TACIT KNOWLEDGE MANAGEMENT IN CONSTRUCTION INDUSTRY BY USING A COLLABORATIVE SOFTWARE

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ABSTRACT

The importance of knowledge management for construction companies has been gradually recognized by the industry. While explicit knowledge has been handled by many existing information systems, tacit knowledge is much more difficult to handle because of its intangible nature, and not many computer systems designed for tacit knowledge management. As tacit knowledge is usually created and transferred in social environment, this paper proposes to use a collaborative software to support tacit knowledge transfer. Basic concepts and the structure of the collaborative software are presented; and the facilities for tacit knowledge management for construction organizations are demonstrated.

KEYWORDS:

Tacit Knowledge, Collaborative Software, Construction Industry

INTRODUCTION

The construction industry is information and knowledge-intensive, and it is characterized as a project-based business that delivers one-of-a-kind products. As teams in construction projects are often disbanded at the end of the project, the knowledge generated in the project is difficult to track after the project is completed. Historically, people have often had to reinvent the wheel, and repeat the same discussion and decisions over and over again. These problems associated with knowledge capture and transfer within companies operating on discontinuous projects have generally been overlooked in previous studies (Dent and Montague, 2004).

As is well known, knowledge exists in two forms: explicit and tacit (Nonaka and Takeuchi, 1995). Explicit knowledge is easer to collect and manage in construction project because the knowledge is available in document form, or it can easily be converted to written format. Tacit knowledge, on the other hand, resides in people's head, and it may exist as expert insights and intuitions. The construction industry has established a formal process of information and documents interchange between participants of a construction project. However, knowledge, especially tacit knowledge, may follow quite different, and usually informal routes, to flow between construction professionals.

As knowledge sharing can help to prevent mistakes that have already been encountered in past projects, most construction professionals agree that knowledge management is necessary and it will benefit a construction project (Tserng and Lin, 2005). Recently, there are some important research work carried out for the knowledge sharing in construction industry.

One of an initiatives for sharing tacit knowledge is Communities of Practice (CoPs) (Huysman and Baalen, 2002). These communities are designed to build a network of knowledgeable experts who work together to learn and solve complex problems when the solutions are needed. In general, they operate informally through meetings, video-conferences, or e-mail communications to exchange knowledge and work practices on topics of interest to the members. Peansupap and Walker (2005) also explained the CoPs' concepts from the perspective of three major Australian construction contractors, and pointed out that CoPs can be an effective support mechanism for ICT innovation diffusion.

Francisco (2001) examined how web technologies may support knowledge management in construction organizations. Some early web technologies such as E-mail, HTML, XML and EDI were discussed in his paper, however, tacit knowledge was not supported by the system.

To support both explicit and tacit knowledge, a knowledge management system needs to be built with content and collaboration technologies. As Duffy (2001) pointed out, technologies to support tacit knowledge are more likely to need human interaction than data-storage technologies. Romaldi (2002) also stressed the value of using

"technologies with hyper-linking and hyper-media capabilities" to effectively capture expert's tacit knowledge and make it explicit.
As knowledge is "highly individualistic and concomitant with the various surrounding contexts within which it is shaped and enacted" (Fernie *et al.* 2003), most of the current methods of knowledge capture and transfer fall short of addressing these problematic issues. Jewell and Walker (2005) expressed the same concerning: "knowledge is about context, the history and hidden myriad of inferences and cause-and-effect loops that explain why something did or did not happen in a particular way". They also agreed that CoPs play an important role in facilitating tacit knowledge transfer.

Based on the fact that researchers generally agree that tacit knowledge management needs human intervention and can be enhanced by advanced IT technology. There are some attempts to build computer systems to support tacit knowledge sharing. Woo *et al.* (2004) presented a Dynamic Knowledge Map which showed us an approach that can assist in the reuse of experts' tacit knowledge. Dynamic Knowledge Map is a Web-based knowledge navigator that searches for experts and facilitates communications with the experts by using Internet technology. Tserng and Lin (2004) proposed a concept of activity-based knowledge management, and presented a system which uses a knowledge-sharing platform for construction projects.

