

# **Motivating Outsource Engineering team by develop Datacentre Inventory and Incident Management System**

**K.H.C.P.H Tillekeratne  
2018**



# **Motivating Outsource Engineering team by develop Data centre Inventory and Incident Management System**

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

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University of Colombo School of Computing  
2018**






# Masters (MIT) Project Final Report

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## Declaration

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

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

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

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## **Abstract**

This dissertation is on a Datacentre Inventory and Incident Management System. DMS Electronics Limited (DMSE) is one of the oldest IT solution provider in Sri Lanka serving the nation for around 38 Years. DMSE is providing Enterprise IT Infrastructure Engineering Services for more than 2 decades and gain lot of experience in an infrastructure related to an airline. DMSE has kept onsite engineering team at the Sri Lankan Airlines Datacentre, Katunayake with SLA (Service Level Agreement) around the clock, 365 days for support enterprise IT infrastructure. However, the vast scope of work and important critical job carried out by the onsite team is neither well recognized by the company management nor the customer due to not having a proper system for work records and statistics.

Onsite team requires proper methodology to provide statistics and identify the work they carried out including Recording activities and managing the datacentre infrastructure equipment inventory by onsite team with better presentation in a different way. Solution capable of Querying about past incident and action taken, Searching and update details about servers and devices, Highlighting System for team members for their work involvements and solutions, innovative ideas, preventive measures, Reporting to both the customer and the DMS management about the progress and the analysis of work load, Daily, Weekly, Monthly. This dissertation is on the design, implementation and evaluation of a prototype and the system is developed on a methodological approach by adhering to the rules of the Object-Oriented Analysis & Design.

For Development, Visual Studio with C# Language and SQL Express Database used. The dissertation also expresses future enhancements and system improvements.

## **Acknowledgement**

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## **List of Abbreviations**

DMSE – DMS Electronics Limited

SLA – Service Level Agreement

SAN – Storage Area Network

O/S – Operating System

PC – Personal Computer

SQL – Structured Query Language

CRS – Customer Requirement Specification

SRS – Software Requirement Specification

GUI – Graphical User Interface

API – Application Programmable Interface

HP – Hewlett Packard

SIM – System Insight Manager

IRS – Insight Remote Support

SNMP – Simple Network Management Protocol

IT - Information Technology

# CHAPTER 1: INTRODUCTION

## 1.1 Objective of the Project

This Project is for delivering a solution for DMS Electronics Ltd, Engineering teams who full time stationed in Enterprise Infrastructure customer sites like Sri Lankan Airlines Data centre, to get the benefit of having a Server Inventory and Incident Management System.

“DMS Electronics Limited (DMSE) is one of the pioneer IT solution provider in the country serving the nation for over 3 decades and in successful business with government and private sector.

Ever since, DMS has been at the forefront of technological stewardship and innovation, bringing many cutting-edge technological concepts and business solutions to the fore, growing and evolving as the country’s most inclusive technology company with deep roots in stakeholder segments across diverse business and industry sectors offering them unparalleled quality and value, and thereby making a significant contribution towards shaping and enriching the lives of fellow Sri Lankans.

DMSE has over 20 years’ experience in providing IT solutions to the Airline Industry. They provided the IT infrastructure backbone to run the airline’s business-critical, mission-critical applications. Sri Lankan Airlines is one of their customers, where services starting from end user PC’s to backend SAN solutions were deployed during last 15 to 20 years.

Because of the heavy involvement with Sri Lankan Airlines DMSE honed and developed skills, know-how and infrastructure to meet requirements of IT needs of an Airline.

In today’s context every airline is heavily dependent on IT systems and data that can be accessed at anytime from anywhere. With the experience gained over the years DMSE is in a position to undertake any airline specific project and deliver it to meet or exceed customer’s expectation [1].”

In order for above purposes DMSE has stationed onsite team at the Sri Lankan Airlines Data Center, Katunayake with SLA (Service Level Agreement) for around the clock, 365 days.

### **Onsite Team scope of work in brief for Sri Lankan Airlines:**

- Backend server infrastructure which includes about 40 Rack Dense Servers and around 100 Server blades.
- Backend SAN infrastructure (Enterprise storages and mid-range storages)
- Enterprise backup solutions (Symantec Backup Exec Enterprise, one of the largest implementations in the country backing up several Terra bytes daily)
- One of the largest Server virtualization solution implementation (VMware / Hyper V)
- Microsoft and Linux O/ S Support
- Windows patch updates
- McAfee Antivirus enterprise solution management

However, the huge scope of work and important critical tasks carried out by such on site teams is neither well recognized by the company management nor the customer due to the below reasons.

### **Challenges for on-site engineering team**

Team is isolated in a remote location and the DMS management has less intervention with the team and no actual idea about what they do, how they do, their work load, work patterns, roster life, culture and passion to work. More elaborated on the same below.

### **Motivation Factors for this project work**

1. Lack of respect to the team as knowledge workers.
2. Wrongfully comparison with other outsource teams in small and medium customers with lesser scopes. E.g.: - PC repairing, End User computing support, Printer support, etc.
3. Lack of knowledge about onsite team's approach to quality control, knowledge sharing and continues improvement, communication styles and internal ethics.

4. Generally, customer's management knows about the DMS on-site team better than the mother company, and the work load they carried out but, pretending like not knowing due to several facts that they can delay payments, requesting additional work and projects from the team without paying additional, trying to extend the SLA scope at zero cost pretending the team has less work and in reality, the work done by on-site team is only a service for the customer and not a fact for appreciation as they have paid for it.

5. DMS management also tends to act as they don't know the work load of the team and trying to put some more work and manage customer's additional requirements and expansions within the team resources available without any expansions or suitable rewards or compensation.

6. Delivering Support Level Agreement (SLA) services and manage the national career's IT infrastructure is very critical and highly responsible job around the clock, but results are not tangible and countable like Sales Team targets achievements, in Annual appraisals and performance awards, generally not much reward waits for the on-site team.

### **Problem Statement in nutshell**

Lack of Information source to find Datacentre Server details (location, specification, configuration, warranty or Service Agreement Information) and lack of information on incidents occurred in those server devices and unable to trace the history and records easily. Currently there is no way to measure the workload carried out by individual on-site engineer in various knowledge domains and identify their differentiation among other DMS engineers who carry out only one particular job role in single Knowledge domain.

## **Aims and Objective of Project**

On-site team requires proper mechanism to provide statistics and quantify the work they carried out and the information related in efficient and effective way

- Designing a Server Inventory for the Datacentre with all the records relating to specification, configuration, warranty / Maintenance contract and Service Level agreement.
- Record activities and incidents handled by onsite team.
- Analyse the work carried out by team for a better presentation in a categorized way. Incidents and the Inventory tables are linked.
- Search Facility for the Inventory and Incidents. At any given time, any audit or customer query about past incident and action taken, information is recorded and easily available, searchable.
- Ranking System for team members for their work involvements and solutions, innovative ideas, preventive measures. Measure the workload carried out by any engineer.
- Reporting to both the customer management and the DMS management about the progress and the analysis of work load, Daily, Weekly, Monthly

## **1.2 Scope of Project**

- This application has an Inventory system with Incident Management system.
- SQL Database with data integrity and backup features
- Various Reports generation using queries and filters
- Warranty and Service Level agreement details for all Datacentre Servers.
- User Interface with login features, (Validation and Authentication) password protected application for add update delete search the Datacentre Inventory and incident management system
- System will provide facility to manage opened case details, update details and closure of an open case.
- Identify Performances of Engineers and workload completed.



### **1.3 Limitations**

Currently aimed at implementing the system only for DMS - Sri Lankan Airlines On-site Engineering Team. However, the system is not targeted to be accessed through internet by external parties at initial stage. Currently the system is intended only to be hosted within the Sri Lankan Airlines Internal Network.

### **1.4 Structure of the thesis**

The rest of this document is organized as follows. In Chapter 2, given an overview of some similar solutions and the review of the same. In Chapter 3, do the Analysis of the functional and no functional requirements to solve the problem. In Chapter 4, given the System Design of the solution. Chapter 5 gives overview of the implementation. Chapter 6 describes how the solution was tested and evaluated. Finally, in Chapter 7, described the conclusion with lessons learnt, limitations and future enhancements

## **CHAPTER2 – BACKGROUND**

There are many Commercial and Open Source Systems available for Datacentre Infrastructure Monitoring and Inventory. The off the shelf available products are highly sophisticated and advanced systems with various features and the cost is also high. These systems are designed to get traps through SNMP or any other monitoring related protocols and real time update the databases and alert the pre-defined parties.

Such Software are capable of integrating with the Hardware and Infrastructure Application layer through APIs and provide the facility to even provision and manage the hardware. However, the lack of inventory in such software like NAGIOS is the issue. There are some experiments done using scripts and plugins but not up to acceptable level with a confirmation and proper support.

Currently the Sri Lankan Airline Infrastructure is being monitored real time with the use of HP SIM, HP IRS and the Virtualized Server Environment using VMware vSphere Vcenter Alerts. Thus, the monitoring and alerting part is sufficiently done but the recording of information of Inventory and Incidents handling is the customer pain point here.

So, considering the client's financial status and the requirement of value addition to the customer through delighting the customer strategy of DMSE, it is advised to develop the customized software based on the specifically identified quantitative set of requirements only.

### **2.1 Troubles without a proper system**

1. It is difficult to locate a server or hardware device in Datacentre
2. Warranty status is not readily available to plan post warranty support contracts or purchase new systems
3. Cannot track the current status of Data centre device Failures.
4. Difficult to trace the history of incidents occurred for particular hardware device.
5. Unable to monitor and analysis quality and quantity of work carried out by engineers

6. When Customer ask various reports about hardware, configurations it is difficult to provide information quickly
7. When it comes to inquiry about particular past incident, It is difficult to capture the information from records.
8. For Management Reports and Customer Presentations, It is difficult to figure out and present the current status and progress.

## **2.2 Similar Systems**

I have observed few similar systems used in industry for IT incident management and inventory requirements. Below are the generally identifiable features found in similar solutions.

- Availability Management
- Change Management
- Configuration Management
- Contract Management (Warranty and support agreements)
- Dashboard
- Incident Management
- Problem Management
- Release Management
- Self Service Portal

## **2.3 Weaknesses or disqualification factors found in above applications**

There are many Datacentre Incident management tools and monitoring tools available which is automated and can real time monitor various devices like Servers, Storages, Network switches, Routers, Firewalls, etc. These systems are highly expensive software and currently being used by state of art sophisticated data centres belongs to large enterprises.

However, the limited budget and the current financial status of the client Sri Lankan Airlines, emphasize the importance of cost cutting and requires minimum cost and effort on monitoring and support tools. So, the environment and client specific reasons behind, this system development is planned as a value addition to the customer from DMS Electronics Ltd.

Since the hardware already supplied by DMS and the current support contracts of longer running for more than two decades, already provided easy testing and delivering the customized Datacentre Inventory and Incident management system for pre-defined, limited and specific requirements at no cost is definitely an added advantage and customer satisfaction along with the customer retention as well as the employee satisfaction and appreciation is the final mission to be accomplished.

Other issue is the products available in the market are mainly falls in to monitoring tools or Incident Management tools. The required specific needs are not met in a single software. So unnecessarily sophisticated and unwanted features are bundled in these commercially available off the shelf products but for higher price.

So, delivering the easy and simple tool with only required features is the decision made towards customer satisfaction.

## **2.4 Existing Solution - MS Excel and MS Access Based systems.**

Currently the onsite team uses an excel sheet to record all the information related to Datacentre Infrastructure, Server Placement and Incidents. But it is very primary level of solution with no integrity, lack of organize, less attractive, un secure, less user friendly, not connected to different information in different sheets.

