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# UTHM Student Attendance System Using Blockchain Technology

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**Abstract**

The Universiti Tun Hussein Onn Malaysia (UTHM) Student Attendance System using Blockchain Technology is designed to enhance the efficiency, data integrity, and traceability of student attendance records. Traditional attendance systems often face issues such as data manipulation and inaccuracies. By integrating blockchain technology, the system ensures immutable and transparent attendance records. The project employs the Prototyping Model, which facilitates iterative development through planning, analysis, design, implementation, and testing phases. The system's core is built using PHP, JavaScript, and Ethereum smart contracts to securely log attendance data. The system is implemented at UTHM to replace conventional methods. The outcome of this system is a robust platform that mitigates fraudulent records, improves data accuracy, and streamlines administrative tasks, benefiting both students and lecturers.

## 1. Introduction

Attendance tracking plays a vital role in academic institutions as it directly influences student performance, compliance, and administrative policies. At Universiti Tun Hussein Onn Malaysia (UTHM), the current attendance tracking system, SMAP UTHM, utilizes Quick Response (QR) code technology to streamline the attendance process [1]. This system, while efficient, is centralized, making it vulnerable to security risks, data manipulation, and breaches. The reliance on a single database exposes attendance records to potential unauthorized access and tampering, which compromises the integrity of the data. Furthermore, students have been known to exploit this system by sharing QR codes, allowing others to mark attendance on their behalf, leading to inaccurate records and undermining the institution's policies [2].

To address these issues, this project introduces a blockchain-based attendance tracking system designed to enhance the integrity and transparency of attendance data at UTHM. Blockchain technology offers a decentralized and tamper-resistant solution, ensuring that attendance records maintain integrity because all the transactions are recorded [3]. By integrating QR code scanning with blockchain, lecturers will generate unique QR codes for each session, which students will scan to confirm their attendance. This data will be immediately encrypted and stored on the blockchain, providing an immutable record that is resistant to fraudulent activities. The decentralized nature of blockchain ensures that no single entity can manipulate the data, promoting trust and accountability in the system.

The primary objective of this project is to develop a web-based attendance tracking system that addresses the limitations of the existing SMAP UTHM platform. The blockchain-based approach is expected to mitigate the risks associated with centralized databases, providing an efficient and secure method for recording and

verifying attendance data. Additionally, the system aims to foster a sense of responsibility among students by making fraudulent practices detectable and traceable [4].

This project specifically targets UTHM's academic ecosystem, involving students, lecturers, and university administrators. Lecturers will be responsible for generating QR codes and monitoring attendance, while students will use their devices to scan the codes. Administrators will oversee user accounts and ensure smooth operation of the system. Blockchain's transparency and immutability will ensure that all parties have confidence in the accuracy of attendance records, addressing the shortcomings of the current system and setting a new standard for attendance tracking at UTHM.

The outcome of this project is the successful deployment of a blockchain-based attendance tracking system that significantly reduces the risk of data manipulation and fraudulent attendance. By leveraging the immutable and decentralized properties of blockchain, this system will enhance the integrity attendance records, ultimately contributing to improved academic management and fostering trust between faculty and students.

## 2. Related Work

This section describes the literature review related to student attendance system, blockchain architecture, blockchain technology and existing comparative system. The goal of literature review is to understand and discuss the project background related to management system and blockchain.

### 2.1 Traditional Attendance Tracking System

Traditional attendance tracking methods in educational institutions have largely relied on manual processes, such as paper sign-in sheets and roll calls. While these methods are straightforward, they are often prone to human errors, including missed entries and inaccuracies, which can compromise the integrity of attendance records [5]. Additionally, these manual systems are time-consuming and inefficient, particularly for large classes, leading to administrative challenges. Physical records are also susceptible to being lost, damaged, or altered, which raises concerns about data integrity. To address some of these limitations, many institutions have adopted digital solutions like RFID scanners and QR code systems [5]. However, these centralized digital systems are not without flaws. They remain vulnerable to unauthorized access, data manipulation, and single points of failure, which can jeopardize data security and reliability. This highlights the need for a more secure and efficient solution, paving the way for technologies like blockchain to enhance attendance tracking.

