Research Article

Majlis Perwakilan Pelajar (MPP) voting system uses blockchain technology.

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Abstract: *This research delves into the realm of electoral systems, focusing on the challenges inherent in the current manual voting system for the election of Majlis Perwakilan Pelajar (MPP) members at the National Defence University of Malaysia (UPNM). The inefficiencies of the existing system necessitate a modernized approach, prompting an exploration into the integration of blockchain technology for a more secure and streamlined voting process. The primary objectives of this study are to develop a web based MPP election system fortified by blockchain technology. The scope encompasses a comprehensive analysis of the existing manual voting procedures, a comparative study with analogous systems at other universities, and the proposal of a novel blockchain-based solution tailored to UPNM's specific requirements. Materials for the study include academic works, publications, online sources, and relevant secondary materials. The methodology involves a thorough examination of the current manual voting system, comparative analyses with similar systems, and an in-depth review of blockchain-based voting systems implemented elsewhere. The study adheres to standard procedures for literature review, data collection, and analysis. Key findings reveal the limitations of the current manual voting system, emphasizing the need for a more accessible and secure alternative. Trends observed in analogous systems underscore the effectiveness of blockchain technology in enhancing the integrity and security of the voting process. The discussion revolves around the implications of the findings, emphasizing the potential of blockchain to address the identified challenges. The abstract concludes with suggestions for future work, encouraging further research and development to refine the proposed blockchain-based MPP election system. This study contributes to the ongoing discourse on leveraging technology to optimize electoral processes within academic institutions.*

Keywords: Blockchain, Voting System, Electoral Process, Majlis Perwakilan Pelajar (MPP)

DOI: 10.5281/zenodo.10921001

1. Introduction

The Student Representative Council (Majlis Perwakilan Pelajar or MPP) at the National Defence University of Malaysia (UPNM) plays a crucial role as a platform for students to voice their needs and interact with university management. Since its establishment in 2006, UPNM's MPP has been dedicated to providing assistance and comfort to students in various issues and challenges. However, the experience of selecting MPP candidates through the existing manual voting system at UPNM poses several challenges that need to be addressed. The background of this project encompasses the need to modernize and improve the process of selecting MPP candidates at UPNM. The previously implemented manual voting system not only presents difficulties for students residing outside the campus or engaged in off-campus programs but also raises concerns about efficiency and data security. This situation calls for a progressive and innovative approach. This project involves the implementation of blockchain technology in the UPNM MPP Voting System as a solution to enhance the integrity, efficiency, and security of the MPP candidate selection process. The use of blockchain will lead to a more efficient, secure, and reliable system, ensuring that the voting results are acknowledged by all parties involved. In the problem statement, we identify several critical issues faced by the current system, including student discomfort, a lack of efficiency, and data security risks. To address these issues, the project encompasses main objectives such as developing a web platform, providing an easily accessible database, and utilizing blockchain technology for enhanced access authorization. The project not only benefits UPNM students in conducting votes but also facilitates management bodies such as the Campus Election Commission (Suruhanjaya Pilihanraya Kampus or SPRK) in carrying out the selection process more efficiently. By employing blockchain technology, it is expected that this system will provide better convenience, security, and integrity to all parties involved in the MPP candidate selection process at UPNM.

2. METHOD & MATERIAL

Methodology plays a crucial role in the development of any system, as emphasized in the System Analysis and Design and Software Engineering courses. It serves as the backbone for constructing a system where data is systematically gathered through qualitative, quantitative, or mixed methods to produce a comprehensive study. For the development of the MPP Voting System using blockchain, communication commenced with continuous user requirement collection, allowing for adjustments throughout the development iterations. The communication process in users' sprints, demonstrating the system to users, and implementing open feedback mechanisms. This ensured active user engagement, a profound understanding of interpreted needs translated into system functions, and swift responses to any queries or issues that might arise. This communication approach complements the effectiveness of the Agile model in ensuring that the developed system genuinely meets user needs. Consequently, the Agile model emerged as the optimal choice for developing this system.

2.1 Methodology Used

Various methodological approaches can be employed to create a system, and the choice of the right process is crucial as it can significantly impact the quality of the software system. The Agile technique has been adopted for this system, as illustrated in Figure 1.

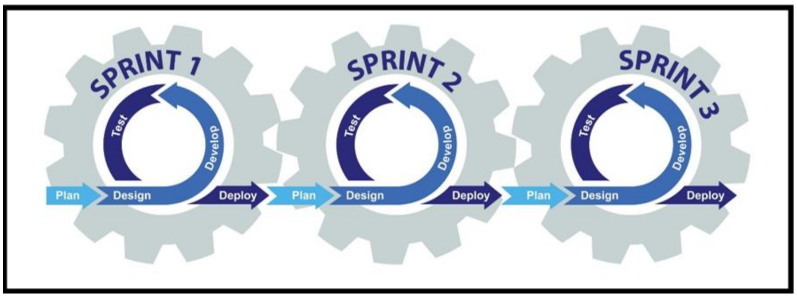

Figure 1. Agile Model Flow adapted from (Metode Agile: Pengertian, Tujuan, dan Prinsipnya., n.d.)

This methodology, with its adaptive development environment, enables organizations to address challenges holistically. Activities are carried out rapidly without prior documentation of requirements, and the organization reviews them later. This means that system requirement adjustments can occur at any time during the development process.

2.2 Blockchain Technique

The proposed blockchain system architecture is depicted in Figure 2, consisting of three main stages: Local Blockchain Network, Client Communication, and Frontend. This diagram illustrates the involvement of voters and the Campus Election Commission (SPRK) in the system. Voters and SPRK interact with Smart Contracts through decentralized software, known as Decentralized Applications (DApps).

