determine how an individual recognizes a given situation; also included is the tendency to behave in a predictable and controlled way to appropriately address the different working situations that may occur in a given context.

The aforementioned KSA dimensions are generally made to correspond to the cognitive, affective and psychomotor learning within Bloom's taxonomy (Bloom, 1956). Education in the cognitive domain is associated with learning mental skills, and can in fact be seen as the development of knowledge. The affective domain implies the development of emotions related to attitude values. Lastly, the psychomotor domain of education represents the maturation of manual or physical skills.

## 2.2. Literature and market review

Organizations are strongly affected by solutions that support and improve the processes of selecting, developing and retaining talent. This is crucial to acquire the right skills and experiences and, at the same time, to define clearly goals and performance evaluation criteria.

Until a few years ago, the HR (*Human Resource*) leaders required mainly the availability of specific features to face some particular processes at the best. However, the most recent trend sees a greater supply of software suites that include several features, trying to partially integrate, at the same time, different applications from the workforce planning to the talent acquisition, from the performance appraisal/assessment to the goals management and so on. For example in a unified suite a manager can move from Performance to Learning Management in order to define the learning plan that fill the employee competency gap. The adoption of a comprehensive suite is still limited. However, the number of customers who wish to purchase most of the components present within the suite (Gartner, 2013) is growing. From this point of view, as highlighted by Hamerman, Kark, Murphy, and Schooley (2013), about half of the surveyed organizations wish to adopt a single solution (coming from a single vendor) to manage the characteristic different processes of training and Human Resource Management. This prospective learning and talent management is the goal of the best talent vendor offerings, including innovative use of social, cloud, and mobile technology. This is also confirmed by the interest of vendors to expand their products toward complementary functionalities.

Vendors are also developing solutions that combine talent management and its formal aspects with informal and social components.

The suite developed by SuccessFactors ([www.successfactors.com](http://www.successfactors.com)), an SAP company, is the strongest indicated by Hamerman, Kark, Murphy, and Schooley (2013), and allows Competence Management with a set of integrated and third party libraries, performance reviews with continuous feedback capabilities, all available in a user friendly and customizable user interface.

Competences within the organization are developed through several channels, and organizations need the constant and usable availability of learning resources from different devices; in fact 51% of the learning resources are unstructured, namely received outside of canonical training activities (Aberdeen Group, 2014). Furthermore, employees need to have at their disposal tools that improve their capacity to share knowledge with colleagues wherever and whenever.

The present analysis did not reveal solutions that integrate significant tactical and strategic aspects and, above all, that include the use of semantic technologies that are particularly suitable for the development of e-Learning and HRM solutions in a Smart City environment.

### 2.3. Challenges and critical issues

According to the explanations in the previous Subsection, the main trend in Human Capital and e-Learning systems is towards the creation of a unique environment in which competences can be measured and, at the same time, learning experience can be provided in symbiosis with Human Resource Management capabilities. Competences are crucial not only at the operational level within the Performance Management System, but are also a key factor at the tactical and strategic layers of the Performance Management process within organizations. In particular, considering them in a holistic system they can improve the performance of Human Resource Management, Learning Management, Performance Management, and Strategic Management systems. In this case, attention should be paid to the whole process not only from the point of view of the enterprise, but also of the person and of the public institution.

Another important challenge is the need to establish a smart environment where employees can exchange ideas and knowledge in order to develop competences in an unstructured way. Social and collaboration capabilities are at the same time attractive and can facilitate the creation of a true learning culture. This last factor plays a very important role especially taking advantage of the technological and cultural innovations that characterize the Smart Cities. Semantic Web technologies can be adopted to facilitate creation, annotation, composition, and exploration of resources involved inside different advanced processes, as for example in training and recruiting systems. In particular, Semantic Web technologies enable the *Knowledge Extraction* process that can transform tacit knowledge within organizations in explicit knowledge and allows identifying unknown *a priori* paths that link entities inside the overall Knowledge Graph. This enables for instance the deduction of non declared competences, from other competences or job position descriptions or career paths, and the optimal management of team building and further activities in the organization.

### 3. The proposed approach

The proposed approach aims at successfully handling the challenges and the critical issues depicted in Subsection 2.3, substantially improving the State of the Art. The approach is based on the ontological modeling of competences in accordance with the main methodologies, languages, and standards of the Semantic Web. The ontological model enables the construction of a Knowledge Base, which can be processed in turn by the languages and tools of the Semantic Web. In particular, the information contained in the Knowledge Base can be processed automatically by heterogeneous systems to extract the contents information of interest and to process, under certain conditions, reasoning automatically. The semantic representation facilitates and optimizes search operations, regardless of the technical mechanisms by which it is carried out. Ontologies are in fact the most powerful tool available to the Semantic Web to express semantic relations between concepts within a domain. Competence modeling permits the reuse of information in different context, from the learning environment to the recruiting environment.

The proposed approach exploits the definition of a methodology for competences matchmaking that supports the training of human resources, their collaboration and composition of work groups, etc. The value of matchmaking takes into account in particular the relationships between competences, allowing inferring not direct matches, the gap between competences and the relevance of the requirements. The approach addresses Knowledge Management thanks to the adoption of a Semantic Framework that makes available the appropriate core functionalities. Furthermore, the improvement of knowledge sharing and discovering processes supports applications to informal learning. The *e-tivities* paradigm is adopted in order to create automatically or semi-automatically teaching experiences and training plans.

