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Backend Design and Development of Thesis Management and Scheduling Application Using Rule-Based Algorithm in Physics Department UPN "Veteran" Jatim

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ABSTRACT

Thesis administration in higher education can be complex, especially in programs like Physics that previously lacked a structured system for managing thesis activities and seminar schedules. To address this, a backend system was developed to streamline these processes using a rule-based algorithm. The system supports multiple user roles—including students, lecturers, thesis coordinators, program coordinators, and administrators—by providing web-accessible API services. Key features include user authentication, pre-proposal submission, advisor assignment, seminar scheduling (proposal and final), oral examination coordination, and graduation document submission. The development followed the Scrum methodology over six sprint cycles, with each cycle aimed at improving functionality and ensuring system stability. To ensure the system met all functional requirements, black-box testing was conducted. The final version was deployed on a cloud hosting platform using Cloud Run, enabling public access to its API services. This solution is intended to enhance efficiency, reduce administrative workload, and provide a centralized, accessible platform for all stakeholders involved in the thesis process.

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1. Introduction

Information system technology continues to evolve in line with the growing capabilities of computers to provide solutions for problems in various sectors, including economics, social affairs, organizations, and education [1]. In the field of education, particularly in higher education institutions, there are several processes that students must go through, such as student registration, the design of course planning (Kartu Rencana Studi), and the preparation of a thesis. These processes require the support of information systems to improve the quality of services in education [2].

An information system is a system within an organization that facilitates data management needs, supports operations, has managerial functions, and aids in strategic activities of an organization or institution. In education, there are various types of information systems that support the learning and administrative processes, such as academic information systems, library information systems, learning management systems, student enrollment management systems [3], and thesis management information systems [4]. Thesis management systems generally encompass many processes, from proposal seminar registration to the final thesis seminar.

A thesis is a scientific work that presents the results of a research problem in a specific field of science. A thesis must be scientifically accountable and carried out based on established rules or procedures. The purpose of a thesis is to enable students to write scientific work in their field, with guidance from a supervisor relevant to that field, allowing them to proceed from the initial proposal seminar stage to the final seminar stage [5].

The proposal seminar represents a critical stage that takes place after a student's research proposal has been completed and approved by their academic advisor for presentation. During this seminar, students present their research plans to a panel of examiners who provide feedback, suggest improvements, and determine whether the research may proceed as proposed or requires revisions. Upon successfully passing the proposal seminar, students advance to the main research phase, where they implement their study based on the approved methodology and begin preparing their final report. Throughout this phase, continuous guidance from the academic advisor ensures that the research is conducted in alignment with its stated objectives[6]. Thesis supervision is a process where the student is guided in writing scientific work, with the advisor providing instructions or explanations to ensure the thesis complies with applicable standards. Students do not undertake this process alone; the faculty or study program assigns an advisor who supervises the thesis to ensure it is carried out properly [7]. The final stage is the thesis defense, where students present, discuss, and defend their research results before a panel of examiners who then decide whether the student has met the graduation criteria or must revise their thesis [8].

The Physics Study Program at Universitas Pembangunan Nasional “Veteran” Jawa Timur (UPNVJT) was established in 2022 and is currently part of the Faculty of Engineering. To date, the Physics Study Program has not yet implemented a system that supports thesis management and seminar scheduling. Based on interviews with the head of the study program and the thesis coordinator, the oldest active semester in the Physics program is currently the fifth semester, which will begin thesis work in the seventh semester. Therefore, there is a need for a Thesis Management and Scheduling Application to manage future students' theses, with the goal of simplifying administration, archiving documents, and automating the scheduling of proposal and final seminars.

A Thesis Management Application is a system designed to support students during their thesis work, from the proposal seminar stage to the final seminar stage [9]. The system to be developed in this study will involve five roles: students, lecturers (as both advisors and examiners), the thesis coordinator, the head of the study program, and the program administrator. The system's features will include proposal seminar registration, where students must meet certain requirements and upload necessary documents. The thesis coordinator can then assign examiners and schedule the proposal seminar, with specific scheduling conditions that must be met. The coordinator will publish the finalized schedule, and students will attend their seminars accordingly. During the seminar, examiners can provide feedback and scores through the system. If revisions are required, the student must complete them and submit for re-review before moving on to the research stage. The thesis coordinator will also assign academic advisors automatically based on the thesis topic's field of interest and expertise. Afterward, students can register for the final seminar by submitting the required documents, and the coordinator will again map the schedule and assign examiners. In the final seminar, examiners can provide scores and feedback to the students. Given the lengthy thesis process, the Thesis Management Application can significantly assist with data management, seminar scheduling [3], and easy access to up-to-date information, which is expected to help students find thesis-related information [7].

