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KNOWLEDGE MANAGEMENT IN BID PREPARATION FOR GLOBAL ENGINEERING AND MANUFACTURING PROJECTS

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Abstract: The core competence of a global engineering and manufacturing enterprise increasingly depends on the quality of its intellectual resources and how these resources are used in critical missions such as bid preparation. This paper discusses the knowledge management issues in the development of VIEWBID, a web-based system for supporting online bidding document preparation for global engineering and manufacturing projects. The VIEWBID system aims to supports inter-enterprise collaboration for compiling accurate bids. The enterprise engineering architectures and methodologies, such as VERA and iRoadmap, have been used to analyze the bidding process to capture different levels of procedural knowledge. A set of component-based technologies has been developed using XML and Java to capture, configure and compose the bidding documents.

Key words: Knowledge Management, Enterprise Engineering, Global Manufacturing

1. INTRODUCTION

With the globalization of business activities, the core competence of a manufacturing enterprise increasingly depends on the quality of its intellectual resources and how these resources are used in critical missions such as bid preparation.

Research in the technologies to support the bidding process has led to the development of the VIEWBID (Virtual Enterprise Workbench for

Worldwide Business Integration and Development) [1], a web-based system for supporting online bidding document preparation for global engineering and manufacturing projects.

The VIEWBID system provides three layers of functionality. The inner layer is a corporate knowledge management platform that serves as the corporate memory. The middle layer is a team collaboration environment for supporting the design and operation of a virtual enterprise, and the management of cross-corporate boundary bidding project team. The outer layer is the bidding workbench that enables the bidding team to prepare the cost estimation and technical proposal for the bidding document.

This paper discusses the knowledge management issues in the development of VIEWBID system that aims to support inter-enterprise collaboration for compiling accurate bids with managed risks. The bidding team needs extensive and up-to-date knowledge about the company's engineering capability and capacity in order to make an inform decision on the technology baselines and costing strategies. The knowledge created in the bidding process will also be captured and utilized as the corporate memory for supporting preparation of following bids. If the bid is successful, the knowledge captured in the bidding phase can also be further used in the following contracting, engineering & procurement, and manufacturing phases.

2. BIDDING PROCESS

To compete in the global business environment, companies need to collaborate across their company boundary to form a virtual enterprise and bid for new projects together. This distributed bidding team involves members from the leading bidding company as well as its partners and possibly the client.

During the bidding process, information entered into the process will need to be captured in a specific structure that can be utilized as part of the corporate memory for supporting the preparation of bids quickly. In addition, the knowledge captured in the bid can also be used for contracting and total product lifecycle support.

A bidding document usually consists of the technical proposal to client's requirements, and the associated terms and conditions. Preparation of the technical proposals for large engineering projects is usually very time consuming. The technical proposals are quite different for different projects or products, but many components of the content are often the same within each proposal. The same components, such as the manufacturing capabilities of the company, may be used in many different bidding

documents. Also, a bidding document developed for one project can also serve as the basis for later projects having similar requirements. Re-use of information based upon similarities between projects is a major goal for knowledge management in bid preparation. On the other hand, different kinds of contextual and procedural knowledge need to be captured during the bid preparation.

The bidding process usually begins with the reception of a client's Request for Proposals (RFP) outlining the capabilities sought from the project. The essential contexts are knowledge relating to the client's statement of capabilities, engineering decisions, notes, standards, correspondence, and a variety of documentation from lower tier suppliers. The bidding team needs to distil this kind contextual information into preliminary technical proposal.

Based on information provided by preliminary technical proposal, the client normally issues a Request for Tender (RFT) to a short list of suppliers. The bidding team of the suppliers then rework and extend the documentation developed in their proposals and include a detailed commercial response to the RFT.

Technical proposals and RFT responses are required to be completed within very limited time periods, such that if documentation is not delivered by the specified due date the proposal or bid will not be considered. Development of proposals and bids are highly competitive and place major pressure on to minimize documentation production cycle times and to maximize the quality of information/knowledge they contain.

3. KNOWLEDGE MODEL

Knowledge is the internal state of an agent following the acquisition and processing of information, here the agent could be a human being or a computer system. To categorize human knowledge, many knowledge models have been proposed. Polanyi [2,3] identified that human knowledge has two major components: the tacit and explicit knowledge. Following Polanyi's concept, Nonaka [4,5] further proposed his theory that tacit knowledge consists of personal relationships, practical experience, shared values and explicit knowledge consists of formal policies and procedures.