#### 3.1. Competence modeling

A competence model is a formal tool intended for the representation and sharing of information about competences, able to support different organization processes including staff recruitment, tailored and targeted training, performance assessment, definition and application of employee reward systems, career path development, skills inventory management, expertise protection. It also allows for the optimization of human resources employment and support planning as well as the development of structural changes inside the organizations. The competence modeling is performed according to the following requirements:

1. use of the KSA approach;
2. relations among competences;
3. evidence-based association of performance levels with competences;
4. association of competences with roles or tasks based on the context to be employed;
5. compliancy with the main analyzed standards to maximize interoperability with external systems;
6. use of Semantic Web techniques and languages.

The key concept behind the model relates to Competence; it describes a single competence following the IEEE RCD standard (IEEE Learning Technology Standards Committee - Competency Data Standards Working Group 20, 2007), and also considering the application of the KSA paradigm and the possibility of organizing the

competences into maps. The competences can be characterized by the context they have been taken from or where they are requested to be applied; the competence possession in a given context could not necessary indicate that it will be employed within another domain with the same performance level. To meet the 2<sup>nd</sup> requirement, listed above, a new property has been added, namely relation that defines relations between competences belonging to the same scheme as well as different schemes. This approach generalizes the concept of a competence hierarchy and adopts three different types of relations:

- *sameAs* which connects a competence to another one or to another semantically similar or related resource, expressed in the same scheme or in a separate scheme (e.g. an RCD (*Reusable Competency Definition*), a Web page, a concept in an external ontology, a topic from Wikipedia , etc.);
- *requires* which connects a competence to another one that is its prerequisite: typically the acquisition of a new competence can only take place when all prerequisites have a sufficient level;
- *suggests* which connects a competence to other competences recommended for the acquisition of the former, that is to say, an analogous although milder relation than required.

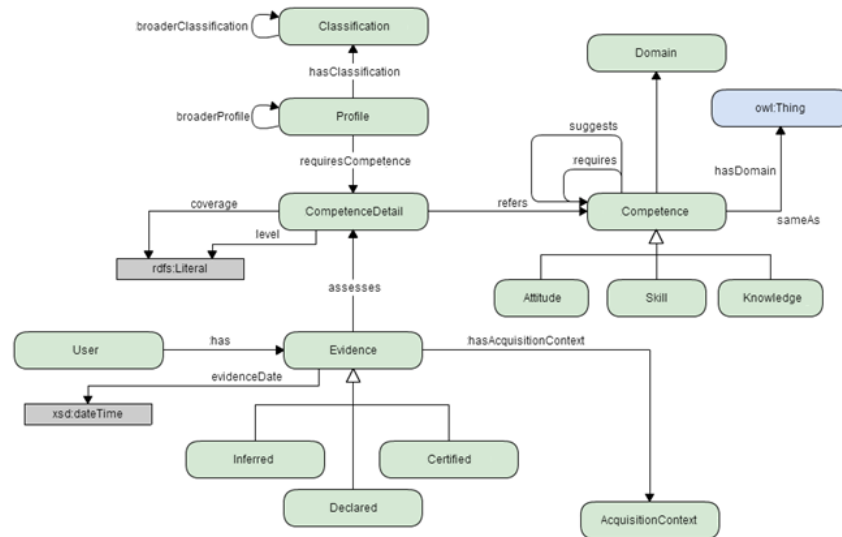
Inside the model, the CompetenceDetail entity describes a competence instance with its corresponding level. It can be associated with a User to state a competence or with a Profile to state a requirement related to a competence. Fig. 1 depicts the main components of the proposed competence model (essentially adopted by MOMA, see Section 4) which contribute to the ontological description of competences. CompetenceDetail can be used for both, to state the knowledge owned by a worker and to indicate a requirement related to a competence for a position, task or an organizational role. In both cases, as prescribed by the 3<sup>th</sup> requirement listed above, it needs to associate the competence with an evaluation expressed as a percentage. It is also possible to add an Evidence that indicates the type of feedback possessed in relation to the attained level. Three types of Evidence (with decreasing confidence level) are allowed:

- *Certified* indicating that the worker has some kind of formal certification for the level of the attained competence level (e.g. certificate, diploma, etc.);
- *Declared* indicating that the worker himself/herself has declared the possession of a competence;
- *Inferred* indicating that the possession of a competence has been automatically deducted by the system (e.g. through activity analysis, or interpreting CV content, etc.).

To meet the 4<sup>th</sup> requirement, moreover, every competence can be associated with the context in which it is attained or where its application is needed. A list of CompetenceDetail(s) can represent a worker's competence profile and can therefore be associated with the User entity. Similarly, a list of CompetenceDetail(s) can represent the competence profile associated with a company position, a role or a task and can therefore be associated with the external Profile entity.

In compliance with the 6<sup>th</sup> requirement, an ontological formalization of the competence model is provided below. Fig. 1 shows the main classes, relations and individuals of the ontology, hereafter defined in the OWL DL language (Smith, Welty, & McGuinness, 2004).





**Fig. 1.** Competence Model

### 3.2. Methodology for search and matchmaking of competences

The *query* made by a user to search for competences within the Knowledge Base can be expressed in a natural language; for example, let us consider the case in which an operator in the HRM sector needs to define the set of competences required in a particular context. In the *start-up* phase of a company system, such competences may be already stored within a *Common Sense Knowledge* (CSK), which can then support the creation of the company's Knowledge Base through the use of concepts also applicable, for example, for the semantic annotation of training resources. In this case, the definition of corporate knowledge can be initiated from the network of concepts in the CSK, in particular to define the necessary competences within the organization. Competences, *knowledge* and *skills* can refer to concepts not directly available in the used CSK (e.g. based on Wikipedia). Then, it is possible to create new concepts able to complement the Knowledge Base and to associate labels to them that will facilitate the search.

