



Masters Project Final Report

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Web Based Corrective Maintenance Management System for OZ Cleaning (PVT) LTD.

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

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University of Colombo School of Computing

2017



Declaration

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

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

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This is to certify that this thesis is based on the work of Mr. H. D. D. S. Amarasekara under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

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Abstract

OZ Cleaning (PVT) LTD Company is a maintenance service providing company in Australia, managed by qualified highly skilled staff. They mainly focus on providing corrective maintenance service to the business organizations such as office blocks, arenas, schools, sporting complexes, convention centers, and hospitals.

This Company is in primitive stage in the technology perspective as there was no proper mechanism to handle their business operations. Since the establishment of the company, all the information maintenance activities are manually done. When considering about their business process we were able to identify that information technology can make a huge impact to improve the efficiency of their business activities more effective and efficient manner.

The implemented system is a web application, and it facilitates for almost all business processes happening within the company and will help to maintain information integrity and up to date information. This system consisted of two main applications called company application and client application. Client Application directly involve with the business clients and it facilitates to manage their maintenance work requests. Major components of client application are, information center, user profile, and work request manager. The major operation of company application is process the client work requests. User profile, user manager, client manager, duty manager service manager, location manager, and administration are main components of the Company application. Both client application and Company application help to improve the productivity, decision making process and quality of services provided by the OZ Cleaning (PVT) LTD in order to find new business opportunities and achieve their business goals.

This web application is adapted model view control architecture with object oriented environment. The system is being developed using Microsoft Visual Studio 2010 integrated development environment and Microsoft SQL Server 2005 as the database server. All server side scripting is written in C#.net. Backend controllers, classes and model classes are written in C#.net and javascript and jquery were used to write client side scripts in .NET Framework. Apart from that online UML tool is being used to draw UML diagrams.

Because of the used development architecture and technologies, system could achieves high throughput, short response time, low utilization of computing resources and high availability of the application.

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List of Abbreviations

AJAX - Asynchronous JavaScript and XML

ASP - Active Server Page

CSS - Cascade Style Sheet

DBMS - Database Management System

ERD - Entity Relationship Diagram

GUI - Graphical User Interface

HTML - Hyper Text Markup Language

IDE - Integrated Development Environment

IIS - Internet Information Services

JSON - JavaScript Object Notation

MIS - Management Information System

MVC - Model, Viewer, Controller

OOD - Object Oriented Design

OS - Operating System

SCADA -Supervisory control and data acquisition

SDLC - System Development Life Cycle

SQL - Structured Query Language

UML - Unified Modeling Language

XML - Extensible Markup Language

CHAPTER 1: Introduction

1.1 Introduction

Today companies are spending large amount of money for their building facilities and related equipments. Therefore they need to maintain those facility related equipments systematic way. Based on this scenario facilities management industry has been developed. The basic idea of facilities management is an interdisciplinary field devoted to the coordination of space, infrastructure, people and organization, often associated with the administration of office blocks, arenas, schools, sporting complexes, convention centers, shopping complexes, hospitals, hotels, etc. [1].

Major objectives of facilities management is listed below

- Maintain a comfortable environment that is suitable for its intended purpose
- Ensure health and safety of the property
- Perform preventive maintenance on the facility
- Promote building-wide energy efficiency

Without achieving these aspects of facilities management a business may face many overheads in correcting those to make a better environment for the core businesses. Most of the companies have separate division to manage facility related maintenance activities. Eg. They may have following hierarchical Staff.

- Facility Manager
- Engineer
- Technicians
- Maintenance Support staff.
- Vendors.

They will carry out several maintenance activities, such as

- Corrective Maintenance
- Preventive Maintenance
- Predictive Maintenance.

In this Project only corrective maintenance is considered and equipment based Maintenance activities have been taken into consideration.

Client / Customer for the Project

OZ Cleaning PTY LTD is maintenance service providing company. They are provide various building maintenance related services. eg: Corrective maintenance, Cleaning

Business Address:

OZ Cleaning PTY LTD,
4,Wallace Avenue,
Dandenong,3175,
Victoria,
Australia.

Corrective Maintenance

Corrective or Breakdown maintenance implies that repairs are made after the equipment is failed and cannot perform its normal function anymore. Besides the equipment based Maintenance there is another area for non-equipment based maintenance.

Equipment not related Maintenance Activities

- Plumbing.
- Cleaning.
- Furniture Repairing.

In order to provide good quality corrective maintenance service they need logical flow to control their day to day operations.

Day to day Main Operations

- Create maintenance work request by tenants or staff.(Maintenance Request)
- Create work order for the work request.
- Create follow-up work orders for incomplete work orders.
- At the end of the day facility manager wants to know the status summary of work orders and work requests required for decision making.
- It is required to provide information about work request with respect to the relevant customers in tenancies.
- Evaluate whether the technicians are completed the assigned work orders within the SLA time.(Service Level Agreement Time is Predefine Time for Work Orders Based on their Service Categories).

1.2 Problem Description and Motivation

Currently “OZ Cleaning PVT LTD” company uses manual System to handle above operations. Manual process is always time consumed and inefficient and human erred. The historical data need to be kept manually and difficult in using the data as per the requirement of management. In manual maintenance process the customer always need to contact FM team or the responsible to report any request or correction and it creates extra stress on customer.

Issues in manual Corrective Maintenance Management Process

- Take more time to prepare reports.
- Overheads are very high.
- Information integrity is very low.
- Take more time for duty assignment.
- Communication among each level is time consuming.
- Difficult to take decisions.

1.3 Aims and Objectives

The objective is to design and automate all the manual processes and develop efficient web base Corrective Maintenance Management system for OZ Cleaning (Pvt) Ltd.

Key Objectives of the proposed System

- Develop a logical flow to control day to day Maintenance Operations.
- Build Proper communication Channel among the Maintenance Team.
- Handle Tenant Work Request and Work Orders in systematic way.
- Develop duty Roster and People Management.
- Track Employee Performance.

1.4 Scope

The scope of the project would be to develop web base Corrective Maintenance Management system to achieve the above mentioned objectives. Figure 1.1 elaborates the scope very clear.

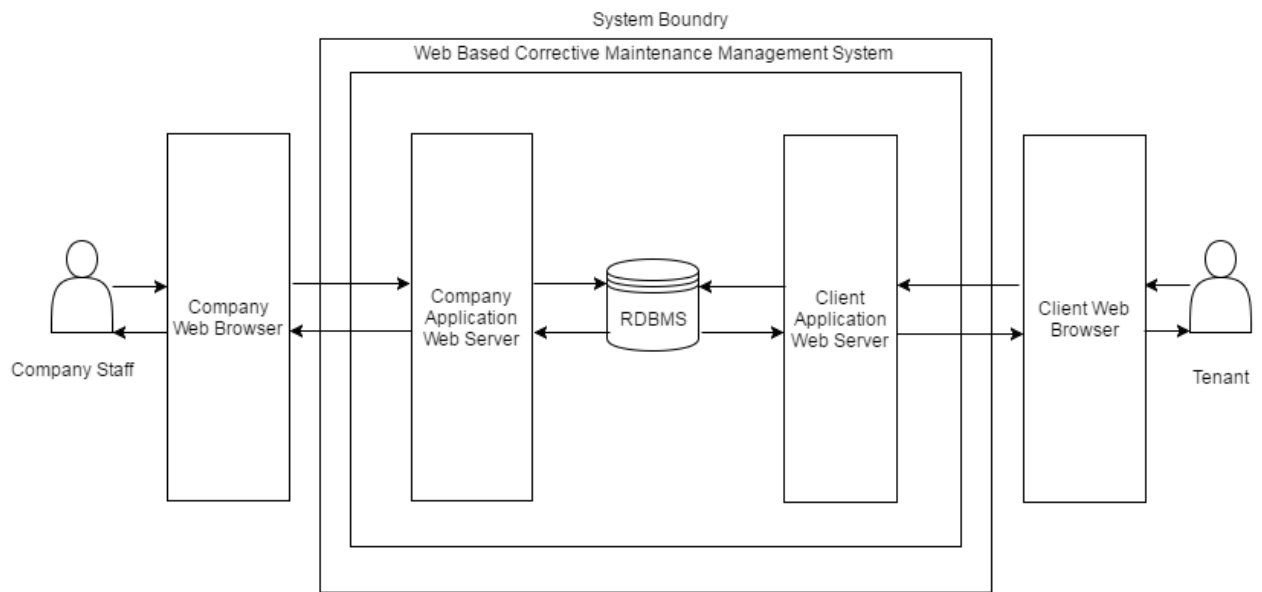


Figure 1.1: Scope of the system

The scope of project determined according to the user requirements, time constraints and available resources. This proposed Web Based Corrective Maintenance management system has main two applications that are,

1. Company Applications: This application facilitates to handle all the work requests created by the business client, allow to register work orders with respect to a work

request and all the administrative functions of the OZ Corrective Maintenance Application.

2. Client Applications: This application facilitates business client to Register Work request, provide feedback for the completed work request and allow to view work request created themselves.

1.5 Structure of the Report

This report consists of six main chapters including current chapter. Current chapter is the introduction which giving the overall picture of this Corrective Maintenance Management Application of the OZ Company. The structure of the report is as follows:

Chapter 2: Background

This chapter explains the review of similar systems available and technologies available and relevant to implement the system. And also this chapter identifies the alternative technologies that are available for implementation with their pros and cons.

Chapter 3: Analysis and Design

Mainly this chapter is divided into two sections called analysis section and design section. The analysis section describes about what are user requirements and techniques used to gather those requirements. Basically this section provides the information about the high level user requirements in analytical way.

The design section describes how analysed requirements in the previous analysis section have been transformed in to the physical and logical design in the system through UML diagrams.

Chapter 4: Implementation.

Development process of designed system will be done within this phase. Furthermore, the developing environment, tools and technologies and coding standards will be described within this chapter.

Chapter 5: Evaluation and Testing.

This chapter elaborates the major test plan of the project, test cases that are going to use for test each module of the system, test data and test results received from testing process. Accomplishment of system requirements will also be evaluated within this phase. User evaluation is also done in this section.

Chapter 6: Conclusion & Future Work.

This chapter contains the conclusion and the future improvements to the system.

CHAPTER 2: Background

This chapter explains the review of similar systems available and technologies available and relevant to implement the system. And also this chapter identifies the alternative technologies that are available for implementation with their pros and cons.

2.1 Similar Applications and Articles

There are lots of maintenance management related software applications available on market. They are provide various user friendly features and work flows to cater the industry needs. In this section discussed few Maintenance Management software products.

2.1.1 ManWinWin by ManWinWin Software

User-friendly software Application, it is very simple to set up and start ManWinWin Software has almost 30 years of experience and know-how in maintenance management. Organize a complete equipment inventory, manage daily preventive, corrective, other, work with alerts, control maintenance costs, track all maintenance history, record and attend maintenance requests, keep record of spare parts used, stock management and purchasing spares or services. Ideal for SMEs: industrial plants of any type, ships, ports [2][3].

Following features are available on this software

- Asset tracking
- Calibration Management
- Inventory Control
- Mobile Access
- Planning calendar
- Preventive Maintenance
- Purchasing
- Scheduling
- Service History Tracking
- Work Order Management

Product Details

- Starting Price: \$5900.00 / One Time
- Free Trial: Yes
- Deployment: Cloud, SaaS, Web, Installed Windows
- Training: Documentation / In Person
- Support: Online /Business Hours

Vendor Details

- Vendor Name: ManWinWin Software
- URL: <http://www.manwinwin.com/>
- Founded 1981
- Country: Portugal

2.1.2 Fiix

Formally Maintenance Assistant. Fiix is your fastest path to better maintenance. Its cloud-based maintenance and asset management software that has helped thousands of customers globally establish preventive maintenance strategies. Completely customizable, mobile, and instantly available through the cloud, Fiix is a flexible solution for organizations of all sizes [4] [5].

Following features are available on this software

- Asset tracking
- Inventory Control
- Planning Calendar
- Preventive Maintenance
- Purchasing
- Scheduling
- Service History Tracking
- Technician Management
- Work Order Management

Product Details

- Starting Price \$29.00/month/user
- Free Version are available
- Free Trial Versions are available: Yes
- Deployment: Cloud, SaaS, Web

- Training: Documentation, Webinars, Live Online, In Person,
- Support: Online, Business Hours

Vendor Details

- Vendor Name: Fiix
- URL: www.fiixsoftware.com/
- Founded 2008
- Country: Canada

2.1.3 UpKeep by UpKeep Maintenance Management

UpKeep's Maintenance Management System is a modern, user-friendly, cloud based, and asset management solution available under the Maintenance management software products. From your desktop to your phone and even your tablet, UpKeep is easily accessible from anywhere at any time. Create work orders on-the-go, get notifications when tasks are updated, and receive alerts straight from your app when assets go down making your business run more efficiently than ever before[5][6].

Following Features are available on this software

- Asset Tracking
- Billing & Invoicing
- Inventory Control
- Mobile Access
- Planning Calendar
- Preventive Maintenance
- Scheduling
- Service History Tracking
- Technician Management
- Work Order Management

Pricing Details

- Starting Price \$25.00/month/user (\$25 per user per month when billed annually)
- Free Version and trial versions are available.

Deployment

- Cloud, SaaS, Web
- Mobile - Android Native
- Mobile - iOS Native
- **Training**
- Documentation
- Live Online

Support

- Online
- Business Hours

Vendor Details

- Vendor Name: UpKeep Maintenance Management
- URL: www.onupkeep.com
- UpKeep Maintenance Founded 2014
- United States

2.1.4 Rosmiman IWMS

Rosmiman IWMS is a Facility Management & Real Estate Management software. It facilitate to control and manage the entire real estate and facilities life cycle, including maintenance planning and control, mobile solutions and integration with CAD, GIS, BIM and financial systems. They offer a comprehensive Asset Management software suite that has been designed and programmed to easily cover all your organizations real estate portfolio maintenance and management needs regardless of its industry or size. This software facilitate to directly transfer work orders to the subcontracted maintenance service providing companies. Rosmiman IWMS reduces the downtime through the Effective Planning [7] [8].

Following features are available on this software.

- Asset Tracking
- Commercial Properties

- Customer Database
- Dispatch Management
- Equipment Management
- Job Costing
- Job Management
- Maintenance Scheduling
- Residential Properties
- Routing
- Scheduling
- Work Order Management

Product Details

Deployment:

- Cloud, SaaS, Web
- Installed - Mac
- Installed - Windows
- Mobile - Android Native
- Mobile - iOS Native

Training

- Documentation
- Webinars
- Live Online
- In Person

Support

- Rosmiman IWMS provide 24/7 Online support

2.1.5 eFACiLiTY®

eFACiLiTY® is a facility management software package, It contain collection of software modules eg: Maintenance Management System, Help Desk and knowledge base management , Visitor Management, Facility Booking System, Time and attendance System, Space Management System, Building Management System Integration etc[9].

eFACiLiTY® -Maintenance Management System contain following functionalities.

- Track, maintain and manage your Assets
- Multi site, multi organization and multi level asset tree
- Generate and manage preventive & breakdown maintenance work orders
- Vendor, Contractor and SLA management
- Extensive inventory / stores module to manage spare parts
- User friendly performance dashboards (KPIs) and 250+ preconfigured reports

2.1.6 Maintenance-Pro

Vendor Name: IMS

Maintenance –Pro is another product available in the market, which is design to track maintenance of non vehicle items such as buildings, tree farms, vessels, computers, copy machines, sanitation equipment, etc. Maintenance-Pro is a customizable software package and it has three versions (standard, Deluxe , Professional). This applications facilitates to enhance productivity and improves analysis of your data with graphs and statistical reports [10].

Their product has following futures

- Asset Tracking
- Preventive Maintenance
- Repair Maintenance
- History Recording
- Maintenance Notification
- Work Orders
- Reporting

2.1.7 iVivaCloud

Vendor name–Eutech Cybernetics

First, is a metadata integration framework that greatly simplifies the integration of multiple management silos; these silos, which exist across the Workplace, create barriers to information sharing, employee collaboration and workplace productivity. Regardless of whether it is an intelligent building system, an enterprise application, a communication device or IT network, iVivaCloud eliminates the barriers and brings all your disparate management systems and applications onto a single operating environment [11].

Iviva cloud is smart workplace management solution. They have following product applications.

- Asset Management
- Integrated building management system
- Incident Management
- Maintenance Management
- Space Management
- Facility Booking
- Energy Management

Their integrated Maintenance Management application allows client to take full control of all maintenance requirements from creating preventative maintenance plans, to generating work orders, to assigning resources, right through to tracking service levels, to ensure uninterrupted functionality of related workflows.

2.2 Available Alternative Development Technologies and Frameworks

There are several development technologies and frameworks available for developing a web base application. In this section it has been mentioned that most available and suitable technologies and frameworks with their pros and cons. It has been identified following major two of alternative technologies and frameworks that suitable to proposed system.

1. Java with J2EE Platform
2. Microsoft .Net Framework with C#

2.2.1 Java with J2EE Platform

Java Platform, Enterprise Edition (Java EE) is the standard in community-driven enterprise software. Java EE is developed using the Java Community Process, with contributions from industry experts, commercial and open source organizations, Java User Groups, and countless individuals. Each release integrates new features that align with industry needs, improves application portability, and increases developer productivity. Today, Java EE offers a rich enterprise software platform [12].

There are several frameworks under this J2EE platform to develop a web application. EJB and Spring & Hibernate are major powerful platforms. Brief descriptions with their pros and cons have been mentioned below.

Enterprise Java Beans (EJB)

It is development architecture for building highly scalable and robust enterprise level applications to be deployed on J2EE compliant Application Server such as JBOSS, Web Logic etc.

Spring & Hibernate

Spring framework is an open source Java platform that provides comprehensive infrastructure support for developing robust Java applications very easily and very rapidly [13].

Hibernate is an Object-Relational Mapping(ORM) solution for JAVA and it raised as an open source persistent framework created by Gavin King in 2001. It is a powerful, high performance Object-Relational Persistence and Query service for any Java Application. [14].

A good comparison has been mentioned below 2.1 table with pros and cons of using J2EE platform in development environment.

Pros	Cons
Runs on any operating system and application server (may need adjustments)	Has a complex application development environment
Handles complex, high- volume, high-transaction applications	Tools can be difficult to use
Has more enterprise features for session management, fail-over, load balancing and application integration	Java Swing environment's ability to build graphical user interfaces has limitations
Is favoured by experienced enterprise vendors such as IBM, BEA, SAP and Oracle	May cost more to build, deploy and manage applications
Offers a wide range of vendor choices for tools and application servers	Lacks built-in support for Web services standards
Has a proven track record	Is difficult to use for quick-turnaround, low-cost and mass-market projects

Table 2.1: Pros and cons of using J2EE platform in development environment [15].

2.2.2 Microsoft .Net Framework with C#

The Microsoft .Net Framework is a platform that provides tools and technologies that need to build Networked Applications as well as Distributed Web Services and Web Applications. Once it installs .NET Framework, it creates the required software environment so that it can provide the appropriate runtime requirements to the software. It supports both Windows and web applications. .NET provides an object oriented environment. It ensures safe execution of the code by performing required runtime validations. Numbers of sub development frameworks and architectures are included with several programming languages in this .net framework. A good comparison has been mentioned below with pros and cons of using .net framework in development environment.

Pros	Cons
Easy-to-use tools may increase programmer productivity	Framework runs only on Windows, restricting vendor choice
Has a strong framework for building rich graphical user interfaces	Users of prior Microsoft tools and technology face a potentially steep learning curve
Gives developers choice of working in more than 20 programming languages	New runtime infrastructure lacks maturity
Is tightly integrated with Microsoft's operating system and enterprise server software	Questions persist about the scalability and transaction capability of the Windows platform
May cost less, due in part to built-in application server in Windows, unified management, less expensive tools	Choice of integrated development environments is limited
Has built-in support for Web services standards	Getting older applications to run in new .Net environment may require effort

Table 2.2: Pros and cons of using .net framework in development environment [16].

Under the .NET Framework it has provided several platforms to develop web applications like ASP .NET Web Forms, ASP .NET MVC, SilverLight, WCF and WPF. Therefore major two kind of suitable development environment have been identified with C# programming language to develop this proposed system that are ASP .NET Web Forms and ASP .NET MVC.

ASP .NET Web Forms

ASP.NET Web Forms is a part of the ASP.NET web application framework and is included with Visual Studio.

ASP .NET MVC

The ASP.NET MVC is a web application framework developed by Microsoft, which implements the model, view and controller (MVC) pattern.

Difference between Asp.Net MVC and Web Forms has been mentioned below (Table 2.3).

ASP.Net Web Forms	ASP.Net MVC
Asp.Net Web Form follows a traditional event driven development model.	Asp.Net MVC is a lightweight and follow MVC (Model, View, and Controller) pattern based development model.
Asp.Net Web Form has server controls.	Asp.Net MVC has html helpers.
Asp.Net Web Form supports view state for state management at client side.	Asp.Net MVC does not support view state.
Asp.Net Web Form has file-based URLs means file name exist in the URLs must have it's physically existence.	Asp.Net MVC has route-based URLs means URLs are divided into controllers and actions and moreover it is based on controller not on physical file.
Asp.Net Web Form follows Web Forms Syntax	Asp.Net MVC follow customizable syntax (Razor as default)
In Asp.Net Web Form, Web Forms(ASPX) i.e. views are tightly coupled to Code behind(ASPX.CS) i.e. logic.	In Asp.Net MVC, Views and logic are kept separately.
Asp.Net Web Form has Master Pages for consistent look and feels.	Asp.Net MVC has Layouts for consistent look and feels.
Asp.Net Web Form has User Controls for code re-usability.	Asp.Net MVC has Partial Views for code re-usability.
Asp.Net Web Form has built-in data controls and best for rapid development with powerful data access.	Asp.Net MVC is lightweight, provide full control over markup and support many features that allow fast & agile development. Hence it is best for developing interactive web application with latest web standards.
Asp.Net Web Form is not Open Source.	Asp.Net Web MVC is an Open Source.

Table 2.3: Difference between Asp.Net MVC and Web Forms [17].

2.3 Available Alternative Database Technologies

The heart of any website or application today is its database. With many different options available for today's web developers and designers, it can be difficult to decide which is best suited for a specific project. Finally two of most powerful and popular database technologies have been identified for the proposed system.

1. Microsoft SQL Server
2. MySQL

2.3.1 Microsoft SQL Server

Microsoft SQL Server is a relational database management system developed by Microsoft. As a database server, it is a software product with the primary function of storing and retrieving data as requested by other software applications which may run either on the same computer or on another computer across a network [18].

Pros and Cons

One of the main benefits involved in choosing the Microsoft SQL Server database management system is its seamless compatibility with other Microsoft Windows and Office applications. The SQL Server has a few extra tools and wizards. But it's not completely free. Therefore it does get some extra agency and neat add-ons. Overall, this makes everything converge and work together more smoothly.

SQL Server is a closed, proprietary storage engine with a more restrictive Sybase-derived engine over the MySQL. SQL Server has some additional advantages that some may argue elevate it above MySQL. And MySQL does not wholly support foreign keys, which means on a relational database scale it falls short in comparison to Microsoft's SQL Server.