Nickols further clarified the intrinsic meanings of various knowledge terms by proposing a testable knowledge model [6] that includes: explicit, tacit, implicit, declaration, and procedural knowledge. As shown in Figure 1, Nickols' model also depicted a testable procedure to distinguish the relationship among different classes of knowledge.

In our approach, we classified the knowledge involved in the bid preparation process into three categories based on Nickols' framework.

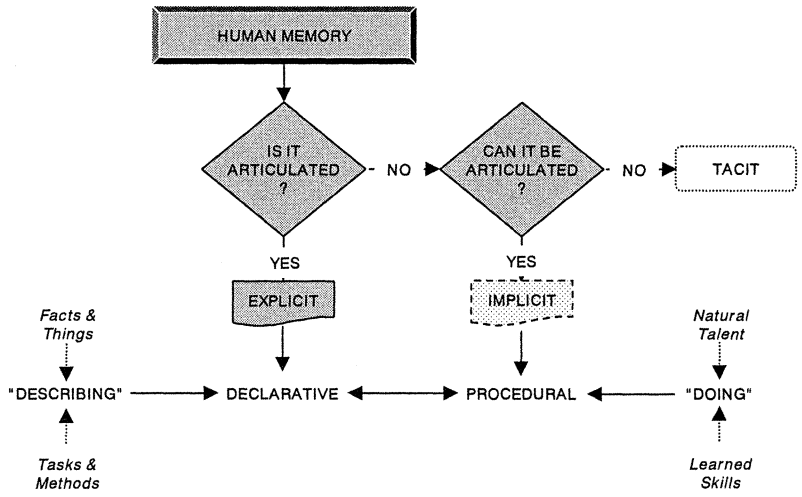

Figure 1. Nickols' Knowledge Model [6]

The first category is the "direct knowledge" or facts, which are the explicit or declarative knowledge. This category of knowledge is visible, written, transferable, sharable and reusable. It is usually documented and stored and transmitted externally to a human brain. In the bidding process, engineers assimilate their information and turn it into bidding documents conveying distilled knowledge. A knowledge management system should help the engineers capture, validate, and preserve knowledge; and assist discovery, reuse, retrieval and transmission of that knowledge.

The second category is the "procedural knowledge" or the best practices, which are usually implicit, and context sensitive. This category of knowledge is related to processes, methods, practices in groups and professions. This type of knowledge needs to be identified, captured and made explicit in the way that can be shared. However, it is not always well documented.

The third category is the "tacit knowledge", which is the most difficult to understand and represent. It is indirect, embedded in experience, owned by individuals and cannot be articulated in words.

Our research presented in this paper focuses on the first two categories of knowledge, aiming to capture and manage the direct and procedural

knowledge. Our previous work has attempted to interpret and convert the tacit knowledge into the direct and procedural knowledge [7]. We found that the direct and procedural knowledge is more critical to the bid preparation process.

4. MANAGING DIRECT KNOWLEDGE

The direct knowledge used in the bid preparation is mainly the factual information about the company and its engineering and manufacturing capabilities to fulfill the client's requirements. This class of information is often available in various forms, such as text documents, diagrams, spreadsheets, and engineering drawings. Traditionally, engineers have been using the "cut and paste" technique to re-use this kind of information.

Basically, managing direct knowledge is to develop an advanced replacement of the "cut and paste" technology. The key issue here is how to "cut" the direct knowledge into "components" with a right size, so that they can be both easily found and "pasted" into the new bidding documents.

Based on our analysis of the bidding documents, and especially the technical proposals, we found it is feasible to segment the re-usable parts of an engineering document according to their functions in the document. These functional segments can further be classified into four categories:

1. Basic Document Component (BDC): this kind of component contains self-explanatory facts. For example, the description of a specific material or equipment.
2. Associated Document Component (ADC): this kind of component is usually associated with a BDC, and used to further depict the content of the BDC. For example, an illustration diagram or a table of operational parameters for a machine that is described by a BDC. The existence of an ADC is depending on the existence of a BDC. If a BDC is modified, its ADCs may also need to be modified accordingly. However, a BDC and its ADCs can be modified independently, as long as they are consistent.
3. Derived Document Component (DDC): this kind of component is usually derived from a BDC or an ADC either automatically or manually. For example, a bar chart (DDC) of a table (ADC) or an image (DDC) of a 3D model (BDC). The existence of a DDC depends on the BDC or ADC from which it derived. Whenever a BDC or an ADC is modified, its derived DDC must be re-created.
4. Composite Document Component (CDC): this kind of component is usually a combination of a BDC with its ADCs and DDCs. For

example, a manufacturing facility can be described using a CDC that consists of a description of the machine (BDC), its major parameters (ADCs), and some charts and images (DDCs).

