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A collaborative methodology for tacit knowledge management: Application to scientific research

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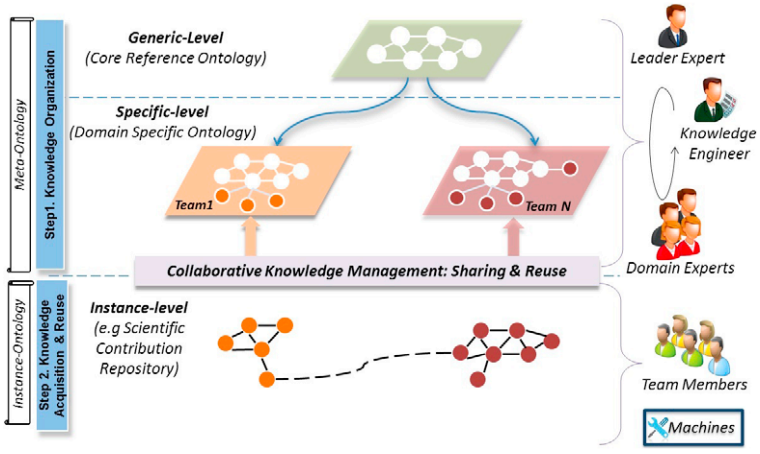
HIGHLIGHTS

- Proposing a methodology for formalizing tacit knowledge to cover social barriers.
- Applying the proposed methodology to the scientific research management.
- Defining the Network and Communication Research Domain Ontology (*NCRDO*).
- Implementing and evaluating a collaborative semantic web platform based on *NCRDO*.

GRAPHICAL ABSTRACT



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ABSTRACT

Tacit knowledge, which refers to the know-how, is critical to understand and reuse since it is located in the human heads. It represents the foremost element for human and team evaluation. Seeking for tacit knowledge is achieved only by communicating with the concerned persons, which makes losing it axiomatic if people leave their work without documenting their know-how. Thus, providing a collaborative environment based on a common conceptualization of the domain to formalize the experts' knowledge and to share their outcomes is required. However, some barriers pertaining to cultural and social factors such as personality traits impede capturing the conceptual model. To cope with these issues, we have proposed a generic two-step methodology that copes with human barriers when capturing the domain experts' tacit knowledge, their skills, and seeds terms in order to converge to a common knowledge representation. Considering the scientific research management as a use case, we followed the proposed methodology to formalize our scientific research knowledge in the context of network and communication research field. Based on the generated ontology, we have developed a semantic web platform that allows collaboratively annotating experts' knowledge in a computer interpretable format

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that can be shared and reused by human and machines. Our evaluation is based on end users' quality of experience and feedbacks.

1. Introduction

Research collaboration plays an important role in evaluating the research team outcomes [1,2]. Successful collaborations take place if research team members and/or external partners can smoothly communicate based on a sharable knowledge that reflects the team skills [3]. Currently, scientific research team knowledge is embedded in unstructured documents including published articles, internal team reports, figures, tables and videos representing demonstrations. Thus, information is everywhere, heterogeneous and poorly organized which hamper knowledge exchange and sharing, and make information seeking is time-consuming.

Advances in Knowledge Management (KM) based on Information Technology (IT) provide important means to increase productivity and achieve the team effectiveness [4] since it provides methods and tools that capture, understand, share, and facilitate knowledge access and reuse by team members to create value [5–7]. However, IT support cannot cover more than 10%–30% of KM [8]. More importantly, domain experts are the main knowledge source. Face-to-face interactions such as interviews, brainstorming, meetings, etc. are the keys for elucidating, capturing and sharing experts' tacit knowledge [9]. It is worth mentioning that the success of KM, especially which relies on the knowledge of experts, strongly depends on the acceptance of people involved in this process. At this end, human collaboration and participation is required to underpin an efficient knowledge transfer and sharing. Nevertheless, some cultural and social factors may hinder the progress of this process, especially if members may feel and think that knowledge sharing depletes the time and the efforts that can be invested in other activities more beneficial for themselves [10]. Moreover, each member has his/her own personality traits and characteristics, which makes managing a group of person complex, in particular if conflicts appear.

