Construction Performance Management and Monitoring System

June Kriss E. Avanzado[1], Christian L. Janobas[1], Leonie A. Cajes[1]
junekrissenteria.avanzado@my.smciligan.edu.ph[1]

[1] St. Michael's College of Iligan

ABSTRACT. The construction industry drives urbanization and economic growth; however, challenges such as cost overruns, delays, and inefficiencies in monitoring progress and managing resources abound. Traditional manual methods are time-consuming, error-prone, and unsuitable for modern projects. This study aims to address these issues by proposing a Web-Based Construction Performance Management and Monitoring System. The system allows QR code-based attendance tracking, monitoring of resources and its budget used in the project, effortless scheduling of tasks, monitoring of the worker's payroll, easy generation of project related reports and visual representation of the project's progress, ensuring greater efficiency with lesser chances of error. The system was developed using HTML, CSS, and Javascript as the front end programming languages, and Django Framework for the backend of the system. To evaluate the usability of the system, we used the System Usability Scale (SUS) and distributed the questionnaires to 27 workers, and a single project manager, foreman, and an admin, totaling to 30 respondents. The system received a final score of 78 which can be interpreted as a rating of "Good" based on the SUS standards. Although the system met its objectives and received a passing rating, the researchers suggest implementing a chat feature into the system so that the users can freely communicate with each other, make the system accessible to more devices, and make some features more automated.

224 words

Keywords*: Management, Monitoring, Tracking, System Usability Scale, Construction Project*

Introduction

Behind the continuous urbanization and economic growth of a society, the construction industry plays a key role in shaping the infrastructure and living environments of modern civilization. However, as a project becomes more complex and large-scale, cost overruns, delays, inefficiencies in managing, and monitoring of progress and the workers will greatly affect the project's outcome and the satisfaction of the stakeholders in an unpleasant way. Traditional methods of monitoring equipment and performance in a construction project proved to be inaccurate and time-consuming as they rely heavily on large scale manual operations [1].

According to the interview conducted by the researchers, inaccuracies that lead to problems like cost overruns and over-payment have been recognized in the current way of tracking the worker's attendance. There is also no efficient way to monitor and manage the supplies and equipment used in the construction project and track the budget used in them to prepare for the needed equipment and materials. Lastly, the researchers found in the interview that there is no convenient way of viewing the current progress of the project as well as the schedules and deadlines to be met. The most commonly used existing method of monitoring and managing a construction project is paperwork and manual processes. According to a study by Gara et al. [2], due to reliance on manual and conventional monitoring methods, project reporting and progress metrics are still labor-intensive, time-consuming, and prone to human error today. This study addresses the inefficiencies and inconvenience resulting from using the manual and paper-based methods by providing a more effective way of managing and monitoring a construction project.

The goal of the researcher is to develop a web-based management and monitoring system to simplify the processes of managing construction projects, and to provide a more efficient way of monitoring construction materials, equipment, and the progress of the workers. The researcher also wants the system to effectively track the project's progress and display important details about the project.

Objectives of the Study

The study aims to develop and implement a system that streamlines the managing and monitoring of construction projects in the Kanooz Industrial Services, with the objectives of designing a system that offers a way to track and record a worker's attendance with the use of QR codes and monitor each worker's progress in a project, developing a system that lets the personnels of a project efficiently record the resources used as well as keep track of the budget allocated for the use of materials and equipment, and lastly, testing and evaluating a system that offers a visualization of the project's progress and offers a way to properly manage the project's schedules by providing a means of creating schedules of tasks and displaying the project's timeline..

