

# **Web Based Procurement Management System for Government Universities in Sri Lanka**

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# **Web Based Procurement Management System for Government Universities in Sri Lanka**

**A dissertation submitted for the Degree of Master of  
Information Technology**

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**University of Colombo School of Computing**

**2020**



## Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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This is to certify that this thesis is based on the work of

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under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor Name:

\_\_\_\_\_  
Signature:

Date:

# **Dedication**

To my parents, wife, and son

## **Acknowledgement**

With a great pleasure, I present this dissertation on “Web Based Procurement Management System for Government Universities in Sri Lanka” for partial fulfilment of my degree Master of Information Technology. It would not be reality without the assistance and dedication of numerous individuals.

First and foremost, I pay my sincere and heartiest gratitude to my supervisor Dr. H. A. Caldera for advice and guidance throughout my project work and preparation of this dissertation. Further I convey my special thanks to the staff of the supply division of the University of Moratuwa for supporting me at every stages of my project even middle of the heavy workloads.

Also, my heartfelt thanks to my parents, wife and my son, for their continuous motivation, commitment and inspiration during this project work, as usual in my life. Last but not least, I express my cordial thanks to my friends for their support and encouragement during this project.

## **Abstract**

Currently government universities in Sri Lanka are facing a lot of difficulties when they try to purchase required capital and consumable items using the existing manual procurement process due to the inefficiency of the manual processes.

This study focuses on analyzing, designing, and implementing a centralized web-based procurement management system for the government universities in Sri Lanka that will help to improve the quality and the efficiency of the entire procurement process. This project is envisioned with the focus of delivering an acceptable solution to these problems. The main object of this study is to develop a web-based application which is capable to assist the university staff to execute the procurement related processes with the minimum effort and minimum time allocation.

Each government university of Sri Lanka has been given facility to registered with the developed system. Inter university administration is done by the super admin user role at the UGC and the internal administration of an individual university is assigned to university admin user role. Inventory owners of each university will be given access to create purchase request through the proposed system and they will be able to monitor the status of the purchase request by login to the system. All the purchase request approval process is handled by the system. System will send email notifications to its' end users with informing the latest events.

Suppliers will be notified about the new bid request via the proposed system. Also, they will be able to securely upload their bids to the system using a cryptographic encryption method. Further, bid opening is also implemented as fully online process without having any physical gathering.

Object oriented methodology and UML was used as the analysis and design approach. Incremental and iterative software development methodology is used for the development of this web application. PHP with MVC CodeIgniter framework is used as the server-side programming language of this system. MySQL is used as the backend database. Ajax, JQuery, JavaScripts, CSS, are used for the client-side development. Meanwhile this system support in any web browsers including google chrome, Edge, Firefox, Safari. Since this is a web-based system, it could be operated in any GUI based operating system like Windows or Linux.

Apart from that, the system is developed using the live hosting environment with live testing. According to the user evaluation and feedback, this system provides better solution to the identified problem at the beginning.

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## List of Abbreviation

CSS	Cascading Style Sheet
DOM	Document Object Model
EER	Enhanced Entity Relationship
GB	Giga Byte
HTML	Hypertext Markup Language
IDE	Integrated Development Environment
MIT	Master of Information Technology
MVC	Model View Controller
PMS	Procurement Management System
QR Code	Quick Response Code
RAM	Random Access Memory
RUP	Rational Unified Process
SD1	Supply Document One
SD2	Supply Document Two
SQL	Simple Query Language
SRS	Software Requirement Specification
SSD	Solid State Drive
TEC	Technical Evaluation Committee
UGC	University Grant Commission
WPMS	Web Based Procurement Management System

# **Chapter 1 Introduction**

## **1.1 Introduction**

Today, the usage of technologies has been increased rapidly. It has reduced the global distance among people live in different countries. This creates a major concern to our country as a developing country. In Sri Lanka, most of the reputed business organizations already came up with ICT based solutions for their business management processes. Now a day Sri Lankan government is always planning to use ICT for the improvement of the quality of the government services too. In order to do so, the government of Sri Lanka has started promoting web-based service platforms for most of the government organizations with the expansion of the fast internet connectivity.

All government universities are under the university grant commission (UGC). In order to improve the quality and efficiency of the management of the universities, UGC always try to come up with centralized web-based solutions. Procurement is one of the major management tasks within the universities which is used for acquisition of goods and services and it is favorable goods and services be appropriate and procured at the best possible cost to meet the requirements of the university in terms of quality, quantity, time and location. Further the procurement management is known to help an organization to save much of the money spent when purchasing goods and services from outside. Since the universities are government funded organizations, they must follow efficient way to fully utilize the fund allocation for a given financial year. Even though the university is a single entity, it consists with large number of departments, divisions, faculties (sub sections). Each sub sections are having different procurement requirements. So, the process is not a simple with compared to some other businesses.

Taking into consideration, this project aims to design and develop web-based procurement management application for government universities in Sri Lanka. The use of such a system could be a great importance, helpful with regard to easy storage of bids and better access of results. Also, stakeholders of the proposed system can use this system as a web application via ordinary web browser and can easily apply to the procurement and participate simply in the place where internet is available.

## **1.2 Problem**

Today, different organizations use various management techniques to carry out their departmental tasks efficiently. Web based procurement management systems are one among them. But most of the government universities still using file-based procurement management

techniques. Those have already become outdated techniques with comparing existence of the current technology.

Supply division of each university is the section which is responsible for handling all the procurement related tasks. Staff of this division are facing a lot of difficulties when they are trying to purchase required capital and consumable items using the existing manual procurement process. As a result, annual fund allocation for the universities again return to the government treasury without purchasing the required items. Further it is difficult to conduct some research activities. Since the equipment purchasing requires large amount of time. On the other hand, procurement related summary report generation has become very difficult and time-consuming task due to the manual document-based system. When placing an order request, respective hard copy must get approval from different officers at different departments/divisions. Therefore, it is time consuming process and there are some chances of losing the respective hard document. After the supply division receives an item purchase request, sometimes they need to get the list of suitable suppliers to request for seal quotations. Due to the unavailability of online supplier catalog, it takes large amount of time to find out the relevant suppliers. On the other hand, quotation requests go to irrelevant suppliers. This type of situations will end with wrong or low-quality biddings. Even after receiving quotations from suppliers, it takes another few month to award the bid to the one of the suppliers. Therefore, selected supplier will not be able to deliver the item with the quoted price due to the increasing of the dollar price. Most often this type of problems ends up with re quoting. Existing manual system, officers need to physically attend their office in order to do the approvals, and respective documents must deliver from one office to another. Most of the delays happen during this approval process. On the other hand, quality report sending is taking another few month due to the manual system. As a result, payment processing will be further delayed. This will lead to poor supplier satisfaction. Further officer who order some items always need physically attend and spend large amount of time to track the process due to the manual system.

On the other hand, existing manual system is more vulnerable for legal and security violations such as possibility of providing some chances to place bids even after the deadline in undetectable manner. Further, some suppliers will not be informed about the tenders due to the manual communication methods and some bidding document will not be delivered to the supply division on or before the deadline due to the manual document delivery methods.

So, this project aims to do the comprehensive requirement analysis and give proper design and implementation of Web Based Procurement Management System (WBPMS) to overcome the drawbacks of the current manual system with a limited scope.



### **1.3 Motivation for the project**

More than 10 years of experiences in the university system, author has faced a lot of difficulties when ordering items through existing manual procurement system. Most cases it is heavy time taking process. Sometimes all the effort has taken to purchase an item, might become useless due to cancellations at the middle of the process. By automating the manual processes of the existing procurement system will increase the efficiency of the communication which is essential for the success of the purchasing process.

Further this is a challenging project. This project would result in improving the author's knowledge, coding skills as well as project writing skills. Additionally, based on the successfulness, this project prototype could be initially implemented throughout the university system.

Finally, yet importantly another key motivation factor to continue this project is to successfully complete the requirement of the "individual project" to gain the qualification, Master of Information Technology (MIT).

### **1.4 Objectives of the project**

This system will be developed for the government university system of Sri Lanka. The researcher is developing this project based on his past experiences within the university system. also, he is currently an employee of University of Moratuwa which creates the possibility of gathering the exact requirement of the stakeholders of the proposed system. Based on the study this project is having a considerably high scope. Researcher is planning to give his maximum effort and achieving the following objectives upon completion of the project.

- Reduce manual work and paperwork.
- Develop a centralized system for entire university system.
- Distributed faculties, departments, divisions and user management for the university system
- Automate the entire approval process without involving hard documents.
- Reduce the workload of supply division by reducing the communication gap between each user groups.
- Maintain a supplier catalog.
- Automate the bid submission and bid opening process.
- More flexible report generation.
- Web application level security implementation.

- Procurement process-oriented security implementation.

## **1.5 List of deliverables**

The following deliverables are expected upon the completion of the proposed WBPMS.

- To create WBPMS where the staff who order the items, administrative decision makers, suppliers, officers at the supply division, and storekeeper are given access to perform the relevant tasks throughout the procurement process.
- To provide means to generate essential reports throughout the procurement process
- To provide detail user manual.

## **1.6 Scope of the project**

According to the finance ministry of Sri Lanka, government procurement process is clearly documented. Procurement Guidelines [1] and the Procurement Manual [2] are the major references for the government procurement process. Supply divisions of each university is one of the main entities which deals with the procurement process and all the supply divisions of the government universities of Sri Lanka use same procurement process. Therefore, the proposed system will allow universities to register with the system and carry on their procurement task separately. Even though the procurement process consists with two main areas such as Goods and Works, this project is only going to develop a Web-based system to automate and speedup some of the tasks relevant to Goods (items) purchases with selective tendering [3]. These tasks can be mainly divided into two sections, such as purchases of consumable items and purchases of capital items. Further repeat orders, foreign purchases are not going to handle through this proposed system. Also, the proposed system is only supported the English language.

## **1.7 Outline of the chapters**

The dissertation offers overall clarification about the WBPMS for government universities. Outline of the chapters is shown below.

### **Chapter 2 – Background**

This chapter includes details about analyzing the current system, processes of the current university PMS, use case diagram for manual university PMS, drawbacks of existing manual system, study about the similar systems including the comparison among them, relevant alternative technologies and proposed solutions.

### **Chapter 3 – System Analysis and Design**

This chapter indicates the methodology used for the developed system, modeling the system with various diagrams along with interface designs.

### **Chapter 5 – System Implementation**

This chapter describes the testing techniques, test plans, system as well as client evaluation.

### **Chapter 6 – Evaluation and Testing of New System**

This chapter describes the experiences gained through the project along with areas for future recommendations.

### **Chapter 7 – Conclusion and Future Work**

This chapter describes the experiences gained through the project along with areas for future recommendations.

### **References**

This chapter is used for the success of this project. This contains web links, books, journals referred during the completion of this project

### **Appendices**

This include further details and supplementary parts relating to all other chapters.

## **1.8 Summary**

In this chapter the overview of the project was depicted. Further it described how much the problem is important for the government universities in Sri Lanka. In the next sub section, the motivation is outlined. Then the objectives of the project, list of deliverables and scope of the project are briefed, respectively. Finally, the chapter outline is summarized.

## **Chapter 2 Background**

### **2.1 Introduction**

The previous chapter contains the problem, motivation, objectives, deliverables and scope of the project. Purpose of this chapter is to give the reader an understanding about the present manual procurement management system of the government universities in Sri Lanka. Then, the processes of the current manual system are listed with the use case diagram of the manual system. Then, drawbacks of the existing procurement system are listed. Further this chapter discuss about the features of available similar procurement management systems around the globe with including the comparison matrix table. Finally, the relevant alternative technologies are discussed.

### **2.2 Analyzing the current system**

Currently the government universities of Sri Lanka are not having a central web-based system to purchase capital and consumable items. All the universities are using the government approved manual file-based system to handle the procurement process. In order to capture the existing manual procurement process, it is required to analyze the existing manual system very closely and carefully. Some of the fact-finding techniques such as interviews, observation of the work environment is mainly used during the analysis of the current system.

### **2.3 Processes of the current university procurement management system**

The existing procurement processes of the university could be briefly listed as the following order.

- I. Office user prepares item purchase request and forward for the next level of the approval process.
- II. Obtain approval from the head of the department/division/faculty based on the university hierarchical structure.
- III. Check the availability of funds by the bursar.
- IV. Prepare tender documents and request bid invitations from registered suppliers by the subject clerk of the supply division.
- V. Registered suppliers (bidders) submit bids as hard documents.
- VI. Closing of the bidding process after the deadline.
- VII. Bid opening will be done by the tender committee. Then the gathered bidders will be announced the total bid value of each bid and if necessary, bank guarantee.
- VIII. Bid summary report and a file including all the documents related to bids from each supplier will be created by the supply officer of the university.

- IX. Bid summary report along with the previously mentioned file will be sent to TEC. Then the TEC will check each bid for its' technical compliance with the given criteria.
- X. With considering the minutes of the TEC, tender will be awarded by the tender committee according to the selection criteria which is mentioned in the tender document.
- XI. Tender awarding results will be announced to all the bidders.
- XII. Prepare and forward the purchase order to the selected supplier.
- XIII. Supplier hand over the items to the main store of the university.
- XIV. Storekeeper issue the good received note to the subject clerk of the supply division.
- XV. Storekeeper issue the goods to the relevant department/division/faculty.
- XVI. Subject clerk of the supply division requests the quality report from the respective department/division/faculty.
- XVII. Completed quality report is sent by the head of the department/division/faculty through the approval process to the supply division.
- XVIII. Payment approval and proceed with the payment by finance division.
- XIX. Enter the purchased items to capital or consumable inventory based on the nature of the item.

### **2.3.1 Use case diagram for existing system**

Following Figure 2.1 shows the complete use case diagram which describes the activities carried out in the existing manual procurement management system.

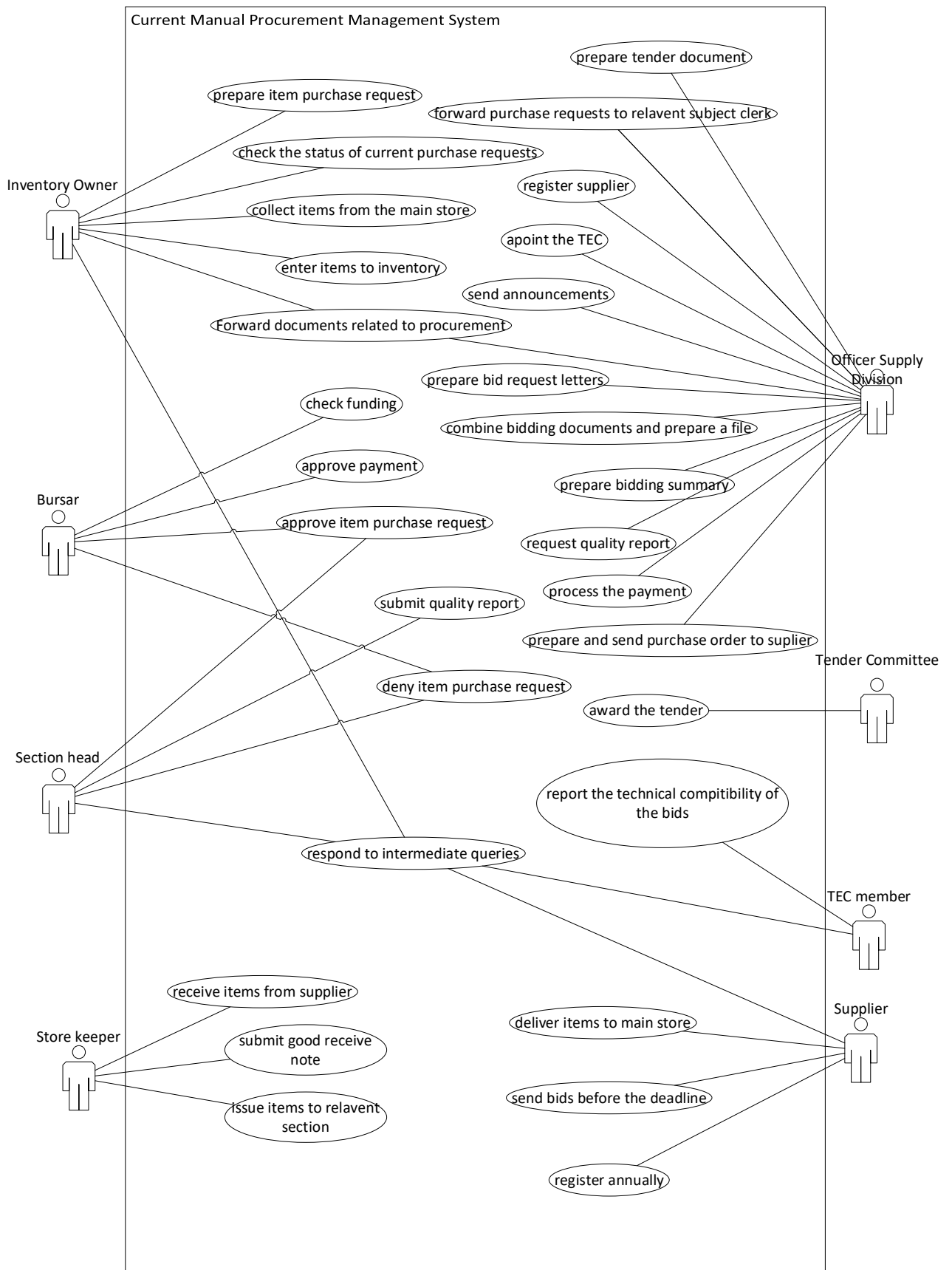


Figure 2.1: Use case diagram for existing manual system

## **2.4 Drawbacks of the existing manual system**

The following drawbacks are identified in the existing system:

- I. Manual procurement management process is difficult and time consuming. So, the supply division will not be able to utilize the total fund allocation for item purchases within a specific financial year.
- II. It is not practical to get the expenditure summary in the middle of the year based on the completed orders.
- III. In the manual system it is difficult to track the supplier behavior over the time.
- IV. In the manual system, a repeat order requires manually searching for previous quotation file with bid summary.
- V. Unable to view the current status of the ongoing item purchase requests due to unavailability of real time report generation methods.
- VI. Due to the heavy involvement of the hard documents, entire process is not efficient.
- VII. Inconsistencies and duplication of information, due to the usage of hard documents and improper maintenance.
- VIII. Sometimes, manual processes generate unexpected errors, such as tax calculation errors.
- IX. As the data is voluminous, more space is required to store it. Furthermore, everything is stored on paper. This type of storage is more prone to damage with the time and due to other accidental factors.
- X. Problem of updating data in the existing system due to the manual system.
- XI. Difficult to find relevant suppliers from the manual supplier catalog.
- XII. Inefficient bidding process.
- XIII. Bid selection takes huge amount of time.
- XIV. Delays in the payment process.
- XV. Poor supplier satisfaction.
- XVI. Manual system is more vulnerable to security and legal violations.

## **2.5 Review of the similar systems**

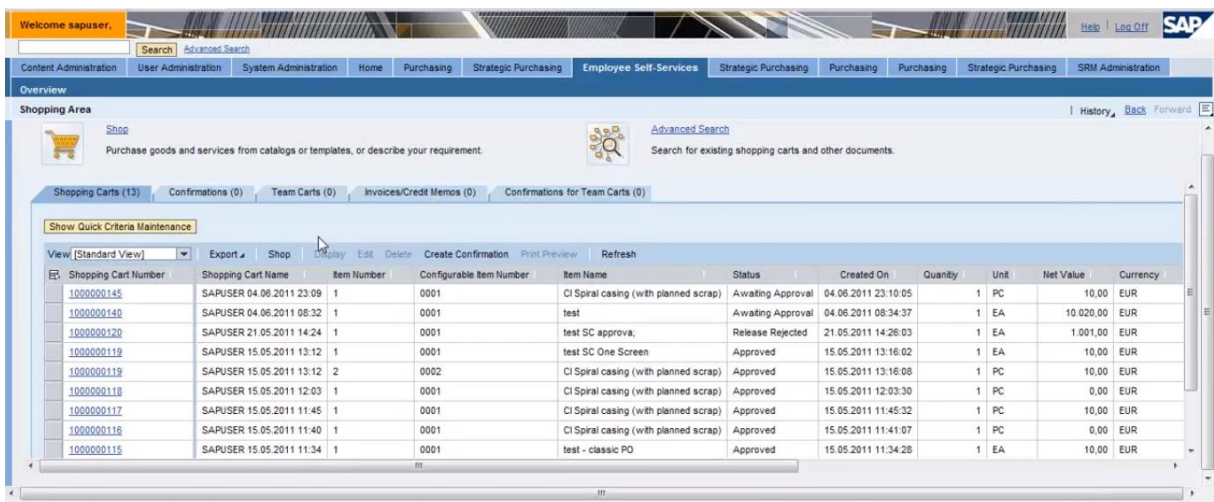
Other than studying the existing manual system, considerable amount of time has been spent to study the available similar systems within the market. Among them several platforms inspired the proposed system. They are namely, SAP Supplier Relationship Management, Tradogram and Oracle Procurement Cloud.

## 2.5.1 SAP Supplier Relationship Management

SAP SRM is very powerful supplier relationship management system available in the market. It helps to improve the procurement process of a company by simplifying the complexity of the manual procurement tasks. Also, SAP SRM is able to automate and centralize all the procurement related processes. Further, SAP SRM is capable of handling all the procurement related processes from start to finish. Since SAP SRM automatically accelerates the operations of the procurement process, procurement management staff do not require to worry about the each and every processes. Additionally, this software platform will be able to enhance the overall spend management of the respective company.

On the other hand, SAP SRM act as a perfect software solution to support to manage the suppliers of a company. Also, contract management is one of another important functions of this software platform. Maintaining high-quality output while reducing the cost of supply is the key advantage produce by the SAP SRM. By handling most of the manual procurement processes, SAP SRM is able to effectively reduce most of the procurement related overhead expenses.

Further, SAP SRM provide better facility to coordinate with the supplier chain of a specific company with its unique methods. Through that company will be able to work more effective with its supplier pool. Help to evaluate and predict purchasing patterns, cut down procurement cycles and engage your partners in real time are some other key functions of SAP SRM. These features will allow companies to stablish long term proven and very reliable partnership with suppliers [4] [5]. Following Figure 2.2 shows the graphical user interface of SAP SRM



The screenshot displays the SAP SRM 'Shopping Area' interface. At the top, there is a navigation bar with tabs for 'Content Administration', 'User Administration', 'System Administration', 'Home', 'Purchasing', 'Strategic Purchasing', 'Employee Self-Services', 'Strategic Purchasing', 'Purchasing', 'Purchasing', 'Strategic Purchasing', and 'SRM Administration'. Below this, the 'Shopping Area' section includes a 'Shop' button and a search bar. A summary bar shows 'Shopping Carts (13)', 'Confirmations (0)', 'Team Carts (0)', 'Invoices/Credit Memos (0)', and 'Confirmations for Team Carts (0)'. A 'Show Quick Criteria Maintenance' button is visible. The main content is a table with columns: Shopping Cart Number, Shopping Cart Name, Item Number, Configurable Item Number, Item Name, Status, Created On, Quantity, Unit, Net Value, and Currency. The table contains 13 rows of data.

Shopping Cart Number	Shopping Cart Name	Item Number	Configurable Item Number	Item Name	Status	Created On	Quantity	Unit	Net Value	Currency
1000000145	SAPUSER 04.06.2011 23:09	1	0001	CI Spiral casing (with planned scrap)	Awaiting Approval	04.06.2011 23:10:05	1	PC	10,00	EUR
1000000140	SAPUSER 04.06.2011 08:32	1	0001	test	Awaiting Approval	04.06.2011 08:34:37	1	EA	10.020,00	EUR
1000000120	SAPUSER 21.05.2011 14:24	1	0001	test SC approva,	Release Rejected	21.05.2011 14:26:03	1	EA	1.001,00	EUR
1000000119	SAPUSER 15.05.2011 13:12	1	0001	test SC One Screen	Approved	15.05.2011 13:16:02	1	EA	10,00	EUR
1000000119	SAPUSER 15.05.2011 13:12	2	0002	CI Spiral casing (with planned scrap)	Approved	15.05.2011 13:16:08	1	PC	10,00	EUR
1000000118	SAPUSER 15.05.2011 12:03	1	0001	CI Spiral casing (with planned scrap)	Approved	15.05.2011 12:03:30	1	PC	0,00	EUR
1000000117	SAPUSER 15.05.2011 11:45	1	0001	CI Spiral casing (with planned scrap)	Approved	15.05.2011 11:45:32	1	PC	10,00	EUR
1000000116	SAPUSER 15.05.2011 11:40	1	0001	CI Spiral casing (with planned scrap)	Approved	15.05.2011 11:41:07	1	PC	0,00	EUR
1000000115	SAPUSER 15.05.2011 11:34	1	0001	test - classic PO	Approved	15.05.2011 11:34:28	1	EA	10,00	EUR

Figure 2.2: Graphical User Interface of SAP SRM



## 2.5.2 Tradogram

As the name implies, Tradogram is a cloud-based electronic-procurement management system. This system is capable of automating procurement related task with the use of simple but powerful tools introduced by this cloud-based software platform. This system is able to give full control to buyers and decision makers when it is required. Also, this software is able to assist companies to managing suppliers, controlling cost efficiently. Also, with the use of Tradogram, companies can easily to connect with their suppliers in timely manner.

On the other hand, Tradogram, names itself as spend management tool. Since it can offer strategic solutions as well as best practices to purchasing. So, it is possible to obtain the lowest price from the products and services. Further, automate purchasing, simplified supply chain management, sourcing events are some of the key features and capabilities of this software platform.

Tradogram cloud-based solutions is universal business solution, which is applicable to all size of businesses including manufacturing, production, construction, retail, healthcare and other service industries. Further this cloud-based platform can be customized according to the individual procurement requirements [6] [7]. Following Figure 2.3 shows the GUI of the Tradogram platform.

