Faculty of Computer Science and Information Technology
University of Malaya
2000/2001

UNIVERSITY OF MALAYA'S ELECTRONIC PROCUREMENT SYSTEM (UMEPS)

VERSION 3.0

CHIA WEE LENG
WET 98016

Under Supervision of

Mr. Ling Teck Chaw

Dissertation submitted in partial fulfilment of the requirements
for the degree of Bachelor of Information Technology

University of Malaya

ABSTRACT

University of Malaya's Electronic Procurement System (UMEPS) is a project in association with the government's mission in implementing Electronic Government, one of the seven flagship applications under Multimedia Super Corridor (MSC). It involves the automation of all business processes in the university.

UMEPS is a Web-based procurement system that allows the faculties or departments in the university to electronically select items to be procured, initiate an electronic approval process and also create, submit and receive purchase orders, delivery orders and other related documents electronically. The six user groups of UMEPS include requestors, suppliers, approvers, treasurers, administrators and managers. The entire system is based on a three-tier client/server architecture. All communications of the system are done via the TCP/IP protocol.

This dissertation introduces the project and provides a description on the topics studied and researched during the literature review. It also extracts the findings from the requirements and analysis process for the intent of system design. Project modules specific to the development of this system include Audit Trail, Archive, Quotation Requisition, Supplier Information and Supplier Profile.

University of Malaya

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION 1

1.1 INTRODUCTION 1
1.2 PROJECT OVERVIEW 1
1.3 PROJECT OBJECTIVES 3
1.4 PROJECT SCOPE 3
1.4.1 Audit Trail 4
1.4.2 Document Management 4
1.4.3 Supplier Registration 4
1.4.4 Supplier Performance Rating 4
1.4.5 Graphical User Interface (GUI) 5
1.5 PROJECT MOTIVATION 5
1.6 PROJECT FEASIBILITY 6
1.7 PROJECT OUTCOME 7
1.8 PROJECT SCHEDULE 7
1.9 PROJECT LAYOUT 9

CHAPTER 2: LITERATURE REVIEW 10

2.1 THE ADVENT OF ELECTRONIC COMMERCE 10
2.2 ELECTRONIC PROCUREMENT SYSTEM (EPS) 11
2.3 EXISTING ELECTRONIC PROCUREMENT SYSTEMS 13
2.3.1 Free Trade Zone - www.freetradezone.com 13
2.3.2 IT Supermall – www.itsupermall.com.my 15
2.3.3 Singapore Electronic Procurement System (SEPS) 16
2.3.4 Imperial College's Electronic Procurement System 18
2.3.5 University of Malaya's Electronic Procurement System 20
2.4 EPS USING WORLD WIDE WEB APPROACH 25
2.5 EPS USING CLIENT/SERVER COMPUTING 26
2.6 EPS USING THREE-TIER ARCHITECTURE 28
2.7 EPS USING LOTUS NOTES/DOMINO 30
2.7.1 Lotus Notes/Domino 30
2.7.2 Features of Lotus Domino 31
2.7.3 Advantages of developing Web Application with Notes/Domino 32
2.8 SECURITY AUDITS 34
2.8.1 Functions of Security Audits 35
2.8.2 Logging and Audit Trails with Lotus Notes/Domino 35
2.9 DOCUMENT MANAGEMENT 36
2.9.1 Elements of a DMS 38
2.9.2 Storage and Retrieval in a DMS 39
2.9.3 Benefits of using DMS 39
2.10 CONCLUSION 40

CHAPTER 3: SYSTEM ANALYSIS AND REQUIREMENTS 41

3.1 INTRODUCTION 41
3.2 ANALYSIS METHODOLOGY 41
3.2.1 Interview 41
3.2.2 Existing System and User Manual 42
3.2.3 Thesis reports 42
3.2.4 Library Research 43
3.2.5 Internet Research 43
3.3 DEVELOPMENT METHODOLOGY 43
3.4 THE ANALYSIS 45
3.5 FUNCTIONAL REQUIREMENTS 45

3.5.1 Tracking of Normal Database Activities 45
3.5.2 Audit Records Archiving 46
3.5.3 Generation of Selected Audit Records 46
3.5.4 Removal of Outdated Audit Records 46
3.5.5 Tracking of Abnormal Database Activity 47
3.5.6 Storage of Obsolete Documents 47
3.5.7 Retrieval of Obsolete Documents 47
3.5.8 New Suppliers Notification 48
3.5.9 Supplier Performance Rating 48
3.5.10 Graphical User Interface 48
3.6 NON-FUNCTIONAL REQUIREMENTS 48
3.6.1 Security 49
3.6.2 Reliability and Availability 49
3.6.3 User Interface 49
3.6.4 Accessibility 49
3.6.5 Robustness 50
3.6.6 Modularity 50
3.6.7 Efficiency 50
3.6.8 Maintainability 50
3.7 CONCLUSION 51

CHAPTER 4: SYSTEM DESIGN 52

4.1 INTRODUCTION 52
4.2 APPLICATION ARCHITECTURE 52
4.3 NOTES DATABASE COMPONENTS 53
4.4 OVERALL DESIGN AND FLOW 55
4.5 DATABASE DESIGN 59
4.5.1 Audit Trail Database 59
4.5.2 Archive Database 66
4.5.3 Supplier Information Database 68
4.5.4 Supplier Profile Database 69
4.6 USER INTERFACE DESIGN 70
4.7 CONCLUSION 72

CHAPTER 5: IMPLEMENTATION 73

5.1 INTRODUCTION 73
5.2 ARCHIVE MODULE 73
5.2.1 Creating the Archive database 73
5.2.2 Creating the Purchase Requisition form 73
5.2.3 Creating a view for Requestors 86
5.2.4 Creating the '$$ViewTemplate for Requestors' form 86
5.2.5 Creating the 'ArchiveDoc' agent 90
5.2.6 Linking database to main page 90
5.3 AUDIT TRAIL MODULE 91
5.3.1 Creating the Audit Log database 91
5.3.2 Creating the '$$ViewTemplate for MiscEvents' form 92
5.3.3 Linking the database to main page 95
5.4 SUPPLIER PERFORMANCE RATING SUB-MODULE 96
5.4.1 Creating the 'CheckDuplicateRating' agent 96
5.4.2 Enabling the execution of agent 98
5.5 SUPPLIER PROFILE SUB-MODULE 98
5.5.1 Creating a 'SendMail' function 98
5.5.2 Creating a 'SendTo' hidden field 99
5.6 INTERFACES 100
5.6.1 Creating icon buttons 100
5.6.2 Rectifying distorted headers and hidden fields 101

University of Malaya

5.7 SYSTEM SETUP 102
5.8 SECURITY SETUP 103
5.8.1 Creating a CA key ring file and certificate 103
5.8.2 Configuring the Domino CA application profile 104
5.8.3 Setting up SSL on the CA server 104
5.9 CONCLUSION 105

CHAPTER 6: TESTING 106

6.1 INTRODUCTION 106
6.2 UNIT TESTING 106
6.2.1 Icon Buttons 106
6.2.2 E-mail notification 107
6.2.3 Supplier Duplicate Rating 109
6.2.4 Archive Documents 110
6.3 INTEGRATION TESTING 111
6.4 SYSTEM TESTING 113
6.5 CONCLUSION 118

CHAPTER 7: SYSTEM EVALUATION & CONCLUSION 119

7.1 INTRODUCTION 119
7.2 SYSTEM STRENGTHS 119
7.2.1 Security 119
7.2.2 Easy Retrieval of Archived Documents 120
7.2.3 Supplier Performance Rating 120
7.2.4 E-mail Notification 120
7.2.5 Efficiency 121
7.2.6 Effective User Management 121
7.3 SYSTEM LIMITATIONS 121
7.3.1 No Electronic Payment 121
7.3.2 Browser's cache information 122
7.4 PROBLEMS ENCOUNTERED AND SOLUTIONS 122
7.4.1 Corrupted Server Identification File 122
7.4.2 Certificate Valid End Date Has Expired 123
7.4.3 Invalid Password or Stash File 123
7.4.4 Building and Modifying Notes Application 124
7.5 FUTURE ENHANCEMENT 125
7.5.1 General Packet Radio Services (GPRS) for Notification 125
7.6 CONCLUSION 125

APPENDIX A: FLOW OF THE PROCUREMENT PROCESS IN UM 131

ABSTRACT I

ACKNOWLEDGEMENT II

TABLE OF CONTENTS III

LIST OF TABLES VI

LIST OF FIGURES VII

University of Malaya

LIST OF TABLES

TABLE 4.1: USERS OF UMEPS..... 56

TABLE 4.2: DATA ACCESS AND FUNCTIONS FOR USER GROUPS OF UMEPS.....58

TABLE 4.3: ACCESS CONTROL LISTS FORAUDIT TRAIL DATABASE.....60

TABLE 4.4: LIST OF AUDIT DESCRIPTIONS AND AUDIT EVENTS.....62

TABLE 4.5: LIST OF FORMS FOR AUDIT TRAIL DATABASE.....64

TABLE 4.6: FORM DESIGN FOR FORM NAME: $$VIEWTEMPLATE FOR MISCEVENTS.....65

TABLE 4.7: EMBEDDED VIEW FOR FORM NAME: $$VIEWTEMPLATE FOR MISCEVENTS.....65

TABLE 4.8: LIST OF AGENTS USED IN AUDIT TRAIL DATABASE.....65

TABLE 4.9: THE ORIGINAL DATABASES FOR BUSINESS DOCUMENTS INVOLVED IN ARCHIVING.....67

TABLE 4.10: ACCESS CONTROL LISTS FOR ARCHIVE DATABASE.....67

TABLE 4.11: LIST OF FORMS FOR ARCHIVE DATABASE.....67

TABLE 4.12: LIST OF AGENTS USED IN ARCHIVE DATABASE.....68

TABLE 4.13: FORM DESIGN FOR FORM NAME: $$VIEWTEMPLATE FOR REQUESTORS.....68

TABLE 4.14: ADDITIONAL AGENT IN THE SUPPLIER INFORMATION DATABASE.....69

TABLE 4.15: LIST OF FORMS MODIFIED FOR SUPPLIER PROFILE DATABASE.....69

TABLE 4.16: ALL FIELDS AFFECTED IN THE MODIFICATION OF NEW SUPPLIER FORM.....69

TABLE 4.17: LIST OF AGENTS MODIFIED FOR SUPPLIER PROFILE DATABASE.....69

University of Malaya

LIST OF FIGURES

FIGURE **1.1:** PROJECT TIMELINE FOR UMEPS....8

FIGURE **3.1:** THE EVOLUTIONARY PROTOTYPING MODEL....44

FIGURE **4.1**: THE THREE-TIER CLIENT/SERVER ARCHITECTURE OF UMEPS....53

FIGURE **4.2**: OVERALL SYSTEM STRUCTURE CHART....55

FIGURE **4.3**: USERS OF UMEPS....59

FIGURE **4.4:** CONTEXT DIAGRAM OF AUDIT TRAIL PROCESS....61

FIGURE **4.5:** CONTEXT DIAGRAM OF DOCUMENT MANAGEMENT PROCESS....66

FIGURE **4.6:** A BROWSER INTERFACE OF UMEPS VERSION 2.0....70

FIGURE **4.7:** AN INTERFACE OF UMEPS VERSION 2.0 WITH DUPLICATION OF BUTTON BARS....71

FIGURE **4.8:** AN INTERFACE OF UMEPS VERSION 3.0 WITH DISTORTED TOP HEADER....72

FIGURE **5.1:** ICON BUTTONS FOR ARCHIVE MODULE....100

FIGURE **5.2:** ICON BUTTONS FOR AUDIT TRAIL MODULE....100

FIGURE **5.3:** THE STANDARD LOGO FOR UMEPS....101

FIGURE **5.4:** THE TOP HEADER AFTER BEING RECTIFIED....102

FIGURE **6.1:** THE ICON BUTTON APPEARS EMBOSSED WHEN THE MOUSE IS ROLLED OVER IT....107

FIGURE **6.2:** A SUPPLIER REGISTERING ITSELF AS PINNACLE....108

FIGURE **6.3:** AN E-MAIL NOTIFICATION WAS GENERATED TO UMEPS@HOTMAIL.COM....109

FIGURE **6.4:** AN ERROR MESSAGE GENERATED BY UMEPS FOR DUPLICATE RATING....110

FIGURE **6.5:** THE MAIN DATABASE AS SEEN BY A REQUESTOR....112

FIGURE **6.6:** WHAT THE REQUESTOR SEES UPON CLICKING THE 'ARCHIVE DOCUMENTS' LINK....113

FIGURE **6.7:** A USER LOGS IN AS 'ADMIN CWL'....114

FIGURE **6.8:** USER 'ADMIN CWL' CLICKS ON THE 'AUDIT RECORD' LINK....115

FIGURE **6.9:** USER 'ADMIN CWL' SELECTS THE AUDIT RECORD OF INTEREST....116

FIGURE **6.10:** USER 'ADMIN CWL' VIEWING THE AUDIT LOG THAT HAS BEEN REQUESTED....117

FIGURE **6.11:** USER 'ADMIN CWL' LOGS OUT OF UMEPS VERSION 3.0....118

University of Malaya

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

In today's lightning-paced business climate, many organisations are still placing, receiving and tracking orders with the phone and fax. This inefficient mode of communication causes significant business pain between buyers and vendors. While the phone and fax are tried and tested procurement tools, it has been rendered almost anachronistic by rapid migration to Web-based solutions, which brings many buyers together with many vendors.

What is happening in the procurement market now is evolution in fast forward mode. Everyone is jumping on the bandwagon – venture capitalist, software providers, and most significantly purchasing organisations themselves. Holec (2000), global leader for Procurement Services for PriceWaterhouseCoopers, observed that virtually every company in the Fortune 500 has implemented or prototyped or piloted an electronic procurement application [1].

Pioneers in the e-procurement marketplace include industrial giants like General Motors, Ford, Chevron and Du Pont [1]. Other companies are beginning to examine how electronic procurement could help them eliminate inefficiencies in their management of purchasing transactions. Based on these arguments, Malaysia must fully embrace not only the vision, but also the reality of a comprehensive electronic procurement system.

1.2 PROJECT OVERVIEW

University of Malaya's Electronic Procurement System (UMEPS) is a web-based procurement system that allows the faculties or departments in the university to electronically select items to be procured, initiate an electronic approval process and

also create, submit and receive purchase orders, delivery orders and other related documents electronically.

The entire system is based on a three-tier client/server application architecture. The six user groups of UMEPS that consists of Requestors, Approvers, Treasurers, Administrators, Managers and Suppliers can access the system from the Web server through the Internet as all system communications are done via TCP/IP Protocol. The data in the system are kept in the database server. Users can access the system from any location and at any time with easy access and round-the-clock availability.

Requestors are able to browse through the catalog database to search for products offered by the registered suppliers of UMEPS and view the funds available for procurement. They are also capable of making Request for Quotations (RFQs), initiate Purchase Requisitions (PR) and sending them for approvals, handling Purchase Orders (PO) and Invoices. After having procured the products successfully, Requestors can retrieve backdated documents for references from the archive database.

Suppliers can register into UMEPS and update their information database in the system once the Treasurers have approved the Suppliers' registration. Suppliers are able to update their product catalog, respond to RFQs by Requestors, and generate Delivery Orders (DO). After the completion of order-fulfillment process, Suppliers are capable of retrieving backdated documents for references from the archive database.

Systems Administrators are able to monitor and track each and every activity of the users through the audit trail database. Should there be any intrusion into the system by outsiders, Systems Administrators can then alert the respective users on the situation. This measure could prevent the system from being jeopardised, thus ensuring the security of all users and organisations involved.

University of Malaya

1.3 PROJECT OBJECTIVES

The primary objective of this project is to review the current University of Malaya's Electronic Procurement System (UMEPS) to find approaches to enhance the entire system. The secondary objective is to find solutions to loopholes identified in the current system, thereby producing an error-free and integrated system.

UMEPS would maintain University of Malaya as the frontier in the Information and Communication Technology (ICT) era. It would also increase the collaboration between University of Malaya and other business partners. Having said that, it is hoped that UMEPS will be implemented in University of Malaya (UM) in the near future.

Summary of Objectives:

- To enhance UMEPS (Version 2.0)
- To rectify bugs identified in UMEPS (Version 2.0)

1.4 PROJECT SCOPE

The scope of this project is based on the project objectives. Hence, in terms of system enhancement, the focus areas involve four main modules, namely audit trail, document management, approval dues and supplier registration. In the aspect of error rectification, target areas include supplier performance rating and graphical user interface (GUI).

University of Malaya

1.4.1 Audit Trail

This module provides systems administrators with information pertaining to users' activities from the time users log in to the system to the time when users log out. The points between the logging in to and logging out from the system are recorded in detail in the audit trail database. An audit trail system complements the existing security features of UMEPS.

1.4.2 Document Management

This module enables the transfer of outdated electronic documents that are more than three (3) months old, such as request for quotations (RFQs), purchase requisitions (PR), quotations, purchase orders (PO), and invoices into an archive database. Users of UMEPS are able to retrieve those archived documents should the need arises. A document management system ensures systematic handling of documents.

1.4.3 Supplier Registration

When a supplier organisation registers with UMEPS, the supplier has to wait for the treasurer to approve its registration before being able to utilise the system. Currently, the status of new registered suppliers is not made known to the treasurer. This module therefore enables the generation of e-mail notification to the treasurer on the amount of supplier registration requests that needs to be approved.

1.4.4 Supplier Performance Rating

In ensuring the best pool of suppliers is obtained for the procurement of all products, requestors can perform supplier evaluation through ratings. Currently, a requestor can do multiple evaluations on the same supplier. This results in a conflict of ratings

University of Malaya

given, and reflect poorly on the integration of the system. A debugging of codes will be done to rectify this error.

1.4.5 Graphical User Interface (GUI)

To achieve perfection in terms of GUI, a restoration of distorted 'top header' in the purchase requisition document, as well as the elimination of duplicate 'action bar' will be carried out. This will also involve the debugging of existing codes.

1.5 PROJECT MOTIVATION

Project motivation serves as a catalyst toward the successful implementation of UMEPS. The motivation refers to the advantages gained from an automated procurement process.

The advantages of UMEPS are evident in terms of efficient communications between buyers and suppliers, and convenience on a 24x7 basis. UMEPS also means lesser time to complete the entire buy/sell process, elimination of processing errors, and up-to-date status and alert. It also provides for more flexibility in that it minimises ongoing maintenance and IT (Information Technology) resources. As a web-based application, it provides UM with a large pool of suppliers, both nationally and internationally. Finally, with the automation of procurement system in University of Malaya, procurement personnel can focus time and effort on other work that are more vital towards the organisation's success.

Summary of Project Motivation:

- Efficiency in terms of tracking, managing and placing orders
- Convenience in terms of accessibility and availability round the clock

University of Malaya

- Speed in terms of order and payment fulfilment
- Accuracy in terms of reduction of processing errors
- Real-time information with up-to-date status and alerts
- More flexibility as there is little need for maintenance
- Instant global business-to-business e-commerce reach
- Strategic usefulness with a shift of focus in workload

1.6 PROJECT FEASIBILITY

The viability of implementing this project is justified in three main areas. A version upgrade of this project does not incur any extra costs as all the hardware, software and tools are readily available in the Network Lab, Faculty of Computer Science and Information Technology, University of Malaya. The scopes of this project are also structured according to the duration given for the project. Most importantly, this project augurs well in accordance to the Malaysian government's vision to realise the electronic government (e-government) flagship application of Multimedia Super Corridor (MSC). This is timely as some local companies in Malaysia has already ventured into electronic procurement.

Summary of Feasibility:

- Cost savings
- Sufficient time
- Appropriateness

University of Malaya

1.7 PROJECT OUTCOME

The final product of this project will see an enhanced and improved version of UMEPS. The functionality of the overall system will be more complete with the Audit Trail System and Document Management System. Besides that, improved features will also be incorporated into existing modules to ensure promptness and smooth flowing in the electronic procurement process. The faults in the current system will also be patched up, resulting in an impressive, state-of-the-art system.

1.8 PROJECT SCHEDULE

Table 1.1 illustrates the milestones scheduled for the development of UMEPS.

University of Malaya

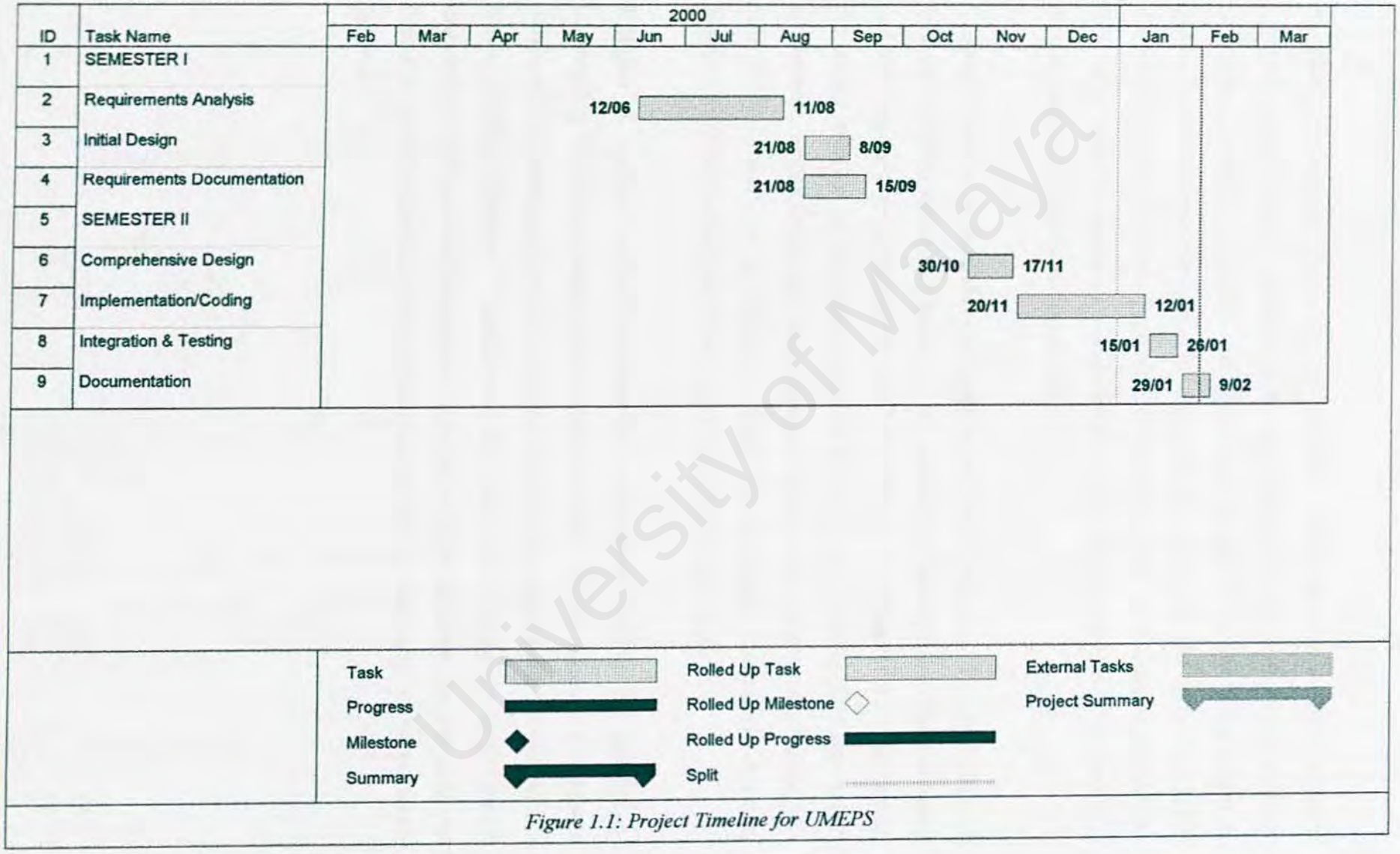

Figure 1.1: Project Timeline for UMEPS

University of Malaya

1.9 PROJECT LAYOUT

Chapter 1 introduces University of Malaya's Electronic Procurement System (UMEPS) with a concise description on the project overview, objective, scopes, motivation, feasibility, schedule and outcome. **Chapter 2** describes the research involved in developing UMEPS. These include the survey on the current UMEPS Version 2.0, other Electronic Procurement Systems (EPS), EPS using client/server, EPS using three-tier application architecture, EPS using Lotus Notes & Domino, security audit and document management.

Chapter 3 covers the methods of analysis as well as the outcome of analysis derived from the literature survey in *Chapter 2*, with a complete description of the functional and non-functional requirements for UMEPS Version 3.0. **Chapter 4** concerns with the design involved in developing UMEPS Version 3.0. These include the system architecture, overall design and flow, database design, and user interface design. The bulk of the database design focuses on these five databases: Audit Trail, Archive, Supplier Information, Supplier Profile, and Quotation Requisition.

Chapter 5 touches on the development environment during the process of constructing UMEPS as well as the implementation of each module. **Chapter 6** delves with the testing involved for different parts of the system and the system as a whole. Finally, **Chapter 7** summarises the entire development process through discussion of the problems encountered together with the solutions, the strengths and limitation of the system, and future enhancements plus a finale wrap-up of the whole project.

University of Malaya

CHAPTER 2: LITERATURE REVIEW

2.1 THE ADVENT OF ELECTRONIC COMMERCE

One of the most popular issues in the business media today is the direction, success and emergence of electronic commerce, or e-commerce as it is widely known. The impact of e-commerce is being felt all over the world, cutting across all boundaries. Such change and innovation has already taken place in the business-to-consumer (B2C) marketplace. Recent years have seen the rise of the consumer-direct model for all manners of products, from computers to toys [2]. Even more opportunity exists for innovation and change in the business-to-business (B2B) portions of supply chains.

Forrester Research predicts that the overall business opportunity for suppliers of Information Technology (IT) equipment, software and applications, to players in e-business worldwide will be worth US$1.3 trillion (RM4.94 trillion) by the year 2003, up from $43 billion in 1998 [3]. Goldman Sachs estimates that total business-to-business revenue will grow to $1.5 trillion in 2004, up from $114 billion in 1999, a rate of 67.5 percent Compound Annual Growth Rate (CAGR). Yet another recent study by consultants A.T. Kearney reveals that within two years as much as one-fourth of all external expenditures among United States companies will be made via the Internet. The volume now is only two percent [4].