Methods

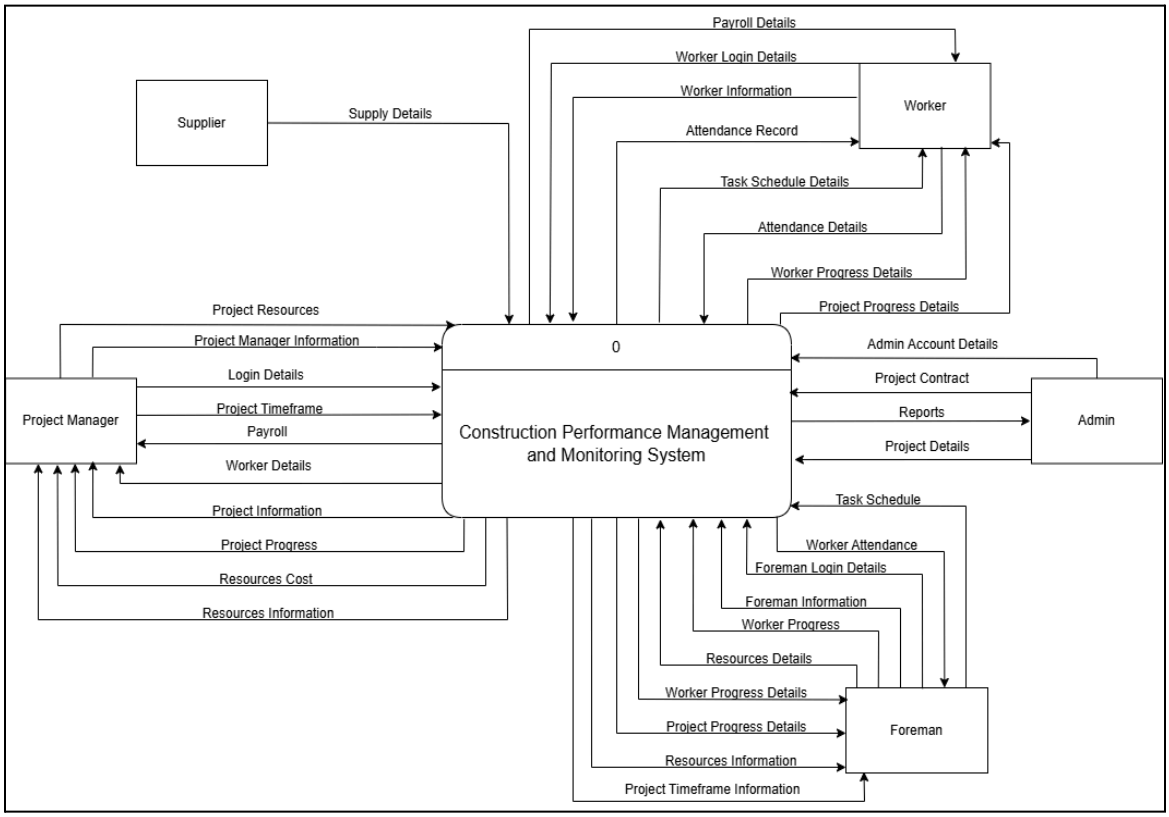

Figure 1. Context Diagram

The diagram shows how the system operates. It involves five entities: the project manager, admin, foreman, supplier, and worker. The project manager, foreman, and worker can log in using accounts created by the admin. The project manager can input their personal information and the project's timeframe. The system then provides them with details such as project cost, progress, contract, resources, team members, and worker payroll. The foreman, after logging in, inputs worker progress, task schedules, project resources, and assigns workers to the project. The system provides the foreman with information about the project's timeframe, progress, worker attendance and progress, and available resources. Worker attendance is tracked via a QR code scanner, and its data is stored in the database. After logging in, the worker can view their progress, the project's progress, task schedules, and attendance records. Lastly, the admin, after logging in, can store key information about the project and its contract. The system then provides the admin with reports of all activities within the system.

