Integrating Trust and Competency Management to Improve Learning

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Abstract—Nowadays, the importance of knowledge management is well understood by managers in the organizations and, at the same time, the great significance of trust, in enabling effective knowledge sharing, is emerging. Presence or lack of trust can have serious implications for organizations with respect to the quality and of their business processes. Several scientific works have confirmed the direct correlation between social-cognitive capital, in terms of competencies and experiences, and a feeling of trust in both learning and working collaborative environments. On the other hand, Competency-Based Management allows organizations to link human resources processes to competencies in order to shape its workforce capabilities and to achieve better results. Typically, employees' competencies (and proficiency levels) are stored and used by specific enterprise software, whereas the trust is not considered or left to managers' feeling. This work proposes an approach to the improvement of collaborative learning activities by refining and allowing (at workers' level) competency-finding processes through the social calculus of trust-in-competencies degree.

Keywords-corporate learning; trust; competency-based management; semantic web; social networking;

I. INTRODUCTION

A. Background and Motivations

According to [1], it is possible to define the trust as *a mental state comprising expectancy (the trustor expect a specific behavior from the trustee) and belief*. Trust is considered one of the main assets available for organizations to proactively manage the knowledge sharing and increase the knowledge capital. In literature, many contributions suggesting a correlation between social-cognitive capital and feel of trust in collaborative environment [2], with regard to working and learning activities [3], have been recognized. According to Ardichvili et al. [4] the lack of trust in competencies may be identified as *one of the main barriers to knowledge sharing in online communities of practice* discouraging any form of motivation and participation in work activities. Moreover, *one's degree of trust in the competence of a community is positively related to one's engagement in knowledge sharing with the community*. Recent studies have confirmed this hypothesis [5] and argue that social motivation in the workplace increases the growth of trustworthiness and directly impacts on employees' performances. Although

several works providing models for trust management in virtual communities and social networks are reviewed in literature [6], they are not related to the trust in competencies the workers need to perform specific jobs. Competencies are identified, classified and managed by a set of processes, namely Competency-Based Management (CBM), ensuring that there is the right person in the right position at the right time in order to achieve better results. Typically, CBM processes are top-down organizational processes supported by enterprise software (e.g. Human Resource Information Systems, etc.) that cannot be exploited to support team building operations in non-formal collaborative learning (and working) activities. The main goal of this work is to define an approach to enrich CBM with trust information in order to support (by enabling competency finding operations) and to improve (by considering trust as a way to increase the quality of knowledge sharing) collaborative learning (and working) activities at the workplace. In order to achieve the aforementioned goal, a semantic-annotated trust-based corporate social network (where nodes are the employees' profiles and arcs are the relationships among the employees) will be defined. The social nature of the network allows to overcome the limitation of traditional CBM by enabling bottom-up competency management operations improved with trust information. Furthermore, trust in competencies will be calculated by using a social approach, i.e. considering direct interactions between two workers and using semantic-annotated social network to propagate trust degrees.

B. A Brief Overview of the Proposed Approach

This work proposes a *trust-based corporate social network* model (Section II) to improve learning (and working) processes regarding human resources in organizations. The idea underlying the proposed approach consists in defining a methodology to calculate the degree of trust a worker has in his/her colleagues' specific competencies. Let us assume the trustor's name is *a* and the trustee's name is *c*. The calculus of trust degree is directly (by analysing the interactions between *a* and *c*) performed if there has been at least one direct experience in which *a* had evidence of a specific competency of *c*, otherwise the trust degree is performed by propagation using the network. In the case of

propagation, for instance, let us also assume the existence of a worker *b*. *b* trusts *c* in a specific competency, *a* trusts *b* in his/her belief about the aforementioned specific competency, so it is possible to calculate the trust of *a* in the specific competency of *c*. Ontologies, taxonomies and vocabularies (modelled with Semantic Web schemes and languages) are used to define a trust-based corporate social network (section II) where employees' profiles and competencies, workplace relationships and information about trust in colleagues' competencies and believes are explicitly asserted. The network will be queried in order to support decision-making tasks (at both organizational and worker's level) regarding learning and working activities. The proposed approach includes the contextualisation (realized by taking care of *work activities* modelled in section III) of an existing method to perform the calculus of trust degree both directly (section IV) and by propagation (section V). Lastly, a brief discussion about the advantages of the proposed approach is provided (section VI).

