APPLIED INFORMATION TECHNOLOGY AND COMPUTER SCIENCE
e-ISSN: 2773-5141

AITCS

Vol. 5 No. 2 (2024) 1-18
https://publisher.uthm.edu.my/periodicals/index.php/aitcs

# Vehicle Sticker System using Blockchain Technology for UTHM

**Lee Kin Wai[1], Nur Ziadah Harun[1]***

[1] *Fakulti Sains Komputer dan Teknologi Maklumat,*
*Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA*

*Corresponding Author: nurziadah@uthm.edu.my
DOI: https://doi.org/10.30880/aitcs.2024.05.02.001

**Article Info**

Received: 14 October 2024
Accepted: 16 October 2024
Available online: 15 Disember 2024

**Keywords**

Blockchain Technology, Vehicle Sticker System, Security, Smart Contracts, Transparency

**Abstract**

In the era of globalization, blockchain technology offers transformative benefits, including improved security, transparency, and efficiency. Traditional vehicle sticker systems face issues like counterfeiting, inefficiency, and vulnerability to security breaches due to their reliance on centralized databases. This project investigates integrating blockchain into a Vehicle Sticker System to enhance security and streamline processes. The proposed system uses blockchain's immutable ledger and smart contracts to ensure sticker authenticity, prevent fraud, and automate issuance and verification. Targeted at UTHM users, this user-friendly web platform aims to provide seamless sticker management, contributing valuable insights into blockchain's application in university administration.

## 1. Introduction

The Vehicle Sticker System (VSS), crucial in managing the growing number of vehicles on the road, employs digital technologies, including blockchain, for enhanced security and efficiency. Beyond indicating compliance with regulations, these stickers play a pivotal role in revenue collection, safety initiatives, and environmental awareness. The system's modernization involves standardized protocols for sticker application, including vehicle registration, application submission, and the issuance of physical stickers with unique identification codes. However, traditional systems face drawbacks, prompting the proposal of a blockchain-powered digital system. This innovative approach aims to overcome security vulnerabilities and inefficiencies by providing a secure, efficient, and tamper-proof solution for managing vehicle stickers and related information.

Implementing the Vehicle Sticker System without blockchain technology presents several potential drawbacks. Firstly, reliance on physical stickers makes them susceptible to counterfeiting and forgery, posing risks of revenue loss and security breaches. Additionally, the traditional system is characterized by inefficiency and delays, particularly in manual verification processes that can be time-consuming, leading to frustrations for both vehicle owners and enforcement authorities, especially during peak traffic hours or busy events. Moreover, traditional systems relying on centralized databases are exposed to security vulnerabilities, risking the confidentiality of sensitive vehicle and owner information in the event of a breach. The integration of blockchain technology can effectively address these challenges by enhancing security measures, improving overall efficiency, and offering more comprehensive and flexible solutions for managing vehicle stickers and related data.

The primary objective of this project is to develop a well-rounded and user-friendly vehicle sticker system catering to the target users, namely the students and the staff of UTHM. The system aims to offer seamless functionality for vehicle registration, sticker application, and sticker verification. Users, particularly students, can conveniently perform these tasks when their devices are connected to the Internet.

Furthermore, the proposed system is designed to be utilized by administrators responsible for managing the overall vehicle sticker processes. An administrator dashboard will be provided for them, allowing comprehensive control over the entire system. Administrators can review and approve sticker applications, and the system will generate a unique digital signature for verification purposes. The verification interface, equipped with QR code scanning capabilities, ensures real-time verification and displays relevant information to authorities.

## 2. Related Work

This section provides a literature review on topics related to vehicle sticker systems, smart contracts, decentralized systems, blockchain technology, security features, and existing comparative systems. The literature review aims to gain a comprehensive understanding and discuss the project background about the proposed system and blockchain.

### 2.1 Vehicle Sticker System

The escalating number of vehicles on the roads, coupled with challenges in accurate vehicle identification, necessitates advanced solutions. Traditional methods, including license plate recognition, face reliability issues due to forgery and obstructions [1]. In this context, a vehicle sticker system proves crucial for controlled access in specific environments like universities, cities, or organizations. Beyond enhancing security by visually indicating authorized entry, these stickers provide a swift means of identifying permitted vehicles, aiding security personnel. In a university setting, the system streamlines the application process for stickers, mitigating traditional system limitations such as counterfeiting risks and data manipulation concerns. Innovative solutions are sought to address the evolving complexities associated with managing vehicle access and identification in contemporary urban environments.

### 2.2 Smart Contracts

Smart contracts, integral to blockchain technology, are self-executing agreements encoded in lines of code that automate contractual terms upon meeting predefined conditions. Their decentralized nature ensures trustless execution, eliminating the need for reliance on central authorities. Platforms like Ethereum have embraced smart contracts, allowing for programmable and automated execution of agreements, a distinctive feature of blockchain compared to centralized systems [2]. In the realm of document validation, smart contracts can enhance security by automating steps like format compliance and cryptographic signature verification. Techniques such as model checking and various semantic analyses contribute to the verification of smart contract systems [3].

However, challenges like code vulnerabilities and bugs pose risks to smart contracts. Vulnerabilities in Ethereum smart contracts span programming language, Ethereum Virtual Machine, and blockchain levels, necessitating thorough code audits and testing for risk mitigation [4]. In the specific context of a vehicle sticker system, smart contracts can revolutionize processes such as issuance, renewal, and transfer, offering automation, transparency, efficiency, and heightened security for managing university vehicle stickers.

### 2.3 Decentralized Systems

Decentralized systems, as opposed to centralized ones, distribute data and processing across multiple nodes, reducing the risk of a single point of failure and enhancing transparency. In decentralized systems, data is distributed across multiple nodes, fostering fault tolerance through redundancy and enabling robust stability even in the face of failures or attacks. This decentralized management approach proves cost-effective and practical, particularly in large-scale systems like power grids [5]. Figure 1 illustrates the fundamental difference between centralized and decentralized systems, with the latter relying on distributed nodes for authority and decision-making, resulting in a more resilient and transparent framework.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 1-18

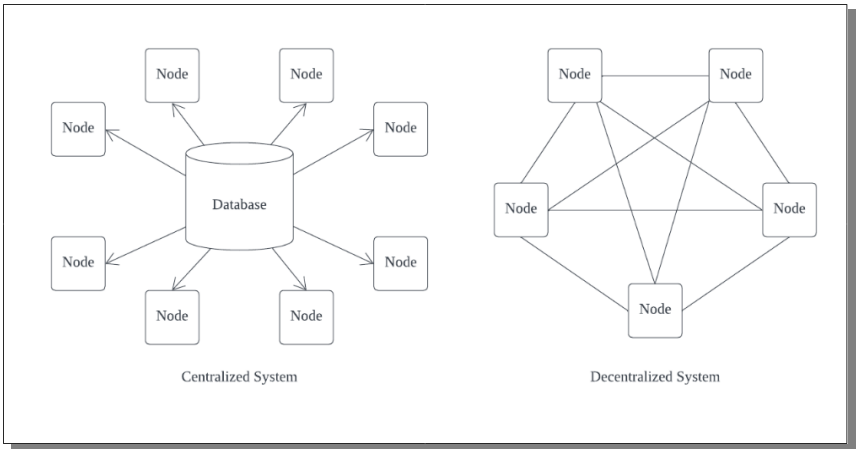



**Fig. 1** *Centralized System and Decentralized System*

The principle of decentralization finds application across various domains, with examples ranging from autonomous decentralized systems in Japanese railways [6] to software-centric approaches in blockchain networks and peer-to-peer networks. In the context of blockchain technology, decentralization involves the distribution of control, decision-making, and data across a network of nodes, contributing to the robustness and potency of the technology. However, challenges arise in achieving scalability as decentralized systems grow in participants, and consensus mechanisms introduce potential latency and overhead.

In the context of a university's vehicle sticker system, a decentralized approach holds the potential to address security concerns and streamline administrative processes. By providing a resilient and trustworthy infrastructure, a decentralized system ensures fair and tamper-resistant access control and authorization processes, adapting dynamically to the system's needs. While decentralized systems offer benefits, challenges such as scalability and consensus mechanisms should be carefully addressed for effective implementation.

## 2.4 Blockchain Technology

Blockchain technology, renowned as the foundation of cryptocurrencies like Bitcoin, is a decentralized and distributed ledger system ensuring secure and transparent transaction recording across a network of computers. Each participant in the network possesses a copy of the entire ledger, ensuring transparency and redundancy [7]. The blockchain's continuous growth comprises timestamped transaction records organized in blocks, and cryptography, consensus algorithms, and distributed theory form its core. Cryptography ensures data security, certification, and user anonymity, while consensus mechanisms like proof-of-work secure the network by validating records and maintaining the order of blocks [8]. This architecture guarantees the immutability of stored data, making tampering extremely difficult.