E.g.: - Server Placement in one sheet and related incidents in different sheets which is not connected with each other.

Reports are not available in this method, user needs to gather information from different sheets, and create a report manually. Different users may use they own formats when data entering, so filtering and searching is always difficult, no way to impose data integrity and validation.

Below are some commercially available solutions,

### 2.5 Remedy IT Service Management

“BMC Remedy IT Service Management revolutionizes enterprise service management. Delivered on-premises or in the cloud, Remedy ITSM is a configurable and extensible platform radically redesigned to meet the needs of any transformative IT organization. Easier to use, faster to deploy, and packed with the latest innovations in service management, Remedy IT Service Management and Remedy On Demand are the most complete and capable IT service management for enterprise [2].”

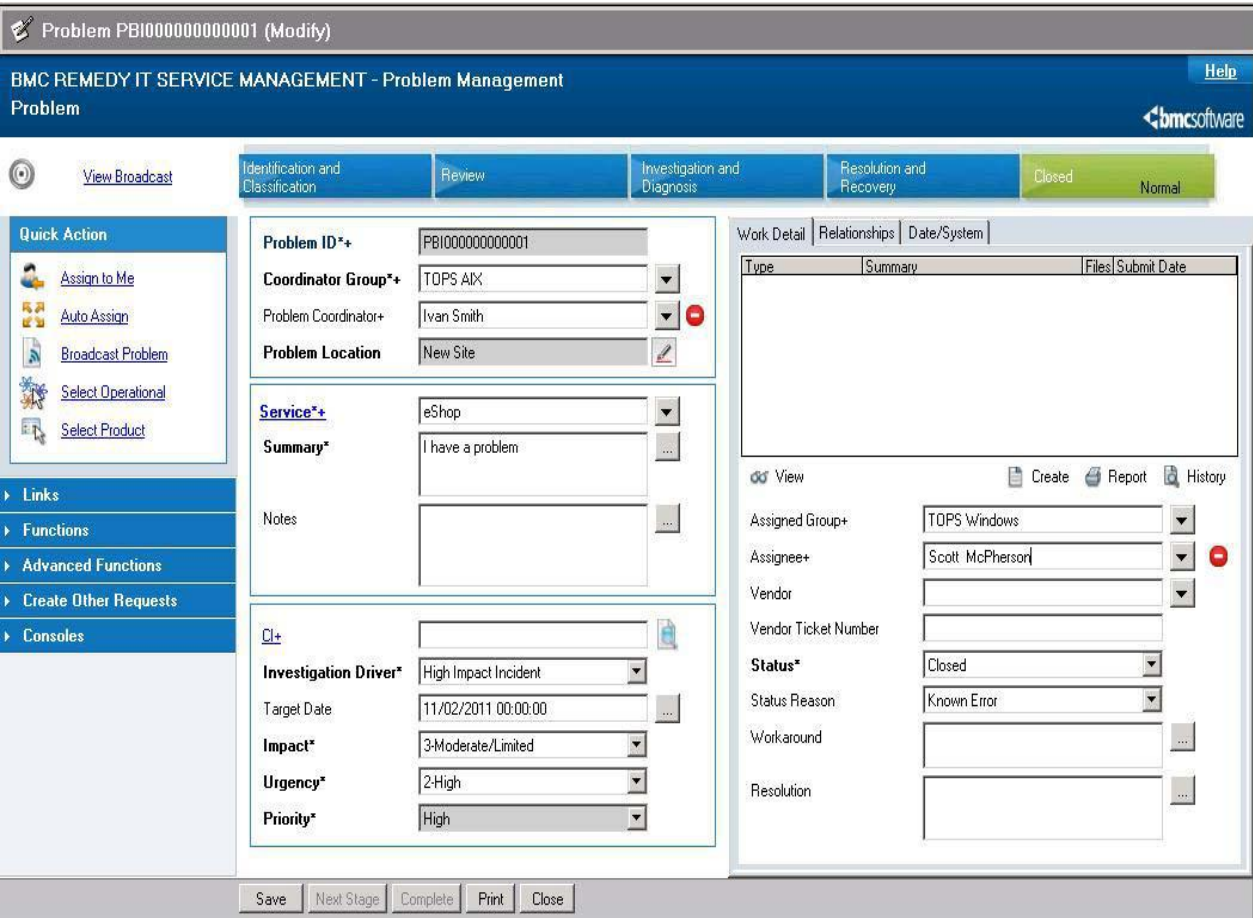


Figure 2.1- BMC Remedy User Interface

Features useful for us,

- Change Management
- Incident Management
- Problem Management

Weaknesses/disqualify reasons

1. Expensive
2. Too much customization required
3. Too much unnecessary features
4. No local support
5. Lack of Inventory feature
6. Lack of recognition for workers
7. Require High End Servers and Capacity for Database

## **2.6 Manage Engine Service Desk**

“ManageEngine ServiceDesk Plus is a Help Desk and Asset Management Software. It offers an Integrated Package with Incident Management (Trouble Ticketing), Asset Tracking, Purchasing, Contract Management, Self-Service Portal, and Knowledge Base at an Affordable Price Point. ServiceDesk Plus provides all that you need to have a Full-Fledged IT Help Desk and a Productive Help Desk Staff. ManageEngine ServiceDesk Plus is available in both On-Premise and On-Demand [3].”

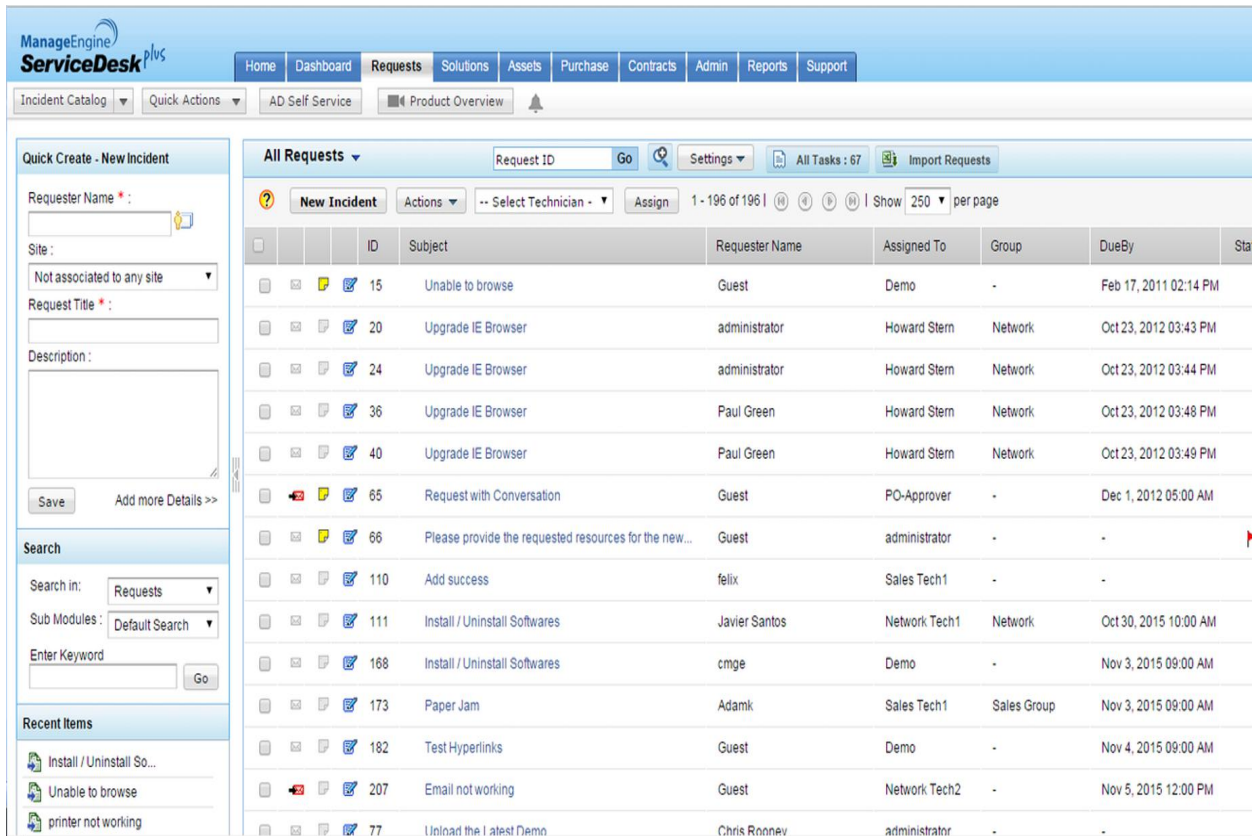


Figure 2.2 – ManageEngine User Interface

### Features useful for us

- Availability Management
- Change Management
- Configuration Management
- Contract Management
- Dashboard
- Incident Management
- Problem Management
- Self Service Portal

### Weaknesses/disqualify reasons

1. Expensive
2. Too much customization required

3. Too much unnecessary features
4. No local support
5. Lack of recognition for workers
6. Required High Processing power and capacity

## 2.7 SupportDesk ITSM

“SupportDesk ITSM provides organisations with a scalable IT Service Management system for streamlining support processes such as Incident, Problem, Request, Change and SLA Management. This feature-rich solution is available in the Cloud or On-Site, and offers a full reporting suite, configurable knowledgebase, email integration, drag and drop dashboards much more. The software's flexibility means that SupportDesk ITSM can be easily evolved as business requirements develop [4].”



Figure 2.3 – SupportDesk ITSM Dashboard



### Features useful for us

- Change Management
- Availability Management
- Configuration Management
- Contract Management
- Dashboard
- Incident Management
- Problem Management
- Release Management
- Self Service Portal

### Weaknesses/disqualify reasons

1. Expensive
2. Too much unnecessary features
3. No local support
4. Lack of recognition for workers
5. Required High Processing power and capacity

## **CHAPTER 3 - Analysis**

### **3.1 Scope of system features and functionalities**

#### 3.1.1 Scope of System User Roles

##### 1. System User

They are the DMS onsite engineers who will enter the inventory details and incident details. They will update the information and initiate the incident closure. Such any case closure or any record deletion needs System Managers approval before committing to the database. Access to the Reports and see the status of records through dashboards and search

##### 2. System Manager

System Manager has more privileges than System User. This User Role will double check whatever the information entered and changes done by users, and then approve to commit permanently to the database. Access to the Reports and see the status of records through dashboards and search

##### 3. Administrator

This is the admin role which has the capability to enter new parameters to system modify any such parameter. User Creation, Backup Taking and Audit Log generation also Administration tasks.

#### 3.1.2 Scope of Technology

The technologies used to develop this system are listed as below:

1. Operating System - Microsoft Windows Server
2. Designing Language - C # .net
3. Integrated Development Environment - Microsoft Visual Studio
4. Database Management System (DBMS) - Microsoft SQL Express
5. Reporting - Microsoft Reports

## 3.2 Requirements Analysis

### 3.2.1 Feasibility study

The important of the preliminary investigation is the determination of the whether the system requested is feasible or not. There are three aspects of feasibility study which should be checked in preliminary investigation.

There are three feasibility studies

- Technical feasibility
- Economic feasibility
- Operational feasibility

#### 3.2.1.1 Technical Feasibility

This feasibility determines whether it is possible to develop the project with available equipment, available software, technology and the manpower. If there is any kind of need in order to develop Software in this case the cost of Hardware, Software and technical equipment are considered. The technical aspect of feasibility is largely concerned with answering the question who, why, where, when.

