AN INTEGRATED WEB-BASED DECISION SUPPORT SYSTEM FOR TENDERING PROCESSES

N.M. Mohamad Noor[1], K.N. Papamichail[2], B. Warboys[3]

ABSTRACT

A Decision Support System (DSS) is an interactive computer-based system that helps decision makers (DMs) utilise data and models to solve complex and unstructured problems. Procurement or the tendering process is a decision problem of paramount importance for any business. A critical and vital procurement task is to select the best contractor during the tendering or bidding process. A case study is drawn from the construction business in order to demonstrate the applicability of our approach. Advancing the application of information technology in tendering is a major international research and innovation endeavour for both scientific establishments and industry. The aim of this work is to implement and evaluate an architecture for modelling and coordinating decision-making activities in tendering processes.

Process modelling techniques are used to capture human behaviour, interactions with computer systems and flows of information through tendering processes. The constructed process models are implemented using a Process Support System (PSS). They are used to facilitate the understanding and communication of electronic tendering processes to stakeholders such as construction managers and contractors. We develop an Integrated Web-based DSS that comprises a Web-based DSS, a Process Modelling for Online Communication System (PMOCS) and a Decisioning for Decision Support in Process (D2P). The Web-based DSS, functioning as a data acquisition module, has been developed to collect information about the clients, contractors, and project details. It manages and facilitates the tendering activities. The PMOCS coordinates the participants of tendering processes and supports the communication and collaboration necessary in preparing tender documents. The D2P coordinates and supports the decision-making phases. The D2P is also a generic model that supports the process of making decisions. It uses a meta-process (a process about processes) for supporting tendering activities. It aids DMs in choosing among of competitive bids for building projects.

KEYWORDS

DA, D2P, Web-based DSS, Process Modelling, Tendering Processes.

[1] Department of Computer Science, Faculty of Science and Technology, University College of Science and Technology Malaysia (KUSTEM), 21030 Kuala Terengganu, Terengganu, Malaysia, maizura@kustem.edu.my
[2] Manchester Business School, The University of Manchester, Booth Street West, M15 6PB, UK, papamichail@mbs.ac.uk
[3] Department of Computer Science, Oxford Road, The University of Manchester, Manchester, M13 9PL, UK, warboys@cs.man.ac.uk

INTRODUCTION

Decision Support Systems (DSSs) are computer programs that aid users in a problem solving or decision-making environment. These systems employ data models, algorithms, knowledge bases, user interfaces, and control mechanisms to support a specific decision problem (Barkhi et al. 2005). A DSS does not simply provide direct solutions, but it rather gives a recommendation based on the input of the Decision Makers (DMs).

The Web-based DSS is fast becoming a vital engine of growth for the world today. It has also enabled many enterprising individuals, firms and communities in all parts of the globe to address economic and social challenges with greater efficiency and imagination. Enormous opportunities are there to be seized and shared by us all, where new technologies are effective promoters for applying technologies. The tendering process in most developing countries is often slower and less efficient. This realisation presents an opportunity to introduce IT in order to create a more cost-effective and innovative public procurement system in this case, specifically for the country of Malaysia. The specific tender analysis procedure studied in this work is based on the Malaysian standard. The role of the DSS is to help industry professionals, in this case construction managers or other chief DMs choose a successful tenderer.

This paper discusses the design of a Web-based DSS which is based on a framework for a generic process approach. The DSS is intended to be used as a general decision-making aid. The system, as a research prototype, facilitates the management of tendering processes. The principal aim of such processes is to select contractors that offer the best value for money. The winner of a tender is the one who makes the best offer based on the evaluation criteria under consideration.

CURRENT PRACTICES IN PUBLIC TENDERING

In general, the public tendering procedure, as a significant economic activity in most countries, usually involves two kinds of players. The first is public industries (procuring entities) that publish their intention to procure goods and services under certain rules and restrictions imposed by the client of each country. The second is contractors that respond to calls for tenders indicating their intention to tender the projects.

Normally, a typical public tendering cycle involves the following processes: tendering, contracting, and trading (Romm and Sudweeks 1998). The tendering process involves the announcement (on the procurer's side) of its intention to acquire certain goods, and the submission of tenders by the contractor. In specific cases, the solicitation documents may require the contractor whose tender was accepted to sign a written tendering contract conforming to the tender.