### 2.2 QR Code-Based Attendance Systems

QR code-based attendance systems are widely adopted in educational institutions due to their simplicity, cost-effectiveness, and ability to automate attendance tracking. These systems allow students to scan a QR code presented by the lecturer using their mobile devices, instantly registering their attendance. This approach reduces manual work, minimizes errors, and accelerates the process, particularly in large classes or events. Additionally, QR code systems provide real-time data collection, enabling instant access to attendance records for reporting and analysis [6].

Despite their advantages, QR code systems face challenges such as proxy attendance, where students share QR codes to falsely register attendance for others. This compromises the system's accuracy and integrity [7]. Moreover, since most QR code systems rely on centralized databases, they are vulnerable to unauthorized access, data breaches, and potential system failures. To mitigate these issues, integrating QR code systems with blockchain technology is gaining traction. Blockchain's decentralized, tamper-proof structure can enhance data security and ensure attendance records are immutable and verifiable, creating a more robust and reliable attendance tracking solution.

### 2.3 Blockchain Technology

Blockchain technology is renowned for providing secure, decentralized, and tamper-proof solutions for data management. It operates as a distributed ledger, recording transactions across a network of computers, making data alteration or deletion nearly impossible once recorded. The technology relies on decentralized storage, consensus algorithms, and cryptography to ensure the security and integrity of data. Each block of data is linked sequentially, with a cryptographic hash connecting it to the previous block, forming a secure and continuous chain of records [7].

A major advantage of blockchain is its decentralized structure, eliminating the need for a central authority to validate transactions. This reduces the risk of single points of failure and enhances system resilience against attacks [8]. In contrast to traditional systems where data is stored on a single server, blockchain distributes data across multiple nodes, ensuring all participants have a copy of the ledger. This enhances transparency and trust, as any changes to the data are visible to all users within the network. Additionally, key management plays a

crucial role in blockchain security, ensuring cryptographic keys used for signing transactions are securely generated, stored, and protected.

Blockchain's versatility extends to smart contracts, which are self-executing agreements with pre-coded rules that automatically trigger actions when conditions are met. These smart contracts reduce the need for intermediaries and minimize human error [6]. Beyond cryptocurrencies, blockchain applications span various sectors, including finance, healthcare, supply chain, and education. Educational institutions, for example, are adopting blockchain to securely manage academic records, issue digital certificates, and track attendance. Despite its benefits, blockchain faces challenges such as scalability, energy consumption, and regulatory compliance. However, ongoing advancements, like proof-of-stake and sharding, aim to address these limitations and improve scalability, making blockchain a promising solution for the future [8]

## 2.4 Smart Contracts

Smart contracts are automated agreements written in code that execute transactions on blockchain networks when predefined conditions are met. This eliminates the need for intermediaries, reducing errors and enhancing efficiency across sectors like finance, supply chain, and digital verification [9]. By leveraging blockchain's decentralized structure, smart contracts ensure transparency and security, making them ideal for enforcing agreements without relying on central authority. This trustless environment enhances data integrity, minimizing the risk of manipulation or fraud.

Despite their benefits, smart contracts face challenges in validation and verification. Errors or vulnerabilities in the code can lead to unexpected outcomes or security breaches, underscoring the need for rigorous testing and evaluation [10]. Researchers have developed methods to assess the quality and security of smart contracts by analyzing performance and compliance with standards. This is particularly useful for applications like attendance systems in educational institutions, where smart contracts can automate record-keeping and protect data integrity, ensuring accurate and tamper-proof attendance tracking.

## 2.5 QR Code Integration with Blockchain

Integrating QR code technology with blockchain offers a secure and efficient solution for attendance tracking in educational institutions. QR codes are commonly used due to their simplicity, allowing students to mark attendance by scanning a code. However, traditional QR code systems face issues like proxy attendance, where students share QR codes with peers, leading to fraudulent records. Blockchain addresses this by creating an immutable ledger, ensuring that attendance records cannot be tampered with or altered [11].

By combining QR codes with blockchain, the strengths of both technologies are utilized. QR codes provide fast data capture, while blockchain guarantees data integrity by securely logging each attendance record on a decentralized ledger. This process ensures that once a QR code is scanned, the record is permanently stored and cannot be changed, offering transparency for both students and faculty to verify attendance in real-time.

