2017

Applying decision tree-based model in tender evaluation: case of Technical University of Mombasa

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Applying Decision Tree-Based Model in Tender Evaluation:

Case of Technical University of Mombasa

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A Thesis submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Information Technology at Strathmore University

Faculty of Information Technology
Strathmore University
Nairobi, Kenya

June, 2017

Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Samuel Kumbu Mandale

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08/06/2017

Approval

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Abstract

Unfair tender evaluation and contract award in public procurement is prevalent in Kenya. This has contributed to low quality of goods, services and projects. Successful implementation of building projects is heavily impacted by taking the right decision during tendering processes. Manning tender procedures can be complex and uncertain, involving coordination of numerous tasks and persons with different priorities and objectives. Bias and inconsistent decision are inevitable if the decision-making process is wholly dependent on intuition, subjective judgement or emotions. In making transparent decision and beneficial competition tendering, there is need for a flexible tool that could facilitate fair decision making.

The purpose of this research was to present a model of an IT solution integrating the concepts of supervised machine learning techniques in the context of tender evaluation in public procurement. A dataset of 100 instances comprising of 53 positive and 47 negative examples was used to train J48 decision tree classifier to build the model. After attribute selection in a WEKA environment, 4 of the 7 attributes of the dataset were used as independent variables (inputs) namely, Experience, Capacity, Number of personnel and Professionalism. A set criteria was used to determine the values of the independent variables. The dependent variable (output) was a category class with either “PASS” or “FAIL” values.

To determine the class of an entity the J48 model considers all the values of the independent variables based on set rules. This algorithm was preferred due to its relatively simple model among other benefits stated herein. The dataset from TUM was divided into test data and training data for the model.

The performance appraisal of the model was based on the accuracy of the classification, the precision, recall ratio, ROC curve and the F- Measure. The model was proven to be impressively accurate with an accuracy of 91.1765 % while the precision obtained was 0.857. The recall ratio was 1 and an F-measure of 0.923.

Dedication

This thesis is first dedicated to my namesake Samuel Keere for the unmatched generosity he showed me during my study. God used him in ways no one can explain. This thesis is also to all my friends and family members for wishing me well in various ways in this journey which has come to an end successfully.

Acknowledgement

I would first like to thank my thesis supervisor Dr. Bernard Shibwabo of the Faculty of Information Technology at Strathmore University. The door to Dr. Shibwabo`s office was always open for me whenever I ran into trouble spot or had a question about my thesis. He consistently allowed this research to be my work, but guided me in the right direction whenever he thought I needed it.

Secondly, I am grateful to the co-supervisor Dr. Mvurya Mgala of the Institute of Computing and Informatics at Technical University of Mombasa. Dr. Mgala made generous but objective comments that added value to my work.

I would also like to acknowledge my fellow students, the likes of Samuel Skeere, Ray Ouko, James Mwasela, Bernard Alaka, and Caroline Chepkurui. They were the first readers of my thesis before submitting my work to my supervisors. They had constructive observations.

Finally, I must express my profound gratitude to my colleagues at the department of electrical engineering TUM, for recognising the value of IT in the department for the engineering students. There comments enabled me to get a study leave. I cannot thank them enough.

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Abbreviations/Acronyms

AI	Artificial Intelligence
ANN	Artificial Neural Network
DSS	Decision Support System
IT	Information Technology
KD-DSS	Knowledge Driven Decision System
MCDM	Multi Criteria Decision Making
ML	Machine learning
PPOA	Public Procurement Oversight Authority
ROC	Receiver Operating Characteristic
RST	Rough Set Theory
SVM	Support Vector Machine
TUM	Technical University of Mombasa
UML	Unified Modelling Language
WEKA	Waikato Environment for Knowledge Analysis

Operational Definition of Terms

Agent: Anything that can be seen as perceiving the surrounding by its sensors and acting upon that surrounding by actuators (Russel and Norvig, 2010).

Artificial Intelligence: Artificial intelligence (AI) is simply the study of agents that exist in surrounding and have the ability to understand and act (Russel and Norvig, 2013).

Machine Learning: Machine learning is a section in the field of artificial intelligence and is the process in which a system can reorganise to new circumstances and recognise and extrapolate patterns by learning from data (Russels and Norvig, 2010).

Prediction Model: Formations of variables with the goal of foretell probabilities and trends (Huang, Chang, and Ho, 2013).

Public Procurement: "Public Procurement" entails procurement by procuring entities using public money (Public Procurement and Disposal Act 33, 2015).

Tenderer: Tenderer is any party submitting bids, including contractor, subcontractor and supplier (Du et al., 2004).

Tendering Process: Tendering process is an invitation to those interested 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).

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Chapter 1: Introduction

1.1 Background

The word "Procurement" covers the entire process of acquiring and utilizing goods or services. It begins when a department identifies a need and decides on its requirements. On the other hand, Evaluation is defined as the assessment of the strengths and weaknesses of programs, policies, personnel, products and organisations to enhance productiveness. Usually we should make inclusive evaluation of many contractors in the process of bid evaluation and choose the best one. If unhelpful choice is made, it will affect the schedule of the project and economic efficiency, and can even result in the failure of the project and cause great loss. So it is of crucial importance to choose a scientific and objective evaluation method (DFAT, 2012; AAE, 2006;Yang & Xu, 2007).

The main objective of a procurement system is to provide value for money by ensuring that funds are utilised in a transparent, efficient and fair manner. In Kenya, "Public Procurement" means procurement by procuring entities using public funds (Public Procurement and Disposal Act 33, 2015). Article 201(d) of the Constitution of Kenya (2010) provides the principle that public money shall be used in a prudent and responsible way. Tendering is an effective contracting method to achieve favourable outcomes for both public and private entities (Smita et al., 2012). Tender evaluation is a critical activity in a capital construction project and is normally the accepted means of obtaining a fair price and good value for undertaking construction works.

Public entities in Kenya usually organise tenders where firms bid for projects supported and financed by the government directly or indirectly. Evaluation of these bids is controlled by the Public Procurement Act 33(2015) which was promulgated alongside guidelines, manuals and regulations to enhance the procurement and tendering processes. Government agencies like Public Procurement Oversight Authority (PPOA) are mandated to ensure that all public entities adhere to the regulations. However, despite all these measures in place, selection of the right contractors/suppliers remains a big challenge to most public entities.

The technical evaluation stage of a tendering process is a very crucial one. This work is done by an ad hoc team of experts/committee as per the new regulations in the Act. Most public entities in Kenya apply paper-based process in the technical evaluation stage. One such public entity is Technical University of Mombasa (TUM) where the case study is based.

Commonly, decision makers tend to make decisions founded on a mix of their intuition, subjective judgment which is rooted on past experience and emotions (Rosmayati et al., 2010). Such criteria lack consistency and objectivity in the tender evaluation process, negatively affecting the outcome. Subjecting a set criterion for execution by an inherently impartial system addresses the problem of intuition and subjective judgment. There is therefore a need for application of Information Communication Technology (ICT) to standardise bid evaluation. The technical evaluation of construction contractors using a model based on machine learning techniques is the focus of this research study.

1.2 Problem Statement

The objective of supplier selection is to identify suppliers with the greatest potential for meeting a firm's needs consistently and at an affordable cost. Therefore, contractor selection is a crucial decision that needs to be taken by the client and his representative, in order to ensure that projects are completed within cost, time and quality standard. When wrong decisions are taken, they can lead to delays, and abandonment of projects (BO-HUI, 2008; Ajayi, 2010). Public entities in Kenya apply paper-based system in evaluation of bidders and the human factor has compromised the credibility of the process. Poor quality of work or unfinished projects by incompetent contractors due to unreasonable evaluation has been the result. This steers to the research problem addressed by this study, which is the fact that, there is wastage of resources in contractor selection occasioned by unfair technical evaluation process in tendering. A technology-based decision tool is needed to assist the decision makers.

A decision tree-based model that will be used to classify bidders into Pass and Fail is proposed. The use of a training data set, which is a set of records, for which we know all feature-attributes (independent variables) and classifying attribute (dependent variable) will be fed to a decision tree-based classifier to create a model. It is this model that will be used to classify unseen data as Pass and Fail in construction projects. Therefore, the proposed solution is expected to be relatively faster, accurate and fair compared to the current approach.

1.3 General Objective

The main objective of this research was to investigate, design and develop a model based on decision tree technique for objective technical evaluation in tendering.

1.4 Specific Objectives

(i) To investigate factors and challenges that influence technical evaluation of tender.

(ii) To assess the models, applications and algorithms that can be used in technical evaluation of tender.

(iii) To design a solution for technical evaluation of tender based on the assessed models.

(iv) To develop a solution for technical evaluation of tender based on the assessed models.

(v) To test the accuracy of the classification model.

1.5 Research Questions

(i) What are the factors and challenges that influence technical evaluation of tender?

(ii) How can models and algorithms be used in technical evaluation of tender?

(iii) How can a solution be designed for technical evaluation of tender using the assessed models and algorithms?

(iv) How can a solution be developed for technical evaluation of tender based on assessed models and algorithms?

(v) How can the accuracy of the classification model be tested?

1.6 Justification

Both private and public sectors are concerned with the efficiency and effectiveness of their operations in production and service delivery. Any technology that helps to control inefficiency and ineffectiveness especially in the public sector should be embraced. The case of public sector in Kenya desperately needs solutions to the wastage of resources in the area of procurement. While the suggested solution cannot take all the parts acted by the tender committee, it will still assist in taking decisions that are valid (Saunter, 2005).

The results of this research can also be beneficial to scholars and future researchers by presenting to the local and international body of knowledge. It can narrow the gap in existing literature by providing techniques based on new perspectives on ways to apply ICT to reduce the wastage of public resources through procurement. Besides, the outcome can be useful in revising the laws and policies of procurement in the public sector by applying the model in the chosen criteria to standardise evaluation process.

1.7 Scope and Limitation

Basically, tendering process has three key stages in its lifecycle. The compliance stage verifies that the applicant submitted all the required documents. It is followed by technical evaluation stage where the contents of the documents are subjected to rigorous test. Lastly is the financial stage where the price is negotiated. This research focuses on the technical evaluation stage for a construction project. The research applies J48 decision tree algorithm for the model development. Additionally, this research is concerned with the automation of technical evaluation of tender and contract award in the public sector. It will narrow down to public universities and in particular Technical University of Mombasa for the case study.

This research is limited by time restraints according to academic requirements. Financial constraints may also limit the number of respondents contacted. The researcher is currently based in Nairobi but the location is in Mombasa. The distance will have cost implication in trying to collect data.

1.8Assumptions

The assumptions include but not limited to the reliability of the instruments used. It was assumed that the respondents fully understood the questions asked and that the respondents would provide honest expression of their knowledge regarding the usability of the prototype.

Chapter 2: Literature Review

2.1 Overview

This chapter begins by looking at the Tendering process in the public sector followed by the factors that influence technical evaluation of tenders. The challenges in contractor selection through tendering are then identified. Existing methods of tender analysis and evaluation are appraised. Current electronic tender applications are also assessed. The concepts of artificial intelligence and decision support systems in tender evaluation are investigated in related works .A theoretical frame of reference is then presented as a completion of this literature review.

2.2 Tendering Process in Kenyan Public Sector

In the construction industry, selecting a good contractor is a major problem that clients have to face at the beginning of every project. It is a well known fact that construction projects consist of various uncertainties and risks and the success of construction projects bank on effective and efficient use of resources (Kog & Yaman, 2014a).

Article 201(d) of the Constitution of Kenya (2010) states that, "public money shall be used in a prudent and responsible way". It further states in article 227(1) that, "When a State organ or any other public entity contracts for goods or services, it shall do so in accordance with a system that is cost effective, equitable, fair, competitive and transparent" The Public Procurement and Disposal Act 33(2015) laws of Kenya, give effect to the cited articles of the Constitution. This is the legal framework within which public procurement operates.

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. The client may include a contractor. Tenderer is any party submitting tenders, including contractor, subcontractor and supplier (Du et al, 2004).There are two types of tendering: the open tendering (every enterprise can submit a tender) and restricted tendering (only enterprises that have been authorized after preselecting can submit tenders) (Hanine, 2008). The analysis and evaluation of tenders is a decisive step in the tendering process (Watt et al., 2009; Costa et al., 2002).The schema in Figure 2.1 shows the main steps of the tendering process.

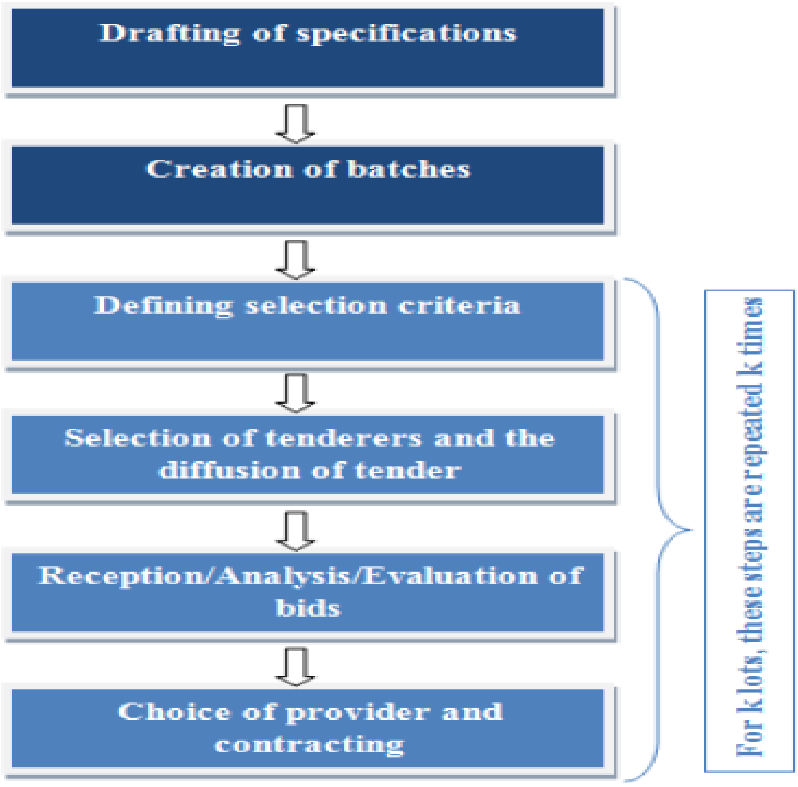

Figure 2.1: Steps of tender processing (Adapted from Amadou et al., 2014 p. 44)

2.3 Public Procurement Procedures

Public procurement is increasingly recognised as a profession that plays a key role in the successful management of public resources, and a number of countries have become increasingly aware of the significance of procurement as an area vulnerable to mismanagement and corruption and have thus made an effort to integrate procurement into a more strategic view of government efforts. As part of the efforts to adopt a long term and strategic view of their procurement needs and management, most countries have resorted to using their annual procurement plans as a possible problem solver (Rosmayati et al., 2010).

Besides the fiduciary obligation to deliver goods and services to the constituents of the particular government administration, public procurement addresses a wide range of objectives (Uyarra, 2009). It has been used by governments to achieve socio-economic objectives such as stimulating economic activity; protecting national industries from foreign competition; improving the competitiveness of certain industrial sectors; and remedying national disparities (Bolton, 2006). Streamlining tender procedures in Technical University of Mombasa using technology therefore contributes to efficiency and effectiveness.

2.4 Factors Influencing Technical Evaluation of Tenders

The principle established to analyze and evaluate tenders is based on the use of criteria called criteria for awarding contracts (Watt et al., 2010). They must be designed so as to be non-discriminatory and linked to the object of the contract. The award criteria generally used for the analysis and evaluation of tenders is based on technical value, quality, profitability, performance, performance in regard to environmental protection (Amadou et al., 2014):

2.5 Issues in the Analysis and Evaluation of Tenders

Many problems occur in the analysis and evaluation of bids (Marty et al., 2011). The importance of this step in the process of tendering makes it significant to pay attention to these challenges and work to their resolutions. The problems include shortcomings of existing techniques of analysis and evaluation, part of subjectivity in the evaluation of tenders and inexistence or inefficiency of control mechanism of the activities related to analysis and evaluation of tenders (Amadou et al., 2014).

2.6 Methods of Analysis and Evaluation of Tenders

There are two fundamental techniques for examination and assessment of tenders: strategies in view of the weighting of the criteria and those in light of the prioritization of the criteria (Bergman and Lundberg, 2013).

2.6.1 Methods Based on the Weighting of Criteria

There are a few strategies in light of the weighting of the criteria however two of them are broadly utilized.

