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MAINTENANCE OF WEB APPLICATION BASED ON MODEL–VIEW–CONTROLLER ARCHITECTURE (CASE STUDY: HUMAN RESOURCE ASSESSMENT TOOLS)

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ABSTRACT
One of the causes of project failure in organizations is the mistake of selecting team members who are not suitable. The HR Assessment Tool Application is a web platform based on MVC architecture that can map employee roles based on individual competencies from various assessment sources. This application was developed to help organizations allocate human resources effectively based on everyone's competencies. However, the HR Assessment Tools Application has some shortcomings that hinder its functionality, requiring maintenance or improvements to address issues and add new features. This project will focus on the application's functionality, both front-end and back-end. Maintenance will be conducted using the Collaboration Model of Software Development, which consists of five phases, communication/requirement, planning, modeling, construction, and deployment. The results of the HR Assessment Tools Application maintenance will be tested using the Black Box Testing method. The Black Box Testing results show that all scenarios meet the expected outcomes. These results ensure that the HR Assessment Tools Application functions optimally and is ready for organizational use.

I. INTRODUCTION

Assessment is an activity used to measure the abilities or competencies possessed by individuals [1]. There are many assessment methods available, such as 360-degree, 720-degree, assessment center, psychometric assessment, competency assessment, performance check-ins, and behaviorally anchored rating scale. In the context of Human Resources (HR), assessments are used by HR management to evaluate employees on skills relevant to organizational effectiveness [2]. Assessments have long been utilized by HR professionals to predict future job performance [1]. Assessment becomes crucial when used by organizations in executing projects. According to [3] in [4], one of the challenges in software development projects is determining the optimal allocation of human resources. Many software development projects fail because project managers do not adequately consider appropriate human resource allocation [3]. The HR Assessment Tools application is a website application based on MVC architecture which is one example of how assessments can be applied to help organizations allocate human resources effectively. This application maps employees' roles according to their competencies and evaluates individual competencies from various sources such as supervisors, subordinates, peers, and self-assessments.

Several HR Assessment Tools applications have been developed. One notable study involves the development of an HR Assessment Tool using the 360-degree method within the Appraisal module [5]. The purpose of this assessment [5] is to measure employee work behavior based on evaluations from multiple sources, such as managers, colleagues, and subordinates. The study employed the Collaboration of Software Development method in its development process. Another study focused on developing an HR Assessment Tool within the profile matching module [6], which aims to compare the competencies of employees with the minimum competencies required for a specific position in the company. This study [6] also utilized the Collaboration of Software Development method. Furthermore, the research applies human resource concepts to each business process, thereby aiming to minimize the risk of project failure in software development across companies. Also, in the research conducted [7] on the website maintenance, the Collaboration of Software Development method was also utilized within the context of the Application Website Maintenance phase. Therefore, in this study, the author decided to employ the Collaboration of Software Development method.

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This research introduces several significant improvements to the HR Assessment Tools application compared to previous studies. Unlike prior research by [5] and [6], which utilized a face-to-face approach, this research employs a collaborative development approach. This methodology enhances coordination and accelerates the development process. Additionally, the application has been optimized by eliminating redundant code in the sidebar and streamlining the role management process. These improvements address key issues identified in previous applications, such as ineffective role management and functionality disruptions, making the application more efficient and effective in assigning project teams based on employees' characteristics, experience, and behavior.

The HR Assessment Tools application has been tested in the context of a Software Engineering course at a university. In this course, the application functions map students' competencies based on their characteristics, enabling the formation of ideal groups according to role requirements. According to [8], based on a survey conducted by the Project Management Institute in 2017, neglecting the needs and roles of team members causes 40% of projects to fail to meet their goals and budgets. From this data, the selection of team members becomes crucial for the success of organizational projects.

Based on the author's experience and that of several colleagues using the HR Assessment Tools application, the primary issue with the application is that some processes do not function as intended, such as the inability of administrators to access the assessment sessions feature, disrupting the overall functionality of the application. Through scenario-based case studies, the author has identified the same issues. Additionally, according to the application administrator, there are problems related to role management within the HR Assessment Tools application. These issues necessitate requests for improvements and feature changes to ensure optimal processes within the application.