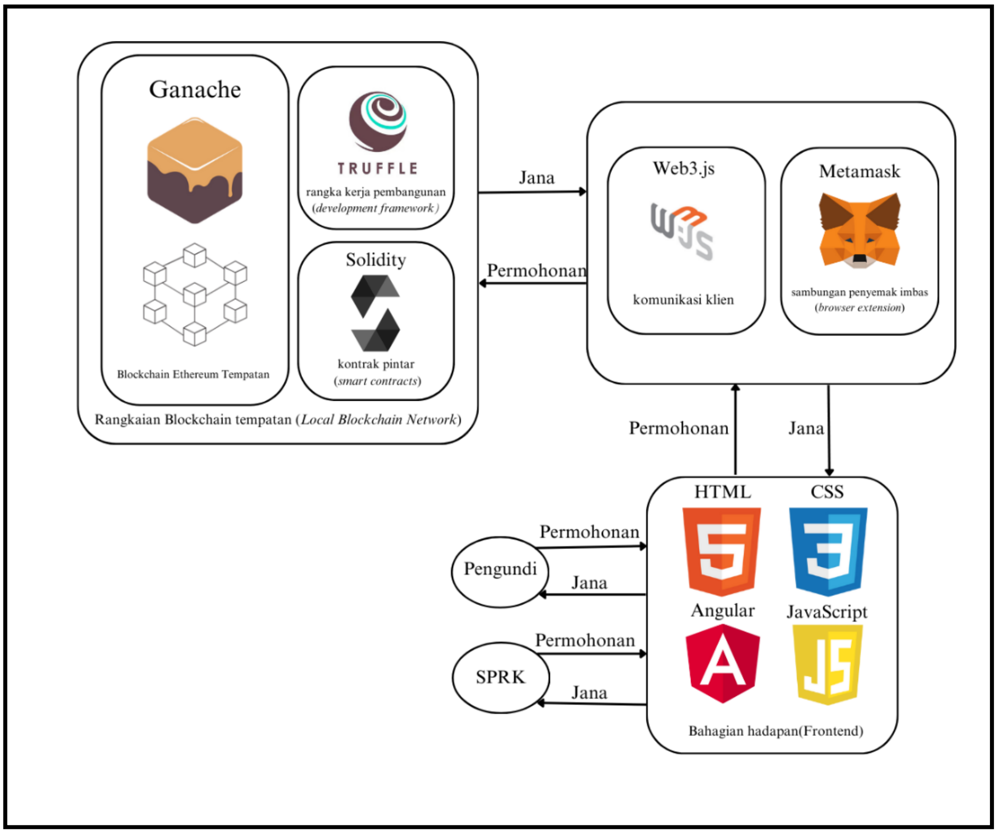

Figure 2. MPP Voting System Architecture using Blockchain

2.2.1 Frontend

a. Voters

Voters utilize the Angular user interface to register, access polls, and make candidate selections. Their interaction involves HTML for voting information, CSS for interface styling, and TypeScript (JavaScript superset) for executing application logic, including verification and submission of voting transactions to smart contracts.

b. SPRK

The SPRK employs the same interface to manage smart contracts overseeing the entire voting process. They use TypeScript for managing smart contract functions, including monitoring voting status and access management. SPRK also uses the interface to view reports and voting statistics, with HTML presenting information clearly. Interaction with the blockchain to verify transactions and ensure the integrity of voting data is also conducted through SPRK's JavaScript skills.

2.2.2 Client Communication

Based on the diagram, a connection between the local Blockchain network and the frontend is formed, enabling voters and SPRK to initiate smart contract functions, recorded on the blockchain. The initial subcomponent of this stage is web3.js, a JavaScript library used to create clients or websites communicating with the blockchain. Web3.js utilizes JavaScript Object Notation Remote Procedure Call (JSON RPC) to connect to the Ethereum Blockchain, facilitating network communication between clients like web applications and servers like Ethereum nodes.

The final component enabling connection to the Ethereum blockchain is the cryptocurrency wallet called MetaMask. It is a browser extension that allows access to decentralized applications powered by Ethereum directly from the browser. MetaMask serves as an Application Programming Interface (API) between Ethereum's web3 and the JavaScript context of every website, enabling DApps to read from the blockchain. The MetaMask framework is depicted in Figure 3.

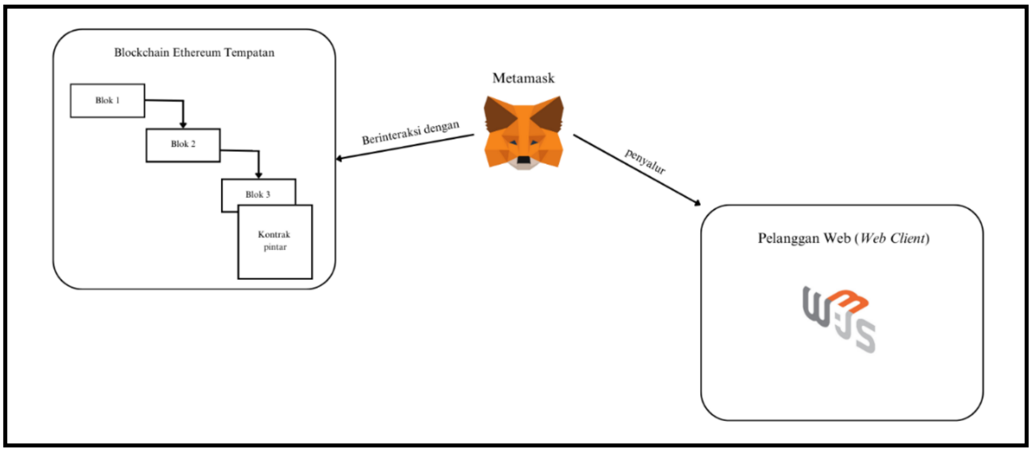

Figure 3. MetaMask Architecture

2.2.3 Local Blockchain Network

Ganache, Truffle, and smart contracts are integral parts of the local blockchain network. Ganache provides a private in-memory Ethereum blockchain, enabling the development, use, and testing of Decentralized Applications (DApps) in a secure environment. Additionally, Ganache provides 10 external accounts, each loaded with 100 fake ethers and having an address on our local Ethereum blockchain.

