38 THE SOCIO-TECHNICAL DESIGN OF A SME KNOWLEDGE COMMUNITY IN THE CONSTRUCTION INDUSTRY

Dora Simões[1,3], António Lucas Soares[1,2]
INESC Porto[1], Faculty of Engineering Univ. Porto[2], ISCA Univ. Aveiro[3], PORTUGAL
dora.simoes@isca.ua.pt, asoares@inescporto.pt

This paper presents the socio-technical design of a knowledge community which is part of a system to support an industrial association based collaborative network in the sector of construction industry. There are many explanations around the virtual community concept. Here is presented a fundamental phase of the Know-Construct project which involved the design of the Construction Industry Knowledge (CIK) Community using three analytical approaches. The generic architecture of the supporting system (Knowledge Community Support - KCS) is described, highlighting information and knowledge management, community building facilities and semantic resources management.

1. INTRODUCTION

It is well known that organizations and the environment in which they operate have changed considerably in the last few decades. The particular case of the organizations in the construction sector is no exception to the rule. They too have to renew themselves rapidly in order to adapt to a more competitive and changing environment, be much more flexible than in the past and also need more sophisticated ways of managing their knowledge assets. Most of knowledge management systems have emerged from document-centric approaches and are able to efficiently support, although only a fraction, of the whole knowledge cycle (classifying, storing, and retrieving knowledge).

The Know-Construct project[1] intends to improve the effectiveness of the Construction Industry (CI) SME's by enhancing and extending the relationship with their customers through an innovative support regarding information and knowledge about products, processes and associated issues. This is achieved through specifically developed tools, supporting in particular the formation and operation of SME's knowledge communities in the context of Industry Association Groups (IAG). More concretely these objectives are to:

- Provide a platform to support the creation and management of a community of CI SME's, coordinated by an association, fostering collaboration and

---

knowledge sharing among its members. Knowledge to be shared includes, besides product and services information; companies' experience (e.g. best practices). This will lead to a wider and deeper technical and professional competence shared by the SME's community, fundamental in its ability to satisfy customer needs, obtained through closer co-operation and knowledge exchange.

- Provide problem-solving support to the individual IAG member's customers regarding the selection of products, their applications and processes, as well as addressing other related problems such as legislative issues, safety issues etc. This will be materialized as an internet-based platform that will offer the possibility to establish a "one to one" communications medium. Manufacturers and wholesalers (SME) may interact with their customers, advising them on specific topics relying also on knowledge created and maintained by a community of SME's mentioned in the previous point.

KC system was then designed to provide comprehensive services to their users regarding a large scope of construction issues, although centred in the SME knowledge community.

This paper describes a fundamental phase of the project which was the characterization of the Construction Industry Knowledge (CIK) Community and the generic architecture of the supporting system (Knowledge Community Support - KCS).

2. CHARACTERIZATION OF THE CIK COMMUNITY

There are many explanations around the community concept. After thorough review of the literature on this subject, we characterize CIK community according three approaches that we agree to be of great importance to the success of creation and maintenance of this community. Accordingly the CIK Community is characterized based on: type of utility, participant's behavior and typology.

2.1 CIK Community as Hybrid Community

The classification of different types of utility (Cornejo, 2003) presents a basic predictive model of different types of communities, with particularly relevance for those that can generate some type of utility for someone. We therefore classify the CIK Community as a hybrid of a *Practice* and *Interest Community* (see Figure 1). On the one hand, company employees as individuals should see a direct utility to their particular jobs when participating in the CIK community. On the other hand this direct utility also comes into light when an employee (and consequently the company) realizes that, when solving a problem for an important customer, the information/knowledge used to reach the solution has been contributed by other community members. Nevertheless, not all the activities can be tracked to a causal benefit to the SME. For example, a chat session between two employees exchanging professional experiences or a report on a concern regarding the performance of a material in a news or blog item by another employee, are activities that make sense in a community but cannot be assigned a concrete and immediate value for the organization.
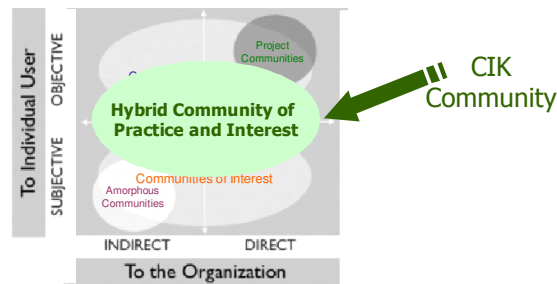
Figure 1 – CIK Community on Quadrant of Communities of Cornejo (2003)