Adding and modifying features necessitates continuous maintenance of the application, commonly referred to as software maintenance [9]. Software maintenance involves planning and executing activities to modify software, aiming to fix issues, enhance performance or other aspects of the software, and adjust it to evolving user needs [10]. Therefore, this research will conduct software maintenance by adding new functionalities and addressing unresolved issues from the development phase of the HR Assessment Tools application, making it more effective in role selection within a company by enabling the appropriate allocation of project teams based on the character, experience, and behavior of each employee.

II. RESEARCH METHOD

A. Problem Solving Methodology

In this research, Collaboration of Software Development [11] is chosen as the method used in performing maintenance, which will later be modified according to the conditions of the team and the development environment. The stages in the systematic approach to solving the problem can be seen in Fig. 1.

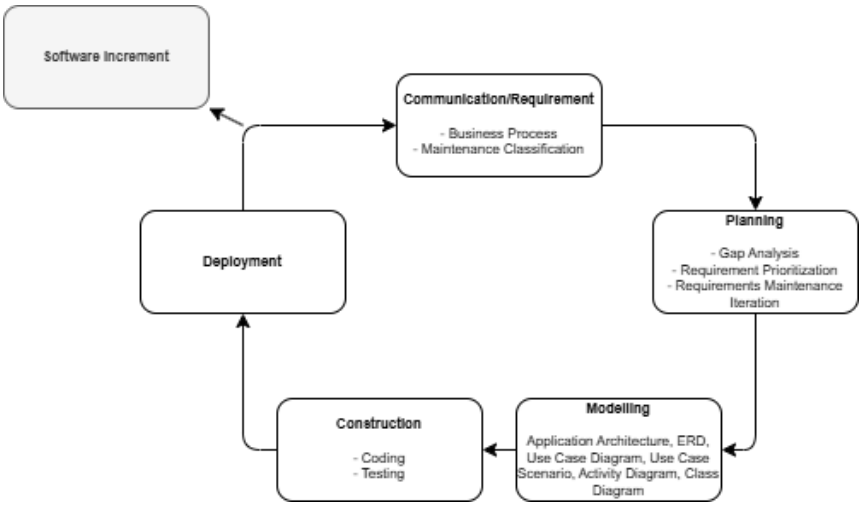

Fig. 1. Problem Solving Methodology

1. Communication/Requirement Phase

   The communication/requirement phase is the stage of clear communication and understanding related to

the project's needs and requirements. The team will interact with the product owner to discuss the needs, gather information, and define the goals clearly. In this phase, there are two stages: the first stage is defining the existing business processes in the HR Assessment Tools application as information for future improvements. The second stage is maintenance classification with the goal of restoring functionality, failures, or system damage. In this stage, several maintenance classifications related to the requirements will be gathered. To obtain detailed requirements for the maintenance of the HR Assessment Tools application, analysis and information gathering will be conducted through direct interviews with relevant stakeholders. Once this information is obtained, the needs will be grouped according to the type of improvement and prioritized as software requirements prioritization.

2. Planning Phase
   The planning phase is the planning stage based on the analysis and interviews conducted previously, involving functional analysis based on existing business processes, maintenance classification, and actor analysis of the HR Assessment Tools application. In this phase, activities include planning the improvements to be made by analyzing the existing conditions with the desired needs, to formulate proposed solutions. The results of this analysis can be used as a basis for performing maintenance.
3. Modelling Phase
   In this phase, several steps are taken for modeling. The first step is designing the application architecture used for mapping existing artifacts in the application. The second step is designing the Entity Relationship Diagram (ERD) used for designing a database and showing relationships between entities. The third step is designing the use case diagram as an illustration of interactions between actors and the system used. The fourth step is designing the use case scenario as a detailed description of the steps taken by actors and the system. The use case scenario can also be used for testing scenarios. The fifth step is designing the activity diagram to model the processes occurring in a system. The final step is designing the class diagram to display the system structure, such as classes, attributes, methods, and relationships between classes. These steps will be used to facilitate the maintenance stage of the application.
4. Construction Phase
   The construction phase is the stage where the project begins with implementation. The team will work to build the solution according to the previous designs, while maintaining regular interactions to ensure the work proceeds according to plan and meets the established requirements and needs. After implementation, the team will create a series of black box tests for each application assessment flow according to the existing limitations.
5. Deployment Phase
   The deployment phase is the final stage of the systematic problem-solving approach, where the application is released for user use. Before this, the team will ensure that the provided solution has been well tested, so the application is ready for use. This phase is not performed just once but several times during the software development until completion. In this phase, there are several steps: the first step is delivery, which involves providing the software results to users. The second step is support, providing software result documentation for all functions and features during deployment. The third step is feedback, where application users can give feedback to developers for further evaluation and improvement. The phases explained above will be carried out in several iterations based on priority. These iterations involve improvements for each role in the application.