II. TRUST-BASED CORPORATE SOCIAL NETWORK

In this section, a model of employees' profiles network is described by integrating and extending existing Semantic Web schemes, based on the W3C Semantic Web stack¹. The main result reported in this section is the definition of the *Trust in Competencies* and *Trust in Belief* model and its correlation with the employees' profiles in order to build the *Trust-based Corporate Social Network*.

A. Competency Model

According to the *Professional Learning Ontology and Competencies (PLOC)* described in [7], competencies are defined as abstractions for making human Knowledge, Skills and Abilities (KSA) manageable and addressable. Before competencies can be managed (by means of CBM processes), they should be classified and their context defined. It seems to be a good choice to divide them into behavioural and technical competencies (see fig. 2). **Behavioural competencies** include all those soft skills and attitudes that enable a person to perform well in a specific function, such as *communication*, *problem-solving*, *integrity*, *planning* and *organisation*, etc. **Technical competencies** are specific and depending on the job. These latter could range, for instance, from the knowledge of *software development methodologies* to skill for *Java programming*. Typically, competencies are organized in a hierarchy of four levels. Main classes and properties regarding the organization of competencies in PLOC are shown in fig. 1.

B. Employees' Profiles and Relationships

In order to model the employees' profiles, at least personal and *curriculum vitae* data have to be considered. In

Figure 1. Organization of competencies in PLOC.

[8] an integrated model constituted by FOAF² (organizing basic employees' information), ResumeRDF³ (modeling the curriculum vitae of employees) and PLOC (modeling competencies and their link with the employees) is presented. In particular, the *foaf:Person* class is crucial to model part of personal information about an employee. Some useful properties are *foaf:firstName*, *foaf:surname*, *foaf:mbx*, *foaf:publications*, *foaf:interest*, etc. Moreover, ResumeRDF is a RDF metadata vocabulary mainly used to describe work and education history of the employees. The main part of the ResumeRDF model is the *cv:CV* class that maintains information about a specific employee (*cv:Person*), his (her) education (*cv:Education*), his (her) work history (*cv:WorkHistory*), and so on. Although, ResumeRDF provides a way to model skills (*cv:Skill*) owned by an employee, it is preferable to use another scheme in order to adhere to a more complete definition (KSA) of competency (see paragraph II-A) provided by PLOC. The PLOC defines *competence:Employee* class and *competence:has-competency* property that are useful to link an employee with its competencies. In order to link *foaf:Person* with *cv:Person* and *competence:Employee*, the subclassing operation is used. In particular, *competence:Employee* becomes a subclass of *cv:Person* that becomes a subclass of *foaf:Person*. The effect of the application of the subclassing operation is that all individuals of type *competence:Employee* are also instances of *cv:Person* class and instances of *foaf:Person* class. So, all properties of *foaf:Person* are inherited by *cv:Person* and all properties of these two classes are inherited by *competence:Employee* class. One of the most important FOAF property is *foaf:knows* that links two instances of the *foaf:Person* class by building a semantic-annotated social network where the employees are nodes and their rela-

¹<http://www.w3.org/standards/semanticweb/>

²<http://www.foaf-project.org/>

³<http://rdfo.org/resume-rdf/>

tionships are arcs. However, in the corporate context, we need richer semantics to model relationships among employees. The RELATIONSHIP⁴ vocabulary represents one of the plausible solution for the aforementioned problem. In particular, *relationship:worksWith* (asserts that person *e* works for the same employer of person *d*) and *relationship:collaboratesWith* (asserts that person *e* has worked at least one time on the same activity with person *d*) are important for our purpose. The two aforementioned properties can be applied between two *foaf:Person* instances and they are symmetrical.

