DYNAMIC RESOURCE MONITORING SYSTEM WITH DYNAMIC AGGREGATE VIEW

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DECLARATION OF ORIGINALITY

I declare that this report entitled "**DYNAMIC RESOURCE MONITORING SYSTEM WITH DYNAMIC AGGREGATE VIEW**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently for any degree or other award.

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ABSTRACTS

The purpose of this project is to develop an information technology (IT) assets management system, known as Dynamic Resource Monitoring System. The proposed system does not aim to compete or improve current market available product, but designed to be a complement application that focuses on supporting decision making. It is a system which enables the top management to have better investment decision making. It assists in selecting area of investment and hardware to purchase. The system is designed to be a web-based application that enables user to view the information remotely without any installation required. The system provides rich graphical user interface that includes grid view, column graph and pie charts for interactive data visualization. For the entire project on going, prototyping methodology method is used. It provides a step by step process or guidance to the developers to follow in order to accomplish the project. In this methodology, phases such as planning, analysis, design, prototype, implementation and testing had been run. In the end of the day, the project successfully developed a prototype system that fulfills the project objective.

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1.1 Introduction

Manually tracking and managing inventory data is costly, time-consuming and error-prone [1]. Inventory data needs to be handled and indexed properly so it can be easily tracked and accessed anytime. However, it is not easy to manage inventory because there are different types of data and records which has complicated relationship. Some organizations hire staffs for such task, thus increased the expenses of the organization. Delay in the business process may cause losses to the organization as it takes extra time to manage and process data. Besides that, nobody is perfect in this world and human is the biggest factor in performing error. There is always one or more errors occur while the data is being processed.

There will be two categories of users in this proposal who are users A and users B. Users A represent the senior management of the organization who requires information for better investment decision making. User B is the IT assets administrator who manages and monitors the performance of IT assets.

Users A may encounter difficulties when employees request to upgrade or purchase some IT assets because they might not know the utilization and the total number of IT assets that need to be upgraded. So, without having the correct information of current IT assets of the organization, users A may find difficult to do the decision.

Besides that, users A may also face the difficulty in choosing a better performance device because they have no idea on the brand which may suitable for the system. With the detail information about the devices such as cost, number of upgrades and maintenance services performed on the IT components, users A can get a better idea on selecting the hardware brand they should purchase.

Return of Investment (ROI) is a way for the users A to evaluate their investment. Users A might need to acquire cost of the assets to calculate ROI value. It will be a troublesome process for the user A to acquire total cost of the IT assets by referring to transaction documents.

To overcome those problems, software developers developed a system which is called IT asset management system. IT management system is a system that applies the fundamental discipline that enables the company to improve its cost control and truer understanding of the business value of IT asset [2]. Gartner research helps organizations develop IT asset management programs that improve procurement, optimize costs and establish IT credibility throughout the enterprise. IT asset management system helps to overcome IT asset management problems by maintaining a recording of all the desired assets. It can hold details of service schedules, maintenance records, depreciated value and schedule for replacement. For example, Tivoli Asset Management for IT from IBM inserts some features which helps their users in reducing IT cost, mitigating risk and optimizing service with effective IT asset management solutions. It also enables effective management of the IT asset lifecycle to lower cost, mitigate license compliance risk, and better align IT with business goals. The system optimizes IT asset utilization and IT service levels as well, not more not less.

1.2 Problem Statement

Some analysis and research had applied on the existing IT asset management system software such as Net Killer IT Asset Management 4 [4], Manage Engine Service Desk Plus 7.6 [5], Total Network Inventory 1.6.8 [6], Tivoli Asset Management [7] and Manage Engine Asset Explorer 5.5 [8] for IT in the literature review of Chapter 2. According to the review, most of the existing IT asset management software provides a good system to manage the IT assets for company or organizations. However, according to feedback of Tivoli's customer, most of the existing IT software management software has the limitations on data access. They tend to have limited, complicated abilities for custom analysis and report creation [1]. Some of the software provide feature to get information about the cost while some provide the feature to get the utilization of IT assets of the organization.

For example, Tivoli Asset Management allows user to obtain data and generate information that previously was either unavailable or too difficult to access. Tivoli provides the reporting function which includes analytic and formatting capabilities that provides more meaningful information to users such as utilization of the IT assets. However, Tivoli may need the service desk information in order to get the reliability of the IT assets. Without the information from service desk, Tivoli may find the difficulty to get the reliability information. In short, Tivoli has the difficulties in retrieving failure rate information.

Besides that, most of existing IT asset management software does not have a comprehensive and concise visualization of the actual assets. Most of the existing software only provides information in sentences or details in graph and table form or basic interpretation of the gathered information from the actual assets. They do not provide graphical user interface feature which can help users to access the information that they want in an easy and interactive way. Comprehensive and concise graphical user interface is needed for the software because it is able to give a better representation and information can be easily accepted by users when they use the software.

1.3 Motivation

This project aims to develop a system that aggregates IT asset management features with important and accurate information such as ROI, utilization and reliability of IT assets for better decision making. These three variables are very important factors for investment decision making.

For instance when the senior management would like to purchase new graphic card; and there is information of two graphic cards available which are graphic card A and graphic card B. Graphic card A costs RM 300 with reliability value 0.6 for three year and graphic card B costs RM 500 with reliability value of 0.9 for three year. According to this scenario, the senior management will likely purchase graphic card B because it is more reliable.

Besides, utilization is another factor in making investment decision. Here is another scenario continues from above scenario; if the senior management need a graphic card that expected be used for one year, the senior management will likely purchase the graphic card A because it is cheaper even its reliability is lower.

Return of Investment, ROI is very important in making investment whether it is in terms of training, capital or equipment. ROI is always being concern whenever the investment is made. ROI will tell the management about the return on the investment of the IT assets that the management can get. Thus, ROI is very important for the management because they could determine if they had made a good investment. However, cost is an important factor in order to calculate the value of ROI because the calculation of ROI cannot be performed without the cost.

Reliability of assets is important as well because it is the first thing that comes to mind whenever purchase is made. Usually, People may only think about purchasing the IT assets with lower cost because this will give them the best value for their money. However, they had forgotten to consider about the reliability and durability of the asset. Reliability of IT assets is very important when purchase is made because time is valuable and reliability problems can consume a lot of time. Reliability can also takes up a significant amount of employees' time and technical support time, with a direct impact on

the productivity and operating cost [3]. In other words, reliability has a measurable impact on costs.

Besides that, the senior management needs to consider the utilization before they make any decision on their purchase because this can helps to reduce the unnecessary expenses. By knowing the utilization of their asset, the senior management will get more information to be considered in making decision. Moreover, the senior management will more understand which product they need to purchase.

In short, ROI, reliability and utilization are very important in helping the senior management making investment decision.

1.4 Project Objective

The first objective of this project is to develop a software system that is able to manage IT asset of an organization and help the management to make a better investment decision. The proposed system able to manage the IT asset by showing all details of assets that is owned by the organization and topography of the entire IT assets. This information includes the specifications, daily performance, cost, reliability, utilization and condition of the asset.

Besides that, the proposed system is able to display the price and calculate return of investment (ROI). The administrator is able to know the utilization of each computer through the system. The maintenance history of the asset is kept to compute the reliability of an IT asset. All of these features are important information to create a good and effective IT management system. By presenting all of that information to user, the software will be able to give an overall condition of IT assets in the company or organization.

Another objective of this project is to develop an IT asset management software system with an interactive and comprehensive graphical user interface. The graphical user interface is created in this software so users can easily use the software without any difficulties. The graphical user interface in this software is also built in order to give a better visualization and representation of actual assets to users so users will more understand the asset in a correct view.

1.5 Project Scope

This software project is developed to run on the Windows Operation System. It will access each component of the asset in order to get the detail information such as the daily log, utilization, maintenance history and condition. This software will then store the information or update the existing information in the database of the system accordingly. When user uses this software, the software will retrieve the data from database and display the result on the webpage.

However, the scope of this project is to develop working system which can map out the IT asset and components of each IT asset and their detail information on a webpage. It helps users to get the return of investment value, reliability and utilization of IT assets with a single product installation that tracks and manages hardware and related information through every phase of the asset life cycle. Research on the equation is required in order to get the right and most suitable equation to compute the return of investment of an organization, utilization, reliability of IT asset.

The proposed system, Dynamic Resource Monitoring System is designed to be a web-based application that provide rich graphical user interface. It enables user to view the structure or department of the organization in hierarchy view. The graphic element of the system includes grid view, column graph and pie chart to provide different view of information.

1.6 Contribution

IT Asset Management is a systematic approach to manage the hardware effectively as taking control of the physical and financial elements of the IT assets in an organization can be a challenge. Dynamic Resource Monitoring System will get the detail information of the IT asset automatically after the installation of sensor developed into each computer. It will keep track the dynamic and static information of the IT component and update its information stored in the database.

For example, Dynamic Resource Monitoring System will detect the changes of the RAM for the selected computer if the users had upgraded the memory of the RAM from 1 GB to 4 GB. The existing information will not be replaced by the updated information. This means that the system keeps all the historical data of IT assets.

Besides, this system helps users who are working as IT technicians, IT administrators, and other IT related field to simplify their work in managing and monitoring IT resources in their company or organization. This will enhances the IT assets management process into another level by minimizing the process done by humans.

Dynamic Resource Monitoring System will show the detailed information of every component and IT assets of the organization through the webpage. Users can get the information anywhere, anytime as long as there is an internet access. Furthermore, the web-based system does not require any installation on the client side. A comprehensive user interface is important allows user to have a clearer view on the report generated. It can helps in squeezing maximum efficiency at minimum cost for every asset.

The system provides users information about return of investment, utilization and reliability of the IT assets in the organization. This can helps the top management to do a better investment decision. The system also provides the return of investment (ROI) of each department, so that the users can know the overall condition and performance of the organization. ROI is very important for the management because they could determine if they had made a good investment. This feature is not only applied to the IT asset but it also applies on each department of the organization.

2 Literature Review

There are a few projects which help in managing the IT assets in the organization and some of the developers are still doing their researches or projects in order to improve the performance of existing IT asset management systems. Chapter 2 reviewed some of technologies which are related to this project and collect the reviews and information from the existing system which may be used to support the objective of this project especially about implementation concept. The analyses are focus on the Reliability, Cost and the utilization of the IT assets. Besides, the user interface of the software is another concern as the useful information can be easily delivers to the user with a comprehensive user interface.

2.1 Definition of Reliability, Utilization and operation Cost

This section will define the reliability, utilization and operation cost in order to show the importance of involving these three terms in this project.

2.1.1 Reliability

Reliability is the probability that an item will perform a required function without failure under stated conditions for a stated period of time (10). Reliability is an important part of any good psychological test as it refers to the consistency of a measure. A test is considered reliable if the same result can be retrieve repeatedly. For example, if a test is designed to measure a trait such as introversion, the results should be approximately the same each time the test is administered to a subject. The test needs to include different types of measurement error because errors in measures play a key role in degrading reliability. Unfortunately, reliability cannot be exactly calculated but it can be estimated by using several different ways such as failure rate, mean time and probability of survival.

2.1.1.1 Measurement of Reliability

Numbers are frequently used without identifying the units it represents in the measurement of reliability. This is because the analyst almost certainly knows the measurement of the works is in inches, hours or square feet. However, numbers is a data where it is meaningless if it is alone. It must be associated with units or operation conditions to transform it to meaningful information.

The Exponential Failure Law is the probability distribution that can be used to determine the reliability of a component or a single system where the system is treated as if it were a single component. Exponential distributions can be used with both time-terminated and failure-terminated data. The time-terminated test will produce one parameter and the mean life or failure rate of the units while all the units involved in the test of failure-terminated tests are all tested to fail in order to get the reliability.

Probability of survival is one of the most important values in the reliability because represent the probability of zero failure. However, everything thing will fail with given enough of time. Therefore, the probability of survival (P_s or R) or its equivalent, the probability of zero failure (P_0), must associated with the time period. The sample size n in reliability is the time sample T while the fraction defective p is changed to the failure rate λ. Therefore, the equation of probability of zero failure had become $\boldsymbol{P_0 = P_s = R = e^{-\lambda T}}$ (1) where λ is the failure rate and T is the time period.

Failure is any event that impacts a system in a way that adversely affects the system criteria. For example, the criteria could include output in a sold-out condition, or maintenance cost or capital resources in a constrained budget cycle, environmental excursions or safety. Besides, failures may be due to errors, ambiguities, oversights or misinterpretation of the specification that the asset is supposed to satisfy, carelessness or incompetence in production, inadequate testing, incorrect or unexpected usage of the asset or other unforeseen problems (13). A failure definition should contain specific criteria and it can change on a given system over time.

Failure rate is defined as the number of failure per unit of time (minutes, hours, miles, actuations, and cycles) (11). The symbol of failure rate is λ which is the Greek letter lambda. The formula for failure rate is $\lambda = f / (\sum t)$ (1) where λ is the failure rate, f is the number of failures in a test, $\sum$ is the summation sign and t is the time to failure for a single unit. However, if it is a time-terminated test, the test will end before all units fail, and t will be the test period if it is a non-failed units.

Mean Life is variously known as m, $\overline{m}$, Mean Time Between Failures (MTBF) and Mean Time To Failure (MTTF). The formula for mean life is $\overline{m} = (\sum t)/f$ or $m = \overline{m}$ = **MTBF = MTFF = 1 / λ** (1) and the measure of mean life is in hours. The general symbol for mean life is m, $\overline{m}$ is the symbol for the mean of a test where actual sample data are available. MTBF is an acronym for mean time between failure and it is used for those units or systems where failures can be allowed and repairs are possible. MTBF can take the place of either the generic m or the sample $\overline{m}$, but it is usually used in connection with sample information. MTTF or Mean Time to First Failure (MTFF) is the terms that used interchangeably for those unit or systems where system where no failure can be tolerated and repairs are not possible.

Failure rate and mean time are just reciprocals of each other where mean life is the time per failure. For example, a failure rate of two failures per hour is a mean life of 1/0.02 = 50 hour per failure. Basically the formula for one is the formula for the other except the reciprocal relationship. This relationship comes out a formula which is $m = 1 / \lambda$ where m is mean and λ is the failure rate.

However, the determination of the total test time (∑t) may sometimes present a problem owing to the different type of tests used even the preceding basic formula is simple. There are four different types of test in the real life with different situation which are.

The first type of test is time-terminated tests where failures of the units are immediately repaired and the test will be continuing after the failure is being repaired. In this situation, the total test time, ∑t is the test period t times the sample size n. Therefore, the equation of the failure rate will become $\lambda = f / nt$ and the equation of mean life is $\overline{m} = nt / f$.

The second type of test is also a time-terminated test but the failure of the units are not repaired and replaced immediately. The failure time of the failure units are logged and the test time, ∑t is the sum of the failure times of the failure units plus the remaining units which refer to those units that did not fail during the test. The total will then times the test period in order to get the total test time, $\sum \boldsymbol{t_r} + (\boldsymbol{n} - \boldsymbol{f})\boldsymbol{t}$. Therefore, the equation of the failure rate is $\boldsymbol{\lambda = f / [\sum t_r + (n - f)t]}$ and the equation of mean life is $\bar{\boldsymbol{m}} = [\sum \boldsymbol{t_r} + (\boldsymbol{n} - \boldsymbol{f})\boldsymbol{t}] / \boldsymbol{f}$.

The third type of test is also time-terminated tests where the failures are not repaired and replaced but the failure time of the failed units are not logged. There are two assumptions can be made in order to determine the total test time for the failed units. The first assumption is that each unit failed exactly halfway through the test. The sum of the failure time in this case will become $\boldsymbol{ft / 2}$ and the total test time is $\boldsymbol{ft / 2 + (n - f) / t}$ (1). The second assumption is that an average number of units completed the test. The total test time of this case will become $\boldsymbol{t [n + (n - f)] / 2}$ (1).

The last type of test is different with the previous test as it is a failure terminated test. In this situation, all the units in the test are tested to failure. The total test time will be the summation of the failure test (∑t). Therefore, the failure rate equation will be $\boldsymbol{\lambda = f / \sum t}$ and the equation of mean life in this case is $\bar{\boldsymbol{m}} = \boldsymbol{\sum t / f}$.

From the information above, the failure rate, λ is equal to the reciprocal of the mean life where $\boldsymbol{\lambda = 1 / m}$, therefore the equation of another distribution equation which is Exponential Failure Law had become $\boldsymbol{R = e^{-T\bar{m}}}$ (1). T is the probability time sample and it is usually determined by the engineering requirements or management judgment. Besides that, the exponential failure law can be found from the Poisson tables by using the c = 0 column and equating $\boldsymbol{\lambda T}$ with $\boldsymbol{np}$ or by the use of a modern hand calculator. The Exponential Failure Law is the first term of the Poisson distribution where there is probability of no failures for a stated time. The probability of the system failing P_f can be get by summing all of the remaining terms, the equation will be $\boldsymbol{P_f = 1 - P_s}$ where the P_s is the probability of survive.

Besides that, IT assets include hardware and software. The hardware faults are mostly physical faults, while software faults are design faults which are harder to visualize, classify, detect, and correct (14). Design faults are closely related to fuzzy human factors and the design process. Design faults may also exist in hardware but physical faults are usually dominated.

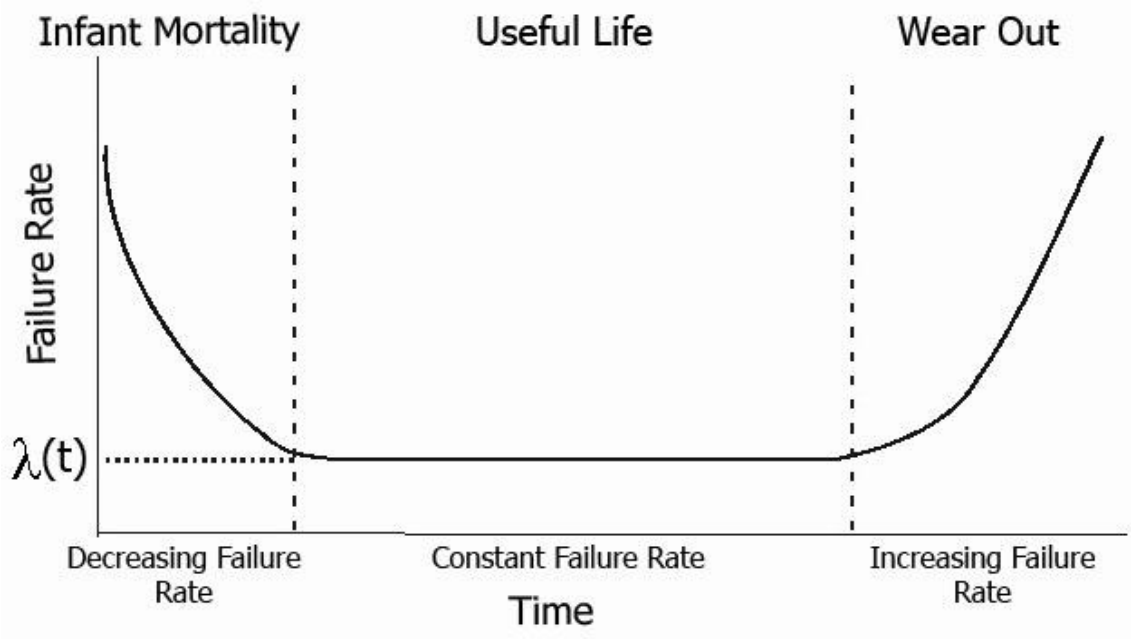

Figure 2.1 Bathtub Curve

The rate of hardware failures do not uniformly occur but it follows a distribution in time commonly described as a bathtub curve (15). The life of hardware can be divided into three regions which are Infant Mortality Period, Useful Life Period and Wear out Period. The failure rate is progressively improves in Infant Mortality Period. The failure rate remains constant in Useful Life Period and the failure rate begin to increase again in the Wear out Period.