It should be however noted that the traditional public tendering process is facing many deficiencies, especially in developing countries that are characterised by bureaucratic procedures and corruption (Celentani and Ganuza 2002) such as complicated procedures and extended relationships, excessive state intervention, bureaucratic functionalities, absence of clear national IT policy, large volumes of paper, lack of flexible centralised control, lack of information quality and resistance to change.

The emergence of information technologies provides the opportunity for the clients to employ Web-based applications as an enabling technology to address these deficiencies. Doing so would not only cut the costs and improve the quality of time, it would also improve the trust and transparency in their tendering processes. The tools of the Internet provide a vehicle for improved information sharing and effectiveness of the tendering process with the contractors. Among the potential benefits of a Web-based DSS for tendering processes are potentially substantial financial savings for the clients, contractors, and businesses.

PROBLEM DOMAIN

Research in the area of competitive tendering strategy models has been in progress since the 1950s (Friedman 1956). Numerous models have been developed, some of which are designed specifically for the construction industry (Stark and Rothkopf 1979). Despite the number of competitive tendering strategy models that have been developed, only a few of these are used in practice, largely because they do not meet the needs of construction contractors (Panayiotou et al. 2004).

The rise of Internet-based IT initiatives makes the exchange of information simple, fast, accessible and accurate (Lloyd et al. 2004). There were a few initial researches on the adoption and use of the Internet-based IT in the construction industry (Ahmad 1999; Hudgins and Chang 2000; Zift 2000). Liao (2003) emphasised the potential of Web technologies and highlighted their usefulness for managing project performance, simplifying operations process and document management, as well as organising communication and coordination between project participants.

Kumaraswamy and Dissanayaka (2000) proposed a DSS model for managing project procurement but they did not focus on tender evaluation or tender analysis. Research on Internet-based electronic purchasing, such as the research report on tendering practices and trend which covered the results from surveys and interviews has included such topics as Internet-based tendering technological processes, technology, and utilisation (Davila et al. 2003). The major objective of a number of initiatives introduced in order to facilitate parts of the whole of the tendering cycle in the private and public sector was to establish an electronic environment that would support public authorities and private companies, in accessing tendering information and exchanging all papers related to tendering activity (Nitithamyong and Skibniewski 2004).

Thus, the tendering practices are mainly based on paper-based procedures and mail, rather than instantaneous electronic communications. Since these documents were transmitted by fax, postal mail, and telex, a series of problems such as legibility, delays and validation have created extra costs on entities through the delay in the execution of contracts or the additional costs of reduced competition in the market place. Under Web-based DSS for tendering processes, these notices would be published online.

In the field of public procurement, the Malaysia directives describe three types of procedures: (1) the open procedure, (2) the restricted procedure, and (3) the negotiated procedure. In the open procedure, all interested contractors may submit tenders in response to a published contract notice. In the restricted procedure, only the contractors who have been invited to participate by the contracting authority can submit a tender. The negotiated procedure allows the contracting authority to consult the contractors of its choice and to

negotiate the terms of the contracts with one or more of them, but only in the cases listed exhaustively in the directives. This research uses the open procedure in order to develop a Web-based DSS for tendering processes. The open procedure is commonly used in Malaysia.

AIM AND OBJECTIVES

The aim of the research is to propose a framework for supporting distributed decision-making. The proposed framework assists DMs in the formulation, evaluation and appraisal stages (Holtzman 1989) of the decision analysis process. The objectives of this research are:

1. To develop a framework of generic decision support for complex and unstructured processes by studying a real-world tendering activity in the construction industry.
2. To use the concept of Decisioning for Decision Support in Process (D2P) (Oquendo et al. 2000), an architecture for modelling and coordinating decision-making activities, in implementing the tendering processes in order to provide a basis for subsequent generalisation of the approach.
3. To demonstrate the applicability of the approach using a real-world scenario by developing an efficient Web-based management system for the tendering process. The system supports tendering, consolidates and analyses tender information from government, semi-government and the private central tender repository of Malaysia.

RESEARCH APPROACH

The need for a more effective analysis and improvement of tendering processes provides the starting point for this research. There are many approaches to developing DSSs, such as knowledge-driven, document-driven, communication-driven and model-driven methods (Power 2002). In this work, we have combined the model-driven and communication-driven methods to develop a hybrid DSS. A model-driven DSS places emphasis on statistical analysis, financial optimisation or simulation. It uses data and parameters provided by DMs in analysing and choosing the best alternative. A communication-driven DSS supports communication, collaboration and coordination among multiple users. The proposed Web-based DSS offers prescriptive advice i.e. its recommendation is based on the input of the DMs. Other DSS applications, for example (Kengpol 2004; Liu and Stewart 2004) are focused merely on supporting decision-making activities. The Web-based DSS however, supports the process of decision-making.

