Hardware e-Inventory Management System

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ABSTRACT

Based on the concepts of e-Commerce and Enterprise Resource Planning (ERP) strategy, this project is to build a web-based Hardware e-Inventory Management System. The purpose of this project is to build an enhanced enterprise's inventory management system for all the Information Technology and Communication (ICT) Companies in Malaysia. Any user on any platform at any time will be able to retrieve or upload hardware inventory information through this system. This system will provide the control & management of inventory, ensuring the sufficiency of inventory, accuracy of data keeping and more profitable relationship with supplier.

In order to produce a more efficient and better quality system, this project will be develop through several stages, by implementing the Waterfall Model methodology. The first two stages, which are requirement analysis and system design will be completed in the first semester. While for system coding, system testing, and system operation is completed in the second semester. This methodology approach was chosen because a web-based management system needs a well organized and structured planning of system design and implementation.

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Chapter 1: Introduction

1.1 Project General View

This project entitles **e-Inventory Management System (Hardware).** It is an approach to the ERP system. The purpose of this project is to develop a self-maintained, user friendly web-based and convenient inventory system, which it's functional, is to manage and control a company's hardware inventory.

Cambridge International Dictionary of English defines inventory as a detailed list of all the items in a place. An inventory is also the amount of goods a shop has, or the value of them.

Throughout this project, we have decided to use an IT company or software house as a model company to utilize this inventory system.

This proposed Hardware e-Inventory Management System consists of different modules as listed below:

1. Hardware Inventory Management
2. Vendor Management
3. User Management
4. Hardware Request
5. Quick Search

1.2 Project Background

The blending of Internet technologies and traditional business concerns is impacting all industries and is the latest phase in the ongoing evolution of business. Thus, the number of traditional businesses changing phase into E-Businesses in Malaysia are increasing rapidly. Malaysia local Information Technology and Communication (ICT) companies are the fastest growing market segment in E-Business industry nowadays. They are also the key-enabling factor to the lucrative Supply Chain and EDI (Electronic Data Interchange) services in the telecommunication business.

In order to raise the profitability and competitive advantages of their E-Business technology, people start to recognize the value of extending their existing Enterprise Resource Planning (ERP) technology for strategic business planning and analysis, while incorporating data from many other key data sources throughout the enterprise. The E-Business approach of customer-centrism requires placing the entire corporation into a unified transaction environment. This strategy implies having one common platform instead of many software applications in independent silos. Today's ERP systems, when fully installed as integrated suites, can be thought of as central repositories of internal corporate information derived from five major processes: finance, logistics, manufacturing, human resources, and sales and marketing.

1.3 Project Definition

This project is built under the concept of Enterprise Resource Planning (ERP). Thus it is important for us to have a glance on the definition of ERP, what it is, and how it works.

ERP is a structured approach to optimizing a company's internal value chain. What ERP really does is organize, codify, and standardize an enterprise's business processes and data. An ERP system, fundamentally, integrates the different processes necessary in a business into a centralized pool that facilitates data sharing and eliminates redundancy.

ERP could also be described as the spinal cord of the digital nervous system, facilitating the exchange of data through the unification of key processes. It is an advanced core business IT system that integrates data across major functions and activities as well as across organizational and geographical boundaries, providing a platform for increased business performance and competitive advantage. All the applications in an ERP suite share a common set of data that is stored in a central database.

1.4 Project Motivation

In the past five years, organizations have spent an estimated $40 billion on enterprise resource planning (ERP), according to Gardner Research. By viewing information as a competitive tool, organizations can more proactively respond to ever-changing competitive landscapes while integrating all sources of information about customers, suppliers and partners in a consistent and easy-to-use format.

Today, organizations that once viewed enterprise resource planning (ERP) solutions as a necessary implementation to maximize their investments for competitive advantage. They recognize the value of extending their existing ERP technology for strategic business planning and analysis, while incorporating data from many other key data sources throughout the enterprise.

While the majority of these ERP implementations have helped to improve transaction processing streamline operations and standardize corporate IT environments, they have not fully addressed the information needs of these organizations. Thus, we should try to unlock the wealth of information collected and stored within their ERP environments.

Because of the foreseen potential of ERP system, it motivate us to try to develop this project as there is merely few IT firm in Malaysia who has tried it.

As for **e-Inventory,** the need of it is significant because whether the goods you sell are stored in a basement or a climate-controlled warehouse, all e-commerce entrepreneurs will need to keep track of inventory, ensuring that products get to customers on time. The key to success is incorporating software solutions, developing

strong relationships with delivery services, and providing good customer support throughout the process. With e-Inventory, it is hope that all this functions and solutions can be achieved successfully.

1.5 Project Objective

In this project, our major objective is to build an integrated system, which is based on ERP concepts. Although there are other ERP systems available in the market today, but there is only a few of these systems, which originates from Malaysia's own web-technology. Thus, after doing researches and analyzing the potential of ERP system, it is worth a try.

This e-Inventory Management System project is committed to delivering the leading Enterprise and E-Business solution purposed for Malaysia Information Technology and Communication (ICT) companies. This is achieved by expanding the line of business application capabilities for its existing customer base to meet the growing demand for an integrated enterprise resource planning (ERP) solution. The entire solution is based on proven Microsoft technologies and platforms to provide an enterprise application framework.

1.5.1 Objective of e-Inventory Management System

As I am developing the Hardware e-Inventory Management System project, the objectives I aim to achieve for this specific module are as following:

- To enable the control and management of *hardware inventory* to be done easily via web technology.
- To ensure the sufficiency of inventory.
- To improve the quality and accuracy in data keeping.

1.6 Project Scope

e-Inventory, by definition, is an electronic based inventory management system online. Its purpose is to allow managing and controlling of inventory being done via web-based technology. As we are looking at the point of retailers, we expected to provide customers with *"real-time visibility" strategy*, where inventory levels-supplying for the customers inventory needs no sooner or later than the goods are needed for manufacturing or distribution.

The e-Inventory can be distributed into back-end and front-end sections, where the inventory department's staffs (administrators) use the back-end section; while the front-end section is to be used by others authorize in the company.

Generally in e-Inventory, there will be a design of several sub-modules, which will cover the functions needed under inventory management such as the following:

1. Login Authentication
2. User Account Management.
3. Inventory Management/Maintenance.
   - Manage Hardware Inventory Record
   - Manage Supplier Record
4. Hardware or Supplier Information Search

1.7 Project Limitation

The limitations of this project are shown as below:

- This project will not support bar coding for the stock code/ product code, as we do not have bar code reader support.
- SQL server, web server and Windows 2000 server will perform into a same computer.
- User does not have the availability to customize the layout of web page.
- Delivery functions are not included.
- Tax charges are not accounted for.
- Currency conversion is not included in this project.
- This project only supports single communication language, which is English.
- The annual physical stock counting for inventory is not included in this project because the model company only exists virtually. However, there will be a function for generating inventory summary report of stock information.

1.8 Project Requirement

Following is a list of facilities that will be needed or essential for the project development:

***Hardware*:**

We need 2 computers with at least 128Mb of RAM - One running as a server and another as a workstation.

Software:

- Windows 2000 Advanced Server
- Internet Information Server (IIS)
- Microsoft SQL Server 2000
- Internet Explorer 6.0
- Microsoft ASP.NET Web Matrix

1.9 Project Scheduling

Project Scheduling is used to plan and control a project efficiently and can determine:

1. The minimal expected completion time for a project.
2. The delay of project activities.
3. The earliest and latest time each activity can be started and completed.
4. The amount of slack for each activity.
5. Whether or not a current project is on schedule or is being completed within budget.

In this project, I have chosen to use Gantt chart to determine a clear timeline between the starting date and the finishing date. An important advantage of this chart over other time-charting technique is its simplicity. By using Gantt chart, a schedule of earliest possible start and finish times for the activities is given that will meet the earliest possible project completion date. There are six major phases in this project: Literature Review, System Analysis, System Design, System Coding, System Testing, and Documentation.

The schedule of this project is as shown in the Gantt chart below:

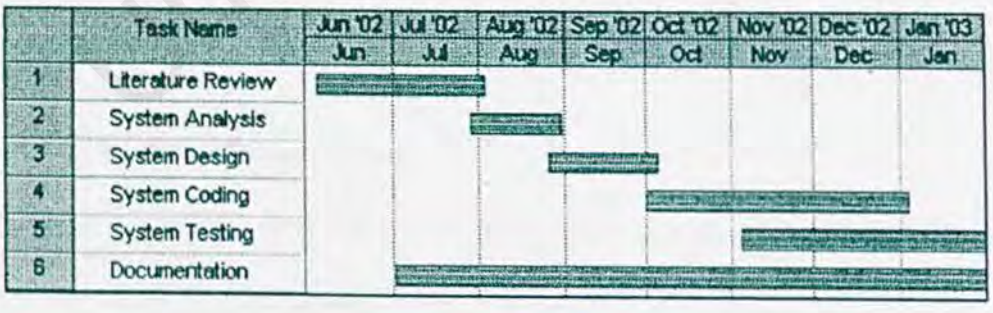


Figure 1.1 Gantt Chart for Project Scheduling

1.10 Project Report Layout

The following layout is to give an overview of the major phases involved during the development of the project. The purpose of this report is to document all the essential information gathered and used to develop this system.

Chapter 1: Introduction

This chapter serves as an introduction to the entire project. It made an overview on the project background, project objectives, project motivation, project scope, project limitation, project requirements and the project schedule.

Chapter 2: Literature Review

This chapter covers all the literature survey done on this project, including reviews on the features, capabilities, system architecture, and system designing tools and so on.

Chapter 3: Methodology

This chapter fairly discusses the development methodology, the functional and non-functional requirements, and also the tools and technology for this project.

Chapter 4: System Design

This chapter describes the design considerations including processing design, the user interface design and also the database design of this project.

Chapter 5: System Implementation

This chapter focuses on how the system being implementing successfully, and also shows example of program coding.

Chapter 6: System Testing

This chapter is about the method of system testing.

Chapter 7: System Evaluation & Conclusion

This chapter discusses about the system strengths, limitations, future enhancements, and also the conclusion of the whole project.

1.11 Expected Outcome

A web-based e-Inventory Management System that will provide an efficient and easy to use system that can carter all parties, including the company, supplier and customers.

1.12 Summary

This chapter focuses mainly on the introduction of this project.

The first part is the brief introduction about the project background and its definition. Then the project objectives for the proposed e-Inventory Manage System were discussed and determined.

Secondly, the scope of this project was shown in Section 1.6, where all the system features and functionality components were stated there. Then, Section 1.7 shows the project limitations of those functions which most probably unable to achieve in this project, while Section 1.8 show the project development requirements.

Finally, there is a project schedule shown by the Gantt chart (Figure 1.1) in Section 1.9 to tell the project's timeline of development; and the project report layout was shown in Section 1.10.

Chapter 2: Literature Review

A review of the literature is an essential part of academic research project. The review is a careful examination of a body of literature pointing toward the answer to research topic.

A literature or a body of literature is a collection of published research relevant to a research question. All good research and writing are guided by a review of the relevant literature. In this case, the research topic is electronic inventory.

Literature review will be the mechanism by which research is viewed as a cumulative process. That makes it an integral component of the scientific process.

By another world, a literature review summarizes, interprets, and evaluates existing literature (or published material) in order to establish current knowledge of a subject. The purpose for doing so relates to ongoing research to develop that knowledge: the literature review may resolve a controversy, establish the need for additional research, and/ or define a topic of inquiry.

Throughout the e-Inventory development, research on various aspects of electronic commerce and electronic businesses has been conducted. Concepts and strategy for both ERP and Inventory Management were also collected to be analyzed. Research on technologies available and development tools is also done under this chapter.

All the information gathered for this project came from two major resources, which are the printed resources (books, journals, newspaper & reports) and electronic resources (websites and also some other CD-based information).

2.1 The Internet

2.1.1 Definition

On October 24, 1995, the FNC unanimously passed a resolution defining the term Internet, This definition was developed in consultation with members of the Internet and intellectual property rights communities.

RESOLUTION: The Federal Networking Council (FNC) agrees that the following language reflects our definition of the term "Internet". [1]

"Internet" refers to the global information system that is:-

- Logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/follow-ons;
- Able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions / follow-ons, and/or other IP-compatible protocols; and
- Provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein.

2.1.2 Growth of the Internet

The Internet has changed much in the two decades since it came into existence. It was conceived in the era of time-sharing, but has survived into the era of personal computers, client-server and peer-to-peer computing, and the network computer. It was designed before LANs existed, but has accommodated that new network technology, as well as the more recent ATM and frame switched services. It was

envisioned as supporting a range of functions from file sharing and remote login to resource sharing and collaboration, and has spawned electronic mail and more recently the World Wide Web. But most important, it started as the creation of a small band of dedicated researchers, and has grown to be a commercial success with billions of dollars of annual investment. [1]

The Internet has not finished changing, it continues to change and evolve at the speed of the computer industry to remain updated and relevant. It is now changing to provide new services such as real time transport, in order to support, for example, audio and video streams. The availability of networking (i.e., the Internet) along with powerful affordable computing and communications in portable form (i.e., laptop computers, two-way pagers, PDAs, cellular phones) provides the ability of having nomadic computer and communication services.

In less than 30 years, the Internet has become one of the most amazing technological and social accomplishments of the century. Millions of people are using a complex, interconnected network of computers. The computers are located in almost every country of the world. The opening of the Internet to business activity helped increase the Internet's growth dramatically. The following shows the amazing growth of the Internet during the past decade. [2]

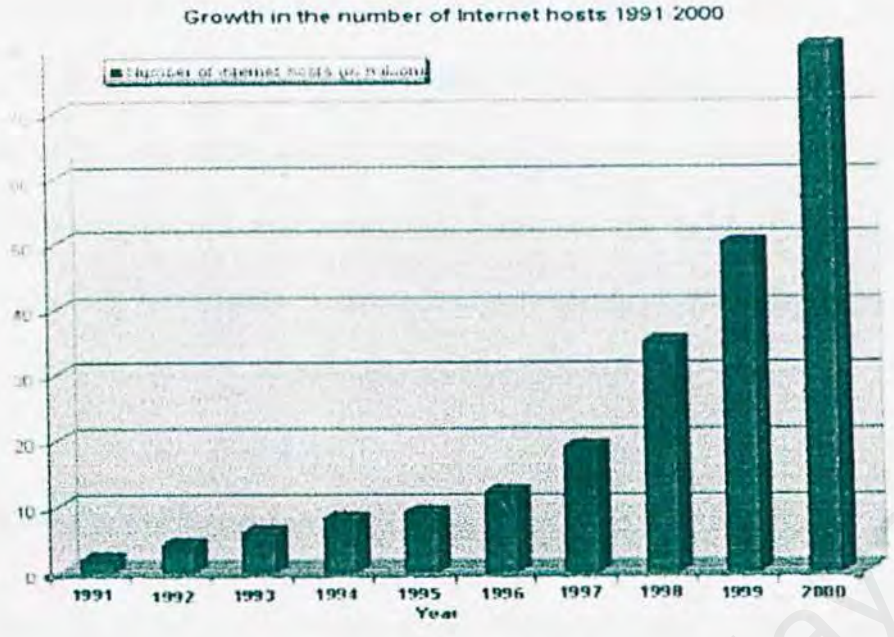


Figure 2.1 Growth of the Internet

2.1.3 Commercialization of the Internet

Commercialization of the Internet involved not only the development of competitive, private network services, but also the development of commercial products implementing the Internet technology. In the early 1980s, dozens of vendors were incorporating TCP/IP into their products because they saw buyers for that approach to networking. Unfortunately they lacked both real information about how the technology was supposed to work and how the customers planned on using this approach to networking. But through years of research efforts, studies and implementations, we are able to find a better way to fully utilize the facilities of Internet in commercial purpose.

The Internet has now become almost a "commodity" service, and much of the latest attention has been on the use of this global information infrastructure for support of

commercial services. This has been tremendously accelerated by the widespread and rapid adoption of browsers and the World Wide Web technology, allowing users easy access to information linked throughout the globe. Products are available to facilitate the provisioning of that information and many of the latest developments in technology have been aimed at providing increasingly sophisticated information services on top of the basic Internet data communications

2.1.4 Internet: The Business View

The Internet is available all over the world, twenty-four hours a day, seven days a week. It is simple to use and the transaction costs for the end user are low. The costs are also extremely low for the vendors on the Internet, compared to traditional distribution channels. The Internet allows two-way communications and is built around open standards. The two-way communication allows for direct feedback of customers and open standards mean interoperability between companies, web sites and services. Once they have been digitized, it is easy to integrate processes, services and products.

2.1.4.1 Why Should Businesses GO Online

- Expanding Market - business is opened to market of several million people from all walks of life globally.
- Visibility - allows a company to present its products and services at very low cost.
- Responsiveness - increase responsiveness to customers and partners.
- Introducing New Services - New services can be provided to customers and

2.2 E-Business

2.2.1 Definition

Electronic business encompasses three stages, which are e-commerce, e-business, and e-partnering. The early stages of a company's e-business activity are almost always focusing on reaching the customer, the later stages on streamlining value-chain activities to deliver more value to the customer. [3]

E-Business is the complex fusion of business processes, enterprise applications and organizational structure necessary to create a high performance business model. It refers to the use of digital technologies to transform both the internal processes as well as an organization's interactions with external parties. In other words, it combine the resources of traditional information systems with the vast reach of the Web and connect critical business systems directly to critical business constituencies - customers, employees, partners and suppliers using Intranets, Extranets and the World Wide Web.

E-Business, the Internet and the globalization all depend on each other. The more global players exist, the more E-Business they want to do. The more E-Business is online, the more people will be attracted to get direct Internet access. And the more people are online, the more global players will arise.

2.2.2 Three Main Area of E-Business

1. It can be within the organization using the so-called Intranet. The Intranet uses Internet standards for electronic communication. People on the Intranet are able to

see organization-specific web sites. These web sites are separated from the rest of the world by firewalls and other security measures. People from outside of the organization are not able to see these private pieces of information.

2. The second area is the business-to-business (B2B) deals that are done over the Extranet. The Extranet consists of two Intranets connected via the Internet, whereby two organizations are allowed to see confidential data of the other. Normally only small parts of information are made available to the partner, just enough to enable the business. Business-to-business networks have existed long before the Internet. Many organizations have had private networks to talk to their partners and customers. But maintaining them was very expensive. Through the usage of the Internet the costs have been cut dramatically. In order to keep the business transactions private virtual private networks (VPNs) are used in most cases.

3. Thirdly there is the business-to-consumer (B2C) area. Traditionally this is what most people know as e-commerce, selling products on the web. Also to keep in mind is the consumer-to-consumer area, also known as peer-to-peer commerce, such as auction sites or digital exchanges like Napster.