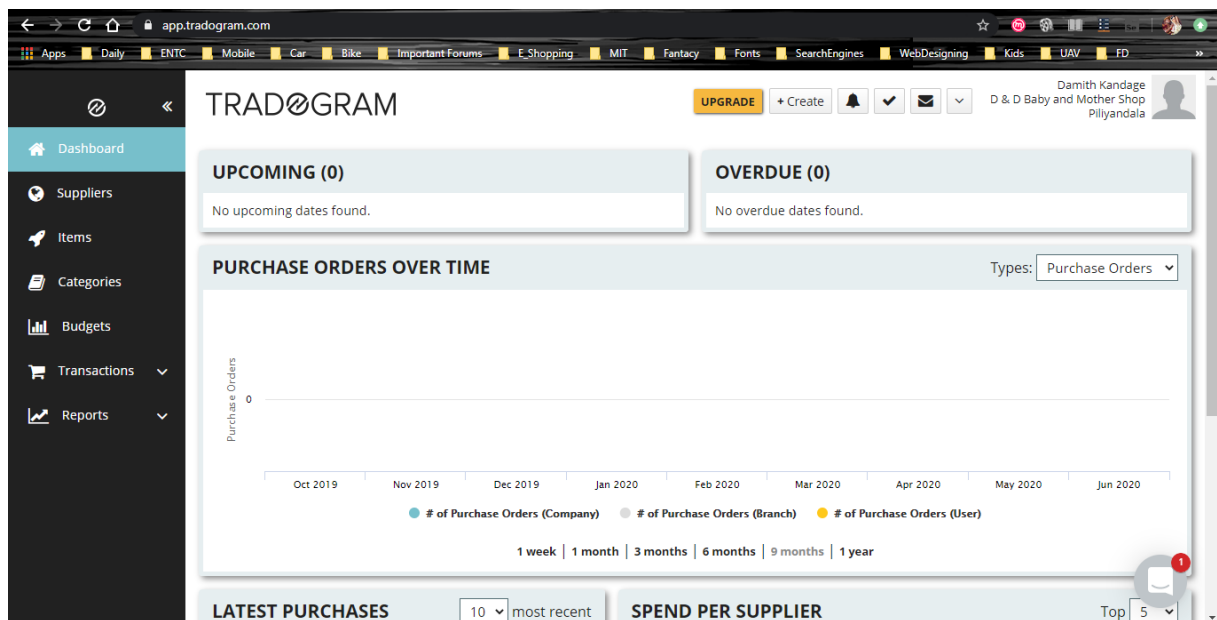


Figure 2.3: Graphical user interface of Tradogram cloud-based platform

## 2.5.3 Oracle procurement cloud

Oracle Procurement Cloud is also another cloud-based software solution which is used to handle the procurement processes. Main objective of this software platform is to control the

cost and achieve higher margins for at the product purchases. Further Oracle Procurement Cloud can simplify the procurement processes and, at the same time modernizes the procurement infrastructure.

Oracle Procurement Cloud will support procuring staff to easily find potential suppliers by effectively filtering out them. This cloud-based software can automate entire procure to pay process from the beginning to the end. Further, this system can speed up the entire procurement process by only allowing procurement experts to do what they do best.

Oracle Procurement Cloud help users come up with better business decisions. This software platform has been optimized for mobile platforms, allowing decision makers to make smart business calls anytime and anywhere. Supplier qualification management, sourcing, procurement contracts, purchasing, self-service procurement, supplier portal are some of the key features of this cloud-based platform [8] [9]. Following Figure 2.4 shows the graphical user interface of the Oracle Procurement Cloud platform.

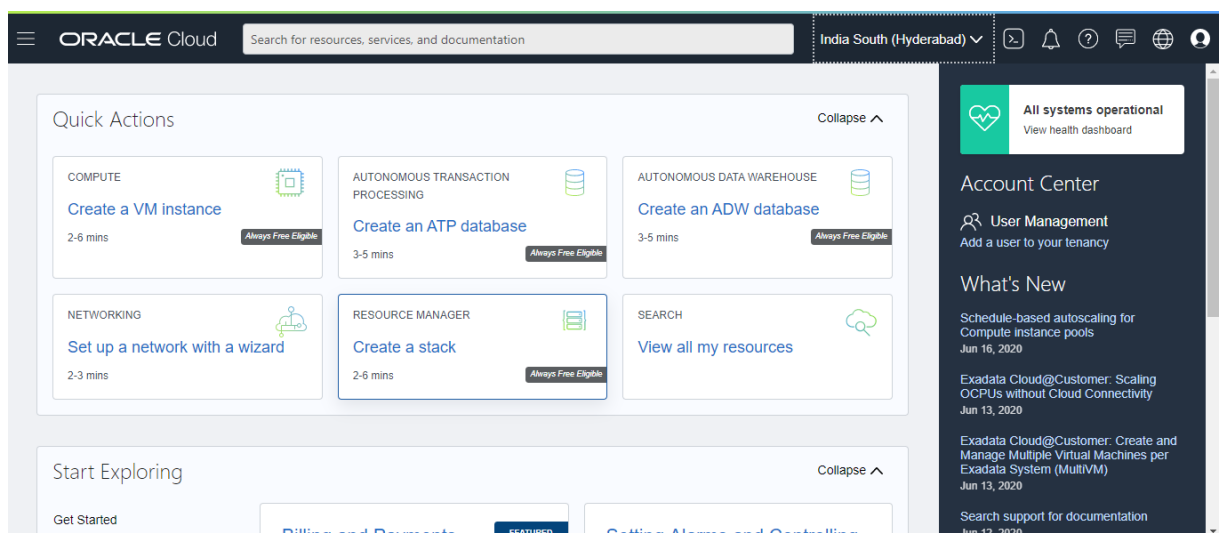


Figure 2.4: Graphical user interface of Oracle Procurement Cloud

### 2.5.4 Comparison matrix of existing systems

Table 2.1 shows the comparison made regarding the functionalities of the existing systems discussed above.

<b>System function/feature</b>	<b>SAP Supplier Relationship Management</b>	<b>Tradogram</b>	<b>Oracle procurement cloud</b>
<b>Devices Supported</b>	Windows, Mac	Windows, Linux, Android, iPhone/iPad, Mac, Web-based	Windows, Mac, Web-based
<b>Language Supported</b>	English, Dutch, Polish, Turkish, Swedish	English	English
<b>Pricing Model</b>	Quote-based	Free, Monthly Payment, Annual subscription, Quote-based	Monthly payment
<b>Deployment method</b>	On premise	Cloud hosted	Cloud hosted
<b>Customer types</b>	Large enterprises, Medium business	Small business, Large enterprises, Medium business	Small business, Large enterprises, Medium business
<b>Customer support methodologies</b>	Email, Phone	Email, Phone, Live support, Training, Tickets	Email, Phone
<b>Available features</b>	Procure-to-pay optimization, Self-service procurement, Service procurement for large and complex services, Centralized contract management, Workforce mobility, Catalog management, Plan-driven procurement, Operational and centralized sourcing, Operational reporting	Purchase to pay, Order requisitions, Approval routing, Delivery tracking, Inventory control, Sales & purchases order management, Instant messaging, Budget tracking, Contract management, Order management, Process automation, Invoice reconciliation	Supplier qualification management, Procurement contracts, Self-service procurement, Sourcing, Purchasing, Supplier portal

Table 2.1: Similar system comparison matrix

## 2.6 Relevant Alternative technologies

In order to produce proper solution to overcome the difficulties of the existing manual system, number of relevant alternative technologies have been considered in background study under different technological domains. Study about the development life cycles, development frameworks, architectural design patterns and hardware environments can be listed as some of the key technological domains.

### 2.6.1 Comparison of development life cycles

There are number of software development life cycle models available in the today's market. But it is highly required to select the suitable model for a specific development project. In the background study, waterfall, spiral, incremental/iterative (agile), v-model is considered as the alternative software development model. Critical study is done about the each of them and following comparison Table 2.2 has been generated.

<b>Model/Feature</b>	<b>Waterfall</b>	<b>Spiral</b>	<b>Incremental/Iterative</b>	<b>V-Model</b>
<b>Specification of all the requirements in the beginning</b>	Yes	Not all and frequently changed	Not all and frequently changed	Yes
<b>Long term project</b>	Inappropriate	Appropriate	Appropriate	Inappropriate
<b>Complex project</b>	Inappropriate	Appropriate	Appropriate	Inappropriate
<b>Frequently changed requirements</b>	Inappropriate	Appropriate	Appropriate	Inappropriate
<b>Cost</b>	Not costly	Costly	Costly	Costly
<b>Cost estimation</b>	Easy to estimate	Difficult	Difficult	Easy to estimate
<b>Flexibility</b>	Not	Less Flexible	Flexible	Little flexible
<b>Simplicity</b>	Simple	Intermediate	Intermediate	Intermediate
<b>Supporting high risk projects</b>	Inappropriate	Appropriate	Appropriate	Inappropriate
<b>Guarantee of success</b>	Less	High	High	High

<b>Customer Involvement</b>	Low	Low, after each iteration	High, after each iteration	Low
<b>Testing</b>	Late	At the end of each phase	After every iteration	develop test plan early on during the life cycle
<b>Maintenance</b>	Less maintainable	Maintainable	Maintainable	Little maintainable
<b>Ease of Implementation</b>	Easy	Complex	Easy	Easy

Table 2.2: Comparison the features of the software development life cycles

According to the nature of the proposed software development project, it can be categorized as a middle size of project with some level of complexity. Also, it is having some level of requirements at the beginning and need to have some additions and modifications of the requirement at the middle of the development. Project will be developed using a modular approach. The guarantee of the success of this project must be high.

Considering nature and the requirements of the proposed project, it is not practical to gather all the requirement at the beginning and then analysis, design, implementation and so on. Also, according to the literature most of the software development projects which are having same background are used to follow a modular approach and develop the system as working parts which are have a business value. After the background study it is very clear that the traditional waterfall approach is not suitable for this kind of project. So, it is decided to follow the principles of iterative and incremental (Agile) software development life cycle for this project.

### 2.6.2 Comparison of development strategies

Proposed system is involving large amount of processes. It is not feasible to hard code the entire system due to the complexity of the system.

MVC based CodeIgniter is a software approach that separate application logic from presentation. In practice, it permits, web pages to contain minimal scripting since the presentation is separated from the Php scripting.

- The Model represents the data structure. Typically, model classes will contain functions that help you retrieve, insert and update information in the database
- The View is information that is being presented to a user. A view will normally be a web page, but in CodeIgniter, a view can also be a page fragment like a header or footer.

- The Controller serves as an intermediary between the Model, the View, and any other resources needed to process the HTTP request and generate a web page.

Object-oriented methodology is used by the CodeIgniter framework. This methodology offers a modular wise system development approach. Object-oriented approach combines data and processes into single entities called objects. This method has been utilized in developing the system as it makes the process easy by allowing reuse of components in coding.

### **2.6.3 Comparison of hardware environment**

Proposed system is required to access using the individual's computer through a web browser. So, the system is developed as a web-based client server application. Compared to other desktop applications, web-based system is more convenient for the procurement management system. Unlike desktop applications, proposed web application doesn't require to individually install any software, other than the web browser. All the details are stored in a central database and data duplication and inconsistencies will be eliminated.

## **2.7 Proposed Solutions**

- I. Design a database which is capable to store all the information related to the transactions of the procurement processes within the scope.
- II. Develop a single web application for all the government universities, which can be accessed using the ordinary web browser application to handle all the related tasks.
- III. Integrate a facility to send user reminders using the email service.
- IV. Facilitate online report generation feature to generate report efficiently and effectively.
- V. Implement the level of user security so that individual users are permitted to access the information based on the user role.

## **2.8 Summary**

In this chapter processes of the current manual procurement management system were analyzed. Thereby, drawbacks of the existing manual system were discovered. Furthermore, number of similar systems were analyzed, and some interesting features were captured. Additionally, features of the sillier systems were compared using the comparison matrix table. Then the alternative solutions for project continuation were discussed with their pros and cons. Finally, the proposed solution was outlined. Next chapter will discuss about the analysis and the design of the proposed system.

## **Chapter 3 System Analysis and Design**

### **3.1 Introduction**

In previous chapter, processes of the current manual procurement management system and the features of the similar systems were discussed. Purpose of this chapter is to give the reader an understanding about the requirement gathering, analysis and the design of the proposed system. The main methodologies of this stage include, better domain understanding, requirement gathering, grouping, structuring, and validation. Appropriate methods and processes are engaged to achieve the analysis phase in a productive manner.

Software design stage is iterative operation in which requirements gathered in analysis are converted into a “blueprint” in developing the system. Other than that, this can be expanded into detailed functional and behavioral requirements. The output of the design stage is the design specification.

### **3.2 Fact-finding techniques**

In the requirement analysis phase, information gathering is an important and time-consuming task. But it should be conducted accurately. Otherwise the requirements of the proposed system cannot be fully understood and documented by the analyst. Sampling of existing documents, research, observation, questionnaires, interviews, prototyping and joint requirement planning are considered as some of the fact-finding techniques.

Multiple techniques were employed in this project to capture the requirements from different user groups. The main methods used for the fact-finding were interview, observation of the work environment and sampling of existing documentation, forms and databases.

#### **3.2.1 Interviews**

Interview is the most commonly used technique to collect information from the face-to-face interviews. The purpose of interview is to find, verify, clarify facts, motivate end-users involved, identify requirements and gather ideas and opinions. The role of interview includes interviewer who is system analyst and interviewee who are system owner or user. Interviewing technique needs good communication skills for interaction between system analyst and user. The interviews were conducted with the office clerks, heads of department/division/faculty, bursars, subject clerks and suppliers.

### **3.2.2 Observation of the work environment**

Observation was carried out to collect implicit information which plays a critical in the system. Relevant documents and paperwork of the existing manual system were analyzed and studied through a sampling process.

Observation is an effective data collection technique. Data gathered by observation is highly reliable. Information is gathered when various staff (office user, bursar, heads of the department/division/faculty, subject clerk, storekeeper) perform their activities in the manual system. It prevents unclear understanding about the system. It allows do work measurements. It is to find out the objectives of each individual work and try to make them cohesive. Watching same activity several times, ensures real information in the manual system. At last finalized actual information is gathered.

### **3.2.3 Sampling of existing documentation, forms and databases**

Sampling technique is the process of combing a representative sample of documents, form and records. This technique provides accurate information compared to the information gathered from human users.

Under this technique, manual item purchase forms (supply document one, supply document two), bid request letters, bid summary reports, tech evaluation panel appointment form, purchase order form, minor and major committee report, good receive note, quality report form and many other relevant documents are analyzed.

## **3.3 Overview of the proposed system**

Entire proposed system is having a super admin account and this account has given separate admin access to register and view each university with the main web-based system. During the registering process, separate university admin account will be created for each university.

This university admin user role will be given permission to manage faculties, departments, divisions, supply office, main store and users of the respective university. One university is having number of departments, faculties and administrative divisions. Supply division is also one of the administrative divisions. Main store operates under the supply division. Registrations of admin users for a specific faculty, department or division are processed during the creation of them by the university administrator.

All other university staff who maintain inventories (inventory owners) can register online. University admin is given access to process their registration requests. All registered users



including admin and inventory owners will get confirmation email through his/her official email address with including his or her login password.

Another main task of the university admin is allocating funds for each faculty, department or division for a specific accounting year. Further setting the accounting year is also done by the university admin.

After creating the internal structure of the university with the web-based system, all the authorized users can login to the system using their university email and a separate password. All the passwords will be encrypted as a security measure. Role bases access control is used to manage the access permissions of each user role of the proposed system.

Next phase of the system will focus on the implementation of the procurement process. Registered staff members who maintain inventories from any faculty, department or division can send goods purchase request according to their capital or consumable item requirements. The authorized user first needs to login to the system. Then the users are given access to two types of online good purchase requests. One is for purchasing consumable items. And the other one is for capital item purchases. Those online forms are generated based on the approved Supply Document 1 (SD1) and Supply Document 2 (SD2) document formats. Please refer Appendix A for the SD1 and SD2 document formats. After submitting the goods purchase request, the request will forward to next immediate officer to get his/her approval. After submitting from one officer to another, separate email notification will be sent to the respective officer with some summary information. All the officers who involved to a specific procurement process can view the current status of a specific good purchase request.

Other than the approving process, proposed system will handle rejections of good purchases also. Any point in the approval process can set a reason and reject the request and forward it to the required bottom level of the approval process.

Proposed system is equipped with supplier catalog management module which is managed by the supply division of each university. In this, suppliers are categorized according to their specialty. Supplier catalog will also be used during the initiation of the goods purchase request. After going through the approval process, good purchase request forward to the supply division. According to the nature of the good purchase (total price, capital item or consumable item) supply division can select the bidding procedure. If the purchase is compatible with selective tendering, all the relevant tender documents will be uploaded when creating the new tender entry. Then selected registered suppliers will be informed through the system itself. Also, system will send official email to official email address of each supplier.

Based on the request suppliers (bidders) need to submit online bid form before the deadline. System will automatically close the submission after the deadline. When submitting bids, bidder needs to upload all the relevant soft copies of the required documents with bid submission. Also, bidder need to give 16 character long strong security token during the bid submission. All sensitive data such as total bid value is encrypted and stored using the given security token. Bidder again needs to enter the security token to decrypt them during the bid opening only. After the bid submission deadline reach the system will automatically close the online bidding process for a specific purchase. Then all bidders will be asked to submit their security tokens within some short amount of time. This is the bid opening time which is executed by the leader of the tender committee. All bidders must enter their security tokens before the given time. Otherwise their bids will be discarded. Then the system will announce the bid amounts summary within all successful bidders. After bidding summary sheet which is generated electronically will be forwarded to the technical evaluation committee (TEC) which is appointed prior to the bidding process. Here also separate email notification will be sent to the panel members with informing the technical evaluation. Technical evaluation committee members can log in to the system and submit the report for the technical compliance of each bid.

### **3.4 Requirements of the proposed system**

#### **3.4.1 Functional requirements**

Functional requirements prompt the required behavior of the system to be built or what the system supposed to do. Following are the list of main functional requirements identified from the requirement gathering phase.

##### **3.4.1.1 User login and user account management**

All users of the system will be able to access the system by entering valid user credentials only. after login into the system all users will be able to view and update their user profile including login password other than the procurement related functions. Apart from that, remember password and forgot password options will be available in this system.

##### **3.4.1.2 Top level administration and management for all universities**

Super admin user of this system will be able to register any government university within the system. While registering the university it is required to assign a technically capable person as the university admin of the respective university. As well as super admin will be given access to view all list of registered universities. Also, super admin user management and the university admin user management functions will be included.

### **3.4.1.3 Individual university level administration and management**

University admin will be granted all the privileges to manage administrative divisions, faculties, department of the respective university and the relevant users of the same. Also, approve the inventory owner registrations and view registered inventory owners of each sub section of a respective university. Moreover, set accounting year and fund allocating for each sub section of a respective university for an accounting year are some of the key functions of the proposed system.

### **3.4.1.4 Inventory owner registration process**

Inventory owners are the staff who maintain one or more inventories of any sub section (administrative division, faculty, department) of a university. Inventory owners will be given separate online registration form to register in the procurement management system. With this registration they must enter their name with initials, emp code, current section, immediate boss and official email address. After submitting the online form inventory owner will be received an email containing the login password. But inventory owner only be able to access the system after receiving the approval from the university admin only.

### **3.4.1.5 Supplier registration process**

Supply division of each university will be able to initiate the registration process of suppliers for a given year. Then the online registration link will be activated and the suppliers who wish to register will be able to register through that link. All the required information for the supplier registration process are uploaded to the system by the supply division of the university. Based on that, supplier will complete the online form and upload all other requested documents as soft copies to the system. Upon the successful registration supplier will receive a confirmation email with including login password. Also, supply division will be given access to review each supplier registration and approve or reject them according to the given selection criteria. Then only supplier will be able to actively participate for bidding process. Additionally, supply division will be able to view the list of registered suppliers for a given procurement year with the supplier category and some of the general information fields.

### **3.4.1.6 Goods purchase requesting process**

Inventory owners will be given access to request item via SD1 or SD2 forms based on their consumable or capital needs. When submitting a purchase request, they must complete all required fields of the online SD1 or SD2 forms. Additionally, specifications for each item must be uploaded with online purchase order request. Also, inventory owner will be able to select suitable supplier categories for each item in the purchase request. Again, the request will be

forwarded to next level for the approval and so on. As well as staff who are involving for a specific purchase request will be able to monitor the status of the order by log into the respective section. If there is any error with the request, denying facility will also be available. Respective officer will be able to write down the reason and then select to whom request is returning and return the request. Finally, the purchase request will be forwarded to the supply division which is described as the procuring entity in the system. Before starting the tender process, it is possible to cancel the purchase order request by the inventory owner.

#### **3.4.1.7 Bid creation and bid invitation process**

As the procurement entity, supply division of any university is given facility to create specific bid after the approved purchase request reached to the supply division. When creating the bid request supply officer will be asked to upload all the relevant document softcopies for the specific bid submission. Also, the original specification of the required items. After the completed bidding request will be announced to the selected supplier categories through the proposed system. Apart from that, respective supplier categories will be notified via emails which will be generated by the system automatically. Additionally, when they log into their dashboard section, bid request notification will be displayed. Further, supply division will be able to distribute any notification related to a specific bid announcement via the proposed system. appoint the tender committee and the technical evaluation committee (TEC) are another main function of the proposed system.

#### **3.4.1.8 Bid submission process**

Supplier must submit online bids before the deadline. They will be notified about new bid request in their dashboard section. In the online bid submission form supplier needs to enter quoted prices for each item for a specific bid request very clearly with the quantities. Also, supplier can view all required information which are uploaded by the supply division of each university when accessing a specific bid submission request. Additionally, all the soft copies of the requested documents must be uploaded along with the online bid submission. Further bid information can be changed before the deadline reaches. One of the main important functions of the proposed system is encryption of quotation prices. Quoted prices will not readable to back end database users. System will use some client-side symmetric key encryption function to facilitate that feature.

#### **3.4.1.9 Bid opening and closing process**

Bid submission closing data and bid opening data of a specific bid are updated during the creation of a specific bid announcement. Supply officer will be given access to send reminder

notice for all the bidders for a specific bid opening. All the bidders must log into system at the given time period and enter their encryption key to decrypt the quoted prices of their bids after the tender committee leader starts the bid opening process. Those bidders who unable to submit the encryption key before the closing of the bid opening their bids will be discarded. This is the major limitation of this proposed system. After the closing of the bid opening process bid value summary sheet will be generated by the system automatically and distribute among successful bidders. That is not the final selection. Also, All the successful bid information and the bid summary sheet generated will be forwarded to the TEC for the technical evaluation automatically.

#### **3.4.1.10 Report generation**

System is capable of generation of different types of managerial reports based on each user role.

### **3.5 Non-functional requirements of the proposed system**

Non-functional requirements expected from the system have been listed below.

#### **3.5.1 Usability**

Usability is considered the degree to which a software can be used to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.

- The system should be easy to use by all stakeholders.
- The system must be quickly accessible by all stakeholders whenever needed.
- The system should provide a simple as well as a user-friendly along with easy navigation methods to access required information.

#### **3.5.2 Performance**

The amount of work accomplished by the system is listed below.

- All the functions should be available to the user every time the system is turned on.
- Key features should be easily accessible in the design layout to ensure fast access and thereby improve the performance.

#### **3.5.3 Reliability**

- The system should offer complete purchase order requests with all required information including the specification to enable bidders to judge the actual purchasing requirement.
- The system should reliably account all bids come from the suppliers before the bid closing deadline.

### **3.5.4 Security requirement**

The security mechanism protects sensitive information. Furthermore, security requirements are important factors in this system as classified data will be stored in the database. User validation will be done during the user login to ensure the validity of the user. Also, each user is only given access to the permitted sections of the proposed system.

Also, bid value data encryption using AES (CBC) symmetric key encryption [10] is one of the key security features which is going to be implemented in this system. With the use of that security requirement sensitive bid value information could be protected from the backend database users.

### **3.5.5 Maintainability**

The system will be easily maintained by the developer or other authorized person. Furthermore, it shall respond as fast as possible in generating reports related to the procurement process.

## **3.6 Constraint**

Following are the major constraints of this system

- before becoming a partner of this system each university needs to register with this system.
- All the administrative division, faculties and departments and all procurement related officers must be created by the university admin before use this system for procurement processing.
- System must be online without any network or power failure.

## **3.7 Proposed architecture for the system**

Describe about the MVC architecture

Figure MVC architecture

## **3.8 Design techniques**

Describe about the design techniques. Object oriented design technique is used as the design technique for this project

## **3.9 Proposed system design**

Use case diagrams are used to summarize some of the relationships between use cases, actors and system. Also, this diagram is used to reflect the system requirements. High-level use case diagram of the proposed system is shown in Figure 3.1.

