E-Maintenance Application: System Development

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Abstract: This is a project regarding development of mobile application E-Maintenance and this application is built for company that requires a lot of scheduled work. The main objectives are design and develop E-Maintenance system which include both android and website. The main scope for this system is company Mega Auto & Electrical Engineering to use our application to let admin make work order for user to follow up on their own. The main method used here is waterfall model where will conduct interview, draw Unified Model Language diagrams and sketch wireframes. The next thing after methodology is analysis and design where the E-Maintenance interface is built here. After the prototype is done the work will continue with implementation.

Keywords: Scheduled, System, Prototype, Maintenance

1. Introduction

Time management is one of important life skills to everyone to work on any work better. There are many ways to do the time management such as organization, prioritization, goal-setting, communication, planning schedule and delegation. There are many benefits can obtain from time management from many ways such as can submit work on time, a better and more efficient work, reduce procrastination, improve study or career growth and also has more time for own leisure. [1] However, human brain has limited memory when there is too much things to remember. For example, an electrical engineering need to remember all maintenance work given by admin and usually the maintenance work is more than one devices. This causes the electrical engineering hard to remember all the task given. Therefore, mobile application, E-Maintenance is introduced. This application allows admin to create user, create technicians and create work orders. Next, E-Maintenance helps to record maintenance details for those devices or applications that is assigned by the admin to user or staff. Once the work order is creating, the maintenance date from the work order will record on the list and the staff in charge will need to make appointment with specific technician and will receive notification one day before the maintenance date.

1.1 Scope

In Mega Auto & Electrical Engineering SDN. BHD. the workflow is done in manually and there is large amount of maintenance devices and requires many maintenances. Besides, admin is very hard to record and remember for each maintenance devices. The schedule for maintenance need to manage often and need to make appointment for each maintenance. Therefore, the objectives of this system are to design E-Maintenance for saving data of maintenance details, staff details and technicians details. Second, this system has the objective of developing E-Maintenance mobile based system that shows notification based on maintenance date and web-based platform for admin to track and manage data more easily. Besides, the system need to perform alpha and beta testing of developed E-Maintenance to target user.

The target user for E-maintenance is for the company, Mega Auto & Electrical Engineering SDN. BHD. which required to do devices maintenance services very often. Another aspect from the company is that the maintenance type of the company has a large number of amounts. The devices available for maintenance is Digital Power Meter, Current Transformer, Air Circuit Breaker, Auto Transformer, Contactor, Earth Leakage Relay, Relay, Molded Case Circuit Breaker, Residual Current Circuit Breaker and Earth Fault & Over Current. Admin will add work order for the staff and technicians. After The maintenance date will display on the list and display only the work order which is not yet completed only. The staff will receive notification to reminds the staff in charge of the maintenance to make appointments with the technicians. After the appointment of the maintenance is made, staff will need to update the work order for the maintenance date, maintenance time and status.

1.2 Expected Results

Throughout this project, E-Maintenance helps admin to arrange the schedule or job to technician. Next, E-Maintenance helps the company to get work order request in a simpler and more convenient way. E-Maintenance helps the client to identify the pricing of the maintenance through simple display and calculation during the work order request. Besides, the maintenance date set in calendar by the admin can helps reminding the technician in charge before the maintenance date.

1.3 Methodology

In this project, the method used is waterfall (Z.son, 2004) because waterfall breakdown project into several smaller phases. In ascending order, the waterfall will be arranged in the form of system and software requirements, analysis, design, coding, testing and operations. [2][3] By using this method, the project can be done more effectively and well planned.

In requirement phase, the deadlines and guidelines are determined and is record as a specification. Next is analysis phase which analyze the system specification to produce a model and business logic. The third phase is design phase, the design of the application will be drawn in ER diagram is to outline the technical design requirements. Furthermore, coding phase is developing source code using models, logic and requirements determined earlier. The next step will be testing and operation. Testing is check whether the application got any issue or bug and this step may causes repetition of debugging. If the test pass, waterfall continue. After testing is operation phase where it determine that whether the application can be apply to live environment or not.

2. Literature Review

A scheduled maintenance system is a manufacturing systems by using optimized schedule for planning workload. [4]A scheduled maintenance should be flexible and easy to use. This system will

be use frequently in a maintenance company. Therefore, the schedule should always be optimized schedule for various changes requirements. This optimized schedule is one very important role in scheduled maintenance system for planning and operation during manufacturing for the purpose of improve efficiency. "There is a trade-off between assigned time to production and available time to perform maintenance actions in production systems" (Yang et al. 2007). [6] The main item in scheduled maintenance system is the calendar that actually records all the property maintenance for the staff to perform. In this calendar, the boss, admin and manager can assign the workload to the staff and will show in the calendar. For example, a manager assign checking work to a staff and the staff will required to check the item condition based on the work given.

There are two types of maintenance which are predictive maintenance and preventive maintenance. Preventive maintenance is maintenance that will repeat at fixed time like maintenance the device once per three months. This preventive maintenance is built for keep the device in good shape at all time. [9] The device normally use checklist to ensure the maintenance is fully done and also to prevent the device to break down. As for predictive maintenance, maintenance work need to done when needed like the device has been broke down. [8] When a device broke down, the problems of the device need to be identify at that time before repair. For this two type of maintenance will be set differently in calendar. For preventive maintenance will be set at regular intervals of date or time while predictive maintenance is only added when maintenance is needed.

2.1   Programming Languages

Programming language is a type of software language which is in a form like instructions or order where it can produce various type pf results. The programming languages can be used in computer or smartphone to give instructions or order in the system or software. There are many types of programming language like Java, Python, C#, Ruby and many other programming languages.

JavaScript is a programming language in web platform for users to interact with the web world. JavaScript helps support event-driven, functional and imperative programming styles. JavaScript is a client-side script which is known as a programming language that will actually performs. Besides, JavaScript can also help with application programming interfaces (APIs). API is actually for software intermediary that allows two applications to talk to each other. Just like when someone sending a message through WhatsApp, they are using API. API is important for client side sends data server and server will receive the data and interprets it. The server will then give back to the client in readable form.[10][11]

JavaScript can use for developing mobile application. Framework is here to help when using JavaScript to develop mobile application. The examples of framework are React Native, JQuery, PhoneGap and Ionic. The benefits of using JavaScript in developing mobile application are fast, efficient, execution occurs at client-side but not server, easy to use and can used to create animation too.

Structure Query Language is also known as SQL in short. SQL is a domain-specific language that applied in program for relational database management system. SQL is a language but not a database, so it need to work with databases. The examples of the database are MySQL. PostgreSQL and Microsoft SQL Server. [12]

By using SQL, we can do relational databases. Relational database can be known as a database that save data in more than one tables and also to retrieve data from the tables. The benefits of using sql is high speed, interactive language and multiple data view. Besides, using SQL in database help to store large amount of data that actually helps us to store data easier and more convenient when compared to store data manually.

Scala combines object-oriented and functional programming in one concise, high-level language. Scala's static types help avoids bugs in complex applications, and its JVM and JavaScript runtimes let you build high-performance systems with easy access to huge ecosystems of libraries.