SQL Server is geared with corporate and enterprise markets in mind. Its pros are widely known to be its feature completeness, functionality, and interfaces for administrative abilities and data modelling. Its complexity means that performance is known to lack slightly when compared to MySQL in the regarding and the speed area. Because Microsoft SQL Server is more complex and feature rich (a great plus), the software sacrifices some disk space, memory and performance.

Where SQL Server lacks in speed it makes up in data recovery. SQL Server is very resistant to data corruption, unlike MySQL. It is just about even when it comes to security and scalability.

2.3.2 MySQL

MySQL is the world's most popular open source database, enabling the cost-effective delivery of reliable, high-performance and scalable Web-based and embedded database applications. It is also used in many high-profile, large-scale websites, including Google Facebook, Twitter, Flickr and YouTube [19].

Pros and Cons

The most popular open-source SQL database management system and it makes it possible for anyone to modify and use the management software once it downloaded from the internet. The greatest feature of this database is the fact that it's open-source, and it's free. Therefore anyone has the option to get the free, easy-to-use community version of MySQL. However if it is the Enterprise edition of MySQL it will be received more feature-rich options.

The main goal with the MySQL database management is speed and performance. The database server is very fast, reliable, scalable and easy to use. It's free to anyone and everyone and it would make sense that the DBMS is accessible to experienced individuals as well as those that are new to database management. Its ease of use leaves MySQL a bit susceptible to data corruption. And also major advantage of the MySQL is that speed and large storage capabilities. Originally it was developed to handle large networks at a fast pace. Now it supports a wide range of APIs and standalone products. Pretty much any application could be supported by this popular and flexible software. Furthermore MySQL database can support a small set of applications and it can grow to manage entire machines or clusters of machines in a network [20].

The selected technologies will be justified in the implementation chapter in detail out of the above mentioned available technologies.

CHAPTER 3: Analysis and Design

Mainly this chapter is divided into two sections called analysis section and design section. The analysis section describes about what are user requirements and techniques used to gather those requirements. Basically this section provides the information about the high level user requirements in analytical way.

The design section describes how analyzed requirements in the previous analysis section have been transformed in to the physical and logical design in the system through UML diagrams.

3.1 Analysis

3.1.1 Fact Finding Techniques

Under this topic below has been described the techniques that have been used for gathering and analysing the requirements for the proposed system. This is the most important phase in SDLC. Because of the system will be built upon the requirements and identifying correct requirements is very critical and will lead to success of the system. There are several issues as follows regarding the identifying correct requirements.

- Communicating problems
- Users do not having technical understanding and awareness
- Developers not possessing the domain expertise and business knowledge.
- Not receiving the correct information

The fact finding techniques used for this project has been described below.

1. Interviews: By conducting several interviews with the employees of company being able to gather lots of requirements about their current business processes and what kind of support they need from this proposed system to improve their business processes.
2. Prototype: Currently a partially implemented system which is developed according to collected requirements through above techniques has been provided to the users of the company. Using that prototype has been able to identify what should be improvements, functions that should be newly added to the system and changes that should be done to the existing prototype.

3.1.2 Existing Manual System

All the business processes of the OZ Cleaning Company are manually handled and efficiency of those manual tasks is very low in the existing system. Functionalities of those manual processes have been described below and Figure 3.1 elaborate the use case diagram for existing system.

1. OZ cleaning (PVT) LTD maintain several building maintenance contracts related to a set of Business Clients.
2. Each contract Business Client has set of tenants.
3. Company keep track of the maintenance contract related customers and their tenant, resident locations, Maintenance related Equipment Details.
4. Set of technicians are assigned to supervisor. Supervisor is responsible for the duty assignment.
5. Technicians may serving on several locations.
6. Tenants make complain through the telephone regarding the equipment break down.
7. Operator register tenant complain and assign supervisor for process the tenant complain
8. Based on the reported complain technician will be allocated to that particular complaint by supervisor. Once technician is allocated to the particular work request, supervisor will be informed the work order details to the Technician.
9. Once technician is completed the assign duty he will inform it to the supervisor.
10. Then supervisor will mark as completed the customer complain.
11. Then end of the day operator will check customer feedback with respect to an all completed complains.

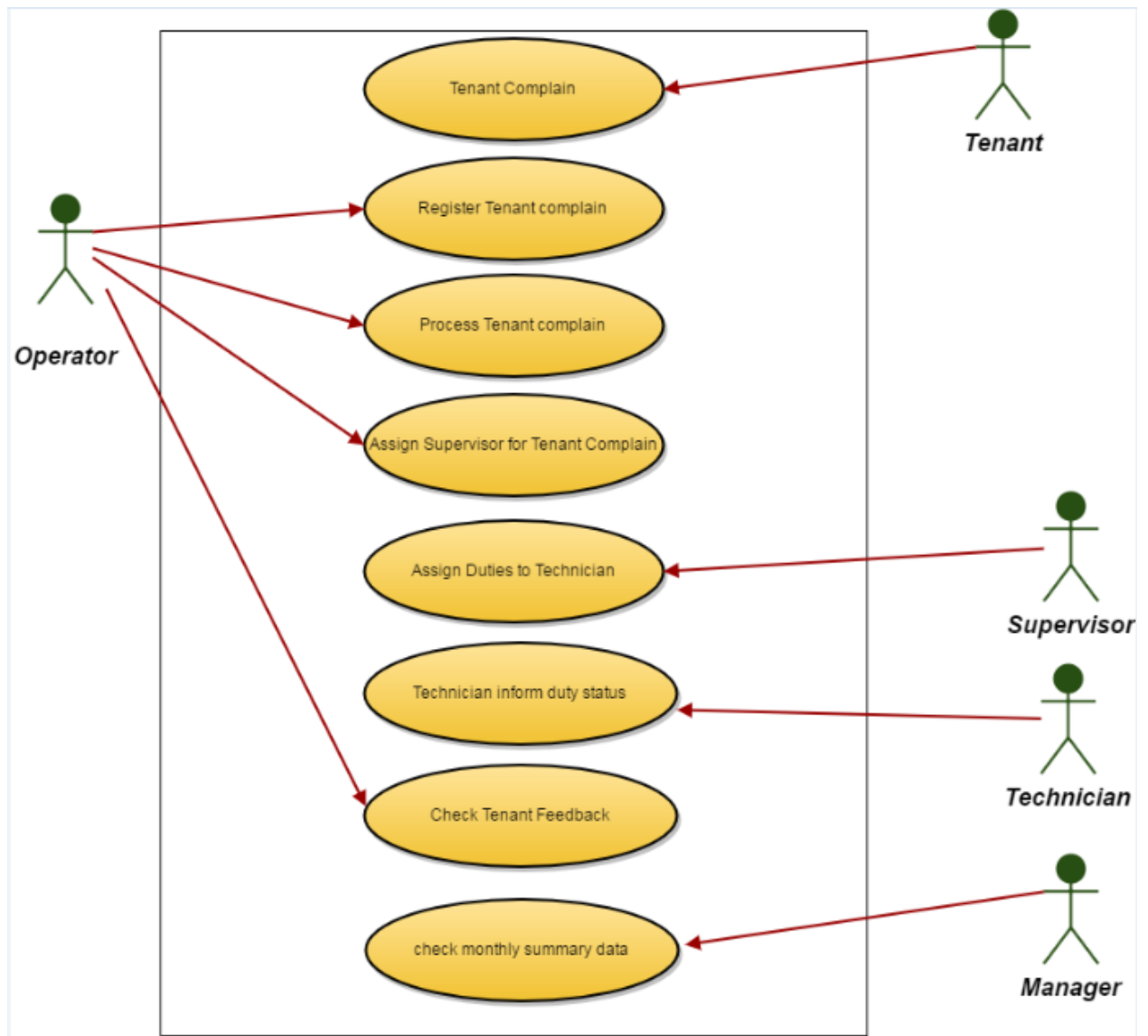


Figure 3.1: Use case diagram for existing system

3.1.3 Drawbacks of the Existing System

Below mention drawbacks have been identified of the existing manual system.

- Same information used in several places for several purposes and because of that data duplication and redundancy has occurred.
- Data integrity is in a very low level.
- Efficiency and effectiveness of business operations is poor and because of that the quality of services supplying to their customers has become low. Eg: Take more time to duty assignment for technicians.
- Data retrieval is very slow. Therefore take more time to generate reports.

- Decision making has been become very difficult without having statistical information in a useful manner.
- Because of not having web site, reputation of the company is not very high and because of that, finding business opportunities is very difficult.

3.1.4 Functional Requirement

Functional requirement defines a function of a system and its components. In this section it's describe the functional requirements of the system. Below you can find detailed description of functionalities that should be included to the system and what should be accomplished through the system.

Figure 3.2 elaborates the major components of the proposed system and Figure 3.3 elaborates the user types of the proposed system

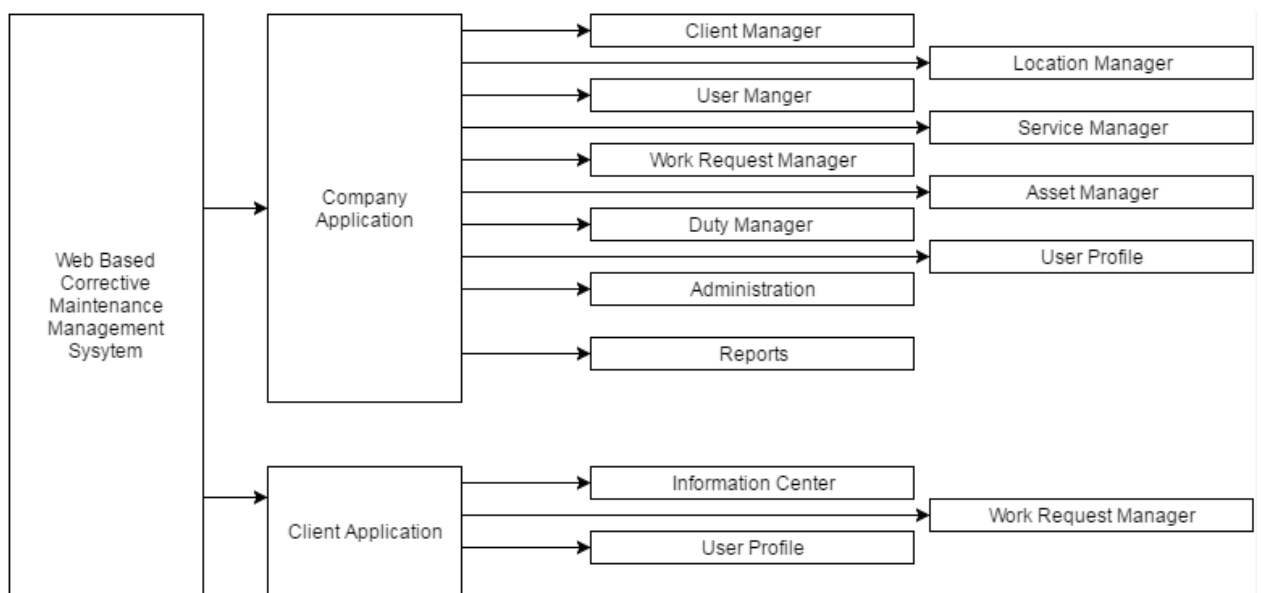


Figure 3.2: Major components of the proposed system

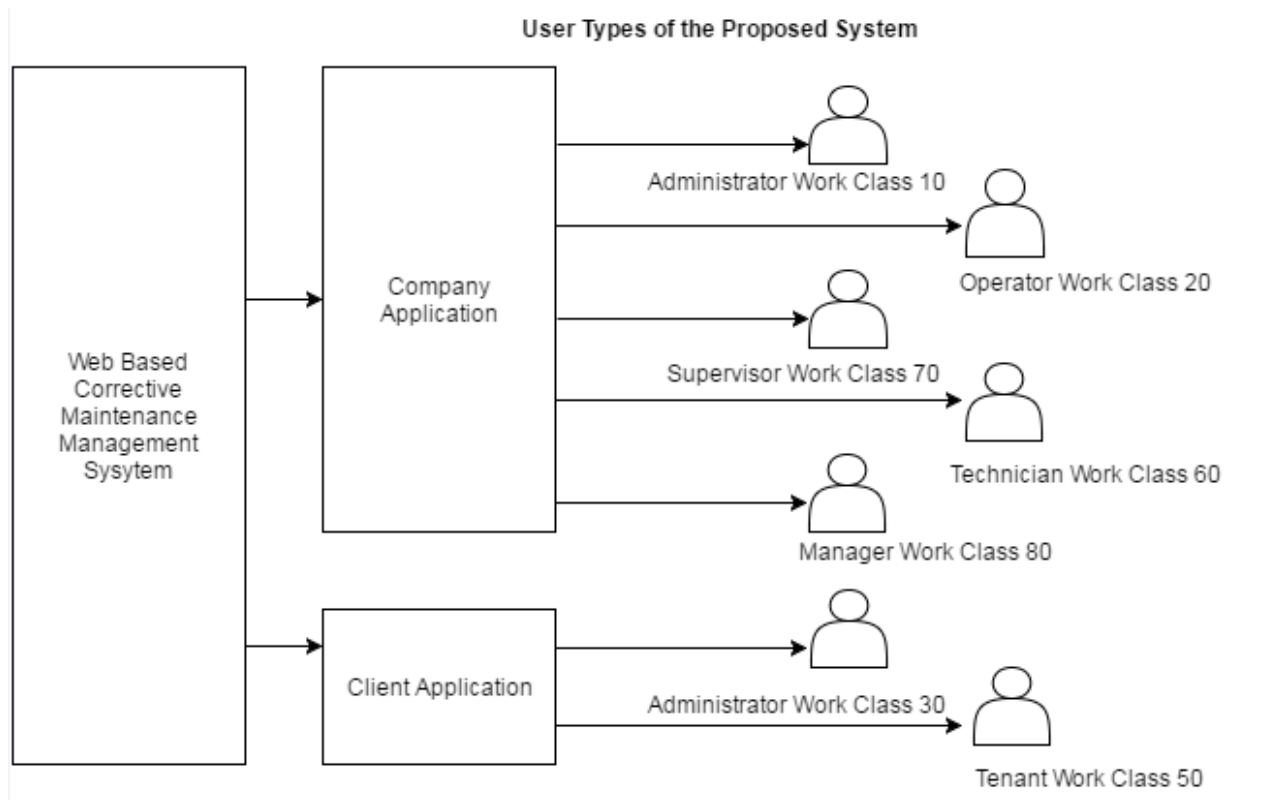


Figure 3.3: User types of the proposed system

Functional Requirements of Client Application

1. Client application may have two kinds of user types that are Admin and Tenant. Each user is assigned a work class. User allowed functionalities are based on the assigned work class.
2. Online customer registration is provided to register as a customer with the OZ Company. Business companies can register with the Company as a customer.
 - Business companies will be created a business account. The person who register the business company as a business client consider as a default admin user of the business client. One business client may have several users to access the system. Those users are created by the admin user of business client. Tenant and admin users are the main user types of a business client. User creation will be explained in the user manager components of client application.
3. User login is provided to the users to log into the system to register work request and operate other allowed functionalities.
 - Business Clients: It has may have two types of users.
 - ✓ Admin User: All work class 30 functions are allowed as a business client.

✓ Tenant: All work class 50 functions are allowed as a business client.

4. User manager option is provided to maintain a set of users for a particular company that registered as a business client.
 - This option is only allowed for admin users of business clients to maintain the users on behalf of that business client.
 - Admin user of a particular business client can create new tenants as well as other admin users on behalf of that business client.
 - Admin user can activate the inactive users of that particular business client.
 - Admin user can deactivate the active users of that particular client.
 - Admin user can reset the user's password of that particular company when required. A newly random generated password has been sent to the user's email account. That particular user can change the password later using the password change option.
5. User profile manager option is provided for each and every that using the client application.
 - Users can update their user details like name, email and other details.
 - Users can change their current password.
6. Business profile manager option is provide following functionalities.
 - Admin users only can access this option.
 - Admin users can update business client profile data like company and other details when required.
7. Work Request Manager is the most important and the core component of the proposed system. This option facilitated to register work request for tenants of a specific business client.
 - Tenants of business Company are allowed to create work request using this option.
 - Tenants are allowed to cancel the work request before take any action by the OZ Company.
 - Once the work request created through the client application, OZ Company can process the work request through the company application.
 - Users are allowed to upload any documents relate to the particular work request like breakdown Asset details and other required documents using document upload option.

- Users are allowed to download the documents that uploaded by the OZ company using document download option.
8. Customer complaint option is provided to clients to make any complaint regarding service of the OZ Company.
 - Business clients are allowed to make customer complaints through the system.
 9. Below mentioned additional options are also provided to increase the customer satisfaction regarding the service.
 - System should allow users to reset their password by them self-using provided forgot password option. A newly random generated password has been sent to the user's email account. That particular user can change the password later using the password change option.
 - System should allow users to inquire relevant past work request details.
 - System should allow users to view the status of work request.
 - Provide edit and delete options to in relevant functionalities.

Functional Requirements of Company Application

1. Company application may have five user types that are admin, operator, supervisor, manager and technician. Each user is assigned a work class. User allowed functionalities are based on the above work class.
2. User login has been provided to the users to log into the system to manage the work request created by the tenants and operate other allowed functionalities.
 - Admin User: user work class is 10. All functions are allowed to this user.
 - Operator: All work class 20 functions are allowed. Create work request on behalf of tenants, post work request without creating work order, reject work request functionalities are allowed to operator.
 - Supervisor: All work class 70 functions are allowed. Create work order, Assign Technician for the work order, post work request, reject work request, Create work order functionalities are allowed to operator.
 - Technician: All work class 60 functions are allowed. Technician update work order start and complete time. Currently these functionalities are initiated by supervisor on behalf of the tenant.
 - Manager: All work class 80 functions are allowed. All work request related report generation are allowed to manager user.

3. Client manager option is provided to maintain the clients that register with the OZ Company.

- This option is only allowed for admin users of the company application to maintain and handle the business client.
- If the new clients are registered online with the application, those clients are in pending status. Therefore admin user of the company application can accept new clients as active clients.
- Admin user can activate the inactive clients.
- Admin user can deactivate the active clients.

4. User manager option is provided to maintain a set of users for the OZ Company.

- This option is only allowed for admin users of the company application to maintain the users on behalf of OZ Company.
- Admin user of company application allowed to register operators, supervisors, technicians, managers as well as other admin users.
- Admin user can activate the inactive users.
- Admin user can deactivate the active users.
- Admin user can reset the user's password when required. A newly random generated password has been sent to the user's email account. That particular user can change the password later using the password change option.

5. User profile manager option is provided for each and every user that using the company application.

Each and every user of the Company application is allowed these options

- Users can update their user details like name, email and other details.
- Users can change their current password.

6. Work Request Manager Option is provided to Register new Work Request on behalf of the Tenant, handle the Work Requests that Registered by the Tenant, Process Work Order with respect to a Registered Work Request, Upload /Download Documents,

- Once client register a work request through the client application, Operator user of the company allowed to following functionalities
Allowed to create work order by assigning supervisor with respect to that particular work request. At this instant system generated Email sent to the supervisor informing the assign work order details
Allowed to post work request by adding comment.
Allowed to reject work request.

- Application is allowed to assigned technician for the work order.
 - Once the technician is assigned, System generated .email notification is send to the technician informing the work order details. Supervisor has to informed work order details to the Technician and at the same time technician response SLA is getting started. Technician should start the work within the response SLA Time. If not response SLA Getting expired. Technician should inform the start time of the Work Order to the Supervisor. When the supervisor update the work order started time status will change as “started” and resolve SLA begin on this time. Technician should completed the Work Order within the Resolve SLA Time. If not Resolve SLA will be expired. After completing the Work Order Technician Should inform the Status to the supervisor. Then supervisor will mark as Post the work order.
 - Operators are allowed to upload any documents related to the particular Work request. Eg: Upload Asset (Equipment) Maintenance related details and other required documents using document upload option.
 - Operators are allowed to download the documents like breakdown asset details and other required documents that uploaded by the Tenant.
 - Once finish the processing of work request, it should be posted for the Tenant in order to add feedback. Only admin user or supervisor can post the request. Tenant is sent a system generated email to requesting feedback for the posted work request.
 - Once client added the feedback added as satisfied with respect to a specific request, that request should be closed. Only posted requests can be closed. Only admin users are allowed to close the request. At this instant Company application is sent a system generated email to informing the relevant work request is closed. If the customer commented as not satisfied on specific work request, new request will automatically generate using the same information.
7. Admin options are provided to admin users to operate the admin functionalities of the Client application.
- Location Manager Functionalities :
 - Allowed to add, edit, activate, and deactivate sites.
 - Allowed to add, edit, activate, and deactivate building.
 - Allowed to add, edit and activate, deactivate Location.
 - Service Manager Functionalities:
 - Allowed to add, edit, activate, and deactivate service categories.

Allowed to add, edit, activate, and deactivate SLA.

Allowed to add, edit, activate, and deactivate problem types.

- Asset Manager Functionalities:
Allowed to add, edit, activate, and deactivate asset category.
Allowed to add, edit, activate, and deactivate Assets.
 - Duty Manager Functionalities.
Allowed update duty roster for the technicians.
 - Manage web page Functionalities:
Client Application related details and instructions can be added. These added details and instructions will be displayed in the client application.
 - Manage web page file upload manager Functionality: Client application related document can be upload. Clients can download these uploaded document in client application.
 - Users can view the client complaints.
8. Report generation option is provided to find decision making activities in order to achieve organizational goals.
- User can generate a Work order status report for a particular date range.
 - User can generate a Work request statement for a selected request.
 - User can generate a Technician wise work order report for a particular date range.
 - User can generate a Technician SLA report for a particular date range.
10. Below mentioned additional options are also provided to increase the increase the efficiency of the Company application functionalities.
- System should allow users to inquire relevant past details.
 - System should allow users to view the status of work request..

3.1.5 Non-Functional Requirement

Non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours [21]. As well as functional requirements, achieving non – functional requirements is also a major goal when implementing a successful system. Non – functional requirements that should be fulfilled within this system has described below.

1. Reliability and Accuracy: Reliability and accuracy of information which are maintained within the system should be very high and this is very important feature, other than that information using decision making will become useless and business operations of the company will not work in proper way.
 - System should be available on 24 x 7 x 365
 - System should be reliable.
2. Consistency: Related information should be kept in a consistent manner within the system to be able to retrieve accordingly.
3. User Friendliness: Technological awareness of system users is considerably low and because of that reason user friendliness of the system is very essential and otherwise system can be a failure.
 - System provides user friendly and attractive interfaces to users.
4. Re – Usability: Implementing a system in a reusable manner is important because, that can useful to save effort require for developing a similar system. Therefore system should be able to reusable with few customizations according to user requirement.
 - Its browser independent.

3.2 Design and Architecture

The detailed design and architecture of the system will be discussed in this section by the entire system is divided into two applications that are Company application and the client application as mentioned in above section.

3.2.1 Process Model

A Process Model describes the sequence of phases for the entire lifetime of a product. According to the nature of activities, constraints, and resources that are used for the project and according to the system user requirements, there are various types of suitable process models for this system. Some models have been mentioned below.

1. Waterfall Model
2. Spiral Model
3. Rapid Application Development
4. Agile development
5. Prototyping
 - Evolutionary Prototyping
 - Throwaway Prototyping

But after the analyzing all requirements the evolutionary prototype model has been adopted as the process model for this proposed project.