Consequently, to handle human barriers that may hamper extracting and sharing the experts' tacit knowledge, we propose a generic two-step methodology that describes processes and actors involved in the conceptualization and knowledge creation based on a multi-level approach. The objective of proposing a multi-level approach is to identify as a first stage a generic domain level that can be reused by any community/group of users interested to this domain, then extending it to support the user-requirements. We applied the proposed methodology to formalize and classify the scientific research activities within our SARA research team.[1]

The rest of the paper is organized as follow. Section 2 draws our proposed generic two-step methodology for experts' tacit knowledge conceptualization. Section 3 provides the results of applying the proposed methodology to formalize the tacit knowledge of our team experts. Section 4 presents our preliminary evaluation of the efficiency of the proposed methodology. Section 5 details existing researches dealing with collaborative scientific knowledge management and describes existing methodologies for building ontologies. Finally, Section 6 summaries our contribution and identifies our future research works.

[1] Services and Architectures for Advanced Networks- SARA: https://www.laas.fr/public/fr/sara.

2. A generic two-step methodology for building ontology

Our methodology follows a top-down approach [11] which is mainly composed on two steps as shown in Fig. 1: the "*Knowledge Organization*" that corresponds to conceptualizing and representing the knowledge in an appropriate format; and the "*Knowledge Acquisition and Reuse*" that allows the users collaboratively producing and consuming the knowledge. The "*Knowledge Organization*" represents the fundamental step. First, it identifies a core ontological model named *Core Reference Ontology (CRO)* describing the generic concepts and relations according to the formalized requirements. Then, it specializes these concepts to reflect the domain experts' skills and knowledge based on their collaboration, and generates the *Domain Specific Ontology (DSO)*. The main contribution of this methodology is to avoid conflicts and human barriers related to the personality characteristics when communicating with experts.

Based on an incremental approach, requirements are captured and refined with the collaboration of the leader expert. Thus, the key concepts of *CRO*, inference and inconsistency rules are identified (1, 2). After preparing the list of concepts and relations, the knowledge engineer identifies existing upper ontologies that can be reused and easily integrated with the *CRO* (3). To personalize the *CRO* in a specific domain, the domain experts are involved to enrich the *CRO* with their own vision and tacit knowledge.

It is truism that each person has his/her specific character and manners to communicate and express his/her knowledge. Studies in psychology have shown that knowledge sharing behavior among individuals is influenced by personality traits [12]. According to Pervin [13], personality refers "*to an individual's unique and stable pattern of thinking, feeling, acting and reacting to his or her social environment*". These patterns, which explain why some individuals are motivated to share knowledge while others are not, can be classified according to the big five taxonomy [14]: *extraversion* that refers to energetic people who prioritize harmony in their social relationships; *agreeableness* that concerns friendly and cooperative people; *conscientiousness* that refers to reliable and responsible people; *openness* to experience that encompasses imaginative and flexible people who are interested in learning new experiences; and *neuroticism* that concerns people who may rapidly experience unstable emotions such as nervosity and anxiety. Accordingly, to avoid barriers related to social and psychological dimensions, our methodology adopts an incremental approach in which the identification of the knowledge structure is decomposed into sub-steps. First, experts are split into groups (4). Each group includes experts working on the same research area. Then, for each group, individual meetings with each expert are organized to discuss with him/her, to formalize his/her vision and to acquire as much as possible knowledge about his/her work (5, 6). By this way, problems such as being influenced by colleagues high in extraversion, and avoiding conflicts with colleagues high in neuroticism are covered. Furthermore, according to the expert character, different methods and questions are adopted to extract his/her knowledge. For example, the knowledge engineer reviews some relevant publications of the expert and extracts a set of keywords that help animating the discussion in order to deal with problems pertaining to people less in agreeableness or less in extraversion.

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