2.6.1.2 Simple Method

This method is the simplest. It gives a note for each tender according to each criterion. Then, for each tender, a weighted sum of these notes obtained according to all criteria is made. This sum represents the total result obtained by the tender. The same is done for the other tenders and total results obtained are compared. The best tender is the one that will have the highest total result (Rillaed, 2011).

2.6.1.3 Comparison Method

This method makes a comparison of the tenders according to each criterion and gives the best tender 100% of points and makes a rule of proportion to give points to other tenders. It guarantees the principles of proportionality and equality in the treatment of tenders (Rillaed, 2011). The problem with this method is its relative aspect. Indeed, the tender to which 100%

of the points are assigned is better than the others; this does not mean that it is intrinsically a good tender.

2.6.2 Methods Based on Prioritization of Criteria

The prioritization of criteria is based on the establishment of hierarchical order among the criteria: it comes to draw up a list in which the criteria are generally in descending order of importance.

The use of methods based on the prioritization of criteria must be justified by demonstrating that it is inappropriate to use the weighting method considering the specificities of contract. The Prioritization method is simpler than weighting method since it consists to do the following operations (Amadou et al., 2014):

(i) A notation of tenders according to the first criteria in descending order of importance.

(ii) A choice based on this criterion alone, unless it leads to judge that all the tenders are equivalent, in which case the same operation is done with the second criterion, till a criterion which is able to discriminate the tenders.

2.7 Appraisal of the Methods of Analysis and Evaluation

Weighting methods are preferred to methods of prioritization because they globally evaluate tenders according to all the criteria in order to decide between them. Every company knows precisely the assessment made of its tender according to each criterion (Amadou et al., 2014).

Concerning weighting methods, some are disadvantaged by the non-intrinsic evaluation of tenders and the rest is disadvantaged by the non-relative evaluation of tenders to the others (Rillaed, 2011). A good weighting method is the one that will be able to evaluate offers intrinsically and relatively from the other offers.

2.8 Some Electronic Tendering Applications

The advent of Information and Communication Technology (ICT) has opened up a wide exploration to the use of Web-based technology in tendering processes. The need of devising strategies to automate current business processes in order to incorporate the technology in day-to-day business processes has become crucial. This is evidenced by various existing electronic tendering applications in many countries such as United States, Canada, Australia, Singapore, Japan, Europe, and Taiwan.

Table 2.1 summarises the type of tender management systems in use in these countries. A comparison is made in terms of functionalities between the applications from various countries. In the Table, 7 functional requirements of the applications have been identified, namely; ability to display tender, online tender forms, download tender documents, upload tender documents, online bidding, tender evaluation tools and tender award notification.

Table 2.1: Electronic Tender Applications (Adapted from Noor et al., 2010 p. 38)

Country	Electronic Tender Application	Tender Display	Online Tender Forms	Download Tender Documents	Upload Tender Documents	Online Bidding	Tender Evaluation Tools	Tender Award Notify
Malaysia	ePerolehan	√	X	√	√	√	X	√
	Tender Direct	√	X	X	X	X	X	X
	e-Construction	√	X	X	X	X	X	X
Canada	MERX	√	X	√	X	√	X	√
Andhra Pradesh	Tender Management System	√	√	√	√	√	X	√
Chhattisgarh	e-Procurement System	√	√	√	√	√	X	√
Europe	Public Contract Scotland	√	√	√	√	√	X	√
	Tender Electronic Daily (TED)	√	X	X	X	X	X	√
	UK Tenders Direct	√	X	X	X	X	X	X
United States	FACNET	√	X	√	√	√	X	√
Japan	JETRO	√	X	X	X	X	X	√

A closer look at Table 2.1 shows that of the 11 applications, none is able to provide all the functionalities stated above. The observation of interest to this study is that all the applications do not provide tender evaluation tool. The inability of the applications to provide automatic evaluation of tenders is because conventional programming cannot address such a complex problem. This is why the study applies machine learning techniques for the evaluation part. Another point is that they are all designed to manage government tenders in those countries according to the source of Table 2.1.

2.9 Artificial Intelligence (AI)

Artificial intelligence (AI) is simply the study of agents that exist in an environment and have the ability to perceive and act (Russel & Norvig, 2013). Most people know the term Artificial Intelligence concerning about how to build an intelligent machine. This machine should have certain capabilities such as: behaves like a human being, smart, problem solver of unstructured and complex problems as human does, understands languages, learner, and able to reason and analyze data and information (Owaied et al., 2010). Selection of contractors presents itself a complex decision-making problem which is featured with multi-criteria, of different nature of the criteria (quantitative, qualitative) and with multi-stages of the decision (Bogdan et al., 2013). Complex problems need consistent intelligence that can only be found in machine for rational decision making processes.

2.10 Machine Learning (ML)

Machine learning is a branch in the area of artificial intelligence and is the process in which a system can adapt to new circumstances and detect and extrapolate patterns by learning from data (Russel & Norvig, 2010). For example, a system can predict if the weather will be sunny or rainy by examining large amount of data with parameters regarding the weather (humidity, time of year, etc.) and finding patterns in this data that correlate with the resulting weather. These patterns can then be used to predict what the weather will, (most likely), be given new input parameters. This process is called classification and is a form of supervised learning, i.e. when a machine learns from examples with explicit input-output pairs (Russel & Norvig, 2010). The learning is performed by using the patterns found in the input data to create an algorithm that classifies new input data by examining the values of the input parameters. Such an algorithm is called a classification model. This study employs decision tree algorithm.

2.11 Decision Tree learning Algorithm

Decision tree is a very popular and much used machine learning technique for the representation of classification using categorical data. The structure of a decision tree is almost the same as that of a binary tree but in some complex problems it may be non-binary also. They are considered as the easiest for the humans in terms of their result interpretation capabilities provided that their complexity is not too high. The first and the node at the highest level of the tree is called the root node where the data is partitioned first using some attribute selection measure. Then the nodes at the lower levels are also partitioned recursively using a test on an attribute. The last level of the tree denotes the output class labels (Han & Kamber, 2010).

The decision tree algorithms are ID3, Simple Cart, C4.5, NBTree, REPTree, BFTree and others. Different Decision tree algorithms use different measures to calculate the information contained in each attribute to select the root node of the decision tree. The most used information measures are: information gain, gain ratio and Gini index (Dahiya & Handa, 2015). Our study used information gain and gain ratio available in the WEKA environment for the calculation of the information contained in the attributes.

C4.5 is a commonly used algorithm for classification in data mining. The decision rules generated using C4.5algorithm are capable of handling both discrete and continuous variables. These rules learnt using the training set can easily classify the test set instances into any one of the categorical class values. C4.5 can handle the missing values and performs well in classification (Dahiya & Handa 2015). In this study we used J48, a Java version of C4.5. The choice of this algorithm was informed by the results of a study by Galathiya et al(2012) where it scored impressively on the parameters of our interest. Explanation ability/transparency of knowledge and dealing with discrete/binary/continuous attributes are some of those parameters. Although on accuracy the algorithm is average, this can be improved with continuous training. Table 2.2 shows the results. Here the rating is given 4 as the best one and 1 as the worst.

Table 2.2 ML Techniques Comparison (Adapted from Galathiya et al., 2012 p.3428)

Parameters	Decision Tree	Naive Bayes	K- Nearest Neighbour	Support Vector Machine	Neural Networks
Accuracy in general	2	1	2	4	3
Speed of learning with respect to number of attributes and the number of instances	3	4	4	1	1
Speed of classification	4	4	1	4	4
Tolerance to missing values	3	4	1	2	1
Tolerance to irrelevant Attributes	3	2	2	4	1
Tolerance to redundant Attributes	2	1	2	3	2
Dealing with discrete /binary /continuous attributes	4	3 (not continuous)	3 (not discrete)	2(not discrete)	3(not discrete)
Tolerance to noise	2	3	1	2	2
Dealing with Over fitting	2	3	3	2	1
Attempts for incremental Learning	2	4	4	2	3
Explanation ability/transparency of knowledge/classifications	4	4	2	1	1

2.12 J48 Decision Tree Classifier

A J48 decision tree is a classifier model that works with recursive partition of the instance space. It is used to represent a supervised learning approach (Dewan Md et al., 2010). It is a simple graphic structure where non-terminal nodes represent tests on one or more attributes and terminal nodes give decision outcomes.J48 builds decision trees from a set of labelled training data using the concept of information entropy. It uses the fact that each attribute of the data can be used to make a decision by splitting the data into smaller subsets.J48 examines the normalized information gain (difference in entropy) those results from choosing an attribute for splitting the data. The entropy is low, and the attribute value is very useful for making a decision (Deepajothi & Selvarajan, 2012). Entropy measures the amount of randomness or surprise or uncertainty i.e. when entropy = 0 implies there is no disorderliness in the item or dataset.

This classifier has been employed successfully in many traditional applications indifferent domains (Jeyarani et al., 2013). Despite the fact that it can be regarded as relatively old technique, it has stood the test of time. For example, decision tree has recently been employed as a machine learning technique to develop classification models that automatically classify pancreatic cancer data (Danso et al., 2013).

Decision based algorithm 'learns' from training examples by classifying instances and sorting them based on feature values. Each node in a decision tree represents a feature of an instance to be classified, and each branch represents a value that the node can include in making a decision. The algorithm starts the process at a root node of the tree. This root node is established by finding the feature that best divides the feature space, and there are numerous approaches to identifying the best feature (Jeyarani et al., 2013).The classes are assigned based on weights that are computed on the features during the processes of learning and these weights are used to classify unseen data.

Due to the approach J48 decision tree uses to search for a solution within the problem space, efficiency tends to be an issue, especially when dealing with large datasets. Decision tree is one of the easier data structure to understand in machine learning. Rules from the training data set are first extracted to form the decision tree which is then used for classification of the testing dataset. A decision tree is necessarily a tree with an arbitrary degree that classifies instances (Patil & Sherekar, 2013).

2.12.1 Advantages of J48 Decision Tree Classifier

The major benefits of using a decision tree include a simple model that helps in decision making, relatively easy to interpret and understand. Besides, a set of production rules can easily be converted from the model and can classify both categorical and numerical data but the resultant attribute is categorical. Additionally, it requires no prior assumptions about the nature of the data.

2.13 Technologies around the Theme of Tender Evaluation

2.13.1 Genetic Algorithm (GA)

The genetic algorithm (GA) is a search technique used in computing to find true or approximate solution to optimization and search problems. GA is categorized as a global search heuristic and it is also a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover. Generally, GA is implemented as computer simulations to resolve optimization problems whereby a population of abstract representations called chromosomes and candidate solutions called individuals evolve towards better solutions (Gaik-Yee & Chee-Tong, 2014).

Genetic algorithm was used in Rankovic et al. (2011) with two different weighting methods for supplier selection. One is the weighted sum, a decision before search method, and the other is the Strength Pareto Evolutionary Algorithm (SPEA), a search before decision method. This proposed approach is able to find the optimized solution with no significant difference between weighted sum and SPEA method (Gaik-Yee & Chee-Tong, 2014).

2.13.2 Fuzzy Analytic Hierarchy Process (AHP)

In a study by Raudini (2015) a Fuzzy Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) approach in selecting proper contractors is used. A descriptive - measurement method is used for this research to gather information from experts of the company to analyze them in order to design a fuzzy model to assess if contractors are qualified or not. In this context, a fuzzy method of AHP (Analytic Hierarchy Process) is applied to determine weights of criteria and sub-criteria in selection of contractors. Then, the fuzzy method of TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) is used to classify the top three contractors who achieved highest points of evaluation.

In another study by Bindu and Ahuja (2010) that uses AHP approach, a method is proposed for calculating relative reliability risk index to compare vendor alternatives. The method helps to obtain ordinal rankings of the available choices by using the AHP and the entropy method for obtaining the weights for the functions considered. By using this method, vendors with low relative reliability risk index values will be screened out and the one with highest relative liability risk index value will be considered as the best supplier. AHP is good at simplifying issues but it is too subjective and complex.

2.13.3Decision Support System (DSS)

DSS are computer-based systems that assist businesses and organizations in complex decision-making environment (Rosmayati et al., 2010). DSS act as supporting tools in assisting users by giving suggestions especially when fragmented information and complex problems are involved.

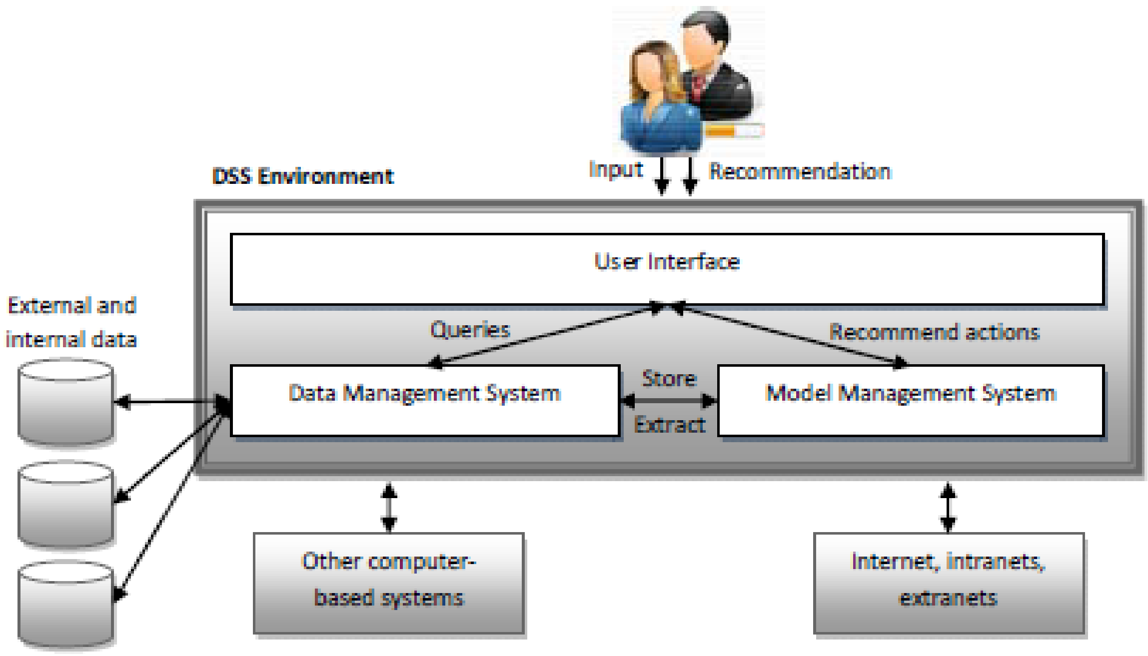

Figure 2.2: shows a general schematic view of DSS (Adapted from Turban, 2007,p.39)

Rosmayati et al. (2010) appreciated the fact that execution of a construction project is heavily impacted by making the right decision during tendering processes. They observed that bias and inconsistent decisions are inevitable if the decision-making process is totally dependent on intuition, subjective judgement or emotion. They further noted that in making transparent decision and healthy competition tendering, there exists a need for flexible guidance tool for decision support.

The study by Rosmayati et al.(2010), was a review of DSS technology in construction tendering process. They came to the conclusion that applying DSS in the entire process of tendering in construction was an extremely complex attempt.

In another study by Mohamad et al. (2007) noted that tender evaluation for tendering process was crucial as it affects the reputation of both the client and the contractor. The study used Multi Criteria Decision Making (MCDM)to analyse and assist decision makers evaluate multi criteria of tender selection. This was an intelligent web based decision support system. According to Power and Warboys et al.(as cited by Armidaya, Noor &Mustafa, 2008) decision support system can be categorized into five types which are Knowledge Driven, Communication Driven, Data- Driven, Document Driven and Model-Driven. In this study we concentrate with knowledge driven type. A knowledge-driven DSS provides specialized problem solving expertise stored as facts, rules, procedures, or in similar structures and it suggests or recommends actions to managers (Daniel et al., 2011).

Daniel et al.(2011) further argue that KD-DSS model has capacity to self-learn, identify associations between the data, and perform heuristic operations, if required. These abilities turn the DSS system into intelligent, increase the capacity of problem solving and improve suggestion accuracy.

2.13.4 Artificial Neural Networks (ANN) in Bid Evaluation Systems

Using artificial neural network technology can take advantage of experts experience to ensure the reliability and validity of bidding, and can avoid interference with human factors. Artificial Neural Network,(ANN) is based on the knowledge of human brain organization structure, activity mechanism. It is a mathematical model of human cranial network (Zhang et al., 2011). In their paper, Zang et al. (2011) were demonstrating how ANN can be applied to build Engineering Project Bid Evaluation System.

