Learning Collaboration Moderator Services: Supporting Knowledge based Collaboration

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Abstract. Collaboration Moderator Services (CMS) as an evolution of earlier Moderator research has emerged to address the issues relating to knowledge based collaboration by providing a set of functionalities such as raising awareness of business opportunities, problems areas, conflicts, change in the item of interests and lessons learned from collaboration. This paper presents a framework for learning CMS within the context of SYNERGY project. It has been shown that knowledge miners of CMS can be used to learn from the databases of the collaborative networked organizations (CNO) and semi-automatically update the CMS Knowledge Base. A case study from construction project has been used to show that the knowledge miner of CMS can "learn" by extracting various kinds of knowledge from Post Project Reports (PPRs) using different text mining techniques. The discovered knowledge in the form of rules relates to improving the processes, identifying recurring problems, good and bad practices, improving customer relationships and enhancing the coordination between members of CNO.

Keywords: Collaborative Networked Organization, Collaboration Moderator Services, Knowledge Discovery, Text Mining, Virtual Organization and PPRs

1 Introduction

Recent organizational trends show an increase in the formation of collaborative networked organizations (CNO) to improve competitive advantage, and provide world class excellence and flexibility to address dynamic and turbulent market conditions. Collaboration of various forms can increase profits by improving chances to capture valuable business opportunities, address market demands and share resources and competences in very competitive and rapidly changing environments[1,2]. Effective knowledge sharing between the members of a CNO is core to the success of the CNO. A critical aspect of effective knowledge sharing within Virtual Organizations (VOs) is the identification of the most appropriate knowledge for reuse or exploitation in a particular context combined with the most efficient tools and mechanisms for its identification, sharing or transfer [3]. In any collaborative activity, an individual partner will at times make decisions that may affect (perhaps unintentionally), some or all of the other collaboration partners; each member therefore needs to be aware of other’s needs as well as their own. The problem is complicated in most situations because of the fact that the members are not even aware of the extent of the effect that their actions can cause. Therefore, a collaboration support system needs a mechanism for checking the occurrence of these sorts of activities and, where necessary, raising awareness of the conflicts detected and situations of interest that occur. Therefore tools and methods are needed to support knowledge sharing through the increasing awareness of possible consequences of actions and other partner's needs during collaboration [4].

Collaboration Moderator Service as an advancement of earlier Moderator research [5-9] to extend the boundaries of the application of moderator technology to support the knowledge based collaboration of individual enterprise, VO and Collaboration Pool (CPool) by raising awareness of business opportunities, problem areas and embedding learning elements. The CMS is one of the services provided by the SYNERGY (FP-7 funded project) system to support knowledge based collaboration [4]. However, the functioning of Collaboration Moderator Service is limited by the knowledge it has about the team members, VOs and CNO. Knowledge acquisition, learning and updating of knowledge are the major challenges for a CMS implementation [7, 10]. These researches shows how a CMS can continuously learn from the operational/past project databases of the company and semi-automatically update the knowledge relating to members of a CPool in CMS-Knowledge base.

2 Collaboration Moderator Services and Its Architecture

The main objective of the CMS is to support individual partners (as well as the collaboration as a whole) by raising awareness of issues affecting any of a partner’s registered items of interest and in cases where problems may be occurring, to raise awareness of which partners may be affected and how. Before CMS can support a user, CMS must acquire knowledge about that user and how the moderation activities for the user need to be carried out. When a change to an item of interest, or another event is detected, the CMS needs to access knowledge from CMS Database. This knowledge is stored in CMS Knowledge base (CMS KB) and is accessed when an event with potential to affect an item of interest occurs [10].

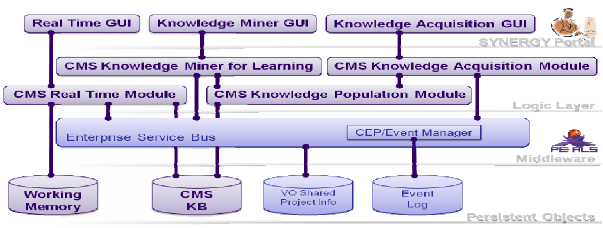

Fig. 1. CMS modules and repositories

2.1 CMS Architecture Component

Figure 1 shows the different modules of the CMS at different layers with various types of repositories. These are briefly discussed as follows; however a detailed discussion is presented in [11]. One of the major tasks for the CMS throughout the VO life cycle is knowledge acquisition. The CMS requires knowledge about each and every one of its subscribers. Knowledge about how CMS can support the subscriber, e.g. knowledge of things that are important to the subscriber or member, "items of interest", etc are held as CMS knowledge in the CMS KB. The **Knowledge Acquisition Module** (KAM) of CMS should be able to capture the information from the user using a simple interface and store it in the knowledge base (KB) of the CMS as shown in figure 2. The KAM should provide the users with facilities to access review and modify the knowledge whenever needed.