Units that pass the Infant Mortality Period have a high probability of surviving the conditions provided by the system and its environment. Failures that occur during the Useful Life Period are residual defects surviving Infant Mortality, unpredictable system or environmental conditions, or premature Wear Out. The failures rate in Wear Out phase

are generally associated with such failure mechanisms as metal migration, hot electron effects, wire bond inter-metallic, or thermal fatigue. Typically, the Wear Out of a semiconductor occurs after many years or even decades, and outlives the lifespan of the system in which the component is used.

2.1.2 Utilization

Utilization is the ratio of actual output to the output that could be achieved if an asset ran at its maximum capacity for 365 days per year while producing 100 percent quality product (16). The purpose of this measurement is to measure the difference between what an asset is capable of producing and what it actually produces. The opportunity gap can be calculated with this data collected. The concept of asset utilization is often disguised behind terms such as uptime, maximum equipment uptime, minimum equipment downtime, and maximum equipment capacity.

At the most basic level, implementing an asset utilization program requires the capture of only two pieces of data which are the actual output and maximum capacity. With this information, it is then possible to calculate asset utilization and the opportunity gap.

Asset Utilization = (actual output / maximum capacity) *100

Figure 2.2 Equation to calculate the asset utilization (17)

Opportunity Gap = maximum capacity - actual output

Figure 2.3 Equation to calculate the opportunity gap (17)

However, the utilization that this project measure is the utilization of the IT assets such as the total usage time of a machine. This project will show the user whether the IT assets is fully utilize by using the total usage time of a machine divide by the total operation hour of an organization. Therefore, the equation of the utilization has been modified to suit this project which is *Computer Utilization = (Total Usage Time of Machine A / Total Operation Hour of an organization) * 100*. The equation of opportunity gap after modified would be *Total Operation Hour of an organization - Total usage time of a machine*.

Note that the operation hour of an organization and machine utilization hour is calculated differently. The utilization hour of a machine is being calculated based on the machine functional hours which mean this project will measure the functional hour of the machine once it was being turned on until it was being shut down by the user. For example, the total usage time of the computer will be 6 hours if the user turn on the computer at 9 o'clock in the morning and shut down the computer at 3 o'clock in the afternoon. While the total operation hours refer to the total hours of the organization operate. For example, the total operation hours of an organization will be 8 hours if the organization start their daily operation at 9 o'clock in the morning and end their operation at 5 o'clock in the evening.

In order for the information about asset utilization to be useful to multiple levels of an organization, it is necessary to provide the ability to summarize, or roll-up the data captured by the program to various levels. This need drives the requirement to create levels of measurement. The reason for this is that the level of detail required by a manager is different than say the level of detail needed by a reliability engineer who is challenged with solving the problem. The following examples illustrate the importance of utilization to improve the business performance of an organization.

2.1.2.1 Lost Profit Opportunity

Lost Profit Opportunity = total product lost * profit per unit or output

Figure 2.4 Equation to Calculate Lost Profit Opportunity

The information about asset utilization can use to calculate the lost profit opportunity of an organization for the past year. The magnitude of the lost profit opportunity defines the quantitatively and helps the senior management to make decision of their investment either on capital or resources. Failure in getting the correct information about the utility of an asset can lead to the unnecessary expenditure of capital. When a company is faced with the decision on allocating its capital budget for the next fiscal year, it would be valuable to understand where each of its assets stands with respect to the utilization.

Besides, it can also define the total amount that the senior management should consider to spend in their purchase. The senior management can read the information about the utilization about their assets before the purchase. Based on the information, the senior management can know the total quantity that they should purchase. This can reduce the unnecessary expenses on the investment.

2.1.2.2 The Standards of Assets

An asset utilization model that includes a discipline category can provide insight into the quality of equipment standards. All lost production due to equipment failure is allocated to an equipment category. There are two problems always exist which are the insufficient of resources to work on the things that need to get done and the insufficient of capital to do the work. An adequately designed asset utilization model may provide the cold hard facts of how much it is costing the company not to take action.

2.1.2.3 The Biggest Causes of Loss

An asset utilization model that includes a process or the level of measurement of a system can provide insight into the quality of a design process. The senior management can use the information about the asset utilization to discover the biggest opportunities that cause

the losses. By knowing the causes of the asset utilization losses in a business, the senior management should set the focus for reliability efforts. Maintenance and reliability professionals should be focused on eliminating opportunity gaps regardless of cause.

However, to develop an effective asset utilization program, it has to do more than just measure the difference between what an IT asset is capable of functioning and what it actually produces. An effective asset utilization program must include a process for documenting the level(s) at which losses occur and the cause(s) of the losses. Once documented, the causes for the losses can be charted based on the impact to the business, and reliability efforts focused on eliminating the cause(s).

Knowing where losses occurred is fine for reporting purposes but it is inadequate in helping to understand why the losses occurred. Understand the cause of the losses and identify solutions will prevent recurrence, requires an additional level of detail. The causes of loss represent the starting point for focusing reliability improvement efforts because they provide the means to help define the problem. Defining the problem is the first step involved in effective problem solving.

However, not all failed functioning incidents are caused by, or within the control of the organization. For this reason, every asset utilization model must include categories to which the losses caused by external sources can be allocated. The following are examples of the types of losses that can occur that may be beyond the control of the plant.

2.1.2.4 Resources Shortage

If the organization has to reduce the operation hours and the functional hours or even shut down due to resource shortage reason, then the opportunity gap would be allocated to the resource shortage category in the asset utilization model.

2.1.2.5 Sales Demand

Some organization may produce products whose the sales demand is seasonal. During the peak period, the business plan may require some selected department to run at maximum capacity in order to maximize the profitability. However, during the periods of off-peak demand, the business plan often requires some selected department to run at reduced capacity to reduce the expenses of the organization. In this situation, the under-utilization reason can be allocated to the sales demand category.

For example, the secondary or primary school may not operate for 365 days in a year as usually there will be around one to two months holidays every year. During the holidays, the teachers may not function their computer or any IT assets, thus this will show a decrease in the utilization level.

2.1.2.6 Acts of Nature

Tsunami, hurricane Alicia, tornadoes and other uncertainty art of nature will have the potential to affect the level of utilization. For example, some organizations along the gulf coast maintain their hurricane preparation plans that include temporary shutting down the operation when certain threshold criteria are met. And while the organizations in Malaysia do not necessarily to prepare to shut down the operation whenever there is an event of volcano eruption. From this example, conclusion can be made that geographic location of an organization a necessary to include to a category called acts of nature.

2.1.3 Return of Investment

Cost is the price per unit of a product or service which may also include the annual cost incurred on a continuous process. Operation cost is the expenses incurred every day when a business is running which includes sales and administration, as opposed to production. However, operating costs do not include the capital outlays or the costs incurred in design and implementation phases of a new process (2).

Cost should be kept tracked in every phases of the assets life cycle and it is one of the variables to be bundled in this IT resource monitoring system. This is because the project is proposed to show the users on the Return of Investment (ROI) where the equation of ROI involved the total cost of investment.

ROI = (Payback - initial investment) / investment * (100)

Figure 2.5 Equation for Calculate Return of Investment (3)

Return of Investment is the amount expressed in percentage where the steps to calculate it is using the revenue or the payback that earned by the organizations minus the initial amount that the organization had invested and the result will then divided by the total capital into earnings before interest, taxes, or dividends are paid. The result that gets after the division will need to times 100 as the final result will be shown in percentage.

Calculating the return on investment (ROI) in business is one of the most important calculations a business performs as it allows businesses to determine the amount of business received from investing a certain amount of money and resources (4). This information is important as it can show the how success is the investment made by the investor. For example, the investor of organization A had invested RM 100,000 in a new department to expand their business and increase the sales. The organization A received 50 orders from the department and it brought RM 500,000 profit to the organization. The result of ROI will be 400 percent after the ROI equation applied in this example.

2.1.4 Discussion about Reliability, Utilization and ROI

According to the information from the reliability section above, the probability of exponential distribution will used to measure the reliability of the IT assets in this project as it can be used with both time-terminated and failure terminated test. As discussed above, the time units must be used to guarantee the failure rate will be less than 1.0. Almost all reliability calculation is having a large time sample, T and the failure rate is relatively small. However, Exponential is able to implement it in most cases. The three formula of Exponential are $R = exp(-T / \bar{m})$, $T = \bar{m} \ln(1 / R)$ and $\bar{m} = T / \ln(1/R)$ (1) where R is the reliability, T is the time sample and $\bar{m}$ is the mean life of the units.

However, the failure rate and mean life of the units need to be determined in order to calculate the reliability because both the failure rate and mean time are used to calculate the probability of survival. Among four types of different test as discussed in the section 2.1.1, the third type of test will be the most suitable to be implemented in this project. The first type of test is not suitable for the project is because the failure of the units in this project will not be repaired immediately. The second type of test was found not really suitable to implement in this project as the failure time of the units in this test are logged. This test will be suitable to be implemented after the users are able to provide the log of the failure times. Besides that, the fourth type of test is failure-terminated test where all the units need to be tested to fail in order to get the failure rate. Fortunately, the third type of tests is able to generate the failure rate of the units as it does not require the log of the failure rate and the failed units does not need to be repaired immediately during the test. Therefore, the third type of test is the most suitable to be implemented in this project.

For the Utilization section, new equations had been created by modifying the original equation in order to suit it to the utilization measurement of this project. This is because the original equation is to calculate the utilization level of a production asset. This project is develop to measure the utilization of an IT asset such as the computer so that the senior management can know the utilization of the department and the organization since the utilization of computer in the department is indirectly show the utilization of the department. Besides, this information can helps the senior management to do better

decision in cost cutting if the senior management would like to cut some expenses to maximize the profit.

Besides calculate on the Return of Investment (ROI), this software is designed to allow user query on each components of the IT assets. Cost is an important variable because it can help the senior management in making decision before the purchase by referring the price for each component of IT assets.

After the discussion and the information from the section above, a conclusion can be made that reliability, utilization and cost are inter-related in order to show the users a clearer view on the investment and current situation of the IT assets that they owned in their organization.

2.2 Introduction on Existing Information Technology Asset Management System

Five technologies had included in the literature review report which are NetKiller IT Asset Management 4, ServiceDesk Plus 7.6, Total Network Inventory 1.6.8, Tivoli Asset Management For IT and ManageEngine AssetExplorer 5.5.

2.2.1 NetKiller IT Assets Management 4

NetKiller IT Asset Management, ITAM 4 (4) is the IT asset management service that consolidates computer hardware and software assets in real time to easily identify the users and the IT assets within the organization. This product is optimized for small and medium sized business and it allows the organization to resolve compliance issues and to optimize IT budget based on IT usage data. It ultimately assists users with the management of IT Asset Life Cycles such as Procure, Deploy, Manage, Retire of IT assets.

This product does not require any special hardware server and applications as its web based tool is a native application running on a cloud hosting platform based on force.com platform invented by salesforce.com. It can leads the organization to switch their existing on-premise IT infrastructures to the cloud based environments and easily integrates with other industry leading cloud services such as Salesforce.com for customer relationship management or Google Apps for email messaging systems. It works with familiar Salesforce environment to provide an easy access to both customer management and asset management applications at the same time.

Netkiller ITAM 4 does not leave any significant track on end user workstations such as computers to observe the real-time scanned data of computer specifications such as memory size of CPU, RAM, Hard disk, IP address, software publisher's license details, name of product, and versions. Based on the real-time scanned software license data, users can compare purchased software quantity and scanned results to analyze shortage and overuse. ITAM 4 is able audits all the hardware and software of the computer in an organization in real time because it is compatible with multiple operating systems from all versions of windows from XP to Linux/Unix workstations.

Besides, this product includes a feature which can help the organization to resolve the compliance issue. If the IT administrator found out any unlicensed software in the organization, the administrator can alert users to uninstall it by clicking the ‘unauthorized’ button on the screen. The organization can optimize the IT budget based on IT usage data.

It allows users to have a unique IT asset management service with agility by providing users to experience an on-demand web solution without additional infrastructure. Users can get a fully customized dashboard with an enhanced interface to view all of the IT asset status with a variety of graphic charts and able to generate custom reports for the company domain. Users can create IT infrastructure policy by generating their own policy rules.

2.2.2 Manage Engine Service Desk Plus 7.6

Manage Engine Service Desk Plus 7.6 manages all the helpdesk needs and communications such as email phone-call or any other mode-of-ticketing from a single point. It makes the helpdesk management complete by providing an integrated asset management and Information Technology Infrastructure Library good practices. It gives users a web based self-service portal to manage the tickets effectively where it can be easily accessed within the network using a browser.

Service Desk Plus is single installable bundled software and it does not require any external dependencies like client application web server or database to install the software. Users can get into production faster in a week time with its quick implementation cycle. It helps to manage the helpdesk across the globe with a single installation of Service Desk Plus and there are no separate modules in Service Desk Plus. All the features are functionalities are integrated within the product which reduces the deployment time considerably.

Service Desk provides users with an accurate inventory of all the hardware, software and complete life cycle tracking of the assets in the organization. The Cost Factors feature is to determine the various costs associated to each asset during its life cycle and maintain their total cost of ownership. Total cost of ownership is the life cycle cost view of an asset which includes acquisition, setup, support, ongoing maintenance, service and all operating expenses. It focuses attention on the sum of all costs of owning an asset, as opposed to the initial or vendor cost, and is useful in outsourcing decisions.

Besides, it will provide user a complete detail about the ownership and history for all assets. It displays user one view of all the IT assets, Non-IT assets, components and consumables. It will track the lease information of all the assets and notify the IT administrator about the lease expiry. The remote control features allow users to access the workstation in the organization. It will create a baseline group for all the assets based on different criteria and import the types of assets from the CSV files.

For the software tracking part, Service Desk can track different types of software such as managed, prohibited, shareware and freeware. It provides site based tracking of software

licenses and maintain software compliance for all managed software based on installations and purchased licenses. The software will notify the IT administrators on any compliance violation or installation of prohibited software after the scan. It will also send email to the users who are using the prohibited software and group all the software into major-minor versions for downgrading licenses propose.

It automatically scans and updates every asset and nodes with an IP address within the network. Service Desk Plus offers IT asset management and network inventory tracking functionality across both Windows and Linux workstations. It will also scan Mac machines and other network devices such as printers, switches and routers access point. It does not require any software to be installed at the client computer and device. It will scan all the assets across different sites and availability of the complete data in the central server. Users can schedule the scanning period. This software is able to identify and scans all new machines added in the network. It will maintain the history of all the software and hardware changes that happens in the network and notifies the IT administrators on any hardware or software change in the network.

Service Desk plus will generate a customized audit reports which will query all the report of every assets in either tabular or matrix form. It provides pre-built reports on all the assets and complete asset summary. The IT administrators can get reports on the machines that have not been scanned over a period of time and export the reports in PDF, CSV, XLS and HTML format.

2.2.3 Total Network Inventory 1.6.8

Total Network Inventory (6) is PC audit and network inventory software for office and large-scale enterprise networks. This software will get the information about the Operation System, service packs, hot fixes, hardware, software, running processes from all the IT assets within the network. The information will report back to the remote machine so that the network administrator can use the information gathered to generate reports about each IT asset on the network. This is an agent-free program which means it does not require any software to be installed on the remote machines.

This software will store the information gathered in the centralized database after it go through the scanning process on all remote assets. The screen will display the information such as computer names, registered users, organizations, workgroups or domains, IP-addresses, setup dates, and the time of the last scan. It adds clarity to the network inventory process by allowing the administrator to add extra inventory information about each machine and its respective user which includes user's real name, department, position, phone, e-mail, etc.

Total Network Inventory provides quick and unobtrusive navigation throughout the program. Users can find themselves immediately in that section of the program once they click on the desired button. It is very user friendly since the main window of the program is free from needless features. This software provides two scanning options which are Online Scan and Logon Script Scan.

Immediate Online Scan can be done though network place overview or IP range Scan. This scan type gives the IT administrators the possibility to make immediate online scan of computers that are connected to the network. The administrators are able either to select computers from network tree or define IP ranges.

The time needed for Logon Script Scan is short; it will scan computers every time the administrators log on to the domain. This scan type gives possibility to add a call to the standalone computer scan program to the users' domain logon script, so that the administrators will be able to collect information about each computer which is logging on to the domain by using the specified logon script. This scan type works for any

windows system which is connected to a domain provided that WMI service is installed. Users can select the method of computer discovery which can be either through a network places overview or by specifying a range of IP addresses to scan.

Total Network Inventory includes a Report Builder feature which allows user to generate reports about the information of the network machines in an easy to read and understandable manner. This feature not only allows users to generate a report on any topic such as the information about a network adapter, IP-addresses, MAC-addresses, DHCP, DNS, and WINS settings for any number of network devices, but users can also create brief reports on any combination of topics for any number of devices. Besides, Report builder offers a "Find" option that enables user to specify a text string to search through the report. It also offers users to scale a report to make it larger or smaller, print reports to paper for offline viewing and view the reports online.

Report builder can export reports to PDF, RTF, and XLSX format or directly to Excel, CSV, HTML, BMP, JPG, or TIFF for further analysis. Users can get an up-to-the-moment overview of all network machines and their content any time with the reports generated in Total Network Inventory.

2.2.4 Tivoli Asset Management for IT

IBM Tivoli Asset Management for IT (TAMIT) (1) provides an effective IT asset management solution to the organization to reduce costs and realize maximum benefit from the tracked assets. This product is able to capture, integrate, and maintain technical and financial information about IT assets from planning to procurement, deployment, and maintenance to end of life and disposal. It maximizes the utilization of property assets and reduces the ongoing support cost by providing an access to the service desk staffs to complete asset and configuration data for a user experiencing problems.