For example, the competence entitled "*Websites construction*" could be automatically enriched by a software module that, by applying linguistic techniques, is able to identify possible alternative expressions for the competence title. This module will access language sources (such as dictionaries) that provide output in any synonyms and lemmas of the words included in the competence title. In the previous case, the word "*construction*" may be related to the terms "*build*", "*develop*", "*implement*", etc.; the language module must be able to recognize any *chunk* (groups of words) within the title, as for example "*web sites*", to which other equivalent expressions may be associated, such as "*internet site*", "*web site*", "*portal*", etc.

The competence expressed in that manner, will be related to a natural language text even if the latter contains inflected or derivative forms; for example, in the natural language text "*within the project I built a portal for information recording*", the text portion "*I built*" is connected to "*Construction*", while "*portal*" is linked to "*website*"

identifying, in essence, the competence "Websites Construction". Each concept created according to this technique is then immersed in a *tag cloud* automatically generated which will be used for the competence *matchmaking* and search. The *matchmaking* and search is based on this linguistic tool to identify the competences based not on the recognition of exact keywords associated with the competence, but taking advantage of the linguistic structure of its description / title analyzing nouns, verbs, inflected forms, synonyms, etc., able to provide equivalent expressions for that competence. The NLP (*Natural Language Processing*) operations used for the competence search and for the *matchmaking* are *Sentence Splitting*, *POS(Part Of Speech) tagging and lemmatization*, as included within the NLP module shown in Fig. 2.

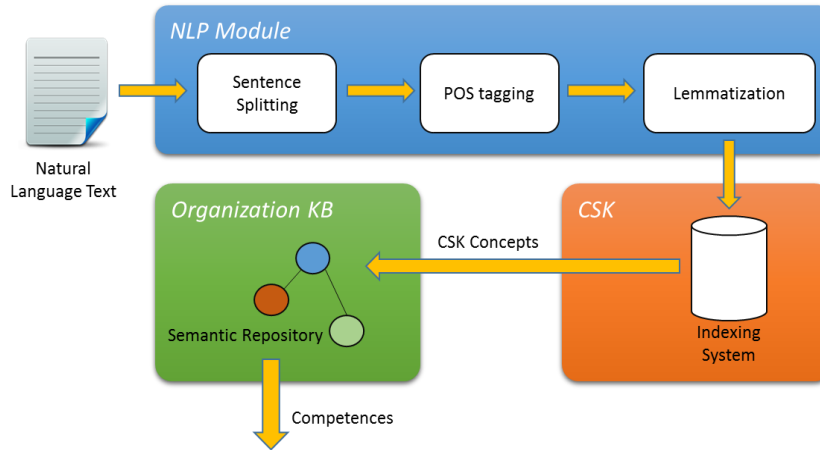


Fig. 2. Competence search

The linguistic structure analysis of the natural language text is used for searching particular concepts in the CSK that may have been used or not in the company's Knowledge Base to describe competences of interest. The organization's KB (*Knowledge Base*) will make use, in particular, of a semantic *repository* (also called *Triple Store*) for the instantiation of the ontological model of competences according to Semantic Web languages and technologies (e.g. OWL, RDF (*Resource Description Framework*), RDFS).

The *matchmaking* process of competences also includes a set of competences called *target*, which, for example, represents the conditions to be met to perform a particular job in terms of knowledge and *skills*. Each of these conditions, in compliance with the ontological model of competences, can be expressed by a minimum level that determines whether the possession constraint is satisfied. The *target set* ( $T$ ) is therefore the competence profile to meet when evaluating the *matchmaking* with the competences owned by the *stakeholders* involved in contexts of interest (company's employees, researchers, individuals looking for their first job, students, organizations, etc.). This set of competences is here indicated by the *candidate set* ( $C$ ). The value of the *matchmaking* ( $m$ ) between the two sets  $T$  and  $C$  can be expressed as:

$$m = \text{sim}(T, C) = f(T, N_{\geq}, N_{<}, N_{\text{not}}, r_{c_l}')$$

where:

- $N_{\geq}$  is the set of competences that are available in  $C$  with a greater or equal level than the required one;

- $N_{<}$  is the set of  $T$  competences that are available in  $C$  with a lower value than the required one or whose required competences are not completely in  $C$ ;
- $N_{not}$  is the set of  $T$  that are not available in  $C$ ;
- $r_{c'_i}$  expresses the importance of the  $i^{th}$  required competence  $c'_i$  and can take a value between zero and one.

The formula for calculating the *matchmaking* considers the relevance of each requirement in  $T$ , represented, according to the ontological model, by the property *relevance*. The value of  $m$  is one in the case of a *perfect match*, or is zero in the case of any lack in correspondence between the sets  $T$  and  $C$ ; it can, however, not be zero if there is at least one competence in the corresponding *candidate set* to one of the *target sets*, albeit with a lower level.

The difference between possessed level and required level can be used to calculate the degree of reward to be considered in the arrangement of a *candidate set* compared to their match with the *target set*. The reward function (or *boosting*)  $p$  can be introduced as function of the desired levels for each competence in the target set and of the owned levels:

$$p = g(l_{c_i}, l_{c'_i})$$

The  $i^{th}$  contribution to the value of  $p$  is equal to one in the case where the corresponding competence is owned with a value equal to the maximum possible value, however, it is zero in case all the required competences are owned with a value exactly equal to the required one. The reward value is not added to the *matchmaking* function, whose value would exceed one, namely a 100% *match* between the two compared competence sets. It may, instead, be used to sort the results obtained from the comparison of multiple *candidate sets* with the *target set*, especially with  $m$  being equal.