One notable application of blockchain is Non-Fungible Tokens (NFTs), which represent unique, indivisible assets with distinct value and identity. Unlike fungible tokens, each NFT is non-divisible and non-mergeable, making them ideal for representing digital or physical assets with unique characteristics [9]. However, the regulatory landscape for blockchain and cryptocurrencies is evolving, introducing uncertainties and challenges, particularly in addressing issues like illegal money laundering, fraud, and terrorist financing. Scholars emphasize the need for effective regulatory techniques to manage blockchain applications and their ecosystem, recognizing the unique challenges posed by this innovative technology [10].

When applied to a university vehicle sticker system, blockchain can provide an immutable and transparent record of sticker issuance, ownership transfers, and compliance history. This exploration underscores the necessity for a comprehensive understanding of blockchain's core principles and mechanisms for optimal development and implementation in various domains, including administrative processes within educational institutions.

## 2.5 e-Pelekat System in UTHM

The e-Pelekat System implemented at Universiti Tun Hussein Onn Malaysia (UTHM) is an example of a technology-driven approach to managing vehicle stickers [11]. It was used before 2017. The user needs to log in to the system and fill out the form. Once the form is submitted, the user can attend the Security Department counter to obtain the vehicle sticker. However, students need to wait until the vehicle sticker is available at the current semester.

## 2.6 mySikap

MySIKAP is an online system operated by the Malaysian Road Transport Department, commonly known as Jabatan Pengangkutan Jalan (JPJ) Malaysia. This platform facilitates various online transactions, including driving license renewal, summons checking, and road tax renewal, streamlining and digitizing these processes for user convenience [12]. Renewing road tax directly through JPJ has always been an offline thing for all of us. However, the government departmet finally delivers online services during the Covid-19 pandemic. It can be one of the best options to avoid additional fees when renewing car road tax online. The system requires users to log in using their mySIKAP ID and password. It is recommended that users never log in via unknown or suspicious e-mail links and never reveal their user ID and password to any party.

## 2.7 MyEG

MyEG is arguably the most popular option and the pioneer when it comes to offering government-related services online. The platform founded in 2000 has improved over the years with a better user interface and more services being offered, and it is certainly one of the most trusted options when it comes to online road tax and auto insurance renewal. It is a web portal designed to efficiently deliver a range of government services from multiple agencies to the Malaysian public. This online platform has demonstrated its significance by providing round-the-clock services to society. Notably, the web portal recorded over 1,800 transactions per day in the first quarter of 2009, a notable increase from the previous quarter's 1,000 transactions. Additionally, the daily sales of motor insurance premiums through the portal rose from 40 to approximately 60 during the same period [13]. MyEG is committed to safeguarding privacy.

## 2.8 Comparison with the Existing Systems

Table 1 shows the comparison between the existing system; e-Pelekat, mySikap and MyEG and the proposed system Vehicle Sticker System using Blockchain Technology. This table compares the characteristics of the system.

**Table 1** *Comparison between Systems*

| Characteristics of System | e-Pelekat | mySikap | MyEG | Proposed System |
|---|---|---|---|---|
| Login Page | Provided | Provided | Provided | Provided |
| Objectives | To apply stickers for vehicles | To renew road tax | To renew road tax or drive license | To apply stickers for vehicles |
| Target user | UTHM students and staff | Vehicle owner in Malaysia | Vehicle owner in Malaysia | UTHM students and staff |
| Verification with QR Scan | Not Provided | Not Provided | Not Provided | Provided |
| Database | centralized | centralized | centralized | decentralized |
| OTP | Not Provided | Not Provided | Not Provided | Provided |
| Blockchain technology | Not Provided | Not Provided | Not Provided | Provided |

All systems provide a login page, but their primary objectives differ. E-Pelekat focuses on applying stickers, mySikap on road tax renewal, and MyEG on road tax or driving license renewal. In contrast, the proposed system aims to facilitate vehicle sticker applications. The target users vary, with e-Pelekat and the proposed system catering to UTHM students and staff, while mySikap and MyEG serve vehicle owners in Malaysia. The proposed system also provides QR scanning features for verification purposes and OTP for security. Database structures differ, with existing systems using centralized databases and the proposed system employing a decentralized approach with blockchain technology, enhancing transparency and security.

# 3. Methodology

This chapter aims to clarify the adopted methodology, emphasizing the selected software development model. It offers in-depth insights into each phase of the chosen model, presenting a systematic workflow in table form for enhanced clarity. The chosen model, Object-Oriented Software Development Model is a more comprehensive and formalized approach to software development that aligns with the principles of Object-Oriented Programming (OOP). The model incorporates OOP concepts into the entire software development life cycle.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 1-18

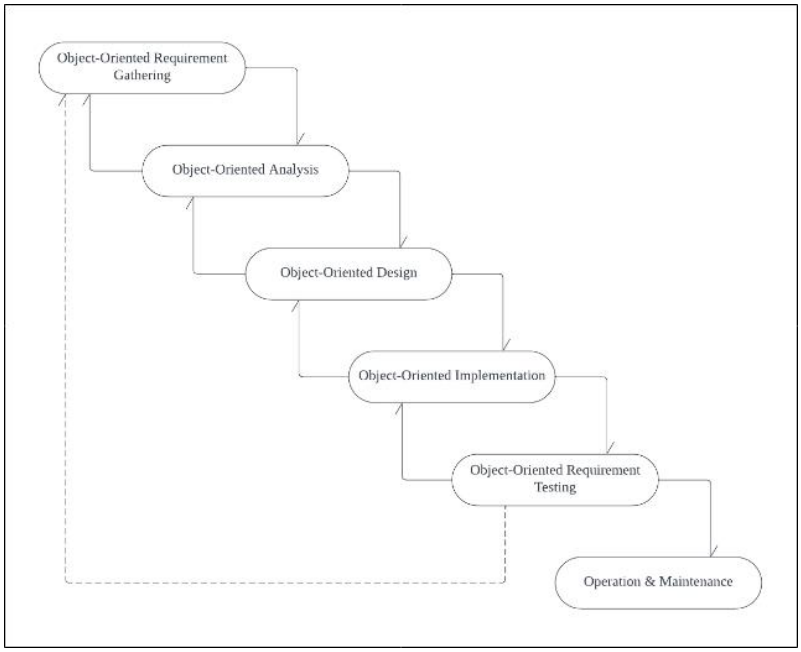



**Fig. 2** *Cycle of Object-Oriented Software Development* [14]

The proposed model for the Vehicle Sticker System adopts a systematic and structured approach to software development, emphasizing the use of object-oriented principles. Object-Oriented Programming (OOP) is favored for its dominant paradigm, prioritizing data structure design before algorithm development. This approach proves logical, especially in dynamic environments where requirements change during development and maintenance [15]. By focusing on designing modular and adaptable data structures (objects), the model aims to create a maintainable system. Algorithms are then developed to operate on these well-defined data structures, aligning with OOP principles. The iterative nature of OOP allows for continuous refinement and improvement, and tools like Unified Modeling Language (UML) will be utilized during the analysis and design phases.

Object-oriented requirement gathering involves identifying key entities and functionalities necessary for the Vehicle Sticker System. This phase includes conducting stakeholder interviews, surveys, and analysing the existing system to define user needs. For instance, the interview form was sent to the Bahagian Keselamatan to gather insights from the security officer regarding questions related to the Vehicle Sticker System. In this phase of Object-Oriented Analysis, the focus is on identifying the core objects, their attributes, and relationships within the system. Objects are tangible entities with stable forms, serving as focal points for thought or action. The development process involves creating visualizations, including class diagrams, use case diagrams, sequence diagrams, activity diagrams, and a system flowchart, using tools like the Lucid application.

Building upon the analysis, detailed designs are created in the object-oriented design phase, outlining the structure of classes, methods, and relationships. This phase focuses on translating the identified objects into a concrete plan for implementation. Additionally, detailed wireframes for modules such as User Registration, Admin, Login and Sticker Application, as well as the system architecture, will be designed using the Lucid Application. The implementation phase involves translating the design into actual code. Adhering to object-oriented programming principles such as encapsulation, inheritance, and polymorphism, the classes and methods are implemented using a suitable programming language which is Java. Coding for the blockchain application, Multi-Factor Authentication (MFA), and encryption will be implemented using the Java language. Furthermore, the web-based system will be designed using Visual Studio Code with HTML and CSS.

In the testing phase, testing strategies include unit testing to validate individual classes, integration testing to ensure components work together seamlessly, and acceptance testing to verify that the system meets the specified requirements. To validate the proposed system, testing will be conducted by students at UTHM and staff from Bahagian Keselamatan. Lastly, post-deployment, ongoing maintenance activities are crucial. This includes addressing issues, incorporating user feedback, and ensuring the system's continued functionality and relevance. The focus is on ensuring the continued functionality and effectiveness of the system. During system operation, it is imperative to implement a robust backup and recovery strategy for both the blockchain data and the associated database. Additionally, as part of maintenance, regular analysis of user feedback should be conducted to identify areas for improvement.

