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# Decision Support for Web-based Prequalification Tender Management System in Construction Projects

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## 1. Introduction

In the ninth Malaysian Plan, the government attempts to optimize the use of Information Communication and Technology (ICT) infrastructure in delivering information to the people (Unit, 2006). Web-based application is being used as a medium to distribute useful information to the people in the most effective way. Most of the public sectors in Malaysia are utilizing Web system in their daily practices, but in several complicated processes, they are still using conventional way in processing the related documents. One of the examples is tendering processes in construction industry.

Tendering processes in construction industry normally will consume longer time to process all tender documents and there are some standard procedures to be followed. Standard procedures for construction in Malaysia are underlined by Department of Work (JKR). As the government is moving towards electronic tendering for the construction industry at the national level, most of public sectors publish open tender advertisements in government Web services but application to handle electronic tendering processes in construction industry has not been completely developed yet. Thus, the construction industry remains to be the most complex and fragmented industry in Malaysia (Weng & Alsagoff, 2006).

Prequalification is an initial phase in tendering processes where all tender documents will be screened out to select the compliance contractor. Prequalification is important as it can minimize risk of construction projects. In this phase, the contractor has to fulfill the tender documents according to the client request. It also provides an analysis on the tender documents by filtering the qualified contractors that have completed all tender documents properly.

Since some of tendering processes are confidential and involves many parties such as clients, consultants and constructors, we proposed Web-based application for prequalification tender management system in construction project or known as PreQTender to facilitate these processes. The proposed model is expected to benefit in terms of security of tender documents, reducing tender administration in terms of workload and paperwork, thus increasing productivity and efficiency in daily responsibilities. Furthermore, handling documents electronically is also to ensure fair and transparency processes.

The PreQTender provides an automated decision making process that reduces the use of manpower and processing time of the tenders. Web-based Decision Support System (DSS)

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has reduced technology barriers and made it easier and less costly to serve decision relevant timely information to the client wherever and whenever they may need it (Delen et al., 2007). The PreQTender is being developed to support contractor selection process.

This paper is organized as follows. First section described the current practices of tendering process. Second section continues with literature review. Third section is explanations of problem statement. Fourth section illustrates the research framework of PreQTender. Fifth section is expected result and lastly ends with conclusions.

## **2. Literature review**

### **2.1 Current practices of tendering processes - background**

Tender is an invitation to offer for an item or work. According to Du et al., tendering process is an invitation to those relevant parties to make an offer to the principal, which must be capable of accepting the offer, thereby creating a legally binding contract (Du et al., 2004). Principal is any party inviting and receiving tenders whilst the client may include a contractor. Tenderer is any party whose submitting tenders, including contractor, subcontractor and supplier (Du et al., 2004).

Tenders can be divided into several types such as open, restricted and negotiation tender. Open tender is a tender that offered to any interested contractors. Negotiated tender is carried out under special circumstances whereby is done when the clients need some expertise that capable in doing such projects. Restricted tender is applied when purchase authority has procedure in place which will definitely lead to the award of a contract. The procedure is restricted because contractors are first invited to express an interest and those contractors that have qualified against certain criteria are invited to submit tender (Du et al., 2004). Tendering processes is a complex process. A typical one involves lots of business procedures such as tender specification preparation, tender advertisement, tender aggregation, tender evaluation, tender awarding, and contract monitoring (Ng et al., 2007).

### **2.2 Prequalification tendering process**

Prequalification tendering process is to identify qualified constructors based on some criteria as requested by clients. Besides that, this stage also certifies all the prequalification documents that are required to be submitted by constructors. Prequalification stage is generally preferred by clients to minimize the risks and failures. It also will enhance the performance levels of selected contractors. (Palaneeswaran & Kumaraswamy, 2001).

The prequalification tendering practices are different between countries according to the rules, regulations and procedures to be followed. In the study done by Palaneeswaran and Kumaraswamy, they examined several prequalification practices in Hong Kong, Australia and USA (Palaneeswaran & Kumaraswamy, 2001).

Construction Industry Development Agency (CIDA) in Australia has recommended three categories of prequalification criteria namely mandatory, additional and reserved. Technical, financial, quality assurance, time performance, human resource management, skill, occupational health and safety are considered as mandatory whilst claims performance and research development are regarded as additional and reserved. However, construction industry in Hong Kong has identified several different prequalification criteria such as experience, corporate, workload, support functions, resources and facilities. Whilst in USA, different public clients use various prequalification ratings.

Other research has been done by Topcu where the study has determined four main prequalification criteria in construction industry in Turkey including ability to complete projects, expertise, experienced technical staff and resources (Topcu, 2004).