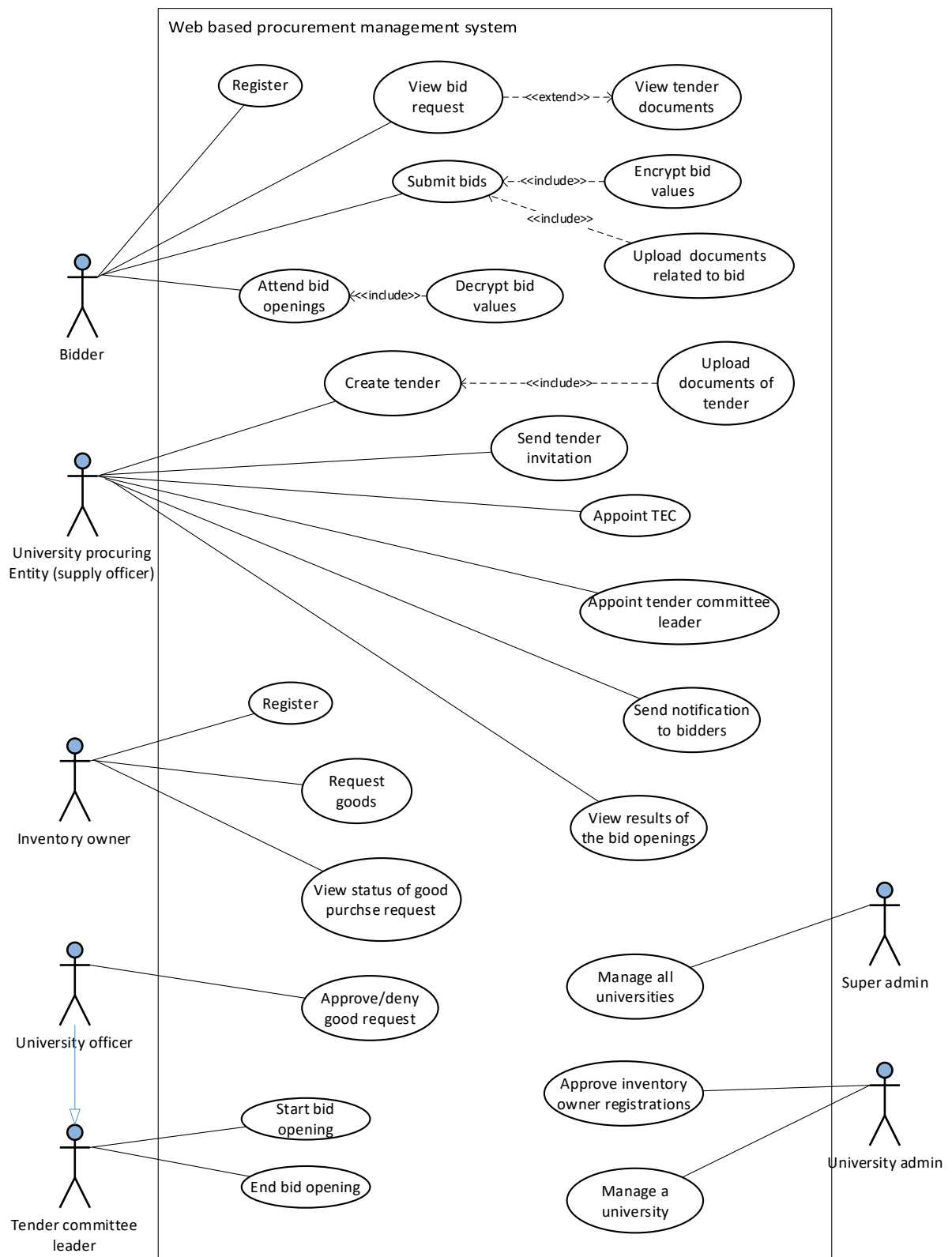


Figure 3.1: High-level use case diagram of the proposed system

### 3.9.1 Detail use case diagrams of the proposed system

#### Use case: Register inventory owner

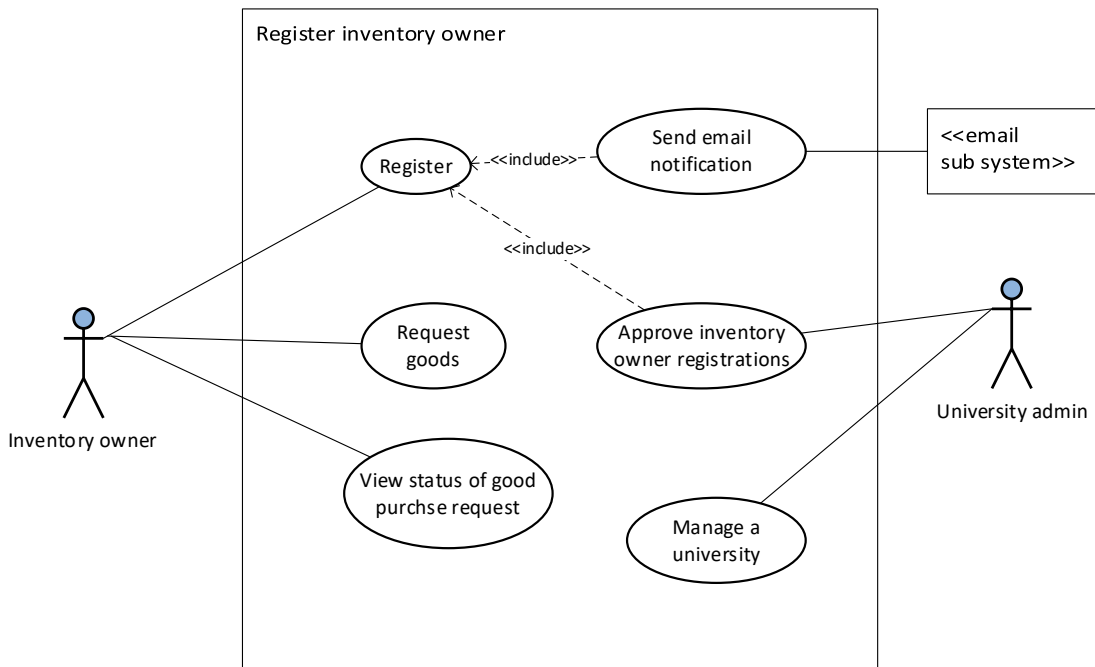


Figure 3.2: Detail use case diagram for inventory owner registration

#### Use case: Manage purchase request

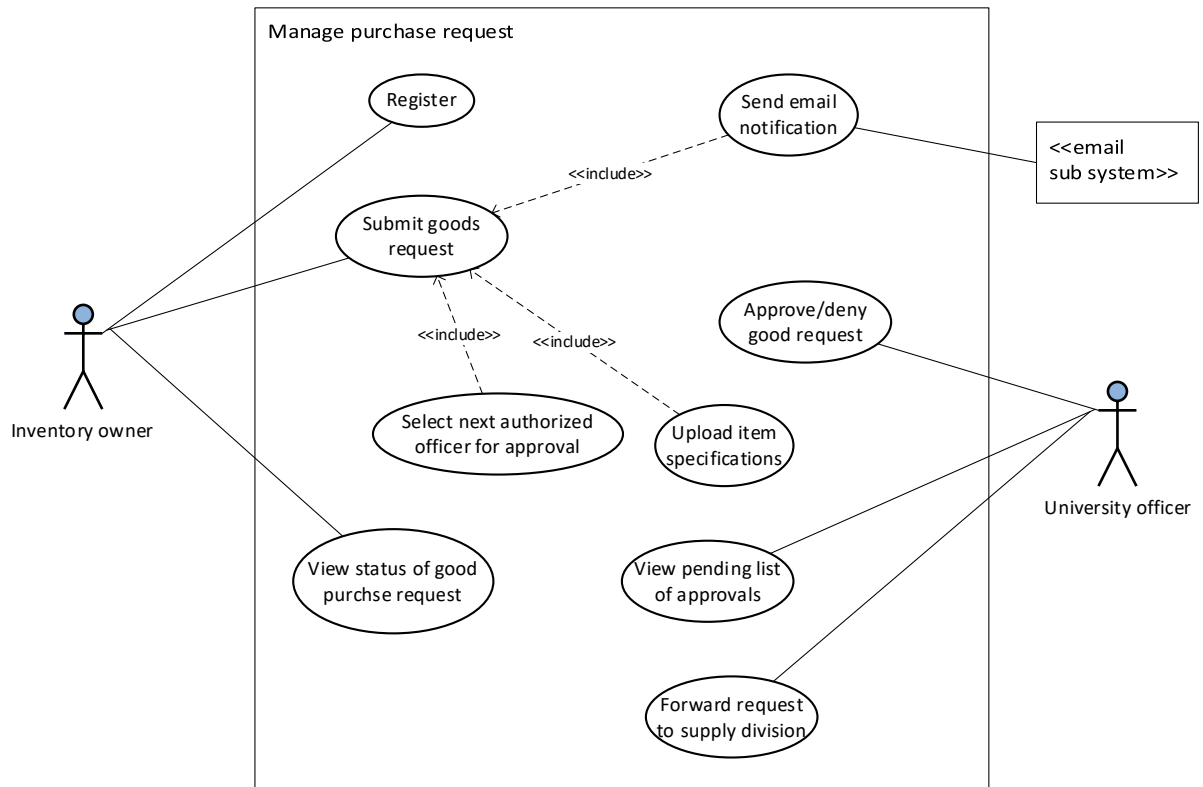


Figure 3.3: Detail use case diagram for managing purchase request



## Use case: Manage bidding request and submission

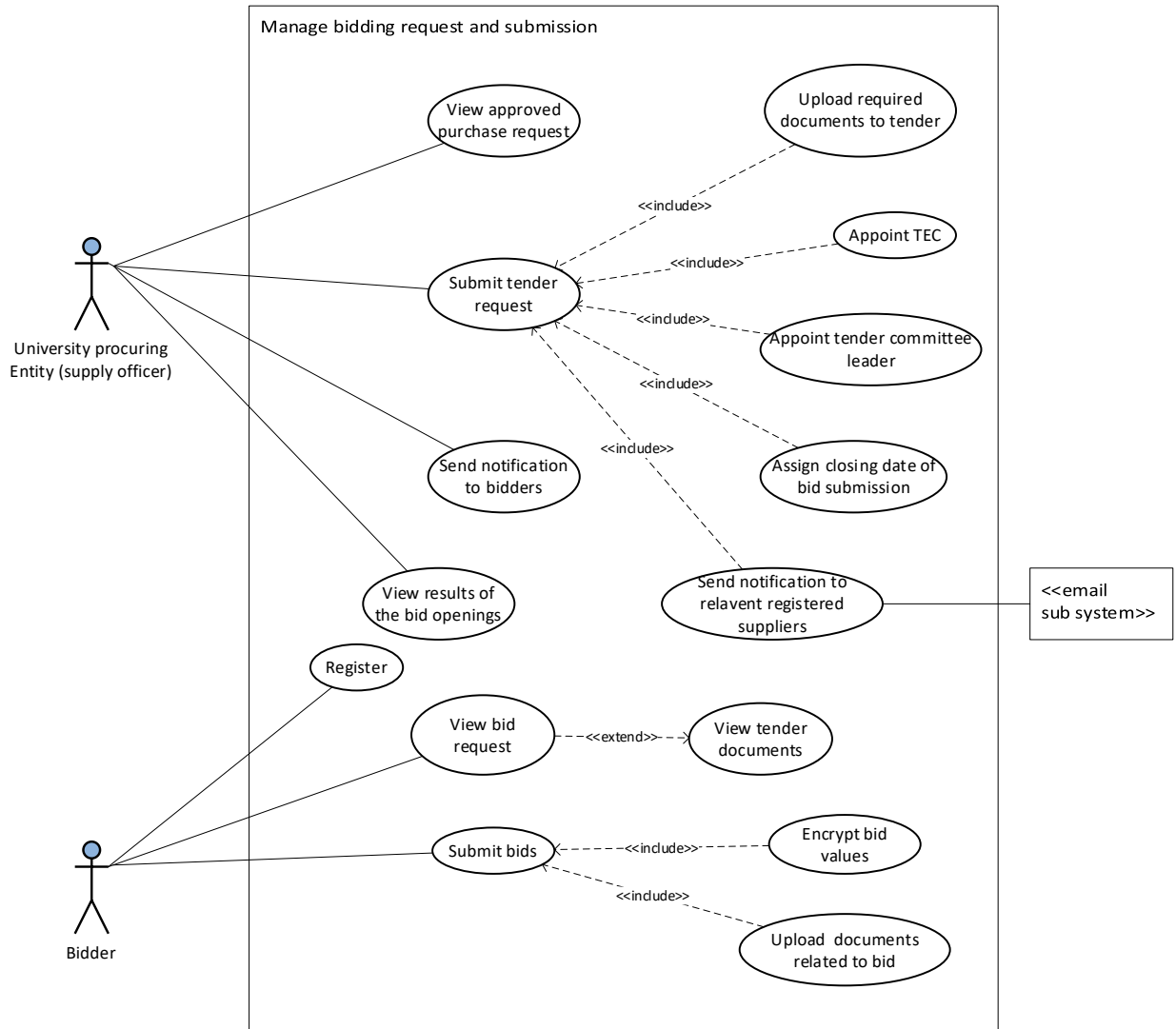


Figure 3.4: Use case diagram for managing bid requests and submissions

## Use case: Manage bid opening

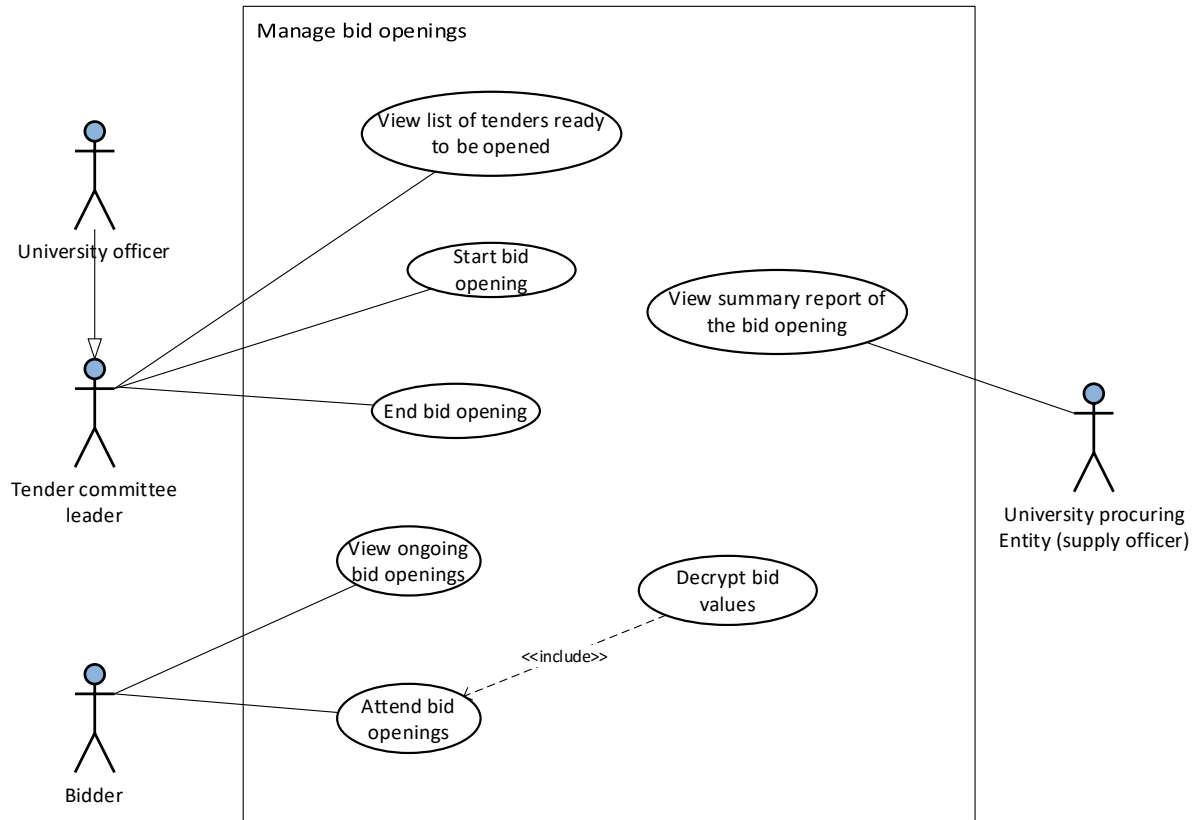


Figure 3.5: Use case diagram for managing bid opening

### 3.9.2 Authority delegation use case view

Super admin of the system is having the highest level of authority of the proposed system. Other user's authority levels are mostly depending on their connection to the procurement process or the job position. Figure 3.6 shows the authority delegation use case view diagram of the proposed system.

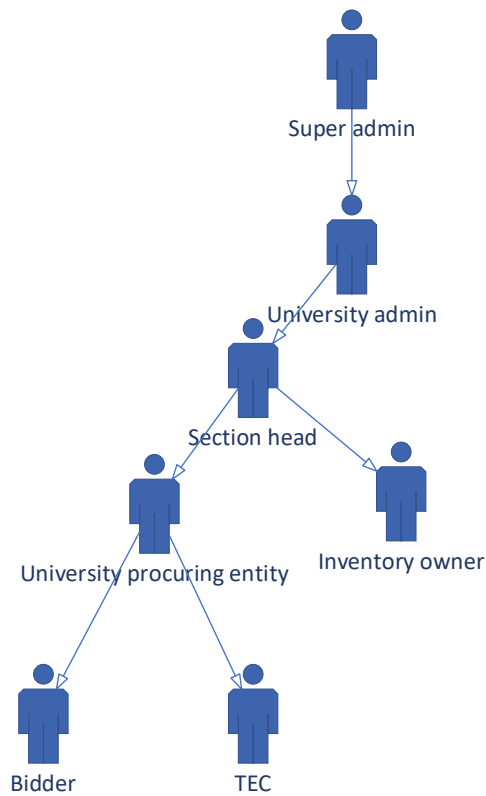


Figure 3.6: Authority delegation use case view

### 3.9.3 Modules of the proposed system

Proposed system will promote the users to emphasize their responsibilities effectively and efficiently by decreasing effort by reducing the manual workload and granting easy access to the resources. The proposed system has been divided into number of modules in order to make the development and comprehension easier. The modules are as follows,

1. User login and user account management module
2. Top level administration module for manage all universities
3. University wise administration module for individual university management
4. Inventory owner registration module
5. Supplier registration module
6. Goods purchase requesting module
7. Bid creation module
8. Bid submission module
9. Bid opening module
10. Report generation module

### 3.9.4 Menu arrangement of the proposed system

Because of the nature of the proposed system, there are considerable number of user-roles operating together to achieve the final goal of the system. Table 3.1 will describe the user-role wise menu assignment of the proposed system.

User-role	Menu assignment
Super admin	<ul style="list-style-type: none"> <li>• Dashboard</li> <li>• Management of universities               <ul style="list-style-type: none"> <li>○ Add university</li> <li>○ View universities</li> </ul> </li> <li>• Admin user management</li> <li>• Profile</li> <li>• Logout</li> </ul>
University admin	<ul style="list-style-type: none"> <li>• Dashboard</li> <li>• University               <ul style="list-style-type: none"> <li>○ Manage supply division</li> <li>○ Manage store</li> <li>○ Manage other divisions</li> <li>○ Manage faculties</li> <li>○ Manage departments</li> </ul> </li> <li>• Inventory owner management</li> <li>• Account year management</li> <li>• Annual fund allocation management</li> <li>• Profile</li> <li>• Logout</li> </ul>
University officer	<ul style="list-style-type: none"> <li>• Dashboard</li> <li>• Purchase request management</li> <li>• Bid opening management</li> <li>• Profile</li> <li>• Logout</li> </ul>
Inventory owner	Register via separate registration form <ul style="list-style-type: none"> <li>• Dashboard</li> <li>• Good purchase management</li> <li>• Profile</li> </ul>

	<ul style="list-style-type: none"> <li>• Logout</li> </ul>
Supplier/bidder	Annually register via separate registration form <ul style="list-style-type: none"> <li>• Dashboard</li> <li>• View announcements</li> <li>• Bid submission management</li> <li>• Attend bid opening</li> <li>• Profile</li> <li>• Logout</li> </ul>
Supply officer	<ul style="list-style-type: none"> <li>• Dashboard</li> <li>• Supplier management</li> <li>• Bid creation management</li> <li>• Bid opening report generation</li> <li>• Profile</li> <li>• Logout</li> </ul>
Storekeeper	<ul style="list-style-type: none"> <li>• Dashboard</li> <li>• Goods receive management</li> <li>• Goods delivery management</li> <li>• Profile</li> <li>• Logout</li> </ul>
Tender committee leader	Tender committee leader is always a university officer. Menu assignment is done under the university officer user role.
TEC member	TEC member is always a university officer. Menu assignment is done under the university officer user role

Table 3.1: User-role wise menu assignment of the proposed system

### 3.10 Architecture design

This system will be designed in a web-based environment which allows users to use the system anywhere and anytime. The identified main users are super admin, university admin, inventory owner, heads, bursar, supply officers, supplier, TEC, tender committee members and storekeeper. The users have different capabilities based on their user-role. All users are connected to the database via the web interface which consists with the business logic. This interface will facilitate easy access to the system users. Figure 3.7 shows the client server architecture design of the proposed system.

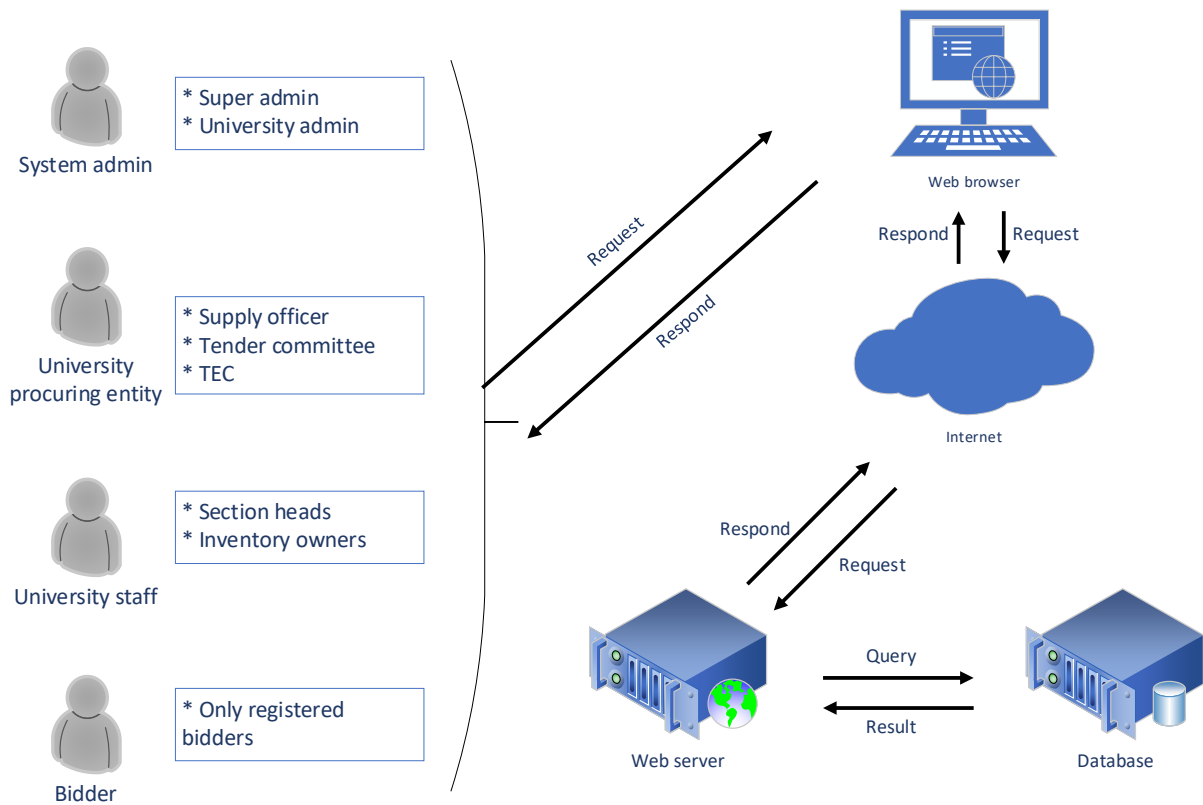


Figure 3.7: Client server architecture design of the proposed system

### 3.11 Database design

Data modelling is used to complete the database design. Database design is a key designing component which is used to describe the structure of business entities used in the proposed system. In order to remove the redundancies, the database tables were normalized into 3<sup>rd</sup> normal form [11]. The following entity relationship diagram in Figure 3.8 depicts the structure of the relational database model of the system. Refer appendix C for detailed description of the database EER diagrams.

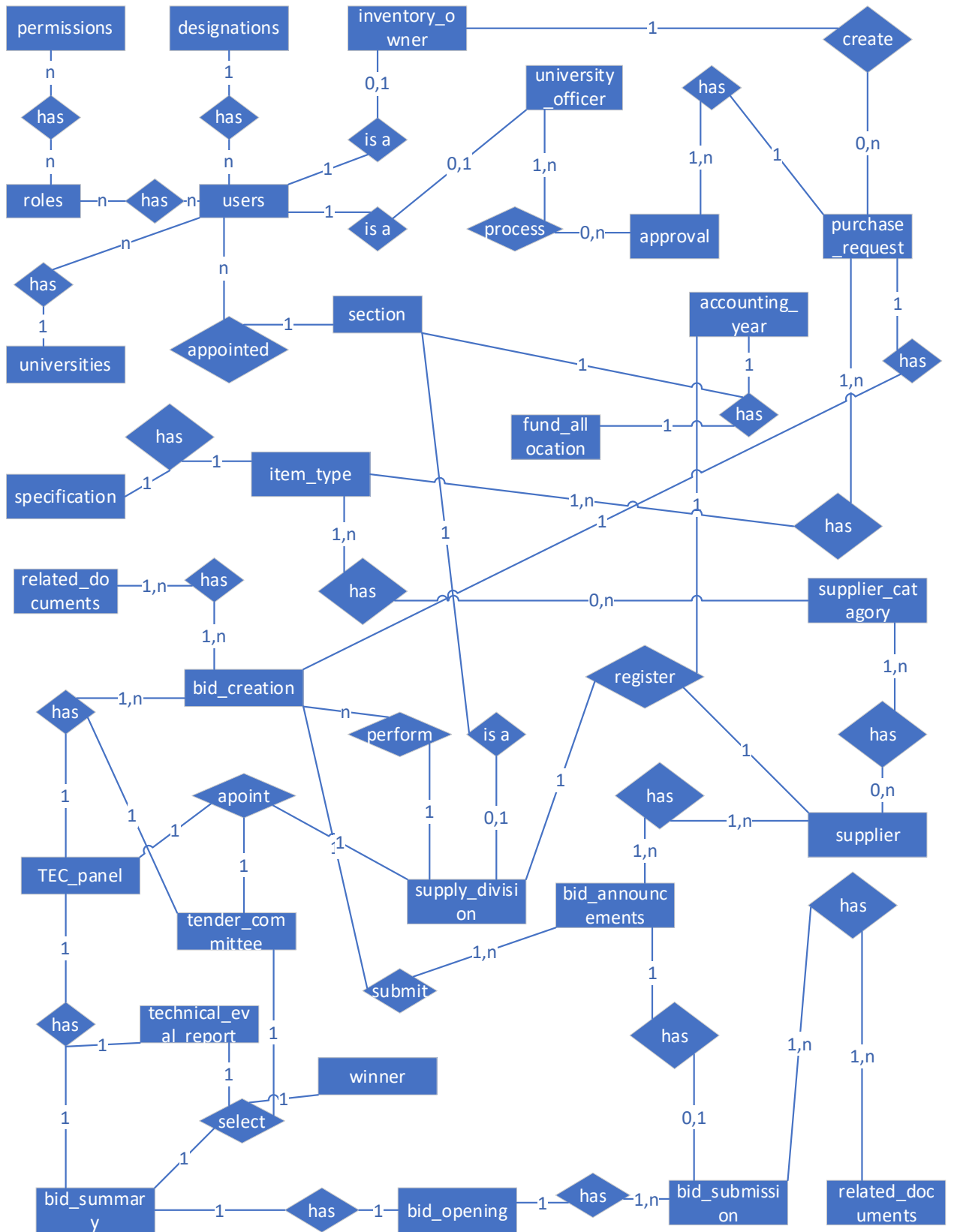


Figure 3.8: Structure of the entity relationship database diagram

### 3.12 Class diagram of the system

UML class diagram is the main building block of object-oriented modeling. It used to describe the conceptual and domain modelling. Objects and classes from a system user's perspective represent a conceptual model. The following class diagram in Figure 3.9 represents both the main objects and or interactions in the application and the objects to be programmed in this Web-based procurement management system.

