

Improvements of Decision Support Systems for Public Administrations via a Mechanism of Co-creation of Value

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Abstract. This paper focuses on a possible improvement of knowledge-based decision support systems for human resource management within Public Administrations, using a co-creation of value's mechanism, according to the Service-Dominant Logic (SDL) paradigm. In particular, it applies ontology-driven data entry procedures to trigger the cooperation between the Public Administration itself and its employees. Advantages in such sense are evident: constraining the data entry process by means of the term definition ontology improves the quality of gathered data, thus reducing potential mismatching problems and allowing a suitable skill gap analysis among real and ideal workers competence profiles. The procedure foresees the following steps: analyzing organograms and job descriptions; modelling Knowledge, Skills and Attitudes (KSA) for job descriptions; transforming KSAs of job descriptions into a standard-based model with integrations of other characteristics; extracting information from Curricula Vitae according to the selected model; comparing profiles and roles played by the employees.

The 'a priori' ontology-driven approach adequately supports the operations that involve both the Public Administration and employees, as for the data storage of job descriptions and curricula vitae. The comparison step is useful to understand if employees perform roles that are coherent with their own professional profiles.

The proposed approach has been experimented on a small test case and the results show that its objective evaluation represents an improvement for a decision support system for the re-organization of Italian Public Administrations where, unfortunately often, people are engaged in activities that are not so close to their competences.

Keywords: Decision support systems, service quality, SDL, co-creation of value, ontology-driven data entry, skill gap analysis.

1 Introduction

Business organizations, and, in particular, Public Administrations, have structures that are continuously modified with the aim of increasing and improving appropriate functionalities. Nowadays, these changes represent fundamental aspects for new techniques of Human Resource Management. Such studies consider two main situations: the improvement in services, with consequent advantages in logistic flows for organizations and in capacity of understanding suitable weak areas inside the organization. Hence, the focus is obviously the human systems management, with a particular attention to social questions [22], [32], rules for business [11], [30], and various mathematical formalizations for problem solving [24]. All the described aspects are summarized in [27], while details on service systems are given in [28] and [29], using the Service Science and the Viable Systems Approach [3], [16], [23].

Indeed, Italian organizations are often characterized by a serious lack in service quality [13], [15], in giving safe, fast and reliable services to a wide community of people. This aspect is predominant in Public Administrations and represents the warning that most of work roles are usually assigned according to factors, which are different from merit, competences and experiences. Hence, employees are in wrong places at wrong times, leading to serious delays in common work operations, with consequent creation of bottlenecks and inconveniences for people who need services.

In [1], the authors presented a skill gap analysis procedure (details are also in [21]) for the analysis of real and wished competences of employees inside Public Administrations. The focus of such previous problem was the identification of weak work areas, thus defining criteria for a Knowledge-based Decision Support System (DSS) for the evaluation of the correct roles of various employees and their competences (similar examples are in [7], [18], [19] while studies on competences are in [2], [9], [10] and [31]). The obtained results, tested in a real office in Italy, proved that work profiles are not always the most suitable ones for the performed roles. Such a conclusion was also confirmed by a team of 'experts', who, making manually the same procedure, gave the first evaluation of the correctness of this skill gap analysis. Naturally, the approach described in [1] was at that time still empirical and new studies and experimentations were required.

In this paper, the authors reconsider the analysis of [1] and enrich the descriptions focusing on the following open questions: matching problems could always arise due to the system's low availability (about 70%); this approach may be implemented as a DSS for the Public Administration.

For the first problem, more technological issues are obviously raised. Indeed, instead of considering such a point of view, a co-creation of value's approach, according to the Service-Dominant Logic (SDL, see [20]), is considered. The whole approach for skill gap analysis is considered as a complex service obtained through activation, coordination and integration of several services and processes, improved by means of Semantic Technologies [12], [14]. In particular, using an ontology-driven mechanism (see [4] and further results in [6]) for data entry, it involves both the Public Administration itself and its employees and leads them to dynamics of co-creation of value.

Public Administrations are guided to construct their databases using the term definition ontology; as for curricula vitae, employees insert their information using a similar methodology. This avoids eventual format mismatching during the data insertion and may simplify the processing of the parser by getting higher the overall reliability of the system.