B. Website

A website is a collection of web pages containing interrelated information that can be accessed via the internet [12]. It serves as an information service using the concept of hyperlinks, which facilitates users in browsing the internet [13]. A website consists of a group of site pages, typically organized under a domain or subdomain, and located within the World Wide Web (WWW) on the internet. A web page is written in HyperText Markup Language (HTML), a protocol used to convey information from a web server to be displayed to users through a web browser [14].

Essentially, a website can be defined as a collection of pages that display information in various formats, such as text, still or moving images, animations, sound, video, or a combination of these, which can be static or dynamic. These pages form an interconnected structure, where each page is linked through networks of pages. Anyone in the world can visit a website at any time, allowing them to learn about an individual or organization, ask questions, or

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provide feedback [15]. A website is considered static if its information remains constant, rarely changes, and its content is one-way from the website owner. In contrast, a website is considered dynamic if its content is frequently updated, and the information is interactive and two-way, coming from both the website owner and users [15].

C. Website Application Framework

Website application framework is a software framework that facilitates the rapid development of websites by providing pre-built functionalities such as database management, user interface management, and more. These frameworks can be used for creating both dynamic and static websites [16]. Examples of web frameworks include Ruby on Rails, Laravel, Grails, Django, Zend Framework, Sails.js, and many others. A web framework typically employs an architectural pattern such as MVC (Model-View-Controller).

Model-View-Controller (MVC) is a concept used to encapsulate data with a process (model), control the process (controller), and manage the presentation (view) to be displayed on an interface, as depicted in Fig. 2. The detailed definitions of the MVC architecture are as follows:

1. Model: Encapsulates data and functionality.
2. View: Displays information to the user. Views are often synchronized with each other and must also be dynamic. Each view is linked with controller components.
3. Controller: Monitors changes within the program's mechanism.

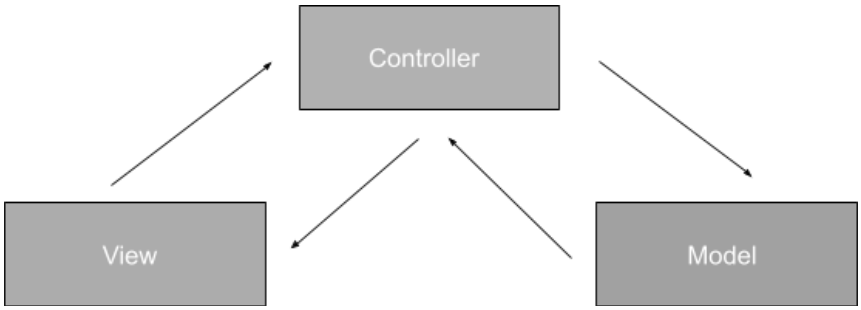

Fig. 2. Model-View-Controller

D. Employee Performance Assessment

Employees are a crucial element in a company, and the success of a company can be seen through the performance of its employees [17]. Employee performance is evaluated based on behavior, attributes, and skills by supervisors over a specific period, following the company's standards and policy procedures, one of which includes the use of assessment methods [18]. This evaluation typically considers job performance analysis, previous performance reviews, experience, and feedback from various parties such as supervisors and colleagues [19]. The results of these evaluations are used objectively by the company to assess and identify the most suitable employees for specific roles and to effectively plan career development [19].

E. Software Engineering

Software engineering includes processes, methods, and tools that enable complex computer-based systems to be built on time and with high quality [9].

Fig. 3. Layer of Software Engineering

Based on Fig. 3, there are several layers of approach in software engineering that can help in understanding the complexity of software systems and building more structured and maintainable systems. The "a quality focus" layer focuses on software quality and includes concepts of testing, verification, and validation. The "process" layer

integrates the technological layers and allows for rational and timely development of computer software. This layer forms the basis for control in software project management and sets the technical methods to be applied.