Evolutionary Prototype Process Model

Evolutionary prototyping is a lifecycle model in which the system is developed in increments so that it can readily be modified in response to end-user and customer feedback. The key benefit of this model is that ability to address risk early in the project, early feedback on whether the final system will be acceptance, and visible progress throughout the project.

Evolutionary prototyping works best when the customer is uncertain about what they want at the outset and their input must be solicited throughout the project to ascertain requirements [22].

This model includes four phases:

1. The identification of the basic requirements. Though we may not be able to know all the requirements since it is a continuous process, we should be able to identify the basic things needed for this project to work.
2. Creating the prototype. There will be several prototypes to be made in this project, with each one better than the one before it to ensure its success.
3. Verification of prototype. This will be done through surveys and experimentation using participants taken from the target market. The customers are the best people to get feedback from to find out whether the system is good or not.

4. Changes for the prototypes. When found that the prototype is seen as insufficient or unsatisfactory, the project team will again make further iterations until such time it becomes perfect, as per feedback from customers [23].

Figure 3.4 show the diagram for evolutionary prototype model

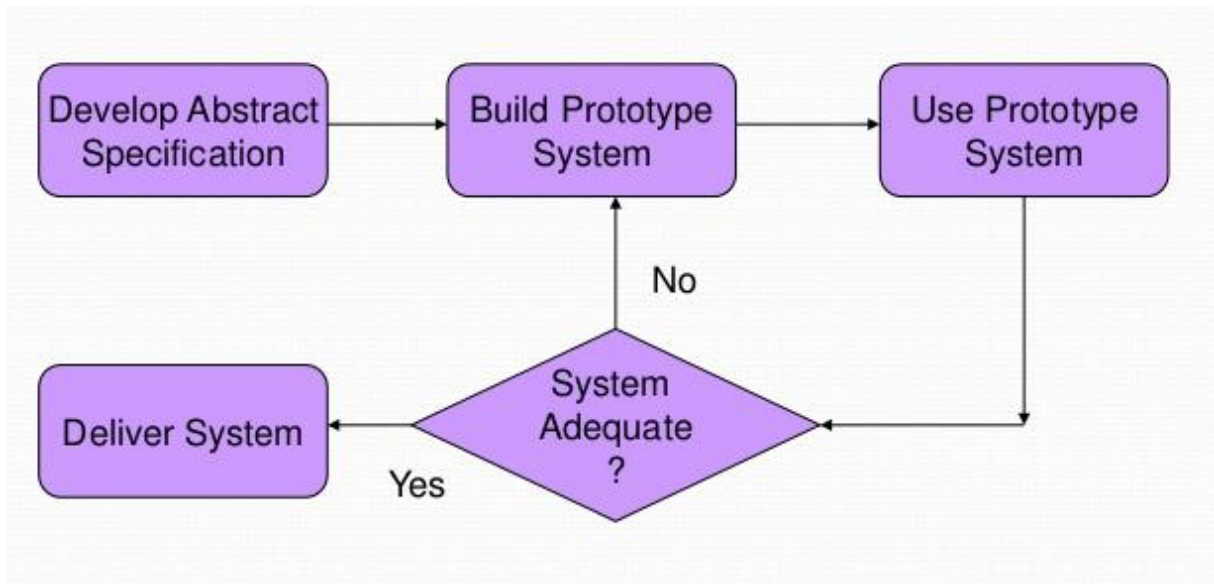


Figure 3.4: Evolutionary Prototype Model [24].

Advantages of using Evolutionary Prototype model has been mentioned below.

- Early feedback whether the final system will be acceptance.
- Easy to manage time schedule.
- Visible progress throughout the project.
- User can experiment with the system to improve requirements.
- Very useful in a situations like having vague requirements.

Justification of selected process model

Justification and reasons have been provided below to selected process model.

1. The company that developed a web base application, they have a manual system. Therefore the company doesn't have much experience using a computerised system. Therefore, at the beginning of the project, it was difficult to identifying all their business requirements and by adopting this model, been able to eventually gather actual requirements through the prototype.
2. This method is very faster that comparing with the other process models as a solution to time constraints.

3. The prototype method is very effective way of gathering requirement and identifying correct requirements out of them.
4. Because of high level of user involvement from the beginning of the project there will not require special or additional training sessions for system users at the end of the system development.

3.2.2 Alternative Solution Analysis

After gathering and analysing all the requirements of the company, main two types of alternative solutions have been identified for the proposed system that are standalone application and web application. Finally web base solution was selected as a best solution that can be adopted for this particular system and below you can find description of those two solutions and the justification for the selected one.

Standalone Application

After gathering and analysing all the requirements of the company, standalone application cannot support for achieve main goals. As mentioned earlier, basic business functionalities for managing day – to – day business activities of the company can be handled using a standalone application. But, when it comes to the customer requirements, customer cannot access a standalone application and will not be able to operate main functions through it. Therefore all expected targets could not be achieved through adopting this approach. Other than that, accessibility of the standalone application is limited to company area.

Web based Application

Even though a web based system is a little bit costly method comparing with the standalone application, that approach can fulfil all functional requirements mentioned earlier and the main limitation of standalone application of customer accessibility can be managed through the using this approach.

Justification of Selected Web based Application

Accessibility of web based solution is higher than other approaches and system user will be able to access the system from anywhere. Although sometimes there can be there can be security threats in web based system, technical solution can be applied to manage those threats. Finally

web base solution was selected. Pros and cons have been mentioned below regarding those two solutions.

Maintenance - web based applications need to be installed only once whereas desktop applications are to be installed separately on each computer. Also updating the applications is cumbersome with desktop applications as it needs to be done on every single computer which is not the case with web applications.

Ease of use - desktop applications are confined to a physical location and hence have usability constraint. Web applications development on the other hand makes it convenient for the users to access the application from any location using the Internet.

Security - web applications are exposed to more security risks than desktop applications. You can have a total control over the standalone applications and protect it from various vulnerabilities. This may not be the case with web applications as they are open to a large number of users in the Internet community thus widening the threat.

Connectivity - web application development relies significantly on Internet connectivity and speed. Absence of Internet or its poor connectivity can cause performance issues with web applications. Desktop applications are standalone in nature and hence do not face any hindrances resulting from Internet connectivity. Connectivity also significantly affects the speed at which desktop and web applications operate.

Cost factor - web application development and its maintenance involve higher costs and mostly recurring in nature. Desktop applications are purchased one time and there are not continually occurring charges. However, in certain cases, maintenance fees may be charged [25].

3.2.3 Assumptions and Dependencies

Major assumptions and dependencies are mentioned below.

1. This system is a web based solution; it will be fully depending on availability of internet connection.
2. Accessing and working speed will be depending on hardware scalability and speed of the network connection of the client computer and the internet connection.
3. I assume that majority of clients will have internet facility to access the system.
4. Most of the features of application will work if javascripts are enabled in the using web browser. Therefore I assume that javascripts are enabled in the web browser.
5. For the testing of the system I will use the latest version of the Mozilla Firefox browser and the Google Chrome browser. Therefore we assume that users will use a browser compatible with features of the application.
6. For testing of the system I will use the Gmail SMTP Server as the mail server.

3.2.4 General Constraints

Below mentioned constraints are consider as general.

1. This proposed system will be implemented as a web based system. Therefore it is require to have Internet facility in user computers in order to access the system for both company and client applications.
2. All the emails are sending through the established mail server. Company must purchase require mail server from the vendor or company must decide to get the service of free mail server. That selected mail server will be integrated with the system.

3.2.5 Design Technique

Object-Oriented design and modelling using UML has been used as a design technique in the designing phase of this system. With the proper implementation of Object-Oriented techniques, development can become smoother and more streamlined. It provides a set of techniques for analyzing, decomposing and modularizing the software system architectures.

And UML is a diagrammatic representation is for specifying the kind of Object Oriented Programming design. UML allows system to be visualized in multiple dimensions, and also it can be used to produce several models at increasing level of detail. In this document we have use UML diagrams such as class diagram, sequence diagrams, use case diagram and activity diagrams to give clear image of the system.

Advantages of using object oriented design can be described as follows:

- OOD provides a more structured plan and design methods.
- Reusability of objects – Objects can be reused in different programs.
- Easier maintenance – Objects can be maintained separately, making locating and fixing problems easier.
- Modularity – Each object composes a separate entity whose internal workings are separated from other parts of the system
- Simplicity of program – Software objects model real world objects. Therefore complexity of program structure is reduced.
- Extensibility – Adding new features or responding to changing operating environments can be solved by introducing a few new objects and modifying some existing ones.
- Modifiability – It is easy to make changes in the data representation or the procedures in an OO program. Changes inside a class do not affect any other part of a program, since the only public interface that the external world has to a class is through the use of methods.

3.2.6 Architectural Strategies

Since the proposed system is very large, its need to consider architectural strategies when developing the system. Therefore some important architectural strategies have been described below.

Performance Strategies

This system is a fully web based system. Therefore system performance basically depends on the bandwidth of the network availability and hardware specification of the server machine.

- The users of the system are permitted to access the system from anywhere through the internet and concurrent access to the same page should be enabled.
- Time limitations are not strictly followed in the system but page loading and transaction time should be lower with high speed performance.

Security Strategies

The system is handling a considerably large database. And also the data is updated frequently. Because of that data should be safe and available every time.

- Data backups will be periodically taken.
- The system will monitor and log activities within the system.
- Maintain the user's password of the both Company and client application are in secure way. Password encryption and decryption methodologies are used for this. And also use secure ways to deliver passwords to the users.

Extendibility & Flexibility Strategies

The company its business activities will be expanded according to the time constraint. Therefore system functionalities are likely to be changed. Therefore, the system should be able to adopt the changes easily and should be flexible to add more features easily in future.

3.2.7 Object Oriented Design

As it has been mentioned earlier, use case model has been used to represent the system. In this section it will be discussing the use case model relevant to the proposed system.

Use Case Model

Use Case model describes the system users and their roles and activities that can be done by each user within the system boundary.

Figure 3.5 shows the higher level use case diagram for proposed system

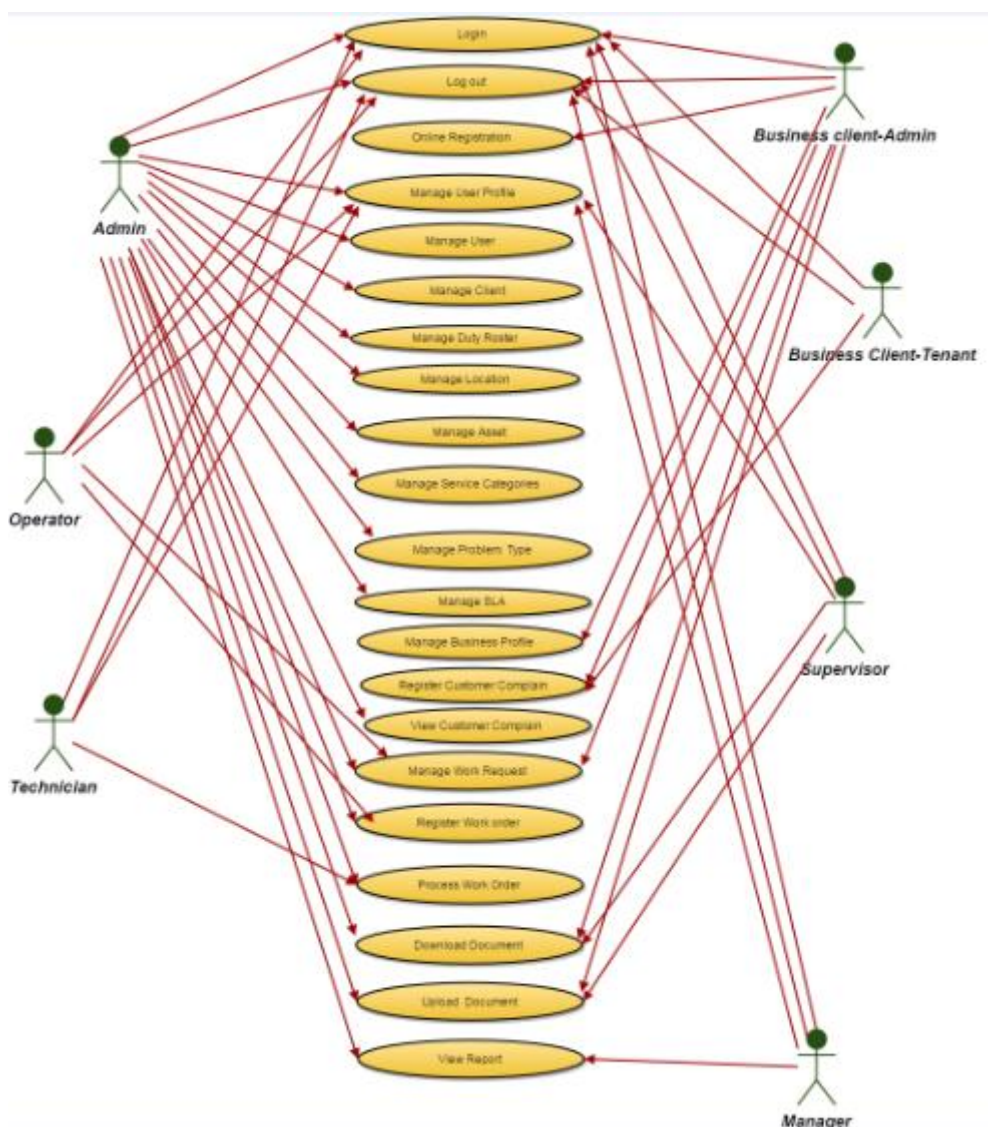


Figure 3.5: Higher level use case diagram for proposed system

Use case narratives for the actors have been mentioned in the appendix B. please refer the Appendix B.

3.2.8 Process Flow Diagrams

Process flow diagrams are used to describe the general flow of processes. Please refer the appendix B to see the process flow diagrams.

3.2.9 Database Design

Data design elaborates the data management architecture within the system database. For this purpose Entity Relationship Diagram (ERD) has been used. After create the ERD, normalization and de – normalization techniques has been used to generate the database table structure.

Please refer Appendix B to see the database diagram.

3.3 User Interface Design

User interfaces will be interacted with the system users. Therefore user interface design is an important thing to success the system. All the technologies that used to design and develop will be discussed in detail in chapter 4. Important interfaces have been shown in appendix F. Please refer the Appendix F.

CHAPTER 4: Implementation

4.1 Introduction

In the Software Development Life Cycle, the actual code is written here. Therefore the all system development and coding activities has been done within this. System implementation phase has been started after the gathering of requirement, analyzing and the designing. This chapter is discussing about the tools and technologies used in the implementation stage and the coding structure that has been used within the program.

4.2 Implementation Environment

4.2.1 Development Technologies and Frameworks Used

There are two kinds of alternative development technologies had been identified in the chapter 2. Finally Microsoft .Net Framework is used to develop the proposed system over the “Java with J2EE Platform” as a core platform with C# programming language.

As explained in chapter 2, it has been identified two main platforms under the .NET Framework that are ASP.Net Web Forms and ASP.Net MVC. Finally “C#.Net/ ASP.NET MVC 2” is used to implement the system apart from the ASP.NET Web Forms.

C#.Net/ ASP.NET MVC 2

The ASP.NET MVC is a web application framework developed by Microsoft, which implements the model–view–controller (MVC) pattern. It is open-source software, apart from the ASP.NET Web Forms component which is proprietary [26].

Reasons for selecting C#.Net/ ASP.NET MVC 2

ASP.NET MVC framework has been a real advantage for developers to build web based applications implementing MVC pattern easy, fast and in an efficient manner.

From a technical standpoint, the organization of code within MVC is very clean, organized and granular, making it easier for a web application to scale in terms of functionality. It promotes great design from a development standpoint. And also the main advantage of this loosely coupled architecture is that it allows the different teams of a project to work on its own area without any dependency from another team. For example the UI team can solely work on only the Views without screwing up the code behind or waiting for some C# developer to check-in his changes. Thus the ASP.NET MVC framework decreases the complexities involved in doing parallel development.

It is easier to integrate with other client side tools like rich user interface tools. More than ever, web applications are increasingly becoming as rich as the applications like on desktop

applications. With MVC, it gives us the ability to integrate with such toolkits such as “jQuery” with greater ease and more seamless than in Web Forms.

It supports multiple views to display the same data as separate outputs. And also it supports unit testing as a part of Visual Studio 2010.

4.2.2 Database Technologies Used

Mainly two kinds of alternative database technologies had been identified in the chapter 2. Finally Microsoft SQL Server is used to implement the proposed system over the MySQL.

Reasons for selecting Microsoft SQL Server

Microsoft SQL Server integrates seamlessly with a number of programming languages and other web-based applications. And also it is only really beneficial with Microsoft based products. Therefore Microsoft SQL Server is fully compatible with the .Net Framework. Because both are Microsoft based products. This makes everything converge and work together more smoothly. Other than that below mentioned special features leads to select the Microsoft SQL Server as the database technology.

Security: SQL Server provides two security models including integration with Windows Authentication to provide robust security platform for managing your organizations information. Security can be managed across all database objects including tables, views and stored procedures and at a very granular level, to provide complete information security. Database encryption is now available as well to secure SQL Server database at rest.

Scalability: SQL Server is a highly scalable enterprise database platform capable of managing pet bytes of data while delivery high performance. This allows organizations to deploy SQL Server databases with the confidence that SQL Server can continue to deliver superior performance even as their needs and businesses grow.

High Availability/Failover: SQL Server provides a variety of high availability features including fail over clustering available on the Standard and Enterprise editions, database mirroring, log shipping, and database snapshots to meet your organizations' needs.

Business Intelligence: SQL Server Standard and Enterprise Editions come with extensive business intelligence capabilities through SQL Server Analysis Services. Analytical models can be developed to breakdown business information to provide business insights for managing and forecasting business needs. SQL Server also comes with integrated reporting capabilities from SQL Server Reporting Services which allows organizations to access business critical

information across the organization. In more recent versions of SQL Server, Power Pivot for Microsoft Excel has been added to allow users another familiar tool for analyzing business data. **Integration:** SQL Server provides a robust set of integration tools call SQL Server Integration Services (SSIS) which can be used confidante data from multiple heterogeneous data sources for holistic data view and comprehensive data analysis. SSIS can also be used to migrate data from other database formats (Oracle, DBase, Paradox, legacy formats, Microsoft Access) to SQL Server [27].

4.2.3 Other Technologies Used

Below mentioned technologies were used to implement the project.

1. Java Script/JQuery/AJAX/XML/JSON

Java Script: JavaScript is the programming language of HTML and the Web. Programming makes computers do what you want them to do.

JQuery: JQuery is a fast, small, and feature-rich JavaScript library. It makes things like HTML document traversal and manipulation, event handling, animation, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers [28].

AJAX: AJAX is about updating parts of a web page, without reloading the whole page. [29].

JSON: It stands for JavaScript Object Notation. It is syntax for storing and exchanging data. And it is an easier-to-use alternative to XML.

XML: Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable. [30].

Justification of using JQuery

Ease of use: This is pretty much the main advantage of using JQuery, it is a lot more easy to use compared to standard javascript and other javascript libraries. Apart from simple syntax, it also requires much less lines of code to achieve the same feature in comparison.

Large library: JQuery enables you to perform hordes of functions in comparison to other Javascript libraries.

Strong opensource community: Several jQuery plugins available. JQuery, while relatively new, has a following that religiously devote their time to develop and enhance the functionality of JQuery. Thus there are hundreds of prewritten pluggings available

for download to instantly speed up your development process. Another advantage behind this is the efficiency and security of the script.

Great documentation and tutorials: The JQuery website has a comprehensive documentation and tutorials to get even an absolute beginner in programming to get the ball rolling with this library.

Ajax support: JQuery lets you develop Ajax templates with ease; Ajax enables a sleeker interface where actions can be performed on pages without requiring the entire page to be reloaded [31].

Justification of using AJAX

Better interactivity: This is pretty much the most striking benefit behind why several developers and webmasters are switching to AJAX for their websites. AJAX allows easier and quicker interaction between user and website as pages are not reloaded for content to be displayed.

Easier navigation: AJAX applications on websites can be built to allow easier navigation to users in comparison to using the traditional back and forward button on a browser.

Compact: With AJAX, several multipurpose applications and features can be handled using a single web page, avoiding the need for clutter with several web pages. It takes just a few lines of code [32].

2. HTML/CSS

HTML is a markup language for describing web documents (web pages). Therefore the user interfaces in the system was mainly developed with HTML

Cascading Style Sheets (CSS) is a style sheet language used for describing the presentation of a document written in a markup language.

[33]

Advantages of using CSS

CSS helps to make the changes of the layout and design of the site very easily. The file size of the CSS is very small hence your web application takes minimal loading time. The external CSS has made easy for the visitors who want to see only the content from the web application. By creating the CSS, it can make the web design flexible. And also the design is fully done with CSS to make the interface user friendly and attractive.

4.2.4 Software Used

Below mentioned softwares were used in the development environment.

- Platform: Windows 7 64 bit
- Database Management System and SQL: SQL Server 2005
- Integrated Development Environment: Visual Studio 2010
- .NET Framework : .NET Framework 4.0
- Development Server : ASP .NET Development Server
- Web Browsers : Mozilla Firefox and Google Chrome
- Bug Tracking Tool: Fire Bug plug-in of the Mozilla Firefox browser
- Email Gateway : Gmail SMTP Server
- Payment Gateway : Testing Simulator

4.2.5 Hardware Used

Below mentioned hardware configurations are used in the implementation environment.

- Intel Core i3 Processor 2.50 GHz
- 320 GB Hard Disk
- 4 GB RAM

4.3 Deployment Environment

Below mentioned softwares are used in the deployment environment.

- Server: Windows Server 2008 or later
- Web Server: IIS Server 7.5
- .NET Framework : .NET Framework 4.0
- Database Management System and SQL: SQL Server 2005
- Email Gateway : Need to purchase from vendor
- Payment Gateway : Need to purchase from vendor

4.4 Implementation Architecture

This proposed system has been developed using the MVC architecture that is a software design pattern for developing web applications. There are lots of advantages that using of this architecture that is reusability, maintainability and consistency. MVC architecture is very useful to reduce the complexity of the program and it divides the application into three parts as model,

view and controller. This MVC architecture is map into the input, processing, output roles in GUI realm. The MVC abstraction can be graphically represented as follows.