The proposal and final seminar scheduling process described above involves several requirements, such as lecturer availability, student and lecturer interests, expertise alignment, and availability of time slots and rooms. Due to the dynamic and complex nature of these conditions, manually scheduling seminars is time-consuming and prone to error. To address this issue, a rule-based algorithm can be used in the system. The need for a thesis management and scheduling system arises from the challenge of organizing time and limited resources. The scheduling feature is designed to ensure the smooth progression of each thesis stage, from the proposal seminar to the final seminar [10].

A rule-based algorithm is a system based on rules where the program is structured as a set of rules used to solve problems [11]. These rules are further processed into knowledge using the if-then format [12]. The choice of a rule-based algorithm in this study is due to its ease of implementation, especially in the seminar scheduling feature, which has clear rules and procedures. Compared to genetic algorithms, rule-based algorithms are more suitable for problems with a well-defined and structured rule set, as they can produce optimal solutions with high efficiency. In contrast, genetic algorithms are more appropriate for problems requiring exploration of a vast and unstructured solution space [13].

The system to be developed includes complex features, as outlined above. This feature complexity necessitates a structured development strategy to ensure each function operates optimally. One strategy is separating the backend and frontend modules. This approach aims to streamline development, allowing each module to be developed independently.

This study focuses on the backend API and admin dashboard, which are responsible for managing master data and displaying API documentation. This approach is taken due to the system's complexity, with the design of the thesis management and scheduling system following the thesis procedures of the Physics Study Program at UPNVJT. Separating the frontend and backend modules facilitates development, as both can be developed independently, connected through a REST API. Moreover, this separation allows for more structured master data management, such as student, lecturer, and schedule lists, via an admin dashboard designed to support data visualization and API documentation. Another reason for this separation is that the frontend does not need to understand the internal structure or complexity of the backend system. In contrast, combining the frontend and backend would complicate updates or feature adjustments, as any small change could impact the entire system. Furthermore, such coupling increases the risk of widespread issues if one component fails [14].

Separating the frontend and backend offers advantages in terms of scalability and modularity, allowing each component to be developed and tested independently without affecting other modules [15][16][17][18]. Scalability supports backend development in distributing computing resources to handle increasing user loads without impacting the frontend [15][19][20]. Modularity enhances flexibility in developing new features, so when system requirements grow, only specific modules need to be updated [21][22].

Considering the background issues, the objective of this study is to design the Backend of the Thesis Management and Scheduling Application Using a Rule-Based Algorithm for the Physics Study Program at Universitas Pembangunan Nasional "Veteran" Jawa Timur. This system is expected to help resolve issues related to thesis management and scheduling.

2. Research Method

The research methodology outlines the steps taken to achieve the objectives of this study. It consists of data collection, requirements analysis, and an application development framework using Scrum, as illustrated in Figure 1.

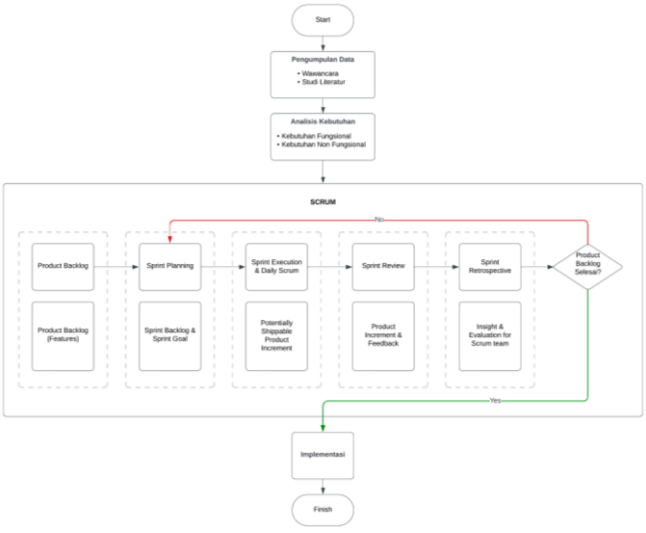

Figure 1. Effects of selecting different switching under dynamic condition

The method include these following steps below:

2.1. Data Collection

Data collection was carried out using two methods: interviews and literature study. Interviews were conducted with Coordinator of the Physics Study Program at UPN "Veteran" Jawa Timur and Thesis Coordinator of the same program. The literature study involved searching for relevant references in the form of research journals and books accessed online, focusing on topics such as the development of Thesis Management Applications, the use of Rule-Based Algorithm as a scheduling system, Backend development, and the Scrum software development methodology. The gathered information was used to compile the literature review, design the research methodology, and support the development of the Thesis Management and Scheduling Application.

2.2. Requirement Analysis

The requirement analysis in this study involves processing data obtained from information about the current thesis process, which is still conducted manually and lacks a dedicated management application in the Physics Study Program. The analysis results are used to define the functional and non-functional requirements to be implemented in the Thesis Management Application under development.

2.3. Scrum

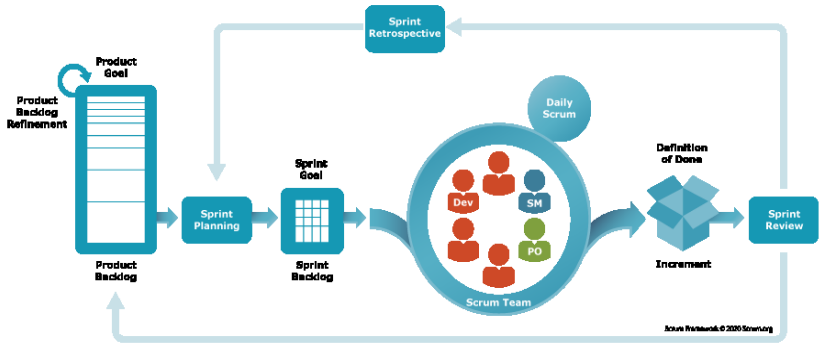

Figure 2. Scrum Methodology (Source: Scrum.org)

Scrum is a structured framework used in the Software Development Life Cycle (SDLC) to manage complex product development [23][24]. It is based on a set of values, principles, and practices, involving three main roles: the Product Owner, who defines and prioritizes features; the Scrum Master, who monitors team progress; and the Development Team, responsible for design, development, and testing [25]. The Scrum method include these following steps below:

a) Product Backlog

At this stage, ideas are transformed into values that will later be worked on to achieve the Product Goal [25].

b) Sprint Planning

At this stage, a meeting is held with the team to confirm the Product Backlog to be worked on and to discuss the relationship between the Product Backlog and the Product Goal [25].

c) Sprint

A stage in the Sprint to ensure that the implementation of the Product Backlog continues to align with the Product Goal [24].

d) Sprint Review

A stage to present the results of the completed Sprint to the stakeholders [25].

e) Sprint Retrospective

A stage conducted to plan ways to improve the quality and effectiveness of the software that has been built and plans improvements to be implemented in the next Sprint [25].

2.4. Implementation

In the Implementation phase, the system that has successfully passed all testing stages will be uploaded to the server to make it accessible online.

3. Result and Discussion

This study's outcomes comprise the design and implementation of a thesis management application. During the design phase, system architecture is created using Conceptual Data Model, Physical Data Model and Unified Modeling Language (UML), which offers a comprehensive toolkit to represent different system elements like classes, components, and their interactions. The UML diagrams utilized include Use Case, Sequence Diagram, and Class Diagrams. The development phase focuses on designing Backend API. After all tasks in the product backlog are finished, the system will be subjected to Black Box Testing.

3.1. Requirement Analysis

This study aims to design and develop a Thesis Management Application to assist in managing student theses—from pre-proposal submission, proposal seminars, to final seminars. With this application, the thesis process in the Physics Study Program can be more streamlined and reduce errors in data recording. The application features five user levels: Student, Lecturer, Thesis Coordinator, Program Coordinator, and Admin. Following a business process analysis, 206 functional requirements were identified and then mapped into use case diagram.