### 2.3 Scenarios of electronic tendering system

The transparent procurement procedure powered by the Electronic Tendering System has been regarded as one of the most important merits embedded in the digital government. Taiwan government demonstrates the framework of electronic tendering system which in turn benefit both government bodies and vendors in terms of time and cost barriers (Liao et al., 2002). This framework is benefit as it simplifies original tendering process where the tasks of obtaining, submitting and opening tender are done via Internet. Continuation to this, in December 2002, the Public Construction Commission statistical reports showed that over 100,000 public agencies have utilized the Electronic Tendering System to upload the procurement documents and over 200,000 firms have attempted to supply construction projects, goods, and services by downloading the documents via the Electronic Tendering System (Chu et al., 2004).

Besides that, Indian government is operating The Indian Government Tenders Information System as the central Source for tenders offered by the Central and State Governments and other public bodies across India (Government, 2008). Kajewski et al. have reported on electronic tendering for construction industry in Australia, United Kingdom, United States of America (USA) and Canada (Kajewski et al., 2001). The report shows that electronic tendering has provided different facilities between countries even though it has similar functions. To make the Web-based more effective, integration between Web-based and DSS technology is implemented.

### 2.4 Web-based DSS: A new transform technology

Web-based has been used widely as it plays an important role in distributing information. Web technology enables the user to access a wide array of information and do transaction processing services easily at any places. Web is a platform of choice for building DSS.

DSS can be categorized into five different types such as Knowledge Driven, Communication Driven, Data-Driven, Document Driven and Model-Driven (Noor et al., 2006, Power and Kaparathi, 2002). In this research, it concentrates on Communication Driven and Model-driven. The integration of DSS and Web technology become popular as its gives a lot of benefit and make it more convenient to the user to access the DSS technology through the Web environment (Bhargava et al., 2007). DSS is a complex system that helps analyze decisions or choose between different options. A model-driven DSS places emphasis on statistical analysis, financial optimization or simulation. These are used by managers and staff members of a business, or people who interact with the organization, for a number of purposes depending on how the model is set up such as scheduling, decision analyses and others. DSS can be deployed via software or hardware in stand-alone personal computers, client or server systems, or the Web.

Prequalification tendering with Web-based Decision Support System (DSS) is a new transform technology that attempts to apply from manual tendering processes to electronic tendering system in order to make the process more efficient and effectiveness. Due to the growing interest in the Web, there are many on-going efforts to develop and implement Web-based DSS in various areas, such as health care, private companies, government, and education (Bhargava et al., 2007).

## 2.5 Advantages of using web-based DSS

Recently, both electronic business and electronic government are increasing their demands for more online data analysis and decision support. A Web-based DSS is a complex software system. It may integrate multidisciplinary data sources and related tools to generate value-added information to support decision-making (Zhang & Goddard, 2007).

One of Web-based DSS benefit is it can reduce management cost. According to Power, using Web-based DSS can reduce cost of operations, administration support and maintenance as well as end user training cost (Power & Kaparathi, 2002). Another advantage of Web-based DSS is it provides a trust security services. Security services have been defined for electronic tendering system with consideration for its legal nature where only authenticated parties will be allowed to access the system (Betts et al., 2006, Du et al., 2004). Moreover, Web-based DSS does not require any specific support from additional software and it is also more accessible and provides an interactive and unique interface.

## 2.6 Decision making models in tendering processes

Tendering process has multi criteria to be considered where each element will be considered as an important element in selecting qualified constructors. These criteria can be divided into qualitative and quantitative attributes.

There are several published models for selection process such as Analytic Hierarchy Process (AHP), Artificial Neural Networks (ANN), Multi Attribute Analysis, Multi Attribute Utility, Case-based Reasoning (CBR), Fuzzy Set Prequalification, Knowledge Based System (KBS), Dimensional Weighting Aggregation (DWA) and PERT model (El-Sawalhi et al., 2007, Holt, 1998).

AHP has been widely adopted to support multi criteria decision. Al-Dughaiter has demonstrated prequalification multi criteria decision making model using AHP (Al-dughaiter, 2006).

AHP is the most powerful and flexible weighted scoring decision making process to help people set priorities and make the best selection when both qualitative and quantitative aspects of a decision need to be considered (Cziner et al., 2005). AHP allows group decision making where group members can use their experience, values and knowledge to break down the contractor prequalification problem into a hierarchy and solve it by the AHP steps (Banaitiene & Banaitis, 2006).

