

Development of Computerized Maintenance Management System for Manufacturing Factory

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Abstract: Every manufacturing factory has their own technicians to take care their own equipment or asset, so by using Computerized Maintenance Management System (CMMS), the company can centralize all the technicians work order, as well as asset management in computer. The project is studied to develop CMMS for manufacturing factory, which is Synapse is the stakeholder. The project is developed using agile method to plan, analyze, design, implement, and test, where several meetings were conducted with the client. A prototype has been developed to get a better picture on how the system will flow and work. The next goal is to develop the system as planned with the client.

Keywords: computerized maintenance management system software, work order, maintenance spare parts

1. Introduction

Computerized Maintenance Management System (CMMS) is a software that helps unify the maintenance data and ease the process of maintenance operation. Some industries are migrating to more systematic maintenance management. It's commonly used in manufacturing, oil and gas, power, and communication industries as a means to regulate their maintenance tasks. There are many free CMMS software available but most of them provide a basic feature and paid version is required to access the additional features.

Maintenance management in big industrial operations is complicated, and it has a considerable influence on corporate income profitability [1]. Most maintenance does not use a system to record the past and future maintenance operations. This is because the records made are conventionally, for example in writing. This causes the maintenance work is being difficult to monitor and evaluate before, during and after it is done.

Therefore, a system will be developed to assist the management of the manufacturing factory to monitor the maintenance work more efficiently and less hassle. One of the goals is to make sure the operating machines are always in good condition.

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2. Related Work

2.1 Computerized

When talk about a computer, everyone knows what it is. Almost every people in this world own one as computer has been found for a long time. The introduction of the IBM personal computer in 1982 resulted in a rapid spread of computer and software applications to existing jobs such as word processing, payroll, and accounting from large corporations to small enterprises and households [2]. In the beginning of 1974, the parallel development of the internet greatly increased the extent and scope of computerization [2].

2.2 Preventive Maintenance

Preventive Maintenance (PM) is the maintenance of equipment or assets on a frequent basis in order to keep them functioning and avoid costly interruptions caused by unexpected equipment breakdown. PM is one of the keys for an effective maintenance. It can both detect and extend the life of assets that are breaking down. Preventive maintenance (PM) was introduced in the 1950s, after the recognition of the need to prevent failure. PM has been used as an alternative to corrective maintenance (CM) for new technologies, as these systems are often more complicated than those dependent on the use of hand tools [3].

2.3 Predictive Maintenance

Predictive Maintenance (PdM) is a successor of PM, and it is usually used in condition-monitoring systems [3]. Because of the urgency of Industry 4.0 and smart systems, more focus is being paid to predictive maintenance solutions which can reduce outage costs and boost industrial equipment availability [4]. As mentioned before, corrective maintenance is the convention way for maintenance which literally not suitable to be implemented for the system. Furthermore, predictive maintenance may estimate an asset's future status by analysing its current state and comparing it to its previous maintenance behaviour [5].

3. Methodology/Framework

Agile development technique will be applied to this project system development. The Agile technique divides the project management into several stages. It needs constant stakeholder interaction as well as continuous development at all stages. Once the job starts, teams go through a planning, execution, and evaluation phase. Continuous collaboration is required among team members as well as the project stakeholders. Every stated phase is implemented within a series of small iterative cycles of the software development process known as sprints, as agile is an iterative and incremental strategy [6].

In this project, web-based approach is used to develop the system. Hence, it requires a proper methodology so the project objectives can be achieved. Due to the characteristics that must cover the whole of the life cycle, web-oriented software creates a specific level of challenge for its design and development. The accessibility of software is one of the primary difficulties, which is related to the development of both the team and the system (Molina Ríos & Pedreira-Souto, 2019) [7].

3.1 Plan

The purpose of the planning phase is to map out the project's procedure and activities in order to ensure project success. The first stage is to work with the stakeholder to define the project's goal. The project's goal is to create a web-based system for maintenance management for a manufacturing factory.