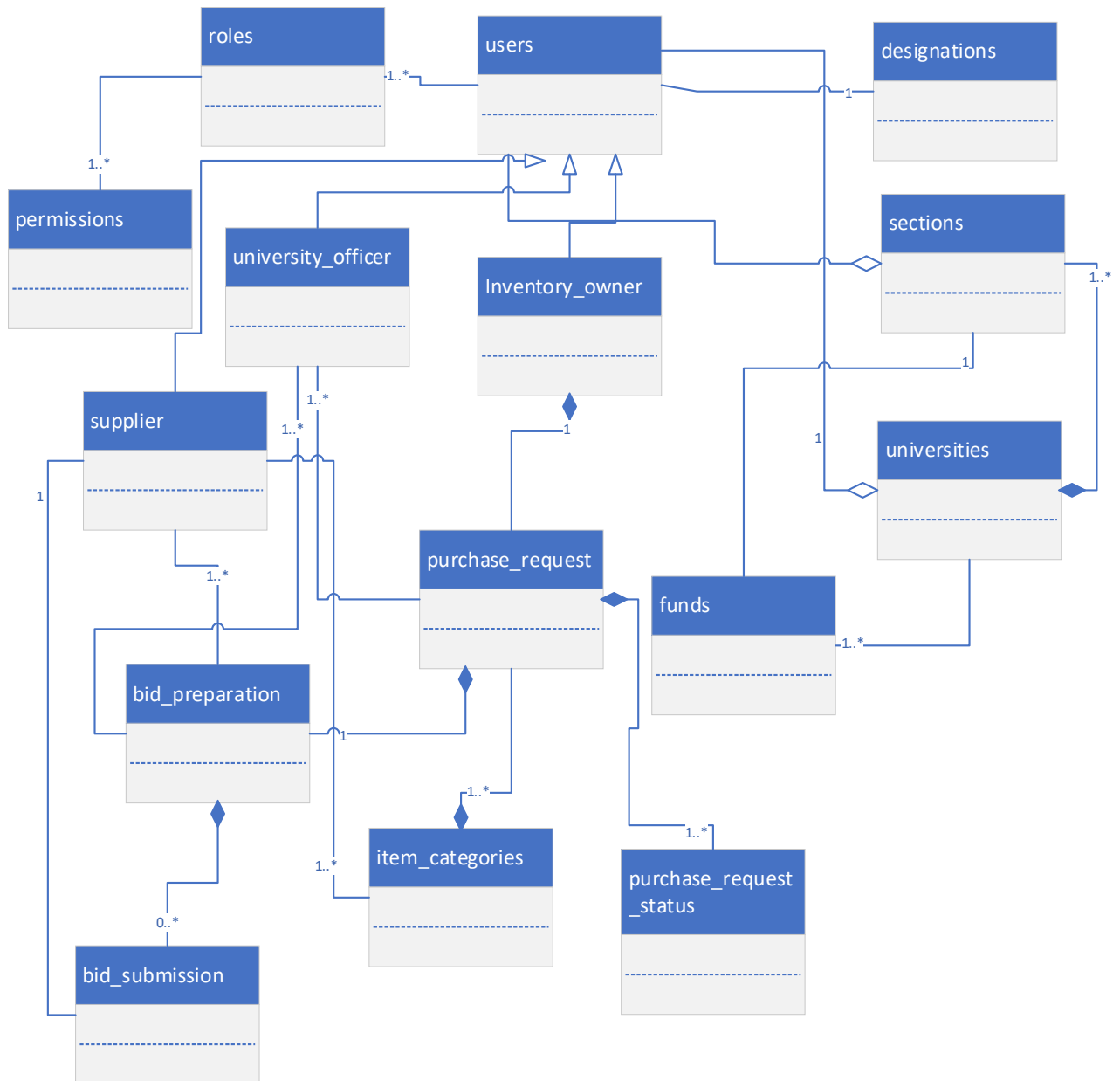


Figure 3.9: Overall class diagram of the proposed system



### 3.13 Sequence diagram

Sequence diagram is used to describe the object interaction with the time sequence. Further it shows the sequence of messages exchanged among the objects in order to carry out the specific system functionality. Figure 3.10 shows the sequence diagram for adding purchase request.

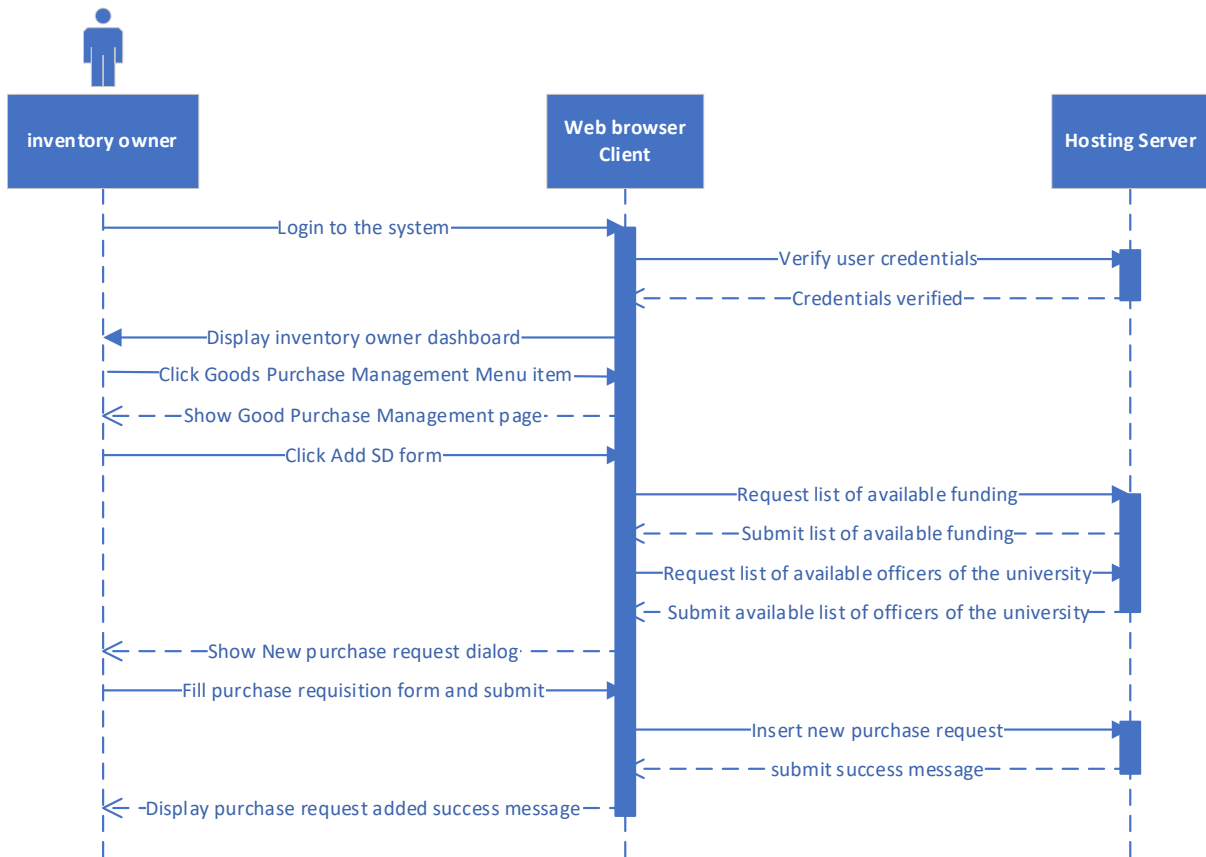


Figure 3.10: Sequence diagram for adding purchase request

### 3.14 User interface design

User interface is the main interaction point with the system and the user. So, it should always user friendly and interactive to the end user. User interface (UI) design mainly focuses on what user is exactly expecting from the system and ensuring the user interface has basis facilities that are easy to access, understand and use. Following are some of the main factors which have been considered during the user interface design of this system.

- Intentionally use texture and colors: make direct attention toward or redirect attention away from items using color, texture, contrast.
- Use common UI elements and build consistency: By using more comfortable common elements, for users and able to get things done fast.
- Avoid unnecessary elements and keep interface simple.

- Use dynamic suggestions fields to minimize the error generation form the users.
- Use input filters to verify data inputs: through the input filters users will not be able to insert incorrect inputs to the respective input field.
- Use typography to create hierarchy and clarity: different sizes, fonts, and arrangement of the text to help increase scalability, legibility, and readability.
- Use responsive user interface: user interface will render based on the screen size of the end user’s device. This will give better user interaction between with user and the system. Following Figure 3.11 shows responsive user interface of the developed system via a smart phone screen.

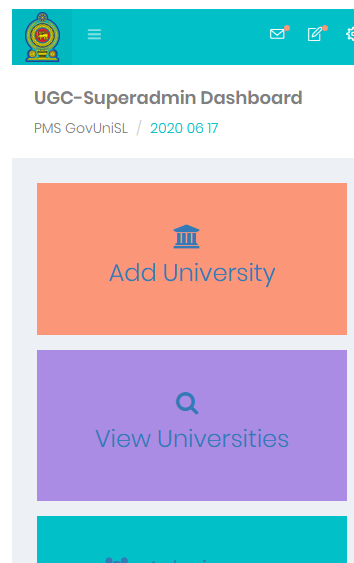


Figure 3.11: Responsive user interface design rendered in smart phone screen

### 3.15 Summary

First part of this chapter discussed about the requirement analysis of the proposed system. under that some of the fact-finding techniques have been used to gather the exact requirements. Based on the findings, overview of the proposed system has been drafted. Further the functional and non-functional requirements have been identified. Second part of this chapter discussed about the proposed system design. In this section proposed system architecture, design techniques, database design, class diagrams, sequence diagrams and user interface design have been discussed. Next chapter will discuss about the system implementation.

## **Chapter 4 Implementation**

### **4.1 Introduction**

Previous chapter discussed about the requirement analysis and the design of the proposed system. Purpose of this chapter is to discuss about the proposed system implementation. Implementation is the process, which is used to convert the software design specification into usable system. In order to do that, front end interfaces and the back end logical statements with database queries are developed based on the design specification. Suitable tools and flexible, comfortable backend development language as well as front end development languages are selected during the process of coding and development. Codes are always written in readable format with the help of indentation proper naming convention. Further the comments are used to explain some of the code sections to increase the understandability of the codes for the future improvements.

### **4.2 Implementation environment**

This is web-based application. So, the application must be hosted under a hosting provider to grant the global access via the internet. Because of the nature of the web application it is required to consider about both server-side environment and the client-side environment during the implementation. Requirements of both environments usually divide into two categories, such as hardware requirements and software requirements.

#### **4.2.1 Server environment**

With considering the complexity of the developed system and the usage of the PHP email function for email notifications, it is decided to do the development in the live hosting environment. So, the system is hosted using a shared cloud hosting facility which support PHP and MySQL. This shared hosting service is equipped with 2 GB of SSD disk space, 2 GB RAM, 3.0 GHz Xeon Processor with 32 Cores. Additionally, server up time is considered as the factor when selecting the cloud hosting service. <http://kddlakmal.tk/pms> URL will be used to access the web-based procurement management system. Additionally, application security and the frequent backup facility are provided by the hosting provider. Following Figure 4.1 shows the control panel of the hosting service.

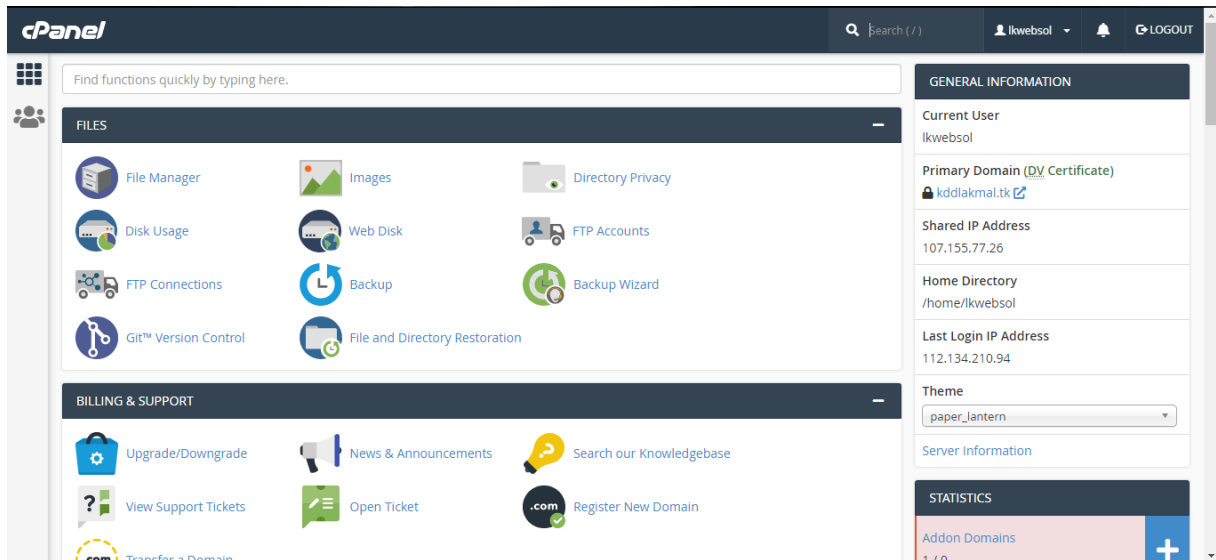


Figure 4.1: Control Panel of the hosting service

#### 4.2.2 Client environment

Client software run in between the user and the server. Client environment must be able to facilitate the access to the server application. Since this is web-based system, web browser like google chrome act as client software. In order to have smooth functionality, System should be rich with the latest technologies and tools. Specially, the web browser should have the recommended latest update to overcome the browser compatibility issues. Developed system is able to function with different hardware and software platforms which is capable of accessing a web browser application. Table 4.1 describe the minimum hardware and software requirements of client environment.

Hardware	Software
2.4 GHz Dual Core CPU or better	Windows 8.1 or higher,
2 GB RAM	Latest google chrome web browser or Microsoft edge
Minimum 250 GB hard disk	Acrobat reader browser plugin
Minimum 100 Mbps Ethernet Adapter or Wifi Adapter for internet connectivity	

Table 4.1: Minimum hardware and software requirements of client environment

### 4.3 Development framework and tools

Following are the development framework, tools, and technologies which were used to develop the system.

#### 4.3.1 Framework

When considering the complexity of the developed system, it is not practical to code the system without having proper architectural pattern. So, Model View Controller (MVC) based PHP CodeIgniter framework has been used for the entire system development. MVC is a better solution for maintaining web application architecture. System is divided in to three sections through this CodeIgniter framework such as model, view, and controller. The model is used for the database interactions. The controller is to send requests and responses back and forth between models, and views. Graphical user interface represents by the views. Figure 4.2 and Figure 4.3 shows the MVC based behavior of the CodeIgniter framework and the file structure of the developed system, respectively. Due to the clear separation of the model, view, and controller, it is clear and easy to remove each controller errors, view errors and model errors.

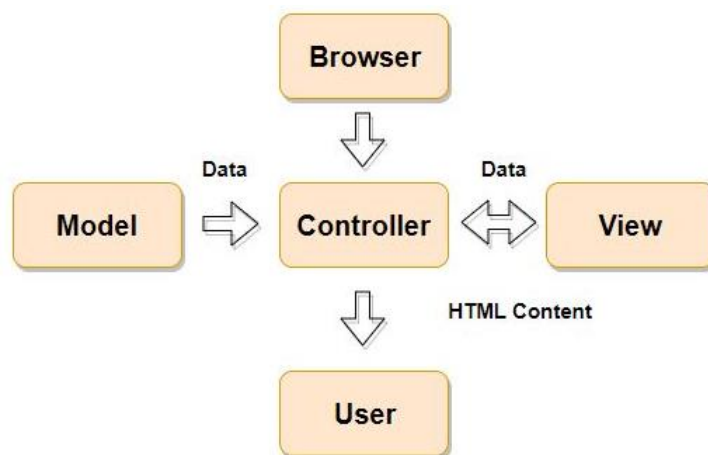


Figure 4.2: MVC based behavior of the CodeIgniter framework

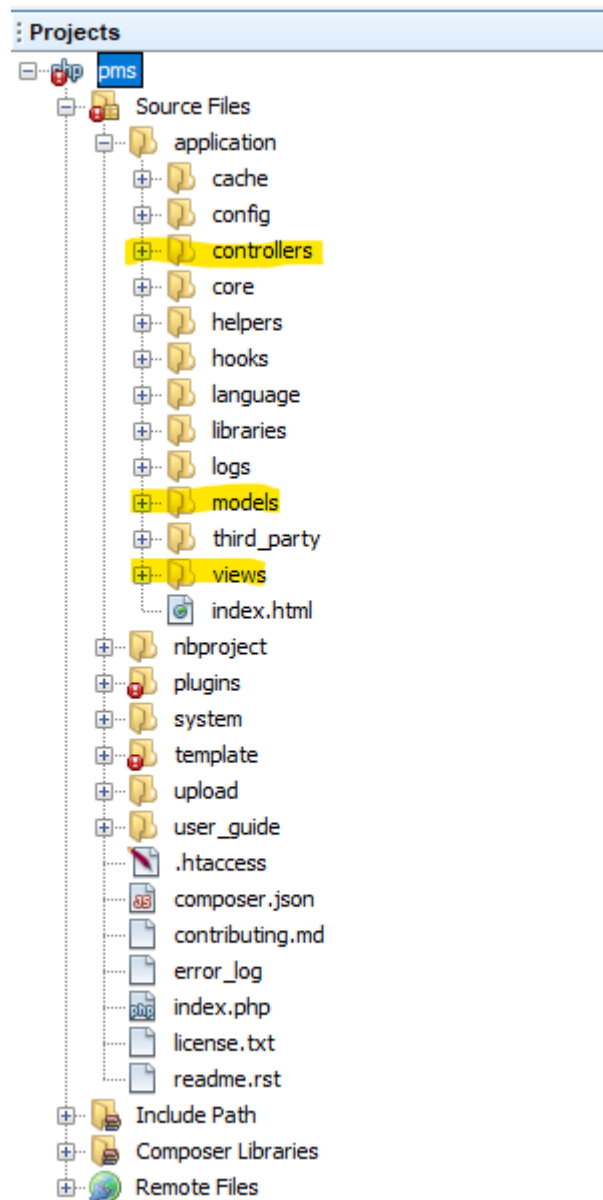


Figure 4.3: File structure of the developed system

Further inbuilt PHP libraries of the CodeIgniter framework have make the development task easier compared to normal code writing. Also, Simplified SQL query writing is one of the major advantages of using the CodeIgniter framework.

## 4.3.2 Tools

### Apache NetBeans IDE 11.2

NetBeans IDE [12] and NetBeans Platform are based on Apache NetBeans from the Apache software foundation and licensed under Apache license version 2.0. This IDE makes the development easy and the quicker with the use of its integrated features. Automatic server synchronization with the FTP layer configuration feature is one of the most useful features

among them. It allows to keep both local copy and the server copy of the developed system same time. Also, live testing has become much easier with the use of this feature without spending extra time to upload files to the hosting server. As well as automatic code generation, code indentation, and automatic code completion in the code editor are some of the other frequently used features.

### **MySQL Workbench 8.0**

MySQL workbench is used to data modeling, SQL development, as a comprehensive administration tool for database server configuration, user administration, and backup etc. Also, this software tool enables developer to graphically create complex EER models and use forward engineering functions to generate MySQL database tables.

### **Firefox Developer Edition**

Firefox developer edition is used to facilitate the live debugging, editing, and monitoring of developed system's CSS, HTML, DOM, and JavaScript. Specially this is highly used to debug the JQuery Ajax requests of the developed system.

### **Microsoft Visio**

Microsoft Visio is used to create all the design diagrams of the developed system.

## **4.4 Selection of Programming Languages**

The system uses the PHP as server side scripting language and HTML as client side scripting language; in addition jQuery is a library for JavaScript that immensely simplifies programming with JavaScript providing very easy to use, condensed syntax to achieve even apparently complex tasks with JavaScript. The use of jQuery has several benefits in this project over using other JavaScript libraries or the raw JavaScript itself.

JQuery, while relatively new, has a following that religiously devote their time to develop and enhance the functionality of jQuery. Thus, there are hundreds of prewritten plugins available for download to instantly speed up this project development process. Another advantage behind this is the efficiency and security of the script.

JQuery added some accessibility and viewing ability to this project for various modules such as purchase request creation, bid request creation, input data validation, etc.

Furthermore, jQuery is an Ajax enables a sleeker interface where actions can be performed on pages without requiring the entire page to be reloaded. This increases the performances of this system into great extent.

Also, Ajax is used to send and receive data asynchronously, CSS is used for styling of web pages.

HTML, CSS, JavaScript, jQuery and Ajax are the best technologies and sometimes may be the only options available. But there are specific reasons to select PHP as the main server-side scripting language among the others such as ASP.NET, JSP, etc.

Following are the list of factors that leads PHP to be selected.

- System is developed using the PHP CodeIgniter framework. It is one of the best powerful MVC bases free and open source framework within the market.
- PHP is compatible with many web servers and can be easily implemented. So, the system can be implemented in various platforms.
- Very easy to work with MySQL database system
- Great online support from many technical communities. So, the process of introducing new functionalities is considerably easy.

#### **4.5 Selection of Database**

MySQL is used in web-based procurement management system due to few reasons which are listed below:

- Most of the hosting services provide MySQL as the backend database management system.
- MySQL is free and open sourced.
- It is easy to work with the MySQL workbench software tool
- Web-based Phpmysql panel provides easy access to the databases.
- MySQL is recognized as one of the most secure database management systems within the globe.

#### **4.6 Network architecture**

This system is hosted using a shared cloud hosting server. Client server network architecture is followed in the system implementation. End users of this system are given access to the system via the internet. Web hosting server is connected to the internet through a firewall. Figure 4.4 shows the network architecture of the developed system.



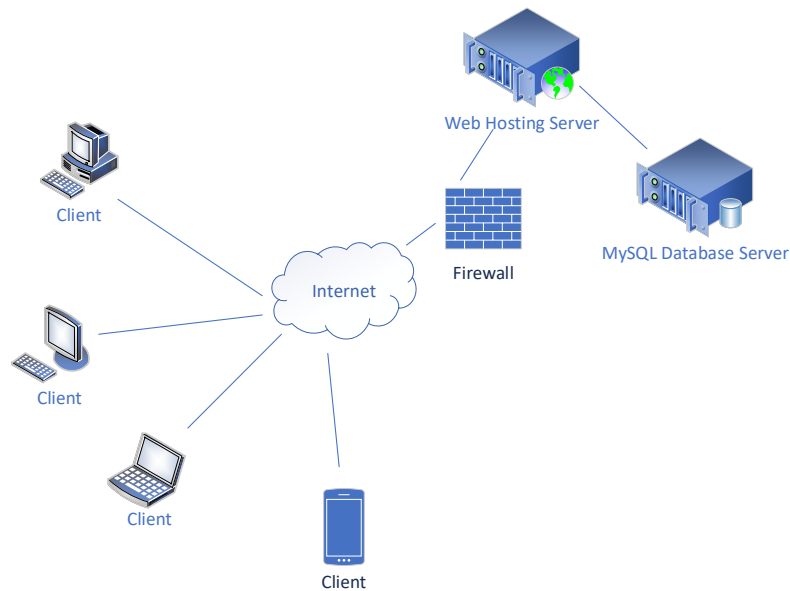


Figure 4.4: Network architecture of the developed system

## 4.7 Main user interfaces

Following section will only show some of the main user interfaces of the developed system in order to give a brief understanding about the interface structure. Appendix D – User Documentation will show the rest of the user interface designs.

### Login page

Interface shown in Figure 4.5 allows the super admin, university admin, university officer, supply officer, inventory owner, and supplier to access the system with correct credentials. Also, input validations have been added with the user login form.

The screenshot shows the login page for the Procurement Management System for Government Universities in Sri Lanka. At the top center is the national emblem of Sri Lanka. Below it, the text reads 'Procurement Management System for Government Universities in Sri Lanka'. Underneath, it says 'Procurement management staff sign in'. There are two input fields: 'Username' and 'Password'. Below the Password field is a checkbox labeled 'Remember me'. At the bottom is a blue 'Sign in' button.

Figure 4.5: Procurement management staff login page interface

## Home page

The homepage provides basic information about the user and his or her section. Further left side menu bar to let the user to navigate easily through the system. Appearance and functions of the home screen will be rendered according the privileges of the respective user role. Following Figure 4.6 shows the dashboard page of the super admin user of the system.