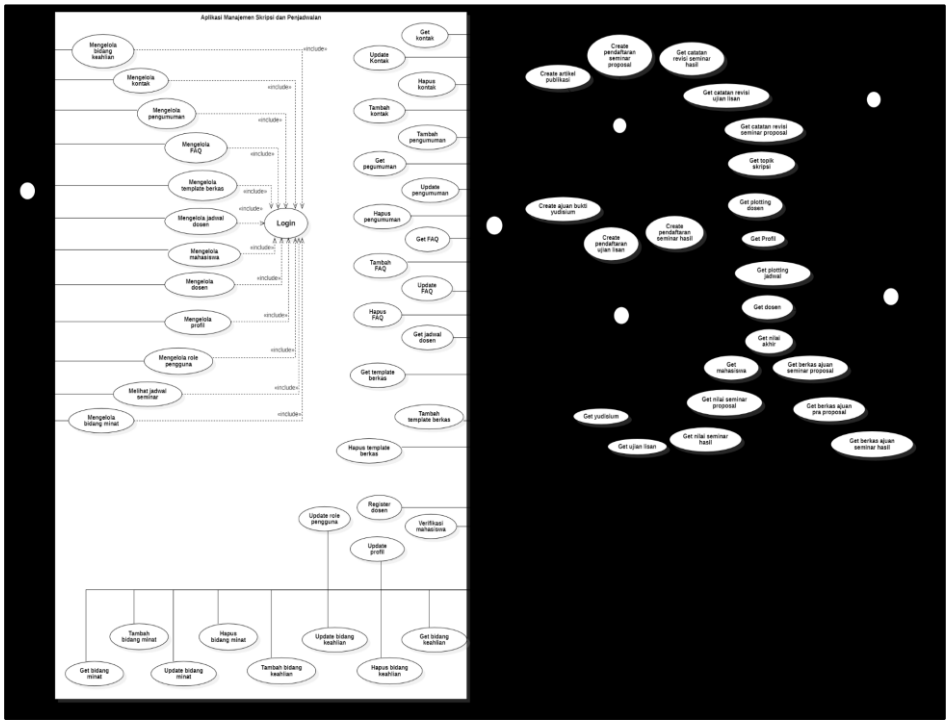

Figure 3. Use Case Diagram

3.2. Sprint Planning

To define the steps in this research, the team created a task list or product backlog. Task priorities, shown in Table 1, were determined through an interview with the Thesis Coordinator of the Physics Study Program. The tasks were then further discussed and divided based on team roles. Prioritization is crucial to ensure that high-priority features receive appropriate attention. The features listed in the product backlog in Table 1 were derived from the system requirements gathered through the data collection process and prioritized based on the system's requirements.

Table 1. Product Backlog

ID	Name	Priority
1	Interface Design (Admin)	High
2	System Design	High
3	Endpoint	High
4	Authentication	High
5	Profile	High
6	Title Submission (Pre-Proposal)	High
7	Advisor Assignment	High
8	Thesis Guidance Card	High
9	Seminar Registration	High
10	Seminar Scheduling	High
11	Seminar Assesment	High
12	Seminar Revision	High
13	Publication Article Submission	High
14	Examiner Assignment (Oral Exam)	High
15	Oral Exam Assesment	High
16	Final Thesis Grade	High
17	Submission of Graduation Completion Proof	Medium

This study focuses on the backend API, particularly for the seminar submission and scheduling modules, which are core features of the application. The development follows the SCRUM methodology, with this module scheduled for the third sprint. The integration aims to ensure the scalability for the future development.

3.3. Sprint Excecution

This phase involves taking items from the product backlog and developing them into functional features or improvements. Throughout this phase, the team collaborates closely to ensure the planned work is completed within the sprint timeframe, maintaining focus on meeting the sprint goals.

Conceptual and Physical Data Model

During the sprint execution phase, items from the product backlog are selected for execution, with a focus on implementing the Conceptual and Physical Data model (see Figures 4 and 5). As this product backlog is high-priority, this sprint emphasizes its successful development.