By using AHP, it allows the decision makers to break down a decision into smaller parts, proceedings from the goal to criteria to sub criteria down to the alternative courses of action. AHP has been used to overcome the difficulties of the prequalification process. It is a sophisticated structured mathematic procedure and it is easy to implement for different applications (Al-dughaiter, 2006).

## 3. Problem statement

In Malaysia, many of the public sectors offer a tender advertisement on the Web, but all documents related during tendering processes are still handled manually. In the manual tendering processes, the client hires a consultancy team made up of experts, such as architects, designers, project managers, quantity surveyors and other construction expertise, while contracting the construction to the selected contractor (Palaneeswaran & Kumaraswamy, 2000).

Manual tendering processes can be long, in term of duration, often taking three month or longer, which is costly for both contractor and supplier organizations (Ng et al., 2007). Weng



and Alsagoff have identified many problems and issues faced in Malaysia construction industry and several are listed here such as problems in authenticating contractor status, insufficient copies of documents available due to high demand, voluminous tender documents to be fulfilled by constructors, incomplete information/ documents, delay due to corrections and amendments before issuance of documents, voluminous documents to vet through, possible for leaking of restricted information of tender documents, possible mix up of documents, problems in issuing and collecting addendums, lack of information for decision making, inconsistency of tender evaluation and uncertainties in validity of information used in tender evaluation (Weng & Alsagoff, 2006).

According to Ng et al., the large volume of papers needs a lot of manpower to arrange tender documents (Ng et al., 2007). This tendering process uses a lot of space to store the tender documents and it usually costly to both client and contractor. The public tendering processes imposed by the government, are aiming at reducing the possibility of waste and abuse of public money (Hameri & Nordberg, 1999). Preparing tendering documentation and conducting tender obtaining processes requires much labor which is costly for suppliers. The management of paper-based documents as product samples and confidential information presents an obstacle (Kajewski et al., 2001, Liao et al., 2002).

Constructors are required to face several crucial phases in tendering processes before awarding a contract. The phases are including tender specification preparation, tender advertisement, tenderer prequalification, tender aggregation, tender evaluation, tender awarding, contract monitoring and others. Conventional prequalification process takes longer time in processing the tender documents. According to Russell, prequalification is the process of screening contractors where the minimal capabilities below which any potential contractors would not be considered for the evaluation phase (Russell, 1992). It is a process of evaluating and determining the competency of companies that appear qualified to perform construction services that meet the client's expectations for such services. The prequalification procedure is often chosen to minimize risk (Topcu, 2004).

The selection of qualified constructors gives confidence to clients in terms of selecting eligible contractor who is believed to achieve the project goals (El-Sawalhi et al., 2007). Contractor selection is a critical activity that plays a vital role in the overall success of any construction project (Liao et al., 2002, Palaneeswaran & Kumaraswamy, 2001). In the construction project, the selection of an appropriate contractor is the most critical for project success (Banaitiene & Banaitis, 2006). To choose the right person for the right project requires a right decision making selection of main contractors for construction work. Contractor selection is one of the main decisions made by the clients. Objectives of the tender system in construction even in the global contexts remain unchanged, that is to devise a most efficient framework to select capable contractors who can complete the construction project within set parameters of time, money, and quality (Alsagoff & Weng, 2006).

Prequalification is also important in the construction process as it is ensuring that the project is built on time, within the budget and based on quality level the owner expects. All the tenders that submitted by the contractor will be checked for the completeness of the documents required, documents verification, registration validation, and mandatory requirement.

This research proposes a design for prequalification tendering process with the aim of using Web technology as a medium to distribute information to the contractors. The objective of this research is to analyze, design and develop an overall framework of the prequalification

tendering processes, namely as PreQTender, and finally test and evaluate the reliability of Web application for prequalification tendering processes in order to make it works properly on real system. This research focuses on tender for construction projects in Malaysia and manages the prequalification tendering process such as obtaining and submitting tender process and also covers the process of selecting the potential contractors that eligible to be evaluating into the evaluation stage. An overall workflow has been created in order to see the prequalification tendering processes clearly.

4. Research framework

4.1 Workflow

Figure 1 shows the overall workflow of PreQTender tendering process. The process starts with invitation to tender (ITT) by client until the selection of potential contractors. Each interested contractor has to submit all tender documents as requested by client. Contractors are allowed to update application before completely submitting tenders in between time given. Addendum is a condition where contractor’s tender has corrections or modification. PreQTender checks prequalification for each contractor who has successfully submitted the tender based on specific criteria as stated by client. Then, PreQTender will evaluate the compliant contractors and finally generate short-listed of qualified contractors before go into evaluation stage.