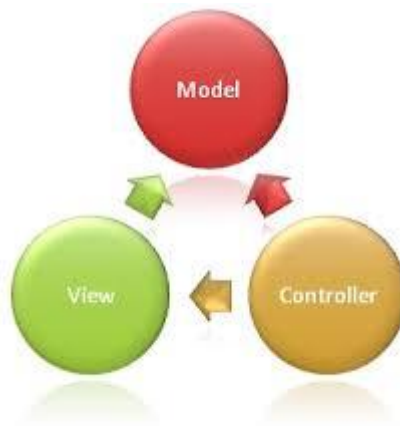


Figure 4.1: MVC Architecture – Basic [34]

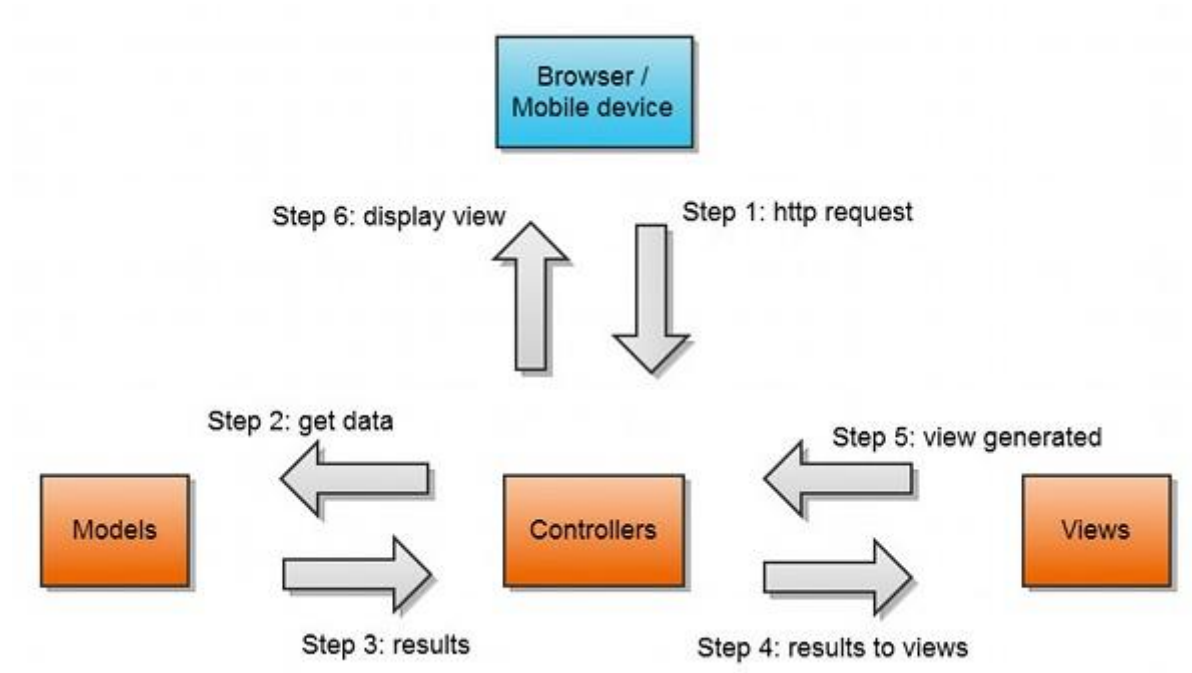


Figure 4.2: MVC Architecture – Detail [35]

Controller:

The controller is responsible for responding to user input and performs interactions on the data model objects. The controller receives the input; it validates the input and then performs the business operation that modifies the state of the data model. Controller processes every

request, and prepares other parts of the system like model and view. Then the system determines what to do by controller's commands.

Model:

The model is responsible for managing the data of the application. It responds to the request from the view and it also responds to instructions from the controller to update itself. Model handles data processing and database works part. Model processes events sent by controller. After processing these events, then it sends processed data to controller or directly to the view side.

View:

A presentation of data in a particular format, triggered by a controller's decision to present the data. They are script based templating systems like JSP, ASP, PHP and very easy to integrate with AJAX technology. View prepares an interface to show to the user. Controller or model tells view what to show to the user. Also view handles requests from user and informs controller. [34] [35] [36]

4.5 Major Code Fragments

Common implementation structure has been used to implement the both Company Application and the Client Application of the system. Here is the general operation overview of the structure.

Views are the pages that users work with it. The entire requests other than redirections from one page to another page are process as AJAX submissions (using JQuery library). That request will direct to relevant method of the relevant controller. In the controller method, initialize the model object and check with primary validations. If validation fails, error message will return. Other vice model object will pass to relevant method in the "Operation" class. "Operation" classes are located at "DbLayer" namespace. In the method if required, Secondary validation method will validate the instance. If validation fails, error message will return. Other vice required operation(s) will process and return the result.

- All images that are used for the project and CSS files are included in the "Content" folder in the project structure.
- All the SQL commands including database connection are implemented in "DbLayer" namespace under the "Controller".

- All the common validations and common utilities are implemented in “Utilities” namespace under the “Controller”.
- All the business logics are implemented in the Controller classes under the “Controller” namespace.
- All the data model classes are implemented under the “Model” namespace.
- All the JQuery libraries, Java Script files and other scripting files are included under the “Scripts” folder with sub folders.
- All the user interfaces are implemented under the “Views” folder with sub folders.
- Encryption and decryption has been used to store the user’s password in secure manner. Please refer appendix E to see the algorithm.

Project structure of Company application

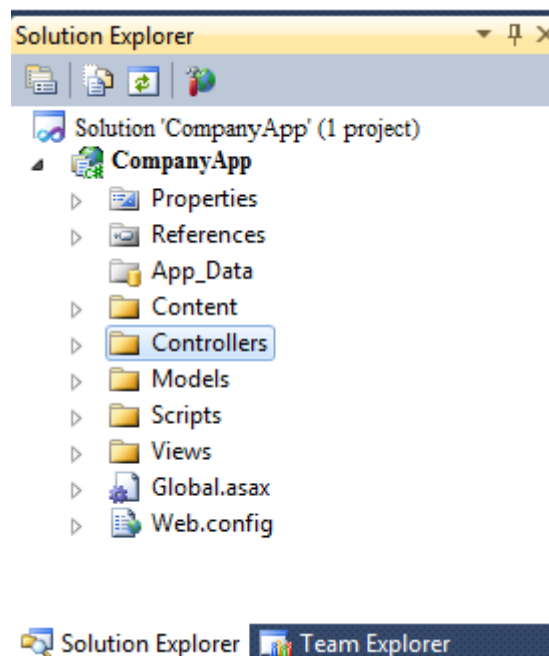


Figure 4.3: Project Structure of Company Application

CHAPTER 5: Evaluation and Testing

5.1 Introduction

Evaluation of a software system is done by carrying out Verification and Validation (V & V) process which is the process of checking the developed software to ensure whether it meets the expected specification and whether it is functionally acceptable. [Sommerville, 2004]

Software testing is a critical element of software quality assurance that represents the ultimate review of specification, design, and code generation. The testing is comprised of Verification and Validation methods. Verification – refers to the techniques of finding out whether the built software meets all the customer requirements and Validation- refers to the techniques that ensure the software meets all the specified functional requirements. The testing process is considered dynamic; given that the process is carried out on an executable function of the system. Testing is a vital process to ensure a perfectly working system with fewer errors is delivered to the customer. [Ian Sommerville, 2007]

5.2 Test Strategies

Test strategies define the number of ways of evaluating the system functionalities to ensure that it performs as expected. These were carried out at different levels in the system implementation and involve different procedures for each. Using these strategies may vary from one project to another based on its nature to ensure the smoothness of the system.

5.2.1 Black Box Testing

This technique was used to ensure that the system is performing as expected as functions. This does not check the code in detail and do testing over the major functionalities, system has tested as components or whole functions.

5.2.2 White Box Testing

The purpose of white box testing is to test the code in detail. This is an isolated testing which tests each line of code to ensure that it performs well as intended. If controls, for loops, case statements etc executed specifically to determine that they are fit for use. Usually this happens throughout the project.

Black box testing and White box testing are the main test strategies in evaluation phase, other than that System testing specifies whether the system's functionalities comply with its specified requirements. This performs on the complete system in accordance with functional requirement specification and system requirement specification.

The system was developed combining the several modules together. So the purpose of conducting Integration testing is to determine whether all those modules/components are performing well after each module is integrated together. Many of the modules may work as it is expected in an isolated environment but not with integrated manner. Therefore the integration testing is much important to specify its performance and reliability when modules are combined with others. Stress testing also carried on the entire system. The main purpose of this is to determine the stability of the system and also it specifies the robustness, availability and reliability of the system. The system was tested under some extreme condition and beyond basic operational capacity. This could identify what are the issues may arise in such circumstances and can implement recovery procedures for prevent the system from data loss or unexpected functionalities.

Finally User Acceptance testing was conducted with the client in order to identify configuration problems and collect suggestions, feedback from user.

5.3 Usability Testing and Evaluation

Mainly two kinds of methods were used for usability testing that are Evolutionary Prototype model and questionnaires.

Evolutionary Prototype Model

In general Evolutionary Prototype model has been used to develop this system as a methodology. This methodology was helpful to evaluate the system with users while developing the system because of the initial prototype is presented to the user. They provide feedback and suggestions for improvements. These are auctioned by the developer who then presents a more refined prototype. The user once more provides feedback. The process is repeated. Therefore at each stage the prototype 'evolves' towards the final system. More details have been mentioned in the chapter 3 under the topic 'Process Model'.

Questionnaire Session

System demonstration and user acceptance testing session was conducted at the client premises. Then set of questionnaire have been provided to the participated users to get the final feedback of them for the developed web application whether it is successful or not. User evaluation has done under five major categories. Twenty users participated for the questionnaire session. Below mentioned summary table shows the summary results of the participated user's feedback under the five major categories.

	Agreed	Disagreed	Neither Agree Nor Disagree
Productivity And Usefulness	85%	5%	10%
User Friendly / Easy To Use	75%	10%	15%
Ensure The Information Security	80%	15%	5%
Support To The Decision Making	89%	11%	0%
Request Further Improvement	70%	15%	15%

Table 5.1: User evaluation result summary

Finally it can be announced that this Web Base Corrective Maintenance Management system has been developed successfully that after analysing the user's feedback.

Please refer the appendixB to see the questionnaire sample and the result summary of the user's feedback with pie charts.

5.4 Test Plan and Test Cases

Test cases are separately developed for each module and test cases, all scenarios within that test case and expected result and the actual result of the testing have been mentioned for both applications separately. **Please refer the appendix to seen test cases and test plan and test cases.**

CHAPTER 6: Conclusion & Future Work

6.1 Conclusion

OZ Cleaning (Pvt) Ltd is maintenance service providing company that provides their maintenance service to the business organizations. They are looking forward to getting a competitive advantage among other competitive maintenance service providers by providing a good service to their customers. According to gathered requirements from them and analyzing those requirements, the system has been designed and implemented to meet those organizational goals and customer expectations. Based on OOD methodologies and UML standards, the system has been designed and as the development architecture, MVC architecture has been used for this system.

With completion of each module, testing and evaluation has been done for this system. According to the developed test plan and test cases, testing procedure was carried out and as results got from those testing, it has been proved that the user requirements have been met from this system.

6.2 Future Work

Below mentioned improvements have been identified for the implemented system as future improvements.

1. Currently, both client and company applications related notifications are sent only through the email. SMS sending functionality should be included to the system.
2. Currently Technician related actions are accomplished by supervisor. It is required to develop mobile support pages for technician related functionalities.
3. It is required to improve all web pages as responsive in order to support mobile devices.
4. Currently application does not support to integrate with supervisory control and data acquisition system (SCADA) in order to create faulty equipment related work orders. Application should improve to support SCADA System.
5. Currently application contains only four reports. It is required to improve the reports based on the customer feedback.

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Appendix A – System Documentation

User documentation provides guidance to the installation process of both Company and client applications developed for “OZ Cleaning (PVT) LTD”. This helps to avoid hesitation during the installation and save the time. Administrator must install the Database server and deploy published folder in IIS 7.5.

Since this is web application, company should have provided separate computer called as server and client. (One computer is sufficient as whereas single user is working with the system via direct login of the server machine. But it is unsecured) In order to install this software, the following pre requisites should be fulfilled.

Server

Hardware	Recommended Minimum Requirements
Processor	Intel Pentium IV 2.8 GHz
Memory	2GB RAM
Hard Disk	2 GB Disk Free Space
Display	1024x768 or resolutions above High .Color 16-bit display.
LAN Adapter	Ethernet card

Table A.1: Minimum Requirements - Server - Hardware

Software	Recommended Minimum Requirements
Operating System	Microsoft Windows Server 2005 or later
Database	Microsoft SQL Express Management Studio Express 2005
.Net Framework	.Net Framework 4.5
Web Server	IIS Server 7.5

Table A.2: Minimum Requirements - Server - Software

Client

Hardware	Recommended Minimum Requirements
Processor	Intel Pentium III 1.0 GHz or higher
Memory	2GB RAM
Hard Disk	2 GB Disk Free Space
Display	1024x768 or resolutions above High .Color 32-bit display.
LAN Adapter	Ethernet card

Table A.3: Minimum Requirements - Client - Hardware

Software	Recommended Minimum Requirements
Operating System	Any operating system released after 2005

Table A.4: Minimum Requirements - Client - Software

Install .Net Framework

1. Double click on the .exe file.



Figure A.1: .exe file of .Net Framework



Figure A.2: Terms and conditions

2. Microsoft .Net Framework 4 Setup window is opened; then check which says that you have read and accept the license terms → Install
3. Click Exit to complete the installation



Figure A.3: Completion .Net framework

Install SQL Server Management Studio Express 2005

1. Run the installation package and it will install the modules and packages that are required by the SQL Server setup.

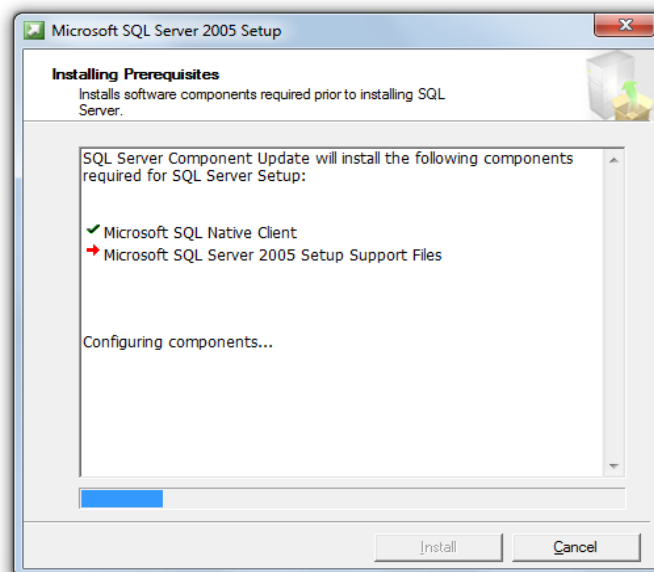


Figure A.4: Installing software components

2. The wizard checks your system configuration and verifies installed and required components. On the Registration Information you can uncheck the "Hide advanced configuration options" check box in order to specify an instance name of the SQL server.

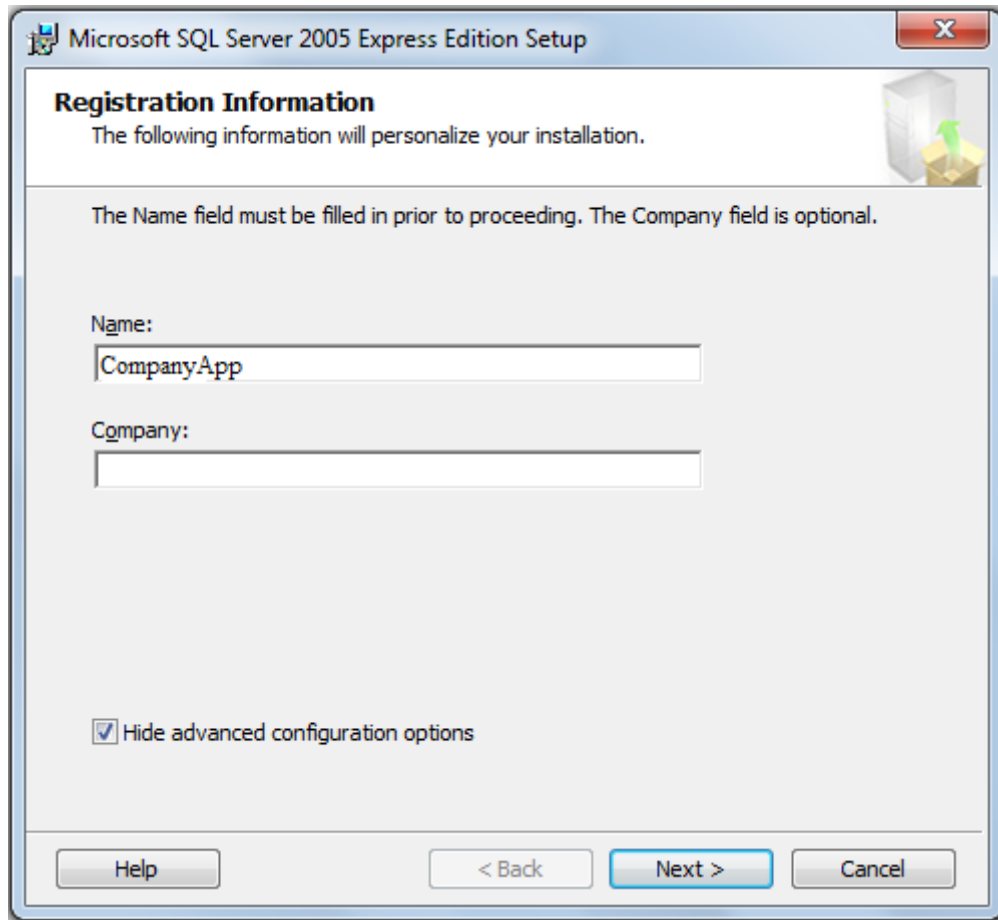


Figure A.5: Configure to show advanced options for the SQL server

3. Click Next to forward the setup to the next page with a selection of features that will be installed.

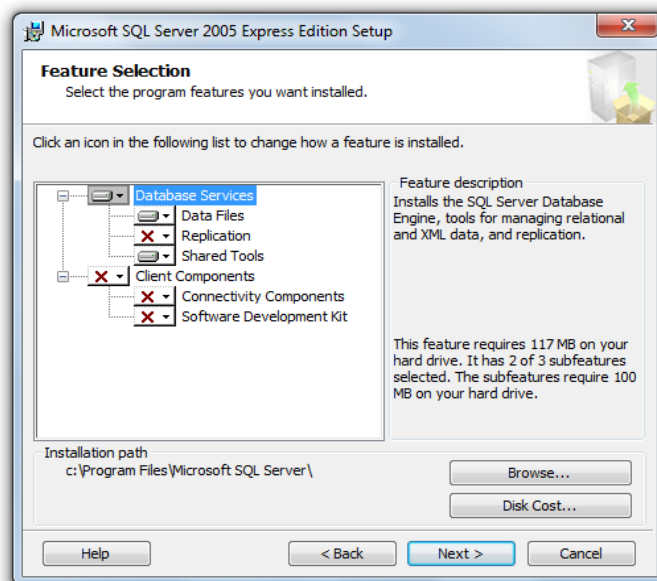


Figure A.6: Select features of the SQL server to install

4. Click Next button to proceed to the selection of Authentication Mode that will be enabled on the SQL server. The Authentication Mode tells the SQL server how to accept connections and which credentials to use in order to authorize those connections, and you can select the "Windows Authentication Mode" or the "Mixed Mode". The "Windows Authentication Mode" tells the SQL server to use current Windows user's credentials under which the connection is made. This is most secure and simple method to handle connections and authorize users on Windows Domain architecture within Active Directory catalog. Otherwise you can choose the "Mixed Mode" to allow the server to authorize users using both Windows Authentication scheme and SQL Server Authentication which enables for the SQL server to have its own user accounts.

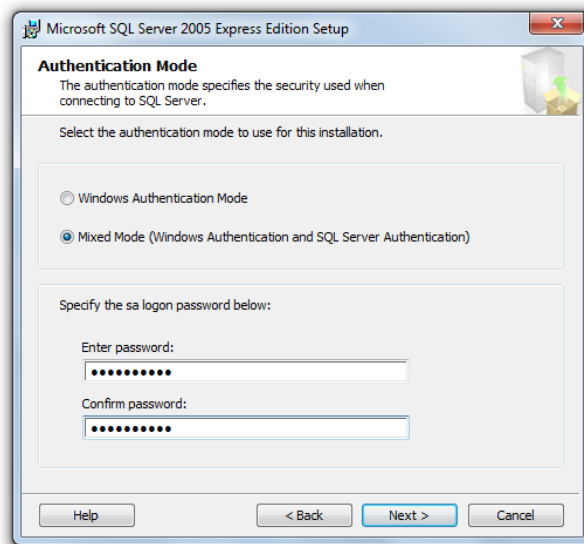


Figure A.7: Choose the Authentication Mode for Microsoft SQL Server 2005

5. Click Next to skip next few dialogs of the wizard with its default settings and to go to the Ready to install page. Click Install button to start installation process of the SQL Server.