In building the model, the paper considered secondary analysis indexes as the input vectors and all valid bidders as output value. The input vector contains quantitative indexes and qualitative indexes. The qualitative indexes can take expert scoring method to convert quantitative indexes. And to the quantization of tender, the paper took ranking method, each bidder was ranked according to the level of output value Y, where the largest number is the worst and the smallest is outstanding tenderer.

ANN has the adaptive ability, learning ability and large-scale parallel computing power. So ANN is comparatively suitable to solving engineering construction bidding evaluation issue that is often incomplete information and much more analysis indexes among which are nonlinear related in the tenderer and tender biding (Zang et al., 2011).

The paper in conclusion put forward and designs the bid assessment system based on ANN theory, and made a test in the construction bidding to do bid assessment automatically. The experiment data showed the reliability of the bid evaluation results. So the system has its practical applicability prospect. The biggest drawback of ANN is that it is too complex to achieve transparency in bid evaluation.

2.13.5 Support Vector Machine (SVM)

According to Ghodsypour and O`Brien (as cited by Jian-Ying et al., 2005), Support vector machine (SVM) is a machine-learning algorithm based on statistical learning theory. This algorithm obtains an optimum network structure based on the principle of structural risk minimization (SRM) and overcomes the drawback of local minimum and empirical risk minimization of artificial neural network (ANN). SVM transforms a nonlinear object into a high dimension feature space and thus gains a good generalization performance (Jian-Ying et al., 2005).

In a study by Jian-Ying et al. (2005) supplier evaluation criteria are first specified. Criteria affecting the supplier selection include quantitative and qualitative factors. Fuzzy membership functions and pairwise comparison are used to quantify the variables. A supplier selection model is developed using SVM as shown in Figure 2.4. The algorithm is then implemented and tested in a case study. The simulation results on Figure 2.5 show that the supplier selection model based on SVM has a better accuracy than fuzzy synthetical evaluation. It can be used in real supply chain, which will help firms to make a satisfied decision (Jian-Ying et al., 2005).

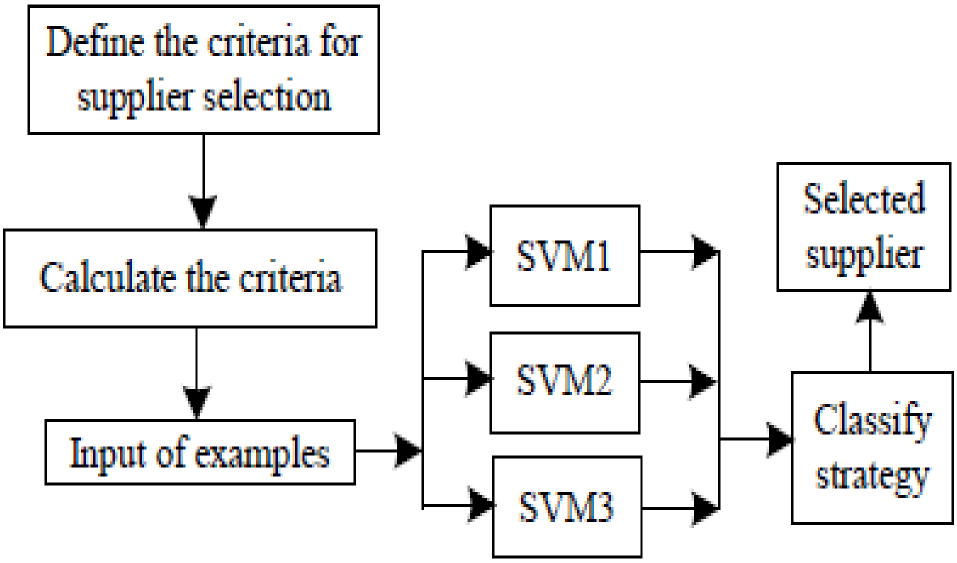

Figure 2.4: Supplier selection using SVM(Adapted from Jian-Ying et al., 2005, p. 3632)

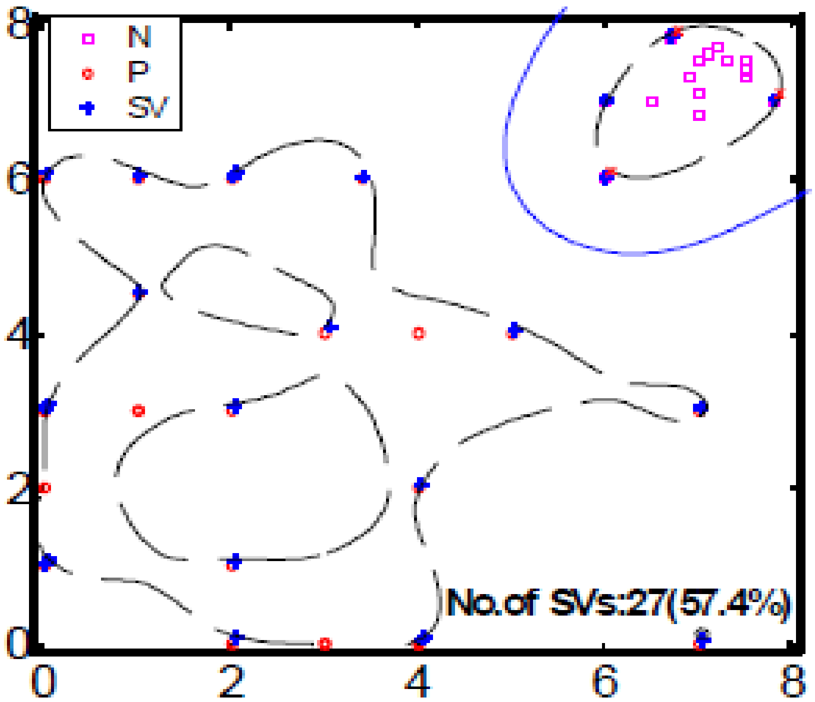

Figure 2.5: The results of SVM Classifier (Adapted from Jian-Ying et al., 2005, p. 3632)

2.14 Conceptual Design of the Proposed Model

The following conceptual design links the reviewed literature with the research problem and the research objectives. This forms part of the plan for negotiation to be scrutinized and reviewed, tested and reformed as a result of investigation.

In order to build the model, a criteria for evaluating contractors is first defined by experts. Values for the vectors to be used are then calculated/determined. Input examples from database are used for training. The input examples are defined by the set criteria. This data is fed to the J48 algorithm after pre-processing for training and validation. Document`s dataset is fed to the new model for prediction of category class. This model is a binary classification which gives a two state output of PASS or FAIL. Output of PASS means a bidder moves to the final phase of financial evaluation and the FAIL output means a bidder did not qualify for the next phase. Figure 2.8 shows general process of the proposed approach for tender evaluation.

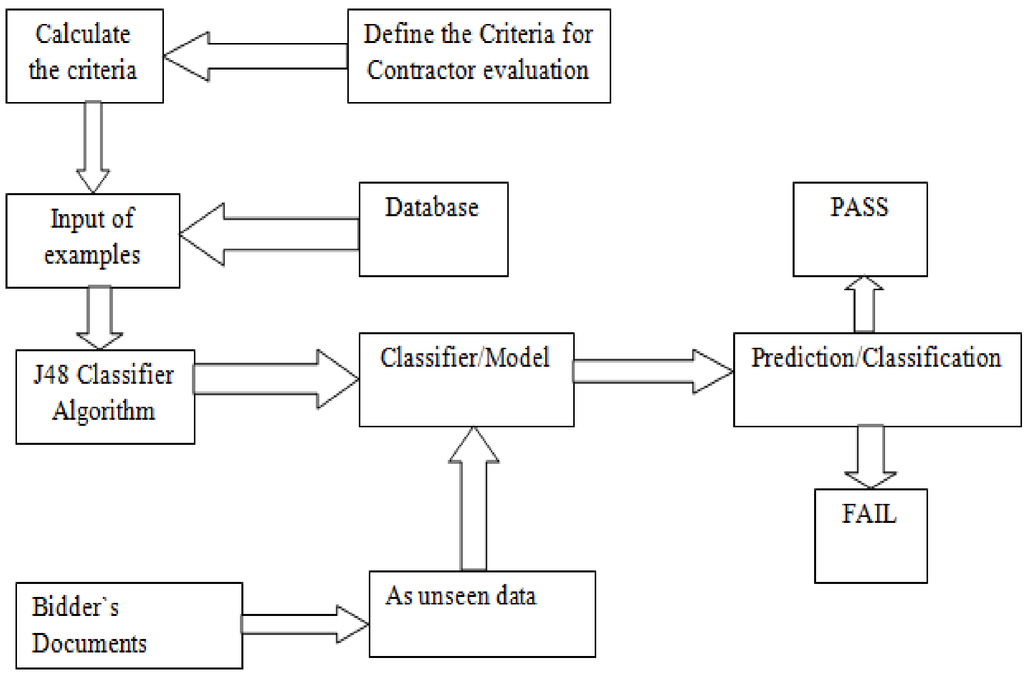

Figure 2.6 Conceptual Design of the Proposed Model

2.15 Conclusion

This chapter was organised into three major sections. They included theoretical framework, empirical framework and the conceptual design of the proposed model. In the theoretical framework a study of the cited literature about tendering process in Kenya and elsewhere addressed objective (i) about factors and challenges that influence tender evaluation. Some of these challenges are found in both public and private sector.

The empirical framework was about existing tender applications, models and algorithms in use or under research. The empirical part revealed that all existing applications cited lack the functionality of evaluating tenders. The algorithms used to build models in the scholarly work in the area of tender or contractor evaluation did not capture the entire desired features. Some models despite reported to have performed relatively better under test, lacked transparency element. A model built from ANN is better in terms of accuracy but it is complex and cannot explain its results. The law of procurement in Kenya as cited earlier stresses on transparency in evaluation processes. Decision tree algorithms have this ability.

The conceptual design was partly about objective (iii) of the study objectives. It was about a model based on machine learning technique. In the entire sources cited, acknowledgement is made on the need for better ways of handling tendering process. There seems to be an agreement that the committee-based system is ineffective, slow and full of impartiality. To these researchers, technology can offer some degree of solution. However, in all cases, no one seems to focus the study to a particular phase of the many phase/stages of tendering process. Coming up with one solution that can address the many challenges that manifest in every stage of the tendering process is near impossible (Gokmen et al., 2010). This study focused on a single stage of technical evaluation in construction project.

Chapter 3: Research Methodology

3.1 Overview

Research Methodology is defined as the process of systematically solving problems. It can be considered as the science of doing research (Bhatnagar &Singh, 2013). Methodology decisions depend on the nature of their search question. This chapter presents the discussions on the research methodology of the study, the subjects, sampling techniques, research instruments, procedure of data gathering, statistical treatment that were used for accurate data analysis and interpretation. The tools for design and development of the prototype are also discussed. In addition, reliability and validity is also addressed. The chapter further highlights the ethical considerations in the course of the study.

3.2 Research Design

Burns and Grove (2003) define a research design as “a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings”. The main focus of this study was to investigate, design, develop and test a machine learning technique-based solution to be used as decision support by tender committees. The study was therefore applied, experimental, qualitative, and quantitative. Applied research is systematic inquiry involving the practical application of science. It accesses and uses some part of the research communities’ accumulated theories, knowledge, methods, and techniques, for a specific, often client-driven purpose. Quantitative research is the numerical representation and manipulation of observations with an aim of describing and explaining the phenomena that those observations represent.

The research is experimental in the sense that the development of the model of interest was done in WEKA environment. WEKA is a machine learning software tool that is used to build models through experiments with datasets. Evaluation of the performance of the built model was also done within the WEKA environment.

Applied research methodology has been chosen because the definition of this methodology fits the activities that were carried out in the study. Accumulated theories, knowledge, methods, and techniques have highly contributed to the design and development of the proposed solution. Quantitative approach was used in the process of testing the functionality of the solution as it involves users.

Qualitative methods focused on the experiences of people involved, in the use of the application and attempt to understand the reasons behind their emotions. The evaluation was carried out using three systems of data collection techniques, literature review, interviews and questionnaires. The literature review was used to collect qualitative data while questionnaires were used to collect both qualitative and quantitative data; thus the two complemented each other.

3.3 Model Development Methodology

To build the J48 classifier model, several steps were taken. The overall implementation was divided into four main phases.

3.3.1 Dataset Generation

The dataset for the building of the classification model was taken from the department of supplies and procurement at Technical University of Mombasa. The target size of the dataset was for a period of 6 years. This could not be achieved because records on the results of tender evaluation at TUM are saved in physical files and time factor could not allow perusing files extending a period of 6 years. The research managed to get dataset covering 3 years which had 100 instances.

3.3.2 Data Pre-processing

The basic dataset in this study refers to the raw dataset that was sourced from the University files. Both the independent and dependent variables were identified and there descriptions in terms of values were also set. The hardcopy dataset was transformed into softcopy using Microsoft Excel application. This application provides features that help in cleaning of dataset. The researcher used the filter feature within the application for further cleaning of the dataset.

3.3.3 Building the Model

The evaluation model considered in our study was based on supervised learning (classification) technique. The software tool used for building the model was WEKA software, an open-source and free software used for knowledge analysis and downloadable from the internet and used under the GNU license.

3.3.4 Model Validation

Model validation is about performance measure of the model and is based on a number of metrics. In this study the following metrics were considered for this classification problem.

Classification accuracy is about the percentage of correct predictions. It is the easiest classification metrics to understand but it does not tell the underlying distribution of response values and it does not tell the types of errors the classifier is making. However, the metric gives the first impression on model performance for further tests.

A confusion matrix is an n-dimensional square matrix, where n is the number of distinct target value. It is used to represent the test result of a prediction model. Each column of the matrix represents the instances in a predicted class, while each row represents the instances in an actual class as indicated in Figure 3.1 below. One benefit of a confusion matrix is that it is easy to see if the system is confusing two classes (i.e. commonly mislabelling one as another). A confusion matrix provides a quick understanding of model accuracy and the types of errors the model makes when scoring records. It is the result of a test task for classification models (Badgerati, 2010).

Prediction

Actual	0	1
0	TN	FP
1	FN	TP

Figure 3.1: Confusion Matrix (Adapted from Badgerati, 2010)

TN stands for true negative and it refers to the number of instances that are correctly predicted as negative. FP stands for false positive which means the number of instances that were incorrectly predicted as positive. FN stands for false negative and it refers to the number of instances that were incorrectly predicted as negative and lastly TP stands for true positive for the instances that were correctly predicted as positive.

Precision refers to when a positive value is predicted, how often is the prediction correct? True positive rate is the rate at which the model always predicts an instance as actually positive. A higher rate is a good measure for the model. False Positive rate is the rate at which the model always predicts an instance as wrongly positive. Low rate is a good measure for the model. The F-measure computes some average of the information retrieval precision and recall metrics. Receiver Operating Characteristics (ROC) curve.

3.3.5 Presentation of Output

Results for the experiments in the process of building the classifier model was presented in figures, graphs, tables and graphics in the case of the decision tree. Figures and graphs were taken from the WEKA classifier output. The decision tree was used to show how and which attributes were used to build the model. It was also produced from the WEKA environment.

3.4 Prototype Development Methodology

Prototype development methodology refers to the framework that is used to structure, plan, and control the process of developing an information system. A wide variety of such frameworks have evolved over the years, each with its own recognized strengths and weaknesses (Linda et al., 2008).

Rapid Application Development approach was adopted for this study. Rapid application development is an Object Orientated approach to software development that includes a method of development as well as software tools (Kendall and Kendall, 2002). According to Kendall and Kendall (2002), there are three wide phases to RAD that engage both users and analysis in assessment, design, and implementation. Figure 3.2 below is a graphical representation of the phases in a RAD. In RAD approach there is some iteration between the requirements and implementation phases as shown in Figure 3.2.