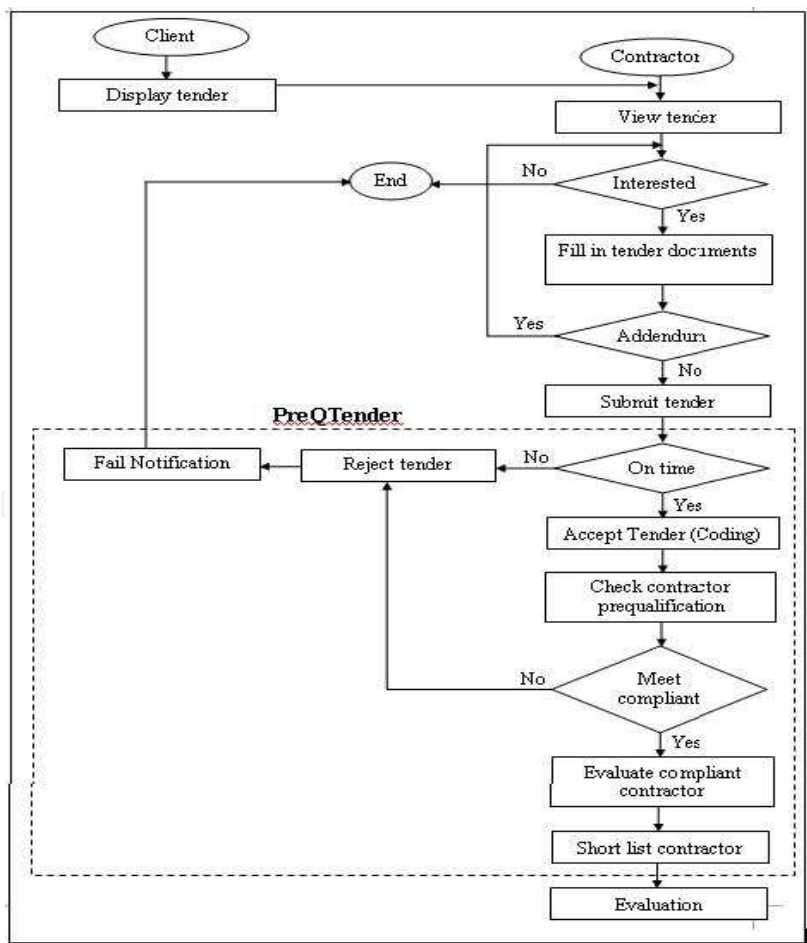


Fig. 1. Overall Workflow of PreQTender

Figure 2 shows the workflow of the contractor selection process. Before short listing the potential constructors, PreQTender will check and control every tender document received (form A-GA) to ensure the completeness of information and documents. The compulsory documents such as copy of bank statement and company account audited for last two years will be thoroughly checked by PreQTender as well as supporting documents. For the supporting documents the contractor has to enclose a copy of bank report of financial records, a letter certified completeness of work for each projects involved, Employees Provident Fund (EPF) for every technical staff of the company, academic qualification of each technical staff and report of current works performance for each project.