According to a new study by Boston Consulting Group (BCG), business-to-business e-commerce will reach a whopping $2.8 trillion by 2003. That figure includes transactions via traditional electronic data interchange (EDI) networks. In 1998, by comparison, United States business-to-business e-commerce exchanges totaled $671 billion, out of which $92 billion transactions were handled over the Internet; the rest were handled via EDI [5].

University of Malaya

On the local front, an analysis on the development of e-commerce industry in Malaysia, based on a study on the e-commerce application server software market, was conducted by an international research company, Frost & Sullivan. It was concluded that the Malaysian market for e-commerce application server software experienced a dramatic growth of 184% in 1998, which resulted in revenue of US$3.8 million. By 2005, the estimated revenue is US$204.7 million [6].

2.2 ELECTRONIC PROCUREMENT SYSTEM (EPS)

The latest technological 'in-thing' is to get on the high-speed information technology highway. For the purchasing industry, electronic procurement is an IT-enabler for procurement - a tremendous powerful tool that will revolutionise the purchasing climate and beef up the organisation's bottom line. It automates and streamlines the laborious routine of the purchasing function, thus freeing up purchasing professionals to focus on more strategic purchases [7].

A recent survey conducted by Deloitte Consulting projects a huge surge in business-to-business e-commerce, with procurement driving a good part of the increase. Electronic procurement is a key part of nine out of 10 companies' business plans, according to the survey, which polled procurement managers at 200 global corporations. The analysts found that dramatic returns on investments (ROI) are behind the jump in business-to-business e-commerce. According to David Roddy, Chief Economist at Deloitte Consulting, e-procurement removes a lot of people from the transaction chain [5].

Electronic Procurement System (EPS) is the automation of the business processes between buyers and sellers [8]. In most countries, Governments are moving towards the direction of electronic procurement. They include the United States, Singapore, Canada, France, Malaysia and Hong Kong [9], among others. In Malaysia, the Government has recently awarded a RM14 million contract to Xybase Technologies

Sdn Bhd under the ePerolehan electronic procurement system project of the electronic government (e-government) initiative [10].

With the technological infrastructures now in place, is it indeed feasible for organisations around the globe to jump into the online procurement bandwagon. By utilising the Internet to streamline their procurement process, not only the buyer organisations stand to benefit from it but also the supplier organisations. It is a win-win situation.

Benefits to buyer organisations:

- Provides a cost effective and efficient virtual market solution for all purchasing needs, simplifying the procurement process.
- Reduces set-up costs through a centralised approach, thereby enabling participation by small and medium size enterprises.
- Reduces processing costs by 70% [11].
- Increases the profit margin [11].
- Reduces cycle time and lowers procurement and accounts payable costs.
- Establishes a platform for the high quality of exchange of information, allowing for integrated reporting of all transactions.
- Decreases the number of people involved in each purchase.
- Transforms employees into strategic buyers [11].
- Promotes active contact with supplier organizations through a community approach, thereby creating a more efficient marketplace.
- Provides a secure environment for electronic procurement.

Benefits to supplier organisations:

- Lowers set-up costs and allows for seamless integration into existing systems.
- Increases sales by establishing access to communities of buyers with similar needs.

University of Malaya

- Increases customer satisfaction with simplified 24x7 quotation, order taking, order tracking, and invoicing capability.
- Provides complete messaging solutions between buyer organisations and supplier organisations.

2.3 EXISTING ELECTRONIC PROCUREMENT SYSTEMS

One of the most dramatic manifestations of e-commerce is the rapid emergence of electronic procurement, or e-procurement. Companies are researching suppliers on the Web and then placing their orders for a range of products and services with no human intervention [4]. To date, there are many Web-based procurement system available on the Internet. Among the systems which have been reviewed thoroughly include the Free Trade Zone, IT Supermall, Singapore Electronic Procurement System (SEPS), Imperial College's Electronic Procurement System, and University of Malaya's Electronic Procurement System (UMEPS). Other existing systems include that of Caltex Corporation's Ariba Operating Resource Managing System (Ariba ORMS) [12], and Clarus Corporation's Clarus eProcurement 5.0 [13].

2.3.1 Free Trade Zone - www.freetradezone.com

The Free Trade Zone is a web-based procurement system that requires only an Internet browser as the software for the client side. It is a suite of integrated online services that address design and procurement tasks relating to electronic components. This includes part research and selection at design time, finding parts, and buying parts in an e-commerce marketplace. The Free Trade Zone is owned and operated by PartMiner, Inc., an independent company [14].

Currently, there are four main modules in this system namely **Marketplace**, **Design Center**, **Shopping Agent**, and **Community**. Supplier account information is made

available to registered users on the site so that buyer can easily contact new sources of product. On the other hand, a buyer's account information is only shared with the suppliers selected as preferred suppliers. The transaction data in a Request For Quotations (RFQ), quotes, negotiations, purchase orders (PO), and PO confirmations is a private exchange.

The **Marketplace** is an online electronic commerce application for electronic components. Buyers can submit RFQs that detail the parts needed and suppliers can respond with quotes on pricing and availability. In addition, the system stores the transaction information for the benefit of the members who can search previous RFQs, quotes, and purchase orders. It also provides an ad hoc discussion tool that permits the buyer and supplier to exchange information much like an e-mail system. The discussion tool can be used to negotiate a price or to arrange alternative products or deal with any other number of issues [15].

The **Design Center** provides information on over 12 million integrated circuits, discrete semiconductors, passives, connectors, opto-electronic devices, and more from thousands of manufacturers. There are three databases in the Design Center namely Semiconductors, Passives, and Connectors. The Design Center consists of four different search methods: Device Search, Parametric Search, Manufacturer Search, and Logo Search. Device Search searches for devices using the manufacturer part number, manufacturer name, keyword, or a combination of the terms. Parametric Search allows searches by selecting a device category and then specifying required parameters and associated values. Manufacturer Search, on the other hand, searches for a device using the manufacturer name or even manufacturer's contact information. Finally, Logo Search permits a visual search of the manufacturer's logo, which is useful in identifying unknown parts. The Design Center supports wildcard searching in all fields. Multiple entries in a search field at one time are also permitted. One of the most powerful features of the Design Center is the Compare feature that displays the parts side-by-side for easy comparison, and highlights attributes with differing values [16].

University of Malaya

The **Shopping Agent** is a web application that searches approximately two dozen electronic component distributor web sites for pricing and availability. The results of the search are displayed in one result set, thus saving the user considerable time in having to locate and search each site individually. It requires an ActiveX Control, a Microsoft design that allows code to be executed at the client workstation. When performing a search, part numbers can be imported from another application, such as Excel, into the search field in the Shopping Agent using the *Import* button. Shopping results can be exported to the local hard drive for later viewing by clicking on the *Export* button [17].

The **Community** pages enable information searching about suppliers in the Free Trade Zone, besides viewing articles about best practices and industry trends, listings of educational opportunities, and industry news. All the editing of profile information and company information are done here. The executions of invitations to new suppliers also take place in the Community pages [18].

2.3.2 IT Supermall – www.itsupermall.com.my

IT Supermall is Malaysia's first web-based procurement site for IT hardware, software and services. It is a business-to-business e-marketplace where corporate buyers can source for IT Suppliers and IT information [19]. Corporate buyers are provided with an e-commerce system for transactions with all other suppliers. IT Supermall is a neutral platform where all buyers and sellers are treated equally. There are no conflict-of-interest unlike buyer-owned or seller-owned portal. The IT Supermall is owned and operated by BDC Internet Business Center Sdn Bhd since June 28, 2000. It currently has 270 registered buyers and sellers [20].

There are two main user groups in IT Supermall namely **Buyers** and **Sellers**. **Buyers**, or Corporate Buyers, drill down to **Buyer's e-Marketplace** to issue Request For Quotation (RFQ) and Purchase Orders (PO). Under *MyGoldmine*, Buyers are able to list procurement transactions either *by date* or *by IT Supplier*. IT

Supermall provides buyers with Management Report for Asset Tracking, Software Tracking and Expenses Tracking, besides personalised terms and conditions of RFQ and PO for suppliers. The benefits of being a Corporate Buyer include the ability to source for the right IT Suppliers based on competitive pricing, stock availability and relevant expertise, fast service, better selection, and efficient e-commerce system [21].

Sellers, or IT Suppliers, drill down to **Seller's e-Marketplace**. Sellers announce company events through *MyCalendar*. Company's expertise, products and services are published in *MyDirectory*. Under *MyGoldmine*, IT Suppliers are able to view Open Bidding, and list e-commerce transactions either *by date* or *by Corporate Buyer*. IT Supermall provides sellers with Management Report on Business Leads and Market Intelligence on customers buying trends. As an IT Supplier, the benefits include the capability to generate business leads from customers who are ready to buy, and penetrate new markets for expansion using an efficient e-commerce system [22].

IT Supermall's unique feature refers to its WAP-powered (Wireless Application Protocol-powered) e-marketplace through its strategic partnership with Aranium.com. With this feature, Corporate Buyers can receive SMS (Short Message Services) or WAP alerts of customer's enquiry and Purchase Orders [23].

MIMOS iVEST and Digicert Digital Signatures are integrated with *MyGoldmine* Security Framework to ensure legality of documents, non-repudiation and authentication. These digital signatures are based on 128-bit encryption [23].

2.3.3 Singapore Electronic Procurement System (SEPS)

The Singapore Electronic Procurement System (SEPS) is a ministry-wide effort by the Singapore government to harness current technology for more effective procurement. SEPS is a complete end-to-end procurement solution, which facilitates

the generation of demand by the buyer to the fulfilment of the demand by supplier. Spearheaded by the National Computer Board (NCB), SEPS was launched in October 1996 [7].

The government's long-term goal is to improve the island state's competitive edge and enhance the efficiency and productivity of its ministries by reducing purchasing cycle time and cost, enhancing budgetary control, eliminating administrative errors, increasing buyers' productivity, lowering prices through product standardisation and consolidation of buy, improving the payment process, and improving information management [7].

Features of SEPS:

- The proficiency and accuracy of routine and repetitive purchases such as housekeeping items and stationery items are improved through the instantaneous online retrieval of the product specifications maintained in a **Centralised Product Databank**.

- The selection of a supplier for the Request For Quotation (RFQ) process is done through a **Centralised Supplier Databank**. The supplier/product relationship built by the intelligent database system is based on past purchases. This enables a pool of suppliers to be automatically presented to the purchasing officer for any specific buy.

- The increased accuracy of information is obtained through reduction in the number of data entry points in the process. All key information relevant to the purchase is entered into the system only once.

- Creation of RFQ, Purchase Requisition (PR), Invitation To Tender (ITT) and Purchase Order (PO) documents for approval are not only done electronically through the system, but is automatically routed to the appropriate approving

University of Malaya

authority. Electronic routing eliminates problems such as loss of documents and the need for manual tracking. Electronic documents can also be routed to personal e-mail addresses for approval.

- With EPS-enabled suppliers, manual data entry is eliminated as delivery information is sent directly to the appropriate mailbox. The Central Receiving Body then retrieves the information from the mailbox and verifies the contents of Delivery Order (DO) against the actual delivery. Any discrepancy between the specified and received quantity is quickly updated in the system.

- Invoices from suppliers are also electronically sent to the appropriate mailbox. Payment for the purchases is made upon the automatic matching of the invoice, the DO and the PO.

2.3.4 Imperial College's Electronic Procurement System

The Imperial College, University of London, consists of an organisation of 8,000 people, 5,000 on the main Kensington site, including undergraduate and postgraduate students, researchers, technical staff, lecturers and senior management. Over the past four years, Imperial College has conceived and implemented an ambitious programme to transform its traditional purchasing process into one based on e-procurement technology to improve the quality of service and offer better value for money for end-users. By doing so, the organisation predicted savings of £8.0 million a year plus freeing up to 70,000 hours of research time a year by ordering products online [24].

Imperial has put in place an e-procurement system, **Active Access**, which, when fully operational, will be the most advanced higher education purchasing system in the world. Its architecture is an extranet sitting on a central server that provides the bridge via HTTP (Hypertext Transfer Protocol) links to university client and supplier servers. The Active Access server has an IIS (Internet Information Server) Web

server, Cold Fusion middleware, Microsoft SQL (Structured Query Language) Server 6.5 database, Microsoft NT 4.0 and network software. Client servers run Netscape Navigator 3.0 and Internet Explorer 4.0 browsers [24].

There are four levels of users. **Account controllers** (divisional directors) are responsible for setting departmental budgets, **account holders** have full visibility of all transactions in their departments, and then there are **administrators** (secretaries) and **end-users** (budget holders). Usefully, the system knows if a user has both the budget and authority to purchase items [24].

The strategies for the project was to focus initial efforts on six areas, all representing high-volume, low value products. Having identified the six key product area that Active Access would first address, the initial pilot project was in purchasing print and photocopying with Xerox, according to Dr James Bayley. Through a central print facility, users go to the Active Access system via the Web page and select the kind of job they require. Xerox then delivers the finished job to desk within two hours. The second area the project focused on was stationery purchasing. An extensive catalogue of items from the selected stationery supplier, Guilbert, is available on Imperial's extranet, managed by the supplier but driven by the procurement team's analysis of what people are buying. Currently, the focus of the project is on the purchasing of laboratory consumables from its supplier, Merck. The Merck catalogue, which is fully integrated with Active Access, can be browsed through users' desktop [24].

Imperial's Purchasing Manager, Brad Swan, emphasised that the constant principle has been to not mandate the method of suppliers' presentation of their goods to users. The suppliers own their catalogue and therefore there is no stipulation on the suppliers' Web site functionality.

Active Access Key Features [24]:

- Full product information, picture, and price details.

- A single data store
- End-users access using familiar and easy-to-use browsers via the Internet which means access from anywhere in the world
- A fully integrated system
- Detailed management information needed to make the targeted savings and improvements

2.3.5 University of Malaya's Electronic Procurement System

The procurement process in University of Malaya begins when the need arises for a faculty or a department to acquire goods such as stationary items for the office or new computers for the upgrading of lab equipments. There are two main approaches to the process of procuring products from vendors: Quotation Process and Tender Process.

The Quotation Process is used for purchases less than RM100,000 while the Tender Process is used for purchases above RM100,000. The Quotation Process involves getting quotes from vendors in order to get the best price for the purchases. On the other hand, the Tender Process involves a more complex process where vendors are invited, normally through the local newspaper to submit their Tender Proposals.

2.3.5.1 Quotation Process

The general steps for a quotation process is as follow:

1. Buyer calls vendors to get quotations (Request for Quotation – RFQ).

2. Buyer summarises all quotations from different vendors and prepares a Summary Report and Table of Evaluation.

University of Malaya

3. Buyer then fills in the Requisition Form (RF) and submits it for approval together with the Summary Report and Table of Evaluation. The Head of Department is the only approving authority needed for purchases below RM5,000. If the total costs of purchases are between RM5,000 and RM99,999, approvals from the Dean of Faculty, Financial Controller or Deputy Vice Chancellor (TNC) is required, depending on the amount of purchases requisitioned.

4. Upon approval, the Purchase Order (PO) is prepared and sent to the vendor.

5. The vendor delivers the goods, together with a Delivery Order (DO), Invoice and a copy of the PO.

6. The faculty receives the goods and forwards the PO, DO and Invoice to the treasury for payment.

The Quotation Process is divided into a few sub-categories known as QP1, QP2, QP3, QBA1, and QBA2. In general, each of these sub-categories follows the same steps as stated in the steps above, with slight variation. Details are as follows:

Quotation Process - 1 [QP1]

- Items purchases at or below RM1,000 in value
- Requires quotation from one (1) supplier only
- Approval from the Head of Department only

University of Malaya

Quotation Process - 2 [QP2]

- Item purchases above RM1,000 and at or below RM5,000 in value
- Requires quotation from three (3) different suppliers
- Requires collation and evaluation of suppliers' quotations followed by preparation of summary report and table of evaluation
- Approval from Head of Department only

Quotation Process - 3 [QP3]

- Item purchases above RM5,000 and at or below RM10,000 in value
- Requires quotations from five (5) different suppliers
- Requires collation and evaluation of suppliers' quotations followed by preparation of summary report and table of evaluation
- Approval from the Dean

Quotation Process with Bursar's Office Approval - 1 [QBA1]

- Item purchases above RM10,000 and at or below RM50,000 in value
- Requires quotations from (5) different suppliers
- Requires collation and evaluation of suppliers' quotations followed by preparation of summary report and table of evaluation
- Approval from the Financial Controller or Deputy Vice Chancellor (TNC)
- Signing of agreement contract

Quotation Process with Bursar's Office Approval - 2 [QBA2]

- Item purchases above RM50,000 and at or below RM100,000 in value
- Requires quotations from five (5) different suppliers
- Suppliers must be registered with the Ministry of Finance

University of Malaya

- Requires collatioin and evaluation of suppliers' quotations followed by preparation of summary report and table of evaluation
- Approval from the Small Tender Board (Financial Controller and TNC)
- Signing of agreement contract and bank guarantee required from the selected supplier

2.3.5.2 Tender Process

The steps for the Tender Process are as follow:

1. Buyer (the requesting department) prepares the tender specifications and the tender document and submits them to the Treasury for approval.

2. Upon approval, the Treasury arranges for the Tender to be advertised in local newspapers.

3. Vendors who wish to respond purchase Tender Documents from University of Malaya and submit their Tender Proposal based on a given deadline.

4. Buyer reviews the Tender Proposals and prepares a Summary Report and Table of Evaluation.

5. A Technical Committee comprising of members from the Faculty evaluates the Tender Proposal.

6. Tender Board (from the Treasury Department) approves the tender.
7. Successful vendor is notified.

8. Stamping Process and Bank Guarantee is done.

9. Buyer prepares PO and sends it to vendor.

University of Malaya

10. The vendor delivers the goods, together with a Delivery Order (DO), Invoice and a copy of the PO.

11. The faculty receives the goods and forwards the PO, DO and Invoice to the treasury for payment.

Tender Process [TP1]

- Item purchases above RM100,000 in value
- Preparation of specifications and tender document by buyer
- Advertising of the tender by the Bursar's Office
- Collation and evaluation of Supplier tender proposals by the buyer
- Preparation of summary report and table of evaluation by buyer
- Evaluation of tender report by Technical Committee (members of committee are from the Department/Faculty)
- Approval by the Tender Board which consists of the Dean of Engineering, Financial Controller and Deputy Vice Chancellor (TNC) is required
- Approval by the Tender Board which consists of the Dean of Engineering, Financial Controller and Deputy Vice Chancellor (TNC) and a representative from the Ministry of Finance is required if the tender value is above RM5,000,000.
- Selection of (1) supplier and one (1) reserved supplier (in case the selected supplier rejects the tender) from the Tender Board meeting
- Sending of an offer letter by the Bursar's Office to the selected supplier. A reply must be obtained within 14 days from the date of the offer letter.
- Signing of an agreement, contract stamping and bank guarantee process within four (4) months from the date of the offer letter upon acceptance
- Negotiation of the agreement letter is not permitted
- Upon rejection from the selected supplier, an offer letter will be issued to the reserved supplier by the Bursar's Office

University of Malaya

2.4 EPS USING WORLD WIDE WEB APPROACH

The World Wide Web (WWW) is a hypermedia-based system for accessing information on the Internet, which integrates text, graphic images, and even links to voice and video into a multimedia document. The documents are composed of hypertext markup language (HTML), and can be located by the address known as uniform resource locator (URL). It is currently the fastest growing part of the network. The key to the power of the WWW is its user interaction model [8].

The Internet and WWW have changed the business rules. The potential savings buried in the buying patterns of companies could not be unlocked until the Internet provided a way to capture information about every purchase in almost real time [1]. By performing the procurement system using the WWW approach, the advantages include:

- **Low Cost**

  The EPS process using WWW can reduce the amount of time and resources used in handling papers and documents, managing the operation of keying and re-keying data into information systems, maintaining stocks of supplies and storage systems for paper products, and paying postage.

- **Ease of Use**

  WWW is based on a much simpler and integrated concept in obtaining information. The Graphical User Interface (GUI) components such as clickable buttons, radio buttons, and checkboxes enables users to easily adapt to the user-friendly system. The hassle of remembering computer commands are eliminated.

- **Integrated Interface**

  Users are allowed to use other Internet services from a single integrated interface through WWW. All that is needed is only a web browser such as Internet Explorer or Netscape Communicator.

University of Malaya

- **Easy to Update**

  A web-based procurement system is easy to update as any corrections, additions and updates to the database can be done easily, thus ensuring up-to-date information in the database. This results in integrity of data and information.

- **Security**

  Communications between buyers and suppliers are securely monitored through WWW using solutions such as the Secure Socket Layer (SSL), Secure Electronic Transactions (SET), digital signatures and firewalls.

- **Better Inventory Control**

  With a continuous Internet access, users of EPS (administrators, requestors and suppliers) can access the system 24 hours a day. This will result in better-managed and controlled inventories through the ability to exploit just-in-time (JIT) inventory techniques, promote direct delivery, speed the internal order process and eliminate paper-based process delays.

2.5 EPS USING CLIENT/SERVER COMPUTING

Client/Server Computing is a distributed computing. Users, applications and resources are distributed in response to business requirements and linked by a single Local Area Network (LAN) or Wide Area Network (WAN) or by an Internet of network [25]. In relation to the Internet, a server-centric model, along with a highly distributed client, offer the best performance to support a retail organisation's high-volume, high-velocity business.

Lawson (2000) pointed out that the key to the overall performance of the client/server system is the concept of "one and done" [26]. An organisation's e-procurement model demands that transactions are entered once then automatically transferred into appropriate operational, activity management and performance

University of Malaya

system. This one-and-done concept is critical to positive customer satisfaction. When a business steadily moves from 10 to 10 million orders a day, it becomes crucial that orders entering the system are integrated and processed in appropriate amount of time. The performance of an e-procurement system is judged not only on how quickly orders are processed for customers, but also how fast they are processed into all back-end systems.

The basic characteristics of client/server architectures are [27]:

- **Interactions and Functions**

  The client or front-end portion interacts with the users, the server or back-end portion interacts with the shared resources. The client process contains solution-specific logic and provides the interface between the user and the rest of the application system. The server process acts as a software engine that manages shared resources such as databases, printers, modems, or high powered processors.

- **Computing Resources Requirement**

  The front-end task and back-end task have fundamentally different requirements for computing resources such as processor speeds, memory, disk speeds and capacities, and input/output devices.

- **Heterogeneous Environment**

  The environment is typically heterogeneous and multivendor. The hardware platform and operating system of client and server are not usually the same. Client and server processes communicate through a well-defined set of standard application program interfaces (API).

- **Scalability**

  An important characteristic of client/server systems is scalability. They can be scaled horizontally or vertically. Horizontal scaling means adding or removing

University of Malaya

client workstations with only a slight performance impact. Vertical scaling means migrating to a larger and faster server machine or multiservers.

The benefits of implementing a procurement system using client/server computing include:

- Shorter software development time
- Ability to provide optimal support for department or organisation units
- Flexibility in allowing heterogeneous hardware and software to be used together
- Decentralised computing
- Existing hardware can remain in use

A client/server environment allows the use of many software development tools that help shorten the application development time. This means that requirements of a department can be met in time. It also allows the best hardware and software to be used to meet users' needs as different hardware and software is suited for different needs.

2.6 EPS USING THREE-TIER ARCHITECTURE

Discussions in recent years about client/server systems have revolved around two-tier, three-tier or n-tier architectures [26]. A three-tier architecture introduces a server or an "agent" between the client and the server. The role of the agent is manifold. It can provide translation services as in adapting a legacy application on a mainframe to a client/server environment; metering services as in acting as transaction monitor to limit the number of simultaneous requests to a given server; or intelligent agent services as in mapping a request to a number of different servers, collating the results, and returning a single response to the client [28].

University of Malaya

A three-tier application is an application program that is organised into three major parts, whereby each is distributed to a different place of places in a network. The three parts are:

- The workstation or presentation interface
- The business logic
- The database and programming related to managing it

In a typical three-tier application, the application user's workstation contains the programming that provides the graphical user interface (GUI) and application-specific entry forms or interactive windows.

The business logic is located on a Local Area Network (LAN) server or other shared computer. It acts as the server for client requests from workstations or clients. In turn, it determines the type of data that is required and its location and acts as a client in relation to a third tier of programming that might be located in another machine. The third tier includes the database and a program to manage its read and write access [29]. While the three tiers could all be located in the same machine, they will often be distributed across multiple physical machines or "classes" of machines.

Three-tier application architecture offers significant advantages in the following critical areas [29]:

- **Reliability**

  In terms of hardware, an application server is inherently more reliable than a desktop machine.

- **Scalability**

  In this context, scalability refers to the ability to add another server at any time that is tuned for a specific purpose; specialisation of servers for application,

University of Malaya

database, or communication; or availability of widely scalable hardware platforms.

- **Control**
  Since the business logic is on the server, the software does not have to be distributed to all its clients. Instead, only the application server needs to be upgraded.

- **Flexibility, Growth and Change**
  Business processes grow and change as time passes. In tandem with that, the application related to it will also change. A three-tier architecture enables these changes to be quickly and effectively implemented on all application users.

2.7 EPS USING LOTUS NOTES/DOMINO

2.7.1 Lotus Notes/Domino

Lotus Notes/Domino is a GroupWare technology from Lotus Development Corporation. It supports communication, collaboration and coordination between people working in groups. The server component refers to Lotus Domino while the client component refers to Lotus Notes. Apart from functioning as the Notes server, Domino also acts as a web server and has the capability to translate Notes databases into HTML format dynamically.

The most important component in Lotus Notes/Domino is the Notes database. This database is unstructured as opposed to relational databases. Each database consists of documents, which in turn may contain fields containing textual information, images and OLE objects. As the Notes database is not a relational database, therefore it does not have primary keys and relationship between databases. Any relationship that needs to be established has to be coded.

University of Malaya

Lotus Notes/Domino allows rapid application development by providing high level application constructs such as forms, subforms, views and agents. Application logic can be created using high level methods such as a point and click dialogue interface to simple commands or Notes formula language. For web application, Domino allows access to scripting languages, Java, Javabeans and ActiveX.

Lotus Notes/Domino gives the premier development environment for building applications which model the business processes, manage workflow, facilitate collaboration and integrate tightly with the enterprise systems. It is a distributed client/server database application that allows users to organise, process track and share information. With Notes/Domino, users can access the same database at the same time and use the information to suit their individual needs [30].