### 3.3. Semantic framework for knowledge management

The proposed approach is based on the adoption of semantic technologies to improve Human Capital and e-Learning systems. This imposes, at the core of any solution implementing our paradigm, a *Semantic Framework* that provides the following functional features:

1. *Entity Extraction*: extracting from textual resources of entities belonging to a particular dataset;
2. *Conceptualization*: extraction, from a text or an entire corpus of documents, and an ontological schema summarizing the contents analyzed;
3. *Classification*: classification of structured information (for example contained in the database) and unstructured (corpus documentary) with respect to a reference schema, such as a taxonomy, through the use of inference mechanisms and not purely keyword-based;
4. *Relations extractions*: possibility to automatically extract relations between concepts within the text;
5. *Summarization*: elaboration of the summary of the content of a text;
6. *Document Similarity*: proposing, as a document a portion of text, and similar documents based on their content;
7. *Sentiment Analysis*: extraction of qualitative information about a possible state of mind from a text;

8. *Q&A*: processing a query in natural language to propose a coherent response to the real user needs;
9. *Semantic Search*: search for documents which content is correlated to a query made in natural language, not based solely on keyword search;
10. *Crawling*: connection structured and unstructured information sources to generate new knowledge;
11. *Linked Open Data*: association of links to public datasets to facilitate the search of documents in the Web.

### 3.4. Applications in informal learning

Mangione, Orciuoli, Ritrovato, and Salerno (2013) demonstrate the added value of the following application scenario by also highlighting the potential of semantic technologies in the development of a *Personal Working and Learning Environment* (PWLE) within companies.

Supposing that a Worker “A” is part of the team involved in the project “X”. For this purpose he/she searches on the Web and finds out interesting scientific and technical material as well as upcoming specialized technical conferences. In this manner, he/she acquires personal (tacit) knowledge. By means of a suitable use of the Organization Knowledge Model and Infrastructure, he/she enables other colleagues to access useful material and conference information for their working needs related in particular to project Y, so transforming his/her personal-tacit knowledge in shared-explicit knowledge. In this scenario, the added value offered by the Smart Cities is clear: it consists in making easier the participation in technical conferences cycle, with technology take-up live sessions and discussions. For example, the worker “A” for the purpose of Project X, goes to the following site: <http://semanticweb.org/> from where he/she can access a list of ontological schemes. The Semantically-Interlinked Online Communities (SIOC) scheme captures his attention; he/she is encouraged to «tag» some pages that he/she thinks relevant for his/her research. In particular he/she finds a scientific paper entitled: “Reusing the SIOC Ontology to Facilitate Semantic CWE Interoperability” and feels the paper as useful for the purpose of project “Y”, of interest to his/her Organization. He/she simply annotates the URL, through a Semantic Social Bookmarking system (included into the PWLE), with the item «Project Y». For example, the Semantic Social Bookmarking can exploit the SIOC ontology to achieve this annotation as the RDF statement: «paper\_uri» sioc: related\_to «project\_Y\_uri». The paper, in turn, tags a series of technical conferences programmed for the next year in the main cities of the country, including where his/her organization is located, by the Knowledge Management Society.

Two months later project “Y” gets started, and worker “B”, who is involved in one of the first tasks of project “Y”, accesses his/her PWLE and specifically the workspace connected with project “Y”. There he/she finds a reference to the paper «tagged» by worker “A” and reads it. By reading this paper, worker “B” activates an individual learning process in that he/she acquires new knowledge about aspects which are important for project “Y”. Also, worker B gets to know and disseminates information about the next technical conferences. His/her company appreciates his/her work and encourages at least three workers of the project team to participate in the conferences. In this manner, the knowledge of worker “A” becomes “shared knowledge” in his/her organization.

### 3.5. Introduction to *e-tivities* paradigm and their composition

The learning experience can be improved through the adoption of *e-tivities* or educational and drilling activities intended for the network (Salmon, 2013). The online learning can be so divided in active and participatory modes. The *e-tivities* are typically provided in an asynchronous mode and take place in a period defined by the interaction among learners through written text communication, designed and conducted by a tutor as an e-moderator, where the users' co-presence is not required. The *e-tutor's* role is to organize and plan the *e-tivities*, which complexity can vary, going from simple individual exercises to more complex activities, generally of a collective nature, which outcome may foresee various phases (Armellini & Aiyegbayo, 2010).

The proposed Learning Management *Framework* provides an environment to define, automatically or semi-automatically, the teaching experience or training plans: a lesson or workflow will be the result of the composition of *e-tivities*, properly orchestrated according to the workflow logic, which target is the acquisition of an increase in competences; e.g. a lesson could envisage the combination of an e-testing phase, of a session in a synchronous mode with the use of a video conference, of a series of contributions entered on a group forum and finally, of a front lesson session.

## 4. Enabling technologies for the proposed approach

To better address the focal points highlighted in the Sections 2 and 3, MOMA, for the most part, provides a methodological and technological solution (HR & PM (*Project Management*) Suite) that allows the management of the entire competences life cycle within a single smart environment. This is in line with the latest trends that emerged from the needs analysis of organizations and ahead with respect to the leading technology solutions providers in this context in terms of considering the whole process and not only single functionalities, and also of adherence to a sound and well-defined methodological framework. HR & PM Suite adopts as a key-feature the functionalities made available by the *MOMA Semantic Framework* (MSF), described in Subsection 4.3 toward the elicitation of new knowledge.