## 4. System Analysis and Design

This section explores systematic analysis and design of the Vehicle Sticker System. The objective is to define system requirements and formulate a well-structured design that incorporates blockchain technology.

### 4.1 System Requirements

System requirements are a detailed description of the functionalities that a system must possess to meet the expectations of its users. Table 2 shows the list of nine functional requirements, Table 3 shows the six categories of non-functional requirements, and Table 4 shows the total of 7 user requirements.

**Table 2** *Functional Requirement*

| Function | Requirements | User |
|---|---|---|
| Register | The system should allow users to register for an account. | Student, Staff, Admin |
| Sticker Apply | The system must facilitate users in applying for a vehicle sticker. | Student, Staff |
| Sticker Renew | The system must provide a mechanism for users to renew their vehicle stickers. | Student, Staff |
| Dashboard | The system must provide an interface for users to view their status. | Student, Staff |
| Notification | The system should have a notification system to keep users informed of the status of their sticker applications. | Student, Staff |
| Feedback | The system should collect feedback from users about their experience with the sticker application and renewal process. | Student, Staff |
| QR Scan | The system should generate the vehicle sticker with a unique QR code. | Student, Staff, Admin |
| Sticker Manage | The system should offer specific functions for administrators responsible for managing sticker applications | Admin |
| Report Generate | The system should allow administrators to search and generate reports on sticker applications and renewals. | Admin |

**Table 3** *Non-Functional Requirement*

| Requirements | Description |
|---|---|
| Security | The system must ensure the security and confidentiality of user and vehicle information. |
| Performance | The system must provide responsive performance to handle simultaneous sticker applications and verifications. |
| Usability | The user interface must be intuitive and user-friendly to ensure ease of use for both applicants and administrators. |
| Reliability | The system must be reliable and available 99.9% of the time. |
| Scalability | The system must be scalable to accommodate an increasing number of users and sticker applications. |
| Compatibility | The system must be compatible with common web browsers and devices. |

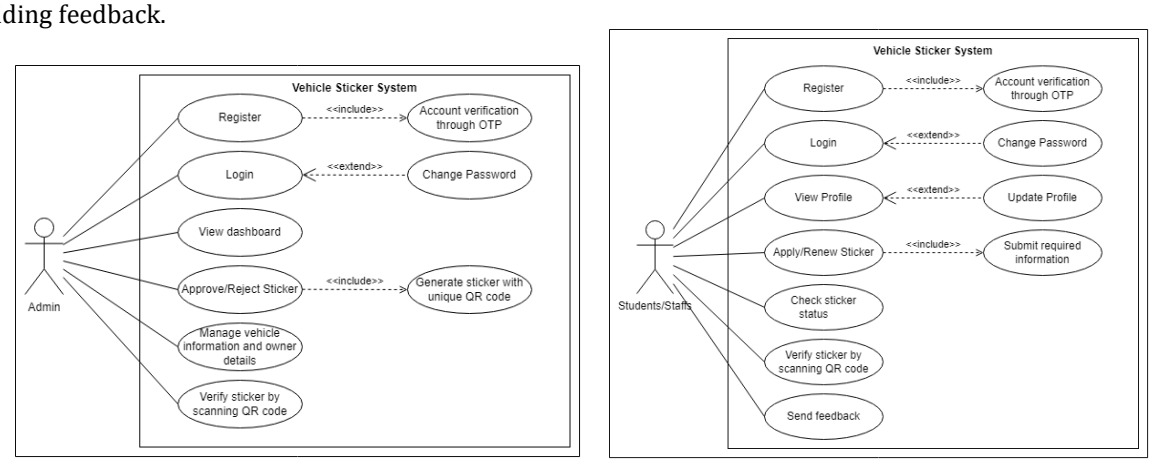
**Table 4** *User Requirement*

| NO | Requirement |
|---|---|
| 1 | Users should be able to register an account on the Vehicle Sticker System. |
| 2 | Users should find the sticker application process intuitive and easy to navigate. |
| 3 | Users should find the sticker application process intuitive and easy to navigate. |
| 4 | Users should receive timely reminders for sticker renewal. |
| 5 | Users should be provided with clear communication regarding the verification process. |
| 6 | Users expect their personal and vehicle information to be treated with the utmost privacy and security. |
| 7 | Users should have access to help resources and support in case they encounter issues. |

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 1-18

## 4.2 System Analysis

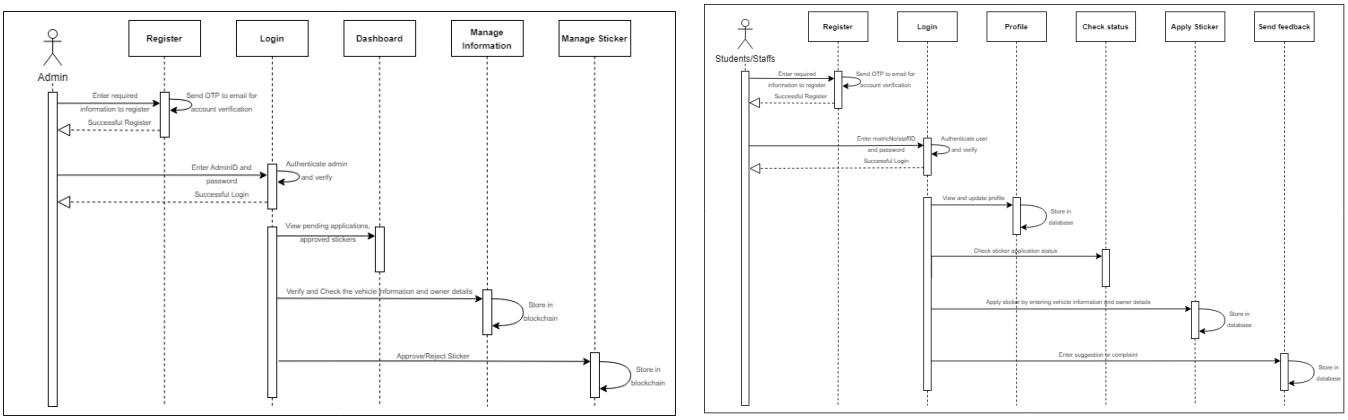
Figure 3(a) illustrates the use-case diagram for the admin. The process begins the admin register an account and verify it by OTP sent from the system. Then, the admin login into the system. Once authenticated, the admin can perform various actions, including viewing the dashboard, approving or rejecting stickers, managing vehicle information and owner details, and verifying stickers by scanning QR codes. In Figure 3(b), the use-case diagram for students or staff is presented. The initial step involves registering into the system and verifying the account through OTP. Following successful login, users can engage in various actions, including viewing their profile, applying or renewing stickers, checking the status of their requests, verifying stickers by scanning QR codes, and providing feedback.




**(a)** **(b)**

**Fig. 3** *Use Case Diagram (a) Admin; (b) Students/Staffs*

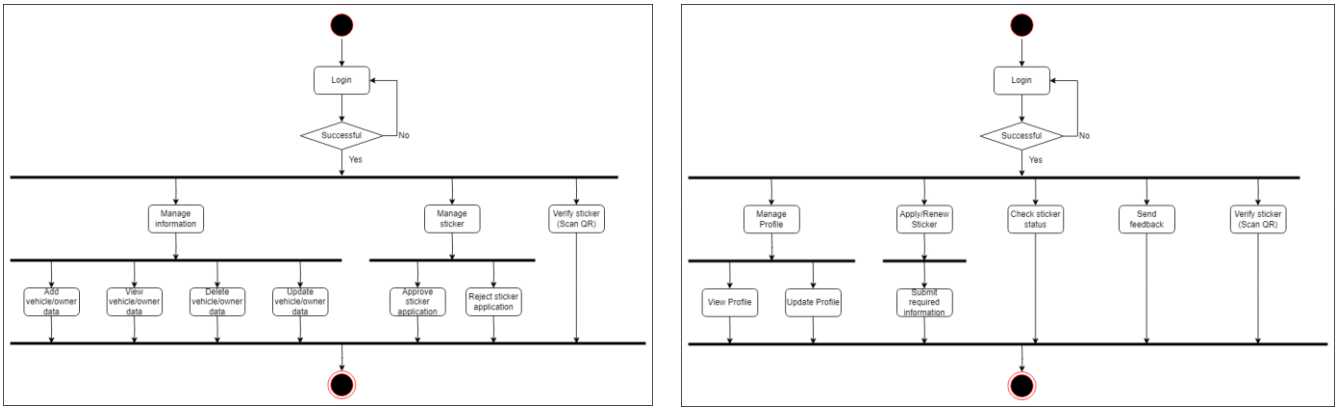
In Figure 4(a), the sequence diagram for the admin is presented. The process initiates with logging in using adminID and password. After authentication, the admin can perform tasks like viewing pending applications, checking vehicle and owner details, and approving or rejecting stickers. Upon approval, data is consolidated and stored in the blockchain. In Figure 4(b), the sequence diagram for students or staff is presented. The login involves matricNo or staffID and password, followed by various activities such as updating profiles, checking application status, applying for stickers, and providing feedback. These diagrams provide a clear representation of the system's functionality and interaction between different components.




