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Proactive problem-solver for construction

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ABSTRACT

Construction is an experience-based discipline. Knowledge or experience accumulated from previous projects plays a very important role in successful performance of new works. More and more construction organizations have adopted commercial Knowledge Management Systems (KMSs) to develop their own Knowledge Management (KM) functionalities. Most of the existing KMSs adopt Communities of Practice (CoPs) for knowledge sharing and exchange. Such an approach is found on the reactive problem-solver (RPS); that is, the problem raised by the questioner in the CoP has to “wait” for the “solution knower” to respond (or reply). Previous research indicated that the RPS approach may suffer in poor time and cost effectiveness. This paper proposes a Proactive Problem-Solver (PPS) approach for the problems encountered in construction engineering and management. Unlike RPS, the PPS proactively solves the problem based on lessons learned from previous projects. Should the solution be not available; the PPS dispatches the problem to the most appropriate domain experts so that the problem can be tackled timely and efficiently. A case A/E consulting firm is selected for implementation of the proposed PPS to demonstrate its applicability. It is shown that the proposed PPS improves more than 89.5% of efficiency both for timeliness and cost-saving of problem-solving. The proposed PPS demonstrates great potentials for improvement of emergent problem solving and enhancement of market competitiveness of a construction organization.

1. Introduction

Problem-solving is in the center of daily operations for construction organizations [1]. Since Construction Engineering is an experience-based discipline, knowledge accumulated from previous projects provides the key to solve similar problems encountered in future projects. Current practice of knowledge management system (KMS) has established an operational framework and a platform for problem solving in construction engineering and management [2]. One most commonly adopted problem-solving platform in a KMS is the Communities of Practice (CoP). According to Wenger and Snyder (2000), the CoP was defined as a group of people informally bound together by shared expertise and passion for a joint enterprise [3]. In an engineering consulting firm, a CoP is usually implemented as a subsystem of a KMS, which forms a virtual community for a group of people (the members of the CoP) who share interests on a professional/technical subject, e.g., structural design, geotechnical issues, material specification, contract management, etc. The common KM activities of the members in a CoP include [4]: (1) publishing articles for requesting of information on the electric forum system; (2) responding to the published articles by publishing additional articles; (3) holding meetings for members to build sense of belonging.

The KMS approach for problem solving poses several desirable features over other methods (such as Systems Engineering) including: (1) the experienced-based solutions that were implemented and verified in real world cases are more realistic and practical than theoretical solutions generated by analytic methods; (2) the collective intelligence supported by domain experts in the CoP provides a broader knowledge base and diverse perspectives to generate a more effective solution; (3) the KMS records all discussions while deriving the solution in CoP, so that the “experiences” of problem solving are automatically stored for future use.

Although the KMS approach poses many desirable features for construction problem solving, there are also essential drawbacks that exist in the traditional KMSs. The most critical disadvantage of a KMS for solving emergent problems is its nature of “reactive mode” of KM (referred hereafter as Reactive Problem-Solver or RPS). That is, the problem raised by the questioner has to wait (passively) for replies and responses from the “solution knower” in the CoP of the KMS. Previous research has indicated that such approach can be the bottleneck to improve the performance of the KMS due to poor time

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and cost effectiveness of the RPS [2]. Moreover, the verification, storage and retrieval of previous solutions (also called "lessons-learned") cause difficulties for the successful application of the traditional KMS for construction problem solving.

The present paper aims at addressing the abovementioned problems encountered in the traditional KMS for construction problem solving. A proactive problem-solving system, namely Proactive Problem-Solver (PPS), is proposed to improve the disadvantages of the traditional RPS. In contrast to the traditional RPS, the proposed PPS proactively "tackles" the problem posed by the questioner in a CoP and replies with the most appropriate solution based on previous lessons-learned. Should the solution be unavailable from historic lessons, the PPS "proactively" dispatches the problem to the most appropriate domain experts (in the organization) who are knowledgeable of relevant tacit (implicit) knowledge and solve the problem manually.

The rest of the paper starts with reviews of related works to provide required backgrounds for PPS; the model of PPS is then proposed with detail discussions of the required functions and components; then a case study is conducted to develop and test a web-based implementation of the proposed PPS for a leading A/E consulting firm in Taiwan; discussions on system strengths, limitations, and potential applications are addressed based on observations from case study results; finally, conclusions and recommendations are provided to interested readers.

2. Review of related works

The term "Proactive Problem-Solving" is not found in literature. However, related issues and similar functions of PPS addressed in the problem statement can be found in some existing works.