The next layer, "methods," provides technical guidelines for building software, covering various tasks such as communication, requirement analysis, design modeling, program construction, testing, and support. Software methods rely on fundamental principles that govern each technology field and modeling activities with other descriptive techniques. Finally, the "tools" layer provides automated or semi-automated support for processes and methods. When tools are integrated, the information created by one tool can be used by another tool, forming a system to support software development known as computer-aided software engineering (CASE).

F. Software Maintenance

Software maintenance is a broad activity that includes enhancing capabilities, fixing bugs, optimizing, and removing outdated features [20]. It is a continuous process needed to ensure that the software system remains functional and usable over time.

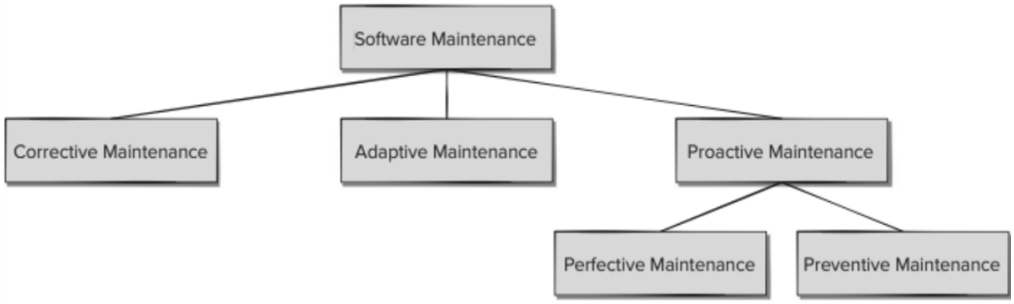

Fig. 4. Types of Software Maintenance

As shown in Fig. 4, there are several types of software maintenance, such as:

1. Corrective Maintenance
   Corrective maintenance is the action taken to fix problems found in the software after it has been used by users, such as bugs discovered when the software is in use [9].
2. Adaptive Maintenance
   Adaptive maintenance involves making changes to the software so it can adapt to new environments, like updating the software to work with a new operating system [9].
3. Perfective Maintenance
   Perfective maintenance is done even if there are no problems. It includes adding new features or cleaning up the code structure to improve performance, code efficiency, and the usability of the software [9].
4. Preventive Maintenance.
   Preventive maintenance aims to prevent problems from occurring in the software, such as updating security to protect against attacks [9].

G. Collaboration of Software Development

Collaboration of Software Development is a model derived from the agile model. This model consists of several phases in software development, as shown in Fig. 5. The first phase is Communication/Requirement, which involves communicating to understand software needs. The next phase is Planning, which involves planning the software development. Then there is the Modelling phase, which involves designing the software. The Construction phase includes developing and testing the software. Finally, the Deployment phase involves releasing the application for public use.

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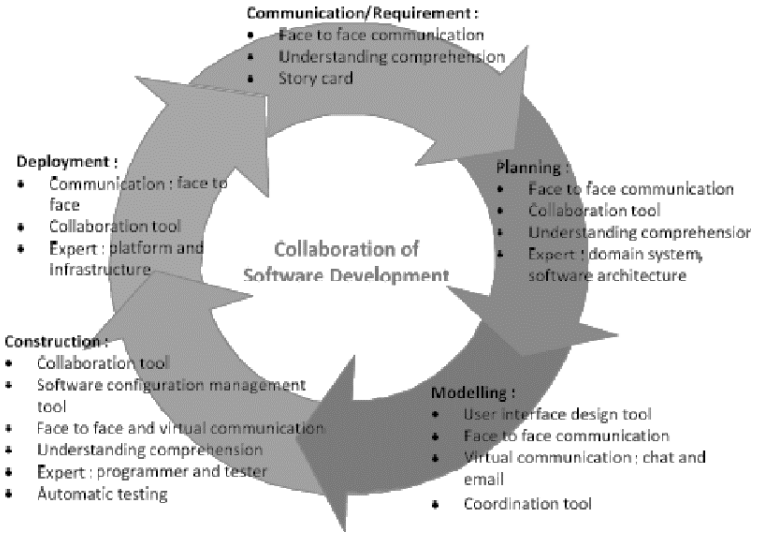

Fig. 5. Collaboration of Software Development Model

These five framework activities can be used to develop small and simple programs, create large web applications, and develop complex large-scale computer systems [11]. Additionally, this model emphasizes direct communication, which will have a positive impact on the productivity level of a team and the quality of the product that will be produced [11].

