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Development of Integrated E-Voting System to Increase the Effectiveness and Transparency of General Elections Muria Kudus University

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Abstract

The rapid advancement of technology has enabled the development of electronic voting systems to support democratic processes, particularly in educational institutions. This study presents the design and implementation of an e-voting system for the General Elections at Muria Kudus University. The waterfall methodology developed the system through stages including requirements analysis, system design, implementation, testing, and maintenance. Data were collected through interviews, observations, and literature review to ensure the relevance and accuracy of the system requirements. The system was designed using Unified Modeling Language (UML) diagrams and implemented using PHP and MySQL. Functionality testing was conducted using the black box method, and results showed that all system features performed according to specifications. The implemented e-voting system enhances transparency, reduces manual errors, minimizes potential manipulation, and improves student participation by offering a user-friendly and accessible voting platform. This solution supports an efficient and accountable electoral process within academic environments.

Keywords: *E-Voting, Student General Election, Transparency, System Effectiveness.*

1. Introduction

The rapid development of technology creates things that help humans in their daily activities. This technology powerfully supports democratic activities, especially in the election of leadership candidates. One nation that respects popular sovereignty is Indonesia. This is governed by Article 1, paragraph (2) of the Republic of Indonesia's 1945 Constitution, which is referred to as the 1945 Constitution from here on. A government is run by, for, and by the people, according to the democratic ideal that Indonesia upholds. The direct holding of general elections expresses the democratic system based on popular sovereignty. Through the broadest possible public participation, elections serve as a vehicle for the people's sovereignty to select leaders. Political engagement, which is demonstrated by extending voting rights to the eligible community, is one way to evaluate the effectiveness of the election administration. One could argue that greater public participation in elections is preferable. [1]. The existence of an electronic voting application is the latest breakthrough in creating a new environment in the electoral process. The electronic voting application automatically processes the votes cast by the voters. Initially, the electoral process, often called general elections, was conducted manually, requiring significant time, space, and costs to mediate. In addition, the ballots are lightweight and easily blown away by the wind, making them prone to damage or loss. This problem makes the operation prone to fraud when the candidates do not have witnesses during the voting, and the KPUM vote counting results are not transparent. The e-voting application saves time and costs in preparing for the voting process because it only takes a few minutes. This efficiency means the voting process is effective because it is available to voters. Voters who choose a pair of candidates are automatically directed to the system that will process their votes. In addition, the voting results are displayed automatically and accurately to not disturb other parties, as everything is controlled by the system's performance in the e-voting application.

E-voting is an election method that uses electronic media to vote and count votes. [2]. Particularly in the election of the OSIS Chairperson at SMA Negeri 1 Geyer, Grobogan Regency, electronic voting is used to provide election results in a timely, accurate, realistic, and precise manner. This system was created through socialization, training, implementation, assessment, and preparation (including system design and equipment purchase). The objective is to establish an electoral process that is effective, transparent, and free from manipulation. The implementation's outcomes demonstrate a faster vote-counting process, increased student involvement, and increased confidence in the electoral process. [3]. In 2021, however, the epidemic prevented ITB AAS Indonesia students from holding an in-person election for the BEM Chair. A web-based electronic voting application was created as a remedy to facilitate the use of online polls. The waterfall technique was used to construct the system through requirements analysis, planning, design, implementation, and testing. Context diagrams, HIPO, DAD table relationships, PHP programming, and MySQL databases are all used in the system design. [4].

2. Research Methodology

Research methods are the procedures and techniques of research. This research has data collection methods, system development methods, and system design. The data collection method is as follows:

2.1. Data Collection Methods

Several steps must be taken for data collection. This is related to the accuracy of the data used in the system to be created. In addition, the data sources must also be relevant, and there should be no discrepancies in the information.

2.1.1. Interview

This interview stage is intended for the Student Election Committee (Panwaslum) of Universitas Muria Kudus and the Student Representative Council (DPM), which are accountable to the KPUM of the Student Association of Universitas Muria Kudus. The purpose of the interview is to obtain information verbally. In addition, this interview is also intended to identify the boundaries and needs related to everything concerning the general election campaign at Universitas Muria Kudus. This step is essential to support the need for all data used for ongoing activities.

2.1.2. Observation

In this phase, the researchers examine how the series of voting activities conducted at Muria Kudus University, from the process flow through the determination of candidate pairs, campaigns, and elections to the event organizers' final voting results. Observation was conducted directly in the field to gain a deeper understanding of the procedures and challenges faced during the implementation of the student election. In addition, observation also serves as a method to evaluate student engagement and the effectiveness of the information system used in the election. This process is essential in identifying the system's needs that are accurate, transparent, and capable of minimizing potential data manipulation. With systematic observation, the writer can compile system specifications that align with real-world conditions on the ground.

