Knowledge Management Framework using Wiki-based Front-end Modules

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Keywords: Semantic Wiki, Tacit Knowledge, Explicit Knowledge, Knowledge Management.

Abstract: Nowadays organizations have been pushed to speed up the rate of industrial transformation to high value products and services. The capability to agilely respond to new market demands became a strategic pillar for innovation, and knowledge management could support organizations to achieve that goal. However, such knowledge management approaches tend to be over complex or too academic, with interfaces difficult to manage, even more if cooperative handling is required. Nevertheless, in an ideal framework, both tacit and explicit knowledge management should be addressed to achieve knowledge handling with precise and semantically meaningful definitions. Contributing towards this direction, this paper proposes a framework capable of gathering the knowledge held by domain experts through a widespread wiki look interface, and transforming it into explicit ontologies. This enables to build tools with advanced reasoning capacities that may support enterprises decision-making processes.

1 INTRODUCTION

In the past, employees used to stay in a company for their entire professional life, and consequently, their knowledge as well. However, nowadays employees are switching jobs several times and when they leave, they take their knowledge with them (Kim, 2005). As a consequence, organizations must be able to capture their employees knowledge and experience to be able to change their personal knowledge into organizational knowledge, so it can be used when they are no longer with them (Jones and Leonard, 2009).

Knowledge can be considered as information that has been understood and embedded in the brain. Thus, it is difficult to transfer between individuals due its individual oriented nature (Osterloh and Frey, 2000). In this context, researchers consider tacit knowledge as the background knowledge a person uses when trying to understand anything that is presented to him (Polanyi, 1967). Explicit knowledge is another type of knowledge, which can be expressed in words and numbers, and can be easily communicated and shared in the form of hard data, scientific formulae, codified procedures or universal principles (Nonaka and Takeuchi, 1995). By transforming tacit knowledge into explicit knowledge, it can be consulted and used by a full community, instead of being locked in a single community's element. However the transformation of tacit knowledge into explicit knowledge can be considered one of the most challenging steps under knowledge management

The more communication, involvement, and interaction of people, more is the chance for organizations to expose tacit knowledge residing in individuals' heads. Thus, the importance of developing services or mechanisms to gather knowledge from domain experts has increased. As main actors, they are who better know how to characterize their domain. The result of involving them directly in the knowledge acquisition process and transformation into explicit knowledge is that tacit knowledge can be managed through communities' knowledge processes, namely: 1) strategic planning; 2) decision making; 3) marketing; and 4) hiring personnel (Jasimuddin and Zhang, 2013).

In this paper, an initial assessment related to the necessity of gathering individual's tacit knowledge and transforming it into explicit is conducted. Based on this necessity, a knowledge based establishment process is proposed where both knowledge engineers

Marques-Lucena C., Agostinho C., Koussouris S. and Sarraipa J..
Knowledge Management Framework using Wiki-based Front-end Modules.
DOI: 10.5220/0005351600790086
In *Proceedings of the 17th International Conference on Enterprise Information Systems* (ICEIS-2015), pages 79-86
ISBN: 978-989-758-096-3

and domain experts contribute to increase communities' knowledge (explicit knowledge). This approach will support a framework for knowledge management using simple wiki-based front-end modules where tacit knowledge can be expressed in a form of explicit knowledge directly by the different employees. Afterwards, an application scenario of the proposed framework followed by some conclusions and future work statements are presented.

1.1 Related Work

Knowledge management tools are pieces of software that enable the user to create, edit or perform other operations over explicit knowledge forms (e.g. ontologies). In Youn et al. (2009), is stated that ontology tools can be applied in all the stages of the ontology life cycle (creation, population, validation, deployment, maintenance and evolution). Some ontology management tools to consider are Ontopia[1], TM4L (Dicheva and Dichev, 2006), and Protégé[2]. They are all very complete, since they all provide support to several types of ontology languages (OWL, RDF, XML) and graphic visualization methods. However, in what concerns domain experts usage, they may be difficult to use without knowledge engineers support. For that reason, the suggested knowledge management approach relies in the collaborative aspects of Semantic wikis to allow collaborative knowledge management in a iterative way by domain experts, which might not have the technical skill required for complex solutions. By using widespread and well-accepted wiki technology, domain experts are able to model and update their knowledge in a familiar environment by reusing externalized knowledge already stored in wikis.