The adopted approach is to use a real-world case study to demonstrate the inherent complexities of decision-making. The plan is to exploit a particular concept of D2P, an implementable framework for supporting the process of decision-making. Unlike other proposed DSS design approaches such as prototyping (Lawrence and Sim 1999), simulation model (Marquez and Blanchar 2004; Ropke et al. 2004), this approach includes a rigorous yet evolvable step-by-step procedure to be implemented in this experiment. The aim of the chosen case study is to select the best tenderer/contractor for certain construction projects or in other words to analyse a tender from tender forms submitted by contractors. This application uses a generic model and is designed in a flexible manner so that it is possible to configure it to analyse different tenders for various construction projects.

A FRAMEWORK FOR SUPPORTING DECISION-MAKING IN TENDERING PROCESSES

The generic definition of a DSS is an interactive computer based system that helps DMs utilise data and models to solve unstructured problems (Sprague 1980). During the decision-making process, input information is of vital importance. The primary source of information is raw data which is converted to information by utilising relevant methodologies. Both data and models are necessary resources that need to be managed efficiently to improve the efficiency and effectiveness of the overall decision-making process.

Figure 1 below illustrates the overall scheme of our research and the relationship between the end-users referred to as business registered end-users and the developers referred to as process modelling engineer. As illustrated in subsequent figures, we developed an Integrated Web-based DSS. The Integrated Web-based DSS comprises a Process Modelling for Online Communication System (PMOCS), a Web-based DSS and, a Decisioning for Decision Support in Process (D2P).

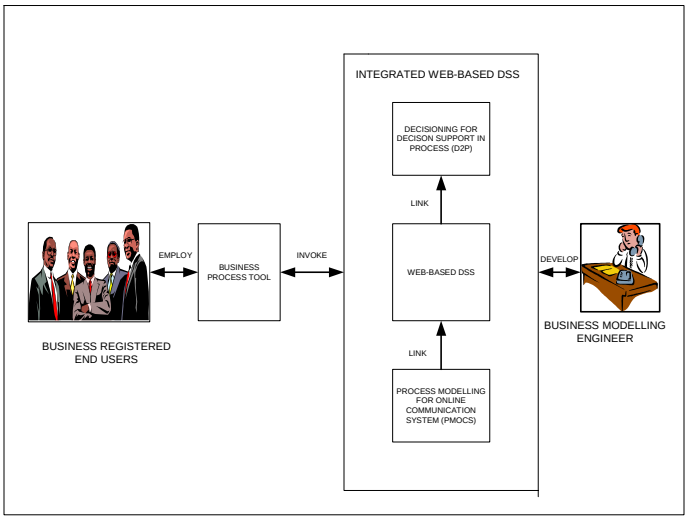

Figure 1: A System Support for an Integrated Business Modelling

Web-based applications are multi-layered applications (Duan et al. 2005). Multi-layered applications divide functionality into separate layers. These layers (sometimes referred to as tiers) can be located on the same computers, but they typically reside on separate hosts. Figure 2 shows the three-layered basic structure of the Integrated Web-based DSS for tendering processes. The three-layers are described as the presentation layer, the application layer and the data layer. Web browsers and Web servers are described within the presentation layer and the application layer respectively. The database and model base servers reside within the data layer. The kernel is composed of the DSS facilities in a traditional sense (i.e. database, model base and user interface) relevant to our problem domain.