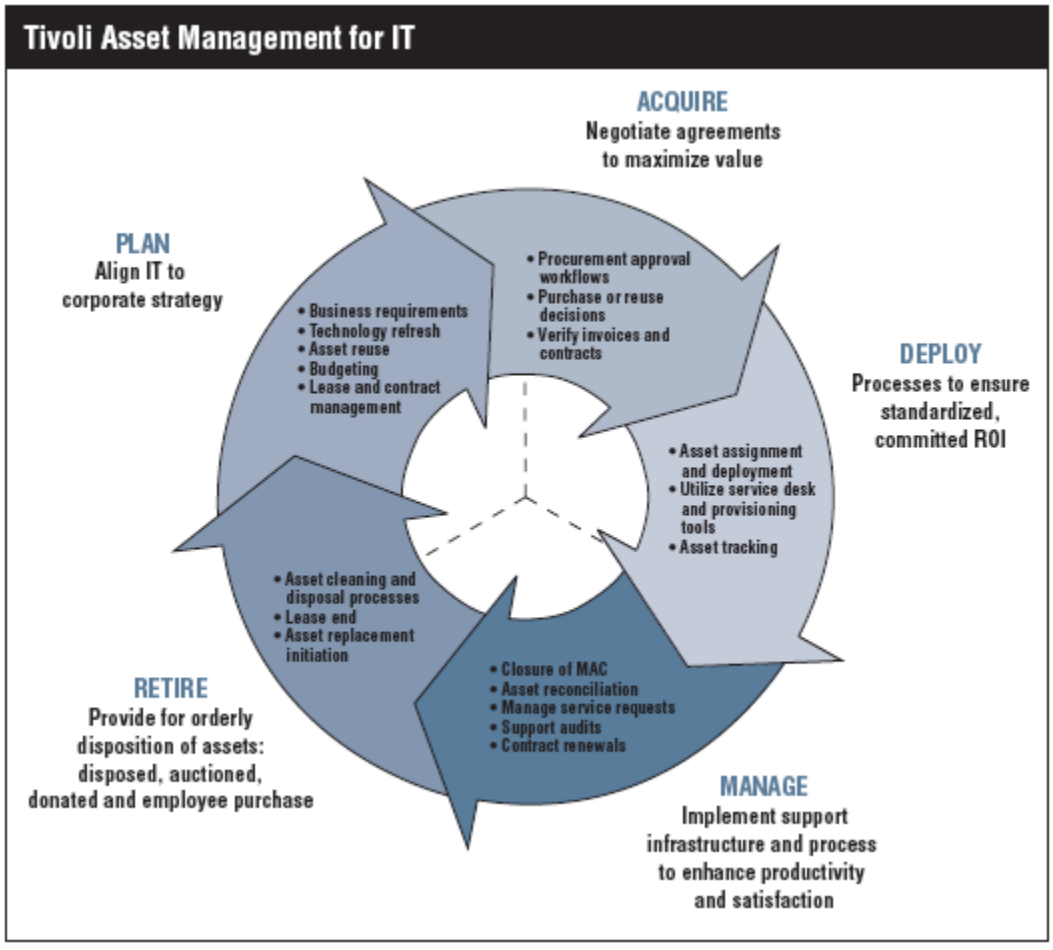

Figure 2.6 Organization Life Cycle Diagram

Tivoli Asset Management for IT manage assets carefully throughout every step of the life cycle which are planning, acquisition, deployment, management and retirement to help control costs, enhance planning and reduce waste.

It support IT budgeting and accounting cycles in the planning phase where it will align the IT budget with business asset requirements and determine appropriate hardware and software for new initiatives. It will also specify technology refresh cycles and dates, analyze and plan leases and terms. Assets will be reuse to return to inventory and determine asset reliability by leveraging service-desk data.

The acquire phase involve negotiate vendor agreements to maximize value; Tivoli will set approval workflows for asset requisitions, purchase requests and purchase orders. It redeploys underutilized assets and automatically reorder based on stock levels. It will validate the invoices after received the assets and it will link the order to contracts.

Deployment is the process to ensure standardize and committed Return of Investment. Tivoli will create a record, tag, assign and deploy for all assets automatically. It will keep track of the changes, movements and returns of every asset.

Management phase of the life cycle is the implementation of support infrastructure and process to enhance productivity and satisfaction. During this phase, Tivoli will perform asset reconciliations which will compare authorized versus deployed assets and record every moves, additions and changes such as lost and stolen assets. It will manage the service request against assets and display the cost of asset operation. It support internal and external audits and manage the warranty and contract renewals of the assets.

Tivoli in the retire phase will strategically plan and track end-of-life options in adherence with corporate and regulatory requirements. It will return users the leased assets and provides end-of-life data which need to be financed after it tracked asset cleaning and manage asset disposal, auction, and donation or employee purchases.

Besides that, Tivoli will also reduce the capital expense by avoiding stock-outs and over-provisioning or under-provisioning of license for software. This helps user to avoid from paying unused software licenses and assures the organization meets software audit

requirements. It will build a list of all software products once the user installs this software in the IT assets of the organization and data center. The list provides detail about each software instance which includes where the software installed, when it is used, how it is used and how much it is being used. This software able to control the internal allocation of the software and compile a report on each license with the costs associated.

Tivoli shortens the time needed to implement the user's unique processes as it provides a starting point to users. It also provides user the opportunity to identify, revise or eliminate outdated, redundant or unnecessary processes. This helps user to improve the visibility and understanding of existing processes.

Tivoli will help in lowering the administration and operational costs because it support automated work flows to process user request on new assets. It allows end-users to verify information and correct errors after they check the assets assigned to them. It implements a common set of procedures and policies which allows every department of an organization to communicate and shared access to data.

It support Virtual Machines in X86 and AIX environments. Virtualization has proliferated over the past several years. The feature discovers and distinguishes between the physical and virtualized servers in the datacenter. Many expect different licensing terms for physical and virtual infrastructure. This will simplify asset management when this happens.

2.2.5 Manage Engine Asset Explorer 5.5

Manage Engine Asset Explorer (8) is an asset management application that offers enterprise-wide asset visibility and control to manage all the IT and Non-IT assets. It offers a single view to track and manage ownership of all assets and helps users to create focused asset groups for better management by grouping assets into Static or dynamic groups which is based on asset properties and for ease of management. Static groups allow users to choose assets with different properties while dynamic groups help users to group asset based on specific criteria.

Asset Explorer scans the network and automatically discovers all software available in each of the workstations across the organization connected over LAN, WAN and VPN. It will scan all Windows workstations from Active Directory and discover Linux workstations and other IT assets such as printers, routers, and switches by using network scan. A report about the details of hardware and software which installed in all workstations can be generated for fine-grained control.

This software will assign assets to users and track them through the asset life cycle. It will track the ownership history and records all the changes of every asset. Users can have the Software Inventory reports and hardware inventory reports. Software Inventory report is about software installed in workstations across the network while hardware inventory reports is about the OS details, CPU details, network information, hard disk details and RAM slots workstations in the network.

Besides that, Software Asset Management groups licensed software which enables users to track the relationship between total numbers of actual installations software versus purchased software licenses to ensure software compliance. The Software License Metering helps users to track the frequency of the software being use so that users can make informed future purchase decisions. It will also inform the users about the renewal due dates of the software.

Audit Trail help users to keep a tab on important changes and the Network Audit History provide comprehensive workstations, hardware and software updates that happen every week. It can manage the software and track the prohibited software installations. Asset

Managers can easily ensure compliance by keeping a check on list of compliant, under and over licensed software. It offers a complete Purchasing system which helps users to manage and implement the complete purchase orders with approvals.

It will show a detailed hardware inventory reports about workstations in the network such as OS details, CPU details, network information, hard disk details, RAM slots. Software Inventory report details software installed in workstations across the network. It helps users group licensed software which enable users to track total number of actual installations versus purchased software licenses.

User can get a clear picture of the owner of the asset in the organization. Asset Explorer will assign assets to users and track them through the asset life cycle. The detailed asset ownership history helps track all previous owners and records all the changes in the asset. Asset Explorer's Auto-Assign helps user in assigning the workstations quickly and the most probable owners based on their login status. This helps user to eliminate manual workstation and owner association by over 80 percent.

Understand the business critical systems by defining asset relationship with software, business service, user and other asset components. Asset Explorer helps to maintain connection, usage or container relationship. It defines the business service or assets to which the asset is connected, the user of the asset, and the software which this asset contains.

Asset Explorer's Audit Trail help users to track everything that ever happens on the network and keep a tab on important changes such as software managed and prohibited software installations, hardware changes that happen every seven days. Detailed Audit reports collate information from discrete changes across the network and get deep insights. Detailed Workstation Audit History reports by changes and timeline helps users to navigate across disparate data and pinpoint a particular event or track Asset changes.

Asset Explorer helps to understand whether the expenditure has been within the limits of the budget defined. Define Purchase cost, Service cost, Moveable cost & disposal cost find out the amount that users have spent on that asset.

2.3 Discussion about Existing Software in Terms of Reliability, Utilization and Cost Information

Software / Information	Net Killer IT Asset Manage-ment 4	Manage Engine Service Desk Plus 7.6	Total Network Inventory 1.6.8	Tivoli Asset Management For IT	Manage Engine Asset Explorer 5.5
Reliability	No	No	No	Semi-Automated. Required service desk information.	No
Utilization	Yes (Software)	Yes (Software)	No	Yes(Software and Hardware)	Yes(Software and Hardware)
Cost	Yes (Software and Hardware)	Yes(Software and Hardware)	No	Yes(Software and Hardware)	Yes(Software and Hardware)

Table 2-0 Software Summarization for Reliability, Utilization and Cost Information

The main objective to develop this project is to deliver the information such as reliability, utilization and return of investment to the users, because these information can helps the senior management in making decision. Among five existing technologies that discussed above, none of the software is able to provide this information of the IT assets.

All the technologies above do not provide the reliability information to the users except Tivoli Asset Management for IT. The discussion in previous section had shown the importance of reliability information. For example, if the senior management would like purchase an IT assets, they may need to decide the brand that they can go for with assumption that the IT asset with brand A and brand B provided. With the information about reliability of the IT asset, the senior manager can have a clearer view on which brand of IT asset that they should go for. This can help to reduces the cost because the senior management can save the maintenance cost and cost to repair the IT asset if the IT asset is reliable that the others.

The reliability information that Tivoli provides is semi-automated as it require information from service help desk to determine the reliability of the IT assets. For

example, an organization is using Tivoli Asset Management for IT as their IT assets management system, if the senior management would like to know the reliability of an IT asset A, they need to gather the failure information about the IT assets to determine the reliability of the IT asset. Without the information from the service desk, the users may find it difficult to get the reliability information. The implementation of getting reliability information will become more effective and efficient if there is an automate sensor to gather the information of the IT assets.

Besides that, most of the existing technologies above provide the utilization information of the IT assets. Net Killer IT Asset Management 4 and Manage Engine Service Desk Plus 7.6 provide the utilization information of the software in the network while Tivoli Asset Management For IT and Manage Engine Asset Explorer 5.5 provide the utilization information of the hardware and software in the network. However, the utilization information that these software provided is not sufficient for users in doing their analysis on utilization. For example, Manage Engine Asset Explorer 5.5 will show the IT administrator about the total number of computers that the organization had purchased and the total number of computers that used by the users in their network. However, Asset Explorer cannot show the IT administrator the utilization level of the computer by showing the total usage hours of the computers.

All of the technologies above except Total Network Inventory 1.6.8 are able to provide the cost information of the IT asset to the users. However, displaying the cost information alone is not really useful because users may need to insert the equation manually after they got the cost information in order to get the total operation cost. For example, if the senior management of an organization wishes to know the total cost of investment that they had made on a selected department, they may need the IT administrator to get them the information. The IT administrator may need to perform at least 2 steps in order to get the information about the total cost of investment that the senior management had made on the selected department. The IT administrator may firstly need to get the cost of every single IT assets in the department by using the software above. Secondly, the user may need to manually sum up all the cost of the department before they can show that to the senior management for decision making.

2.4 Discussion about Implementation of Existing Software

Software / Features	Net Killer IT Asset Manage-ment 4	Manage Engine Service Desk Plus 7.6	Total Network Inventory 1.6.8	Tivoli Asset Management For IT	Manage Engine Asset Explorer 5.5
Report Customization	Yes	No	No	Yes	No
Hierarchy Reports	No	Yes	Yes	Yes	Yes
Scalability Interface	No	No	Yes	No	No
Dynamic Query	No	Yes (SQL query)	Yes	Yes	Yes(SQL query)
Format of Report Generation (Export)	xls	pdf, csv, xls and html	pdf, csv, xls and html, bmp, jpeg, tiff and gif	N/A	pdf, csv, xls and HTML
Web-based	Yes	Yes	No	No	Yes
Agent-Based / Agent-Free	Agent-Based	Agent-Free	Agent-Free	N/A	Agent-Based and Agent-Free
Centralized Control	Yes	Yes	Yes	Yes	Yes
Remote Assistant	Yes	Yes	Yes	N/A	Yes
Platform	Windows, Linux	Windows, Mac and Linux	Windows	Windows, Linux and UNIX	Windows and Linux

Table 2-1 Summarization of Implementations on Existing Software

The report customization refers to the ability of the technologies that allow users to build custom reports to analyze specific assets. Net Killer IT Asset Management 4 and Tivoli Asset Management for IT enable the users to change the dashboard of the report generated. For example, Net Killer IT Asset Management 4 provides real time view of different aspect of IT information. It creates a presentable chart and report that it can customize it based on the user's preference. Net Killer users are able to change the type of the report from pie chart to tabular form, line graph or matrix form.

Most of the technologies above present the information of IT assets in the network of the organization to the users in a hierarchal way expect Net Killer IT Asset Management 4. Visual hierarchy is the visual cues of the IT assets based on importance to help the IT administrator or the users of the resource monitoring portal process the information or manage the IT assets. A comprehensive user interface of the resource monitoring portal should include the visual hierarchy of the IT assets because visual hierarchy can act like a map which will helps the users view and process the information or the IT assets based on the categories.

The visual hierarchy of the resource monitoring portal can ensure the users or the IT administrator to reach every webpage from at least one static link in order to get the information about the IT assets.

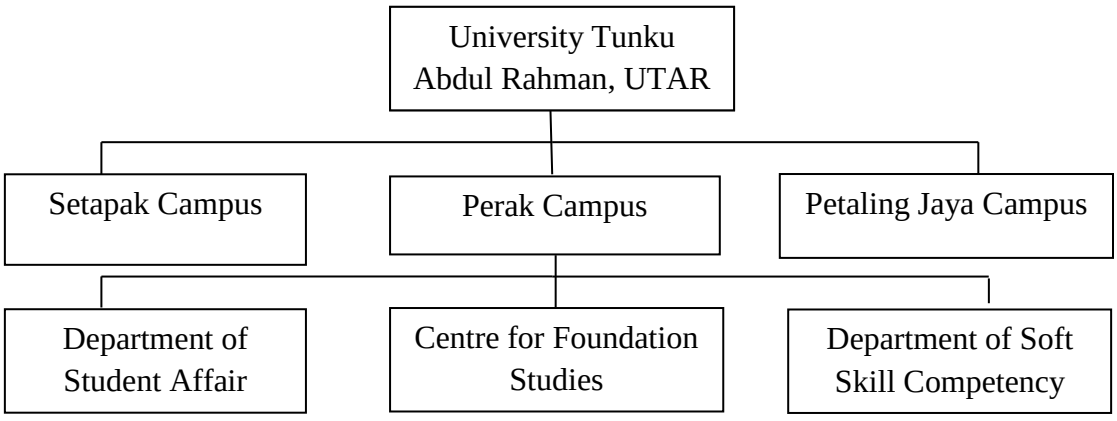

Figure 2.7 Hierarchy diagram of UTAR organization

The diagram above shows the campuses and departments of UTAR organization in a hierarchy view. The portal with the visual hierarchy features will show the sequence with

Perak Campus → Department of Student Affair if the users or the IT administrator of UTAR would like to view the IT assets or information of the department of student affair in the Perak campus. This will makes the users work become easier as the users can just click on the Perak Campus link on the resource monitoring portal and follow by clicking the Department of Student Affair rather than searching for the information of the department of student affair manually.

The term scalability refers to the ability of software in providing a better visualization of report generated. The scalability feature provides detail and simple interface to users. All the software above provides dynamic features to the users except Net Killer IT Asset Management 4. Dynamic query feature provides flexibility for users to query the information about the IT assets of the organization. The software with this feature can gain competitive advantages as it is able to generate the report of the IT assets based on the condition and situation that set by the users. However, the dynamic query feature of Total Network Inventory 1.6.8 and Tivoli Asset Management for IT is not sufficient. This is because both of the software only enables their users to query the IT assets without the specific conditions. For example, Tivoli and Total Network Inventory will only show the total units of computers in a department A but both of the software cannot show the users the total units of computers in department A with the brand name DELL. This can be done by Manage Engine Service Desk Plus 7.6 and Manage Engine Asset Explorer 5.5 as both of the software allows their users to generate the report of the IT assets in the any department of their organization by using the SQL query.

Most of the existing software enables their users to export the report. Users can export the report into different document format or images type to view it offline. Net Killer IT Asset Management 4 allows users to export the report to XLS format; Manage Engine Service Desk Plus 7.6 and Manage Engine Asset Explorer 5.5 allows their users to export the report to PDF, CSV, XLS and HTML format and the Total Network Inventory 1.6.8 enable their users to export the report not only in different document type such as PDF, CSV, XLS and HTML format but it also enable the users to export the report to different images type such as JPEG, bmp, TIFF and GIF.

Net Killer IT Asset Management 4, Manage Engine Service Desk Plus 7.6 and Manage Engine Asset Explorer 5.5 are web-based software while Total Network Inventory 1.6.8 and Tivoli Asset Management For IT are application based software. Web-based software is a specific and relatively new class of software where all software components will reside on a web server. Web-based software will be more convenience than the application based software because the users can access to the web based software application through a web-browser and the web based software is only needs to be installed on one web server machine. Users can gain quick and timely access to a wider variety of existing information, anytime, and from anywhere in the world as long as there is an internet access.

Net Killer IT Asset Management 4 implement agent-based model in its software; Manage Engine Service Desk Plus 7.6 and Total Network Inventory 1.6.8 are implementing agent-less model while Manage Engine Asset Explorer 5.5 is more advance which is implement both agent-less and agent-based model.

All technologies above include the centralized control implementation in their software. Central control is usually implemented with client and server model where the server as the central and it is able to store and handle all IT information; and perform task requested by its client through network connection to it. Synchronization are achieved easier by implementing centralized control environment because all changes, requests, and services are done in centralize server. It helps to maintain the integrity of information preserved, provide precise and correct services and also reduce the cost of maintenance. By implementing centralized control, users are able to configure and manage their IT assets from any of the configuration screen in the network easily.

Remote control is to provide convenience to the authorize person to control the system. All the existing technologies had included this feature in their software. Besides that, all the technologies above are designed for the Windows users. However, Net Killer IT Asset Management 4, Manage Engine Service Desk Plus 7.6, Tivoli Asset Management For IT and Manage Engine Asset Explorer 5.5 are also designed for Linux OS.

3 Methodology

There are several things that were needed before this project was going to be implemented. Research methodology, risk identification and assessment, development tools and project planning need to be prepared before this project was going to be started. Research methodology was needed in order to make sure that the project would be developed in an appropriate method. Development tools were needed in order to develop the project. Implementation Issues and challenges are important for this project in order to identify and prevent problems that might occur through the development process. The solution need to be identified as it can encounter the problem whenever it occurs. Project planning is one of the important parts in developing this project to manage the project through the available time. Therefore, the progress of the project would undergo accordingly and the project could finish on or before the end of time available. Chapter 3 contains of methodology of this project, development tools being used for this project, project planning, and also implementation issues and challenges that might occur through the development process.