2.1. Problem-solving in construction

Problem solving plays the central role of daily construction operations. Li and Love [1] developed a framework of problem-solving for construction engineering and management. Their research identified several characteristics of construction problems that should be tackled in order to solve them quickly, correctly, and cost-effectively, such as the ill-structure nature, inadequate vocabulary, little generalization and conceptualization, temporary multi-organization, uniqueness of problems, and hardness in reaching the optimal solution. Two areas of problem-solving researches tackle the abovementioned issues: the cognitive science and decision support system (DSS). The cognitive science-based approach is the most widely adopted as it is the basis for manual problem-solving techniques. The decision support systems (DSSs) are widely tested in academia. Many researchers develop their own DSSs for special purposes, such as cost estimation, technology selection, mark-up decision-making, duration estimation, etc.

In addition to these two areas, Yu et al. [2] propose a third approach called Knowledge Management integrated Problem-Solver (KMiPS) to solve emergent construction problems. The KMiPS adopts a KMS and a special designed CoP, namely SOS, for emergent problem solving. Yu et al. proved that the KMiPS achieved both quantitative and qualitative benefits better than the traditional problem-solving approaches. Their research showed that KMS provides desirable functions to tackle the special characteristics of construction problems identified by Li and Love. However, some essential drawbacks (such as "reactive mode" of problem solving) exist in the traditional KMSs, which may cause poor performance of timeliness and cost effectiveness.

2.2. Knowledge classification and knowledge map

While applying KMS for construction problem solving, the storage and retrieval of previous lessons-learned are crucial. Such issues become critical as the number of historic lessons grows. As a result, the methods of knowledge classification or knowledge map were developed. Kim et al. [5] proposed a practical method for capturing and representing the knowledge that is critical in knowledge management. The method employs a knowledge map as a tool to represent the knowledge of a firm. Their procedure consists of six steps: (1) defining organizational knowledge; (2) analyzing process map; (3) extracting knowledge; (4) profiling knowledge; (5) linking knowledge; and (6) validating map knowledge. Effective knowledge maps help identify intellectual capital, socialize new members, enhance organizational learning, and anticipate impending threats and/or opportunities [6]. Caldas et al. [7] proposed an automatic document classification method based on text mining. Their work successfully classified 4000 documents automatically with the Construction Document Classification System (CDCS) they developed. Although the abovementioned methods provide feasible alternatives for knowledge classification of the previously accumulated knowledge, none of them addresses the consideration of business domains and the organizational structure of the firm that may significantly affect the effectiveness of classification of the knowledge for problem solving.

2.3. Automatic Answering System (AAS)

Automatic Answering System (AAS) serves as a domain expert who is able to answer the question posed by the questioner instantly. Various types of AAS's have been developed in construction industry. The Advanced Construction Technology System (ACTS) was developed in the University of Michigan at Ann Arbor by Ioannou et al. [8]. ACTS provides a technology information system for construction planners and managers to select the most appropriate state-of-the-art construction technologies during the project planning stage. More than 400 technologies are recorded with 25 attributes such as general description, cost benefit, construction constraints, special application, operation environment, test criteria, etc. The Architecture and Engineering Performance Information Center (AEPIC) was developed by Loss at the University of Maryland [9]. The AEPIC provides information of failures so that the mistakes won't be repeated again. The On-Line Reference Library (OLRL) was developed by the Bechtel Inc. to provide engineers with real-time reference manuals of SPECs. The Civil Engineering Information System (CEIS) of Kajima Corp. is similar to ACTS and OLRL, which stores more than 300,000 technical documents [10]. Even though the abovementioned systems provide some features of AAS, most of them are database systems equipped with search functions. None of them provides complete functionalities required for proactive problem solving, such as automatic problem characterizing, intelligent information retrieval, problem dispatching, and solution repository. Moreover, they are information system rather than problem-solving system.

2.4. Lessons-learned system

Another issue related to construction problem-solving is the compilation of previous learned knowledge that is useful to solve future problems. Such knowledge is usually called "lessons-learned". There have been many existing lessons-learned systems reported in literature, which provides references for the present research. The Hypermedia Constructability System (HCS) was developed in collaboration between the Indiana Department of Transportation (INDOT) and the Purdue University [11]. The HCS stores historic lessons-learned in multi-media format so that construction engineers can learn from previous lessons more effectively. The Constructability Lessons Learned Database (CLLD) and Integrated Knowledge-Intensive System (IKIS) were developed by Kartam and Flood [10,12] to provide a repository for previously learned lessons. The major difference between CLLD and IKIS and the abovementioned lessons-learned systems is that the former verifies historic lessons-learned by the domain experts before storing in the database.