In this paper, the methodology for the skill gap analysis in Public Administration becomes as follows: Public Administrations construct databases for organograms and each employee creates his/her curriculum vitae by using the ontology-driven mechanism. The organograms of Public Administrations and job descriptions of work profiles are analyzed. A competence model [25], based on Knowledge, Skills and Attitudes (KSA), similar to taxonomies [5] and implemented in SKOS language [8], [26], is constructed for each job description and integrated with other

characteristics, producing a description of the ideal competences which the employee, occupying the post related to that job description, should possess. On the other hand, a parser allows extracting the competences of employees from their curricula vitae according to the ISFOL-ISTAT¹ KSA model. In this case, due to the ontology-driven data entry steps, the parser reliability is naturally increased (and, therefore, even the reliability of the following matching process is improved). Finally, the skill gap analysis between the competences of ideal and real employees is made and represents the picture able to support decisions related to the organizational structure of Public Administrations.

A case study is proposed, according to the same real office presented in paper [1], namely the General and Legal Affairs Office of the Technical-Administrative Department of the Health Service in an Italian region. The analysis involved different work roles. The characteristics of profiles, divided into Constraints, Qualifications and KSA, have been kept in a Microsoft Access Database. Then, using a matching algorithm, the skill gap analysis was made among real and ideal profiles. The results indicated that some discrepancies occur, showing the gap percentages for each work position. Hence, the chosen profiles are not always the most suitable ones for the performed roles. A team of 'experts' also confirmed such a conclusion. They gave the evaluation of the profile figures according to their subjective opinions and confirmed how the overall approach might give a support in strategic decisions by identifying the weak areas inside the Public Administration or, simply, the people having the highest gap with respect to the roles they play.

As for practical implications of the proposed problem in Public Administrations, the obvious advantages derive from the good work quality, coming from placing 'the right employees in the right places'. Such employees are considered according to the defined and studied objective quality standards, trespassing the usual Italian 'barriers' due to preferential choices.

The structure of the paper is the following. Section 2 shortly describes four macro-scenarios, which usually occur inside Public Administrations, with a meaningful emphasis on the co-creation of value's mechanism due to the ontology-driven data entry. Furthermore, methodological steps for a correct analysis of competence profiles of employees are considered. In Section 3, a case study of a real office in an Italian region is presented, with attention to the results for three different work roles. Such results are different from the ones described in [1], because of the ontology-driven data entry. Conclusions are given at the end of the paper.

2 Competences in Public Offices and Co-creation of Value

In all Public Administrations, and in particular in the Italian ones, some activities are simply results of other ones, creating the so-called 'cascade effect', namely: the last activity is well done if all previous tasks have been correctly finished. Consequently, also little problems in managing some activities could create disastrous effects. The eventual damages become very serious if the real beneficiary is the citizen, who does not perceive an appropriate service quality. In particular, the service quality in Public Administrations represents the possibility of producing safe, fast and reliable services to a wide community of common and uncommon people. This phenomenon occurs only if logistic flows, seen as a sequence of consecutive activities, are able to work properly within the context of the Public Administration itself.

Although the vision of such a problem appears to be very simple, there are some evident weak points as the various activities are carried out by employees, whose competences are not always suitable for some services. This often happens as work roles are assigned on the basis of factors, which do not consider real capacities and the excellence. This meaningful aspect often implies a total reorganization of human resources in order to redistribute workloads and roles of employees, so as to improve the perceived service quality.

¹ ISFOL – ISTAT represents an Italian standard for the classification of work profiles and their characteristics. ISFOL – ISTAT KSA models contain further information, which is not always captured by the basic KSAs for work profiles.

The most obvious solution is a correct knowledge of profiles for all employees, in terms of their competences. Indeed, besides this aspect, there is also the important topic of recognizing, in absolute objectivity, the real value of employees via evaluations of lack of competences for the determined work role.