3.2 Analyse

It is vital to have a thorough understanding of a product before developing it. In this stage, the end user's requirements are analysed to make sure that the project meets their needs. During this phase, any

question must be addressed right away. For instance, a meeting was conducted to clarify of what the CMMS will do. The client talked about how a manufacturing factory experiences difficulty in managing personnel workload for technician maintenance. Hence, all the problems and ideas were noted to analyse the best possible solution.

3.3 Design

In this phase, the system will be designed first to get a clear picture of what the system will do and how the system works. This phase is conducted to meet the requirements that have been discussed in the previous phase, which is the analysis phase. The first thing to do is to construct flowchart that shows how the process flow. The designed chart must be matched with the client requirements. For instance, the client wants the user to log in first before they can use the CMMS, so the process flow for the user log in must be designed too.

3.4 Develop

This is the phase where development is started. The system will be developed from coding and programming, with debugging at the end. This phase is divided into another sub phases, which are frontend development and backend development. The frontend development is a process developing the system user interface (UI) and user experience (UX). The technology that will be used to develop this frontend is Vue.js. The Vue.js is used to design the interface with custom preferences such as custom button, text field, etc, while Laravel is used to handle the backend part. Laravel is one of the PHP frameworks that is available free, which use Model-View-Controller architecture. This can handle how the data is transferred between the client and server.

3.5 Test

The system must be tested after the development process to confirm that it meets all of the criteria. Before testing can begin, a test plan must be created first. Many types of testing are carried out throughout the testing process, which are user acceptability testing, quality assurance testing, and system integration testing. Once the test has been passed, it can be released to the user.

3.6 Release

During this phase, the client, which is Synapse was given access to the system. During this time, system users might receive training to learn on how to use the system. After the system's first release, the responsibilities for this project must be continued, which are expanding the product's functionality and keeping the system operating by providing customer care.

4. Results and Discussion

The analysis results describe the results of the work from the analysis phase that has been used to develop a web-based management system. While design refers to the selection of methods or technologies to develop the system. Design is one of the important elements in the development of a system because it describes the entire system developed. Then, implementation is conducted so that the objectives of this project can be achieved.

4.1 Use Case Diagram

A use case diagram is one of the diagrams that shows a set of interaction sequences between a use case and also the actors involved in the environment of a system. The actors for this CMMS consist of admin, supervisors and technicians. The use cases that play a role to interact with actors in this system are the management of asset, supervisor and technician, view asset master list, create work order and so on. Figure 1 shows the Use Case Diagram for CMMS:

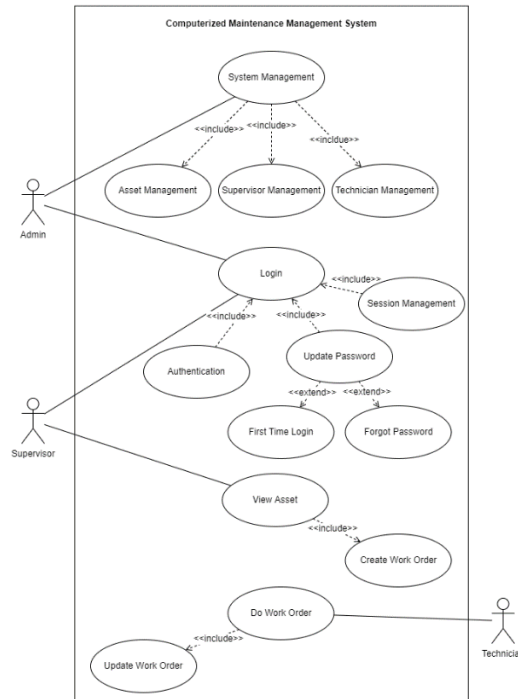


Figure 1: Use Case Diagram

4.2 Entity Relationship Diagram

Figure 2 in Appendix A shows the ERD for the system. One admin can manage many assets and one asset can have many parts. For the work order entity, one supervisor can handles many work orders, which also can be done by one technician. This work order can have one asset at a time. The work order history is used to store the past work order that has be done or finished.