The learning solution realized by MOMA, which is the learning component of the above HR & PM Suite, is based on the adoption of semantic technologies. These technologies enable the smartness in education with the ability to elicit in the context of Smart Cities high quality, cross related resources and taking advantage of the mutual interaction between the Smart City and its citizen, especially for competences development. In particular, all semantic technologies allow to quickly finding cross-related material from large knowledge repositories, such as Wikipedia, YouTube, available MOOCs, Smart City specific resources, etc. The presented solution improves the performance of adaptive learning systems due to the possibility to better understand the content meaning, by using common sense knowledge, and to estimate the relevance of the knowledge or skills achievement, moving from a traditional and totally structured, often also not adaptive, learning path, to a demand-based, knowledge-driven, non-linear learning approach, and acting like a sort of “zapping” within knowledge repositories according to the needs of Smart City Citizens (considering pace, expertise, curiosity).

In the following Subsections we address the MOMA solutions including the paradigm of our approach, as pointed out before. State of the Art references to the specific technologies create the starting point for the explanations.

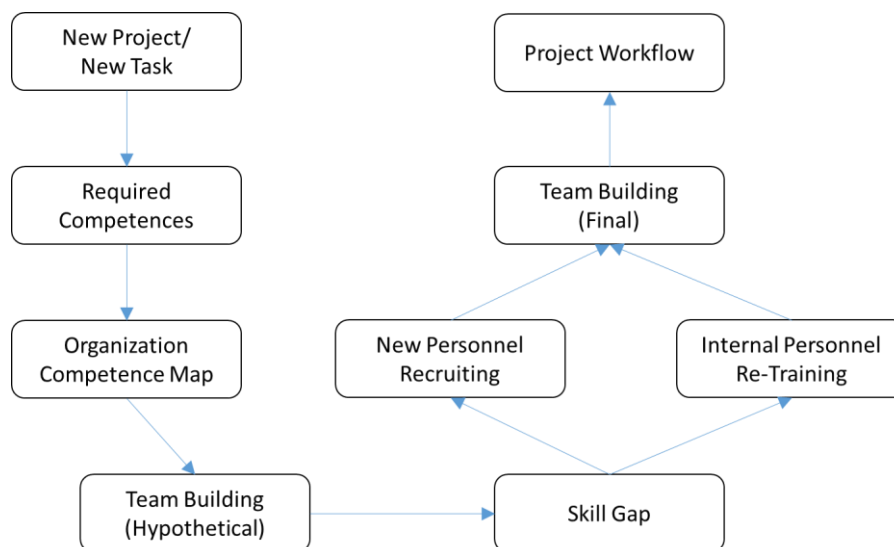
#### 4.1. The MOMA suite for HRM and e-learning

As stated in the Subsection 2.2, the main trend regarding e-Learning and HRM systems is built around their integration in a unique environment available within organizations.

The MOMA suite of products for HRM and e-Learning allows exploiting the full potential of Human Capital, synergistically integrating aspects related to Human Resource Management and activities optimization of company projects within a flexible and modular architecture. The MOMA solutions in this context are designed to meet specific market needs, such as:

- reducing recruitment time and cost and improving quality of selections;
- drawing a map of competences and corporate experiences, allowing for an instant access to relevant information on company's human resources;
- defining an accurate and punctual needs in terms of competences and experiences for the creation of assets and corporate projects;
- avoiding inadequate allocation of resources, reducing the risk for unproductive workers;
- training and managing project teams, in accordance with the defined *governance* model;
- and identifying and preventing problems by supporting their collaborative resolution under the project implementation.

The suite offers a set of modules and advanced functionalities that facilitate the management of human resources for the organization's activities and projects. From the company's point of view, it is well known that facing a new requirement, ideally represented by a new project, a number of non-trivial activities are needed that are preparatory to the management and the actual implementation of the project. The path leading from the realization of a new requirement to the project operational management able to meet the need, is schematically shown in the following Fig. 3.



**Fig. 3.** Path for the realization of a new project

After analyzing the requirement, the involved competences to respond effectively and efficiently to such request need to be defined. Being able to have a map of competences and corporate experiences that allows an immediate access to relevant information on the company's human resources, the second step goes toward the easy composition of the project team. Likely the resources available for the scope are not enough to cover all the required roles and/or do not possess appropriate knowledge for the project; therefore, it is necessary to proceed with the analysis of the so-called *skill* gap aimed at identifying these discrepancies. To fill the gaps revealed by the previous analysis, the following two methods can be applied:

- recruiting new resources owning the "missing" skills within the company and required by the project;
- training the available resources to let them attain the "missing" skills within the company and required by the project.

Whatever the chosen path (i.e. recruitment, training or, more widely, their appropriate combination), it will be possible to proceed with the allocation of the project team and start the project activities being assured to have all the required skills.

The different modules of the suite offer concrete support in all the phases described above, facilitating and automating many of the defined tasks. For example, the module for the preparation and management of the skills and company profiles map enables the definition of the best work team, suitably trained and/or making recourse to external recruitment, aspects fully supported by other modules of the suite.

#### 4.2. MOMA for e-learning

Essalmi, Ayed, Jemni, and Graf (2010) deal in deep with the concept of customization parameters in learning experience. The personalization of learning experiences can be distinct in *personalized instruction* and in *personalized learning*, from the teacher and the student point of view respectively. Cakir, Simsek, and Tezcan (2009) show that the personalized instruction is to be considered as one of the major phenomena capable of exploiting the potential of Web 2.0, and, in agreement with Tian, Zheng, Gong, Du, and Li (2007), the personalized learning is a procedure in which different strategies of learning are made available to adapt the course to the different personalities of the students.