Sri Lankan Airlines is Currently running a server infrastructure with enough processing and capacity to cater this server requirement so the infrastructure is already there. C# net is widely spread across world as a very familiar development language, so there are many resources in the country and the community version will give freely availability for develop without cost. SQL Express free version is adequate for the initial requirement.

### 3.2.1.2 Operational Feasibility

Simple User Interfaces and Help Menus will provide easy access and learning for users and get used to the application at less effort. The Validation Rules imposed will avoid the users from inserting false data.

### 3.2.1.3 Economic Feasibility: -

In this situation, client's financial status was highly concerned and value addition is the requirement. So, this software is being developed for customized and specific requirement and minimizing the licensing and development cost. Then It saves lot of money to organizations of not looking for highly expensive tailor made commercial applications. Since We are using C # .net community version and Microsoft SQL Express free edition, the economic feasibility is highly maintained.

## 3.2.2 Fact Finding Techniques

Below fact finding methods used for requirement analysis. Requirements for the project gathered by discussions, interviews and studying existing systems.

- Interview
- Observation
- Record Review (Previous solution and documentation evidences)

### 3.2.2.1 Interview

Discussions with On-site Team Engineers. Team Leads and managers. Discussions with customer representatives also. datacentre Supervisors, Operators and Infrastructure managers are from Sri Lankan Airlines

### 3.2.2.2 Record review

Study Existing Information Recording methods in excel sheets. Identified how they use it to record and retrieve information and up to what extent the information is available. Below documentation also checked.

E.g.: Change Requests, Service Request Information forms

### 3.2.2.3 Observation: -

Observer interaction between Customer and system user. What are the scenarios customer requires information and when the user requires the system to get information like user appraisals, history incident reviews, root cause analysis, Post Incident Inquiries and customer audit information requests.

## 3.3 Functional Requirements

Functional requirements of a system can relate to hardware, software or both in terms of calculations, technical details, data manipulation and processing or other specific functionality that defines what a system is supposed to deliver as the end result. A functional requirement can be in the form of a document explaining the expected types of outputs after processing certain inputs when the device (system) is placed in a certain kind of environment. A functional requirement is a final form of a system design because a design is the outcome of overcoming a certain kind of a problem (technical/non-technical) which trying to solve. To ensure this system solves the aimed problems, it should have following functions.

1. Administrator Functionalities
2. User Functionalities
3. System Manager Functionalities

Analysis of above functionalities-

So, after analysing the requirements using aforementioned technologies below Customer requirement specification (CRS / SRS) was made.

### 3.3.1 Administrative Functionalities

- Login - Change password for the first time, change password later.
- See the status of system (Inventory, Incident Management)
- Add new users. Fill details and set user roles with assigned privileges.
- Add, Update and Delete System parameters. E.g.: - New Incident Type, New Server Brand Name. Deletion Requires Manager Approval.
- See the reports and audit logs for user logins

<u>Input</u>	<u>Process</u>	<u>Output</u>
Login / Change Password User Info System Parameters	Login / Authentication / Validation to existing Add,update,delete records to database	Search Results, Reports, Help Feature,

*Table 3.1 - Administrative Functionalities*

### 3.3.2 System User Functionalities

- Login - Change password for the first time, change password later.
- See the status of system (Inventory, Incident Management)
- Search for particular item (Inventory item, Incident)
- Add, Update, Delete Inventory Records based on different categories
- Add, Update, Delete Incident Records based on different categories
- Complete (Close Tickets)
- Transfer Records to Authorization/approval to System Manager
- Get System Help Menu support

- See the reports.
- View Dashboard and check status(various information , opened tickets, severity level by number of tickets, personal score and performance level, warranty expire status, high risk area alerts, etc)

<u>Input</u>	<u>Process</u>	<u>Output</u>
Login / Change Password Search Add,Update,Delete Records	Login Authentication /Validation to existing. Search Database Add,update,delete records to database	Search Results, View Status/Dashboard Reports, Help Feature, Transfer to corresponding approver

*Table 3.2 - System User Functionalities*

### 3.3.3 System Manager Functionalities

- Login - Change password for the first time, change password later.
- See the status of system (Inventory, Incident Management)
- Search for particular item (Inventory item, Incident)
- Add,Update,Delete Inventory Records
- Add,Update,Delete Incident Records
- Approve Records ( eg:- closed ticket status, any deleted records)
- See the reports. (some reports restricted to be checked by manager role only)
- View Dashboard and check status(various information , opened tickets, severity level by number of tickets, personal score and performance level, warranty expire status, high risk area alerts, etc)

<b><u>Input</u></b>	<b><u>Process</u></b>	<b><u>Output</u></b>
Login / Change Password Search Records Add,Update,Delete Records	Login Authentication /Validation to existing. Search Database Add,update,delete records to database	Search Results, View Status/Dashboard Reports, Help Feature, Approve the Corresponding Changes

*Table 3.3 - System Manager Functionalities*

### 3.3.4 Reports

Various Pre-Designed Reports to be generated in the system as per the requirements as follows.

System Parameters List

Audit Log (user Login details, User changes/ activities done, time stamps)

#### **Inventory**

Category wise Item Reports (Servers, Storages, Switches, etc)

Warranty Status/Expiration Reports

History of incidents for particular item



### **Incidents ( time wise, category wise)**

Category wise Incident Reports (Failures, Change Requests, New Installations, etc)

Incident severity wise reports (Critical, Medium, Low)

Time Wise Incident Reports (according to date range given)

Opened Incidents

Closed Incidents

### **User Wise Reports**

User activity Report (User handled Incident)

User wise New Innovations Report

User Progress Report

## **3.4 Non-Functional Requirements**

Non-functional requirements are often called qualities of a system. Terms for non-functional requirements are security, performance requirements, reliability, constraints, quality attributes, quality goals and quality of service requirements. Most of the non-functional requirements will be checked in the testing phase.

- Security – Secure access of confidential data (user’s details). All the data should be kept securely. If there is an unauthorized access, it's not secure, fraud information made through this will lead to huge loss in information and also in brand value.
- Reliability and Availability– 24 X 7 availability and real time updates.

- Performance – Better component design to get better performance at peak time. System or the app should not be stuck.
- Maintainability – Flexible architecture will be highly desirable for future extension.
- Easy to understand and adaptable GUI
- Usability - Easy to navigate help menu system for self-reference
- Recoverability - Daily Backup options to recover in an application failure
- Scalability - to cater the growth of data capacity in future
- Data integrity - Incident and Inventory to be maintained with data integrity

# CHAPTER 4 – System Design

## 4.1 Methodology

### Design Strategy

This system is planned to cater a specific requirement for DMS Electronics and the problem scope is somewhat unique to the current circumstances. In this case it is decided to develop the software from the scratch using development tools and database. Due to the nature of availability of enormous resources and references on Microsoft Development platforms , it was decided to use C sharp .net with Microsoft Visual Studio. Open Source components were not brought up here as the lack of references and resources and the limited time to do trial and error.

At this level The system is supposed to run on-premise hardware in the datacenter and in future even this can be hosted in a cloud virtual machine also. In this scenario Sri Lankan Airlines already have purchased Microsoft Windows Server Datacenter Licenses, that enables they can create theoretically unlimited Virtual Machines in their environment. This system to be used in a Window Virtual machines for Application and Databases.

Microsoft Visual Development Platforms are already licensed by this customer and in house development teams occupied with necessary licenses for Visual Studio. In this case it is optional to use Microsoft Visual Studio community version which is freely available but with only the community support. Microsoft SQL Database is well known and compatible with this development platform natively, so it was decided to use same database since both from same vendor and the support channel which will deliver the peace of mind to the developer and the customer.

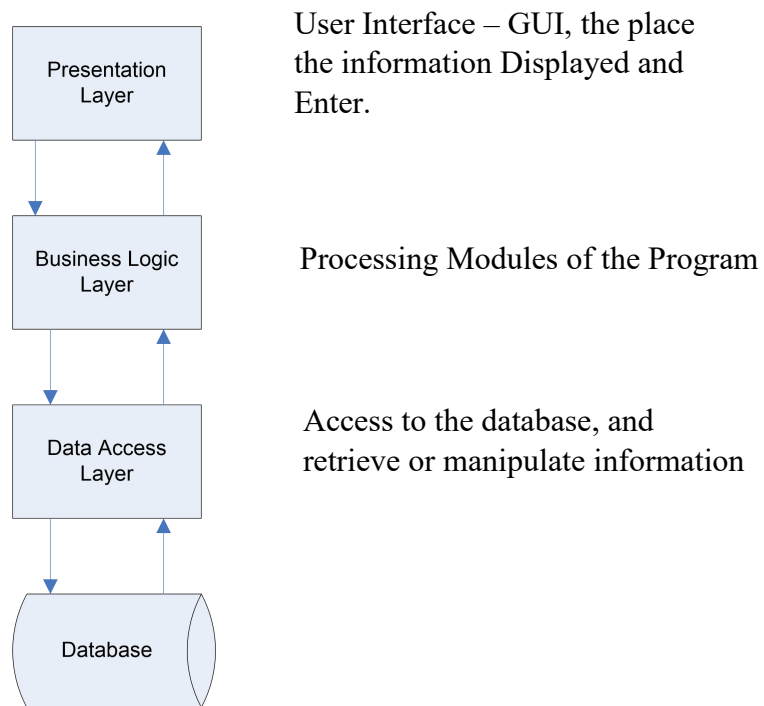
### Object Oriented Analysis and Design (OOAD)

OOADM is used to model a system with the objects and interactions among them. Objects are the representatives of real life entities of the system. Objects are identified by its class, its state and its behaviour. Unified Modelling language (UML) is used to represent Object Oriented models. UML class diagrams use case diagrams.

## 4.2 Architecture

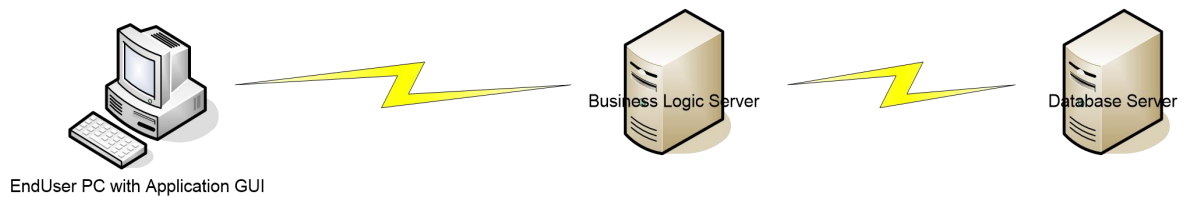
This Application will have a three-tier architecture which represents the client server communication.

### Logical View



*Figure 4.1 – Logical View*

### Physical View



*Figure 4.2 – Physical View*

- Client send request operations such as adding, deleting and updating to the business logic server via Sri Lankan Airlines IT Department Building Local Ethernet Network.
- Business Logic Server is a Server resides in Sri Lankan Airline Internal Datacentre network
- Business Logic Server will process the requests based on the application programme logic and then sent instructions to database server via Datacentre Ethernet Network .
- Database Server is a Server resides in Sri Lankan Airline Internal Datacentre network
- Database Server receives requests and manipulate the database then return the relevant results to the business logic server.
- Then Business Logic Server will send the results to client end.

### **4.3 Flowcharts**

Work flow is shown in 2 different diagrams for Inventory Management and Incident Management Separately.

#### **Work Flowchart for Inventory Management**

Generally Customer will initiate a change or addition in the Inventory which means a new server delivery or the changes in existing Server Hardware.If it is new item, DMS Engineer will gather all the required information and create a new item in the inventory.If it is a change of configuration or hardware upgrade in existing inventory item, the existing records are updated accordingly. Then DMS Manager will evaluate the changes and confirms.