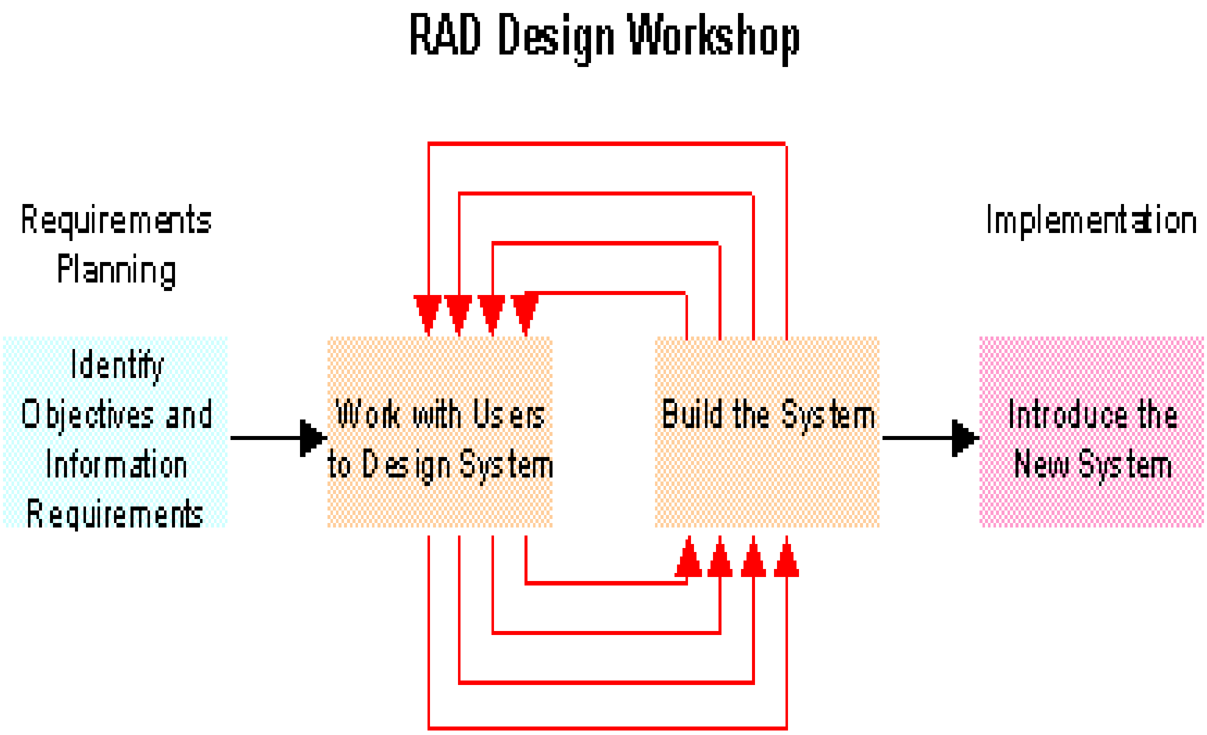

Figure 3.2: Rapid Application Development (Adapted from Kendall & Kendall, 2002)

This study chose rapid application development because the operation version of the application is available much faster and at a lower cost than Waterfall, Incremental or Spiral framework. Besides, standard system analysis, design and implementation can be fitted in this framework. Figure 3.2 shows the three main phases that this study followed in the development of the prototype. The stages are equivalent to system analysis, system design and system implementation and testing.

3.4.1 Requirements Planning

During requirements planning for the prototype development under rapid application development approach, the objectives and information requirements are identified. Figure 3.2 above shows the first step. In this study, the researcher applied observation, informal and informal interviews as techniques of collecting data or information needed for planning.

3.4.2 Prototype Analysis

There are three approaches in information system development section; data-oriented, process oriented, and object-oriented approaches. The object-oriented method, unlike its two predecessors that lay emphasis either on data or process, combines processes and data into single entities called objects (University of Missouri, 2001).

Object-oriented Analysis (OOA) is the concept used in this research. OOA escalates the understanding of problem domains because OOA promotes a smooth transition from the analysis phase to the design phase and offers a more ordinary way of establishing specifications.

This study focused on use-case modelling and class modelling to explore the various approaches that are conducted in the analysis of the system. In the object-oriented system development life cycle, use-case modelling is established in the analysis phase. Use-case modelling is done in the initial stages of system development to help the developers gain a perfect understanding of the functional requirement of the system without worrying about how those requirements will be applied (University of Missouri, 2001).

A use-case model consists of use cases and actors. An actor is an external entity that interacts with the system and a use case denotes a sequence of interrelated activities initiated by an actor to achieve a precise objective (Hoffer, 2001).

3.4.3 Prototype Design

Object-oriented design (OOD) techniques were used to refine the object requirements definition identified during system analysis and to define design specific objects. Design class diagram was used for general conceptual forming of the software systematics. Design class diagram also entails comprehensive modelling to translate the models into programming code and for data modelling (Sparks, 2001).

The research adopted design class diagram to embrace classes which comprise the main methods, objects and interactions of the system. Entity Relationship Diagram (ERD) was also used, which is a graphic that demonstrates the relationships between objects, places, people concepts or events within a system. It enabled the researcher to outline business procedures and to develop relationships between entities and their attributes in a relational database.

3.4.4 Prototype Implementation

System implementation is the process of defining how the prototype should be built, ensuring that the prototype is operational and used plus it meets quality standard (Grady, 2010). Implementation is the process of moving an idea from concept to reality. It is the physical design stage.

In this study, Java programming language was used in the Netbeans environment to build the user interface. MYSQL was used as the relational database management system for data storage supported on Apache server. The classifier model was developed in WEKA environment and saved in an application configuration file format for use in the prototype.

3.4.5 Prototype Testing

Usability testing was used to test the functional and non-functional requirements of the system. Usability testing entails testing; validation of communicating components on each screen e.g. text inputs and buttons, validation of navigation flow, Ease of navigation, responsiveness and user friendliness. A demonstration of the prototype was done and users were given questionnaire to provide feedback.

3.5 Research Site

As stated earlier, this research is case-based. The study focused on Technical University of Mombasa as an example of public entity. This University is located in the coastal town of Mombasa, Kenya. It was elevated to a fully fledged Public University in 2013. The

University is fast expanding its physical infrastructure to meet the growing demand of higher education in the country. Many construction projects have been undertaken and more are lined up. Most completed projects fell short of the expected quality and standard. Perhaps improving the criteria of evaluating contractors could remedy this trend.

3.6 Target Population

Kothari (2004) defines a population as all the items that are found in any field of inquiry. Population can also be referred to as “Universe”. Completely going through all items in the population is often referred to as a census inquiry. Like stated earlier, this study is also based on case study specifically Technical University of Mombasa. This study had two types of population as a target to be used in the inquiry. For the development of the model in the WEKA environment, a population of instances was needed. Technical University of Mombasa could only provide 100 instances. This data was sufficient enough to prove the concept. Besides, getting more instances would have required extra time as the records were in different physical files. For the purpose of usability test of the built prototype the targeted population was 80, covering all types of stakeholders.

3.7 Sampling

The sample was taken from the database of all stakeholders. Samples give results with known accuracy that can be calculated mathematically. The sampling method used was probability sampling. A probability sampling techniques is one in which every item in the population has a chance of being selected in the sample, and this probability can be accurately determined. The study used specifically simple random sampling. Lottery method was employed. This sample was of the respondents used in the usability testing. The study picked 70 respondents whom in the opinion of the researcher were representative enough.

3.8 Data Collection Instruments

Data-collection techniques allow researchers to systematically collect information about the objects of study (people, objects, phenomena) and about settings in which they occur. In the collection of data we have to be systematic. If data are collected haphazardly, it will be difficult to answer the research questions in a conclusive way (Kongmany, 2009). Various data collection techniques can be used which include using available information, Observing, interviewing (face-to-face), administering written questionnaires, and focus group discussion. This study applied literature reviews, questionnaires, observations and interviews as described next.

3.8.2 Questionnaire

A written questionnaire is a data collection tool in which written questions are presented that are to be answered by the respondents in written form. This method has the following advantages: is less expensive, permits anonymity and may result in more honest responses. Additionally, it eliminates bias due to phrasing questions differently with different respondents. This study administered written questionnaires for the Case study. The analysis of the collected data was for the usability test feedback.

3.8.3 Interview and Observation

Interviews were used to gather information from the procurement officers. The interviews offered a better approach in understanding the current process of tender evaluation for construction contractors. Open interviews provided an avenue for more explanation which also helped gather facts on user requirements.

3.9 Data Analysis Techniques and Presentation

Analysis of data is a process of inspecting, cleansing, transforming, and modelling data with the view of revealing useful information, suggesting conclusions, and enhancing decision-making. The purpose of this research was to finally come out with a solution addressing the problem of unfair tender evaluation. The developed prototype was given to users to test its functionality. Out of the 70 respondents, 65 returned filled questionnaires. This study used Microsoft Excel application for the analysis of data gotten from the distributed questionnaires. Results were presented in pie charts for better interpretation and pictorial view.

3.10 Reliability and Validity

In carrying out this study, the validity as well as the reliability of the data being collected and analysed must be ensured. Kothari (2004) defines Validity as the extent to which tests are able to measure what we actually want to measure. He then defines Reliability as something that focuses on the precision and accuracy of a measurement procedure. One of the easiest ways to determine the reliability of the empirical measurements is by retest method. This method gives the same test to the same people after a period of time. The consistency of the results indicates good reliability of the test instrument. This study employed retest method. To ensure validity, content validity approach was used in this study. This approach measures the degree to which the test items represent the domain or universe of the trait being measured. The total population was identified and using a Lottery method a sample was randomly picked.

3.11 Ethical Consideration

According to Neville (2007), ethical issues and concerns may emerge at any or even all stages of the study. For this reason he gives a brief list of the considerations that researchers need to be aware of. The key ethical considerations observed in this study included; Interviewers/researchers will act and behave in a manner that is professional and objective; The researchers need to respect the rights of privacy of individuals; Voluntary nature of participation means individuals have a right to withdraw from the study either partially or completely; Researchers need to take into account what effect data that is analysed and reported will have on the participants; Researchers must receive explicit consent from participants, and avoid any deception.

Chapter 4: Prototype Analysis and Design

4.1 Overview

System design is the process of defining the top-down description of the system`s structure (architecture), modules, interfaces, components of a system in order to satisfy the specified user requirements (Faisandier, 2012). Further, system analysis and design has been defined as a step-by-step process for developing high quality information systems (Harry, 2014). Object oriented approach has been employed in the analysis and design of the prototype in this study.

4.2 Fact Finding

System analysis begins with data collection. Several appropriate and effective methods are used to collect data in order to define and specify user's requirements. Data was collected from the University on the current system through observation and informal interviews. In the current system technical evaluation of tenders is a paper-based exercise. Ad hoc expert committees formulate criteria and apply it to assess bidders from the documents submitted. The records for the participants' results are saved in physical files.

By observing the current paper-based process of evaluation and reviewing the literature, we brainstormed and were able to capture the requirements specifications. The requirement specification outlines the general user's requirements to identify the system's functional as well as non-functional requirements.

4.3 Functional Requirements

Functional requirements capture the intended behaviour of the system. This behaviour may be expressed as services, tasks or functions the system is required to perform (Bredemeyer, 2001). In software engineering, a function is also described as a set of inputs, the behaviour and outputs. Additionally, functional requirement may be calculations, technical details, data manipulation and processing and other specific functionality that show how the use case are to be satisfied. The minimum functional requirements and descriptions of the modules are presented next.

(i) Administrator Module**-** This module provides administrative functionalities for the administrator. A user with this status can manage the global data and set the data that is going to be used by other users. Besides, the administrator can enable or disable the administrator rights of users.

(ii) Login Module- Every user including the administrator has to login before accessing the functionalities of the system.

(iii) Evaluator Module- This is a data processing/manipulation functionality that classifies bidders based on the values of the independent variables.

(iv) User Registration Module- Allow users to register their account in the system.

(v) Report Module- A user can view or print out a report of the evaluation results.

4.4 Non-Functional Requirements

Non-functional requirements include constraints and qualities. Qualities are properties or characteristics of the system that its stakeholders care about and hence will affect their degree of satisfaction with the system. Constraints are not subject to negotiation and, unlike qualities, are (theoretically at any rate) off-limits during design trade-offs (Bredemeyer, 2001). Any information system has attributes and characteristics that can be used to determine its performance. The following are some of the non-functional requirements that were considered in the development of the system:

(i) User friendliness interface

The design of user interface should be user friendly and easily understood for end user to user to operate it. Attractiveness, infers that users enjoy using or attached to use the system due to their appealing design.

(ii) Response time

The response time should be within a reasonable interval time where all the desirable information should be available to users at any point in time.

(iii) Performance

The system must be able to process queries reasonably fast to reduce shorter the performance time. It must also be able to recover fast if the system breaks down.

(iv) System modification

Some extra function can be built into the system in future.

(v) Robustness

The system must be able to handle unexpected error and echo back with proper responses. It should handle errors effectively and error messages will be displayed if any unexpected error occurs.

(vi) Reliability

The application system, software and hardware, shall be reliable and shall not cause unnecessary and unplanned downtime of the overall environment.

(vii) Security

The system should be able to do authentication to verify user's identity using the username and password during the login session. This is to prevent the disclosure information to unauthenticated user. System administrator has full control over the information in the system databases. This system provides password encryption to make the system more secure.

4.5 System Architecture

The prototype architecture operates as shown in Figure 4.1. During evaluation of tenders the procurement officers through a graphical user interface requests data from the database. The MYSQL database has been employed on apache server. The database responds after which the officer passes the data to the model for evaluation. The model returns results upon which the officer will download or save to the database for the records.

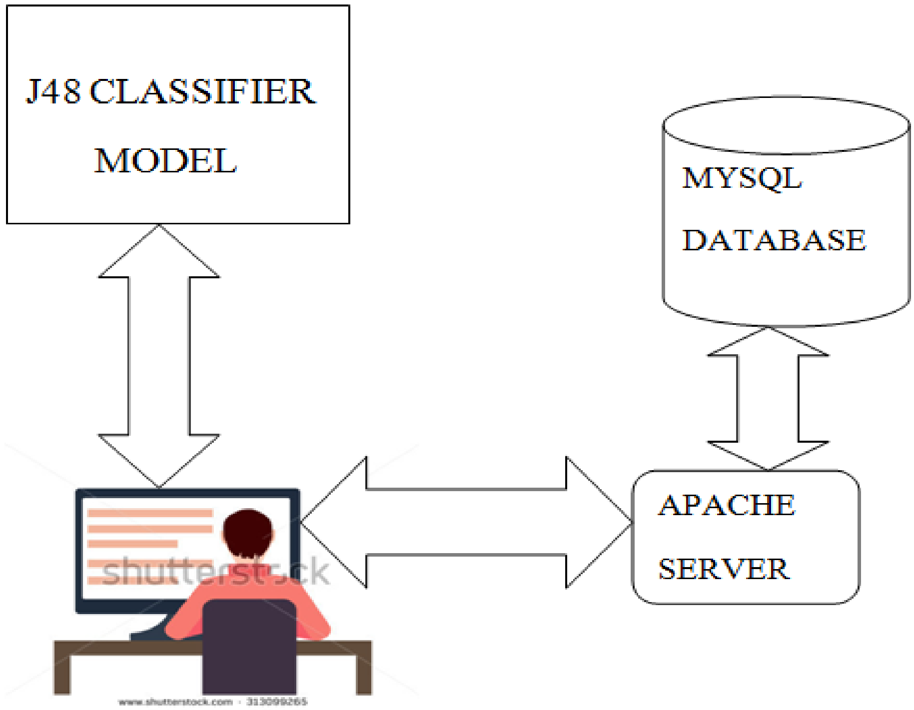

Figure 4.1: Proposed Prototype architecture

4.6 Use Case Diagram

In order to identify and partition the system into Use Cases and Actors, Use Case diagram is used where use cases represent the behaviour of the system actors representing the system users. The actors included System administrator, Bidders, Evaluator and the Vice Chancellor. The use cases contain text description of what happens during the particular interaction with the system.