The MOMA solution for e-Learning is the MOMAMOOC platform, developed under the ARISTOTELE FP7 project (Del Nostro, Orciuoli, Paolozzi, Ritrovato, & Toti, 2013) from the previous platform IWT (*Intelligent Web Teacher*), is able to adapt to the needs of the individual learner in both corporate and consumer areas, and encompasses the previous mentioned aspects. In fact, the training courses are dynamically generated and customized based on cognitive state and learning preferences of any single user. Although MOMAMOOC is included in the suite described in Subsection 4.1, it has a special role in the MOMA solution, also for historical reasons, being the first to be developed but overall for the qualitative aspects related to the explicit ontological and pedagogical models. These issues make MOMAMOOC unique in the scenario of available learning platforms, both proprietary and open source.

MOMAMOOC is a "modular" user-centric virtual environment based on the explicit knowledge representation, enabling to set up and run scenarios "customized" to the specific needs and characteristics of single users (i.e. cognitive state and learning style), and improving the knowledge transfer as well as sharing through collaborative

environments, *social networking*, community, integration of computational, simulation, virtual reality and competency management tools. It arises from the consideration that each specific context requires a specific solution, characterized by a set of services and orchestrated into composite processes dependent on the domain, also adapting content, knowledge sharing models, presentation modes of supporting information and tools. MOMAMOOC offers tools and functionalities to support all key activities of the workflow in the education sector.

The added value of this learning solution mainly lies in the possibility to define and execute the most suitable learning experience depending on context and disciplinary domain. It supports the principles of didactic individualization, in order to offer experiences tailored to the cognitive state and learning styles of individual learners. Opportunely using specially designed ontologies, in fact, it is possible to meet user needs and to optimally provide resources and services, adapting the paths to better support the student in achieving desired goals.

Each student has a profile also encompassing a cognitive state, i.e. the set of skills owned by the learner, including those related to the topics covered in the attended courses. In particular, the set of competences vary and gets updated during the participation in the courses, consisting of a set of Learning Objects (LO). The user profile also includes the educational preferences of the learner, in terms of learning styles, interactivity level, favorite media types, etc.

MOMAMOOC allows students to enjoy the learning experience going through the typical course catalog view or describing their training needs in natural language. The learner simply expresses a training need in natural language, and MOMAMOOC suggests high-level training goals that are semantically close to the expressed need. With the authoring tools available in MOMAMOOC he/she can create hypertext links within a thematic Learning Object, among different Learning Objects and also to other resources, both internal and external to the system.

This personalized path is not characterized by a sequence of static resources (e.g. a sequence of video lessons and/or handouts), but by a targeted objective. An objective is defined as a set of concepts of an ontology related to the domain of interest which the path is designed on. There are functionalities that allow managing and sharing dictionaries and ontologies to structure and organize the knowledge. The learning objects are enriched, then, with semantic annotations (concepts of ontologies), metadata and mechanisms enabling an advanced search.

MOMAMOOC satisfies the main requirements of a Learning Management System (LMS) and Learning Content Management System (LCMS) in terms of management of web-based learning (e.g. user management, classes, registrations, course delivery, results monitoring), collaboration between students/teachers (learning communities) and resources archiving and cataloging, according to the current trends of e-Learning 2.0. The platform allows to prearrange classroom environments by configuring sets of available services and to use Web 2.0 collaborative features.

MOMAMOOC supports the major standards for knowledge representation and learning (e.g. OWL, SCORM ([www.adlnet.gov/resources/scorm-1-2-specification](http://www.adlnet.gov/resources/scorm-1-2-specification)), IEEE LOM ([www.imsglobal.org/metadata](http://www.imsglobal.org/metadata)), IMS LIP ([www.imsglobal.org/profiles](http://www.imsglobal.org/profiles)), IMS Learning Design ([www.imsglobal.org/learningdesign](http://www.imsglobal.org/learningdesign))). It also adopts the specifications introduced by the W3C and other related consortia. MOMAMOOC tracks all tasks completed by a user and allows the creation of reports dedicated to a student, tutor or teacher.



#### 4.3. The MOMA semantic framework

A *Semantic Framework*, thanks to languages, techniques, and methodologies characteristics of the Semantic Web (Shadbolt, Hall, & Berners-Lee, 2006), enables Knowledge Management features, in particular inside organizations and Smart Cities.

The MOMA Semantic Framework (MSF) allows the workers and, more generally, the citizens of the Smart City to experience an environment in which they can develop their competences through informal learning. In this manner, MOMA semantic technologies provide the right tools for information discovery and knowledge sharing.

The MSF platform is an array of semantic tools offering advanced features for information classification and search. From this point of view, the MSF can be regarded as a "tool box" through which standalone vertical solutions or extensions of existing system scan be implemented. This is specifically enabled by the ability to process a variety of contents (structured and unstructured), analyzing the information meaning rather than checking for keywords. As opposed to a monolithic approach, the modular and flexible idea behind the MSF allows for the implementation of customized solutions for individual customers, choosing the right tools to every problem and specific need. The MSF has been employed in medium/large organizations with the aim to enhance their business processes (*e.g. Document Management Systems, Content Management Systems, E-Commerce Platforms, Customer Relationship Management, and Incident Management*).