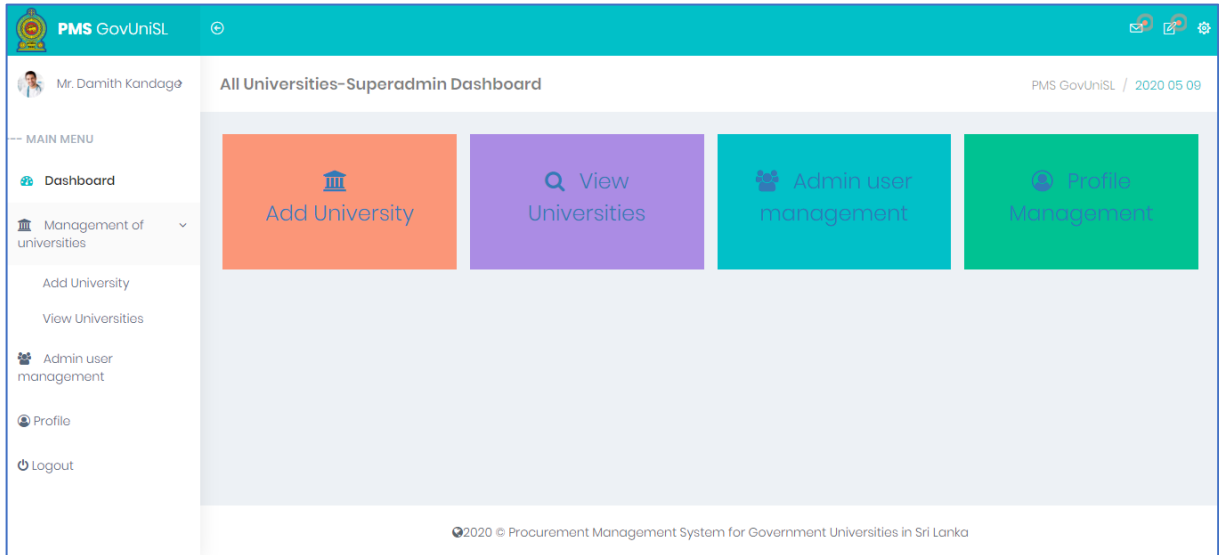


Figure 4.6: Dashboard page of the super admin user

## Data entry form

This system has forms in each module to input or update data. Figure 4.7 shows sample form module which is used for adding new university by the sure admin user.

The screenshot displays the 'All Universities-Add University' form. It includes a left-hand navigation menu with options: Dashboard, Management of universities (with sub-options: Add University, View Universities), Admin user management, Profile, and Logout. The main content area is titled 'ADD UNIVERSITY' and contains a 'Details of the University' section with the following fields: 'University Name' (text input with 'University of Colombo'), 'Website URL' (text input with 'http://www.cmb.ac.lk' and a validation message 'Please enter a valid website URL'), 'Email' (text input with 'info@cmb.ac.lk' and a validation message 'Email address is invalid'), and 'Details of the University Administrator' section with a 'Title' dropdown menu (currently showing 'Choose..'). The top right corner shows the user's name and the date '2020 05 09'.

Figure 4.7: Add university data entry form

## Dialogs

In order to give the better user experience jQuery UI dialog boxes are used to display information via dialog boxes. This reduced the page loading time and increased the speed of the entire system by eliminating page reloads. Ultimately, this will increase the end user satisfaction. Following Figure 4.8 shows the new purchase request dialog box which is used to display data input form, related to place new purchase request.

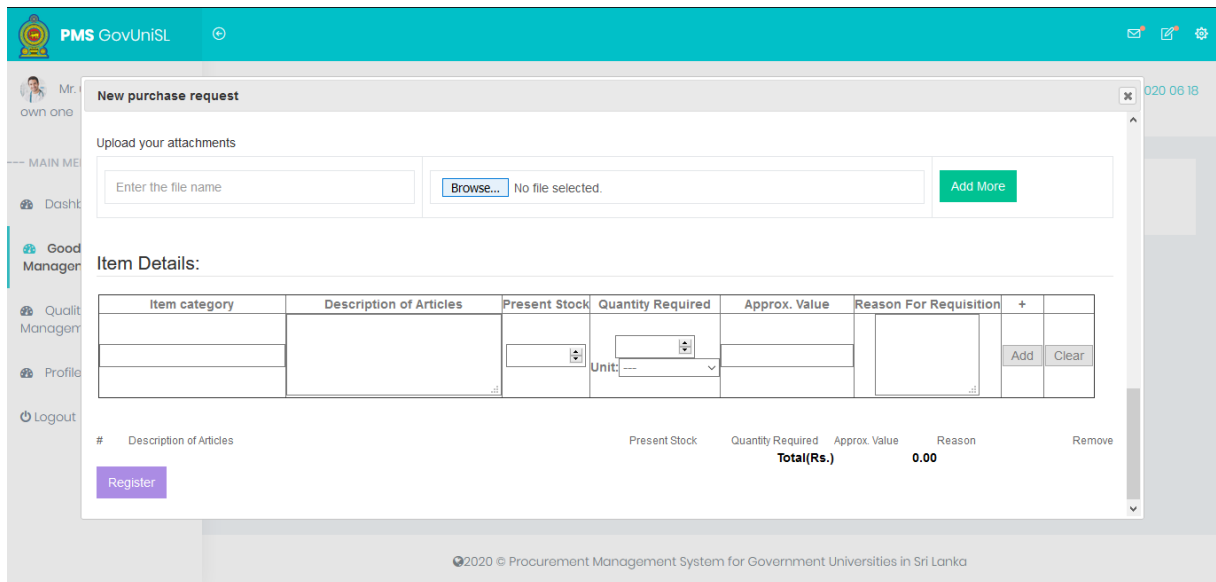


Figure 4.8: New purchase request dialog box

## Data Tables

In this system, most of the generated information has been displayed using table views. To give rich interaction with the generated tables jQuery UI data tables plugin has been used. Sorting, Searching, highlighting, and paginating are some of the rich features acquired through that. Following Figure 4.9 shows the data table view which is used to show the list of available purchase requests with their status.

SD ID	Request Category	Short Description	Last Action	Last Action Date	Next Pending Action	Relevant Officer	Action
38	SD1	test sd form one	bid_opening_closing	2020-06-16 12:14:10	Supply division	Supply officer	<a href="#">View</a>
39	SD1	test sd one two	tender_request	2020-06-13 11:10:29	Supply division	Supply officer	<a href="#">View</a>
41	SD1	test sd form three	approve_and_forward	2020-06-11 08:20:49	approve_and_forward	Samantha Perera	<a href="#">View</a>
42	SD1	test sd form five	create_purchase_request	2020-06-11 23:17:16	approve_and_forward	Nuwan Dayananda	<a href="#">View</a>
43	SD2	asdfa	bid_opening	2020-06-16 12:15:02	Supply division	Supply officer	<a href="#">View</a>

Figure 4.9: Data table view of list of available purchase requests of specific inventory owner

## **4.8 Summary**

In this chapter discussed about the server-side and client-side environment under the implementation environments. Then the development framework and tools used the develop the system were explained. Further selection of programming languages and database management system were discussed. Finally, the network architecture of the developed system was diagramed and some of the key user interfaces were explained. Next chapter will discuss about the user evaluation and testing of the developed system.

## **Chapter 5 User Evaluation and Testing**

### **5.1 Introduction**

In the last chapter, the implementation of the system was discussed. Testing and evaluation are a critical factor to ensure product quality. Hence increasing the product quality will eventually increase the usability of the system. So, it is vital to test and evaluate the developed system. The testing methods usually attach with Verification and Validation [13]. Validation refers to check whether the system is developed according to the requirements. On the other hand, verification refers to check whether the system functions are implemented correctly. Further, the goal of the testing and evaluation is to check whether the promises about the software development by the developer and the requirements of the end user are met on an acceptable level.

### **5.2 Testing procedure**

Basically, the software implementation and testing are iterative processes. Most of the time both stages work as simultaneous system components. The developed system was tested while the development was ongoing. Unit testing emphasizes the verification effort on the smallest unit of software design such as a software component to module. Further, it is a dynamic method for verification, where program is compiled and executed. unit testing was performed in parallel with the coding phase. Each modules of the web-based procurement management system were tested using test university staff, supplier, purchase items, data.

Structural testing techniques were followed in this phase including “white box” testing which tests “how a program/system does something”. Functional testing techniques were used, which includes “black box” testing which tests the behavior of the developed system.

Object oriented methodology is followed for the system development. So, object-oriented testing was also carried out in this phase. Individual operations associated with each object were tested initially, followed by testing individual classes and clusters of objects, and finally test the system as a whole. User acceptance testing was done with the participation of few university staff members with the use of test data.

### **5.3 Test plan and test cases**


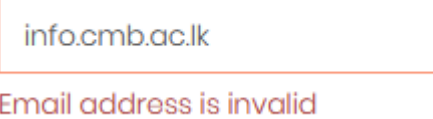
Testing starts with the implementation. While doing the coding, code testing was also completed as an iterative task. Test plan was created with including all the test phases. Also, this test plan was used as the guide for the entire test process. Test plane was designed before

the start of the system implementation. Basically, test objectives, test strategies, schedule, and logistics, specially test cases are included to the test plan.

Test cases are consisting with test data, procedures, and expected results. When designing test cases, they were designed based on individual modules of the system in order to reduce the complexity of the testing process. Additionally, manual testing was used for the testing process rather than the automated testing processes.

Following Table 5.1 to Table 5.4 describe some of the key test cases of the developed system.



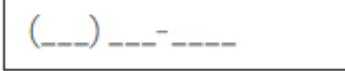
**Test case: Add university**

Test case Id	01		
Module name	Top level administration module		
Test case	Add university		
Expected output	<p>If any compulsory data input is missing or input date is invalid, form will not be submitted and missing, or incorrect input fields will be marks in red color with the error message.</p> <p>if all the input fields are correct and completed, successfully insert both university and university admin records to the database and successful message will be displayed.</p> <p>Upon successful registration university admin will receive an official email with mentioning the login password.</p>		
Test case description			
No	Test case	Actual output	Status
01	Press register button with empty compulsory fields	<p>Form submission failed.</p> <p>Empty field was highlighted with red color.</p> <p><b>University Name</b></p> 	Pass
02	Enter incorrect email address	<p>Incorrect email field was highlighted with red color and “Email address is invalid” message displayed.</p> <p><b>Email</b></p> 	Pass

03	Start typing official designation and Section input field values	<p>Autocomplete dropdown list appeared with list of available official designations and sections of the universities.</p> <p><b>Official Designation</b></p> <div style="border: 1px solid black; padding: 2px;">sys</div> <p>Programmer Cum Systems Analyst Grll Systems Engineer Grll</p> <p><b>Section(Faculty/Department/Division)</b></p> <div style="border: 1px solid black; padding: 2px;">in </div> <p>Center for Information Technology Services Faculty of Engineering</p>	pass								
04	Press register button with all correct input field values	<p>New university added to the back-end database with university admin registration.</p> <table border="1" data-bbox="563 891 1281 969"> <thead> <tr> <th>id</th> <th>name</th> <th>weburl</th> <th>email</th> </tr> </thead> <tbody> <tr> <td>34</td> <td>Rajarata University</td> <td>http://rjt.ac.lk</td> <td>info@rjt.ac.lk</td> </tr> </tbody> </table> <p> Delete 71 Mr. R. D. Perera damith88@gmail.com</p> <p>University admin received email containing login password.</p> <p>Password  <span style="border: 1px solid gray; padding: 2px;">Inbox x</span></p> <p> lkwebsol@ultrawp.lankahost.net to me ▾ ~^s2TWnW URL: <a href="http://kddlakmal.tk/pms">http://kddlakmal.tk/pms</a></p> <p>Browser popup with successful message.</p> <div data-bbox="563 1563 1129 1753" style="border: 1px solid gray; padding: 5px; background-color: #2e8b57; color: white;"> <p> <b>Success</b> University created successfully!</p> <p style="text-align: right;">PMS GovUniSL / 2020 06 18</p> </div>	id	name	weburl	email	34	Rajarata University	http://rjt.ac.lk	info@rjt.ac.lk	pass
id	name	weburl	email								
34	Rajarata University	http://rjt.ac.lk	info@rjt.ac.lk								

Table 5.1: Test case for adding new university

## Test case: Manage supply division

Test case Id	02		
Module name	University wise administration module		
Test case	Manage supply division		
Expected output	<p>If any compulsory data input is missing or input date is invalid, form will not be submitted and missing, or incorrect input fields will be marks in red color with the error message.</p> <p>if all the input fields are correct and completed, successfully register the supply division with the system and display supply head registration form.</p> <p>Upon successful registration head of the supply division will receive an official email with mentioning the login password.</p>		
Test case description			
No	Test case	Actual output	Status
01	Press save button with empty compulsory fields	<p>Form submission failed</p> <p>Empty field was highlighted with red color.</p> <p><b>General email</b></p> 	Pass
02	Enter incorrect email address	<p>Incorrect email field was highlighted with red color and “Email address is invalid” message displayed.</p> <p><b>General email</b></p> 	Pass
03	Try to enter more than 10 digits or character letters for direct telephone field	<p>Unable to enter more than 10 digits or enter characters other than digits for direct telephone field</p> <p><b>Direct telephone</b></p> 	Pass
04	Press save button with all correct input field values	Supply division registered successfully and display supply head registration form.	pass



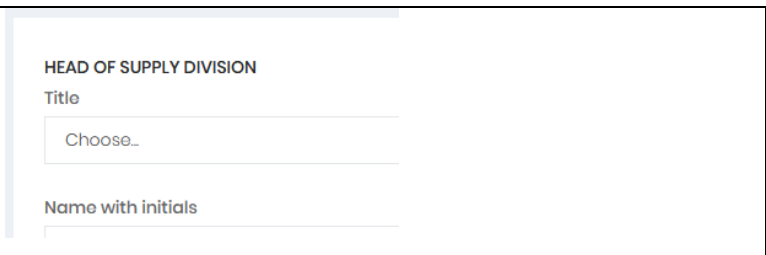
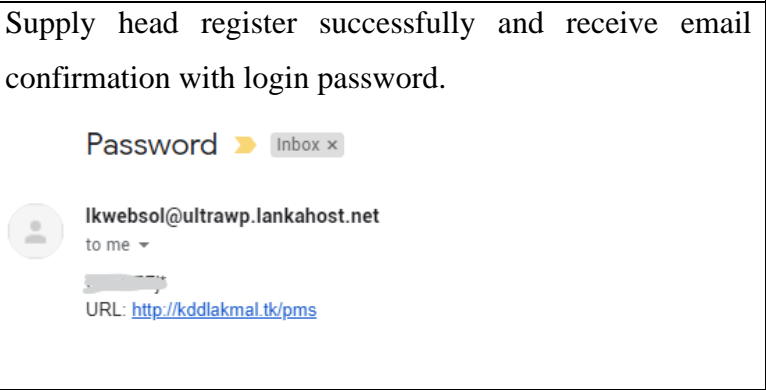

			
05	Press save button of the supply head registration form with all correct input field values	<p>Supply head register successfully and receive email confirmation with login password.</p> 	pass

Table 5.2: Test case for manage supply division

**Test case: Register new inventory owner**

Test case Id	03		
Module name	Inventory owner registration module		
Test case	Register new inventory owner		
Expected output	<p>If any compulsory data input is missing or input date is invalid, form will not be submitted and missing, or incorrect input fields will be marks in red color with the error message.</p> <p>University name select input field only show registered universities.</p> <p>If all the input fields are correct and completed, successfully register the inventory owner under the respective university.</p>		
Test case description			
No	Test case	Actual output	Status
01	Press register button with empty compulsory fields	<p>Form submission failed</p> <p>Empty field was highlighted with red color.</p> 	Pass
02	Click university name select input field	List all registered university institutes	Pass

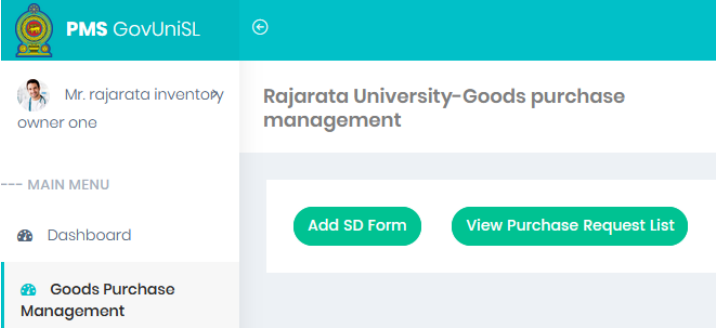
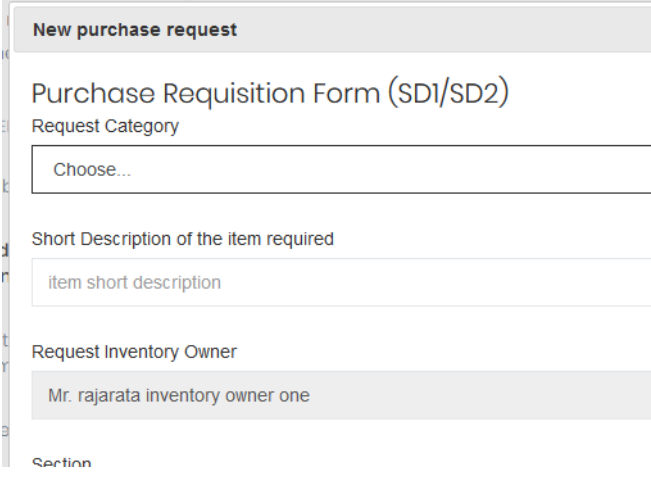
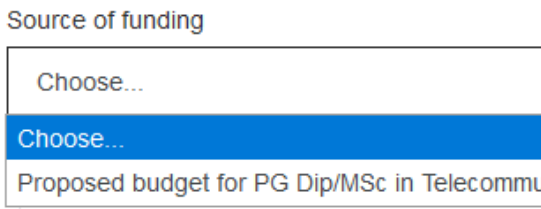
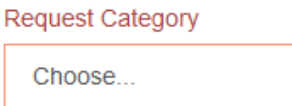
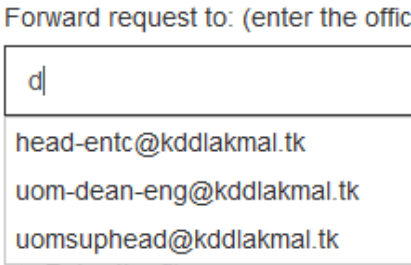
		<p><b>REGISTER INVENTORY OWNER</b></p> <p>University Name</p> <div style="border: 1px solid black; padding: 5px;"> <p>Choose...</p> <p style="background-color: #007bff; color: white; padding: 2px;">Choose...</p> <p>Rajarata University</p> <p>UGC</p> <p>University of Colombo</p> <p>University of Jaffna</p> <p>University of Moratuwa</p> </div>	
03	Press register button with all correct input field values	<p>New inventory owner added to the procurement management system under the relevant university successfully.</p> <div style="background-color: #d9e1f2; padding: 5px; border: 1px solid #ccc;"> <p>73 Mr. rajarata inventory owner one rjtinovnone@kddlakmal.tk</p> </div>	pass
04	Newly created inventory owner try to log in to the system using the email address as user name and emailed password	<p>Newly created user is able to log in to the system</p> 	Pass

Table 5.3: Test case for register new inventory owner

**Test Case: Add SD form**

Test case Id	04
Module name	Goods purchase requesting module
Test case	Add SD form
Expected output	<p>Open “New Purchase request” dialog box when inventory owner click Add SD Form button.</p> <p>Display all empty compulsory input fields of new purchase request using read color.</p>

	After click register button with all compulsory inputs, new purchase request added to the system and display purchase request added success message.		
Test case description			
No	Test case	Actual output	Status
01	Inventory owner click “Add SD Form” button	<p>Display new purchase request dialog box</p> 	Pass
02	Click “Source of funding” select input field	<p>Only display relevant funding sources of the relevant section of the relevant university.</p> 	Pass
03	Keep compulsory field empty before submitting	<p>Mark compulsory input field using red color before submitting the form.</p> 	Pass
04	Start typing the email address of next authorized officer to forward the purchase request	<p>Autocomplete input field will give suggestions for respective university officers within the respective university only.</p> 	Pass

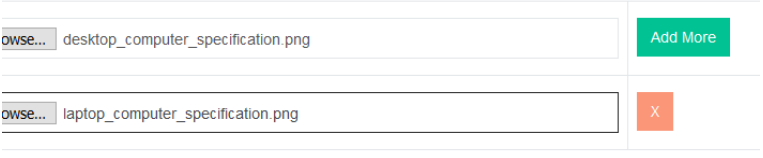
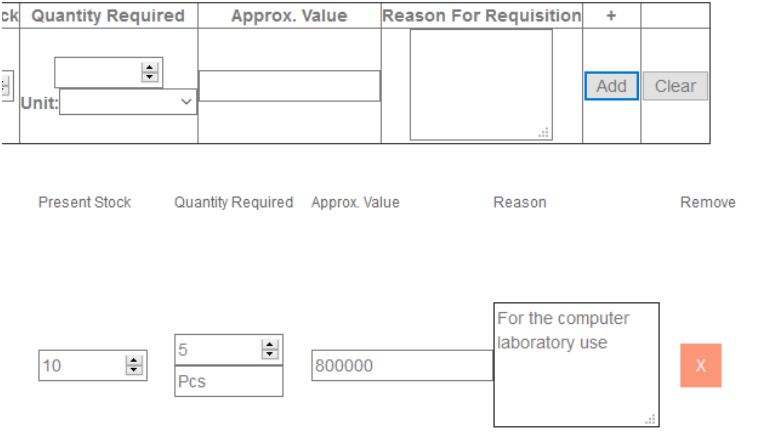
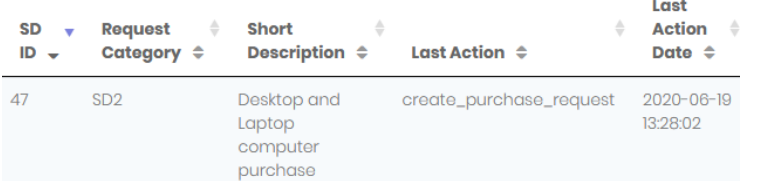
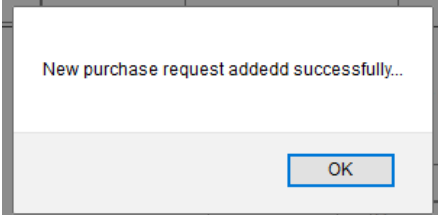
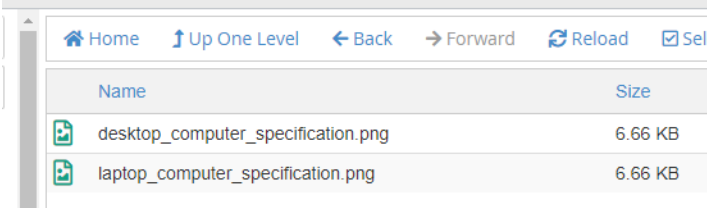
05	Click “Add More” button under “Upload your attachments”	<p>Generate another file upload link dynamically to upload another file</p> 	Pass
06	Input single item details and click “Add” button of the “Item Details” table	<p>New item added to the item list of the purchase request</p> 	Pass
07	Click “Register” button with all the correct compulsory input data value related to new purchase request	<p>Purchase request added to the procurement management system and forward to the respective university officer.</p>  <p>Purchase request added successfully message displayed.</p>  <p>All the attached related files were uploaded to the remote server.</p> 	Pass

Table 5.4: Test case for Add SD form

## 5.4 System Evaluation

Final goal of the system development is to develop a system which is able to satisfy the end users' requirements. Under the system evaluation section, actual end user groups of the system have been asked to test the system. At the end of the system testing, their feedbacks have been captured using a simple questioner form. By analyzing the questioner results, system usability has been measured. End user group of the system evaluation was consisted with university staff members who involve with the university procurement management process. Inventory owners, head of the departments, supply clerks, systems analysts, systems engineers, assistant bursars, tender committee members, technical evaluation committee members are some of the user categories among them. Also, few suppliers were included to the evaluation team. The survey questioner which was used to gather the feedback of the end users has been attached separately in Appendix F.

### 5.4.1 Findings of the survey

After analyzing the results of the survey, summary of the survey results has been converted into graphical bar charts. During the analysis, each question was considered individually. Following Figure 5.1 to Figure 5.7 show generated bar charts.

Q1. Web application interfaces are simple enough to understand.

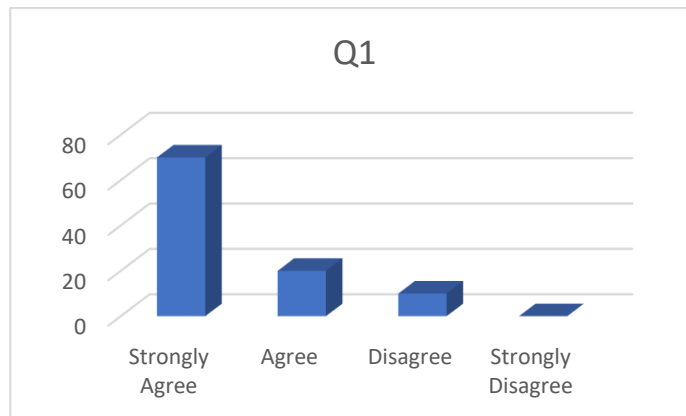


Figure 5.1: Survey Q1: Analysis results bar chart

Q2. Web application increases the efficiency of the entire procurement process.

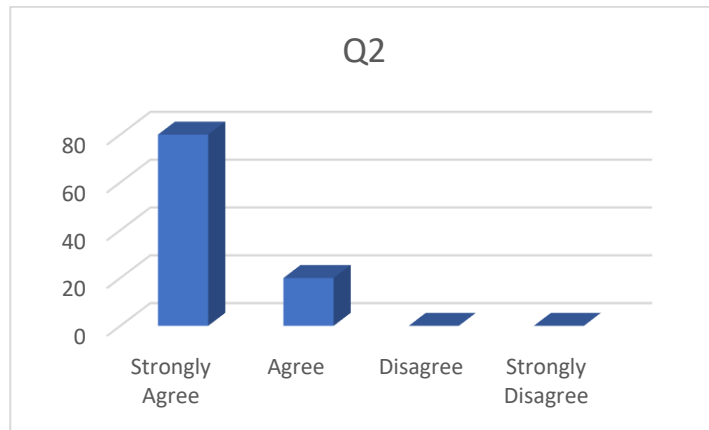


Figure 5.2: Survey Q2: Analysis results bar chart

Q3. System menu navigation is simple and easy to understand.