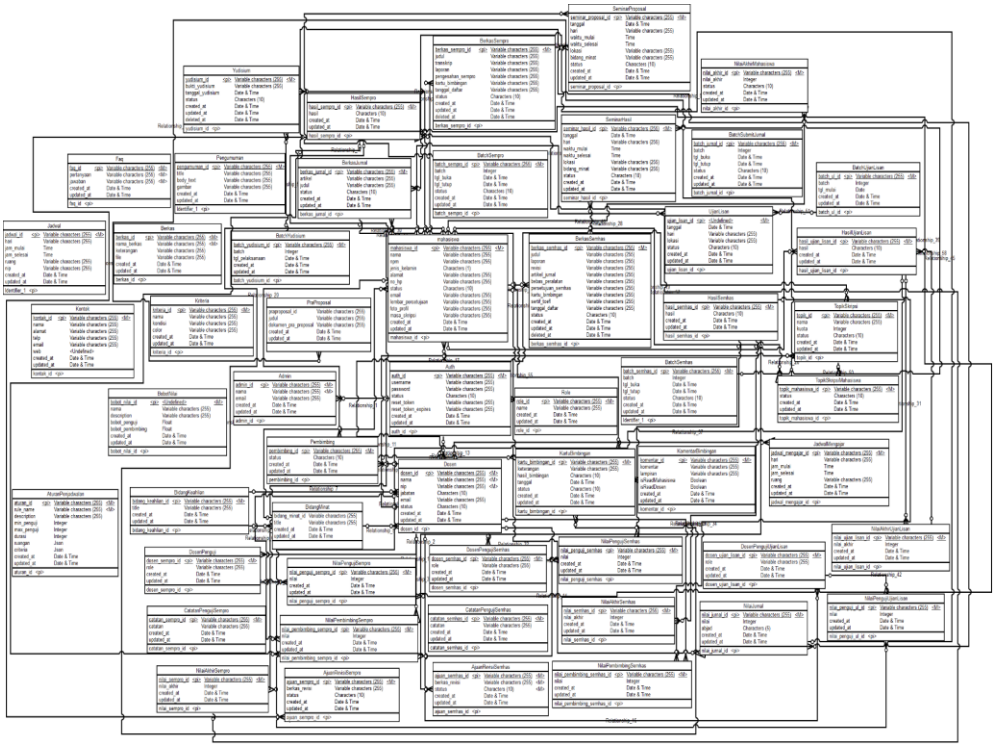

Figure 4. Conceptual Data Model

Each box in the diagram represents an entity or a table in the database, containing essential attributes such as primary keys (marked with "PK"), foreign keys ("FK"), and other data columns. The lines connecting the entities indicate the relationships between tables, whether one-to-one (1:1), one-to-many (1:N), or many-to-many (M:N) relationships. The structure of this ERD demonstrates that the system consists of many interconnected components and features, including modules for users, academics, finance, scheduling, administration, and more. The complexity of the relationships between tables indicates that the system is designed to handle various business processes in an integrated manner, such as student data management, seminar or thesis submissions, schedule processing, lecturer management, grading, and other administrative tasks. Furthermore, this ERD highlights the importance of normalization in database design, as seen in the numerous specific entities and systematic relationships between tables. This approach aims to minimize data redundancy, maintain data integrity, and facilitate long-term system maintenance.
Overall, this diagram reflects how the data architecture is structured to support the smooth operation and efficiency of a large-scale information system, ensuring that each data element is logically and functionally connected throughout the entire system.