3.1 Project Methodology and Development Process

The prototyping approach under Rapid Application Development (RAD) methodology is chosen as the methodology to develop this project. RAD is a software methodology that involves iterative development and quick construction of prototypes. James Martin comments in his book that the RAD is a development lifecycle designed to accelerate the project development and provides a higher quality results than those achieved with the traditional lifecycle. It is designed to take the maximum advantage of powerful development software that has evolved recently (1).

Professor Clifford Kettemborough of Whitehead College, University of Redlands, defines Rapid Application Development as an approach to build a computer system with the combinations of techniques, user-driven prototyping, and stringent project delivery time limits into a potent, tested, reliable formula for top-notch quality and productivity. Besides, RAD can drastically raise the quality of finished systems while reducing the time and costs it takes to build them (1).

Prototyping is an iterative software development process. In this methodology, the requirements determined will be quickly converted into a working system. The phase in the prototyping methodology, planning, prototype analysis, prototype design, prototype implementation, prototype testing and full system implementation, will be continuously revise until the user's requirements are met. It involves close collaboration between the users and developer.

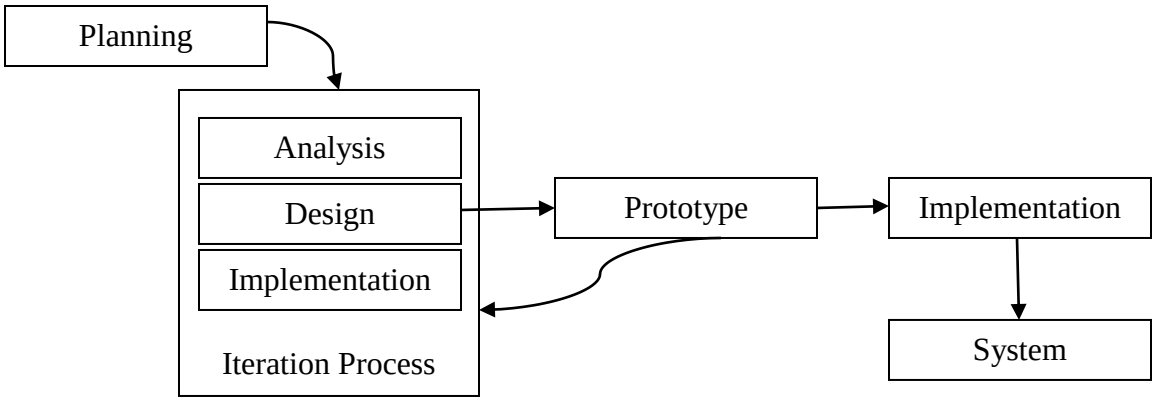

Figure 3.0 Prototyping

The first phase will be the system planning. After that, it will proceed to system analysis, design and prototype implementation. The prototype developed will be tested until the requirements are met. Here, the phases analysis, design and prototype implementation will be on revising until refinement is occur. Once the system prototype is agreed by the user, developer will move to the system full implementation phase. The final steps of the methodology would deliver a complete system.

3.1.1 Planning

Planning is an important stage as a good planning will bring good impact to the project. In this stage, the developer needs to decide the requirements of the project which includes a set of functionalities and constraints that expects from the system which fit the objective of the project. Basic analysis and research in the field of the project should be done in order to get the requirements as this can helps to understand the problem of existing technology. The objective of the project is defined based on the problems that had been identified. All the information related to this project are collected and reviewed to get a clear understanding on how the project is going to be developed. This can helps in defining the scope and timeline of the project. The project planning works such as introduction, problem statement, objective and the scope of the project was completed and it stated clearly in the chapter one of this project.

3.1.2 Analysis

Analysis can be done by comparing and reviewing the existing technologies and software from the same field in the market. The knowledge area of the proposed system has been investigated and studied as shown in chapter two. It includes the reviews on the implementations and application of the three variables which are reliability, cost and utilization in the existing technologies. Besides that, analysis should be done on the interface of each existing technologies and gather every useful features of the existing systems and applied it on the proposed project. In this phase, studies and analysis had been done on existing business and similar system. The IT assets management systems chosen to be analyzed are NetKiller IT Assets Management 4, Manage Engine Service Desk plus 7.6, Total Network Inventory 1.6.8, Tivoli Asset Management for IT and Manage Engine Asset Explorer 5.5. Features that integrated in these systems are listed and compare among systems. From the research done, it will be analyzed and compiled those information that are usable for Dynamic Resource Monitoring System.

3.1.3 Design

Initial system architecture is developed after the studies and reviewed on the existing technologies. The flow of the software development will be defined based on the objectives of the project. The requirements documents from the project planning will be transform into the design specification for the new system. This includes the range from a simple confirmation of existing features to a complex design document. Normally, it will starts by outlining system, data and reporting standards. Since the project is proposed so that three variables which are reliability, cost and utilization of the IT assets can be applied to enhance the IT assets monitoring system. Therefore, the design of the database, web interface designs and system configuration details will also be included in the detailed design documentation. Besides that, the algorithms that will be used in developing the software will also be defined.

In this phase, Entity Relationship Diagram (ERD) and database design will be illustrated based on the analysis phase. The output of this stage is able to describe this system as a collection of modules. Other than diagram illustration, this phase also include illustration of screen layouts and user interface. As mentioned in the objective section of this project, the user interface design plays an important role in system design phase.

There will be two major focuses on the user interface of this project where the first focus would be the ability for the interface of the software to be customized to different format. For example, the users are able to customize the type of the reports generated from pie chart to bar graph. The purpose of doing that is to reduce the complexity and provides a clear interface to the users. The second focus would be providing a visual hierarchy for the IT assets in the networking. This will provides the users with a structure interface and this can help the users to reach the information by few clicks.

3.1.4 Implementation

The system will start to be developed based on the design. Therefore, the database will be built in order to store the data that captured by the sensor. Database is needed to retrieve the data so that it can be visualized to the users with a comprehensive user interface. Coding is the major activity ongoing in this phase. The system design will be converted into basic system, system prototype with main features and functionalities included. After the coding process, it will move to another phase which is system prototype. There, the system prototype will be tested. Development tools such as Visual Web Developer 2010 Express and Microsoft SQL Server 2008 R2 are used in developing the system.

3.1.5 Prototype

Users and developer will together evaluate and test the system prototype built which meet the user requirements needs on basic functionalities and features. The prototype of Dynamic Resource Monitoring System created is closer match to the complete version. The user here can be the project supervisor and the developer will build the prototype according to the requirements of the supervisor, refine the system prototype until it fulfills all the user requirements.

After the prototype is built, the features will be tested to ensure the software works as expected and to determine the quality of the software. The testing phase is also meant to look for some bugs while the program is being used. If there are any unexpected events or bugs while the software is being executed, the software will be fixed. From the result of program testing, improve the performance by eliminate the weaknesses and debugging the program to ensure the stability. The phase of analysis, design and implementation in the project would be revised from time to time as the iterative concept is applied. Iterative process would be required throughout the stages so that the developers can learn through the trails and errors that would be occurred during the process.

3.2 Development Tools

Hardware and software is a basic specification for a system development. Without either one of the specification, the system could not be developed. Hardware needed to be specific in order to ensure the chosen hardware is able to support the system development

3.2.1 Hardware

Computer or notebook with any Windows Operating System installed is needed to develop this project. Since the project is to develop the interface of the web-based software, therefore one computer or laptop is enough to develop this project. The computer specification does not need to be outstanding; a standard computer specification will be able to do the development process. However, the table below shows the laptop that will be used during the development.

Processor	Intel(R) Core(TM)2 Duo CPU T6400 @2.00GHz
Memory	4.00 GB
Primary Storage	250GB
Display Resolution	1280 x 800
Wireless Modem Router	Aztech 605EW

Table 3-0 Computer Hardware Specification

3.2.2 Software

Software is needed to be specified in order to fulfill the system development too. All these software chosen is to carry out the system development all along the project timeline and depending on the task needed to be done.

Category	Software	Functionality
Development tools	Visual Web Developer 2010 Express	Web Editor
	Microsoft SQL Server 2008 R2	Database Server
Operating System	Windows 7 professional	Computer Platform
Application	Google Chrome 10	Browser
	Mozilla Firefox 4	
	Internet Explorer 8	
Documentation	Microsoft Word 2010	Proposal Documentation
	Microsoft Power Point 2010	Presentation Slide
	Microsoft Visio 2010	UML Diagram

Table 3-1 Software specification

3.3 Implementation Issues and Challenges

Difficulties and challenges are to be found during implementation of this project. Solving difficulties before the deadline of this project is a must. There are several risks that are the issues of this project and expected will occur throughout the developing process of this project. Some challenges are predicted to occur during the development process as well. This section identifies issues and challenges that will likely to occur in this project, and also several actions that can be done to manage them.

3.3.1 Time Constraint

Time is the foremost leading factor any tasks or projects. Results must be produced before meeting deadline. Time management is crucial for developing a software program from scratch. There is not much time given in order to complete this project. Time is needed in doing research, survey and study on the relevant field so that the knowledge can help in developing a workable project. Massive of time is usually needed to write and debug the new written software and the programming language that will use to develop this project is totally new for the developer. Even though the schedule of this project has been created and it seems that the project will finish within the time given, it does not guarantee that the developing process will follow the schedule nicely. There are some difficulties that might appear which will delay certain tasks while developing this project. There are certain tasks that are dependent to another task, means the next task can only be done if and only if previous task is done. So when one task is delayed, it will cause the next task to wait for the completion of the previous task. Hence, solution is always needed so that the problem can be handled.

3.3.1.1 Possible Solutions

This risk can be avoid only if the entire tasks can be done according to or earlier than the schedule of this project. Time management also will help the progress of this project to go well by fully utilize the available time throughout the developing process. Fortunately, there will be three month holidays from October 2010 to December 2010. Tutorial on the programming language can be found easily from the internet or books. Therefore, Research and studies can be done on the programming language during the holidays.

3.3.2 Knowledge and Experience

Complexity of algorithm is the biggest challenge of this project. Knowledge and experience has become a risk in doing this project. The programming language that will be used in this project is C#. The implementation knowledge on the software is a must in order to develop the project. Without the implementation knowledge, the progress of the project will be affected and this will drag back the progress of the overall schedule. Experience is another major factor in developing the software. With experience, the project can be done with efficient and effective as the problem that may face in the development phase can be solve in a short period of time.

3.3.2.1 Possible Solutions

In order to overcome this challenge, developer will take time as fast as possible to enhance the knowledge and understanding in the area of this project and all the necessities that are needed to develop this project. Consultation and asking help also will be done from those who are experienced in this project field. Computer science or information technology undergraduate or postgraduate student majoring in computer or information security will be asked for help. Consultation with Mr. Alex Ooi Boon Yaik who is the supervisor of this project would be another solution as he has knowledge and experience in this project field. Developer does not limit the guidance from academic field only. Consultation from those people who are in the same field with this project will be very helpful too.

3.3.3 Software Failure

Software failure is one of the issues that might occur during the developing process. The software that fails during the process can be Operating System of the computer, compiler, and also the GUI application developer. There is no way to avoid this issue to occur, but there are ways to encounter it.

3.3.3.1 Possible Solutions

The backup is needed in order to save the program that is being developed from being loss and this practice must be performed as frequent as possible because this issue is unpredictable. The operating system needs to re-install if the Operating system fail or corrupted. Same goes to the compiler and GUI application developer, when both of these software fail, re-install is the best way to solve the issue.

3.4 Project Timeline

Project planning is one of the important roles for this project. Scheduling the progress in developing a project is a crucial factor in ensuring the accomplishment of a project within the given deadline. With a good planning, hopefully the project can be developed accordingly and follow the flow of how it is supposed to be. If a project is not progressing as it should, action must be taken to ensure the project is a success. This section shows the timeline of this project as well as the explanation of it.

3.4.1 Project Timeliness for Project One

There are total twelve available weeks to complete the project 1 which includes the first three chapters of the project thesis.

ID	Task Name	Start	Finish	Duration
1	Data Gathering & Choosing Topic	5/31/2010	6/4/2010	5d
2	Topic Selection	6/7/2010	6/11/2010	5d
3	Study & Research	6/9/2010	6/17/2010	7d
4	Define problem statement, project objectives, scope and contribution	6/18/2010	7/2/2010	11d
5	Literature Review	6/30/2010	7/30/2010	23d
6	Project methodology, development tools and planning	8/2/2010	8/13/2010	10d
7	Project finalization and submitting the proposal	8/13/2010	8/16/2010	2d
8	Presentation Preparation	8/17/2010	8/19/2010	3d
9	Proposal Presentation	8/20/2010	8/20/2010	1d

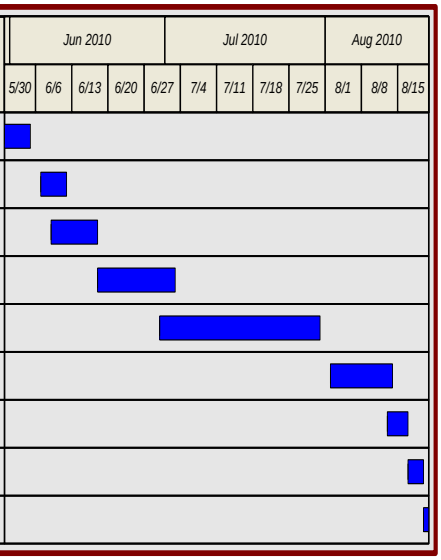

Figure 3.1 Gantt chart for Final Year Project I

The Gantt chart above shows the timeline used for writing documentation of proposal and literature review for methodologies used. Due to the simplicity of the Gantt chart, a table of explanation based on task completed is shown below.

No	Task	Description
1	Data gathering	All information about final year project from all lecturers was considered and finding related information for candidate of project.
2	Supervisor and Topic selection	Select topic title and go for the supervisor who has strong knowledge background in the field of this Project.
3	Study and research	Research on the field which related to topic to identify the problem statement, objective of this project.
4	Project Planning and documentation	Create the project plan and schedule a timeline for project development. Documentation of the project will be start all along the research.
5	Define problem statement, project objectives, scope and contribution	Clearly defined the problem statements after the research on existing technologies. Explain the objectives of the project based on the problem statement. Define the project scope which describes what will be delivered at the end of project. Describe the contribution of this project. All information in this task explains why this project is proposed. Chapter one completed within this duration.
6	Finalization on chapter one	Finalize every subtopic in chapter one and includes the technologies involved section as the preliminary report need to be submitted. Includes conclusion for the chapter one.
7	Literature review	Review related projects and practices as the consideration and comparison to this project. Study on the development tools which will be used to develop the software. Identify the calculation of the three variables in this project. All the reviewed information is elaborated in Chapter two of this project which is literature review.
8	Project methodology, development tools and risk assessment	Researches on information related to methodology and select the appropriate methodology to be applied into this project base on the Literature Review. Specify difficulties and challenges that may face or faced during the development phase and specific solutions to encounter it. Start the project planning for the project two and finalize the project planning for project one. Chapter three completed within this duration.

9	Project finalization and project submission	Makes appropriate changes to the documentation. Finalize everything of the project which including checking on the contents, list of tables, list of figures, references, page margins and page number of project proposal according to the requirements stated before submit it to the FGO office.
10	Preparation for proposal presentation	Prepare for the project presentation.
11	Proposal presentation	Present proposal to supervisor and moderator.

Table 3-2 Documentation of Proposal Tasks Explanation

3.4.2 Project Timeliness for Project two

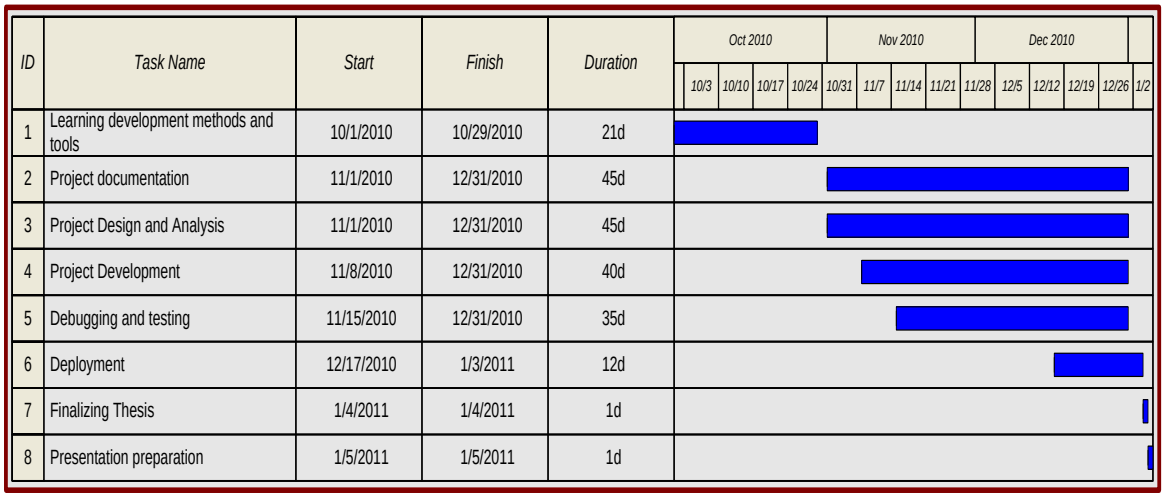

Figure 3.2 Gantt chart for Final Year Project II

The Gantt chart above shows the tasks scheduled for project development. The timeline for project 2 includes the three months semester break. The explanation for tasks is shown in the next table. If there are no difficulties encountered in this project, the project will be finalized according to the timeline.

No	Task	Description
1	Learning development methods and tools	Familiarize with the developments tools and understand the methods used for this project. Enhance the knowledge from books and online tutorial or material so that workable software can be developed.
2	Project documentation	Documentation will be started from the beginning until the end of the project.
2	Project Design and Analysis	Design the skeleton of the program to have an idea on the function and ability of the software to fulfill the basic requirements of the project. The design phase will be more focus on the interface of the project. Analyze every available equation to make sure it is suitable for different case and situation. Discussion with the supervisor may be needed.
3	Project Development	Write all algorithms that need to develop the software. Start the development process based on written algorithm.
4	Debugging and testing	Test the final result of the program and make sure the program achieves the objectives of the project. Solve problems in existing configuration.
5	Deployment	Integration between the finished system and the sensor and database to finalize the complete system.
6	Finalizing Thesis	Perform finishing touches to the project and thesis documentation.
7	Presentation preparation	Prepare for the presentation about the demonstration part.

Table 3-3 Documentation of Proposal Tasks Explanation

4.0 System Design

The purpose of this chapter is to plan a solution of the problem specified. The design of a system plays an important role because it is the most critical factor affecting the quality of the software (1). Besides, it has a major impact on the testing and maintenance phase. System design aims to identify the modules that the system should have, the specifications of modules, and the interaction to produce the desired results.