A possible starting point for a correct knowledge management is a competence model [25], which is defined in terms of Knowledge, Skills and Attitudes: Knowledge is the set of support information for the determined task; Skill is the practical ability for the development of the task; Attitude is a specific behavior in some situations. In the proposed approach, the competence model, which deals with Knowledge (K), Skills (S) and Attitudes (A), shortly indicated as KSA Model [13], has been realized via lightweight ontologies, similar to taxonomies [5] and implemented in SKOS language [8], [26]. Such ontologies allow the description of a particular domain in a hierarchical way and define simple semantic relations. Each element of type K, S and A has a score, that discriminates the competence levels for the knowledge domain. The hierarchical organization of concepts describing competences and the aforementioned semantic relations allow improving of the matching process among the ideal work profiles and real ones owned by employees. In particular, the adoption of a semantic matching algorithm, which does not rely only on syntactic matching among the terms describing the two profiles, but is able to exploit semantic relations among competencies (e.g., by applying inference techniques for exploiting subsumption relations among competences), is able to improve greatly the performance of the matching process.

Besides KSA models of work profiles of employees, other possible forms of competence representations are possible, such as the ISFOL-ISTAT standards, which enrich the possible descriptions obtained by simple KSAs. Hence, a possible analysis within Public Administrations starts considering possible profiles according to the ISFOL-ISTAT standards based on KSAs, with consequent identification of ideal work profiles, which have to be compared with the real ones owned by the employees in the next phase of skill gap analysis.

To achieve this aim, the initial idea is to study the information about whole working situation, which consists of an organogram, a function flow chart, job descriptions and job specifications. The focus is on job specifications, with consequent analysis of characteristics of job descriptions. Four macro scenarios are usually possible within Public Administrations:

1. *Job specifications have a structural and formal approach, according to ISTAT-ISFOL standards.* This case is the optimal one for a correct problem solving and represents the solution to which Public Administrations tend to converge nowadays. Knowledge extraction techniques, based on vocabularies and ontologies, allow a high degree of accuracy as for the knowledge representation.
2. *Job specifications allow a non-structured and informal approach, based on ISFOL-ISTAT criteria.* In this situation, a generic job specification follows ISFOL-ISTAT standards, but there are some difficulties in the representation. Knowledge extraction techniques are useful for the knowledge reconstruction with a quite good degree of accuracy. Indeed, such methodologies are more difficult than the ones described in the previous scenario, because the description is informal, namely: vocabularies and ontologies are not always adequate for problem solving and further integration techniques involving knowledge management are often required.
3. *Job specifications follow a structured and/or semi-structured, formal and/or informal approach, according to non-ISTAT-ISFOL standard.* In this case, job specifications refer to the standard, that is different from the one used by the system. Obvious difficulties occur if documents are not structured and not formalized. The difference among the various standards generally considers unusual vocabularies and different skills and attitudes. Such a situation is still workable – as it refers to a standard – if correspondences and rules with the ISTAT-ISFOL representation are found. The knowledge representation foresees a

preliminary analysis and matching steps (of automatic, semi-automatic and manual type) to establish rules to translate the non-ISTAT-ISFOL standard.

4. *The descriptions of job specifications foresee a non-structured, informal and non-standard approach.* In this last case, job specifications do not obey structures and standards; hence, the impossibility of a correct knowledge representation occurs.

Indeed, there is another important aspect to consider. In fact, besides the various standards for knowledge representation, there are also problems connected to data entry procedures, namely suitable databases have to be constructed for activities and for employees' curricula vitae of a Public Administration. Thus, automatic evaluation of employees' competences is strictly dependent on factors that are the result of cooperation between the Public Administration and its employees. This represents a fundamental aspect for improving the service quality.

In this work, according to the Service-Dominant Logic paradigm [26], the final service is obtained via the activation, coordination and integration of more isolated services, leading to a mechanism of co-creation of value. The value is co-created by means of a collaborative process involving both the Public Administration and its employees, whose final aim is to enhance the quality of the Skill Gap Analysis process. In order to achieve this aim, the process has to face eventual problems due to the automatic evaluation of matching among the required competences for work roles included in the organogram and the competences owned by employees. Such an operation, that seems to be very complicated, is solved considering an ontology-driven mechanism (depicted in Figure 1) involving the Public Administration and the employees in the previous step, namely when the organograms, related job descriptions and the curricula vitae, are stored into databases.