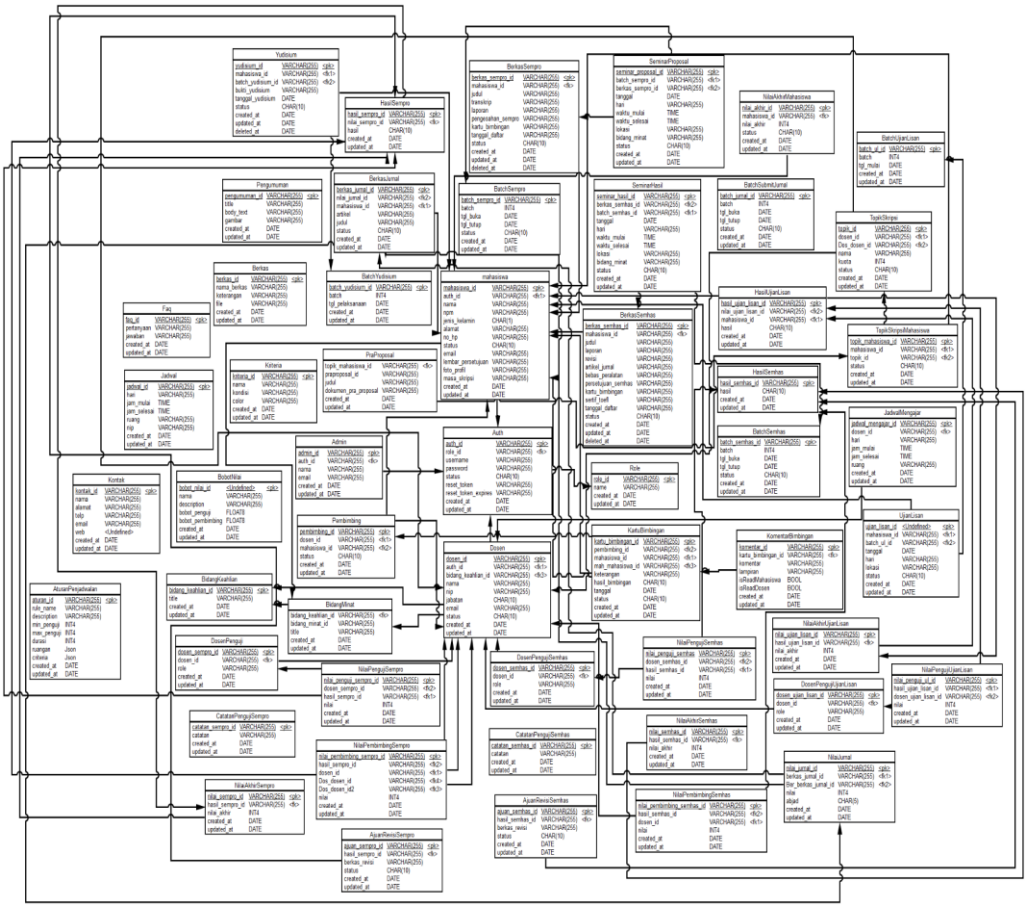

Figure 5. Physical Data Model

Rule Based Algorithm

The Rule-Based Algorithm implemented for the seminar scheduling feature was developed based on the system design outlined in the product backlog. As detailed in Table 1, seminar scheduling was identified as a high-priority task, reflecting its critical role in the thesis process. The algorithm was designed following interviews with the Thesis Coordinator of the Physics Study Program and tailored to the specific requirements gathered during the data collection phase. By using a rule-based approach (see figure 6), the

scheduling logic accommodates constraints such as student and lecturer areas of interest, academic roles, and availability, ensuring fair and efficient seminar allocations.

