# Using experience based cases to support construction business processes

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ABSTRACT: Many business processes in the construction supply chains involve creation and consumption of massive amount of knowledge. Some construction organisations may use such knowledge as a competitive differentiator. The benefits that an organisation in the supply and value chain reaps from relevant experiences will also be beneficial to the organisation's clients, suppliers, and business partners. However, there is normally a lack of explicit knowledge about their business processes.
Recent research indicates a trend toward increased emphasis on a smooth integration of knowledge and business processes (O'Leary and Studer 2001; Lee and Wang 2001; Glushko *et al*. 1989). The real issue for construction organisations is how to gather, organise and reuse the knowledge generated by previous business processes to beat competitors. Case-based reasoning is a technology for problem solving based on recall and reuse of specific experiences. Case-based reasoning offers techniques for acquiring, representing and managing previous experiences, augmenting a set of specific experiences with generalised knowledge and formalising a typically informal body of knowledge. This paper argues that experience-based continuous learning is essential for improving business processes in established areas of construction business. It presents an approach to the implementation of the experience-based organisational learning using case-based reasoning processes.



## 1 INTRODUCTION

Since a construction supply chain spans over multiple organisations, knowledge management happens in the background –in real time. It is done by everyone as part of the day-to-day business. Thus, knowledge and experience are becoming critical success factors for an enterprise's business processes.

Recent research indicates a trend toward increased emphasis on a smooth integration of knowledge and business processes (Glushko *et al*., 1989; Lee and Wang, 2001; Smith and Farqukar, 2000; O'Leary and Studer, 2001). Besides, the importance of capturing and representing knowledge-intensive business processes as part of the organisational learning processes is recognised (Tautz, 2001). The real issue for construction organisations is how to gather, organise and use the knowledge generated by previous business processes to beat competitors, bearing in mind, however, their project-by-project mode of operation.

Case-based reasoning is a technology for problem solving based on recall and reuse of specific experiences. Case-based reasoning offers techniques for acquiring, representing and managing previous experiences, augmenting a set of specific experiences with generalised knowledge and formalising an otherwise typically informal body of knowledge.

This paper argues that experience-based continuous learning is essential for improving business processes in established areas of construction business. It presents an approach to the implementation of the experience-based organisational learning, using a case-based reasoning approach.

## 2 KNOWLEDGE A KEY FACTOR IN CONSTRUCTION BUSINESS PROCESSES

The role and importance of knowledge as a key source of potential advantage for construction organisations have been addressed by several authors (Egbu *et al*., 1999; Kulunga *et al*., 1998; Quintas *et al*., 1997).

It is recognised that in many construction organisations, there is normally a lack of explicit knowledge about their underlying processes, products and technologies. Usually, such knowledge is built up through individual learning from experience of the people involved. The discipline of organisational learning tries to improve the scope for individual (human) learning in the interest of a whole organisa-

tion. Besides, improving group learning also includes documenting, acquiring and representing relevant knowledge, and storing it to reuse and share it in a distributed corporate memory (Egbu, 2000).

Business transactions are accompanied by various issues in order to assure follow-up and action, such as the required ordering information, technical specifications, organisational and legal prerequisites, delivery procedures and definition of results. Each side in a business transaction develops their own business processes in order to facilitate and assure that the client/customer needs are fully satisfied within the supply chain (Vrijhoef and Kostela, 2000).

A business process is "a set of one or more linked procedures or activities which collectively realise a business objective or policy goal, normally within the context of an organisational structure defining functional roles and relationships" (Lawrence, 1997). Any business in the construction supply chains, (ranging from a construction contract to the supply of building components for a project), can be viewed as a set of processes. A single business process can be anything from a work order to a detailed design. For example, in a business transaction involving the contracting of work by a contractor to a subcontractor, the main processes may include: preparing production documents and specifications; selecting a subcontractor; negotiating; contracting; supervising; accepting. In the same transaction, the subcontractor may develop the following processes: preparing proposal; preparing production documents; and executing.

Many business processes involve creation and consumption of massive amounts of knowledge. Therefore, capturing and reusing such knowledge and experience is essential for the effectiveness of business transactions in the construction supply chains. Some organisations in the supply chain use their knowledge as a competitive differentiator, some sell it directly, and others offer services and technology to enable their clients to improve their own knowledge management. Although, the construction supply chain is different for each project, the experience-based knowledge will be pertinent for all participants. Thus, the benefits that an organisation in the construction supply chain reaps from the experience-based knowledge accumulated along its projects will also be beneficial to the organisation's clients, suppliers, and alliance partners.