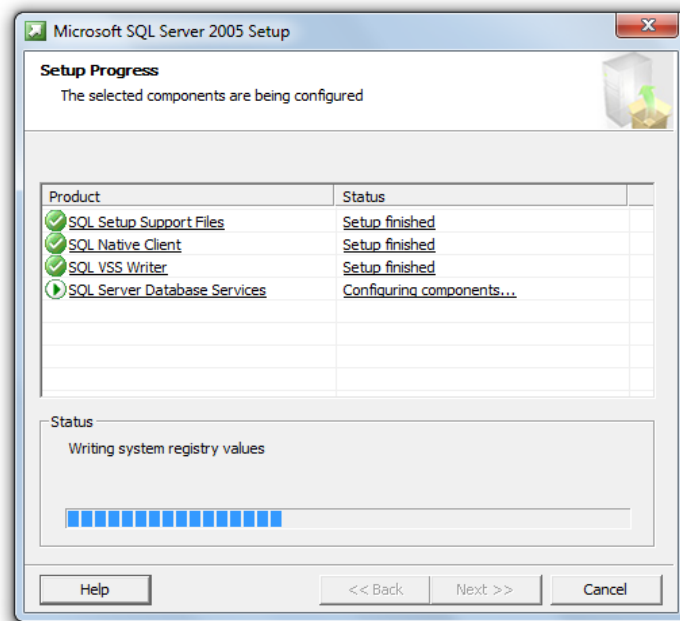


Figure A.8: Selected features and configuration of the SQL server are being installed

6. At the end of the installation, click Close.

Restore “CompanyApp” Database

1. Log in to SQL Server 2005.
2. Right click on “Databases” → “New Database”
3. Type “CompanyApp” in the Database name field.
4. Click OK.
5. Right click on “CompanyApp” under “Databases” → Tasks → Restore → Database

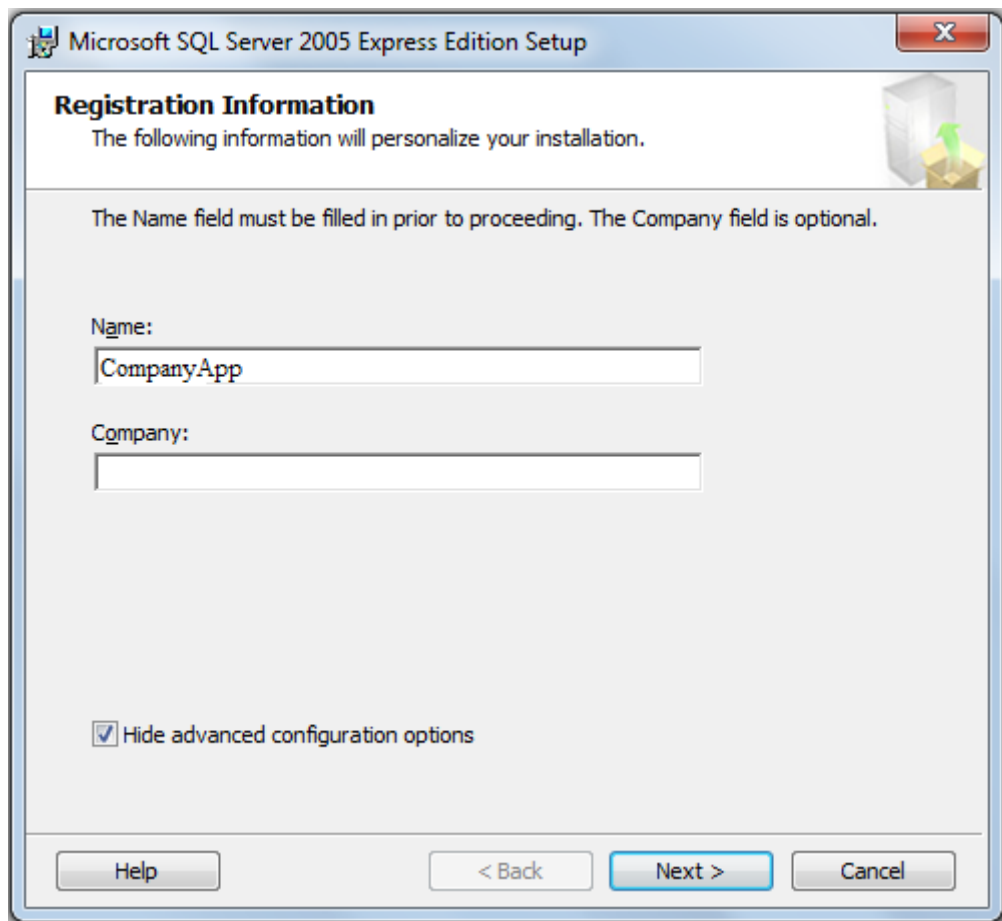


Figure A.9: SQL Server Restore Database

6. Select “From device” browse the “CompanyAppDb.bak” file.
7. Tick “check box” at restore column.
8. Click “OK”.

Deploy “Company App” publish folder in IIS

1. Open IIS Manager
2. Open Project -> Sites.
3. Right click on “Default Web Site” and click on “Add Application”.

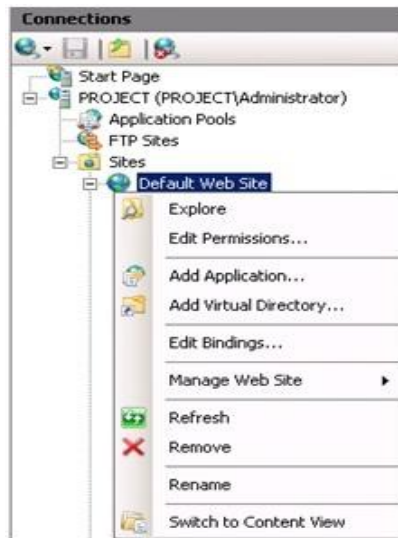


Figure A.10: IIS Default Web Site

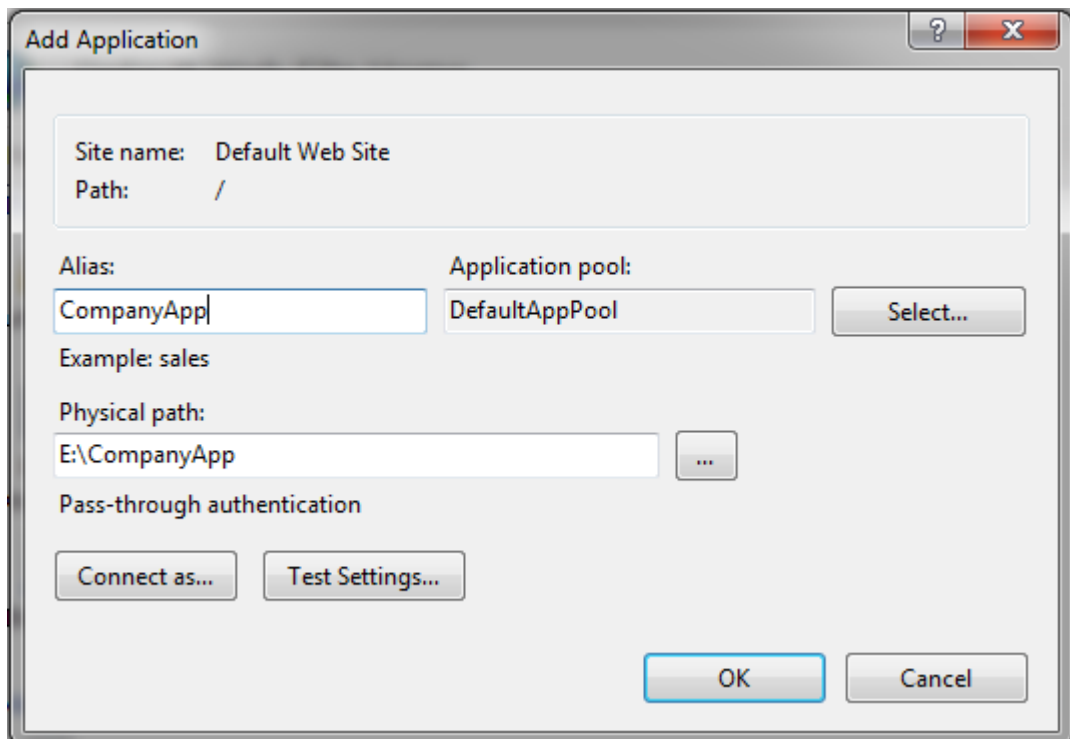


Figure A.11: IIS Add Application

4. Type an "Alias" name
5. Brows physical path of the publish folder.
6. Click OK.

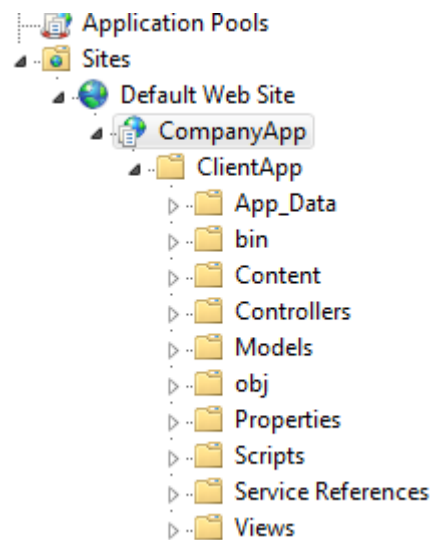


Figure A.12: Company App File Structure

1. Folder published.
2. Right click on the published folder → Manage Application → Browse.

Deploy “Client App” publish folder in IIS.

Follow all the steps that used to deploy “Company App” mentioned above.

Appendix B – Design Documentation

In this document it will explain the diagrams that related to the design stage. Use case narratives, process flow diagrams and database diagrams are included this section.

Use Case Narratives

High level use case diagram is show in the chapter 2. Here has showed that some use case narratives related to the actors.

High Level Use Case Diagram - Admin – Company Application User

Use Case	High Level Use Case Diagram - Overall View
Actors	Admin – Company Application User
Overview	
Mange overall operations related to the admin of the Company Application.	
Pre – Conditions	
<ol style="list-style-type: none">1. User have log into the system as admin user of Company application2. Allow all the functions that have work class 10	
Flow of Events	
<ul style="list-style-type: none">• Select the relevant function to be operate from main menu of the system• Proceed with relevant and allowed functions• Log Out the system	
Post – Conditions	
<ul style="list-style-type: none">• Terminate Process	

Table B.1: High Level Use Case Diagram - Admin – Company Application User

High Level Use Case Diagram - Operator – Company Application User

Use Case	High Level Use Case Diagram - Overall View
Actors	Operator – Company Application User
Overview	
Mange overall operations related operator of the Company application.	
Pre – Conditions	
<ol style="list-style-type: none"> 1. User have log into the system as operator in Company application 2. Allow all the functions that have work class 20 	
Flow of Events	
<ul style="list-style-type: none"> • Select the relevant function to be operate from main menu of the system • Proceed with relevant and allowed functions • Log Out the system 	
Post – Conditions	
<ul style="list-style-type: none"> • Terminate Process 	

Table B.2: High Level Use Case Diagram - Operator – Company Application User

High Level Use Case Diagram - Supervisor – Company Application User

Use Case	High Level Use Case Diagram - Overall View
Actors	Supervisor – Company Application User
Overview	
Mange overall operations related Supervisor of the Company Application.	
Pre – Conditions	
<ol style="list-style-type: none"> 2. User have log into the system as Supervisor in Company Application 2. Allow all the functions that have work class 70 	
Flow of Events	
<ul style="list-style-type: none"> • Select the relevant function to be operate from main menu of the system • Proceed with relevant and allowed functions • Log Out the system 	
Post – Conditions	
<ul style="list-style-type: none"> • Terminate Process 	

Table B.3: High Level Use Case Diagram - Supervisor – Company Application User

High Level Use Case Diagram - Technician – Company User

Use Case	High Level Use Case Diagram - Overall View
Actors	Technician – Company Application User
Overview	
Mange overall operations related Technician of the Company Application.	
Pre – Conditions	
<ol style="list-style-type: none"> 3. User have log into the system as Technician in Company Application 2. Allow all the functions that have work class 60 	
Flow of Events	
<ul style="list-style-type: none"> • Select the relevant function to be operate from main menu of the system • Proceed with relevant and allowed functions • Log Out the system 	
Post – Conditions	
<ul style="list-style-type: none"> • Terminate Process 	

Table B.4: High Level Use Case Diagram - Technician – Company Application User

High Level Use Case Diagram - Manager – Company Application User

Use Case	High Level Use Case Diagram - Overall View
Actors	Manager – Company Application User
Overview	
Mange overall operations related Manager of the Company Application.	
Pre – Conditions	
<ol style="list-style-type: none"> 4. User have log into the system as Manager in Company Application 2. Allow all the functions that have work class 70 	
Flow of Events	
<ul style="list-style-type: none"> • Select the relevant function to be operate from main menu of the system • Proceed with relevant and allowed functions • Log Out the system 	
Post – Conditions	
<ul style="list-style-type: none"> • Terminate Process 	

Table B.5: High Level Use Case Diagram - Manager – Company Application User

Table B.3: High Level Use Case Diagram - Admin – Business Client User

Use Case	High Level Use Case Diagram - Overall View
Actors	Admin – Business Client User
Overview	
Mange overall operations related to the admin of the client application.	
Pre – Conditions	
<ol style="list-style-type: none"> 5. User have log into the system as admin user in client application. 2. Allow all the functions that have work class 30 with business client. 	
Flow of Events	
<ul style="list-style-type: none"> • Select the relevant function to be operate from main menu of the system • Proceed with relevant and allowed functions • Log Out the system 	
Post – Conditions	
<ul style="list-style-type: none"> • Terminate Process 	

Table B.6: High Level Use Case Diagram - Admin – Client Application User

High Level Use Case Diagram - Tenant – Business Client User

Use Case	High Level Use Case Diagram - Overall View
Actors	Tenant – Business Client User
Overview	
Mange overall operations related to Tenant user of the client application.	
Pre – Conditions	
<ol style="list-style-type: none"> 6. User have log into the system as Tenant in client application. 2. Allow all the functions that have work class 50 with business client. 	
Flow of Events	
<ul style="list-style-type: none"> • Select the relevant function to be operate from main menu of the system • Proceed with relevant and allowed functions • Log Out the system 	
Post – Conditions	
<ul style="list-style-type: none"> • Terminate Process 	

Table B.7: High Level Use Case Diagram - Operator – Client Application User

Process Flow Diagrams

As mentioned in chapter 3, several important process flow diagrams are shown in this section in detail.