4.1 Use Case Diagram

A use case diagram in the Unified Modeling Language, UML is a type of behavioral diagram defined by and created from a Use case analysis. It provides a high-level graphical view of the functionality supported by the system. It is a diagram that shows the relationship or dependencies between actors and its goals within a system by showing which roles can invoke each use case.

Use case diagrams are often used to provide an overview of all or part of the usage requirements for a system or organization in the form of an essential model or a business model. It will map out the scope of a development project and model the analysis of requirements in the form of a system use case model. This high-level view of the system provides a context for the readers of the more detailed use case specifications.

There are usually three components in a use case diagram which are actors, use case and system boundary box. Actor is a person, organization, or external system that plays a role in one or more interactions with the system. Actors are drawn as stick figures. A use cases usually drawn as a horizontal ellipse; it describes a sequence of actions that provide something of measurable value to an actor.

Associations between actors and use cases are indicated in use case diagrams by solid lines. An association exists whenever an actor is involved with an interaction described by a use case. Associations are modeled as lines connecting use cases and actors to one another, with an optional arrowhead on one end of the line. The arrowhead is often used to indicate the primary actor within the use case.

System boundary boxes is a rectangle box around the use cases which indicates the scope of the system. The functionality of a system is everything inside the system boundary box.

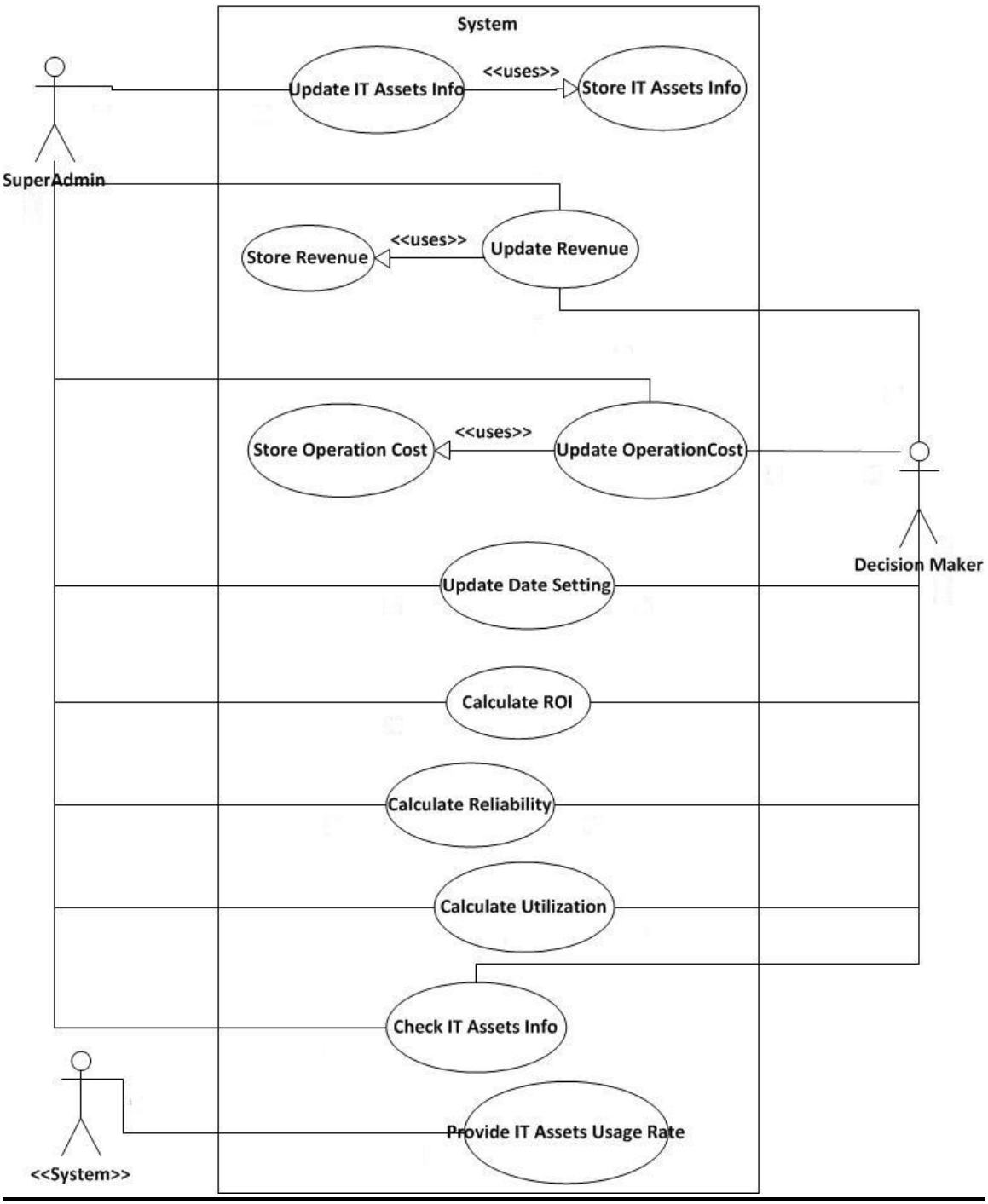

Figure 4.1 Use Case Diagram of Dynamic Resource Monitoring System

In Dynamic Resource Monitoring Portal, three users had been identified. Super Admin can be system developer and IT administrators. Decision maker is referring the senior management or the person who will make decision on the investment or purchase. Super admin can access or perform all the action that decision maker can perform such as update the total revenue and operation cost of a faculty, calculate the Return of Investment, reliability and utilization. Super admin can update the IT assets information which is an action that decision maker cannot perform. System is the last actor in the use case diagram; it is a sensor detection system which will keep track the status of the computer and update the database if the computer is in active or on mode.

4.2 Database Design

The database of Dynamic Resource Monitoring System is developed using Microsoft SQL Server 2008 R2. The database will store the data provided by the users and sensor. This section will show the design of the database by Entity Relationship Diagram and data dictionary of the database. Entity Relation Diagram is a high level data model that includes all major entities and relationships. Data dictionary contains information about the attribute used in each table.

4.2.1 Entity Relationship Diagram

Entity Relationship Diagram (ERD) is a specialized graphic that illustrates the interrelationships between entities in a database. ERDs often use symbols to represent three different types of information. Normally, boxes are used to represent entities, diamonds are commonly used to represent relationships and ovals are used to represent attributes. It is a data modeling technique that creates a graphical representation of the entities and the relationships between entities of a database.

There are three main components of an ERD which are entity, attributes and relationships. Entities are things about needed information; it can be a person, object, place or event for which data is collected. Attributes are the collected date about the entities. The relationship is the interaction between the entities. Relationships provide the structure needed to draw information from multiple entities. There will be cardinality for each relationship which will define the relationship between the entities in terms of numbers.

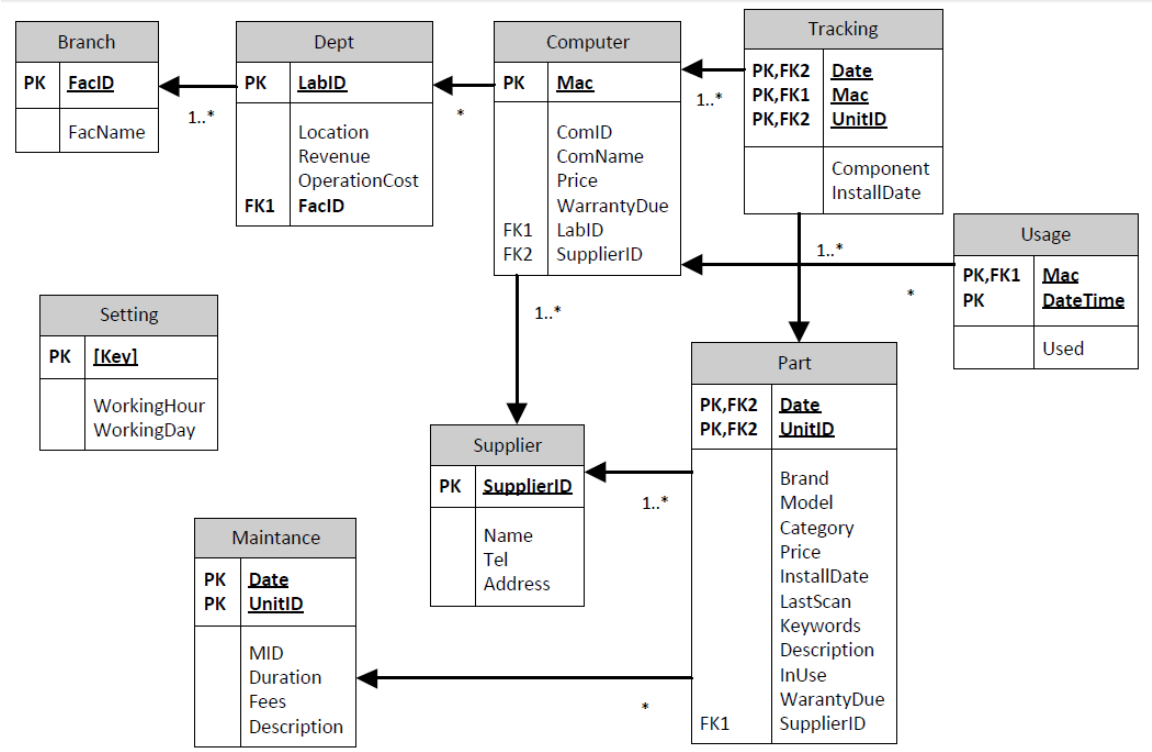

Figure 4.2 Entity Relationship Diagram

Figure 4.1 illustrates the Entity Relationship Diagram for Dynamic Resource Monitoring System. There are total nine tables had been identified in this project boundary which is branch table, *dept* table, computer table, tracking table, part table, usage table, supplier table, *maintance* table and setting table.

4.2.2 Data Dictionary

Data dictionary is a term for information that describes the data that will be held in a database. It is an integral part of a database, which holds information about the database and the data that it stores. Data dictionary provides database administrators and other user an easy access to the type of data that they should expect to see in every table and view of the database without actually accessing the database. It is a simple yet effective add on to ensure data consistency.

Column Name	Data Type	Size	Column Status
FacID	Varchar	10	PK, Not Allow Nulls
FacName	Varchar	100	Allow Nulls

Table 4.1 Data Dictionary of Branch Table

Column Name	Data Type	Size	Column Status
LabID	Date	10	PK, Not Allow Nulls
Location	Varchar	10	Allow Nulls
Revenue	Money	8	Not Allow Nulls
OperationCost	Money	8	Not Allow Nulls
FacID	Varchar	10	Not Allow Nulls

Table 4.2 Data Dictionary of Dept Table

Column Name	Data Type	Size	Column Status
Mac	Varchar	17	PK, Not Allow Nulls
LabID	Varchar	10	Allow Nulls
ComID	Varchar	10	Allow Nulls
ComName	Varchar	25	Allow Nulls
Price	Money	8	Not Allow Nulls
SupplierID	Varchar	10	Not Allow Nulls
WarrantyDue	Date	3	Allow Nulls

Table 4.3 Data Dictionary of Computer Table

Column Name	Data Type	Size	Column Status
UnitID	Varchar	10	PK, Not Allow Nulls
Mac	Varchar	17	PK, Not Allow Nulls
Component	Int	20	Not Allow Nulls
InstallDate	DateTime	8	Allow Nulls

Table 4.4 Data Dictionary of Tracking Table

Column Name	Data Type	Size	Column Status
UnitID	Int	4	PK, Not Allow Nulls
Brand	Int	4	Not Allow Nulls
Model	Int	4	Not Allow Nulls
Category	Int	4	Not Allow Nulls
Price	Money	8	Not Allow Nulls
SupplierID	Varchar	10	Not Allow Nulls
InstallDate	DateTime	8	Not Allow Nulls
LastScan	DateTime	8	Not Allow Nulls
Keywords	Varchar	500	Not Allow Nulls
Description	Varchar	500	Allow Nulls
InUse	Char	1	Not Allow Nulls
WarrantyDue	Date	3	Allow Nulls

Table 4.5 Data Dictionary of Part Table

Column Name	Data Type	Size	Column Status
Date	Date	3	PK, Not Allow Nulls
UnitID	Varchar	10	PK, Not Allow Nulls
MID	Varchar	10	Not Allow Nulls
Duration	Int	4	Allow Nulls
Fees	Money	8	Not Allow Nulls
Description	Varchar	200	Allow Nulls

Table 4.6 Data Dictionary of Maintance Table

Column Name	Data Type	Size	Column Status
SupplierID	Varchar	10	PK, Not Allow Nulls
Name	Varchar	30	Allow Nulls
Tel	Varchar	10	Allow Nulls
Address	Varchar	200	Allow Nulls

Table 4.7 Data Dictionary of Supplier Table

Column Name	Data Type	Size	Column Status
Mac	Varchar	17	PK, Not Allow Nulls
DateTime	DateTime	8	PK, Not Allow Nulls
Used	Int	4	Not Allow Nulls

Table 4.8 Data Dictionary of Usage Table

Column Name	Data Type	Size	Column Status
[Key]	Int	4	PK, Not Allow Nulls
WorkingHour	Int	4	Not Allow Nulls
WorkingDay	Int	4	Not Allow Nulls

Table 4.9 Data Dictionary of Setting Table

Column	Alias	Table	Group By	Filter
FacID	-	Branch	Group By	-
LabID	-	Dept	Group By	-
Mac	-	Computer	Group By	-
WorkingDay	-	Setting	Group By	-
WorkingHour	-	Setting	Group By	-
DateTime	-	Usage	Where	>DateAdd (DD, -30, SYSDATETIME())
Sum(dbo.Usage.Used) / (dbo.Setting.Workingday *dbo.Setting.WorkingHour * 12.0) *100	Utilization	-	Expression	-

Table 4.10 Data Dictionary of Temp View

Column	Alias	Table	Group By	Filter
UnitID	-	Part	-	-
dbo.Part.Price + ISNULL (dbo.Maintance.Fees,0)	Total	-	-	-

Table 4.11 Data Dictionary of Part View

Branch table in this ERD will store the detail information of every faculty of the organization and the *dept* table will store the Labs which belong to the faculty. Each lab is belongs to one faculty and one faculty can have many labs. The cardinality for the relationship between *dept* table and computer table is zero to many, assuming that the database keep track of a newly build or empty labs.

Mac address was chosen as a primary key in computer table because of its uniqueness. Users can get the price and warranty due date information of every computer from computer table. Tracking table will store the unitID and installDate of every component by taking Mac address of the network card as primary key. Besides, it will also store the historical and current data of the hardware components. Users can know the date and location where the hardware components had been installed in the computer. UnitID in the tracking table is referring the unit ID of the hardware component. Component attribute allows user to enter the type of hardware component such as graphic card, keyboard and mouse.

Part table will store the detail of the hardware specifications, category, price, supplier, warranty due, installation date and last scan. The cardinality for the relationship between tracking table and part table is one to many; tracking table will store the detail of a computer and the details of every component of the computer will be stored in part table. In part table, the Category attribute indicates the component whether is original or additional parts. Both keywords and description attribute descript the specification of a component. However, keyword attribute stores the summarized hardware specification where description attribute stores more detailed information about the hardware. Table 4.12 shows the content of keywords and description attribute from part table by taking Asus EAH5850 as a component example.

	Keywords	Description
Asus EAH5850	1GB GDDR5, 4000 MHz Memory Clock, 2560 x 1600 Max resolution, ATI Radeon HD 5850	ASUS Exclusive Voltage Tweak Technology for up to 50% performance. It has up to 20% cooler during game play and up to 35% quieter under idle mode than generic HD 5830 with Direct CU Technology.

Table 4.12 Example of Keywords and descriptions attribute of Part table

Maintance table will store every maintenance log of hardware components. *Maintance* table uses date and unitID as primary key to track all the maintenances history of a component. The MID column is not allows to have null value because it allows users to check the duration, fees and description of the maintenances. The description column allows user to enter the summary of the maintenance.

Supplier table consists of supplier's ID, name, contact number and address. Usage table stores the usage of every computer. The data type that is used for attribute is integer (int), because the installed sensor will detect the status of computer for interval of five minutes. The value 1 will be sent to database according to its MAC address when the computer's status is in active or on mode.

Setting table is used to store the amount of working hours and days of the organization. These values are important in order to calculate and get the IT assets utilization of the organization. [Key] is used to represent the primary key of setting table, but the value of it is only a dummy value. The purpose of implementing it is due to value of WorkingHour and WorkingDay which are not unique to be used as primary key of setting table.

4.3 Interface Design

Interface design plays an important role in preparation of the technical specification for user inputs and outputs. The layout of the system is important in order to provide user with a user friendly system and intuitive user interface. A good interface design can help in reducing training cost and increase user satisfaction. Below is the template design of Dynamic Resource Monitoring System:-

a. Homepage: **Default.aspx**

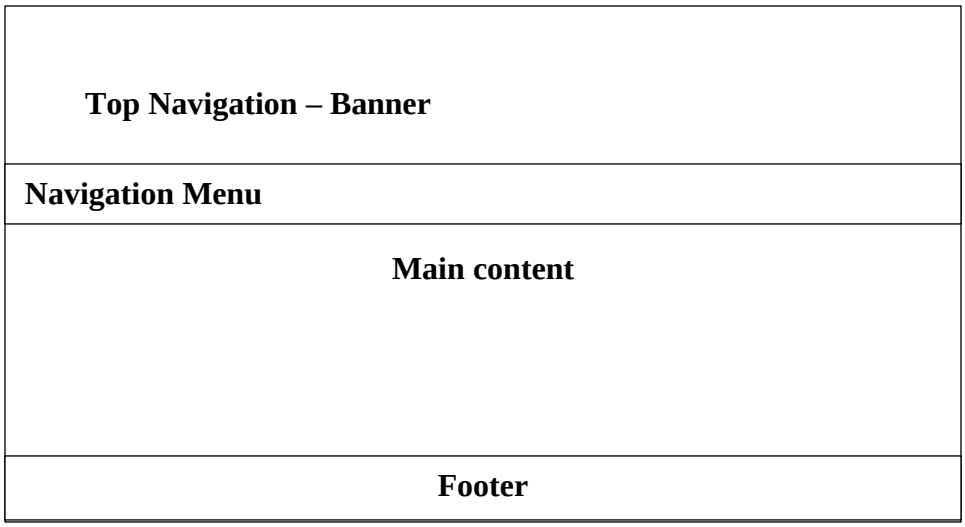

Figure 4.3 Homepage

Description

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Return of Investment, Reliability, Utilization and Setting. Sub-webpage will be placed under its main webpage.
Main Content	An image will be display to the users.
Footer	Sitemap will be included on the bottom of the page.