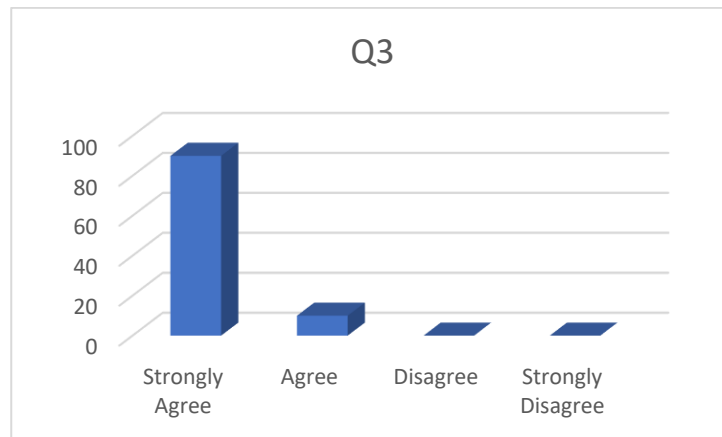


Figure 5.3: Survey Q3: Analysis results bar chart

Q4. Data processing speed of this system is at a considerable level compared to other web-based applications.

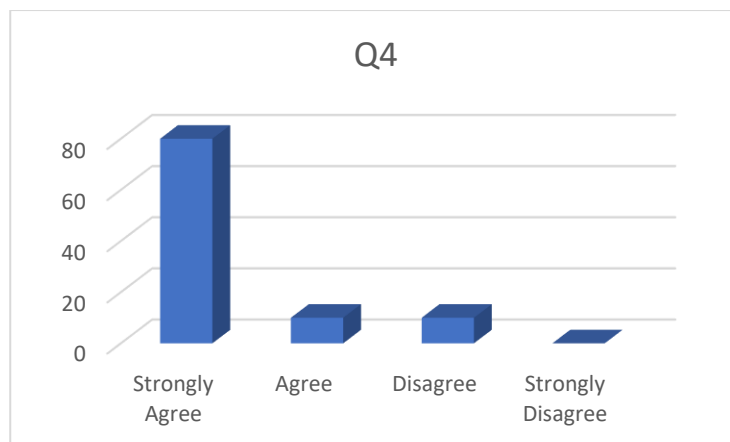


Figure 5.4: Survey Q4: Analysis results bar chart

Q5. Keeping central web-based system to manage entire procurement of the Sri Lankan government universities is effective.

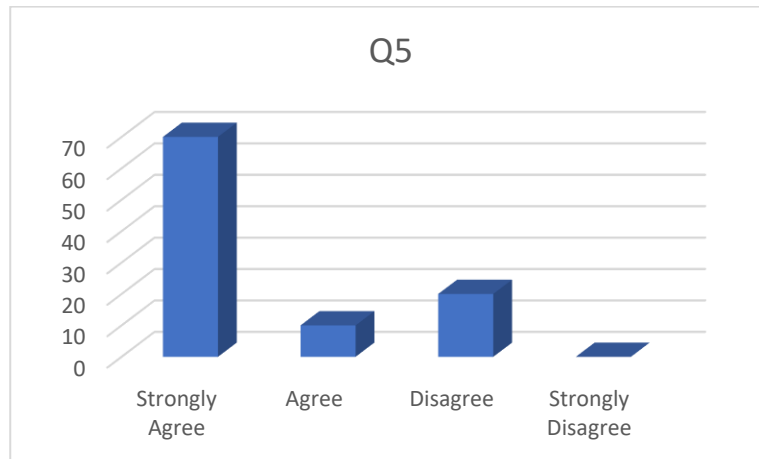


Figure 5.5: Survey Q5: Analysis results bar chart

Q6. Fully online data encryption-based bid submission and bid opening system features increase the efficiency of the bidding process.

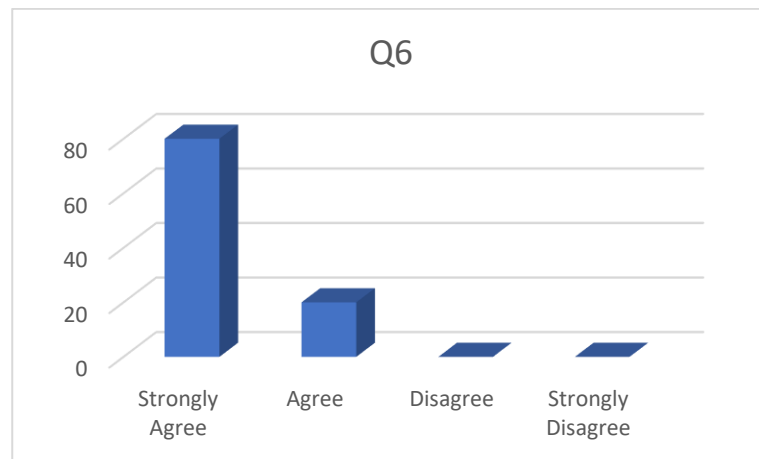


Figure 5.6: Survey Q6: Analysis results bar chart

Q7. System needs to be improved with new features such as tender award management, purchase order management, goods receive management.

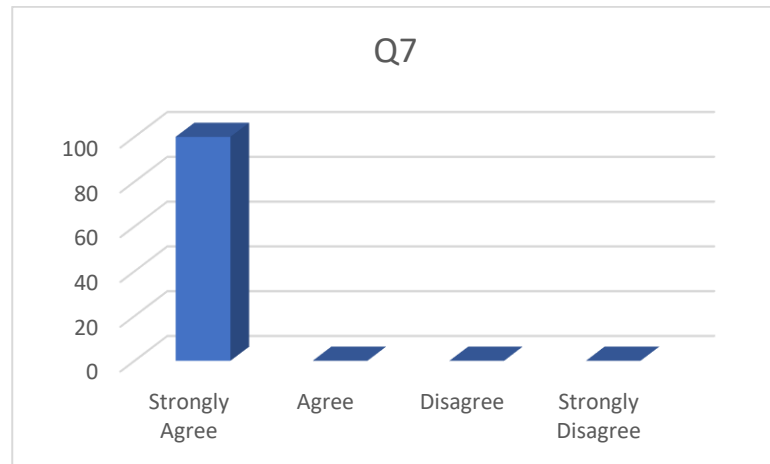


Figure 5.7: Survey Q7: Analysis results bar chart

## 5.5 Summary

In this chapter mainly focused about the end user evaluation and testing. First the test procedure was explained. Then the test plan has been proposed with the test cases. Some of the major test cases are described in detail. User evaluation procedure was discussed as the next part of this chapter. End users were asked to test the system and complete the survey questioner. Survey results has been analyzed and displayed using graphical bar chart format. In the next chapter conclusion, problem encountered in the system development, and limitations of the developed system will be discussed.



## **Chapter 6 Conclusion**

### **6.1 Introduction**

This is the last chapter of the dissertation on Web-based procurement management system for government universities in Sri Lanka. Also, this chapter will wind up the overall achievements of this project. Discuss about the achievements of the project objectives, explain the problems encountered, describe the limitations of the developed system, explain the learning outcome, and illustrate the future enhancements of this project are the main objectives of the chapter.

### **6.2 Achievements of Project Objectives**

Web-based procurement management system is centralized solution to overcome the inefficiency of the manual procurement process of the government universities in Sri Lanka. This system is develop based on the requirements of the government university procurement system.

Developed system is very much compatible with the initial project objectives. One of the major objectives of this project is the capability to handle the procurement system of multiple universities in same time. That was successfully achieved through this project. Further project was completed up to the bid opening function. Up to that function all the processes are handled by the system and no hard papers documents are used. Further all the document approval and forwarding processes can be handled by the system itself.

Additionally, online bid submission and bid opening functions are the most complex objectives achieved in this project. Using this bid submission function suppliers/bidders are able to submit their bids with an encrypted format using a private encryption key. Only the respective supplier knows the key for each bidding. Also, during the execution of bid opening function suppliers are asked to enter their encryption key to decrypt the bid value information. Using this feature no one can see the bidding value details until the bid opening taken place.

### **6.3 Problem encountered**

As all software development projects faced, requirement gathering was the major difficulty of this project. Most case staff of the university supply division do not have enough IT knowledge to explain the exact product requirement at once. Sometimes they were extremely busy with their official works and difficult to conduct meetings with them. Most case observation is used to capture the requirements.

Other than the requirement gathering, another major problem is the complexity of this project. This project has not developed for an individual university. So, the database design was

extremely difficulty and had to change the entire database structure several times to cater the exact system requirement. Also, handling the procurement related workflow was really difficult task.

Additionally, SQL query writing was highly complex with the hierarchical structure of this project. Lot of background tutorials, readings and code studies were used to gather the required knowledge related to implement this project. Also, large amount of time has been expended to study to additional resources and get the familiarity with the CodeIgniter framework.

#### **6.4 Limitations in Web-based procurement management system**

Following are the list of major limitations of the web-based procurement management system.

- a) Universities need to register with the procurement management system before start using this system. Also, separate university wise admin user needed to be assigned for each university. This university admin must setup university structure including all divisions, departments, faculties, and staff of each section.
- b) All communications are done via the system notifications and email notifications. So, users must frequently check those notifications to keep the system live.
- c) All the bid submissions are done through the system itself. So, suppliers/bidders must be careful about those deadlines.
- d) One of the major limitations of this system is supplier must attend to the bid openings withing the given time frame. Otherwise their bids will be discarded.
- e) With the current development stage system is only capable of handle the procurement up to bid opening process. Other functions including bid awarding need to be develop as future works.
- f) This system is only capable of supply goods from registered suppliers with their registered item categories.

#### **6.5 Lesson learnt**

This is a complex web-based project with high number of user-roles and user-permissions. Due to the complexity of this project PHP CodeIgniter framework has been chosen to develop this system. So, it has been given valuable opportunity to learn the CodeIgniter framework. Also, from the beginning to the end, iterative and incremental software development approach has been used for this project. It was a great opportunity to practice the software development principals which were learnt from the MIT degree program.

Additionally, complex database designing process was associated with this project. In order to produce some user views, complex join queries were written using the CodeIgniter database library class. Also, theories learnt related to the MVC framework have been used every where in this project. Technologies like, jQuery, AJAX, were used to increase the system performances. So, lot of tutorials and lessons related to those technologies have been studied. Other than the technical skills, this project helped to improve the intellectual skills, time management skills also.

## **6.6 Future enhancements**

According to the project objectives, this project is only developed up to implementing online bid opening functionality. In order to complete this web-based procurement management system as a complete solution, following modules need to be included to the current system.

### **Technical evaluation and bid awarding process**

Each member of technical evaluation committee will be able to view bid information and submit technical evaluation report for each product of each supplier using the online form submission. Upon completion of all the technical evaluation, system will forward the bid selection request to the tender committee. Then bid will be awarded based on the TEC evaluation results and based on the awarding criteria by the tender committee. The leader of the tender committee is given access to assign the winner(s) for each item(s) in the purchasing request. Also, tender committee is given access to view all the information related to a specific purchasing request. Then all the bidders will be notified about the bid winning information. Also, purchase orders will be generated automatically and forwarded to the winners of the respective tender.

### **Goods delivery and acceptance process**

Storekeeper will be given access to update good receive note and good delivery note online. Upon completion of above tasks system automatically generates the quality report and forwarded to the inventory owner. Inventory owner will be notified by the system generated email and dashboard notification. Completed quality report can be submitted online for the approval of next level and so on. Based on the status of the quality report items will be confirmed and payments will be approved by the system.

## **6.7 Summary**

This chapter was committed to deliberate the approach how objectives of the project were accomplished, limitations of the system, and the problems encountered. Referring to all the previous chapters it can be clearly mention that developed system has been achieved all the

objectives of the project of web-based procurement management system for government universities in Sri Lanka.

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# APPENDIX A - ANALYSIS OF THE EXISTING MANUAL SYSTEM

සැකැස්ම 1/ S.D. 1

... අංශයේ /දෙපාර්තමේන්තුවේ පාරිභෝගික භාණ්ඩ මිලදී ගැනීම සඳහා ඉල්ලුම්පත						
Purchase requisition for Consumable goods to the .....Division/Department						
දිනය Date	14/08/2017	අවශ්‍ය ප්‍රමාණය Quantity Required	දළ වටිනාකම Approx. Value	සැපයීම් අංශයේ ප්‍රයෝජනය සඳහා For use of Supplies Department		
අංකය Number	විස්තරය Description of Articles			අනුමැති අංකය හා දිනය Order Number & Date	සපයන ලද ප්‍රමාණය Quantity Supplied	මෙහෙත් Remarks
එකතුව / Total						

බඩු ඉල්ලීමට හේතුව / Purpose :  
 ඉතා කැපීපෙනෙන අවශ්‍යතාව හේතුව  
 If urgently required, reasons:  
 ඉල්ලුම්පත පිළියෙල කළේ/ Requisition prepared by  
 නම:  
 Name:  
 අත්සන:  
 Signature: .....  
 දුරකථන:  
 Ext. No: .....

.....  
 දෙපාර්තමේන්තු ප්‍රධාන / අංශ ප්‍රධාන  
 Department / Branch Head  
 දිනය / Date : .....

හිතදේශ කරමි / අනුමත කරමිසඳු  
 Recommended / Approved  
 දිනය / Date:

.....  
 පීඨාධිපති / ලේඛකාධිකාරී / මූල්‍යාධිකාරී  
 Dean / Registrar / Bursar

අනුමත කරමිසඳු / Approved  
 දිනය / Date : .....

.....  
 ලේඛකාධිකාරී / උපකුලපති  
 Registrar / Vice Chancellor

කරුණාකර සැපයීමට කටයුතු කරන්නසඳු  
 Please take action to supply  
 දිනය / Date : .....

.....  
 ජ්‍යෙෂ්ඨ සහකාර මූල්‍යාධිකාරී (සැපයීම්)  
 Senior Assistant Bursar/Supplies

කාර්යාලීය ප්‍රයෝජනය සඳහා / For office use only.

Figure A.1: Supply Document 1 (SD 1 form)

ආකෘති සංකීර්ණ 2 Form S.D. 2		ප්‍රාග්ධන කාණ්ඩ මිලදී ගැනීමේ ඉල්ලුම් පත්‍රය Capital Equipment Purchase Requisition Form				Requisition No.	
දෙපාර්තමේන්තුව / අංශය Department / Branch							
මූල්‍ය සාධකය Funding Source						දිනය / Date :	
අංකය Number	වස්තුව විස්තරය Description of Articles	වර්තමාන පොහොසත Present Stock	අවශ්‍ය ප්‍රමාණය Quantity Required	දළ වටිනාකම Approx. Value	ඉල්ලීමට හේතුව Reason for Requisition	සැපයීම් අංශයේ ප්‍රයෝජනය සඳහා For use of Supplies Department	
						අනුමත අංකය හා දිනය Order Number & Date	අනුමත ප්‍රමාණය Quantity Ordered
එකතුව / Total							
ඉල්ලුම්පත සිදුකළ කළේ Requisition prepared by නම: ..... අත්සන: ..... දිනය: ..... දුරකථන අංකය: ..... Ext. No: .....		ප්‍රාග්ධන මුදල් අලබය/නොලබය Capital Funds are available/not available ----- ජ්‍යෙෂ්ඨ සහකාර මූල්‍යවේදියා/පාඨශාලකයා Senior Assistant Bursar/Faculties දිනය /Date :-----			අනුමත කරමිනි / Approved ----- ලේකම්වරයා / උපලේකම්වරයා Registrar / Vice Chancellor දිනය / Date:-----		
----- දෙපාර්තමේන්තුවේ ප්‍රධාන / අංශ ප්‍රධාන Department / Branch Head දිනය / Date : .....		නිර්දේශ කරමිනි / අනුමත කරමිනි Recommended / Approved ----- පීඨාධිපති / ලේකම්වරයා / මූල්‍යවේදියා Dean / Registrar / Bursar දිනය / Date : .....			කාර්යාලයට සැපයීමට කටයුතු කරන්න Please take action to supply ----- සේවකුලසෘජු (සැපයීම්) / S.A.B (Supplies) දිනය / Date : .....		

Figure A.2: Supply Document 2 (SD 2 form)

## APPENDIX B - SYSTEM DOCUMENTATION

This documentation provides the guideline to configure the hosting server with the developed system. Softcopy of the procurement management web application software along with the database file are submitted with the CD attached with this dissertation. Following Table B.1 and Table B.2 will list the hardware and software requirement which are necessary to host this web application, respectively.

### Minimum hardware configuration of the shared hosting server

Hardware	Minimum requirement
Processor	3.0 GHz Xeon Processor with 32 Cores
Memory	2 GB
Hard drive space	2 GB SSD
Connectivity	24/7 up time

Table B.1: Minimum hardware configuration of the hosting server

### Minimum software configuration of the shared hosting server

Software	Minimum requirement
Apache version	Minimum 2.4.43
PHP version	Minimum 7.2.31
MySQL version	Minimum 5.7.30
Operating system	Linux/Windows
cPanel version	Minimum 88.0 (build 10)

Table B.2: Minimum software configuration of the hosting server

### Web application configuration procedure

- a) Upload all the file and folders related to procurement management system web application from the given CD to hosting server. cPanel file manager or FTP client software can be used to complete this task.
- b) Go to cPanel of the hosting provider and create new database and import the database backup file given in the CD.
- c) Go to the root directory of the uploaded web application in the hosting server using the file manager and then go to /application/config/ folder and open config.php file through code editor. Then change the base\_url with your domain name.



```
26 // $config['base_url'] = 'http://localhost/pms/';
27 $config['base_url'] = 'http://kddlakmal.tk/pms/';
```

- d) Go to /application/config/ and open database.php file through the code editor and type the database configurations.

```
76 $db['default'] = array(
77     'dsn' => '',
78     'hostname' => 'localhost',
79     'username' => 'lkwebsol_pms',
80     'password' => 'lkwebsol_pms',
81     'database' => 'lkwebsol_pms',
82     'dbdriver' => 'mysqli',
83     'dbprefix' => '',
84     'connect' => FALSE
```

- e) Go to /application/models and open Ftpconnection.php file through the code editor and type new ftp configuration settings.

```
15 // Use ftp server address
16 $fserver = "ftp.kddlakmal.tk";
17
18 // Use ftp username
19 $fuser="pms@kddlakmal.tk";
20
21 // Use ftp password
22 $fpass="lkwebsol_pms";
```

- f) Access the web application through any web browser by entering the configured URL in the address bar of the web browser. User login windows will be displayed, and initial login credentials of the super admin account has been set to, username: superadmin and password: admin1234.

# APPENDIX C - DESIGN DOCUMENTATION

## Database design

Following Figure C.1 shows the entire EER diagram of the Web-based procurement management system. All the tables, relational tables and their relationships with the cardinality are displayed in this diagram.

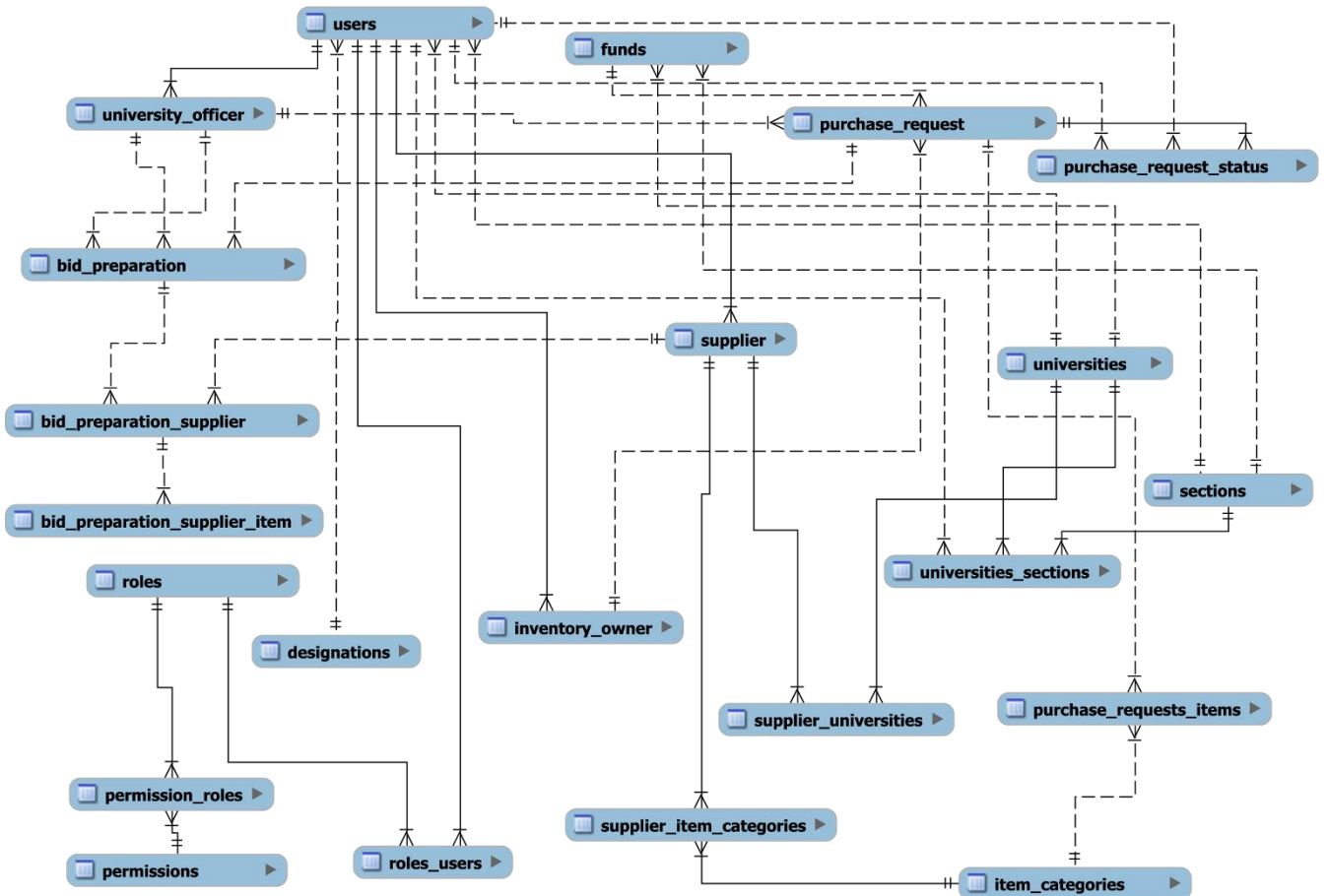


Figure C.1: EER diagram of the web-based procurement management system

Following details EER diagrams will show the detail structure of the database design of some of the major modules of the developed system.

Figure C.2 shows the detail database structure of user registration, user-role and role-permission management module.