The Authors of this paper are attempting to use and further develop a collaborative software to support tacit knowledge management in construction industry. As the creation and transfer of tacit knowledge usually occur in the process of social interaction, collaborative software which can support communication between project members represents an ideal technology for capturing tacit knowledge and making the tacit knowledge explicit. In the natural course of exchanging E-mails, participating in discussion forums, or contributing to virtual workspace to achieve common goals, individuals are encouraged or forced to express their tacit knowledge in written format. Project participants help in documenting their knowledge as a by-product of their routine cooperative work, rather than as separately assigned work tasks. By facilitating access to common repositories of information, collaborative technologies can readily and inexpensively wire everyone in an organization together. Collaborative software provides an ideal environment for exchanging knowledge both explicit and tacit, and it can be used for asynchronous communication across different time zones. Collaborative software is also valuable for use in fragmented and transient team settings, because it can allow knowledge transfer from individuals to a central repository and thus facilitate the knowledge storage in an organization. The collaborative software discussed in this paper is named LIVENET and its functionalities are presented in the following sections.

A COLLABORATIVE SOFTWARE -- LIVENET

LiveNet is originally developed as a generic collaborative software in the Faculty of IT, University of Technology Sydney (Xue and Cole, 2001). Recently, joint research was established between the researchers in the area of IT and construction management at UTS. This research is to develop LiveNet to a knowledge management system for construction industry by implementing a knowledge management model designed for the industry (Wang, 2004).

LiveNet was built up on a set of semantic model concepts (Hawryszkiewycz, 2000). These concepts were used to describe collaborative behavior, and their relationships are shown in Fig. 1. The important relationships are briefly explained as follows:

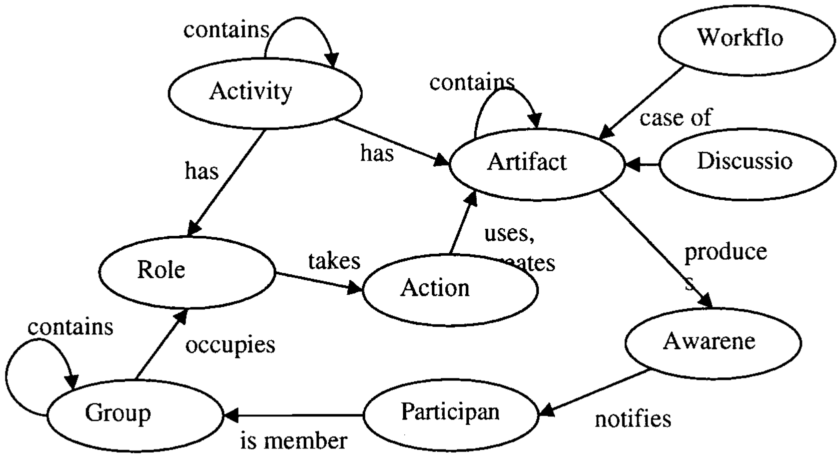


Fig. 1 Semantic Model of LiveNet

- A LiveNet user, referred as a participant in Fig 1, “is a member of” one or more groups. Group is a collection of users, which can evolve independently, and may “contain” subgroups. A personal group contains the user him/herself as the only member.

- An activity (or project) "has" any number of roles. Each role is 'occupied' by a group, and all of its member have the role capabilities. An activity may "contain" sub-activities, *i.e.*, activity hierarchy is supported in the semantic model.
- An activity "has" any number of artifacts, and an artifact can either be an atom artifact or a container artifact, which contains a number of other artifacts. (Artifacts can be meeting schedules, drawing documents, discussion forum, *etc.*)
- A role defines its accessibility to artifacts and "takes" actions.
- An action may "use or create" artifacts.
- An artifact may "produce" some types of awareness, which reflect the cooperation status. The awareness can "notify" the participant via a number of communication means.

A workspace in LiveNet is a virtual area for an activity to take place. The workspace supported by LiveNet can be composed of any number of sub-workspaces. Each workspace supports a certain activity that could be a big project or a small task. Within a workspace it is possible to create any number of folders to store documents. It also allows group members to create any number of different roles with different levels of accessibility to the online documents and information. Other collaboration facilities in the workspace include discussion forum, chat room, team calendar, to-do-list, workflow, *etc.*.