2.7.2 Features of Lotus Domino

Lotus Domino has all the functionality of a normal web server. It is able to handle CGI scripts as well as Java Servlets. Apart from that, Domino is also capable of translating Notes databases into HTML format dynamically. This enables application developers to develop web applications with dynamic contents [31].
Domino is also able to run stored procedures in Notes databases, known as agents. These agents are natively written in LotusScript but can also be written in Java. These agents are normally triggered during the submission of as HTML form where the agent does the necessary processing such as updating database content, validation and generating responses to users. These agents can also be triggered through buttons on an HTML document.

The Domino server also acts as a mail server. It supports SMTP, IMAP, NNTP, and POP3. Specifically it has a task called SMTP MTA (Message Transfer Agent) that is used for normal Internet mail but also functions to translate Notes mail to SMTP standard and otherwise.

University of Malaya

Besides that, Domino also supports Basic Authentication that works together with Notes Security, specifically the Access Control List (ACL) of Notes databases. The drawback of Basic Authentication that allows readability of usernames and passwords sent by the browsers to unauthorised people is solved using Secure Socket Layer (SSL). SSL encrypts all data transmissions between the browser and the server. Using these features, a web application is made to be more secured.

Domino is multi-platform. It runs on Windows NT 4.0, OS/2, AIX, HP-UX, Novell NetWare 4.11 and Solaris. Domino also allows integration with other databases such as DB/2, SAP/R3, Oracle 7/8, Sybase System 10/11, ODBC, SQL and Informix.

2.7.3 Advantages of developing Web Application with Notes/Domino

Developing applications which model business processes, manage workflow or incorporate collaborations, as required by an EPS, demands additional systems and significant amount of coding. Lotus Notes/Domino provides a high-level, visual development environment allowing developers to create Web applications quickly and easily. The advantages of using Lotus Notes/Domino are evident in these areas:

- **Workflow Agents**

  Workflow agents act like a human agent hovering over the server, monitoring the flow of work against a predetermined set of conditions defined in a script. When the work process deviates from the script, the agent can take action by notifying the proper individuals or updating the work in process [32].

  Notes application developers can create programmable agents that perform some type of actions, such as updating a workflow process. Notes support a variety of agents. These agents can be run from a menu or button, run at specified intervals, or triggered in response to a database event. Agents can be powerful tools in allowing users to automate repetitive functions or in carrying out tasks across the

network. This combination of functionality provides a unique application platform for managing the integrity of the work process.

- **Business Process Application**

Business Process Applications are oriented around defining and coordinating the activities of people working collaboratively to perform a business process. These processes may encompass an extended organisation, including customers and suppliers, and involve the need to share, track and route many types of information [32]. These applications focus on maintaining the integrity of the work process as well as managing the information needed to support the business functions.

Lotus Notes provides the tools necessary for building applications that automate business processes. These tools allow developers to design features that support individual users, distribute unstructured information in documents, manage time, and act as agents to control the workflow.

- **Advanced Security**

Lotus Notes employs an RSA Public-Key/Private-Key encryption scheme to provide the highest level of security available for client/server applications. Notes security performs the functions of authentication. access control, maintaining confidentiality, and source verification and integrity. All this is provided in a manner that is extremely flexible.
There are five levels of security in Notes [29]:

- *Server-level security*: First and most general layer of security.
- *Secure Sockets Layer (SSL)*: Strongest security available for non-Notes client.
- *Database-level security*: Handled by the database Access Control List (ACL)

University of Malaya

- *Document-level security*: Consists of the document's read access list.
- *Field-level security*: Refers to encryption of the field.

- **Replication**

  Replication is the process through which a Notes database with copies on multiple servers is synchronised. Notes allows databases on different servers to be synchronised at intervals scheduled by the system manager. Replication makes all copies of a database essentially identical. If a user makes changes in one copy of the database, replication ensures that those changes are added to all copies across the network, as long as the Replication options are set up to do so.

- **Rapid Application Development Environment**

  Domino provides high-level application constructs and uses coding only when necessary, which allows for rapid development of new workgroup applications [31].

2.8 SECURITY AUDITS

There is an escalating growth in the awareness of computer and networking securities as hackers, ex-employees and competitors gain access to confidential information. According to Ernst & Young, there is a much greater willingness among organisations to devote resources on issues pertaining to security as compared to previous years [33]. White (1995), national director of information security effectiveness at consultants Ernst & Young, stated that the greater focus is shifting towards acquiring human resources and evaluating security tools and solutions, and that the escalating risks go hand in hand with the rise of distributed computing.

University of Malaya

2.8.1 Functions of Security Audits

Security audits are concerned with ensuring that a company can track all changes to its databases and has the capability of detecting a security violation when one occurs [32]. The target of security audit is to detect an attempt to violate the systems security services and perform pre-defined automatic operations as a result. In some cases, security audit tools that enable analysis of network and predict vulnerabilities are used [33]. Further analysis of the security audit is achieved by analysing information that is automatically stored in logging files. Information can be stored in different levels of details, starting with pure statistics and up to storing and analysing user's data.

The network is usually not static. As time passes there are more intruders and they are becoming more sophisticated. The same goes to the security protection tools. In this aspect, security audit enables the organisation to control and follow up on these developments and be aware of new security vulnerabilities and security violation attempts. Hence, prevention is better than cure.

2.8.2 Logging and Audit Trails with Lotus Notes/Domino

Although authentication and access control form the basis of all security systems, the activities of users in any systems should be recorded to provide for reconstruction of any security violations. There are two levels of recording that needs to be considered, namely logging and audit trails.

Logging is simply collecting information about any security-related event, such as logging into a system. Most systems today, including Notes, routinely log this type of information [32]. Two types of log files can be created: output- or input-only. Output-only log files depict everything that appears on a user's workstation screen. Input-only log files reveal only the data typed by the user, each line of which is preceded by a time stamp [34].

University of Malaya

The second level of monitoring, audit trails, is based on logging. A log becomes a useful audit trail when it contains context information, such as the time and the specific actions (such as documents accessed) that occurred. The second thing that must happen for a log to become a useful audit trail is that the log must be protected. It must be impossible for the log to be deleted or modified. This includes all users, including administrators [32]. The Notes log meets the first essential characteristic of an audit trail. It logs essential access-control events and it records much of the context surrounding each event. However, in Notes there is no way to prevent any administrator from changing the log, so the Notes log in and of itself is not a foolproof audit trail.

An audit trail is of utmost importance because to be able to analyse an incident after the fact requires the need to be able to analyse an audit trail. Besides that, a true audit trail provides a higher confidence level that the log is accurate [32].

2.9 DOCUMENT MANAGEMENT

Current document management technology grows out of the business community where some 80% of corporate information resides in documents [35]. The need for greater efficiencies in handling business documents to gain an edge on the competition has fuelled the rapid development of Document Management System (DMS) in the past seven years. The challenge of document management is to maximise the time-to-market benefits of concurrent engineering while maintaining control of the data and distributing it automatically to the people whom need it, and when they need it [36].

Document management is the automated control of electronic documents through their entire life cycle within an organisation, from initial creation to final archiving [35]. In this context, electronic documents refer to page images, spreadsheets, word processing documents, and complex, compound documents. Document management

can also be viewed as the art of organising both paper and electronic files for maximum accessibility and usefulness [37].

Document management allows organisations to exert greater control over the production, storage, and distribution of documents, yielding greater efficiencies in the ability to reuse information, to control a document through a workflow process, and to reduce product cycle times. The full range of functions that a DMS may perform includes document identification, storage and retrieval, tracking, version control, workflow management, and presentation [35].

Boyle (1997) asserts that a DMS is not a single entity but a collection of complementary technologies. The three most crucial ones are the repository (document storage), workflow, and searching-and-indexing technology [38]. The document repository, the core component of a DMS, stores, controls, and manages documents. Key repository functions include library services which refers to controlling access to individual documents, document cataloguing, check-in/check-out, and searching for and retrieving documents. Another key function is version control, including a history of all instances of a document as it changes over time.

Cleveland (1995) maintains that there are two classes of document management. The first class refers to the management of fixed images of pages while the second one refers to the management of editable documents. These two classes exhibits contrasting features and functions in that images are static and systems supporting images focus on access with input, indexing and retrieval as important functions. On the other spectrum, editable documents are dynamic and changing. Systems supporting editable documents focus on creation with joint authoring, workflow, and revision control as the focal point [35].

In general, electronic documents fall on a continuum with static documents at one end and complex, compound documents at the other [35]. The trend in document management is away from the management of static documents towards complex, compound documents.

University Of Malaya

2.9.1 Elements of a DMS

- **Storage**

  The core of the DMS is the database and search engines supporting storage and retrieval of documents. Today, DMSs are moving toward object-oriented databases (ODBMS) from its traditional relational databases (RDBMS). However, a third genre of database cease to exist in this context. Such databases are called Object-Relational Database Management System (ORDBMS).

- **Underlying Infrastructure**

  An appropriate underlying infrastructure is a prerequisite to supporting a DMS. The infrastructure is the set of desktop computers, workstations, and servers that are interconnected by LANs and/or WANs. It must have characteristics such as network operating sytem independence, file format independence, location independence, long file names, and link tracking.

- **Workflow**

  Workflow is a central aspect of document management because it allows organisations to get control of, and increase the efficiency of, the flow of documents that support their business.

- **Library Services**

  This is a term used specifically by the document management community to refer to document control mechanism such as check-in, check-out, audit trail, protection/security, and version control.

- **Presentation/distribution services**

  Presentation and distribution concerns the form and manner in which users are provided with information. DMSs should allow "multipurposing" where information can be distributed in different formats, such as viewed on a network (e.g., the Web), or printed on paper. Businesses can reuse information, putting it into a format determine by the target market or business function

University of Malaya

2.9.2 Storage and Retrieval in a DMS

A document management system must allow users both to store and manage documents, and to find and retrieve them [39]. These functions are discussed in terms of finders and keepers, which are resources (human or software) made available to the user to assist them in these tasks.

The keeper is concerned with the safekeeping of documents, so that they are neither lost nor changed, access is controlled, and the source of the documents is verifiable. Attributes essential to a keeper includes accessibility of documents to all who need them, and compatibility with the finders agency so that users are required to use only one search protocol. There must also be an audit trail reflecting the history of modification of the document as a measure of authenticity.

The finder is used to locate and to retrieve information. The important attribute of any software implementation of a finder is that it supports fixed attribute searching, free-text searching and higher-level retrieval. Besides that, it is also capable of operating over distributed keepers on a variety of different hardware and software platforms [39].

2.9.3 Benefits of using DMS

The benefits of document management for businesses include:

- Ease of search and retrieval
- Ability to share documents
- Insured document integrity
- Leveraging intellectual capital such that knowledge is created once, then reused many times
- Managing workflow, controlling the flow of information through all phases of a process

University of Malaya

- Delivering products faster with better customer service
- Allowing rapid response to events.

2.10 CONCLUSION

The developers of UMEPS Version 1.0 used a combination of the Internet, Client/Server computing, and Lotus Domino/Notes in developing the system. The research conducted indicates that this approach is indeed viable and practical.

The focus areas for the development of UMEPS Version 1.0 include the creation of electronic catalogue, supplier database, request for quotations, as well as on purchase requisitions, budgetary control and order fulfilment. Developers of UMEPS Version 2.0 further enhanced the system by incorporating the supplier subsystem, in addition to modifications made to the supplier database, electronic catalogue and requisition process in order to support the supplier subsystem.

However, the latest version of UMEPS, Version 2.0, still lacks certain functions and features. Based on the survey conducted on similar electronic procurement systems mentioned in *Section 2.3*, it was found that UMEPS Version 2.0 did not have an audit trail system as well as a document management system, which is essential for a web-based system. These two aspects will be the enhancement focus for the current system.

University of Malaya

CHAPTER 3: SYSTEM ANALYSIS AND REQUIREMENTS

3.1 INTRODUCTION

As a sequel to *Chapter 2*, this chapter serves to identify and explain with intricate details the functional and non-functional requirements for UMEPS Version 3.0. Based on the reviews of existing electronic procurement systems as laid out in *Section 2.3*, a few distinct functions from other systems are adopted for the development of UMEPS, as follows.

3.2 ANALYSIS METHODOLOGY

During the analysis phase, five different methods were used for capturing requirements for UMEPS Version 3.0. These techniques include interview, existing system and user manual, thesis reports, library research and Internet research.

3.2.1 Interview

UMEPS was developed by two batches of undergraduates from the Faculty of Computer Science and Information Technology as part of their final year thesis. As they are more apt with the system, an interview was conducted with one of the developers of UMEPS Version 2.0, Ms. Tan Siew Hui, to gain a better understanding on the existing system as well as views on the focus areas for enhancements.

University of Malaya

3.2.2 Existing System and User Manual

An analysis on the current system, particularly the front-end portion, was done to get an overall perspective on the mechanism and workflow of the system. The method of conducting this analysis is through simulation of the complete electronic procurement process, with the assistance of the user manual. The focus of simulation is on the quotation requisition process. The tender requisition process is omitted for this purpose.

User identifications for each of the six categories of users were created. Logging in to the system as a *requestor* for the university allows the creation of requisition form by the user. This form is then submitted to the *approver* to be approved. After being approved, a quotation requisition form is published to the general or selected *suppliers*. The interested suppliers will respond by providing quotes to the requested items. A tally of the supplier's quote and the requestor's/treasurer's budget results in the generation of purchase order. The order fulfillment process in which the supplier generates an invoice and delivery order to the requestor, who then transfers them to the treasurer, follows this. Finally, the treasurer acknowledges the delivery order and issues the payment to the supplier.

At each stage of the procurement process mentioned above, the response of the related users were noted and analysed. Their impacts on other users were also taken into account. This method is most suitable to ascertain the best way to enhance the existing system as well as to discover the capabilities and limitations of the current system.

3.2.3 Thesis reports

The systems documentation recorded in the thesis reports of the previous developers of UMEPS were read, studied and analysed thoroughly. The documentation provided

University of Malaya

a detailed and complete picture of the systems which is vital for the future implementation of the system.

3.2.4 Library Research

This traditional approach to research was conducted to study the trend and evolution of the procurement process, from the paper-based to the web-based procurement, as well as industry standards pertaining to electronic procurement to further enhance UMEPS Version 2.0. This was done using the materials obtained through the library cataloging system, a variety of journals, magazines, conference papers and other relevant documents.

3.2.5 Internet Research

This modern tool for research was used to identify websites of corporations of similar electronic procurement technology. Subsequently, the features and functions of a few selected and unrestricted websites were explored and compared to UMEPS Version 2.0. This is a useful strategy in determining improvements for the existing system.

3.3 DEVELOPMENT METHODOLOGY

The evolutionary prototyping model is adopted for the purpose of developing the system. Using this model, user requirements that are known at the time of the project's outset are gathered. The initial prototype is a working system based on the best-understood, most straightforward requirements. Users are able to see and use the working version of a system that incorporates the basic requirements immediately. All errors or missteps identified by users or developers are dealt with

University of Malaya

before continuing on. The users and developers are able to evaluate the initial product and help further define requirements for the next iteration of the evolution.

The prototypes that are developed are not discarded after the initial exploration stage. Instead, many components are modified and refined continually until the intended design is achieved. The feasibility in using the evolutionary prototyping approach include:

- It delivers a working product to the user early in the process
- It adapts easily to changes in requirements
- It does not require definition of requirements up front
- It gives the user a correct program
- It reduces the risks associated with the development of a system

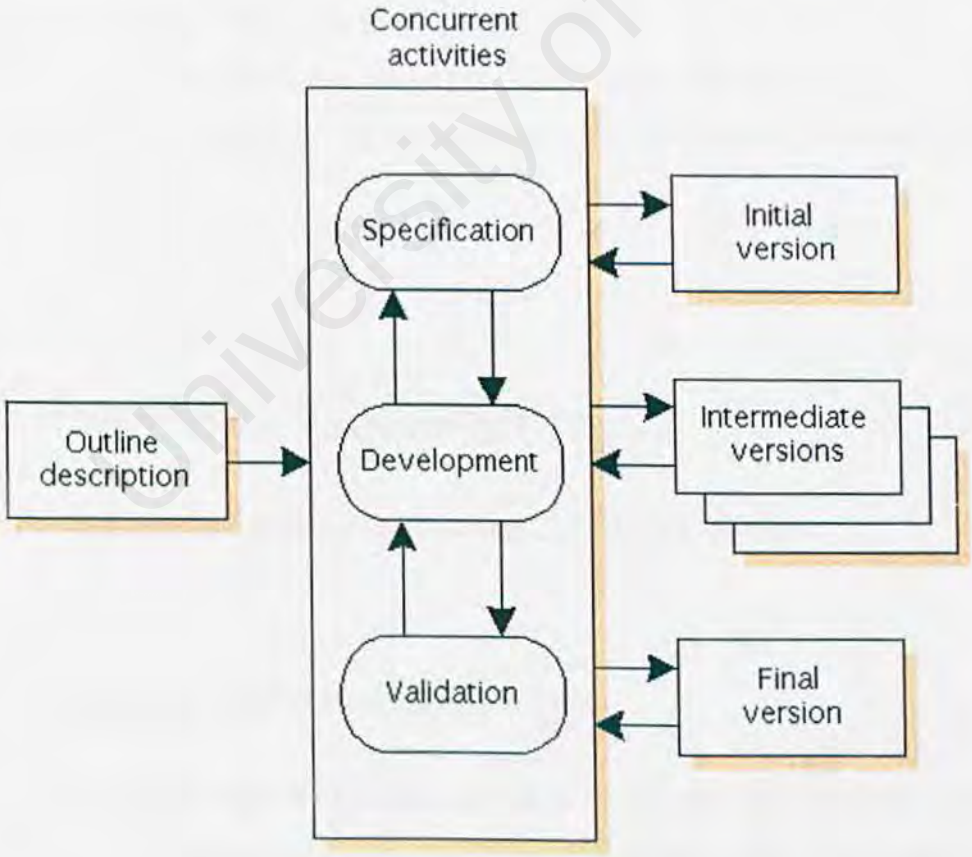

Figure 3.1: *The evolutionary prototyping model*

University of Malaya

3.4 THE ANALYSIS

The backbone of the procurement process in University of Malaya lies in its process workflow. Based on the workflow, a document is passed from one user to another user to enable the next user to read and modify the document as needed. The workflow of the procurement process in University of Malaya is detailed in *Section 2.3.5* (Refer to *Appendix A* for the complementing flowchart diagrams).

An analysis on the process workflow of the procurement process in UM contends that the workflow will remain unchanged. The overall analysis, based on the analysis methodologies stated in *Section 3.2,* concludes that a few changes with reference to the security of the overall system need to be done. This involves the development of an additional module to enhance the current security features available.

That aside, another separate module is also needed for the storage of outdated business documents. This will inevitably involve the development of a separate module for repository functions. Other minute flaws and defects of the entire system will also need to be rectified. All these changes affect the hard-coded section of the system.

3.5 FUNCTIONAL REQUIREMENTS

The following are the functional requirements for UMEPS Version 3.0.

3.5.1 Tracking of Normal Database Activities

The system must be able to monitor all the activities selected for the purpose of normal audit trail. These activities, also known as audit events, occur when a user triggers any action bars on any documents, which resides in the UMEPS database. The monitoring process will include all system users, recording all the input and/or

output at each terminal on the system from the time user logs in until each log out. These recordings have to be done on a real-time basis. When a user triggers any action bars on the user interface screen, an audit record will be sent to the audit trail database immediately.

3.5.2 Audit Records Archiving

The audit records sent to the audit trail database will be archived and sorted according to the date and time of the activity, with the latest available audit record succeeding the other records. The archiving of audit records should ease the process of generating selected audit records to users.

3.5.3 Generation of Selected Audit Records

Through a browser user interface, administrators of departments or faculties should be able to request for any audit record for a specified date and time period. The system should be able to fulfill the user's request by generating audit records requested by users of the system, provided the audit records have not been purged out from the audit trail database. All administrators should not be granted access to delete, change or add information on the audit records displayed on their client workstations.

3.5.4 Removal of Outdated Audit Records

All audit records should not be allowed to reside in the audit trail database for too long. After duration of one (1) month, the system should have the ability to purge audit history records. This duration is determined from the date of last update of the documents. This function is needed to avoid cluttering useless audit records in the audit trail database.

University of Malaya

3.5.5 Tracking of Abnormal Database Activity

When starting to audit for suspicious or abnormal database activity, audit options to system users should be set more generally at first. Once preliminary audit information is recorded and analysed, the general audit options should be turned off and more specific audit options enabled. This process should continue until enough evidence is gathered to make concrete conclusions about the origin of the suspicious database activity. When auditing for suspicious database activity, the audit trail database must be protected so that audit information cannot be deleted, added or changed without being audited.

3.5.6 Storage of Obsolete Documents

All business documents involved in the transaction of procurement process are kept in their respective databases for a timeframe of three (3) months. After the stipulated period, the system should transfer these documents to another database, namely the archive database, for housekeeping. The documents mentioned earlier refers to the request for quotations (RFQs), purchase requisitions (PRs), quotations, purchase orders (POs), and invoices.

3.5.7 Retrieval of Obsolete Documents

All users of UMEPS Version 3.0 should be able to retrieve outdated business documents from the archive database. This retrieval process should be done easily through the click of a mouse button and a graphical user interface residing on the client's web browser. The function of document retrieval is essential for users who need to perform cross-referencing of past procurement activities.

University of Malaya

3.5.8 New Suppliers Notification

The treasurer for a department or faculty in UM should be sent e-mail notification the moment a new supplier registers with the UMEPS website. The treasurer should immediately activate the new supplier's account to enable it to update its company information and products information. If after a period of seven (7) days the new supplier has yet to complete its payment to UM, action should then be taken by the treasurer to warn the supplier. If payment is not received within the next five (5) days, the treasurer should terminate the supplier's account.

3.5.9 Supplier Performance Rating

All requestors and administrators of UMEPS Version 3.0 should only be allowed a one-time rating on the performance of a supplier. This evaluation method is done by selecting the number of stars, which is commensurate with the supplier's overall service. Should any requestors or administrators attempt to perform a second rating on the same supplier, an error message should be prompted to deny the action of the above-mentioned users.

3.5.10 Graphical User Interface

The outlook of UMEPS should give all system users the impression of a flawless graphical user interface (GUI). With this objective in mind, a standardised interface must be achieved to provide users with a proper flow of the system, thus eliminating any confusion which may arises.

3.6 NON-FUNCTIONAL REQUIREMENTS

University of Malaya

3.6.1 Security

The system must be able to perform authentication and authorisation of valid users. Mandating a user to input a username and password before being allowed access into the system should do this. It should also provide privacy and confidentiality of messages transmitted through the Internet. Transmission of confidential data must be secure and not susceptible to eavesdroppers or hackers.

3.6.2 Reliability and Availability

The system must be available to users at all times, 24 hours a day. Unexpected downtime of the overall environment should be minimal with quick recovery within 30 minutes from the start of downtime occurrence.

3.6.3 User Interface

The system should employ a user-friendly interface with WIMP (Window, Icon, Menu and Pointing device) features that will shorten the learning curve for new users. New users should be able to use the system to perform required tasks within two (2) hours of learning based on the self-explanatory, easy-to-use menus, and graphical interface. The user interface should also reflect the flow of the processes clearly.

3.6.4 Accessibility

The system should be accessible to a wide community of suppliers with Internet access as well as to the user community in UM with access to UM's Local Area Network (LAN).

University of Malaya

3.6.5 Robustness

The system should be able to handle extraordinary situations smoothly, and be able to continue running even when faced with minor disruptions. In the event of a user mistake, the user should be informed of the mistake to allow for action to be taken against the mistake.

3.6.6 Modularity

The system should be developed with a modular approach to enable easier maintenance and debugging of system besides accommodating for easier future module additions.

3.6.7 Efficiency

The system should be efficient in the use of resources such as data storage, processing power and time. There should be no duplication of processes. To the extent possible, automation is used to replace manual procedures.

3.6.8 Maintainability

The system should be easy to maintain. In the event of a change of process flow of business rules, the system should only require an acceptable amount of changes, not a major overhaul of the entire system.

University of Malaya

3.7 CONCLUSION

Based on the analysis and development methodologies structured for the development of UMEPS Version 3.0, a complete set of functional as well as non-functional requirements were specified. These requirements were used as the basis for designing the architecture, database, and user interface of the system. The subsequent chapter discusses this in further detail.

University of Malaya

CHAPTER 4: SYSTEM DESIGN

4.1 INTRODUCTION

The functional and non-functional requirements that were gathered from the preceding chapter, *Chapter 3*, were used to construct and develop the design of UMEPS Version 3.0. Areas of design include that of application architecture, overall flow and design, database design and user interface design. The database design includes the structuring of context diagrams, forms and fields specification relevant to the database being developed.

4.2 APPLICATION ARCHITECTURE

The application architecture of UMEPS is a three-tier client-server architecture, which consists of the Web clients, application server, and data server. The users, through their Web browsers, form the first tier of the architecture. The first tier communicates with the business logic part of the system that forms the second tier of the architecture. The second tier or application server is also known as the Domino Web Server. The second tier, application server, retrieves data from the third tier to the first tier, and adds data to the third tier from the first tier. The third tier or data server is also known as the Notes Server. *Figure 4.1* illustrates the three-tier client/server architecture of UMEPS.

University of Malaya

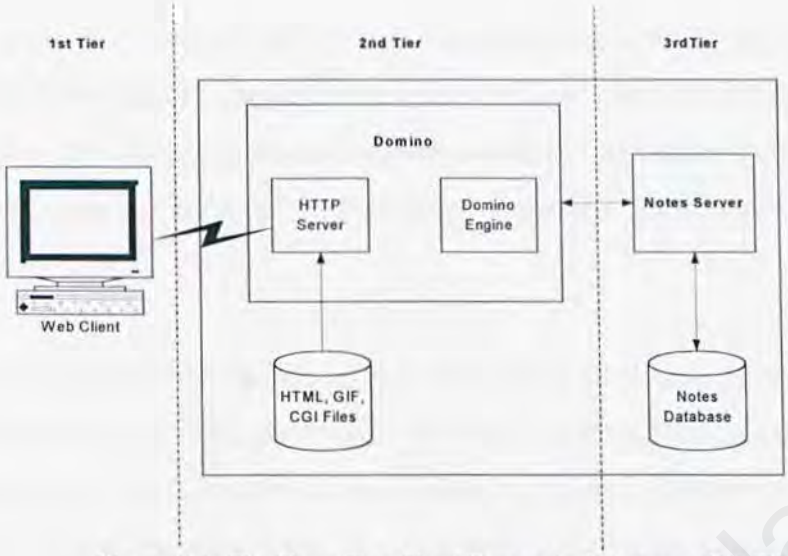

Figure 4.1: The Three-Tier Client/Server Architecture of UMEPS.