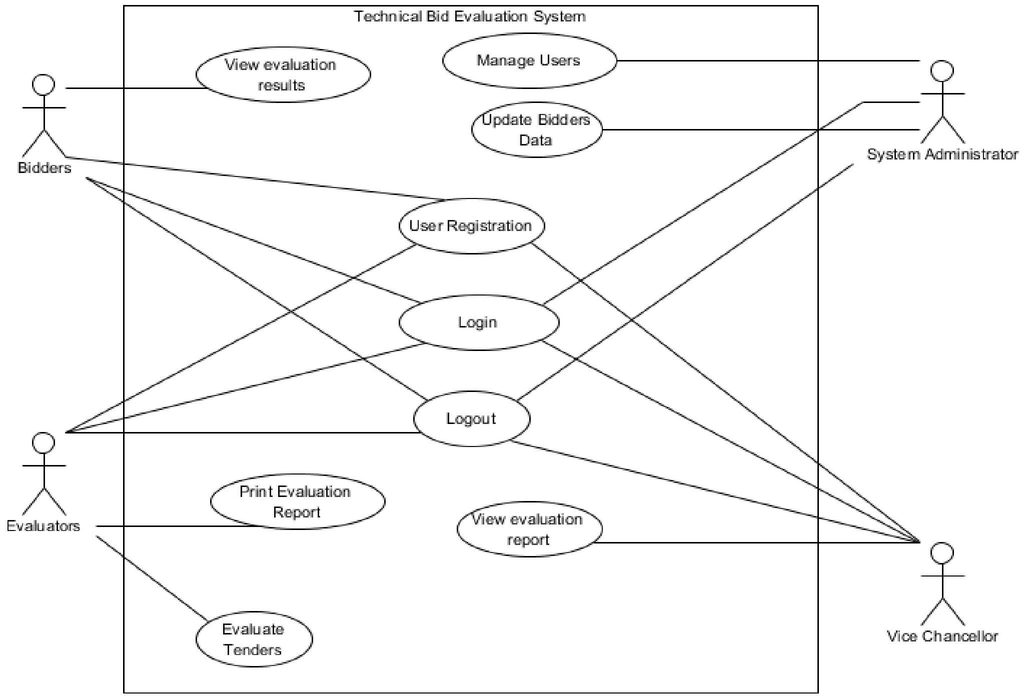

Figure 4.2: Use Case Diagram of Technical Bid Evaluation System

4.7 Process Control

Software process refers to an abstract representation of a software process (Scacchi, 2001). This represents a standardized format for planning, organising and implementing a software project. It comprises of objects, networked sequences of activities and events that entail strategies for handling software evolution.

4.7.1 Data Flow Diagram (DFD)

(i) Context Level Diagram

The prototype is handled by four categories of users namely: System administrator, Vice Chancellor, Bidders, and Procurement Officer. The main process is to evaluate bidders credentials by classifying them into pass and fail based on set criteria. The System administrator registers and views authorised persons. This creates credentials for authorised persons to log in. The authorised parties can login and view reports of the evaluation process and they include Vice Chancellor and bidders. The procurement Officer does the actual evaluation on the system. They can also view and download reports of the evaluation process.

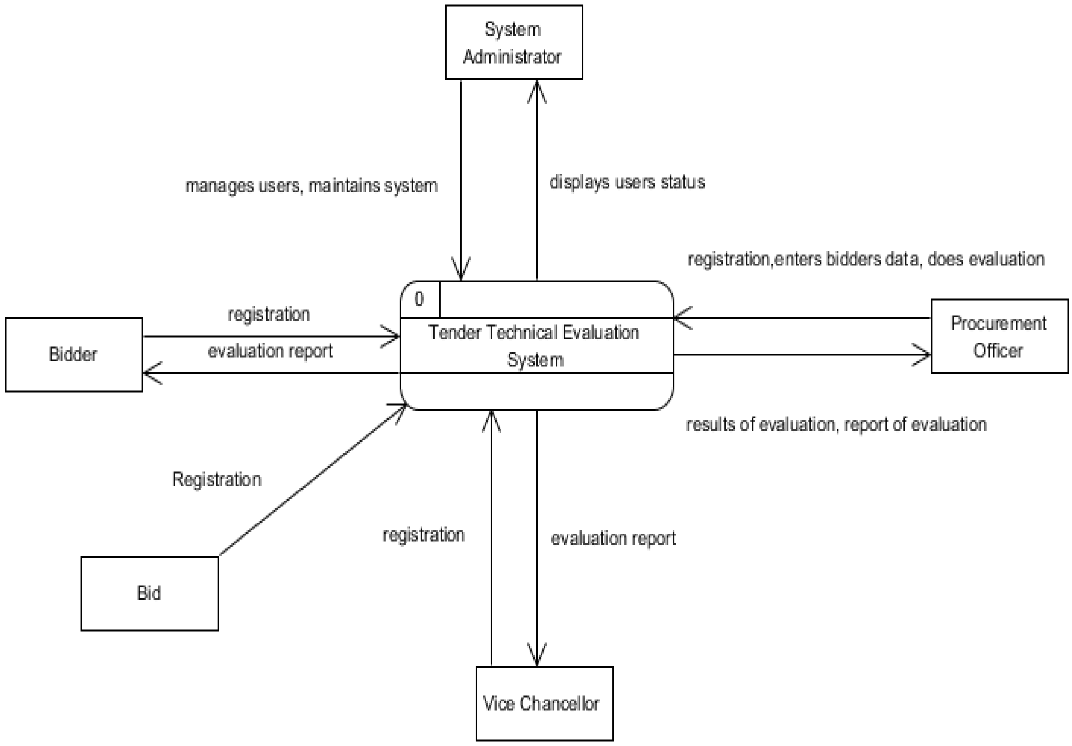

Figure 4.3: Prototype Context Diagram

(ii) Level 0 diagram

In order to understand further how the system works in terms of information flow between different components, context level was broken down to Level 0. A DFD level 0 notates each of the main sub-process that together forms the complete system. The study identified five processes and how the actors interact with the relevant processes. The diagram also shows where data from each process is stored.

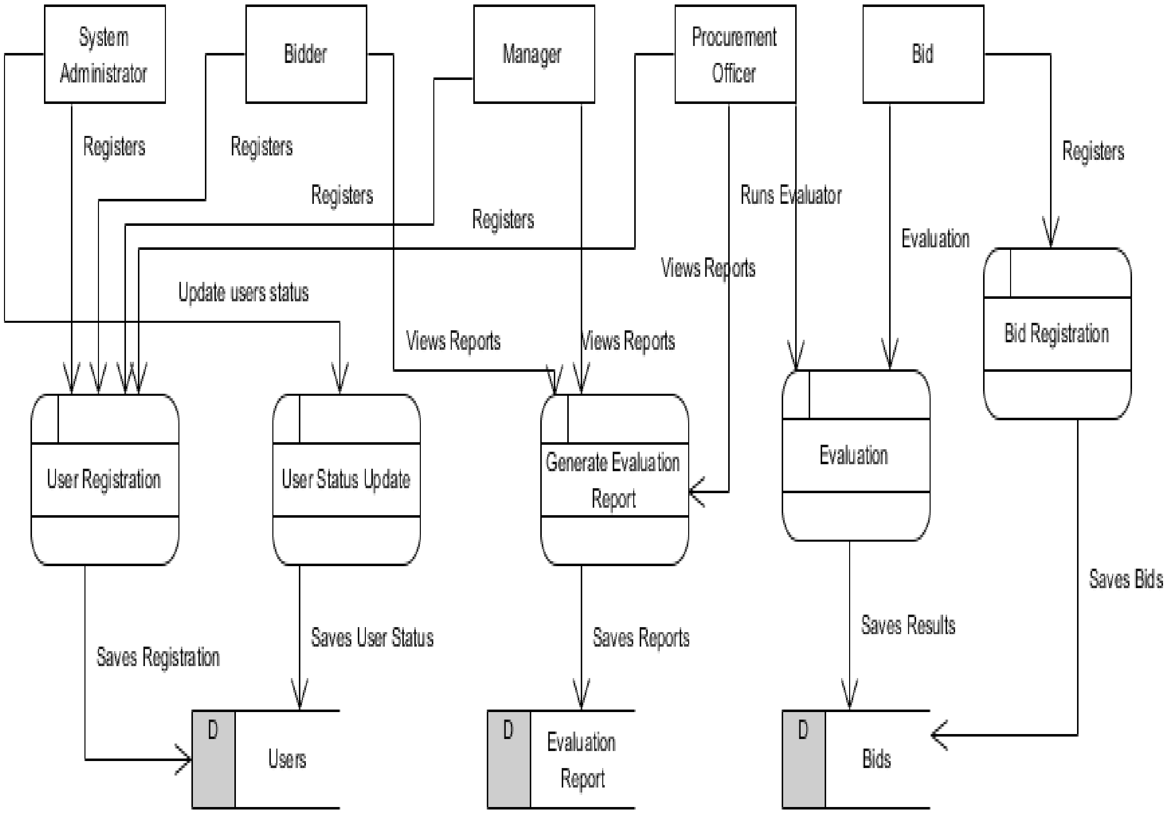

Figure 4.4: Data Flow diagram Level 0

4.7.2 Class Diagram

A class diagram was used to show various entities of the system. The relationship between them with the corresponding attributes and operations of implementations are illustrated in Figure 4.4. The system administrator can deal with one or many users and register 1 or many Tenders. A procurement officer can evaluate one or many tenders while the Manager or Vice Chancellor can approve one or many tenders. A bidder can bid zero or many bids.

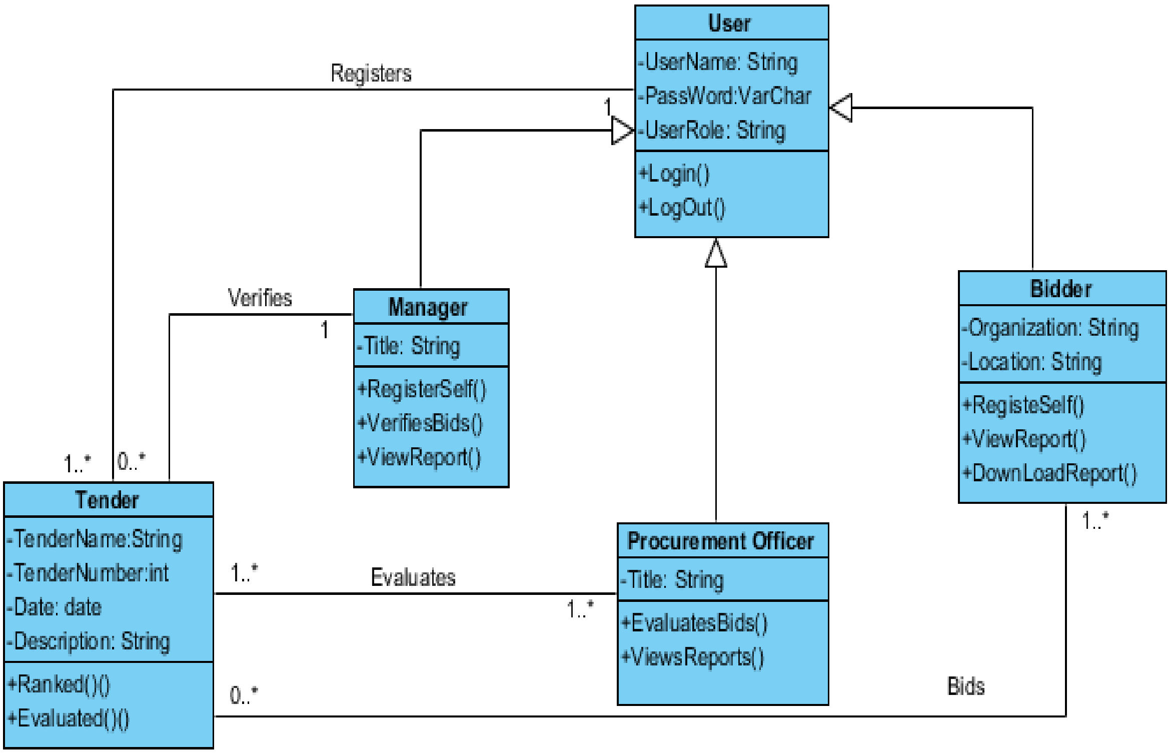

Figure 4.5: Class Diagram of the Evaluation system

4.7.3 Sequence Diagram

System Sequence diagram displays the sequential flow of the information passing between an actor and the system (Kruchten, 2012). For the designed system, Figure 4.5 shows the system sequence diagram of a procurement officer requesting evaluation of a bid. Figure 4.6 shows sequence diagram of registration event message flow.

The procurement officer first enters his/her details for authentication and verification by the administrator and the database respectively. For the evaluation, the user asks for details of the bidders from the database through bidders details interface. The user passes the data to the model for evaluation through the bidders interface again. After evaluation the model returns results of PASS and FAIL to the user. The user saves the results in the database.

During registration of new user, details are entered through the registration interface. Request is sent to the administrator to create account. The administrator checks details of the given information and new account is created in the database. Successful registration message is returned.

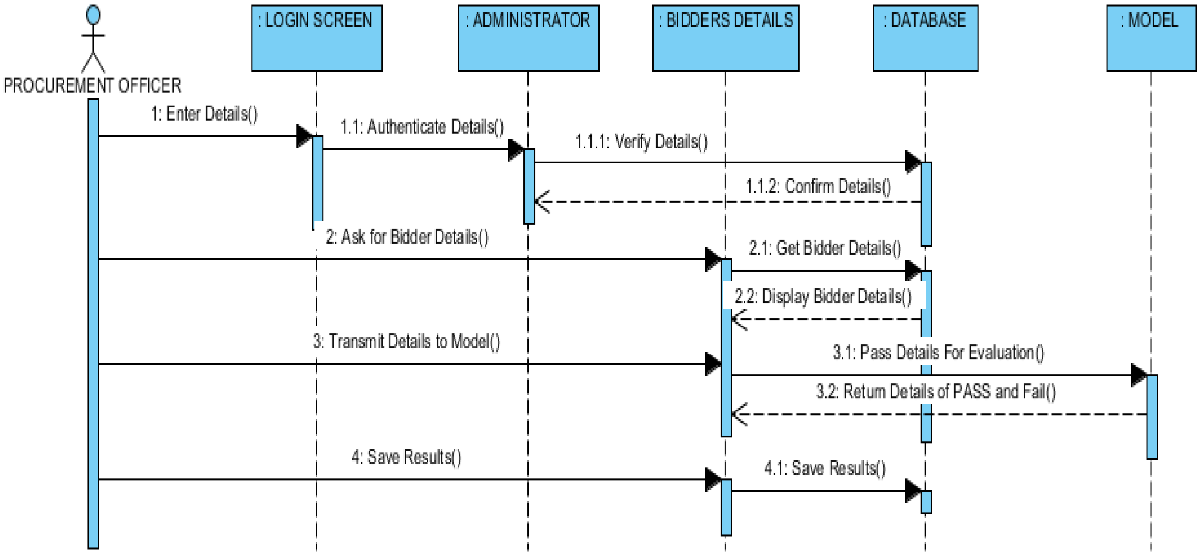

Figure 4.6: Sequence Diagram for Bid Evaluation

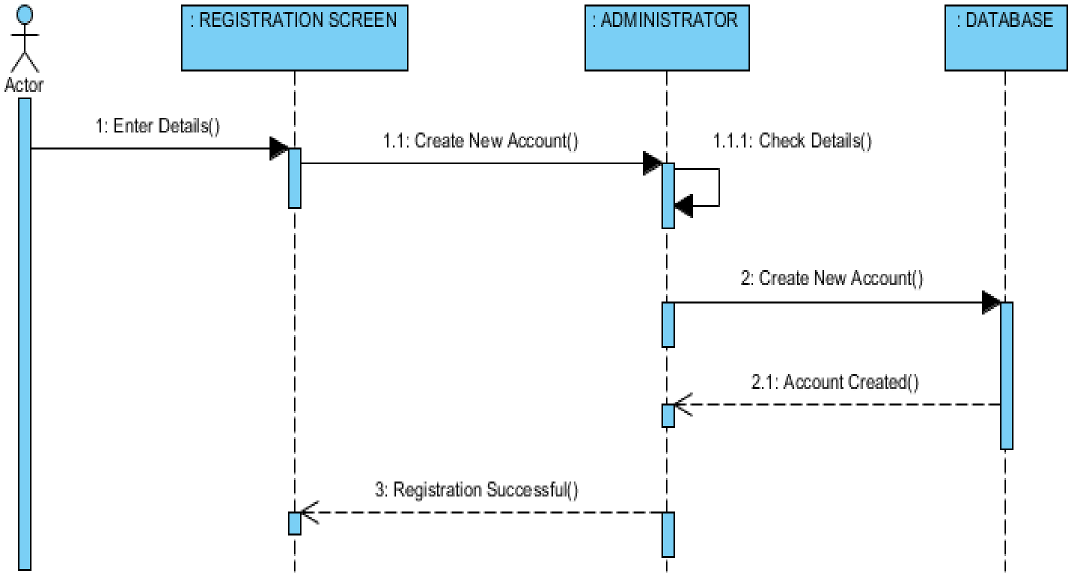

Figure 4.7: Sequence Diagram for an Activity of User Registration

4.7.4 Entity Relationship Diagram

The prototype was designed to handle all the data for all entities and components in the entire system. These include bid details, user details, evaluation results and reports. A MYSQL database hosted on an apache server was implemented for data storage. The logical model of the database is represented in the ERD shown in Figure 4.7.