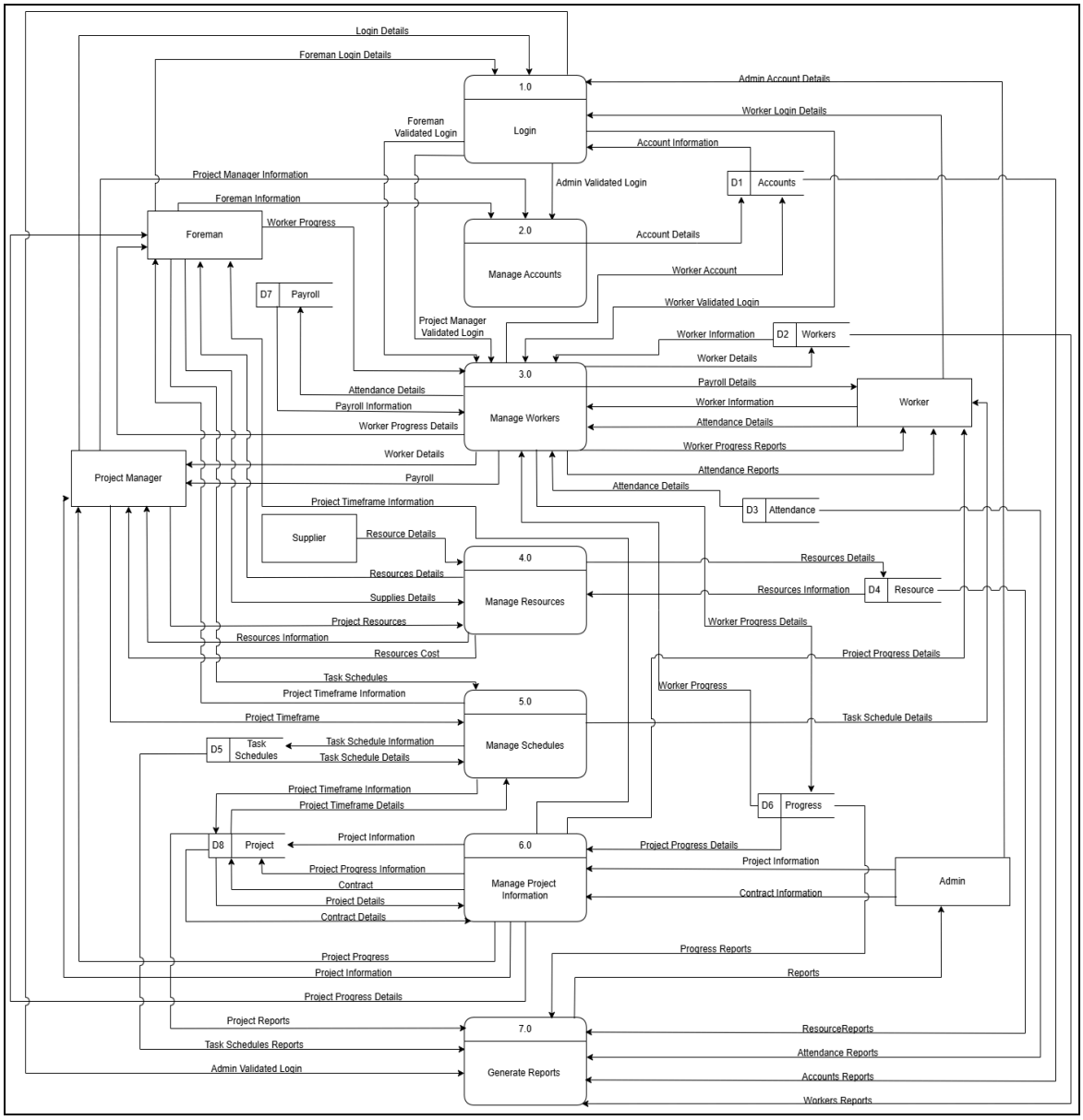

Figure 2. Data Flow diagram

Figure 2 provides a detailed view of how the system operates, involving five entities, seven processes, and eight databases. The system first validates user accounts by checking their existence in the database and directing them to the appropriate page based on access level. The admin manages account creation for project managers, foremen, and workers, storing these in the accounts database. Workers, after logging in, can input personal information stored in the workers database, while their progress and attendance, updated by the foreman and recorded via QR code, are stored in the progress and attendance databases. The system provides relevant data to both workers and foremen. Project resources are managed by the foreman and project manager, with input stored in the resources database and the data used in calculating total costs. Scheduling is handled through the project timeframe submitted by the project manager and task schedules by the foreman, both stored in their respective databases with these used to provide timelines to the foreman and tasks to the workers. The admin inputs project and contract information, which is stored in the project database. The system calculates the overall project progress using worker data, stores it, and shares it with the project manager, foreman, and workers. Finally, the system gathers all stored data and generates activity reports for viewing by the admin and project manager.