Additionally, smart contracts can automate the attendance process. When a QR code is scanned, smart contracts can verify the student's identity and instantly record the data on the blockchain. This reduces the administrative workload for lecturers and ensures accurate, reliable attendance records. This integration not only enhances security but also streamlines attendance management, making it an attractive solution for universities seeking to modernize their systems [12].

## 2.6 SMAP UTHM

Sistem Maklumat Akademik Pelajar (SMAP) is Universiti Tun Hussein Onn Malaysia's official system for managing student records and tracking attendance. The system uses QR codes generated by lecturers for each class, allowing students to scan and mark their attendance efficiently. Attendance data is stored in a centralized database managed by the university. SMAP UTHM also provides reporting features, enabling lecturers to monitor and generate attendance summaries for academic purposes. Students must log in with their university credentials to access the system, ensuring only registered users can participate. The system is mobile-friendly, allowing QR codes to be scanned using smartphones for convenience. Despite its benefits, SMAP UTHM faces challenges like security risks and proxy attendance, where students share QR codes with others to mark false attendance [13].

## 2.7 UFUTURE UiTM

UFUTURE is an online learning platform developed by Universiti Teknologi MARA (UiTM) to enhance digital and blended learning. The platform supports lectures, assignments, quizzes, and attendance tracking, providing comprehensive learning experience. A key feature is the QR code-based attendance system, where lecturers generate QR codes for each class. Students scan the codes with their mobile devices, and attendance is automatically recorded. UFUTURE allows real-time attendance monitoring, enabling lecturers to track student

participation during live and virtual sessions. The platform is accessible via web and mobile devices, making it convenient for students to attend classes and access materials from anywhere. UFUTURE also includes data analytics tools to analyze attendance and track student engagement. However, the system relies on a centralized database, making it vulnerable to security risks and proxy attendance, where students share QR codes to falsify attendance [14].

## 2.8 Comparison with the Existing System

Table 1 shows the comparison between the existing system SMAP UTHM, UFUTURE UiTM and the proposed system UTHM Student Attendance System using Blockchain Technology. This table compares the characteristics of the system.

**Table 1** *System's Comparison*

| Features | SMAP UTHM | UFUTURE UiTM | Proposed system |
|---|---|---|---|
| Technology | Centralized Database | Centralized Database | Decentralized Blockchain |
| Attendance Method | QR Code Scanning | QR Code Scanning | QR Code with Blockchain Integration |
| Data Storage | Centralized Database at UTHM | Centralized Database at UiTM | Distributed Ledger |
| User Access | Web and Mobile Compatible | Web and Mobile Compatible | Web and Mobile Compatible |
| Target User | UTHM Students and Staff | UiTM Students and Staff | UTHM Students and Staff |
| Immutable | No | No | Yes |
| Traceable Transaction | No | No | Yes |

Table 1 compares three attendance systems: SMAP UTHM, UFUTURE UiTM, and the proposed blockchain-based system. Both SMAP UTHM and UFUTURE UiTM rely on centralized databases and QR code scanning for attendance, which leaves them vulnerable to data manipulation and security risks. In contrast, the proposed system integrates blockchain technology, offering a decentralized and immutable distributed ledger for storing attendance records. This approach enhances data integrity, ensuring transactions are traceable and tamper-proof.

While all systems provide web and mobile compatibility for user access, the proposed system introduces QR code integration with blockchain to mitigate proxy attendance and unauthorized data changes. This innovation makes the system more secure and transparent, addressing the weaknesses present in the current centralized systems used at UTHM and UiTM.

## 3. Methodology

This section explains the methodology used to develop the UTHM Student Attendance System Using Blockchain. Selecting the appropriate methodology is crucial for ensuring a systematic and efficient approach to completing the project. For this system, the Agile methodology has been adopted due to its iterative and flexible nature, which allows continuous feedback and improvement during development. This section also discusses the phases of the methodology, project planning, and tools or techniques employed in the system's development. Each phase in the methodology is designed to address specific objectives, ensuring the successful completion of the project.