Truffle, a framework facilitating the development of decentralized applications on the Ethereum blockchain, is the next subcomponent. It comes with a set of tools to create smart contracts in the Solidity programming language, allowing for testing and use of smart contracts on the local blockchain using the Truffle framework.

The smart contract is the final and most crucial subcomponent of the local blockchain network. In simple terms, a smart contract is a program executed on the blockchain when certain criteria are met. It is often used to automate the execution of agreements so that all parties are instantly certain of the results without intermediary involvement or time loss. Once the predefined requirements are met and verified, the system executes the specified activities, and the blockchain is updated, becoming immutable after the transaction is completed.

2.2 Material

Detailed information regarding the hardware and software requirements essential for the system is provided in Table 2.1. The effectiveness of core functions, as well as the processing and storage of voting data, depends on the availability of suitable software and hardware.

Table 1. Hardware and Software

Software/Hardware	Description
Node.js	JavaScript platform used for server-side code execution.

Python	Versatile programming language for web development.
JavaScript	Programming language used for creating dynamic interfaces and implementing client logic on the web system.
Solidity	Smart contract programming language used on the Ethereum platform to define smart contract logic.
Angular	Web application framework for building dynamic user interfaces.
CSS	Styling language used to enhance the user interface in web application development.
HTML	Markup language used for page structure in user interface development.
Bootstrap	Open-source framework facilitating responsive and attractive interface development using HTML, CSS, and JavaScript.
Truffle	Development and testing tool for smart contracts in the Ethereum environment.
Ganache	Local Ethereum blockchain simulation for development and testing.
MetaMask	Crypto wallet browser extension enabling user interaction with Ethereum web applications.
sqlite3	Lightweight and efficient SQL database library used for data storage in this system.
TypeScript	JavaScript superset with static typing, used in Ethereum development for high-quality code.

3. FINDINGS

System analysis is a crucial step in investigating issues and finding appropriate solutions. This section encompasses data obtained from conducted studies and provides comprehensive data and analysis to facilitate readers' understanding.

Additionally, this section describes system analysis using techniques such as system context diagrams, data flow diagrams, flowcharts, and other drawing techniques used in the system development process.

System analysis helps identify solutions to problems within the existing system by breaking down components into smaller units, ensuring that the resulting solution meets the system's requirements accurately. There are several factors driving the need for system analysis, including:

a. Providing an initial overview of the system development journey to ensure the smoothness of this process.

b. Clarifying the system flowcharts used in the development of this system.

c. Ensuring that the system development process can be carried out more efficiently, easily, and systematically.

3.1 Analysis Phase

In this overall system analysis process, it encompasses steps in developing the system by considering every requirement and system's desires. It consists of four main components: requirement modelling, data and process modelling, object modelling, and transitioning to system design. Refer to Figure 4 for further clarity.

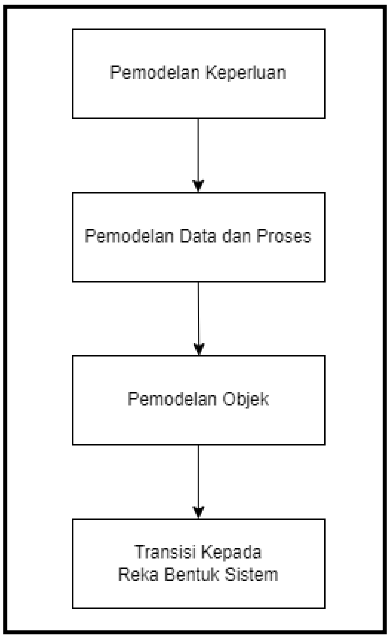

Figure 4. Analysis Phase Process

3.2 Data Modelling Phase

Through the data and process modelling phase, an entity relationship diagram can be presented to illustrate the flow of data and the functions of each module within the system. This modelling phase portrays the internal movement of the system through easily understandable graphics. For simulation based on blockchain methodology, a data flow diagram will be presented. The data flow diagram will visualize the flow of data within the system, from the "input" process to the "output" process. At this stage, several diagrams are used to depict these processes, such as Data Flow Diagrams (DFD) or Data Flow Charts.

A Data Flow Diagram (DFD) provides an explanation of the information flow within a system or program from the initiation of input processing to output. DFDs are used because there are many workflow streams that are difficult to explain or are better explained visually. Additionally, diagrams can effectively depict the entire workflow and are easier to understand.

Figure 5 illustrates the Context Diagram of the MPP Voting System using blockchain methodology. In this diagram, two main entities are visible, namely the Voter and the Electoral Commission (EC). The process of registering login information for the Voter entity will be conducted by the EC. After that, the Voter will use their voter ID, password, and One-Time Password (OTP) to log into the system. Only if the voter's ID, password, and OTP are valid can the voter access the system to cast their vote. All voting information will be recorded and stored within the system.