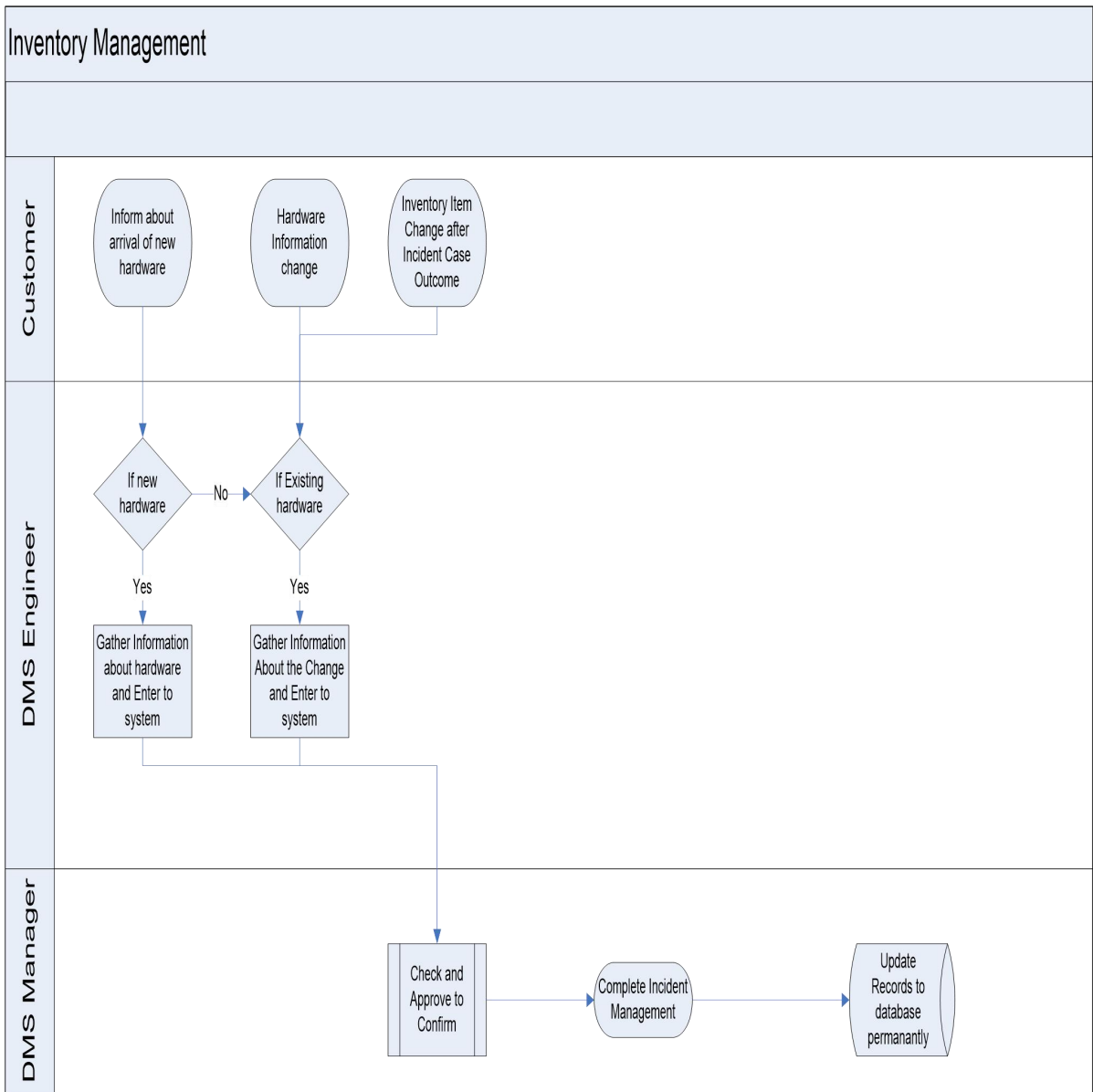


Figure 4.3 – flowchart for Inventory Management

## **Work Flowchart for Incident Management**

There can be incidents occurred by various ways such as Change Requests from customer, Alerts Generated by Server in build monitoring systems or visual alerts , any other identified System Failures which is reported by either the customer, or detected by DMS engineers due to different issues like performance degravations, system halts, system partial outages or complete system breakup.

In some minor cases DMS Engineer would diagnose the issue and remediate immediately.Eg:- Power cable pulled out mistakenly or loosen in a server. If the issue is more serous and need to investigate more, Then the system Incident ticket will be opened. Then the Level 1 , 2 and 3 engineers of Sri Lankan Airlines will attempt to remediate the issue. If not success the next option is to leverage the technical support from the product principle ( For HP Servers principle is HP) which is signed back to back agreements by the customers.

After the aforementioned escalation followed, the final outcome to be reviewed by the DMS Manager and confirm as solved or the case closed. Of course there are certain situations the problem was not completely solved but workarounds are applied to remediate the issue with mutual understanding between all the parties. So the incident closure is the final step.

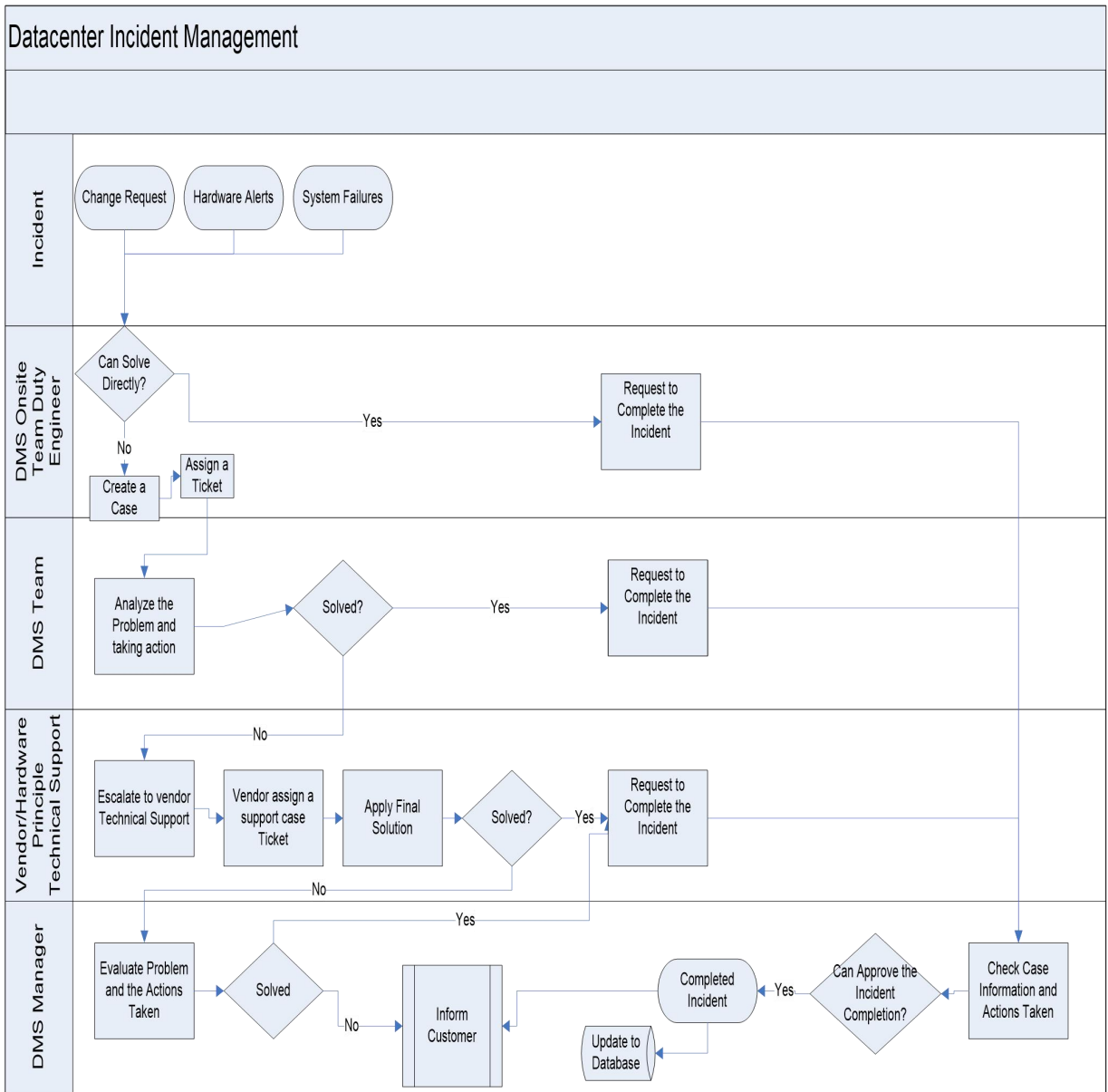


Figure 4.4 – Flowchart for Incident Management



## 4.4 Use Case Diagram

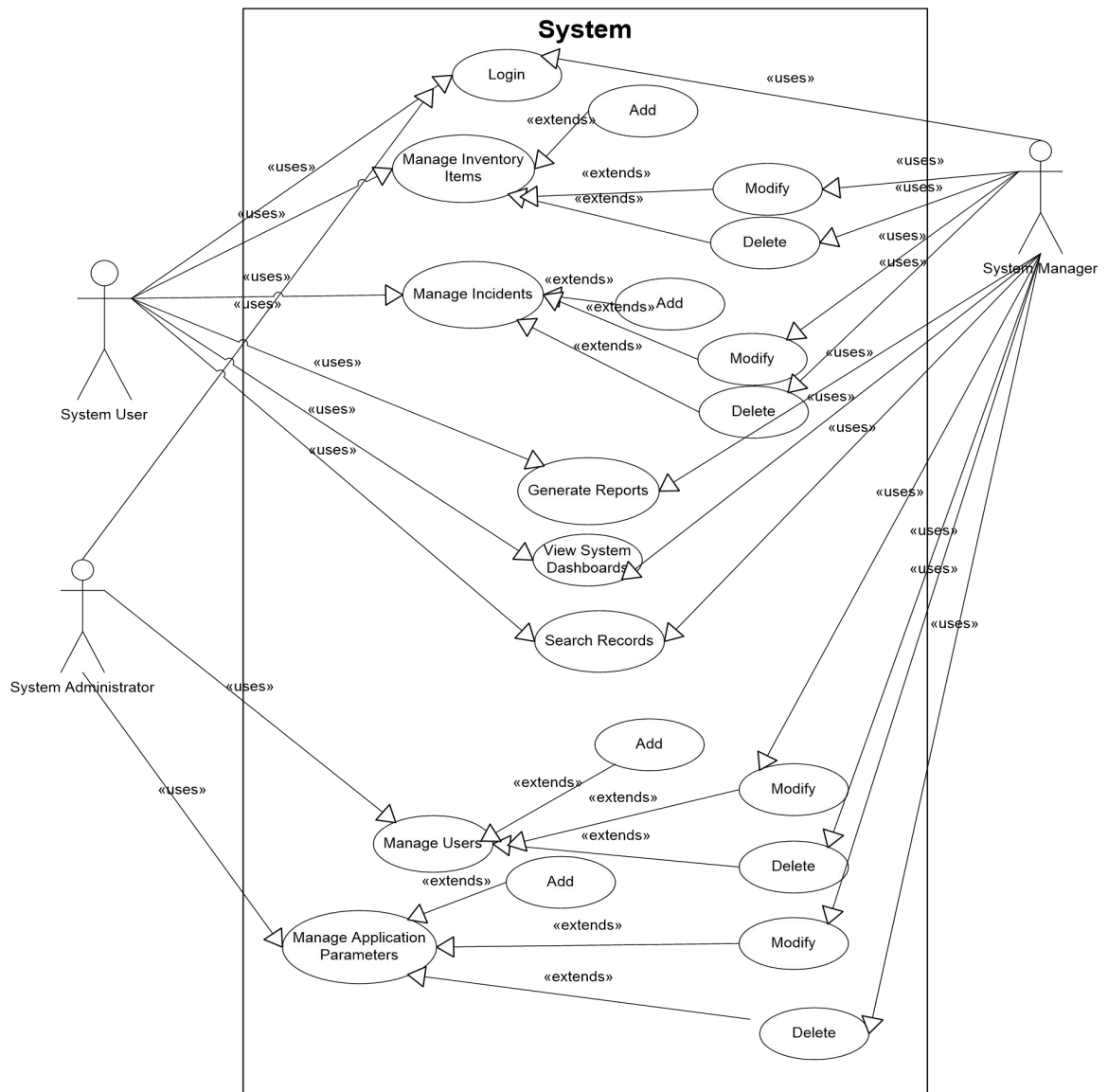


Figure 4.5 – User case Diagram

Above User Case Diagram Shows the User activities with the system boundary. All the types of users have to first validate their credentials and login in to the system. System Administrator will have the manage users and manage application parameters as specialized functions.