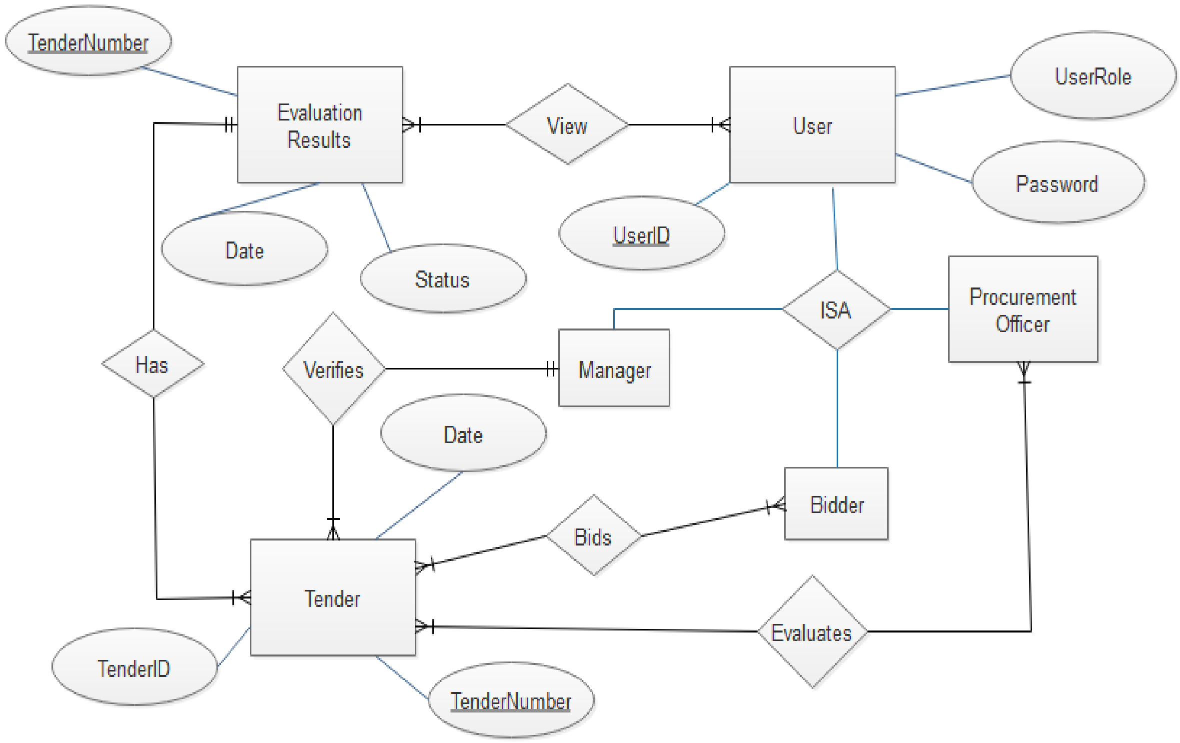

Figure 4.8: ERD of the Proposed Solution

Chapter 5: Prototype Implementation and Testing

5.1 Overview

This chapter describes the implementation and testing process conducted on the prototype. It is about transforming the designs in chapter four into programs. To begin with, the J48 algorithm based classifier model was built in WEKA environment. Various tests were done within the environment. Development environment, programming tools, development platform, database used and levels of system users are also discussed. Finally, prototype testing and user testing are done to close the chapter.

5.2 Development Environment

Suitable development environment has to be established to ensure that the implementation process runs smoothly. Tables 5.1 and 5.2 describe the software and hardware requirement for the development process.

5.2.1 Hardware Requirements

Table 5.1 describes the hardware requirements for the prototype.

Table 5.1: Hardware Requirements

Hardware	**Description**
Processor	Intel Centrino 1.6 Ghz Processor or higher or other equivalent processors
Memory	At least 512 MB ,Recommended: 1GB or more
Hard Disk Space	At least 50MB
LAN	Internet access

5.2.2 Software Requirements

Table 5.2 describes the software requirements for the prototype.

Table 5.2: Software Requirements

Software	**Description**
Operating System	Microsoft Windows 7
Relational Database Management System	MySQL 5.0.45
Programming languages	Java and Python
Machine Learning toolkit	WEKA

Internet Browser	Google Chrome, Mozilla
Application used	Microsoft Excel
IDE	Netbeans
Web application server	Apache

5.3 Experimental Setup

In order to develop the classification model based on J48 algorithm, an experiment was set up in WEKA environment. Real data from database or direct from human expert was used in the experiment. The process of building the model took several stages in sequence so as to achieve the best results.

5.3.1 Dataset Description

In this study, technical evaluation dataset from TUM was used to conduct the experiments. The dataset contained 7 independent variables whose values are either nominal or integer. There is one dependent variable which forms the class variable with either Pass or Fail values. A total of 100 instances were available for this study. There were 53 positive examples and 47 negative examples. A descriptive summary of the dataset is given in Table 5.3

Table 5.3: Dataset Description

Variable	Description	Possible Values
Experience	Similar successful jobs done	>5 yrs, <5 yrs or 5 yrs
CRB Report	Financial Integrity	Good, Very good or Bad
Professionalism	Registered with professional bodies	Yes or No
Equipment Capacity	In terms of technology and number of equipment	Good, Very good, Average or Bad
Number of workers	Number of personnel able to do the job	Enough, Average or not Enough
Location	Physical location-in the country or foreign company	Within or without
Bank Statement	Financial status	Good or Bad
Class	Category/actual outcome	Pass or Fail

5.3.2 Data Processing

The attributes from the original dataset were not necessarily of the most analytical relevance in the study. For example, tax compliance, company registration and value added taxes (VAT) are mandatory by statute in public procurement. Therefore, they are considered in the compliance stage without which a company is eliminated. The researcher filtered these attributes out. Further processing was done on the data on attributes that had number value. For example attribute "no. of Personnel" indicted figures like 20 people. This had to be converted to categorical for the J48 algorithm to work with. The value therefore changed to either "enough, not enough or average".

5.3.3 Attribute Selection

Attribute selection feature in the WEKA software searches through all possible combinations of attributes in the dataset and finds which subset of attributes works best for classification. Decision tree algorithms use Information gain and gain ratio for the ranking of the attributes. The attributes used in this study were ranked in order of importance using information gain and gain ratio as attribute evaluators. Information gain evaluates the worth of an attribute by measuring the information gain with respect to the class while gain ratio evaluates the worth of an attribute by measuring the gain ratio with respect to the class. The search method used for both information gain and gain ration was Ranker.

The two attribute selection modes of full training set and cross validation of 10 folds were used in the experiment. The results revealed helped confirm the importance of the attribute in the evaluation by the developed model. Appendix E shows the results of the experiments.

5.3.4 Model Building

The dataset gotten from the physical files was later transformed into computer document file using Microsoft Excel. The document had to be converted to comma separated values (csv) format for the purposes of loading into the WEKA environment. WEKA manipulates files with an extension of attribute relation file format (Arff). Attribute relation file format is an ASCII text file that describes a list of instances sharing a set of attributes. The csv format was formatted to Arff by the WEKA tool.

In building the classification model in the WEKA environment, percentage split was used as a test option. The default percentage split in WEKA of 66% was used for training while the remaining 34% was used for testing. Percentage split was chosen in favour of cross validation and training set because it gave impressive results on accuracy compared. Besides, results from using full training set does not necessarily give the right impression about the model performance because the whole set has been exposed to the model. The same applies to cross validation. Percentage split extrapolates the generalization to unseen data.

5.3.5 Model Validation

To validate the results of the model, a confusion matrix, classification accuracy, F-measure, True Positive Rate, False Positive Rate, Precision curve and ROC were used. Appendix E captures the results of the validation.

For the purpose of interpreting results in more meaningful way, the Precision and ROC curves were produced. Precision is represented on the y-axis while Recall is on the x-axis of the precision curve. The ROC curve has False Positive Rates on the x-axis while the y-axis has True Positive Rates. The displays of these two curves reveal a lot about the performance of the model. Figure 5.5 and Figure 5.6 show the Precision and ROC curves respectively.

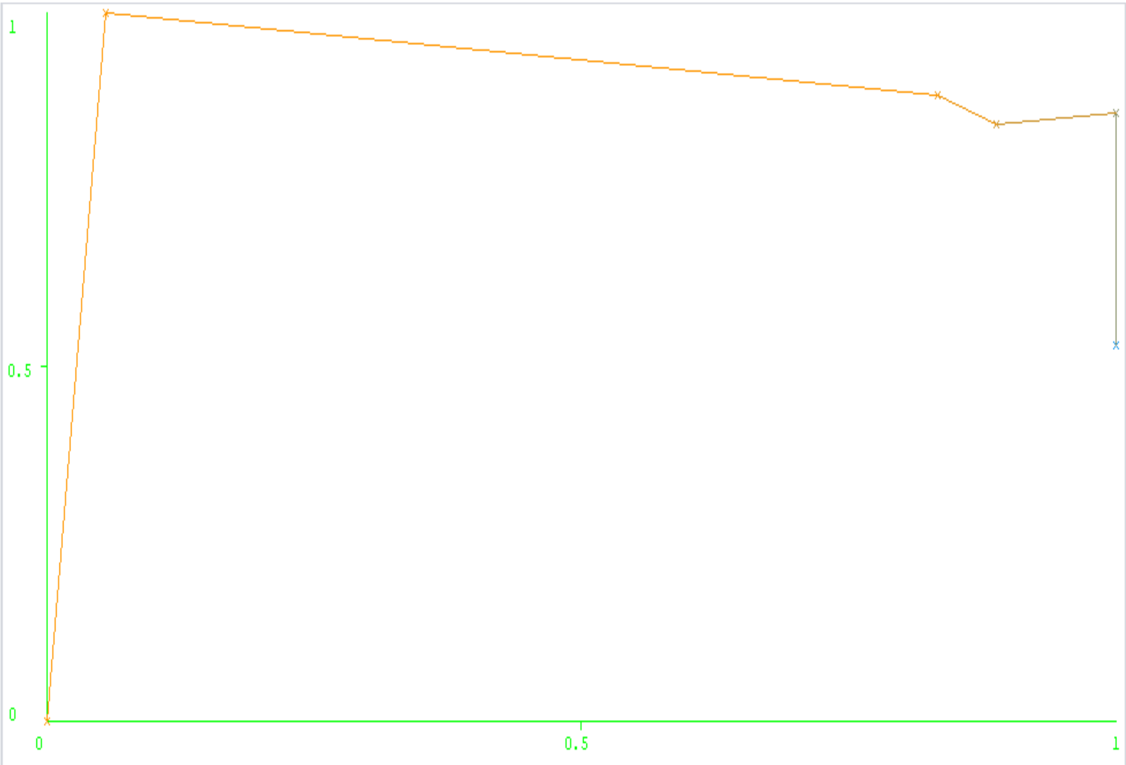

Figure 5.5: Precision Curve

Figure 5.6: ROC Curve

5.4 Prototype Development

In developing the prototype, the most important component was the J48 classifier model. The source code for the model was taken from the WEKA environment. Instead of embedding it directly to the java main code of the application, the source code was saved in a separate configuration file. This is because it is easier to retrain the model while in a separate file than when it is in the main code of the application. The database was implemented using MYSQL software. This project contains a WEKA wrapper application which uses WEKA libraries to provide native machine learning programming in Java. Figures 5.8, 5.9, 5.10 show the main evaluation interface of the application. Figure 5.8 displays an output ready for the process. A user clicks the button "get data" and displays contractor data on the bigger table on the interface, shown on Figure 5.9. The user then presses button "evaluate" to send the data to the model for evaluation and returns results on the smaller table. Figure 5.10 shows the complete output of the process.

Figure 5.7: Evaluation Interface without data

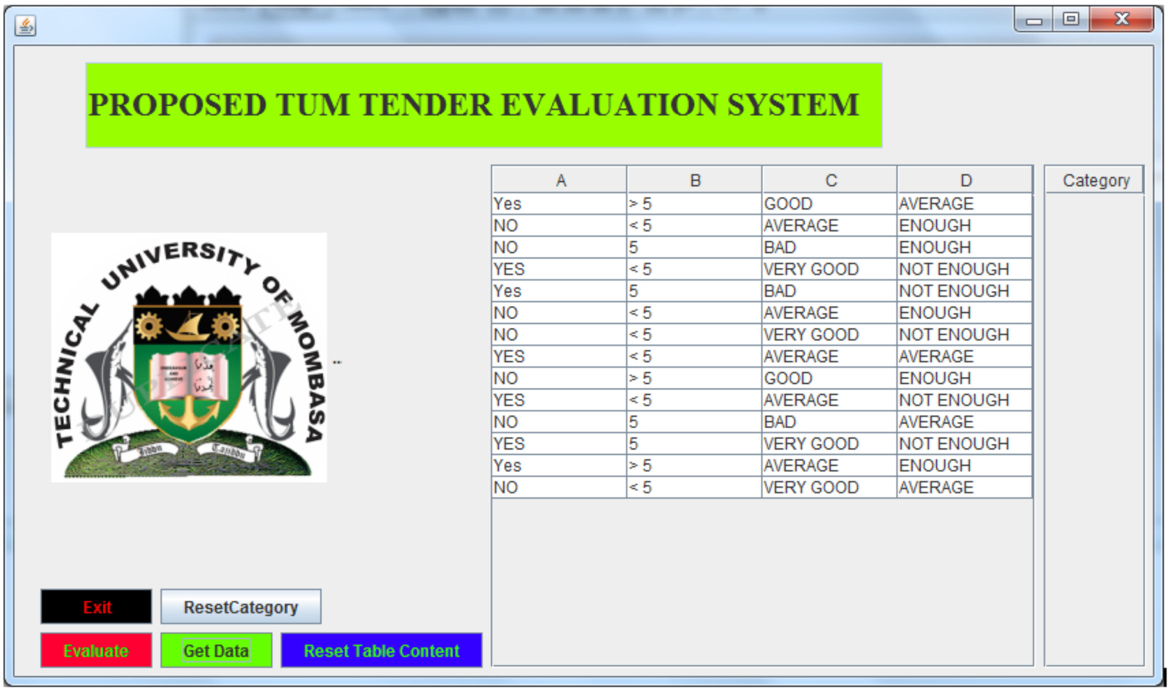

Figure 5.8: Evaluation interface with data from Database

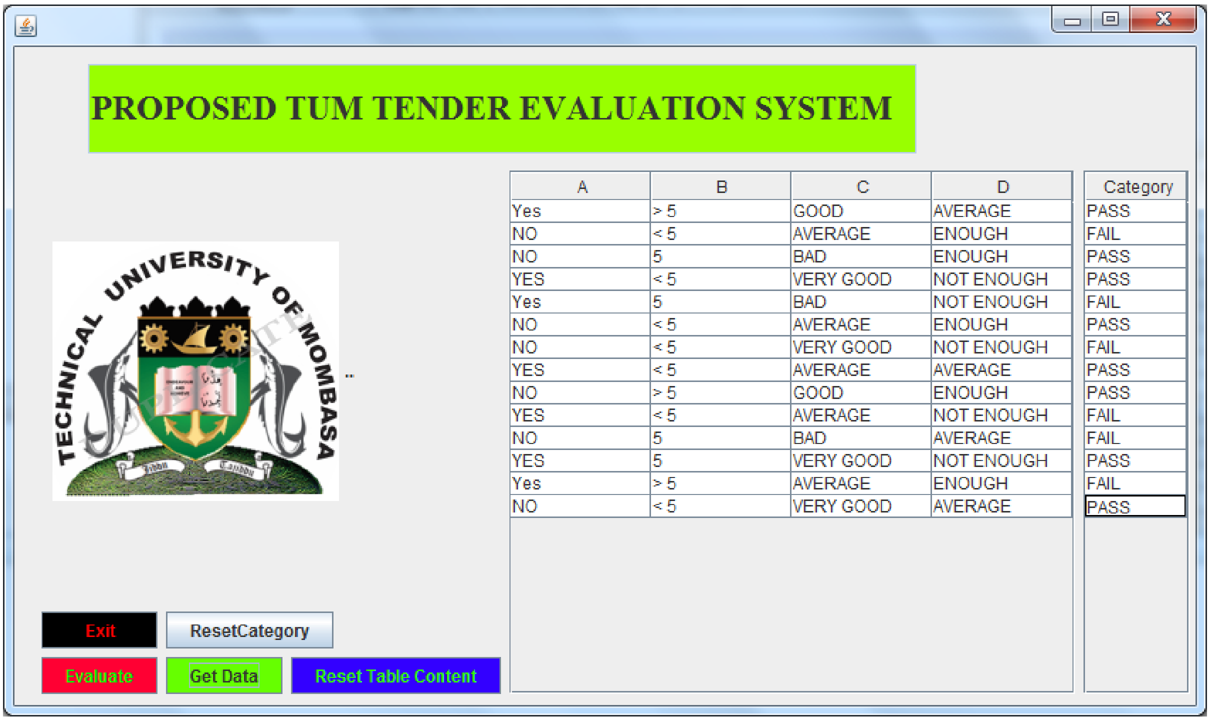

Figure 5.9: Evaluation Interface complete with Results

5.5 Users of the Prototype

As identified in Chapter 4 there are four types of potential users of the system, namely System administrator, Vice Chancellor, Procurement officers, and Tenderers. In this section, the responsibilities of every user are discussed in detail while demonstrating how the roles of each relate to the testing procedure that will be discussed in Section 5.7.