Semantic wikis enrich wiki systems for collaborative content management with semantic technologies (Krötzsch et al., 2007). An overview of relevant research can be found in Völkel (2006), where is possible to verify that prominent wikis like Semantic MediaWiki (Krötzsch et al., 2006), ikeWiki (Schaffert, 2006), and SemperWiki (Oren, 2005), manage to disseminate semantic technologies and are used to support several semantic applications. Thus, domain experts and ontologies are able to cooperate in one system while wiki pages are presented in a human-readable format in parallel to the formal ontologies. Some works to consider are Vrandecic and Krötzsch (2006), and also Dello et al. (2006). In the first work, the authors gather wiki knowledge by defining a set of relations between Semantic MediaWiki annotations and OWL DL concepts (Vrandecic and Krötzsch, 2006). In the latter, the authors also focus on Semantic MediaWiki annotations, but with some interactive assistance to support users in the knowledge representation process (Dello et al., 2006). They provide functionality for collaboratively authoring, querying and browsing Semantic Web information. In both their works, explicit knowledge is achieved through a set of mappings that relate with ontological concepts. This is very powerful when one is aiming to build machine reasoning and intelligence capabilities. Nevertheless, in their proposal, all the textual and descriptive information is lost, which can be a major drawback when a feedback loop based on natural language needs to be maintained with Human users. The proposed work addresses this challenge complementing the state of the art by building a knowledge base where not only annotations are used to create ontological relations, but also content from wiki articles, gathering natural language descriptions in data properties, and consequently obtaining a richer representation of a domain.

[1]http://www.ontopia.net/page.jsp?id=about

[2]http://protege.stanford.edu/

2 KNOWLEDGE BASE ESTABLISHMENT PROCESS

The proposed knowledge base establishment process intends to enable knowledge management features, able to facilitate the gathering of tacit knowledge and transforming it into explicit knowledge, ready to be used by a specific community. It is a fact that when an information system intends to represent a domain's knowledge it needs to be aligned to the community that it represents. Consequently it is required to have a solution where community members could present their knowledge about the domain and discuss it with their peers. Additionally, such knowledge must be available and dynamically maintained by all the involved actors. The proposed knowledge base establishment process is based on Sarraipa et al. (2014) and it is presented in Figure 1. As can be observed, one of the knowledge management approach components is an explicit information front-end, where the knowledge is kept in a format that allows domain experts to utilize it. In turn, domain experts need to be able to use the explicit information to turn it into their own personal knowledge in order to create and share additional (explicit) knowledge from it. This corresponds to the bottom cycle of Figure 1, which is aggregated through automatic synchronization with the upper cycle of the figure, in such way that if there is new knowledge added by a domain user, it would smoothly be available in the knowledge base for any further community application (e.g. enhanced searching or reasoning services).

The result is an ontology, whose model is constantly refined accordingly with the explicit information front-end module in order to better handle the knowledge provided by the domain experts. Depending on the ontology structure, synchronization services between the front-end and the ontology are implemented.

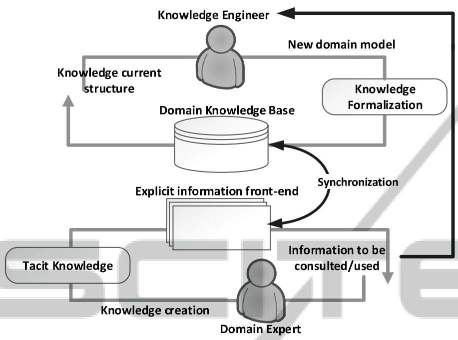

Figure 1: Knowledge Management approach.