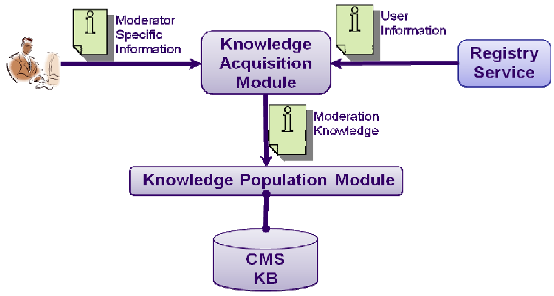

Fig. 2. CMS–KAM retrieving information and populating the knowledge base

The **CMS Knowledge Population Module** (KPM) is there to create, populate, update and delete the expert modules for the subscribed members. The knowledge captured from the user is fed to the KPM which stores them as persistent objects in the CMS KB. The KAM utilises the KPM to manage (create, access, change, delete etc) persistent CMS knowledge within its knowledge base as shown in Figure 2.

The role of **CMS Real Time Module** is to monitor the flow of subscribed events which relate to a user's "item of interest" and analyse with the help of the CMS knowledge base if there are any possible conflicts or problems, or any changes or occurrences that a subscriber should be made aware of. When a likely event is detected, the second step is to assess the situation. This step includes retrieving knowledge and additional information from repositories and other services. If the CMS then determines that a problem has arisen, a conflict has been caused or any object of user's interest has been changed, it communicates this to the user in the third step and raises his / her awareness of the situation or current activities which may be relevant to their work or contributions to the VO (or CPool).

The purpose of the **CMS Knowledge Miner for Learning** (KML) is to perform mining activities on the log of events (or other suitable data sources) to extract meaningful information and knowledge for updating the expert modules and CMS-KB. On the request of the user, this module should perform data mining for knowledge discovery on available data from various sources and present the user with the results. At the same time, the user is presented with options to update the knowledge base with the extracted knowledge. After verification from the user, the

CMS knowledge base is updated with the help of KPM. To demonstrate the concept, the following section discusses construction project based collaborative networks and post project reports and thereafter it has been shown that how KML can be used to extract knowledge to semi-automatically update CMS-KB with the help of KPM.

3 Construction Project based Collaborative Network and PPR

The construction industry is very diverse and faces widely fluctuating demand cycles, project specific product demands and uncertain production conditions. A construction project based collaborative network (CPCN) may contain many SME firms, contractors, subcontractors, material and equipment suppliers, engineering and design teams and consulting firms [12]. Collaboration between the various entities of the CPCN is temporary and may vary from project to project. The lifecycle of a virtual organization is limited to its particular project. PPRs of construction projects are one of the most important and common approaches to capture knowledge and lessons learned from the lifecycle of a CPCN. They provide opportunities for the project partners to share discuss and explain their experiences through face-to-face, facilitated interactions before a project is closed and the VO is dissolved. PPRs therefore allow multi-disciplinary teams to critique a project to determine both positive and negative aspects, potentially capturing tacit knowledge as learning points to improve the planning, execution and design of VO for upcoming construction projects [12].

PPRs are a rich source of data and information for organisations - if organisations have the time and resources to analyse them. Too often these reports are stored, unread by many who could benefit from them. If these reports were analysed collectively, they may expose important knowledge and experiences which have perhaps been repeated across a number of projects. However, most companies due to lack of resources to thoroughly examine these PPRs, leading to missed opportunities to learn from past projects. This research attempts to capture hidden knowledge from PPRs using the CMS-Knowledge Miners. Knowledge Miners uses techniques of knowledge discovery in text (KDT) and text Mining (TM) approaches to uncover patterns, associations, and trends in text based unstructured PPR reports. The application of KDT and TM methods on PPRs can extract useful knowledge relating to good or bad practices, process performance, avoid reinventing solutions, and re-use lessons learned on previous projects etc [12]. Identified knowledge can then be verified by the user before updating the expert modules (EM) in the CMS-Knowledge base.