2.1.3. Literature Study

This phase seeks additional information from articles, journals, books, and manuals to use that information as supplementary references. A literature study was conducted to understand the basic concepts of information systems, software development methods, and the implementation of e-voting in the context of higher education. The literature reviewed also includes previous studies on data security, the validity of electronic voting, and the role of technology in supporting the transparency of campus democratic processes. The information obtained is a theoretical foundation for designing a system that meets user needs. Additionally, references from national and international journals strengthen the arguments and technical justifications in the system development.

2.2. System Development Methods

The system development method used is waterfall. The waterfall method is a systematic and sequential system development method, but it is often referred to as the linear sequential method nowadays [5]. The waterfall method is implemented sequentially in several steps, starting with requirements analysis, system planning and design, system implementation, system testing, and maintenance [6].

2.2.1. Needs Analysis

This phase includes several steps, such as field interviews, observations, and an informative literature review on all types of requirements used in e-voting applications. The needs analysis process aims to identify the functional and non-functional requirements of the system to be developed. Functional requirements include key features such as user authentication, vote election, and vote result recap. Meanwhile, non-functional requirements relate to aspects of security, reliability, and system ease of use. Reasonable requirements analysis techniques can minimize development errors and ensure the system operates according to stakeholder expectations. Therefore, active user involvement in the requirements-gathering process is crucial to ensure the accuracy and relevance of the system being developed.

2.2.2. System Design

System design is used to understand a system's work according to the entity-relationship diagram. This step is used to find an overview or prototype of the system that will be used to understand the appearance of each menu in the application. Design encompasses structural and functional aspects, including using tools such as Use Case Diagrams, Class Diagrams, Activity Diagrams, Sequence Diagrams, and user interface (UI) design. This stage aims to produce a system design that is efficient, easy to understand, and meets user needs. Good interface design also considers usability so users can interact with the system intuitively. A modular design approach is often applied to facilitate the system's development, testing, and maintenance processes.

2.2.3. System Implementation

This stage is also the core process regarding the appearance and functionality of the system, as developers engage in coding to create the initial process until the final stage of the application system to be developed. At the implementation stage, all system design results begin to be translated into programming languages that meet the technical needs of the application. This process also includes integrating system components, such as databases, user interfaces, and business logic. Developers usually use specific frameworks to speed up the development process and maintain an organized code structure. In addition, technical documentation is also being prepared to facilitate

maintenance and further development processes in the future. This stage must be carried out gradually and systematically to minimize errors in the system from the beginning.

2.2.4. System Testing

System testing is the core phase where the entire application process is evaluated. Where deficiencies are identified, improvements are made to achieve the outcome of the intended application. This testing ensures that all system functions operate according to the specified requirements and specifications. The testing method used is black-box testing, which is a testing approach that focuses on the system's functionality without examining the internal structure or program code. This testing ensures that every input produces the appropriate output based on functional requirements. Additionally, testing includes validating each feature to ensure it operates according to the designed flow. Documentation of test results is essential to provide a record of system repair history and validation. This stage also serves as the basis for deciding whether the system is ready to be launched into the production environment.

2.2.5. System Maintenance

This is the stage where the system can avoid damage from various factors so that the application remains safe and does not disturb users while they are using it. System maintenance includes bug fixes, performance improvements, and feature updates according to user needs. This stage is continuous because the system needs to adapt to technological changes, organizational needs, and potential security vulnerabilities. There are three main types of maintenance: corrective (bug fixes), adaptive (adjustments to new environments), and perfective (system enhancements). The development team must provide documentation and a regular monitoring system to ensure optimal application performance. Good maintenance will extend the system's lifespan and maintain user trust in the application.

2.3. System Design

At this stage, strict modeling rules are applied to the reciprocal relationships of Unified Modelling Language (UML) artifacts, and there are also implementations, such as rules related to diagram consistency. Unified Modelling Language (UML) is a "language" that has become an industry standard for visualizing, designing, and documenting software systems. [7]. Unified Modelling Language (UML) modeling contains standard rules that must be consistently applied to all objects. [8].

2.3.1. Use Case Diagram

A model produced by system design analysis that aims to describe system requirements is called a use case diagram. Users will implement the system requirements in order to illustrate the system design. A use case is a written description of how one or more actors interact with the information system. Use case diagrams are abstract representations of how actors and the system interact. As a result, selecting an abstraction that meets the requirements is crucial. A use case diagram illustrates how a system is used and describes the everyday interactions between the administrator and the user. [9]. Use cases determine which features are available in the information system and who can utilize them. An illustration of the interactions that take place between users (actors) and the system is called a use case diagram [10]. This diagram can be a helpful tool for clearly defining the limits of a system and providing context. Figure 1 shows the use case diagram for the electronic voting application General Elections Muria Kudus University used.