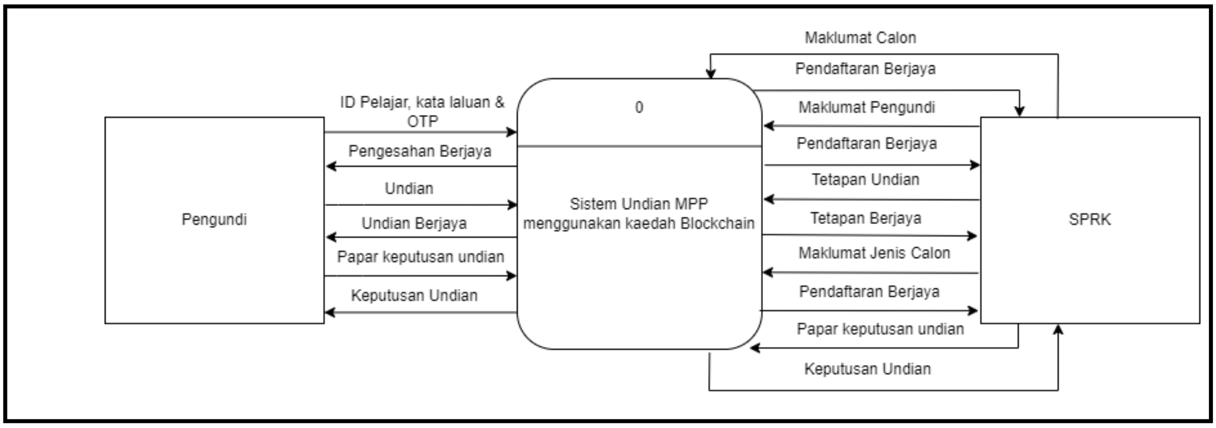

Figure 5. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Context Figure

3.3 Zero Level Data Flow Figure

Figure 6 is a continuation of the context diagram, referred to as the Zero-Level Data Flow for an abstract view. The Zero-Level Data Flow Diagram is created to depict the system as a single process in relation to external entities. Through this diagram, the data flow at the zero level can be explained in the MPP Voting System using blockchain methodology.

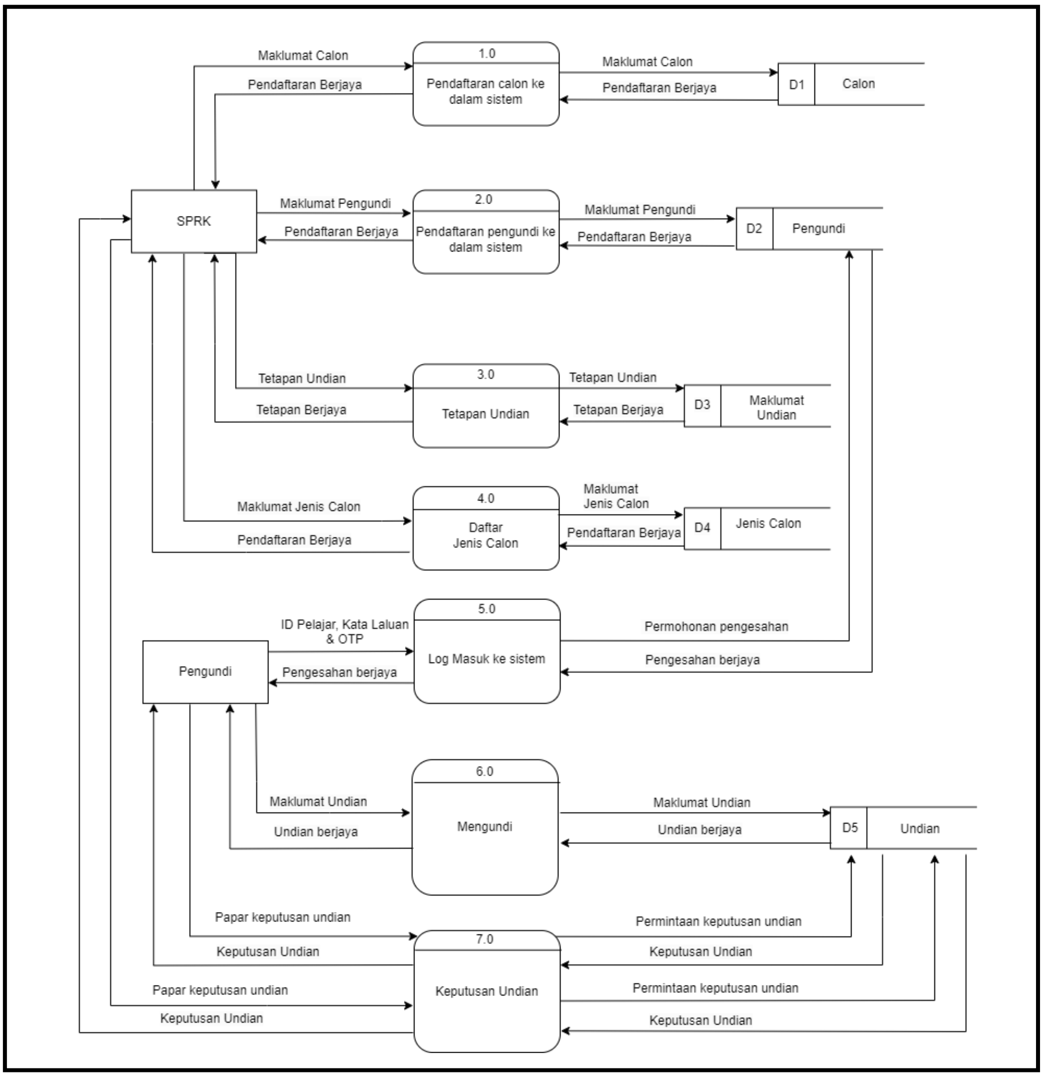

Figure 6. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Zero Level Flow Diagram

The voter and candidate registration procedures of the system are depicted in Figure 6. The Electoral Commission (EC) will register voters and candidates by entering their information into the system. The third process indicates where the EC entity will set the voting parameters. In the fourth process, the EC will input the types of candidates contesting. For the fifth process, the voter entity will log into the system using their voter ID, password, and OTP as input. If the voter's information is valid, the voter will be issued as output. The sixth step illustrates where the voter entity will cast their vote within the system, as well as information about the candidates involved in this election. The sixth step of this system will display the final system output, which is the voting decision process, where the EC entity will obtain voting data from the system.

3.4 Transition Phase to System Design

This phase represents a crucial transition from the data modelling and analysis process to a more concrete design stage for the system under development. In this phase, system design will be developed and presented in a more detailed form, including hierarchy charts that depict the hierarchical relationships between system elements, a data dictionary comprising definitions and detailed descriptions for each data element, and flowcharts that visualize the workflow processes in the system clearly. With this approach, system development can be carried out more systematically, ensuring that each element and process has been carefully executed.