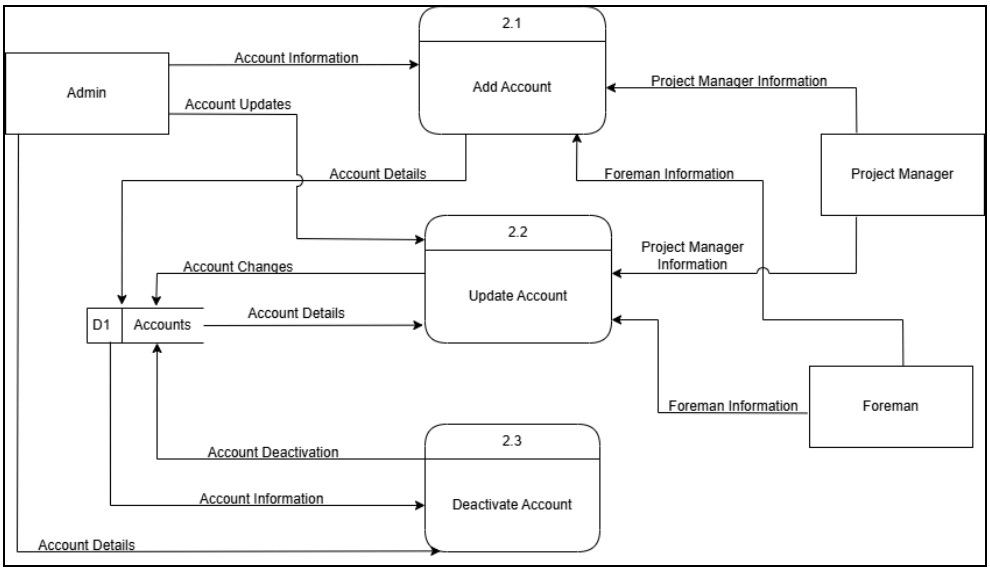

Figure 3. Process 2 Decomposition

The second process can be broken down into three processes. The system will receive account information from the admin and will be modified by the project manager and the foreman with their personal information. They can also update their accounts while the admin can deactivate accounts through the system.

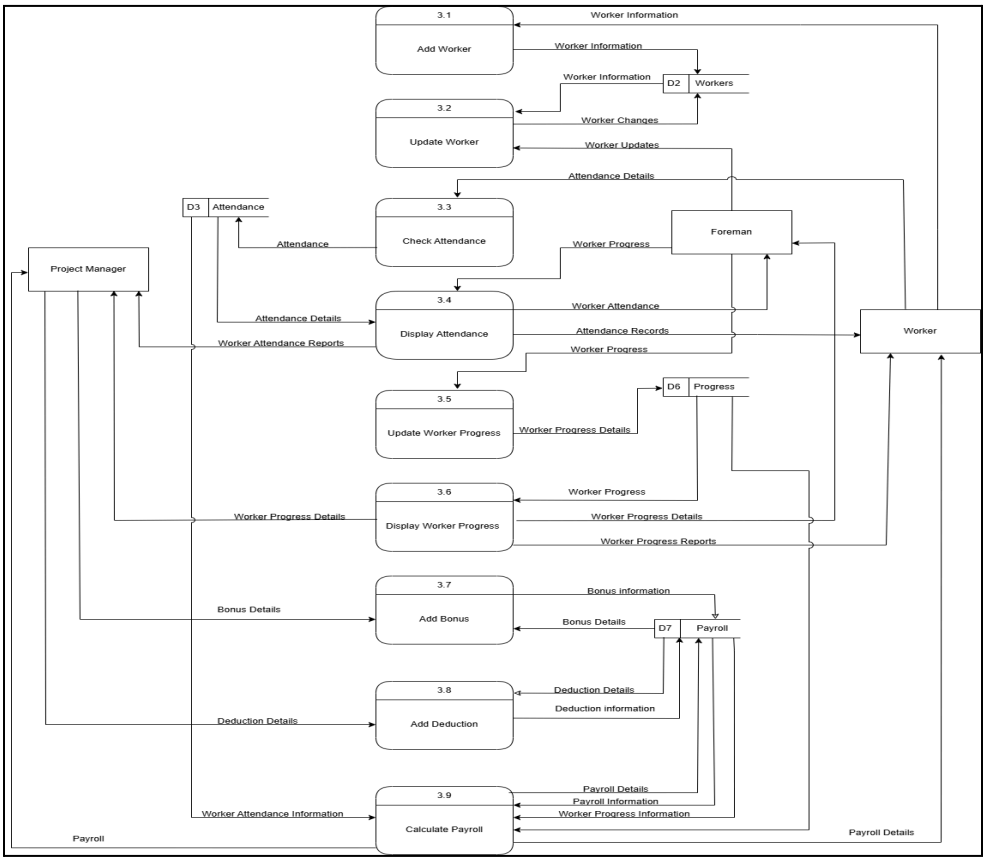

Figure 4. Process 3 Decomposition

The third process is divided into nine sub-processes. The foreman can add and update worker information stored in the workers database. The system records worker attendance and stores it in the