H. Software Requirements Prioritization

Software Requirements Prioritization is the process of determining the needs or features of an application. Prioritizing requirements is crucial in designing or improving an application. Sometimes, developers cannot fulfill all the needs proposed by customers or stakeholders because they are not given priority by the customers, making it unclear which needs should be addressed first [20]. Factors that can be used to determine prioritization are listed in Table 1.

TABLE 1
Priority Determining Factors

Term	Definition
Importance	How urgent the implementation of a requirement is. If the need is vital, it should be prioritized higher.
Time	The duration required to implement the candidate requirement.
Risk	The potential loss if the application fails due to project uncertainties.
Cost	The number of resources spent to implement the candidate requirement.
Value	The value of the requirement compared to other needs.
Penalty	The consequences faced if a requirement is not implemented correctly.

I. Black Box Testing

Black box testing is designed to validate functional requirements without considering how the program works. It focuses on the software's information domain by partitioning the input and output domains in a way that provides thorough test coverage [9]. Black box testing is used to determine application functionality, focusing mainly on the available inputs and the expected outputs for each input value. This testing method is based on software requirements where the internal workings of the tested item are unknown to the tester [21].

III. RESULTS AND DISCUSSION

In this session, we will discuss the implementation process of analysis and design for the maintenance of the HR Assessment Tools application.

A. Communication/Requirement Phase

1. Identify Actors

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There are several actors with specific tasks that support the business process of the HR Assessment Tools application. The actors involved in this application include super admin, company admin, and assesses/assessor. The details of each actor's tasks can be found in Table 2.

TABLE 2
Actor Job Details

Actor	Job Description
Super admin	Responsible for managing the overall assessment system and managing companies and company admins.
Admin company	Responsible for managing company users, setting up assessments, scheduling assessments, and monitoring results.
Assesses/Assessor	Participates in assessments and completes assessment questions.

2. Business Process

In addition to actor tasks, the author analyzed the existing business processes in the HR Assessment Tools application, as shown in Fig. 6.

Fig. 6. Business Process Assessment

This business process starts with the super admin registering a company and creating a company admin. The company admin then manages users, creates competency groups, competencies, key behaviors, and assessment sessions. Next, the company admin maps the competency model, assesses, and assessor, creates team, job targets, and maps job targets. The assesses/assessor performs assessments, and the assessment results are viewed by the company admin as recommendations and assessment reports.

3. Maintenance Classification

In this stage, the researcher conducted interviews with the product owner, application admin, and users who had used the application. The researcher also analyzed the application functions according to the business process. From the interviews and analysis, the researcher created requirements and mapped them to the affected roles as shown in Table 3.

TABLE 3
Mapping Maintenance Classification with Requirements

Actor	Problem Description	Impacted Feature	Code	Maintenance Classification
Super Admin	Master menu does not appear unless accessed directly via URL. Side impact: Users can bypass URLs to pages that do not match the assigned role.	CRUD data master	SA01	Corrective
	Error accessing landing page	Landing page	SA02	Corrective
	Email already in the database can still be inputted	User assessment and credential	SA03	Adaptive
	Sidebar not dynamic	Sidebar	SA04	Perfective
Admin company	Email already in the database can still be inputted	User assessment and credential	AC01	Adaptive
	Password needs to be reset when editing employee data	Edit employee data	AC02	Preventive
	Error displaying assessment sessions	Display assessment sessions	AC03	Corrective
	Error editing assessment sessions	Edit assessment sessions	AC04	Corrective
	Cannot log in with new admin user	Admin login	AC05	Corrective
	Master data appears in company admin role	Master data	AC06	Perfective
	All job targets appear	Job target data	AC07	Perfective
	All team appear	Team data	AC08	Perfective

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	New admin cannot see assessment session page	Assessment session	AC09	Corrective
	New admin cannot see assessment report page	Assessment report	AC10	Corrective
	New admin cannot see competency model page	Competency model	AC11	Corrective
	New admin cannot see competency group page	Competency group	AC12	Corrective
	New admin cannot see profile matching dashboard	Profile matching dashboard	AC13	Corrective
	Default competency group dropdown appears when editing competency	Edit competency	AC14	Preventive
	Gap analysis results do not appear	Gap analysis report	AC15	Corrective
	Sidebar not dynamic	Sidebar	AC16	Perfective
	Error accessing landing page	Landing page	AC17	Corrective
Assessee/Assessor	Sidebar not dynamic	Sidebar	AA01	Perfective
	Error accessing landing page	Landing page	AA02	Corrective

B. Planning Phase

In this phase, we will prioritize the requirements using a requirements prioritization technique, as shown in Table 4.