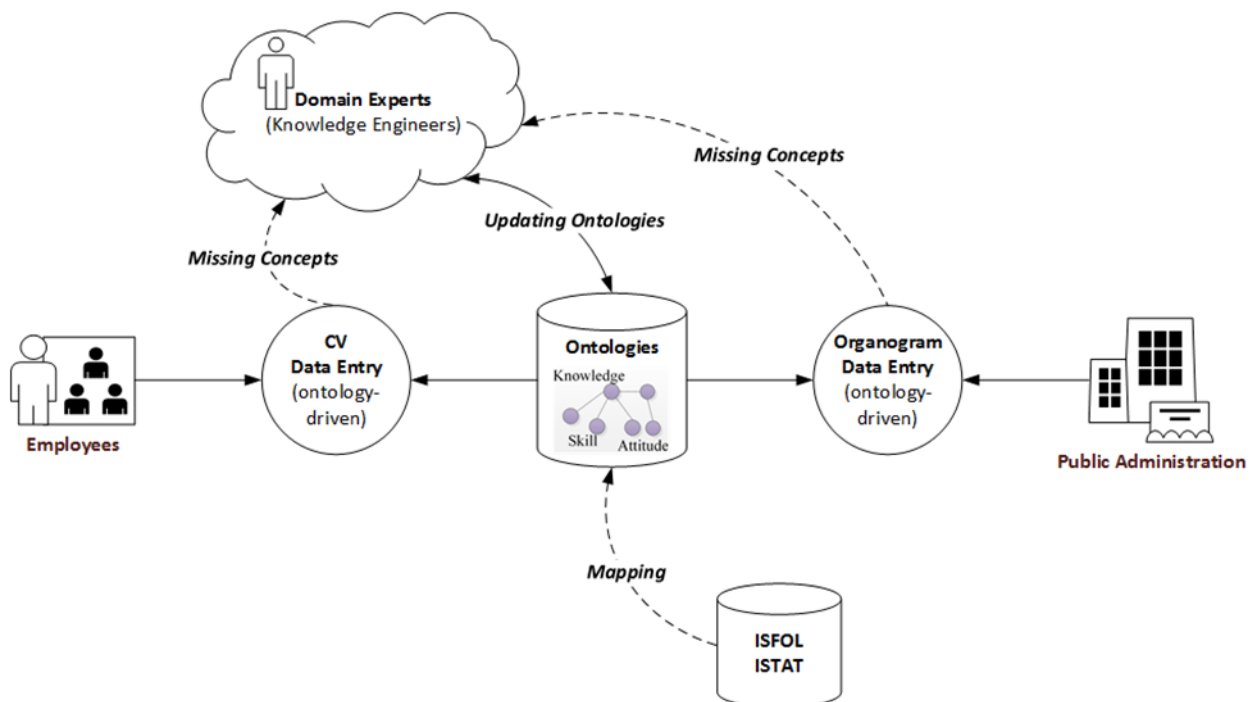


Figure 1. Model for the co-creation of value by means of a Collective Knowledge System

Typically, the data entry is realized with form-based interfaces. The counterpart of this approach is that the forms are generally simplistic, as they conform to the database structure. Moreover, considering that many attributes are represented as strings, it is difficult to ensure high data quality, especially with regard to the semantics of the inserted terms [4]. To overcome this issue, it is important that the semantics of the data are captured along with the inserted data. This can be realized by employing lightweight ontologies, as introduced before in this section, that, for instance, allow exploiting the semantics of the terms used by employees for inserting

their curricula in the database. As an example, for this purpose a semi-automatic approach can be used where the users, namely employees or Public Administration, clarify the meaning of the terms they have used (e.g., by selecting one among all the meanings of a term, represented as ontological concept) using an interactive process (see the approach proposed in [6]). This means that, as for the organogram and inner job descriptions, the Public Administration is guided to construct its database using the term definition ontology; as for curricula, employees themselves insert their information using similar methodology. The advantages of such a procedure are obvious and evident: technological issues are not excessively stressed and the real problem due to the usage of a parser with possible problems of format mismatching is reduced to an appropriate data insertion. Hence, such two meaningful actors allow bypassing, in a natural and simple way, most of the technical difficulties.