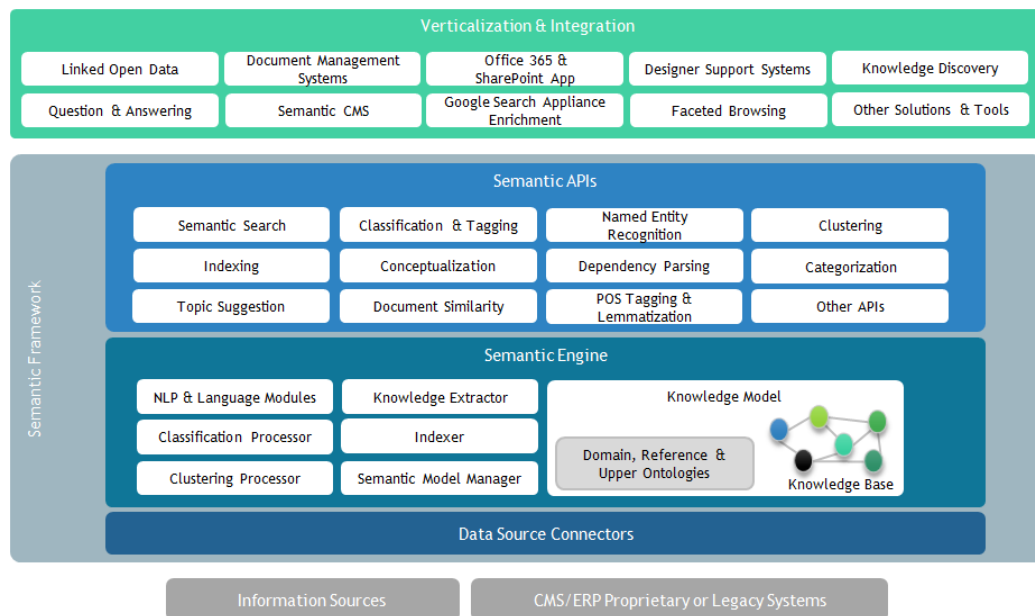
The MSF exposes its functionality through a set of APIs according to service-oriented standards independent on a given platform. The high-level logical architecture of the MSF is structured into three main levels as shown in Fig. 4:

- **Data Source Connectors:** This layer represents the interface point toward external data structures allowing the connection with both, structured information sources (ER (*Entity Relationship*) Tables, file XML, noSQLDB (*No Structured Query Language Database*), RDF store, HTML, etc.) and unstructured ones (Microsoft Word text documents, PDF, etc.). Within this layer, additional connectors can also be add, able to meet specific needs linked for example to interfacing systems of different types:
  - Document archives,
  - RDBMS (*Relational Database Management System*),
  - Legacy Systems,
  - Enterprise Content Management Systems,
  - Web Pages, etc.
- **Semantic Engine:** The *Semantic Engine* is the *core* of the whole platform and hosts modules for the delivery of the platform base functionalities. This layer also hosts data structures of reference and in particular the **Knowledge Model**, namely a set of ontological structures opportunely organized, able to describe the knowledge of interest and enabling inference operations in different processes of **Knowledge Management**. The knowledge description is carried out using the main semantic standards, such as:
  - RDF/RDFS (*Resource Description Framework Schema*),

- SKOS (*Simple Knowledge Organisation System*),
- OWL (*Web Ontology Language*),
- SPARQL (*SPARQL Protocol and RDF Query Language*).

The *Semantic Engine* moreover, is not a monolithic system, since it can be easily re-modulated according to specific needs.

- **Semantic APIs:** The *Semantic APIs* allow, through widely used protocols, such as REST and JSON, accessing the **semantic functionalities** and integrating them with other systems and innovative applications.



**Fig. 4.** MOMA semantic framework architecture

## 5. Applications to smart city of the future

The Smart City of the Future will be more and more based on the synergic combination of Knowledge and Human Capital, in a context of increasingly available and powerful resources and tools for Information Management and Fruition and Knowledge Building. For this purpose, the Smart Cities have to enable processes of skills and career development by means of an environment in which smart technologies, pervasively spread, support the citizens in training activities. This training (formal or not) allows Smart Citizens to acquire new knowledge, with benefits to their quality of life, and to develop new skills they can use in the working environment, both to enhance their employability and to improve their activities' performance, by achieving potentially positive effects with respect to their professional careers.

Within the Smart City, learning takes a key role in that it supports the Smart Citizens in developing their competences in terms of the dual identity of citizens and human resource (Mangione, Pierri, & Salerno, 2009). The presence of an advanced learning ecosystem also has a direct effect on the development of the territories under

different aspects, from the spread of services to attracting more industrial investments (Giovannella, 2014).

In line with the above, the MOMA semantic technologies allow for discovering new knowledge from the information available in the Smart City as well as the user interactions with the Smart City itself. The Smart City can also promote the formation of expert networks, simplifying the search, and the provision of social tools that support collaboration and exchange among Smart Citizens (Salerno, 2014). Moreover, learning can take place also as a side-effect of working and collaborative activity according to the paradigm of informal learning (see Subsection 3.4).

### *5.1. Application scenario*

We consider, as an example, the following application scenario:

Worker "A" is supported by the platform in carrying out activities within the Project "Y". In particular he/she, through his/her workspace, is able to browse the organizational Knowledge Base to get support in an unexpected (that is, not defined in advance) way, so discovering useful, hidden connections (Nunes et al., 2014).

Worker "A" can discover these connections browsing several linked ontologies, such as Projects, Courses, Experts, and Competence Ontologies (Nunes et al., 2013). Worker "A" may also identify who, within the Smart City, has some knowledge on particular topics. He/she may find such experts navigating the Knowledge Graph of project "Y" and decide to see if some of these experts are willing to work with him/her. In addition, Worker "A" can gather information on how to bridge his/her knowledge gap, identifying courses to follow effectively achieving the project objectives. In this way, Worker "A" individual and implicit knowledge has been formalized and socialized, becoming explicit and shared knowledge.