TABLE 4
Requirements Maintenance Prioritization and Iteration

Code	Priority Score	Iteration	Justification
SA01	1	1	Users can still access via direct URL, causing access rights issues
SA03	1	1	Affects initial user experience but does not impact other features
AC01	1	1	Serious security risk and potential data chaos
AC03	1	1	Reduces efficiency but does not directly hinder end-users
AC04	1	1	Serious security risk and potential data chaos
AC06	1	1	Causes inconvenience as users are unaware that the password has been changed
AC05	2	2	Issue that blocks a critical function of the application
AC07	2	2	Issue that blocks a critical function of the application
AC08	2	2	Blocks new admin from accessing the application
AC09	2	2	Serious security issue affecting data integrity
AC10	2	2	Privacy risk
AC11	2	2	Privacy risk
AC12	2	2	Assessment session page shows a blank page
AC13	2	2	Assessment report page shows a blank page
SA02	3	3	Competency model page shows a blank page
SA04	3	3	Competency group page shows a blank page
AC02	3	3	Profile matching dashboard page shows a blank page
AC14	3	3	Confusing but does not hinder core functionality
AC15	3	3	Important for strategic analysis but not urgent
AC16	3	3	Reduces efficiency but does not directly hinder end-users
AC17	3	3	Affects initial user experience but does not impact other features
AA01	3	3	Reduces efficiency but does not directly hinder end-users
AA02	3	3	Affects initial user experience but does not impact other features

C. Modelling Phase

In this phase, we will analyze the Entity Relationship Diagram (ERD) and Class Diagram.

1. Entity Relationship Diagram
   Based on the analysis of the ERD in Fig. 7, the current database structure does not need changes. The existing database design meets business needs and ensures data integrity after evaluating entity relationships, attributes, and functional dependencies.

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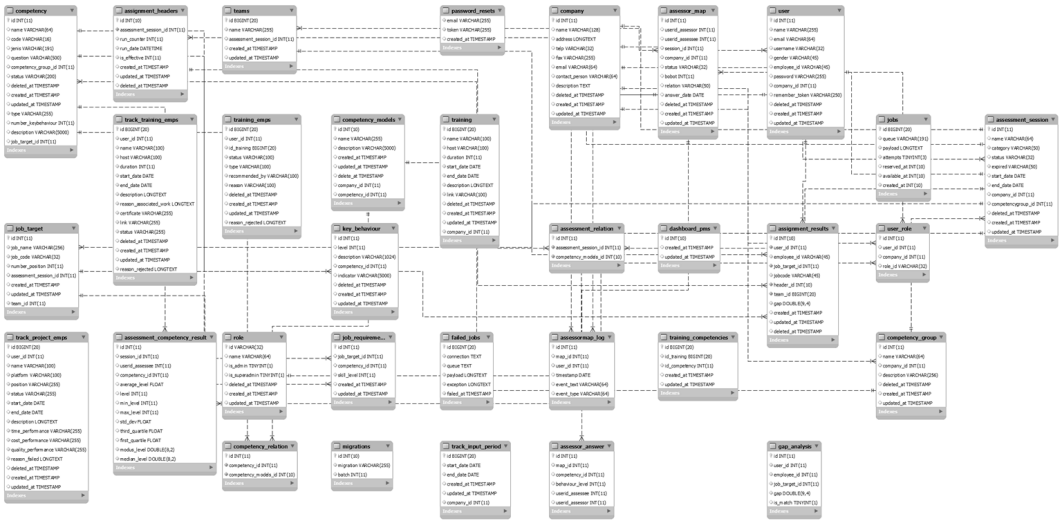

Fig. 7. Entity Relationship Diagram

2. Class Diagram

To show the structure of the maintenance being done, including classes, attributes, methods, and class relationships, a class diagram will be created. The class diagram can be seen in Fig. 8.