2.2 Authentication

Authentication is a way to ensure something or someone is the specific thing or person. Authentication plays important role in cybersecurity. Authentication uses database to record authorized users. Authentication is a process that will check the credential given by the users whether is match the credentials in database from the authentication server. [14]

The reason of using authentication is to increase security of a company. There is various type of authentication which include password-based authentication, two-factor authentication, multifactor authentication, one-time password, three-factor authentication, biometrics, mobile authentication, continuous authentication and API authentication. Password-based authentication will have required username or id and password during account creation in a website or application. When user want to access the account must type the username and password without a single mistake. For two-factor authentication is another layer of protection that will produce verification code from email, text message or phone number. When user forgot password of account and request "forgot password" help to the website or application, a one-time password will actually produce automatic through email for user to login and change password.

2.3 Existing System

The existing system are eMaint and Upkeep. Both of this system has common and different in characteristics and also its pros and cons. This part will discuss about how the existing system work and their background.

eMaint is an online maintenance system (eMaint Reviews: Pricing & Software Features 2020 - Financesonline.com, 2021). The characteristics of this eMaint is flexible and easy-to-use that enable more users to adapt as soon as possible. eMaint is normally used to take part of all facets for all maintenance required and also for the facilities management. eMaint is a web-based management application to let users to manage processes or work easier and convenient. For example, request and inventory control. eMaint is an application that can be used on multiple type of devices, include mobile phone, desktop and even tablet. The advantages of using eMaint is that it has top class support, fast performance, integration with current ERP Systems and also affordable price. For the deployment language is English only. [15][16]

Next, the feature of eMaint is to document storage. This is to store the document needed from the company. Second feature is that it can preventive maintenance and predictive maintenance. So basically it means that eMaint can schedule a regular maintenance schedule and also monitor the ability of specified devices to decrease the chances of failing. For maintenance scheduling, it save costs for better plan and more flexible schedule. Third feature is that it does inventory and asset management. It is basically manage the real time stock and current assets. For asset management, it establish asset hierarchies, track maintenance history and work prioritization. Forth feature is request and work order. The work order management is by generate work orders and submit through login, email or form. The last feature is able to view dashboards and reports. This feature is for overview of the company. [17]

Furthermore, the three main stakeholders for eMaint are team, professional and also enterprise. As for team, it consists of 3 users, standard CMMC features, unlimited helpdesk support, software updates and upgrades, 24 hours per day services and able to use on mobile devices with the price of 33 dollars per month. However, for professionals will consist of more than 3 users, advanced feature set, dedicated account management, interactive image mapping, workflows that is automatic and giving work request with the price of 85 dollars. The last stakeholder is enterprise which can hold more than 5 users, unlimited for work request and user login, accessible for Web API, Multi-site toolkit and single-sign-on with the price of 120 dollars.

The login interface is the interface that has authentication for users to access. The authentication key is User ID or Email and Password. Both of these keys must be correct to access to eMaint account. Figure 2.1 is the login interface of eMaint system.

Figure 2.1: Login interface eMaint

Next, eMaint support asset tracking function too. Figure 2.2 shows how eMaint do asset tracking by using search function.
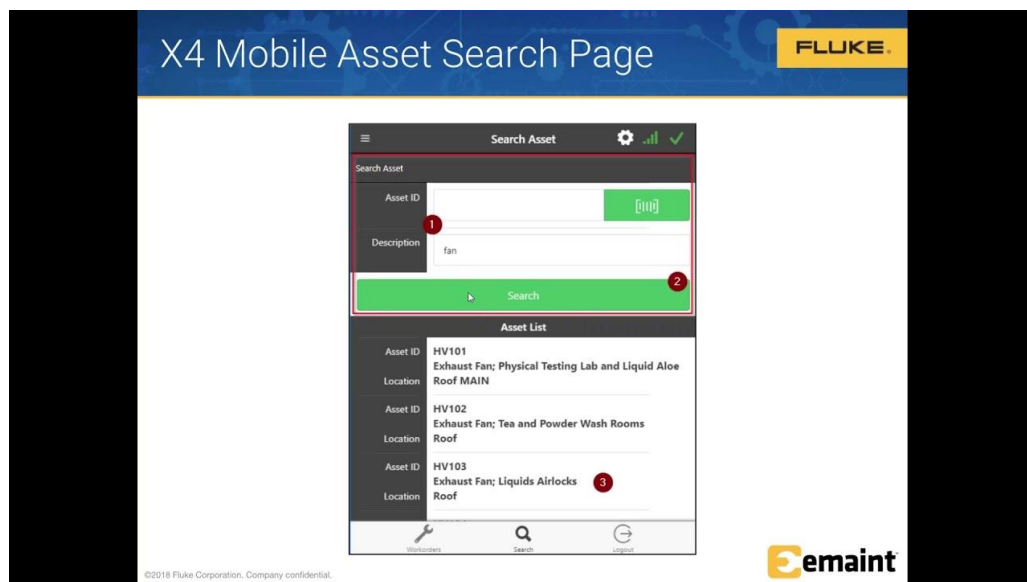

Figure 2.2: eMaint Asset Search Page

Next, UpKeep is a maintenance management system which in the group of CMMS (UpKeep Reviews: Pricing & Software Features 2020 - Financesonline.com, 2021). UpKeep allows multiple types of users which include managers and supervisor. UpKeep also able to use in multiple types of business and as well as industries. UpKeep is supported by web and mobile based to increase the awareness of each member for their tasks given respectively. UpKeep does work order and work requests too. Basically, UpKeep helps to manage real time inventory, workflow management, tracking costs and generation of report. The deployment of UpKeep includes Cloud Hosted and Open API. As for language support include English, Dutch, Polish, Turkish and Swedish. The main stakeholders are small business, medium business and large enterprises. [18]

The advantages can obtain by UpKeep include create work orders and requests. The work orders and requested will be arranged in order form. It does contain calendar and list for better and well-organized listing. Work request can be submitting from mobile and its webpage too. Next, it does monitor and maintain inventory. UpKeep uses barcodes for parts and our devices can scan to show the details of the part. Another way of managing parts is using QR code and it can be scan by any

QR reader. The third advantage is to track maintenance costs and time. Tracking maintenance costs for better planning in future and also knowing the details like driving time. The next benefits is that UpKeep can produce reports for operational excellence. UpKeep is able record and produce a report regarding work order completion rates, productivity, real-time inventory and also work order status.