2.1 Framework for Knowledge Management

The framework instantiates the knowledge management approach and uses ontologies and wiki front-end modules, able to facilitate the achievement of explicit knowledge from domain experts' tacit knowledge. Since the knowledge is constantly refined and updated by the domain experts' community, it would allow to make decisions based on individual's tacit knowledge. As can be observed in Figure 2, the proposed framework is composed by four modules: 1) wiki-based front-end; 2) Synchronization module; 3) Knowledge Base; and 4) Reasoning and Decision Making module. Framework's input is the front-end user's knowledge, which is processed and consumed by the community that uses it to re-feed this cycle with more knowledge.

The first module is a wiki-based front-end which corresponds to the explicit information front-end of the knowledge base establishment process presented in Figure 1. It is characterized by being collaboratively edited by domain experts based on the knowledge consulted. However, the content of wiki-based front-ends is characterized by being human readable only. This means that its content is not formalized to facilitate computerized use (e.g. reasoning). For that reason, the synchronization module is composed by 2 sub-modules: 1) Contents formalization; and 2) Synchronization. In the contents formalization sub-module a knowledge formalization methodology is

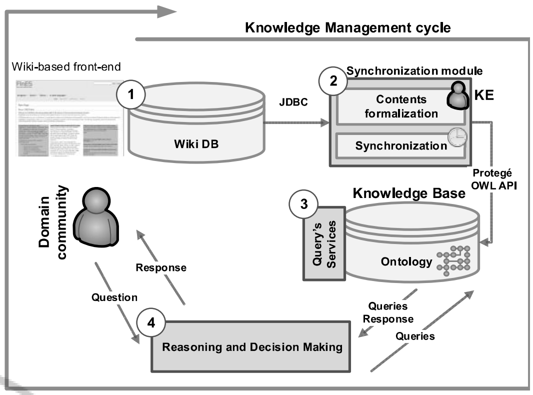

Figure 2: Framework for Knowledge Management using wiki-based front-end modules.

required and will be presented in the next sub-section. The synchronization sub-module is responsible for the synchronization itself between the knowledge provided by the domain experts in the front-end and the domain knowledge base.

The purpose of the ontology, modeled by knowledge engineers, is to hold the explicit knowledge about a domain in a formalized way so that it can be used by the community for reasoning purposes. Such functionality is performed by the module Reasoning and Decision making, which is able to provide structured and useful contextual information.

2.1.1 Wiki-based Front-end Contents Formalization Methodology

Wiki-based front-ends are encyclopaedias that are collaboratively edited by its users, which contribute with their (tacit) knowledge. A key factor to extract knowledge from wiki-based front-ends is that such pages often follow a global template that facilitates the retrieval of information. Such front-ends provide categories that are used to classify articles and other pages. These categories are implemented by MediaWiki[3]. They help readers to find, and navigate around, a subject area, to see pages sorted by title, and thus find articles relationships. One particularity is that the resulting category system can consist in a hierarchical representation of categories related, as an example, by the relation 'is a', as the classes in an ontology.

Organized using several body sections, wikis use their headings to clarify articles and break the text, organizing its content (e.g. article title, sections, subsections). Some sections of articles can contain hyperlinks, and they point to a whole category, article or specific element of an article. A hyperlink between

[3] http://en.wikipedia.org/wiki/MediaWiki

several pages, can somehow, be compared to a relation between instances of an ontology. Therefore, the organization of an article can be seen as a characterization by properties of its content (object and data properties).

Based on that organization of wiki-based front-ends the methodology for contents formalization of Figure 3 is proposed. As can be observed, the step 0 of the methodology consists in the creation of a wiki root class in the ontology. It will handle the knowledge represented by the domain experts in the wiki-based front-end. The process of assigning categories to other categories, in the proposed methodologies (step 1), will be used by the knowledge engineers to build ontology's classification taxonomy, being the tagging between them handled as the ontological relation 'is a'. The classification of categories' contents can be facilitated if a classification taxonomy of those contents is defined (step 2). This will allow to better structure the gathered knowledge and visualize relations between knowledge base's instances.