4.3 NOTES DATABASE COMPONENTS

This section discusses the various aspects of the Notes database that are used in the development of UMEPS Version 3.0. The important features and components of the Notes database are summarised here to ease the description of the database development later in this chapter.

The core components of a Notes database is as follows:

Forms

The purpose of forms is two-fold. Firstly, forms are used for data input and data display. Forms have fields that allow data to be entered through them, thereby functioning as a way to store data into Notes document. Secondly, forms are used as templates to hold views. This usage of forms is used extensively in most databases in UMEPS, and it allows a view's design to be flexible. Images, titles and other user interface can be included in these forms.

University of Malaya

Views

Views allow the listing of documents in a database according to optional criteria. They are the analogy of queries when compared to a relational database. Views also allow documents in a database to be categorised and sorted according to field values. Views are important in retrieving documents or specific fields in a document.

Agents

Agents are stored procedures in the database. They are normally written in LotusScript but can also be written in Java. In UMEPS, agents are also used extensively for data processing, searching and data validation. Agents are the primary way of running programs from the Web in the Notes database.

Roles

Roles are similar to user groups. In UMEPS, almost every database uses roles. Roles provide a way to hide form elements that are either not relevant to the user or is out of bounds for the user to see or use.

Readers and Authors Field

These two special fields are used to restrict access to the record. The Readers field keeps the names of all authorised users/groups/roles that are allowed to read the document. The Authors field is a list of users/groups/roles who can edit the document. These fields are very useful for access control. A user can only read documents that list the user as a reader and may only edit documents that list the user as an author. Documents that are confidential and not relevant to certain users will not be available to them.

Field Types

There are four field types:

- *Editable*

  This type of field allows editing by users

University of Malaya

- *Computed*

  A computed field does not allow data entry. Instead it stores data through a formula. For example, a computed field with a formula '@Username' computes the current username and stores it in the field

- *Computed when composed*

  This type of field is computed only once, which is during the creation of the document and does not change thereafter. This type of field is used especially to store document reference numbers such as the Purchase Order number.

- *Computed for display*

  This type of field does not store data into a document. Instead, each time a form that has a computed field is used to display a document, a value is computed (based on a formula) and displayed for the user to see.

4.4 OVERALL DESIGN AND FLOW

The overall system structure of University of Malaya's Electronic Procurement System (UMEPS) is shown in *Figure 4.2*:

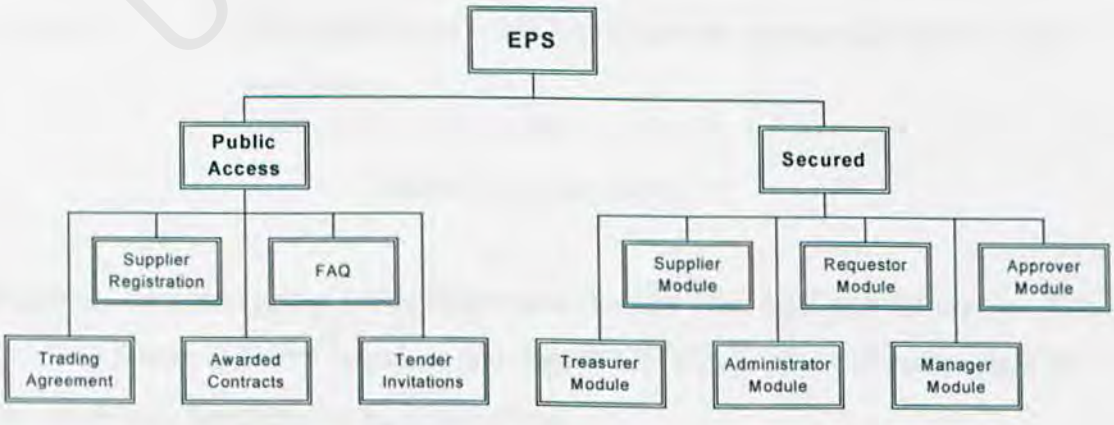

***Figure 4.2**: Overall System Structure Chart*

Public Access Zone

This zone provides unrestricted access to the general users. The public is allowed to register with UM as a registered supplier, view the awarded orders page that holds a list of registered suppliers that have been awarded orders by UM, view frequently asked questions (FAQ), read UM's trading agreement, and view and respond to invitations to tender.

Secured Zone

This zone is restricted to authorised users only. It is divided into six areas, corresponding to the six user groups of UMEPS. The six user groups are explained in detail in *Table 4.1*.

GROUP	MEMBERS
Suppliers	Companies registered with UMEPS
Requestors	Staffs or purchasing personnel of the university from various departments or faculties whom forms the population of buyers in UM.
Approvers	Head of the department or faculty, officers from the Bursar's Office, and representatives from the Ministry of Finance.
Treasurers	The people from the Bursar's Office
Administrators	Consist of two groups, namely the central administrators and department/faculty administrators.
Managers	The people responsible for registering central administrators and treasurers.

***Table 4.1**: Users of UMEPS*

Depending on which group a user belongs to, the user who logs into the system will be able to access different functions and data of UMEPS. *Table 4.2* summarises the data access and functions for each user group.

University of Malaya

GROUP	DATA ACCESS	FUNCTIONS
Suppliers	- Product Catalog - Product Categories - RFQ/RFTs for suppliers - POs for suppliers - Invoices by suppliers	- Add/Modify/Delete own product information - Respond to RFQ/RFTs - View purchase orders - Invoice UM for products purchased
Requestors	- Product Catalog - Supplier Information - RFQ/RFTs and supplier responses - Own requisitions - POs initiated through own requisitions - Archive Documents	- Search and select products from product catalog - Search for suppliers and view suppliers' information - Create RFQ/RFTs and view responses - Create Purchase Requisitions - Initiate Tender Requisitions - Update PO status when products are delivered - Retrieve historical business documents (i.e., RFQ, RFT)
Approvers	- Funds Information - Requisitions - Archive Documents	- Check for fund availability - Approve requisitions by requestors - Retrieve historical business documents (i.e., PR)
Treasurers	- Fund Categories - Fund Information - Supplier Profile - Approval Workflow	- Maintain a list of fund categories - Maintain funds information (type and amount for each

University of Malaya

	- Invoices	department) - Activate supplier accounts - Maintain approval profile - Update invoice status to indicate payment
Administrators	- User Profile - Department/Faculty Profile - Approval Workflow - Product Categories - Audit Records	- Add/Modify/Delete users in the Requestor and Approver groups for the department the administrator is in charge of - Update department information. Select the workflow to be used in own department - Create/Modify approval workflow - Maintain Product Category - View audit records of all users under the department the administrator is in charge of
Managers	- User Profiles - Department Profiles	- Create and manage users in the Administrator and Treasurer group - Create and manage department profiles

***Table 4.2**: Data access and functions for user groups of UMEPS*

University of Malaya

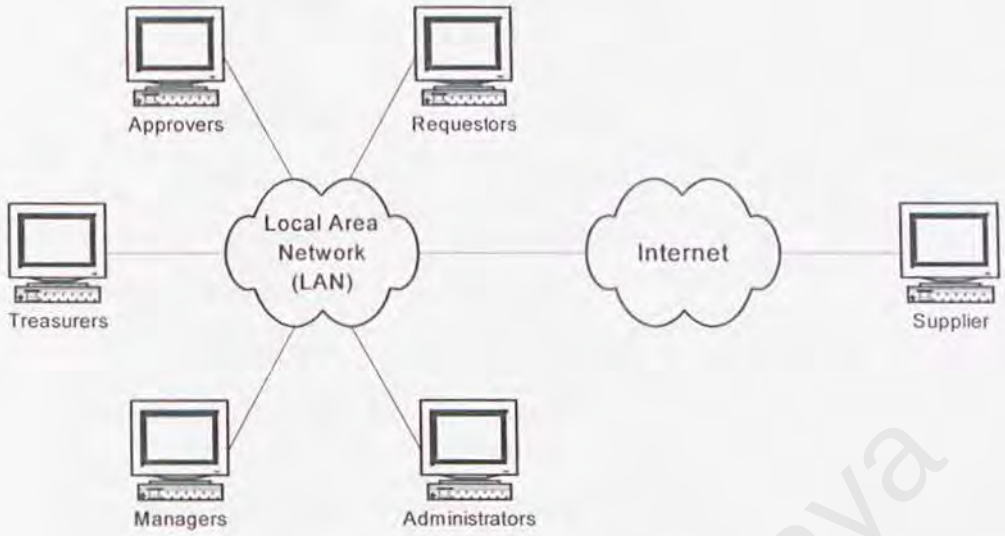

Figure 4.3: Users of UMEPS

4.5 DATABASE DESIGN

4.5.1 Audit Trail Database

This database is used to track and store the record of activities triggered by users of UMEPS. These users include all six user groups, namely requestors, suppliers, managers, treasurers, approvers, and administrators. A user activity that generates an audit record is based on audit events, which causes any changes to the documents in a database. It may also include audit events which will be useful in the event of an audit trail check, although these category of activities do not cause any changes in the documents.

The access control lists for this database is listed in *Table 4.3*.

University of Malaya

User Roles	Access Right
Default	No Access
Requestors	No Access
Suppliers	No Access
Approvers	No Access
Treasurers	No Access
Managers	No Access
Administrators	Reader

Table 4.3: *Access Control Lists for Audit Trail database*

University of Malaya

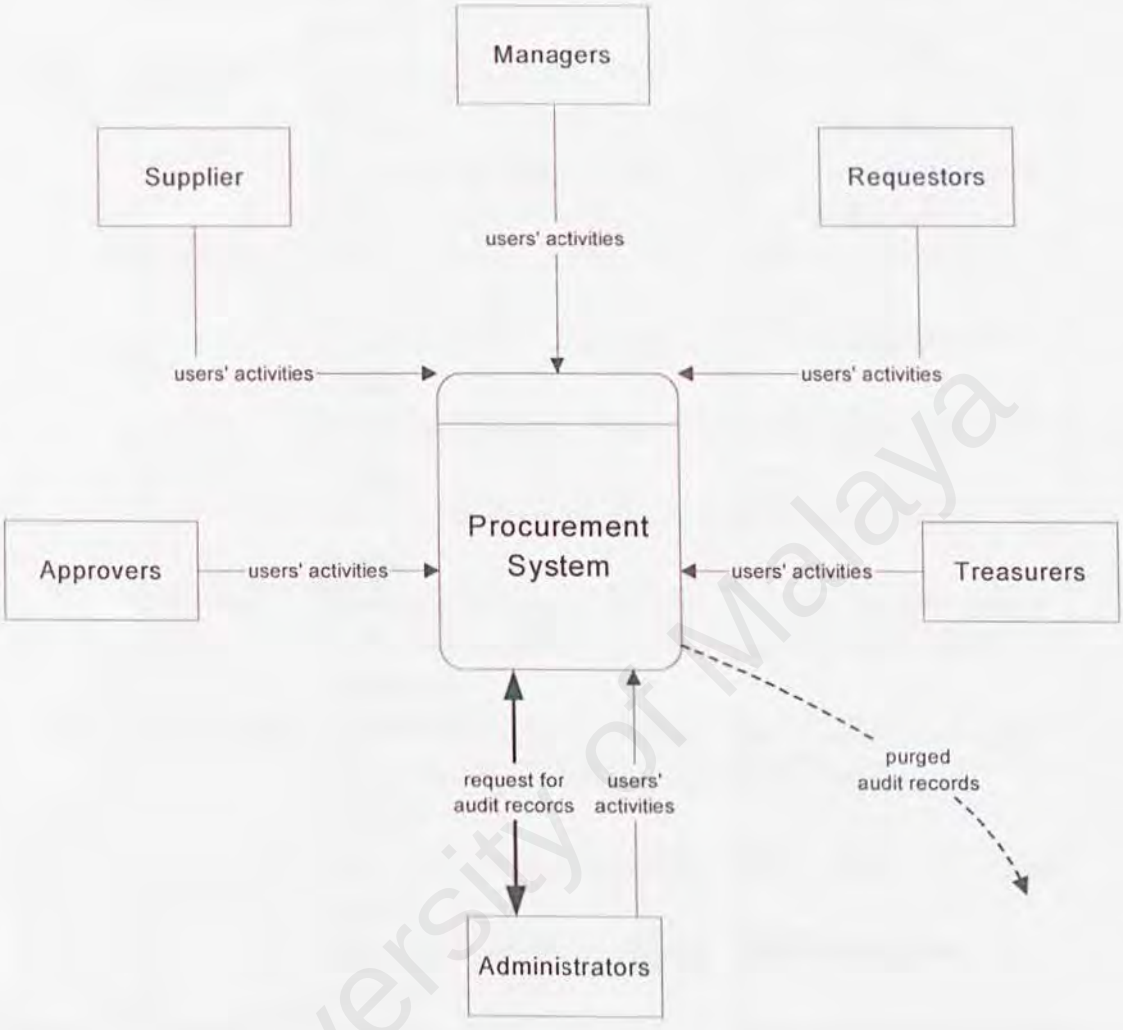

Figure 4.4: *Context Diagram of Audit Trail Process*

The following table lists the audit descriptions that will be recorded when the audit events are performed:

University of Malaya

USERS	DATABASE	AUDIT DESCRIPTION	AUDIT EVENT
All Users	Main Database	[user] logs in	Login button triggered
		[user] logs out	Logout button triggered
Administrators	User Profile	[admin] creates new [user]	New User button triggered
		[admin] saves changes made to [user]	Submit button triggered
		[admin] edits information of [user]	Edit Document button triggered
		[admin] deletes information of [user]	Delete button triggered
	Approval Profile	[admin] creates new [approval profile]	New Approval Profile button triggered
		[admin] saves changes made to [approval profile]	Save Only button triggered
		[admin] edits information of [approval profile]	Existing approval profile link clicked
		[admin] deletes information of [approval profile]	Delete button triggered
	Department Profile	[admin] edits [department] information	Edit Document button triggered
		[admin] saves changes made to [department]	Save Only button triggered
	Product Category	[admin] creates new [product category]	New Category button triggered
		[admin] saves changes made to [product category]	Submit button triggered
		[admin] edits information of [product category]	Edit Document button triggered
		[admin] deletes information of [product category]	Delete button triggered
Requestors	Purchase Requisition	[requestor] creates new [requisition]	New Requisition button triggered
		[requestor] saves changes made to [requisition]	Save Only button triggered
		[requestor] publishes [RFQ] to suppliers	Publish RFQ button triggered
		[requestor] publishes [RFT] to suppliers	Publish RFT button triggered
		[requestor] opens [quotation]	Open Quotation button triggered
		[requestor] opens [tender proposal]	Open Proposal button triggered
		[requestor] submits [requisition] for approval	Submit for Approval button triggered
	Quotation/ Tender	[requestor] reopens closed [RFQ]	Reopen to Suppliers button triggered
		[requestor] creates [purchase order]	Create PO button triggered
	Purchase Orders	[requestor] acknowledges delivery of products	Delivered button triggered
	Supplier Information	[requestor] gives rating to [supplier]	New Rating button triggered

University of Malaya

		[requestor] saves rating given to [supplier]	Submit button triggered
		[requestor] edits rating given to [supplier]	Edit Document button triggered
Supplier	Main (User Info link)	[supplier] edits [company] information	Edit Document button triggered
		[supplier] saves changes made to [company] information	Submit button triggered
		[supplier] changes password	Change Password button triggered
	Product Catalog	[supplier] adds new [product]	New Product button triggered
		[supplier] saves changes made to [product] information	Submit button triggered
		[supplier] edits [product] information	Edit Document button triggered
		[supplier] deletes [product] information	Delete button triggered
	RFQ/RFT	[supplier] responds to [RFQ]	New Response button triggered
		[supplier] saves changes made to [RFQ] responded	Submit button triggered
	Invitation to Tender	[supplier] creates new [tender enrolment]	New Tender Enrolment button triggered
		[supplier] submits [tender enrolment]	Submit for Enrolment button triggered
		[supplier] responds to [RFT]	New Response button triggered
		[supplier] submits [tender proposal] form	Save Only button triggered
	Purchase Orders	[supplier] acknowledges [PO]	Acknowledged button triggered
		[supplier] rejects [PO]	Rejected button triggered
		[supplier] creates [invoice]	Invoice button triggered
Approvers	Purchase Requisition	[approver] approves [requisition]	Approve button triggered
		[approver] denies [requisition]	Deny button triggered
	Reopen RFQ	[approver] reopens [RFQ] to suppliers	Reopen to Suppliers button triggered
Treasurers	Tender Requisition	[treasurer] creates [PO]	Create PO button triggered
		[treasurer] resends[PO]	Resend PO button triggered
	Tender Enrolment	[treasurer] approves [tender enrolment]	Approve button triggered
		[treasurer] denies [tender enrolment]	Deny button triggered
	Department Funds	[treasurer] creates new [fund]	New Fund button triggered
		[treasurer] saves changes made to [fund]	Submit button triggered
		[treasurer] edits [fund]	Edit Document button triggered
		[treasurer] deletes [fund]	Delete button triggered
	Fund Category	[treasurer] creates new [fund category]	New Category button triggered
		[treasurer] saves changes made to [fund category]	Submit button triggered

University of Malaya

		[treasurer] edits [fund category]	Edit Document button triggered
		[treasurer] deletes [fund category]	Delete button triggered
	Invoices (link)	[treasurer] updates [invoice] status to 'Paid'	Offset Invoice & Submit button triggered
	Supplier Profile	[treasurer] changes payment status to 'Yes'	Submit button triggered
		[treasurer] gives rating to [supplier]	New Rating button triggered
		[treasurer] saves rating given to [supplier]	Submit button triggered
		[treasurer] edits rating given to [supplier]	Edit Document button triggered
Manager	Department Profile	[manager] creates new [department]	New Department button triggered
		[manager] saves changes made to [department]	Submit button triggered
	User Profile	[manager] registers new [user]	New User button triggered
		[manager] saves changes made to [user] information	Submit button triggered
		[manager] edits [user] information	Edit Document button triggered

Table 4.4: *List of audit descriptions and audit events in relation to the users of UMEPS*

The following tables provide a summary of the design of this database:

Form Name	**Purpose**
Event	Used to display audit records requested by administrators of UMEPS
$$ViewTemplate for MiscEvents	Used to display the list of audit records

Table 4.5: *List of Forms for Audit Trail database*

Field	Description
Top Header	Represents the standard header for all UMEPS web page
Previous	A link to the set of views prior to the current set
Next	A link to the set of views after the current set
User Profile	Provides access to the user profile database
Dept Profile	Provides access to the department profile database
Approver Profile	Provides access to the approver profile database
Product Category	Provides access to the product category database
Audit Record	An indication on the page that the user is currently situated

Table 4.6: *Audit Trail database Form Design for Form Name: $$ViewTemplate for MiscEvents*

Embedded View	Description
MiscEvents	The pane where all documents is published and accessible to all administrators only.

Table 4.7: *Embedded view for Form Name: $$ViewTemplate for MiscEvents*

Agent Name	Description
autoDelete	Deletes (purges) the audit records from this database after a stipulated period (i.e., after one month).

Table 4.8: *List of Agents used in Audit Trail database*

University of Malaya

4.5.2 Archive Database

This database is used to store and retrieve obsolete documents from the system. These obsolete documents are transferred from their original database to the Archive database. An obsolete document, in this context, refers to business documents, which has come to the end of its document life cycle. This includes RFQs, RFTs, Purchase Requisitions, Purchase Orders and Invoices.

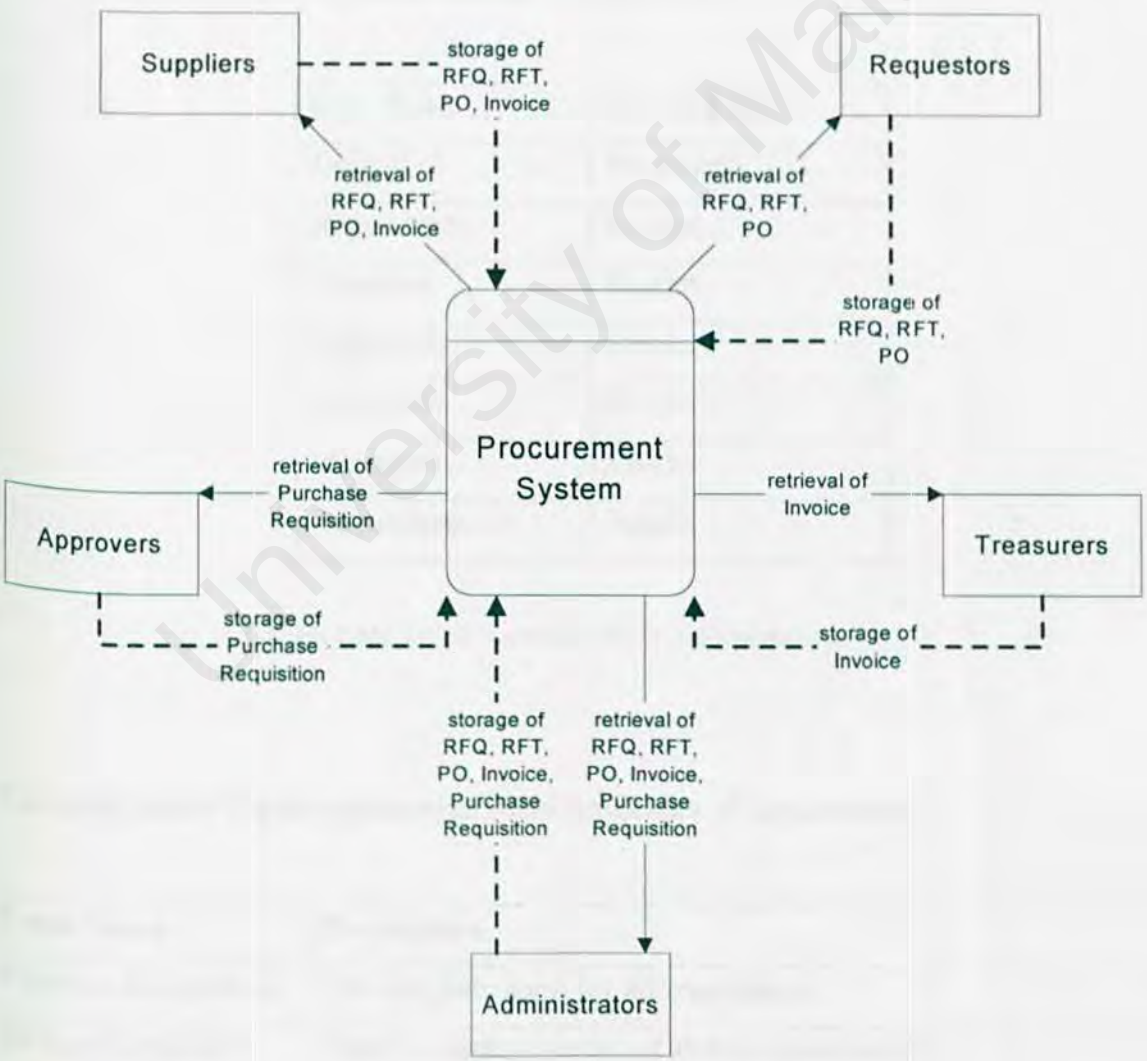

Figure 4.5: Context Diagram of Document Management Process

University of Malaya

The following table links the business documents to its respective database of origin:

Document Type	Original Database
RFQ	Quotation Requisition
RFT	Tender Requisition
Purchase Requisition	Quotation Requisition

Table 4.9: *The original databases for business documents involved in archiving*

The access control lists for the database is listed in *Table 4.10*:

User Roles	Access Right
Default	No Access
Requestors	Reader
Suppliers	Reader
Approvers	Reader
Treasurers	Reader
Managers	Reader
Administrators	Reader

Table 4.10: *Access Control Lists for Archive database*

The tables below are the summarisation of the design of this database:

Form Name	Description
Purchase Requisition	The template form for all requisitions
$$ViewTemplate for Requestors	Used to display the list of archive documents

Table 4.11: *List of Forms for Archive database*

University of Malaya

Agent Name	Description
AutoDelete	Deletes (purges) the archive records from this database after a period of 10 years.
ArchiveDoc	An agent from the requisition databases that sends its outdated documents to the Archive database.

Table 4.12: *List of Agents used in Archive database*

Field	Description
Top Header	Represents the standard header for all UMEPS web page
Previous	A link to the set of views prior to the current set
Next	A link to the set of views after the current set
Requisition	Provides access to the requisition database
Quotation	Provides access to the quotation database
Catalog	Provides access to the product catalog database
Supplier	Provides access to the supplier profile database
PO	Provides access to the purchase order database
Archive	Provides access to the archive database
DirectView	Provides access to the direct requisition view

Table 4.13: *Form Design for Form Name: $$ViewTemplate for Requestors*

4.5.3 Supplier Information Database

Using an additional agent to perform the functions required as described in *Table 4.14* further enhances this existing database:

University of Malaya

Agent Name	Description
CheckDuplicateRating	Runs when an attempt to save a supplier performance rating is made. It checks for duplicate ratings given by a requestor to the same supplier, thus allowing a save if a duplicate is found.

Table 4.14: Additional Agent in the Supplier Information database

4.5.4 Supplier Profile Database

The tables below summarises the modification done to the design of this database:

Form Name	Description
New Supplier	Functions as an online form for new suppliers who wish to register with UMEPS.

Table 4.15: List of Forms modified for Supplier Profile database

Hidden Field	Description	Data Type
SendTo	Specifies the person whom will be alerted when the 'New Supplier' form is submitted. This is done by sending an e-mail to notify the person	Text (Editable)

Table 4.16: All fields affected in the modification of New Supplier Form

Agent Name	Description
RegisterSpl	Notifies the treasurer to register new suppliers immediately upon receipt of registration fee from the suppliers.

Table 4.17: List of Agents modified for Supplier Profile database

University of Malaya

4.6 USER INTERFACE DESIGN

The user interface for any system serves as the first and lasting impression to the users of the system. The usability of the system is based on the user interface. Hence, a good graphical user interface is vital for effective and friendly user interaction.