The interface of UpKeep is simple and so it is easy to understand. It uses authentication by password-based authentication where the id is email address and required password to access it. Users can login to main interface after that. The interface has navigation on the left and it shows that it has work order, dashboard, requests, location, assets and so on. Another good thing in UpKeep is that it can arrange the work order based on due date which helps to identify which work need to prioritize. The login interface is the interface that has authentication for users to access. The authentication key is Email and Password. Both of these keys must be correct to access to UpKeep account. Figure 2.3 is the login interface of UpKeep system. [19]
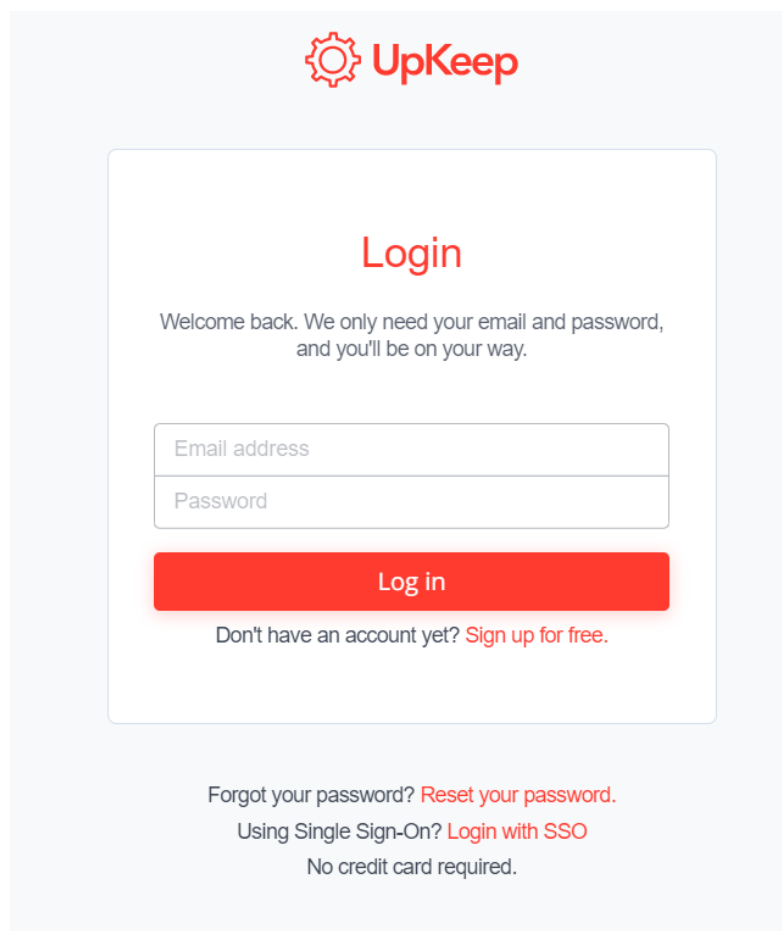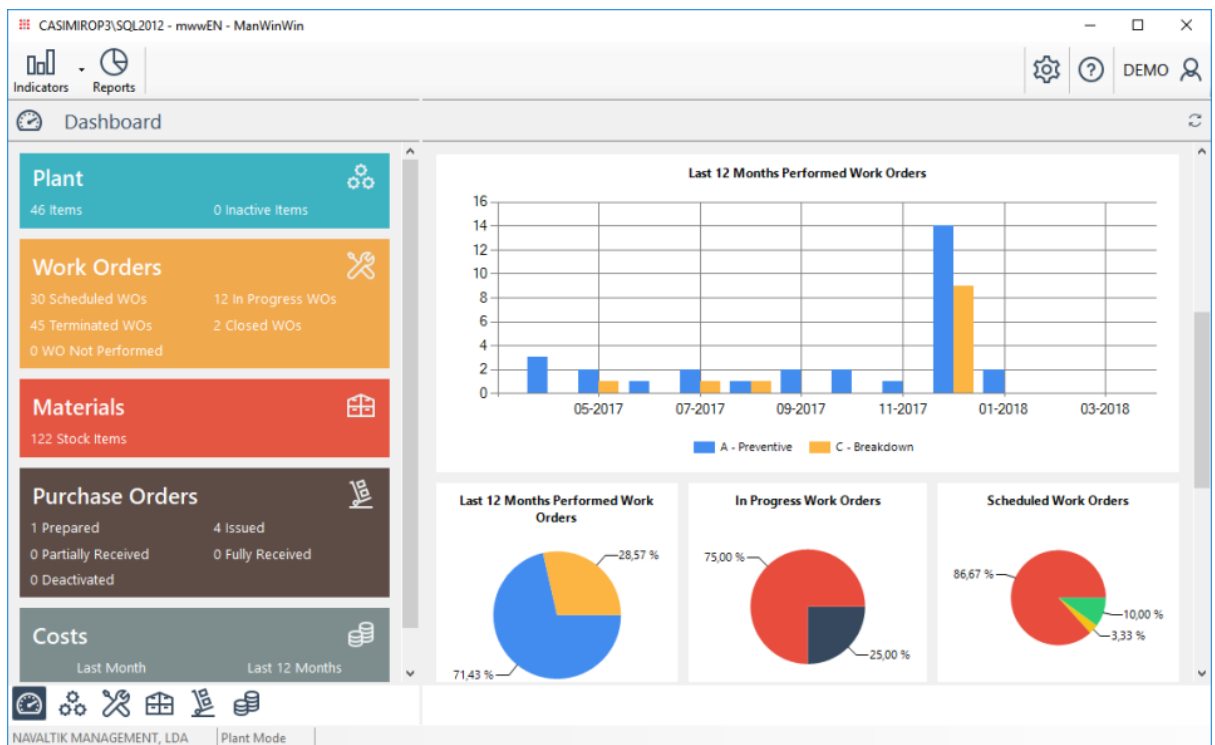

Figure 2.3: UpKeep Login Interface

Next the work orders are listed in the interface below. Figure 2.4 shows how the work order is listed and the conditions of the work order.
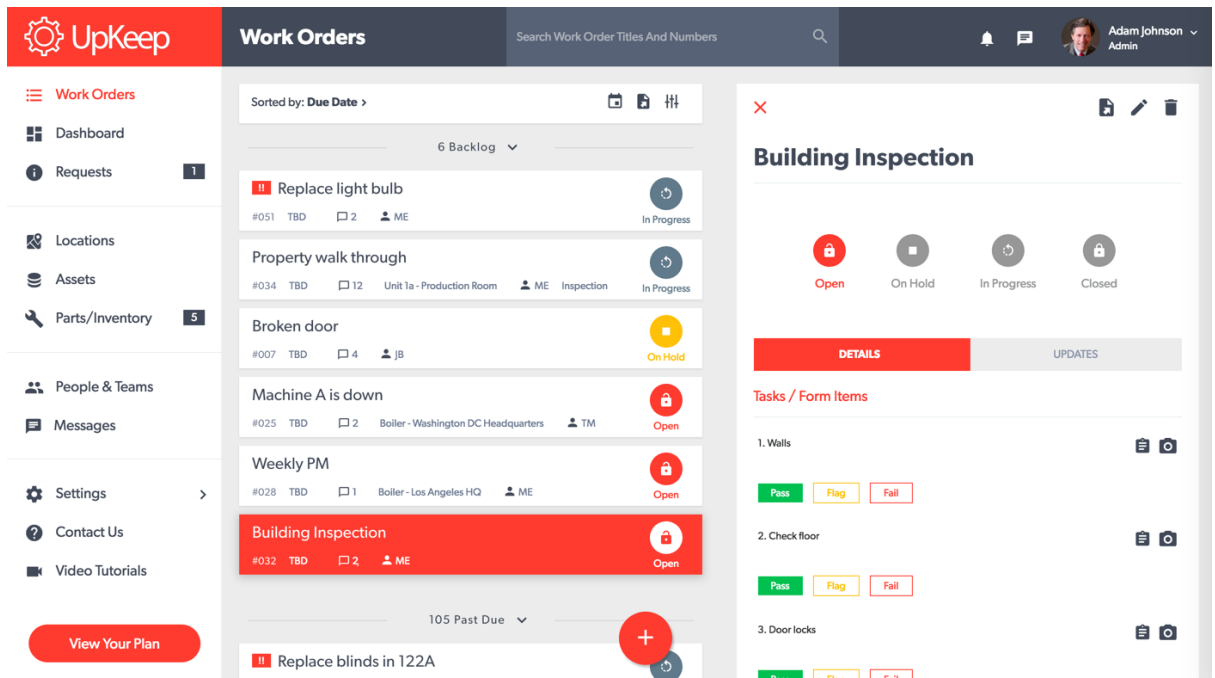
Figure 2.4: Work order in Upkeep

The next interface is the system will produce final report or monthly report to shows the overview of the system as shown as Figure 2.5.