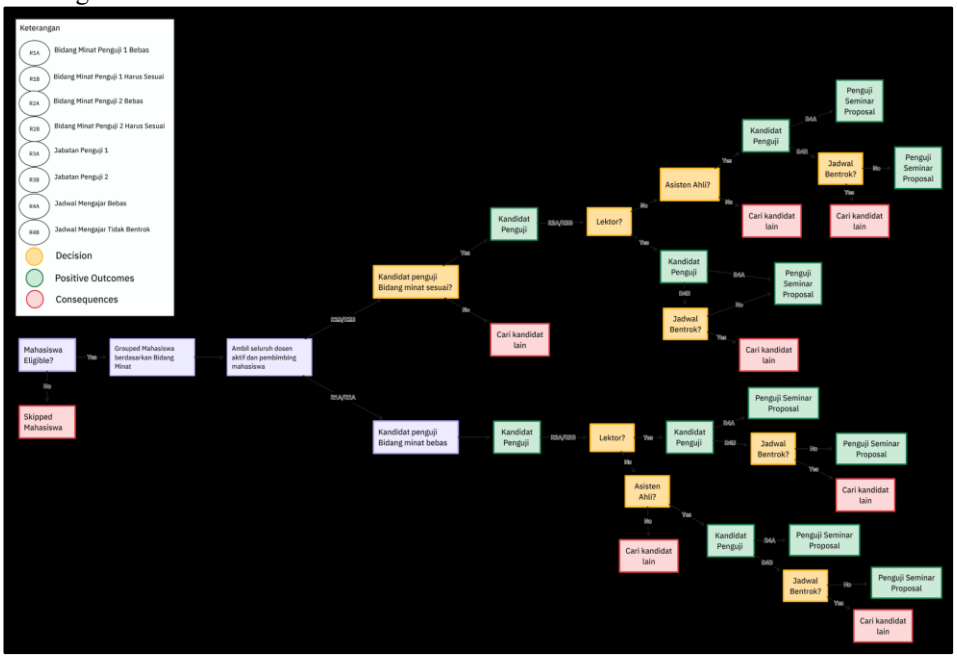

Figure 6. Rule-Based Algorithm Tree

Sequence diagrams

The next execution begins with creating sequence diagrams for the seminar scheduling using Rule-Based Algorithm and scheduling processes (see Figures 7), which serve as clear guides for the development team in implementing these features into the system.

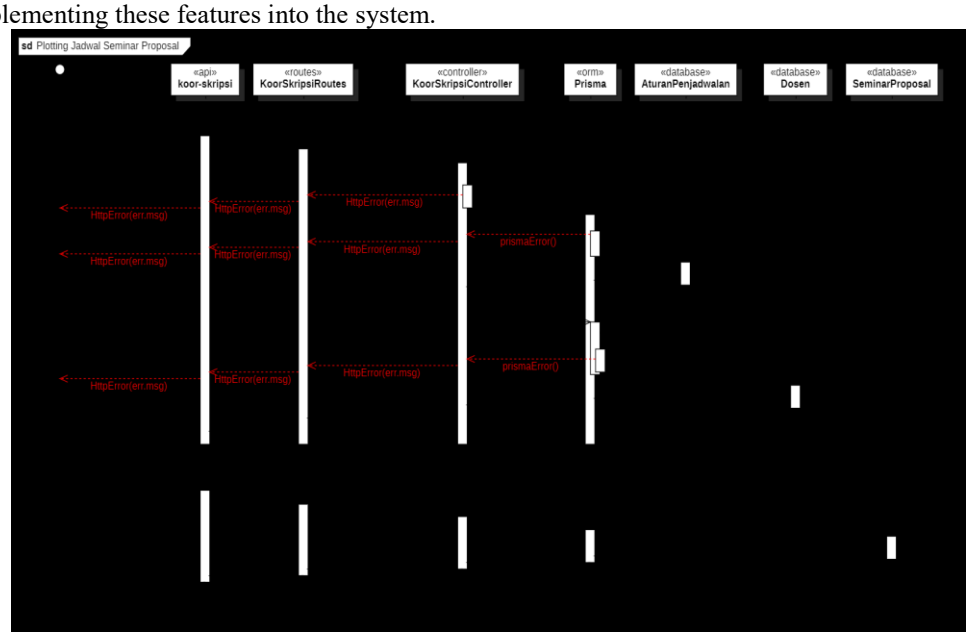

Figure 7. Seminar Scheduling Sequence Diagram

API Result

When the Seminar Scheduling API Use Case is executed with the implementation of the Rule-Based Algorithm, the API processes student and lecturer data based on predefined rules—such as matching research interests, academic roles, and availability to generate an optimized seminar schedule. The output ensures that the scheduling aligns with academic guidelines while maintaining fairness.