2.2 CIK Community as Professional Community

Looking at professional development as the process of continually developing knowledge, skills and attitudes of professionals by means of formal and informal learning in the course of practice, the use of on-line knowledge communities for this, implies that an on-line knowledge community has to support this process. As a KC community member, professionals in the construction sector will have a place for continual professional development that gives: individualized, flexible and easy access to a coherent and current knowledge domain, a range of opportunities to interact with like-minded persons, and a range of opportunities to develop and exploit the knowledge domain. An example of this is: applying knowledge, learning from it, guiding others, disseminating ideas and results or doing research, embedded in a professional network. What do we expect from this use? Given the discussion so far, our premise is that the membership of professionals of an on-line knowledge community will have positive effects on their continuing development not only expressed in competences like knowledge, skills, experiences and attitude, but also, the development of organizational knowledge assets expressed in the growth and elaboration of the professional knowledge, applicability of knowledge and legitimacy of knowledge.

So, based on work of de Vries *et al.* (2004), we synthesize the following characteristics of CIK Community:

- The goal is to **develop and exploit knowledge** about civil construction sector.
- There are continuous interactions between participants in order to meet these goals.
- Information and communication processes are continuously made explicit.
- It **adds value to the participants** (professionals within the sector and customers alike).
- The on-line meeting place that is **usable**.
- The **culture focuses on the needs of the participants** as the route to high performance; involvement and participation create a sense of responsibility and ownership and, hence, greater commitment to the community.
- The context is highly complex and constantly evolving and the CIK Community will have to **continuously comply with the expectations** of its participants and their contextual of use of the system.

2.3 CIK Community as a Organization-Sponsored Community

Based on the typology of virtual communities proposed by Porter (2004) where the communities are classified under two levels: establishment and relationship orientation (see **Figure 2**), we classify the CIK Community as an organization-sponsored community relatively to **type of establishment** and as commercial community relatively to the **relationship orientation**. CIK Community will be a commercial organization-sponsored community because it will be sponsored by commercial organizations (SME's and associations) of the construction sector. This community will have key stakeholders and/or beneficiaries (ex. customers) that will play an important part in sponsoring the community's mission and goals. Being an organization-sponsored community, will foster relationships both among members (e.g. professionals belonging to the associations of the project partnership) and between individual members (e. g. customers) and the sponsoring organizations (associations of the project partnership).
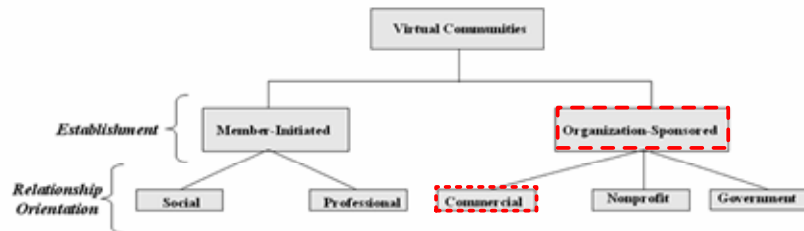

Figure 2 - Typology of virtual communities (Porter, 2004)

Based on the classification of the CIK Community under the virtual community concept and the attributes commonly suggested in the literature to characterize virtual communities (Mueller-Prothmann and Siedentopf, 2003; Blanchard, 2004; Burnett, G. and Buerkle, H., 2004), we now specify the key attributes of the CIK Community. The key attributes that will allow characterization of the CIK Community can be summarized as the Five Ps (Porter, 2004): Purpose (Content of Interaction), Place (Extent of Technology Mediation of Interaction), Platform (Design of Interaction), Population (Pattern of Interaction) and Profit Model (Return on Interaction).