C. Trust in Competencies and Trust in Belief

The employees' profiles network, described with Semantic Web schemes, has to be enriched with information regarding trust. In particular, in [9] the authors build a formal-semantics-based model for the calculus of trust and refer to two basic types of trust: *trust in performance* and *trust in belief*. The first one is the trust about what the trustee performs, whereas the second one is the trust about what the trustee believes. The present work starts from the results of [9] and extends them in order to deal with the concept of *trust in competencies*. In particular, we propose the following statements:

$$trust_c(d, e, apply(e, x), k), \quad (1)$$

$$trust_b(g, d, apply(e, x), k). \quad (2)$$

The statement 1 indicates that employee *d* (trustor) trusts employee *e* (trustee) regarding the capability of *e* to apply competency *x* in context *k*. The statement 2 indicates that employee *g* (trustor) trusts employee *d* (trustee) regarding *d*'s belief about the capability of *e* to apply competency *x*. Note that, in the Semantic Web-based modeling, *d*, *e* and *g* are individuals of type *competence:Employee*, *x* is an individual of type *competence:Competency*, whereas *k* can be interpret as an instance of a *skos:Concept*. SKOS⁵ is a Semantic Web scheme used to build taxonomies and controlled vocabularies. For the aim of this work, SKOS will be used to model a controlled vocabulary of contexts of interest in a given organization using *skos:narrower* and *skos:broader* properties to relate instances of *skos:Concept*.

The table in Fig. 2 shows variants of 1 and 2 for all competency types.

Now, a Semantic Web-based scheme is needed in order to model trust statements of Fig. 2. The *Trust Ontology*⁶. The *Trust Ontology* is a small ontology, written on OWL, that allows people to say how much they trust in other people. It is defined as an extension of the FOAF scheme. The most important class of the *Trust Ontology* is *trust:TopicalTrust*. The

Category	Sub-category	Examples	Statement
Technical Competencies	Knowledge	Java language syntax	$trust_c(d, e, use(e, x), k),$
		Description logics	$trust_b(g, d, use(e, x), k)$
		UML notation	
Behavioural and Cognitive Competencies	Technical Skills	Java programming	$trust_c(d, e, apply(e, x), k),$
		OWL modeling	$trust_b(g, d, apply(e, x), k)$
		Project management	
	Thinking Skills	Problem-solving	$trust_c(d, e, apply(e, x), k),$
		Innovation & creativity	$trust_b(g, d, apply(e, x), k)$
		Continuous learning	
	Interpersonal Skills	Teamwork	$trust_c(d, e, apply(e, x), k),$
		Relationship management	$trust_b(g, d, apply(e, x), k)$
		Communication	
	Action Skills	Teaching others	
		Decision-making	$trust_c(d, e, apply(e, x), k),$
		Results orientations	$trust_b(g, d, apply(e, x), k)$
	Personal Qualities	Planning & organization	
		Integrity	$trust_c(d, e, reveal(e, x), k),$
		Self-motivation	$trust_b(g, d, reveal(e, x), k)$
		Responsibility	
		Self-management	

Figure 2. Managing different types of competencies

Figure 3. Extended Trust Ontology.

classes *trust:TrustInCompetency* and *TrustInBelief* have been defined by subclassing *trust:TopicalTrust* in order to respectively model trust in competencies and trust in belief. Subclasses of *trust:TrustInCompetency* could be defined in order to model all types of competencies illustrated in Fig. 2. The individuals of *trust:TrustInCompetency* allow to link an instance of *competence:Employee* (trustor) with another instance of *competence:Employee* (trustee) and with the specific target of the trust, i.e. an individual of type *competence:Competency*. The data property *trust:trustValue* is used to assign a value to the trust in the target competency of the trustee. Fig. 3 shows how the extended *Trust Ontology* is instantiated.