attendance database, while worker progress, submitted by the foreman, is stored in the progress database. The system then displays both attendance and progress data to the project manager and the worker. It also manages the addition of bonuses and deductions to the worker's payroll. Finally, using the stored attendance and progress, the system updates the payroll and saves the data in the payroll database.

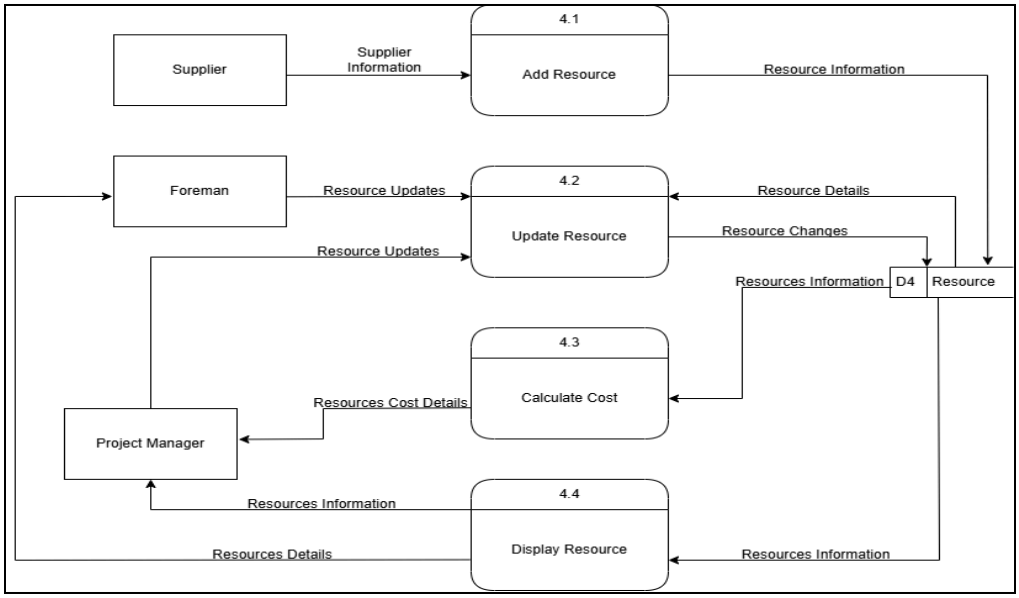

Figure 5. Process 4 Decomposition

The fourth process can be broken down into four processes. The first two processes are for managing the resources information. The foreman, and the project manager can add resources information into the database resources and update the resources information that is stored in the database. In the third process, the system will provide a calculated cost of the resources stored in the database. And lastly, the fourth process displays the stored resources information in the database to the project manager.