**(a)** **(b)**

**Fig. 4** *Sequence Diagram (a) Admin; (b) Students/Staffs*

In Figure 5(a), the activity diagram for the admin illustrates the flow of module activities. Following a successful login, the admin is authorized to manage information, handle sticker-related tasks, and verify stickers by scanning QR codes. In Figure 5(b), the sequence diagram for students or staff is present. For students, the process involves entering matricNo and password, while for staff, staffID and password are entered. The system then verifies and authenticates the user. Upon a successful login, users can choose various activities, including viewing and updating their profile, checking sticker application status, applying for stickers by entering vehicle information and owner details, and submitting suggestions or complaints for feedback.




**(a)** **(b)**

**Fig. 5** *Activity Diagram (a) Admin; (b) Students/Staffs*

Figure 6 shows the class diagram for the Vehicle Sticker System. The class diagram represents the main classes in the system, such as User, Sticker, and Administrator, with their attributes and relationships. There are a total of 10 class diagrams.

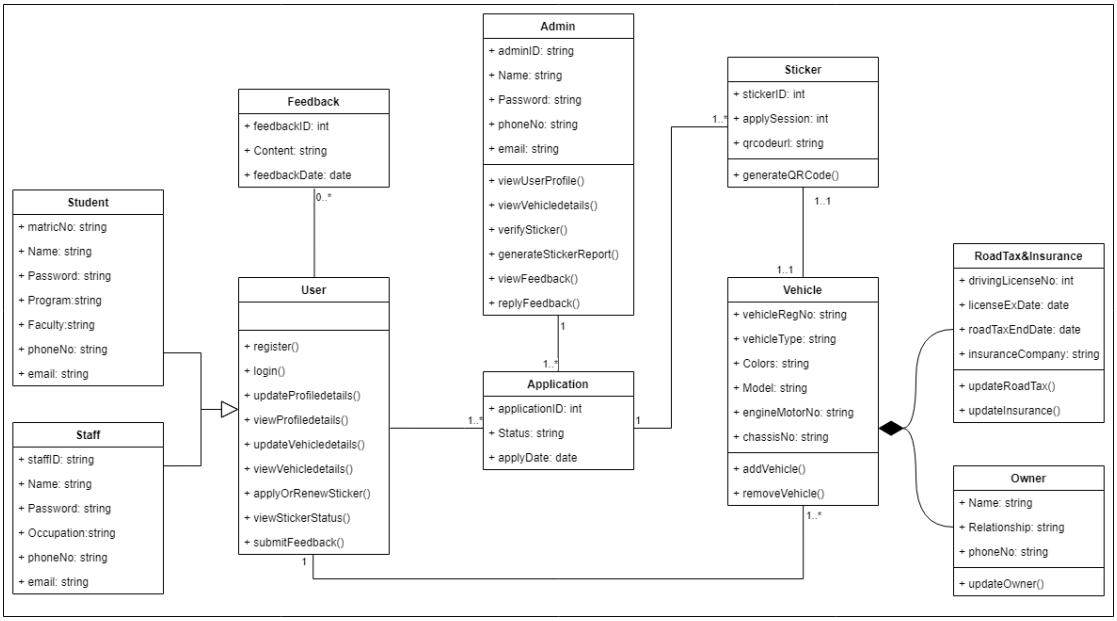



**Fig. 6** *Class Diagram for Vehicle Sticker System*

## 4.3 System Design

The system design depicts the system architecture for the Vehicle Sticker System, outlining the components that constitute the overall structure. The system architecture serves as a visual representation to illustrate both the structure and functionality of the system. Figure 7 shows the architecture design of the proposed Vehicle Sticker System.

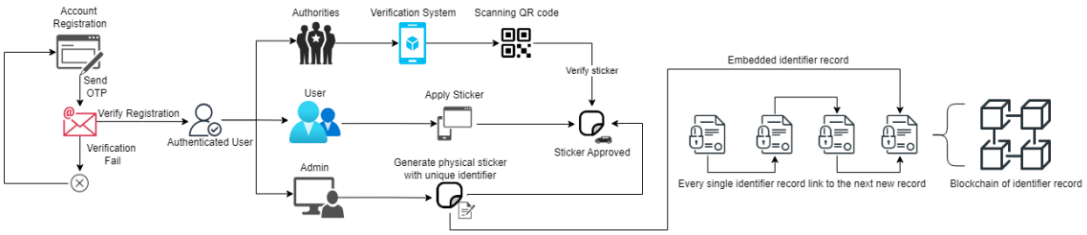



**Fig. 7** *System Architecture of Vehicle Sticker System*

In the Vehicle Sticker System, there are three main user roles: the user, admin, and authorities (Bahagian Keselamatan UTHM). The process begins with account registration for the user and admin. After successful verification through OTP, they become an authenticated user for the system. Then, the user can apply for a sticker through the system. Subsequently, the admin reviews the user's vehicle information and details to decide

whether to approve or reject the sticker application. Upon approval, the system generates a sticker with a unique identifier in the form of QR code. This identifier record is then embedded and linked to the previous record, creating a blockchain of identifier records, ensuring the sticker's authenticity and preventing counterfeiting or forgery. Furthermore, authorities can log in to the system as admins and use the verification system to scan the QR code on the sticker, thereby distinguishing its authenticity.

## 4.4 Interface Design

Figure 8 shows the admin module for the system. The admin can view the dashboard, manage vehicles, manage stickers, navigate to profile, navigate to the feedback list, navigate to QR Scan, and logout at this module.

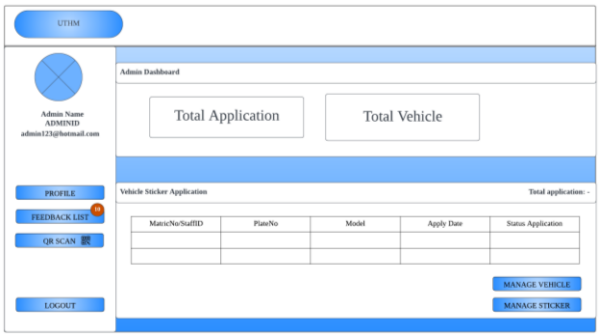



**Fig. 8** *Interface Design*

## 5. Implementation

This chapter discusses the implementation of VSS. The implementation of security modules, user modules, admin module, and blockchain environment will be described clearly.

## 5.1 Implementation of Security Module

This section discusses the security measures implemented in the proposed system. Three key modules have been developed, including input validation and sanitization, strong password authentication and sending OTPs for account verification. To prevent SQL injection attacks, input validation and sanitization are rigorously implemented across all input fields in the system. This includes the registration form, login form, OTP form, profile update form, vehicle registration form, vehicle update form, and feedback form. To avoid malicious attackers might disable JavaScript in the browser, both client and server side have employed this feature for added security. Figure 9(a) illustrates the input validation in JavaScript on the client side while figure 9(b) demonstrate the server-side implementation of input sanitization and validation in PHP.

```javascript
if (name === '') {
  showErrorToast('Name is required');
  valid = false;
} else if (!nameRegex.test(name)) {
  showErrorToast('Name must contain only letters and spaces');
  valid = false;
} else if (email === '') {
  showErrorToast('Email is required');
  valid = false;
} else if (!emailRegex.test(email)) {
  showErrorToast('Invalid email format');
  valid = false;
} else if (phoneNo === '') {
  showErrorToast('Phone Number is required');
  valid = false;
} else if (!phoneRegex.test(phoneNo)) {
  showErrorToast('Phone Number must contain 10 or 11 digits');
  valid = false;
} else if (faculty === '') {
  showErrorToast('Please select a faculty');
  valid = false;
} else if (programme === '') {
  showErrorToast('Please select a programme');
  valid = false;
} else if (occupation === '') {
  showErrorToast('Occupation is required');
  valid = false;
} else if (!occupationRegex.test(occupation)) {
  showErrorToast('Occupation must contain only letters and spaces');
  valid = false;
}
```