Table 1 - Conceptualization of the CIK Community attributes

Purpose	To share professional knowledge aiming to provide a better individual service to company's customers.
Place	Virtual place where companies develop and maintain social and economic relationships, mostly virtual, but also physical (e.g., association meetings, customer contacts, etc.).
Platform	Synchronous and asynchronous communication (hybrid). Interactivity is multi-modal: co-presence based interaction through instant messaging; differed interaction through basic mechanisms such as forums or weblogs, and through complex tools such as content management tools, fostering coordination mechanisms (workflow).

Population	The Association is both the context of interaction and an actor in it. Companies and individual professionals are actors. Individual professionals can assume both an individual role (the professional) or organizational role (company's representative). Customers can assume also the role of actor in the community. The motivation of the interaction is due to both individual interests and company orientated goals. Companies also look for enhanced reputation and improved levels in efficacy and efficiency. Individual professions may also seek peer recognition and personal improvement. Such companies, associations and individual professionals are geographically and socially dispersed and focus on the functional benefits of the community such as information acquisition or problem solving. It is likely that the interaction patterns will be characterised by a mix of small group characteristics (where strong ties tend to dominate), and network characteristics (where weak ties are prominent and stressful ties are likely). Relationships are addressed by user needs, where small group and network attributes are blended.
Profit model	Revenue generation of individual companies in the construction sector. Although the CIK community will provide mainly intangible benefits, it is expected that by providing a better service to customers, individual companies will increase their revenues.

2.4 CIK Community Concept

To summarize we define the CIK Community as *an aggregation of professionals and customers who interact around a specific shared interest of construction sector, sharing information and knowledge about products, services, techniques, legal aspects, experiences, etc, and where the interaction is totally supported and/or mediated by web technology and guided by some agreed protocols or norms*.

3. THE GENERIC ARQUITECTURE OF KCS SYSTEM

As mentioned before, the KC project has a very specific goal: to enable individual SME's to better solve the problems of their customers. Therefore, KCS is focused on pursuing this goal in the first place. Although a knowledge community encompasses, as stated before, mechanisms that surpass this simple instrumental goal, the initial vision of the KCS system was specifically conceived with this in mind. This means that the KCS system supports CIK community building in a broad sense, though focused fundamentally in generating wide ranging and detailed knowledge to be used in managing the SME's customers' relationship, particularly in problem solving. The operationalization of the KCS system is made through the use of mechanisms (Nabeth et al., 2002; Hearn et al., 2002; Simões and Soares, 2004) that will allow:

1. For the support the social processes (trust building, group formation and coordination), i.e., conditions for tacit knowledge exchange;
2. For increased levels of interactivity and to stimulate the dynamic exchange of knowledge (collaborative content management systems);

3. To support the personalization of user interaction (via the selection and presentation of content), maximize the impact of distributed knowledge and also to facilitate the development of new relationships between the users).

3.1 The KCS system concept

Keeping in mind the basic idea that the KCS system should support the CIK Community building in a broad sense, but focused fundamentally in generating a knowledge base that is as comprehensive and detailed as possible to be used in managing the SME's customers' relationship, particularly in problem solving, the following general functions (see Figure 3) of this module were specified:

1. **Community building tools**: this part of the KCS system supports the processes of community building by providing the instruments to foster professional interaction and socialization. Forums and weblogs are two such instruments and are tailored in KCS to be tightly integrated with the semantic structure supporting knowledge management in KC.
2. **Semantic resources management**: this is the infrastructure and corresponding set of functionalities that support information and knowledge acquisition, organization and storage in KCS system. More specifically, they enable the (i) management of classifications, thesauri and vocabulary, (ii) the acquisition of knowledge from digital content (including forums and weblogs entries, web pages, etc.) both internal to the CIK and from external sources, (iii) the maintenance of an ontology which is the base of knowledge representation, access and storage.
3. **Knowledge resources access**: creating, searching and updating knowledge resources is a fundamental set of functionalities in KCS. Although much of the community's information/knowledge will be created in communication/interaction processes (forums, weblogs), there will be also the need to create/access knowledge in a more structured way. Digital content management and document management are the natural approaches regarding this issue.