4.3 Design

The project will move onto the design phase after all of the user requirements have been successfully analysed. Both the interface and the database were built during this phase to aid in the visualisation of the system before it was coded. Appendix B shows the architecture design of the system. It consists of four modules which will be implemented in the system.

4.4 Implementation

The project then continue to implementation phase. In this system, there are two types of user that will use the system, which are admin and supervisor. Admin will handle all the management responsibility, such as asset management, supervisor management and technician management. Supervisor however will handle the work order management.

The system is developed using Laravel as the backend, VueJS as the frontend. For the database, the system is using MySQL which is used to handle all the create, read, update and delete (CRUD) operation. The database connection is handled by Laravel by defining the database configuration. As mentioned earlier, VueJS will be used for the front end part. Hence, an API is needed for VueJS to read and write data directly to database. First, the API URL is defined in api.php, then Axios is used to call the URL by using common methods, such as get and post. Figure 2 shows how the API URL is defined. To access the URL, Axios needs to define such as <http://127.0.0.1/api/asset>.

```
Route::apiResources(['asset' => AssetController::class]);
```

Figure 2: Snippet code of declaring the API

Figure 3 shows the login page for the system, which VueJS used for the interface, and Laravel for the backend part. The user needs to choose their role, whether it is admin or supervisor. Then, enter their email and password to login.

Figure 3: Login Page

After the user login as an admin, the system will redirect to a page intended for admin. Figure 4 shows the home page or dashboard for admin. The admin can view the list of asset with its health, the work orders status, and also view the total assets, work orders, pending and completed work orders at the top of the page. At the sidebar menu, there are three other pages for admin can access, which are asset, supervisor, and technician. These three pages lead to their own corresponding management.

ID	Barcode	Asset	Description	Health
1	123431322	Piston	None	■
7	3213124577	CCTV	Watching	■

Work Order ID	Technician	Asset	Assigned By	Status
WO334163	Michael Daniel	Piston	Rahman Talib	Pending
WO236674	Susan Lee	CCTV	Joe Doe	Completed
WO198152	Susan Lee	CCTV	Joe Doe	Pending

Figure 4: Admin Dashboard Page

Admin can manage their assets by navigating the asset button. Then, a page as shown in Figure 5 will be shown. From this page, admin can view the list of asset, can add new asset, edit, and delete the existing assets. To add new asset, click the add button. To delete the existing assets, choose one or more asset by checking the checkbox, then click the delete button. To edit the asset, click the edit button.