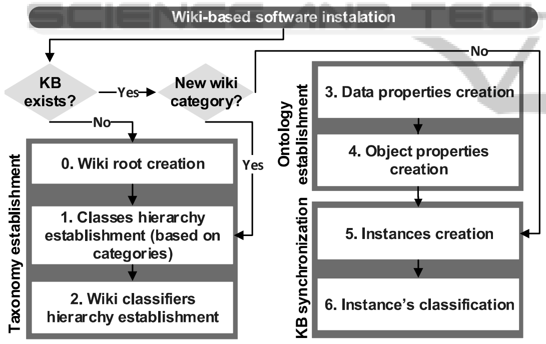

Figure 3: Methodology for wiki-based front-end contents formalization.

In this methodology it is assumed that the content of all pages under a specific category follows the same structure. With that assumption, it is possible to follow with the steps 3 and 4 of the methodology. In step 3 and 4, for each article section is created a data property or object property to represent that knowledge in the ontology. The object properties created will connect the classes under the wiki root class and those under the classifiers taxonomy previously defined. Data properties will represent knowledge that is not under that taxonomy.

The process of assigning articles to categories, in the proposed methodology (steps 5 and 6) will be used to instantiate the ontology. This is done by creating an instance under the class with the article's category name (step 5). Then, based on HTML analysis of articles' content, the knowledge of its sections can be represented in the data and object properties of the previously created instance (step 6).

The methodology also covers the creation of a new category on the front-end after the knowledge base is defined. It is aligned with the necessity of domain experts to share new kind of knowledge, which is not formalized yet. An example of how the methodology here presented is used can be found on section 3.2.

2.1.2 Synchronization between Wiki-based Front-end Modules and Ontologies

The synchronization module runs periodically and starts by connecting to the wiki front-end database in order to verify if any changes occurred since its last run. JDBC (Java Database Connectivity) is used to querying the front-end database[4]. By querying the wikimedia table 'recentchanges', the authors have access to the set of changed pages, and its type: edition, creation, or removal. If the change is an edition or a creation, through the link to the table text (links to new & old page text) it is possible to have access to the current content of the front-end page.

After the collection of the recent changes the HTML of each article or category's page is processed in order to create/ populate the necessary instances, data properties and object properties in the knowledge base (steps 5 and 6 of the proposed methodology). In these steps of the execution flow it is also verified if the information remains consistent (e.g. the pages (articles) of the same category have the same structure). After the processing of all detected changes, the update of the ontology is made. This update is made using Jena OWL API. It provides the necessary classes and methods to load and save OWL files and to query and manipulate OWL data models.

3 SUPPORTING THE EISB DURING THE ENSEMBLE PROJECT

ENSEMBLE (Envisioning, Supporting and Promoting Future Internet Enterprise Systems Research through Scientific Collaboration)[5], was a Support Action funded by the European Commission (EC) that coordinated and promoted research activities in the domain of Future Internet Enterprise Systems (FInES), providing a sustainable infrastructure for the FInES community to contribute and support the EISB (Enterprise Interoperability Science Base) initiative

[4]http://upload.wikimedia.org/wikipedia/commons/4/41/Mediawiki-database-schema.png

[5]http://www.fines-cluster.eu/jm/ENSEMBLE-Public-Category/ensemble-objectives.html

(Jardim-Goncalves et al., 2013), as well the 2015 Roadmap (FInES Research Roadmap Force, 2012). The FInES cluster, now DBI community[6], has been supported by the EC in support of the Digital Agenda for Europe, a flagship initiative of the Europe 2020 strategy.

The following scenario is related to the gathering of tacit knowledge from the FInES community and transforming it into explicit knowledge, so that it could be available to the full community, and support knowledge intensive initiatives such as the EISB. To achieve that, a wiki-based front-end (explicit information front-end) has been used, the FInESPedia[7]. It provides explicit knowledge to the community users and allows them based on that, to create new tacit knowledge and post it in the front-end. Moreover, the knowledge provided by the users is formalized in the EISB reference ontology.