Figure 2.5: Dashboard UpKeep with reports

Table 2.1: Comparison Existing Application with proposed Application

Features	eMaint	UpKeep	E-Maintenance
Supported Devices	Both web and mobile-based	Both web and mobile-based	Mobile-based
Language supported	English	English, Dutch, Polish, Turkish, Swedish	English
Inventory storage	Yes	Yes	Yes
Work order management	Yes	Yes	Yes
Work Schedule	Yes	Yes	Yes
Deployment	SaaS/Web/Cloud Mobile - Android Mobile - iOS	SaaS/Web/Cloud Mobile - Android Mobile - iOS	Android
Key and Lock Management	No	Yes	No
Asset Tracking	Yes	Yes	No
Service history tracking	Yes	Yes	Yes
API	Yes	Yes	Yes

In this chapter, it includes the maintenance scheduled maintenance system about its definition. JavaScript and SQL will be include in the process of developing proposed system. Using authentication is to increase security level of the application. Review on existing system is done and compare with proposed system to see the difference and similarities.

3. Methodology/Framework

In chapter 3, this chapter will explain the method used during developing the proposed system. In area 3.1, this part will explain the method in this project is mobile application development. For area 3.2 will be explaining project planning.
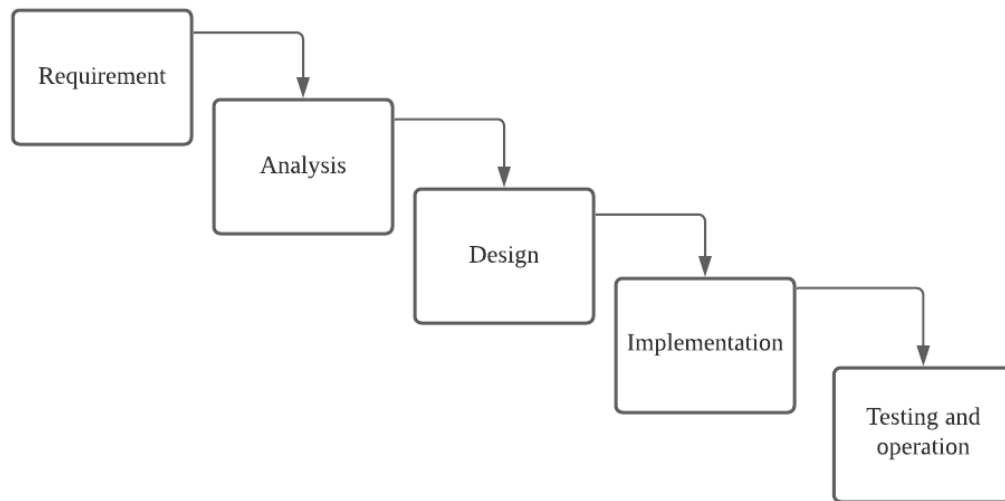
3.1 Waterfall model

In this project, the method used is waterfall (Z.son, 2004) [3] because waterfall breakdown projects into several smaller phases. In ascending order, the waterfall will be arranged in the form of system and software requirements, analysis, design, coding, testing and operations. By using this method, the project can be done more effectively and well planned.

In the requirement phase, the deadlines and guidelines are determined and are recorded as a specification. Next is the analysis phase which analyses the system specification to produce a model and business logic. The third phase is the design phase, the design of the application will be drawn in ER diagram to outline the technical design requirements. Furthermore, the implementation phase is developing source code using models, logic and requirements determined earlier. The next step will be testing and operation. Testing is checking whether the application got any issue or bug and this step may cause repetition of debugging. If the test passes, the waterfall process will continue.

After testing is the operation phase where it determines whether the application can be applied to the live environment or not. The figure 3.1 shows the flow of the waterfall model. In developing mobile applications, it is required to do it in a systematic way to meet the requirements for more accurate and better user experience. There are nine attributes in mobile application development which include phasing and placing, architecture line, mobile test-driven, development, continuous integration, pair programming, metrics, agile software process, off-site customer and user-centered focus.

Figure 3.1: Waterfall Model

In requirement phase, the goal and functions of the application need to be set in this phase. This phase is basically to get the main idea for this application. Another aim in this phase is to analyze the application domain by getting to know the viewpoint from users. For the goal and function in this mobile application is to help the company, Mega Auto Electrical Industry Sdn. Bhd. to manage schedule for maintenance and work order flow. Hence, an interview is conducted here with the staff in the company. Interview plays an important role in the requirement analysis phase as it help developers to get to know the company, how the company runs, the staff included in the company, the target audience in the application and most importantly how to benefit or solve the problem for the company. [20] [21]

The interview is start by preparing 10 interview questions for the manager or admin to answer. The interview questions can be seen at the attachment. After questions are prepared nicely, interact with the manager or admin to propose our interview purpose and attempt to book a time for the interview. Once the interview time is successfully booked, make sure the questions prepared are not too hard for the interviewer to answer to prevent awkward moments during the interview. After the interview is conducted, all the answers are being collected and analyzed.

In this phase, the problem statement is declared here including the workflow is all done manually. Secondly, the procedure for the workflow is complicated as it needs to go through multiple entities for one maintenance work to start if it follows the manual procedure. Thirdly, time-based preventive maintenance is needed for many devices in the company.

Based on these problems, the application going to build will consist of the function work schedule. Work schedule helps to receive work orders from the client and admin, manager and technician can follow up with the work order. Next, the second function is a calendar to record all the dates booked for maintenance for both types of maintenance which are preventive maintenance

and predictive maintenance. The benefit can obtain from this application is increasing productivity, better schedule planning and also maximize the lifetime of assets.

Next, analysis phase in mobile application is done using mobile application architecture. In this phase, the mobile application architecture will be done based on the requirements. There are various types of layer in mobile application architecture which include presentation layer, business layer and data layer. The product of this phase is an architecture design diagram which is for showing the architecture of the system.

Before starting to design these layers, there are few things to be considered. Firstly, the device type needs to be determined because there are various types of smartphones out there and the devices have similarities and differences as well. The features in smartphones need to consider are screen resolution, screen size, CPU features, storage space, memory and availability of the development framework. Secondly, the navigation method needs to choose wisely as the application consists of front-end and back-end. Thirdly, the process flow is needed to consider too.

A small presentation is conducted to the manager and admin to make sure the application meets the requirements. The presentation will use an architecture design diagram because it simplifies the complexity of the system.

Furthermore, design phase is referring to designing the pages for the interaction for the user to navigate across, into and back out from page to page. This interaction is known as a navigation relationship that connects the pages in an application because the application will have more than one page. This phase will produce a case diagram and activity diagram.

This phase is important to show how the function of the application flows. Case diagram and sequence diagram will show how all the users can interact with the application. Before starting drawing the activity diagram, the functions and processes are identified. The characteristic of navigation bars is needed to consider is that the number of menus should not be too much or too less, make sure the menu is visible at all pages and let users know which page they are at. Based on the function and characteristics of the navigation bar, type of navigation bar is chosen in this phase too.

For the page design is referring to developing the functions for each of the pages. There are two types of pages which include static pages and dynamic pages based on its function. If the page shows only content, it is a static page and for dynamic pages is for pages that are required to complete any task. Wireframes are drawn to show the function of each page. Wireframe is the user interface design

Besides, the build of the database is in this phase too. The database building will be shown by using a Class Diagram. Database is important to store users and details like maintenance date with the help of MySQL. Basically, the product in this phase will produce a class diagram.