In the remainder of this paper, a knowledge miner of a CMS is implemented on the PPR based database as part of a knowledge acquisition process to extract explicit knowledge from the PPR based database, so that it can be used to (1) equip the expert module with knowledge which was previously only available to the project team members by reading the PPRs and (2) update the content of an expert module as soon as a project finishes. The ultimate aim is to show how a CMS-knowledge miner can be used to extract useful knowledge for semi-automatic update of CMS knowledge base.

4 Knowledge Miners for Learning from PPRs: A Case Study

As shown in figure 3, multiple projects at different stages of their lifecycle can co-exist simultaneously in a collaboration pool. Hence, any company can participate in several VOs involving different stakeholders. Inevitably, during the life cycle of a VO, problems will arise due to conflicting decisions. In such situations, an intelligent software tool such as CMS might be used as a special manager to proactively raise the awareness of potential opportunities and problem areas based on registered “items of interest” that might affect the team members. The CMS-KB needs to be populated with knowledge about each of the team members and things that are important to each of them. For example, the main contracting company is interested in a number of key knowledge areas that have been identified as important to the success/failure of the project. In order to perform the moderation activity, CMS must be able to identify when events occur which affect any of these key knowledge areas and therefore the expert module within CMS-KB representing the main contractor must contain knowledge related to these knowledge areas. PolyAnalyst 5.0 software system has been used in this research as an instance of a CMS-Knowledge Miner. It applies techniques such as text analysis, link analysis and text OLAP to discovery variety of useful knowledge from PPR database. A brief overview of these techniques is presented in [13]. Once the knowledge is discovered, it is presented to the user for verification and knowledge can then be updated in the appropriate expert modules using the KAM interface. The whole process of knowledge discovery works in several stages including understanding the problem domain, process, identification of data source and its type, data cleaning, data transformation, data selection, data mining, pattern evaluation and knowledge representation. A CMS-Knowledge Miner is equipped with several modules to perform these functionalities at each stage of knowledge discovery as required.

4.1 A Case Study from Construction Industry

This example is based on PPR documentation from a construction company relating to 40 projects over the three years. The reports are quite long, typically 15- 25 pages, and analysis has been carried out with an aim to discover useful knowledge to improve decision making in future projects and reduce mistakes by identifying patterns of good or bad practices. An iterative methodology was therefore designed for this research.

1. Discussions with domain experts to determine key knowledge areas and types of knowledge which should be found and Ontology development.
2. KDT and TM using the PPR reports
3. Evaluation of the TM results by domain expert.
4. Representation of knowledge and update of items of interest in the EMs.

Ontology development: An ontology is developed so that particular types of knowledge can be targeted for knowledge discovery in the PPRs. An ontology based approach can also deal with semantic issues and issues of multilingualism.

Data Preparation Module performs the pre-processing tasks to transform the textual data into a form suitable for the application of algorithms. It includes transformation of data, data cleaning and other pre-processing tasks.

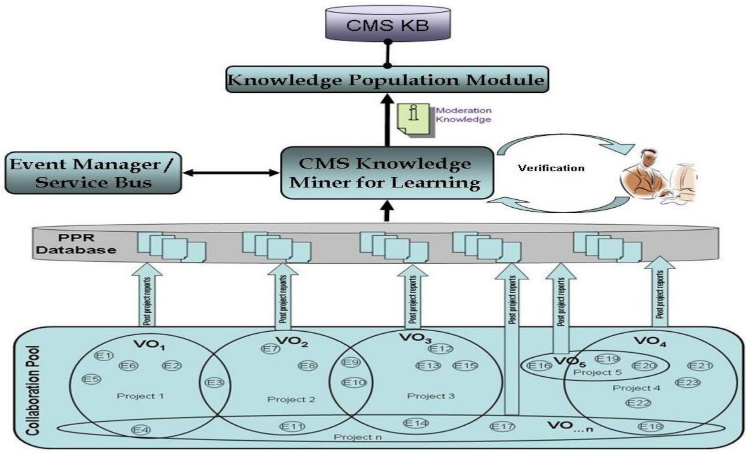

Fig. 3. Functioning of CMS-Knowledge Miner for Learning

Text Mining Module: involves the application of various algorithms to extract patterns, trends and discover useful knowledge as illustrated below.