The concept of electronic business had been invented before the Internet became popular. In the 1970's E-Business was already popular for financial networks, for example, which used propriety hardware and software solutions. Electronic Data Interchange (EDI) was also available long before the Internet was used for it. But without the Internet E-Business would not have been possible on such a large scale. The private networks, which were used in the 1970's and 1980's, cost too much for

smaller enterprises and were not accessible for public use.

E-business improves business performance by using electronic information technologies and open standards to connect suppliers and customer at all steps along the value chain. It significantly improves business performance by strengthening the linkages in the value chain between businesses and the ultimate consumer. E-business focuses on effectiveness through improved customer service, and reduced costs.

2.3 E-Commerce

2.3.1 Definition

In general Electronic Commerce is the exchange of goods or services - buying and selling through the Internet. It is a modern business methodology that addresses the needs of organizations, merchants, and consumers to cuts cost while improving the quality of goods and services and increasing the speed of service delivery. [4]

E-Commerce can also be defined as the use of electronic data transmission to implement or enhance any business process. Frequently people use this term to refer to commerce on the Internet or Web because they are most extensive data transmission networks. [2]

2.3.2 Areas of e-commerce application

E-commerce includes transactions within a global information economy. In almost any business function today, e-commerce is at work for some companies. Here are some of the areas in which businesses are applying e-commerce:

- **Corporate Purchasing**

  E-commerce allows supply chain management to link inventory, billing and shipping between suppliers and customers to ensure a smooth coordination of supply and demand.

- **Marketing and Promotions**

  E-commerce allows an online channel to run various marketing and promotion

activities. Generally, marketing uses e-commerce to:

- Attract new customers through marketing
- Provide customer service and support for existing customers
- Develop new markets and distribution channels for existing products
- Coordinate sales and marketing efforts

Brand Management and Awareness

The Web enables organizations to get the word out faster and to larger audiences than ever before.

E-Mail Advertising

In business-to-business e-commerce, e-mail advertising can be used to increase brand awareness and to introduce new products and services to business partners.

Inventory Management between Branches

Ordering, storing, and tracking inventory over a large geographical area presents a major challenge that can be answered by electronic commerce. By using either decentralized or distributed inventory databases, organizations and their business partners can use e-commerce to access those databases around the world, at any facility at any time. Inventory management also helps ensure that inventory will arrive when needed. This means that suppliers can also improve their own internal efficiency by knowing inventory requirements in advance.

Supply Chain Management

Every member of the supply chain needed accurate and current information about orders, shipping and the response of customers. E-commerce helps solve this

problem by automating the information system so that it can be used by the members of the supply chain.

- **Customer Relationship Management**

  Electronic commerce increased speed and accuracy of information sharing between organizations and their customers; improved relationships with customers; and allow faster response to customer orders, requests, and problems, which ultimately helps increase customer satisfaction.

- **Help Desks**

  Online help desks allow customers to check the status of orders, have questions answered and access an information database that can help them solve problems.

2.3.3 E-commerce Issues

For companies that wish to join the realm of e-commerce, one must first make consideration and studies on the following:

- **Electronic Commerce Standards**

  There are a number of standards associated with e-commerce. Such as: Bank Internet Payment System (BDPS), Joint Electronic Payments Initiative (JEPI), Open Profile Standard (OPS), Open Buying On the Internet (OBI), and Open Trading Protocol (OTP) etc. All these have been developed targeted specifically to support commerce on the Web. For example, OBI was created to support Business-To-Business (B2B) commerce where it manages the exchange of pricing, tax, and authorization data. It also leverages electronic data interchange

technology, SSL, and digital signatures for security. [4]

- **Electronic Commerce Architecture**

System architecture is important in developing e-commerce applications. Because e-commerce is not a specific product but actually a business solution, therefore it must include several components and features for the maximum effectiveness.

The characteristic of the system architecture should include the following feature:

- Flexibility and scalability - The e-commerce design and infrastructure must be able to adjust and expand. The e-commerce software must be able to interpret different data formats and transform these formats into a universal format.
- Security Authentication, encryption and restricted access must be anticipated carefully in the applications.
- Web support - Software modules in an e-commerce system must support Web capabilities.
- Data storage - Data must be regularly saved in archive storage for appropriate transaction management.
- User Support - E-commerce design and operations personnel must continuously support users.

- **Electronic Commerce Security Issues**

Electronic commerce security is extremely important. Any commerce security policy has to address secrecy, integrity, necessity, and intellectual property rights. Threats to E-commerce can occur anywhere in the commerce chain, beginning with a client computer and ending with the commerce and back office servers. Thus, effective security policies along with adequate detection and enforcement

are the only ways to safeguard electronic communications and commerce transactions. [2]

Secure Socket Layer (SSL) encryption and Secure Electronic Transaction (SET) encrypted authentication are among the most common examples of e-commerce security measurement recently. SSL provides a security handshake in which the client and server computers exchange their information through authentication and data encryption technology. SSL resides on top of the TCP/IP layer of the Internet protocol suite, thus it can secure many different types of communications between computers. SET is a method for providing secure credit card transaction on the

Internet; the SET protocol is designed to allow consumers, merchant, and banking software companies to independently develop software for their respective clients and to have them inter-operate successfully.

Besides all these protocols and software, there is also service such as CERT - the Computer Response Team, which was formed to address security outbreaks by linking key scientific experts. When large security outbreaks occur, the member scientists can converge and discuss method to locate and eliminate the electronic attacker

2.4 ERP (Enterprise Resource Planning)

2.4.1 Definition

Enterprise Resource Planning, also known as ERP, is a structured approach to optimizing a company's internal value chain. It is an enabling technology, a set of integrated software modules that make up the core engine of internal transaction processing. [3]

The software connects the components of the enterprise through a logical transmission, across major functions and activities as well as across organizational and geographical boundaries, providing a platform for increased business performance and competitive advantage.

What ERP really does is organize, codify, and standardize an enterprise's business processes and data. The software transforms transactional data into useful information and collates the data so that it can be analyzed. In this way, all of the collected transactional data becomes information that companies can use to support business decisions. For example: when data such as a sale becomes available at one point in the business, it courses its way through the software, which automatically calculates the effects of the transaction on other areas, such as manufacturing, inventory, procurement, invoicing, and booking the actual sale to the financial ledger.

2.4.2 ERP background

The background of ERP is in the traditional inventory control that dictated the style of software packages in the 1960s. In the 1970's, production companies implemented

materials requirements planning (MRP) systems to rationalize and streamline production.

In the 1980's these information systems matured into manufacturing resource-planning (MRPII) systems, which embraced other functions such as processing, manufacturing, and distribution. The integration it embodied naturally made it attractive to other functions, and so it gradually spread its tentacles to finance, human re-sources, and project management. During the 1990s, the goal of ERP has been to integrate core business processes. An order shipped should automatically generate an invoice and decrement the finished goods inventory system. Waste and redundancy would be eliminated. The ERP system would provide an end-to-end window for mission-critical operations, enabling workgroups and departments to view the ramifications of their activities for the enterprise as a whole. [5]

2.4.3 Between ERP and E-Business

ERP, as what lies behind the web page (a back end unit) is necessary to fulfill the promises made on the web page, which are the promises made by e-business, the front end unit (web site). ERP is focused on internal process efficiency and effectiveness. E-business is focused on external, cross-enterprise process efficiency and effectiveness and on product promotion. While ERP technology supports current business strategy, e-business opens the doors to new strategic opportunities.

Except for a very few companies that do nothing but aggregate information and match buyers and sellers, all companies need some sort of internal transaction engine to match internal information flow with the actual flow of goods or services, as well as

money. Every company has to perform their business information tasks, and all of these are facilitated by ERP. The Web based technology (e-business) comprises the 'electronic' portions of the electronic enterprise, but the ERP comprises the 'enterprise' portion. Also, each company needs to decide on its own strategy, in terms of both ERP implementation and e-business. That strategy will be driven by customer demands, competitive pressure, and the current state of enterprise (its technical capabilities). [3]

2.4.4 Complementary Technologies of ERP and E-business

ERP is the internal technological hub of a single enterprise. Web based technology extends each enterprise's internal information infrastructure into external environment, representing the company brand and projecting it to the marketplace. To marry ERP and web based technology successfully and push each to achieve its maximum benefit, the providers of each must understand the benefits that each provides to the other. Web based technology provides connections via the Internet to a host of external parties. ERP software helps organizations effectively and efficiently manages all their internal information resources to meet overall goals. Stand-alone e-business software is available for each of theses relationships, usually from providers who focus on building the best applications to handle any given process. Knowledge management is not associated with any one technology. It is depicted as a process that requires an organization to tap the data in all information channels and consolidate that information so that it is meaningful to the business. [3]

2.4.5 ERP Functions

An integrated ERP system is the hub of an enterprise and is used to support existing business strategies. This strategy implies having one common platform instead of many software applications in independent silos. ERP provides a company the flexibility required to improve customer responsiveness (the demand side) and to better manage production needs and inventory (the supply side). With ERP a company can create a new information foundation by replacing many legacy systems of varying vintages that house data in different ways. ERP provides a consistency of information across a global enterprise and integrates the following: [5] & [3]

- **Back-office operations**

  First to be covered by ERP system is Resource Planning which provides function such as forecasting and planning, purchasing and material management, warehouse and distribution management, product distribution, and accounting and finance. All these disparate functions are being integrated into one package.

- **Supply Chain Management (SCM)**

  This function enables companies to optimize the entire logistics, production, and distribution process, from acquiring raw materials from suppliers to scheduling production and shipping products to customers on time. This reduce cycle time and inventory levels, also improves a company's cash position.

- **Sales force automation (SFA)**

  SFA adds functionality to aspects of the sales process such as contact management, sales forecasting, and order management.

- **Customer relationship management (CRM)**

  CRM connects the various experiences a customer has with a company-marketing, product selection, purchasing, receiving, complaints and post-sale support-into a managed relationship, where a company is able to identify which customers it should focus its limited resources on and how to do so effectively.

- **Knowledge Management**

  This includes creating a data warehouse, a central repository for the enterprise's data; performing business analysis on this data; providing decision support for enterprise leadership; and creating future customer-based strategies.

In a fully integrated ERP system, all the activities stated above are accomplished by utilizing five tightly integrated modules: finance, manufacturing, logistics, sales and marketing, and human resources. These modules comprising ERP operate specific business processes within functional areas. These enable companies to plan and manage resources on a real-time basis. When changes are entered into one module of the system, other related data elements and modules are automatically updated. The underlying integration across various modules provides operational transparency, which allows managers to follow what's happening across the business, even on a global basis.

2.4.6 ERP Architecture

ERP applications are most commonly deployed in a distributed and often widely dispersed manner. While the servers may be centralized, the clients are usually spread to multiple locations throughout the enterprise. Generally speaking, there are three

functional areas of responsibility that are distributed among the servers and the clients. First, there is the database component - the central repository for all of the data that is transferred to and from the clients. Then, of course, there are the clients; here raw data gets entered, re-quests for information are submitted, and the data satisfying these requests is presented. Lastly, we have the application component that acts as the intermediary between the client and the database. Where these components physically reside and how the processes get distributed will vary somewhat from one implementation to the next. The two most commonly- implemented architectures are outlined below. [6]

- Two-tier Implementations

  In typical two-tier architecture, the server handles both application and database duties. The clients are responsible for presenting the data and passing user input back to the server. While there may be multiple servers and the clients may be distributed across several types of local and wide area links, this distribution of processing responsibilities remains the same. Figure 2.2 below provides a simple illustration of a two-tier implementation.

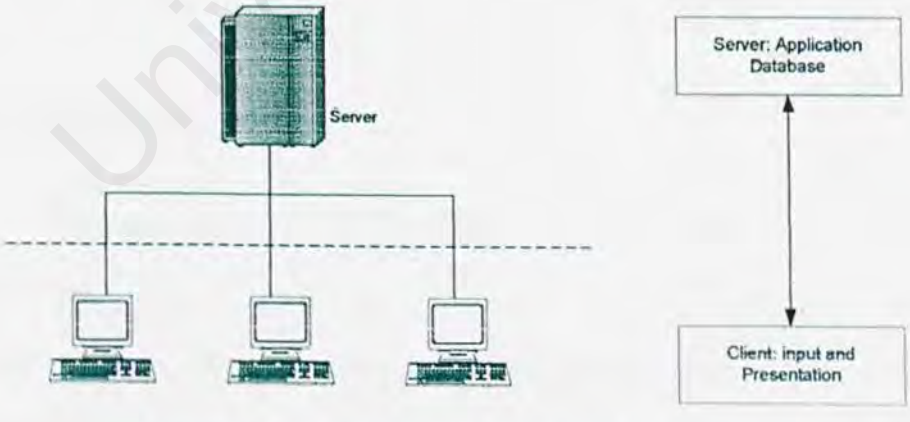


Figure 2.2 The 2-Tier Client/Server Architecture

- Three-tier Client/Server Implementations

  In three-tier architectures, the database and application functions are separated. This is very typical of large production ERP deployments. In this scenario, satisfying client requests requires two or more network connections. Initially, the client establishes communications with the application server. The application server then creates a second connection to the database server.

  Figure 2.3 below illustrates this type of implementation.

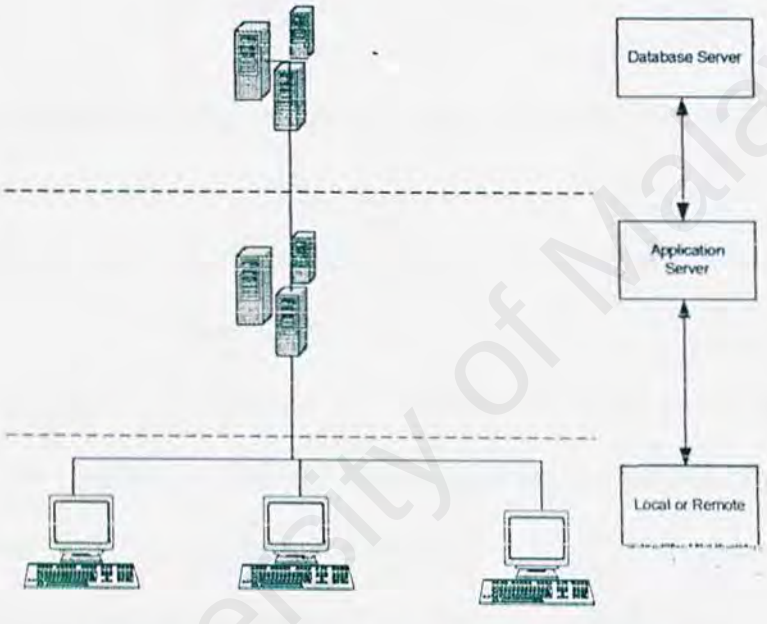


Figure 2.3 The 3-Tier Client/Server Architecture

2.4.7 ERP: The Conclusions

There are five major benefits of implementing ERP, which could be summarizing as the following:

- on-line/real time information throughout all the functional areas of an organization
- data standardization and accuracy across the enterprise
- "best-practices" included in the applications

- the efficiency they force an organization to undertake
- the analysis and reporting that can be used for long term planning

Besides the benefits, we should also understand that an ERP applications and transactions are probably unlike anything else that you have running on your network. It is not safe to assume that the network will handle them well. Every ERP deployment is different. The application modules are customized, and the architecture of the system and distribution of computing resources will be unique to your environment.

The following should come into consideration before you wish to implement ERP into your business:

- It is critical to understand how your application performs on the network before beginning enterprise-wide deployment.
- Test your network in advance to understand how these applications will perform and what impact they will have on existing applications. Pay particular attention to WAN links and heavily utilized LANs.
- The location of computing resources may have a significant impact on how the application performs, particularly in three-tier environments. Understand the traffic flows between the client and the server as well as the server-to-server communication flows.

2.5 Inventory Management

2.5.1 Definition

Inventory is defined as a stock of goods. More generally, inventory could be regarded as a resource that has economics value. An inventory is made up of one or more items where each item is a unique supply item, raw material, purchase or manufactured part, assembly, or final product. [7]

Inventory Management involves the control of the assets that are produced to be sold in the normal course of the firm's operations. [8]

2.5.2 Types of Inventory Management System

It is difficult to classify the various inventory management system in an orderly fashion. Common types of inventory control system are the perpetual, two-bin, periodic, optional replenishment, and material requirements planning system. The perpetual, two-bin, periodic and optional replenishment systems usually apply to end items, while the material requirements planning system applies to materials and component used to produce an end item. [9]

a) Perpetual Inventory System

A perpetual inventory system keeps records of the amount in storage, and it replenish when the stock drops to a certain level. This system is based on the concepts of economic order quantity and reorder point. Under this system the reorder point and order quantity are fixed, the review period and demand rate are variable, and the lead-

time can be fixed or variable. With the perpetual system, each time a unit is issued from stock the withdrawal is jogged and the stock position is compared with the reorder point. If the stock position is at or lowers than the reorder point, an order is prepared for a fixed number of units. If the stock position is higher than the reorder point, no action is taken. Thus, with the perpetual system there is constant or perpetual accountability on all items.

Advantages of Perpetual System:

- An efficient, meaningful order size
- Safety stock needed only for the lead time period
- Relative insensitivity to forecast and parameter changes.
- Less attention for slow-moving items

Disadvantages of Perpetual System:

- If manager do not take the time to study inventory levels of individual items, order quantities tend to be established by clerks.
- Reorder points, order quantities and safety stock may not be restudied or changed for years.
- Delays in posting transactions can render the system useless for control.
- Numerous independent orders can result in high transportation and freight costs.
- Large combination orders, which can frequently results in supplier discounts based on dollar value, must be foregone.

b) Two-Bin Inventory System

The distinguishing features of two-bin system are the absence of a perpetual inventory record. The two-bin system is a fixed order size system, and it has several advantages. The most important advantage is the reduction in paperwork.

Records are not maintained for each transaction. The reorder point is determined by visual observation. When the stock in one bin is depleted, an order is initiated, and demands are then filled from the second bin.

The system can even be used with only one bin. An order can be trigged when the inventory level reaches a physical marks such as a painted line or a given volume level. The reorder point quality can also be placed in a bag or container, so that when the stock is drawn to the scaled quantity an order is placed.

The two-bin system is best suited for items of low value, fairly consistent usage and short lead-time, such as office supplies, nuts, bolt and so forth.

c) Periodic Inventory System

In a periodic inventory system the number of items, in the storage is reviewed at a fixed time interval. A count must be taken of the goods on hand at the start of each period. In the perpetual system an actual count is not required since the inventory records contain receipts, issues and balances on hand. With the periodic system the quantity to be ordered is not fixed, and the decision makes changes the quantity ordered to reflect changes in the demand rate. Under this system, the review period is fixed; the order quantity, the demand rate, and the reorder point are variable; and the

lead-time can be fixed or variable.