3.2 The KCS system layers

This generic architecture can be decomposed in two layers: *KCS Core Services layer* and *Systems/Applications layer*. KCS Core Services layer provide a set of services centered in the semantic resources management of KC.

The basic architectural idea of KCS is to have a set of services to be used by specific, adaptable and, eventually, off-the-shelf systems/applications. The rationale is to take advantage of as great a number of open source systems/applications as possible that already provide the end user functionalities required in a knowledge community. For example, we can use a content management system (CMS) such as Zope/Plone[2] or OpenCMS[3] providing off-the-shelf functionalities to organize reports, data sheets, legal documents, and to publish web pages related with some community topic. The CMS is configured and extended to use content/document services, search services and semantic navigation services in order to provide value added knowledge management to the community.

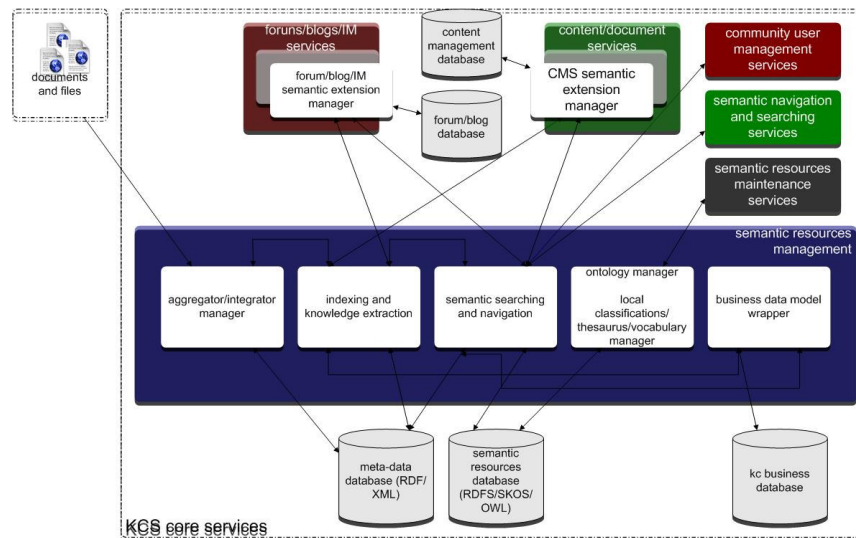[2]   http://plone.org
[3]   http://www.opencms.org

Figure 3 – KCS System Functional Architecture

The KCS core (see Figure 4) services are divided into a *Semantic Resource Management* layer and a set of functionalities that provide the systems/applications with access to the semantic resources as described below.

Ontology manager - this part of the semantic resources management deals first with all the aspects of maintaining the CIK community's ontology and allows users to: browse the entities, add/remove concepts/relations, create new attributes, deprecate a concept, import taxonomies, and configure system settings. It should also handle multilingual ontologies. Closely related with the ontology manager, is the *local classification/thesaurus manager*. Classifications, thesaurus, vocabularies are important semantic resources in the CI sector. This functionality is fundamental in managing the local aspects of the CIK community.

Indexing and knowledge extraction - a CIK Community is a dynamic social organization. It is obvious that the community knowledge will evolve and consequently, that the way in which the participants organize their knowledge will also change with time. This requires that KCS system be able to cope with these dynamics by enabling the CIK ontology to be (to some extent) automatically updated from the knowledge sources managed by the community (documents, web pages, etc.) and from content generated interactively such as weblogs and forums entries. This sub-system provides a set of functionalities that implement the before mentioned ontology updates, as well as functionalities to classify the digital content used by the community.

Semantic searching and navigation - this is a set of services provided to the upper layer systems/applications for searching and navigating the KC content using the ontology/thesaurus as the underlying structure. In order to support the KC system's sophisticated searching capabilities, this set of functionalities includes the capacity to search and reason about metadata.

Aggregator/integrator - specific external knowledge sources related with the CIK Community must be accessed by the KC user. This part of the semantic

resources management will aggregate meta-data descriptions in the case these are available. If they are not, this manager will support the generation and integration of the metadata.