After the design phase is done it will continue with the phase implementation. Implementation is referring to how the project plan starts into action. Basically, this phase will produce E-Maintenance with all the requirements obtained from the requirement phase. In this phase, the development of E-Maintenance will proceed using programming language with the help of Android Studio and React Native. The language used here is JavaScript. This phase is a big process as it requires a lot of work. The design has helped to build the wireframes as a guideline during this phase.

Once the application is successfully built, testing on a mobile device or smartphone is necessary to check if there are any mistakes or bugs in the application. Another thing to check is if the application works differently on different sets of hardware and software versions. Test plan will be carried out to check every function work. User acceptance form is created to check all the functions requested by the user is a successful build and can function.

3.3 Software and Hardware Requirements

Software and hardware requirements will be required during the development of this application. For all the software and hardware requirement play their own role and has relationship between each other during the development of this application.

The software required in this project is Android Studio, Java Development Kit, Java RunTime Environment, MySQL and React Native. Android Studio is the main platform for the coding. Next, Java Development Kit will have all a lot of useful tools during implementation of web application. As for MySQL, it is a database platform to connect to the page designed in order to save data. Furthermore, React Native is a framework that allows the usage of JavaScript programming language during development of E-maintenance. The table of software requirement is stated in Table 3.1.

Table 3.1: Software Requirements

Software	Specification
1. Android Studio	Provide environment for structured code module
2. Java Development Kit	Includes tools useful for developing programs and testing programs
3. Java Runtime Environment	Runs the virtual machine
4. MySQL	Store data in databases
5. React Native	Framework enable using JavaScript to develop mobile application

As for hardware requirements, a computer device is needed and the device used is Lenovo ideapad 330. Laptop device needs to support the Intel Virtualization Technology (VT-x) which able to run the virtual machines. Next the RAM of laptop device is important for the laptop device able to handle the software stated in software requirements. Another hardware is the 64-bit environment for workstation to develop programs that supports higher android version. The table of hardware requirement is stated in Table 3.1.

Table 3.2: Hardware Requirements

Hardware	Specification
Lenovo ideapad 330	Laptop device that supports virtual machine
12GB RAM	Support the software during development of application
64-bit environment for workstation	Build programs that support android 2.3.x (Gingerbread) and higher version

4. Results and Discussion

4.1 Introduction

This chapter will explain about the design and implementation phase for E-Maintenance. This phase plays an important role in waterfall model. As for area 4.2, it will explain about the system architecture. In area 4.3, requirements analysis is going to explain. Next, UML diagram will be shown and explain in area 4.4. In this area, use case diagram, sequence diagram and activity diagram

will be drawing and explained. The database design is explaining in area 4.5 by using class diagram and database table. In area 4.6 will explain the test plan. As for user acceptance testing form is in area 4.7. The last part in this chapter is user interface in area 4.8.

4.2 System Architecture

The system architecture shows the relationships, constraint and the overall view of the system. A good system architecture must have both interface and function. An architecture design diagram is drawn and shows in Figure 4.1. The architecture starts by user in login interface. The user can either register or login to the device and the user database is related with login and register. The function in this application consist of add device, work order request, add maintenance date and assign staff. Add device will add the devices in device database and work order request will request the device database and event database for the device maintenance and maintenance date. Add maintenance date will request the data from event database. Assign staff is from the user staff added in user database.
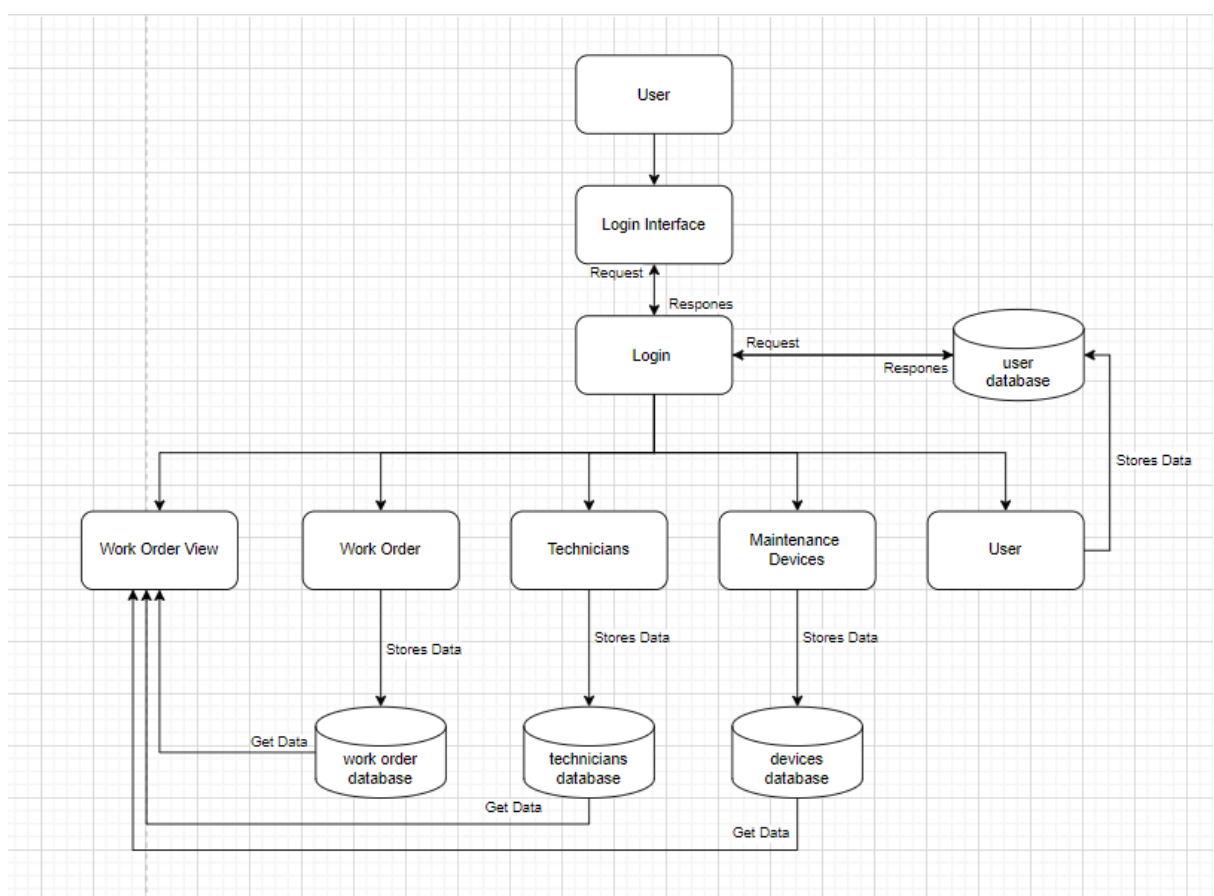
Figure 4.1: Architecture Design Diagram

4.3 Requirement Analysis

Requirement analysis plays an important role to solve the problem statement which stated in Chapter 1. Requirements analysis helps to identify on how E-Maintenance should work for every module. There are two type of requirements analysis which are functional requirement analysis and non-functional requirement analysis.

Functional requirements are the features or functions that should include in the application. As the first functional requirements is the register and login function for client and technician. Both of

the users should able to register themselves as new users in E-maintenance. However, the registration will need the approval from the admin. There are other modules with their functionalities is stated in the table 4.1.