Text Analysis (TA) : provides the morphological and semantic analysis of unstructured textual PPR reports in a database format. TA extracts and counts the most important words and word combinations from the textual PPR reports, and stores terms-rules for tokenizing database records with pattern of encountered terms. Domain expertise may be needed to determine the relevancy and importance of combinations of terms identified in this manner. TA can be used to highlight the commonly used words in various areas of PPRs such as planning, estimation, errors or mistakes, quality, health and safety, defects and many more using visualization techniques like Link Analysis. They can then be captured as “item of interest” in the EM so that the moderator can make the partner aware of potential problems that may arise when they occur in future projects.

Link Analysis: reveals and visually represents complex patterns of correlations between various keywords that exist in the textual data. Figure 4 shows an example of the application of LA on the PPRs. LA has been applied on the ontology developed for the VO. The strength of the link shows the correlation between keywords or phrases. Exploration of these links provides the user with a set of knowledge where one keyword or phrase has effect on the other. Figure 4 shows the linkages between finance and time, i.e. various attributes of “Time” are linked with attributes of “finance”. This knowledge can then be transferred in the form of IF-THEN rules by the user and added to the EMs manually for further use by Moderators. For example, let us consider 2 “item of interest” such as design change and accident. The knowledge can be represented as follows:

IF “there is a change in design” THEN “alert the contracting company for possible loss” AND “negotiate with designing team for redesign”.

IF “accident happens” THEN “alert the contracting company for extension of project”.

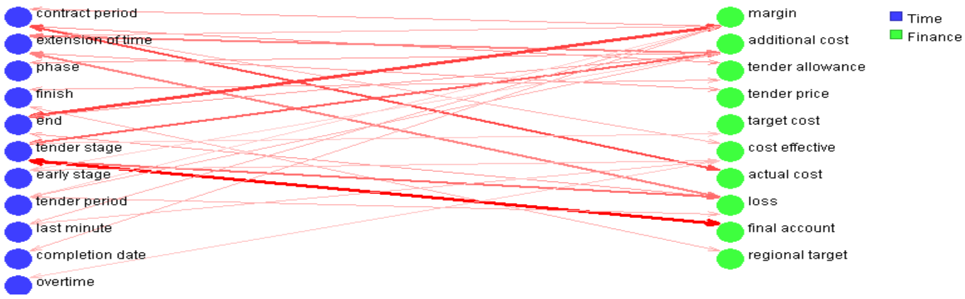

Fig.4. Linkages between attributes of finance and time

However, a limitation of LA is that it only relates two keywords at a time. To overcome this, the next section discusses the use of a dimensional matrix or Text Online Analytical Process (OLAP).