Table 4.13 Description of Homepage

b. ROI Page: **FacROI.aspx, LabROI1.aspx**

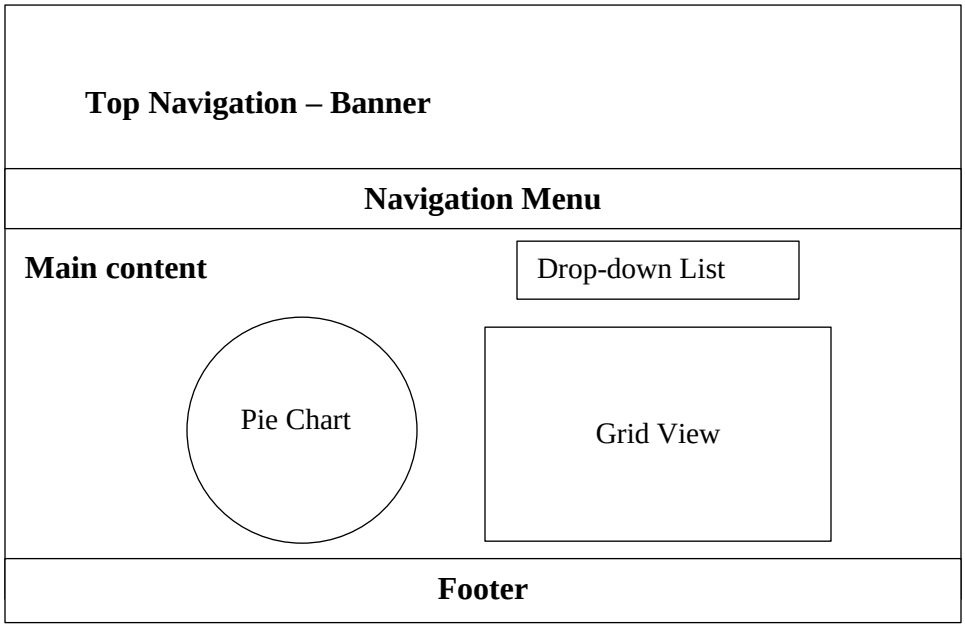

Figure 4.4 Return of Investment (ROI) Page For faculty and Lab

Description

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Return of Investment, Reliability, Utilization and Setting. Sub-webpage will be placed under its main webpage.
Main Content	The pie chart and grid view table will display the Return of Investment (ROI) value of every faculty and labs. Users can change the chart's type from the dropdown list. The value of Faculty ID column in the grid view table will link users to LabROI1.aspx page. The value of Lab ID will link user to ComList.aspx page.
Footer	Sitemap will be included on the bottom of the page.

Table 4.14 Description of Return of Investment Page

c. List of Computers Page: **ComList.aspx**

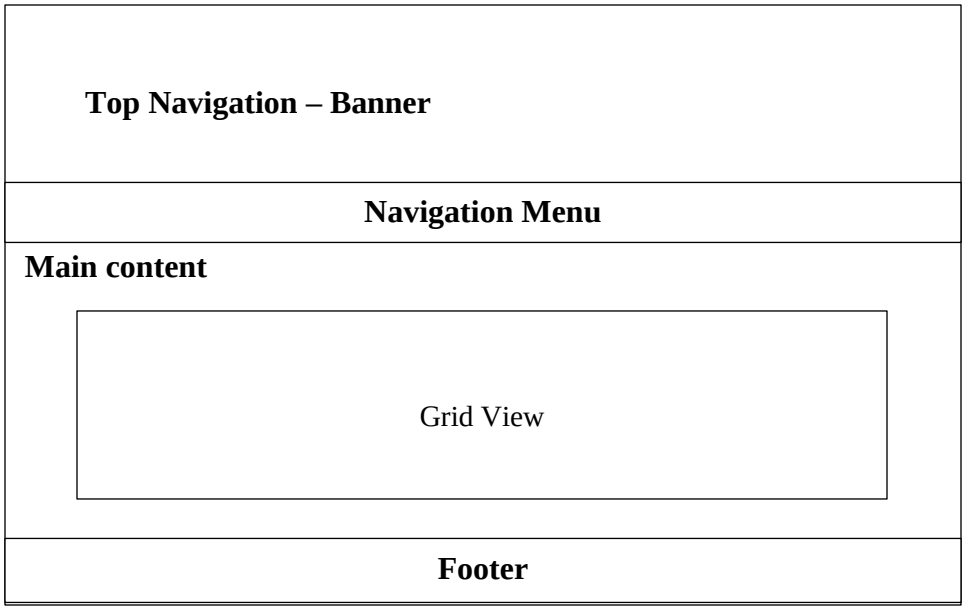

Figure 4.5 List of Computers Page

Description

Division	**Description**
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Return of Investment, Reliability, Utilization and Setting. Sub-webpage will be placed under its main webpage.
Main Content	All computers of the selected lab will be listed in the grid view. In order to know the information of the selected computer and its components, users can click the value of Mac Address column to reach ComInfo.aspx page. The value of Supplier ID column in the grid view table will link users to the Supply.aspx page.
Footer	Sitemap will be included on the bottom of the page.

Table 4.15 Description of List of Computers Page

d. Computer and Component Information page: **ComInfo.aspx**

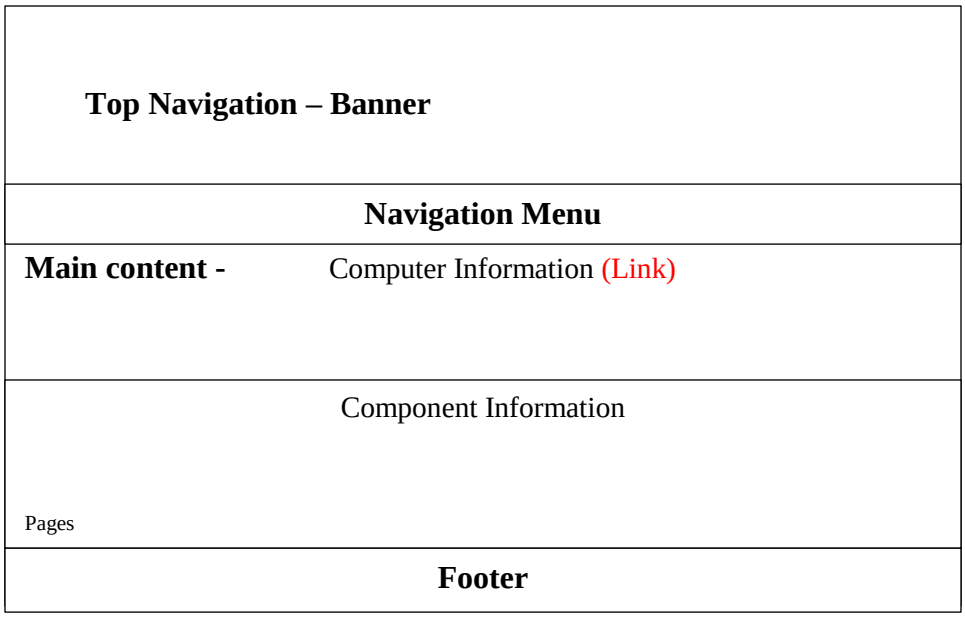

Figure 4.6 Computer and components Information Page

Description

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Return of Investment, Reliability, Utilization and Setting. Sub-webpage will be placed under its main webpage.
Main Content	The computer's information will be displayed on the top part of the main content section. Every component's information of the computer will be display in different page after the computer's information. The link besides the title of computer Information will link users to read the live data of components.
Footer	Sitemap will be included on the bottom of the page.

Table 4.16 Description of Computer and Component Information page

e. Supply Page : **Supply.aspx**

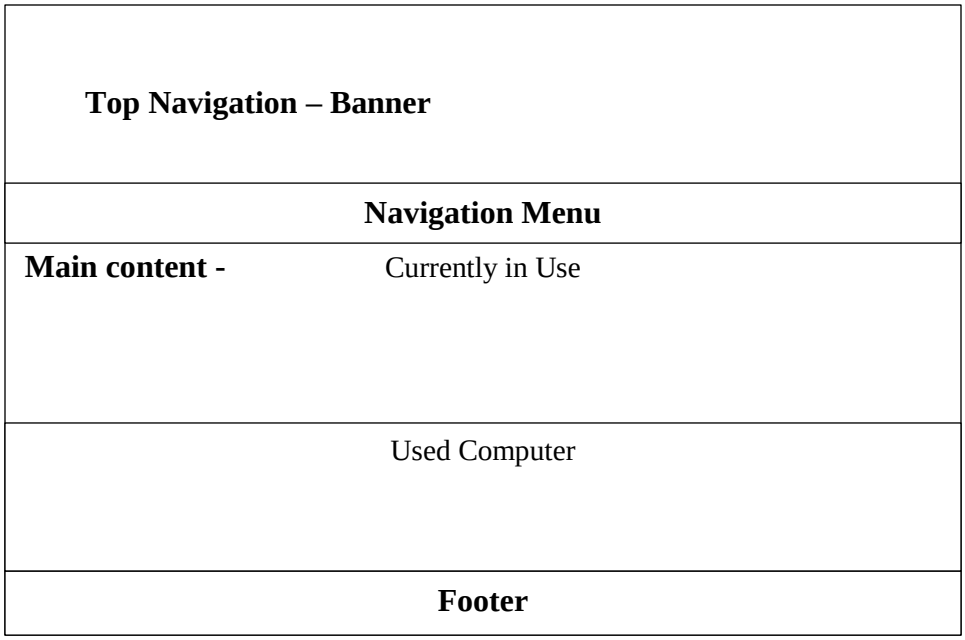

Figure 4.7 Supply Page

Description

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Return of Investment, Reliability, Utilization and Setting. Sub-webpage will be placed under its main webpage.
Main Content	Information about components and computers that currently in use will be displayed on the top part of the main content section. Information about used components can be found at the second part. User will be directed to ComInfo.aspx page from Supply.aspx page by clicking the Mac Address's value.
Footer	Sitemap will be included on the bottom of the page.

Table 4.17 Description of Supply page

f. Reliability Page (Brand): **Reliability.aspx**

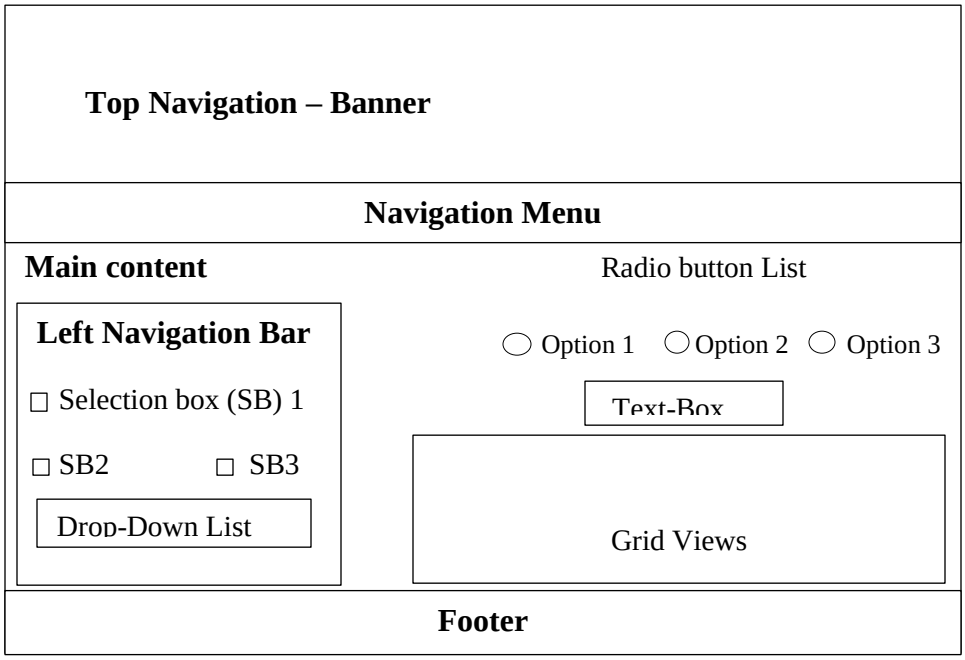

Figure 4.8 Reliability Page (Brand)

Description

Division	**Description**
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Duration, Reliability, Return of Investment and Setting. Sub-webpage will be placed under its main webpage.
Main Content	There are two tabs of page. There are three checkbox and one dropdown list on the left navigator bar. User can check the checkbox to know the reliability of supplier, brands and models of components. Every models of the selected brand will be listed once the user selects the drop down list's value. The radio button list allows user to check the reliability within three years. Users can enter a value to the text box to check the reliability too. Result will be displayed on grid view table. User will be directed to Supply.aspx by clicking the value of Supplier ID column. HardwareReliability1.aspx can be reach from Reliability page by clicking the value from Model column in the gird view table.
Footer	Sitemap will be included on the bottom of the page.

Table 4.18 Description of Reliability Page (Brand)

f. Reliability Page (Hardware): **HardwareReliability.aspx**

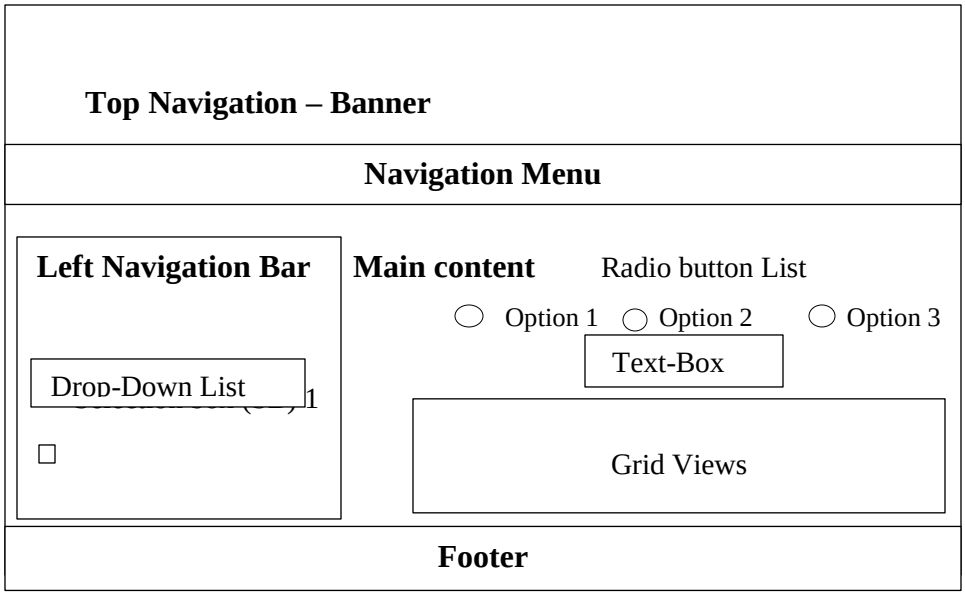

Figure 4.9 Reliability Page (Hardware)

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Duration, Reliability, Return of Investment and Setting.
Main Content	There are two tabs of page. There are one dropdown list and checkbox on the left navigator bar. Every brands of the selected hardware will be listed once the user selects the drop down list's value. The radio button list allows user to check the reliability within three years. Users can enter a value to the text box to check the reliability too. Result will be displayed on grid view table. User will be directed to HardwareReliability1.aspx from Reliability page by clicking the value from Model column in the gird view table.
Footer	Sitemap will be included on the bottom of the page.

Table 4.19 Description of Reliability Page (Hardware)

g. Utilization page: **Utilization.aspx, LabUti.aspx and ComUti.aspx**

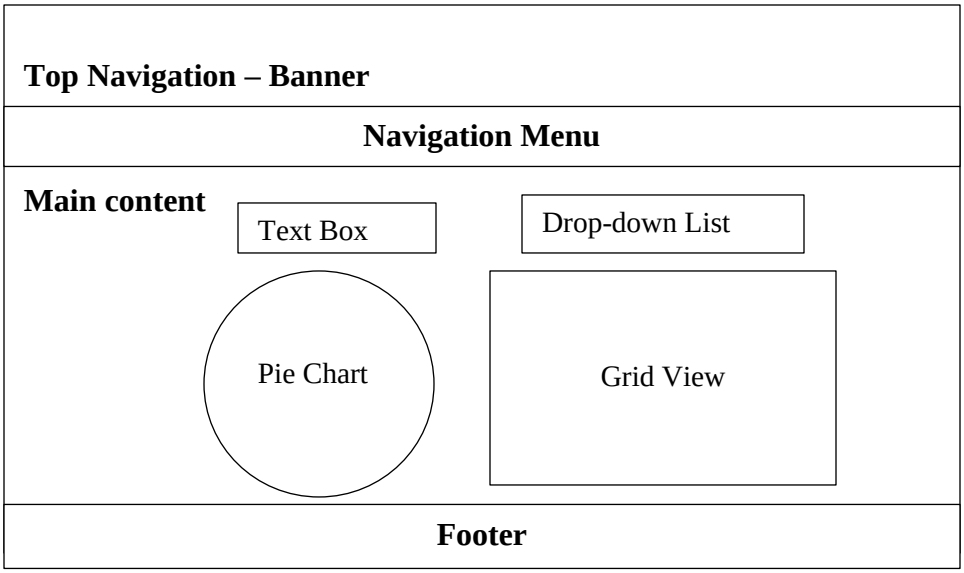

Figure 4.10 Utilization Page For faculty, labs and computers

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Return of Investment, Reliability, Utilization and Setting.
Main Content	The pie chart and grid view table will display the Utilization of every faculty, labs, and computers. The chart's type can be change by selecting value from the dropdown list. Users can enter a value into the textbox; the value entered indicates the total days that users would like to get the utilization since today's system date time. The value of Faculty ID column in the grid view table will link users to LabUti.aspx page. The value of Lab ID column will link user to ComUti.aspx page. User will be directed to ComInfo.aspx page from ComUti.aspx page by clicking the Mac Address's value.
Footer	Sitemap will be included on the bottom of the page.

Table 4.20 Description of Utilization Page

h. Setting Page: LabSet.aspx

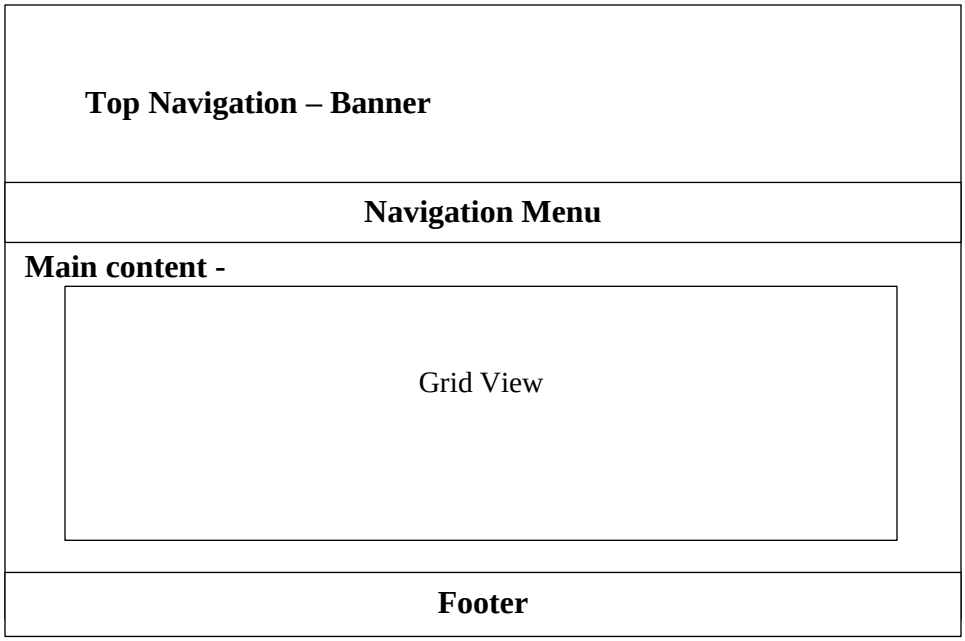

Figure 4.11 Setting Page

Description

Division	Description
Top Navigation	Includes banner and name of the system.
Navigation Menu	Consist of five menus that will link to another page which are webpage of Homepage, Duration, Reliability, Return of Investment and Setting. Sub-webpage will be placed under its main webpage.
Main Content	Grid view will list out every labs of an organization. There is an Edit button in the grid view; it enables users to update the Revenue and Operation cost for each labs to calculate the Return of Investment value.
Footer	Sitemap will be included on the bottom of the page.