Figure 2 shows the basic functional modules of LiveNet (Gao, *et al.*, 2003). This picture illustrates an outline that what functions LiveNet may provide to its users. The modules in the bottom level are those fundamental functions for a collaborative system, *i.e.*, user login, group forming, activity creation and permission assignment. The modules in the middle level are the communication and information process facilities, and the basic functions to manipulate artifacts created in the activities. The advanced functions are located in the top level, they handle more specific and complex collaborative tasks. The functions on the lower levels are to support those on the higher levels.

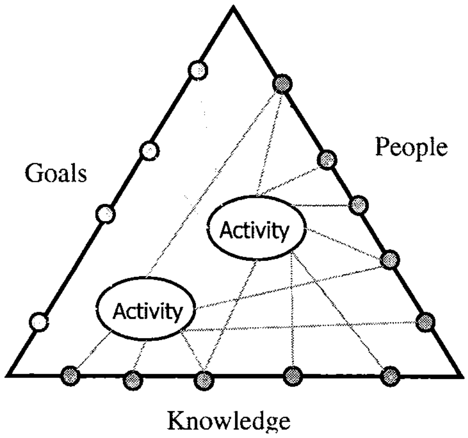
Workflow	Chat Room	To Do List	Task Schedule	Meeting Schedule	Plan and Milestone	Workspace Template	Agent System	Advanced Functions
View Management	Basic Artifact Manipulation	Awareness Mechanism	Email, Message Facilities	Search Engine	Logging Mechanism			Basic Functions
Authentication and Security Management	Permission Control Schema	Activity Management	Group Management	User Management				Foundation Functions

Fig. 2 Functional modules of LiveNet

SUPPORT TACIT KNOWLEDGE SHARING IN LIVENET

Some tacit knowledge can be extracted into structured or unstructured information. Once this kind of tacit knowledge is extracted, they can be maintained and managed with the assistance of document management tools. The problem with tacit knowledge is how it can be effective extracted. In another aspect, there are some tacit knowledge that cannot be extracted into document format, *e.g.*, knowledge that exists as an intuition. This kind of knowledge is usually created and transferred by face-to-face communication in a social cooperative environment. In this case, knowledge flow channel is more important than knowledge storage. LiveNet provides facilities to collect and store tacit knowledge in explicit format. For tacit knowledge that cannot be extracted into document format, LiveNet provides facilities to simulate a real-world collaborative environment for it to flow easily and effectively.

Activity is the basic working unit for construction projects, and people work together to achieve common goals of an activity. The logic relationships between activities, people, and aimed goals in LiveNet are shown in Figure 3. The top level activity may represent a construction project, while the lower level activities may represent tasks or procedures which are basic working elements related to the project. When knowledge is saved in LiveNet, explicit knowledge is in the format of document, usually includes specifications, contracts, reports, drawings, change orders, *etc.*. In contrast, extracted tacit knowledge may include process records, problems faced, problems solved, expert suggestions, innovations and notes on experience, *etc.*. These information and knowledge is better saved in activity-related units to facilitate classification and searching by system users. Figure 4 shows that collaboration groups can be set up in a flexible way in an organization by using LiveNet, which support tacit knowledge transfer. The following sections give details on four important aspects of tacit knowledge management in the system.



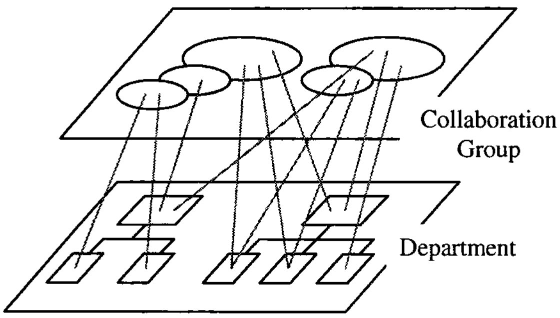


Fig. 3 Knowledge encapsulated in activity-based unit

Fig. 4 Multiple ways to group people together

LESSONS LEARNED FROM ONGOING OR COMPLETED PROJECT

Different projects may have similar activities. When a problem emerges in a new construction project, the user of LiveNet can use the knowledge search engine to try to find a similar problem that has been discussed or solved in previous or ongoing projects. Because all the activities which are involved in solving the problem are encapsulated in the project unit, it is easy to find out how the problem was raised, what discussion was involved, what procedures was proposed to solve the problem, and what outcome was produced, by simply re-visiting the record of the relevant project. A well maintained knowledge context plays very important role to help people recognize a best practice and how it may be applied (Jewell and Walker, 2005). Storytelling, no matter it is a story of success or failure, is a good culture to encourage employees to shout about their experience so that others can learn from it. LiveNet provides a hierarchical activity structure to record and organize all the project related elements. After a project completes, all the activities involved in the project were reviewed, categorized and stored. This information can be accessed by geographically dispersed project team members.