3.5 Hierarchy Chart

A hierarchy chart plays a role in documenting program structure. It helps present an overview of the modules or functions used in the program. In Figure 7, we can see a hierarchy chart related to the MPP Voting System using the blockchain technique. This chart consists of voters, login, voting, Electoral Commission (EC), homepage, voter registration, candidate registration, voting parameters, and check voting results.

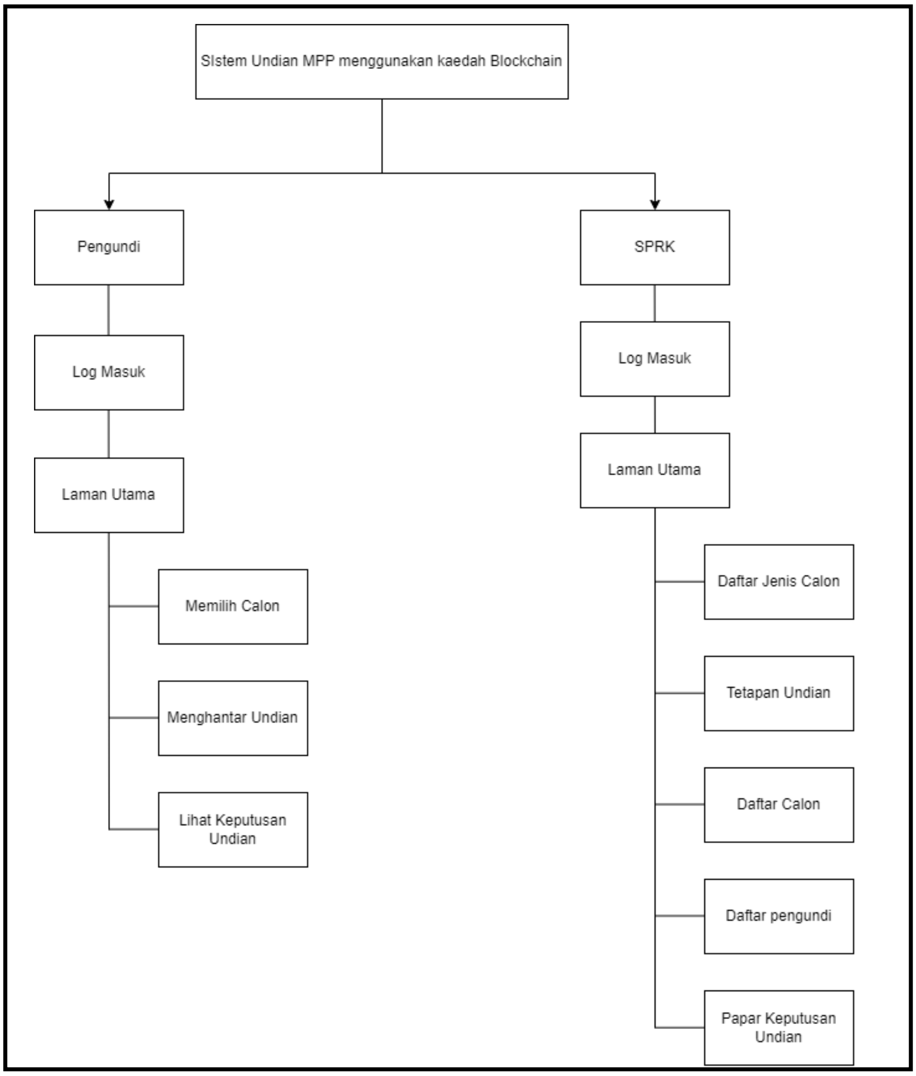

Figure 7. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Hierarchy Chart Diagram

3.6 Flowchart

Flowchart modeling is a method used to connect each process. By using geometric shapes such as rectangles, circles, and trapezoids, each decision can be depicted in its movement within the process. This allows for the portrayal of movement and workflow within the system in a more detailed and structured manner.

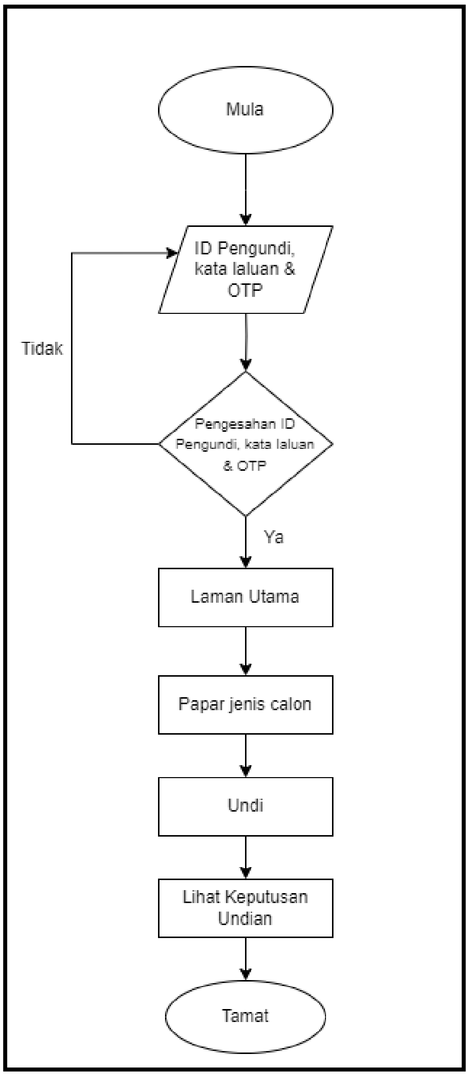

Figure 8. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Flowchart – Voter

Figure 8. depicts the flowchart of the voter process, where the voter inputs their Voter ID, password, and OTP correctly to receive a valid login status. After that, the voter will be able to access the system. The voter will then review the candidates and cast their vote. Once all procedures are completed, the voter can exit the system.