In the perpetual system, replenishment order is initiated as soon as the inventory level drops to the reorder point. In the periodic system, the inventory position is checked only at specified time intervals. The perpetual system treats them discretely and dependently.

d) Optional Replenishment Inventory System

The optional replenishment inventory system, which is also referred to as a min-max system, is a hybrid of the perpetual and periodic systems. Stocks levels are reviewed at regular intervals, but orders are not placed until the inventory position had fallen to a predetermined reorder point. The maximum inventory level is at established for each item. If the inventory position is above the reorder point on the review date, no order is placed. If the inventory positions is at or lower than the reorder point on the review date, an order is placed. The order quantity is the maximum inventory levels minus the inventory level at the review period.

e) Material Requirements Planning Inventory System

The material requirements planning (MRP) inventory system is used extensively with planned production. For items that are materials or components used by end items, stocks levels are derived from the requirements dictated by the end item. The material requirement planning system is a derived order quantity system. This system function by working backward from the scheduled completion dates of end products of major assemblies to determine the dates and quantities of the various component parts and

materials that is to be ordered. The system works well when a specific demand for an end product is known in advance the demand for an item is tied in a predictable fashion to the demand for other items.

f) Just-In-Time Inventory Control System

Just-In-Time inventory control system has the aim to operate with lowest average level of inventory possible; within the EOQ (Economic Order Quantity) model the basics are to reduce (1) ordering costs and (2) safety stocks. The relative new JIT approach to inventory control is growing in popularity as an attempt to obtain additional cost savings by reducing the level of inventory a firm needs to have in hand. Instead of depending solely one its own inventories, the firm relies on its vendors to furnish supplies "just-in-time" to satisfy the firm's production requirement. The MRP tends to be static, because once numbers are entered into the computer; no one has responsibility to change them. JIT works exactly the opposite way. As soon as improvements are made, new improvements are sought. There are many benefits to a successful implementation of JIT such as reduced work-in-process inventory (therefore less space and cost), higher productivity, short lead times, and visible & predictable amounts of inventory.

2.5.3 The Major Functions of Inventory

The usual/basic function of inventory control is making decision for the following:

a) How often the inventory status should be determined?

b) When a replenishment order should be placed?

c) How large the replenishment order should be?

There are five major functional classifications of Inventory: [10]

a) **Decoupling stock** - Inventory can act as a buffer between processes to avoid delay and inefficiencies. Large amount of inventory tend to exist between firms, or between divisions within a firm. An effective supply chain management must take into account to reduce inventory levels.

b) **Cycle inventory** - an attempt to order or produce in batches instead of one units at a time. The reasons for batch replenishments include, economies of scale (because of large setup cost), quantity discounts in purchase price or freight cost (suppliers offer discounts for large orders)

c) **Anticipation inventory** - consists of stock accumulated in advance of expected peaks in sales. Storage according to supply and demand (different season different rates). Thus during the period of high anticipated requirements, extra demand can be serviced from stock rather than from working overtime in the plant.

d) **Safety stock** - is the amount of inventory kept on hand, on the average, to allow for the uncertainty of demand and the uncertainty of supply in short run. Safeties stocks are not needed when the future rate of demand and length of time it takes to get complete delivery of an order are known with certainty.

e) **Pipeline (or work-in-process) inventory** - include goods in transit between adjacent workstations in factory. The pipeline inventory of an item between two adjacent locations is proportional to the usage rate of the item and to the transit

time between the locations.

2.5.4 Important Factors and Modeling Strategies for Inventory System

Through empirical studies and deductive mathematical modeling, a number of factors have been identified that are important for inventory management. Below is Table 2.1, showing us the Inventory Planning Decision Variables based on the source from *A. Saipe, Partner, Thome Stevenson & Kellogg, "Managing Distribution Inventories," Executive Development Program, York University, Toronto, Canada, September 12, 1982.*

Service Requirements	**Supply Situation**
• Customer expectations • Competitive practices • Customer promise time requirement • Order completeness required • Ability to influence and control customer • Special requirements for large customers	• Lead times • Reliability • Flexibility • Ability to expedite • Minimum orders • Discounts (volume, freight) • Availability
Demand Patterns	**Customer Ordering Characteristics**
• Variability • Seasonality • Extent of deals and promotions • Ability to forecast • Any dependent demand? • Substitution?	• Order timing • Order size • Advanced information for large orders • Extent of open or standing orders • Delay in order processing

Cost Factors	**Nature of the Product**
• Stock out (pipeline versus customer) • Carrying costs • Expediting • Write-offs • Space • Spoilage, etc	• Consumable • Perishable • Recoverable / repairable

Table 2.1 Inventory Planning Decision Variables

Now that we have identified the costs and other key variables for inventory planning decision, we comment on three types of modeling strategies. Three types of strategies involve some modeling:

1. **Detailed modeling and analytic selection of the values of a limited number of decision variables**

   The strategy here is to develop a mathematical model that permits the selection of the values of a limited set of variables so that some reasonable measure of effectiveness can be optimized. A classical sample is the economic order quantity (EOQ) that, under certain assumptions, minimizes the total of ordering and inventory carrying costs per unit time. In general, a mathematical model may permit a deductive (closed-form) solution, an interactive solution (such as in the simplex method of linear programming), or a solution by some form of trial-and-error procedure (such as in the use of a simulation model).

2. **Broader Scope Modeling with Less Optimization**

   Here the strategy is to attempt to develop a more realistic model of the particular

situation. However, the added realism often prevents any clearly defined optimization; in fact, there may not even be a mathematically stated objective function. One strives for a feasible solution that will provide reasonable performance. This is the philosophy underlying Material Requirement Planning (MRP).

3. Minimization of Inventories with Little Modeling

Here the strategy is to attempt to minimize inventories without the help of mathematical models. The Just-In-Time (JIT) and Optimized Production Technology (OPT) philosophies fall into this category. They strive for elimination of waste (including inventories) and for continuous improvement. These powerful philosophies have been supplemented with the mathematical models that help managers refine and explain their operation. However, the philosophies are not grounded in models, but in an approach to doing business.

2.6 Existing System Review

There are ERP software available on the web, which contains integrated solutions designed to organize goods, track inventory, and manage accounts, or we can choose an inventory-management firm to handle the business. There are also many systems on the web, which offer standalone inventory management software.

Let us make a review on these existing systems, what services and features they have for inventory management & control.

2.6.1 Epicor Software Corporation (www.epicor.com) [11]

The inventory management (under the module eDistribution) by Epicor allows balancing of inventory levels, product profitability, and customer service. It provides all these function stated below:

- Inventory tracking to improve accuracy throughout all locations
- Integrated with EDI and Bar-coding technology
- Warehouse management including multiple locations
- Powerful pricing and promotions options
- Instant access to all costing information
- Extensive reporting capabilities
- Flexible controls to meet your specific business process needs

eDistribution's Inventory application lies at the heart of the distribution suite and lets you manage your inventory with the control and level of flexibility most appropriate for your business. It simplifies routine tasks with automatic processing, which can

immediately improve productivity in your warehouses, ensuring lower costs and fewer errors. It issue, receive, count or adjust inventory quickly and accurately with an intuitive user interface that supports efficient data entry, ensuring lower costs and fewer errors.

2.6.2 Alcie Computer Network Corp. (www.alcie.com) [12]

The Aide's Inventory Control module provides multi-company, multi-currency enterprise-wide inventory management application. It provides full inventory control including receipts, issues, transfers, physical cycle counts and ABC analysis. Automatically integrates with other installed modules such as Purchase Order & Requisitions, Sales Order Processing, Bill of Materials, Bulk Distribution, Project Accounting, Job Shop Manufacturing, General Ledger, Accounts Payable, and Accounts Receivables.

The following shows some of it features:

- Supports stocked, non-stocked and phantom items.
- Virtually unlimited warehouses and stocking locations.
- Real-time inventory receipts, issues, and adjustment transactions
- Stock transfers with in-transit tracking and reporting
- Hazardous Material processing.
- Units or measure with automatic conversion at receiving and shipping time.
- Vendors per item & Substitute items.
- Accessories or options per item & Item comments.
- Extensive Inventory stock status query and reporting

- Inventory valuation. Usage exception, ABC analysis, & Lead time exception reporting.
- Automatic calculation of order controls, including order point, line point, safety stock and usage
- Replenishment action report.
- Calculation of vendor review cycle.
- History quantity override for stock with exceptional usage.

2.6.3 Collaborative Inventory Planning of iBaan (www.ibaan.com) [13]

The iBaan's Collaborative Inventory Planning supports a real-time, vendor-managed inventory process between a company and its corporate customers. This application template is designed to help reduce inventory, improve manufacturing and transportation efficiencies and increase the level of customer service provided by all business partners involved - and can help achieve:

- Real-time information sharing and alerts improve supplier response time, leading to more flexibility and agility in manufacturing
- Significant reductions in working inventory and improvements in customer service
- Significant improvement in the velocity of information and material flow
- Increased trust and more profitable relationships with business partners

The features available are:

- Exception-based inventory planning
- Real-time Internet visibility of customer orders, forecasts, manufacturing orders,

distribution orders, deployment orders, planned shipments, in-transits, inventory projections, alerts

- User-defined view configuration supported - tables, relater views, graphs and charts available
- User-defined problem notification by alerts
- User-defined, context-sensitive drilldowns to support rapid problem resolution
- User-defined, multi-party negotiation process for inventory replenishment
- Inventory projection is monitored as a key performance indicator (KPI). Monitoring KPIs such as inventory projection makes it possible to identify supply chain problems early on
- Replenishment agent monitors inventory levels and automatically generates replenishment recommendations
- Supports user-defined 'bucketisation" of data
- Supports complex ad hoc XML queries for supply chain information

2.6.4 AccuTrak Inventory Specialists (www.accutrakinventory.com) [14]

AccuTrak is a company leading the inventory consulting services industry, offering prospective business owners an opportunity to build a successful franchise and generate increased personal income. The entire retail and wholesale market segments are potential AccuTrak customers.

AccuTrak has developed programs tailored to provide several levels of inventory consulting services to virtually any retail sales company. Depending on the depth of your clients inventory analysis needs, AccuTrak offers an appropriate program.

Specialized AccuTrak computer hardware and software can aid you in generating valuable reports to assist your clients in successful inventory control.

AccuTrak Services are as following:

- Inventory Reporting
  - Simple Valuation: Calculates the total dollar value of inventory - especially useful for tax purposes or in a transfer of ownership.
  - Quantity On-Hand Report: Assists owners by providing relative stock levels for all inventories.
- Inventory Management
  - Loss Shrinkage Control: Identifies the possibility of customer or employee theft
  - Merchandise Trend, Product Mix & Profit Analysis: Shows fluctuations of inventories and sales over a period of time.
- Employee Management
  - Determines the sales performance of individual employees by tracking sales volume.
- Detailed Sales Reporting
  - Identifies profit opportunities and isolates problem areas by creating profitability reports using various customer specific criteria.

2.6.5 Comparison of IBS: E-Inventory with existing system

In this section, I will do comparison of my system, which is the e-Inventory with the existing traditional inventory control system, and also with the computerized inventory control system (Table 2.2). There is a fact that most of the local ICT companies still practicing traditional/manually inventory system, while a few of them are using the inventory software in running their business. Thus, this comparison is being done to show the strength of e-Inventory to improve the usage of information technology in local companies.

Traditional Inventory System	e-Inventory
▪ Time consuming and inefficient (record handling by manually) ▪ Unable to construct 'real-time' visibility strategy ▪ No integration between inventory control, monitoring and retailing system ▪ Time consuming to prepare reorder item lists	▪ Allow computerized data and record keeping (fast & efficient) ▪ Provide 'real- time' visibility for inventory level supplying ▪ Integrated with other relevant modules. (e-Monitoring) ▪ Reorder item lists can be prepared fast and easy

Table 2.2 Comparison of Traditional Inventory System and e-Inventory

2.7 Technology Consideration

As stated from very beginning, this Literature Review also included the consideration of technology that is currently available. The purpose is to choose a suitable development environment and development tools to lead this project into success. The fields I have covered for technology consideration can be divide into the following:

1) Development Models
2) Web Servers
3) Server Platforms / Operating Systems
4) Client/Server Architecture
5) Databases
6) Programming Environment and Languages
7) Development Tools
8) Others

2.7.1 Development Models

a) Waterfall Model

One of the first models to be proposed is the waterfall model where the stages are depicted as cascading from one another. One development stage will be completed before the next begins. Thus, when all the requirements are elicited form the customer, analyzed for completeness and consistency, and documented in a requirements document, then the development team can go on to system design activities. [15]

The waterfall model can be very useful in helping developers lay out what they need to do Its simplicity makes it easy to explain to customers who are not familiar with software development; it makes explicit which intermediated products are necessary in order to begin the next stage of development. The advantages and disadvantages of the waterfall model are as follow: [15] & [16]

Advantages:

1. Very structured (logical flow)
2. Predictable
3. Involves user participation (gathering requirements)
4. Good visibility
5. Inexpensive
6. Easy to manage
7. Encouraged reviews at each stage
8. Gave greater control over the project by dividing it into stages and sub-stages

Disadvantages:

1. Requirements must be well defined first
2. User must wait until the end in order to see the developed product
3. Each individual stage must be completed before mowing on
4. Product failure signals process failure
5. Increases in cost-to-fix or change software occur throughout the life cycle process

b) Prototyping Model

A prototype is a partially developed product that enables customer and developers to examine some aspects of proposed system and decide if it is suitable or appropriate for the finished product. In other words, prototyping means building a small version of a system, usually with limited functionality that can be used to help the user or customer identify the key requirements of a system and demonstrate of a design or approach. [17]

Prototyping is often used to design a good user interface: the part of the system with which the user interacts. Since the prototyping model allows all or part of a system to be constructed quickly to understand or clarify issues, it has the same objectives as engineering prototype, where requirements or design require repeated investigation to ensure that the developer, user and the customer have a common understanding both of what is needed and what is proposed. One or more of the loops for prototyping requirements, design or the system may be eliminated, depending on the goals of the prototyping. However, the overall goal remains the same that is reducing risk and uncertainty in development. The advantages and disadvantages of the prototyping model are as follow: [18]

Advantages:

1. Allow errors to be detected early
2. More opportunity for changes
3. User orientation (to develop system that meet user needs to a greater extend)
4. Fast development time
5. Reduces development cost

Disadvantages:

1. Object system may be less efficient
2. System planning is not always complete
3. Visible use of computer resources
4. Requires cooperation between user and Information System
5. The development process of advanced versions does not always exploit the investment made in the earlier stages.

2.7.2 Web Servers

a) Apache Web Server

Apache Web Server is among one of the popular web server on the market today. Some of its strengths are its reliability, performance and rich set of features. In large part, its popularity is due to the fact that its code is freely distributed. Among its features are [21]

- Freeware

  The software can be downloaded free of charge.

- Multiple platforms support

  Apache can support a variety of platforms such as Windows 9x, Windows NT, Linux, O/S 2, Novell Netware, Macintosh and others.

- Logging

  Apache can write to multiple log files and these log files can be automatically cycled or archived. The server also can generate referrer log entries and non-hit

entries (such as comment). It can track individual users in log file.

- Protocol Support

  Apache can support the Windows Common Gateway Interface (CGI), HTTP/1.1 protocol. User can access the server state variables through CGI or scripting languages.

Despite all its strength, Apache also has some weaknesses. These include:

- Setup and maintenance of the server is done via command-line scripting tools. Apache does not offer browser-based maintenance facility.
- It does not have any Graphical User Interface (GUI) configuration or administration tools.
- The security is low and it does not support secure communication using Secure Socket Layer (SSL).

b) Internet Information Server (IIS)

Microsoft Internet Information Server (IIS) has the reputation for being one of the best web servers on the market. Although it is only available for Windows 20007 Windows NT, IIS has transformed their platform into a viable solution for deliver web-based applications. IIS is considered by experts to be just as powerful and much easier to set up and maintain than many of its UNIX-based competitors.

The three major goals of Internet Information Server are that it is focused on the server side of the Internet world, to have the capability of supporting in intranet as well as the Internet and to form the basis that will enable future product development.

Internet Information Server provides three basic services to users, which are World Wide Web server, File Transfer Protocol server and Gopher server. Some of its features are: [20]

- Free download

  It is available for free download.

- Superior administration control

  Site administration for IIS is performed using the Microsoft Management Console (MMC). Via this interface the users can manage access and security restrictions at the site, directory and file level. If the users are using virtual sites, then they can specify the estimated daily traffic for each site (which controls how much memory IIS allocates for each web site) and limit the amount of server bandwidth a particular site can use. Most settings can also be configured remotely using Microsoft Internet Explorer. Active Server Pages (ASP) improvements in the latest release of IIS include additional support for transaction processing and memory isolation.

- Excellent collection of server tools

  It offers a variety of tools including a Transaction Server (for building distributed applications, Certificate Server (managing digital certificates), Site Analyst (site management and usage), Internet Connection Services for Microsoft Remote Access Service (creation of Virtual Private Networks), Mail Server and Network News Transfer Protocol (NNTP) News Server.

- Indexing tool also handles Microsoft Office documents

It also includes an indexing tool called Index Server. The Index Server is used for indexing HTMP pages and can also handle Microsoft Office documents.

- Integrated search engine

  Internet Information Server provides the integrated search engine capabilities, which the users can create custom search forms with Active Server pages, ActiveX Data Objects and SQL queries.

The weaknesses of Internet Information Server (IIS) are as follows:

- Lack of support for UNIX platform.
- Only runs on Server edition of Windows NT/Windows 2000
- Complicated to configure
- SMTP does not support POP mailboxes
- Mediocre documentation

2.7.3 Server Platform / Operating Systems

a) Windows 98

One of the products in Microsoft's evolution of the Windows operating system for personal computer is Windows 98. An important of the user interface of Windows 98 is the Web technology and it was released with its tightly integrated browser. Microsoft Internet Explorer is an integral part of the operating system in the Windows 98. Users can view and access desktop objects that reside on the World Wide Web as well as local files and application using the Active Desktop of Windows 98. In fact, Windows 98 desktop is a Web page with HTML links and features that exploit

Microsoft's ActiveX controls.

It also provides a 32-bit file allocation table (FAT32) that allowing a single-partition disk drive larger than 2Gbytes. The other features in Windows 98 includes supports for Universal Serial Bus (USB), which make it easy to plug in new devices support for Digital Versatile Disc (DVD), support for a new industry standard form of power management called Advanced Configuration and Power Interface (ACPI).

Windows 98 enables the news and other content to be set up and pushed to the user from specified Web sites. When using it as Web server, Personal Web Server (PWS) need to be installed in order for the Windows system to serve Web pages through Internet.

b) Windows NT

Windows NT is the operating system for personal computer created for users and business requiring advanced capability. It is actually comprised of two products: Microsoft NT Workstation and Microsoft NT Server. The workstation is a little safer than Windows 98 and Windows 95. It is designed for users especially business users, who need faster performance. The server is designed for business machines that need to provide services for LAN-attached computers. Together with an Internet server such as Microsoft's Internet Information Server (IIS), it is required for a Windows system that plans to serve Web pages. The latest version, the Windows NT Server version 5.0 is now available, called Windows 2000.