Figure 5 shows a project in LiveNet. The project has some participants taking different roles, and they have access to various artifacts (*e.g.*, document folders, *etc.*). One of the artifacts is "unsolved problems", where problems encountered in the project can be discussed here, and once it is solved, it is moved to "Solved problems". The facilities here could encourage people to contribute to solve the problem, and also keep a record for future references.

BRAINSTORM IN DISCUSSION FORUM

Discussion forum is an ideal technology for capturing tacit knowledge that is usually difficult to document. The use of forum can promote collaboration and understanding, and facilitate the informal exchange of tacit knowledge. The topics in forum can be related to existing and future work in the project activities, or other topics that people are interested in. The pattern of querying-answering-debating provides a great opportunity for people to share ideas, encourage innovation, transfer know-how and create new knowledge. This process increases the possibility of making "the intangible" to "the tangible" through the explicit sharing of ideas within a particular context for decision making and problem solving. Information stored under the topics, threads and statement can also be easily retrieved later when needed, and this contributes to organizational learning and organizational knowledge storage. Figure 6 is a screen copy from LiveNet which shows a discussion forum.

MULTIPLE AND FLEXIBLE WAYS TO GROUP PEOPLE TOGETHER

In LiveNet, people can be grouped either by their organizational department, or by the project that they participate in, or by the discipline area, *etc.*, as shown in Figure 4. For example, an architect works for Project A and B may join in the project A group and Project B group, and he/she may also belongs to the architecture department of his/her company, and he/she can also join some Communities of Practice (CoPs), *etc.*. These groups are foundations for knowledge flow, sharing and management. Because groups associated with a particular project are dismissed upon completion of the project, other professional groups play important roles in long-term knowledge sharing. Industrial wide common problems and more generic knowledge are better discussed and exchanged in those groups (Peansupap and Walker, 2005). This flexible structure has obvious advantages over the traditional project-based system, which is very difficult for users working for different projects to share information and knowledge (Wang, 2004).