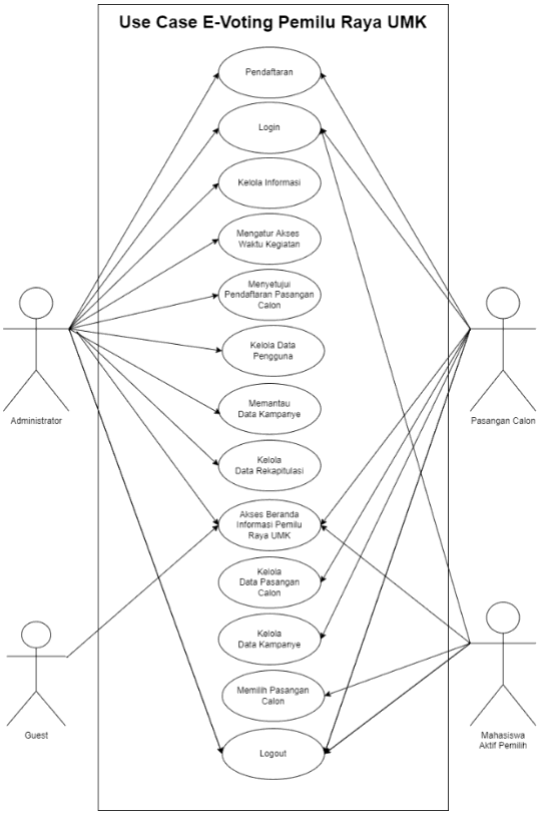


Fig. 1: Use Case Diagram E-Voting General Elections Muria Kudus University

2.3.2. Class Diagram

Class diagrams are UML structural diagrams that show how classes, properties, methods, and the relationships between each item are structured and described. Class diagrams can take many different forms and serve as a visual representation of the program structure. A class diagram shows how a database will operate inside the system that will be constructed. Another name for class diagrams is a grouping of classes and their connections. In the logical view of a system's design model, a class diagram displays the relationships between classes and thoroughly explains each class. "multiplicity" or "cardinality" describes the relationship between classes. A class diagram shows the objects, attributes, and class and how they relate. A class diagram can offer a system's overall perspective. The current classes and how they relate to one another reflect this. There are typically multiple class diagrams in a system. Class diagrams are an excellent tool for showing a system's class structure. In system modeling, this diagram is frequently utilized. Class diagrams describe the many kinds of system objects and how they relate to one another. [9]. Figure 2 shows the class diagram for the General Elections Muria Kudus University electronic voting system.