For UMEPS, most of the interface design has already been defined in the first version. The interface design for the second and subsequently the third version of UMEPS is made to resemble those in the pioneer version. *Figure 4.6* represents the main page of UMEPS Version 3.0.

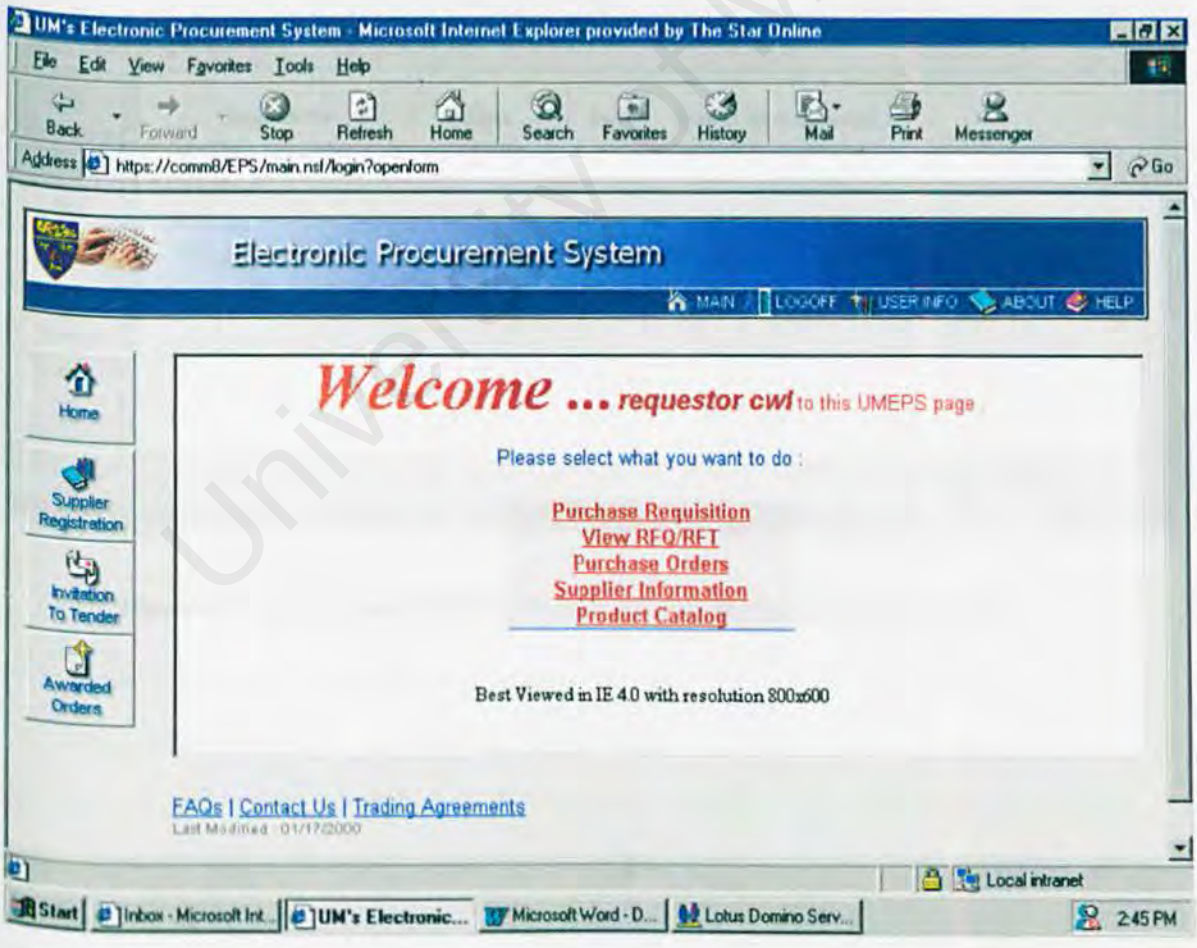

Figure 4.6: *A browser interface of UMEPS Version 2.0*

In addition to that, some rectification, which displays duplications of button bars and distorted top headers, are being made to the existing system. Examples of pages with errors in its graphical user interface aspect are shown in *Figure 4.7* and *Figure 4.8.*

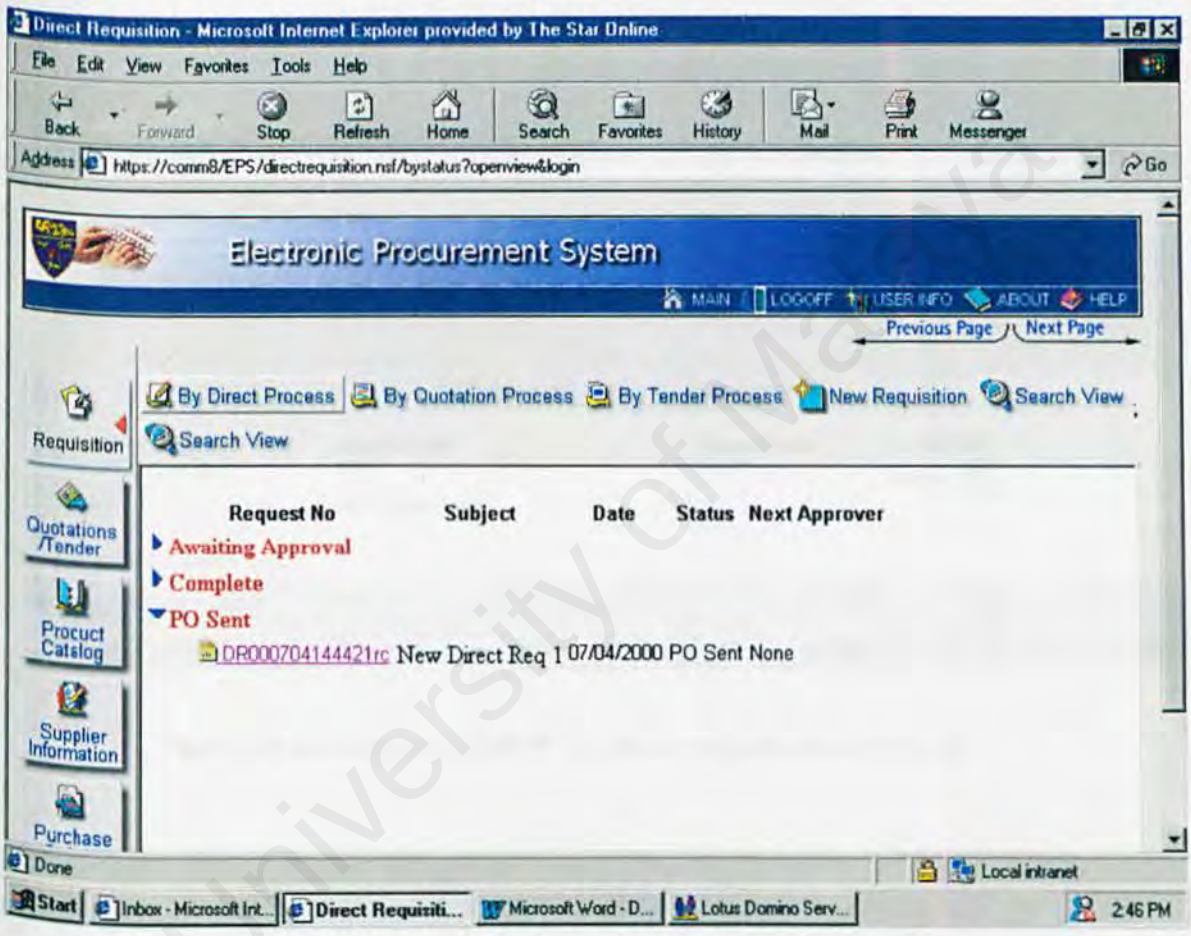

Figure 4.7: *An interface of UMEPS Version 2.0 with duplication of button bars*

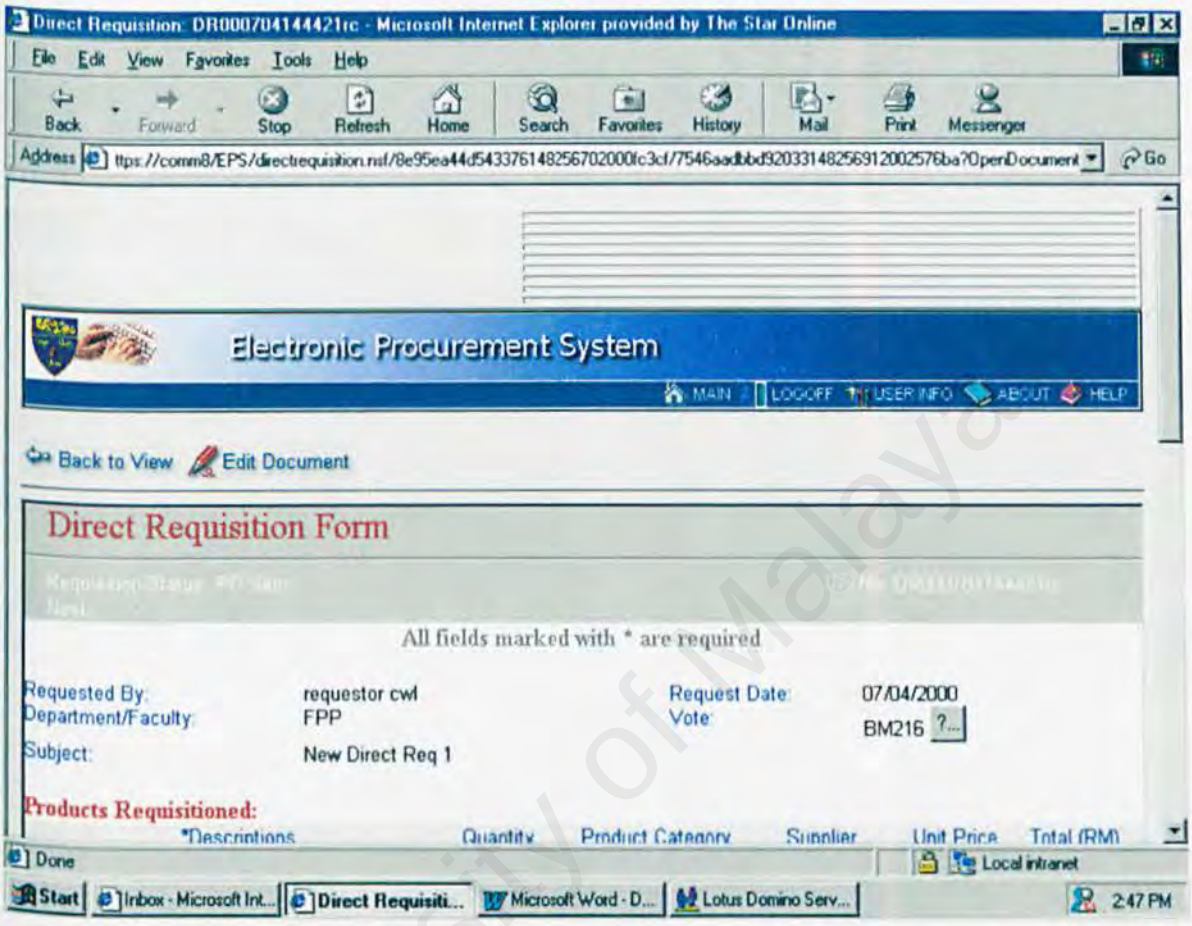

Figure 4.8: *An interface of UMEPS Version 3.0 with distorted top header*

4.7 CONCLUSION

In summary, the initial system design as discussed in this chapter will serve as an essential guideline for the implementation of UMEPS Version 3.0. The main focus for the comprehensive system design is the development of two new databases namely Audit Trail database and Archive Database. The sub focus includes the modification of Supplier Profile database, Supplier Information database, and Purchase Requisition database.

University of Malaya

CHAPTER 5: IMPLEMENTATION

5.1 INTRODUCTION

As a sequel to *Chapter 4*, this chapter serves as the implementation ground of UMEPS Version 3.0. Using the previous chapter as the basis, the system design that had been put to paper will now be executed practically. This chapter describes the technicalities involved in the implementation of this system according to the individual modules as designed in *Chapter 4*. These modules include archive module, audit trail module, supplier performance rating sub-module, supplier profile sub-module, interfaces and security setup.

5.2 ARCHIVE MODULE

Below are the steps involved in developing this module. These steps are according to its numbered sequenced:

5.2.1 Creating the Archive database

In structuring this module, the first step was to create a database using the blank template. The name of this database is **ARCHIVE.NSF**. The process of constructing this database involved form creation, view creation, as well as agent creation.

5.2.2 Creating the Purchase Requisition form

The next step is to build a form named **Purchase Requisition**. This form consists of many fields and hidden fields. This is how the form looks like:

University of Malaya

SwapImg	JavaScript	
$$Return		
Authorised Authors		
Authorised Readers		
User		
Doc ID		
Server Name		
Req Status		
Action, App Comment, Req No, valid Total		
Top Header		
Back2	Edit2	
Refresh	Save	Submit approval
Create PO	Deny	

```
[<hr><table border=0 width=760 bgcolor="white" cellspacing=0
cellpadding=0><tr height=2><td width=2><img
src="/icons/ep_img/topleft2.gif" width=2 height=2></td><td
width=756><img src="/icons/ep_img/topborder2.gif" width=756
height=2></td><td width=2><img src="/icons/ep_img/topright2.gif"
width=2 height=2></td></tr><tr><td width=2 valign="top"><img
src="/icons/ep_img/leftborder2.gif" width=2 height=360></td><td
width=756 valign="top">]
```

PURCHASE REQUISITION FORM

	Requestor		ReqDate
	Dept		
	Subject		
			Clear

Description	Qty	ProductCategory	Supplier	Unit Price	Total
					Amount

University of Malaya

```
</td><td width =2 valign="top"><img
src="/icons/ep_img/rightborder2.gif" width=2 height=900></td></tr>
<tr height=2><td width=2><img src="/icons/ep_img/bottomleft2.gif"
width=2 height=2></td>
<td width=756><img src="/icons/ep_img/bottomborder2.gif" width=756
height=2></td><td width=2>
<img src="/icons/ep_img/bottomright2.gif" width=2
height=2></td></tr></table>
```

The coding for each of the fields is as below:

SwapImg:

```
"<script language=\"javascript\">" + @NewLine +
"function swapImg(imgname, imgfile){" + @NewLine +
"      newimg =\"/icons/ep_img/\" + imgfile;" + @NewLine +
"      obj = eval(imgname);" + @NewLine +
"      obj.src = newimg;" + @NewLine +
"}" + @NewLine +@NewLine +
"</script>"
```

This field contains a function to swap between images.

JavaScript:

```
RFPPath :=  @ReplaceSubstring(@LeftBack(@Subset(@DbName;-1); "\\");
"\\"; "/") + "/proposal.nsf";
dbpath :=@ReplaceSubstring(@Subset(@DbName; -1); "\\"; "/");
@NewLine +
"<script language=javascript>" + @NewLine +
" RFP = document.forms[0].RFP" + @NewLine +
" RFQSubject = document.forms[0].RFQSubject" + @NewLine +
" RFQClosingDate = document.forms[0].RFQClosingDate" + @NewLine +
" NextAction = document.forms[0].NextAction" + @NewLine +
```


University of Malaya

```
@NewLine +

"function nextClick() {" +  @NewLine +
"  switch (NextAction.value){" +  @NewLine +
"     case \"Select Product\":" +  @NewLine +
"          productBox();" +  @NewLine +
"          break;" +  @NewLine +
...

"function productBox() {" +  @NewLine +
"    prURL = \'/" + dbPath + "/Product?OpenForm\';" + @NewLine +
"    opts =  \'dependent=yes, width=490 ,height=310\';" + @NewLine +
"    prWin=window.open( prURL,\'prWindow\', opts);" +  @NewLine +
"}"  +  @NewLine + @NewLine +

"function approveClick(){" + @NewLine +
"   document.forms[0].Action.value = \"Approve\";" + @NewLine +
"   enterComment();" + @NewLine +
"}" + @NewLine +

"function denyClick(){" + @NewLine +
"   document.forms[0].Action.value = \"Deny\";" + @NewLine +
"  enterComment();" + @NewLine +
"}" + @NewLine +

"function about(){" + @NewLine +
"    aboutURL = \'/icons/abouteps.htm\';" + @NewLine +
"    opts =  \'dependent=yes, width=400 ,height=285\';" + @NewLine +
"    aboutWin=window.open( aboutURL,\'aboutWindow\', opts);" +
@NewLine +
"}" +  @NewLine +

"</script>"
```

This field contains several javascript functions which upon execution will prompt the relevant pop-up boxes, such as the 'product' box from which users can select the

University of Malaya

items to be requisited, and the 'about' box from which users get information about the system version and developers, to name a few.

$$Return:

```
Dbpath :=@ReplaceSubstring(@ReplaceSubstring(@Subset(@DbName; -1);
"\\"; "/");" ";"+") ;
ViewName := @If(@IsMember("[Approver]"; @UserRoles);
"AwaitingApproval"; "ByStatus");
view := dbpath + "/" + viewname + "?OpenView";

Thanks := "<h2>Thank you, " +@Name([CN];@UserName) + "! Form
submitted.</h2>";
App := "<a href=/"+view+">Purchase Requisition</a></center>";
Home := "<a href=\"/\">Home</a>";

OkMsg :=  "<center>" + Thanks + "<b>" + Home + " | "  + App +
"</b></center>";
Path := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
AppPath:=@If(Path = ""; ""; Path + "/");
Profile := AppPath + "userprofileredirect.nsf/userprofile?openform";
Logoff := "http://logoff:logoff@comm8.fsktm.um.edu.my/" +  AppPath +
"logoff.nsf" +"/logoff?Openform";
About := "javascript:about()";
Help := DbPath;
Main := AppPath + "main.nsf/login";
...
```

This field is programmed to display a customised response when a user clicks any submit button on the system.

Authorised Authors:

```
@If(@IsNewDoc; @Name([CN]; @UserName ):"[Manager]";
AuthorisedAuthors)
```

This hidden field specifies the criteria of a valid authorised author.

Authorised Readers:

```
@If(@IsNewDoc; @Name([CN]; @UserName ):"[Manager]";
AuthorisedAuthors)
```

This hidden field specifies the criteria of a valid authorised reader.

User:

```
@Name([CN]; @UserName)
```

This field computes the name of the user currently logged on to the system.

Doc ID:

```
@Text(@DocumentUniqueID)
```

This field translates the document unique identification number to the appropriate text version.

App Path:

```
@ReplaceSubstring(@LeftBack(@Subset(@DbName;-1); "\\"); "\\"; "/")
```

This field specifies the path name of the database.

Req No:

```
TimeNow := @Now;
YearString := @Right(@Text(@Year(TimeNow)); 2);
```

University of Malaya

```
MonthString := @Select(@Month(TimeNow); "01"; "02"; "03"; "04";
"05";
"06"; "07"; "08"; "09"; "10"; "11"; "12");
DayNumber := @Day(TimeNow);
DayString := @Select(DayNumber; "01"; "02"; "03"; "04"; "05"; "06";
"07"; "08"; "09"; @Text(DayNumber));
HourNumber := @Hour(TimeNow);
HourString := @If(HourNumber = 0; "00"; @Select(HourNumber; "01";
"02";
"03"; "04"; "05"; "06"; "07"; "08"; "09"; @Text(HourNumber)));
MinuteNumber := @Minute(TimeNow);
MinuteString := @If(MinuteNumber = 0; "00"; @Select(MinuteNumber;
"01";
"02"; "03"; "04"; "05"; "06"; "07"; "08"; "09";
@Text(MinuteNumber)));
SecondNumber := @Second(TimeNow);
SecondString := @If(SecondNumber = 0; "00"; @Select(SecondNumber;
"01";
"02"; "03"; "04"; "05"; "06"; "07"; "08"; "09";
@Text(SecondNumber)));
user := @If(Requestor = "";@Name([CN];@UserName); Requestor);
"DR" + YearString + MonthString + DayString + HourString +
MinuteString + SecondString + @Left(user; 1) +
@MiddleBack(user; " "; 1)
```

This field generates the requisition number automatically.

valid Total:

```
msg := "Total is more than RM1000.00. Please use quotation or tender
requisition form.";
@If(Amount <= 1000; @Success; @If( @ClientType="Web" ; "<SCRIPT
language=JavaScript> ; alert(\'" + msg + "\'); history.go(-1)
</SCRIPT>" ; @Failure(msg)))
```

This field validates the total amout of requisition. If the amount is more that what is allowed, an error message is prompted.

University of Malaya

Top Header:

```
Path := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
AppPath:=@If(Path = ""; ""; Path + "/");
DbPath := @ReplaceSubstring(@Subset(@DbName; -1); "\\"; "/");
Profile := AppPath + "userprofileredirect.nsf/userprofile?openform";
Logoff := "http://logoff:logoff@comm8.fsktm.um.edu.my/" +  AppPath +
"logoff.nsf" +"/logoff?Openform";
About := "javascript:about()";
Help := DbPath;
Main := AppPath + "main.nsf/login";

"<img src=\"/icons/ep_img/header.gif\" ><br><table width=760
border=0 cellpadding=0 cellspacing=0><tr ><td width=3 height=17><img
src=\"/icons/ep_img/leftborder.gif\" height=17 width=3></td><td
width=754 height=17 bgcolor=\"#000084\"><div align=\"right\">" +
"<a href = \"/" + Main  + "\"><img src=\"/icons/ep_img/main.gif\"
height=17 border=0></a>" +
...
```

This shared field contains the links and graphics for the standard header of UMEPS Version 3.0.

Back2:

```
Path := @ReplaceSubstring(@Subset(@DbName; -1); "\\"; "/");
ViewName      :=      @If(@IsMember("[Approver]";      @UserRoles);
"AwaitingApproval"; "ByStatus");
back := Path + "/" + ViewName + "?OpenView";
"[<a href=\"/" + back + "\"><img src=\"/icons/ep_img/backview.gif\"
border=0  alt=\"Back To View\" name=\"backbtn\"
onmouseover=\"swapImg(\'document.backbtn\', \'backview_over.gif\')\"
onmouseout=\"swapImg(\'document.backbtn\', \'backview.gif\')\"
></a>]"
```

This field brings a user to the previous page.

University of Malaya

Edit2:

```
@Command([EditDocument]); @Success
```

This field enables a document to be edited.

Refresh:

```
@Command([ViewRefreshFields]); @Success
```

This field refreshes a document to reflect the current version.

Save:

```
FIELD Action := "Save";
@Command([ViewRefreshFields]);
@Command([FileSave]);@Command([FileCloseWindow])
```

This field saves and closes a document.

Submit Approval:

```
FIELD Action := "Submit";
FIELD Descriptions_1 := @Trim(Descriptions_1);
...

@Command([ViewRefreshFields]);
@Command([FileSave]); @Command([FileCloseWindow])
```

This field submits an approval document, saves and closes it.

Create PO:

```
FIELD ProAction := "CreatePO";
```

University of Malaya

```
@Command([ToolsRunMacro]; "RefreshQuantity");
@Command([ToolsRunMacro];"Create Manual Purchase Order");
@Command([FileCloseWindow])
```

This field functions to create a manual purchase order throught the execution of an agent named 'Create Manual Purchase Order'.

Requestor:

```
@If(@Trim(Requestor)="";@Name([CN];@UserName);Requestor)
```

This field validates a user who has requestor authority.

Dept:

```
ViewName := "Requestor";
DeptPath     :=     @ReplaceSubstring(@LeftBack(@Subset(@DbName;-1);
"\\");"\\"; "/") + "/userprofile.nsf";
Temp := @DbLookup ("":"NoCache"; "":DeptPath; ViewName; Requestor;
"Dept");
@If(@IsError(Temp)|Temp = ""; "Undefined"; Temp)
```

Subject:

```
msg := "The subject field is empty. Please go back to the form and
enter it before submitting the form";
Java := "<script language = JavaScript>; alert (\'" + msg + "\');
history.go(-1)</script>";
errmsg := @If(@ClientType = "Web"; Java; msg);

@If(@Trim(Subject)=""; @Failure(errmsg); @Success)
ReqDate:
```

University of Malaya

ReqDate:

```
@Today
```

This field computes the requisition date.

Clear:

```
"[<INPUT TYPE=\"button\" VALUE=\"Clear All\"
onClick=\"clearProductList()\">]"
```

This field clears the list of products upon clicking.

Descriptions:

```
@Trim(Descriptions)
```

Quantity:

```
msg := "Product quantity is a required field1.";
Java := "<script language = JavaScript>; alert (\'" + msg + "\');
history.go(-1)</script>";
errmsg := @If(@ClientType = "Web"; Java; msg);
msg2 := "Please enter a valid number for Quantity.";
Java2 := "<script language = JavaScript>; alert (\'" + msg2 + "\');
history.go(-1)</script>";
errmsg2 := @If(@ClientType = "Web"; Java2; msg2);

msg3 := "Quantity requested for first product is more than quantity
available.";
Java3 := "<script language = JavaScript>; alert (\'" + msg3 + "\');
history.go(-1)</script>";
errmsg3 := @If(@ClientType = "Web"; Java3; msg3);

AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName;-1); "\\");
"\\"; "/");
```

University of Malaya

```
prodb := @If(AppPath =""; ""; AppPath + "/") + "productcatalog.nsf";
qty := @DbLookup(""; "": prodb; "BName"; Descriptions_1; "ProQty");
ModType := @DbLookup(""; "": prodb; "BName"; Descriptions_1;
"ModType");

msg4 := "First product not found.";
Java4 := "<script language = JavaScript>; alert (\'" + msg4 + "\' );
history.go(-1)</script>";
errmsg4 := @If(@ClientType = "Web"; Java4; msg4);

NumQty := @TextToNumber(Qty_1);
NumOldQty := @TextToNumber(oldQty_1);
DifQty := NumQty-NumOldQty;
qtyOrder := @If(ReqStatus = "New"; NumQty; NumQty-NumOldQty);
qty2 := @If(ModType = "Online"; qty; @TextToNumber(qty));

@If(@Trim(Descriptions_1)!=""; @If(@IsError(qty); @Failure(errmsg4);
@If(@Trim(Qty_1)=""; @Failure(errmsg);
@If(@IsError(@TextToNumber(Qty_1)); @Failure(errmsg2); @If(qtyOrder
> qty ; @Failure(errmsg3); @Success))))
 ; @Success)
```

Product Category:

```
msg := "Incorrect product category.";
Java := "<script language = JavaScript>; alert (\'" + msg + "\');
history.go(-1)</script>";
errmsg := @If(@ClientType = "Web"; Java; msg);

msg2 := "Incorrect product category.";
Java2 := "<script language = JavaScript>; alert (\'" + msg2 + "\');
history.go(-1)</script>";
errmsg2 := @If(@ClientType = "Web"; Java; msg2);
...
```

This field prompts the user in the event of an incorrect product category.