Whereas, system requirements for Windows NT 4.0 Option Pack are the system need

to be install both Windows NT Service Pack 3 and Service Pack 4 and Microsoft Internet Explorer 4.01. In order to run Internet Information Server 4.0 (IIS) and any other features on the Windows NT 4.0 Option Pack.

In term of networking, Microsoft Windows NT Server 4.0 works with Microsoft LAN Manager, Microsoft Windows for Workgroups operating system, AppleTalk, DECPATH WORKS, IBMLAN Server, IBMSNA networks, the Internet, NFSnetworks, Novell NetWare, Remote Access Services by way of ISDN, X.25, and standard phone lines and TCL/IP networks.

c) Windows 2000

The latest version of Microsoft's evolving Windows operating system is Windows 2000. Before that, it is called Windows NT 5.0. Microsoft emphasizes that Windows 2000 is evolutionary and is built on NT technology. Most users of Windows 98 and Windows NT will in time move to Windows 2000. It is designed especially for small business and professional users as well as to more technical and larger business market for which the NT was designed.

It was reported in earlier reviews that Windows 2000 is more stable that Windows 98/NT systems. It is less likely to clash. A significant new feature is Microsoft's Active Directory that enables virtual private networks to be set up by a company, data locally on the network to be encrypted, and to give users access to share files in a consistent way any network computer.

The other features of the Windows 2000 are it has a fully customizable administrative

console that can be based on tasks rather than files, applications, or users. Also Dynamic Domain Name Server (DNS), which replicates changes in the network using the Active Directory Services, the Dynamic Host Configuration Protocol (DHCP), and the Windows Internet Naming Service (WINS) whenever a client is reconfigured.

Besides that, it also has the ability to create, extend, or mirror a disk volume without having to shut down the system and to back up data to a variety of magnetic and optical storage media. In addition, it also has close integration with and supports for Microsoft's Message Queue Server, Transaction Server, and Internet Information Server (IIS).

d) Red Hat Linux

What is now known as Linux began life as a small student project at the University of Helsinki in Finland. The Linux operating system is a small, UNIX-like operating system, which is a rather remarkable operating system that works very well, is very stable, and rivals offerings from Microsoft, Apple, and Sun. Linux offers the following features:

- Multitasking

  Linux natively runs more than one task (program) at a time in a UNIX-like fashion. It also supports preemptive multitasking, where priorities can be set for different processes.

- Multi-user

  Many users can be networked to a single Linux server. Linux is the least expensive, and perhaps best-featured, multi-user operating system on

the planet today.

- User-friendly

  The X Window System interface and a slew of great tools make Linux easy to use.

Today, Linux claims half a million users, and that number keeps growing every day. One reason is cost—Linux itself is free of charge, and only those who package a Linux distribution charge for it (and many don't charge at all). These distributions, such as Red Hat Linux, vary as to their installation processes and accompanying tools. [21]

However, Linux also have several weaknesses: [22]

- Installation problem

  Even though Linux does a reasonably good job of detecting all the hardware components on a computer, it does require some enlightened input from the installer. Disk partitioning and mounting of file systems are relatively advanced concepts, especially for users who are used to the simple drive letters of Windows.

- Lack of high-end features

  Linux developers have not so far access to high- end and expensive hardware. It not yet scale well beyond 4 Central Processing Unit (CPUs), has no support for high-availability clustering, Cache-Coherent Non-Uniform Memory Access (CCNUMA) architectures and cannot host multiple independent operating system on the same machine.

2.7.4 Client/Server Architecture

The client/server model is an approach to software in which one application (the client) asks for and receives services from another application (the server). Client/server is a concept of computing as seen from the enc user's viewpoint- not that of the system or the application. In a client/server environment, data are manipulated at the user level. Client/server computing can be considered totally user-driven, and the client/server environment can be envisioned as a multivendor, multiproduct, multi-application implementation. Essentially, client/server computing is a software-based architecture that enables distributed computing resources on a network to share common resources among groups of users at intelligent workstations.

The client requests services form the server; the server processes the request and returns the result to the client. Though client/server architecture can be very complex, there are generally speaking, two kinds of client/server infrastructures to choose from. That is the Two-tier architecture and the Three-tier architecture.

a) 2-Tier Client/Server Architecture

The two-tiered architecture contains two computers - a client, and a server- with areas of logic combined on the client. The three components of an application- presentation, processing, and data are divided between the two tiers: client application code and database server. A robust client application development language and a versatile mechanism for transmitting client requests to other server are essential for a two-tier implementation. Presentation is handled exclusively by the client, processing is split between client, and server, and data is stored on and accessed through the server.

Advantages of Two- Tier Client-Server

- Application development speed. In most cases, a two-tier system can be developed in a small fraction of the time it would take to code a comparable but less- flexible legacy system.
- Most tools for two-tier are very robust and lend themselves well to iterative prototyping and rapid application development (RAD) techniques.
- Two-tier architectures work well in relatively homogeneous environments with fairly static business rules.

Disadvantages of Two-Tier Client-Server

- The two-tier architecture faces several potential version control and application redistribution problems, a change in business rules would require a change to the client logic in each application in a corporation's portfolio affected by the change.
- System security in the two-tier environment can be complicated because a user may require a separate password for each SQL server accessed.
- Client tools and the SQL middleware used in two-tier environments are also highly proprietary and the PC tools market is extremely volatile. The volatility of the client/server tool market raises questions about the long-term viability of any proprietary tool and organization may commit to and complicates implementation of two-tier systems.

b) 3-Tier Client/Server Architecture

The components of three-tiered architecture are divided into three layers: a presentation layer, a functionality layer, and the data layer. Each of these layers must

be logically separate. The three-tier architecture attempts to overcome some of the limitations of the two-tier scheme by separating presentation, processing, and data into separate distinct entities. The middle-tier performs calculations or makes requests as a client to additional server. Middle-tier functionality servers may be multithreaded and can be accessed by multiple clients, even those from separate applications. Although three-tier systems can be implemented using a variety of technologies, the calling mechanism from client to server in such a system is most typically the remote procedure call, or RFC (remote procedure call).

Advantages of 3-Tier Client-Server

- Unlike in most two-tier implementations, the three-tier presentation client is not required to understand SQL. This added flexibility allows a firm to access legacy data and simplifies the introduction of new data base technologies.
- Having separate software entities allows for the parallel development of individual tiers by application specialists.
- Provides for more flexible resource allocation. Middle-tier functionality servers are highly portable and can be dynamically allocated and shifted as the needs of the organization change. Network traffic may be reduced.
- Reusable logic reduces subsequent development efforts, minimizes the maintenance workload, and decreases migration costs when switching client applications.

Disadvantages of 3-Tier Client-Server

- Three-Tier brings with it an increased need for network traffic management, server load balancing, and fault tolerance.

- Current tools are relatively immature and require more complex 3GLs for middle-tier server generation.

2.7.5 Databases

a) Microsoft SQL Server Version 7.0

Microsoft SQL Server Version 7.0 is the most robust database for the Windows family. SQL Server is a client/server relational database management system (RDBMS) that is highly integrated with the Windows NT operating system. By using SQL Server, modern application can be developed that separate the client application and the database service. SQL Server Transact-SQL supports the ANSI-92 standard and provides extensions to the SQL language. [23]

Microsoft SQL Server™ supports a set of features that result in the following benefits:

- Ease of installation, deployment and use

  SQL Server includes a set of administrative and development tools that improve your ability to install, deploy, manage and use SQL Server across several sites.

- Scalability

  The same database engine can be used across platforms ranging from laptop computers running Microsoft Windows 95/98 to large, multiprocessor server running Microsoft Windows NT, Enterprise Editor.

- Data warehousing

  SQL Server includes tools foe extracting and analyzing summary data for Online Analytical Processing (OLAP). SQL Server also includes tools for visually designing database and analyzing data using English-based questions.

- System integration with other server software

  SQL Server integrates with e-mail, the Internet and Windows.

SQL Server includes OLAP Services, Data Transformation Services and English Query, and works with over 45 ISVs that form Data Warehousing Alliance. By using Windows 2000, SQL is the fastest database for SAP, based on the SAP Retail benchmark.

b) Microsoft SQL 2000

Microsoft SQL 2000 is an enterprise-level database and is the latest version of Microsoft SQL 7 It is enhanced with Extensible Markup Language (XML) support that enables data return in XML and also enables XML be used to insert, update, and delete values in the database. SQL Server 2000 supports enhancements to distributed partitioned views that allow users to partition tables horizontally across multiple servers. Its full-text search includes change tracking and image filtering.

In the security point of view, SQL Server 2000 uses Kerberos to support mutual authentication between the client and the server, as well as the ability to pass the security credentials of a client between computers. Moreover, SQL Server 2000 introduces a new, more easily understood model for specifying backup and restores

options. In term of scalability, it Scales up to 32 CPUs and 64 GB RAM.

c) Microsoft Access

Microsoft Access 2000 is a Windows-based database management system, which runs under the Windows 95/98/2000/NT operating system. Access offers an easy-to-use database for managing and sharing data. It also adds increased integration with the Web for easier sharing of data across a variety of platforms and user levels. It enables sharing of database among the co-workers over the Internet, searching and retrieving the information quickly, and taking advantage of automated, pre-packaged solutions to quickly create databases.

Also, Stat/Transfer can be used to convert data between Microsoft Access and your favorite spreadsheet, database or statistical package. Besides that, data in Microsoft Access can be migrated to the Microsoft SQL Server.

Benefits of Microsoft Access:

- An easy-to-use tool for easily finding information that provides consistency and integration with the other applications in the office suite.
- Access 2000 allows easily sharing information via the corporate Intranet and the ability to easily host a database within the browser.
- User may create solutions that combine the easy-to-use of the Access interface (client) with the scalability and reliability of SQL server.

d) Oracle 9i Database

Oracle 9i Database is the latest database product from Oracle Corporation. It provides transparent application scalability by sharing cluster-wide caches for coordinated data access It also includes business intelligence capabilities, and provides programmatic access, centralized management, and multi-channel delivery of Internet services. A key feature of the database is the facility to recover from disaster situations.

Besides that, Oracle 9i database is designed with integrated manageability that creates a complete business view of all components powering e-business processing. As any other database software in the market, Oracle 9i provides multiple layers of security to prevent any unauthorized access to the database. Oracle 9i is compatible with UNIX and Windows NT.

2.7.6 Programming Environment and Languages

a) Active Platform

Microsoft has a very 'active' perspective on how application architectures should be created. For that matter, the word 'active' or more specifically, the term Active X, has become a standard part of packing just about every product concept released from Microsoft within the last years.

Active Platform is the name given to Microsoft component-based application development model for the web. Active Platform is divided into 3 major sections:

- Active Desktop

  An Active X enabled client architecture designed to house component, and language-independent scripting environments.

- Active Server

  Primarily intended to provide an execution environment for running business logic distributed across enterprises application servers.

- Active X Technologies
  - The object-based underpinnings of all the above.
  - Commonly referred to as the Component Object Model (COM).

Active X

In the simplest terms, Active X is an architecture that lets a program (the active X control) interacts with other program over a network (such as the Internet). It is quite a different animal than Java, which is an entire new programming language plus a specification for a virtual machine. The Active X architecture uses Microsoft 's Component Object Model (COM) and distributed COM (DCOM) standards, whereby:

- COM allows different application to talk to each other locally;
- DCOM provides communication over a network.

It is use to activate web pages, and also add application functionality. Furthermore, it is faster than a speeding Java applet.

To write an Active X control, the developer can use a number of popular programming languages, including Microsoft Visual C++ 5.0, Microsoft Visual Basic

6.0, etc. Active X controls are self-contained pieces of a program or stand-alone components. Developers can reuse them in other programs even programs written in another language. For example, you can take a control written in Visual Basic and insert it into a program in Visual C++.

Active X evolved from OLE; in fact, Active X objects are basically OLE objects with additional functions that enable them to work on the World Wide Web. Because OLE has been around for a while, developers have written many OLE objects that can now be used as ActiveX controls.

b) CGI (Common Gateway Interface)

The Common Gateway Interface (CGI) is a standard way and format that browsers use to send data to the server, as well as the format the server uses to hand the data off to a script.

The Common Gateway Interface was introduced as a standard protocol for extending the functionality of web server with additional applications. Most CGI applications are simple executables that are launched every time they are requested.

The CGI provides a consistent way for data to be passed from the user's request to the application program and back to the user. This means that the person who writes the application program can make sure it gets used no mater which Operating System the server uses. It's simply a basic way for information to be passed from the web server about your request to the application program and back again.

c) Visual Basic

Visual Basic is a Microsoft Windows programming Language. Visual Basic programs are created in an Integrated Development Environment (IDE). The IDE allows the programmer to create, run and debug Visual Basic programs conveniently. IDEs allows the programmer to create working programs in a fraction of the time that it would normally take to code program without using IDEs.

Visual Basic is derived from the Basic programming language. Visual Basic is a distinctly different language providing powerful features such as graphical user interfaces, event handling, access to the Win32 API, object-oriented features, error handling, structured programming, and much more. The ActiveX DLLs is one of the functions of Visual Basic, which allows the programmer to create a type of COM-based object, which is not executable by itself -- but is intended to be used by another application. It resides in memory and loaded into the same process (i.e., memory) as the application that uses the component. [25]

d) Java

The JAVA programming language is a high-level language that can be characterized as Object-oriented, architecture-neutral, portable, interpreted, distributed, high performance, secure, dynamic, and robust.

A Java program is compiled into bytecodes, and a Java Virtual Machine (JVM) will interpret these bytecodes. Java technology is both a programming language and a platform. The Java platform differs from most other platforms in that it's a software-

only platform that runs on top of other hardware-based platforms.

The Java platform has 2 components:

- The Java Virtual Machine (JVM)
- The Java Application Programming Interface (API)

The following Figure 2.4 depicts a program that's running on the Java platform. As the figure shows, the Java API and the virtual machine insulate the program from the hardware.

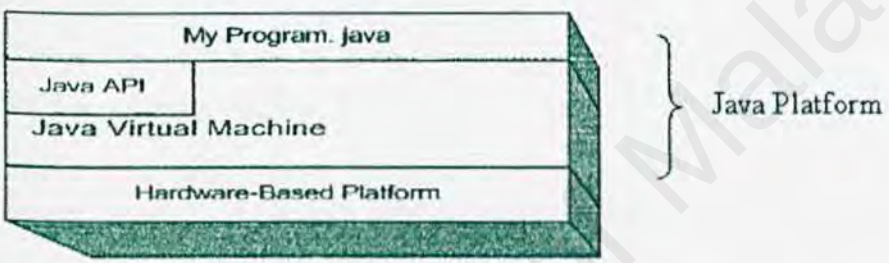


Figure 2.4 Java Platforms

JVM base for the Java platform and is ported onto various hardware-based platforms. The Java API is a large collection of ready-made software components that provide many useful capabilities, such as Graphical User Interface (GUI) widgets...etc. The API supports all these kinds of program within packages of software components. Every full implementation of the Java platform gives the following features:

- The essentials: Object, strings, threads, numbers, input and output etc.
- Applets - The set of conventions used by applets.
- Networking - URLs, TCP (Transmission Control Protocol), UDP (User Datagram Protocol) sockets, and IP (Internet Protocol) addresses.
- Internationalization - Help for writing programs that can be localized for users worldwide.

- Security - Both low level and high level, including electronic signatures, public and private key management, access control and certificates.
- Object serialization - Allows light weight persistence and communication via Remote Method Invocation (RMI).
- Java Database Connectivity (JDBC™) - Provide uniform access to a wide range of relational database.

The Java platform also has APIs for 2D and 3D graphics, accessibility, servers, collaboration, telephony, speech, animation, and more. [25]

e) Active Server Pages (ASP)

Active Server Pages (ASP) is a programming environment that gives the ability to generate dynamic html pages with the help of server side scripting. With ASP, you can combine HTML pages, script commands, and ActiveX components to create interactive Web pages or powerful Web-based applications.

ASP is a server-side scripting environment that you can use to create and run dynamic, interactive, high-performance Web server applications. VBScript is the default scripting language for ASP, but if you like you can use VBScript, JScript, Perl or any other scripting language for server side scripting in an ASP page. An ASP page is almost the same as a HTM or HTML page... the only difference is that an ASP page has the '.asp' extension. Active Server Page can include both client side and server side scripts. In an ASP page VBScript is usually used as the server side and Java Script as the client side scripting language. [26]

ASP includes the several modern technologies. The details for each technology are as follows: [27] & [28]

- Advanced Data Connector (ADC)

  It provides client-side database access. This means that the entire set of database data (such as query results) is send to the browser, which the user can then continue to manipulate. This will reduce the amount of traffic on the network connection and also the load on the server. A simple example of a client-side database task is sorting a set of data with some criteria. If the results of the query are already in the web browser, it seems wasteful to contact the server to re-sort the results by phone number instead of last name when all of that information is already in the browser.

- ActiveX Database Objects (ADO)

  It is the server-side components that dynamically connect data in a database to web pages. These objects can be used to both client and server information for building dynamic content web pages. The server takes the database data (such as a query) and integrates it into a web page template, which produces a custom-generated HTML page. This page will be display in the client's browser.

- VBScript

  The glue that binds ADO and ADC into the Active Server Pages model is VBScript. This web scripting language is subset of Microsoft Visual Basic programming language. It applies Event-driven technique that makes it easy to learn and implement in the project. VBScript is comparable to server-side JavaScript implementations like Netscape LiveWire. Unfortunately, some browser

such as Netscape does not support VBScript unless installing some kind of plugins.

f) Java Server Pages (JSP)

Java Server Pages allows web developers and designers to rapidly develop and easily maintain, information-rich, dynamic web pages that leverage existing business systems. As part of the Java family, Java Server Pages enables rapid development of web-based applications that are platform independent. Java Server Pages technology separates the user interface from content generation enabling designers to change the overall page layout without altering the underlying dynamic content.