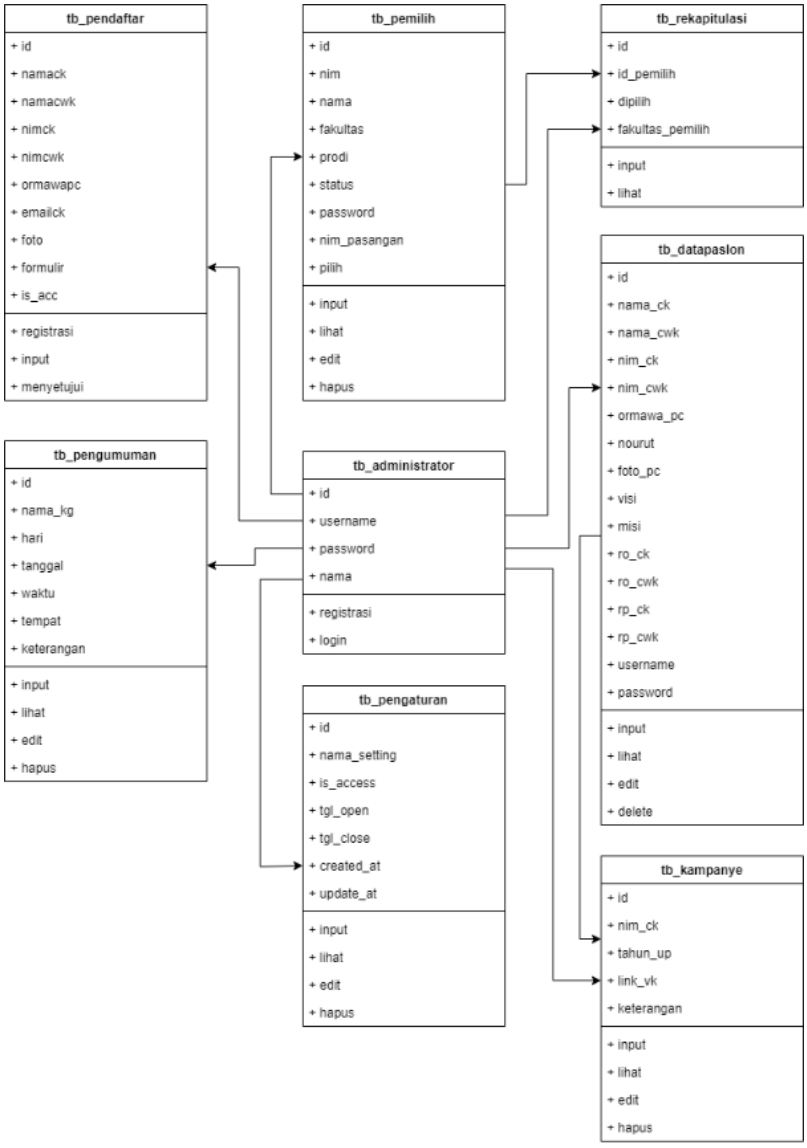


Fig. 2: Class Diagram E-Voting General Elections Muria Kudus University

2.3.3. Activity Diagram

An activity diagram is a graphic that shows how the system operates. Activity Diagrams can depict the system's workflow and the progression of events throughout the system modeling stage. [11]. Making this activity diagram will make it simpler for developers to comprehend how the system works. [12]. An activity diagram is a type of diagram used to represent the system's operational procedures. The system's flow or process may be a set of menus or business procedures. This is the election activity diagram. Voting for the pre-selected candidate pair is open to current students who are not candidates. Voters can then use their right to vote by selecting a candidate pair from each Universitas Muria Kudus student organization, according to Figure 3.

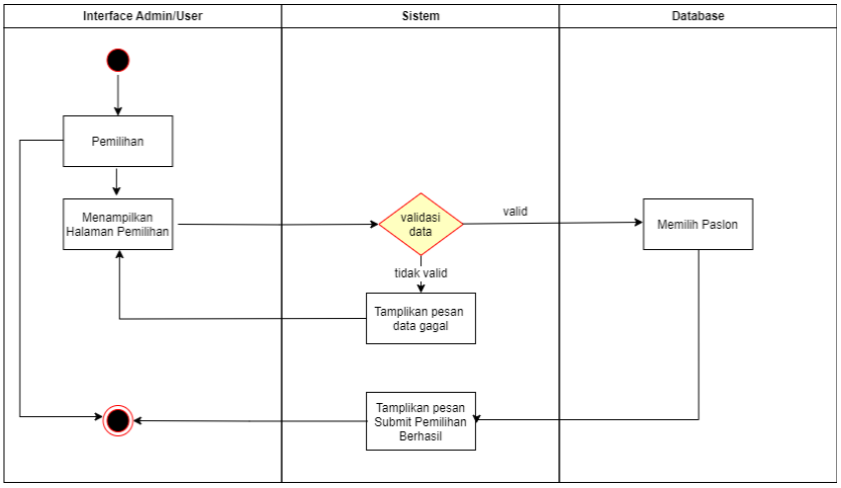


Fig. 3: Activity Diagram Election E-Voting General Elections Muria Kudus University

2.3.4. Sequence Diagram

One type of diagram that is part of UML is the sequence diagram. A sequence diagram is a graphic representation of how item sequences might work together. An event diagram or event scenario is another name for a sequence diagram. [13]. interactions across classes, operations, the order in which they are performed, and the data required for each operation. [10]. Active students not running for office can cast ballots for the pre-selected candidates throughout the election process. Voters can thus use their right to vote by selecting candidates for each Muria Kudus University student. The sequence diagram in Figure 4 below explains this scenario.

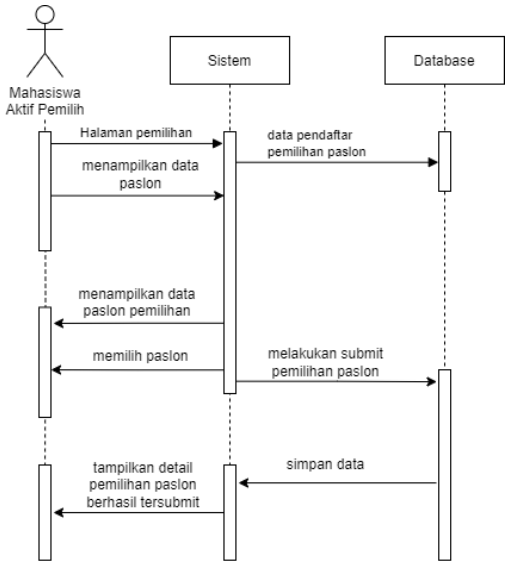


Fig. 4: Sequence Diagram Election E-Voting General Elections Muria Kudus University

3. Result and Discussion

An examination of Muria Kudus University's student general election system (Pemilu Raya) reveals that every step of the election process, from creating the permanent voter list to casting ballots to tallying the results, is still done by hand. This procedure is considered inefficient because it takes a long time, involves extra labor, and is vulnerable to manipulation and human mistakes. Additionally, given that the committee must complete the recapitulation process in phases, openness and speed in reporting election results continue to be challenged. The manual system's lack of adaptability and accessibility to all students, particularly those enrolled in online courses or engaging in extracurricular activities, is another flaw. This impacts students' low election turnout and waning faith in the voting process. Given the problems mentioned above, a technology-based solution is required to facilitate the adoption of a general election that is more effective, responsible, and transparent. The final, usable system implementation results are included in the results and discussion. These are the outcomes of General Elections Universitas Muria Kudus's e-voting system implementation, SIMERA.

3.1. System Implementation

The implementation of this system is the result of the previous system design. Here are the results of the implementation of the e-voting system at Muria Kudus University.