Table 4.1: Functional requirements in E-Maintenance

Module	Functionalities
Login	Able to login to E-Maintenance if the input of username and password is correct.
	Error message will display if any input is invalid
Notification	There will be a notification comes out one day before the maintenance date
Work Order	Able to manage work order with create, edit, view and delete
	User can view and update date, time and status only
	Display current work order and history work order separately
User	Admin able to manage users with create, edit, view and delete
Technician	Admin able to manage technicians with create, edit, view and delete
Maintenance Devices	Able to manage Maintenance Devices with create, edit, view and delete

The non-function requirement is referring to the security, reliability, performance maintainability and usability. E-Maintenance will need the confidential of the report. All the non-functional requirement analysis is stated in Table 4.2.

Table 4.2: Non-functional requirements in E-Maintenance

| Module	Functionalities
Confidentiality	System should keep the system confidential
Security	User can only access the application with correct email and password
Usability	User should able to update work order and admin able to track

4.4 Unified Modelling Language (UML)

Unified Modelling Language is known as a modelling language by using diagrams. The purpose of using this UML is to visualize the E-Maintenance applications in terms of the architecture and how the process flow. The diagrams used are Use Case Diagram, Sequence Diagram, Activity Diagram and Class Diagram.

Use case diagram is used during the development of E-Maintenance. Use case diagram is drawn to show whether the requirements of E-Maintenance is correct and available. For the use case diagram has 3 entities but only 2 panel are used because technician and client can use the same panel in this application. Another panel is for the admin. The functions and accessibility of each entity is shown below in Figure 4.2.
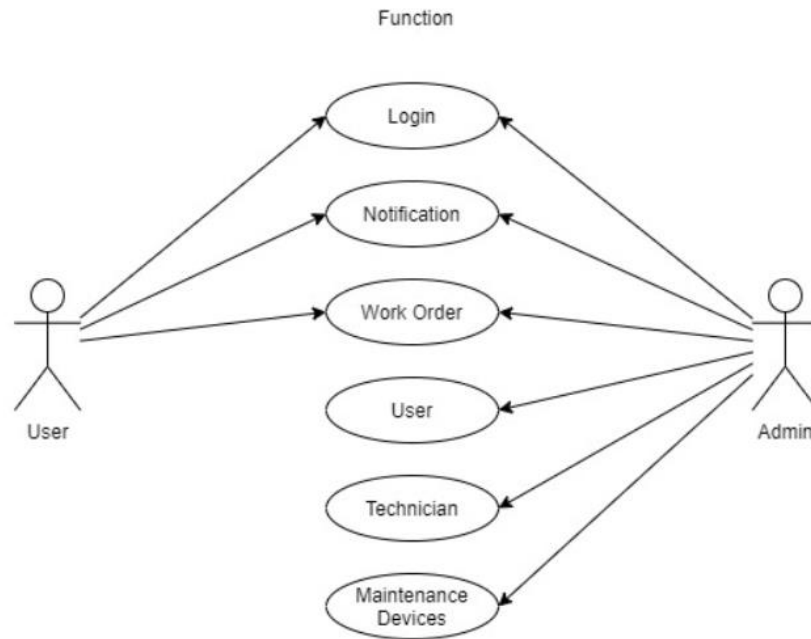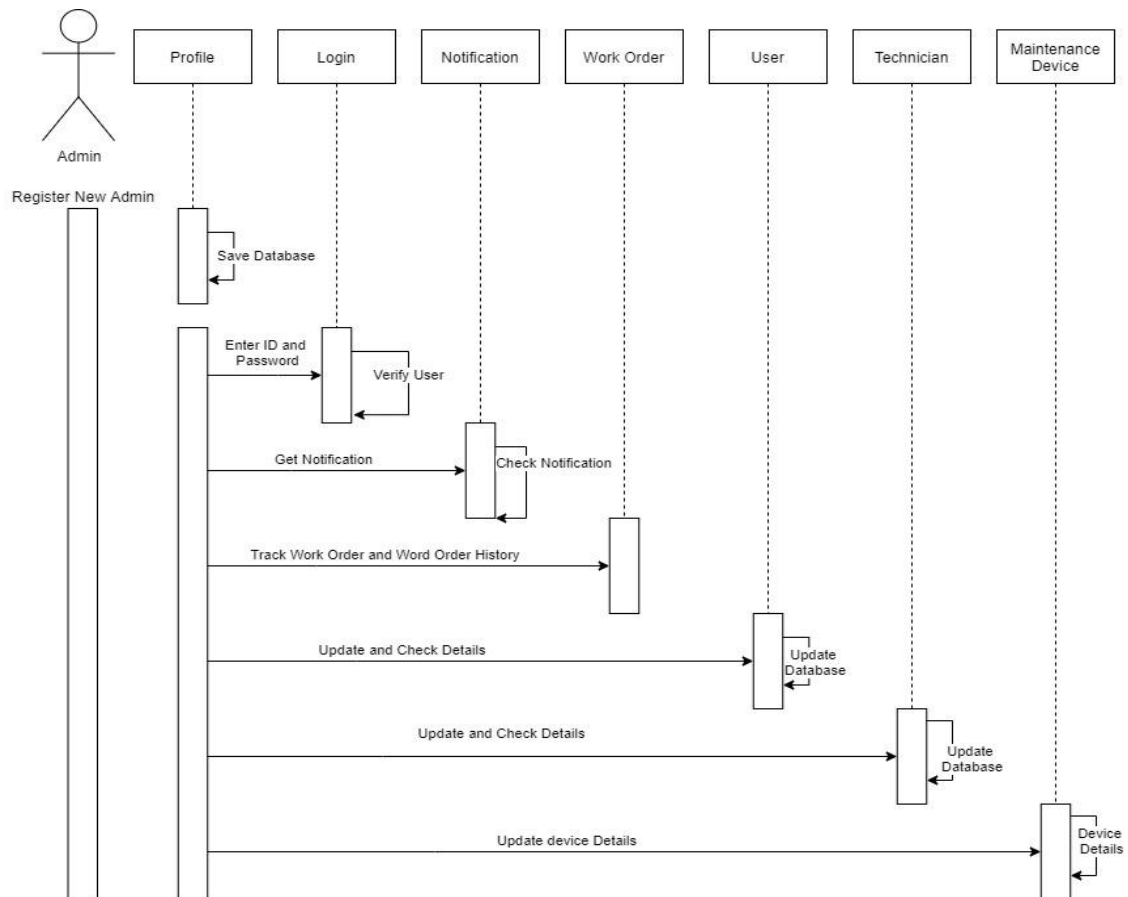
Figure 4.2: Use Case Diagram