University of Malaya

Supplier:

```
msg := "The supplier does not offer the first product.";
Java := "<script language = JavaScript>; alert (\'" + msg + "\');
history.go(-1)</script>";
errmsg := @If(@ClientType = "Web"; Java; msg);
msg2 := "Supplier does not offer the the first product the chosen
category.";
...
```

This field prompts an error message if the product requested is not offered by the particular supplier.

Unit Price:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName;-1); "\\");
"\\"; "/");
prodb := @If(AppPath =""; ""; AppPath + "/") + "productcatalog.nsf";
price := @DbLookup(""; "": prodb; "BName"; Descriptions_1;
"ProPrice");
@If(@IsError(price); 0; price)
```

This field computes the unit price of a product.

Total:

```
total := @TextToNumber(Qty_1)*UnitPrice_1;
@If(@IsError(total); 0; total)
```

Amount:

```
@Sum(d_Total_1:d_Total_2:d_Total_3:d_Total_4:d_Total_5);
REM "@If(@IsNewDoc; 0; @If(@IsError(sum); 0 ; sum))";
```

This field sums up the total price of the products.

University of Malaya

5.2.3 Creating a view for Requestors

After the Purchase Requisition form has been created, a view corresponding to this form is created. The name of this view is **Requestors.** This view consists of some fields from the Purchase Requisition form namely Request No, Subject, Date, Status, and Next Approver.

5.2.4 Creating the '$$ViewTemplate for Requestors' form

Once the Requestor view has been completely done, another form named **$$ViewTemplate for Requestors** was created. This form serves as the template for web browsers and consists of an embedded view that is **Requestors.** This form looks similar to this:

Top Header	Previous	Next
<table border="0" cellpadding="0" cellspacing="0" width="760"> <tr> <td valign="top" rowspan="4" width="92" align="left"> </td>		
Requisition | Quotation | Catalog | Supplier | PO | Archive		
<td valign="top" align="left" rowspan="4" width="20"><img src="/icons/ep_img/inborder.gif" width=1 height=550></td> <td width="2"></td>		
<td>	Direct View	</td>

University of Malaya

```
<td width="2"> </td> </tr>
<tr> <td width="2"><img src="/icons/ep_img/topleft2.gif" width=2
height=2></td>
    <td width="644"><img src="/icons/ep_img/topborder2.gif" width=670
height=2></td>
    <td width="2"><img src="/icons/ep_img/topright2.gif" width=2
height=2></td> </tr> <tr>
    <td width="2"><img src="/icons/ep_img/leftborder2.gif" width=2
height=530></td>
    <td width="644" valign="top"bgcolor="#ffffff">
```

EMBEDDED VIEW (REQUESTORS)

```
</td>
    <td width="2"><img src="/icons/ep_img/rightborder2.gif" width=2
height=317></td> </tr>
<tr> <td width="2"><img src="/icons/ep_img/bottomleft2.gif" width=2
height=2></td>
    <td width="644"><img src="/icons/ep_img/bottomborder2.gif"
width=644 height=2></td>
    <td width="2"><img src="/icons/ep_img/bottomright2.gif" width=2
height=2></td>
</tr>
</table>
```

To create an embedded view, click Create – Embedded Element – View. The display properties of the embedded view **Requestors** was set to "Using View's display properties", not "Using Java Applet" or "Using HTML".

The coding for the fields is as below:

Requisition:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
```

University of Malaya

```
req := @If(AppPath = ""; ""; AppPath + "/") +
"quotationrequisition.nsf/ByStatus?OpenView";
"[<a href=\"/" +req + "\"><img src=\"/icons/ep_img/requisition.gif\"
alt=\"Purchase Requisition\" width=80 height=67 border=0
name=\"req\" onmouseover=\"swapImg(\'document.req\',
\'requisition_over.gif\')\" onmouseout=\"swapImg(\'document.req\',
\'requisition.gif\')\"></a>]"
```

This field links to the Requisition database.

Quotation:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
DbPath := @ReplaceSubstring(@Subset(@DbName; -1); "\\"; "/");
Quotation := @If(AppPath=""; ""; AppPath + "/")
+"RFT_tender.nsf/YourRequest?OpenView";
"[<a href=\"/" + Quotation + "\"><img
src=\"/icons/ep_img/quotender.gif\"alt=\"Quotations/Tender\"
width=80 height=67 border=0 name=\"quo\"
onmouseover=\"swapImg(\'document.quo\', \'quotender_over.gif\')\"
onmouseout=\"swapImg(\'document.quo\', \'quotender.gif\')\"></a>]"
```

This fields links to the Quotation database.

Catalog:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
Catalog := @If(AppPath=""; ""; AppPath + "/")
+"productcatalog.nsf/ByProName?OpenView";
"[<a href=\"/" + Catalog + "\"><img
src=\"/icons/ep_img/productcatalog.gif\" alt=\"Product Catalog\"
width=80 height=67 border=0 name=\"cata\"
onmouseover=\"swapImg(\'document.cata\',
\'productcatalog_over.gif\')\"
```

University of Malaya

```
onmouseout=\"swapImg(\'document.cata\',
\'productcatalog.gif\')\"></a>]"
```

This field links to the Product Catalog database.

Supplier:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
Supplier := @If(AppPath=""; ""; AppPath + "/")
+"supplierprofile.nsf/ByCoName?OpenView";
"[<a href=\"/" + Supplier + "\"><img
src=\"/icons/ep_img/supplierinfo.gif\" alt=\"Supplier Information\"
border=0 width=80 height=67 name=\"sup\"
onmouseover=\"swapImg(\'document.sup\', \'supplierinfo_over.gif\')\"
onmouseout=\"swapImg(\'document.sup\',
\'supplierinfo.gif\')\"></a>]"
```

This field links to the Supplier Profile database.

PO:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
PO := @If(AppPath=""; ""; AppPath + "/")
+"purchaseorders.nsf/Purchase+Orders?OpenView";
"[<a href=\"/" + PO + "\"><img src=\"/icons/ep_img/po.gif\"
alt=\"Purchase Orders\" border=0 width=80 height=67 name=\"po\"
onmouseover=\"swapImg(\'document.po\', \'po_over.gif\')\"
onmouseout=\"swapImg(\'document.po\', \'po.gif\')\"></a>]"
```

This field links to the Purchase Order database.

University of Malaya

Archive:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
DbPath := @ReplaceSubstring(@Subset(@DbName; -1); "\\"; "/");
"[<a href=\"/" + DbPath + "/Requestors?OpenView\"><img
src=\"/icons/ep_img/archive_over.gif\"  width=80 height=67
border=0></a>]"
```

This field links to the Archive database.

5.2.5 Creating the 'ArchiveDoc' agent

The following step for this module is to create a shared agent in the Direct Requisition database. This agent is named **ArchiveDoc.** Its function is to transfer requisitions from the Quotation Requisition database that is more than three months' old (90 days). Under "When should this agent run?", it is set to "On Schedule Weekly". This means that the agent will execute once in a week.

Under "Which documents should it act on?", it is set to "All documents in the database which dates created is more than 90 days.". Under "When should this agent run?", it is set to run a simple action. This simple action performs the actions: "Copy to Database **ARCHIVE.NSF**" and "Delete Documents".

5.2.6 Linking database to main page

The last step for this module is to link it with the main homepage of UMEPS. To achieve this, the **MAIN.NSF** database is opened. Under the Requestors' table, a new column is added. This column is attached with an action hotspot called 'Archive Documents'. The formula for this action hotspot is as below:

University of Malaya

```
@URLOpen("/" + @LeftBack(@Subset(@DbName; -1); "\\") +
"/Archive.nsf/Requestors?OpenView&login")
```

Once this has been done, a field named 'archive' is inserted to all databases accessible to Requestors. These databases include **DIRECTREQUISITION.NSF, RFQ_QUOTATIONS.NSF, SUPPLIERPROFILE.NSF,** and **PRODUCTCATALOG.NSF.** The formula for the field name 'archive' is as follows:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
DbPath := @ReplaceSubstring(@Subset(@DbName; -1); "\\"; "/");
Archive := @If(AppPath=""; "archive.nsf"; AppPath + "/Archive.nsf")
+"/Requestors?OpenView";
"[<a href=\"/" + Archive + "\"><img
src=\"/icons/ep_img/archive.gif\" width=80 height=67 border=0
name=\"archive\" onmouseover=\"swapImg(\'document.archive\',
\'archive_over.gif\')\" onmouseout=\"swapImg(\'document.archive\',
\'archive.gif\')\"></a>]"
```

5.3 AUDIT TRAIL MODULE

The methodology used to develop this module is similar to the section prior to this, the archive module. Below are the steps involved in the order of numbering:

5.3.1 Creating the Audit Log database

This module involved the structuring of a new database created from the Notes Log template. The name of the database is LOG.NSF.

University of Malaya

5.3.2 Creating the '$$ViewTemplate for MiscEvents' form

Using the view template Miscellaneous Events, a new form is created. This form serves as the template for web browsers when viewing log events. The name of this new form is **$$ViewTemplate for MiscEvents**.

The form looks similar to this:

Top Header	Previous	Next

```
<table border="0" cellpadding="0" cellspacing="0" width="760">  <tr>
<td valign="top" rowspan="4" width="92" align="left"></td>
```

User Profile	Dept Profile	Approver Profile	Product Category	Audit Record

```
<td valign="top" align="left" rowspan="4" width="20"><img
src="/icons/ep_img/inborder.gif" width=1 height=346></td>
<td width="2"></td> <td></td> <td width="2"> </td> </tr>
<tr>  <td width="2"><img src="/icons/ep_img/topleft2.gif" width=2
height=2></td>
     <td width="644"><img src="/icons/ep_img/topborder2.gif" width=676
height=2></td>
     <td width="2"><img src="/icons/ep_img/topright2.gif" width=2
height=2></td>
</tr>
<tr>  <td width="2"><img src="/icons/ep_img/leftborder2.gif" width=2
height=317></td> <td width="644" valign="top"bgcolor="#ffffff"></td>
```

EMBEDDED VIEW (MISC EVENTS)

University of Malaya

```
<td width="2"><img src="/icons/ep_img/rightborder2.gif" width=2
height=317></td>
</tr>
<tr> <td width="2"><img src="/icons/ep_img/bottomleft2.gif" width=2
height=2></td>
    <td width="644"><img src="/icons/ep_img/bottomborder2.gif"
width=644 height=2></td>
    <td width="2"><img src="/icons/ep_img/bottomright2.gif" width=2
height=2></td>
</tr>
</table>
```

The coding for each of the fields is as below:

User Profile:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
user    :=    @If(AppPath="";    "";    AppPath    +    "/")    +
"userprofile.nsf/users?OpenView";
"[<a href=\"/" + user + "\"><img
src=\"/icons/ep_img/userprofile.gif\" alt=\"User Profile\" width=80
height=67 border=0 name=\"user\"
onmouseover=\"swapImg(\'document.user\', \'userprofile_over.gif\')\"
onmouseout=\"swapImg(\'document.user\',
\'userprofile.gif\')\"></a>]"
```

This field links to the User Profile database.

Dept Profile:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
path := @If(AppPath=""; "departmentprofile.nsf"; AppPath +
"/departmentprofile.nsf") +"/department?openview&login";
```


University of Malaya

```
"[<a href=\"/" + path + "\"><img
src=\"/icons/ep_img/deptprofile.gif\" width=80 height=67 border=0
name=\"imgdeptpro\" onmouseover=\"swapImg(\'document.imgdeptpro\',
\'deptprofile_over.gif\')\"
onmouseout=\"swapImg(\'document.imgdeptpro\',
\'deptprofile.gif\')\"></a>]"
```

This field links to the Department Profile database.

Approval Profile:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
apppro := @If(AppPath=""; "approvalprofile.nsf"; AppPath +
"/approvalprofile.nsf") +"/ByQuotation?openview&login";
"[<a href=\"/" + apppro + "\"><img
src=\"/icons/ep_img/approvalprofile.gif\" width=80 height=67
border=0 name=\"imgapppro\"
onmouseover=\"swapImg(\'document.imgapppro\',
\'approvalprofile_over.gif\')\"
onmouseout=\"swapImg(\'document.imgapppro\',
\'approvalprofile.gif\')\"></a>]"
```

This field links to the Approval Profile database.

Product Category:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
path := @If(AppPath=""; "productcategory.nsf"; AppPath +
"/productcategory.nsf") +"/bycategory?openview&login";
"[<a href=\"/" + path + "\"><img
src=\"/icons/ep_img/productcategory.gif\" width=80 height=67
border=0 name=\"imgproductcat\"
onmouseover=\"swapImg(\'document.imgproductcat\',
\'productcategory_over.gif\')\"
```

University of Malaya

```
onmouseout=\"swapImg(\'document.imgproductcat\',
\'productcategory.gif\')\"></a>]"
```

This field links to the Product Category database.

Audit Record:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
auditrecord := @If(AppPath=""; ""; AppPath + "/")
+"Audit_record.nsf/MiscEvents?OpenView";
"[<a href=\"/" + auditrecord + "\"><img
src=\"/icons/ep_img/auditrecord_over.gif\"alt=\"Audit Record\"
width=80 height=67 border=0 ></a>]"
```

This field links to the Audit Record database.

The template form named **Events** is used as the basis for the display of the event logs in the Notes database.

5.3.3 Linking the database to main page

The last step for this module is to link it with the main homepage of UMEPS. To achieve this, the **MAIN.NSF** database is opened. Under the Administrators' table, a new column is added. This column is attached with an action hotspot called 'Audit Records'. The formula for this action hotspot is as below:

```
@URLOpen("/" + @LeftBack(@Subset(@DbName; -1); "\\") +
"/log.nsf/MiscEvents?Openview&Login")
```

Once this has been done, a field named 'audit record' is inserted to all databases accessible to Administrators. These databases include **USERPROFILE.NSF, DEPARTMENTPROFILE.NSF, APPROVERPROFILE.NSF** and

University of Malaya

PRODUCTCATEGORY.NSF. The formula for the field name 'audit record' is as follows:

```
AppPath := @ReplaceSubstring(@LeftBack(@Subset(@DbName; -1); "\\");
"\\"; "/");
auditrecord := @If(AppPath=""; ""; AppPath +  "/") +
"log.nsf/MiscEvents?OpenView";
"[<a href=\"/" + auditrecord + "\"><img
src=\"/icons/ep_img/auditrecord.gif\" alt=\"Audit Record\" width=80
height=67 border=0 name=\"auditrecord\"
onmouseover=\"swapImg(\'document.auditrecord\',
\'auditrecord_over.gif\')\"
onmouseout=\"swapImg(\'document.auditrecord\',
\'auditrecord.gif\')\"></a>]"
```

5.4 SUPPLIER PERFORMANCE RATING SUB-MODULE

5.4.1 Creating the 'CheckDuplicateRating' agent

For this sub-module, an additional function is included to disallow requestors and approvers to perform duplicate performance rating on the same supplier. For this reason, an additional agent, a shared agent, is created on the database named **SUPPLIERPROFILE.NSF.** The name given to this agent is **CheckDuplicateRating**. This agent should run on UMEPS once any documents are created or modified. The scripting language used to create this agent is LotusScript. Below are the scripts for this agent:

```
Sub Initialize
    Dim exists As Integer
    Dim session As New NotesSession
    Dim db As NotesDatabase
    Dim collection As NotesDocumentCollection
    Dim doc As NotesDocument
```


University of Malaya

```
	Set doc = session.DocumentContext
	Set db = New NotesDatabase( "" ,  "EPS/supplierprofile")
	Set collection = db.AllDocuments

	doc.SaveOptions = "1"
	exists = checkDuplicate(doc , collection)

	If exists Then
		Print "<h2>Performance rating already exist!</h2>"
		Print "<hr>"
		Print link
		doc.SaveOptions = "0"
	Else
		Call doc.save(False , True)
		Print "<h2>Your document was saved</h2>"
		Print "<hr>"
		Print link

	End If
End Sub

Function CheckDuplicate (doc As notesdocument , coll As
Notesdocumentcollection) As Integer
	Dim tempdoc As NotesDocument

	Set tempdoc = coll.getfirstdocument()

	While ( Not ( tempdoc Is Nothing) )

		'don't compare with original document
		If (doc.Universalid <> tempdoc.UniversalID ) Then
			If tempdoc.Type(0) = doc.Type(0) Then
				checkDuplicate = 1
				Exit Function
			End If
		End If
		Set tempdoc= coll.getnextdocument(tempdoc)
```

University of Malaya

```
    Wend

    checkDuplicate = 0

End Function
```

5.4.2 Enabling the execution of agent

To enable this script to run, additional formulas has to be added to the form named **Performance Rating.** Under the object tab, the WebQuerySave object for this form is included with this formula:

```
@Command([ToolsRunMacro]; "CheckDuplicateRating")
```

5.5 SUPPLIER PROFILE SUB-MODULE

5.5.1 Creating a 'SendMail' function

For this sub-module, an additional function has been incorporated to automate e-mail notifications to treasurers upon the registration of new suppliers. Using the existing agent called **RegisterSpl,** a function is included to perform the above-mentioned task. This function is called **SendMail.** The scripts are as follows:

```
Sub SendMail(CoName As String, FullName As String, RegNo As String)
'send a mail to the admin to notify him/her on the registration of
new supplier

    Dim s As New NotesSession
    Dim maildb As NotesDatabase
    Dim maildoc As NotesDocument
```


University of Malaya

```
Dim RTF As NotesRichTextItem
Set maildb = s.currentdatabase
Set maildoc = New notesdocument(maildb)
Set RTF = maildoc.CreateRichTextItem("Body")

'Print "calling send"
maildoc.Form = "Memo"
maildoc.SendTo = SendTo
'Print "<br> sending mail to " & SendTo
'Print "<br> sending mail to " & maildoc.SendTo(0)
maildoc.Subject = "Registration with UM"
Call RTF.AddNewLine(1)
Call RTF.Appendtext("Your company has registered with UM and
your login name has been activated. ")
Call RTF.AddNewLine(1)
Call RTF.Appendtext("The registration number is:<"&RegNo$ &
">.")
Call RTF.AddNewLine(1)
Call RTF.Appendtext("Your login name is : <"&FullName$ & ">.")
Call maildoc.send(False)
'Print "<br> A Mail has been sent to the admin."