Login Process for both Application

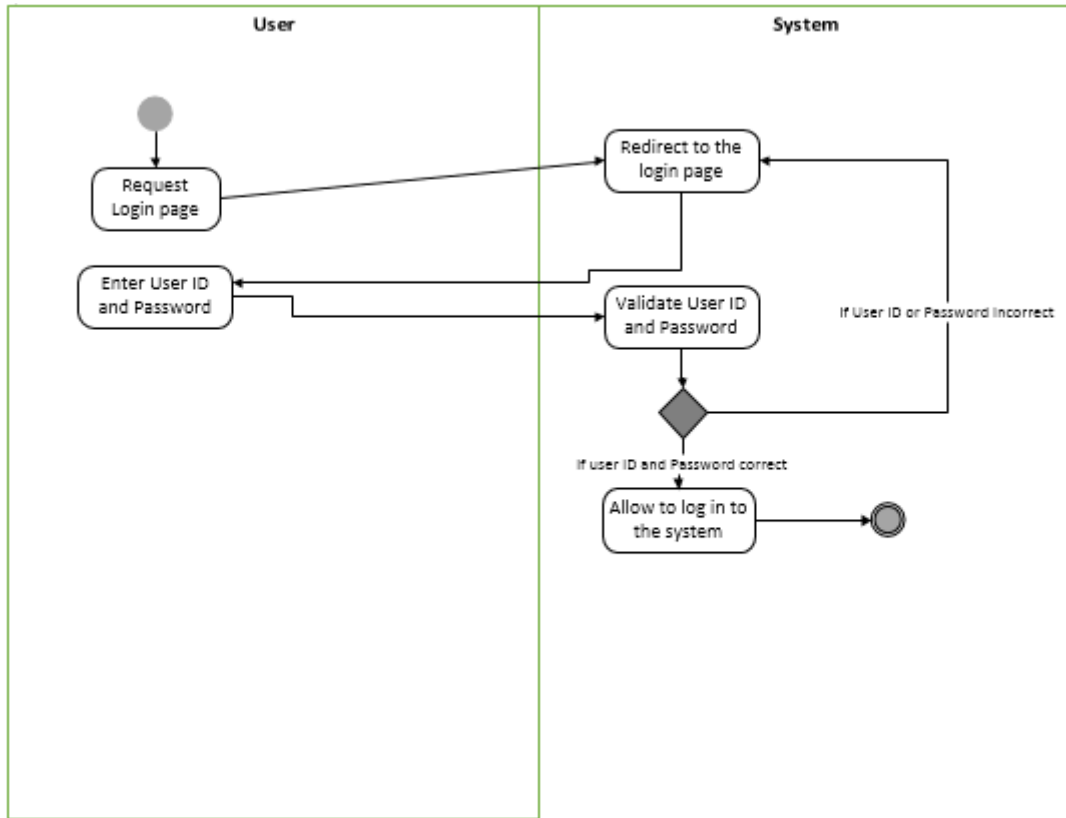


Figure B.1: Login Process for both Applications

Online User Registration for Business Client

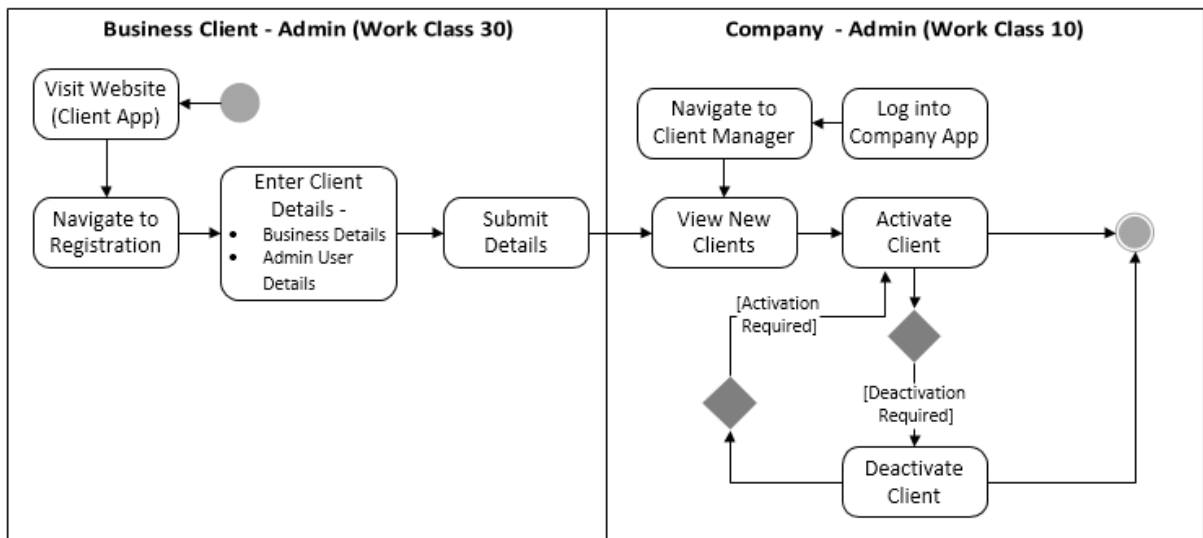


Figure B.2: Online User Registration for Business Client

Operate the Administration Functions of Company Application

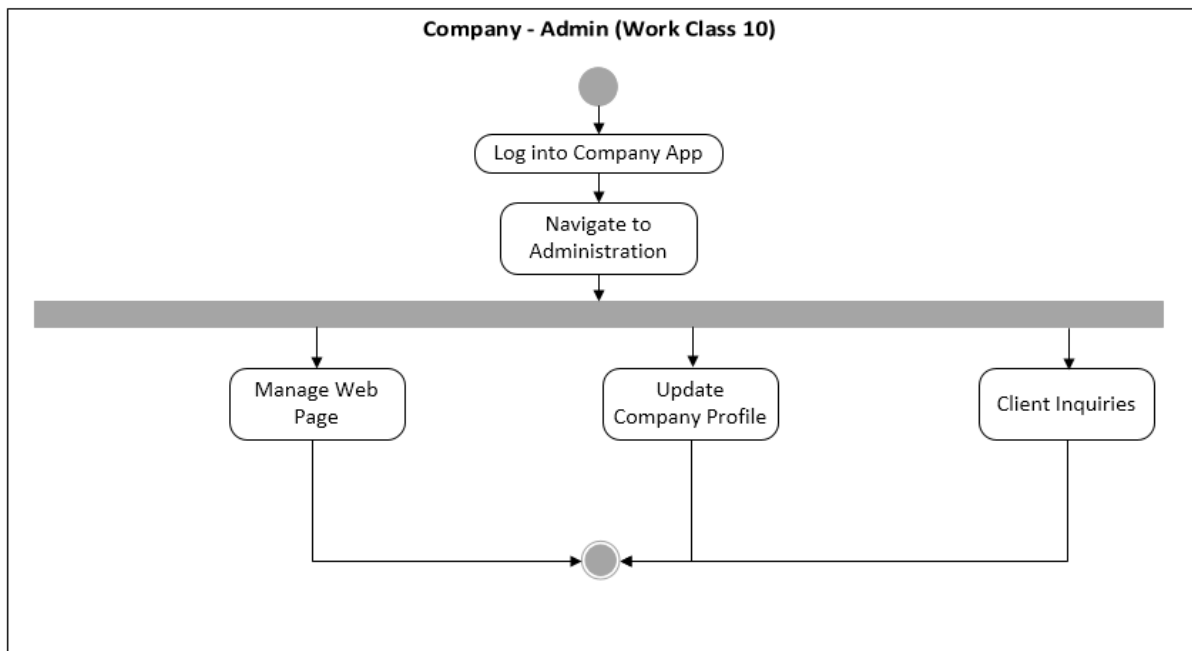


Figure B.3: Operate the Administration Functions of Company Application

User Management Process for Company Application

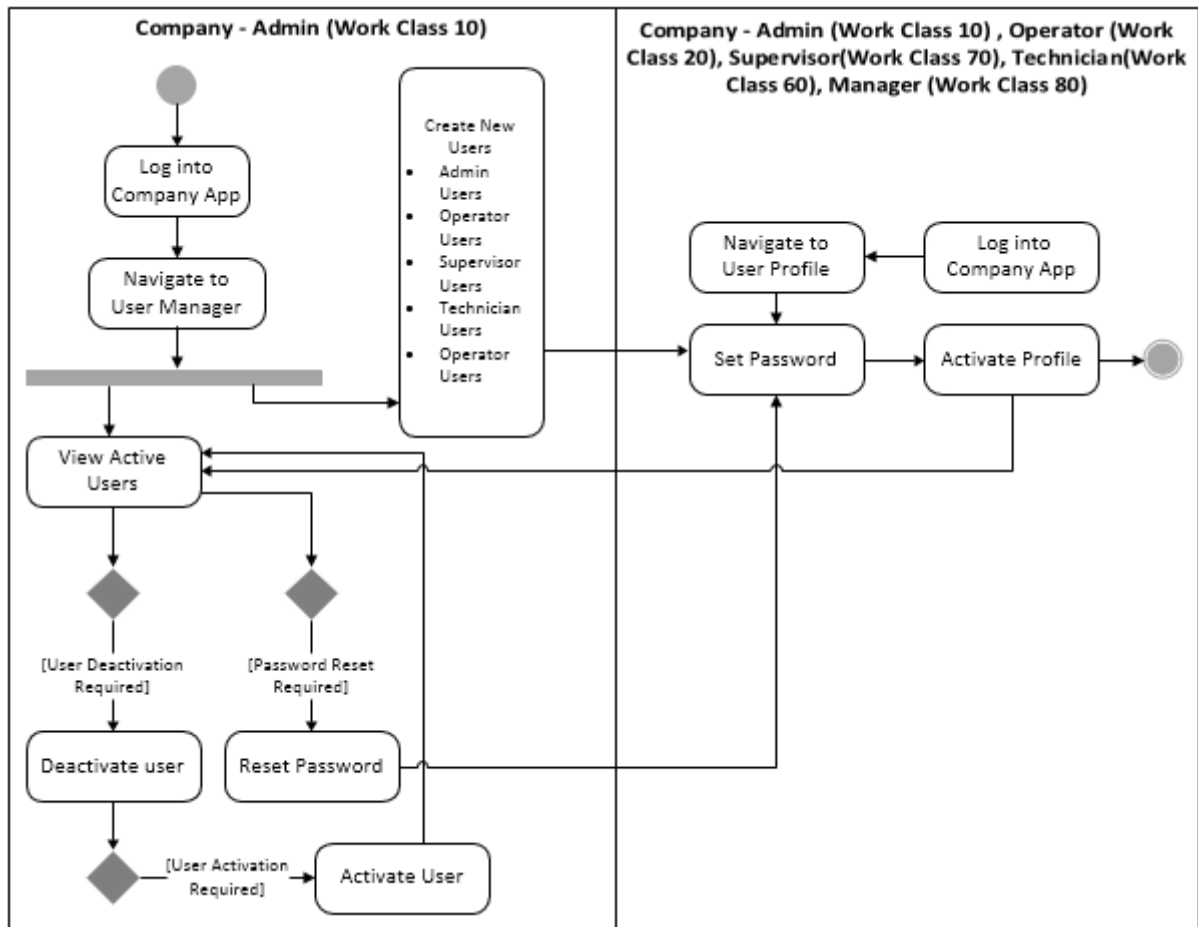


Figure B.4: User Management Process for Company

User Management Process for Business Client

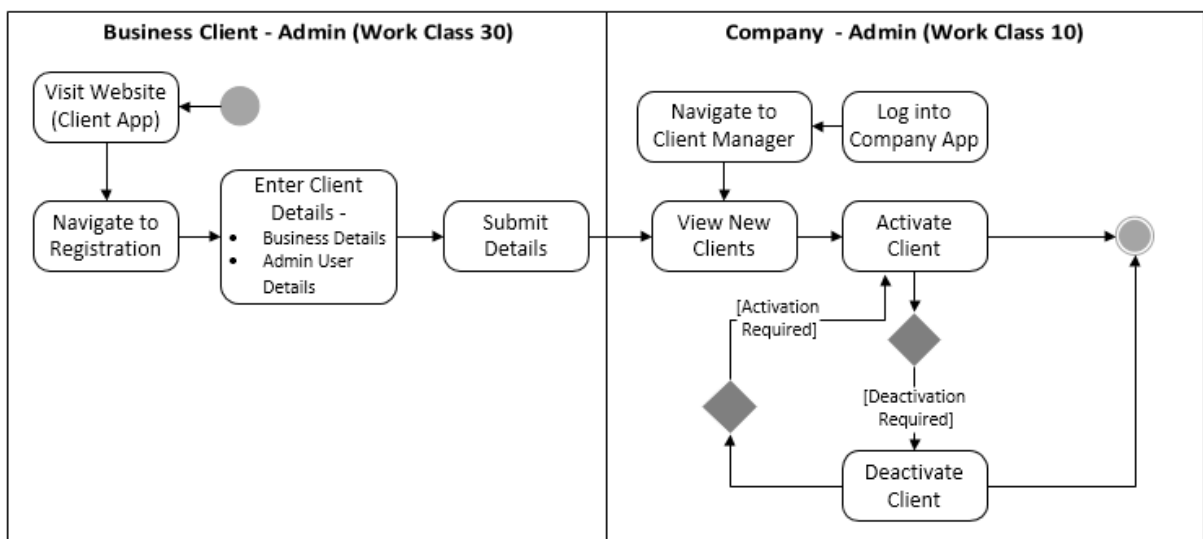


Figure B.5: User Management Process for Business Client

User Profile Manager Process for Company Application

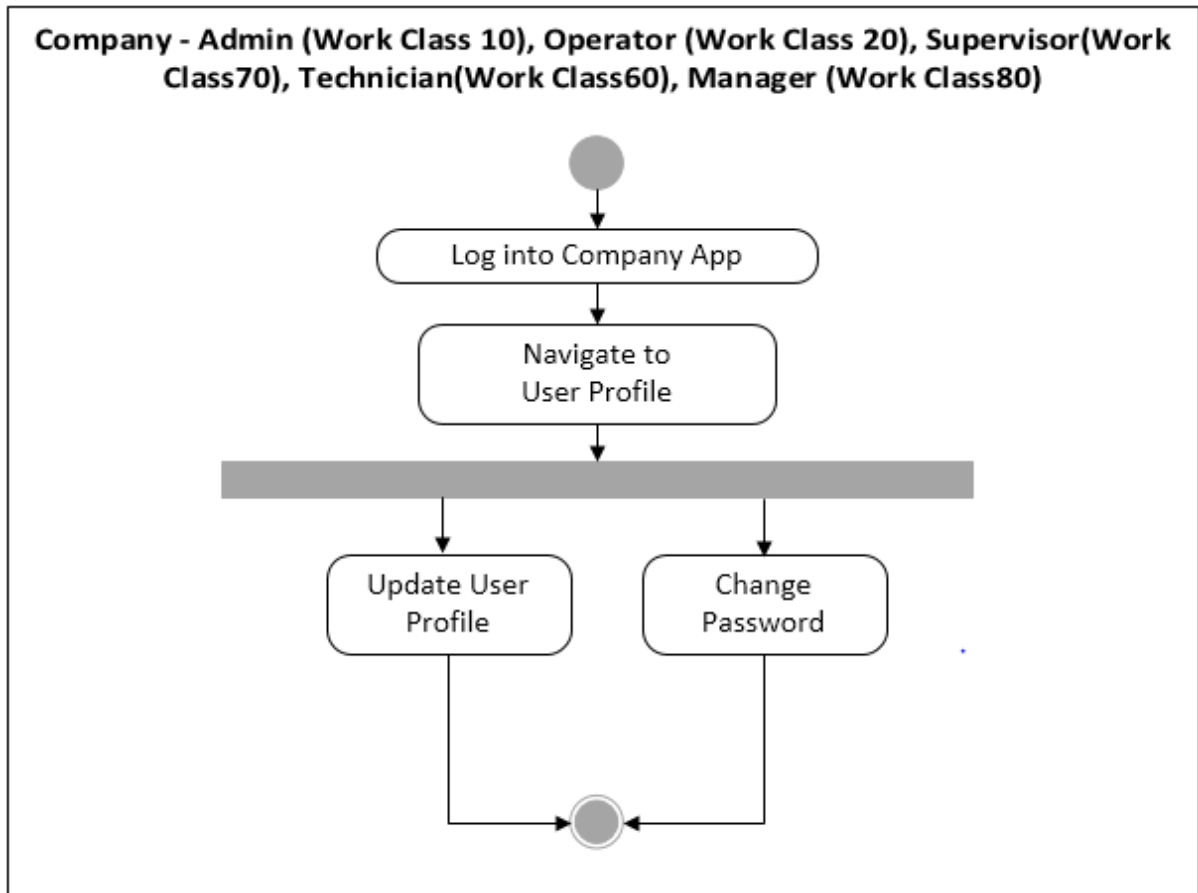


Figure B.6: User Profile Manager Process for Company

User Profile Manager Process for Clients

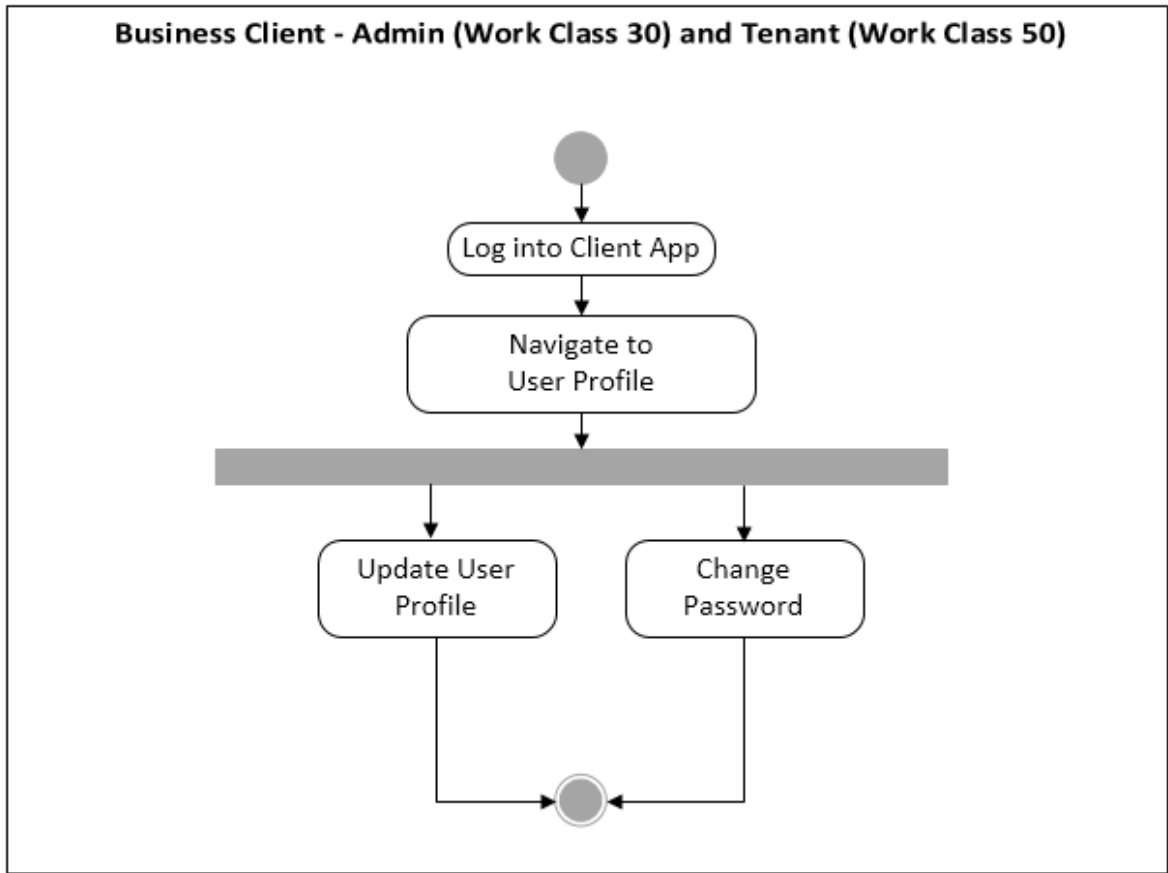


Figure B.7: User Profile Manager Process for Clients

Report Generation

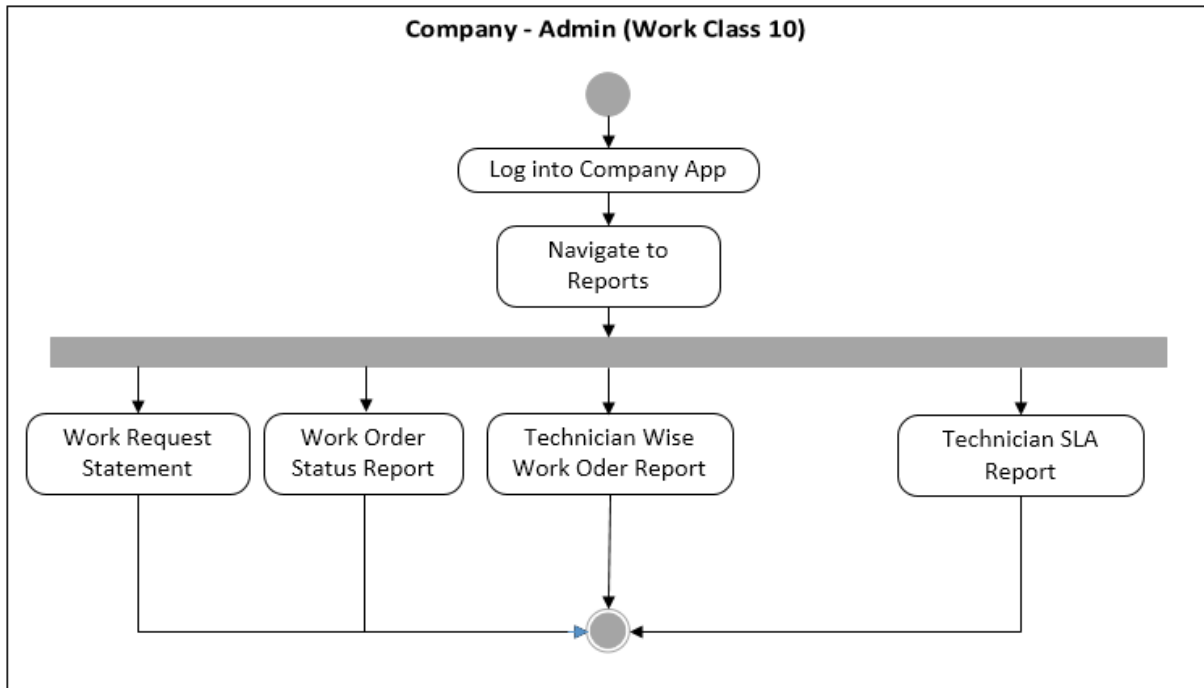


Figure B.8: Report Generation

Database Diagram

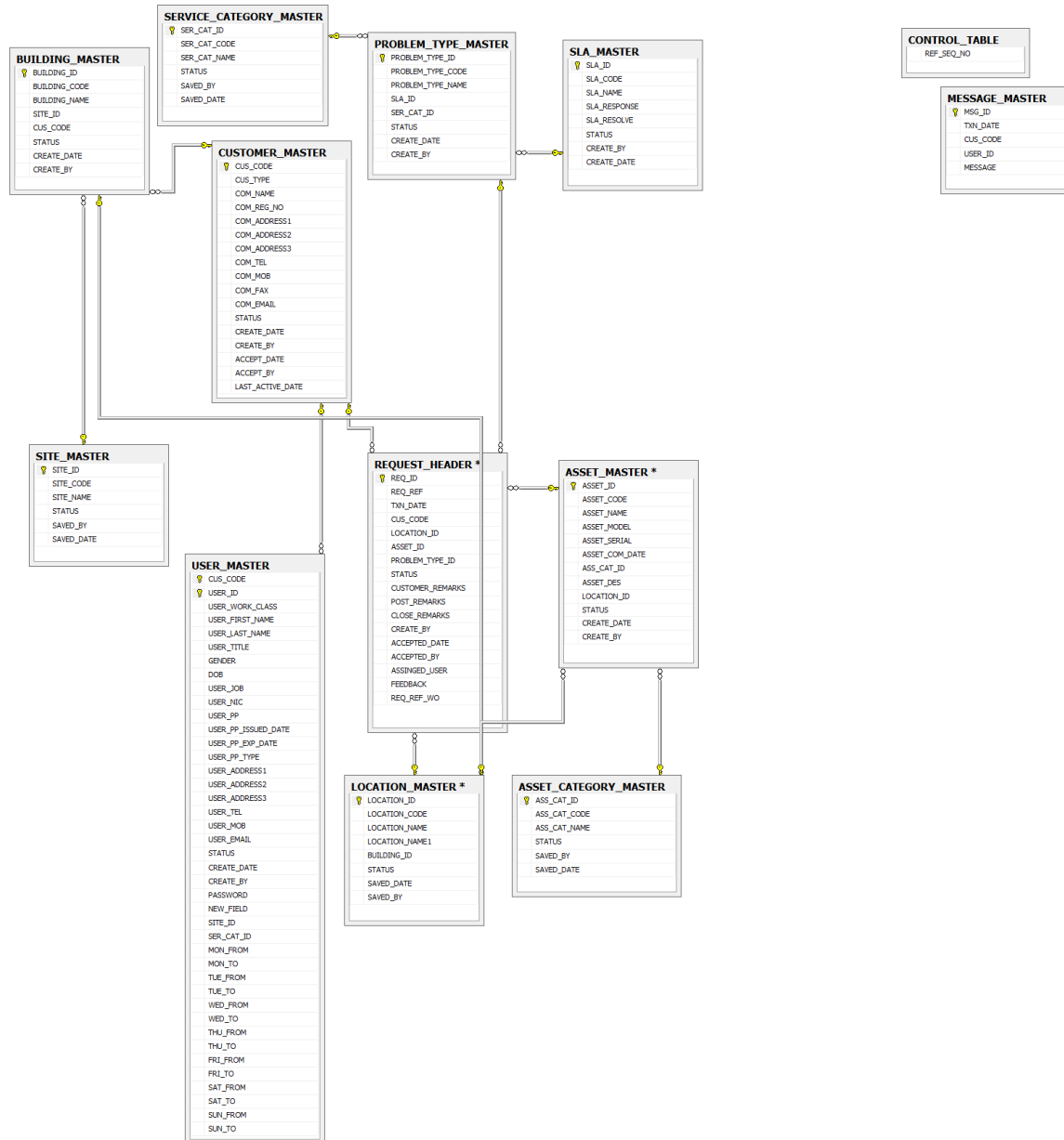


Figure B.9: Database Diagram

**User Guide for
Web based Corrective Maintenance
Management System for OZ Cleaning
(PVT) LTD.**

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1. Introduction

1.1 About the Guide

This document is to provide general guidance for the users who intend to use the developed Web Based Corrective Maintenance Management System to carry out their operations with implemented system functionalities.

1.2 System Users & User Work Classes

This system has main two applications, Company application and Client application. Company application has five user types call Admin, Operator, Supervisor, Technician, and Manager. Client application has two kinds of users call admin user and tenant user. Each and every user type has been allocated a work class. User privileges are allowing and working with the allocated work class.

2. Company Application Functions

This application has been provided for the OZ company to operate the all functionalities related to the work request, processing work orders, manage locations, manage Assets, manage duty roster, client handling, manage service categories, SLA, Problem types user handling and report generation with more system functionalities.

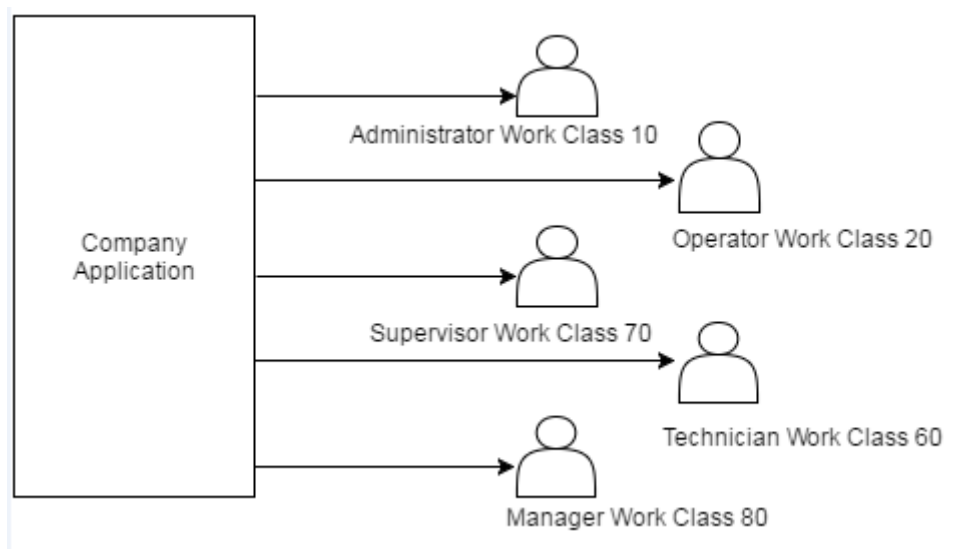


Figure C.1: User Types – Company Application

2.1 Login

Operators, Supervisors, Technician, Manager and admin users of the Company can log into the system using valid user name and password.

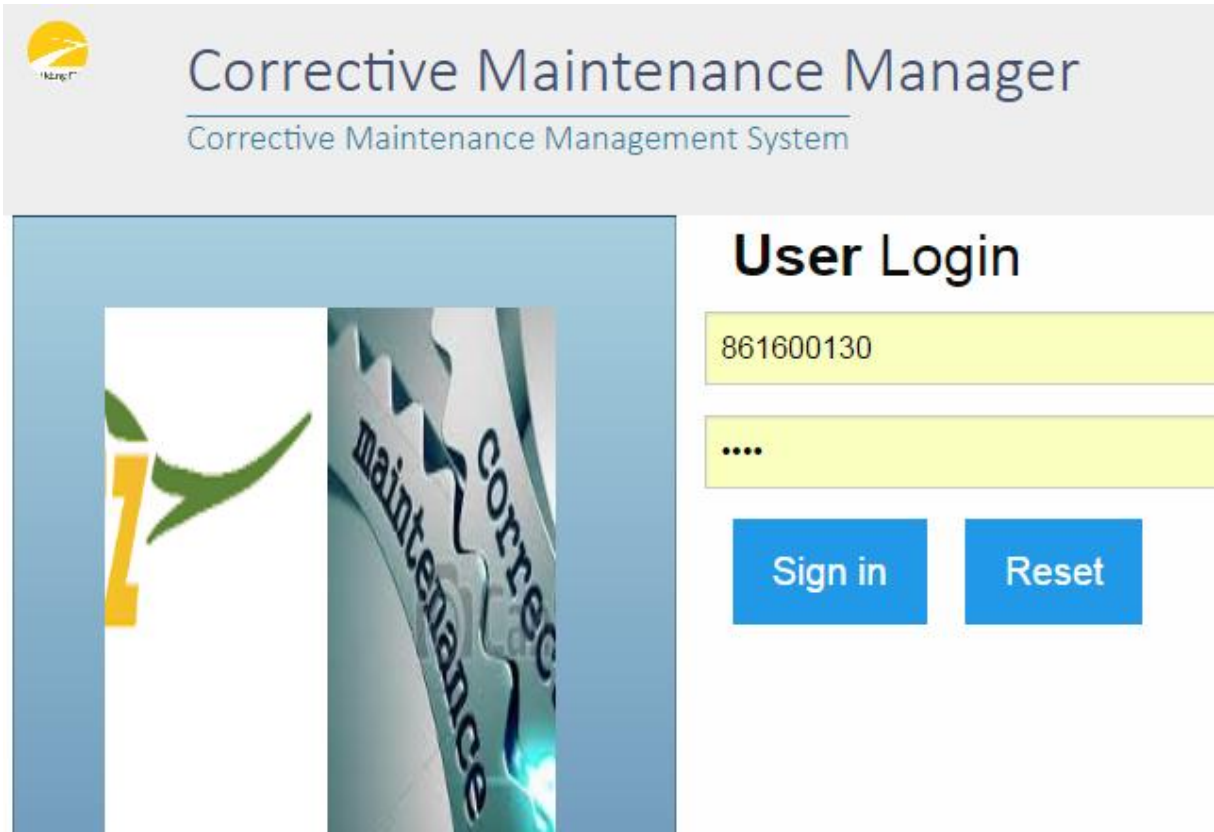


Figure C.2: Login - Company

2.2 Home

Once user successfully log into the system, home page will be displayed. .

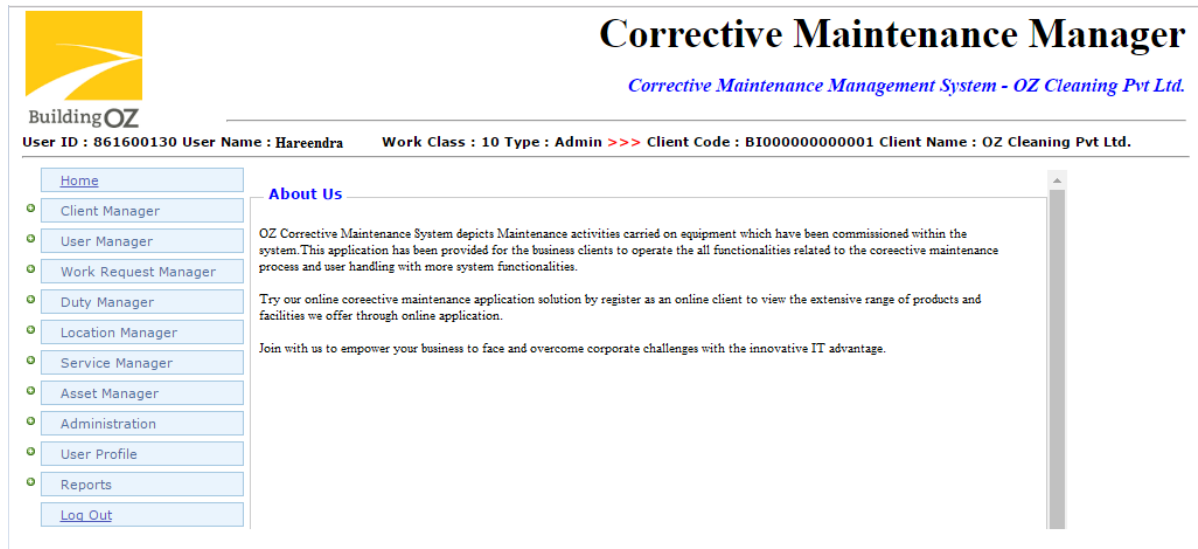


Figure C.3: Home - Company

2.3 Client Manager

This option is only allowed for admin users of the company to maintain and handle the business client. Main three options gave been provided.

2.3.1 New Clients

If the new clients are registered online with the client application, those clients are in pending status. Therefore admin user of Company application can accept new clients as active clients. Once admin user click the “New Clients” link, all pending client list is loaded.