Sequence diagram is drawn to show how the functions in E-Maintenance works. The sequence diagrams drawn are based on user (client and technician) and admin. Figure 4.3 will show the user sequence diagram and Figure 4.4 shows the admin sequence diagram.
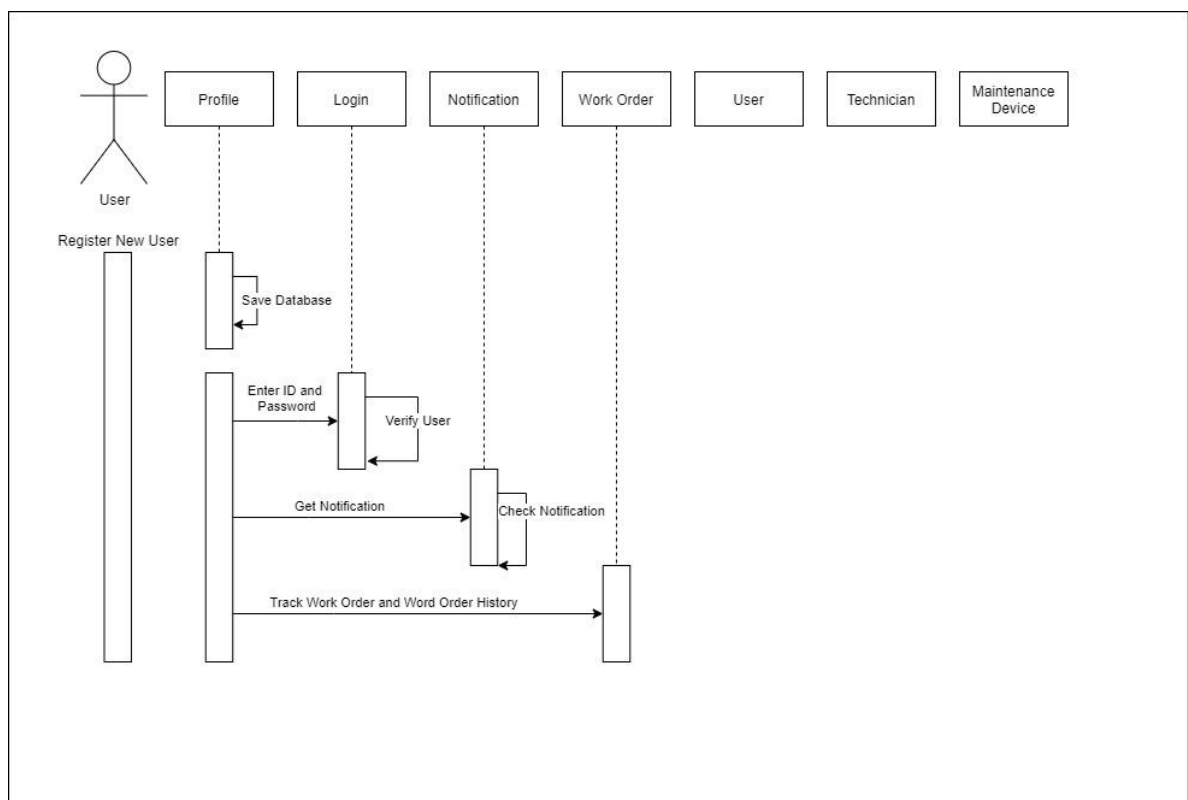

Figure 4.3: User sequence diagram

Figure 4.4:; Admin sequence diagram

4.4.3 Activity Diagram

An activity diagram is one way to present the overall flow of the system graphically. Activity diagram can be known as flowchart too. An activity diagram has been draw for E-Maintenance application. The first interface of E-Maintenance is the login page. Users can register as new user for E-Maintenance here. Another function in this page is for authentication for user to login to the application. The following platform is the dashboard which is known as homepage too. For user panel (client and technician), there are 3 main functions which are work order request, view user details and view work order status. As for admin, it include the 3 main functions in user panel and other 2 main functions. The functions stated are view user registration and add device. For the add device is for the choice of user during work order request. The activity diagram of E-Maintenance is drawn and show in Figure 4.5 as below.
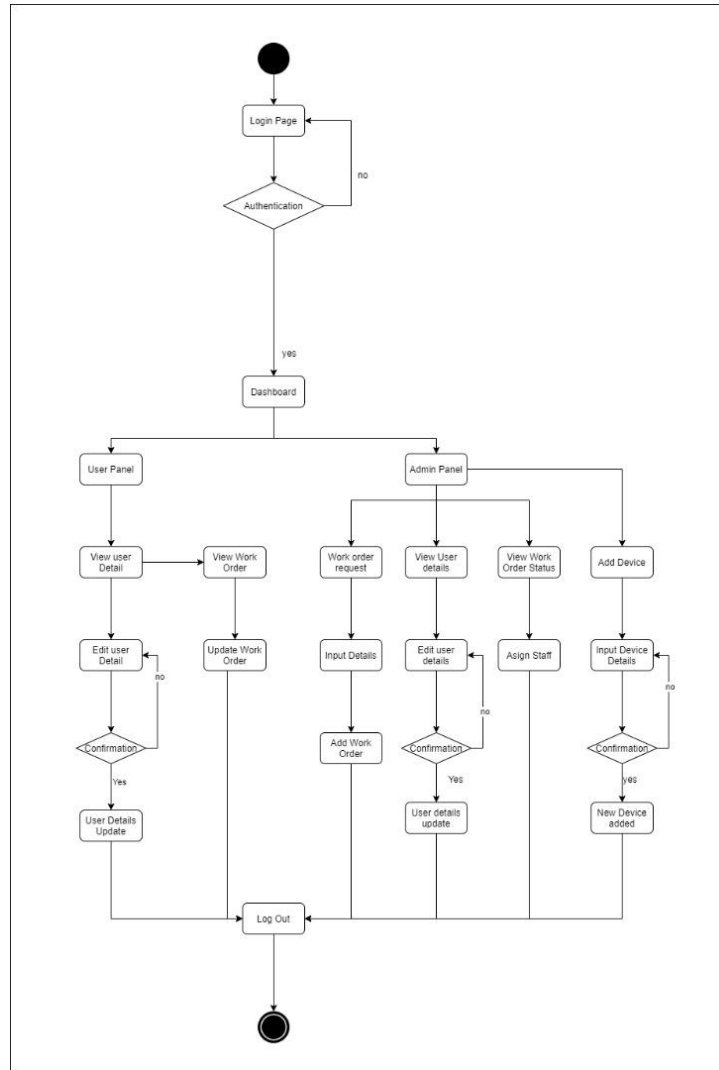
Figure 4.5: Activity Diagram of E-Maintenance

4.5 Database Design

Database design is how the data is organize and arrange. Database is a form of table and different types of variables store in different database tables. The database tables have their own connection or links.