Business data model wrapper - provide access to relevant content in the KC business database through the metadata structure. The relevant content is indexed and will be accessed through the semantic navigation and searching services.
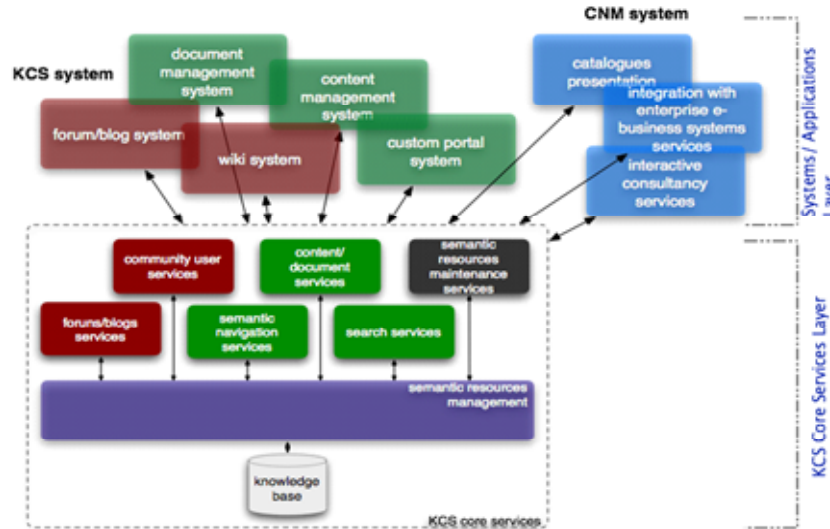

Figure 4 – KCS Core Services

Besides the semantic resources management functionalities, the KCS system core services will provide a set of functionalities to link the KCS semantic resources to the end-user systems applications. These include:

- **Content/document services** - these are the services that provide access to indexing, knowledge extraction, semantic navigation and searching for the content and document management functionalities.
- **Forums/weblogs/IM services** - these are the services that provide access to indexing, knowledge extraction, semantic navigation and searching for the forums, weblogs or instant messaging functionalities.
- **Semantic navigation and search services** - will provide access to semantic navigation and searching to upper layer applications that are not part of the two previous categories.
- **Community user management services** - these services encompass all that is necessary to create, maintain and access the profiles of the end-users from a community point of view. This includes the support to social relationships through sophisticated searching and matching of profiles and content.
- **Semantic resources maintenance services** - the maintenance of the CIK ontology and the local ontologies is accessed by the upper layer applications through these services.

3.3 The KCS system design

Semantic web technologies are a fundamental option if the KCS is to provide complex information retrieval, both internally and externally to the CIK community. We think that compliance with the semantic web is potentially one of the major success factors for Know-Construct. This concurs with the opinion expressed by the CEN Workshop Agreement on European eConstruction Ontology (EeO) (CWA 15142, 2004) stating that it is possible to rely on a standard "foundation" where complementary efforts can be combined in a harmonic and holistic way, especially regarding the developments related to the Semantic Web.
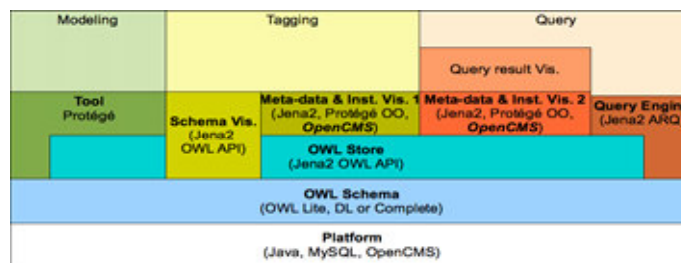

Figure 5 - KC high-level design and development tools

A strategic aspect then to be considered is the compliance with the Semantic Web in the sense that the European Ontology for the construction sector has to be aware of the recommendations and developments promoted, mostly, by the W3C. According to this view, a high-level design was developed which organizes KC functionalities in four main areas: modelling (ontology development and use), tagging, query, and visualization. As infrastructure and development tools, Jena2, Protégé, and OpenCMS were chosen (see Figure 5).