Table 4.21 Description of Setting Page

5 Implementation

After the system design phase completed, it will go to system implementation phase. The system implementation proceeds based on the user, hardware and software requirement stated in chapter 3. This chapter will provide a clear view of the system implementation phase which begins from the software installation to the end of technical part process such as programming part.

5.1 Software Installation

In the software installation phase, a few software needed to be installed to proceed the system development or build the system. Software such as compiler, Microsoft Visual Web Developer 2010 Express, database software, Microsoft SQL Server 2008 R2 is needed to be installed.

5.1.1 Installation of Microsoft Visual Web Developer 2010 Express

In order to install Microsoft Visual Web Developer 2010 Express, an offline installer is needed. The installer is in .iso file format which can be downloaded from Microsoft website http://www.microsoft.com/express/Downloads/#2010-All. The .iso file needed to burn into a DVD or extract it using Winrar application before it is executable. The steps of installing the Microsoft Visual Web Developer 2010 Express using executable file are listed below:-

a. Go to the folder which contains Microsoft Visual Web Developer 2010 Express after extracted from .iso file using WinRAR application; double click on setup.exe executable file.
b. Upon the setup.exe file executed, a window will pop out for user to choose which application module to install. Click on Microsoft Visual Web Developer 2010 Express.

c. Another window will pop out to ask for permission to execute the application. Click yes to proceed.
d. On the welcome window, uncheck the box "yes, send information about my setup experiences to Microsoft Corporation". Click Next.
e. On the license agreement window, tick the checkbox with a sentences "I have read and accept the license terms" beside. Then click next.
f. Make sure that the box "Microsoft SQL Server 2008 Express Service Pack 1" is checked. Click Next.
g. The next window defined the destination folder to install the program. Browse to c:\Program Files (x86)\Microsoft Visual Studio 10.0\ and click Install.
h. The next window will show the installation progress. Wait until all the applications successfully installed, the setup is completed. Click Exit to complete the installation.

5.2 Database Development

Microsoft SQL Server 2008 R2 Express was used to create database applications for Dynamic Resource Monitoring System. It can be downloaded from the website http://www.microsoft.com/express/Database/InstallOptions.aspx. The steps of installing the Microsoft Server Management Tools 2008 R2 using executable file are listed below:-

a. Double click on SQLEXPRWT_x64_ENU.exe file. This will extract the necessary files for the installation. A dialog box will pop out to ask permission to run the program. Click Yes.
b. A window will pop out and shows the options for installation. Click on "New Installations or Add Features to an Existing Installation".
c. A dialog box will prompt out to show that the installation process is undergoing.
d. A window will prompt the license agreement of using this application. Check the box "I accept the license terms" and click the "Next" button.
e. Setup Support Files will then executed. Click Next to proceed after setup process finished.

f. In Features Selection, make sure all the box is checked and click the "Next" button.
g. Click on the button "Default Instance" in Instance Configuration window. Click Next.
h. Make sure that SQL Server Database Engine startup mode is automatic type, click the "Next" button
i. In Database Engine Configuration, click on button "Windows authentication mode" and specify SQL Server administrator. Click Next.
j. On the Error Reporting Windows, uncheck the box so that error report will not send to Microsoft. Click Next.
k. The setup will then lead into the installation progress. Wait until the running process finish and then click the "Next" button.
l. The installation process is finally completed. Click Close to complete the installation. A dialog box is then prompt to restart the computer. Click OK and restart the computer.

5.3 Interface Development

The template of each interface design had been illustrated in chapter four. The physical design of the system will be implemented in this stage. A good user interface is important as it will not confuse the end users and can get into different page in few clicks. There are five main user interfaces in the development of Dynamic Resource Monitoring System, which are home page, return of investment page, reliability page, utilization page and setting page.

5.4 Programming Development

The initial stage of the programming development is the database connection establishment. Figure 5.0 is the sample of connection string that attach in the coding part of the system.

```
<asp:SqlDataSource runat="server"

ConnectionString="<%$ ConnectionStrings:ITAssetConntring
%>" >
```

Figure 5.0 Example of database connection coding

Besides that, there are several namespace declarations need to include before the functions are written. Figure 5.1 shows the example of namespace declaration used in the system.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;
using System.Data.Odbc;
```

Figure 5.1 Example of namespace declaration

The following figure will demonstrate on the SQL query part for selection, insertion and modification to the database. There are two views created in the system.

A view had been created in utilization page so that the utilization rate for every faculty, labs and computer can be queried out easily. Figure 5.2 shows the view creation which includes the formula to get the utilization rate for each faculty, labs, and computers. Total working days and working hours are needed in order to calculate the utilization rate. The view will display the default value stored, therefore the view need to be first being dropped before it is create. Same technique had been used in order to get the return of investment (ROI) value of each faculty, labs and computers.

```
string sqldrop = "DROP VIEW [TempView]";

System.Data.Odbc.OdbcCommand sqldrop1 = new
dbcCommand(sqldrop, conn);

sqldrop1.ExecuteNonQuery();

String sqlcreate = "create view TempView as SELECT TOP
(1000000) Branch.FacID, Dept.LabID, Computer.Mac,
SUM(Usage.Used) / (Setting.WorkingDay * Setting.WorkingHour *
12.0) * 100 AS utilization FROM Usage INNER JOIN Computer ON
Usage.Mac = Computer.Mac INNER JOIN Dept ON Computer.LabID =
Dept.LabID INNER JOIN Branch ON Dept.FacID = Branch.FacID
CROSS JOIN Setting WHERE (Usage.DateTime > DATEADD(DD, -  " +
TextBox1.Text +" , SYSDATETIME())) GROUP BY Branch.FacID,
Dept.LabID, Computer.mac, WorkingDay, Setting.WorkingHour
ORDER BY Branch.FacID, Dept.LabID";

System.Data.Odbc.OdbcCommand sqlcreate1 = new
OdbcCommand(sqlcreate, conn);

sqlcreate1.ExecuteReader();
```

5.2 Example of SQL statements on creating utilization view

Figure 5.3 shows the SQL query to get the total utilization for each faculty from the view created.

```
SELECT FacID, avg(utilization) as Utilization From TempView
group by FacID ">
```

Figure 5.3 Example of SQL statements on getting utilization of every faculty

The system will display the utilization of labs under the faculty selected by the user. The faculty ID value of the main utilization page will then bring to the LabUti.aspx to display the utilization owed by the selected faculty. Figure 5.4 shows how the FacID value from the grid view column is being transferred to LabUti.aspx webpage.

```
<asp:hyperlinkfield  DataTextField="facid"
DataNavigateUrlFormatString="LabUti.aspx?facid={0}"
DataNavigateUrlFields="facid" HeaderText="Fac ID"
SortExpression="FacID" />
```

Figure 5.4 Migration of FacID value to LabUti.aspx webpage

Figure 5.5 shows how the LabUti.aspx webpage get the FacID value from the Utilization page. The webpage will display user the utilization of labs which is under the selected faculty.

```
SelectCommand="select facid, labid, AVG(utilization) as
Utilization from tempview WHERE (FacID = @FacID) group by
facid, labid">
<SelectParameters>
<asp:QueryStringParameter Name="FacID"
```

Figure 5.5 Example of SQL query statement on getting faculty ID

Dynamic Resource Monitoring System will display users the information of the computers and components in each labs. The information includes the location, physical address, price, supplier of the computer. Brand, model, last scan, installed date and description of the hardware component will be retrieved from the database and display to the users.

Figure 5.6 shows how the computer and hardware component's information was queried from the database. The result will be displayed in a table without border to easier user to read.

```
<ItemTemplate><asp:Table ID="Table1" runat="server"
CellPadding="5" CellSpacing="5" HorizontalAlign="Center"
Width="900px" ForeColor="Black">

<asp:TableRow ID="TableRow1" runat="server">
<asp:TableCell ID="TableCell1" runat="server" ColumnSpan="2"
Font-Bold="True"
HorizontalAlign="Center" Font-Underline="true">Computer
Information     <asp:LinkButton ID="LinkButton1"
runat="server" Font-Bold="True"
ForeColor="Red">(View Live Data)</asp:LinkButton>
</asp:TableCell></asp:TableRow>

<asp:TableRow ID="TableRow2" runat="server"><asp:TableCell
ID="TableCell2" runat="server" Font-Bold="True"
Width="350px" >
Location : Lab <asp:Label ID="LabIDLabel" runat="server"
Text='<%# Bind("LabID") %>'  Font-Bold="false"
/></asp:TableCell><asp:TableCell ID="TableCell3"
runat="server" Font-Bold="True" Width="350px">Computer :
<asp:Label ID="ComIDLabel" runat="server" Text='<%#
Bind("ComID") %>' Font-Bold="false"  />   <asp:Label
ID="ComNameLabel" runat="server" Text='<%# Bind("ComName") %>'
Font-Bold="false" /></asp:TableCell> </asp:TableRow>

<asp:TableRow ID="TableRow3" runat="server"> <asp:TableCell
ID="TableCell4" runat="server" Font-Bold="True">Physical
Address : <asp:Label ID="MacLabel" runat="server" Text='<%#
Eval("Mac") %>'  Font-Bold="false" /></asp:TableCell>
<asp:TableCell ID="TableCell5" runat="server" Font-
Bold="True">
Price : RM<asp:Label ID="PriceLabel" runat="server" Text='<%#
Bind("Price", "{0:f}") %>' Font-Bold="false"
/></asp:TableCell></asp:TableRow>

<asp:TableRow ID="TableRow4" runat="server"><asp:TableCell
```

Figure 5.6 Example of SQL statements on retrieving computer Information

Dynamic resource monitoring system will provide a webpage so that users can update the revenue of each lab. Investment is the total expenses the organization had spent on maintenance, purchase new computer and hardware component. Figure 5.7 shows the SQL query statement to calculate the ROI value for each lab. The equation to get the ROI value is ***(Revenue - Investment) / Investment***.

```
SELECT Dept.LabID, (Dept.Revenue - ISNULL(SUM(Maintance.Fees),
0) + SUM(Computer.Price) + SUM(Part.Price) +
Dept.OperationCost) / (ISNULL(SUM(Maintance.Fees), 0) +
SUM(Computer.Price) + SUM(Part.Price) + Dept.OperationCost) *
100 AS ROI, Dept.Revenue, Dept.OperationCost FROM Tracking
INNER JOIN Part ON Tracking.UnitID = Part.UnitID INNER JOIN
Computer ON Tracking.Mac = Computer.Mac INNER JOIN Dept ON
Computer.LabID = Dept.LabID INNER JOIN Branch ON Dept.FacID =
Branch.FacID LEFT OUTER JOIN Maintance ON Part.UnitID =
```

Figure 5.7 Examples of SQL query statement to get ROI value

Dynamic Resource Monitoring System allows users to check the reliability of supplier, brand and model of hardware component within a period. Figure 5.8 shows the SQL query statement to get the reliability of an organization's hardware component suppliers in descending order.

```
SELECT Part.SupplierID, Supplier.Name, POWER(2.71828, -
(CAST(COUNT (Maintance.UnitID) AS Decimal) / SUM(DATEDIFF(day,
Part.InstallDate, Part.LastScan))) * 365) AS Reliability FROM
Tracking INNER JOIN Part ON Tracking.UnitID = Part.UnitID
INNER JOIN Computer INNER JOIN Dept ON Computer.LabID =
Dept.LabID INNER JOIN Branch ON Dept.FacID = Branch.FacID ON
Tracking.Mac = Computer.Mac LEFT OUTER JOIN Supplier ON
Part.SupplierID = Supplier.SupplierID LEFT OUTER JOIN
Maintance ON Part.UnitID = Maintance.UnitID GROUP BY
Part.SupplierID, Supplier.Name Order By Reliability DESC
```

Figure 5.8 Example of SQL query statement to get supplier's reliability

Figure 5.9 shows the SQL query statement to get the reliability of a hardware component's brand in descending order.

```
SELECT Part.Brand, POWER (2.71828, -
(CAST(COUNT(Maintance.UnitID) AS Decimal) / SUM(DATEDIFF(day,
Part.InstallDate, Part.LastScan)))* " + num + ") AS
Reliability FROM Branch INNER JOIN Dept ON Branch.FacID =
Dept.FacID INNER JOIN Computer ON Dept.LabID = Computer.LabID
INNER JOIN Tracking ON Computer.Mac = Tracking.Mac INNER JOIN
Part ON Tracking.UnitID = Part.UnitID LEFT OUTER JOIN
Maintance ON Part.UnitID = Maintance.UnitID GROUP BY
Part.Brand Order By Reliability DESC
```

Figure 5.9 SQL query statement to get reliability of a hardware component's brand

Figure 5.10 shows the SQL query statement to get the reliability of a hardware component's model with selected brand in descending order.