It is important to note that in origin the class *trust:TopicalTrust* did not support values for distrust (that is the opposite of trust) and untrust (that is the status in which the degree of confidence is insufficient to trust) in order to solve some reasoning problems. We have extended the *Trust*

⁴<http://vocab.org/relationship/>

⁵www.w3.org/2004/02/skos/

⁶<http://trust.mindswap.org/trustOnt.shtml>

Ontology with the new data properties *trust:distrustValue* and *trust:untrustValue*. In the extended ontology, trust, distrust and untrust have values in [0, 1]. The graph in fig. 3 states that *Paolo* trusts *Mario*, with value 0.6, to apply the *Project Management* competency (for sake of simplicity the graph does not report the competency level) in the context *ResearchProject*. The modelling of a statement for trust in belief is similar to that for trust in competencies. In this case of trust in belief, the property *trust:trustSubject* does not link a competency, it links a context (an individual of *skos:Concept*).

III. WORK ACTIVITIES

In order to calculate trust, distrust and untrust degrees it is important to understand how organizational activities are modelled. In particular, the PLOC provides the *competence:OrganizationalEntity* class. The *competence:Task* subclass of *competence:OrganizationalEntity* can be used as a basis to define a work activity in which an employee (worker) executes a specific task by means of the *competence:is-in* property (with domain *competence:OrganizationalEntity* and range *competence:Employee*). Furthermore, the *competence:requires-competency* property (with domain *competence:OrganizationalEntity* and range *competence:Competency*) is needed to indicate the competencies that are required in order to successfully carry out a specific task. In order to complete the Work Activities model we need to include a supervisor and the possibility for the supervisor to review the performance of the worker. So, the *trust:supervises* property and the *RDF Review Vocabulary*⁷ have to be introduced. The first one is used in order to relate instances of *competence:Task* class (supervised tasks) with instances of *competence:Employee* (supervisors). The second one provides a set of classes and properties useful to attach a review (*rev:Review* class) to a resource (in this case the resource will be an individual of type *competence:Task*). The underlying idea is that the supervisor assigns a rate (*rev:rating* is a numeric property with domain *rev:Review*) to the performance of the employee involved in the task. The rate can be interpreted as a value indicating the how the required competencies have been applied during the execution of the task. Supervisor and worker are both individuals of *competence:Employee* class.

IV. CALCULUS OF TRUST, DISTRUST AND UNTRUST

In this section, a method to calculate degrees for trust, distrust and untrust is proposed. For this aim, the probabilistic approach illustrated by the authors in [9] has been adapted for context and purpose of this work. The aforementioned contextualisation and the use of semantic-annotated data are

advancements with respect to the results of [9]. Trust is interpreted as a probability distribution over three mental states (believing, disbelieving and undecidable) corresponding to trust, distrust and untrust. Intuitively, the trust α of e (trustor) for d (trustee) in successfully applying a competency x in context k can be approximated with the probability that e will successfully apply x in context k . Distrust β is the opposite of trust. Instead, untrust γ , corresponding to the third state of the probability distribution, can be calculated by using the formula $\alpha + \beta + \gamma = 1$. Authors in [9] propose to calculate probability measures in terms of frequencies of positive experiences between the trustor and the trustee. More in details, in the case of **trust in competencies** the following formula (3) can be used.

$$\alpha = td_c(d, e, apply(e, x), k) = n/m, \quad (3)$$

where m is the total number of situations, experienced by d (trustor), in which e (trustee) has applied competency x in the context k , and n is the number of the trustor's positive experiences in that set, β (distrust) can be calculated with the same formula (3) of α by replacing n with l and td_c with td_{dc} , where l is the number of negative experiences in the same set. Values for n and l can be calculated with the following:

$$n = \sum_{i=1}^m e_p(i), l = \sum_{i=1}^m e_n(i), \quad (4)$$

where $e_p(i), e_n(i) \in [0, 1]$, representing the degree of the experience i being positive or negative separately, and $e_p(i) + e_n(i) \leq 1$. In the context of this work, a positive (negative) experience of a trustor with a trustee is represented by a task, that requires competency x , where the supervisor (trustor) d has provided a positive (negative) review rate $e_p(i)$ ($e_n(i)$) to the worker (trustee) e for the application of competency x in the context k . Moreover, in the case of **trust in belief** the following equations can be used.