4. CONCLUSIONS AND FURTHER WORK

In this paper was presented the characterization of the Construct Industry Knowledge (CIK) Community according to three approaches in the context of the Know-Construct project. Summarizing, the CIK Community was conceptualized as *an aggregation of professionals and customers who interact around a specific shared interest of construction sector, sharing information and knowledge about products, services, techniques, legal aspects, experiences, etc, and where the interaction is totally supported and/or mediated by web technology and guided by some agreed protocols or norms*.

To present the generic architecture of the KCS (Knowledge Community Support) system that supports the CIK community, it was described the concept, layers and high-level design of KCS system. The high-level design organizes KC functionalities in four main areas: modelling (ontology development and use), tagging, query, and visualization. The future work will involve, obviously, the implementation and validation of the system. Further, one of the crucial development and validation tasks are related with the ontology implementation and the associated functionalities. Although the phase regarding the analysis and specification of the CIK ontology (high-level) and local ontologies integration

process definition has been comprehensive, and involved the users (Soares *et al.*, 2006), it has been necessary to refine the requirements and design options through the use of an early prototype. This process is complex as we are dealing with virtual communities, thus there was the need of using innovative ways to establish a social test environment in order to achieve the goals of prototyping. This will be the subject of a forthcoming paper.

REFERENCES

1. Blanchard, A. (2004). Virtual behaviour settings: An application of behaviour setting theories to virtual communities. Journal of Computer Mediated Communication, 9(2).
2. Burnett, G., & Buerkle, H. (2004). Information exchange in virtual communities: A comparative study. Journal of Computer Mediated Communication, 9(2).
3. Cornejo, M. (2003). Utility, value and Knowledge Communities. Knowledge Communities. online: http://www.providersedge.com/docs/km_articles/Utility_Value_and_K-Communities.pdf   (last accessed January 2006)
4. Gronau, N. and E.-M. Kern (2004). Collaborative Engineering Communities in Shipbuilding. Virtual Enterprises and Collaborative Networks (PROVE'O4), Toulouse, France, Kluwer Academic Publishers.
5. Hearn, P., A. Bradier, et al. (2002). "Building communities: organizational knowledge management within the european comission's information society technologies programme." ITcon 7: 63-68.
6. Maedche, A., B. Motik, et al. 2003. "Ontologies for enterprise knowledge management." IEEE Intelligent Systems (Intelligent Information Processing): 2-9.
7. Mueller-Prothmann, T. and C. Siedentopf (2003). Designing online knowledge communities: developing a usability evaluation criteria catalogue. 3rd European Knowledge Management Summer School, San Sebastian, Spain.
8. Nabeth, T., A. A. Angehrn, et al. (2002). Towards Personalized, Socially Aware and Active Knowledge Management Systems. E-business and E-work - Challenges and Achievements in E-business and E-work, Amsterdam, Holland, IOS Press.
9. Porter, C. E. (2004). "A Typology of Virtual Communities: A Multi-Disciplinary Foundation for Future Research." Journal of Computer-Mediated Communication (JCMC) 10 (1), Article 3.
10. Simões, D. and A. L. Soares (2004). The Formation and Dissolution of Organizational Networks: A Knowledge Management Perspective. Virtual Enterprises and Collaborative Networks (PROVE'O4), Toulouse, France, Kluwer Academic Publishers.
11. Soares, A.L., Silva, M. Simões, D., 2006, Selecting and structuring semantic resources to support SMEs, ICEIS 2006,
12. Staab, S., J. Angele, et al. (2000). AI for the Web: Ontology-based Community Web Portals. AAAI/IAAI Conferences.
13. Staab, S., R. Studer, et al. (2001). "Knowledge processes and ontologies" IEEE Intelligent Systems(Knowledge Management): 26-34.
14. Stojanovic, N., A. Maedche, et al. (2001). SEAL: A Framework for Developing SEmantic PortALs. K-Cap, Victoria, Canada.
15. Vries, S. d. and P. Kommers (2004). "Online knowledge communities: future trends and research issues." International Journal of Web Based Communities 1(1): 115 - 123.
16. Weib, P. and A. Maedche (2003). Towards adaptive ontology-based virtual business networks. PRO-VE'03, Lugano, Switzerland.