4.5.1 Class Diagram

Class diagram is a diagram that shows how E-Maintenance classes, attributes and operations have relationships between each other. Based on the class diagram drawn in Figure 4.6, the user can create user with the variables stated in Class User. User is able to place work order too. Admin can check the work order and also add device. Staff will be assign and calendar event will create. Based on the calendar event, the notifications will be alert to specific users.
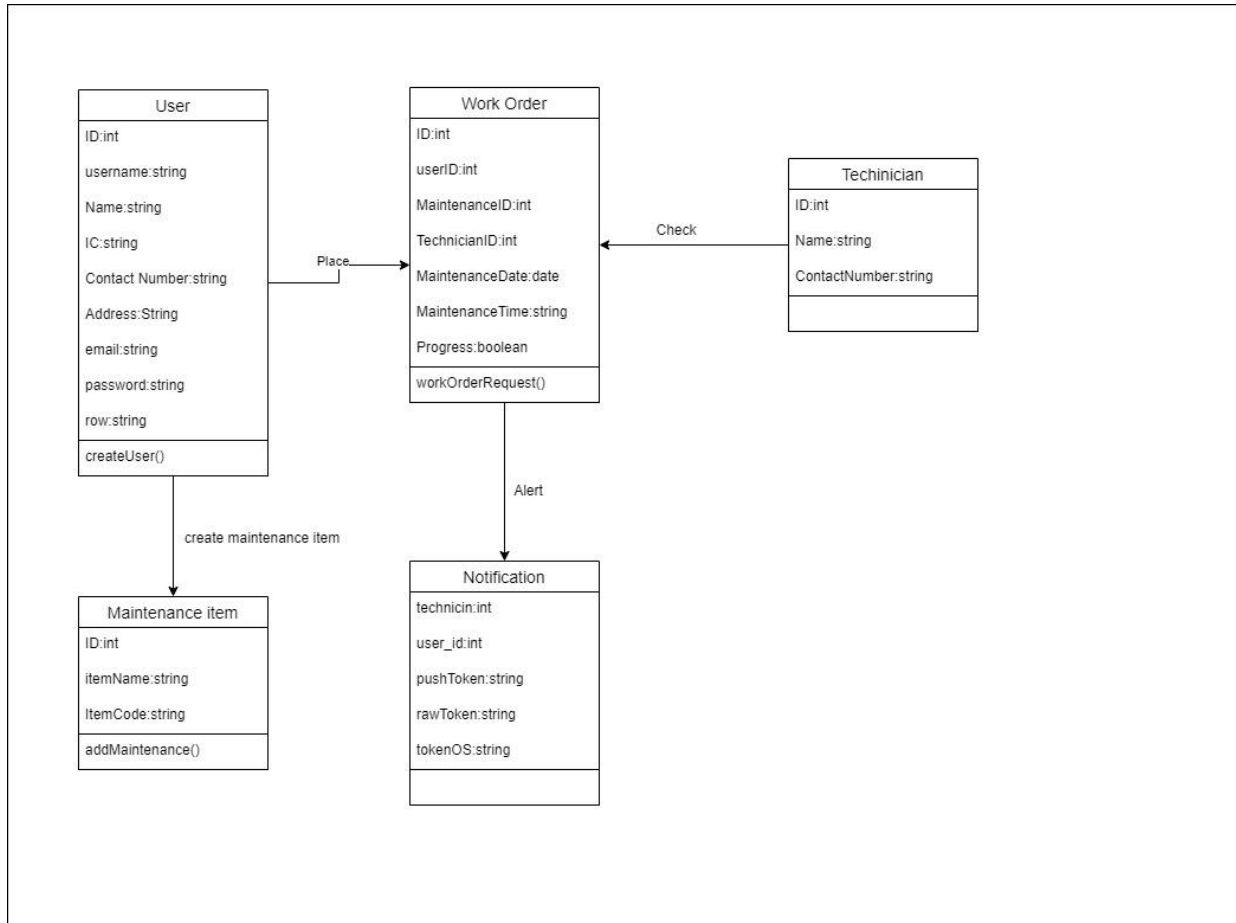
Figure 4.6: Class Diagram for E-Maintenance

4.5.2 Data Dictionary

Data dictionary contains metadata. The purpose of having data dictionary is to save the information of the variables in database. The data dictionary will be recorded by using tables. The database tables in E-Maintenance includes users, technicians, maintenance_item and work_order.

Table 4.3: Table users

Field	Information	Data type
Id	Unique id	Long (optional)
Username	Record data	String
Name	Record data	String
IC number	Record data	String
Contact Number	Record data	String
Address	Record data	String
Email	Record data	String
Password	Record data	String

Table 4.4: Table technicians

Field	Information	Data type
id	Unique id	Long (optional)
name	Record data	String
contact_number	Record data	String

Table 4.5: Table maintenance_item

Field	Information	Data Type
Id	Unique id	Long (optional)
item_code	Record data in short form	String
item_name	Record data in full	String

Table 4.6: Table work_order

Field	Information	Data Type
Id	Unique id	Long (optional)
User id	Get id from user	Long
Maintenance id	Get id from maintenance_item	Long
Technician id	Get id from technician	Long
Maintenance date	Record data	Date
Maintenance time	Record data	String
Status	Record data	String

4.6 Test Plan

Test plan is a good way to check E-Maintenance whether the functions available meet the requirements of the user. The category of test plan will be separated into 3 categories which stated in Table 4.10.

Table 4.10: Test Plan Category

Test Category	Description
1	Test the functionality of the system able to do basic operations of users module
2	Test the functionality of the system able to do basic operations of maintenance_item and technician module

3	Test the functionality of the system able to do basic operations of work order module

Next, the testing plan will be perform and record based on the category. The test plan is as shown as Table 4.11.

Table 4.11: Test plan

Test Category	Description	Expected Result	Actual Result
1	User Module I. add, edit, delete, view	I. Able to perform basic operations	pass/fail
2	Technicians Module I. add, edit, delete, view	I. Able to perform basic operations	pass/fail
2	Maintenance Item Module I. add, edit, delete, view	I. Able to perform basic operations	pass/fail
3	Work Order Module I. add, edit, delete, view	I. Able to perform basic operations II. Able to choose staff as in user created III. Able to choose Maintenance Item as created IV. Able to choose technicians as created	pass/fail

Next table will explain on how to check the security of E-Maintenance. Table 4.12 will show the checklist.

Table 4.12: Security List for proposed application

No	Checklist	Actual Result
1	When user input username and password, if one of it does not match will reject the user to login into system	pass/fail
2	Get the user to use stronger password by requiring user to use combination of alphabets, numbers and symbol	pass/fail
3	Get the user to use longer password by requiring user to use longer password which is more than 6 digits.	pass/fail
4	Password should be obscured in textbox	pass/fail

4.7 User Acceptance Testing Form

In user acceptance testing form will evaluate the user satisfaction on E-Maintenance. The first method is through application testing form follow by security check. Application

A) Application Testing (Scale for Test 1-very dissatisfy to 5-very satisfy)

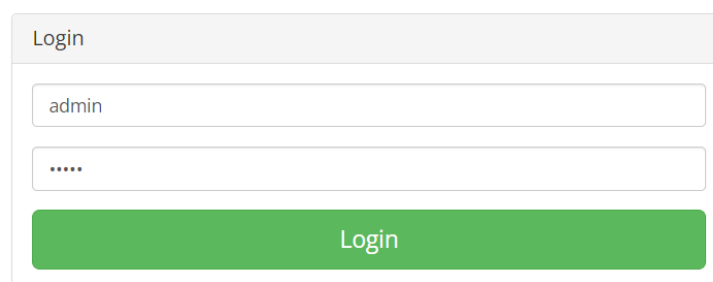**Table 4.13: Application Testing Form**

No	Acceptance Requirement	Test by scaling (1-5)
1	The system must execute from start to end	
2	User able to register and login	
3	Admin able to add new work order request	
4	User able to edit work order	
5	User able to track work order status	
6	User able to view work order history	
7	User able to receive notification when maintenance date is approaching	
8	Application is smooth and fast performance	
9	The system is user friendly and easy to use.	

B) Security Check (pass or fail)

Table 4.13: Application Testing Form

No	Security Requirement	Test (Pass-P, Fail-F)
1	Invalid credential will not able to login and display error message	
2	The password must use combination of alphabet, number and symbol	
3	The password must be longer than 6 characters	
4	Password should be obscured in textbox	

4.8   User Interface

Figure 4.7 : Login Interface

Figure 4.8: User Interface

Figure 4.9: Maintenance items interface

Figure 4.10: Technicians interface

Figure 4.10: Work Orders Interface

5. Conclusion

The conclusion in this development is the chapter include proposal, literature review, methodology, Analysis and Design and user interface. The project has been built by waterfall method and go through different phases.

Acknowledgment

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