Java Server Pages technology uses XML-like tags and scriptlets written in the Java programming language to encapsulate the logic that generates the content for the page. Additionally, the application logic can reside in server-based resources that the page accesses with these tags and scriptlets. Any and all formatting (HTML or XML) tags are passed directly back to the response page. This makes Java Server Pages technology makes it faster and easier than ever to build web-based applications. Together, JSP technology and servlets provide an attractive alternative to other types of dynamic web scripting/programming that offers platform independence, enhanced performance, separation of logic from display, ease of administration, extensibility into the enterprise ,and most importantly, ease of use.

g) PERL (V5)

Perl is a high-level programming language and derived from the C programming language Perl's process, file, and text manipulation facilities make it particularly well-suited for tasks involving quick prototyping, system utilities, software tools, system management tasks, database access, graphical programming, networking, and world wide web programming. Perl is flexible and extensible to use on virtually any task, from one-line file-processing tasks to large, elaborate systems. For many people, Perl serves as a great replacement for shell scripting. For others, it serves as a convenient, high-level replacement for most of what they'd program in low-level languages like C or C++. But Perl has some drawbacks. Firstly, it has somewhat of a reputation for being unreadable and this can leads to difficulties in maintaining the problem. Secondly, as Perl does has any formal support, it sometimes difficult to get any support when needed. Lastly, there would be a penalty in the execution time of Perl Language as it is a interpreted language.

h) Java Script

Java Script is a lightweight scripting language developed by Netscape Communications Corporation in such a way that it allows users to create dynamic Web pages. However, Java Script is not Java. It is merely a scripting language that is parsed and executed by the parser. Java Script is a simple scripting language that is very similar to C programming.

Java Script is an object-based scripting language that is designed for developing Internet applications. Java Script is used as a means to tell an application what to do,

unlike languages that are used to create applications; it cannot do anything without the application.

User can develop server applications or client applications with Java Script. The term server" is referring to the computer where the Web page resides. The term "client" is referring to the browser application that loads and displays Web page. Java Script is an extension to HTML that lets users create more sophisticated Web pages than they ever could with HTML alone.

Using Java Script, even less-experienced developers will be able to direct response from variety of events, objects and actions. It provides anyone who can compose HTML with the ability to change image and play different sounds in response to specified events, such as a users' mouse click or screen exit and entry.

i) VBScript

VBScript, the newest member of the Visual Basic family of programming languages, brings active scripting to wide variety of environments, including Web client scripting in Microsoft Internet Explorer version 3.0 and Web server scripting in Microsoft Internet Information Server version 3.0.

For people who are already know Visual Basic or Visual Basic For Applications, VBScript will be very familiar. Even if they don't know Visual Basic, once they learn VBScript, they are on their way to programming with the whole family of Visual Basic language.

VBScript talks to host applications using ActiveX Scripting. With ActiveX Scripting,

browsers and other host applications don't require special integration code for each scripting component. ActiveX Scripting enables a host to compile scripts, obtain and call entry points and manage the namespace available to the developer.

With ActiveX Scripting, language vendors can create standard language run times for scripting. Microsoft is working with various Internet groups to define the ActiveX Scripting standard so that scripting engines can be interchangeable.

j) Visual Basic .NET [29]

Visual Basic .NET has many new and improved language features — such as inheritance, interfaces, and overloading — that make it a powerful object-oriented programming language. As a Visual Basic developer, you can now create multithreaded, scalable applications using explicit multithreading. Other new language features in Visual Basic .NET include structured exception handling, custom attributes, and common language specification (CLS) compliance.

Visual Basic .NET adds several features that take advantage of the CLS. Any CLS-compliant language can use the classes, objects, and components you create in Visual Basic .NET. And you, as a Visual Basic user, can access classes, components, and objects from other CLS-compliant programming languages without worrying about language-specific differences such as data types.

Visual Basic .NET supports many new or improved object-oriented language features such as inheritance, overloading, the Overrides keyword, interfaces, shared members, and constructors.

Also included are structured exception handling, delegates, and several new data types.

- **Inheritance**

  Visual Basic .NET supports inheritance by allowing you to define classes that serve as the basis for derived classes. Derived classes inherit and can extend the properties and methods of the base class. All classes created with Visual Basic .NET are inheritable by default. Because the forms you design are really classes, you can use inheritance to define new forms based on existing ones.

- **Exception handling**

  Visual Basic .NET supports structured exception handling, using an enhanced version of the Try...Catch...Finally syntax supported by other languages such as C++.

- **Overloading**

  Overloading is the ability to define properties, methods, or procedures that have the same name but use different data types. Overloaded procedures allow you to provide as many implementations as necessary to handle different kinds of data, while giving the appearance of a single, versatile procedure.

- **Overriding properties and methods**

  The Overrides keyword allows derived objects to override characteristics inherited from parent objects. Overridden members have the same arguments as the members inherited from the base class, but different implementations.

- **Shared members**

  Shared members are properties, procedures, and fields that are shared by all instances of a class. Shared data members are useful when multiple objects need to use information that is common to all. Shared class methods can be used without first creating an object from a class.

- **References**

  References allow you to use objects defined in other assemblies. In Visual Basic .NET, references point to assemblies instead of type libraries.

- **Namespaces**

  Namespaces prevent naming conflicts by organizing classes, interfaces, and methods into hierarchies.

- **Assemblies**

  Assemblies replace and extend the capabilities of type libraries by describing all the required files for a particular component or application. An assembly can contain one or more namespaces.

- **Attributes**

  Attributes enable you to provide additional information about programmed elements. For example, you can use an attribute to specify which methods in a class should be exposed when the class is used as a XML web service.

- **Multithreading**

  Visual Basic .NET allows you to write applications that can perform multiple tasks independently. A task that has the potential of holding up other tasks can

execute on a separate thread, a process known as multithreading. By causing complicated tasks to run on threads that are separate from your user interface, multithreading makes your applications more responsive to user input.

k) Active Serve Pages for .NET (ASP.NET) [29]

ASP.NET builds on the .NET Framework's programming classes, providing a "web application model" in the form of a set of controls and infrastructure that make it simple to build web applications and XML web services. Developers are exposed to a set of ASP.NET controls that encapsulate common HTML user interface widgets such as text boxes, drop down menus, and so on. These controls actually run on the web server, however, and simply project their user interface as HTML to a browser.

ASP.NET makes building real world web applications dramatically easier. ASP.NET server controls enable an HTML-like style of declarative programming that let you build great pages with far less code than with classic ASP. Displaying data, validating user input, and uploading files are all amazingly easy. Best of all, ASP.NET pages work in all browsers — including Netscape, Opera, AOL, and Internet Explorer.

Unlike classic ASP, which supports only interpreted VBScript and JScript, ASP.NET now supports more than 25 .NET languages (including built-in support for VB.NET, C#, and JScript.NET — no tool required), giving you unprecedented flexibility in your choice of language.

2.7.7 Development Tools

a) Microsoft Visual Interdev 6.0

Microsoft Visual Interdev is a comprehensive, web-based application development tool. It provides an integrated environment that brings together various technologies to work toward a common goal of building robust and dynamic applications for the web. It integrates many of existing tools for web development, and also throws in a few hefty tricks of its own for good measure. [30]

Its main features are:

- Support for Microsoft new Active Server Pages, a method for server-side scripts to generate HTML pages on the fly.
- Support for databases integration from desktop (Access and Microsoft FoxPro) to high-end (ODBC compatibility).
- Support for VB script and Java Script (Microsoft Java script implementation) in your HTML files.
- Support the ability of building components using the Microsoft Component Object Model (COM).
- Visual design tools, templates and wizards to generating SQL commands, point-and-click interface to manipulating exposed Active X objects etc.
- A special version of Microsoft FrontPage for WYSIWYG editing.
- A color-coded HTML text editor.
- Web project file management and link management tools.
- Support for VB script to automate repetitive tasks in Visual InterDev.

Visual InterDev is, first and foremost, a programmer's tool. Each aspect of the program that you use for high-end development follows the same general pattern: -

1. Start out with a wizard or template wherein you give a general description of what you want to do.
2. A visual InterDev tool or add-in generates script for you.
3. You go into the source editor and fine-tune the functionality you want.

This process follows no matter whether you're generating a blank HTML template or a server-side script to generate a page based on a SQL query.

b) ColdFusion

ColdFusion is a popular set of product for building Web sites and serving pages to users, which enable a content database to be built by using input templates and combine these with application programs to create a Web site in which pages are developed dynamically as they are served. It consists of ColdFusion Studio, which is used to build a site, and ColdFusion Server, which serves the pages to users. ColdFusion Studio is described as "a complete integrated development environment (IDE)" and ColdFusion Server as "a deployment platform".

The most valuable feature for ColdFusion is the ability to build Web sites as "piece parts" that can be stored in a database and then reassembled for Web pages, e-mail, newsletters and other users. ColdFusion provides a visual interface for building Web page directly or for building the "piece parts". ColdFusion is also a popular tools for building e-commerce sites

ColdFusion has its own page markup language called ColdFusion Markup Language iCFML) CFML encompasses the Web's Hypertext Markup Language HTML and Extensible Markup Language (XML). A just-in-time (JIT) compiler turns the CFML into the pages that get served. ColdFusion can be coordinated with distributed applications that use CORE A or Microsoft's DCOM to interact with other network applications.

c) Visual Studio .NET [29]

Visual Studio .NET is a complete set of development tools for building ASP web applications, XML web services, desktop applications, and mobile applications. Visual Basic .NET, Visual C++ .NET, and Visual C# .NET all use the same integrated development environment (IDE), which allows them to share tools and facilitates in the creation of mixed-language solutions. In addition, these languages leverage the functionality of the .NET Framework, which provides access to key technologies that simplify the development of ASP web applications and XML web services.

- **Language enhancements**

  The initial languages that comes with Visual Studio .NET are Visual Basic, C#, C++ and Jscript and they leverage the functionality of the .NET Framework, which provides access to key technologies that simplify the development of ASP web applications and XML web services. We will cover each of these languages in detail in the following pages.

- **Web Forms**

  Web Forms are an ASP.NET technology that you use to create programmable web pages, web Forms render themselves as browser-compatible HTML and script, which allows any browser on any platform to view the pages. Using web Forms, you create web pages by dragging and dropping controls onto the designer and then adding code, similar to the way that you create Visual Basic forms.

- **Windows Forms**

  Windows Forms is the new platform for Microsoft Windows application development, based on the .NET Framework. This framework provides a clear, object-oriented, extensible set of classes that enables you to develop rich Windows applications. Additionally, Windows Forms can act as the local user interface in a multi-tier distributed solution.

- **XML web services**

  XML web services are applications that can receive requests and data using XML over HTTP. XML web services are not tied to a particular component technology or object-calling convention and can therefore be accessed by any language, component model, or operating system. In Visual Studio .NET, you can quickly create and include XML web services using Visual Basic, Visual C#, JScript, Managed Extensions for C++, or ATL Server.

- **XML support**

  Extensible Markup Language (XML) provides a method for describing structured data. XML is a subset of SGML that is optimised for delivery over the web. The World Wide Web Consortium (W3C) defines XML standards in a way that structured data will be uniform and independent of applications. Visual Studio .NET fully supports XML, providing the XML Designer to make it easier to edit XML and create XML schemas.

d) Microsoft ASP.NET Web Matrix

This tool is used in the interface design and the coding stage. Web Matrix provides all the adequate tools to help the developer in designing the interface. It also provides tools to create connection to the databases.

2.7.8 Others Tools

a) Adobe Photoshop 6.0

Photoshop offers a lot of features for image rendering. Photoshop uses palettes for quick access to functions such as navigation, colors, layers, and actions (macros). User can draw objects and text that remain editable and that print at the resolution of the output device, producing crisp edges no matter how much the user enlarges the image. The new custom Shapes palette makes it easy to generate standard geometric shapes, or to draw preset shapes (hearts, stars) in the document. The smoothness of text edges can be controlled, and a neat warping tool lets user instantly shape your text into arcs, bulges, and fish eyes.

b) Microsoft Paint

Microsoft Paint provides another alternative in image editing. Paint's interface is straightforward that its usage does not require any help with most common tasks. Besides that, it also has a set of advanced tools to perform to ease image-editing process. Paint supports both bitmap (raster) images and vector objects. But unlike the rest of the packages, Paint integrates its vector tools seamlessly and elegantly so that it is easy to switch back and forth between vector and bitmap tools.

But, Paint fails in one critical area: print proofing. It does not include a standard CMYK preview.

2.8 Summary

All these researches were done mainly to gain information for this project. The information gathered includes information regarding the Internet, E-Business, E-commerce, Enterprise Resource Planning (ERP), concepts and strategies of Inventory Management, reviews on the existing ERP and Inventory Management application, development methodologies, and development tools.

Research on Internet, E-business, E-commerce and ERP is to study the strengths and values from their business aspect. Meanwhile the study on Inventory Management's concepts and strategies is to help the developer to have a better understanding on the requirements of this project. Assessing current existing systems/applications allows identification of the weaknesses that are to be overcome in this project.

As for the development methodologies, this review focuses on two development models, the Waterfall Model and Prototyping Model, each having its own distinct features. The development model that has been chosen for this project will be mentioned in the next chapter.

Various development tools for the project were analyzed, using the information gathered from the Internet and reference books. Information on four different server platforms were gathered, they are Windows 98/NT/2000 and red hat Linux. The strengths and weaknesses of these operating systems are summarized into a comparison table and will be shown in the following chapter.

Besides, the Web Servers such as Apache Web Server and Internet Information Server (IIS) are also studied. Other information such as system architecture,

databases, programming environment and languages are also analyzed, including Client-Server Architecture, SQL server, Active Platform, Visual Basic, Java, Active Server Pages (ASP), Java Server Pages (JSP), Perl and not forgetting the latest Visual Basic.NET and Active Server Pages.NET.

Finally, there is research on suitable development software, where in this project, I have made consideration between Microsoft Visual Interdev 6.0, ColdFusion and Microsoft Visual studio.NET.

Chapter 3: Methodology

System Development Methodology is a formal and precise system development that defines a set of activities, methods, best practices, deliverables and automated tools to develop and maintain most, if not all Information System.

I have decided to use the Waterfall Model as my development methodology for the proposed system after comparing it with the Prototyping Model. The Prototyping Model was not suitable because it requires more professional programmers to develop the desired prototype. It also requires much time and resources.

3.1 The Waterfall Model

One of the first models to be proposed is the waterfall model where the stages are depicted as cascading from one another. One development stage will be completed before the next begins. Thus, when all the requirements are elicited form the customer, analyzed for completeness and consistency, and documented in a requirements document, then the development team can go on to system design activities. [15]

The waterfall model can be very useful in helping developers lay out what they need to do Its simplicity makes it easy to explain to customers who are not familiar with software development; it makes explicit which intermediated products are necessary in order to begin the next stage of development. The advantages and disadvantages of the waterfall model are as follow: [15] & [32]

Table 3.1 below shows some of the advantages of using the Waterfall Model.

Advantages	Description
1. Involves user participation	In order to develop a system that meets the user requirements, we will need to gather information from all the potential users of the system.
2. Predictable	It allows us to estimate the completion time of each stage so that the complete system can be developed in time.
3. More efficiency	The developers can manage the project more efficiency as the time and resources can be well determined.
4. Good visibility	We can identify and well define all the requirements needed.
5. Very structured	Logical flow is used to design the system.

Table 3.1 The Advantages of Waterfall Model

The Waterfall Model is illustrated in the Figure 3.1 below:

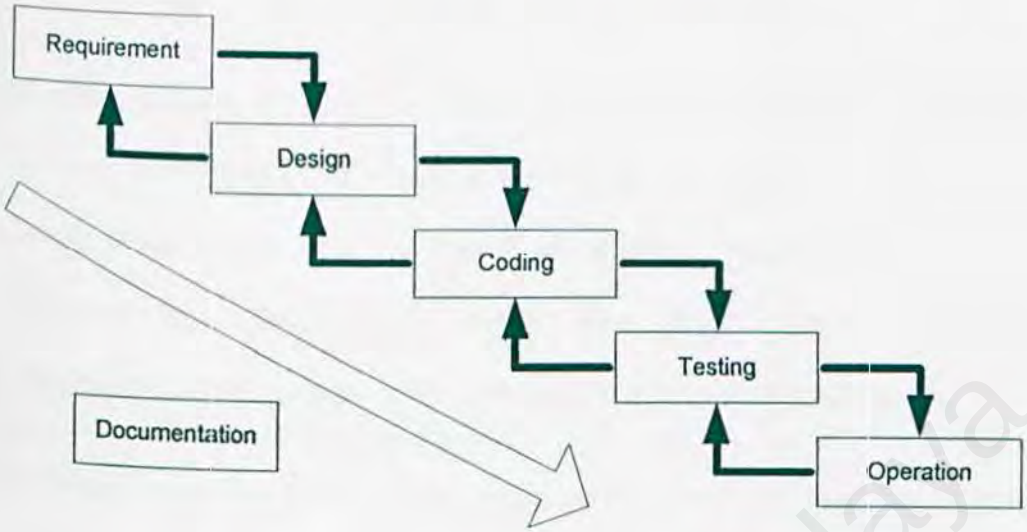


Figure 3.1 The Waterfall Model

There are a total of six processes in the Waterfall Model. The following section would briefly describe what these processes are all about.

i) **Requirements** - This is the first phase of the system development life cycle. In this phase, we will need to analyze the system in the form of identifying the problems, the opportunities and the objectives. The real problem will be determined and the best solution is then decided. Opportunities can be conceived of as the observation of the problem, and improvement can be defined as changes that will result in increment yet worthwhile benefits. Then the specification and the constraints of the project can be determined to define information requirement.

ii) **Design** - In this stage, planning is work out so that to meet the specification. The information collected earlier is use to accomplish the logical design of the system. The analyst will design accurate data-entry procedures, files or databases, user

output (either on-screen of printed) that meets information needs, and finally the controls and backup procedures to protect that system and the data.

iii) **Coding** - During this phase, the analyst works with the programmers to develop any original software that is needed. Programmers have a key role in this phase because they design, code and remove syntactical errors form the program. To ensure quality, a programmer may conduct either a design or a code walk-through to explain complex portions of the program to a team of other programmers.

iv) **Testing** - Before the system can be used, it must be tested. It is much less costly to catch problems before the system is signed over to users. A series of tests to pinpoint problems is run first with sample data and eventually with actual data from the current system.

v) **Operation** - In this last phase of the system development, the analyst helps implement the system that involves training the users to handle the system. Some training is done by the vendors, but oversight of trainings is the responsibility of the system analyst. Additionally, the analyst needs to plan for a smooth conversion files form old systems to new one. This process includes converting files from old formats to new ones or building a database, installing equipment and bringing the new system into production.

vi) **Documentation** - This integrated process takes place every phase. Activities of each phases are documented in the report form so that to provide a clear view of the progress of the each stage.

3.2 Summary

The choice of a suitable methodology is very important in system development. The methodology chosen must be suitable for the whole development process. Considerations have to be made on the constraint that the developer possesses, such as development time, resources and others. The model chosen have to reflect the goals of development.

After the process of selecting a system development model, we can move on to system requirement analysis, which is the first part of the Waterfall Model, in the proceeding chapter.

Chapter 4: System Analysis

4.1 Introduction

System analysis or system requirement analysis is a process which identifies the entire requirement in the system development phase. As mentioned in the preceding Chapter 3 (Methodology), the approach that is selected for the development of the proposed system is the Waterfall Model. The development plan will follow closely on what the Waterfall Model shows.