Then the system user will use the system for search, view , add , update and delete records. Update and Deletion of the records should be approved by system Manager before taken as valid record.

## 4.5 Class Diagram

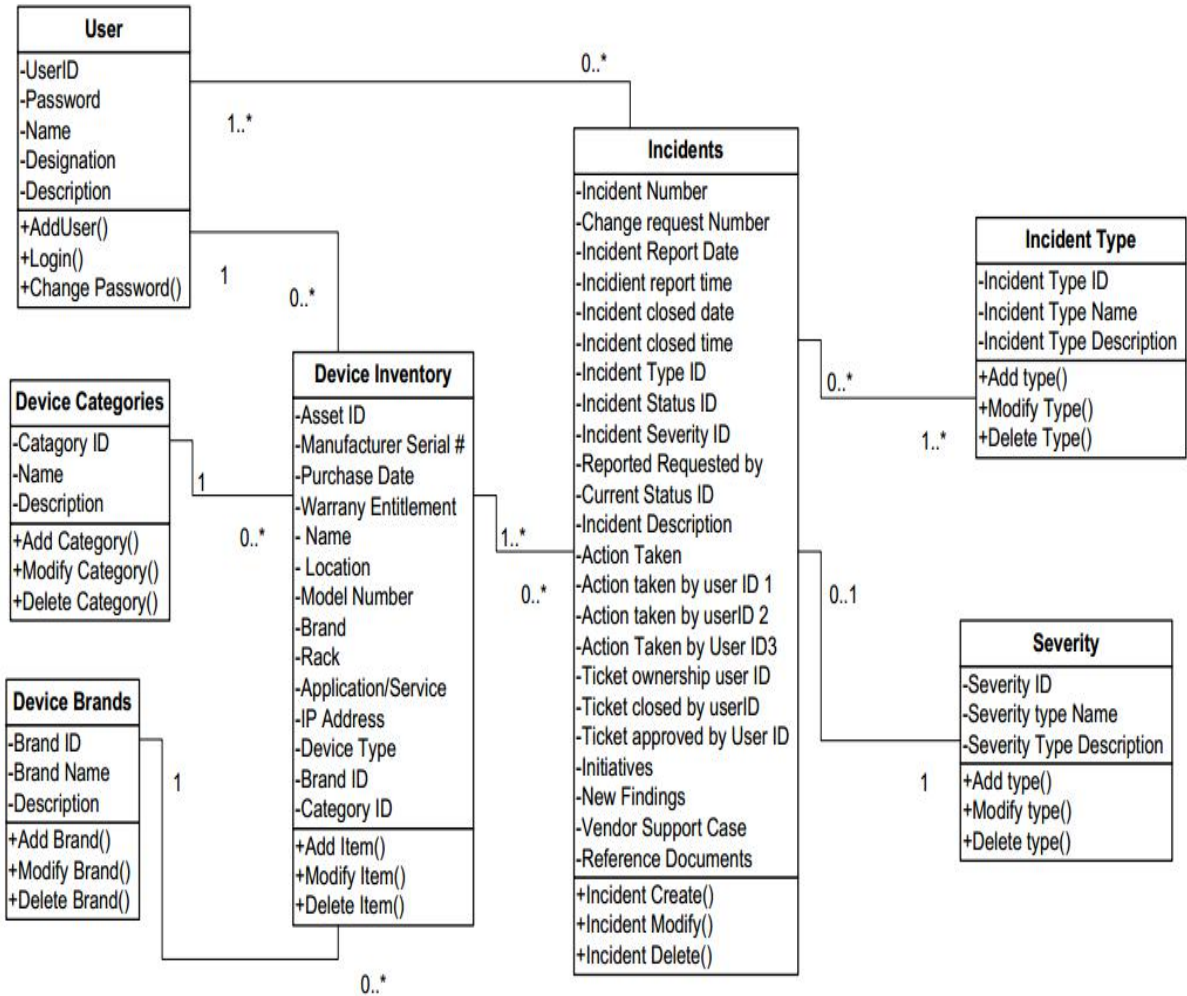


Figure 4.6 – Class Diagram

Class Diagram is showing the entities identifies in the system. Every Device Category can have none or many devices in the inventory. Any Such Device should belong to a single brand. A single brand can have zero or many devices. Add or modify details in to Inventory is done by a single user. However, handling the Incident can be done by one or many users. Every Incident is having an incident type or can be belong to few incident types.

## **Software and Database Setup**

The Database contains a master table for Inventory which will hold all the Information related to Datacenter Servers. This will be the unique name, Serial Number , Configuration Details, Location information, Warranty information, etc.

Warranty Processing and reporting of expired items and categorized reports for different types of items can be done.

Then there will be another table to keep Incidents listed. Incidents occurs for the items in the inventory, so the foreign key relationship established between two tables. Incident table consist of all the information related to the incident like date , time , type of issue, action taken and the engineer information who handles the incidents. It is used to generate reports on time based incidents, type based list of incidents and engineer wise work carried out and the work flow of incident follow up and confirmation of solution.

The system has another parameter tables which are used to keep system parameters like incident types, user role types , Datacentre item types. User table also kept in the database and currently the system user table authentication used.

Software has different modules for Inventory ,Incident Management , administration tasks ,setting up parameters and reporting

# **CHAPTER 5 – Implementation**

## **5.1 Introduction**

One of the most important phase of the development process is implementation according to the previous analysis and design. In this chapter it will describe the implementation environment (hardware/software), tools used, existing software components that is re-used and major code and module structures. System user interfaces are introduced in this chapter.

## **5.2 Implementation Environment**

Production Server: 2 Core, Intel Pentium Processor, 4GB Memory

Operating System: Windows Server 2012 Standard Edition

Test Environment: 2 Core, Intel Pentium Processor, 4GB Memory

Operating System: Windows 10

Development and Testing:

Visual Studio 2017 with C# Programming Language

Built in SQL Express Local DB as the Database

Microsoft Reports

Other Tools:

Chrome Web Browser, Adobe Photoshop

### 5.3 Visual Studio Community Version Overview

“**Microsoft Visual Studio** is an [integrated development environment](#) (IDE) from [Microsoft](#). It is used to develop [computer programs](#), as well as [web sites](#), [web apps](#), [web services](#) and [mobile apps](#). Visual Studio uses Microsoft software development platforms such as [Windows API](#), [Windows Forms](#), [Windows Presentation Foundation](#), [Windows Store](#) and [Microsoft Silverlight](#). It can produce both [native code](#) and [managed code](#).”

The Community edition was announced on 12 November 2014, as a new free version similar in functionality to Visual Studio Professional. Prior to this date, the only free editions of Visual Studio were the feature-limited Express variants. Unlike the Express variants, Visual Studio Community supports multiple languages, and provides support for extensions. Visual Studio Community is oriented towards individual developers and small teams

Visual Studio supports 36 different [programming languages](#) and allows the code editor and debugger to support (to varying degrees) nearly any programming language, provided a language-specific service exists. Built-in languages include [C](#),<sup>[6]</sup> [C++](#), [C++/CLI](#), [Visual Basic .NET](#), [C#](#), [F#](#),<sup>[7]</sup> [JavaScript](#), [TypeScript](#), [XML](#), [XSLT](#), [HTML](#) and [CSS](#) [6]”

### 5.4 About C# Programming Language

“Both C++ and C# are [object-oriented languages](#), although C++ is considered a harder language to work with. Both of them can be used in web and desktop applications, but C# is much more popular now for both applications. C++ is considered a more prestigious language used for applications such as games, operating systems, and very low-level programming that requires better control of hardware on the PC or server.

If your application is a simple web or desktop application, most developers will urge you to work with C# if it's their language of choice. If you want an application that works directly with computer hardware or deals with application development that C# is not efficient with, your developer will likely urge you to go with C++ [5].

A general rule of thumb is that web and desktop development is done using a higher level language such as C#. C# is a part of the [.NET language](#), which is especially targeted for web development, but it also works easily with a Windows-based program. Although Microsoft is trying to port their language to Linux systems, it's best to stick with C# and Windows environments [7].”