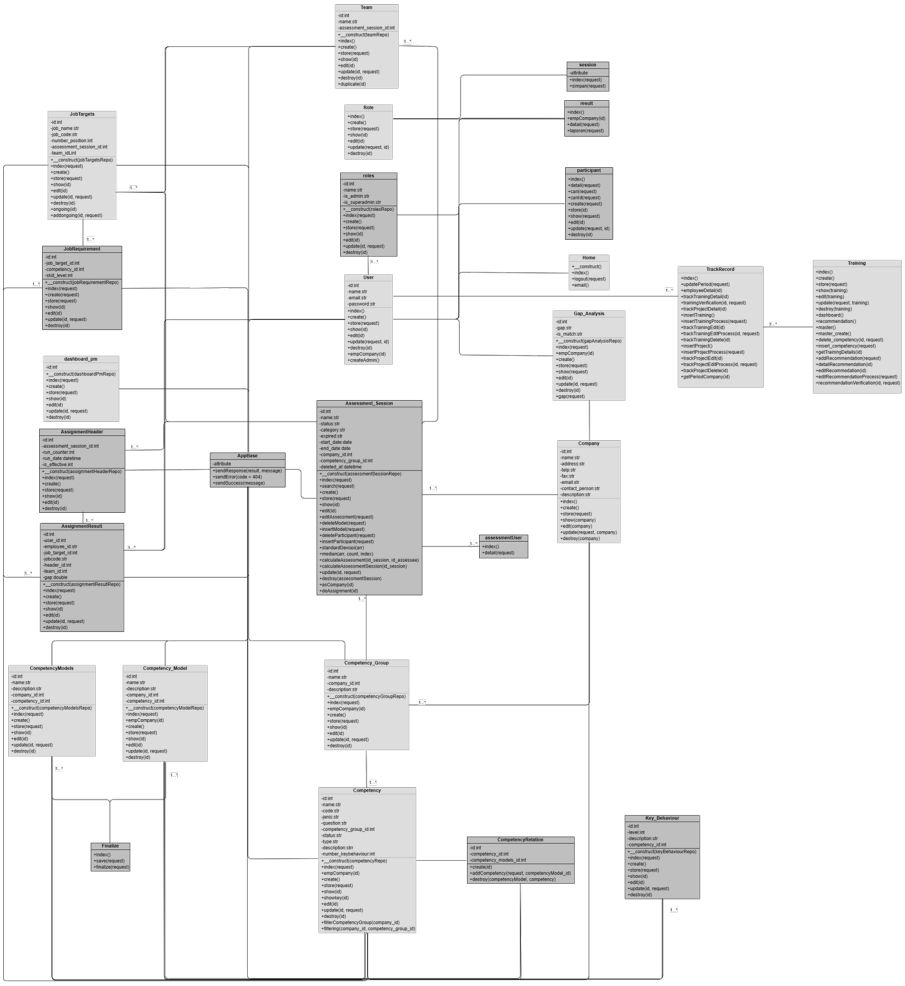

Fig. 8. Class Diagram

D. Construction Phase

In this phase, the researcher will divide it into two stages: coding and testing.

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1. Coding Stage
   In this stage, website maintenance is done based on the system analysis in the modeling phase. Maintenance is performed using the PHP programming language with the Laravel framework.
2. Testing Stage
   After maintenance is complete, the next stage is testing the maintenance results using Black Box Testing, as shown in Table 5.