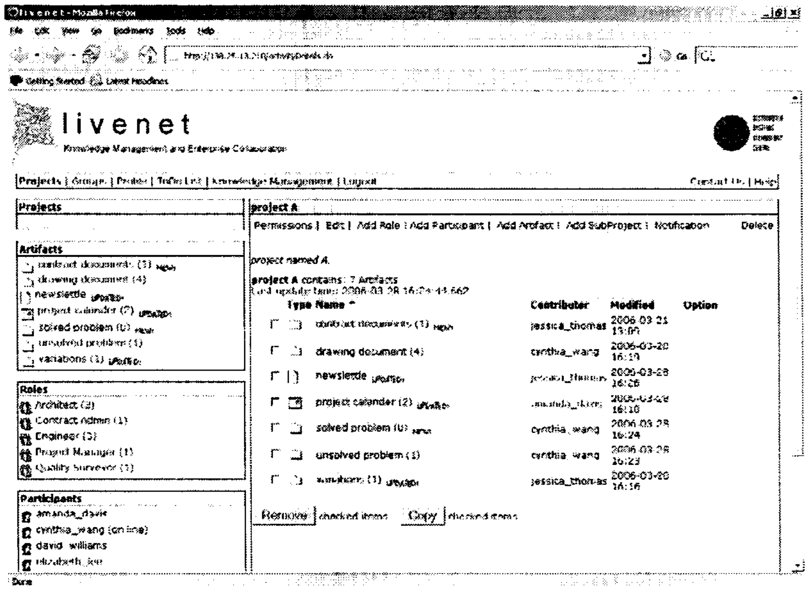


Fig. 5 An ongoing project in LiveNet

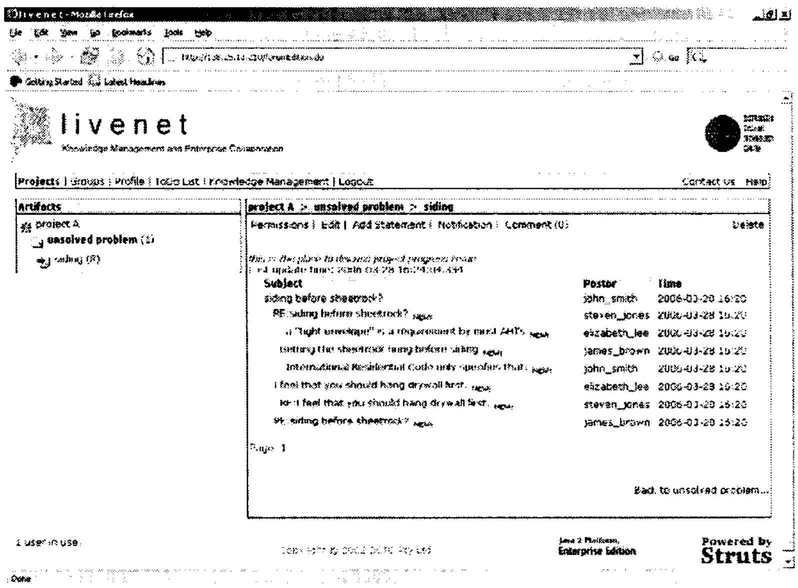


Fig. 6 A discussion forum in LiveNet

People can be grouped by other common interest, too. For example, groups for mentoring and coaching may be set up in the system. This virtual knowledge channel between junior employees and their mentors can play an important role when senior staff do not work in the same geographic location with the junior staff. Figure 7 shows some groups established in LiveNet, and Figure 8 shows a mentoring group activities.