This classification scheme facilitates us to capture, re-use and update the direct knowledge used in the bid preparation.

5. MANAGING PROCEDURAL KNOWLEDGE

The procedural knowledge for bid preparation is the best practices that lead to a winning bid. We classified those best practices into three levels according to their coverage.

The top-level procedural knowledge is the information roadmap, or iRoadmap [8]. The iRoadmap is developed based on the Virtual Enterprise Reference Architecture (VERA). Along the lifecycle of a virtual enterprise (VE), extensive amount of critical information is created, shared, used, modified and disposed. The iRoadmap attempts to trace the content and flow of such information in the whole life of a VE. The iRoadmap for the bid preparation in a global engineering and manufacturing network environment provides a guideline for the bidding team, and enables the development of knowledge management system to support the bidding process.

The middle-level procedural knowledge is the bidding decision-making and bidding document configuration processes. These best practices will help the bid manager in analyzing the business opportunities, and adopt a suitable bidding strategy according to market, technology, or alliance considerations. With the selected bidding strategy, the engineering baseline, cost estimation, and risk exposures can be established. Furthermore, the structure of the bidding document, including the technical proposal and terms and conditions can be defined. Most re-usable components for the bidding document can be identified and included shortly after the configuration of the bidding document is determined.

The detailed-level procedural knowledge is the know-how of how technical, financial, and legal information is used in the bid preparation. These best practices may include the selection of manufacturing equipment, the specification of design or operation parameters, trade-off in production processes, and selection of corresponding testing and validation methods. It may also include advise to the bidding team about alternative clauses of terms and conditions as well as their impacts and consequences.

The top-level procedural knowledge could be developed and tailored to suit any bidding team in a virtual enterprise setting. However, the middle-level procedural knowledge could only be developed for a specific industry sector or a specific group or network of companies. The detailed-level

procedural knowledge could only be developed for a specific company. This is because the best practice in one company could be disastrous for another.

6. IMPLEMENTATION AND CASE STUDIES

A proof-of-concept VIEWBID bidding workbench has been implemented. The Lotus QuickPlace [9] has been used as a web-based collaboration platform to support the whole bid preparation process, from receiving the RFP or RFT, through to the online co-authoring of technical proposal, to the final delivery of the bidding document.

The various document components are defined using XML DTDs, which are then used to create forms and templates in the QuickPlace to enable the capturing and re-use of direct knowledge. A Java based modeling and execution tool has also been implemented to capture the procedural knowledge in the bidding process, however, only selected a few of them have been implemented in QuickPlace as agents.

Two case studies have been conducted. The first case study looks at the bidding process for the design and build of an airframe component. The second case study investigates the feasibility of implementing SMART 2000 [10], the Australian Defence Industry guideline for bidding and contracting in bid preparation for defence projects.

Our case studies indicate that development of a knowledge management system for bidding requires careful analysis of the bidding process, and the effectiveness and efficiency of such a system largely depends on the easiness of capturing and reusing existing knowledge. Managing knowledge as intangible assets in the dynamic virtual enterprise environment is still a challenging research topic [11].

7. CONCLUSION

This paper presented an investigation on the knowledge management issues in the development of VIEWBID, a web-based bid workbench for global engineering and manufacturing projects. We classified knowledge involved in the bid preparation process into three categories, and focused our research on the capturing and management of the direct and procedural knowledge, while trying to interpret and convert the tacit knowledge into the direct and procedural knowledge.

The enterprise engineering architectures and methodologies, such as VERA and iRoadmap, have been used to analyze the bidding process to capture different levels of procedural knowledge. A set of component-based

technologies has also been developed using XML and Java to capture, configure, and compose the bidding documents.

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