Let us explain how the process of data entry (Figure 1) allows co-creating value by means of a collective knowledge system [17]. The process foresees the exploitation of the available lightweight ontologies during the data entry phase. When a user is not able to identify a concept of the ontology for representing a specific competence (i.e., the competence is not represented in the ontology), he/she can ask a community of expert users to have the ontologies updated. Such experts verify the actual ontologies and evaluate the possibility of inserting new concepts (creating new value for the Public Administration and, consequently, for the citizens) or they suggest to employ different already existing concepts for expressing user's competences. This approach allows employees and Public Administration to collaboratively create shared ontologies, to co-create value in terms of better representation of their competences. As a result, the process of Skill Gap Analysis may lead to better results. It allows improving of the organization itself and, finally, delivering higher quality services to citizens.

From previous considerations and, in particular, for the most usual case (represented by the macro scenario 2), the possible steps are the following:

- *Analysis of the organogram of the Public Administration.* This initial phase is useful to identify all work roles needed by the Public Administration.
- *Construction of KSA models for all job descriptions.* For each identified work role there is a job description. This phase elaborates these descriptions by using an ontology-driven mechanism able to avoid eventual mismatching problems and represents the ideal employees for the Public Administration.
- *Integration of KSA models with other data.* In this step, some contingent constraints are evaluated and used to create an enhancement of the basic KSA models by considering information about work styles/conditions and behavioral issues.
- *Construction of KSA models for all employees' curricula.* The curriculum vitae of each employee is reduced to a competence profile in KSA using a parser. To bypass problems due to the parser's reliability, an ontology-driven mechanism allows loading data using appropriate terms of the vocabulary, which is identical to the one used by ISFOL for the description of the professional units. Moreover, besides the ordinary ISFOL terms, further integration of the vocabulary allows the descriptions of additive knowledge and professional experiences. The importance of this procedure is the possibility of defining KSAs of employees by respecting the ISFOL-ISTAT standard constraints.
- *Skill gap analysis between competences of real employees and ideal employees.* This phase represents the core of the whole proposed approach. It does the matching among KSAs of real employees and KSAs of ideal employees obtained in the previous steps. These results are useful to show if real employees are the most suitable ones for their performed roles inside the Public Administration.
- *Improvements in supporting decisions.* In this final step, the matching results allow identifying the employees with highest competence gaps and the inner the organogram of weak areas. This represents an improvement for the decision support system able to

give managers or administrators suggestions in taking some decision for the reorganization of these areas and the reallocation of the identified employees. Figure 2 shows the first architectural view of this DSS.