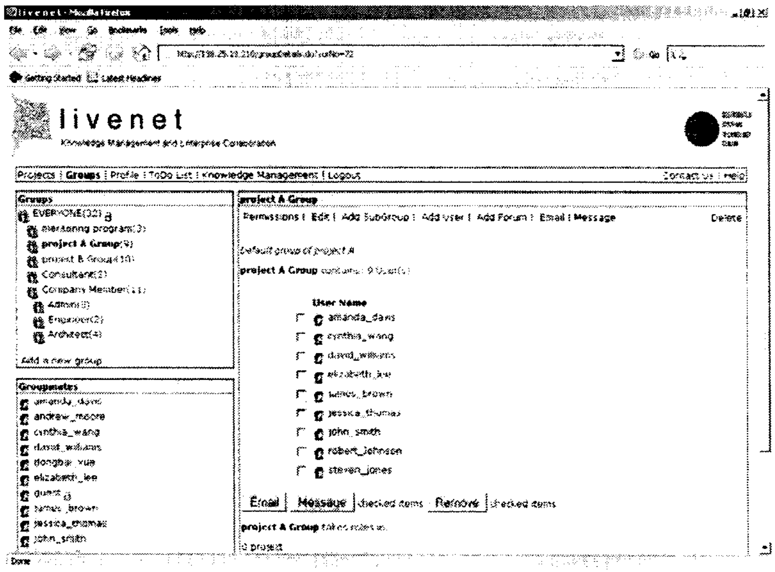


Fig. 7 Collaboration groups in LiveNet

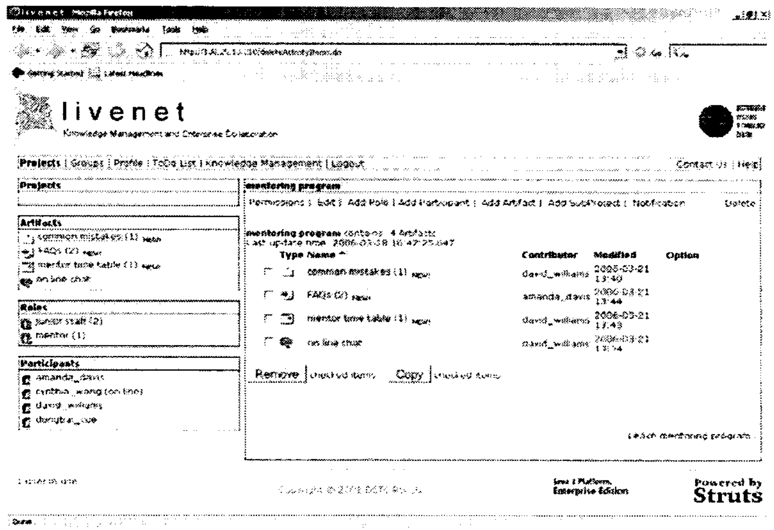


Fig. 8 A mentoring activity created based on a mentoring group in LiveNet

FIND AND TALK TO AN EXPERT

Promoting awareness is one of the most important functionalities for a collaboration system. LiveNet has been equipped with number of awareness facilities which enable the project participants to know whom they are working with, what are the problems they are facing and where the process is going on. LiveNet users may specify their own expertise, interests and job positions in their user profiles. System users may easily find experts in a certain area by using keyword search functions. People can also register to be notified when a new user with similar interests or expertise joins the system, thus they can be aware of the new "contact" available for them to ask for help if needed.

Figure 9 shows how experts in a particular area can be found in LiveNet system, and how users can be notified when a new expert joins.

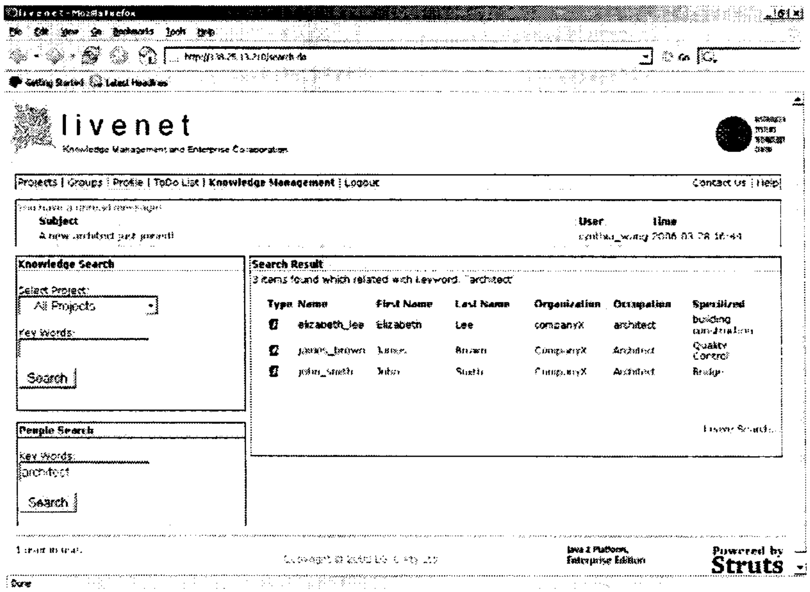


Fig. 9 Searching for experts in LiveNet

CONCLUDING REMARKS

By using collaborative software in construction industry, construction professionals may not only benefit from the advantages of working effectively without geographic and time restriction, but also enjoy the virtual collaboration that enables them to simulate a real social environment and promotes tacit knowledge transfer. This paper presents how the collaborative software LiveNet could help to extract tacit knowledge, and to encourage and support people to share their tacit knowledge in construction organisations. The computer system is still in the early stage of implementation, and further development and validation process will be reported in later papers.

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FOREWORD

Welcome to the 31st Annual AUBEA Conference held at UTS 12- 14 July 2006. AUBEA is not only the biggest and most important Australian conference in its field but is now well established as an important international conference attracting offers of papers from North and South America, Europe, Africa and Asia: a total of twelve different countries as well as all Australasian university schools of building,.

The papers included in this volume of proceedings have gone through a rigorous reviewing process. Initially all abstracts were reviewed by a panel of experts in the areas covered by the conference. The full papers, based on accepted abstracts, were then independently peer reviewed by a minimum of two Australian and/or international experts and where substantial rewriting was required, these changes were again reviewed. As a result of this process, the revisions required were frequently very significant and at the same time the rejection rate was quite high.

The result, we think, is a set of stimulating, thought provoking and significant papers that we hope you will enjoy for their contribution to our discipline.

Göran Runeson and Rick Best
July 2006