TABLE 5
Black Box Testing Results

Case	Description	Code	Expected Result	Actual Result	Status	
					Valid	Invalid
Manage User Company	Super admin can manage company user data	SA03 AC01 AC02	Super admin can manage company user data by adding, viewing details, editing, and deleting company user data.	Super admin can manage company user data by adding, viewing details, editing, and deleting company user data.	✓	
Manage Job Target	Company admin can manage job target data	AC07	Company admin can manage job target data by adding, viewing details, editing, and deleting job target data.	Company admin can manage job target data by adding, viewing details, editing, and deleting job target data.	✓	
Manage Competency Model	Super admin can manage competency model data	AC11	Super admin can manage competency model data by adding, viewing details, editing, and deleting competency model data.	Super admin can manage competency model data by adding, viewing details, editing, and deleting competency model data.	✓	
Manage Competency Group	Company admin can manage competency group data	AC12 AC13	Company admin can manage competency group data by adding, viewing details, editing, and deleting competency group data.	Company admin can manage competency group data by adding, viewing details, editing, and deleting competency group data.	✓	
Manage Competency	Company admin can manage competency data	AC14	Company admin can manage competency data by adding, viewing details, editing, and deleting competency data.	Company admin can manage competency data by adding, viewing details, editing, and deleting competency data.	✓	
Manage Assessment Session	Company admin can manage assessment session data	AC03 AC04 AC09	Company admin can manage assessment session data by adding, viewing details, editing, and deleting assessment session data.	Company admin can manage assessment session data by adding, viewing details, editing, and deleting assessment session data.	✓	
Manage Team	Company admin can manage team data	AC08	Company admin can manage team data by adding, viewing details, editing, and deleting team data.	Company admin can manage team data by adding, viewing details, editing, and deleting team data.	✓	
Manage Report Assessment	Company admin can manage assessment reports	AC10	Company admins can access the assessment report page, select a company, view detailed assessment results, and view individual report details smoothly, including viewing scores.	Company admins can access the assessment report page, select a company, view assessment result details, and view individual report details smoothly, including viewing scores.	✓	
Display Gap Analysis Result	Company admin can display gap analysis results	AC15	Company admin can select company, view participant list, and view gap analysis smoothly.	Company admin can select company, view participant list, and view gap analysis smoothly.	✓	

E. Results Analysis

The maintenance testing of the HR Assessment Tools application has successfully demonstrated a 100% success rate. This indicates that the HR Assessment Tools application, which was maintained, is now ready for use by the company to enable the appropriate allocation of project teams based on each employee's character, experience, and behavior. Previously identified issues, such as errors in several processes that disrupted the application's overall functionality (including bugs that prevented report viewing) and problems related to role management that caused access rights errors (e.g., new administrators being unable to access the 360-degree assessment process), have been resolved, which was previously found in previous research [5] [6].

During maintenance, challenges such as code complexity and inadequate documentation can hinder the process. Complex or poorly documented code can complicate maintenance efforts, requiring additional time and effort to understand and modify the code. This complexity also increases the risk of errors during repairs or updates. Furthermore, inadequate or outdated documentation can further impede maintenance, as the team may struggle to

comprehend the software's functionality or the impact of changes on the system. The lack of proper documentation also raises the risk of mistakes during maintenance.

A well-maintained HR Assessment Tool application can greatly improve a company's effectiveness in selecting project roles. This is because the team selection will be aligned with each employee's characteristics, experience, and behavior.

IV. CONCLUSION

Based on the research conducted on the maintenance of the HR Assessment Tools application, the following points are concluded:

1. The maintenance process required by users involves collecting feedback from face-to-face interviews and analyzing application scenarios. This results in the identification of user requirements for maintenance, which are then mapped based on maintenance classification for easier identification.
2. The implementation process for improvements to the HR Assessment Tools application was carried out using a phased approach, starting with updates to the view layer, followed by adjustments to the controller layer according to the established iterations and priorities. This research also involved changes to the data structure and logic, which were re-modeled as part of the enhancements.
3. Black box testing is crucial to ensure the system functions as expected after maintenance without needing to understand the internal code details. This method views the system from the user's perspective, finding issues users truly experience. Additionally, black box testing is faster and more resource efficient as it does not require deep knowledge of the code. Other methods like white box testing need a deep understanding of the system's internal structure, consuming more time and resources. Grey box testing, combining both approaches, while useful, is not always efficient for focusing on external functionality post-maintenance. Therefore, black box testing is the best approach to ensure system quality and reliability after maintenance or changes.
4. The testing process for the HR Assessment Tools application involved functional testing using Laravel Dusk. With Laravel Dusk, all test scenarios were identified and tested using Black Box Testing. The goal was to ensure that every function in the application works well after maintenance. We ensured all testing scenarios matched the defined requirements and that all requirements were met. The testing results provide assurance that the application functions properly and is ready for use without any issues.

For future research, it is recommended to focus on code maintenance, particularly through refactoring, to optimize the performance of the HR Assessment Tools application. Additionally, it is advisable to implement White Box Testing methods to evaluate the performance of the HR Assessment Tools application comprehensively.

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