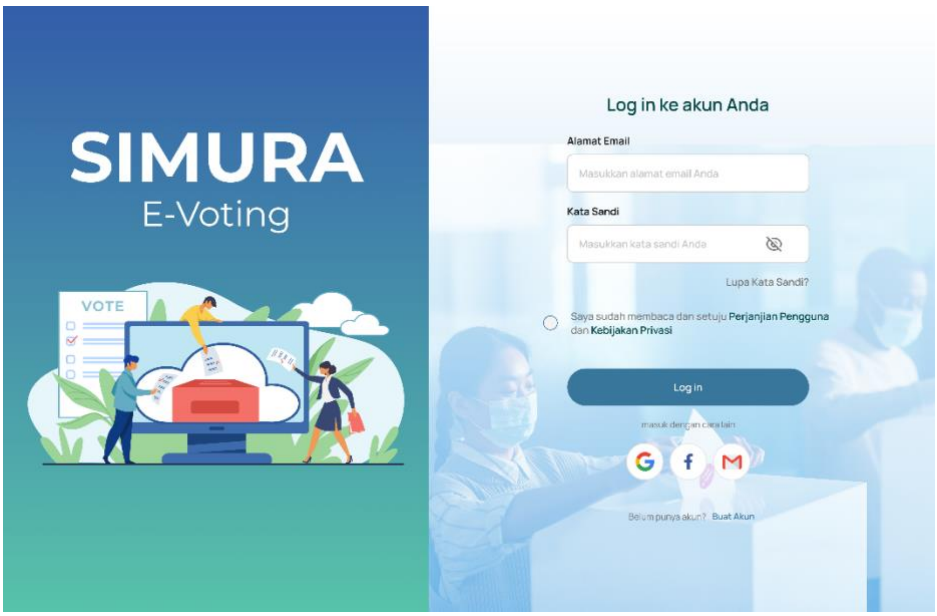


Fig. 5: User Login Page SIMURA E-Voting

User login page SIMURA E-Voting in Figure 5 is used to access the system by entering an email address and password that match the data in the database. After successfully logging in, users will be directed to the dashboard page. This page has a forgotten password feature, terms and policy agreement, and options to log in using Google, Facebook, or Gmail accounts. The link to create a new account is available, but it is generally only accessible by certain admins.

Fig. 6: User Home Page SIMURA E-Voting

The Home Page in Figure 6 is the initial view when voters access the SIMURA E-Voting website. This page displays a welcome message and brief information about the campus election conducted digitally, practically, and transparently. There are three main menus in the middle of the page, namely Campaign to display candidate information, Voting Booth to cast votes, and Recapitulation to display the voting results. In addition, there is a navigation menu on the left side and voter account information at the top of the sidebar.

Fig. 7: User Information and Requirements Page SIMURA E-Voting

The information and requirements for the SIMURA e-voting system in Figure 7 explain the goals and benefits of implementing the e-voting system. It contains the requirements that prospective election participants must meet. At the bottom, a button directs users to register the candidate pairs. The page layout is designed to be informative and straightforward, and it is equipped with navigation on the left side to facilitate access to other features.

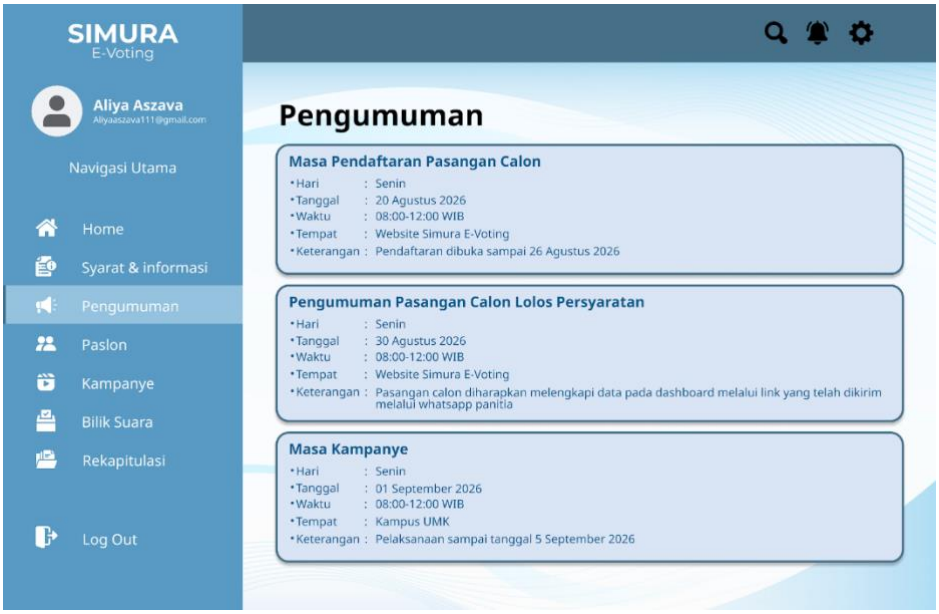


Fig. 8: User Announcement Page SIMURA E-Voting

The Announcement Page on the SIMURA E-Voting system in Figure 8 contains essential information about the election stages. The registration period for candidate pairs will be held from August 20 to August 26, 2026, through the SIMURA website. Next, the candidates who meet the requirements will be announced on August 30, 2026, and the selected participants will be asked to complete their data through a link sent by the committee. The campaign period starts on September 1 and runs until September 5, 2026, with the event taking place at the Muria Kudus University (UMK) campus.