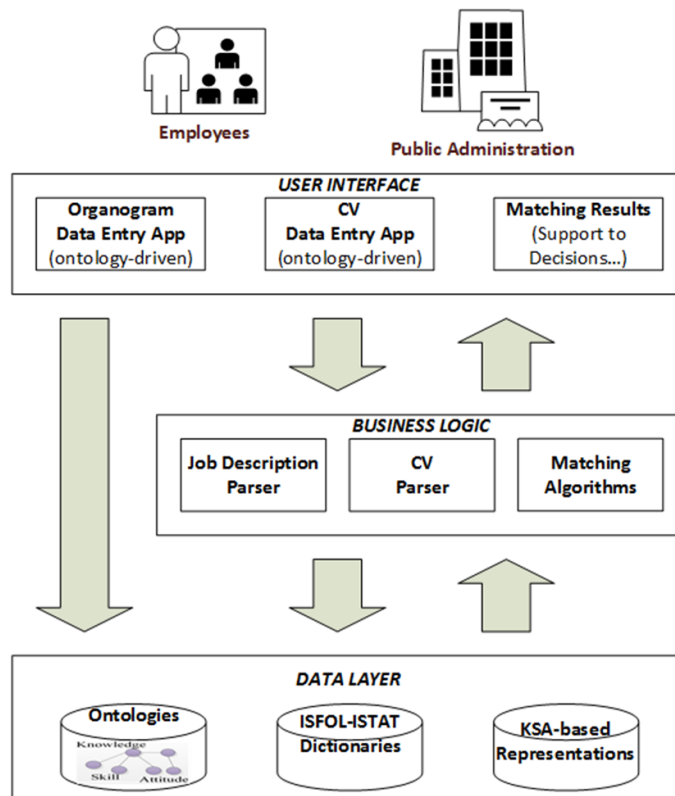


Figure 2. An architectural view of the DSS

3 Real Case Study of a Public Office in an Italian Region

The dynamics of a public office, precisely the General and Legal Affairs Office of the Technical-Administrative Department of Health Service in an Italian region, has been analyzed to study the described approach. Such an example, already proposed in [1] shows how in these contexts various employees are not always appropriate for their own work roles. Here the novelty in respect to the example in [1] is a better refinement of the overall procedure, especially in terms of the ontology-driven mechanism.

This early experimentation regards about 25 people and work roles, but we may show the details related only to those of public domain. In particular, the organogram that we may show is in Figure 3 and the roles that we may treat and describe in depth are administration manager, administration secretary and legal expert.

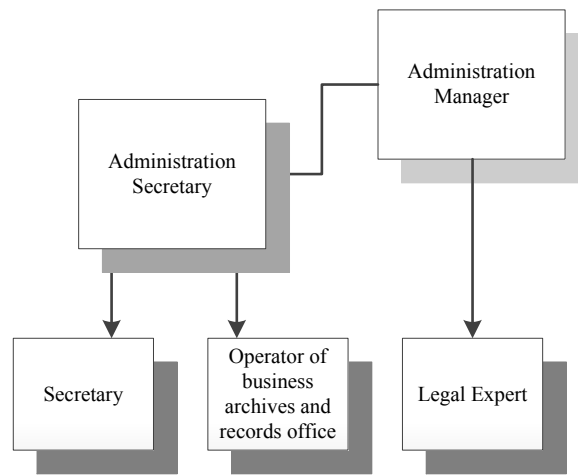


Figure 3. Organogram of the case study

Besides the organogram, the job descriptions, that rely on roles, tasks and essential qualifications, are considered. Essential qualifications arise from either business characteristics or law articles, in terms of rules and constraints for the employees' roles.

By elaborating these descriptions, our *job description parser* extracted the ideal KSA profiles. Precisely, each of them consists of KSA mapped on terms of the ISFOL vocabularies and integrated with essential knowledge constraints, qualifications and necessary experiences.

The ideal KSA profiles have very complicated structures. They are difficult to represent completely. However, for a better comprehension, an extract from that of the administration manager role is in Figure 4.