3.1 FInESPedia

FInESPedia aims at providing an overview of the state of the art in Future Internet Enterprises Systems. This source of knowledge, more focused on the collaborative gathering and sharing of information from domain experts, is accessible through the FInES cluster portal[8]. As can be observed in Figure 4, its homepage is dived into four main sections, namely: 1) FInES Research Roadmap 2025; 2) FInES Position Paper Towards Horizon 2020; 3) Enterprise Interoperability Science Base (EISB) where this use case is focused; and 4) FInES Task Forces.

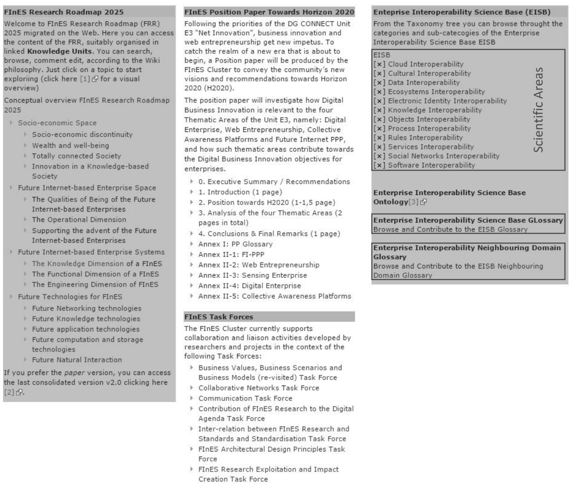

Figure 4: FinESPedia Main Page.

[6]http://www.dbi-community.eu
[7]http://finespedia.epu.ntua.gr/
[8]http://www.fines-cluster.eu/jm/

Going into further detail (on the EISB), the FInESPedia is essentially composed by Scientific Areas, EISB Glossary and also the Neighbouring Domains Glossary, that are being synchronized with the EISB ontology, as explained next. To the formalization of FInESPedia front-end knowledge, the methodology of section 2.1.1 was followed.

3.2 Application of the Methodology

The EISB knowledge base is a component that intends to capture ENSEMBLE community knowledge with precise and semantically meaningful definitions. As explained along the paper, it also serves as a facilitator for knowledge reasoning, allowing different views of the information gathered from the wiki. Having this kind of knowledge would facilitate the search of specific information, for instance papers or methods of a specific EISB area, or a specific set of tutorials related to a specific EISB topic, or even a set of expert researchers. Furthermore, this ontology can be a valuable asset for the scientific base itself, gathering meta-information relevant to both Enterprise Interoperability and the neighbouring domains (Agostinho et al., 2009).

3.2.1 Taxonomy Establishment based on the Methodology

Figure 5 represents the application of the methodology to establish the knowledge base taxonomy. As can be observed, step 0 of the methodology consists in the creation of the class 'EISB_Wiki', which will handle the categories' taxonomy represented in the wiki-based front-end.

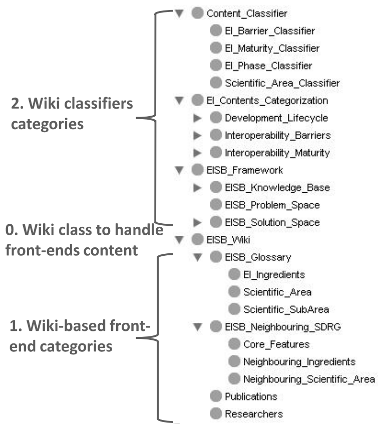

Figure 5: Knowledge Base's taxonomy establishment.