The very first step to development according to the selected development model, the Waterfall Model is known as Requirement Analysis. There are several approaches in completing this task, and the two approaches that are used in this project is:-

- Research - Research is done by referring to printed materials and also electronic media. The results of these researches can be viewed in Chapter 2 (Literature Review).
- Review and analysis - Review and analysis were conducted in order to identify problems, requirements, opportunities and objectives of the project.

Information that is gathered from these approaches is analyzed to outline the requirements; which is divided into functional requirements and non-functional requirements, and also the selection of tools for development.

4.2 Functional Requirements

Functional requirements specify what actions a system design must provide in order to benefit the users of the system. The functional requirements for the Hardware e-Inventory Management System are as follows:-

- The system must provide adequate security measures to protect the system from being invaded by unauthorized user. Both the user and the administrator should take charge in protecting user's information integrity.
- The system must provide adequate security measures to provide its data integrity. Data from one facility mustn't be altered by staff from another facility.
- A proper management for the users account where the administrators and only the administrators have rights to alter the data in this field.
- The inventory module should allow authorized user to alter the data when necessary.
- The vendor's list should be maintained by the administrator and facility staffs that are authorized. This list will be able to only authorized user to view and alter.
- Allow all authorized user to perform the search function.
- Generate reports according to specified criteria.

Below is a clearer view of the functionality of all the modules:-

i) User Authentication

To take security measurement, there will be a user authentication for all the registered user of e-Inventory. This is to make sure that only the authorized user can access the restricted area of the system, which is the back-end of the company.

ii) User Account Management

Only the Inventory Staff (Administrators) can use this function. By using this module, they can view user information, add a new user, edit user information, delete existing user account and search for user.

iii) Inventory Management/Maintenance

This module is sub-divided into three main categories as follows:-

- **Manage Hardware Inventory Record (Add/Edit/Delete)**
  - The *Add* option is used for entering new items into the inventory record. In this page you can find two special fields (Parts and Software), which are optional to the users. We need these two fields because some of the hardware might come with parts and original licensed software.
  - Meanwhile the *edit* option enables us to make modifications to the existing inventory record.
  - As for the *delete* function, we need it to erase item that has been write of, donated or destroyed.

- **Manage Supplier Record (Add/Edit/Delete)**
  - This module enables the user to add new supplier record, edit existing supplier record and delete any supplier record that is no longer in use.

iv) Search (View/Sort)

The user can look for the inventory or supplier information they wanted by using this search function. They can also sort out all the information they wish to review by using this function.

v) Generate Summary Report

The user may also generate their inventory status report of selected store form time to time. In a report, one can see inventory data stated above for the selected store.

4.3 Non-Functional Requirements

The non-functional requirements specify certain criteria, which the system must satisfy in order for the system to be more usable. These actions are not actual actions taken by the system but they are further restrictions on what the system must be able to handle. [31]

The following are the non-functional requirements that are embedded into the proposed system:-

- User friendliness is very important to avoid any unnecessary difficulties to users when they are manipulating with the functions of the system. A good user interface is required to perform this criterion.
- Readability is the extents to which a system can be expected to perform its intended function with required precision and accuracy. Thus, the system should be reliable in performing its daily functions and operations. For example, whenever a button is clicked, the system should be able to perform some functionality as generate some message to inform the user what is happening.
- The system have to be maintainable in the sense that whenever a problem occur, the problem should be easily detected, understood and debugged for recovery. Also, maintainable also means that backing up of data is available to assure that normal operation of the system is not disrupted should there be any disaster happens to the database.

- The system should be equipped with sufficient security. Each access by the user should be authenticated and validated by the system. Te system should not show any potential of leakage of information. The password should be encrypted.

- The system should have the capability to migrate as a client or server to machines of greater or lesser power, depending upon requirements, with little or no charge to underlying components.

- The degree of expandability is important for future enhancement to the system which is developed.

4.4 Technology Consideration

After severe analyzing of the information on the development tools that is gathered, a set of tools which is considered best and most appropriate to suit the requirement is chosen.

The selected tools are as follow:-

- Server Platform/Operating System - Microsoft Windows 2000 Server
- Web Server - Microsoft Internet Information Server
- Database - Microsoft SQL 2000
- Programming Language - ASP .NET
- Development Tools - Microsoft ASP.NET Web Matrix

The following chapter will discuss on the *advantages* and the reason behind why these tools are selected.

4.4.1 Platform/Operating System

Advantages of Windows 2000 Server:

- An enhancement of Windows NT 4.0.
- Built-in application such as Microsoft Internet Information Server 4.0 (IIS) and Internet Explorer 5.0 browser
- It is suitable for enterprise or organizational level.
- Showing high performance, reliable, secure and easy-to-manage characteristics for information sharing and running applications.

4.4.2 Web Server

Advantages of Microsoft Internet Information Server:-

- Fully supported by Windows 2000 and provide powerful security, administration and development functionality.
- Offers a superb platform for building sophisticated Internet applications.
- Easy to install and uninstall
- Accessible since all kinds of browsers can work with it.
- Allows for hosting multiple sites.
- Provides capabilities for secure transactions with the SSL (Secure Sockets Layer) support and for authentication.
- Windows-based Web authoring and development tools are supported.

4.4.3 Database

Advantages of Microsoft SQL 2000:-

- XML support- The relational database engine can return data as Extensible Markup Language (XML) documents. Additionally, XML can also be used to insert, update, and delete values in the database.
- User defined function- The programmability of Transact-SQL can be extended by creating your own Transact-SQL functions. A user-defined function can return either a scalar value or a table.
- Multiple instances of SQL server- SQL Server 2000 supports running multiple instances of the relational database engine on the same computer. Each computer can run one instance of the relational database engine from SQL Server version

6.5 or 7.0, along with one or more instances of the database engine from SQL Server 2000. Each instance has its own set of system and user databases. Applications can connect to each instance on a computer similar to the way they connect to instances of SQL Servers running on different computers. The SQL Server 2000 utilities and administration tools have been enhanced to work with multiple instances.

- 64-GB memory support- Microsoft SQL Server 2000 Enterprise Edition can use the Microsoft Windows 2000 Advanced Windows Extension (AWE) API to support up to 64 GB of physical memory (RAM) on a computer.
- Kerberos and security delegation- SQL Server 2000 uses Kerberos to support mutual authentication between the client and the server, as well as the ability to pass the security credentials of a client between computers, so that work on a remote server can proceed using the credentials of the impersonated client. With Microsoft Windows 2000, SQL Server 2000 uses Kerberos and delegation to support both integrated authentication as well as SQL Server logins.

4.4.4 Programming Language

Advantages of ASP .NET:-

- Easy Programming model- ASP.NET server controls enable an HTML-like style of declarative programming that let you build great pages with far less code than with classic ASP. Displaying data, validating user input, and uploading files are all amazingly easy. Best of all, ASP.NET pages work in all browsers, including Netscape, Opera, AOL, and Internet Explorer.

- Flexible language options- Unlike classic ASP, which supports only interpreted VBScript and JavaScript, ASP.NET now supports more than 25 .NET languages (including built-in support for VB.NET, C#, and JScript.NET, no tool required), giving user unprecedented flexibility in your choice of language.
- Great tool support- The Enterprise versions of Visual Studio .NET deliver life-cycle features to help organizations plan, analyze, design, build, test, and coordinate teams that develop ASP.NET web applications. These include UML class modeling, database modeling (conceptual, logical, and physical models), testing tools (functional, performance and scalability), and enterprise frameworks and templates, all available within the integrated Visual Studio .NET environment.
- Rich class framework- Application features that used to be hard to implement, or required a 3rd-party component, can now be added in just a few lines of code using the .NET Framework. The .NET Framework offers over 4,500 classes that encapsulate rich functionality like XML, data access, file upload, regular expressions, image generation, performance monitoring and logging, transactions, message queuing, SMTP mail, and much more.
- Compiled execution- ASP.NET is much faster than classic ASP, while preserving the "just hit save" update model of ASP. However, no explicit compile step is required! ASP.NET will automatically detect any changes, dynamically compile the files if needed, and store the compiled results to reuse for subsequent requests. Dynamic compilation ensures that your application is always up to date, and compiled execution makes it fast.

- Rich output caching- ASP.NET output caching can dramatically improve the performance and scalability of your application. When output caching is enabled on a page, ASP.NET executes the page just once, and saves the result in memory in addition to sending it to the user. When another user requests the same page, ASP.NET serves the cached result from memory without re-executing the page.
- Web-Farm session state- ASP.NET session state lets user share session data user-specific state values across all machines in their Web Farm.
- Enhanced reliability- ASP.NET ensures that your application is always available to your users.
- Memory leak, deadlock and crash protection- ASP.NET automatically detects and recovers from errors like deadlocks and memory leaks to ensure your application is always available to your users.
- Easy deployment- ASP.NET takes the pain out of deploying server applications.
- Dynamic update of running application- ASP.NET now lets user update compiled components without restarting the web server. With ASP.NET, user simply copy the component over the existing DLL, ASP.NET will automatically detect the change and start using the new code.
- Easy migration path- User doesn't have to migrate your existing applications to start using ASP.NET. ASP.NET runs on IIS side-by-side with classic ASP on Windows 2000 and Windows XP platforms.
- XML web services- XML web services allow applications to communicate and share data over the Internet, regardless of operating system or programming language.

- Mobile web device support- ASP.NET Mobile Controls let user easily target cell phones, PDAs, over 80 mobile web devices. User writes their application just once, and the mobile controls automatically generate WAP/WML, HTML, or iMode as required by the requesting device.

4.4.4 Development Tools

Advantages of Microsoft ASP.NET Web Matrix:-

- **ASP.NET Page Designer** - Rapidly create ASP.NET pages using the rich WYSIWYG designer. Drag and drop ASP.NET Server controls from the Toolbox onto your page. Select individual server controls to get in-place designer editing support as well as full property grid customization. Simply double-click a server control to get automatic event wire up of server event handlers.
- **SQL and MSDE Database Management** - Integrated support to create and edit SQL and MSDE databases. Create new databases, add/edit/delete tables and stored procedures, and edit data content all directly within the Web Matrix tool. Auto-generate ADO.NET code to execute SQL statements and stored procedures using built-in code builders.
- **Easy Data Bound UI Generation** - Web Matrix makes it easy to create data bound pages without writing code. Drop SQL tables on your page to create data-bound grids, or start with Data Page templates for reports or Master/Detail pages. Code builders help you generate code to select, insert, update and delete SQL data.

- **XML Web Services Support** - Easily add XML Web Service support to your applications. Web Matrix provides support for developers to easily expose a SOAP-based XML Web Service, as well as call and consume a XML Web Service hosted on another server.
- **Build Mobile Applications** - Write mobile-web-enabled applications for a wide variety of mobile devices such as cell phones, pagers and PDAs. Web Matrix provides drag-and-drop design support for authoring mobile pages using ASP.NET and the Mobile Internet Toolkit.
- **Project less File and FTP Workspaces** - Web Matrix supports both FTP-based and file-based workspaces that allow developers to easily organize and edit their ASP.NET applications. Simply double-click a file within the workspace tree to open it for editing. No FrontPage server extensions or project system required.
- **Development Web Server** - Develop and test your ASP.NET applications, without requiring IIS. Web Matrix includes a lightweight personal web server that serves most web content, including ASP.NET pages and XML Web Services, for local requests.
- **Community Integration** - Web Matrix provides a built-in gateway to the ASP.NET community right within the IDE -- allowing you to browse community web sites and search the ASP.NET Forums and Newsgroups for help.

4.5 Hardware Requirement

4.5.1 Hardware Requirement for Server

- Pentium 200MHz and above (or equivalent)
- Memory 64Mb RAM or above
- 2.0GB hard disk or above
- Network card NIC 10/100

4.5.2 Hardware requirement for Client

- Pentium 133MHz and above (or equivalent)
- Memory 64Mb RAM or above
- 2.0GB hard disk or above
- Network card NIC 10/100

4.6 Summary

From the research done on the development model in Chapter 3 (Methodology), the process of requirement analysis and tools selection had been a success. All the system requirement, which is the functional and non-functional requirements have been successfully identified. The analysis for the hardware requirement also had been done from the analysis of the tools which is selected.

Chapter 5: System Design

All the requirements that are discussed in the previous chapter will be transformed into the real world application in the system design phase. This transformation will be developed conceptually and logically. The transformation is a creative process of creating the solution for all the problems. A design specification will describe the feature of the system, the components or the elements of the system and their appearance to the user. In general, a system design is formulated to include the following criteria, which is:-

- Incorporating system features that are easy to understand
- Deters user's error or carelessness
- Prevent failure or improper procedures that will cause system failure
- Function in a manner that seems natural to the user

In this chapter, we will discuss on the designing of the proposed system. This discussion will cover on the

1. System Architecture
2. System Structure
3. Data Flow Design
4. Interface Design
5. Database Design

5.1 System Architecture

Following is a diagram of the 3-tier client/server architecture that will be implemented in this system (Figure 5.1).

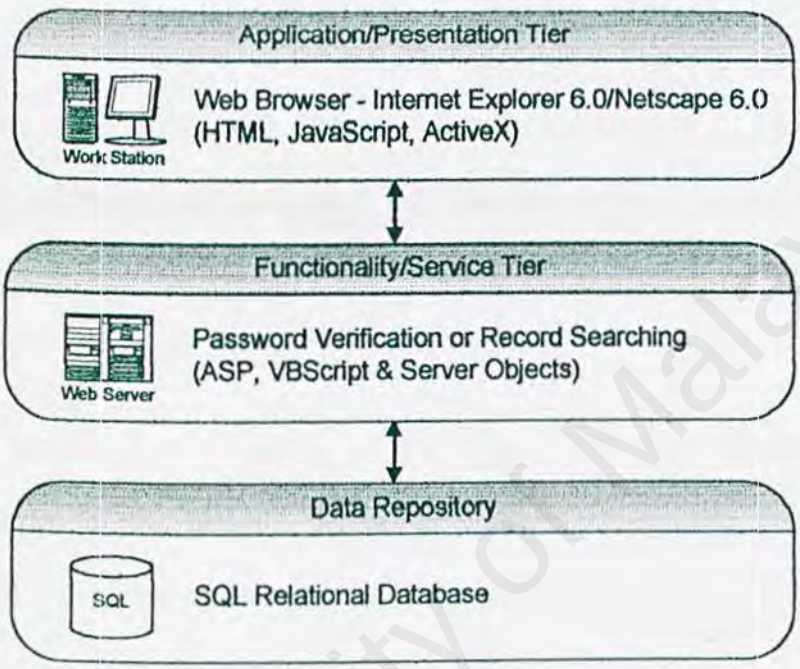


Figure 5.1 3-Tiers Client/Server Architecture

The top layer, or known as the application/presentation layer consist main application component. This component is the web browser, which at the same time provides the user with the user interface. The activation of this layer consists of the web languages and web scripting languages such as HTML and JavaScript. The web browser will always reside inside the Internet Information Server, which is the chosen web server for this project.

The functionality/service layer consists of the components that are created to support this system as password verification, searching for records, and others configuration. All these components require Active Server pages (ASP), VBScript and Active X objects to perform the functions in the web servers. The IIS in this tier will process the requests from the client and produces the result in web pages format. The IIS will also process any data request of the user by linking to the database server, which is contained at the bottom tier of the three-tier client/server architecture. The IIS will do other extra additional activity during the data processing. The communications between this tier and the application layer depends on the Hypertext Transfer Protocol (HTTP) for the web pages transfer.

The data Repository layer is build up of the Microsoft SQL Server 2000 and act as a main database for the system. The communication between this layer and the functionality/service layer is through SQL query and ODBC.

5.2 System Structure

The determining of the System Structure for the proposed system is one of an important step in the system design phase. It shows the high-level abstraction of a particular system and describes the iteration between all the independent modules. All the major functions can be sub-divided into small components.

Following is Figure 5.2 that shows the complete structure of the proposed e-Inventory Management System (Hardware).

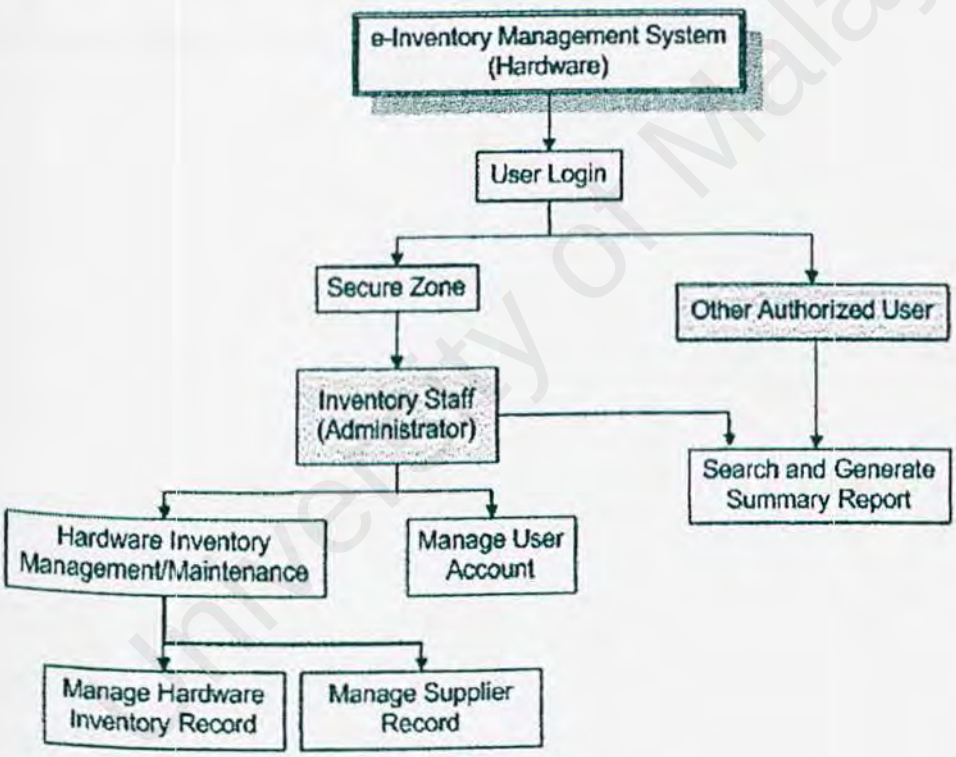


Figure 5.2 System Structure Chart

The proposed system consists of two types of users that can use this system: the Inventory Staff (Administrators) and other authorized users.

It is important to design the Inventory Staff to be in a *secure zone* to ensure that the data of inventory can only be modified by the people in inventory department. Under the secure zone, the inventory staff may have sub-modules such as managing the user accounts, managing inventory or supplier record which by that clearly stated their power on accessibility and control towards this e-Inventory system.

Other authorized users can only retrieve information (inventory/supplier information), and to generate summary report.