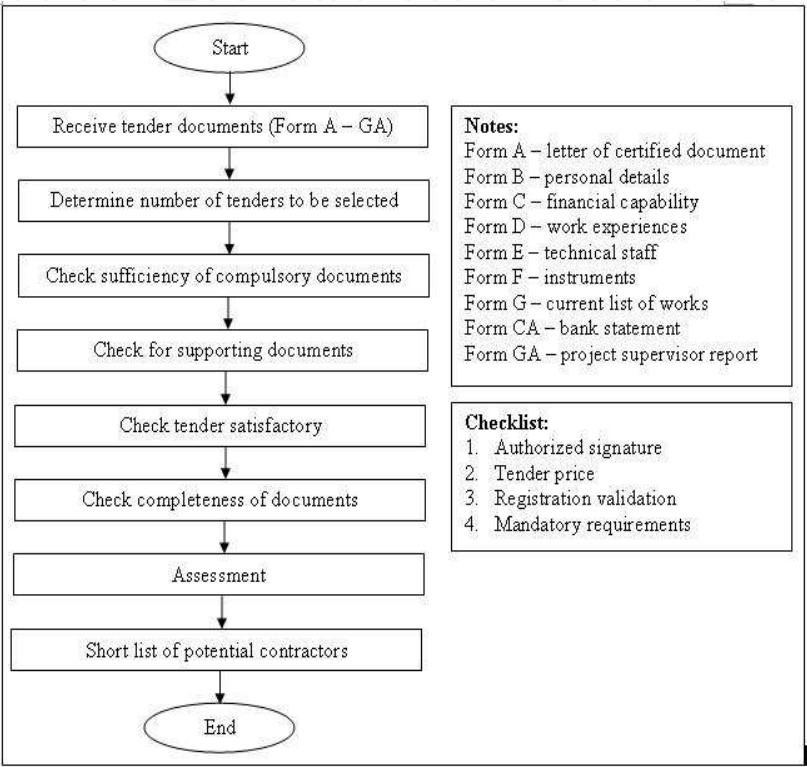


Fig. 2. Work flow of Contractor Selection Process

4.2 Framework

Figure 3 depicts the framework of PreQTender where it consists of five main modules. The modules are preparation of tender documents, obtaining of tender documents, submission of tender documents, opening tender documents, and prequalification tendering analysis. Client involves in preparation and opening of tender documents while contractor involves in obtaining and submission of tender documents. Before the contractors enter to the obtaining module, they are required to make certain payment.

4.3 Software architecture

The World Wide Web and database technologies have been employed to facilitate the functions of PreQTender. Figure 4 shows the software architecture of PreQTender. World-Wide-Web browser is used to access the Web server via the HTTP protocol. Web-based DSS support three quarter architecture which a Web browser sends HTML request using the hypertext transfer protocol (HTTP) to a Web server. The Web server



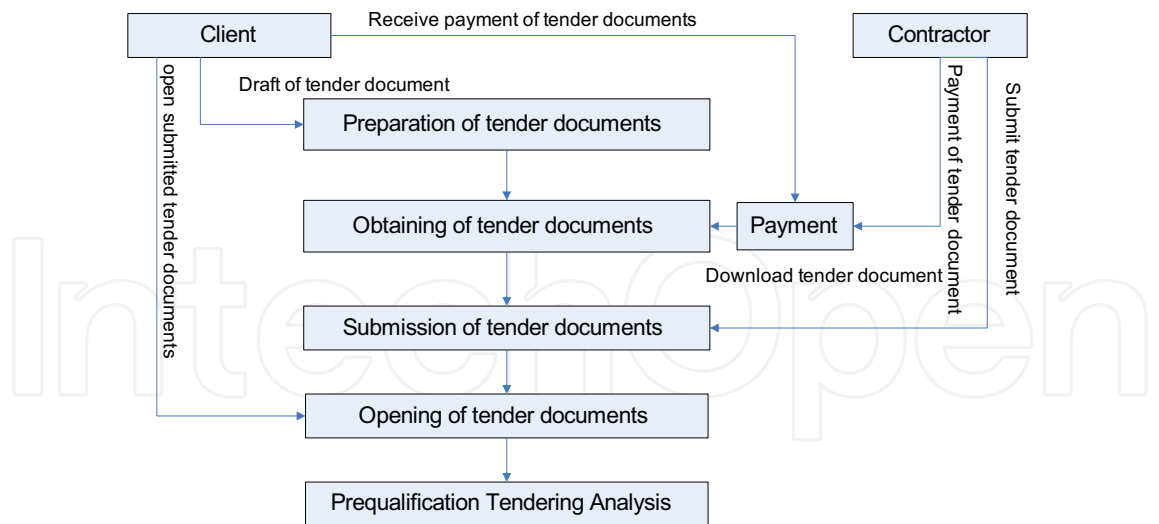


Fig. 3. Framework of PreQTender

processes these requests using a common Gateway Interface Script (CGI) script. The CGI handles model processing, SQL generation, post-SQL processing, HTML formatting. Application server sends requests to a modelling program or a database server. Tools like Java and JavaScript are improving the display of results and the interactive analysis of data and models. In order to require user interaction, scripting languages such as JavaScript and Hypertext PreProcessor (PHP) are used.