Fig. 9: User Candidate Pair Page SIMURA E-Voting

The Candidate List Page in Figure 9 displays a list of pairs of candidates participating in the election. Each candidate pair is shown complete with their number, photo, name, and position. This page helps voters recognize and compare candidates before casting their votes. The layout is designed to be informative and straightforward, with a menu navigation on the left side of the screen.

Fig. 10: User Campaign Page SIMURA E-Voting

In Figure 10, the Campaign Page features videos from each pair of candidates (pairs) participating in the election. Voters can watch the videos to learn about the candidates' vision, mission, and work programs. Each video is accompanied by a description of the candidate pair's number and can be accessed through the navigation menu on the left side of the screen.

Fig. 11: User Voting Booth Page SIMURA E-Voting

The Polling Booth page in Figure 11 is where voters cast their votes by selecting one of the candidates. Each candidate is displayed with complete information and a selection button. After selecting, voters can press the "Select" button to confirm. The interface is designed to be user-friendly and straightforward, with a menu navigation on the left side of the screen.

Fig. 12: User Recapitulation Page SIMURA E-Voting

The Recapitulation Page in Figure 12 displays the final voting results data from each Faculty Student Council (BEM) and University Student Council (BEM) at Universitas Muria Kudus. Each is displayed with the total number of votes received. The display is neatly arranged in information boxes, making it easy for users to view and compare the election results between faculties. This page serves as an informative and easy-to-read summary of the accumulated votes.

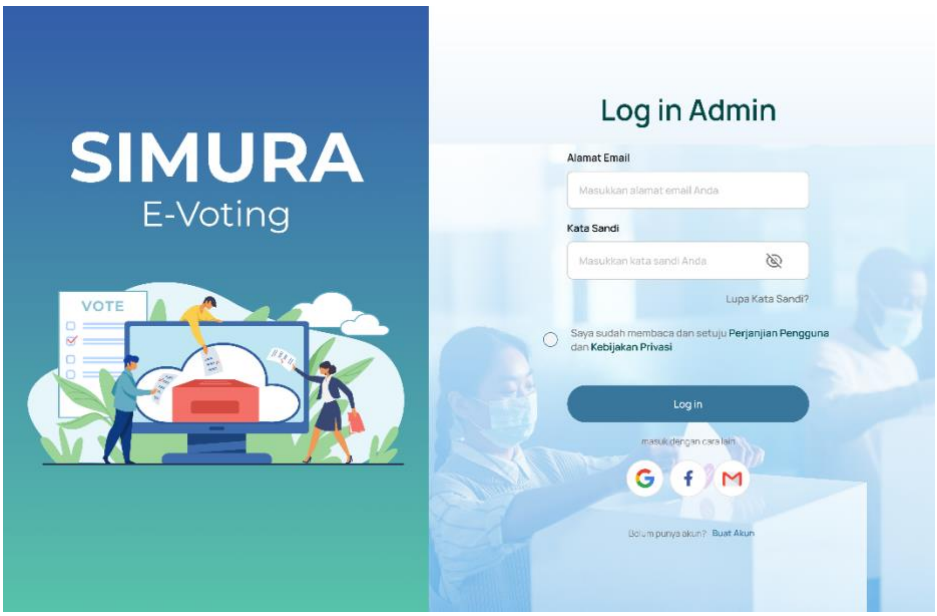


Fig. 13: Administrator Login Page SIMURA E-Voting

The SIMURA E-Voting administrator login in Figure 13 allows the administrator to access the system by entering an email address and password that match the data in the database. After successfully logging in, the administrator is directed to the dashboard page. This page has a forgotten password feature, terms and policy agreement, and options to log in using Google, Facebook, or Gmail accounts. The link to create a new account is available, but it is generally only accessible by certain admins.