## 5.5 User Interfaces of the Application

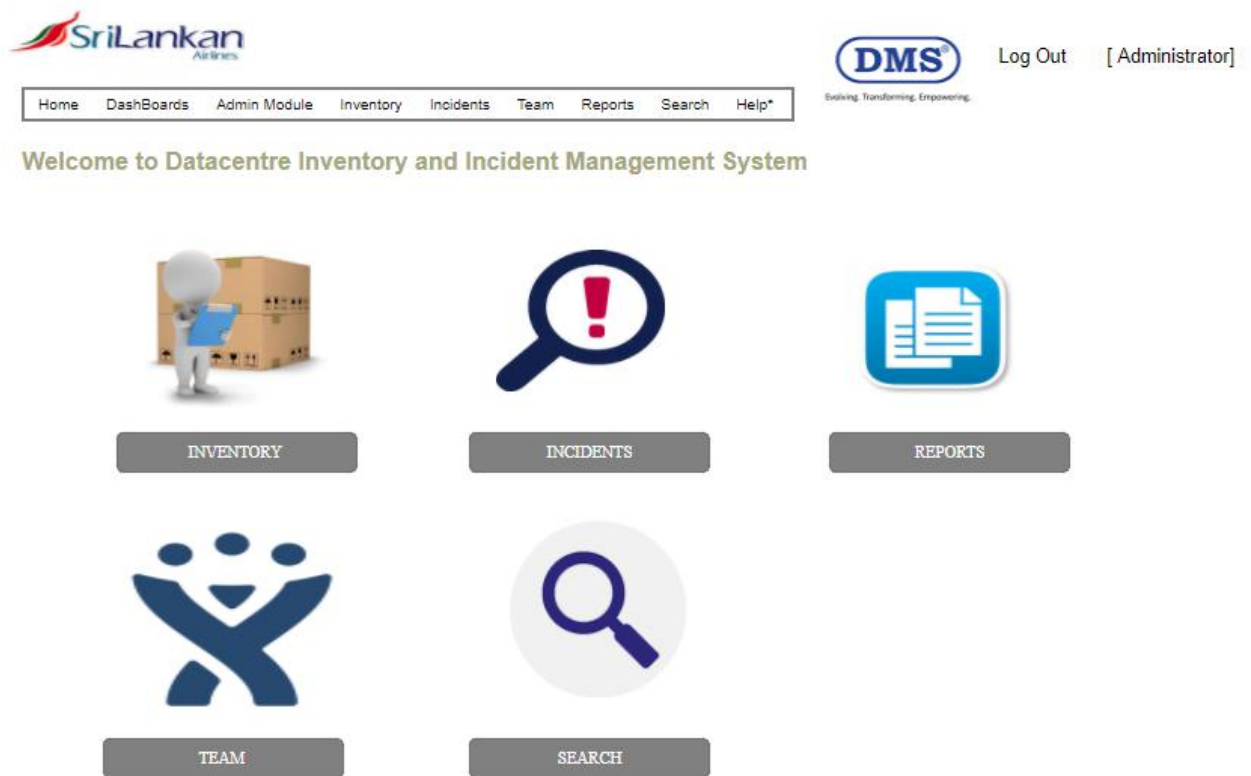


Figure 5.1 – Home Interface

ID	<input type="text" value="1"/>	Start date	<input type="text" value="26-Apr-15"/>	Close date	<input type="text" value="27-Apr-15"/>
		Start time	<input type="text" value="3:55:00 PM"/>	End time	<input type="text" value="12:40:00 PM"/>
Severity	<input type="text"/>	Incident_type	<input type="text" value="Failure"/>	Description	This problem was reported with HP regarding this disk purchased through DMS and re inserted as per HP's recommendations as this disk could not be ungrouped due to the
CR Number	<input type="text"/>	SLA_SCOPE 1	<input type="text" value="Failure"/>	Action taken	This problem was reported with HP regarding this disk purchased through DMS and re inserted as per HP's recommendations as this disk could not be ungrouped due to the lack of the disks of the particular disk group which owns this disk with error.
SLA_SCOPE 2	<input type="text" value="Suggestion_Innovative Idea"/>				

Figure 5.2 – Example of Configured Parameters for Incident Types


Incident Description		 DMS ELECTRONICS (PVT) LTD Developed by Prabath Tillekeratne	
Severity	<input type="text" value="Disk Failures"/>	Description	This problem was reported and a case logged with HP regarding this. This disk has not been purchased through DMS. Disk was pulled out and re inserted as per HP's recommendations as this disk could not be ungrouped due to the
Incident_type	<input type="text" value="Disk Failures"/>	Action taken	This problem was reported and a case logged with HP regarding this. This disk has not been purchased through DMS. Disk was pulled out and re inserted as per HP's recommendations as this disk could not be ungrouped due to the lack of the disks of the particular disk group which owns this disk with error. Then
CR Number	<input type="text"/>		
SLA_SCOPE 1	<input type="text" value="Disk Failures"/>		
SLA_SCOPE 2	<input type="text" value="EVA"/>		

Figure 5.3 – Example of Configured Parameters for 'Incidents related to' categories

Incidents Prabath Tilak involved					
SLA_SCOPE	Start date	Incident_type	Product Model	Description	Action taken
Disk Failure	26-04-2015	1 Failure	EVA8100 Storage	Informed By Data Center Operator Palitha about the Amber Colour LED Alert	This problem was reported and a case logged with HP regarding this. This disk has not been purchased through DMS. Disk was pulled out and re inserted as per HP's recommendations as this disk could not be ungrouped due to the lack of the disks of the perticular disk groupe which owns this disk with error. Then regrouped the disk to the groupe which owned the disk. Problem was solved then. This should be monitored further.

Page 1 of 1

Figure 5.4 – Sample Report of ‘Incidents Handled By Engineer Name’

## 5.6 User Interfaces of the Administration

The screenshot displays the administration interface of the DMS system. At the top, there is a navigation bar with the SriLankan Airlines logo on the left and the DMS logo with the tagline 'Building, Transforming, Empowering' on the right. The navigation menu includes links for Home, DashBoards, Admin Module, Inventory, Incidents, Team, Reports, Search, and Help\*. The main content area is titled 'ADMIN MODULE' and contains the instruction 'Use Below Options to Manage System Parameters'. Below this instruction are seven buttons representing different administrative functions: USER ADMINISTRATION, ASSET CATEGORY, INCIDENT CATEGORIES, INCIDENT STATUS TYPES, INCIDENTS RELATED TO, INCIDENT SEVERITY LEVELS, and CUSTOMER DETAILS. In the top right corner, there is a 'Log Out [ Administrator]' link.

Figure 5.5 – Administration Module



## CHAPTER 6 – Testing and Evaluation

This is the chapter that describing the testing methods and user evaluation details of the new Application. Test plans are included here. The sample tests carried out and the results of the tests are presented here. It is provided with a detailed system evaluation that includes evaluation methodology used, the user groups to evaluate and the results of the evaluation.

### 6.1 Scope and Objectives of the System Testing

Testing scope includes unit, integration, Validation, system and client acceptance testing approaches.

#### Unit Testing

“In [computer programming](#), **unit testing** is a [software testing](#) method by which individual units of [source code](#), sets of one or more computer program modules together with associated control data, usage procedures, and operating procedures, are tested to determine whether they are fit for use [8] ”

#### Integration Testing

“**Integration testing** (sometimes called **integration and testing**, abbreviated **I&T**) is the phase in [software testing](#) in which individual software modules are combined and tested as a group. It occurs after [unit testing](#) [9].”

#### Validation Test

“In [software project management](#), [software testing](#), and [software engineering](#), **verification and validation (V&V)** is the process of checking that a software system meets specifications and that it fulfills its intended purpose. It may also be referred to as [software quality control](#) [10].”

- User Requirements Specification validation
- User input / Authentication validation
- Verification for: Completeness, Correctness, Consistency
- Error Handling

All functional requirements and application performance will be tested as well as the end to end testing and testing of all interfaces of system will be done with the interaction of customers.

The objectives of the system testing are, to ensure that the system meets all functional requirements and non-functional requirements (quality requirements) and fit metrics for each quality requirement and satisfies the use case scenarios and maintain the quality of the product. And identify all issues and associated risks and ensure that all issues are addressed in an appropriate manner before the release of the system.

## 6.2 Features to be tested/Not to be tested

### 6.2.1 Features to be tested

Below table lists the features that will be tested during the evaluation period and summarized the basic test plan

<b>Features to be tested</b>	<b>Test Description</b>
<b>Login to the system</b>	This section tests the Login Interface of the system and validate the functionality
<b>Navigating Interfaces</b>	This test is to verify the different user levels ability to navigate through relevant user interfaces and the access the required authorized functions and relevant User Interfaces.
<b>Check GUI Functions and Operating Components</b>	Test the GUI and the operators functionality is included the following below tests (Buttons, Combo Boxes, Text Boxes , Navigation, etc)
<b>Adding Users to the Database</b>	Adding System Users and Customer Users to the database
<b>Adding Parameter to the system Database</b>	This test is conducted to check if a category of parameter is successfully added to the system and represents in the data entering screens for used when data enter in g in to such categories.

<b>Adding Devices to the Inventory Database</b>	This test is conducted to check if an item is successfully added to the system and displayed in reports and available in search results
<b>Adding Incidents to the Database</b>	This test is conducted to check if an incident is successfully added to the system and displayed in reports and available in search results
<b>Update and Delete Inventory and Incident Records</b>	This test will verify the functionality of database record updates and deletions . Check whether the records updated after the proper approval process.
<b>Generating Reports</b>	This test is to verify the anticipated results are available in the reports and the queries are functioning and providing valid outputs.

*Table 6.1 - Features to be tested*

### 6.2.2 Features not to be tested

<b>Predictions</b>	This system is only a prototype with limited set of data and prediction or analysing future growth, Future Incidents or Future Performance of Engineers is not available.
<b>Maximum Limits and Thresholds</b>	Current System is designed to use the SQL Express version with certain limitations, but due to the nature of prototype and the available records, the maximum growth and thresholds not tested. This Limits and Growth Requirements addressed in Future Enhancements Section.
<b>Ad hoc Information Requests and Requirements</b>	System is designed to provide pre agreed set of reports and parameters pre agreed. Curranty generating ad hoc queries and customizable reports is not supported and not to be done by average system user

*Table 6.2 - Features not to be tested*

\*\*Note: For detailed test cases and results, refer to Testing part in Appendices

### **6.3 Pass / Fail Criteria**

The main Intention of this evaluation steps is to see whether the intended functionality is there in the system and find faults in the system/component so that they can be addressed accordingly. Hence it is really mandatory to define the pass/fail criteria of the system to understand which sections of the system require a developer's focus. Here, in each of the test case, I define the Expected output as well as the actual result. After testing each test case with a variety of inputs, I can conclude the components are in a state to compare the expected result to the actual result received.

If the actual result in the document match with the expected test result, Conclusion of the test considered as pass and if the actual test result and the expected result vary, the test is Identified as fail. Whenever a test fails, It is required identify the which input/sequence of inputs caused the test to fail and therefore can identify with the root cause and the corrective measures so that the error does not repeat in the future.

### **6.4 Test Approach**

The tests carried out follow for the most part of the testing the unit testing strategy and to be more specific, Integration Testing. Testing with various different input values, scenarios in which the user can deal with the different system, interfaces and components, and test whether if the expected output matches the actual result of the tests being carried out. This will show the different errors/ behaviours and exceptions that can occur in the system/component with the different range of possible inputs.

For each input field/case I have considered some inputs that the user can mistakenly or purposely feed in which may create and erroneous situation which the system to break or the database inventory to unstable. The result of these tests will help me to know on which user input and validation the system crashes and thus preventive measures and corrections to be taken to prevent the any changes being submitted to the database for the incorrect inputs.

Further, during the testing, I also test if the correct user inputs are correctly updates to the database, cross checking if the data fields updated its target table at the correct time. This test will require all the user inputs to be valid to be successfully tested.

In this part, I choose to check if the user is able to access the components that are available and if the user is able to traverse through the GUIs without trouble.

## **6.5 User Evaluation and Feedback**

This Application was given to selected users from DMS Electronics Limited and Sri Lankan Airlines. Specially the application was targeted the Onsite Team of DMS Electronics Limited who stationed in Sri Lankan Airlines Datacentre. So, there are six engineers onsite and one manager onsite also used the application for testing. For Limited time period, the system users created for Sri Lankan Airlines staff from Datacentre Operations and System/Network Engineering teams to build the trust and confidence on the system and it will helpful to accept data or information provided by DMS onsite staff is accurate and timely. System Management Modules were given to DMS Electronics Limited Management for testing purposes.

After the User Acceptance tests completed, the system can be given to the engineering teams in Colombo DMS Electronics Limited Head office to use in their day to day activities in other enterprise e customer environments, subject to the parameter changes and customization of this application accordingly specific to different environments.

The sample users belong to various staff levels as operators, Engineers and Managers. All of them are from Professional backgrounds. User feedback was collected through questioners.

Most of the user comment was the system is easy to use and simple with required features up to the expected level. Simplicity and easy to learn is the most attractive part for test users.

According to the user feedback, the application has achieved the required satisfaction target.

*See Appendix: User Feedback Graphs*

## **CHAPTER 7 – Conclusion**

### **7.1 Overview**

From the beginning stage to the implementation point, the project was done in a methodological approach.

In view of that it was anything but difficult to plainly distinguish the end user needs and to give them what they required.

Knowing the product for sure clearly was a remarkable point to go for the right strategy for improvement and to have a abnormality free product toward the end. This dissertation is the proof of work done from the point of starting the project until the point when the customer / end user acknowledged expectations are given over to the customers. More details are incorporated into the appendices.