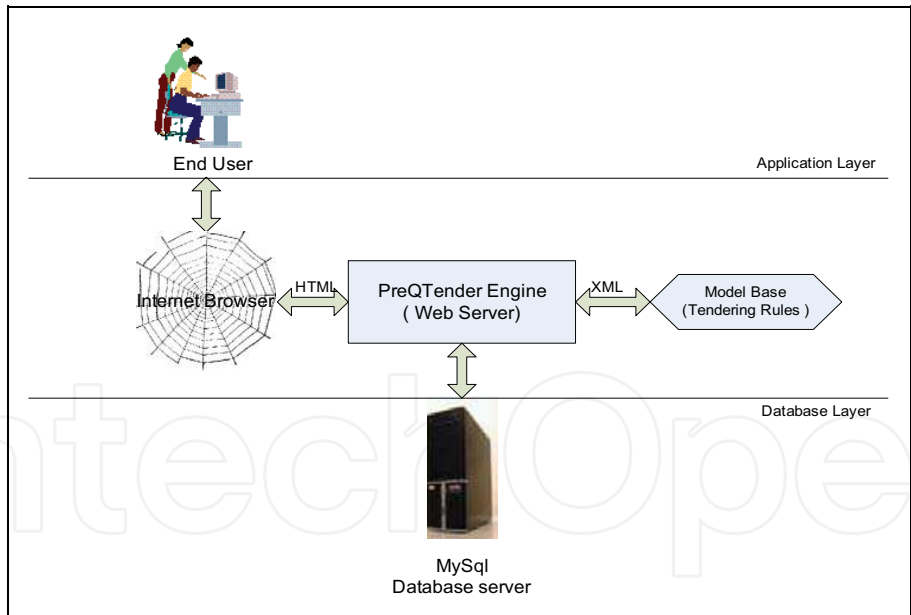


Fig. 4. Software Architecture of PreQTender

Prequalification tendering engine is a collection of software procedure written in PHP and hosted on Apache Web server. This Web server will retrieve the information from the model-based in doing the decision making for contractor selection. Model-based is the part where DSS element is embedded here. This model supports the decision making process where all the tender documents will be processed before storing them into the database. Then all the information will be stored in MySQL Database. The results of the selected contractors will be returned to the user's Web browser for display.

4.4 Phases in PreQTender

There are three phases involved in PreQTender as stated below.

Phase 1: Analyzing on Prequalification Tendering Process.

In this phase, analysis on prequalification criteria for tendering processes has been done in order to identify current problems and possible solutions. Analyzing is the process of understanding the problem and the requirements for a workable solution.

Phase 2: Designing and Developing PreQTender.

DSS is a concept that helps decision maker in processing large quantity set of tender documents that have been submitted by interested contractors. Web-based application is used to apply the conventional process to electronic format. Specific method and tools is used in developing PreQTender. In this phase, the application design is developed on the basis requirements, scopes and objectives that have been identified previously. It involves design framework and model for the system and validates it against requirement and present to the client for approval.

Phase 3: Testing and Evaluating PreQTender.

In this phase, the actual code based on the design is created and tested against requirements and test cases. The system will be tested in order to make sure the reliability of the system that has been developed.

5. Expected results

In this paper, we have presented a Web technology application with DSS to design the tendering process for construction projects. PreQTender will provide secure process and can be accessed only by the registered members. Currently, we are working on design and developing phase. Figure 5 depicts the list of available tenders while Figure 6 shows the interface that setting the priority of criteria. Client is responsible to determine this task.