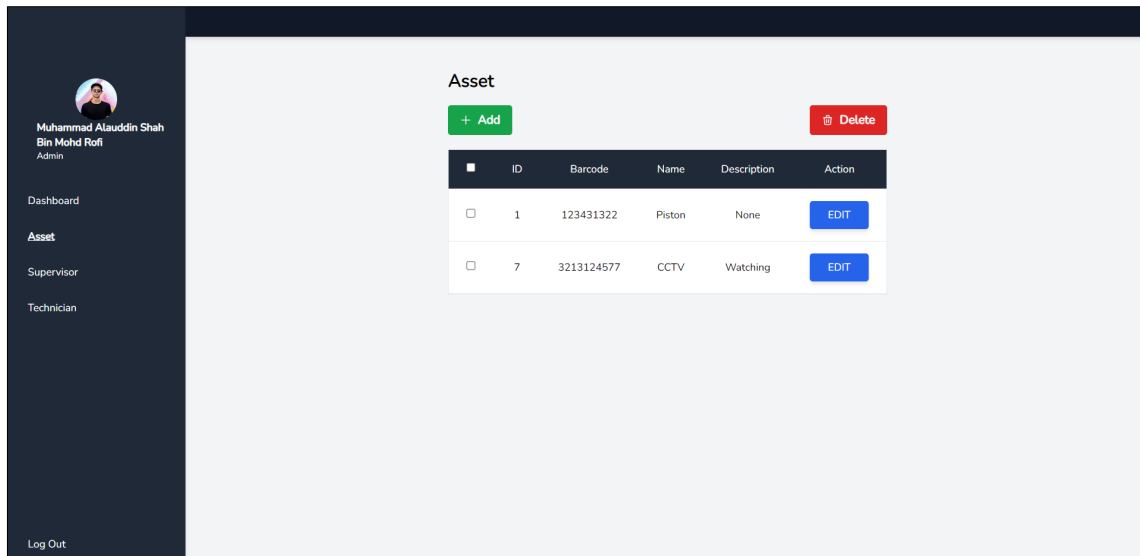


Figure 5: Asset Management Page

To add new asset, the admin needs to enter the asset barcode, name and its description. The barcode must not same with the existing one. Figure 6 shows the snippet code of add method for AssetController. AssetController is used to handle all the CRUD operations for asset entity. When this method is called, it will check the entered barcode first to make sure the new barcode is not the same as existing one. If not same, it will instantiate a new model instance with the barcode, name and description attributes. Then, the model will be saved into the database. If same, the method will return exists response to VueJS indicates that the barcode is already existed in the database.

```
public function add(Request $request)
{
    $asset = Asset::firstOrCreate(
        ['barcode' => $request->input('barcode')],
        ['name' => $request->input('name'), 'description' => $request->input('description')]
    );

    if ($asset->exists) {
        return response()->json('exists');
    } else {
        $asset->save();
    }
}
```

Figure 6: Snippet code of add method in AssetController

The above operation is same with the supervisor and technician management. What make them difference is the table used for the operation.

For the supervisor, from the login page, the user needs to choose Supervisor and enter the email and password. Then, the system will redirect to supervisor dashboard page, as shown in Appendix C.

Just like admin, the supervisor can view the asset list, work order list, and the total number of assets and work orders. From this dashboard, the supervisor needs to click view from one of the asset. Then, the supervisor can decide to create a new work order based on the asset health. If the asset has pending work order, the system will prompt the supervisor telling that the asset has pending work order.

4.5 Testing

After the system has been developed, the system needs to be tested. Testing should be conducted to ensure that the system is running as expected. If there is any bug or error, it should be fixed. Every module of the system was tested and there are some errors occur. Thus, the errors have been debugged and it's should be fixed now. After debugging, the system is tested again to ensure the objective of this project is achievable. Table 1 shows the results of system testing.

Table 1: System Testing Results

No	Testing Case	Expected Result	Actual Result
1	Login Module		
	Login the system with either two types of user	Only authorized admin or supervisor can access the system. Both of the user has their own page of access	Success
2	Asset Management Module		
	Admin are able to manage asset by adding, deleting or updating the asset.	The admin can view the list of asset, add new asset, delete or update the existing asset. Duplication of asset barcode is not allowed.	Success
3	Supervisor Management Module		
	Admin are able to manage supervisor by adding, deleting or updating the supervisor.	The admin can view the list of supervisor, add new asset, delete or update the existing supervisor. Each of the supervisor must have unique ic number, email, and phone number. The password for supervisor is created from the IC number.	Success
4	Technician Management Module		
	Admin are able to manage technician by adding, deleting or updating the technician.	The admin can view the list of technician, add new asset, delete or update the existing supervisor. Each of the technician must have unique ic number, email, and phone number.	Success
5	Work Order Management Module		
	Supervisor are able to view and create work order from an asset.	The supervisor needs to choose an asset to view. Then, create a work order if needed. If the selected asset has pending work order, a new work order is not allowed	Success