$$\alpha = dt_b(g, d, k) = n'/m', \quad (5)$$

where $dt_b(g, d, k)$ approximates $dt_b(g, d, apply(e, x), k)$, m' is the total number of experiences observed by g (trustor), in which d (trustee) has applied any competency in context k , and n' is the number of positive experiences in that set. β (distrust) can be calculated by using the same formula (5) and replacing n' with l' , where l' is the number of negative experiences in the same set.

$$n' = \sum_{i=1}^{m'} e'_p(i), l' = \sum_{i=1}^{m'} e'_n(i), \quad (6)$$

⁷http://danja.talis.com/xmlns/rev_20071109/index.html

where $e'_p(i), e'_n(i) \in [0, 1]$, representing the degree of the experience i being positive or negative separately, and $e'_p(i) + e'_n(i) \leq 1$. In this case, a positive (negative) experience of a trustor with a trustee is represented by a task where the supervisor (trustor) g has provided a positive (negative) review rate $e'_p(i)$ ($e'_n(i)$) to the worker (trustee) d for the application of any competency in the context k .

V. PROPAGATION OF TRUST

In the previous section (IV) a method to calculate trust, distrust and untrust, between two nodes (employees) in the network, is provided. Now, a model of propagation of trust degrees in social networks [10] has to be exploited in order to calculate the trust in competencies between employee e and employee d also if e has never supervised a task performed by d in which d has used the required competency x in context k . In this case, it is possible to use the corporate social network and trust in belief to propagate trust in competencies (and also trust in belief) by contextualising the approach presented in [9]. In fig. ??, a piece of the semantic-annotated corporate social network is depicted. In particular, for employee e there are not values for trust, distrust and untrust for competency x of employee g in context k . But, it is possible to obtain the aforementioned values by exploiting trust in belief (in context k) of e for d and trust in competency x of d for g in context k . In ?? only degrees for trust and distrust are indicated. In particular td_c and $dttd_c$ are values for $td_c(d, g, apply(x, k))$ and $dttd_c(d, g, apply(x, k))$, td_b and $dttd_b$ are values for $td_b(e, g, k)$ and $dttd_b(e, g, k)$. ptd_c and $pdttd_c$ are values calculated by using the formulas 7 and 8.

$$ptd_c = td_b(e, d, k) \cdot td_c(d, g, apply(x, k)) + dttd_b(e, d, k) \cdot dttd_c(d, g, apply(x, k)), \quad (7)$$

$$pdttd_c = dttd_b(e, d, k) \cdot td_c(d, g, apply(x, k)) + td_b(e, d, k) \cdot dttd_c(d, g, apply(x, k)). \quad (8)$$

The formulas 7 and 8 can be used to propagate trust, distrust and untrust by considering paths of any length over the corporate social network. Trust in belief is propagated by replacing, in 7, $td_c(d, g, apply(x, k))$ and $dttd_c(d, g, apply(x, k))$ with $td_b(d, g, k)$ and $dttd_b(d, g, k)$. The propagation of distrust degrees is obtained in the same way by modifying formula 8.

VI. FINAL REMARKS

The proposed approach enables several scenarios in which competency-finding is executed by workers that, when introduced in project teams, can exploit feelings of trust in their peers' capabilities in order to activate help seeking processes. The competency search operation is refined by calculating trust degrees. For instance, a non-formal learning activity, like peer-coaching, is improved (trust improves

learning as asserted in Section I) when the coach is selected by the worker by using, not only the required competencies as search parameters, but also the trust degree of the learner for the potential coach. The approach will be experimented and exploited in ARISTOTELE project to develop a trust-based Decision Support System for team building.

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