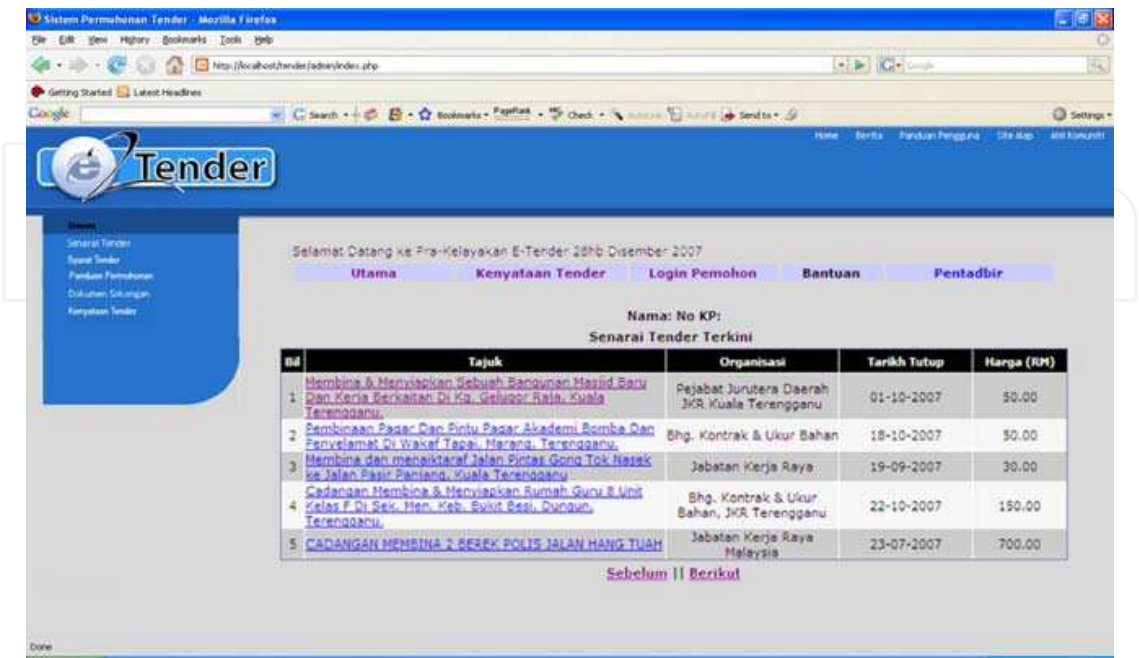


Fig. 5. List of Tenders

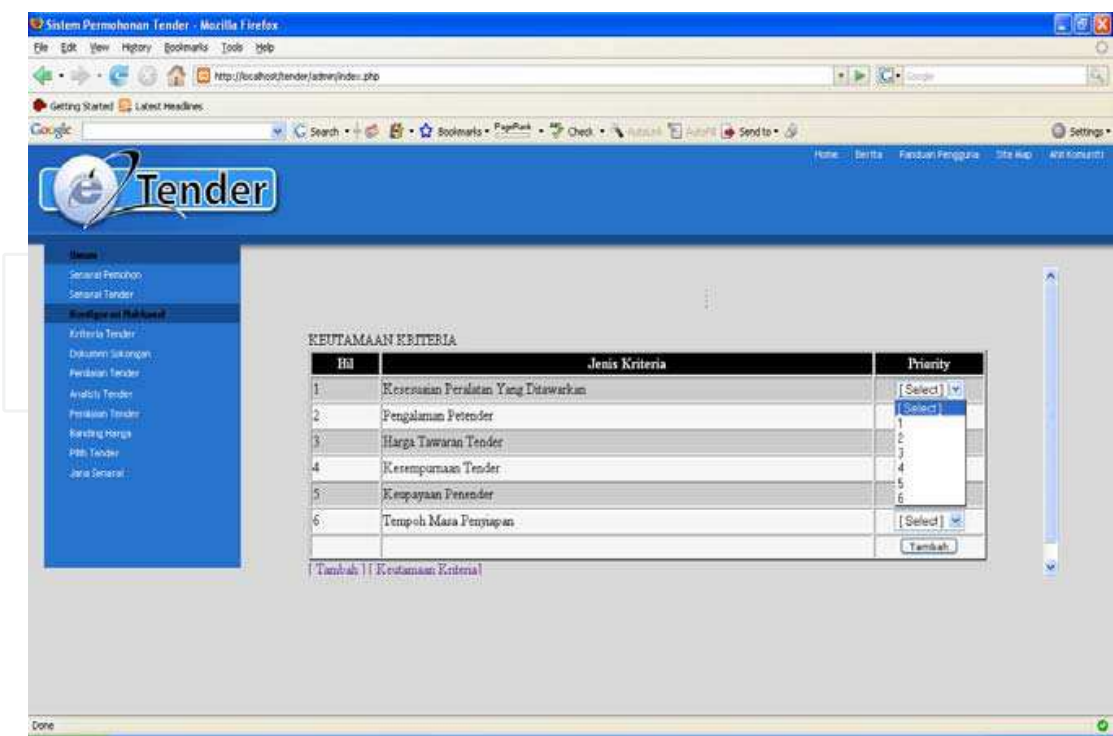


Fig. 6. Priority of Criteria

The PreQTender user interface has menu-data driven dialogues that offer a friendly environment for the user to perform the tasks that are currently available in the PreQTender. This user interface is also responsible for the overall control of the PreQTender, accessing and changing information with other menu within the PreQTender. The user interface has been implemented as a set of Web pages. The Web-based user interface enables the users to register, submit, retrieve process and manipulates data. Menus are created within each Web page. Registered users can perform operations on the project data by selecting the appropriate menu item from the Web page.

This new way of distribution information will provide better communications process between the contractor and client. Obtaining and submitting tender can be accessed easily via the Internet. The contractors also can manage their accounts and at any time. All of the information will be stored safely in database and it can prevent the data from lost or corrupted. Contactor selection process will be easier by using this prequalification process which takes shorter time and it can be conducted at any location. Figure 7 shows generated tender reports. This PreQTender will become more reliable, secured and in the end it will enhance the productivity on the client perspective.

The proper designed system can simplify the contractor selection and recent improvements in Internet technology and connectivity provide an opportunity to make the process of tendering for construction works more transparent and efficient.

## 6. Conclusion

This Web application for the tendering processes is hope to improve the manual tendering processes and yet make it convenient to the contractors and clients to manage the tenders. It is also will increase the integrity and transparency of the prequalification tendering processes.