Construction organisations are all under pressure to cut costs, stay competitive in their markets, and penetrate into new markets. Therefore, enabling construction organisations to gather, organise, share and reuse the experience of their business transactions is seen as important to competing in the current economy. However, knowledge and experience from a construction organisation perspective involves the implementation of knowledge in such a way that it adds value to the organisation. The technology available today allows organisations to easily share the knowledge they create with their business partners (Piatetsky-Shapiro, 1999). For example, knowledge acquired from analysing a financial or marketing database could contribute to revising business practice and influencing management policy.

## 3 CAPTURING EXPERIENCE KNOWLEDGE INTO BUSINESS TRANSACTIONS

Business processes are increasingly being used to capture and store experience (Funk, 2001). Some processes have been refined and improved over long use and capture the experience gained by people handling them. They are an important source of lessons learned (successes and failures). Besides, business processes may capture lessons learned in a wide area of applications, e.g. product specifications, planning, budgeting, and inspection.

A business process consists of a set of activities that are carried out to reach a specific goal. To implement a business process, people have to communicate and collaborate. To carry out an activity within that process, people need specific skills and knowledge as well as concrete information as an input for the task at hand. This knowledge should be attached to the activities carried out as part of the business process in question, thus showing that the knowledge is goal-oriented and focused on what is needed to perform the job. Therefore, business processes may capture experience and lessons on a wide variety of issues, and if reused can be a key to an organisation's success. The captured experience and lessons are expensive to gain and are often acquired over a long period of time, and so building experience bases is an important issue in most business areas of a construction organisation. Thus, business transactions allow organisations to capture enormous amount of knowledge.

A construction project generates a lot of information available for reuse. Construction organisations must learn to gather and share intelligence. As part of engineering the business, organisation, planners capture business processes in models and implement them as enterprise applications. Besides, many construction companies have people working on different construction projects. Savings are considerable if lessons learned from prior transactions can be transferred and reused efficiently between those people using proven techniques such as case-based reasoning, as we will now show.

Cases have long been recognised as a valuable knowledge source and a potential tool for collecting, representing, storing and sharing knowledge (Leak and Sooriamurki, 2002). Every previous process can be captured and stored as a case in an experience base. Cases may also store additional information on



where, when and how many times the case has been reused.

In today's economy, construction companies want to maximise their margins. Integrating, accumulating and reusing experience can be a cost effective way to maximise margins. Gathering, representing and reusing business process knowledge in cases is become easier as vendors line up with case-based reasoning (CBR) software packages. CBR approach offers new opportunities to transform transaction information generated in the construction supply chains into business intelligence.

## 4 WHY THE CASE BASED REASONING MODEL

Case-base reasoning (CBR) is a problem solving paradigm that is able to utilise the specific knowledge of previously-experienced, concrete problem situations (Aamodt and Plaza, 1994).

In CBR systems, knowledge is embodied in a library of cases. Each case typically contains a description of the problem, plus a solution and/or the outcome. Single cases may be kept as concrete experiences, or a set of similar cases may form a generalised case. Cases may be stored as separate knowledge units, or split up into subunits and distributed within the knowledge structure. A typical case is usually assumed to have a certain degree of richness of information contained in it, and a certain complexity with respect to its internal organisation.

In the CBR approach, a case represents a problem situation. A previously experienced situation, which has been captured and learned in a way that can be used in the solving of future problems, is referred to as a past case. Correspondingly, a new case or an unsolved case is the description of a new problem to be solved.

At the highest level of generality, a general CBR cycle may be decomposed into the following four processes (Althoff, 1989):

1 Retrieve the most similar case or cases
2 Reuse the information and knowledge in that case to solve the current problem
3 Revise the proposed solution
4 Retain the parts of this experience likely to be useful for future problem solving

Many CBR enterprise applications have been developed to capture experiential knowledge in order to support future decision-making (Leak et al., 2000; Sengupta et al., 1999; Watson, 1997). Examples of such types of systems includes: HIPCAP (Weber et al., 2001) and CALVIN (Leak et al., 2000). HICAP is a multi-modal reasoning system for active lesson delivery. CALVIN captures and delivers lessons about where and how to find information relevant to the user's decision-making task. Thus, CBR provides a technology for lessons-learned systems (Bagg, 1997; Weber et al., 2001).