End Sub
```

5.5.2 Creating a 'SendTo' hidden field

Also, under the **New Supplier** form, an additional hidden field named 'SendTo' is included. This field specifies the person to whom it will be alerted upon submission of the form.

University of Malaya

5.6 INTERFACES

5.6.1 Creating icon buttons

There are two parts to the implementation of interfaces. The first part involved creating icon buttons for the new modules using Paint Shop Pro 5. Below are the icon buttons created for the two new modules:

Figure 5.1: *Icon buttons for Archive Module*

Figure 5.2: *Icon buttons for Audit Trail Module*

Besides that, the Logo of UMEPS was also modified to reflect the new version of the application. This is the result:

University of Malaya

Figure 5.3: The standard logo for UMEPS

5.6.2 Rectifying distorted headers and hidden fields

The second part of the interface implementation includes the rectification of distorted Top Headers in the web application. The databases involved in this process are **DIRECTREQUISITION.NSF, QUOTATIONREQUISITION.NSF, AND TENDERREQUISITION.NSF.** The forms involved in the rectification in all these three databases are the Purchase Requisition forms.

The table of hidden fields that were not hidden causes the distortion in the header from the web users. The approach in solving this is to change the 'hide-when' properties of the table. This is done by enabling the "hide paragraph from web browsers" function. With this, the distortion is recovered.

University of Malaya

As for the **PRODUCTCATALOG.NSF** database, the same concept is used to eradicate the hidden fields that were displayed on the web browser.

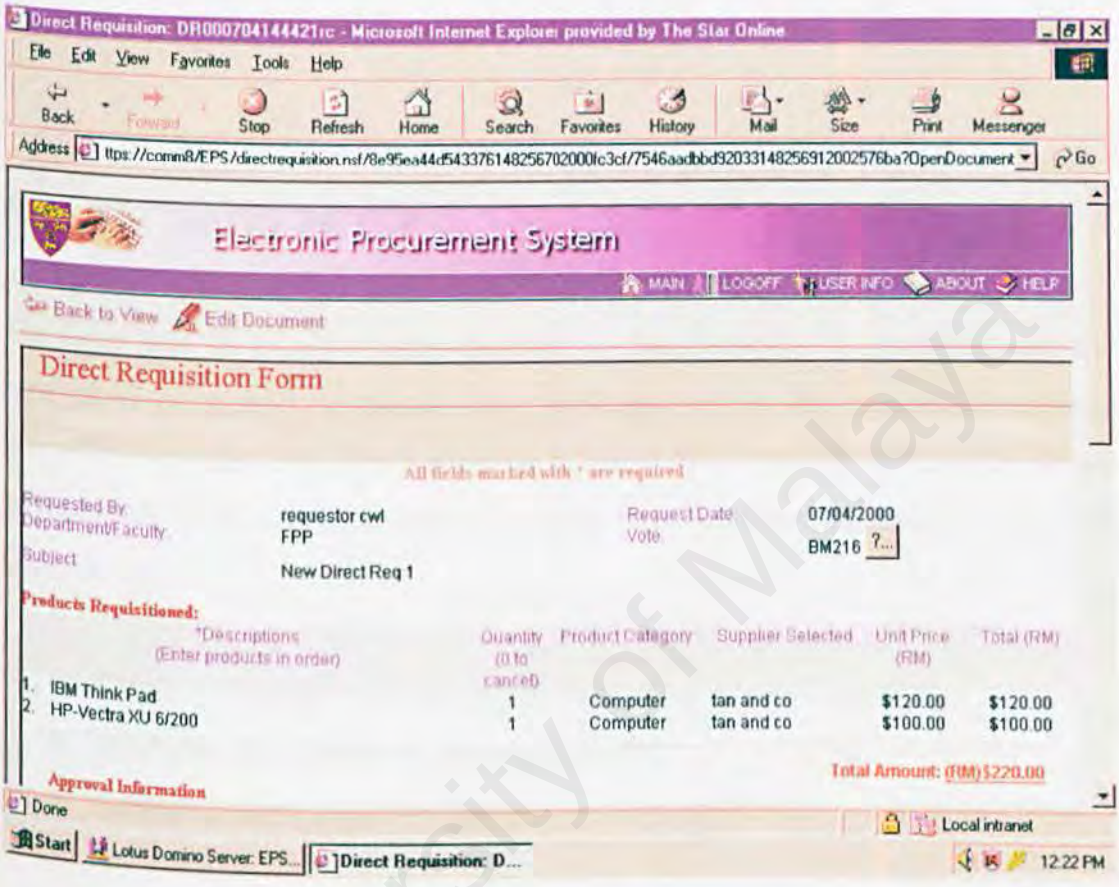

***Figure 5.4:** The Top Header after being rectified*

5.7 SYSTEM SETUP

A system setup was deemed unnecessary as the implementation of the previous two versions of UMEPS was done on the same site (i.e. 202.185.109.178). There was an attempt, however, to install Notes Client on another machine as the current machine is being over-utilised, thus slowing down system performance.

The attempt was scrapped off after considering a number of adverse factors arising from it. One of the setbacks was that the application development on the new client

machine would be interrupted or staggered should the local area network be down. This is the main concern that would inevitably affect the time needed to complete the project development.

5.8 SECURITY SETUP

The focus area for security setup concerns the Secure Socket Layer (SSL) and the renewal of its expired certificate. The certificate used by the previous developers lasted for two years only, hence needs to be renewed in order to maintain the secure environment of the web application. Basically, there are three main steps involved in this process:

- Creating a Certificate Authority (CA) key ring file and certificate
- Configuring a Certificate Authority profile
- Setting up SSL on the CA server

5.8.1 Creating a CA key ring file and certificate

The Domino Certificate Authority application is set up prior to the creation of a CA key ring file and certificate. The Domino Certificate Authority was accessed from the Domino Administrator, under the Files tab. These fields are configured as such:

University of Malaya

CA key ring

Key ring file name	: C:\Lotus\Notes\Data\CAKeyNew.kyr
Common name	: UMEPS3 SSL CA
Organisation	: University of Malaya
State	: Kuala Lumpur
Country	: MY
Certificate valid from	: 09/01/2001 to 07/01/2011

5.8.2 Configuring the Domino CA application profile

The link labeled 'Configure Certificate Authority Profile' was clicked on the Files tab of Domino Administrator. The TCP/IP DNS name of the server that runs the CA application in the Certificate Server DNS name field was entered. This name is comm8.fsktm.um.edu.my or 202.185.109.178. Once this was done, the application was saved and closed.

5.8.3 Setting up SSL on the CA server

Because server administrators and clients use browsers to access the CA server to request and pick up certificates, SSL is used to protect the CA server. When the CA server is set up for SSL, the server key ring file was created and a server certificate was requested. Domino automatically approves the server certificate and merges the CA certificate as a trusted root.

The link labeled 'Create Server key Ring & Certificate' was clicked on the Files tab of Domino Administrator. These fields are completed:

University of Malaya

Server key ring

Key ring file name	: C:\Lotus\Notes\Data\keyfile.kyr
Common name	: comm8.fsktm.um.edu.my
Organisation	: University of Malaya
State	: Kuala Lumpur
Country	: MY

Next, the server key ring file was copied to the Domino data directory on the server. The Domino CA application creates the file locally; however, the server needs the key ring file to use SSL.

After the certificate has been renewed, the Secure Socket Layer (SSL) port is configured from the Server document. The SSL port status is enabled to allow SSL connections on the port.

5.9 CONCLUSION

Once the entire implementation process has been completed, as adhered to the system design outlined in *Chapter 4*, it is then appropriate to step into the next stage of the system development life cycle – Testing. However, some testing strategies are performed simultaneously during the coding process. The next chapter discusses on the strategies and techniques implemented for testing purposes.

University of Malaya

CHAPTER 6: TESTING

6.1 INTRODUCTION

Testing is an integral part of system development. Without testing, unexpected errors cannot be uncovered. For a system as complex as UMEPS, testing is necessary to identify bugs and consequently rectify them.

Some testing processes are executed incrementally in parallel with the system coding. Others are done after the completion of system coding. The testing strategies that will be used include unit testing, integration testing, and system testing. Each of these strategies will be discussed in further detail in the following sections.

6.2 UNIT TESTING

In a unit test, individual components are tested to ensure that they operate and function correctly. For the purpose of unit testing, four units have been selected:

6.2.1 Icon Buttons

To test whether the JavaScript for the icon buttons of the two new modules function correctly, it was accessed through the web browser using registered users' identification.

The objective of this test was to determine the behaviour of the icon on two situations. Firstly, when the mouse is rolled over the icon. Secondly, when the mouse is rolled out of the icon. When the mouse is rolled over the icon, the icon should appear as embossed. When the mouse is otherwise, it should be in its original state.

University of Malaya

This test was performed on the Archive button and the Audit Record button. It was thus found to be working in accordance to the script.

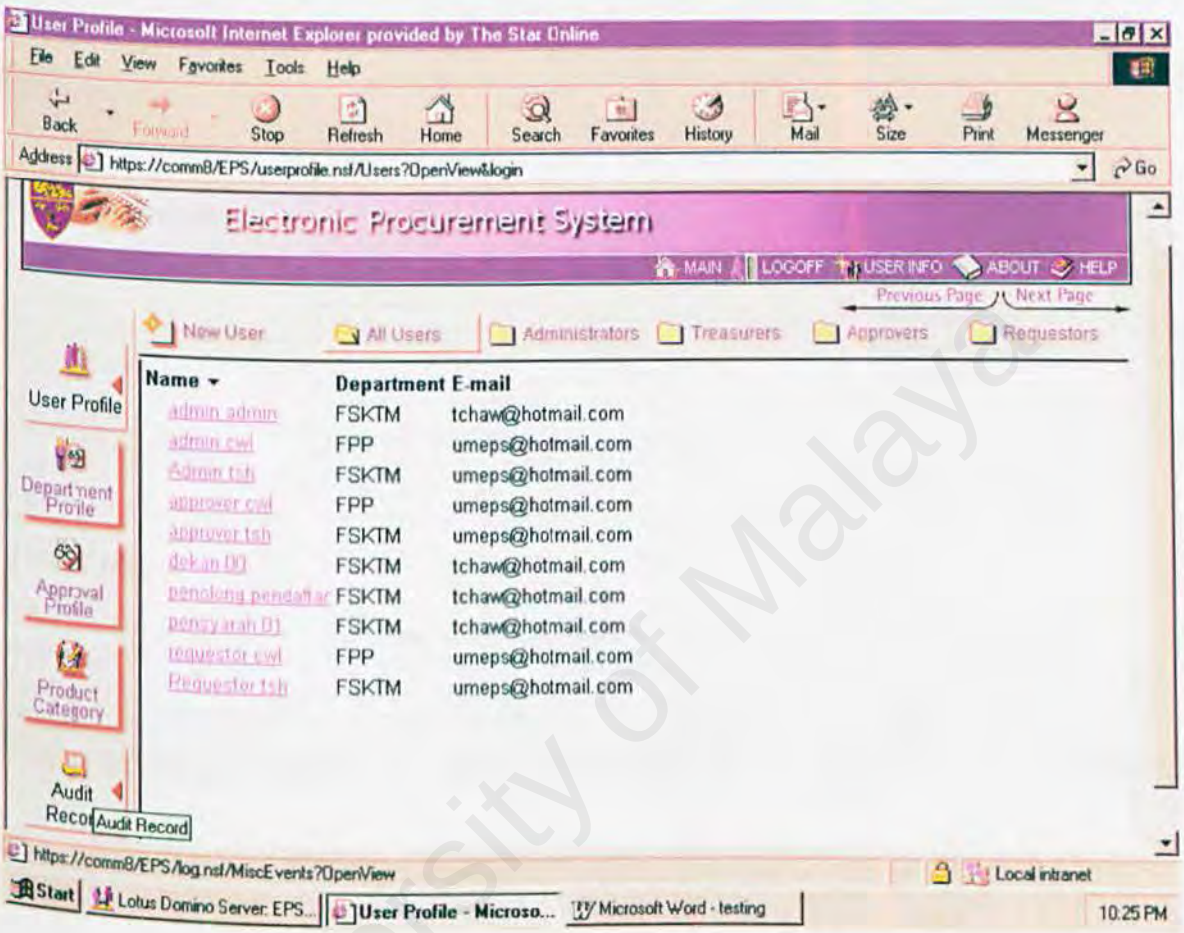

Figure 6.1: *The icon button appears embossed when the mouse is rolled over it.*

6.2.2 E-mail notification

For this unit test, a simulation was done whereby a new supplier was made to register with UMEPS. An e-mail account was also created for this purpose, in which all e-mail notification to the treasurers will be generated to umeps@hotmail.com.

It was tried and tested that a few minutes upon a new supplier's registration, an e-mail notification was generated to umeps@hotmail.com. The following two figures illustrates this simulation.

University of Malaya

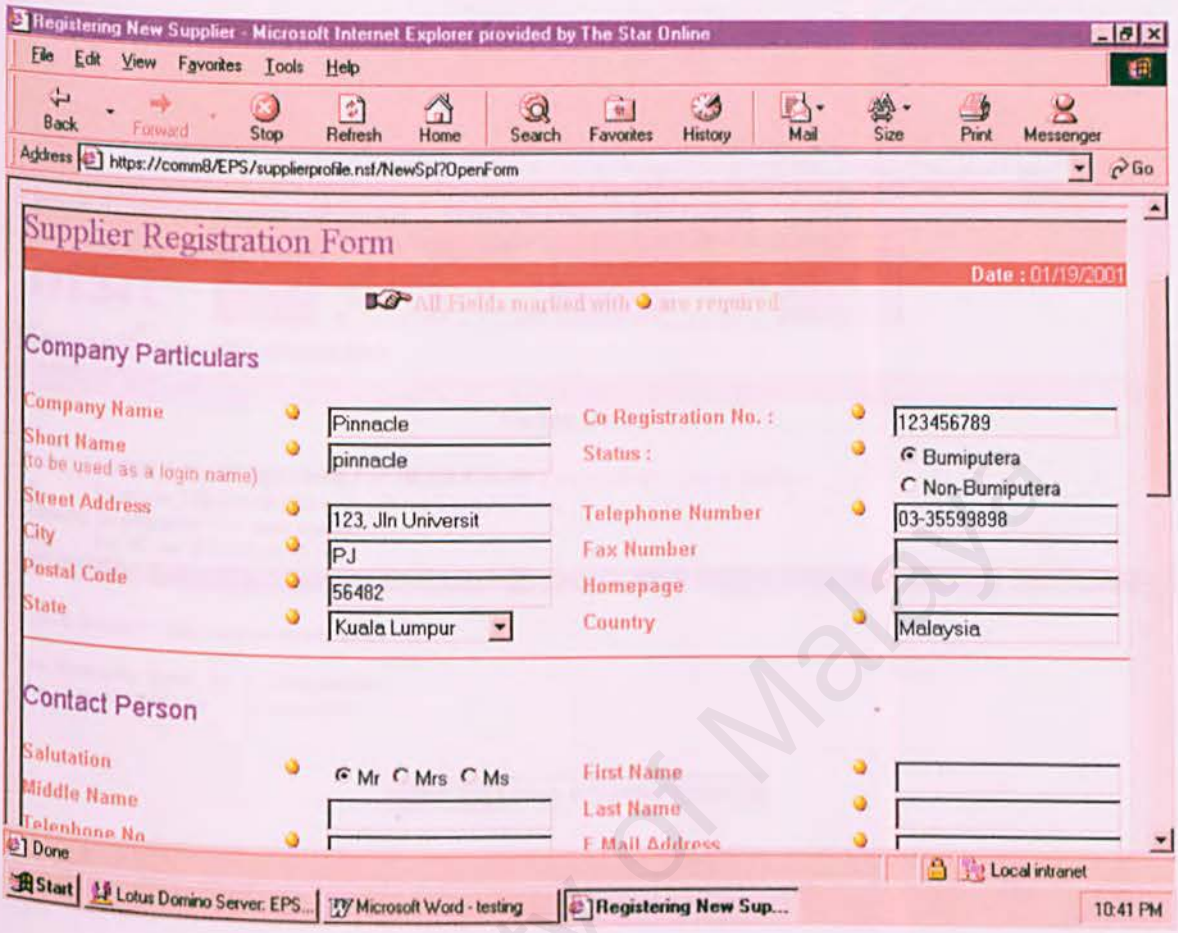

Figure 6.2: *A supplier registering itself as Pinnacle*

University of Malaya

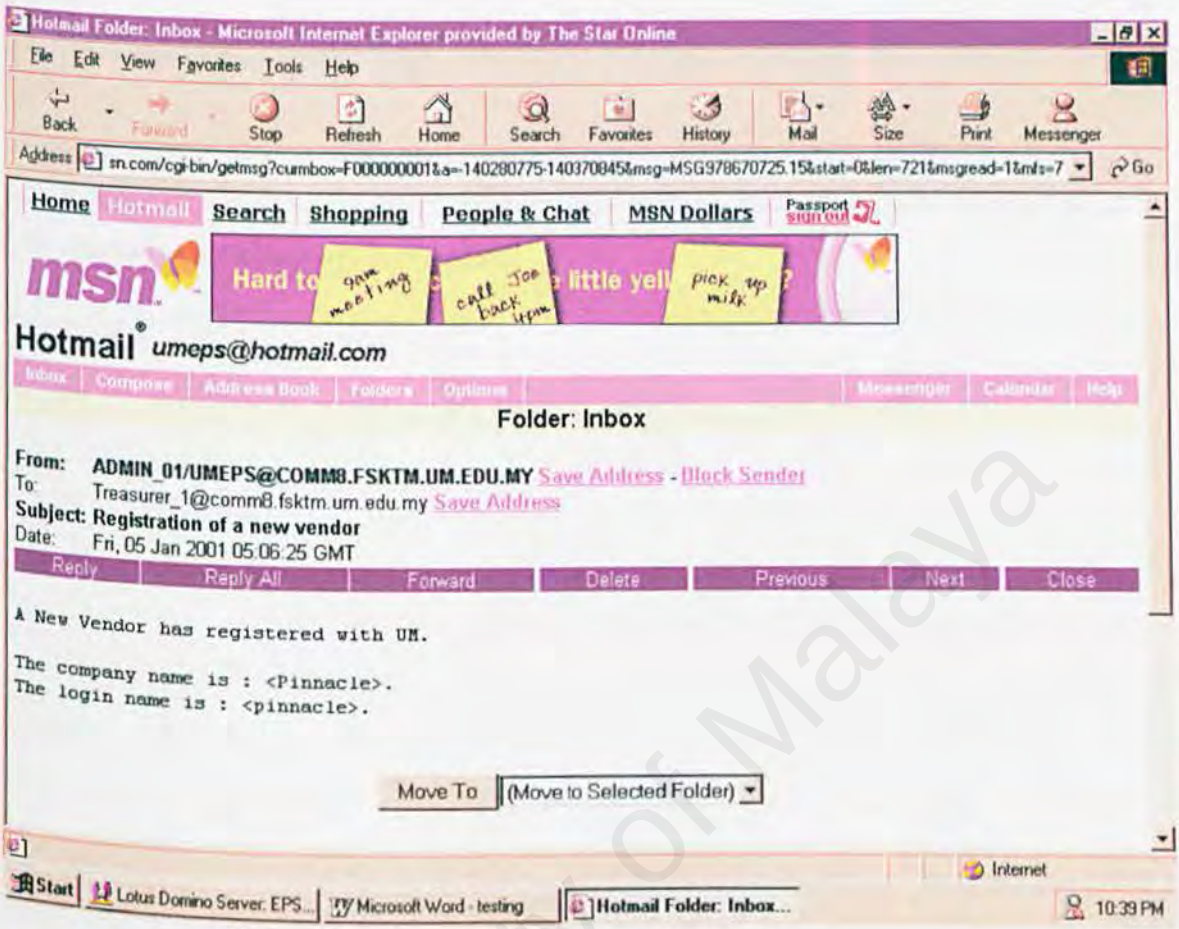

Figure 6.3: An e-mail notification was generated to umeps@hotmail.com

6.2.3 Supplier Duplicate Rating

This unit test aims to check on the error message generated by the system upon detecting a requestor or approver who tries to produce two or more performance rating for a particular supplier. This is the screen display obtained when a requestor or approver performs the forbidden activity.

University of Malaya

Figure 6.4: *An error message generated by UMEPS for duplicate rating*

6.2.4 Archive Documents

The method used to identify whether the agent 'ArchiveDoc' performed its archiving function is by resetting the schedule of the agent activity to every 5 minutes and specifying the archiving of documents created on a particular date.

For this intention, the agent was scheduled to run every 5 minutes and to archive documents created on 02/01/01. This proved to be successful when the Archive link was opened. All documents created on 02/01/01 could be seen in the view.

University of Malaya

6.3 INTEGRATION TESTING

In an integration test, testing are conducted to uncover errors associated with interfacing. The integration is planned and coordinated systematically so that fault could be recognised if a failure occurs.

For this purpose, the two new modules are merged into the existing system. The Main database (**MAIN.NSF**) which contains links to the new modules is tested to make sure that it links and connects properly to the specific databases.

Integration tests are also done within a few databases in a module. As an example, for the Archive database, all button bars are tested to ensure that it links to the Direct Requisition database, Quotation Requisition database, and Tender Requisition database after an additional field for the Archive button is incorporated into the relevant forms.

The integration tests mentioned above is done to ensure that all databases could communicate properly with one another as well as to ensure that the correct data are retrieved from the databases. As an example, when a user swaps from the Requisition database to the Archive database, the correct database must be published. Any miscommunication would lead to disintegration.

University of Malaya

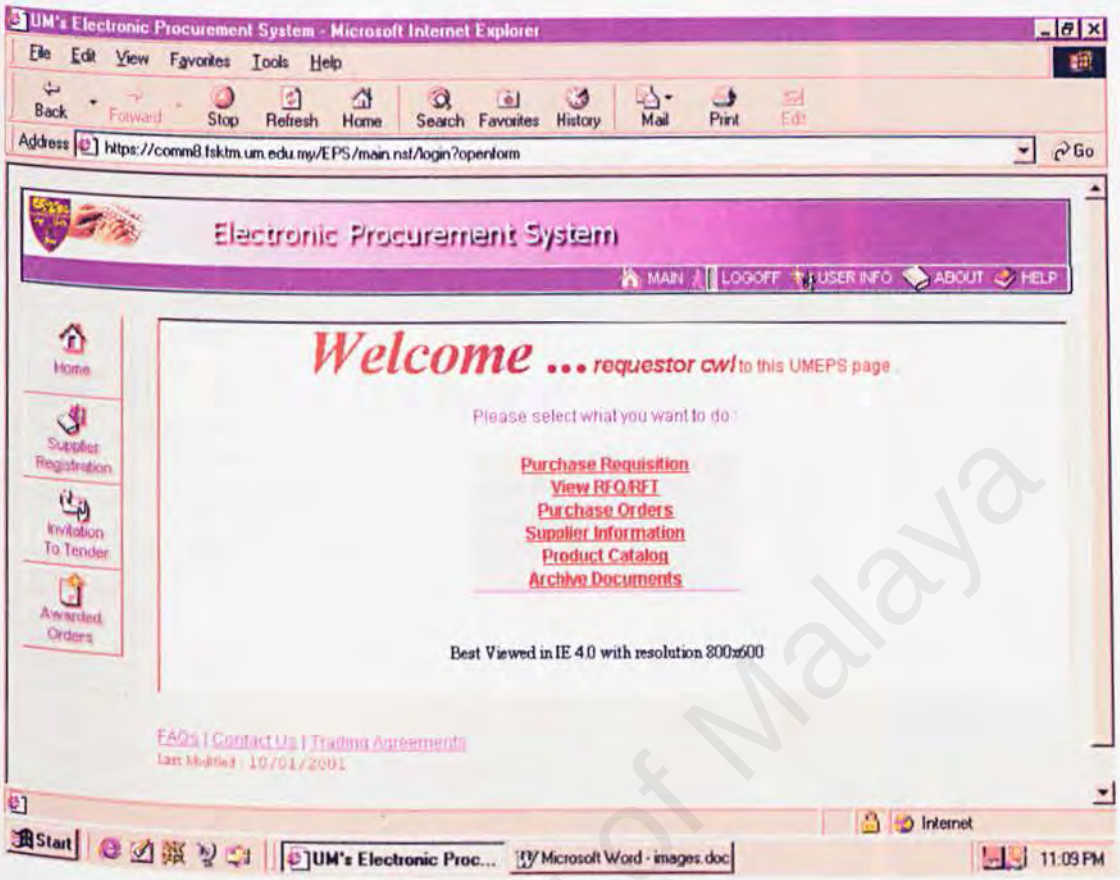

Figure 6.5: *The Main database as seen by a requestor. Notice the 'Archive Documents' link*

University of Malaya

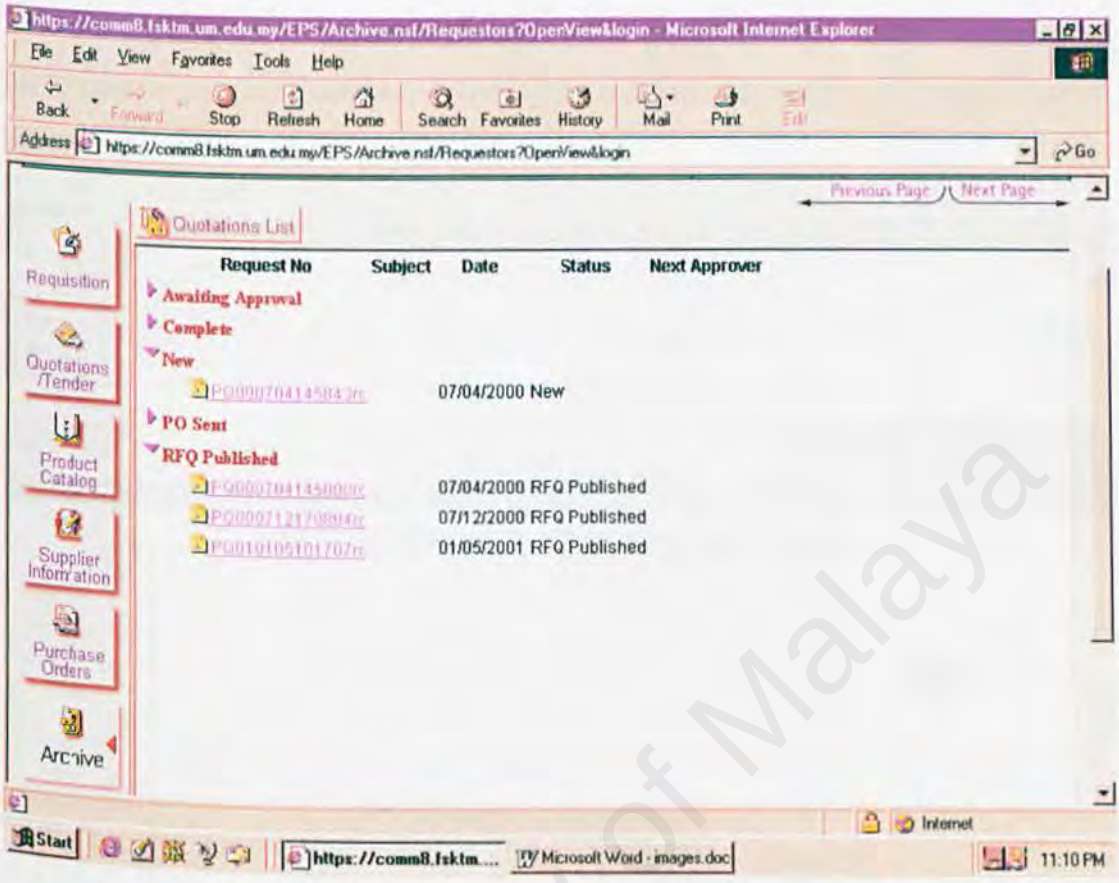

Figure 6.6: What the requestor sees upon clicking the 'Archive Documents' link

6.4 SYSTEM TESTING

Under the system testing, the whole procurement process was simulated and followed through until the end. This involved registering users and suppliers, performing mock requisitions and requisition approvals, and finally executing order fulfillment. Among the areas tested were the login and logout function, access rights and restrictions, links between databases and overall flow between the various pages.

Subsequently, corrections are done to the relevant components upon detection of faults or errors.

University of Malaya

Below is the simulation of part of the system testing. This involves the logging in to the system as an administrator, to viewing the audit record, and finally logging out of the system.

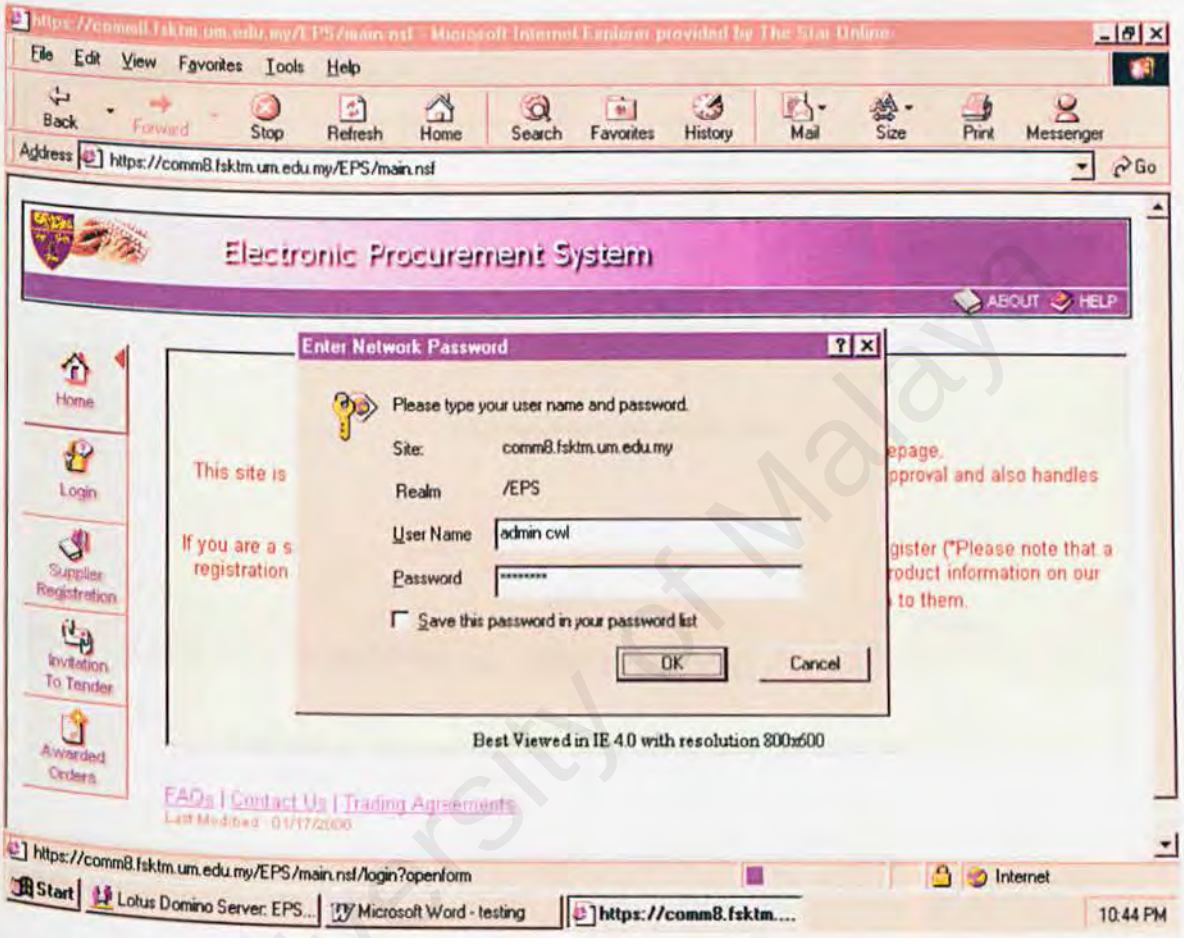

Figure 6.7: *A user logs in as 'admin cwl'*

University of Malaya

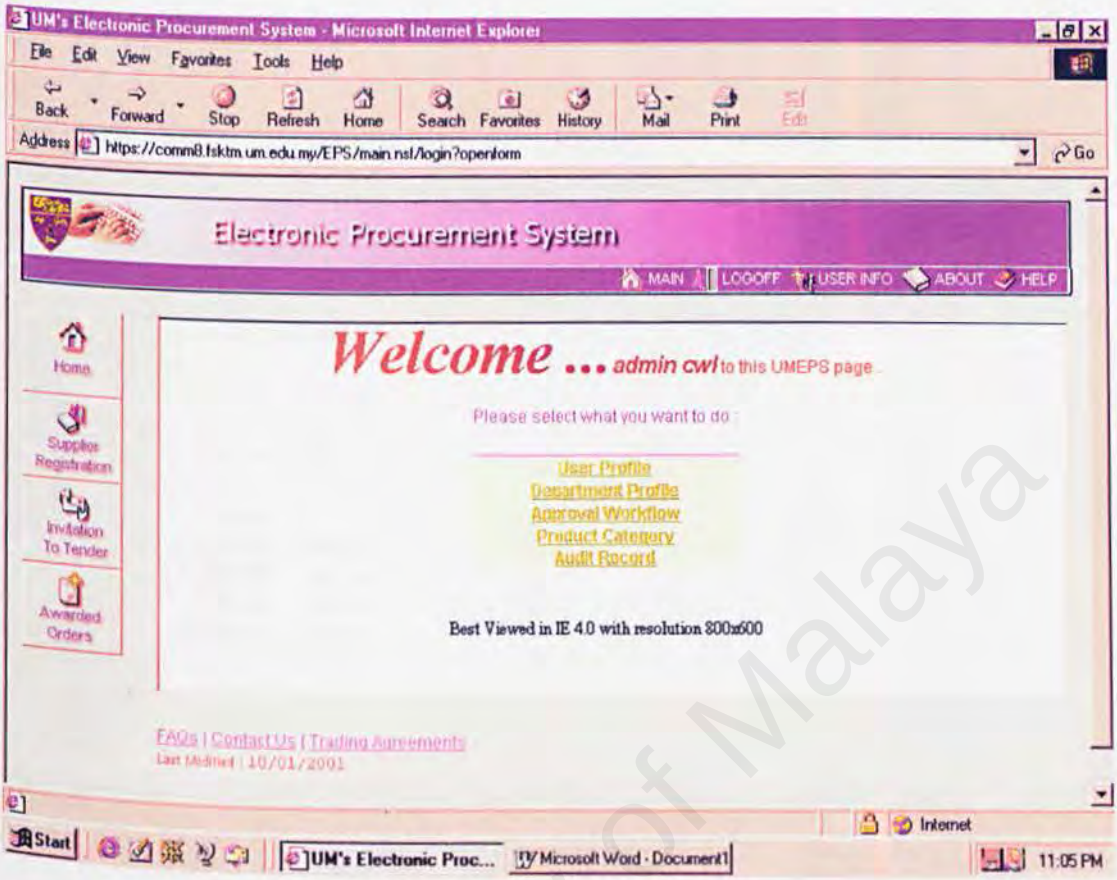

Figure 6.8: *User 'admin cwl' clicks on the 'Audit Record' link*

University of Malaya

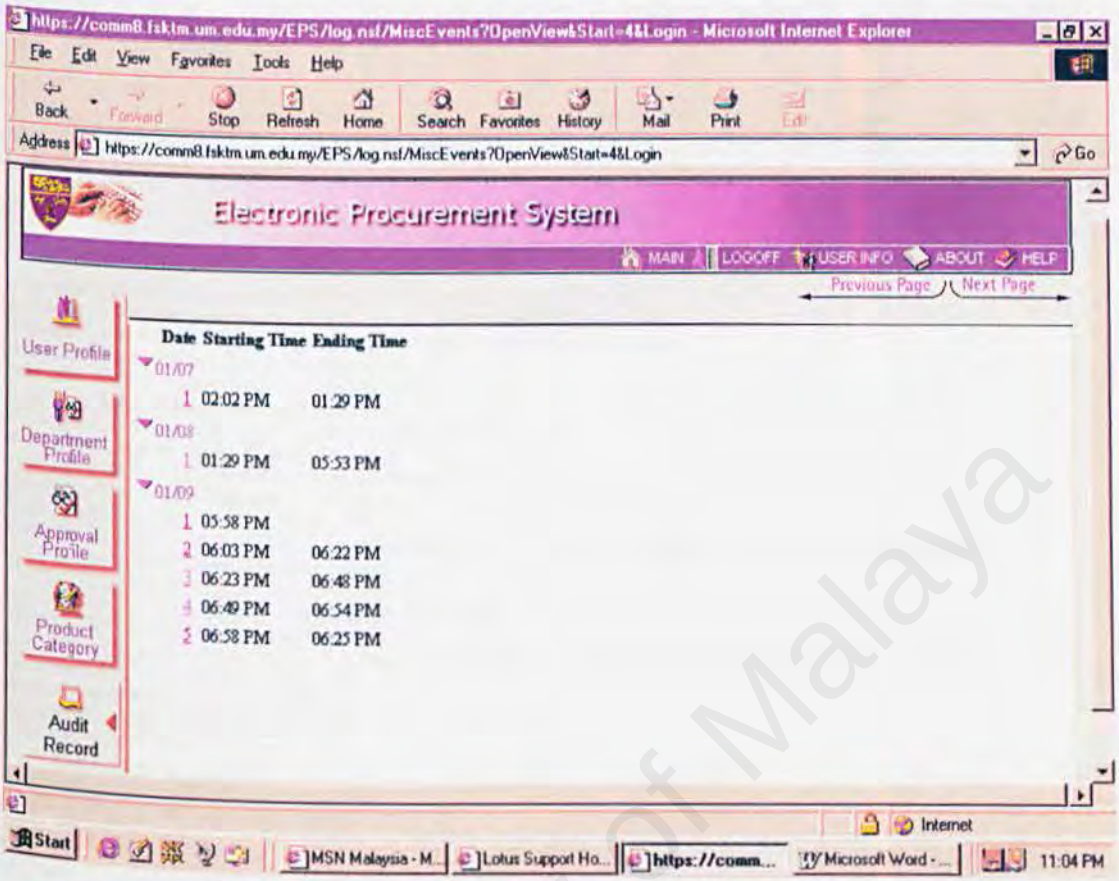

Figure 6.9: *User 'admin cwl' selects the audit record of interest*

University of Malaya

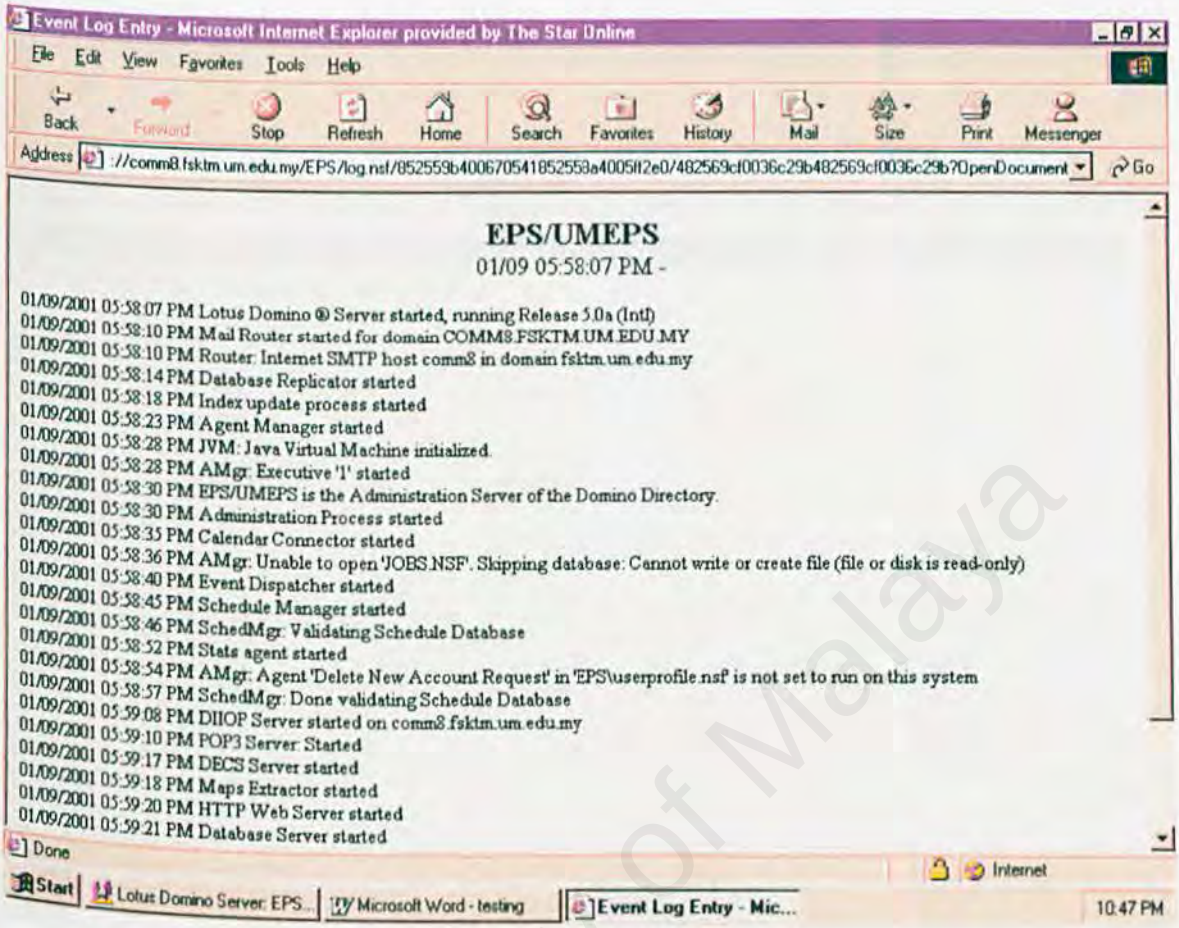

Figure 6.10: *User 'admin cwl' viewing the audit log that has been requested*

University of Malaya

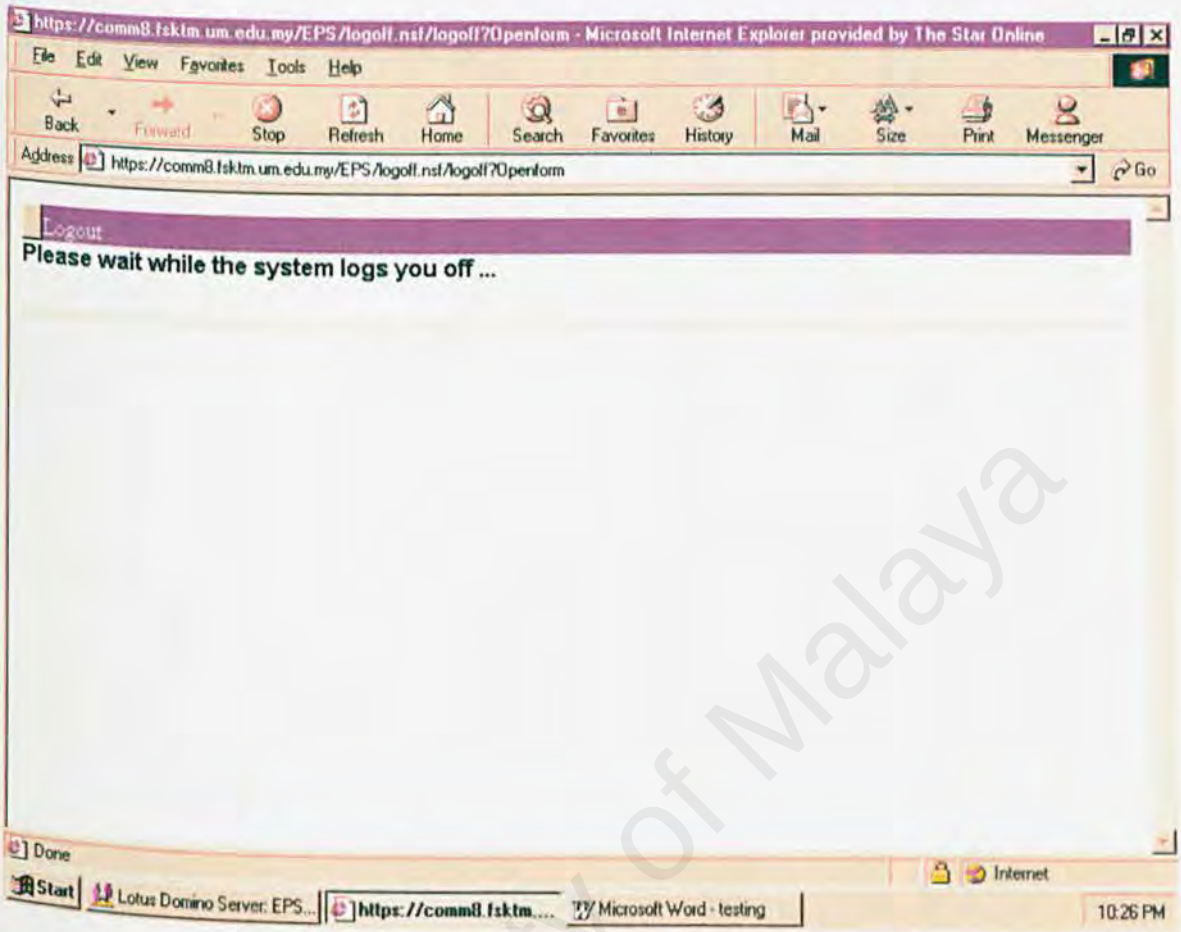

Figure 6.11: User 'admin cwl' logs out of UMEPS Version 3.0

6.5 CONCLUSION

The testing strategies as outlined in this chapter cannot be executed concurrently. Testing has to start from the bottom-up, namely from unit testing to implementation testing, and finally to system testing. The order in which it is performed is important to ensure that all areas of loopholes are covered extensively. Once testing has been completed, the full-fledge system is ready to be put to production.

University of Malaya

CHAPTER 7: SYSTEM EVALUATION & CONCLUSION

7.1 INTRODUCTION

To evaluate the degree of success of the system being implemented, a system evaluation is done on UMEPS Version 3.0. This evaluation is done after the system has been put to use by the users of UMEPS. The process involved identifying the strengths and weaknesses of the system, listing down the problems encountered during the implementation stage and the solutions to those problems, as well as suggestions for further enhancements in the near future.

These areas will be delved into further details in the following sections.

7.2 SYSTEM STRENGTHS

7.2.1 Security

UMEPS is embraced with tight security measures. Starting from its seven layers of Access Control List (ACL) protection, UMEPS is protected from data tampering from unauthorised users. Moving on to the Secure Socket Layer (SSL) protocol, private information is secured by encrypting the data as it passes between the server and the client. The databases are shielded using the authentication of username and passwords. Any attempts of unauthorised logging will be immediately reported to the Audit Trail database, which can be tracked by Administrators of UMEPS.

University of Malaya

7.2.2 Easy Retrieval of Archived Documents

To avoid congestion of documents in a database, all purchase requisition forms which lifespan is more than three months will be transferred to the Archive database. These transferred documents, however, are not deleted from the system altogether. Should the archived document be needed in any event, it is easily retrieved through the Archive icon button or the Archive Documents link in UMEPS Version 3.0.

7.2.3 Supplier Performance Rating

Requestors and treasurers are able to evaluate the standard and quality of the suppliers registered to UMEPS. This rating is also published to other requestors and treasurers in the system, as a reference or second opinion before they decide to purchase from the recommended suppliers. When rating a supplier, a particular requestor or treasurer is only allowed a one-time rating. Any attempt to perform another rating by the same personnel will be disallowed immediately.

7.2.4 E-mail Notification

Users of UMEPS are always made aware of the events in the system which are important to them. Treasurers are being informed of new suppliers' registrations through electronic mail, after which the treasurers would activate the suppliers' account. Suppliers, on the other hand, are notified by e-mail of any invitation to quote prices for items, if any. Requestors are also notified by e-mail of any responses from the selected suppliers of their price quotes.

University of Malaya

7.2.5 Efficiency

The automation of all business processes through the electronic procurement system has resulted in an increase in efficiency. Electronic forms remedy the shortcomings of paper forms. They are intelligent, catching incomplete and incorrect entries before passing them on. They also contain routing information, automatically handling exceptions. They can proceed through a workflow in sequential order or in parallel, and they provide a level of security that paper cannot match.

7.2.6 Effective User Management

UMEPS has the ability to differentiate among the users, which are allocated different roles. The division of users into groups ensures them of access to data and functions that are only related to them. What is not within their jurisdiction will be invisible to users.

7.3 SYSTEM LIMITATIONS

7.3.1 No Electronic Payment

One of the protocols that have been set by University of Malaya is that the university is not allowed to make or receive any Visa payments [29]. With this very reason, UMEPS is unable to incorporate electronic payment into its system. This results in payments being done manually through the treasury department and indicated on UMEPS as 'paid' or 'not paid' only.

University of Malaya

7.3.2 Browser's cache information

The problem with web browsers occurs when there are multiple users accessing the same computer. These users share the same cache directory, which gives rise to the possibility of confidential data being exposed to unauthorised users. In order to avoid this problem from occurring, each user needs to clear the cache on its computer upon logging out of the system, which can be troublesome and tedious.

7.4 PROBLEMS ENCOUNTERED AND SOLUTIONS

7.4.1 Corrupted Server Identification File

Due to inept experience in handling the server identification file, also known as SERVER.ID file, the SERVER.ID file was corrupted. Without this essential file, the server cannot be started altogether. This in turn resulted in the temporary halt in the development work on Domino Designer.

In reacting to this serious problem, much research has been done by reading books for Notes/Domino developers. Besides that, consultation was also obtained from previous developers of UMEPS, a Lotus Notes Certified professional, as well as developers from the Notes.net discussion forum.

The various responses from all parties are accumulated together and analysed thoroughly. Replacing the corrupted file finally rectified this problem. This is done using a copy of the backup file that was obtained from other directories on the server. The replacement process is not as simple as deleting the corrupted file. It involves renaming the corrupted file as SERVER.OLD first, then inserting the backup copy of SERVER.ID file into the appropriate directory, namely the Data directory of Domino server.

University of Malaya

7.4.2 Certificate Valid End Date Has Expired

In the midst of system development, the server console of Domino reported the following error:

```
HTTP Error: Certificate valid end date has expired. SSL not enabled.
```

This error has affected the security of the system as well as the configuration in the Server document of UMEPS. All configurations that indicate redirection to SSL cannot be done as the SSL certificate has expired. This in turn results in the UMEPS homepage being unable to be displayed on the web browser. Users of UMEPS were prompted with a Domain Name Service (DNS) error everytime a request is sent to the server to download the UMEPS page.

There are two alternatives to tackle the above-mentioned problem. The first is to disable SSL, meaning that the Server document is reconfigured to disable SSL. This solution raises a security issue deemed critical to the system. Without SSL, data communication between the server and clients are not encrypted, thus exposing users to threats from malicious parties.

The second alternative is more practical. This solution involves renewing the SSL certificate through the Domino Administrator. Once the SSL certificate has been renewed, SSL can be enabled, thus ensuring security of the system. Further details were discussed in *Chapter 5 - Section 5.6: Security Setup.*

7.4.3 Invalid Password or Stash File

When the HTTP task loads on the Domino server, the following error is displayed on the server console:

```
HTTP error: Invalid password or stash file
```


University of Malaya

Even though the HTTP task still loads, SSL is not enabled on the server. A stash file is a file with extension .STH and the same root name as the key ring file found in the same directory. This error occurs immediately after the renewal of SSL certificate.

The source of the problem was identified. This error message occurs when the stash file (KEYFILE.STH) is not found in the same directory as the key ring file (KEYFILE.KYR). When SSL is configured for a server, the KEYFILE.STH and KEYFILE.KYR were not created in the Data directory of the Domino server. In rectifying this problem, the KEYFILE.STH was restored to the appropriate directory.

7.4.4 Building and Modifying Notes Application

Learning to build Notes application is indeed a very challenging task. One has to get acquainted with the various programming languages used such as LotusScript, Formula language, HTML as well as JavaScript. The simultaneous usage of these languages can cause confusion for an amateur developer of Notes.

Knowing how to modify the existing codes of the system is another challenge. It is indeed not easy to decipher the codes written by five other previous developers of UMEPS as each one of them has their unique style of programming. This was not viewed as a problem but rather a challenge to behold.

In dealing with the two challenges mentioned above, research has been done by reading books for Notes/Domino developers. Besides that, consultation was also obtained from previous developers of UMEPS, a Lotus Notes Certified professional, as well as developers from the Notes discussion forum.

University of Malaya

7.5 FUTURE ENHANCEMENT

The following are some recommendation on how to enhance the current system:

7.5.1 General Packet Radio Services (GPRS) for Notification

Currently, treasurers, requestors, suppliers, approvers, administrators and managers of UMEPS receives electronic mail notification in the event of any responses triggered by another party of UMEPS which involves them. It is suggested that notification be done through other modes of communication, in particular using mobile phones.

Instead of being notified through e-mail, an alternative would be notification through Short Message Services (SMS) using the General Packet Radio Services (GPRS) technology. With the mushrooming of mobile phone users in Malaysia, the incorporation of this module would benefit procurement personnel who are always on the move.

7.6 CONCLUSION

This project has accomplished its mission in enhancing the electronic procurement system of University Malaya. Loopholes from the previous version have been covered to the minutest of detail. Additional modules have also been incorporated to the existing system to provide a complete package to users who procure electronically.

However, the fact remains that there is still room for improvement. Elaboration to the current system can be done to stay in pace with the latest technology. A case in

University of Malaya

point is the use of mobile phones in sync with Internet. This is in line with the age of Information and Communication Technology (ICT).

Throughout the course of this project, new skills were acquired and learnt. As a solo developer for this project, one has to be resourceful in handling problems, besides being apt in various technical knowledge required for the project. Most of all, one needs to have the passion for developing the system that was proposed.

University of Malaya

REFERENCES

[1] Kelleher, J. (2000). *Unleashing Corporate Purchasing Power*. [Online]. Available: http://www.fortune.com/section. [2000, August 22].

[2] Down, B. (March, 2000). *The supply chain's future in the e-Economy*. Supply Chain Management Review, 4 (1), pp. 28-35.

[3] Moreira, C. F. (June, 2000). *From dot-coms to $coms*. [Online]. Available: http://www.thestar.com.my. [2000, July 28].

[4] Quinn, F.J. (March 31, 2000). *Survival of the e-fittest*. Logistics Management & Distribution Report, pp. 37.

[5] King, J. (January 10, 2000). *Electronic procurement catching on among businesses*. Computerworld, pp. 41.

[6] Ekta Sivasriamphai. (August, 1999). *Is Malaysia experiencing its first wave of e-commerce growth?* IT Malaysia Executive.

[7] Chia, C. N. (1999, April 20). *Increase your profit margin through Electronic Procurement*. [Online]. Available: http://www.arraydev.com/commerce/JIP/9802-01.htm. [2000, August 20].

[8] Ng, A. L. (1998/1999). *Electronic Procurement System*. Kuala Lumpur: Faculty of Computer Science & Information Technology, University of Malaya.

[9] Bangsberg, P. T. (April 10, 2000). *Electronic procurement system goes live.* Journal of Commerce, pp. 3.

[10] Rozana Sani. (June 29, 2000). *Xybase gets contract in e-government initiative.* Computimes (Malaysia), pp.1, 4.

[11] (June, 2000). *Using web-based procurement to improve your bottom line*. Managing The General Ledger, pp. 5-6.

[12] (March 23, 2000). *Caltex to automate entire supply chain*. Business Times (Malaysia), pp. 6.

[13] (February, 2000). *New Purchasing Link*. Electronic Commerce World, 10 (2), pp. 59.

[14] (2000). *Free Trade Zone FAQ: General*. [Online]. Available: http://www.freetradezone.com/about/general.html. [2000, June–August].

University of Malaya

[15] (2000). *Free Trade Zone FAQ: Marketplace*. [Online]. Available: http://www.freetradezone.com/about/marketplace2.html. [2000, June–August].

[16] (2000). *Free Trade Zone FAQ: Design Center*. [Online]. Available: http://www.freetradezone.com/about/design_center2.html. [2000, June–August].

[17] (2000). *Free Trade Zone FAQ: Shopping Agent*. [Online]. Available: http://www.freetradezone.com/about/shopping_agent2.html. [2000, June–August].

[18] (2000). *Free Trade Zone FAQ: Community*. [Online]. Available: http://www.freetradezone.com/about/community2.html. [2000, June–August].

[19] H. Amir Khalid. (July 4, 2000). *E-procurement platform for IT industry*. The Star: In Tech, pp. 36.

[20] (2000). *Helpdesk - FAQ: Overview*. [Online]. Available: http://www.itsupermall.com.my/ITSmhome.nsf/HD_FAQOverview1?OpenForm. [2000, June-August].

[21] (2000). *Helpdesk - FAQ: Corporate Buyers*. [Online]. Available: http://www.itsupermall.com.my/ITSmhome.nsf/HD_FAQOurEMarketplace?OpenForm. [2000, June–August].

[22] (2000). *Helpdesk - FAQ: IT Suppliers*. [Online]. Available: http://www.itsupermall.com.my/ITSmhome.nsf/HD_FAQITS?OpenForm. [2000, June–August].

[23] (2000). *Helpdesk - FAQ: MyCorporatePortal*. [Online]. Available: http://www.itsupermall.com.my/ITSmhome.nsf/HD_FAQMCB?OpenForm. [2000, June–August].

[24] Poston, T. (1999, December 2). *E-Procurement's First Class Honours*. Computer Weekly, pp. 30.

[25] Stallings, W., & Slyke, R. V. (1998). *Business Data Communications*. Prentice Hall International.

[26] Lawson, R. (2000). *How retailers can move from vision to reality in their quest to become web-based organisations*. [Online]. Available: http://www.executivetechnology.com/exec14.html-ssi. [2000, August 5].

University of Malaya

[27] (2000, July 16). *What are the characteristics of client/server architecture?* [Online]. Available: http://www.landfield.com/faqs/client-server-faq/section-14.html. [2000, July 17].

[28] (2000, July 16). *What is a Three-Tier Architecture?* [Online]. Available: http://www.landfield.com/faqs/client-server-faq/section-8.html. [2000, July 17].

[29] Tan, S. H. (1999/2000). *University of Malaya's Electronic Procurement System – Version 2.0.* Kuala Lumpur: Faculty of Computer Science & Information Technology, University of Malaya.

[30] Richards, C. (1998). *Special Edition using Lotus Notes and Domino 4.6.* Que Publishing.

[31] Thong, B. K. (1998/1999). *Electronic Procurement System for University of Malaya.* Kuala Lumpur: Faculty of Computer Science & Information Technology, University of Malaya.

[32] Dahl, A. (1996). *Lotus Notes Administrator Survival Guide.* Sams Publishing

[33] (2000). *Security Audit.* [Online]. Available: http://www.radguard.com/CWwhtppr.html. [2000, August 12].

[34] (2000). *Security software for event recording and analysis.* [Online]. Available: http://www.raxco.co.uk/prd_audit.html. [2000, August 25].

[35] Cleveland, G. (1995, June). *Overview of document management technology.* [Online]. Available: http://www.ifla.org/VI/5/udtop2/udtop2.htm. [2000, August 25].

[36] (2000). *New Media Technologies.* [Online]. Available: http://www.newmediatech.com/services.htm. [2000, August 25].

[37] (1999, February 8). *Document Management.* [Online]. Available: http://www.amdoc.com/docmanagement.htm. [2000, August 25].

[38] Boyle, J. (1997, May). *A blueprint for managing documents.* BYTE Magazine.

[39] Commonwealth of Australia. (1996). *Document Management – Part 1.* [Online]. Available: http://ww.defence.gov.au/imsc/edmsc/iedmpt1.htm. [2000, August 25].

[40] Chan, C. T. (1998/1999). *Electronic Procurement System for University of Malaya*. Kuala Lumpur: Faculty of Computer Science & Information Technology, University of Malaya.

[41] (1999, December 28). *Does Notes/Domino Have the Ability to Track User Login Activity?* [Online]. Available: http://support.lotus.com/lshome.nsf. [2001, January 14].

[42] Lotus Education. (1996). *Developing Interactive Internet Applications for Notes Developers.* Lotus Development Corporation.

[43] Lotus Development Corporation. (1996). *Working with Lotus Notes and the Internet.* Lotus Development Corporation.

University of Malaya