**(a)**

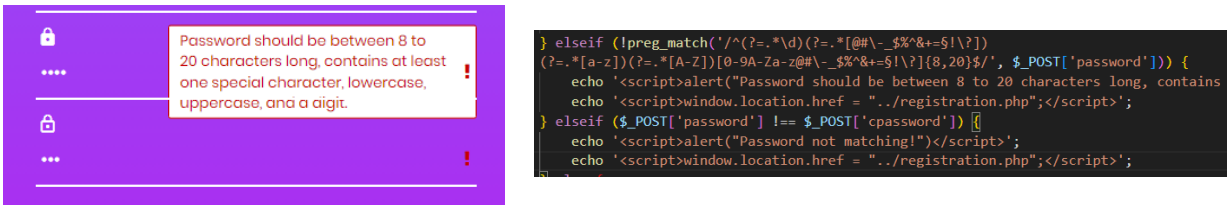
```php
$matricNo = filter_input(INPUT_POST, 'matricNo', FILTER_SANITIZE_FULL_SPECIAL_CHARS);
$name = filter_input(INPUT_POST, 'name', FILTER_SANITIZE_FULL_SPECIAL_CHARS);
$email = filter_input(INPUT_POST, 'email', FILTER_SANITIZE_EMAIL);
$phoneNo = filter_input(INPUT_POST, 'phoneNo', FILTER_SANITIZE_FULL_SPECIAL_CHARS);
$password = password_hash($_POST['password'], PASSWORD_DEFAULT); // Hash the password
    // Validate input
    if (empty($matricNo) || empty($name) || empty($email) || empty($phoneNo) || empty(
        echo '<script>alert("Please fill in all the fields!")</script>';
        echo '<script>window.location.href = "../registration.php";</script>';
    } elseif (!preg_match("/^[A-Z]{2}\d{6}$/", $matricNo)) {
        echo '<script>alert("Incorrect format. Should be 2 capital letters and 6 digi
        echo '<script>window.location.href = "../registration.php";</script>';
    } elseif (!preg_match('/^[a-zA-Z ]{1,200}$/', $name)) {
        echo '<script>alert("Name: Only letters and space allowed!")</script>';
        echo '<script>window.location.href = "../registration.php";</script>';
    } elseif (!filter_var($email, FILTER_VALIDATE_EMAIL)) {
        echo '<script>alert("Incorrect email format!")</script>';
        echo '<script>window.location.href = "../registration.php";</script>';
    } elseif (!preg_match('/^\d{10,11}$/', $phoneNo)) {
        echo '<script>alert("Phone Number: Only 10 or 11 digits mobile numbers allowe
        echo '<script>window.location.href = "../registration.php";</script>';
    } elseif (!preg_match('/^(?=.*\d)(?=.*[@#\-_$%^&+=§!\?])(?=.*[a-z])(?=.*[A-Z])[0-9
        echo '<script>alert("Password should be between 8 to 20 characters long, conta
        echo '<script>window.location.href = "../registration.php";</script>';
    } elseif ($_POST['password'] !== $_POST['cpassword']) {
        echo '<script>alert("Password not matching!")</script>';
        echo '<script>window.location.href = "../registration.php";</script>';
```

**(b)**

**Fig. 9** *Input Validation (a) in JavaScript; (b) and Input Sanitization in PHP*

The proposed system implements strong password authentication to enhance security. Users are required to set passwords that are between 8 and 20 characters in length, and must include at least one special character, one lowercase letter, one uppercase letter, and one digit. Figure 10(a) illustrates the output for users who do not

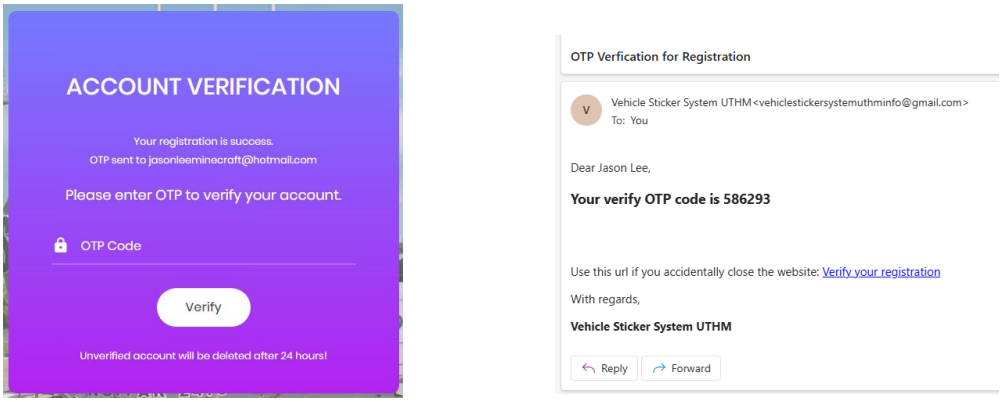
meet the password requirements and figure 10(b) show the code implementation of strong password authentication.




**(a)** **(b)**

**Fig. 10** *Strong Password Authentication (a) Output; (b) Implementation Code*

After a user of any role registers an account, the system automatically sends an OTP to the registered email address. The user is then required to enter the OTP to complete the verification process. Upon successful verification, the system redirects the user to the main page and displays a success message. Figure 11(a) shows the OTP form, while figure 11(b) provides an example of an email sent by the system.




**(a)** **(b)**

**Fig. 11** *(a) Interface of OTP form; (b) OTP Email Sent by System*

## 5.2 Implementation of User Module

The implementation of the user module is the same for both students and staff. The module includes user dashboard, vehicle register form, vehicle update form, profile update form, vehicle sticker apply form, QR scan module and feedback module. Before applying for a sticker, users must first register for a new vehicle. After registering it, users can apply for a sticker by selecting a plate number. The application status will be displayed, with statuses including approved, rejected, pending, and expired. Figure 12 shows the vehicle sticker application form.

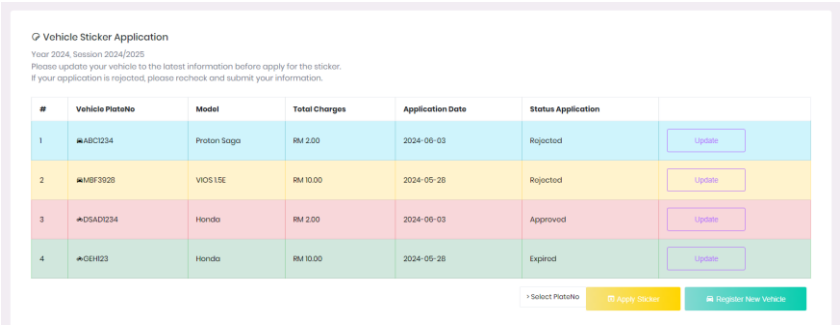
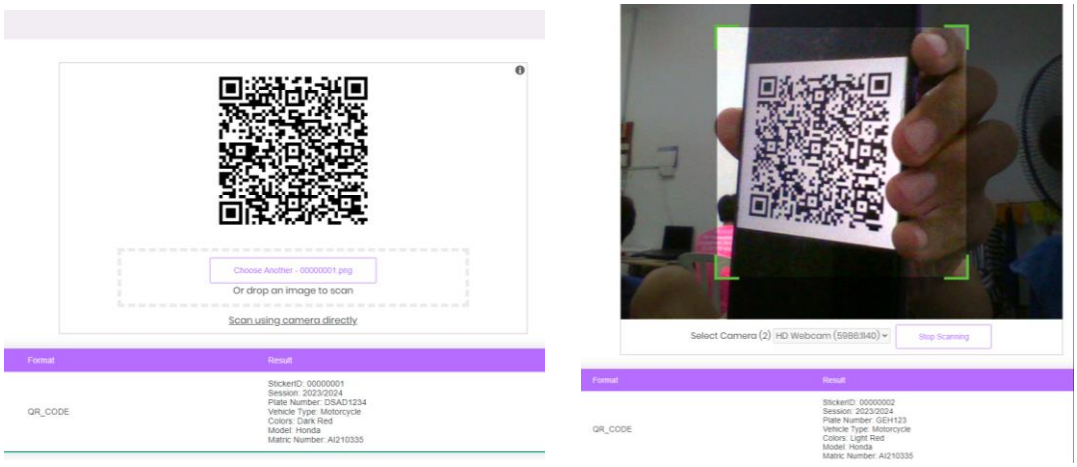



**Fig. 12** *Vehicle Sticker Application Form*

The QR Scan Module provides users with two methods to scan QR codes: uploading an image or using a detected camera on their device for direct scanning. This functionality is also implemented in the admin module. Figure 13(a) shows the upload image method, while figure13(b) demonstrates the camera method.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 1-18




**(a)** **(b)**

**Fig. 13** *QR Scanning (a) Upload Image Method; (b) Camera Method*

## 5.3 Implementation of Admin Module

The implementation of the admin module is designed to manage sticker approvals. The key features include the admin dashboard, sticker application approval or rejection, blockchain integration module, QR Scan module, and feedback list. The admin dashboard displays useful system information, such as the total number of sticker applications, total feedback, total registered users, and total registered vehicles. Figure 14 shows the interface of the admin dashboard.