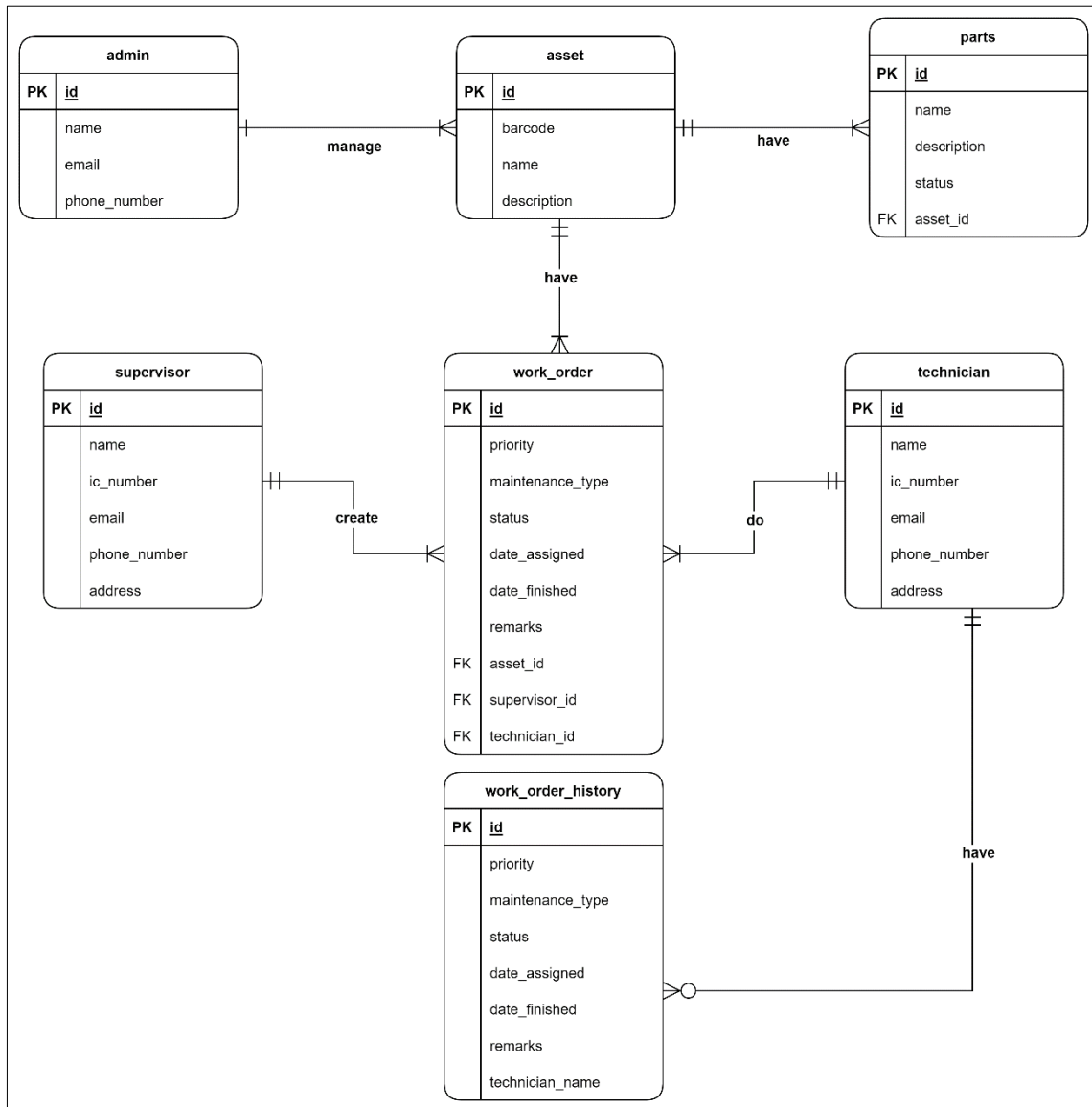
5. Conclusion

After planning and designing have been done, the project can be continued with implementation phase. For this phase, it will be done according to the methodology stage. When follow the planned design, the system will be successfully developed with just minor problems. All advantages and disadvantages are also discussed in this project. Recommendations are also determined so this project or system can be improved in further time.