```
SELECT Part.Brand, Part.Model, POWER(2.71828, -
(CAST(COUNT(Maintance.UnitID) AS Decimal) / SUM(DATEDIFF(day,
Part.InstallDate, Part.LastScan)))* " + num + ") AS
Reliability FROM Branch INNER JOIN Dept ON Branch.FacID =
Dept.FacID INNER JOIN Computer ON Dept.LabID = Computer.LabID
INNER JOIN Tracking ON Computer.Mac = Tracking.Mac INNER JOIN
Part ON Tracking.UnitID = Part.UnitID LEFT OUTER JOIN
Maintance ON Part.UnitID = Maintance.UnitID GROUP BY
Part.Brand, Part.Model Order By Reliability DESC
```

Figure 5.10 SQL query statement to get reliability of a hardware component's model

6.0 Testing

System testing, or also known as system evaluation is the last phase in the software development. In this phase, few types of testing will be ran to ensure the system is free from bugs and error; technical or logical error. The result of each testing will be shown in the Appendix A.

6.1 Change Diagram View

This is a test about changing the diagram view in FacROI.aspx, LabROI1.aspx, Utilization.aspx, LabUti.aspx, ComUti.aspx page.

Testing Object	**Testing Procedure**	**Testing Result**
User change the diagram view from pie chart to column chart and reversely.	1. Click on the drop down list to change current diagram view (pie chart-default)	The diagram view had been changed from pie chart to column chart.
Status: Pass		

Table 6-1 Diagram View Test Table

6.2 Check Reliability of IT Assets with Different Timeline

This is a test about the usability of radio button list and text box in both HardwareReliability.aspx, Reliability.aspx page.

Testing Object	**Testing Procedure**	**Testing Result**
User select the value from the radio button list provided or insert value into textbox.	1. Change value on radio button list. 2. Insert value into text box.	The result on table changed according to user input.
Status: Pass		

Table 6-2 Timeline Scalability Test Table

6.3 Check Usability of Left Navigation Bar (Hardware)

This is a test about whether the result on table in HardwareReliability.aspx, Reliability.aspx page will change according to user input

Testing Object	Testing Procedure	Testing Result
User change the values of the checkbox list and drop down list on the left navigation bar (Hardware).	1. Change value of checkbox list 2. Change value of dropdown list	The result on table changed according to user input.
Status: Pass		

Table 6-3 Navigation Bar Usability Test Table

6.4 Check the Functionality of Updating Table

This is a test about functionality to access and update the value in database for LabSet.aspx page.

Testing Object	Testing Procedure	Testing Result
User update table in setting page.	1. Click on "Edit" button on a particular row 2. Change the value in textbox 3. Click the "update" button	Value of the table in database changed accordingly.
Status: Pass		

Table 6-4 Update Table functionality Test

6.5 Check the Functionality of Utilization Timeline

This is a test about whether the result displayed on both pie chart and grid view in Utilization.aspx page changed accordingly

Testing Object	**Testing Procedure**	**Testing Result**
User change the value in textbox	1. Insert value into textbox	The result displayed on both pie chart and grid view changed accordingly.
Status: Pass		

Table 6-5 Utilization Functionality Test Table

6.6 Check the Accessibility of Every Hyperlink

This is a test about whether the user is able to navigate throughout all pages in the system with no dead link.

Testing Object	**Testing Procedure**	**Testing Result**
User navigate throughout the system	1. Click on each link in every page.	User is able to access to each desired page without dead link.
Status: Pass		

Table 6-6 Page Accessibility Test Table

7 Conclusion

In summary, all the phases from the software methodology had been completed and a prototype of Dynamic Resource Monitoring System had been built. The purpose of developing Dynamic Resource Monitoring System is to prove that return of investment value, utilization and reliability of IT assets can help in making investment decision. All the features had been tested out before it is present to the end user.

Besides that, IT asset monitoring system is important because it can help users in tracking and managing inventory data which is costly, time-consuming and error-prone. It can provide maximum visibility and control over the inventory, usage, entitlements and purchasing data related to IT assets. With this, users are able to control the physical and financial elements of IT assets. These solutions will help in enhancing the IT asset utilization, lower operating costs, improve IT risk management and make better IT investment decisions.

7.1 System Strength

Dynamic Resource Monitoring System has several strengths.

- Decision making assistant. The system can help in making investment decision by providing return of investment value, utilization and reliability of IT assets.
- Web-based. The developed system is machine independent and does not require any installation.
- Interactive. The system provides rich graphic user interface elements.
- Hierarchical view. The system allows user to view data in different level of details.
- Easy to use. Users can access to most of the data with only mouse click.
- Scalability. Users can adjust the input value with the text box provided in order to get the information that they need.

7.2 System Limitation

However the system has some limitation because it is just a prototype.

- Limitation reliability measure. Reliability of IT assets could only be measured if the products are currently using or were used previously by the organization.
- Inflexible view of information. Users could not query the information that they need. They only able to access the information provided by the system.
- Limited choice of diagram view. The system only displays result in bar graph and pie chart.

7.3 Future enhancement

The system can have more enhancements in order to improve the functionality and application.

- Includes software information. The system could be enhanced by adding in software tracking system to identify software condition such as unauthorized or expired software in the organization.
- Records software utilization rate. Tracking the utilization of each software application to identify most useful/useless software for the whole organization. For example, the IT administrator can use the result generated to decide whether to upgrade the software.
- Report generation. Report generation features can be bundled into the system so that users can export the report into different type of document.

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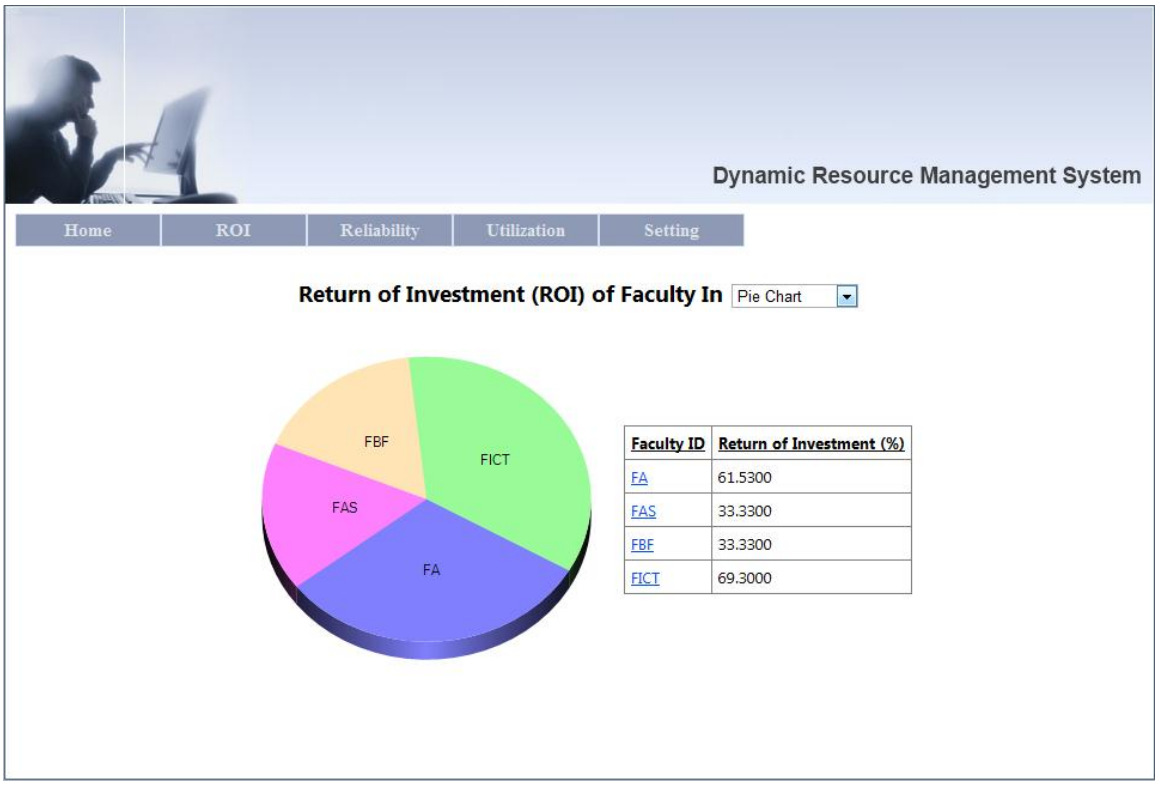
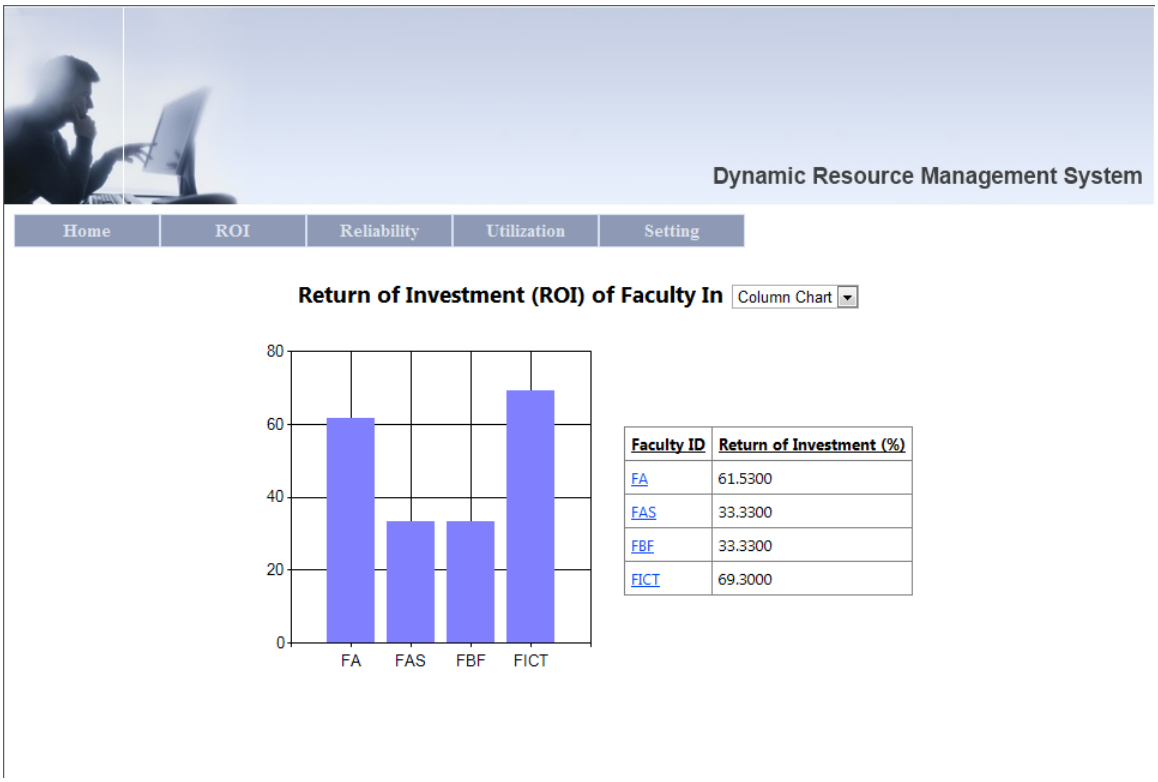
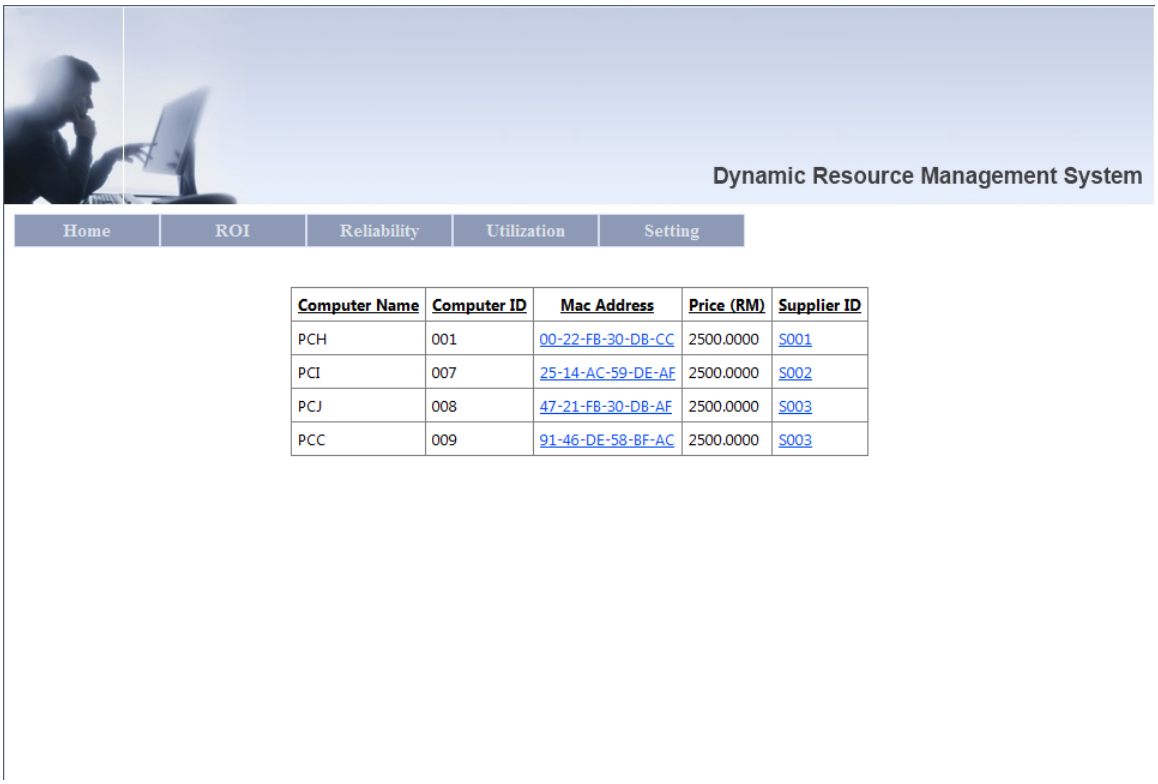
FacROI.aspx – Result in Pie Chart



FacROI.aspx – Result in Column Chart



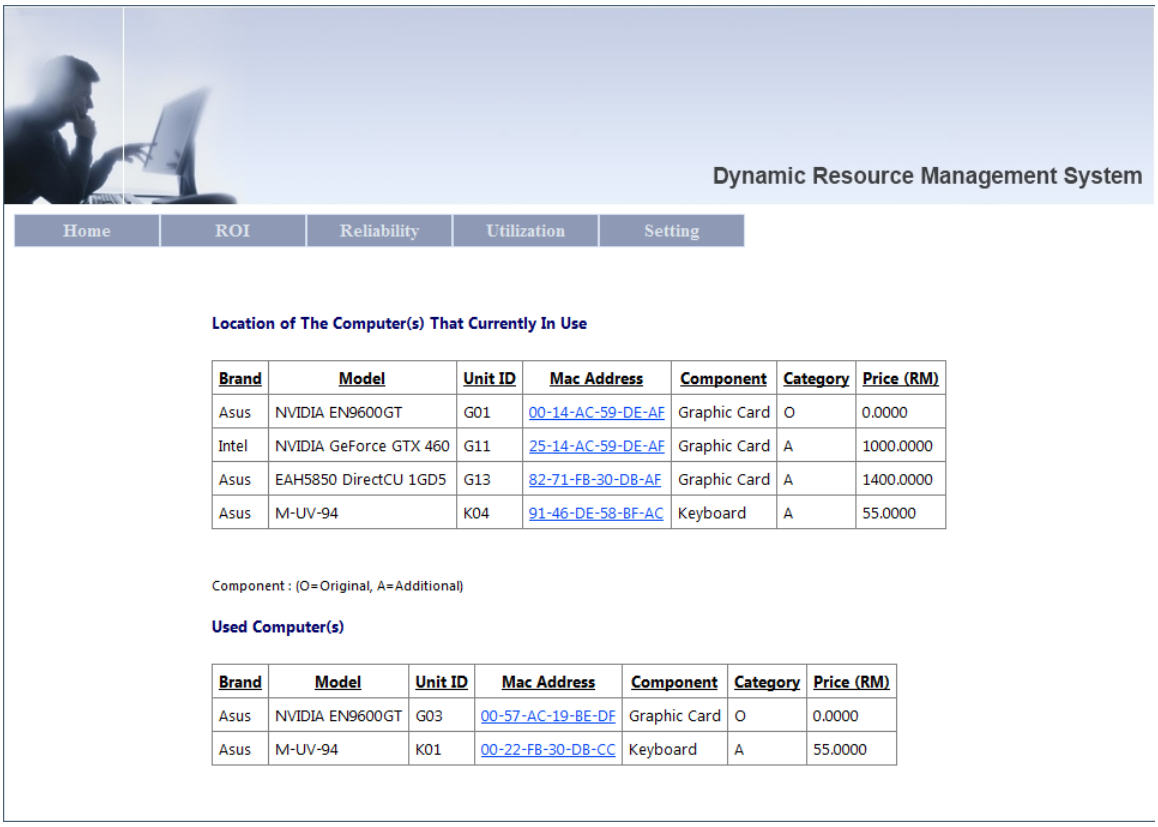
ComList.aspx



Computer Name	Computer ID	Mac Address	Price (RM)	Supplier ID
PCH	001	00-22-FB-30-DB-CC	2500.0000	S001
PCI	007	25-14-AC-59-DE-AF	2500.0000	S002
PCJ	008	47-21-FB-30-DB-AF	2500.0000	S003
PCC	009	91-46-DE-58-BF-AC	2500.0000	S003

ComInfo.aspx

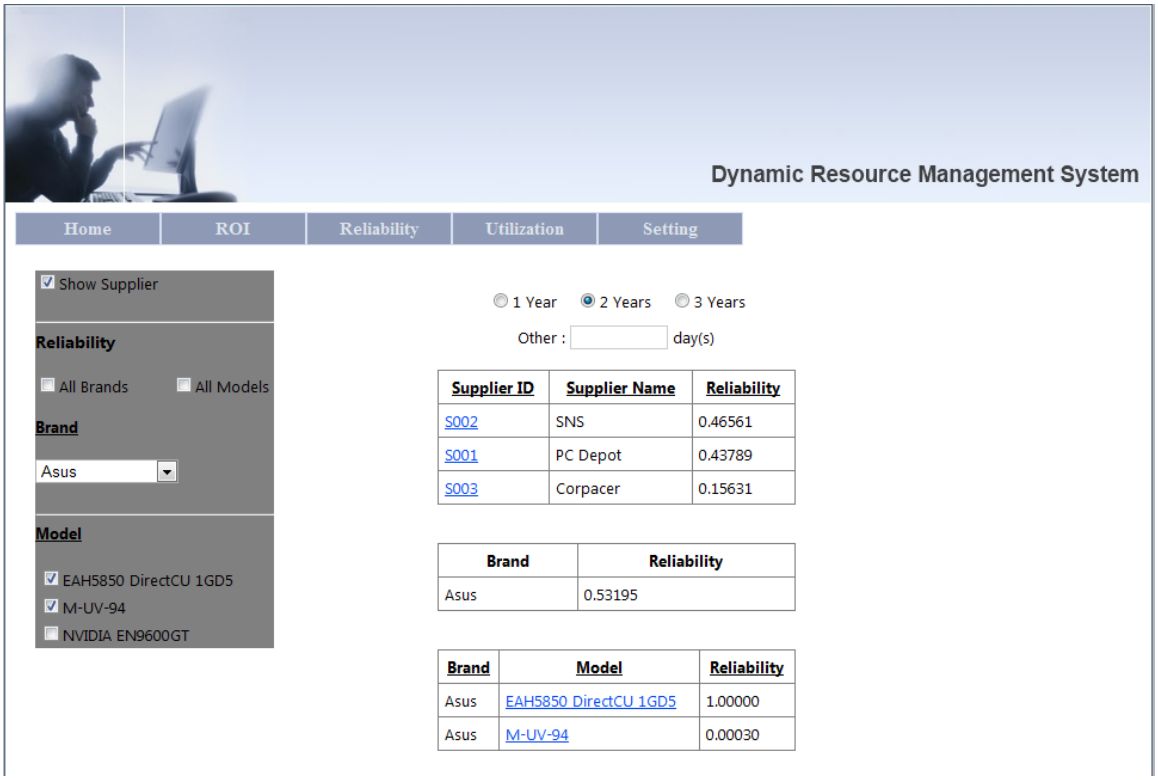
Supply.aspx



Brand	Model	Unit ID	Mac Address	Component	Category	Price (RM)
Asus	NVIDIA EN9600GT	G01	00-14-AC-59-DE-AF	Graphic Card	O	0.0000
Intel	NVIDIA GeForce GTX 460	G11	25-14-AC-59-DE-AF	Graphic Card	A	1000.0000
Asus	EAH5850 DirectCU 1GD5	G13	82-71-FB-30-DB-AF	Graphic Card	A	1400.0000
Asus	M-UV-94	K04	91-46-DE-58-BF-AC	Keyboard	A	55.0000

Brand	Model	Unit ID	Mac Address	Component	Category	Price (RM)
Asus	NVIDIA EN9600GT	G03	00-57-AC-19-BE-DF	Graphic Card	O	0.0000
Asus	M-UV-94	K01	00-22-FB-30-DB-CC	Keyboard	A	55.0000

Reliability.aspx

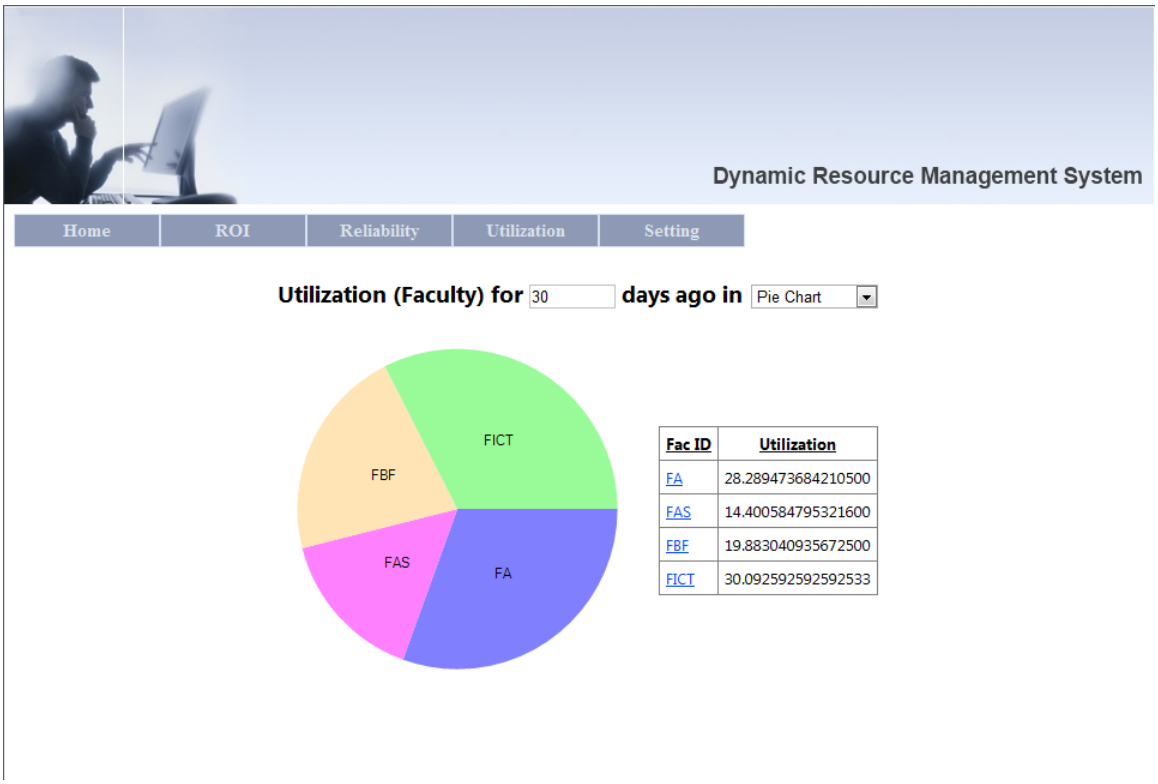


Supplier ID	Supplier Name	Reliability
S002	SNS	0.46561
S001	PC Depot	0.43789
S003	Corpacer	0.15631

Brand	Reliability
Asus	0.53195

Brand	Model	Reliability
Asus	EAH5850 DirectCU 1GD5	1.00000
Asus	M-UV-94	0.00030

Utilization.aspx



LabSet.aspx