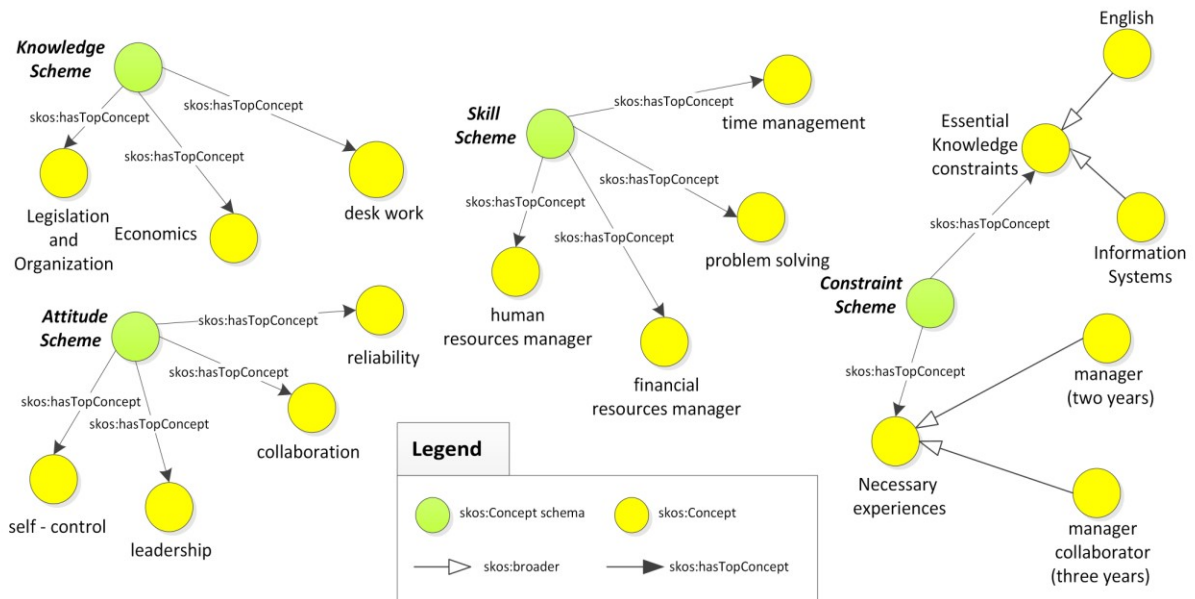


Figure 4. A portion of the ideal KSA profile for the administration manager role

As already mentioned in the previous section, the implementation is made via lightweight ontologies by means of SKOS language. The representation of this ideal KSA profile (redefined with respect to the one described in [1]) consists of 53 concepts, divided into categories and subcategories, that correspond, respectively, to different *skos:ConceptScheme* and *skos:Concept*.

In the example of Figure 4, categories and subcategories are the following:

- *Knowledge*: legislation and organization, economics, deskwork.

- *Skills*: human resources manager, financial resources manager, problem solving, time management.
- *Attitudes*: self-control, leadership, collaboration, reliability.
- *Qualifications*: degree in law, Master in Organization of Public Administration.
- *Constraints*:
 - *Essential Knowledge*: English, information systems.
 - *Necessary experiences*: two years as a manager in Public Administration, three years as a manager collaborator in Public Administration.

For the construction of the real KSA profiles, curricula vitae (of public domain) of the employees have been considered. Our *CV parser*, by means of the lightweight ontologies and ISFOL vocabularies, identified the concepts and represented the real KSA profiles. For the employee with responsibilities of administration manager, the parser recognized 36 concepts.

Finally, the *Matching algorithms* did a skill gap analysis and returned, as *matching results*, all the uncovered concepts. They are the competences needed by the Public Administration for the roles belonging to its organogram and that are not present in the real profiles of employees.

Notice that, in the preliminary example in [1], concepts of the real KSA for the administration manager role were 33. In our new case, 36 concepts are recognized. The same happens also for the role of administration secretary and legal expert; precisely, further 3 and 4 concepts are, respectively, recognized.

After all, the matching algorithms compared ideal KSA profiles and real KSA profiles and identified the existing gaps. Table 1 shows the results in detail. In particular, for simplicity, acronyms AM, AS and LE represent, respectively, the various work positions, namely administration manager, administration secretary and legal expert.

Table 1. Skill gap analysis: results for the different profiles

Position	Ideal KSA Profiles			Real KSA Profiles			Gaps			Suitability (%)		
	AM	AS	LE	AM	AS	LE	AM	AS	LE	AM	AS	LE
Knowledge	8	8	5	6	5	3	2	3	2	75%	63%	60%
Skills	16	15	13	10	12	10	6	3	3	63%	80%	77%
Attitudes	22	20	22	16	16	19	6	4	3	73%	80%	86%
ISFOL KSA	46	43	40	32	33	32	14	10	8	70%	77%	80%
Essential Knowledge constraints	3	4	2	2	2	2	1	2	0	67%	50%	100%
Qualifications	2	1	2	1	0	2	1	1	0	50%	0%	100%
Necessary experiences	2	1	1	1	1	1	1	0	0	50%	100%	100%
Integration	7	6	5	4	3	5	3	3	0	57%	50%	100%
TOTAL	53	49	45	36	36	37	17	13	8	68%	73%	82%

In the rows, Table 1 shows the number of knowledge, skill and attitude elements and the number of integrations including essential knowledge elements, qualifications and necessary experiences. Table 1 reports these numbers for both ideal KSA profiles and real KSA profiles. Sideways, there are the gaps calculated by comparing the numbers of the real KSA profiles with respect to the ideal KSA ones. In the last columns, there is the suitability that represents the coverage of real competences and integrations with respect to the ideal requirements for each work role.