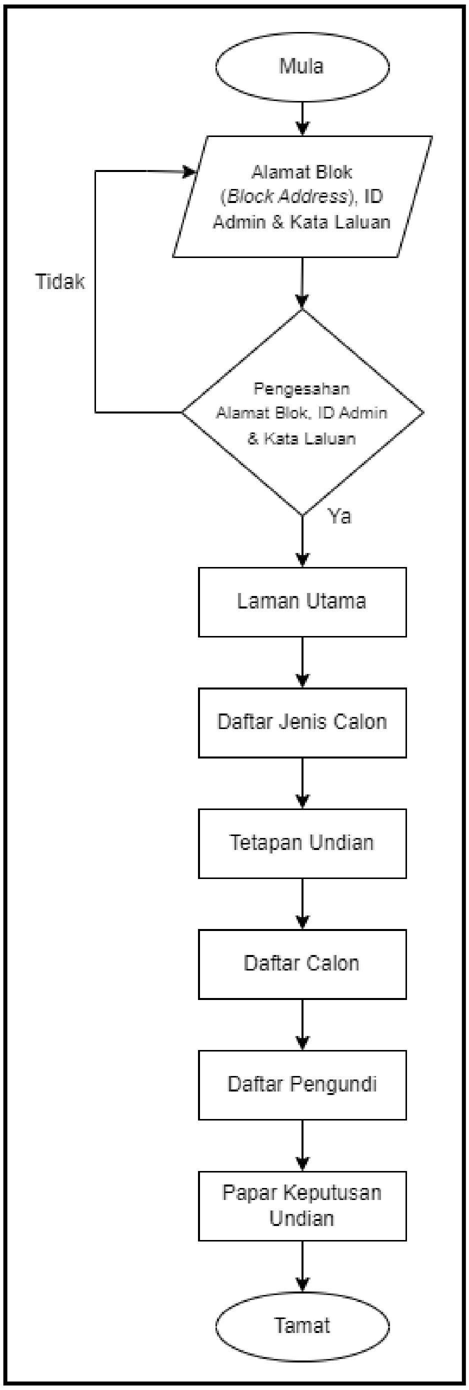

Figure 9. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Flowchart – Admin

The flowchart of the MPP Voting System using blockchain methodology is shown in Figure 9 for the Electoral Commission (EC) utilizing this system. The EC, as the system administrator, must log into the system until it is verified using the Block Address, Admin ID, and valid password as an admin. Once verified, the EC will register voters and candidates in the system. The EC will also set voting parameters to enable voters to cast their votes. This flowchart will end after the EC confirms the voting results once the voting process is completed.

3.6 System Architecture

The system architecture for the voting process begins with voters securely logging into the system, where user credentials are verified against an authentication database. Once authenticated, voters gain access to the main menu, providing a centralized hub for various interactions within the voting system. Subsequently, voters initiate a voting transaction by selecting their preferred candidate or option, generating a unique transaction ID, and encrypting vote details for privacy. These encrypted details are then broadcasted to a decentralized network of nodes, ensuring redundancy and reliability through peer-to-peer communication. The network collaboratively validates the submitted vote transaction using consensus algorithms, such as Proof-of-Work or Proof-of-Stake. Upon successful validation, the vote transaction is added to the blockchain, a distributed ledger that offers a tamper-resistant and chronological record. With the completion of the vote transaction, voters securely log out of the system, terminating the session and preventing unauthorized access. This architecture ensures a transparent, secure, and decentralized voting process, leveraging blockchain technology for integrity and reliability.

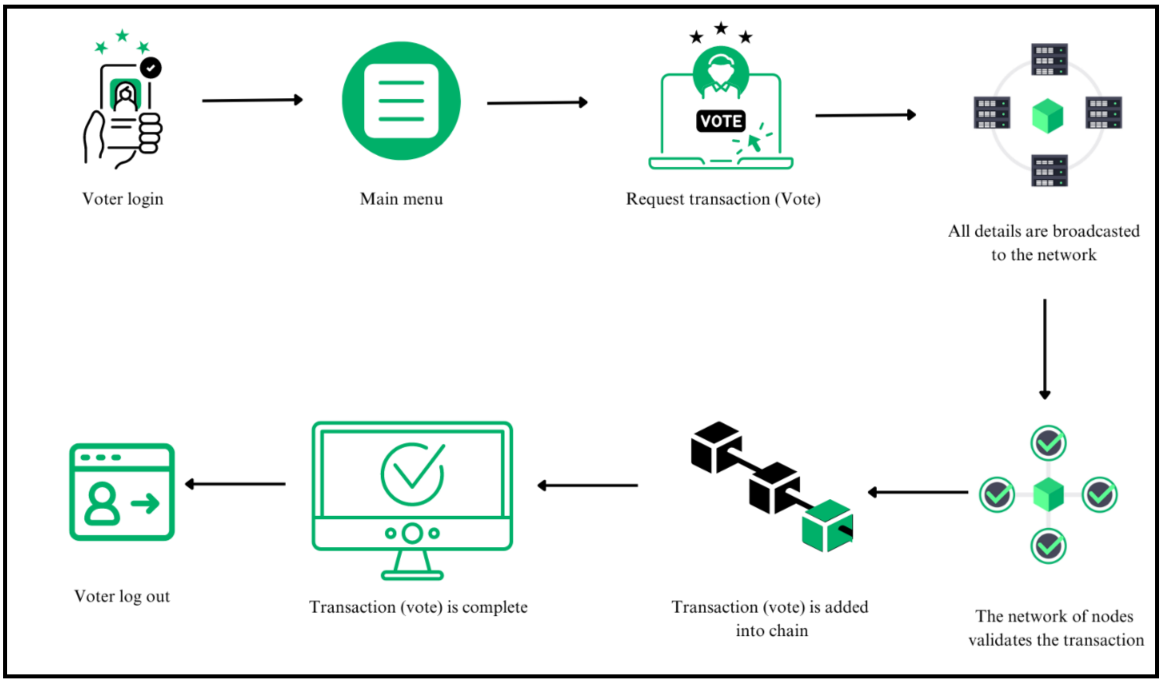

Figure 10. System Architecture

3.7 Interface

Figures 11, 12, 13 and 14 show the interface design of the developed system.