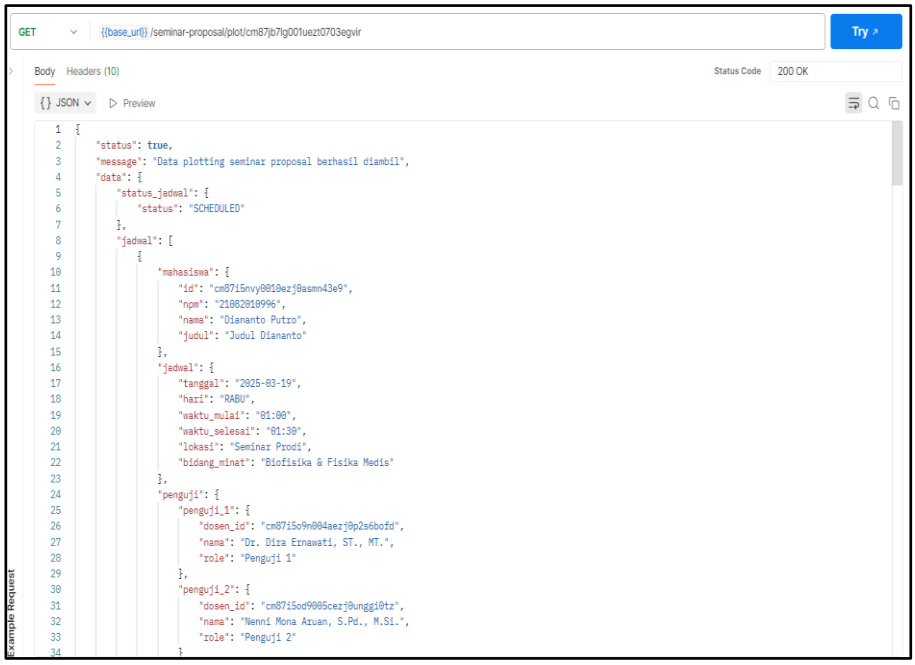

Figure 8. Seminar Scheduling API Result

After the plotted schedule data is displayed, the thesis coordinator can save the results by using the save seminar schedule API. Two saving options are available: as a draft or as scheduled using parameter query. The request is then processed by the function and check for validation. If the data is invalid, the function returns a failure response to the client. Otherwise, a success response is returned to the client.

Black Box Testing

After the design and development of the Backend API were completed, black box testing was conducted, as shown in Table 2 below.

Table 2. Black Box Testing

No.	Test Scenario	Expected Result	Actual Result	Status
4.	User performs seminar schedule plotting by entering a seminar date after the plotting date.	Seminar Scheduling Success	Seminar Scheduling Success	PASSED
5.	User performs seminar schedule plotting without entering the seminar date.	Seminar Scheduling Failed	Seminar Scheduling Failed	PASSED
6.	User saves the seminar schedule plotting result by selecting a storage type (draft or scheduled).	Seminar Scheduling Success	Seminar Scheduling Success	PASSED
7.	User saves the seminar schedule plotting result without selecting a save type (draft or scheduled).	Seminar Scheduling Failed	Seminar Scheduling Failed	PASSED

The daily scrum held during the sprint iteration showed significant progress in the application's development. It was concluded that the thesis coordinator can plot seminar schedules. Positive progress was also seen in the backend development of this module, which reached 100% completion. All bugs identified by the QA during the third sprint were resolved within the same sprint.

3.4. Implementation

The implementation was carried out by deploying the code to the Google Cloud Run Server, allowing the system to be publicly accessed. At the end of the development phase, the team demonstrated the Thesis Management Application to lecturers and students of the Physics Department at UPN “Veteran” Jawa Timur.

4. Conclusion

The backend system for managing theses and scheduling seminars in the Physics Study Program at UPN "Veteran" Jawa Timur has been successfully developed to support the program's administrative workflow. Utilizing the Scrum methodology over six two-week sprints across three months, the development began with system design and progressed through full implementation.

During the design stage, the team produced one Use Case Diagram, 63 Sequence Diagrams detailing core features, and one Class Diagram. In the development phase, a single application was created, comprising 206 backend functions to facilitate various thesis processes—such as topic selection, pre-proposal submission, supervision tracking, seminar registration and assessment, publication submission, oral exam management, and graduation documentation.

At the final stage, black-box testing was performed to ensure functionality. A total of 163 test cases were executed, covering major system features across five user roles: students, lecturers, thesis coordinators, program coordinators, and administrators. Upon successful validation, the application was deployed to a public cloud server via Cloud Run.

A key component of the system is the rule-based algorithm integrated into the scheduling feature. This algorithm automates the arrangement of proposal and final seminars as well as supervisor assignments, considering factors such as student research interests, lecturer expertise and position, and lecturer availability.

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