New Client List

Options	Client Code	Client Name	Client Type	Create Date	Status
	BI160208010014	SK Enterprise	Business	2/8/2016 1:00:14 AM	New Entry
	IN160103023120	MY	Individual	1/3/2016 2:31:20 PM	New Entry
	IN160209102930	zdgb	Individual	2/9/2016 10:29:30 AM	New Entry
	IN160209103047	zdgb	Individual	2/9/2016 10:30:47 AM	New Entry

Showing 1 to 4 of 4 entries [First](#) [Previous](#) [1](#) [Next](#) [Last](#)

- Accept Option

Figure C.4: New Clients - Company

2.3.2 Activate Clients

The entire inactive client list will be displayed, once user clicks on this link. User can activate the inactive clients by clicking record in the data table.

Inactive Client List

Options	Client Code	Client Name	Client Type	Create Date	Last Deactivated Date	Status
	BI001		Business	1/1/0001 12:00:00 AM	2/8/2016 12:55:13 AM	Inactive
	BI002		Business	1/1/0001 12:00:00 AM	2/7/2016 3:40:31 PM	Inactive

Showing 1 to 2 of 2 entries [First](#) [Previous](#) [1](#) [Next](#) [Last](#)

- Activate Option

Figure C.5: Login - Company

2.3.3 Deactivate Client

The entire active client list will be displayed, once user clicks on this link. User can deactivate the active clients by clicking record in the data table.

Active Client List

Options	Client Code	Client Name	Client Type	Create Date	Last Activated Date	Status
	BI000000000001	OZ Cleaning Pvt Ltd.	Business	1/1/0001 12:00:00 AM	1/16/2016 10:52:07 AM	Active
	BI160103022922	PVT LTD	Business	1/3/2016 2:29:22 PM	1/1/0001 12:00:00 AM	Active
	BI160208124014	Matara Foreign Agency	Business	2/8/2016 12:40:14 AM	1/1/0001 12:00:00 AM	Active
	IN160208124727		Individual	2/8/2016 12:47:27 AM	1/1/0001 12:00:00 AM	Active

Showing 1 to 4 of 4 entries First Previous 1 Next Last

 - Deactivate Option

Figure C.6: Deactivate Client

2.4 User Manager

This option is only allowed for admin users of Company application to maintain the users on behalf of the OZ Company. Company may have admin users, operators, supervisors, technician and Manager.

2.4.1 Create/Deactivate/Reset Users

The entire active user list will be displayed, once user clicks on this link. Admin user of the Company application can create new operators as well as other admin users on behalf of that company by clicking create button.

Admin user can deactivate the active users of Company app by clicking record in the data table. And also can reset the user's password of the Company app when required. A newly random generated password has been sent to the user's email account.

Active User List

Add

Options	Client Code	User ID	User First Name	User Last Name	User Type	Status
	BI000000000001	851600130	Ravi	Perera	Admin	Active
	BI000000000001	851600131	Kasun	Alwis	Operator	Active

Figure C.7: Create/Deactivate/Reset Users

2.4.2 Activate Users

The entire inactive user list will be displayed, once user clicks on this link. Admin user can activate the inactive users of Company app by clicking record in the data table.

Inactive User List

Options	Client Code	User ID	User First Name	User Last Name	User Type	Status
	BI0000000000001	561600130	Ranga	Perera	Technician	Inactive
	BI0000000000001	861600141	SOFT	OPA	Operator	Inactive
	BI0000000000001	861600142	SOFT	ADDIM	Admin	Inactive
	BI0000000000001	861600150	f	g	Admin	Inactive
	BI0000000000001	911600130	Ranga	Abe	Supervisor	Inactive

Showing 1 to 5 of 5 entries First Previous 1 Next Last

- Activate Option

Figure C.8: Activate Users

2.5 Work Request Manager

This option has been provided to the Company users to handle and process the work requests that applied by the clients.

2.5.1 New Requests

Once client make a work request created through the client application, admin, operator, and supervisor user of the Company allowed to do following functionalities.

- Online request option allowed register work request on behalf of a tenant.
- Create work order by assigning supervisor.
- Allowed to post work request without taking further actions
- Allowed to Reject Work Request

New Work Request List

[Online Request](#)

Options	Request No	Txn Date	Client Code	Status
	RQ170112114702	1/12/2017 11:47:14 AM	BI0000000000001	New Entry
	RQ170112120540	1/12/2017 12:05:51 PM	BI0000000000001	New Entry
	RQ170112062232	1/12/2017 6:22:40 PM	BI0000000000001	New Entry

Showing 1 to 3 of 3 entries First Previous 1 Next Last

Figure C.9: New Work Requests

2.5.2 Process work order

All Work order list is loaded once user click this link. In this section allowed to assign Technician to the work order, Update work order start time and End time the work order. And also notification can send to the tenant informing the work order status.

Show 10 entries		Search:			
Options	Request No	Txn Date	Client Code	Assinged User	Status
<input checked="" type="checkbox"/>	RQ170112114045	1/12/2017 11:40:59 AM	BI000000000001	911600130	Pending Processing
<input checked="" type="checkbox"/>	RQ170112041206	1/12/2017 4:12:06 PM	BI160208124014	911600130	Pending Processing

Showing 1 to 2 of 2 entries First Previous 1 Next Last

- Sending Notification/Status Updating Option

Figure C.10: Process Requests

2.5.3 Download Documents

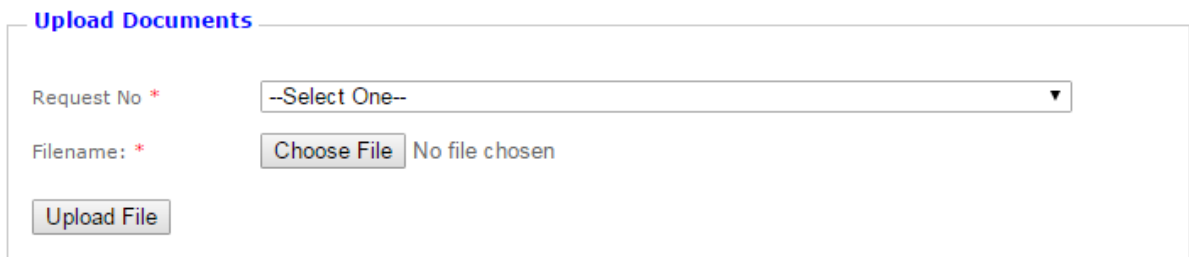
All pending request list is loaded once user click download document link. Once operator selects a work request, all the tenant user of client uploaded documents will be displayed. Operator can download the documents. Operators are allowed to download the documents like breakdown asset related document are uploaded by the client.

Show 10 entries		Search:			
Options	Request No	Txn Date	Client	Country	Status
	RQ170108114550	1/8/2017 11:46:13 AM	BI160208124014		Close
	RQ170108114619	1/8/2017 11:46:28 AM	BI160208124014		Close
	RQ170112114045	1/12/2017 11:40:59 AM	BI000000000001		Pending
	RQ170112114702	1/12/2017 11:47:14 AM	BI000000000001		New Entry
	RQ170112120540	1/12/2017 12:05:51 PM	BI000000000001		New Entry
	RQ170112031137	1/12/2017 3:11:45 PM	BI160208124014		Close

Figure C.11: Company App Download Documents

2.5.4 Upload Documents

Operators are allowed to upload any documents relate to the particular work request by using the upload document option.



Upload Documents

Request No *

Filename: * No file chosen

Figure C.12: Upload Documents

2.5.5 Post Work Requests

All pending work request list is loaded once user click this link. Once finish the processing of work order, related work request should be posted to the tenant user of the client, in order to add the tenant feedback.

Pending Work Request List For Post

Options	Request No	Txn Date	Client Code	Assinged User	Status
	RQ170112114045	1/12/2017 11:40:59 AM	BI000000000001	911600130	Pending
	RQ170112041206	1/12/2017 4:12:06 PM	BI160208124014	911600130	Pending

Showing 1 to 2 of 2 entries [First](#) [Previous](#) [1](#) [Next](#) [Last](#)



- Post Option

Figure C.13: Post Work Requests List for Post

2.5.6 Close Work Requests

All posted request list is loaded once user click this link. The request should be closed, once client feedback is added as satisfied for the particular request. If client is not satisfied new work request will automatically generate using initial request details.

Pending Work Request List For Close

Options	Request No	Txn Date	Client Code	Assinged User	Status
 	RQ170112041206	1/12/2017 4:12:06 PM	BI160208124014	911600130	Post

Showing 1 to 1 of 1 entries First Previous 1 Next Last

Figure C.14: Close Requests

2.6 Location Manager

Location Manager consist following configuration options.

- Allowed to add, edit, activate, and deactivate sites.
- Allowed to add, edit, activate, and deactivate building.
- Allowed to add, edit and activate, deactivate Location.

2.6.1 Configure site

This sections allows to con figure site. Site is base Location of client.

Site List

[Add](#)

Options	Site Code	Site Name	Status
 	site1	site site 12	Active
 	site2	srg	Active

Showing 1 to 2 of 2 entries First Previous 1 Next Last

 - Edit Option  - Activate Option  - Deactivate Option

Figure C.15: Site List



- In this section user Allowed to add, edit, activate, and deactivate sites.

2.6.2 Create Building

This Section allow user to add, edit, activate, deactivate buildings under the specific Site.

Building List

Add

Options	Building Code	Building Name	Status
 	buil1	bu11	Active

Showing 1 to 1 of 1 entries First Previous 1 Next Last




 - Edit Option  - Activate Option  - Deactivate Option



Figure C.16: building List

2.6.2 Create Location

This section allow user to configure location under the Specific building.

Location List

Add

Options	Location Code	Location Name	Status
 	loc1	l11	Active

Showing 1 to 1 of 1 entries First Previous 1 Next Last




 - Edit Option  - Activate Option  - Deactivate Option

Figure C.17: Location List

2.7 Asset Manager

Asset Manager allowed to add, edit, activate, and deactivate asset categories and assets.



2.7.1 Create Asset Category

Each Asset belongs to a specific Asset category. In this section allowed user to add, Edit, deactivate, and activate Asset Category.

Eg: Fan coil unit, Flow Control Unit, Blinds, Air Handling Unit, Light

Asset Categories List

Add

Options	Asset Category Code	Asset Category Name	Status
 	ASS1	Assxxxxcc	Active

Showing 1 to 1 of 1 entries First Previous 1 Next Last








 - Edit Option  - Activate Option  - Deactivate Option

Figure C.18: Asset Category List

2.7.2 Asset Registry

In this section allowed user to Add, edit, activate, and deactivate, Asset.

Asset List Add

Options	Asset Code	Asset Name	Status
 	asssss	aaaaaa	Active
 	aa	aaaa	Active

Showing 1 to 2 of 2 entries First Previous 1 Next Last


 - Edit Option  - Activate Option  - Deactivate Option

Figure C.19: Asset List

2.8 Service Manager







Service Manager consist following functionalities.

- Create service Category
- Create SLA\
- Create Problem Type

2.8.1 Create Service Category

OZ Company provide maintenance service with respect to set of service categories. In this section allowed to add, edit, activate and deactivate service categories.

Service Categories List Add

Options	Service Category Code	Service Category Name	Status
 	SER 12	SERVICE 11	Active
 	Electrical	Electrical	Active
 	Plumbing	Plumbing	Active

Showing 1 to 3 of 3 entries First Previous 1 Next Last




 - Edit Option  - Activate Option  - Deactivate Option

Figure C.20: Service Category List

2.8.2 Create SLA

SLA – Service Level Agreement

Each SLA Consist of two properties called response SLA and Resolve SLA. Response SLA begin when technician is assigned to particular work order. Resolve SLA begin when technician start work order. Application allowed to add, edit, activate and deactivate SLA.

Add SLA

SLA Details

SLA Code *

SLA Name *

SLA Response Time *

SLA Resolve Time *

[Save](#) [Cancel](#)

Figure C.21: SLA List

2.8.3 Problem Type

In this section allowed to edit, add, activate and deactivate problem types. Each problem type is assign to a work order.

Problem Types List [Add](#)

Show 10 entries Search:

Options	Problem Type Code	Problem Type Name	Status
	PROB 1	PROBaaaaavvvvv	Active
	PROB 1	PROB	Active
	PROB 14	PROBnm	Active

Showing 1 to 3 of 3 entries [First](#) [Previous](#) **1** [Next](#) [Last](#)

- Edit Option - Activate Option - Deactivate Option

Figure C.22: Problem Type List

2.9 Duty Manager

Duty Manager allowed to configure duty roster for technicians.

3.0 Administration Functions

Manage web page, Update Company and Client Inquiries option exist under the administration Section.

3.1.1 Create Web Page

Client application related instructions and other required details related can be configure using this option. These added details and instructions will be displayed in the client application. Already added countries list is loaded.

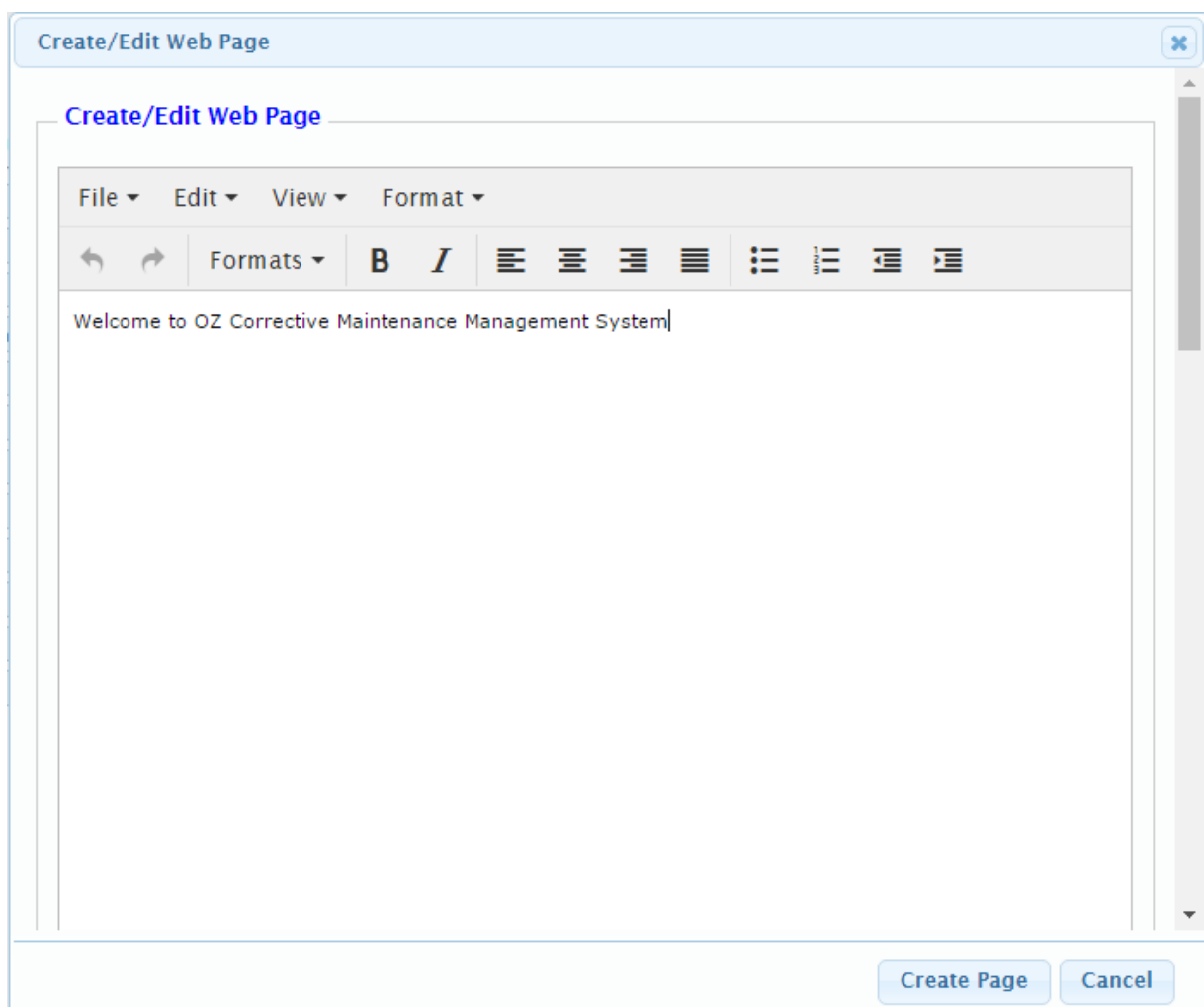


Figure C.23: Create Web Page

3.1.2 Client Inquires

Users can view the client inquiries using this option. Client inquiry list is loaded. Admin user can view those inquiries.

3.1.3 Company Profile

Admin user of company application can update the company profile.

3.2 User Profile

This option allowed all users of company application and it's provide following two options.

- Update User Profile
- Change Password

3.2.1 Update User Profile

Users can update their user details like name, email and other details using this link.

3.2.2 Change Password

Users can change their current password. In-order to change the password user must need to enter their old password for verification.

3.3 Reports

Following reports are exist under the report option

- Work Order Status Report
- Technician Wise Work Order Report
- Technician SLA Report
- Work request statement

3.3.1 Work Order Status Report

User can generate a work order status report for a particular date range.

3.3.2 Technician Wise Work order Report

User can generate a technician wise work order report for a selected request.

3.3.3 Technician SLA Report

This report is most important report in the system. By using this report Management can check whether the technician has completed the assign duties within the assign SLA Time Period.

User can generate a technician SLA report for a particular date range.

3.3.4 Work request Statement

In this option allowed to generate each work request details as a statement.

4. Client Application Functions

This application has been provided for the business clients to manage all functionalities related to the work request, user handling with more system functionalities.

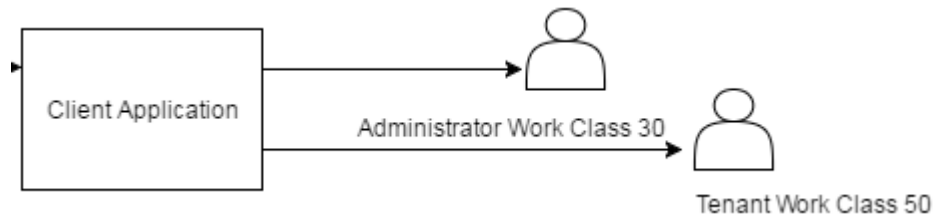


Figure C.24: User Types – Client Application

4.1 Login

Tenant and admin users of the business client can log into the system using valid user name and password.

User Login

The login form consists of two input fields and two buttons. The first input field contains the username '761600131'. The second input field contains four dots '....' representing a password. Below the input fields are two blue buttons: 'Sign in' and 'Reset'.

[User Registration](#)
[Forgot Password?](#)

Figure C.25: login – Client Application

4.2 Home

Once user successfully log into the system, home page will be displayed. Welcome message and important summary results related to Client applications be displayed here. Figure C:26 show the home page.



Corrective Maintenance Manager - Client Module

Corrective Maintenance Management System - OZ Cleaning Pvt Ltd.

User ID : 761600131 User Name : Hareendra Dimuthu : 20 Type : Operator >>> Client Code : BI160208124014 Client Name : Capital Tower

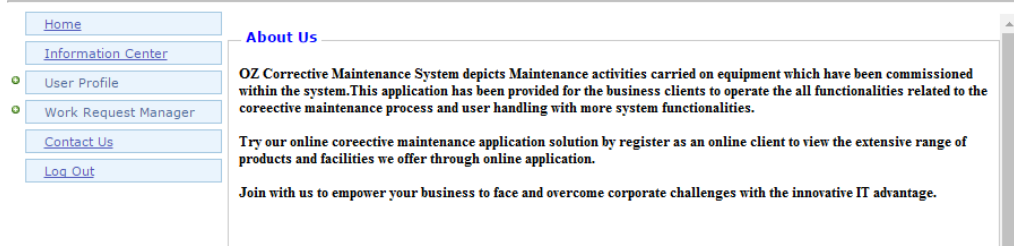


Figure C.26: Home - Client

4.3 User Registration

User can register in online as a business client. The person who register the business company as a business client consider as a default admin user of the business client. Both company details and user details should enter to the system when register. User should click the “User Registration” link on the login page to register. See the figure x

4.4 Information Center

All the instructions and details relevant to the Client application displayed on this section.

User can download the Application instruction manuals on this page using provided download link.

User can access this feature by clicking the link “Information Center” on the main menu. See the figure x

4.5 Work Request Manger

Users of business client can access this feature by clicking the link “Work request Manager” on the main menu. Following functionalities are exist under the work request manager.

- Work Request
- Upload Document
- Download Document
- Close Work request

4.5.1 Work Request

This option allows to users of business client to register maintenance request regarding the Asset break down.

4.5.2 Download Documents

Users are allowed to download the documents that uploaded by the OZ Company using document download option.

4.5.3 Upload Documents

Users are allowed to upload any documents relate to the particular work request using document upload option.

5.6 Business Profile

Business clients are allowed this option. Admin users only can access this option. Two options have been provided under this.

5.7 User Profile

Each and every user of the client application is allowed this option. Two options have been provided under this.

5.7.1 Update User Profile

Users can update their user details like name, email and other details using this option.

5.7.2 Change Password

Users can change their current password. User must need to enter their old password for verification.

5.8 User Manager

This option is only allowed for admin users of business clients to maintain the users on behalf of a company. Business client may have admin users as well as Tenant.

5.8.1 Create/Deactivate/Reset Users

The entire active user list will be displayed, once user clicks on this link. Admin user of a particular company can create new tenant as well as other admin users on behalf of that company by clicking create option.

Admin user can deactivate the active users of that particular company by clicking record in the data table. And also can reset the user's password of that particular company when required. A newly random generated password has been sent to the user's email account.

5.8.2 Activate Users

The entire inactive user list will be displayed, once user clicks on this link. Admin user can activate the inactive users of that particular company by clicking record in the data table.

Appendix D – Evaluation & Test Results

This section provide overview of how does the system functions were tested in order to ensure software programs has no bugs and pitfalls and it is best possible fit for the needs of a client.

Testing process was carried out as mentioned in the Chapter 5.

User evaluation results also mentioned here with pie chats as mentioned in the Chapter 5.

Questionnaire

Web Based Corrective Maintenance System for OZ Cleaning PVT LTD				
Questionnaire: Usefulness, Satisfaction, IS and Ease of use				
Please tick the usability of the applied system compare with previous manual system;				
Try to respond to all the items				
	Agree	Disagree	<i>Nether Agree or Disagree</i>	Comments
I think, this system would enhance productivity and efficiency of the overall business process?				
I think, the features and functions provided in this system are user friendly and make easy to do my job				
I think, this system would help to quick and accurate decision making process				
I think, this system would ensure the proper information security approach				
I think, it is better to apply future improvements on this system.				
Do you have any thought how to improve this?				
<i>Thank You Very Much.</i>				

Table D.1: Questionnaire

Results under “Productivity and Usefulness”

Q1. I think, this system would enhance productivity and efficiency of the overall business process?