The step 1 of the methodology was accomplished by navigating in the front-end articles' category classification, as was explained in section 2.1.1 It results in the identification of four main classes to be handled under the class 'EISB_Wiki':

- EISB Glossary - Representation of the contents of the glossary page of FInESPedia, including: EI Ingredients, including the detailed information about the various EISB ingredients (e.g. methods, tools, experiments); Scientific Area, regarding the EISB scientific areas represented in the wiki page; and Scientific SubAreas, regarding scientific sub areas represented in the FInESPedia (Lampathaki et al., 2012);
- EISB Neighbouring SDRG - Serves the same purpose of the EISB Glossary, but refers to the Neighbouring domains instead; (see Agostinho et al. (2014) for technical details on the neighbouring domains);
- Publication -Information regarding the publications presented in FInESPedia;
- Researchers -Information about the researchers acting in the EISB community.

Step 2 of the methodology consists in the categories contents' classifiers. This is a knowledge engineers' works in which they analyze the knowledge that the domain experts want to represent in order to create a classifiers taxonomy from it. The four main classes of the classifiers taxonomy are:

- EI Contents Categorization - that aims to represent the information about the different categories that the content of the wiki can take, namely: Interoperability Maturity, which holds the information about the various maturity models available; Development Lifecycle, which houses the information about the different development phases of certain publication (Assessment, Design, Implementation); and Interoperability Barriers, Indicating which type of EI barrier is targeted accordingly with the image of the ISO standard 11354 (ISO/TC 184/SC 5, 2011);
- Content Classifier - which stores information relative to classifications of the EISB contents: EI Barrier Classifiers, which assigns (High-Low) relevance of a certain content regarding its interoperability barrier (e.g. Technical- High); EI Maturity Classifier, which has the information relative to the maturity of the wiki content (e.g. mature, infant,); Phase Classifier, which classifies publications relatively to its development lifecycle (e.g. Design-High); and Scientific Area Classifier, which classifies a wiki content with the relevance pertaining to a certain scientific area (e.g. Data Interoperability - Medium);
- EISB Framework -the purpose of this class is to hold information about the elements that compose the EISB universe. It handles the knowledge about the framework components: EISB Knowledge Base (the scope of the previous descriptions); EISB Problem Space; and EISB Solution Space (Hypothesis, Laws, etc.) (Agostinho et al., 2009).

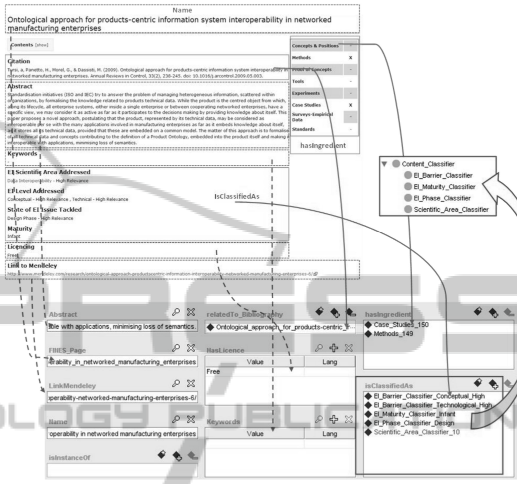

Figure 6: New Publication demonstration Scenario.

3.2.2 Ontology Properties Establishment based on the Methodology

In this subsection, the steps 3 and 4 of the methodology are demonstrated. The type of pages that were selected to exemplify the methodology were those under the category 'Publications'. It was assumed that the articles under this category follow the same structure of the page illustrated in the top of Figure 6. Concerning its content and the classifiers taxonomy established on step 2, the data properties (green dotted areas of Figure 6) defined are: 'Abstract'; 'FINES_Page'; 'Keywords'; 'HasLicence'; 'Link_Mendeley'; and 'Name' (step 3 of the methodology). The object properties (blue line continued areas) defined were: 'hasIngredient'; 'IsClassifiedAs'; and 'related_to_Bibliography'.

3.3 Ensemble's Knowledge Base Synchronization

After structuring the information retrieved from the wiki front-end, and concerning the scenario of a new publication creation, it is possible to do the synchronization between the front-end and the ontology in order to populate the knowledge base with domain experts' knowledge. The synchronization tool is triggered by a 'cron job' that runs daily. Then, the recent changes are analysed in order to verify if there is any new publication in the FInESPedia. That verification is made by analysis of the HTML content of the pages to verify in which category the page belongs.