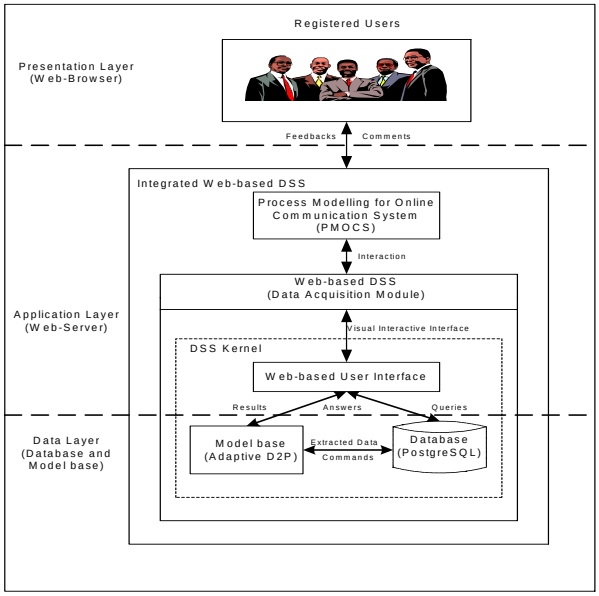

Figure 2: The High-Level Architecture for An Integrated Web-based DSS

The architecture of the generic Integrated Web-based DSS in tendering processes is depicted in Figure 3. There are six major components in this architecture, which are database, model base, Internet user interface, input, output and registered user(s). A database is one of the three fundamental components in a DSS. The central component of the software system is a relational database, implemented using PostgreSQL (Worsley and Drake 2002). The database resides at the Web-server and therefore is available to all registered users of the system via their Web-browsers. The database also contains the data that is relevant to the tendering processes such as clients, contractors and project details, various forms such as financial capability and adjustment price forms.

Models are an integral part of any DSS. They are employed to support individual semi-structured decisions. Mathematical calculations are used for the structured parts, leaving the DMs to exercise judgment in handing the unstructured parts. The main model in the Integrated Web-based DSS for tendering processes is the analysis model, which is developed by using a model-driven DSS approach. Since the integrated DSS is intended for use over the Web, the user interface makes use of a Web-browser. It uses the concept of the visual interface which is presented as dynamically generated HTML documents. It is an effective communication medium that allows clients (e.g. tendering managers) to view, explore, navigate, search, compare and classify submitted tenders. Information is delivered to the user via the produced HTML and related files, which are displayed by the Web-browser.

Data entry or the input of files in HTML format can be completed by DMs and the contractors via password-protected Internet-based forms. Output files display the ranked list of alternatives. The gateway is implemented using the Common Gateway Interface (CGI) thus enabling it to function with any Web-browser. In order to minimise the needs for excessive typing by the end users, pull down menus enables the users to select items from a

list. The use of pull down menus also serves to reduce the incidence of errors when typing in pure text,