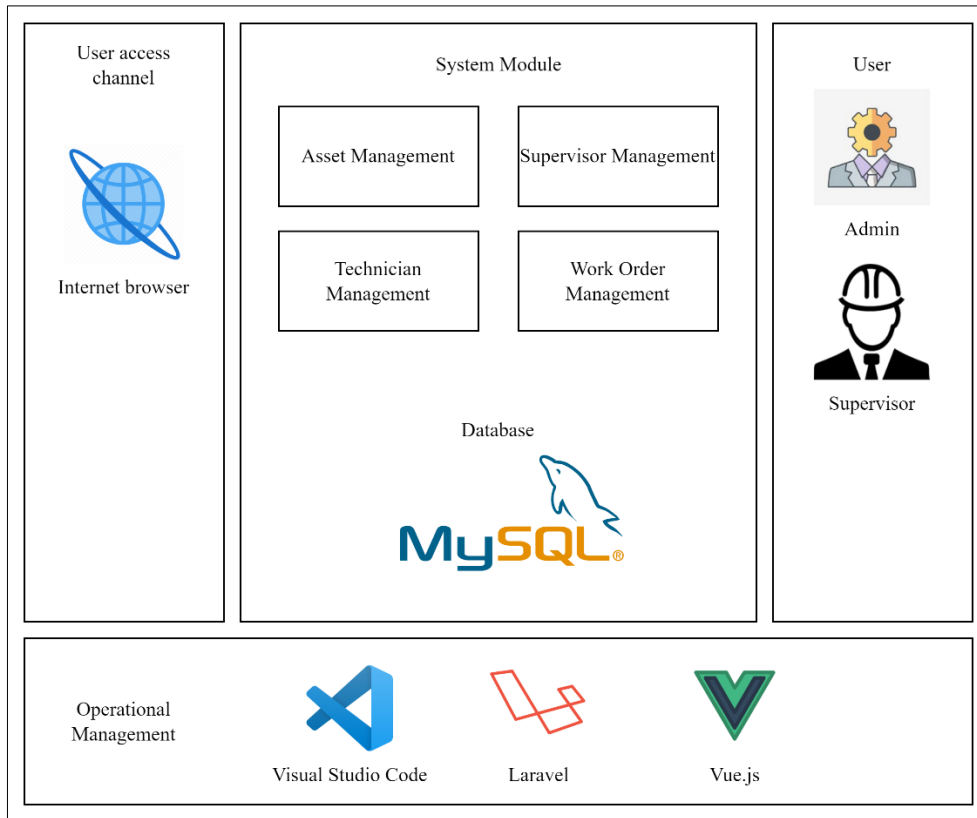
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Appendix A - ERD



Appendix B – Architecute Design



Appnedix C – Supervisor Dashboard

The Supervisor Dashboard provides a comprehensive overview of system metrics and operational details. The user is identified as Edgar Jones, Supervisor.

Summary Metrics:

- Total Assets: 2
- Total Work Orders: 3
- Pending Work Order: 2
- Completed Work Order: 1

Asset Health Table:

ID	Barcode	Asset	Last Serviced	Health	Action
1	123431322	Piston		88%	VIEW
7	3213124577	CCTV	2022-06-07 07:15:49	88%	VIEW

Work Order Table:

Work Order ID	Technician	Asset	Assigned By	Status
WO334163	Michael Daniel	Piston	Rahman Talib	Pending
WO236674	Susan Lee	CCTV	Joe Doe	Completed
WO198152	Susan Lee	CCTV	Joe Doe	Pending

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