Results of Table 1 are interpreted as follows. For instance, for the position of administration manager, the ideal KSA profile consists of 53 competences (see row Total in Table 1). The real KSA profile for the same role indicates that the employee has only 36 competences, with a consequent gap equal to 17, namely: the administration manager performs his role with a 68% suitability. It is possible to observe the same results in a different way, as shown in Figure 5. For

administration secretary and legal expert roles, the situation is the following: competence gaps for the administration secretary and the legal expert are, respectively, 13/49 and 8/45, with 73% and 82% suitability.

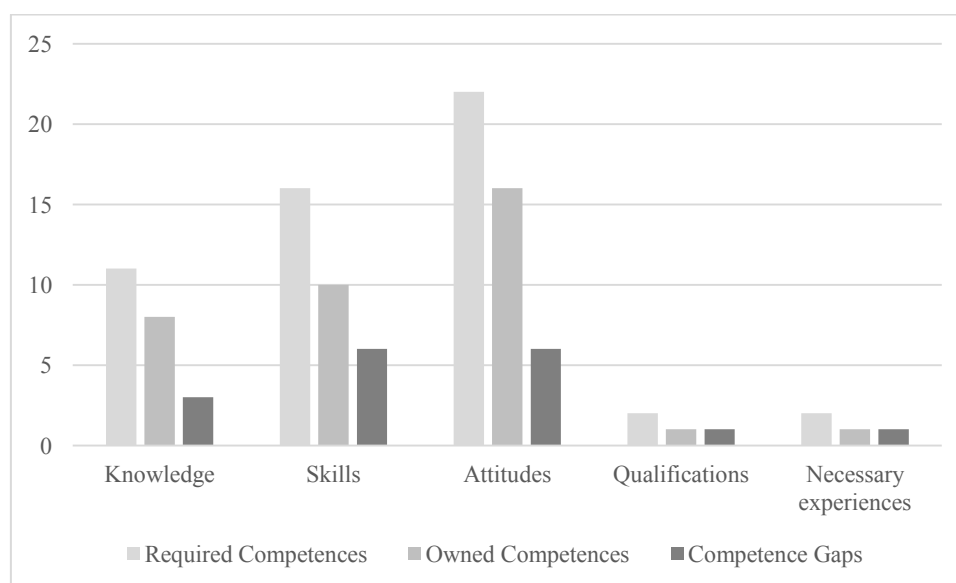


Figure 5. Administration manager role: histogram of results

The proposed approach appears to be promising, as the discussed results are due to accurate automatic processes, which do not have elements of subjectivity in evaluations, unlike the human case. Indeed, to test the reliability of the new results, according to the already followed approach in [1], some experts (precisely 5) have been consulted. Such experts, unaware of the skill gap analysis, have analyzed the curricula vitae and the job descriptions of the three professional roles described before.

Their opinions are shown in percentage in Table 2, at the following levels of correspondence: Low, Sufficient, Good and High.

Table 2. Opinion of experts: percentage of correspondence for the three considered work roles

Position	Low	Sufficient	Good	High
Administration manager	79%	15%	5%	1%
Administration secretary	70%	25%	3%	2%
Legal expert	2%	8%	75%	15%

Opinions of experts have a good degree of correspondence with the results due to the skill gap analysis, namely: the less corresponding profile is the administration manager one. Such results agree with the ones described in paper [1].

4 Conclusions

This paper describes an automatic/semi-automatic process to support decisions of Human Resource Management within Public Administrations. Its particular focus is on the General and Legal Affairs Office of the Technical-Administrative Department of Health Service in an Italian region.

We designed, realized and experimented a DSS prototype according to a co-creation of value's mechanism, given by an ontology-driven approach.

After this early experimentation, the results appear to be good and they encourage us to continue this research by defining opportune bounds to express judgements about the employees' suitability in the roles they perform and extending the experimentation to other wider contexts of the Public Administrations.

In fact, we applied our approach to a small organogram having a few job descriptions and a set of few CVs. Nevertheless, the results may be synthesized as in the following. First, they underline that the ontology-driven approach adopted in both parsers increased the reliability of the method described in [1]. Secondly, the analysis shows clearly the gaps and may represent a concrete improvement in supporting management decisions. It may lead re-organization processes or internal transfers aimed at increasing the overall quality of the Public Administration itself and the functions and services it offers to the citizens.

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