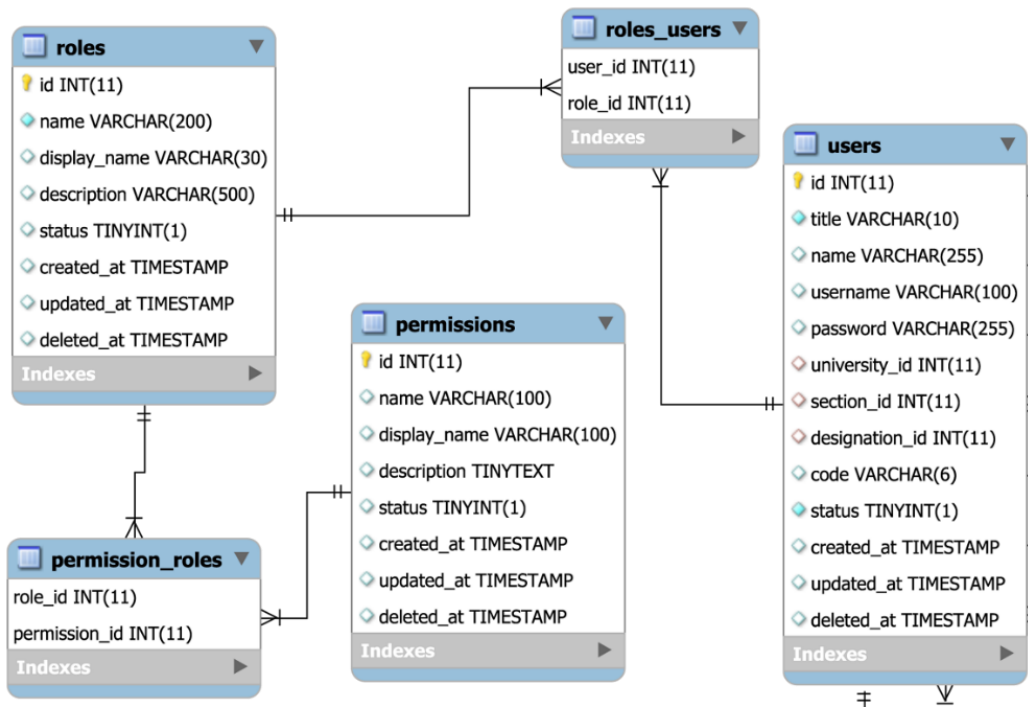


Figure C.2: Database relationship diagram of user, role, and permission management module

Detail database relationship diagram of purchase request module shows in Figure C.3

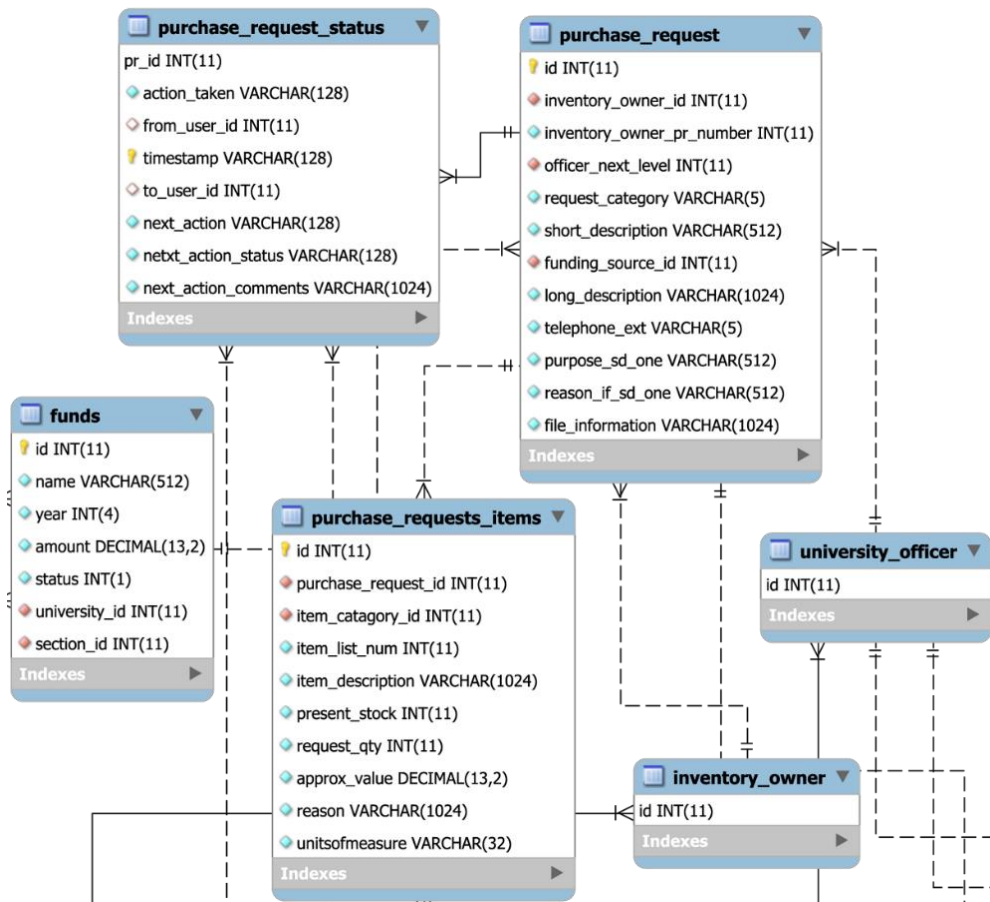


Figure C.3: EER diagram of purchase request module

Bid preparation and bid submission module table relationship diagram display in figure C.4

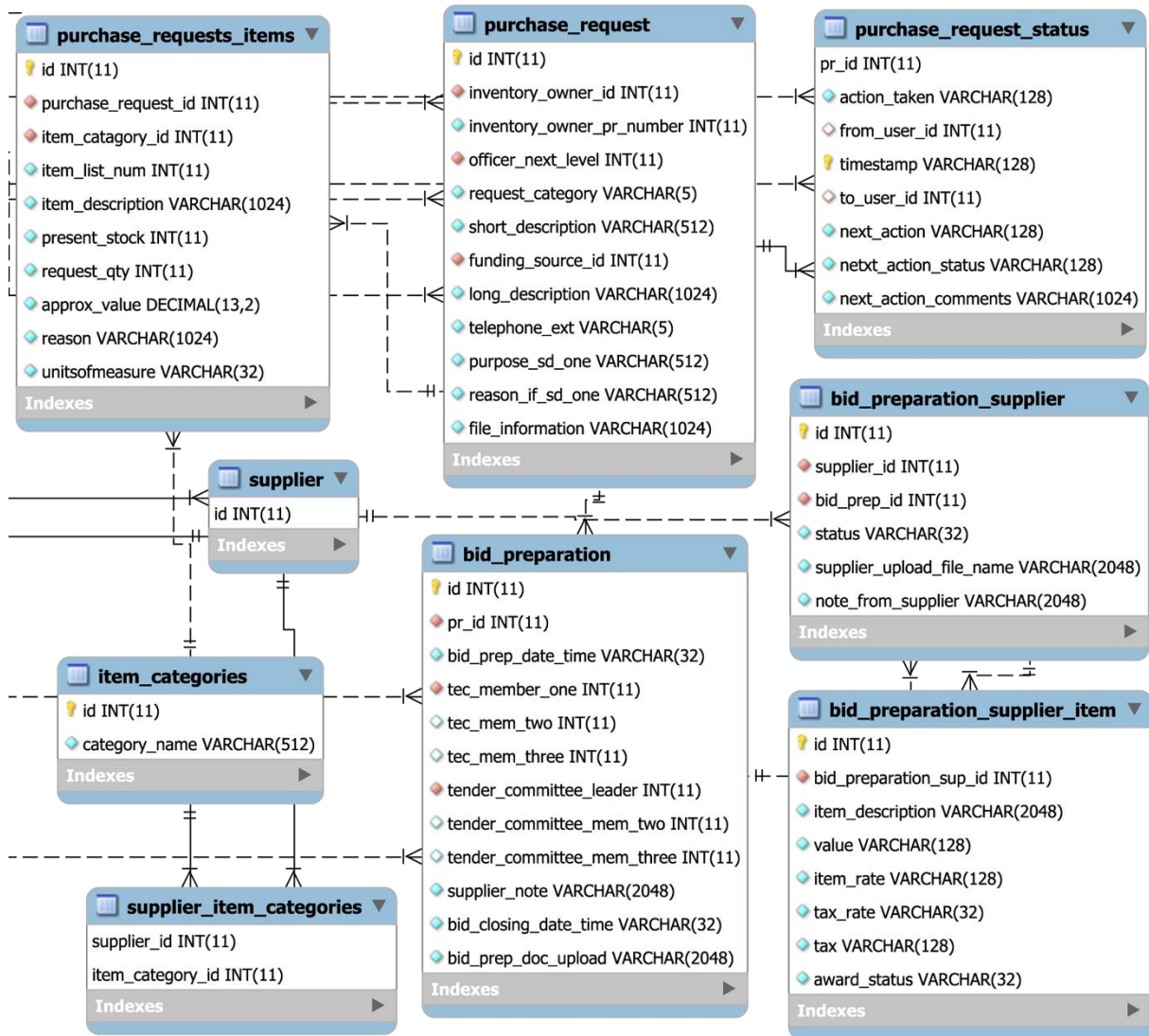


Figure C.4: Bid preparation and bid submission module EER diagram

## APPENDIX D - USER DOCUMENTATION

Following figure number D.1 to D.15 will show the rest of the main user interfaces of the developed system.

- a) User interface for manage supply division of a university by the university admin user.

The screenshot shows the 'University of Moratuwa-Manage Supply Division' interface. The header includes the PMS GovUniSL logo and navigation icons. A sidebar menu on the left lists options like Dashboard, University, Manage Supply Division, Manage Store, Manage Divisions, Manage Faculties, Manage Departments, Inventory Owner Management, and Account Year Management. The main content area is divided into two columns. The left column, titled 'GENERAL INFORMATION OF SUPPLY DIVISION', contains fields for 'University name' (University of Moratuwa), 'Name of the division' (Supply Division), 'General email' (supply@ent.mrt.ac.lk), 'Direct telephone' ((01) 265-0650), and 'Office extension' (3333). The right column, titled 'HEAD OF SUPPLY DIVISION', contains fields for 'Title' (Mr.), 'Name with initials' (uom supply head), 'Official Email' (uomsuphead@kddlakmal.tk), and 'Official Designation' (Assistant Bursar). An 'Update' button is located at the bottom of the right column.

Figure D.1: University supply division management interface

- b) Inventory owner registration user interface.

The screenshot shows the '-Inventory Owner Registration' interface. The header includes the PMS GovUniSL logo and navigation icons. A sidebar menu on the left lists options like Register Inventory Owner and Logout. The main content area is titled 'REGISTER INVENTORY OWNER' and contains fields for 'University Name' (Choose...), 'Title' (Choose...), 'Name with initials' (A. B. C. Perera), 'Official Email' (abcperera@cmb.ac.lk), and 'Official Designation'. A partially visible field for 'Contact Number (Department/Division)' is also present at the bottom.

Figure D.2: Inventory owner registration interface

c) Goods purchase requests management interface used by the inventory owner of a university.

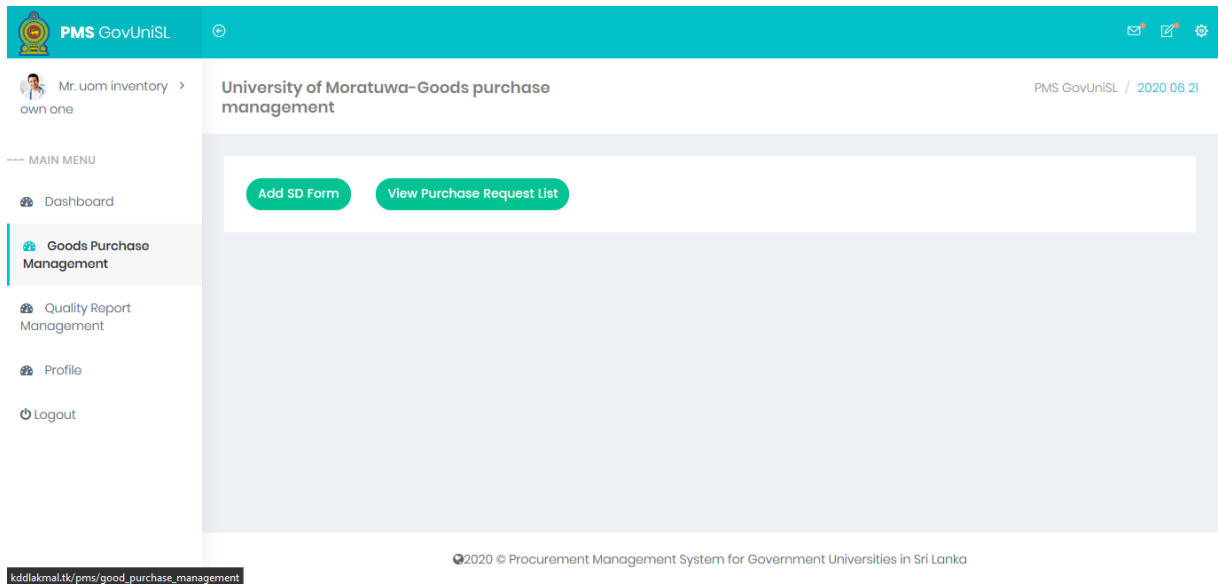
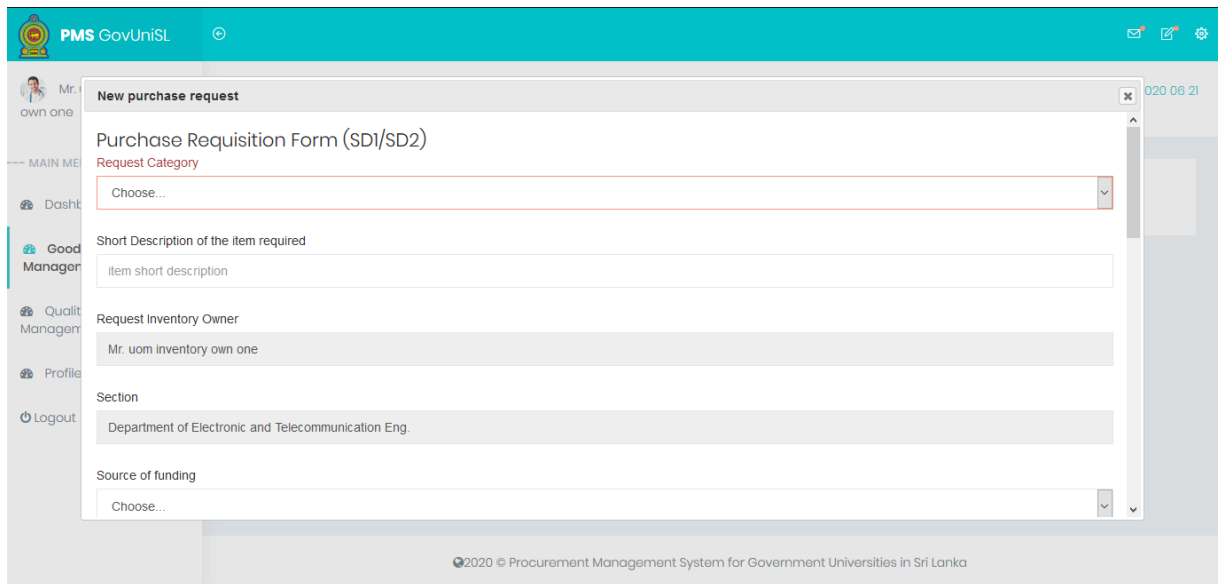


Figure D.3: Goods purchase management interface

d) User interface used to add new purchase request.



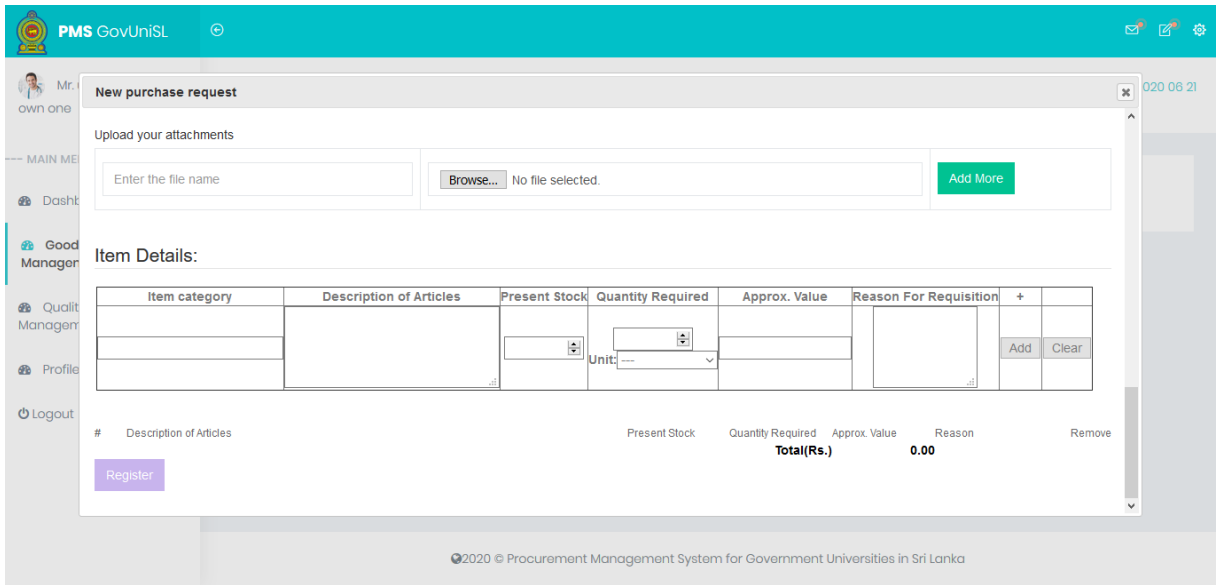
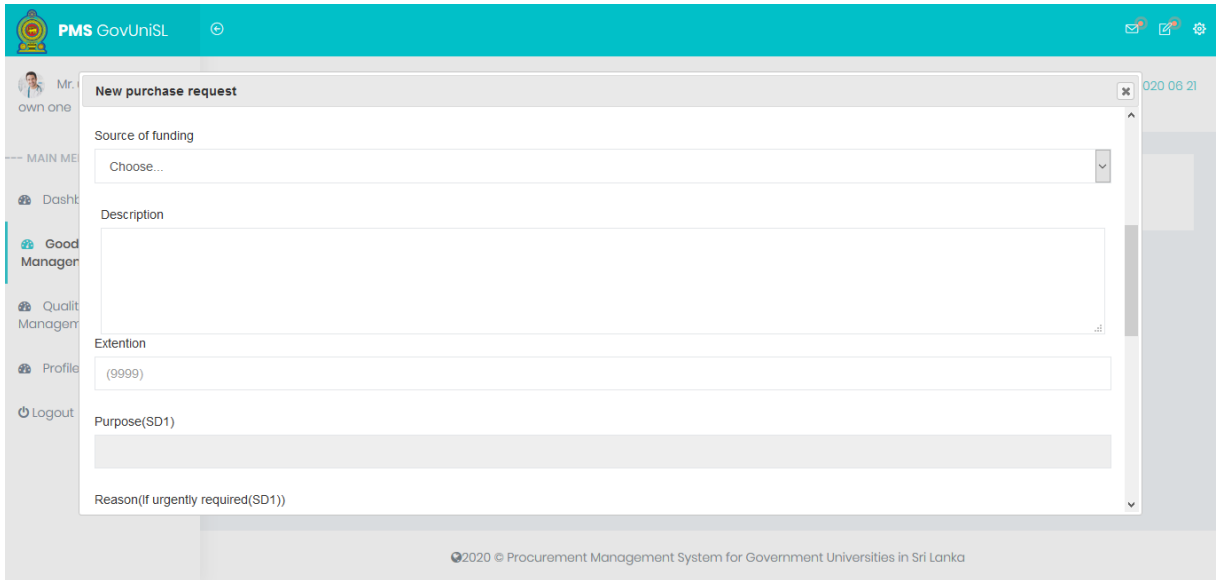


Figure D.4: User interface used to add a new purchase request

- e) User interface used to list all the purchase requests submitted by an inventory owner with their current status.

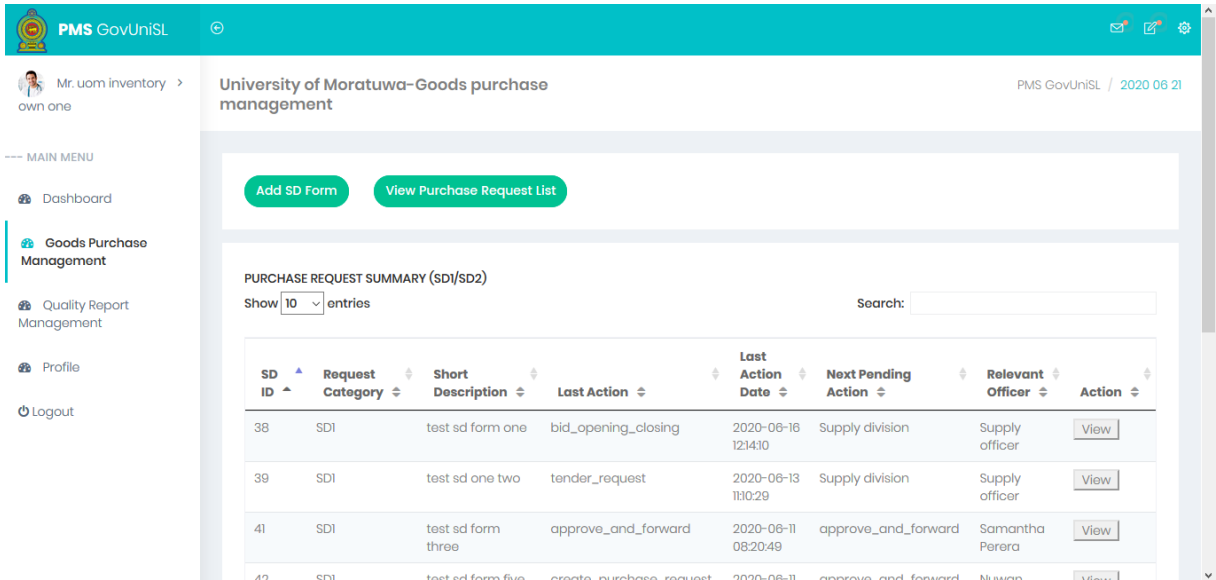


Figure D.5: User interface to view list of purchase requests with their status

f) User interface used to view list of approval pending purchase request for an officer of a university

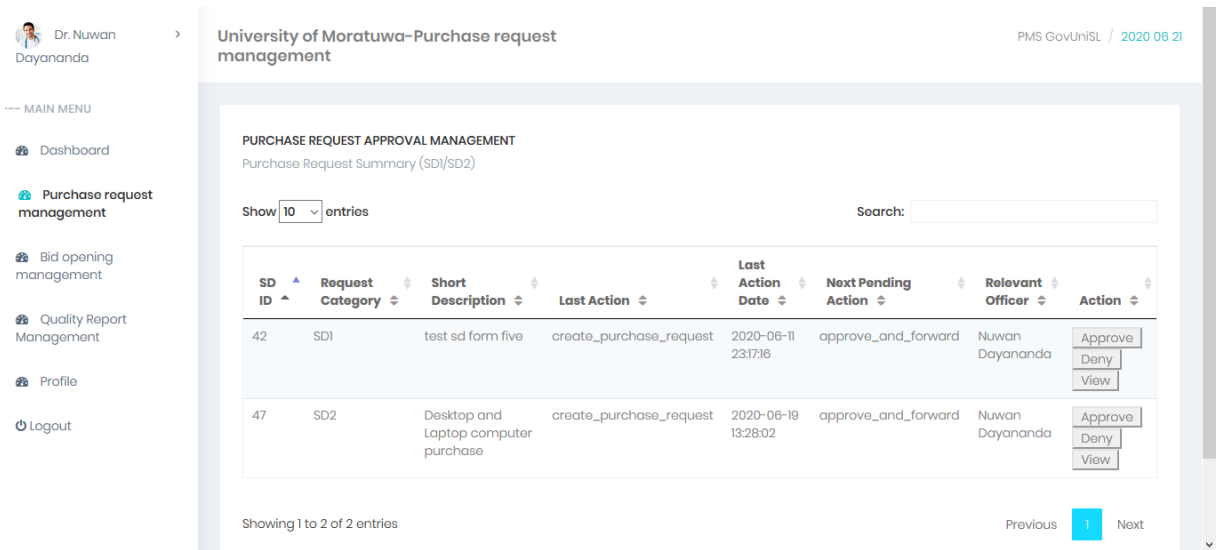


Figure D.6: User interface to view approval pending list of purchase requests



g) User interface used to approve a purchase request by an officer of a university.

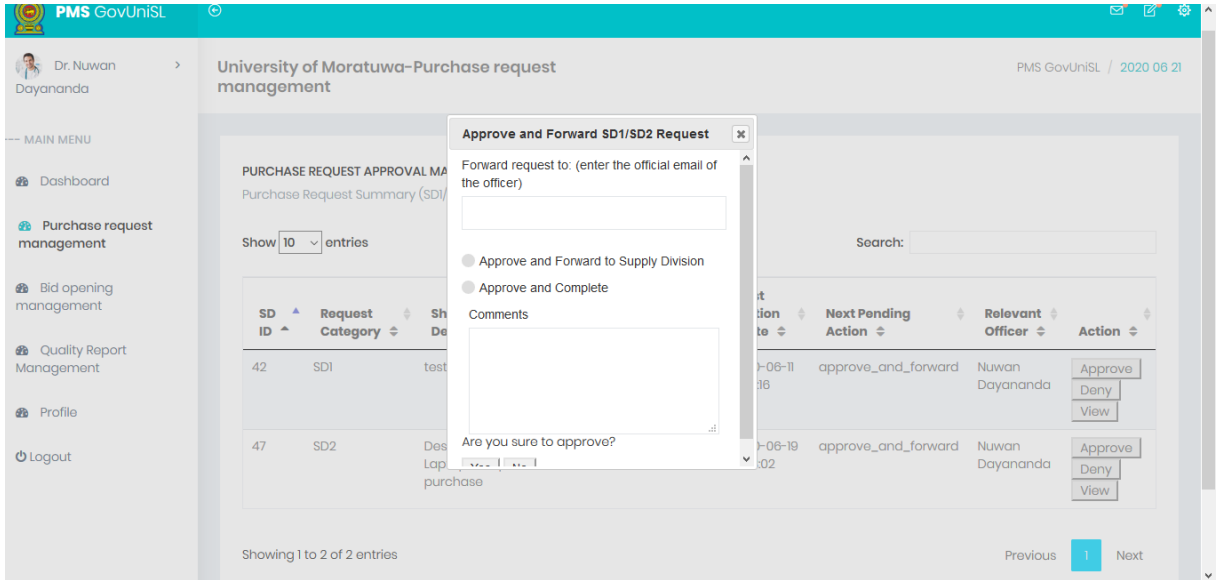


Figure D.7: User interface used to approve a purchase request

h) User interface used to show the list of purchase request which are ready for bid requisition by the supply officer of a university.

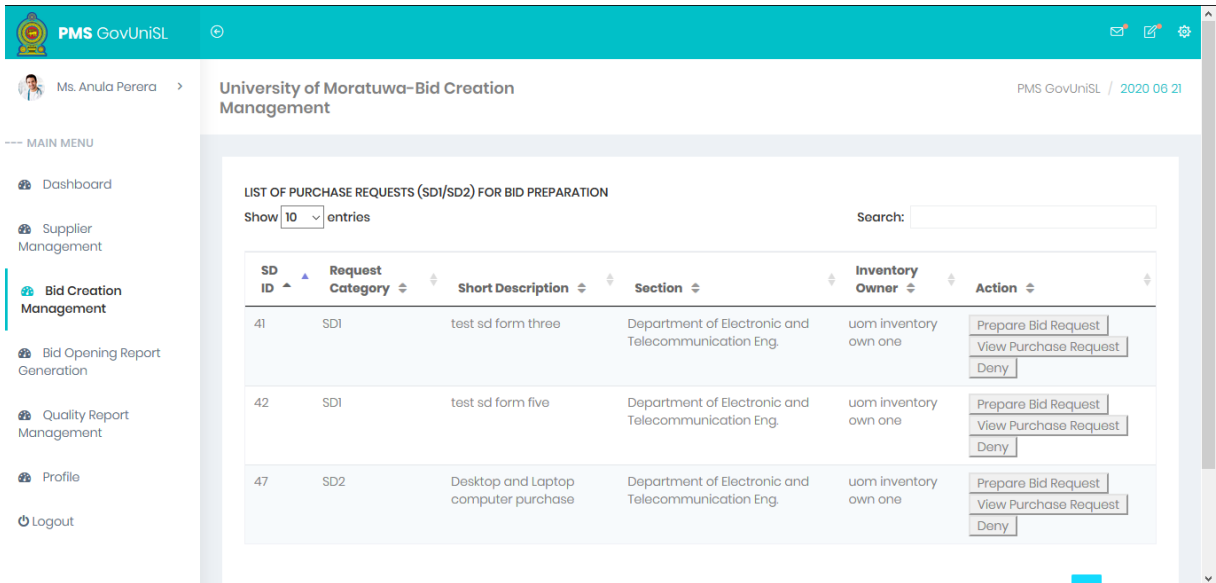


Figure D.8: User interface used to show list of purchase requests which are ready for bid requisition

- i) User interface used to prepare and submit bid request to registered suppliers by a supply officer of a university.