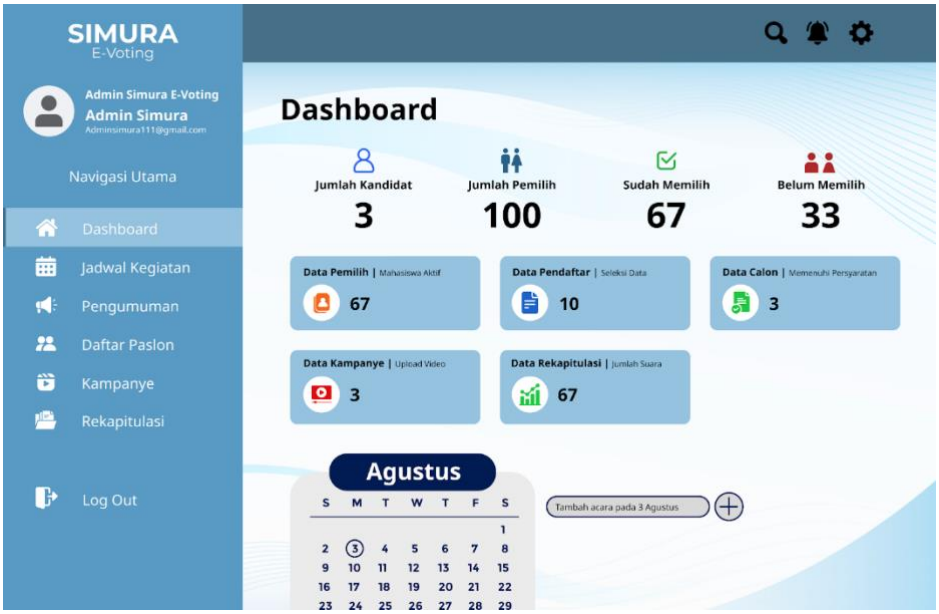


Fig. 14: Administrator Dashboard Page SIMURA E-Voting

In Figure 14, The Admin Dashboard is the main page after the admin successfully logs in. This page displays a summary of election data, such as the number of candidates, voters, those who have voted, and those who have not voted. In addition, there is a navigation menu to access the activity schedule, announcements, candidate list, campaign, and vote recapitulation. Admins can also add events through the available calendar. This page is designed to facilitate the efficient management of the e-voting system.

Software architecture for distributed systems that emphasizes scalability and generalization of the interface between system components is known as Representational State Transfer. Another way to describe it is as a way to deliver system or product capabilities via the internet. Interface for Application Programming An application is a software development document that outlines the functions offered by a system and acts as a guide for all of its available features. Its purpose is to assist developers in understanding the system that is currently in use. [14]. The initial step in utilizing the RESTful Application Programming Interface (API) is gaining access to the chosen API. The first step is to create a folder inside XAMPP's htdocs folder. Next, create a file within that folder that will be called when the browser is launched. Next, acquire the API we'll be using to retrieve the data. Information can be in the form of a URL, where the URL is a PDDikti API pertaining to Universitas Muria Kudus data. The API's content is seen in Figure 15.

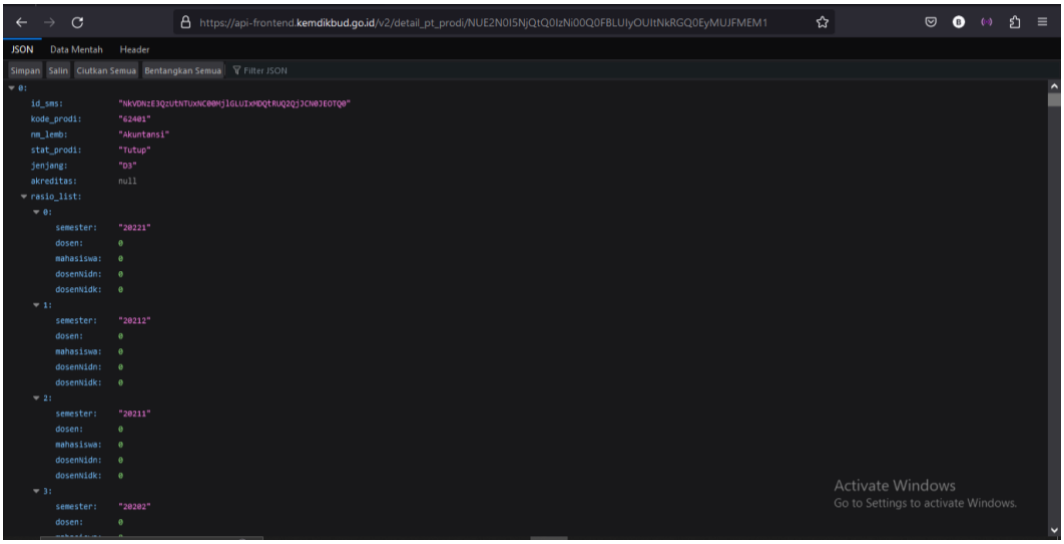
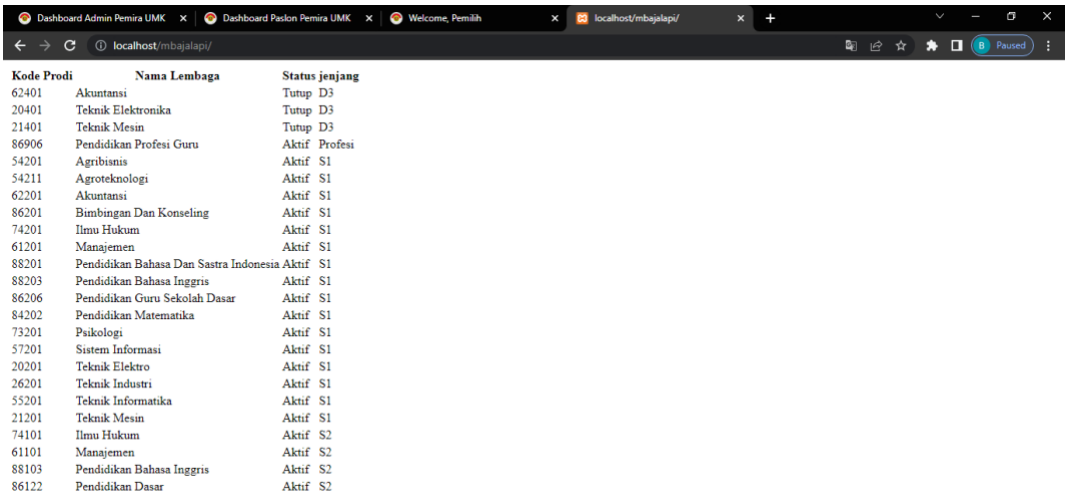