5.5.1 System Administrator (SA)

SAs are responsible for system management and maintenance. The key role played by the SA involves updates, adding new, editing or removing details of others Users, Tender details and Model configuration.

5.5.2 Tenderers

Company representative have the responsibility of viewing reports and download the same. They also verify details of the tenders entered.

5.5.3 Procurement Officers

These officers are the actual users who run the prototype during evaluation. They can download, save and print the results.

5.5.4 Vice Chancellor

Ultimate responsibility in the procurement process according to government regulations lies with the most senior officer. His/her role is to view softcopy of results and other details and get the hardcopies of the same for the records.

5.6 Prototype Testing

Prototype testing was based on the functional requirements of the solution. To ensure that the prototype meets the user requirements provided, some tests were done and the results captured in Table 5.4.

Table 5.4: Results of Prototype Testing

ID	Case	Expected outcome	Comments
1.0	**Login**		
1.1	Username or Password left out	Error Dialog box	Pass
1.2	Wrong Username or Password entered	Error Dialog box	Pass
2.0	**User Registration**		
2.1	Leaving out a Required Field	Error Dialog box	Pass
2.2	Invalid data in a Field	Error Dialog box	Pass
3.0	**Tender Evaluation**		
3.1	Missing Values	Error Dialog box	Pass
4.0	**View Reports**		
4.1	Wrong report ID	Error Dialog box	Pass
5.0	**Tender Registration**		
5.1	Leaving out a Required Field	Error Dialog box	Pass
5.2	Invalid data in a Field	Error Dialog box	Pass

5.7 Usability Testing

Usability testing was important in this study since the proposed prototype was meant to address user`s challenges and therefore the users were required to interact with the prototype. The test focused on various aspects such as acceptability, functionality, user friendliness and aesthetics. The results of the different test were presented in a pie chart format.

5.7.1 User Interface Aesthetic Value

An information gathering about the application`s aesthetic value based on users` was carried out and the results obtained from 65 respondents. Given the options of Very Appealing, Average and Irritating, 45 respondents selected Very Appealing, 15 responded with Average while the remaining 5 gave a feedback of Irritating. Figure 5.10 gives a pictorial representation of this data.

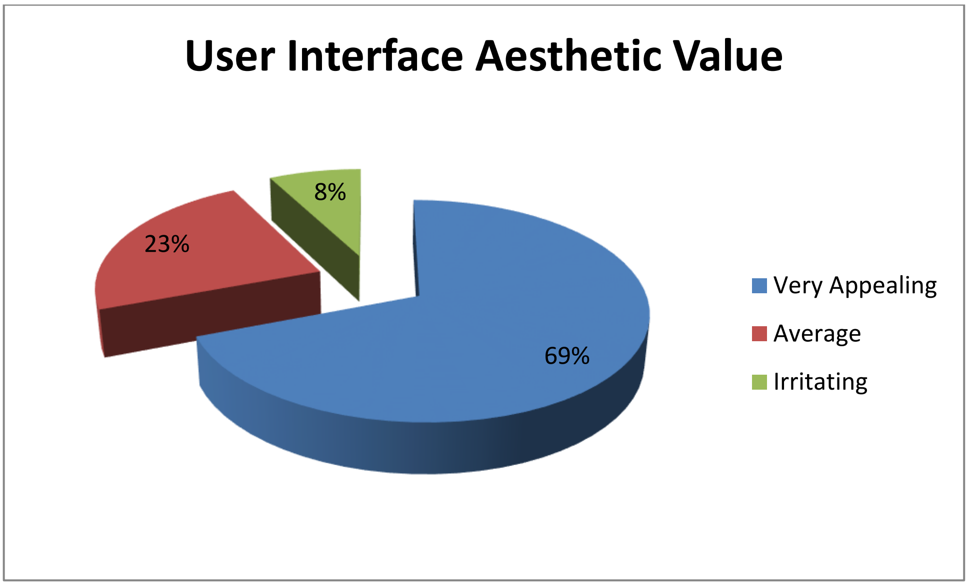

Figure 5.10: User Interface Aesthetic Value

5.7.2 User Friendliness

On User Friendliness test, the question put forward had the options of Simple, Average and Difficult. 50 of the respondents selected Simple, the Average option had 12 respondents while 3 said interface was Difficult. This data is captured in Figure 5.11.

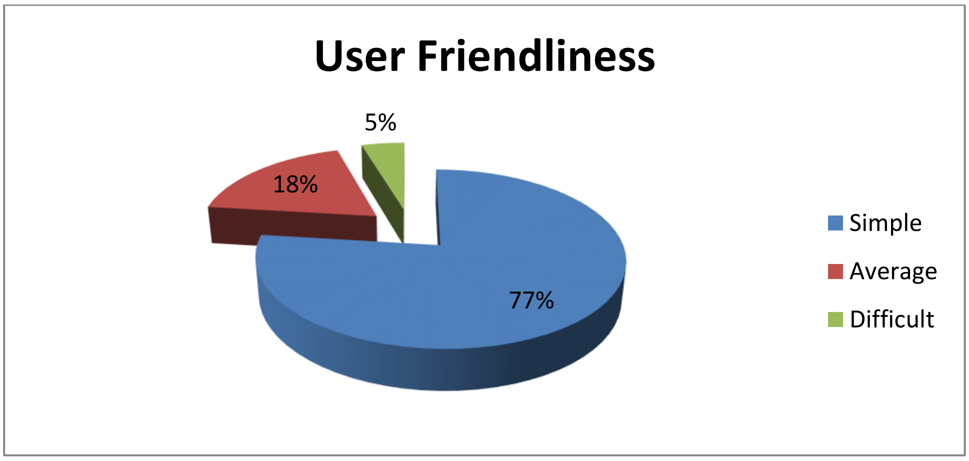

Figure 5.11: User Friendliness

5.7.3 Functionality

The functionality of the proposed prototype is essential since the solution was expected to meet the user requirements. Towards achieving this, users were requested to state the functionality satisfaction level while using the application. The choices available in the questionnaire were; Good, Above average, Average and Below average. . Of the 65 respondents, 53 selected Good, 7 picked Above Average, 4 said Average and 1 respondent chose Below average for the answer. Figure 5.12 summarises these results.

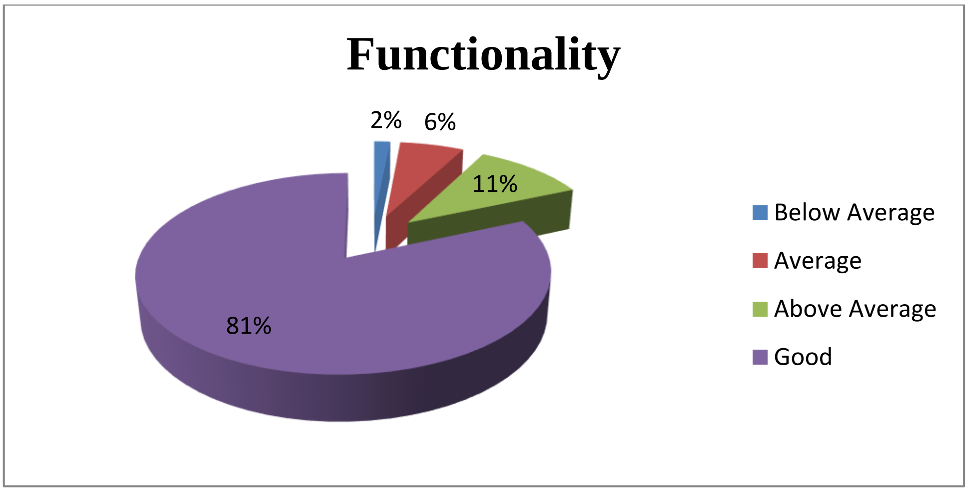

Figure 5.12: Prototype Functionality Test

5.7.4 Acceptability Test

Acceptability test was carried out to determine how users would accept and adopt the developed solution to address the challenges of procurement especially on fairness. Out of the 65 participants, 61 accepted the solution, 3 were not sure and 1 rejected. Figure 5.13 shows a representation of this data.

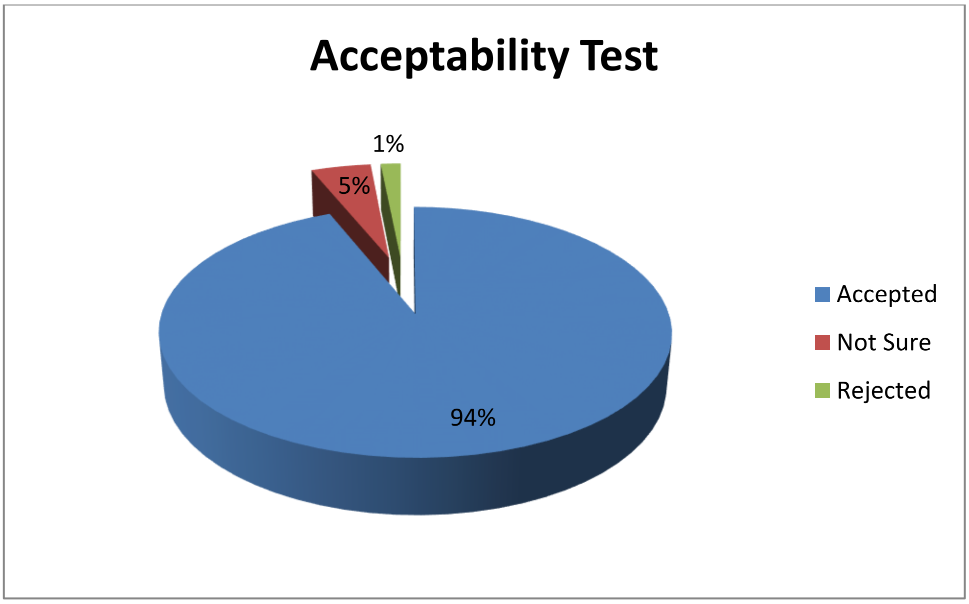

Figure 5.13: Acceptability Test

5.7.5 User Feedback Test

The main aim of this proposed solution is to address the issue of subjectivity in tender evaluation process. Therefore users were asked to give their opinion on whether the prototype has the potential of achieving that. The question put forward had the following choices: Most likely, Likely, Unlikely and Not sure. 40 of the 65 participants selected Most Likely. 10 chose Likely and another 10 picked Unlikely for the answer. 5 of the respondents said they were Not sure. Figure 5.14 summarises this data.

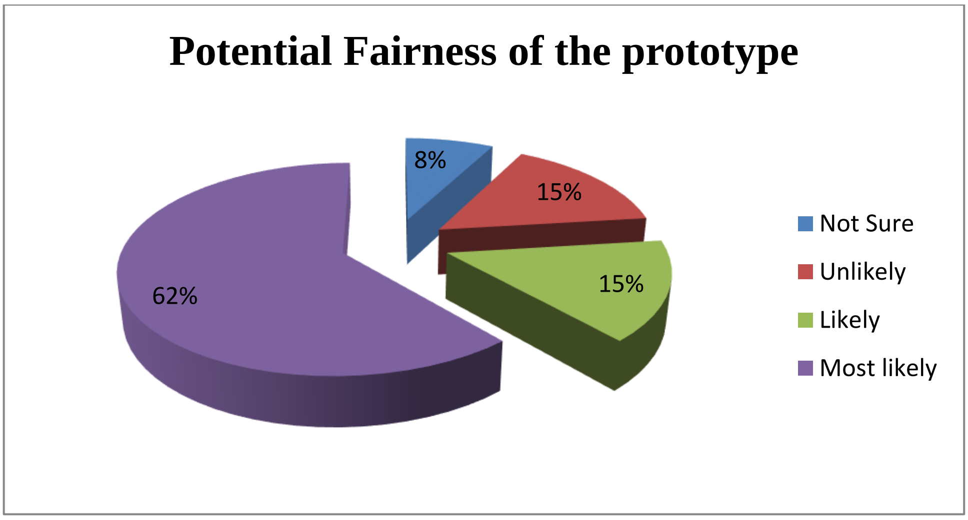

Figure 5.14: Potential Fairness Test

5.8 Model Test Results

The results of the experimental analysis in predicting the class category of the tender are discussed in this section. The metrics of interest to the researcher were the classification output, detail of accuracy by class, Precision measure, F measure, Receiver Operating Characteristic (ROC) curve, True Positive (TP) rate, False Positive (FP) rate and the classification matrix.

5.8.1 Classification Output

Table 6.1 shows the details of the accuracy between correctly classified instances and incorrectly classified instances. An impressive performance of 91.1765% on the part of the algorithm was achieved. The percentage figure means that of all the instances recorded either positive or negative in total 91.1765% were correct. The recorded percentage for the incorrectly classified instances was 8.8235%. This means that of all instances reported either positive or negative only 8.8235% were incorrect. However, more different results need to be considered before drawing any conclusions. This is because classification accuracy is the easiest classification metric to understand but it does not tell the underlying distribution of response values. It is however the first metric to give an impression on model performance.

Table 5.5 Classification Output

Correctly classified instances	31	91.1765%
Incorrectly classified instances	3	8.8235%

5.8.2 Detailed Accuracy by Class

The performance evaluation for the classification of tenders based on the precision recall ratio and F-Measure per class as stated in Chapter 3 are shown in Table 6.2.

Table 5.6 Detailed Accuracy by Class

TP Rate	FP Rate	Precision	Recall	F-measure	ROC Area Class	Class
1.000	0.188	0.587	1.000	0.923	0.922	PASS
0.813	0.000	1.000	0.813	0.897	0.922	FAIL
0.912	0.099	0.924	0.912	0.911	0.922	

TP rate of 1 in the table is an excellent report. It means every time a positive instance is classified by the model is true. There was minimal error for false positive of 0.188. For all positive instances reported, there was a chance of 0.188 for false positive every time a classification is done. This is almost a negligible error.

The best practise of interpreting the values of Precision and Receiver Operating characteristic area class is to project these results in a graph. Figure 5.6 in chapter 5 shows a graph of the results of precision. When a curve tends towards the y-axis then parallels' the x-axis, that is an indicative of a very good model. The graph in Figure 5.6 shows something close to that achievement. It can be concluded based on the meaning of the curve that the model is good.

Further interpretation of the ROC curve in chapter 5, Figure 5.7 shows similar behaviour on the part of the model. The curve tends towards value 1 on the y-axis and straightens along the x-axis then turns down. An ideal curve for an excellent model moves to value 1 along the y-axis and again turns to parallel the x-axis.

5.8.3 Confusion Matrix

The confusion matrix that was obtained from the classification was as illustrated in Table 6.3. The confusion matrix contains information on the actual and predicted classifications. There were a total of 100 instances that were used to train and test the network. 53 instances of the Pass target were presented to the network. 48 instances were correctly classified as Pass while 5 were incorrectly as Pass. There was a total of 47 Fails. Only 5 were incorrectly classified as Fails but 42 were positively classified as Fail.

Table 5.7: Confusion Matrix

A	B
48	5
5	42

A=PASS and B= FAIL

In the experiments conducted and results obtained from the standard tests, it can be stated that the model built can be relied upon to make crucial prediction on classification problems of the nature of contractor evaluation.

5.9 Prototype Test Results

Prototype tests were about functional requirements of the system. Table 5 show the results. It is clear that all functional requirements were successful. The meaning of this is that the model has been converted to a working prototype. Being a prototype, the research was interested in the most basic functionality with direct link to the main goal of the study.