5.3 Data Flow Design

A Data Flow Diagram (DFD) is a graphical illustration that shows the flow of data and logic within a system. Table 5.1 below shows a supplemental conventions table that gives a clear view of what the data flow diagram is portraying.

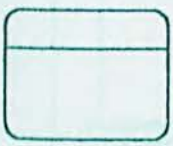
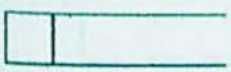
Symbol	Description
 Source or destination of data	External sources or destinations of data that interacts with system but is outside its boundary.
 Process	It represents the transformation or processing of information within a system
 Data Store	It is used for showing the data storage or referred by a process
Data Flow	It is used to show the movement of data from an origin to a destination with the head of arrow pointing towards the destination.

Table 5.1 Symbols using Gane and Sardon Method

Context Level Diagram (Figure 5.3) is the first level of Data Flow Diagram. It clearly explains the relationship and information/data flows among all the modules with the proposed e-Inventory Management System (Hardware). All the entities involve will have the access towards the process of e-Inventory and retrieve information they needed as shown in the diagram.

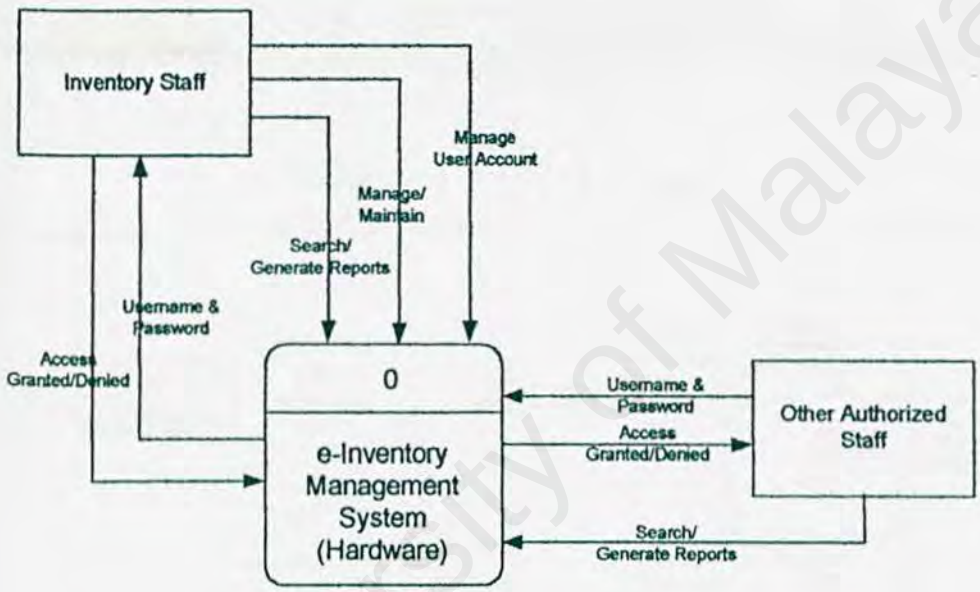


Figure 5.3 Context Diagram

Following is the **Diagram 0** for this system (Figure 5.4). From this diagram, we can see how the users from each module login to the inventory control system and carry out their own task in the different level of inventory functions.

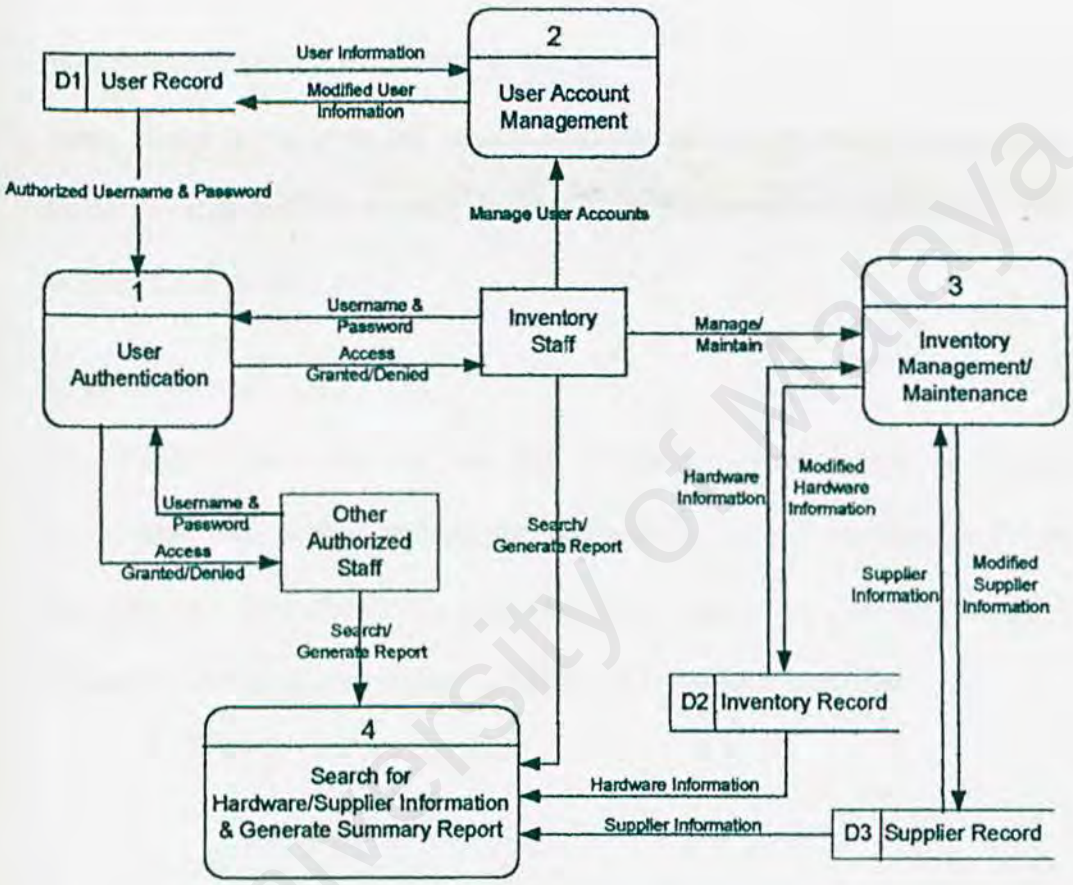


Figure 5.4 Diagram 0

The first phase of the data flow is *user authentication.* This is necessary because e-Inventory acts like a back-end module for a company, so it only allow specific users to use this system, whereas other ordinary users can just retrieve some related information they needed from this system. There are 2 specific types of user which have been recognized:

1. *Inventory Staff (Administrators)*

   Users of this group have *full control* over the whole e-Inventory Management System, where they can conduct their daily duty of *inventory management and inventory maintenances.*

2. *Other Authorized User*

   The group of user can only use this inventory control system to retrieve information they needed without the authority to change anything in the e-Inventory modules. Please take note that there is no access for the company's customer. The whole e-Inventory is basically only for back-ends user.

Below you can find another 3 diagram which will describe in details about the data flow for User Account Management (Figure 5.5), Inventory Management/Maintenance (Figure 5.6), and Search/Generate Summary Report (Figure 5.7)

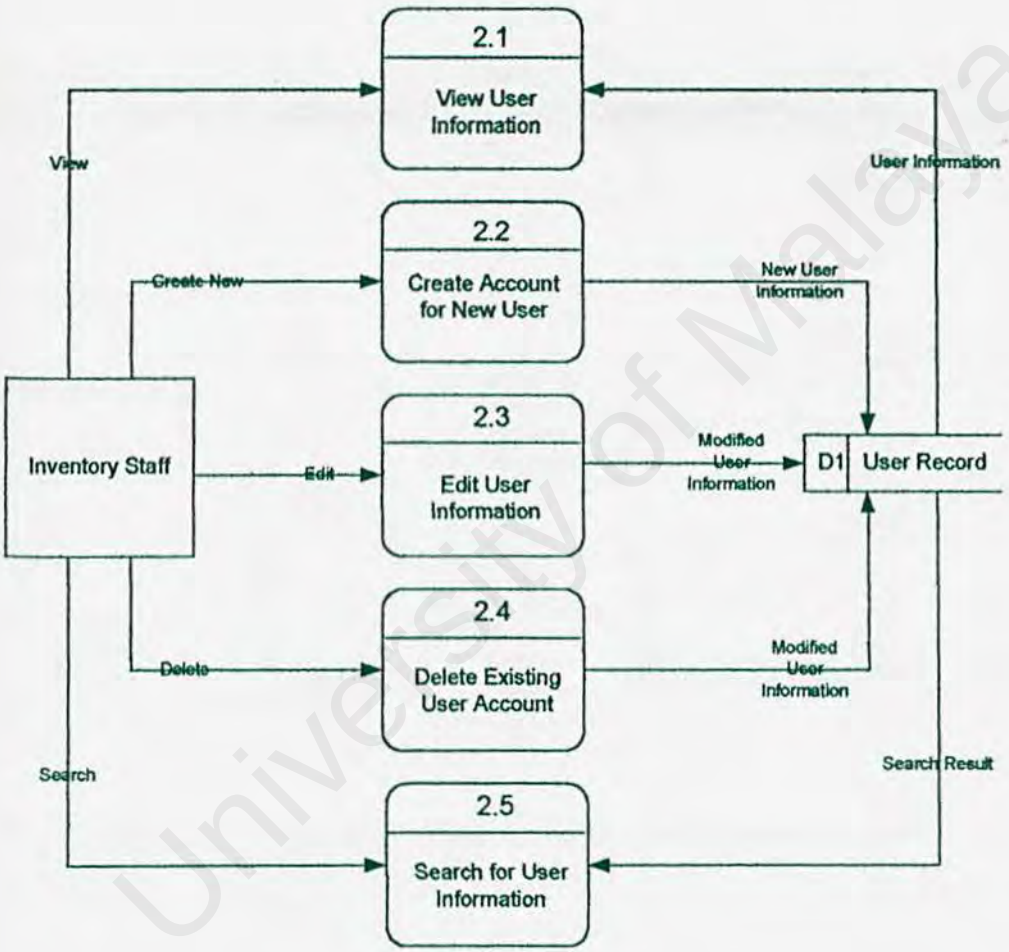


Figure 5.5 Data Flow of User Account Management

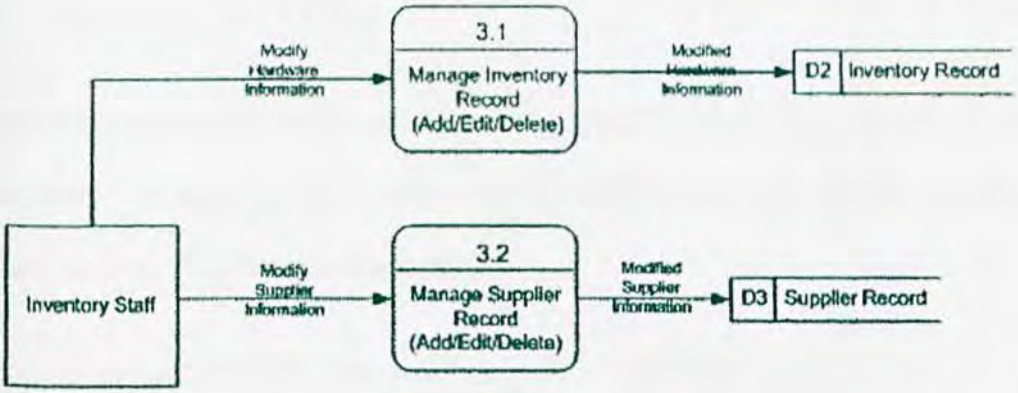


Figure 5.6 Data Flow of Inventory Management/Maintenance

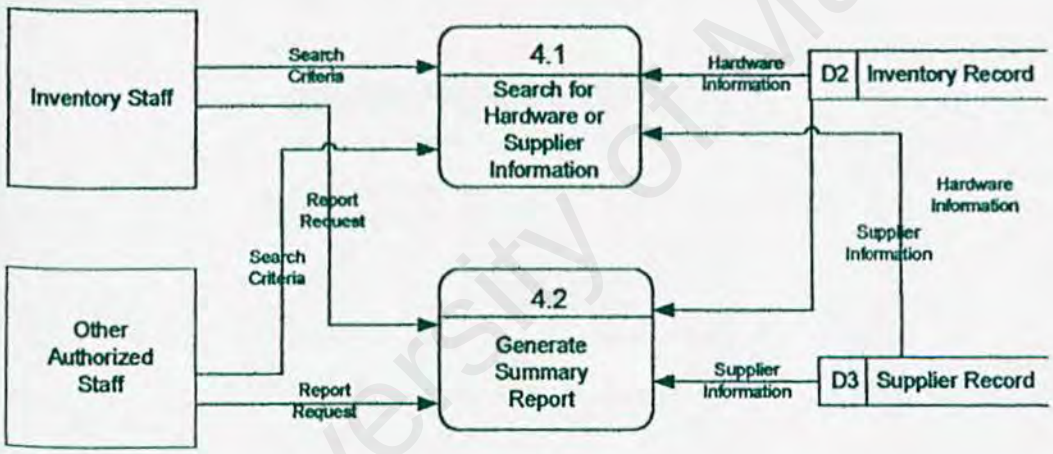


Figure 5.7 Data Flow of Search and Generate Summary Report

5.4 User Interface Design

An interactive system requires an interactive graphical or form-based user interfaces. The effort in designing, specifying and implementing a user interface plays a significant role in application development.

Below is an example of my system outcome of user interface design:-

Figure 5.8 Interface Design for Login Module

5.5 Database Design

The database that will be used is the Microsoft SQL Server 2000. This is one of the relational database management system (RDBMS) that is very popular among system developer. The design of a database is very important because it can affect greatly on the performance of data retrieval, updating and query as well in run-time period of the system.

5.5.1 Data Requirement and Types

Below is a table showing the most commonly used data types of Microsoft SQL Server 2000.

Data Type	Description
Int	To store integers from -2,147,483,648 to 2,147,483,648
Float	To store floating number data from -1.79E + 308 to 1.79E + 308
Smalldatetime	To store dates range from Jan 1, 1900 to Jun 6, 2079
Char	Stores character strings, such as STATE abbreviations; for example, the length of the column will always be two characters long.
Nvarchar	Variable-length Unicode character data of *n* characters. *n* must be a value from 1 through 4000. Storage size, in bytes, is two times the number of characters entered. The data entered can be 0 characters in length.

Table 5.2 Microsoft SQL Server Data Types

Following you can find four major tables containing the data requirements for the proposed system.

Field Name	Data Type	Size	Description
LoginID	varchar	50	Unique login ID for every user
Password	varchar	50	Password to login
Answer	varchar	50	Answer to a secret question (needed if user want to change password)
Name	varchar	50	Full name
Department	varchar	50	Department
Position	varchar	50	Position
Contact1	varchar	50	1st contact number
Contact2	varchar	50	2nd contact number
Email	varchar	100	User e-mail address
lastLogin	varchar	50	Date and time of user last login

Table 5.3 userRecord Table (D1)

Field Name	Data Type	Size	Description
ItemID	Int	4	Item ID (auto increment by 1)
Name	varchar	50	Item name
Model	varchar	50	Model number/name
VendorID	varchar	50	Vendor ID
Serial	varchar	50	Serial number
Status	varchar	500	Item's status
EntryDate	varchar	50	Entry date
LastUpdatedBy	varchar	50	UserID, Date and Name of the person who last updated that item.

Table 5.4 inventoryRecord Table (D2)

Field Name	Data Type	Size	Description
VendorID	varchar	50	Unique vendor ID
Name	varchar	50	Vendor's name
Address	varchar	500	Address
ContactPerson	varchar	50	Person to contact
Phone	varchar	50	Phone number
Fax	varchar	50	Fax number
Email	varchar	500	E-mail address
Remark	varchar	500	Remarks

Table 5.5 vendorRecord Table (D3)

Field Name	Data Type	Size	Description
ID	Int	4	Hardware request ID (auto)
Title	varchar	500	Request type
Descriptions	varchar	500	Request descriptions
RequestedBy	varchar	50	Requester
Date	varchar	50	Date
Status	varchar	500	Status

Table 5.6 requestRecord (D4)

5.6 Summary

It is very important to follow closely the job sequence of the system design phase in order to achieve a good outcome of the project. The first step is to decide on the System Architecture. Then we will need to design the System Structure and the Data Flow Design of the system. Data Flow Diagram is used to show the flow of the information/data in the whole system and it must be defined before other components. This follow by the designing of a few graphical user interfaces. Finally, you can find a Data Dictionary that defines all the necessary attributes of the database.

Chapter 6: System Implementation

The implementation phase follows after the design phase. In this phase, the designs of the Hardware e-Inventory Management System are transformed into a workable system. This chapter will bring take you through the process of implementation. It consists of three main sections, which are implementation requirements, program development, program coding, implementation environment and database connection and the system functions.

6.1 Implementation Tools

6.1.1 Microsoft ASP .NET Web Matrix

This tool is used in the interface design and the coding stage. Web Matrix provides all the adequate tools to help the developer in designing the interface. It also provides tools to create connection to the databases.

6.1.2 Internet Information Server (IIS)

In this project, IIS is an important tool that serves as a platform for the web tools and applications. The Internet services are run and managed by using the Internet service manager, which the administration feature is provided by the IIS. Properties such as virtual directories, virtual servers and access permissions are configured.

6.1.3 ASP .NET

ASP .NET is a server-generated page that can call other programs to access databases, serve different pages to different browsers. Typically, the script in the web page at the server uses input received as the result of the user's request for the page to access data

from a database and builds or customizes the page on the fly before sending it to the requestor. ASP .NET is as efficient as writing code directly to server's application program interface.

6.1.4 VB .NET Script

In the development of system, it can put an Internet server to work either by actually storing the data or causing some action to take place on the server based on the information given. VB .NET, which is the newer version after VB 6.0, helps validates data, pricing, provides impressive multimedia feedback, and initiating data storage. The user can use VBScript to sequence the questions based on responses.

6.1.5 Microsoft SQL Server 2000

MS SQL Server 2000 is used to develop the database for the system. It is an easy to use tool where all the important data concerning the system are stored in a database developed using it.

6.2 Implementation Requirements

6.2.1 Hardware Requirements

The server computer hardware requirements are:

1. A server with at least Pentium 166MHz MMX processor.
2. At least 64MB RAM.
3. Network Interface Card (NIC) and network connection with recommended bandwidth at 10Mbps.
4. Others standard computer peripherals.

The client computer hardware requirements are:

1. Any compatible PC with recommended at least Pentium MMX processor and 32MB RAM.

6.2.2 Software Requirements

1. Windows 95, 98, NT, 2000 and XP as the client Operating System
2. Internet Explorer 5.0 or above is recommended as the web browser
3. Internet Information Server 4.0 as the web application server host
4. Microsoft Visual Studio .NET or Microsoft ASP .NET Web Matrix as the HTML document layout design tool

6.3 Program Development

Program development is the process of creating the programs needed to satisfy the system process requirements. It consists of 5 steps, which are reviewed the program documents, design of the program, code the program, completion of the program documentation. Figure 6.1 shows the steps of the program development.