### **7.2 Lessons learnt during the project**

Throughout the time period spend for this project was a new thing in life with learning new things related to technology and human relationships, the nature of problems as an opportunity and how to find solutions in a methodological approach. Going beyond the task of learning a programming software subject, the analysing designing and implementing a real-world solution for real world burning issue is wonderful experience with different people with different views and opinions.

In a large scope of a problem. Selecting the appropriate sample from a large population and identify the problem and definitions through a literature review was really helpful in developing the pathway to solve the problem in the inception level. Defining the scope of the problem and the scope of the solution was very important for setting up the objectives for the project.

It was understood that the simplicity and the easy to learn manner of the system is really a factor looking by human by nature. People are by default not willing to take challenges and do changes from their comfortable zones. So, the introducing of the new application was well planned and communicated with highlighting the positive impact on their future prospects and what this system can do to enhance their day to day work life.

As a student from non-programming background, learning and experimenting the programming concepts and tools was not an easy thing, however I'm confident enough that by learning this subject and completing the project, a student can demonstrate the project managing capacity and the understanding of the project management concept which will be useful in all the lifetime manoeuvres rather than mastering a programming tool or language.

The Guidelines and the project management subjects taught the must to have knowledge on how to prepare a project document in professional way. This guideline and the practice with word processors, gained me a lifetime knowledge required for my future career projects.

### **7.3 Achievement of Objectives**

When it has come to an end of the project life cycle now it is time to go back to the beginning and check the outputs with the project goals and objectives to come to an idea that the project has

become a success. The unsatisfied team of onsite workers now has a tool with multi benefits for their day to day work life. Now They have improved their record keeping and updating facilities. On the other hand, the customer Sri Lankan Airlines now has more trust and confidence on DMS Onsite Team better than in history because they are now organized with a proper system with information readily available.

Most critical Infrastructure components are now in an inventory with all the incidents recorded and easy to find for future references.

Onsite Engineering team now has the evidences and systematic proof of what they have done to the company and the client as a knowledge worker, which can be useful for their annual reviews and the customer meetings, presentations.

## **7.4 Challenges Faced**

As I have been granted special approval to complete the project in my 5<sup>th</sup> Year in exceptional situation considering my request, it was a great happiness and challenge to complete the project within a short time. As I'm a newbie to software development and programming, it was again a difficult task to concentrate in learning a new area from the scratch. However, I'm confidence that following the project guidelines and completing the project, I have gained a good knowledge and experience on how a project is managed and the results are delivered to customer in more organized and evaluated manner and well documented in the systematic way which will helpful in my future career progress as a Head of Enterprise Infrastructure Solutions company.

## **7.5 Future Enhancements**

### **Current System Limitations**

Current System is not capable of automated workflow. So the incident closure , Inventory changes , are not automatically triggers for the approval. Its a manual process to see what are the unapproved changes and review.

This system is on premise installation within the Sri Lankan Airlines. However as a service provider like DMS Electronics Ltd, If it is cloud based, DMS Service desk in Colombo can centrally monitor and get alerted of incidents.

This application not capable of listening to hardware generated alerts through health / network monitoring protocols like SNMP.

Currently this system is not integrated with the call centre.



## **Enhancements for Future**

As next phase of development. The following enhancements will be useful and will be beneficiary to both the clients and the service providers like DMS Electronics Ltd. DMS is offering onsite support and implementations for many Large, small and medium enterprise businesses, so they can bundle this application with their solutions as a value addition which will be gain the competitive advantages over their competitors.

- Hots in a cloud environment with multi-tenant feature for various customers. Then the easy access from anywhere for anyone will be a massive advantage, Then DMS Management and the Customer Management can see the current situation real time
- Need to study and add the functionality of auto discovering Datacentre equipment using network monitoring protocols like SNMP.
- Need to study and add the functionality of auto creation of alerts of Datacentre devices through SNMP and other health Monitoring protocols
- It will be useful to add the call centre/ service desk application as an added option
- Improve the dashboards and reports with more graphical and attractive ways to the end user.

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## Appendix: Sample test cases with test data and test results

### 1. Test Case 1 : Login Testing

<b><u>Test Case ID</u></b>	<b><u>Input</u></b>	<b><u>Purpose</u></b>	<b><u>Output</u></b>	<b><u>Result</u></b>
1.1	Enter with Empty User Name and Password	Login Testing	Error Message: User name or password cannot be blank	Passed
1.2	Enter with either Empty User Name or Password	Login Testing	Error Message: User name or password cannot be blank	Passed
1.3	Invalid User Name and Password	Login Testing	Error Message: Login Details Incorrect	Passed
1.4	Valid User Name and Incorrect Password	Login Testing	Error Message: Login Details Incorrect	Passed
1.5	Valid User Name and correct password	Login Testing	Message: Logged in successfully	Passed
1.6	Check the User Interface	User Interface Testing	Checked all the User Interface Elements Functionality	Passed

*Table 8.1 - Login Testing*

2. Test Case 2 :Admin Module Testing

<b><u>Test Case ID</u></b>	<b><u>Input</u></b>	<b><u>Purpose</u></b>	<b><u>Output</u></b>	<b><u>Result</u></b>
2.1	Login Using Non-Administrator Role User	Access Rights Testing	Error Message: User have no rights for the module	Passed
2.2	Login Administrator Role User	Access Rights Testing	User can successfully access the module	Passed
2.3	Empty Filled parameters fields	Functionality Testing	Error Message: Please fill all necessary fields	Passed
2.4	All the Fields filled correctly	Functionality Testing	Message: Updated Successfully Can see the updated system parameters when check later	Passed
2.5	Invalid inputs and characters not appropriate to the field	Validation testing	Error Message: Invalid Details entered.	Passed
2.6	Check the User Interface	User Interface Testing	Checked all the User Interface Elements Functionality	Passed

*Table 8.2 - Admin Module Testing*

### 3. Test Case 3 : Inventory System Testing

<b><u>Test Case ID</u></b>	<b><u>Input</u></b>	<b><u>Purpose</u></b>	<b><u>Output</u></b>	<b><u>Result</u></b>
3.1	Checked whether the required System Parameters available for data entering	Functionality Testing	Checked all the category types, Incident Types, Severity Types, Incident Related to types, User Types, and all the other pre-defined system parameters set in previous test stage	Passed
3.2	Empty Filled parameters fields	Functionality Testing	Error Message: Please fill all necessary fields	Passed
3.3	All the Fields filled correctly	Functionality Testing	Message: Updated Successfully Can see the updated records when check later	Passed
3.4	Invalid inputs and characters not appropriate to the field	Validation testing	Error Message: Invalid Details entered.	Passed
3.5	Search by Keyword	Functionality Testing	Search Results successful	Passed
3.6	Edit / Delete Records	Functionality Testing	Verify the updated records there in the database and the deleted records are removed from the database	Passed
3.7	Check the User Interface	User Interface Testing	Checked all the User Interface Elements Functionality	Passed

*Table 8.3 - Inventory System Testing*

#### 4. Test Case 4: Incident System Testing

<b><u>Test Case ID</u></b>	<b><u>Input</u></b>	<b><u>Purpose</u></b>	<b><u>Output</u></b>	<b><u>Result</u></b>
4.1	Checked whether the required System Parameters available for data entering	Functionality Testing	Checked all the, Incident Types, Severity Types, Incident Related to types, User Types, and all the other pre-defined system parameters set in previous test stage	Passed
4.2	Empty Filled parameters fields	Functionality Testing	Error Message: Please fill all necessary fields	Passed
4.3	All the Fields filled correctly	Functionality Testing	Message: Updated Successfully Can see the updated records when check later	Passed
4.4	Invalid inputs and characters not appropriate to the field	Validation testing	Error Message: Invalid Details entered.	Passed
4.5	Search by Keyword	Functionality Testing	Search Results successful	Passed
4.6	Edit / Delete Records	Functionality Testing	Verify the updated records there in the database and the deleted records are removed from the database	Passed
4.7	Check the User Interface	User Interface Testing	Checked all the User Interface Elements Functionality	Passed

*Table 8.4 - Incident System Testing*

5. Test Case 5 : Generating Reports

<b><u>Test Case ID</u></b>	<b><u>Input</u></b>	<b><u>Purpose</u></b>	<b><u>Output</u></b>	<b><u>Result</u></b>
5.1	Empty parameters fields	Functionality Testing	Error Message: Please fill all parameters required to query the report results	Passed
5.2	All the Fields filled correctly	Functionality Testing	Message: Report Generated Successfully	Passed
5.3	Invalid inputs and characters not appropriate to the requested parameter	Validation testing	Error Message: Invalid Details entered.	Passed
5.4	Check the User Interface	User Interface Testing	Checked all the User Interface Elements Functionality	Passed
5.5	Generate All the Reports	Functionality Testing	For All the Reports repeat above tests	Passed

*Table 8.5 - Reports Testing*

## Appendix: User Evaluation Questionnaire

Name:

Designation:

Age:

Sex:

Email:

- Comparing to other software I have used, I found this application to be:

**Very difficult to use 1 ... 2 ... 3 ... 4 ... 5 ... 6 Very easy to use**

- The User Interfaces and Menu Items organized and easy to get familiar

**Strongly disagree 1 ... 2 ... 3 ... 4 ... 5 ... 6 Strongly agree**

- It is easy to understand each of menu items

**Strongly disagree 1 ... 2 ... 3 ... 4 ... 5 ... 6 Strongly agree**

- All of the required functions and options are available and working

**Strongly disagree 1 ... 2 ... 3 ... 4 ... 5 ... 6 Strongly agree**

- The buttons were well designed and aligned , easy to use.

**Strongly disagree 1 ... 2 ... 3 ... 4 ... 5 ... 6 Strongly agree**

- Navigating around the Application screens are



Very difficult 1 ... 2 ... 3 ... 4 ... 5 ... 6 Very easy

- Ultimate experience and impression of the Application is

Very negative 1 ... 2 ... 3 ... 4 ... 5 ... 6 Very positive

- Would you like to support use and be a tester for future enhancements and Usability?