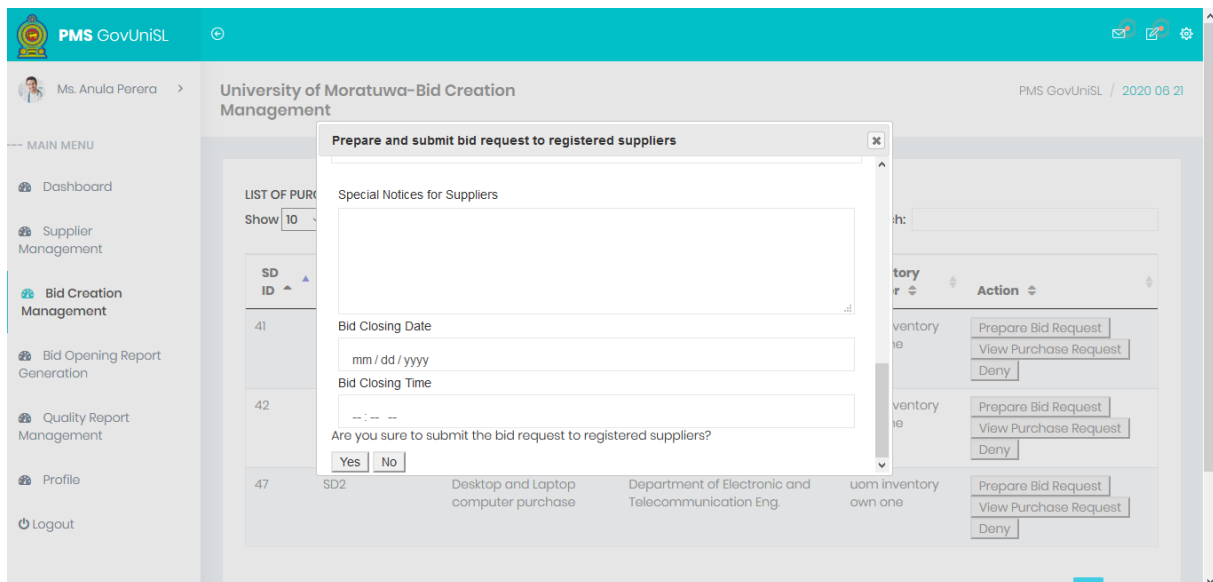
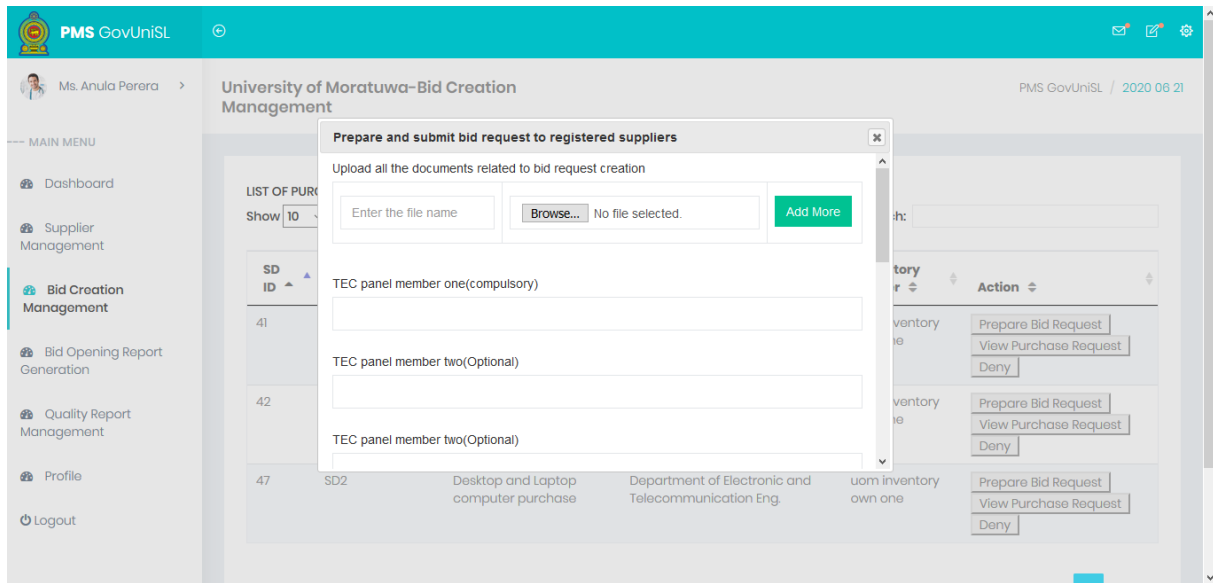


Figure D.9: User interface used to prepare and submit a bid request to relevant registered suppliers

j) User interface used to show list of pending bid submission requests to registered supplier.

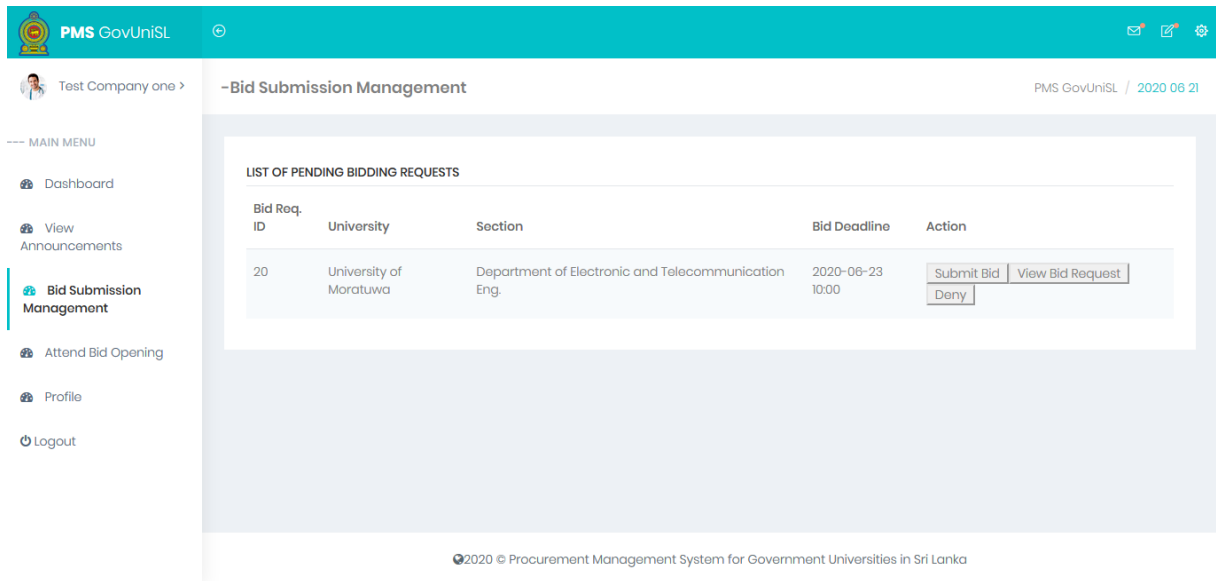
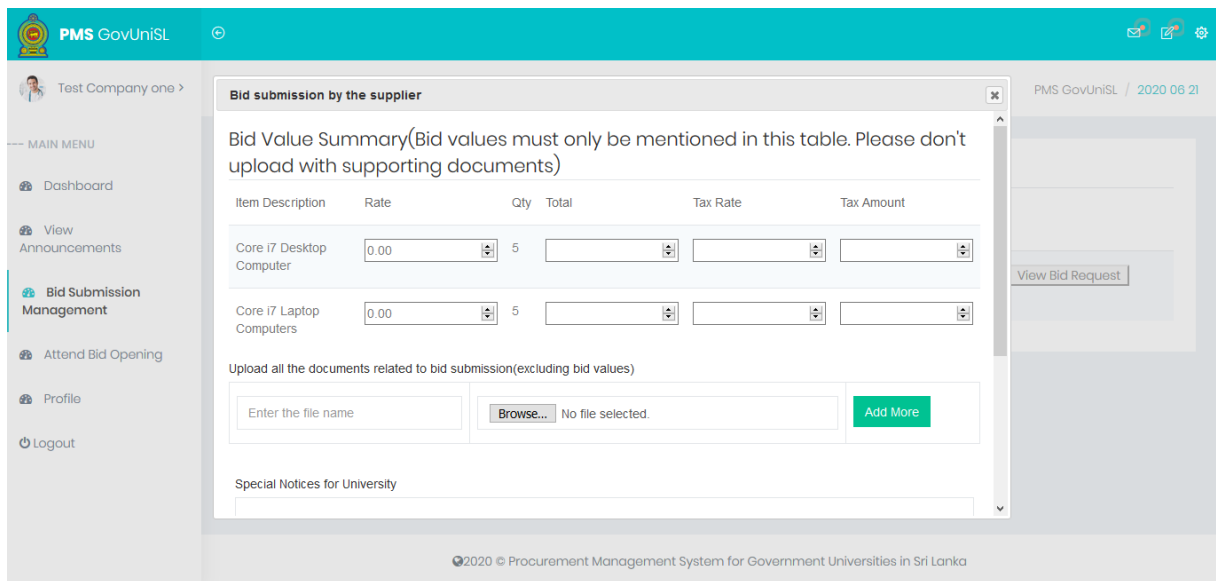


Figure D.10: User interface to show list of pending bid submission requests

k) User interface used to submit bids for items with encryption key by a registered supplier



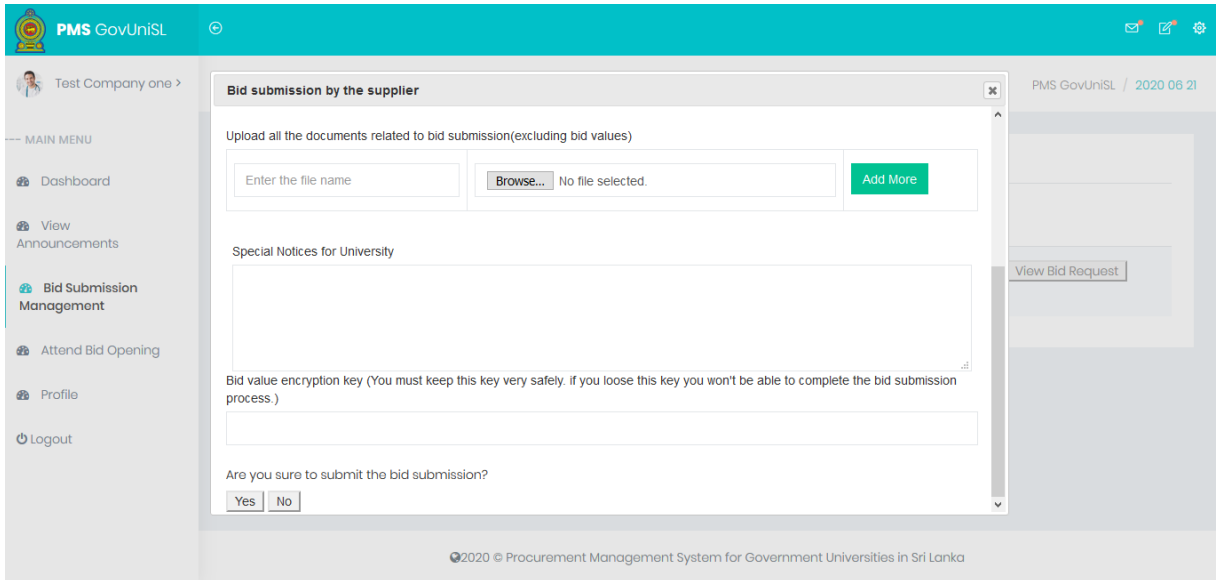


Figure D.11: User interface used to submit bids with encryption key

- 1) User interface used to show list of bid submissions which are ready to be opened by the respective tender committee leader of a specific tender request.

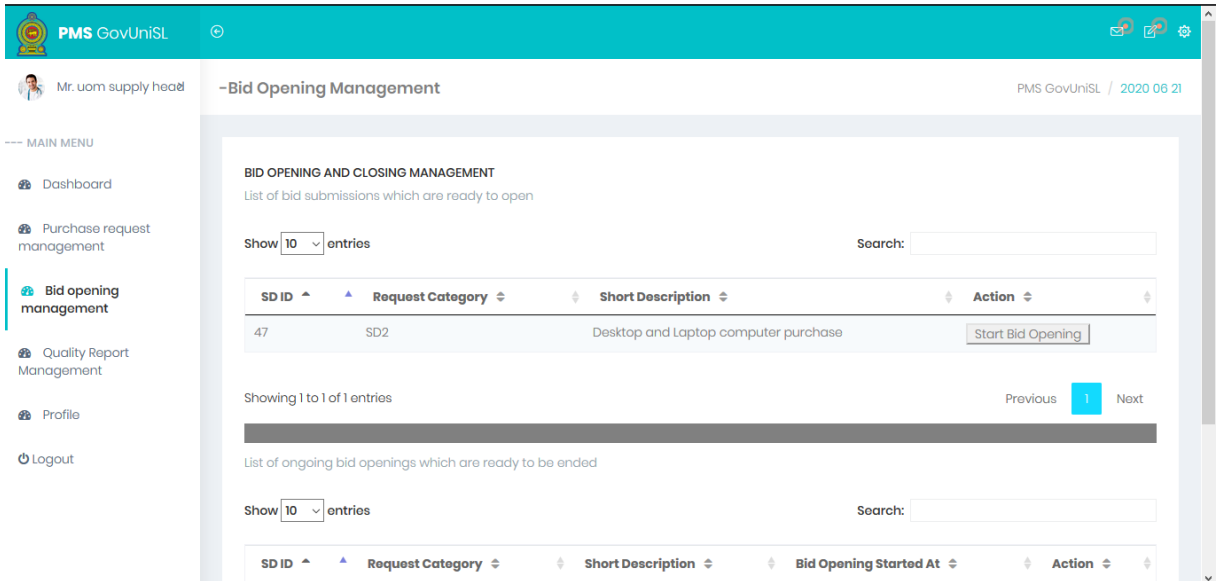


Figure D.12: User interface used to show list of bid submissions which are ready to be opened

m) User interface used to participate for bid opening by a relevant supplier with entering encryption key to decrypt the bid values.

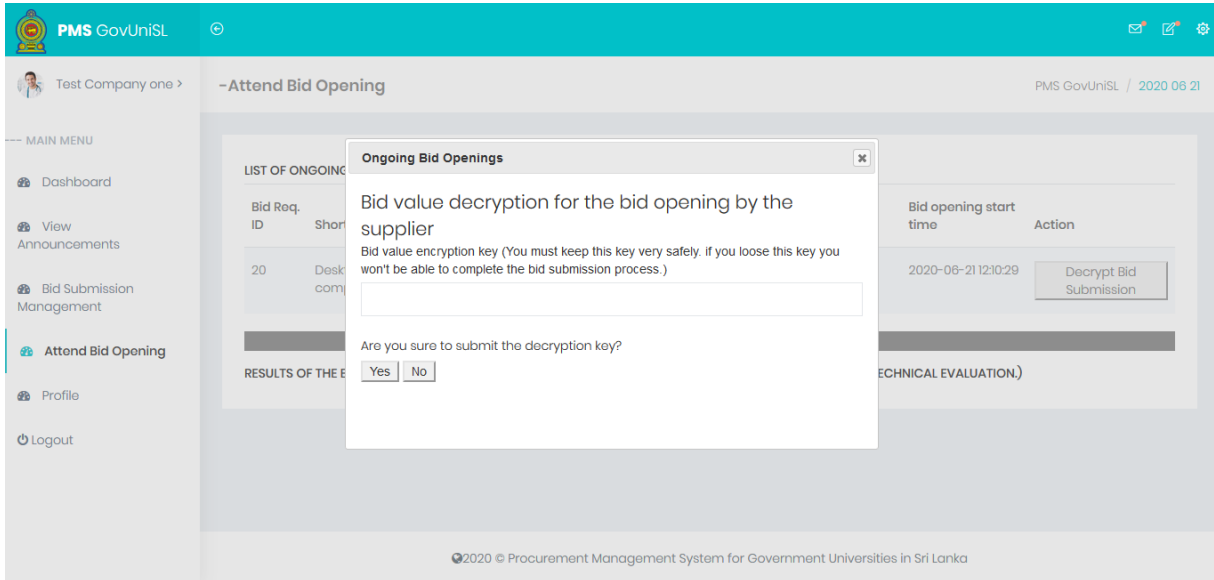


Figure D.13: User interface used to participate for an ongoing bid opening by a supplier

n) User interface used to end an ongoing bid opening.

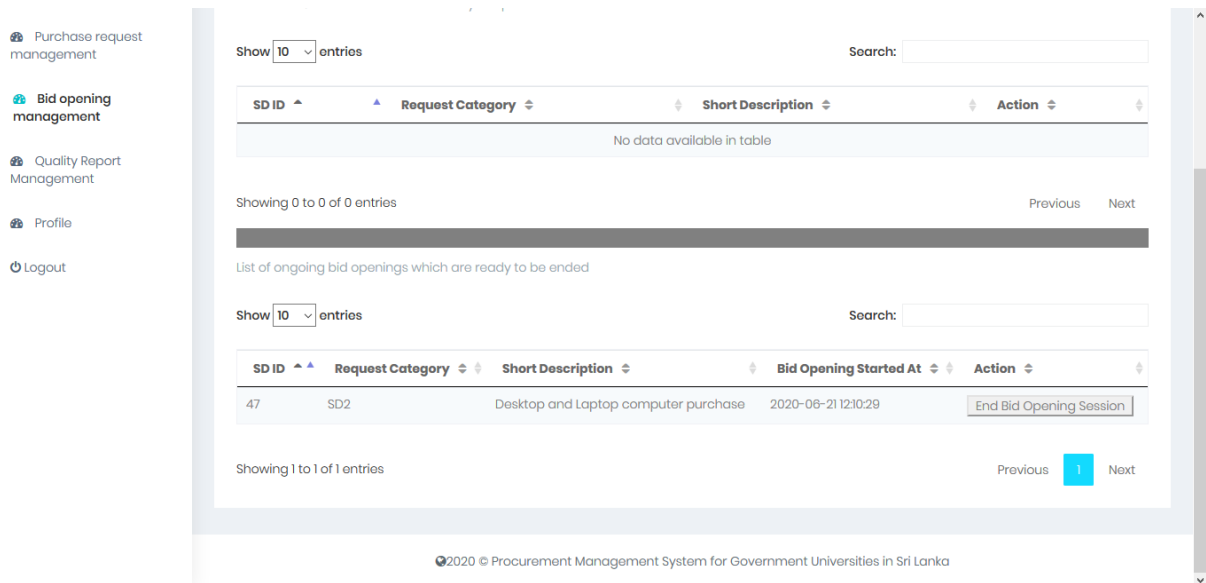


Figure D.14: User interface used to end an ongoing bid opening

o) User interface used to show to bid opening summary report by a supply officer of a university.

RESULTS OF THE COMPLETED BID OPENINGS (THIS IS NOT THE FINAL AWARDED LIST. IT WILL BE PUBLISH AFTER THE TECHNICAL EVALUATION.)

Show  entries Search:

Bid Prep. ID	Supplier Name	Item Description	Bid Submission Deadline	Value
10	Test Company one	computer	2020-06-10 13:00	1500.00
18	Test Company one	Core i7 Desktop Computers	2020-06-12 10:00	875000.00
18	Test Company one	Core i7 Laptop computer	2020-06-12 10:00	250000.00
18	test supplier two	Core i7 Desktop Computers	2020-06-12 10:00	900000.00
18	test supplier two	Core i7 Laptop computer	2020-06-12 10:00	275000.00
20	Test Company one	Core i7 Desktop Computer	2020-06-20 10:00	850000.00
20	Test Company one	Core i7 Laptop Computers	2020-06-20 10:00	1000000.00

Showing 1 to 7 of 7 entries Previous 1 Next

Figure D.15: User interface used to show the bid opening results of a university

## APPENDIX E - REPORTS

Following are list of summary reports generated by the Web-based procurement management system.

PURCHASE REQUEST SUMMARY (SD1/SD2)

Show  entries Search:

SD ID	Request Category	Short Description	Last Action	Last Action Date	Next Pending Action	Relevant Officer	Action
38	SD1	test sd form one	bid_opening_closing	2020-06-16 12:14:10	Supply division	Supply officer	<a href="#">View</a>
39	SD1	test sd one two	tender_request	2020-06-13 11:10:29	Supply division	Supply officer	<a href="#">View</a>
41	SD1	test sd form three	approve_and_forward	2020-06-11 08:20:49	approve_and_forward	Samantha Perera	<a href="#">View</a>
42	SD1	test sd form five	create_purchase_request	2020-06-11 23:17:16	approve_and_forward	Nuwan Dayananda	<a href="#">View</a>
43	SD2	asdfa	bid_opening	2020-06-16 12:15:02	Supply division	Supply officer	<a href="#">View</a>
45	SD2	Core i7 Desktop Computers and Laptop	bid_opening_closing	2020-06-16 13:56:13	Supply division	Supply officer	<a href="#">View</a>
47	SD2	Desktop and Laptop computer purchase	create_purchase_request	2020-06-19 13:28:02	approve_and_forward	Nuwan Dayananda	<a href="#">View</a>

Figure E.1: List of purchase orders generated by a supply owner of a specific department

RESULTS OF THE COMPLETED BID OPENINGS (THIS IS NOT THE FINAL AWARDED LIST. IT WILL BE PUBLISH AFTER THE TECHNICAL EVALUATION.)

Show  entries Search:

Bid Prep. ID	Supplier Name	Item Description	Bid Submission Deadline	Value
10	Test Company one	computer	2020-06-10 13:00	1500.00
18	Test Company one	Core i7 Desktop Computers	2020-06-12 10:00	875000.00
18	Test Company one	Core i7 Laptop computer	2020-06-12 10:00	250000.00
18	test supplier two	Core i7 Desktop Computers	2020-06-12 10:00	900000.00
18	test supplier two	Core i7 Laptop computer	2020-06-12 10:00	275000.00

Showing 1 to 5 of 5 entries Previous [1](#) Next

Figure E.2: Results summary of bid opening of a university

## APPENDIX F - TEST RESULTS

Following Table F.1 shows the survey form used to gather the feedback of the end users of the developed system.

<b>Survey on</b>					
<b>Web-based procurement management system for government universities in Sri Lanka</b>					
Date:		Name:		Designation:	
This survey is conducted to achieve the evaluation on the developed web-based system. I would appreciate your help by participating to the system testing and complete the below server questioner by putting “X” to appropriate column.					
#	Question	Strongly Agree	Agree	Disagree	Strongly Disagree
Q1	Web application interfaces are simple enough to understand.				
Q2	Web application increases the efficiency of the entire procurement process.				
Q3	System menu navigation is simple and easy to understand.				
Q4	Data processing speed of this system is at a considerable level compared to other web-based applications.				
Q5	Keeping central web-based system to manage entire procurement of the Sri Lankan government universities is effective.				
Q6	Fully online data encryption-based bid submission and bid opening system features increase the efficiency of the bidding process.				
Q7	System needs to be improved with new features such as tender award management, purchase order management, goods receive management.				
Any other comments					
Thank you					

Table F.1: Survey form



## APPENDIX G - CODE LISTINGS

Following are some of important code segments used to develop the system.

### a) Function used to encrypt the bid values

```
14 // function used to encrypt the bid value details
15 function encrypt($message, $encryption_key) {
16     $key = hex2bin($encryption_key);
17
18     $nonceSize = openssl_cipher_iv_length('aes-256-ctr');
19     $nonce = openssl_random_pseudo_bytes($nonceSize);
20
21     $ciphertext = openssl_encrypt(
22         $message,
23         'aes-256-ctr',
24         $key,
25         OPENSSSL_RAW_DATA,
26         $nonce
27     );
28     return base64_encode($nonce . $ciphertext);
29 }
```

### b) Function used to decrypt the encrypted bid values

```
31 // function used to decrypt bid value details
32 function decrypt($message, $encryption_key) {
33     $key = hex2bin($encryption_key);
34     $message = base64_decode($message);
35     $nonceSize = openssl_cipher_iv_length('aes-256-ctr');
36     $nonce = mb_substr($message, 0, $nonceSize, '8bit');
37     $ciphertext = mb_substr($message, $nonceSize, null, '8bit');
38
39     $plaintext = openssl_decrypt(
40         $ciphertext,
41         'aes-256-ctr',
42         $key,
43         OPENSSSL_RAW_DATA,
44         $nonce
45     );
46     return $plaintext;
47 }
```

### c) Function used to get list of ongoing tender openings which are ready to end

```
413 function get_list_of_purchase_orders_ready_to_close($tender_committee_head_id){
414     $this->db->select('bid_preparation.pr_id, purchase_request.request_category, '
415         . 'purchase_request.short_description, purchase_request_status.timestamp');
416     $this->db->from('bid_preparation');
417     $this->db->join('purchase_request', 'bid_preparation.pr_id = purchase_request.id');
418     $this->db->join('purchase_request_status', 'purchase_request.id = purchase_request_status.pr_id');
419     $current_date_time_value = date("Y-m-d H:i:s");
420     $this->db->where('bid_preparation.tender_committee_leader', $tender_committee_head_id);
421     $this->db->where('bid_preparation.bid_closing_date_time <', $current_date_time_value);
422     $this->db->where('purchase_request_status.next_action', 'bid_opening_closing');
423     $this->db->where('purchase_request_status.netxt_action_status', 'no');
424     $query = $this->db->get();
425     $data = $query->result_array();
426     return $data;
427 }
```

d) AJAX function used to submit encrypted bid values of each item.

```
141 | $(("#submit_bid_to_university").on('submit', function (e) {
142 |     e.preventDefault();
143 |     $.ajax({
144 |         type: 'POST',
145 |         url: '<?php echo base_url(); ?>bid_submission_management/submit_bid_iteams_values',
146 |         data: new FormData(this),
147 |         contentType: false,
148 |         cache: false,
149 |         processData: false,
150 |         beforeSend: function () {
151 |             $('#uploading_message').html("<label class='text-success'>Purchase Request Sending...</label>");
152 |         },
153 |         success: function (data)
154 |         {
155 |             alert("Bid value submitted successfully...");
156 |         }
157 |     });
158 | });
159 |
160 |
161 |
```