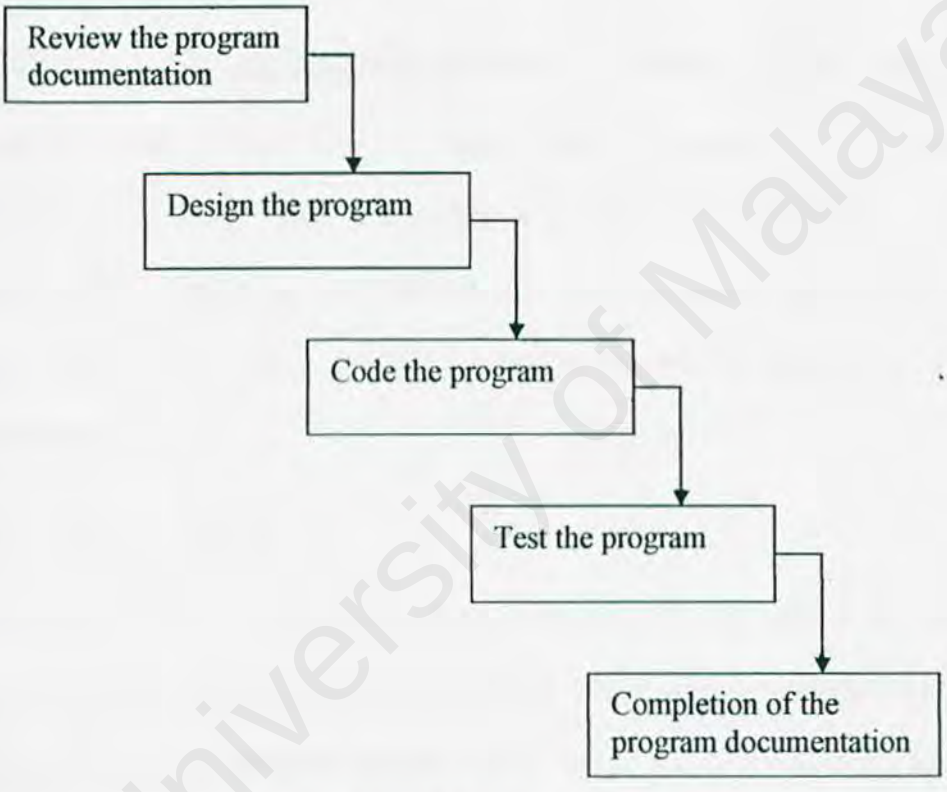


Figure 6.1 Steps of Program Development

6.3.1 Review the Program Documentation

The first step of the program development is to review the previous program documentation. The program documentation of the Hardware e-Inventory Management System consists of simple system description, system requirements and database design. This documentation helps me to understand better the task that has to be covered during this coding phase.

6.3.2 Design the Program

After the program documentation review, I need to design the program, which is the second level of the program design during the system development. For this second level of program design, I have decided how the program can accomplish the system requirements by developing a logical solution to the programming problems. The logical solutions, or logic, for a program is step-by-step solutions to most programming problems.

6.3.3 Code the Program

This is the process of writing the program instruction that implements the program design. Design specification must be translated into a machine-readable format. If design is performed in a detailed manner, coding can be accomplished mechanically.

6.3.4 Test the Program

This process is to ensure the system function by testing the program thoroughly. Testing is a must before the program processes actual data and produces information on which people will rely. I will perform several types of test on an individual program, which will be discussed further in the following chapter.

6.4 Program Coding

6.4.1 Coding Principles

Throughout the coding phase for the Hardware e-Inventory Management System, several principles are followed in order to ensure the quality and the structure of the generated code. They are as follows:

1. **Readability**

   Easy to read codes are essential for the future system enhancement by another developer. To cater for this, meaningful variables and label names have been used. Comments are written in most of the coding pages to explain their every functionality. Proper indentations are followed to enhance readability.

2. **Maintainability**

   Codes should be easily read, corrected and revised. To achieve this, codes should be readable (as explained above), highly cohesive and loosely coupled. Codes that performs functions for one module should be grouped together and try our best as much as possible to achieve high cohesive and loose coupling.

3. **Robustness**

   Codes should be robust in terms of handling errors and responding by displaying appropriate error messages and try to avoid system failure.

6.4.2 Coding Methodology

In the coding phase, two approaches have been used, which are the top-down and the bottom-up approach. Both of the approaches are used to obtain the benefits from them.

1. **Top-Down Approach**

   This approach starts by looking at the large picture of the system and then exploding to smaller parts or subsystem. Top-Down approach allows the higher-level modules to be coded first before the lower level modules.

   This method ensures that the important or core modules of the system to be developed and tested first. Deploying the methods gives a preliminary version of the system sooner. The advantages of using this approach are as follows:

   - Prevents the developer from getting so mixed in the detail that they loose track of what the system is suppose to do.
   - Avoiding the chaos of attempting to code a system all at once
   - This method is compatible with the general system thinking of normal human nature.

2. **Bottom-Up Approach**

   In contrast with the top-down approach, the bottom-up approach starts coding at the lower level modules before the higher-level modules. The higher-level module acts as an empty shell that calls these lower level modules. The completed lower level module will then be integrated with the newly completed higher-level module.

6.4.3 Database Implementation

For Hardware e-Inventory Management System, the database is stored in a PC in which Microsoft SQL Server 2000 is installed. Any data creation, updates or data retrieval will be connected directly to the database server. The database includes tables to keep inventory item details, vendor info and user details.

After the system is completed and tested successfully, all the dumb data were flush from the database. All the unnecessary tables were eliminated from the database to avoid data overlapping and to reduce workload of the entire system when deployment.

Chapter 7: System Testing

7.1 Introduction

The main function of testing is to establish the presence of defect in a program. Meanwhile, testing is used to judge whether or not the program is usable in practice. Nevertheless, testing can only demonstrate the presence of error. It cannot show that there is no error in the program. Therefore, suitable approach must be chosen to reduce the possibility or error in a program. Several rules serve well as program testing objectives.

a) Testing is a process of program execution with explicit intents to find errors and run-time program bugs.

b) An effective test case is one that contains unexpected testing record sets with high probability of detecting undiscovered errors during the program design and development phase.

c) A successful test is also not one that uncovers only few expected error, but it is which constantly provides new challenges to its programmers over time.

The different between testing modules during the development phase and testing them during software integration is that error can be fixed as they are found the integration phase must be recorded and the bugged module must be returned to its development team or programmers for further correction based on its errors logs. Hardware e-Inventory Management System has gone through three stages of testing before it is completed. These three stages are the component testing, integration testing and acceptance testing.

7.2 Testing Process

In general, the testing process of the system can be shown in the following figure.

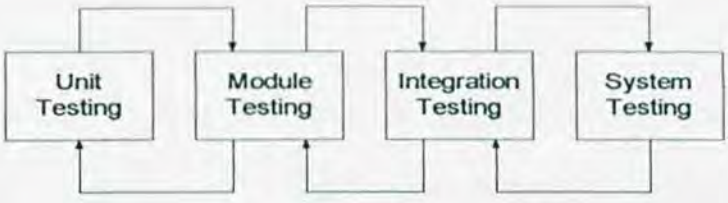


Figure 7.1 Testing Process

The testing procedure will be started from component testing to ensure the codes implemented in the system will properly fit the system requirements. This is follow by the integration testing, which is tested for the overall functionality and performance of a few modules that are integrated together. Lastly, the testing procedure, user is required to test the system carefully to ensure that the implemented system will function according to their requirements. If any mistake or defects are discovered at any stage, the previous stages might need to be repeated for correction and modification.

7.3 Testing Approach

The testing approach adopted in this system is the bottom-up approach. Using this approach, each module at the lowest level of the system hierarchy is tested individually. Then, the next module to be tested is that module that calls the previously tested module. This approach is followed repeatedly until all modules have been tested.

7.4 Component Testing

The details of how each stage takes place in this system are described in the following sections.

7.4.1 Unit Testing

Unit testing is a process to test the individual component to ensure that they function properly. Each component is tested independently without the interference from other system component. Unit test is time-consuming and labor intensive stage of any software development. Several techniques had been used in the system to perform unit testing as stated below:

a) Code Review

Before the function is run in the browser, codes are reviewed line by line to discover any syntax error as well as semantic error. If errors are discovered, they are corrected immediately.

b) Breakdown Of Codes

The Microsoft ASP .NET Web Matrix Project can display the codes of all the pages into three views. The first one shows the HTML codes where all the ASP .NET scripts and HTML are shown. The second part shows all the VB .NET script which is used to handle all the web controls and the last part shows all of the codes together.

7.4.2 Module Testing

After the unit-testing phase, module testing will be implemented to uncover error in each unit. A module is a collection of dependent components. During this stage, all the related units or functions will be integrated and tested in the module level. In

performing module test, different test cases are applied to the module and the test results are recorded. If errors occurred in this level, each unit will be retested to figure out the problems. The main reason is, although each sub module performs its task correctly, the end result produced may be incorrect when all the sub modules work together.

7.4.3 Integration Testing

7.4.3.1 Sub- System Testing

After the module-testing phase, the entire module will be integrated into sub – system for further integration. Test will be conducted to check the functionality of the integrated modules. The most common problems that arise when modules are integrated together are module interface mismatch. Therefore, the main concern in integration test is to exercise the interface repeated to defect any interface mismatch problem. Several important aspects are checked to reduce the possibility of interface problem as listed below:

- Is it necessary to perform a checking redirect the user to the correct module?
- Is the number of parameter received in the receiving module?
- Is the type of parameter tally with the type of parameter received?
- Is type conversion necessary? Is the valve of parameter truncated during type conversion?
- Is the information passed sufficient for the receiving module to perform its task?

7.4.4 System Testing

After the sub – system testing, all sub systems will be integrated to make up the complete system. Therefore, the main purpose in system test is to find errors that result from unanticipated interactions between subs – system. Besides, it is used to validate whether the system meets its functional and non-functional requirements. Functional test checks that the integrated system performs its function as specified in the requirements, whereas performance test is to compare the integrated component with the non-functional requirements.

Once the functional test is completed, performance is performance to compare the integrated module with the non-functional system requirements. These requirements include reliability, efficiency, maintainability, user friendliness and others to ensure that the system being developed is fully functional and optimized.

7.5 Acceptance or User testing

The final testing procedures in Hardware e-Inventory Management System is the acceptance or user testing whereby users will be actively involved in this stage to test the system to ensure that the system meets their requirements. The main purpose of this testing is to verify whether the system has fulfilled the user's requirements. During this test, besides the functionality of the system is demonstrated to the end users, the users are given the opportunity to experience and explore the system themselves.

7.6 Summary of System Testing

At the end of the testing phase, the system should be able to perform the task required and free of some errors. The user should use the system. However, there are still some critical problems and errors will occurred only after some time of using the system. Therefore, work of testing should not just end up in this phase but have to keep on every now and then making sure the system is functioning well. This will last for a long period.

Chapter 8: System Evaluation

8.1 Introduction

Evaluation is the ultimate phase of developing a system and an important phase before delivery the system to the end users. Evaluation was related to user environment, attitudes, information priorities and several other concerns that are to be considered carefully before effectiveness can be concluded. At all phases of the system approaches, evaluation is a process that occurs continuously, drawing on a variety of sources and information.

8.2 Problems Encountered and its Solutions

8.2.1 Problems in selecting Tools and Languages

Since developing an e-commerce system is a new technology, it is difficult in selecting the most appropriate tools and software for the development of Hardware e-Inventory Management System in the beginning stage. It is because the process of choosing the suitable technology and tools for project development is a very critical process as different tools has its strength and weaknesses.

Hence, to learn more information in web-based application in the Hardware e-Inventory Management System, in dept studies and research on the programming language and tools using were conducted in the earlier stage of the development. The studies and research activities including Internet surfing, reference books, review the current systems in the market and others.

8.2.2 Difficulties in Determining System Scope

Without experience in web-based development, it is difficult to define the scope of the system in the early stage. Due to the insufficient knowledge and time constraint, it is impossible to build a full-scale complete system within the given time frame.

To solve this problem, reference and analysis on current web sites has been conducted in order to understand the system design of each web site and try to adopt some of the ideas into the system design of Hardware e-Inventory Management System.

8.2.3 Lack of Knowledge in the Language and Tools Chosen

Due to the time constraint, it is very difficult in learning the chosen language and tools. Without a strong base of the language, I need more time in looking for solution to solve technical and non-technical problems that were encountered during the development of Hardware e-Inventory Management System. It consumes a lot of time in the beginning stage of development to learn the new programming language. All these need some research on the component before knowing how to use the component and how to apply it in the modules. To solve these problems, Internet was the most vital source. There are lots of source codes and free tutorials in the World Wide Web. In addition, forum was also another way to help to solve the problems occurred during the Hardware e-Inventory Management System development.

8.2.4 Lack of time

There are still many features that can be built into the Hardware e-Inventory Management System to make it useful. Due to the time constraint this system only implements crucial features and functionality.

8.3 Evaluation by the End User

As Hardware e-Inventory Management System is proposed to make inventory record keeping easier and more effective, the final stage of the system development which is the system testing becomes critical and it needs feedbacks from all respective users in judging the correctness of these functionalities, precise data flow as well as enhance interface of the system.

Anyway, as the scope of Hardware e-Inventory Management System is large, development was conducted with the objective to cover the scope briefly, which means that the whole system was developed quickly to have the overall structure and potential of the system but the system was not refined to show its full efficiency.

The overall feedback from the end users is good and Hardware e-Inventory Management System is expected to serve the targeted group well after refining.

8.4 System Strengths

8.4.1 Simple and user-friendly Interface

By employing the graphical user interface, Hardware e-Inventory Management System can be evaluated as an easy-to-use system. Unlike those command-based environments, Hardware e-Inventory Management System is more user-friendly to interact with. Sufficient instruction and guidelines are provided to assist users. Users are required only minimum typing and inputs when they interact with the system.

8.4.2 Security

1. Like most system, security is one of the most important aspects in the system. System security is implemented using **LoginID** and **Password**. A valid LoginID and Password is required to access and make changes to the system's database.
2. This system provides two levels of user login controls which are the **User** and **Admin**. Every login has their own privileges and this will determine the scope of their task. With windows 2000 or Windows XP as the server operating system, all client machine that connect to it must have a trusted connection or granted permission to manipulate the database stored inside.
3. Another special features of this system is that it can record the date and time of the user's **Last Login.**
4. Besides that, every inventory item will have a **LastEditedBy** field where it will record down the LoginID, Date and Time of the user that has last editing that particular item.

8.4.3 Hardware Request Module

This module enables the Inventory Staff to request for hardware on behalf of the user who has called them. The Inventory Staff can easily login to the system and post this request. The Admin will later reply this request with either a rejected or an approved result. The Inventory Staff can view the status in the Forum. This make hardware request procedure more organized.

8.4.4 Quick Search

An effective quick search engine is provided in Hardware e-Inventory Management System. It is very easy to use because user doesn't have to key in any field. They just have click on the dropdown menu and the available items will be shown there.

8.4.5 Maintainability

The system is easy to maintain because some of the functions are stored in files. Meanwhile every object type is written in standard form and the file name of every component also rename in a standard way. This is important for administrator in doing maintenance work.

8.4.6 Consistency

The screen design maintains its consistency throughout the system. All the functions hypertext is always displayed at the same position although the user switches from one document to another. Thus users faced less difficulty seeking for a particular option, which there require.

8.4.7 System Transparency

System transparency refers to the condition where the users do not need to know where the database resides, how is the system structure, its database management system and anything related to the system built. This feature is very important to avoid confusion that could lead to destruction of the important data.

8.5 System Limitations

- **JavaScript Enabled Web Browser**

  The browser been use must be JavaScript compatible. As mention earlier, JavaScript has been use as client side scripting for error checking and data handling.

- **Long Loading Time**

  As there is only one web server and one database server for uses of all e-faculty system, both servers are expected to have a high workload during normal working hour. Thus the loading time will be slow down and affect the working efficiency of the users of this system.

- **Lack of Functional Modules**

  Currently, the available function module in the system is very limited. This is because of lack of inventory management information collected during data collection.

- **User Cannot Obtain Password through Web**

  Another limitation is the user cannot obtain their password through web. This limitation exists due to the central maintenance by administration. However, this structure will increase the security of the system.

- **Very limited Reporting Function**

  There is also another limitation where there reporting function in the system is very limited. The browsers need to load all the record into the web page before printing can be done. If it load too many record, it will take up many memory from the client PC until the client PC is out of memory. Therefore, it need third party software to help supporting printing of web page reporting consist of a huge

amount of record. However, these third party soft wares are not available during the development phase of this system.

- **Limited Online Help**

  Because of the time constraints, online help for this system is not really completed.

- **Insufficient Functionality**

  Due to time constraints, this system does not reflect the real inventory management system in the market. It only provides very basic and limited function.

8.6 Future Enhancements

System development is a dynamic process. This system was developed in less than three month. While developing this system, new ideas have come about. However, due to time constraint, not all of these ideas could be incorporated into the system. Some of the ideas that come about are as follows:

1. There is not password encryption used in this system. Passwords are store directly into the database. If password can be encrypted, then the system will be much more secured.
2. The report function in this system should be enhancing to support more report format and print any size of report without any problem.
3. The interface of the system can be designed in a more standardized way which shows the professional of designing a system.
4. The system should provide database backup so that data can be recover if the database is corrupted.

5. The system does not provide function for storing picture of user or inventory system. Therefore, it is better if the system can provide this function for ease of knowing the user or item better.
6. Provide more efficient online user guide to guide user to user the system efficiently.

8.7 Knowledge Gained

Valuable knowledge was gained throughout the development of this system. Author has expose to client -server development environment, database distributed system, programming and concepts, as well as LAN configuration.

User have learn many skills on how to develop application using software tools like Microsoft ASP.NET Web Matrix, Microsoft SQL Server 2000, Microsoft FrontPage, Macromedia Dreamweaver MX, Adobe Photoshop 6.0 and other unmentioned software tools.

The user also has chance to applied theories and knowledge gained through the course of computer science studies like system analysis, design and software engineering. User also understands better on the inventory management concept.

There is also improvement in skill of finding information and classifying facts, besides improving skill of problem solving and trouble -shooting.

8.8 Overall Conclusion

Overall, the main objectives of the project had been achieved through there are still plenty rooms for improvements.

However, like other software application, this system is not escapable from its limitation. But these all can be overcome in time, by making the necessary future enhancement.

Finally, it is hope that this project really helps improving inventory management in any company who used this system