Yes No

### User Feedback Graphs

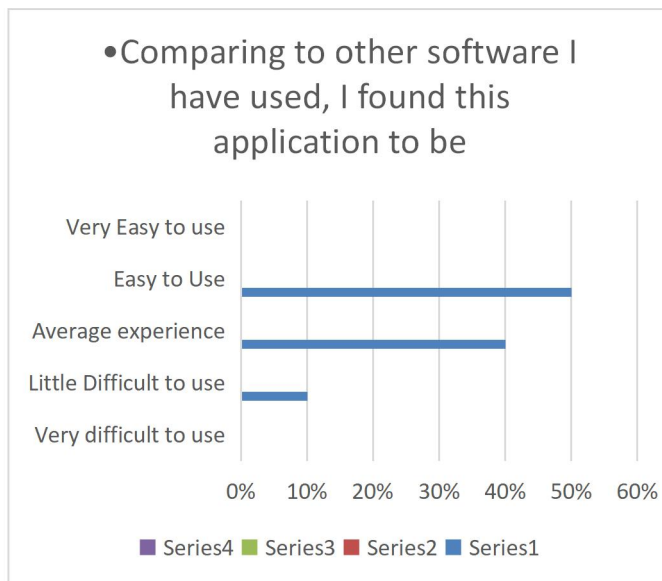
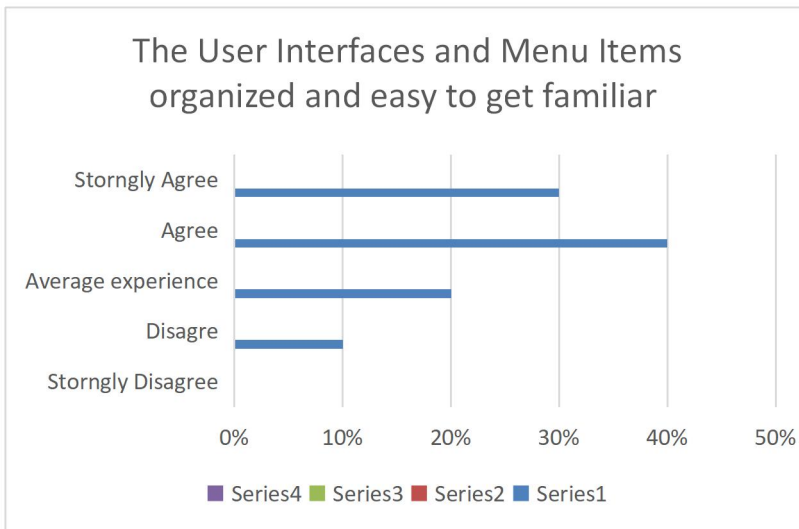
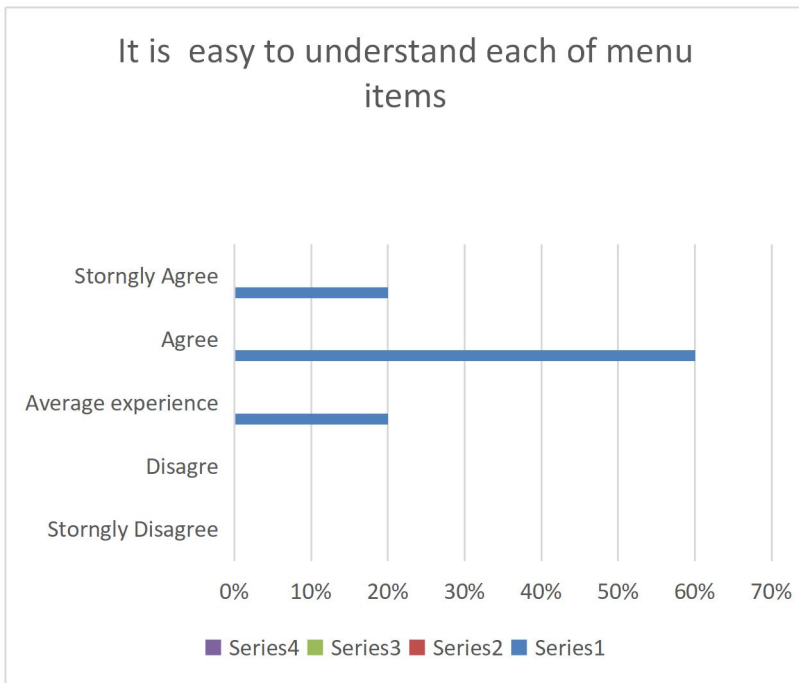


Figure 8.1 – User Evaluation Survey Results 1



*Figure 8.2 – User Evaluation Survey Results 2*



*Figure 8.3 – User Evaluation Survey Results 3*

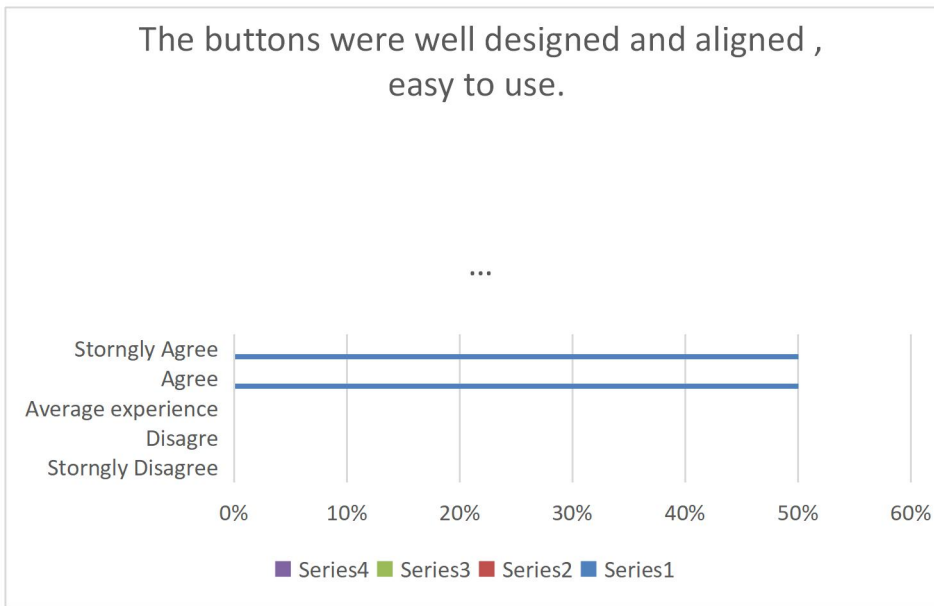


Figure 8.4 – User Evaluation Survey Results 4

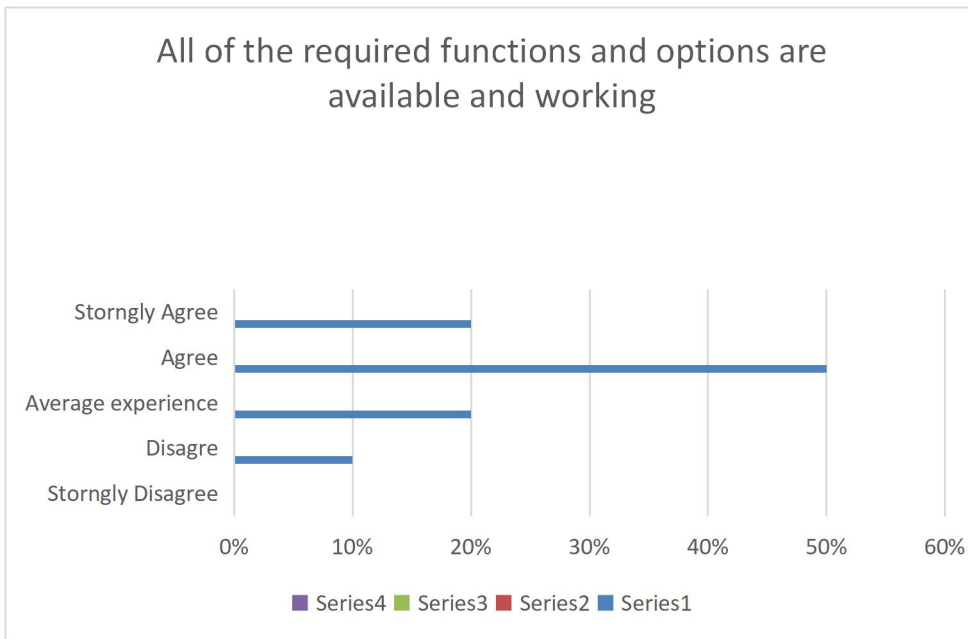


Figure 8.5 – User Evaluation Survey Results 5

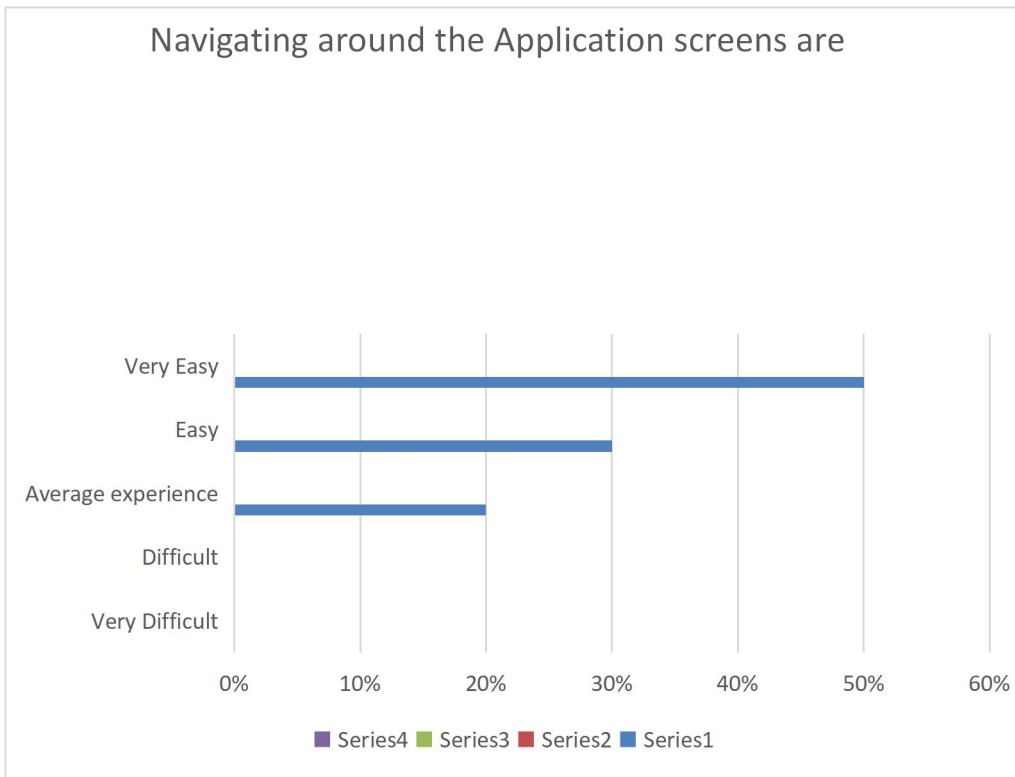


Figure 8.6 – User Evaluation Survey Results 6

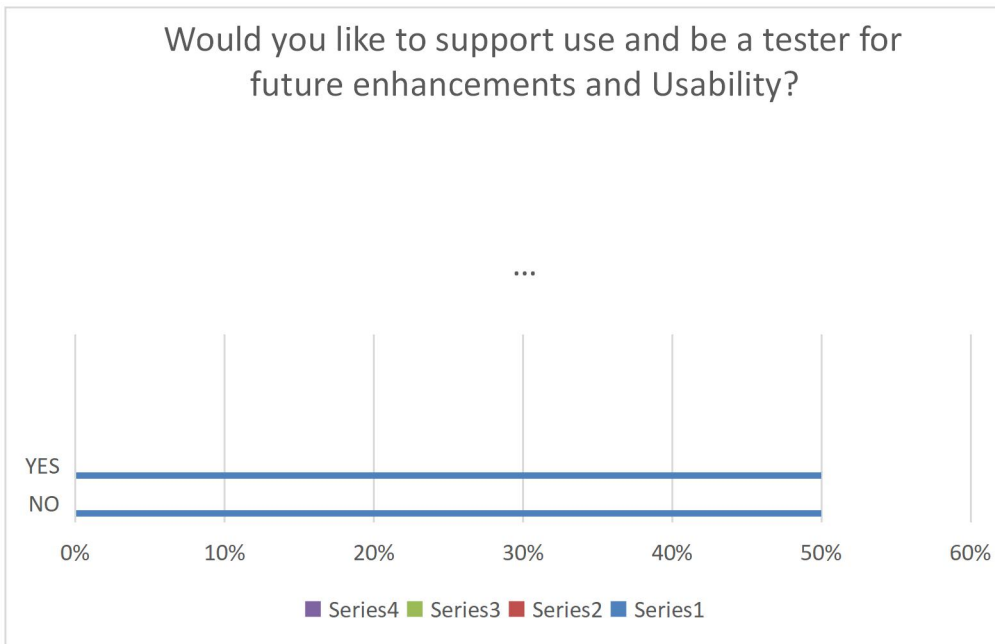


Figure 8.7 – User Evaluation Survey Results 7