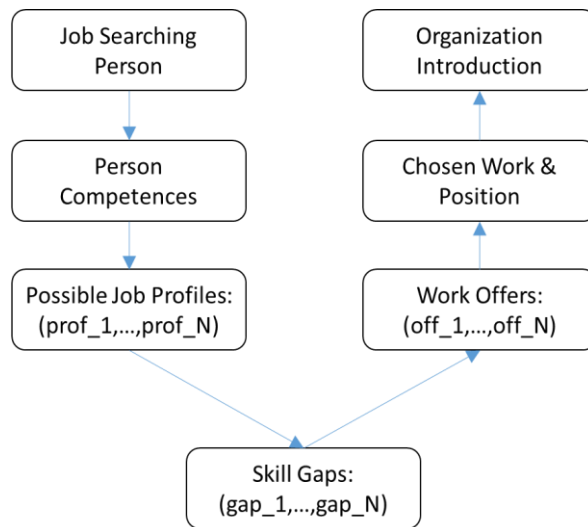
In a more complex scenario, Worker "A" can work on the project proposal, for his/her organization, on a particular topic provided by the call for proposals of a research sponsoring organization (for instance Horizon 2020 program of the European Commission). In this scenario, there are several aspects that need to be addressed: Worker "A" must in fact firstly prepare the project idea, then to identify potential partners taking into account their previous experience within other calls, and select people that he/she may contact according to their role and expertise.

The Smart City added value is evident, since it enhances the connectivity between people and organizations, and gives for instance the chance to participate in live events and courses, or to meet and start "face-to-face" discussions with well-known experts in the field, and acquire new qualified information and knowledge.

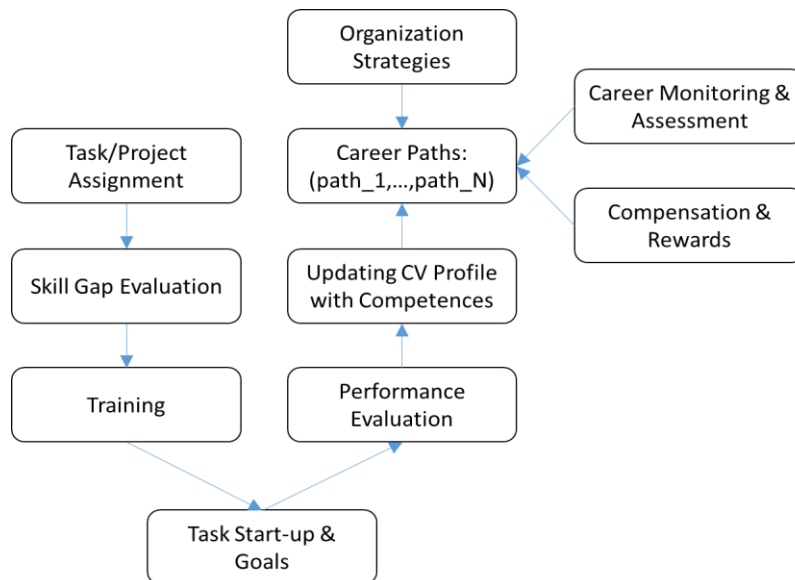
### *5.2. Integrated environment for competences and talents management*

An integrated environment for collaboration supports the preparation, governance and collaborative implementation of complex projects. The individual modules of the suite are designed in accordance with the principles of functional autonomy and modularity, in order to facilitate the set-up and the optimal composition according to the specific organizational needs. Moving the point of view from the organization to the individual, the suite allows for accompanying the workers throughout their career in the particular company, from the very moment when their resumes are acquired by the system, helping them to grow professionally through their involvement in projects that are the most suited

to their skills and enabling them to acquire new ones by means of challenging jobs as well as targeted and personalized training programs. An individual can be supported in finding a new job by comparing his/her competence profile with profiles sought by companies as illustrated in Fig. 5. This individual, with respect to a particular professional profile, may need to fill specific knowledge gaps (skill gaps) in order to successfully submit his/her application. In the optimistic case, in which the company considers his/her updated competence profile as appropriate, he/she will be introduced within the new workplace through the implementation of appropriate training plans specific to his/her job position and to his/her knowledge of corporate processes of interest.



**Fig. 5.** Job searching



**Fig. 6.** Competences development in an organization

The allocation of a human resource on a given activity, assigning him/her a specific role, requires to assess any skill gap that once overcome would greatly improve the employee's performance within the project as shown in Fig. 6. After identifying this gap, a process of targeted training is activated that allows for taking the worker to a better level of preparation with respect to the due task. The competences acquired by the employee will be evaluated after the training process and also verified during the activities according to the objectives to be achieved. Consequently, once the project activity ends, the worker competence profile will be appropriately updated, directing the employee towards possible career plans within the organization. The presentation of these plans will be obviously influenced by specific corporate strategies and the employee can opt for one of them evaluating the foreseen career advancement (also from the economic point of view), or, thanks to his/her experience, whether the market offers a more interesting job position for him/her to exploit his/her knowledge at the best.

### 5.3. Conclusions and future work

As illustrated by the two previous Subsections, the added value and the distinctive features offered by a Smart City emerge in terms of a higher level offering of knowledge resources, as for both, quantity and quality, which "makes a difference" for the Smart City Citizens: in terms of this, we speak of a Smart City of the Future as the semantic-enabled evolution of the present Smart Cities.

As future work, we plan to define, design and develop further applications, based on Semantics and Knowledge, for instance directed toward enabling the participation of citizens in the social life, the definition of policies, and decisions concerning their Smart City, aimed at the full deployment of the potential and of the distinctive features of the Smart Cities.

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