Lessons learned from prior business transactions constitute validated working knowledge, derived from successes or failures that, when reused in the future, can impact on an organisation's processes (Tautz, 2001). Lessons learned can be used for reducing costs, improving quality, and/or increasing decision-making speed. They have been used extensively to support collection and dissemination of knowledge (Weber et al., 2000).

The lessons learned from past business transactions include both lessons learned about the transaction domain and lessons about how to find information that is useful to the problem-solver – information about resources that are useful in particular contexts. Typically, case-based lessons – learned - support reuse by capturing solutions for previous problems and providing them as starting points for future business transactions. They provide help about how to perform the supporting business process to address novel transactions.

Case-based reasoning (CBR) offers techniques for acquiring, representing and managing previous experiences, augmenting a set of specific experiences with generalised knowledge and formalising a typically informal body of knowledge. CBR is a technology for problem solving based on recall and reuse of specific experiences.

Some of the characteristics of a domain that indicate that a CBR approach might suitable include:

1 records of previously solved problems exist;
2 historical cases are viewed as an asset which ought to be preserved;
3 remembering previous experiences is useful;
4 specialists talk about their domain by giving examples;
5 experience is at least as valuable as textbook knowledge
6 case library can be developed incrementally

A very important feature of CBR is its coupling to learning. Learning from experience in CBR happens as a natural by-product of problem solving. Learning is an intrinsic part of CBR, because the solutions to past problems and their outcomes are stored as cases to extend the reasoner´s knowledge (Wilson et al., 2000).

Since CRB approach provides the capability for continuous learning in an enterprise environment, we believe that cases encapsulating business process knowledge, and lessons learned for guiding business processes, have the potential to significantly aid in finding needed solutions and information, both for novices and experts. Therefore, CBR approach can be of significant importance to allow experience to be effective in the kind of innovative setting that currently is expected of the construction industry.



## 5 A CASE BASED FRAMEWORK

CBR systems as currently developed tend to fall into three categories (Sengupta *et al*., 1999): *task-based*, *enterprise-based* and *web-based*. Typically, *task-based* implementations have addressed applications goals based only on the constraints imposed by the reasoning task itself. Recently, there has been an increasing trend to incorporate CBR into enterprise applications to leverage corporate knowledge assets (eg. Weber *et al*., 2001; Kitano and Shimazu, 1996). Currently, CBR *web-based* applications are taking advantage of the recent developments in knowledge representation and sharing on the world-wide-web (eg. Gardingen and Watson, 1998; Doyle *et al*., 1998). However, integrating CBR implementations with enterprise systems imposes standardisation constraints.

The *enterprise-based* framework that we propose and which is being developed combines process-specific knowledge with models of general domain knowledge and with lessons that were learned during practical application of the knowledge. With this approach, the CBR framework, besides acquiring experience cases, should also acquire domain and process knowledge. The framework includes collecting, documenting, representing, and storing such knowledge in the form experience cases in an experience library, which is an organisation's memory for relevant knowledge and experience. Knowledge (in the form of process and models) can be enriched by explicit experience drawn from as lesson learned over time.

What knowledge can be stored as a "case"?

- Background knowledge that is required to reach a specific goal.
- Business process knowledge (procedures, working instructions).
- Lessons learned during practical applications of process knowledge (practical knowledge or skills directly observed from participation in a particular task of a business process including guidelines, observations and problems).
- Context information such as information about the project, contract or transaction.

Cases should be structured as business process packages in an experience base (EB), which is an organisation's memory for relevant process knowledge and lessons learned (figure 1). The aim is to increase the effectiveness of individual human learning for whole organisation.

Within the EB included in our framework, all kinds of knowledge and lessons learned that are necessary for daily business should be stored as cases using CBR technology (figure 2). Thus, each business process package should be implemented as a "case" based on a structured CBR approach. This includes a domain ontology for modelling different types of case concepts and case attributes, together with the respective indexes and similarity measures, as well as relations between cases. A business process package may represent a process-step (e.g. Inspection, kick-off meeting) or a process (e.g. bidding, budgeting). Each business process package should have at least one objective or goal which it was established to achieve.

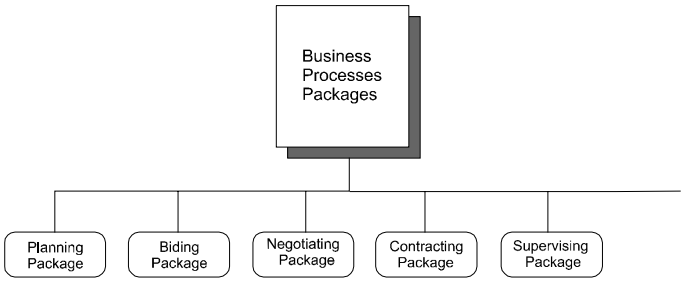


Figure 1. A view of the business processes packages

The goal of the EB is to categorise business process packages based on certain features.