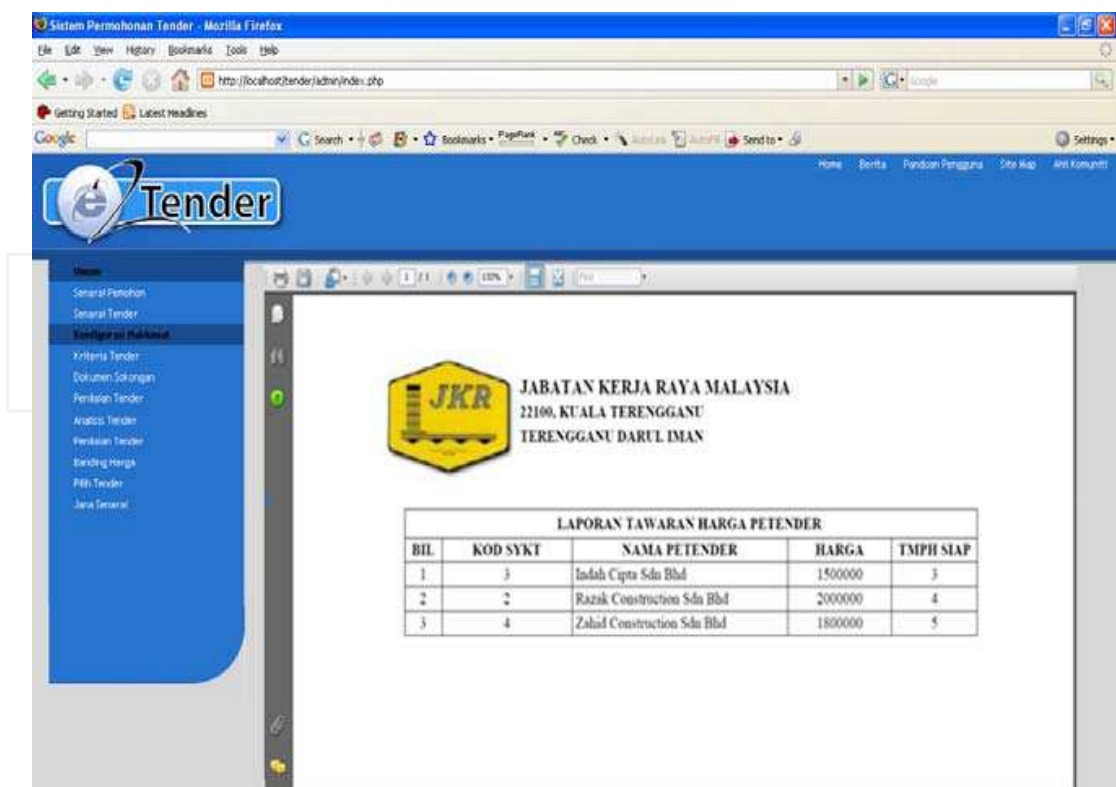


Fig. 7. Tender Reports

In addition, this system integrates the structure of various Integrated Web-based DSS services, including tender invitation document preparation, uploading, tender obtaining, tender submitting, tender opening and tender analysis. Owing to this system, tendering efficiency is increased and the possibility for tender collusion is severely reduced. Contractor participation is thus encouraged and a nation’s competitive ability is consequently increased.

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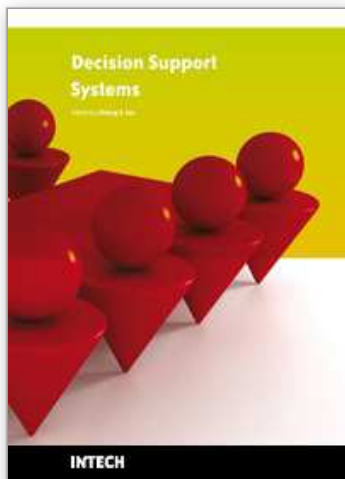
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Decision support systems (DSS) have evolved over the past four decades from theoretical concepts into real world computerized applications. DSS architecture contains three key components: knowledge base, computerized model, and user interface. DSS simulate cognitive decision-making functions of humans based on artificial intelligence methodologies (including expert systems, data mining, machine learning, connectionism, logistical reasoning, etc.) in order to perform decision support functions. The applications of DSS cover many domains, ranging from aviation monitoring, transportation safety, clinical diagnosis, weather forecast, business management to internet search strategy. By combining knowledge bases with inference rules, DSS are able to provide suggestions to end users to improve decisions and outcomes. This book is written as a textbook so that it can be used in formal courses examining decision support systems. It may be used by both undergraduate and graduate students from diverse computer-related fields. It will also be of value to established professionals as a text for self-study or for reference.

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