5.10 Usability Test Results

Usability test was based on 4 key metrics touching on the characteristics of the prototype. On the aesthetic value of the user interface, up to 69% respondents said that it was appealing. This means that majority would enjoy working with the proposed system. User friendliness scored 77% for those who chose simple as the answer. It means people can learn quickly the model and be productive. Functionality had 81% participants' choice agreeing that the prototype met the user requirements. This was a great achievement for the study. Finally, acceptability test scored the highest with 94% of the respondents agreeing to the adoption of the model in addressing the subjectivity issue in tender evaluation. A summary of these results are captured in Table 6.4.

Table 5.8: Usability Test Results

METRIC	**RESPONDENTS**
User interface aesthetic	69%
User friendliness	77%
Functionality	81%
Acceptability	94%

5.11 Conclusion

This chapter discussed test results of the model and the prototype. The model had three tests presented in tables as Classification accuracy, confusion matrix, and details accuracy by class. In addition to the details accuracy by class in Table 6.2, visual results by way of curves for ROC and Precision were provided in chapter 5 to support the good results shown in figures in the Table. In classification problems, the stated metrics are adequate in providing information regarding performance of the model. As for the prototype tests, functional and non-functional tests were done. The functional test were on the prototype itself while non-functional were for the usability tests. In all the tests, results obtained indicated success.

Chapter 6: Conclusions and Recommendations

6.1 Conclusions

The main objective of this study was to model a solution for technical evaluation of construction contractors. Towards this end, the main objective was broken down into five specific objectives for systematic approach in achieving the main goal. The objectives were achieved as follows:

(i) To investigate the factors and challenges that influence technical tender evaluation.

(ii)To appraise the models, applications and algorithms used in the evaluation of tenders.

The first two objectives were achieved by the application of secondary data which was gotten from existing literature in scholarly work and organisations reports. The factors and challenges helped the researcher in the application of the independent variables in design and experiment. Appraising the models, applications and algorithms guided the research in identifying the existing gaps. Therefore chapter two responded partly to chapter one and gave directions to chapter four.

(iii) To design a solution for technical evaluation of tender.

This objective was achieved in chapter four. The research had a fact-finding phase where through informal interviews and observations, requirements were sought. This followed a representation of the solution in a conceptual manner to guide implementation of the solution. Using special tools like Visual paradigm software, diagrams were drawn to represent the key components of the solution and how those components interact to achieve a common goal.

(iv) To develop the solution

(v) To test the prediction performance of the solution.

The above two objectives were achieved in chapter five. There were three components forming the entire solution. Component one was the model itself. J48 decision tree algorithm was used to design, build and test the model in WEKA environment. User interface, which is the second component, was built using Netbeans environment. The last component was the data store which was designed using MySQL database management system software supported on apache server. Prototype and usability testing were done on the finished product in the lab and through survey for the prototype test and usability test respectively. The tests were for functional and non-functional requirements.

6.2 Challenges encountered

There were a couple of challenges in the entire period of study. The first challenge was technical in nature and it was during implementation. It was a big challenge to integrate the source code of the model from the WEKA environment to Python environment. The research abandoned that idea because it involved many technical issues of interface. It took time before arriving at that decision. The use of configuration file and executive files for the model source code proved difficult at first.

The other challenge was in the area of data collection. The location of the research was in Mombasa and the researcher was based in Nairobi. This is a distance of about 500km. The cheapest mode of transport is by road but time consuming. The study had to rely on some people on the ground to provide the information and distribute and collect feedback from the questionnaires. Even the dataset gotten from TUM was from physical files and therefore not necessarily reliable. In those circumstances we had to operate on trust and given the fact that data collected formed a crucial component of the study, this to the researcher was a big challenge that touched on the quality of the research results.

6.3 Limitations of the Study

Although the study has successfully demonstrated that machine learning techniques can be used to assist decision making in contractor evaluation, it has certain limitations in terms of applicability. This study considered a section of the entire tendering process. The research had identified three key stages in the tendering process namely, compliance stage, technical stage and the financial stage. Technical stage was the area of interest. This meant that certain variables in the remaining stages were not considered and in the opinion of the researcher could influence the accuracy and general performance of the proposed model. Further, the sample size of the dataset (100 instances) was average in size. A bigger dataset would allow many experiments.

Time frame for this study was an academic requirement and as such it put some constraints on how much more could be done in the study. Whatever that could not be addressed by way of omission in this study can be linked to time constraints.

Finally, the study was on tenders for construction projects in the public sector governed by statute which influenced design and implementation. For example building the solution that is web-based would have the potential of compromising some key principles of procurement like confidentiality.

6.4 Recommendations/Future work

It is recommended that further research be undertaken in the following areas:

(i) An ensemble of decision tree algorithms and artificial neural networks can build an evaluation model that is transparent and with very good accuracy. Decision tree models are transparent and the artificial neural networks have better accuracy.

(ii) Future research work should consider the entire phases of tendering process so as to capture many variables for better chances of improving accuracy.

(iii) Instead of having a model for every tender, research can focus on building a model that is integrated. A model that will provide a single platform for evaluation of any tender.

(iv) This research also recommends working with larger datasets (like 2000 instances) in future research.

(v) It is also the recommendation of this study that attempts be made to have the evaluation process online with some caution as regards confidentiality.

6.5 Contributions

The current findings add to a growing body of knowledge both locally and internationally on the application of machine learning techniques in business decision making processes. This is the first attempt, to the best of the researcher's knowledge, based on the sources accessed, to apply decision tree algorithm to build a model for the purpose of technical evaluation of tender in construction projects.

When fully implemented, such a prototype contributes to the fight against unfairness in the current process of tender evaluations in the public sector. It is therefore a tool that can be used by even policy makers to formulate regulations with a view of ensuring professionalism on the part of procurement officers and by extension draw on innovative solutions to societal challenges.

Last but not least, if published, this work will allow the public to engage with research. To go behind the headlines and look at the scientific evidence therein. It allows the research results to be reused for new discoveries.

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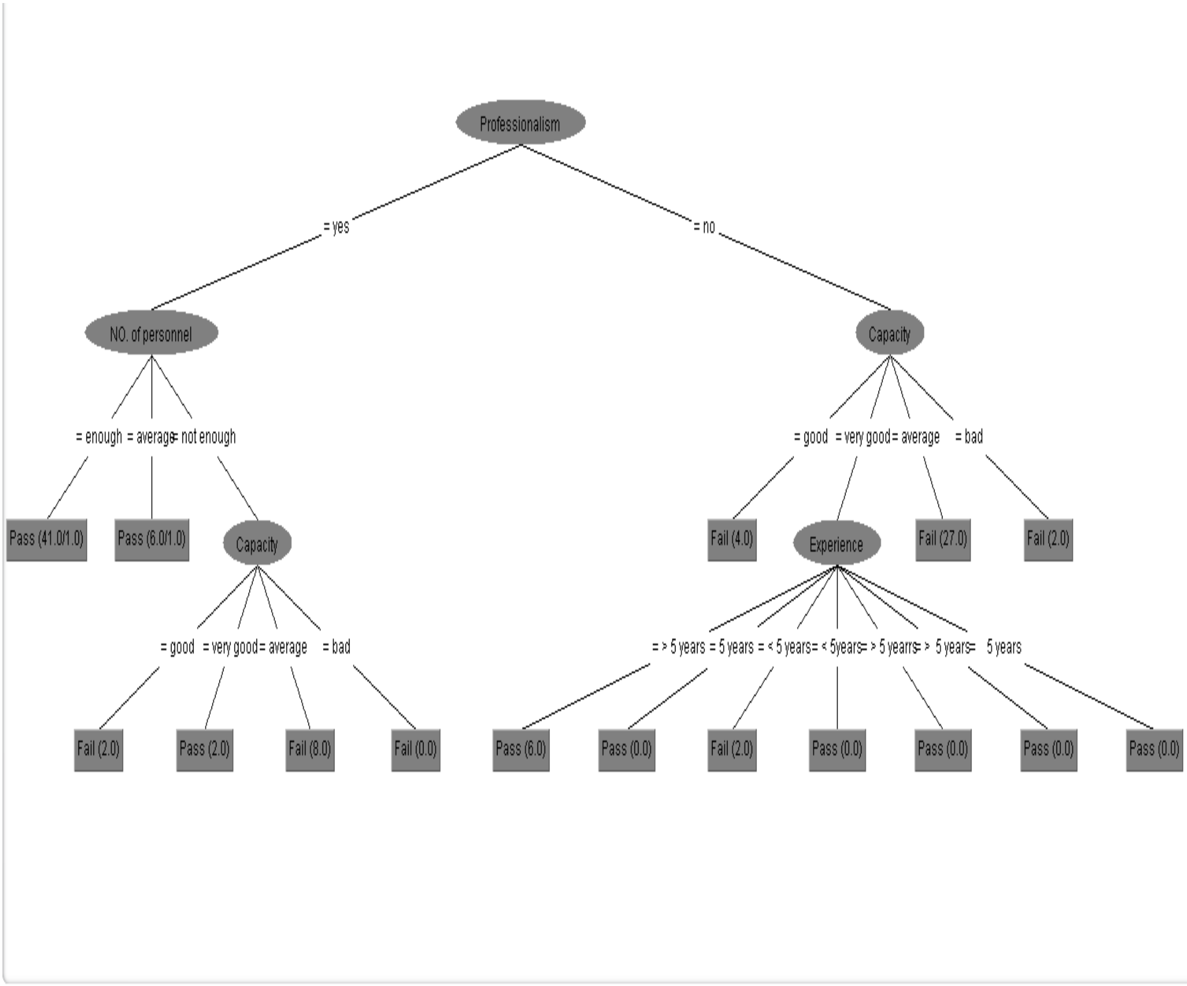
Appendix A: Classifier Source Code

```
class WekaClassifier {

  public static double classify(Object[] i)
    throws Exception {

    double p = Double.NaN;
    p = WekaClassifier.N14165060(i);
    return p;
  }
  static double N14165060(Object []i) {
    double p = Double.NaN;
    if (i[2] == null) {
      p = 0;
    } else if (i[2].equals("yes")) {
    p = WekaClassifier.N192e4b01(i);
    } else if (i[2].equals("no")) {
    p = WekaClassifier.N976c0a3(i);
    }
    return p;
  }
  static double N192e4b01(Object []i) {
    double p = Double.NaN;
    if (i[3] == null) {
      p = 0;
    } else if (i[3].equals("enough")) {
      p = 0;
    } else if (i[3].equals("average")) {
      p = 0;
    } else if (i[3].equals("not enough")) {
    p = WekaClassifier.N20ddd82(i);
    }
    return p;
  }
  static double N20ddd82(Object []i) {
    double p = Double.NaN;
    if (i[1] == null) {
      p = 1;
    } else if (i[1].equals("good")) {
      p = 1;
    } else if (i[1].equals("very good")) {
      p = 0;
    } else if (i[1].equals("average")) {
      p = 1;
    } else if (i[1].equals("bad")) {
      p = 1;
    }
    return p;
  }
```

```
  static double N976c0a3(Object []i) {
    double p = Double.NaN;
    if (i[1] == null) {
      p = 1;
    } else if (i[1].equals("good")) {
      p = 1;
    } else if (i[1].equals("very good")) {
    p = WekaClassifier.N2e5e8b4(i);
    } else if (i[1].equals("average")) {
      p = 1;
    } else if (i[1].equals("bad")) {
      p = 1;
    }
    return p;
  }
  static double N2e5e8b4(Object []i) {
    double p = Double.NaN;
    if (i[0] == null) {
      p = 0;
    } else if (i[0].equals("> 5 years")) {
      p = 0;
    } else if (i[0].equals("5 years")) {
      p = 0;
    } else if (i[0].equals("< 5 years")) {
      p = 1;
    } else if (i[0].equals("< 5years")) {
      p = 0;
    } else if (i[0].equals("> 5 yearrs")) {
      p = 0;
    } else if (i[0].equals(">  5 years")) {
      p = 0;
    } else if (i[0].equals("   5 years")) {
      p = 0;
    }
    return p;
  }
}
```

Appendix B: J48 Tree Model Visualization

The J48 Tree for the Tender Evaluation



Appendix C : Questionnaire

User Requirements Questionnaire

Researcher: Samuel Kumbu Mandale

MSc. IT Strathmore University

Letter of Introduction

Dear Respondent

I am a graduate student at Strathmore University undertaking a Master`s degree program in Information Technology. In partial fulfilment of the requirements of this degree, I am conducting a research on the use of an intelligent software application in the evaluation of tenders in public entities. Your response will be treated with confidentiality and used for academic purpose only.

Application Usage Experience

1. How friendly is the application?

- Simple
- Difficult
- Average

2. Is the application visually appealing?

- Very appealing
- Irritating
- Average

3. Did you find the application helpful and would you accept it for use in tender evaluation?

- Not sure
- Accept
- Reject

4. Rate how well the application solution performed its tasks?

- Good
- Below average
- Average

- Above average

5. From your usage experience is the application potentially fair in evaluation?

- Most likely
- Unlikely
- Not sure
- Likely

6. Kindly suggest in further improvements on the solution.

....
....
....

Appendix D: Originality Report

SAM THESIS

by Samuel Mandale

SAM THESIS

ORIGINALITY REPORT

%26	%16	%12	%19
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Strathmore University Student Paper	%2
2	research.ijcaonline.org Internet Source	%1

FILE	SAM_THESIS_-_MODEL.DOCX (4.25M)		
TIME SUBMITTED	06-APR-2017 07:00PM	WORD COUNT	17747
SUBMISSION ID	795395552	CHARACTER COUNT	117262

Appendix E: Experiment Results

```
Evaluation mode:    evaluate on all training data



=== Attribute Selection on all input data ===

Search Method:
        Attribute ranking.

Attribute Evaluator (supervised, Class (nominal): 8 Class):
        Information Gain Ranking Filter

Ranked attributes:
 0.4425   2 Capacity
 0.3718   4 NO. of personnel
 0.3412   1 Experience
 0.3212   3 Professionalism
 0.2515   5 CRB report
 0.0635   7 Bank statement
 0.0178   6 Location

Selected attributes: 2,4,1,3,5,7,6 : 7
```

Information gain Ranked attributes Results

```
=== Attribute Selection on all input data ===

Search Method:
        Attribute ranking.

Attribute Evaluator (supervised, Class (nominal): 8 Class):
        Gain Ratio feature evaluator

Ranked attributes:
 0.329    3 Professionalism
 0.2982   1 Experience
 0.2881   4 NO. of personnel
 0.2749   2 Capacity
 0.1726   5 CRB report
 0.0646   7 Bank statement
 0.0179   6 Location

Selected attributes: 3,1,4,2,5,7,6 : 7
```

Gain ratio Ranked attributes Results

```
=== Evaluation on test split ===

Time taken to test model on test split: 0 seconds

=== Summary ===

Correctly Classified Instances          31               91.1765 %
Incorrectly Classified Instances         3                8.8235 %
Kappa statistic                          0.8211
Mean absolute error                      0.1394
Root mean squared error                  0.2933
Relative absolute error                 27.9756 %
Root relative squared error             58.7701 %
Total Number of Instances               34

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 1.000    0.188    0.857      1.000    0.923      0.835    0.922     0.884     Pass
                 0.813    0.000    1.000      0.813    0.897      0.835    0.922     0.925     Fail
Weighted Avg.    0.912    0.099    0.924      0.912    0.911      0.835    0.922     0.903

=== Confusion Matrix ===

  a  b   <-- classified as
 18  0 |  a = Pass
  3 13 |  b = Fail
```

Evaluation on Test Split

```
=== Attribute selection 10 fold cross-validation (stratified), seed: 1 ===

average merit      average rank  attribute
 0.331 +- 0.034     1.3 +- 0.46     3 Professionalism
 0.301 +- 0.013     2.5 +- 1.02     1 Experience
 0.29  +- 0.02      2.6 +- 0.92     4 NO. of personnel
 0.277 +- 0.012     3.6 +- 0.49     2 Capacity
 0.173 +- 0.011     5   +- 0        5 CRB report
 0.066 +- 0.016     6   +- 0        7 Bank statement
 0.019 +- 0.007     7   +- 0        6 Location
```

Ranked attributes Results

```
Evaluation mode:    evaluate on all training data



=== Attribute Selection on all input data ===

Search Method:
        Attribute ranking.

Attribute Evaluator (supervised, Class (nominal): 8 Class):
        Information Gain Ranking Filter

Ranked attributes:
 0.4425   2 Capacity
 0.3718   4 NO. of personnel
 0.3412   1 Experience
 0.3212   3 Professionalism
 0.2515   5 CRB report
 0.0635   7 Bank statement
 0.0178   6 Location

Selected attributes: 2,4,1,3,5,7,6 : 7
```