Fig. 15: View of Accessed API

The call API function can then be added to our code editor. The data used can then be loaded from the API and displayed. We can run the source code in our browser after inputting it. The output of the source code we wrote is shown here in Figure 16.



Kode Prodi	Nama Lembaga	Status jenjang
62401	Akuntansi	Tutup D3
20401	Teknik Elektronika	Tutup D3
21401	Teknik Mesin	Tutup D3
86906	Pendidikan Profesi Guru	Aktif Profesi
54201	Agribisnis	Aktif S1
54211	Agroteknologi	Aktif S1
62201	Akuntansi	Aktif S1
86201	Bimbingan Dan Konseling	Aktif S1
74201	Ilmu Hukum	Aktif S1
61201	Manajemen	Aktif S1
88201	Pendidikan Bahasa Dan Sastra Indonesia	Aktif S1
88203	Pendidikan Bahasa Inggris	Aktif S1
86206	Pendidikan Guru Sekolah Dasar	Aktif S1
84202	Pendidikan Matematika	Aktif S1
73201	Psikologi	Aktif S1
57201	Sistem Informasi	Aktif S1
20201	Teknik Elektro	Aktif S1
26201	Teknik Industri	Aktif S1
55201	Teknik Informatika	Aktif S1
21201	Teknik Mesin	Aktif S1
74101	Ilmu Hukum	Aktif S2
61101	Manajemen	Aktif S2
88103	Pendidikan Bahasa Inggris	Aktif S2
86122	Pendidikan Dasar	Aktif S2

Fig. 16: Run Results in the Browser

The testing conducted for the e-voting system in the General Election uses Black Box Testing. Black Box Testing is a type of testing based on functionality and user interface design when the user runs the program. [15]. In the Black Box testing, the overall conclusion was that all existing features functioned as previously defined. Between the actions and the flow that has been established, everything is functioning well according to the needs present in the application. The results of the Black Box Testing are in Table 1.

Table 1: Black Box Testing

No.	Tested features	Test scenario	Expected results	Test results	Description
1.	On the homepage Home button	Click the button to view the page	The home page appears	Succeed	The home appeared successfully
2.	Candidates registration button	Click the button to view the page	The registration pair candidate appears	Succeed	Registration page candidate pair appeared successfully
3.	Temporary candidate pair data button	Click the button to view the page	The temporary candidate list page appears	Succeed	Temporary candidate pair list page appeared successfully
4.	Login button	Click the button to view the page	The election login page appears	Succeed	The voter login page successfully
5.	Admin button	Enter the correct username and password	Enter the admin dashboard page	Succeed	Admin login successful
6.	Candidate pair login	Enter the correct username and password	Go to the candidate pair dashboard page	Succeed	Candidate pair login successful
7.	See the election page	Login to enter the election page	The election page appears	Succeed	The election page is displayed
8.	Select a candidate pair	Click on the photo on one of the cards for each candidate pair's student organization	Card of selected candidate pair	Succeed	Selected card of candidate pair successful
9.	Submit election data	Click the submit button	After submitting, the data sent	Succeed	Data submission was

			and returning to the login page		successful
10.	Campaign Button	Click the button to view the page	The campaign page appears	Succeed	The campaign page has successfully appeared
11.	Recapitulation button	Click the button to view the page	Show the recapitulation page	Succeed	The recapitulation page has been successfully displayed

4. Conclusion

The results are based on analysis, planning flow, and implementation of the e-voting system for the General Elections. Muria Kudus University concluded that applying the built e-voting system could assist the event organizing committee carry out the activities. The system that operates automatically helps in the efficiency and effectiveness of implementing activities in the field and minimizing errors and intentional or unintentional violations. From the results of the Black Box testing conducted, the features in the application are functioning as expected. Based on the tests, the e-voting application for the General Elections Muria Kudus University can function according to its intended purpose.

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