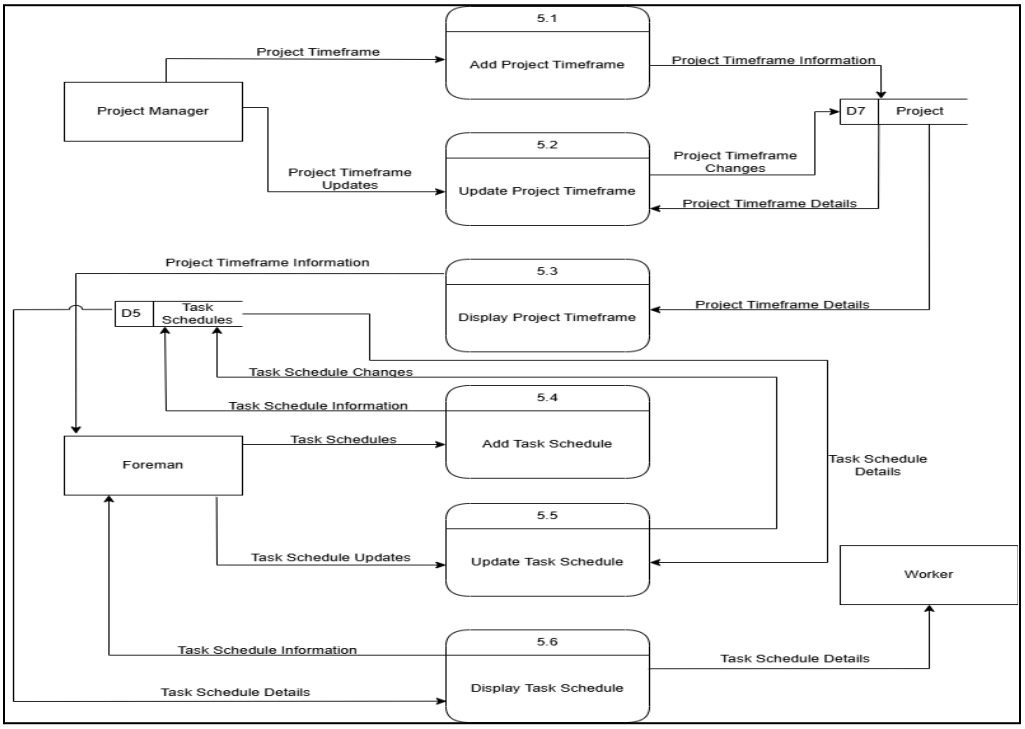

Figure 6. Process 5 Decomposition

The diagram above shows the decomposition of the fifth process in the data flow diagram. The system can add the project's timeframe that is inputted by the project manager into the database project. The project manager can also update the project's timeframe through the system. The system can then add task schedules by the foreman as well as let them update the stored information in the database schedules. And lastly, the system will display the stored project's timeframe to the foreman, and the stored task schedules to the worker.