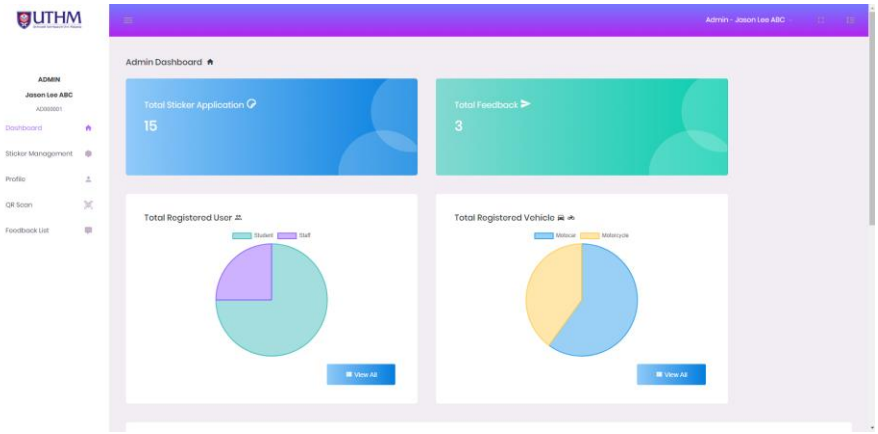



**Fig. 14** *Vehicle Sticker Application Form*

The sticker application approval or rejection module enables the admin to do action on applications submitted by students or staff. The admin can review all relevant details, including personal profiles and vehicle information, to make an informed sticker approval decision. Additionally, the system allows the admin to manually update the year and session. Any stickers that exceed the current session will automatically expire. Figure 15 shows the overview of this module.

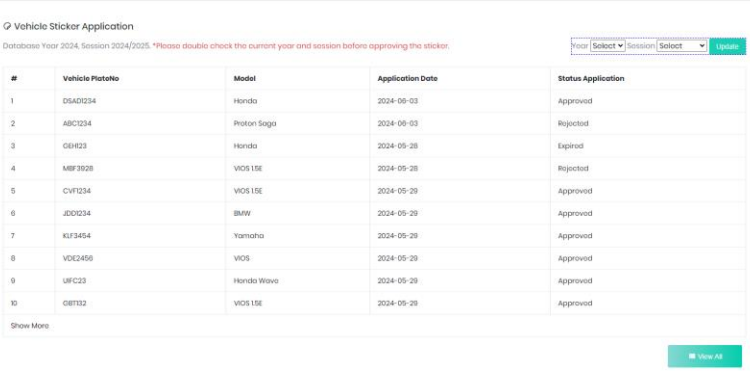



**Fig. 15** *Module of Sticker Application Approval or Rejection*

## 5.4 Implementation of Blockchain Environment

The setup of the blockchain environment involved installing several essential tools, including Ganache for creating a local blockchain, Node.js for backend operations, and the MetaMask extension for Google Chrome to facilitate blockchain interactions. Additionally, the Solidity Extension on Visual Studio Code was installed, as Solidity is the programming language commonly used in blockchain development. Figure 16 illustrates the basic configurations settings such as host IP address, port number, and network ID in Ganache.

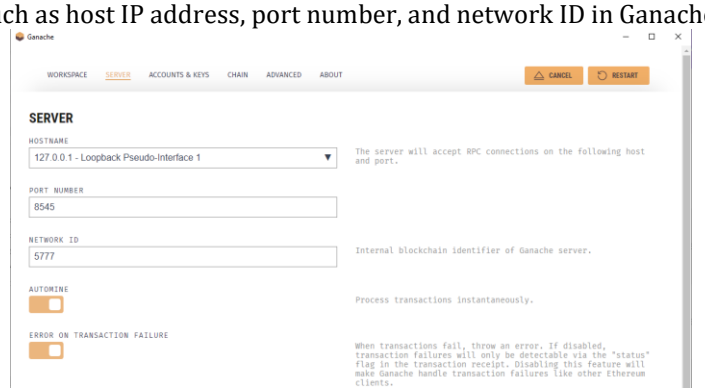



**Fig. 16** *Basic Configuration on Ganache*

Following the installation of Node.js, Visual Studio Code was used to install the Truffle console using npm commands. Truffle is a framework for blockchain development using the Ethereum Virtual Machine (EVM). It provides built-in functionalities for smart contract compilation, linking, deployment, and binary management. The configuration was then set up in the truffle-config.js file to connect Ganache to the localhost web page. Figure 17 demonstrates the connection configuration for Ganache.

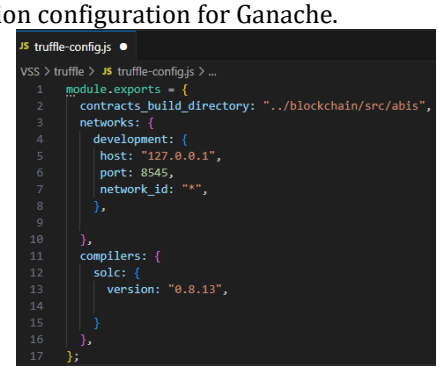
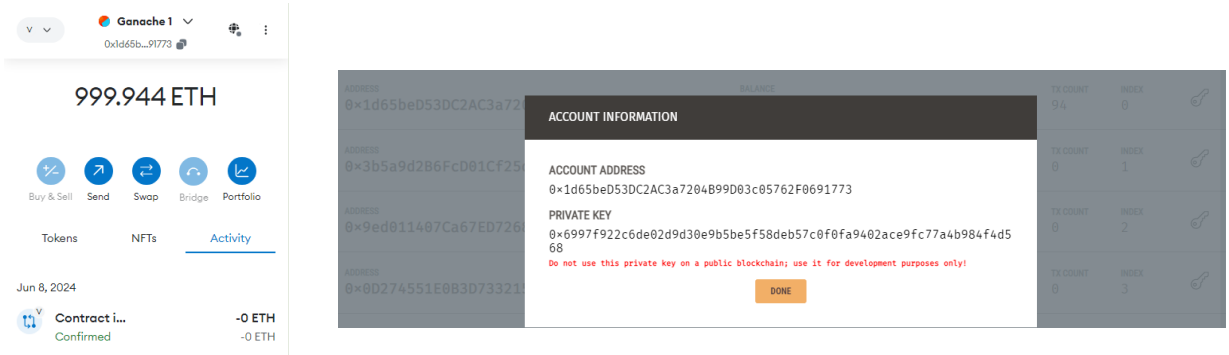



**Fig. 17** *Ganache Connection to Localhost Configuration*

MetaMask enables the system to interact with Ganache by facilitating cryptocurrency transactions. To set up MetaMask, an account from Ganache is imported by entering its private key. Once imported, MetaMask displays the account balance and allows the admin to store data into Ganache by spending gas and mining a block on it. Figure 18(a) shows the imported account from Ganache in MetaMask, while figure 18(b) displays the private key of an account in Ganache.




**(a)** **(b)**

**Fig. 18** *(a) Imported Account on MetaMask; (b) Private Key of an Account in Ganache*

The Inter-Planetary File System (IPFS) is a peer-to-peer distributed file system primarily used for data that cannot be stored directly on a blockchain. For storing PNG files of QR codes, Pinata has been chosen as the IPFS

platform. IPFS pins the PNG file and generates a hash, which is then stored in Ganache. Upon account registration, a free API key is provided for accessing IPFS from localhosts. Figure 19 displays the code for the API key used to configure the connection.

```
const PINATA_JWT = 'eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJ1c2VySW5mb3JtYXRpb24iOnsiaWQiOiJmY2FmYjI2ZC0yNTllLT
```

**Fig. 19** *API Key from Pinata for Connection*

The sticker management module is developed using ReactJS, one of the most flexible front-end frameworks for building blockchain applications. However, since ReactJS use port 3000, some configurations are necessary to transfer data between the Apache port. Figure 20(a) shows the PHP code for data crossing ports, and figure 20(b) displays the configuration of the XAMPP file (httpd.conf).

```php
<?php
//Allow from any origin
if (isset($_SERVER['HTTP_ORIGIN'])) {
    //should do a check here to match $_SERVER['HTTP_ORIGIN'] to a whitelist of safe domains
    if ($_SERVER['HTTP_ORIGIN'] === "http://localhost:3000"){
        header("Access-Control-Allow-Origin: {$_SERVER['HTTP_ORIGIN']}");
        header('Access-Control-Allow-Credentials: true');
        header('Access-Control-Max-Age: 86400');    // cache for 1 day
    }
}
//Access-Control headers are recevied during OPTIONS requests
if ($_SERVER['REQUEST_METHOD'] == 'OPTIONS') {
    if (isset($_SERVER['HTTP_ACCESS_CONTROL_REQUEST_METHOD']))
        header("Access-Control-Allow-Methods: GET, POST, PUT, DELETE, OPTIONS");
    if (isset($_SERVER['HTTP_ACCESS_CONTROL_REQUEST_HEADERS']))
        header("Access-Control-Allow-Headers: {$_SERVER['HTTP_ACCESS_CONTROL_REQUEST_HEADERS']}");
}
```