The framework shown in figure 2 must operate in conjunction with enterprise database systems and be integrated within the corporate Intranet to allow people to share the EB resources. The framework can be accessed via a general proposal browser. The enterprise CBR framework consists of five components: CBR engine, Experience base maintainer, Web server, Interface to legacy systems and a General-purpose browser.

At the core of the framework are the CBR engine and the EB. The CBR engine should have the capability to reason over multiple local case bases. Commercial tools available for the CBR engine include the CASEADVISOR and RECALL. The experience base consists of several case bases storing process packages in the form of cases. Cases can be structured in the case base using a partonomic hierarchy because a business process package is a complex set of information and lessons.

The Experience Maintainer module is critical for the EB maintenance over time including extracting, updating and revising cases.

## 6 CONCLUSION

The CBR approach has been applied to capture and share experience-based knowledge in order to aid future decision-making in several areas. Therefore, CBR supports knowledge reuse by capturing solutions from prior problems and lessons gained from practical application of knowledge. Capturing and managing process knowledge and experience plays a key role in improving construction business processes. Process knowledge and lessons learned from practical application of process knowledge can be captured and organised in the form of cases in an

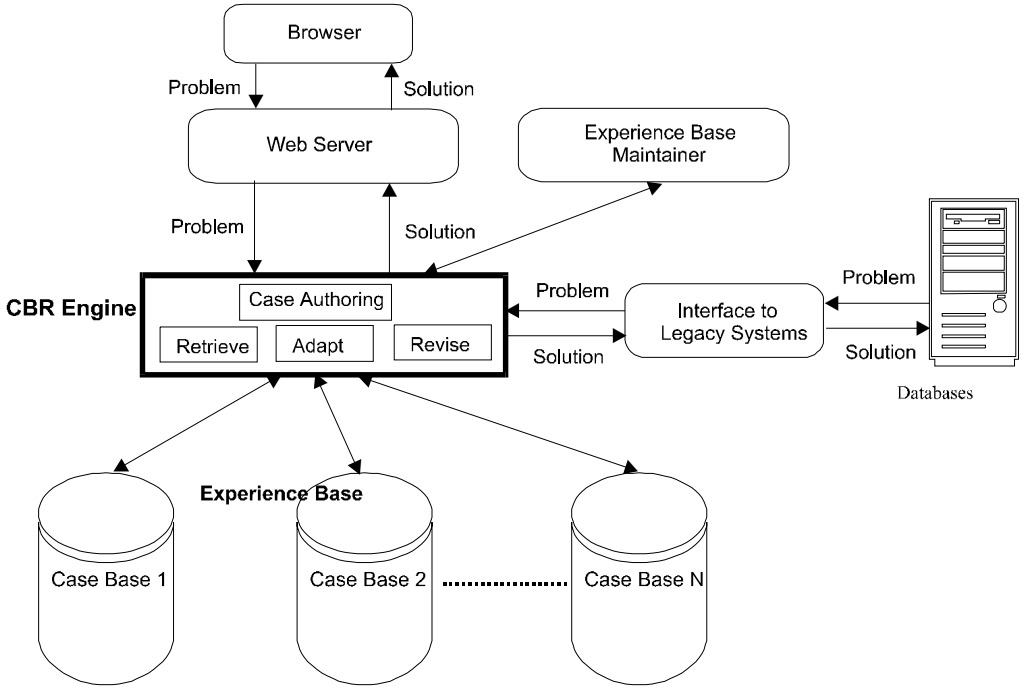


Figure 2: A case based framework

experience base. Cases are recognised as a suitable source of knowledge within an enterprise application.

The importance of the CBR approach for capturing, documenting and sharing business process experience has been highlighted in this paper. Continuous accumulation and reuse of prior process experience is an adequate way to manage and improve business processes within the construction supply chains. Individuals and organisations can take advantage of the remarkable possibilities of accumulating, reusing and sharing knowledge and experience gained from prior transactions. CBR can facilitate content gathering, organisation, browsing, parametric search, and in general, more intelligent access to online information and services.

In this paper we presented an enterprise CBR framework to capture, represent, store and reuse these experiences. At the core of such a framework are the CBR engine and the EB. The proposed framework can be integrated within an enterprise information technology environment and implemented using a commercial CBR tool.

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