The wiki front-end to ontology synchronization of a new publication is illustrated in Figure 6 It is possible to verify that the various sections of the wiki page have a direct correspondence in the ontology (result of knowledge engineers work), and all the contents are therefore successfully migrated. It is also possible to verify that the object property 'IsClassifiedAs' relates the wiki pages content with a taxonomy under the classifiers defined in step 2.

After contents formalization, the knowledge management framework is capable of handle articles' creation, edition and elimination without the intervention of knowledge engineers. However, if other non-modelled category occurs (other type of tacit knowledge), knowledge engineers need to re-follow the proposed knowledge structuring methodology. In such way, the new sub-domain knowledge inserted by the domain experts can be transformed into explicit knowledge to be presented to the community.

3.4 Enabling the Integration with Other Works

By having explicit knowledge formalized, it also becomes much easier to integrate complementary knowledge. In the case of ENSEMBLE this situation became very clear with the example of the FInES 2025 roadmap. Like the EISB, also the roadmap has been supported by an ontology for knowledge management with a wiki front-end (in this case only to visualize information). Due to both ontologies links were easily defined between knowledge domains, enabling readers to navigate through the wiki between the roadmap and the EISB knowledge, increasing their awareness of the FInES and enterprise interoperability domains.

4 CONCLUSIONS

To increase the competitiveness level, organizations must be able to keep its employees knowledge inside the organization, even when they leave. The same happens with researchers and scientists so that the community can capitalize their knowledge. Hence, responding to those needs, a knowledge management framework based on wiki front-end modules was implemented. With the proposed framework, domain experts can actively contribute to the knowledge of their community through a simple and, considerably well-known interface, as wiki-based front-ends. This kind of front-ends are known by being easy to setup and use, tracking of changes, and on-the-fly publishing. Thus are being largely selected to share knowledge in several areas like teaching (Parker and Chao, 2007), collaborative modeling (Dengler and Happel, 2010), process development (Dengler et al., 2009), and others. However, beside the mentioned advantadges, wikis are also characterized for being human readable only. This means that its content is not formalized to facilitate computerized use, an issue addressed by Semantic wikis. Most of the state of the art solutions are based on mappings between semantic annotations and ontological relations. The presented solution is able to complement that, handling all of the wiki articles content in natural language.

This paper proposes to use simple web-based interfaces, in the form of wiki modules, which allow domain experts to contribute with their tacit knowledge through an intuitive front-end. That knowledge is then transformed into explicit knowledge, in the form of ontologies, following a semi-automatic methodology. With this process, knowledge becomes available for querying and intelligent reasoning. Other knowledge bases can be integrated, providing users extended awareness of the domain and enriched feedback information that can motivate the refinement of the front-end and more suitable decisions.

The Authors applied successfully these ideas in the ENSEMBLE case and are currently working on forms to decrease the level of participation of knowledge engineers in tacit knowledge gathering. Currently, in order for a new concept to be detected and formalized in the ontology, knowledge engineers need to be constantly verifying the wiki contents and manually instruct the synchronization tool to recognize and handle such knowledge. In future work, the authors plan to automatize such procedure. Moreover, when the knowledge is gathered by a full community, an article can be edited several times and, it may be useful to keep track of those changes in the ontology (e.g. versioning mechanism). As an instance, the amount of changes that a page suffers in a specific period of time can be an indicator of a community interest in a specific topic. Also, the authors intend to apply this approach to other domains of knowledge management (e.g. requirements engineering, collaborative education curriculum creation, etc.).

ACKNOWLEDGEMENTS

The research leading to these results have received funding from the European Union 7th Framework

Programme (FP7/2007-2013) under grant agreement: ENSEMBLE[9] n 257548, ALTERNATIVA[10] , and also through OSMOSE[11] nr 610905 which is enabling to continue this line of research.

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