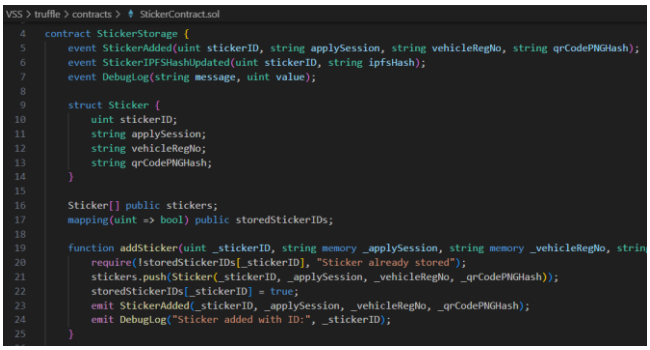
**(a)**

```
<IfModule mod_headers.c>
    Header set Access-Control-Allow-Origin "*"
    Header set Access-Control-Allow-Methods "GET, POST, PUT, DELETE,
OPTIONS"
    Header set Access-Control-Allow-Headers "Content-Type, Authorization"
</IfModule>
```

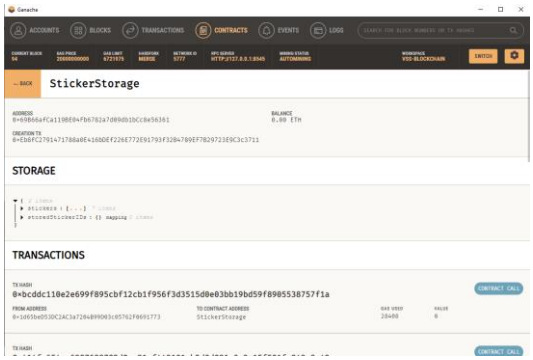
**(b)**

**Fig. 20** *(a) PHP Code for Data Crossing Port; (b) Configuration of XAMPP file for Cross Port*

To enable storing and retrieval from Ganache and uploading to IPFS, a Solidity (SOL) contract is configured and deployed. Figure 21(a) presents the SOL code, while figure 21(b) shows the deployed contract on Ganache.




**(a)**

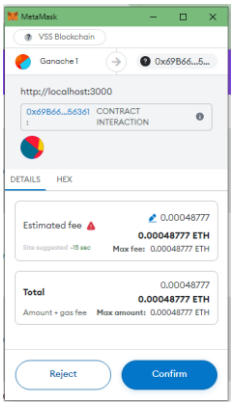



**(b)**

**Fig. 21** *(a) SOL Code for Sticker Storage Contract; (b) Deployed Contract of Sticker Storage on Ganache*

With all required setup and deployed contract, the blockchain integration for the module has been successfully implemented. The admin can now store the sticker information as a string and the hash of the QR Code into Ganache, along with pinning the PNG file on IPFS. Figure 22 to 24 illustrate the process of storing sticker information into the blockchain.

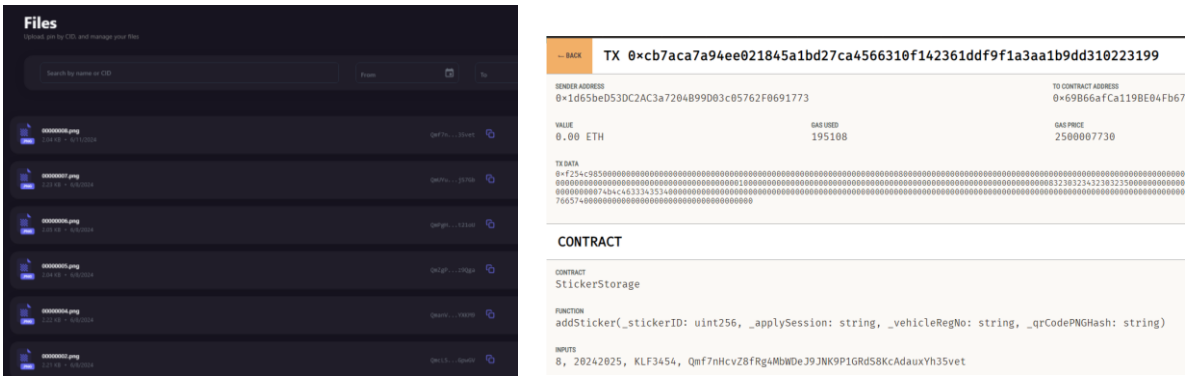

**(a)**




**(b)**

**Fig. 22** *(a) Pressing Button to Store Into Ganache; (b) Pop-Up of MetaMask Asking for Transaction to Store*


**Fig. 23** *Result of Linked QR Code after Confirming Transaction*




**(a)** **(b)**

**Fig. 24** *(a) Result of Pinning PNG on IPFS; (b) Result of Stored Sticker Info and QR Hash in Ganache*

## 6. Results and Discussion

This section discusses the testing results of the proposed system. Two types of testing results are presented: the test plan result and the user acceptance result. The testing phase encompassed the entire system to verify its security and adherence to project requirements.

### 6.1 Test Plan Result

The results of the test plan are presented here. Table 5 displays the result of the functionality test plan, while Table 6 outlines the results of the security test plan.

**Table 5** *Functionality Test Plan Result*

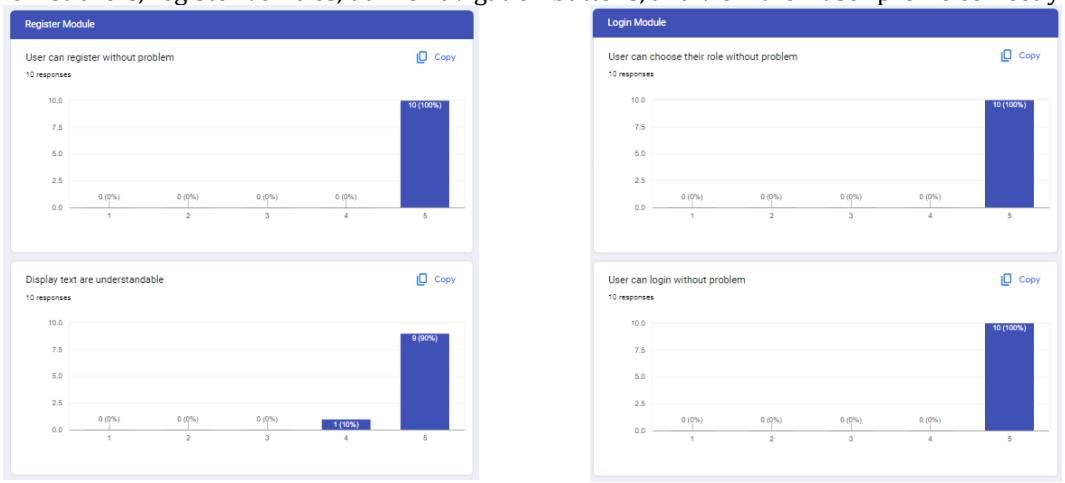
| Check List | Expected Result | Actual Result |
|---|---|---|
| Register (All required input fields are in correct format) | Register successfully and redirect to login module | Pass |
| Login (Input Correct matricNo/staffID/adminID and correct password) | Login successfully and redirect to user/admin module | Pass |
| Login (Input correct matricNo/staffID/adminID and wrong password) | Login fail and display message “Wrong User ID or password, please try again” | Pass |
| Login (Input correct matricNo/staffID/adminID and correct password) | Login fail and display message “Wrong User ID or password, please try again” | Pass |
| Login (Input wrong matricNo/staffID/adminID and wrong password) | Login fail and display message “Wrong User ID or password, please try again” | Pass |
| Feedback (Enter suggestion and click the submit button) | Display message: “Feedback sent successfully” | Pass |
| Profile (Update personal information and click save button | Display message: “Profile saved” | Pass |
| QR Scan (Click the scan button and scan the QR Code on sticker | Display the vehicle and user details such as matricNo and plateNo | Pass |

**Table 6** *Security Test Plan Result*

| Check List | Actual Result |
|---|---|
| User and Admin should be able to register based on their role | Pass |
| User and Admin should be able to login based on their role | Pass |
| User and Admin should be able to login with valid ID and password only | Pass |
| Session is destroyed after logout | Pass |
| Password is obscured in the textbox | Pass |
| Password is obscured in the textbox | Pass |
| Password is obscured in the textbox | Pass |
| Minimum length and maximum length in input field is specified | Pass |

## 6.2 User Acceptance Form Results for User Module

The results of the user acceptance form for the user module are presented below. The purpose of conducting this testing was to gather user experiences from the user's perspective while using the system. The test was implemented based on each module provided within the user module. The target users are the students of UTHM. Figure 25(a) indicates that 10 responders felt very satisfied with the registration process, while 9 respondents felt very satisfied, and 1 respondent felt satisfied with the clarity of the displayed text. Figure 25(b) demonstrates that 10 respondents were very satisfied with their ability to choose their role and login without any issues. Figure 26 shows that 10 respondents were very satisfied with their ability to view sticker status, apply for new stickers, register vehicles, utilize navigation buttons, and view their user profile correctly.