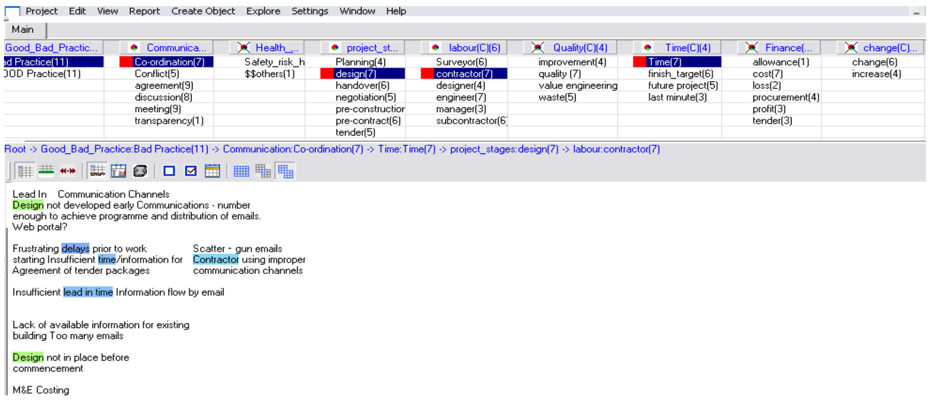

Fig.5. Dimensional Matrix representing key knowledge areas

Text OLAP (Dimension Matrices): uses the OLAP - On-Line Analytical Processing feature which provides the user with the capability of performing multi-dimensional analysis of the data. Each column consists of different cells where each cell (block) represents the key word(s)/rules to be searched within the PPR Reports. For example, the first column represents Good_Bad_practices consisting of good practice and bad practice keywords. Here bad practice consists of a rule IF(the PPR report contains bad practice words such as poor, bad, slow, delay, late, wrong or worse) THEN (include that PPR report). However, these bad practice words alone are not sufficient to extract knowledge therefore they need to be combined with several other keywords. As shown in Figure 5, the bad practice keywords are combined with several other keywords such as coordination which comes under the communication column, delay which comes under TIME column, design which comes under project stage column, and contractor which comes under labour column. Finally, a set of reports have been identified which contain knowledge relating to these keywords. In this manner, it can be seen that CMS knowledge can be derived from PPRs based on the domain expertise using Text OLAP.

5 Conclusion

Collaboration Moderator Service has been developed to support knowledge based collaboration of individual enterprise, VO and Collaboration Pool (CPool) by raising awareness of business opportunities, problem areas and embedding learning elements. Functioning of a CMS is limited to the knowledge it has about the team members. This paper presents a framework for CMS to enable them to continuously learn from the operational databases of the company and semi-automatically update the corresponding expert module in CMS-KB using CMS-Knowledge Miners for learning. An example has been presented and emphasis has been placed on how a variety of knowledge can be extracted from PPRs using a variety of techniques from TM. This knowledge can then be verified by the domain experts and considered for addition or update of an expert module in CMS-KB.

References

1. Camarinha-Matos, L.M. and Afsarmanesh, H, "Collaborative Networked Organization: A research agenda for emerging business models", Springer Press, 2004.
2. Camarinha-Matos, L.M. and Afsarmanesh, H, "Collaborative networks: a new scientific discipline", Journal of Intelligent Manufacturing, 16 (4), 439-452 (2005).
3. Camarinha-Matos, H. Afsarmanesh and M. Ollus, eds, Methods and Tools for Collaborative Networked Organizations. New York edn. Springer, 257-274.
4. SYNERGY Project, http://www.synergy-ist.eu/, 2008, Last accessed 30th March 2010.
5. Harding, J.A. and Popplewell, K., "Driving concurrency in a distributed concurrent engineering project team: a specification for an Engineering Moderator", International Journal of Production Research, 34(3), 841(1996).
6. Harding, J.A., Popplewell, K. and Cook, D., "Manufacturing system engineering moderator: an aid for multidiscipline project teams", Int. J of Prod. Research, 41(9), 1973 (2003).
7. Harding, J.A., Popplewell, K, Lin, H. K. "A generation of moderators from single product to global E-supply," in *Knowledge and Technology Management in Virtual Organizations: Issues, Trends, Opportunities and Solutions* G. D. Putnik and M. M. Cunha, Eds. Portugal: IGI Publishing, 2007, pp. Chapter 5.
8. Lin, H., Harding, J.A. and Shahbaz, M., "Manufacturing system engineering ontology for semantic interoperability across extended project teams", Int. J. of Prod. Research, 42(24), 5099-5118(2003).
9. Lin, H. K., Harding, J. A. and Teoh, P. C., "An inter-enterprise semantic web system to support information autonomy and conflict moderation," Proc. Inst. Mech. Eng. Pt. B: J. Eng. Manuf., vol. 219, 903-911(2005).
10. Das, B., Harding, J. and Swarnkar, R., "Knowledge Modelling Requirements of Collaboration Moderator", Internal report D3.1, Wolfson School of mechanical and manufacturing engineering, Loughborough University, 2009
11. SYNERGY, D7.1, "Conceptual Architecture of SYNERGY Integrated System", http://www.synergy-ist.eu/docs/SYNERGYD7.1FINALSUBMITTED.pdf (2009).
12. Choudhary, A.K., Oluikpe, P.I., Harding, J.A. and Carrillo, P.M., "The needs and benefits of Text Mining applications on Post-Project Reviews", Computers in Industry, 60(9), 728-740(2009).
13. Feldman, R. "Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data", Cambridge University Press, (2006).