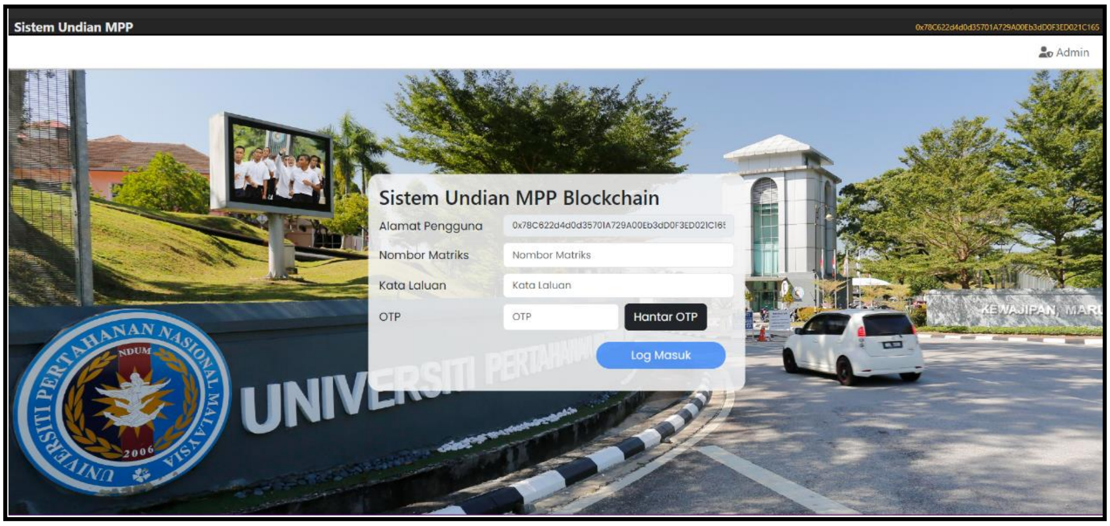

Figure 11. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Login Interface

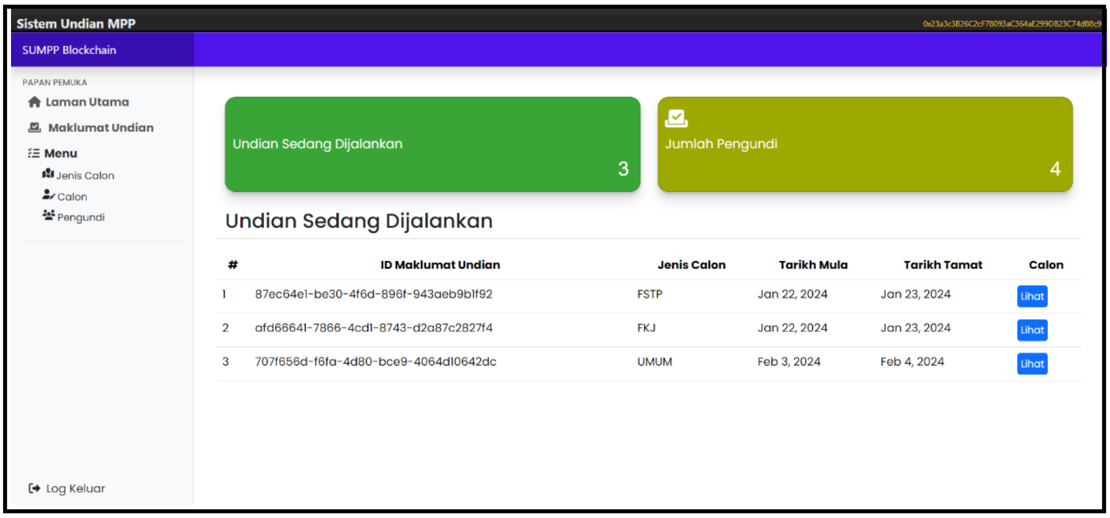

Figure 12. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Homepage Interface

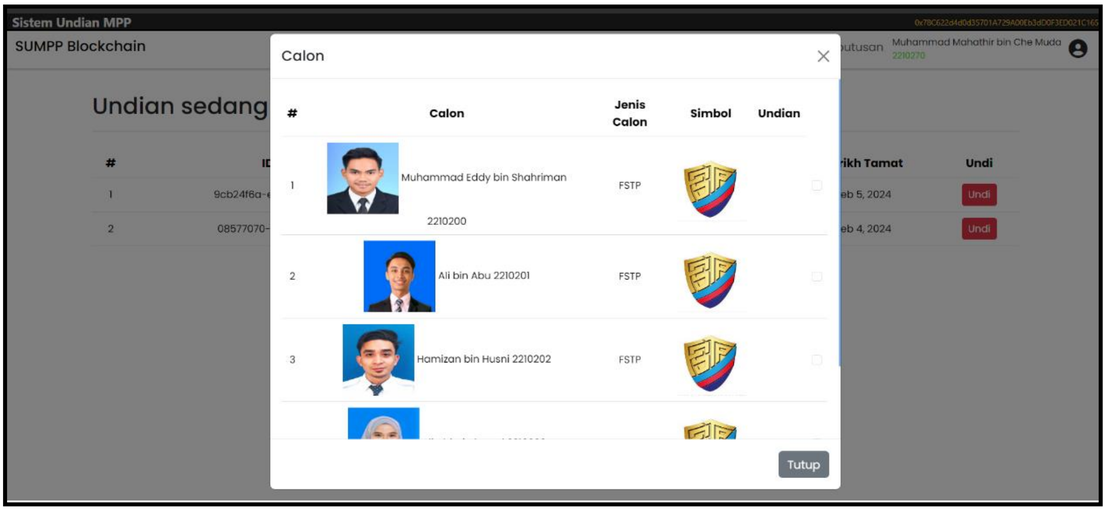

Figure 13. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Candidate View Interface