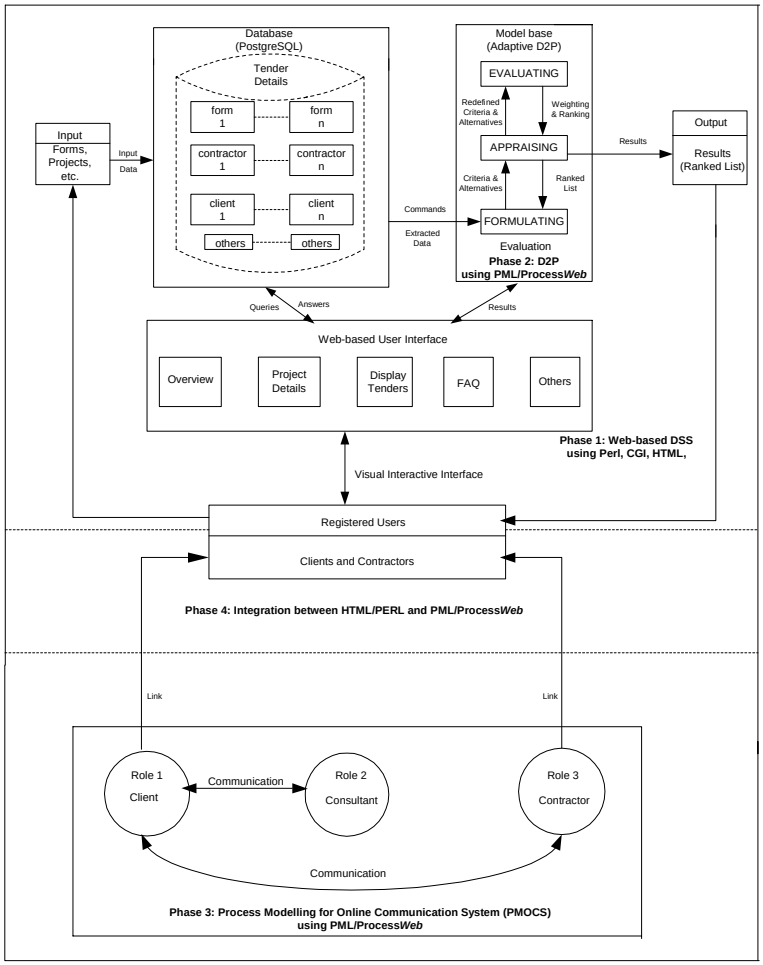

Figure 3: A Generic Integrated Web-based DSS

As mentioned by Etter (1988), any methodology that facilitates information flow and the associated decision analysis has the effect of reducing risk for making a decision. The Integrated Web-based DSS uses a decision analysis model in order to process and evaluate the submitted tenders. The system offers functionalities similar to other tender evaluation systems that employ Multi Criteria Decision Making (MCDM) methods to rank criteria by score (Costa et al. 2002). However this system is unlike other traditional DSSs as it also facilitates real-time communication between users for example clients, consultants and contractors (communication-driven DSS).

The system operates on Process*Web*, a Process Support System (PSS) for managing complex software engineering problems (Warboys et al. 1999). Process*Web* enables the real-time communication between the client, contractor and consultant roles. As mentioned

above, D2P is a generic model that represents decision-making processes (Papamichail and Robertson 2002). We have also adapted the D2P to reflect the properties of the tendering process (see Figure 4). The specialised D2P model is developed by using Process Management Language (PML) and enacted on Process*Web*. This model is evolvable in the sense that it recurses i.e. it instantiates another decision process when required in order to address the changing requirements of the tendering process. The enactable model constitutes the communication module, which is connected to the other components of the Web-based DSS.

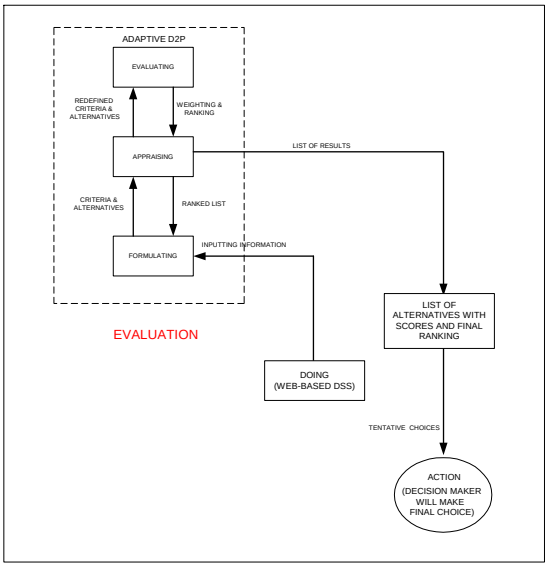

Figure 4: The Architecture for Domain Specific (Adaptive D2P)

The following is a description of the generic tendering process using the concept of the D2P meta-process. Regarding the problem resolution strategy, a procedure is proposed to evaluate tenderers based on several criteria. The criteria for the tender evaluation include financial capacity, technical capability, past performance, past experience and the availability of technical staff. It involves the use of mathematical models and calculations for the evaluation of tenders. As a means of reflecting the different degrees of importance attached to different criteria in a complex tender analysis, the DMs assign weights (in the form of points or percentages) to important measurable criteria before tenders are received. Each tender is then assessed against these criteria, and is assigned scores to reflect how well a tender satisfies each of them. The weighted scores for each criterion are then calculated and aggregated. This function is referred to an additive value function. All the results are utilised as a guideline to support the process of making decision.

CONCLUSIONS

DSSs are becoming increasingly more critical to the daily operations of organisations (Phillips-Wren et al. 2004). In general the tendering processes have become increasingly

complex so that it is no longer possible to use traditional methods for managing the tendering process. Clients and contractors who wish to actively manage their tenders are faced with the problem of choosing among the contractors by employing the most efficient tools. As Tserng and Lin (2002) had pointed out it is crucial to select appropriate contractors to implement the specific project. The ultimate goal of this research is therefore to employ a generic application for supporting complex and unstructured decision problems in the tendering process within the construction industry by developing an Integrated Web-based DSS for supporting the tendering processes that facilitates real time communication and coordination between clients, contractors and consultants using process support technologies. Our Integrated Web-based DSS, as a research tool will assist tendering managers in evaluating tenders in a systematic way and contractors in submitting tenders. Adding transparency into the tendering process can improve understanding and acceptance of the decisions taken.

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