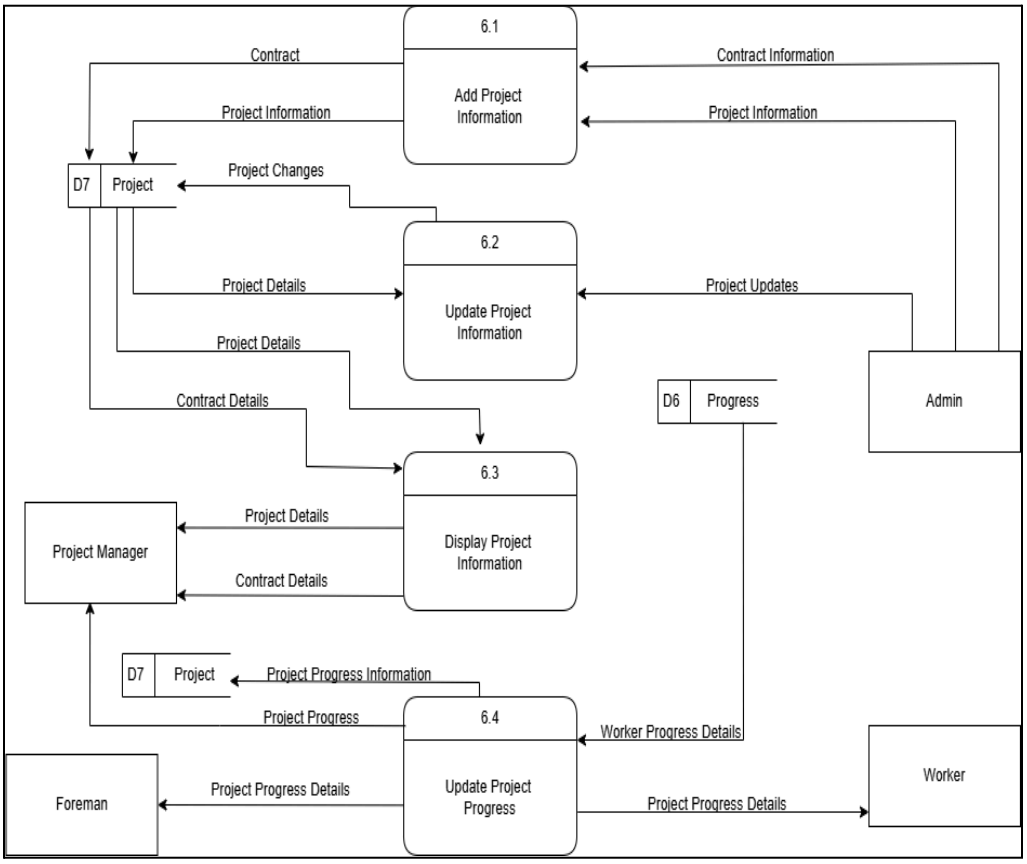

Figure 7. Process 6 Decomposition

The sixth process can be broken down into four processes. The system lets the admin add the project and contract information, and provides a way to update the stored data in the database project. The third process is where the system will display all the stored project information into the project manager. The system also uses the worker's progress from the database workers and calculates it to acquire the overall project's progress. After calculating, the system will make the data available for the project manager, the foreman, and the worker and store the data into the database project.

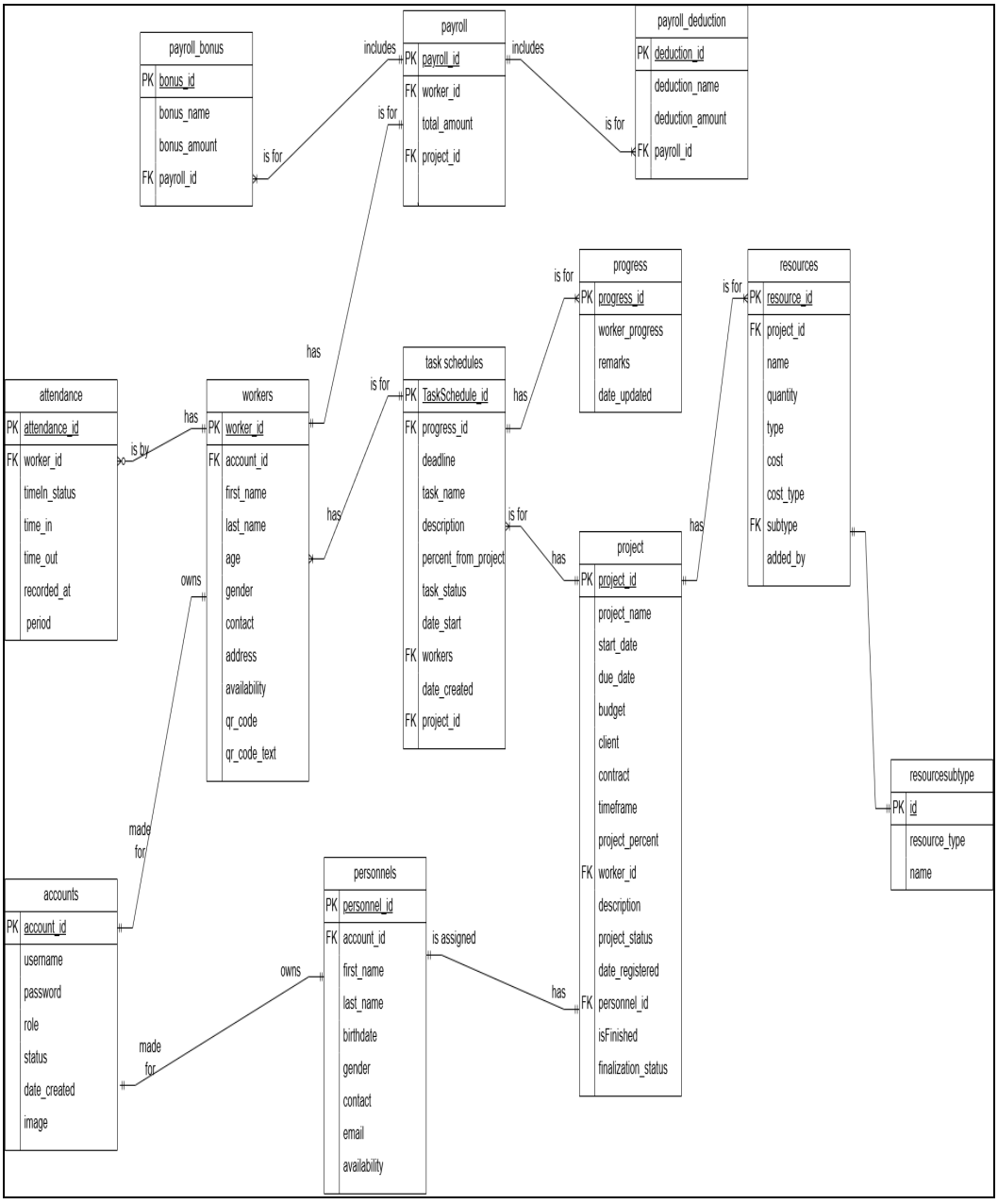

Figure 8. Entity Relationship Diagram

Figure 8 shows the attributes inside the six databases utilized in the system, presenting the relationships between the accounts, workers, personnel, attendance, project, task_schedules, progress, resources, resourcesubtype, payroll, payroll_bnus and payroll_deductions.