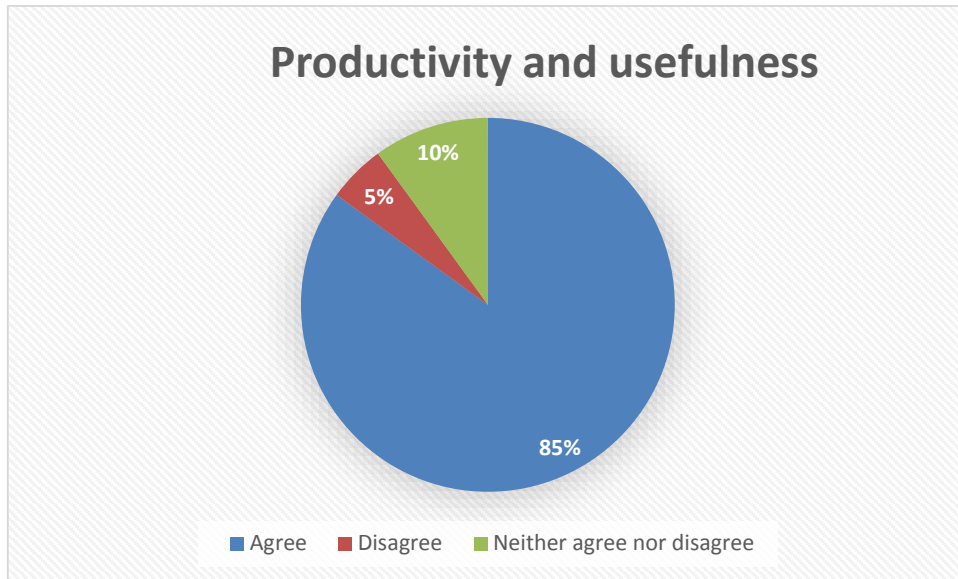


Figure D.1: Productivity And Usefulness

Results under “User Friendly / Easy To Use”

Q2. I think, the features and functions provided in this system are user friendly and make easy to do my job

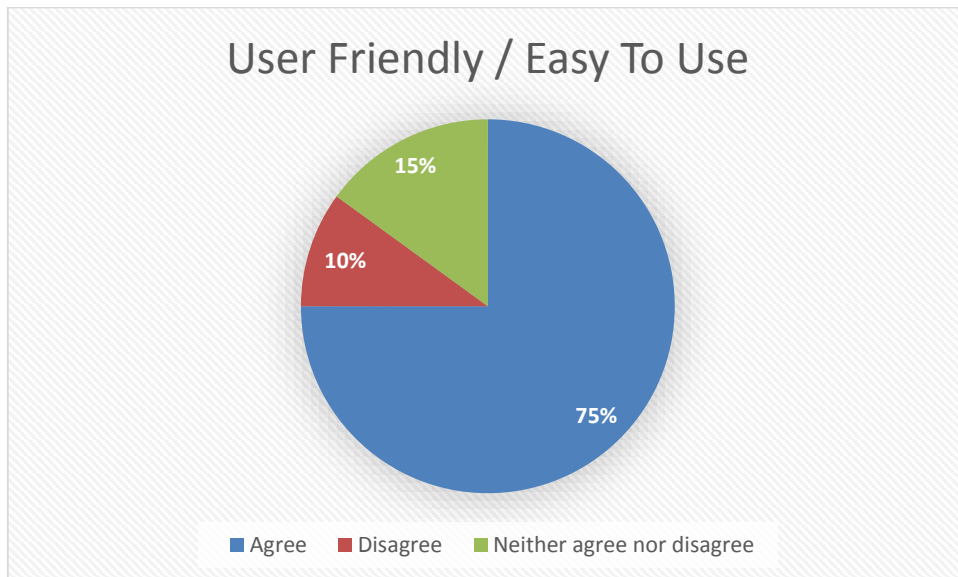


Figure D.2: User Friendly / Easy To Use

Results under “Ensure the Information Security”

Q3. I think, this system would ensure the proper information security approach

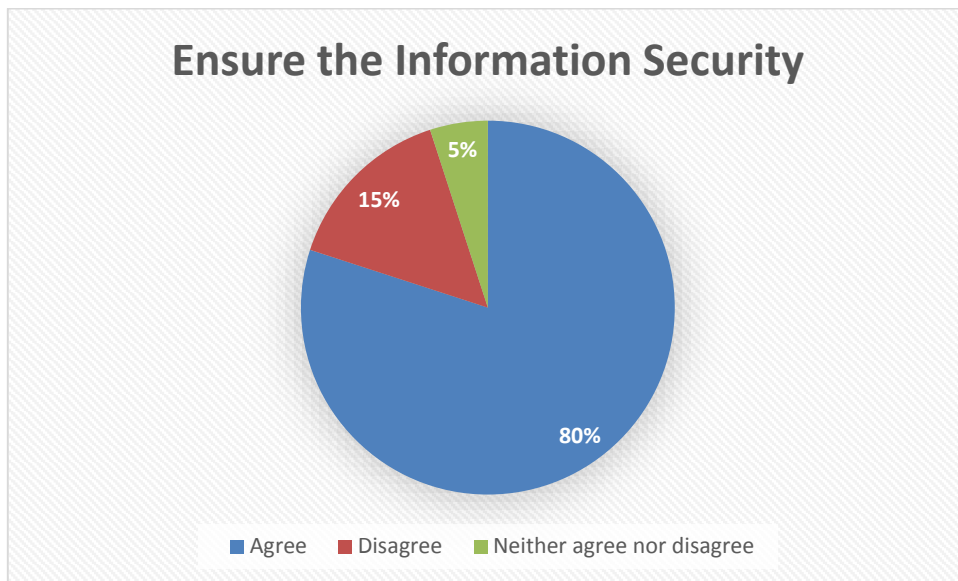


Figure D.3: Ensure the Information Security

Results under “Support to the Decision Making”

Q4. I think, this system would help to quick and accurate decision making process

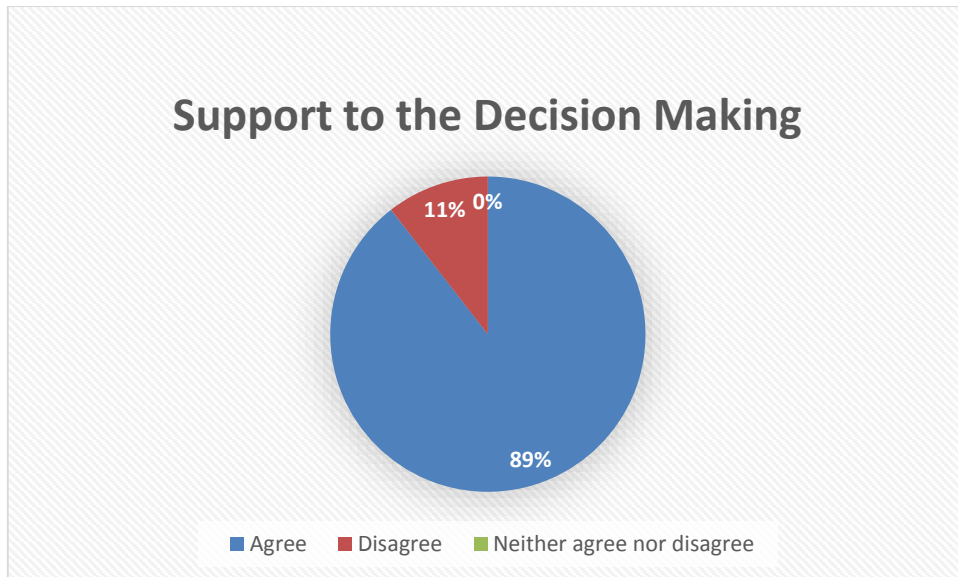


Figure D.4: Support to the decision making

Results under “Request Further Improvement”

Q5. I think, it is better to apply future improvements on this system.

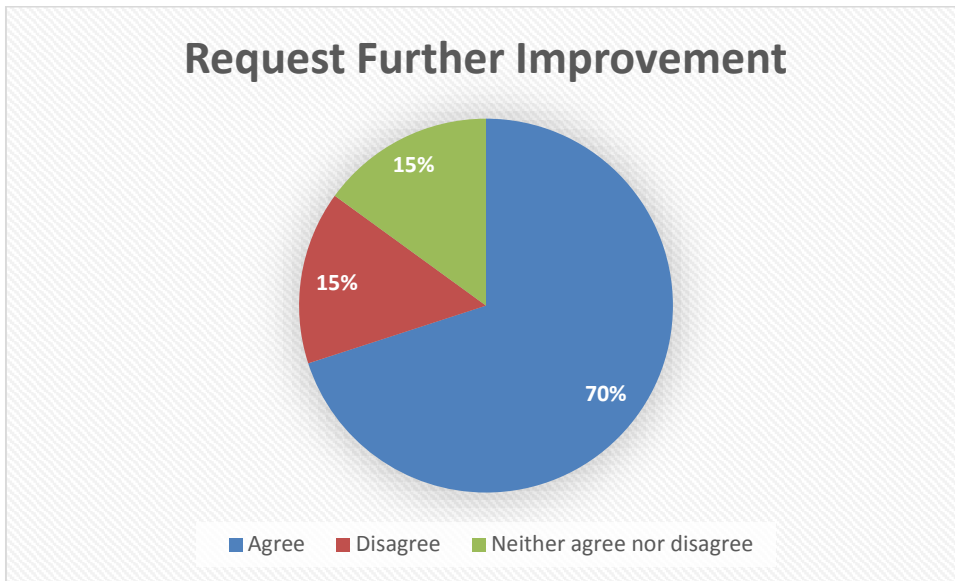


Figure D.5: Request Further Improvement

Test Plan & Test Case – Company Application

Test No	Test Case Description	Steps to Test	Expected Results	Actual Results	Status
1	Check user login	Go to the Company application link	Load the login page and user can log into the system with valid user name and password. Admin, operator, supervisor, technician and manager users of Company can log into the system.	Same	Pass
2	Check home page	Click on “Home” link	Load the home page with summary details.	Same	Pass
3	Check client manager options	Click on “New Clients” link	Only admin users are allowed this option. Load new client list to accept. User can view and accept the client request.	Same	Pass
		Click on “Activate Clients” link	Only admin users are allowed this option. Load inactive client list to activate. User can view and activate the client.	Same	Pass
		Click on “Deactivate Client” link	Only admin users are allowed this option. Load active client list to deactivate. User can view and deactivate the client.	Same	Pass
4	Check user manager options	Click on “Create/Deactivate/Reset Users” link	Only admin users are allowed this option. Load active user list of Company to deactivate and reset users. Admin user can view user details and deactivate the selected user or reset the selected user’s password. Email is send to the particular user when password is reset. New user creation option also provided to Company. Admin users, supervisor,	Same	Pass

			technician, manager and operators can be created for company.		
		Click on “Activate Users” link	Only admin users are allowed this option. Load inactive user list of Company to activate. Admin user can view and activate the users.	Same	Pass
5	Check Work request manager options	Click on “New Work Requests” link	Load new work request list with create new work request, create work order, post work order reject work request functionalities. These functionalities are allowed only for admin users and operator users.	Same	Pass
			Create new work request allowed option allowed create work request on behalf of tenant.	Same	Pass
			Work order can create with respect to specific work request by using create work order option.	Same	Pass
			Work request can reject by using reject work order option	Same	Pass
			Work request can be post without creating work order and only adding comment	Same	Pass
		Click on “Process work order” link	Newly created work order list display. Operators can send emails to the tenants that informing the current status of the work order.	Same	Pass
			Allowed to assign technician to a work order. At this instant system generated email notification sent to the technician informing the work order details.	Same	Pass

			Response SLA Time started when the technician is assigned to a work order.	Same	Pass
			Technician and supervisor are allowed to update the start time of the work order. At this moment system check whether the Response SLA expired or not. If it is expired work order status is display as “Stated Response SLA is expired”.	Same	Pass
			Technician and supervisor are allowed to complete the work order. When work order time updating system will check whether the Resolve time is expired or not. If it is expired work order Status displayed as resolve time is expired.	Same	Pass
		Click on “Download Documents” link	All pending work requests list is loaded. Once operator selects a work request, all the client uploaded documents will be displayed. Operator can download the documents.	Same	Pass
		Click on “Upload Documents” link	All pending work requests list is loaded. Once operator selects a work request, document upload option has been provided to upload document for the selected request for the admin user.	Same	Pass
		Click on “Post Requests” link	All work requests list is loaded that already completed the associated work orders. Supervisor and admin user can post the request. Once request is posted, feedback add option getting enabled.	Same	Pass

		Click on “Close Requests” link	All posted requests list is loaded. Only admin user can close the request.	Same	Pass
6	Check “Service Manager” functions	Click on Create Service Category	Already created list of service categories displayed with Add, Edit, Activate, Deactivate options.	Same	Pass
			Add new Service Category option Allowed to add new service categories	Same	Pass
			Edit option allowed to edit already existing Service Category	Same	Pass
			Activate service category option allowed to activate already added deactivated service categories.	Same	Pass
			Deactivate Service category option allowed to deactivate Already activated service categories.	Same	Pass
		Click on create “SLA”	List of configured SLA are display with add, edit, activate, deactivate options	Same	Pass
			Add option allowed to create new SLA.	Same	Pass
			Edit option allowed to edit already existing SLA.	Same	Pass
			Activate option allowed to activate already deactivated SLA.	Same	Pass
			Deactivate option allowed to deactivate already activated SLA.	Same	Pass
7	Check “Location Manager” Functions	Click on “Create a Site” link	List of configured Site displayed with add, edit, activate and deactivate options.	Same	Pass
			Add option allowed to create new Site.	Same	Pass

			Edit option allowed to edit already configured Site.	Same	Pass
			Activate option allowed to activate already deactivate Site.	Same	Pass
			Deactivate option allowed to deactivate already activated Site	Same	Pass
		Click on “Create a Building” link	List of configured buildings displayed with add, edit, activate and deactivate options.	Same	Pass
			Add option allowed to create new Building under the specific Site.	Same	Pass
			Edit option allowed to edit already configured Building.	Same	Pass
			Activate option allowed to activate already deactivate Building.	Same	Pass
			Deactivate option allowed to deactivate already activated Building	Same	Pass
		Click on “Create a Location” link	List of configured locations displayed with add, edit, activate and deactivate options.	Same	Pass
			Add option allowed to create new Location under the specific building.	Same	Pass
			Edit option allowed to edit already configured Location.	Same	Pass
			Activate option allowed to activate already deactivate Location.	Same	Pass
			Deactivate option allowed to deactivate already activated Location	Same	Pass
8	Check Asset Manager functions	Create Asset Category	List of asset categories displayed with add, edit, activate, deactivate functionalities	Same	Pass

			Add option allowed to create new Asset Category	Same	Pass
			Edit option allowed to edit asset category	Same	Pass
			Activate Asset Category option allowed to activate already deactivated Asset Category.	Same	Pass
			Deactivate Asset Category option allowed deactivate already activated service category.	Same	Pass
		Click on “Asset Registry”	List of configured Asset display with add, edit, activate, deactivate functionalities.	Same	Pass
			Add option allowed to create new asset.	Same	Pass
			Edit option allowed to edit already existing asset.	Same	Pass
			Activate option allowed to activate already deactivated asset	Same	Pass
			Deactivate option allowed to deactivate already activated asset.	Same	Pass
9	Check Duty Manager Functions	Click on “Duty Roster”	All Active technician list display and duty roster can update for each technician by using the update duty roster option.	Same	Pass
10	Check administrative functions	Click on “Create Web Page” link	Client application related instructions and other required details related can be configure using this option. These added details and instructions were displayed under the client application. Already added countries list is loaded.	Same	Pass

		Click on “Client Inquires” link	Client inquiry list is loaded. Admin user of Company Application can view those inquires.	Same	Pass
		Click on “Update Company profile”	Allowed to update company profile information	Same	Pass
11	Check user profile manager options	Click on “Update User Profile” link	Logged user details can be updated the user profile.	Same	Pass
		Click on “Change Password” link	User can change the password and can enter new one.	Same	Pass
12	Check reports generation options	Click on “Work Order Status” Report	Verified that “Work Order Status Report” generated successfully.	Same	Pass
		Click on “Technician Wise Work Order Report”	Verified that “Technician Wise Work Order Report” generated successfully.	Same	Pass
		Click on “Technician SLA Report”	Verified that “Technician SLA Report” generated successfully.	Same	Pass
		Click on “Work request statement” link	Verified that “Work Request Statement” Generated Successfully.	Same	Pass

13	Check log out option	Click on “Log Out” link	Log out the system successful.	Same	Pass
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Table D.2: Test Plan & Test Case – Company Application

Test Plan & Test Case – Client Application

Test No	Test Case Description	Steps to Test	Expected Results	Actual Results	Results
1	Check user login	Go to the client application link	Load the login page and user can log into the system with user name and password	Same	Pass
2	Check home page	Click on “Home” link	Load the home page with summary details.	Same	Pass
3	Check online user registration	Click on “User Registration” link on login page	User can register in online as a business client.	Same	Pass
4	Check on information center	Click on “Information Center” link	Logged user can view instructions and details that are updated by OZ Company.	Same	Pass
5	Check work request manager	Click on “Work Request” link	List of configured Work request display with, add, edit, activate, and deactivate options. User of client can add, edit, activate, and deactivate work request.	Same	Pass
		Click on “Download	User can download related documents that relevant to the	Same	Pass

		Documents” link	particular work request that uploaded by Company.		
		Click on “Upload Documents” link	User can upload relevant documents for a particular work request.	Same	Pass
6	Check user manager options	Click on “Create/ Deactivate/ Reset Users” link	Load active user list with Add/ Deactivate/ Reset Users options. User can Add/ Deactivate/ Reset Users.	Same	Pass
		Click on “Activate Users” link	Load inactive user list to activate.	Same	Pass
8	Check business profile manager options	Click on “Update Company Profile” link	Logged admin user of business clients can update their company details.	Same	Pass
		Click on “Manage Employees” link	Already added users list is loaded for a logged business client. User of particular company can add new employees. And also existing employees can be edited or deleted.	Same	Pass
9	Check user profile manager options	Click on “Update User Profile” link	Logged user details can be updated.	Same	Pass
		Click on “Change Password” link	User can change the password and can enter new one.	Same	Pass
10	Check contact us page	Click on “Contact Us” link	Load the contact us page with contact details. Clients can put complaints using this page.	Same	Pass

11	Check log out option	Click on “Log Out” link	Log out the system successful.	Same	Pass
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Table D.3: Test Plan & Test Case – Client Application

Appendix E – Major Code Fragments

In this section it will include the logic of encryption and decryption that use to store user's password in secure manner.

```
public class DbEncripDecrip
{
    /*Encription*/
    // This constant string is used as a "salt" value for the PasswordDeriveBytes function calls.
    // This size of the IV (in bytes) must = (keysize / 8). Default keysize is 256, so the IV must be
    // 32 bytes long. Using a 16 character string here gives us 32 bytes when converted to a byte array
    private const string initVector = "tu89geji340t89u2";

    // This constant is used to determine the keysize of the encryption algorithm.
    private const int keysize = 256;

    public static string Encrypt(string passwrd, string salt)
    {
        byte[] initVectorBytes = Encoding.UTF8.GetBytes(initVector);
        byte[] plainTextBytes = Encoding.UTF8.GetBytes(passwrd);
        PasswordDeriveBytes password = new PasswordDeriveBytes(salt, null);
        byte[] keyBytes = password.GetBytes(keysize / 8);
        RijndaelManaged symmetricKey = new RijndaelManaged();
        symmetricKey.Mode = CipherMode.CBC;
        ICryptoTransform encryptor = symmetricKey.CreateEncryptor(keyBytes, initVectorBytes);
        MemoryStream memoryStream = new MemoryStream();
        CryptoStream cryptoStream = new CryptoStream(memoryStream, encryptor, CryptoStreamMode.Write);
        cryptoStream.Write(plainTextBytes, 0, plainTextBytes.Length);
        cryptoStream.FlushFinalBlock();
        byte[] cipherTextBytes = memoryStream.ToArray();
        memoryStream.Close();
        cryptoStream.Close();
        return Convert.ToBase64String(cipherTextBytes);
    }

    public static string Decrypt(string cipherText, string salt)
    {
        byte[] initVectorBytes = Encoding.ASCII.GetBytes(initVector);
        byte[] cipherTextBytes = Convert.FromBase64String(cipherText);
        PasswordDeriveBytes password = new PasswordDeriveBytes(salt, null);
        byte[] keyBytes = password.GetBytes(keysize / 8);
        RijndaelManaged symmetricKey = new RijndaelManaged();
        symmetricKey.Mode = CipherMode.CBC;
        ICryptoTransform decryptor = symmetricKey.CreateDecryptor(keyBytes, initVectorBytes);
        MemoryStream memoryStream = new MemoryStream(cipherTextBytes);
        CryptoStream cryptoStream = new CryptoStream(memoryStream, decryptor, CryptoStreamMode.Read);
        byte[] plainTextBytes = new byte[cipherTextBytes.Length];
        int decryptedByteCount = cryptoStream.Read(plainTextBytes, 0, plainTextBytes.Length);
        memoryStream.Close();
        cryptoStream.Close();
        return Encoding.UTF8.GetString(plainTextBytes, 0, decryptedByteCount);
    }
}
}
```


Appendix F – User Interfaces

User interface design is most important part of the system. Following section show two main user interface exist in the system.

Home page of the Company application

Following user interface is the home page of the company application.

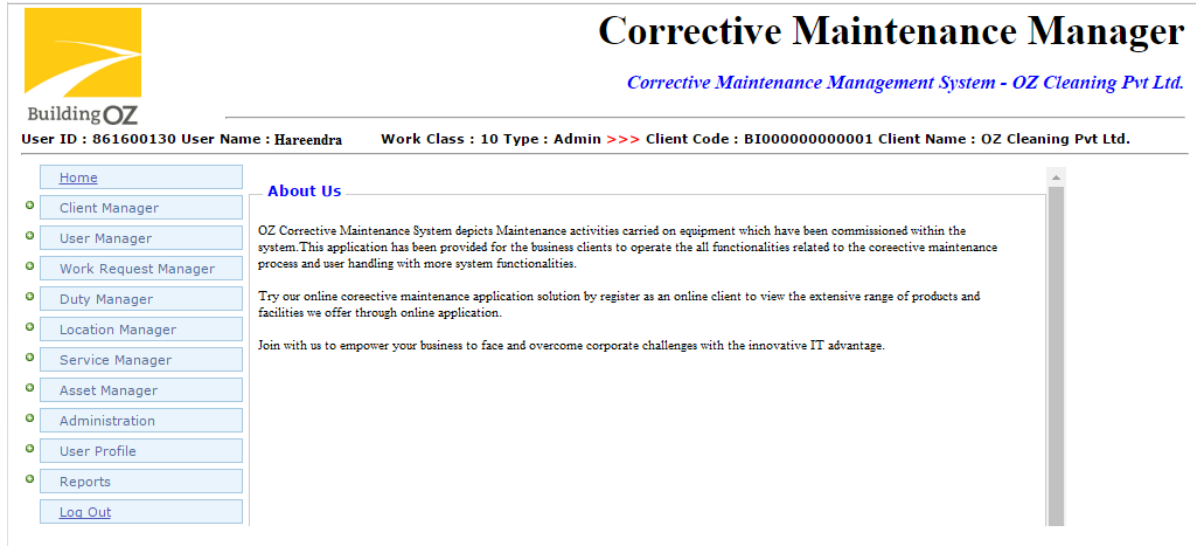


Figure F.1: Home Page-Company Application

Home page of the client application

This is the home page of the client application. Main menu is on left side.



Figure F.2: Home Page-Client Application