**(a)** **(b)**

**Fig. 25** *Result (a) Register Module; (b) Login Module*


**(a)** **(b)**

**Fig. 26** *Result of User Module*

Figure 27(a) reveals that 10 respondents were very satisfied with their ability to view and update their profile, and figure 27(b) indicates that 10 respondents were very satisfied with their ability to submit suggestions without any issues. Figure 28(a) shows that 10 respondents were very satisfied with their ability to scan QR codes. Figure 28(b) shows that the 10 respondents were very satisfied with the overall system usage. Additionally, 9 respondents were very satisfied, and 1 respondent was satisfied with the user-friendly interface.


**(a)** **(b)**

**Fig. 27** *Result (a) User Profile; (b) Feedback Module*


**(a)** **(b)**

**Fig. 28** *Result (a) QR Scan Module; (b) Overall System*

## 6.3 User Acceptance Form Result for Admin Module

The results of the user acceptance test for the admin module are presented on Table 7. This testing was conducted to gather user feedback from the admin's perspective. The form was filled out by the Security Officer at Bahagian Keselamatan. Table 7 summarizes the responses from Bahagian Keselamatan. The results indicate that the admin was satisfied with the registration process, finding it straightforward and the displayed text easy to understand. Regarding the login module, the admin was very satisfied with the role selection process but felt neutral about the login function, as the OTP was not received at the registered email address. The admin expressed high satisfaction with the dashboard view, vehicle details management, and profile display. They were also satisfied with the sticker approval process and the functionality of the navigation buttons. Furthermore, the admin was very satisfied with the sticker storage in the blockchain. For the feedback list module, the admin was satisfied with the viewing and replying to functions. They felt neutral about the QR code scanning module. Finally, the admin was neutral about the overall system but very satisfied with the user-friendly interface. Additionally, they suggested that the system should include dual language support.

**Table 7** *User Acceptance Form Result for Admin Module*

| No | Question | Result |
|---|---|---|
| | | Dissatisfied 1 – 5 Satisfied |
| **Register Module** | | |
| 1 | Admin can register without problem | 4 |
| 2 | Display text are understandable | 4 |
| **Login Module** | | |
| 3 | Admin can choose their role without problem | 5 |
| 4 | Admin can login without problem | 3 |
| **Admin Module** | | |
| 5 | Admin can view dashboard clearly | 5 |
| 6 | Admin can manage the vehicle details | 5 |
| 7 | Admin can approve or reject sticker | 4 |
| 8 | All navigate buttons are functioning | 4 |
| 9 | Admin profile is displayed correctly | 5 |
| **Admin Profile** | | |
| 10 | Admin can view their profile | 4 |
| 11 | Admin can update their profile | 4 |
| **Sticker Management Module** | | |
| 12 | Admin can approve sticker application without problem | 4 |
| 13 | Admin can reject sticker application without problem | 4 |
| 14 | Admin can store sticker information into blockchain and upload PNG file to IPFS | 5 |
| **Feedback List Module** | | |
| 15 | Admin can view the list without problem | 4 |
| 16 | Admin can reply the feedback without problem | 4 |
| **QR Scan Module** | | |
| 17 | Admin can scan the QR Code on sticker | 3 |
| **Overall System** | | |
| 18 | Admin can use the system without problem | 3 |
| 19 | The interface is user-friendly | 5 |

## 7. Conclusion

In summary, the Vehicle Sticker System using Blockchain Technology has been developed with complete functionality. The system successfully fulfills the objectives defined in the project scope, system requirements, and user requirements.

The Vehicle Sticker System offers a few advantages which are the system hashes passwords in the database for enhancing security, sends OTPs for account verification for ensuring user authenticity, generates a unique QR code based on plate number, user ID and application session, scans QR code and display the corresponding information, and stores the QR code data into Ganache to avoid forgery sticker.

However, there are also disadvantages on the system which are the verification of sticker integrity on the blockchain is implemented manually, Pinata IPFS has limited file storage capacity, and storing strings and sticker hashes is done one by one, which slows down transaction confirmations.

Based on the analysis of the system's advantages and disadvantages, there are the following improvements can be made to the Vehicle Sticker System. Firstly, improve the speed of transaction confirmations. Then, implement secure code on cross-port interfaces. Furthermore, develop a search function for blockchain integration to simplify integrity verification.

## Acknowledgement

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support.

## References

[1] Z. Ding and W. Mo, "Vehicle sticker recognition based on multi-feature encoding and feature matrix distance," in *2017 6th International Conference on Computer Science and Network Technology (ICCSNT)*, 2017, pp. 443–448. doi: 10.1109/ICCSNT.2017.8343736.

[2] A. Abuhashim and C. C. Tan, "Smart Contract Designs on Blockchain Applications," in 2020 IEEE Symposium on Computers and Communications (ISCC), 2020, pp. 1–4. doi: 10.1109/ISCC50000.2020.9219622.

[3] D. Magazzeni, P. McBurney, and W. Nash, "Validation and Verification of Smart Contracts: A Research Agenda," Computer (Long Beach Calif), vol. 50, no. 9, pp. 50–57, 2017, doi: 10.1109/MC.2017.3571045.

[4] L. Zhao, T. Wen, H. Wang, and W. Pang, "Research on smart contract evaluation method for open source blockchain," in 2023 3rd International Symposium on Computer Technology and Information Science (ISCTIS), 2023, pp. 475–479. doi: 10.1109/ISCTIS58954.2023.10213088.

[5] H. Rtibi and S. Elloumi, "Robust decentralized nonlinear control for multimachine power systems," in 2017 International Conference on Advanced Systems and Electric Technologies (IC_ASET), 2017, pp. 473–480. doi: 10.1109/ASET.2017.7983739.

[6] H. Takahashi and U. Lakhani, "Implementation of Smart Contract on Autonomous Decentralized Voting Blockchain," in 2023 IEEE 15th International Symposium on Autonomous Decentralized System (ISADS), 2023, pp. 1–7. doi: 10.1109/ISADS56919.2023.10092152.

[7] Z. Wang, L. Yang, Q. Wang, D. Liu, Z. Xu, and S. Liu, "ArtChain: Blockchain-Enabled Platform for Art Marketplace," in 2019 IEEE International Conference on Blockchain (Blockchain), 2019, pp. 447–454. doi: 10.1109/Blockchain.2019.00068.

[8] M. Xie, Z. Liao, and L. Huang, "Data Security Based on Blockchain Digital Currency," in 2020 3rd International Conference on Smart BlockChain (SmartBlock), 2020, pp. 5–10. doi: 10.1109/SmartBlock52591.2020.00009.

[9] K. B. Muthe, K. Sharma, and K. E. N. Sri, "A Blockchain Based Decentralized Computing And NFT Infrastructure For Game Networks," in 2020 Second International Conference on Blockchain Computing and Applications (BCCA), 2020, pp. 73–77. doi: 10.1109/BCCA50787.2020.9274085.

[10] P. Shen et al., "A Survey on Safety Regulation Technology of Blockchain Application and Blockchain Ecology," in 2022 IEEE International Conference on Blockchain (Blockchain), 2022, pp. 494–499. doi: 10.1109/Blockchain55522.2022.00076.

[11] "PELEKAT UTHM." Accessed: Nov. 27, 2023. [Online]. Available: https://pelekat.uthm.edu.my/Siswa/index

[12] G. Obunadike and A. Ahmad, "Usability Evaluation of a Web-Based Portal (Mysikap) Using ISO 9241-11 Model." [Online]. Available: https://www.researchgate.net/publication/358977209

[13] K. Nasir, N. H. M. Ariffin, and F. M. Shuib, "User interface design using cognitive approach: A case study of Malaysian government web portal," in 2010 International Conference on User Science and Engineering (i-USEr), 2010, pp. 174–178. doi: 10.1109/IUSER.2010.5716746.

[14] G. Pomberger, W. Bischofberger, D. Kolb, W. Pree, and H. Schlemm, "Prototyping-Oriented Software Development - Concepts and Tools," Structured Programming, vol. 12, Dec. 1998.

[15] A. N. Dunlop, "MODERN OBJECT-ORIENTED SOFTWARE DEVELOPMENT," *1997 CERN SCHOOL OF COMPUTING*, p. 143, 1997.