Results and Discussions

Software testing using the System Usability Scale (SUS)

The system is further evaluated through a survey questionnaire adapted from the System Usability Scale (SUS) as a tool to measure perceived ease-of-use, system satisfactions and subscales of usability and learnability.

Evaluation Metrics

Table 1

Usability of the Construction Performance Management and Monitoring System

Indicators	SUS Score
I think that I would like to use this system frequently.	95
I found this system unnecessarily complex.	50
I thought the system was easy to use.	85
I think that I would need the support of a technical person to be able to use this system.	60
I found the various functions in this system were well integrated.	90
I thought there was too much inconsistency in this system.	50
I would imagine that most people would learn to use this system very quickly.	85
I found the system very cumbersome to use.	55
I felt very confident using the system.	95
I needed to learn a lot of things before I could get going with this system.	75
Final SUS Score	**78**

Table 1 presents the usability evaluation of the Construction Management and Monitoring System. The statement "I think that I would like to use this system frequently." received a high SUS score of 95, indicating strong user satisfaction and a positive experience. Users showed a clear interest in regular use, reflecting strong engagement. However, some users found the system slightly complex, as reflected by a mean score of 50. This suggests a learning curve, though it doesn't significantly hinder usability.

The system was rated 85 on the statement "I thought the system was easy to use," indicating overall user-friendliness. Nonetheless, some users scored 60 on needing technical help, suggesting that while most functions are accessible, a few may require additional support. Despite this, the need for assistance was not seen as a major issue and did not significantly impact the positive perception.

Features like reporting and task tracking scored 90 under the statement "I found the various functions in this system were well integrated," pointing to smooth and cohesive functionality. However, concerns about system consistency were noted, with a score of 50. This indicates room for improvement in ensuring uniformity across different tasks and workflows.

Ease of learning was also evaluated positively, with a score of 85 on the statement "I would imagine that most people would learn to use this system very quickly." Still, some users found certain processes awkward, giving a score of 55, suggesting potential workflow inefficiencies. On the other hand, confidence in using the system—particularly for monitoring construction progress—was strong, earning another high score of 95.

Lastly, the statement "I needed to learn a lot of things before I could get going with this system." scored 75, showing that while some learning is required, it isn't overwhelming. The overall SUS score of 78 reflects a generally positive user experience. While usability is strong, improvements in interface design and workflow efficiency could enhance satisfaction further. Despite minor issues, the system is regarded

as effective and functional for construction management purposes.

Conclusion

An effective tool in managing and monitoring construction projects is the Web-Based Construction Performance Management and Monitoring System. This system is user-friendly and will track worker attendance, resources, and project progress-all important factors that contribute to enhancing the overall efficiency of construction management. Although the usability ratings of the system are generally positive, there is still a need to address areas such as complexity and inconsistency to further optimize the user experience. Continuous refinement and updates to the system, along with an emphasis on reducing the need for technical assistance, will help maintain its effectiveness in the long term.

Recommendation

The researchers suggest implementing several enhancements to improve the system's functionality and usability. One recommendation is to add a chat feature that would allow project personnel to communicate freely, including communication between workers and personnel for questions and clarifications. They also propose including a feature that integrates worker IDs into payroll calculations, potentially enabling benefits for the workers. To improve accessibility, the researchers recommend making the system available on more devices, particularly mobile devices, so users can access it conveniently on-site without needing bulky equipment like laptops. Another suggestion is to allow the admin to input the project's payment details upon completion and enable the system to calculate the total received payment automatically. Lastly, the researchers recommend having the task percentage from the overall project progress be automatically calculated based on the task's length and duration, where longer tasks contribute a larger percentage to the project's progress.

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