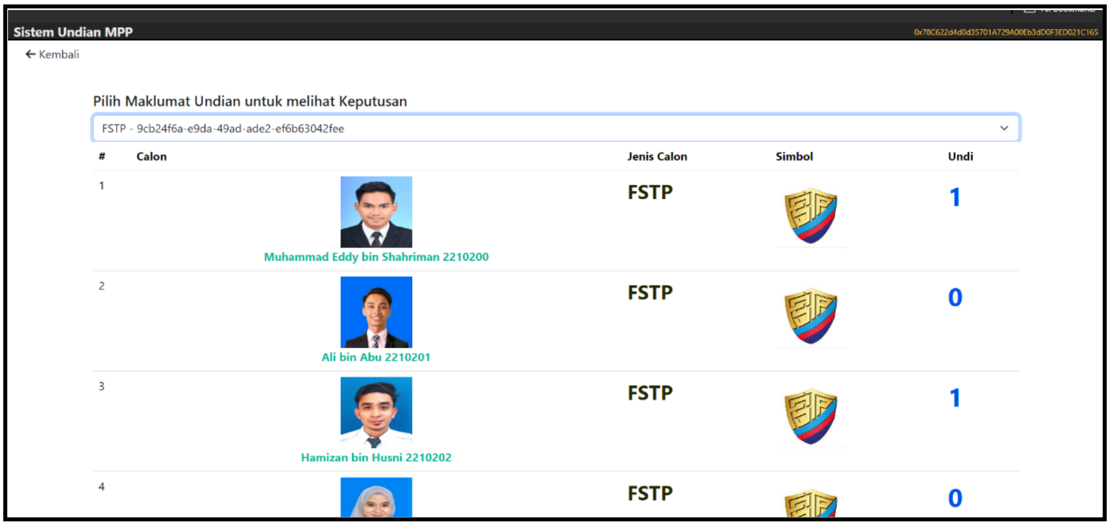

Figure 14. Majlis Perwakilan Pelajar (MPP) Voting System Uses Blockchain Methods Voting Results Interface

4. DISCUSSION

4.1 Achievements

The development of the MPP Voting System using blockchain technology has successfully met the outlined objectives, marking several notable achievements as detailed in Chapter one. The system transitioned effectively from traditional physical voting to an online MPP Voting System at UPNM. It established a functional database for MPP candidate elections, ensuring the secure storage of voting information. The sophisticated web-based system, designed using blockchain technology, guarantees enhanced access security, allowing for meticulous monitoring of transactions and interactions on the platform. The system's recognition and attainment of the Gold Award in the International Creative Innovation Idea Competition (ICIIC) 2024 further validate its success, as documented in Appendix C.

4.2 System Advantages

The MPP Voting System utilizing blockchain technology presents numerous advantages that address inherent issues in traditional systems. Firstly, the approach is time-efficient and reduces paper usage, allowing voters to cast their votes securely from any location with system login credentials. The system's security features, rooted in blockchain technology, ensure automatic security, integrity, and reliability of data. Its user-friendliness is enhanced by high standards, providing ease of use for voters. Moreover, a user guide module is available for reference, facilitating the voting process. The system boasts a secure database for information storage, utilizing SQLite3 to safeguard all reservation details. Administrative controls, such as voter registration, contribute to protecting the system from unauthorized users.

4.3 System Weaknesses

Despite the successful development of the MPP Voting System using blockchain, it is not without its weaknesses. One notable drawback is the limitation of using Ganache for free licenses in development and testing. This limitation hampers the functionality and module access for comprehensive system development. Overcoming this issue requires continuous monitoring, innovation, and improvements to the system.

4.4 Future Recommendations

To ensure the full utilization of the developed system by UPNM campus residents, ongoing development and system improvement are crucial to align with technological advancements. Evaluation of system effectiveness and user experience should guide further enhancements. Future recommendations include developing a mobile application for voter display, enabling result and voting-related information printing, restricting the number of votes cast, and considering a transition to real-world blockchain software widely used in the industry.

5. Conclusion

In conclusion, the introduction of the UPNM MPP Voting System, incorporating blockchain technology, represents a progressive and transformative step towards addressing the challenges faced by the manual voting system. The project, driven by the necessity to enhance the efficiency, security, and accessibility of the MPP candidate selection process, has successfully achieved its objectives. By adopting blockchain technology, the system not only streamlines the voting process for UPNM students but also mitigates issues related to physical attendance, inefficiency in ballot counting, and potential data manipulation. The three main objectives, including the development of a user-friendly web platform, the creation of an easily accessible database, and the implementation of blockchain for secure access authorization, have been effectively realized. The significance of this project extends beyond the immediate benefits to students. It introduces a new era of technological advancement in the realm of student representation, ensuring that the MPP selection process is transparent, efficient, and secure. The integration of blockchain technology not only safeguards the integrity of the voting process but also aligns with contemporary trends in secure and decentralized systems. Moreover, the UPNM MPP Voting System demonstrates a commitment to embracing innovation and addressing the evolving needs of a technologically savvy student body. It provides a model for universities and institutions grappling with similar challenges in their student representation processes, showcasing the potential of technology to revolutionize traditional systems. In essence, the successful implementation of this project marks a pivotal moment in the evolution of UPNM's MPP selection process, offering a more inclusive, secure, and efficient system that caters to the diverse needs of the university's student community. This initiative serves as a testament to the institution's dedication to progress, innovation, and the holistic improvement of the student experience.

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