**Fig. 1** *Agile Model*

In the Requirements Phase, the project objectives, scope, and needs are established by gathering input from key stakeholders, including students and lecturers. This phase involves analyzing existing systems like SMAP UTHM and UFUTURE to identify gaps and areas for improvement. The tools and technologies, such as blockchain frameworks, PHP, and QR code integration, are selected, and risks like data security and compatibility are assessed. A detailed project plan outlines timelines, resources, and milestones.

The Design Phase focuses on translating requirements into system specifications. Wireframes and prototypes are developed using tools like draw.io and Figma, providing a blueprint for the user interface and user experience. Key design elements, including database structures and blockchain architecture, are crafted with the creation of diagrams such as Use Case and Sequence Diagrams. This phase ensures a clear vision of how components interact and prepares the system for development.

During the Development Phase, the designs are transformed into a functioning system. Front-end development follows UI wireframes, while the blockchain backend is integrated to ensure secure attendance tracking. Smart contracts are created to manage attendance records, providing immutability and transparency. QR code functionality is also embedded to facilitate easy attendance registration. This phase involves rigorous coding and system-building.

The Testing Phase ensures the system functions as intended through multiple testing stages, including unit, integration, system, and user acceptance testing (UAT). These tests identify bugs, verify interactions between modules, and confirm the reliability of blockchain components. Real users, such as students and lecturers, participate in testing to validate usability and performance, ensuring the system meets all requirements.

In the Deployment Phase, the completed system is launched and made accessible to users. The web platform and blockchain components are activated, and smart contracts are deployed. Attendance data is securely logged on the blockchain. Training materials and user guides are provided to facilitate smooth onboarding. System performance is monitored post-launch, with updates and fixes implemented as needed.

The Review Phase serves as the final checkpoint for each development cycle. Stakeholders review the system's performance, providing feedback for continuous improvement. Demonstrations are conducted, and adjustments are made based on user input to refine features for future iterations. This phase emphasizes collaboration and ensures the system evolves to meet user needs.

## 4. System Analysis and Design

This section explores systematic analysis and design of the Student Attendance 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 six functional requirements, Table 3 shows the six categories of non-functional requirements, and Table 4 shows the total of six user requirements.

**Table 2** *Functional Requirement*

| Function | Functionality | User |
|---|---|---|
| Register | The system should allow users to register for an account | Admin |
| Login | The system shall allow authorized accounts to allow login into the system. | Admin, Lecturer, Student |
| Home | User can view the main menu to use the system | Admin, Lecturer, Student |
| QR Code Generation | Generate a unique QR code for each class session based on lecturer inputs. | Lecturer |
| QR Scan | Allow students to scan QR codes to mark attendance. | Student |
| Attendance Monitoring | Provide lecturers with access to attendance reports for academic evaluation. | Lecturer |

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

| Requirements | Description |
|---|---|
| Performance | The system must process QR code scans and store data on the blockchain within 5 seconds. |
| Security | Attendance data must be encrypted before storage on the blockchain. |

**Table 3** *(cont.)*

| Requirements | Description |
|---|---|
| Usability | The user interface should be simple, intuitive and user friendly for ease use. |
| Scalability | The system must handle attendance tracking for multiple classes and sessions simultaneously. |
| Reliability | The system must ensure 99% uptime, particularly during peak usage times. |
| Compliance | The system must comply with data protection standards to safeguard sensitive student data. |

**Table 4** *User Requirement*

| No | Requirement |
|---|---|
| 1 | Students should be able to scan QR codes to mark their attendance quickly and efficiently. |
| 2 | Lecturers should find the QR code generation process intuitive and easy to use. |
| 3 | Student and Lecturer should receive real-time confirmation of attendance submissions or QR code generation status. |
| 4 | Lecturers and administrators should have easy access to attendance reports and data for evaluation. |
| 5 | Administrators should be able to configure system settings and manage user roles effectively. |
| 6 | The system should ensure user privacy and security, protecting sensitive data such as attendance records. |

## 4.2 Context Diagram

A context diagram is a diagram that represents the entire system. The purpose of this diagram is to show the expected inputs and outputs from the system. This context diagram was created based on the user of the system perspective. There are three factors involved which are Admin, Students and Lecturer. Fig. 2 shows the context diagram of UTHM Student Attendance System Using Blockchain.

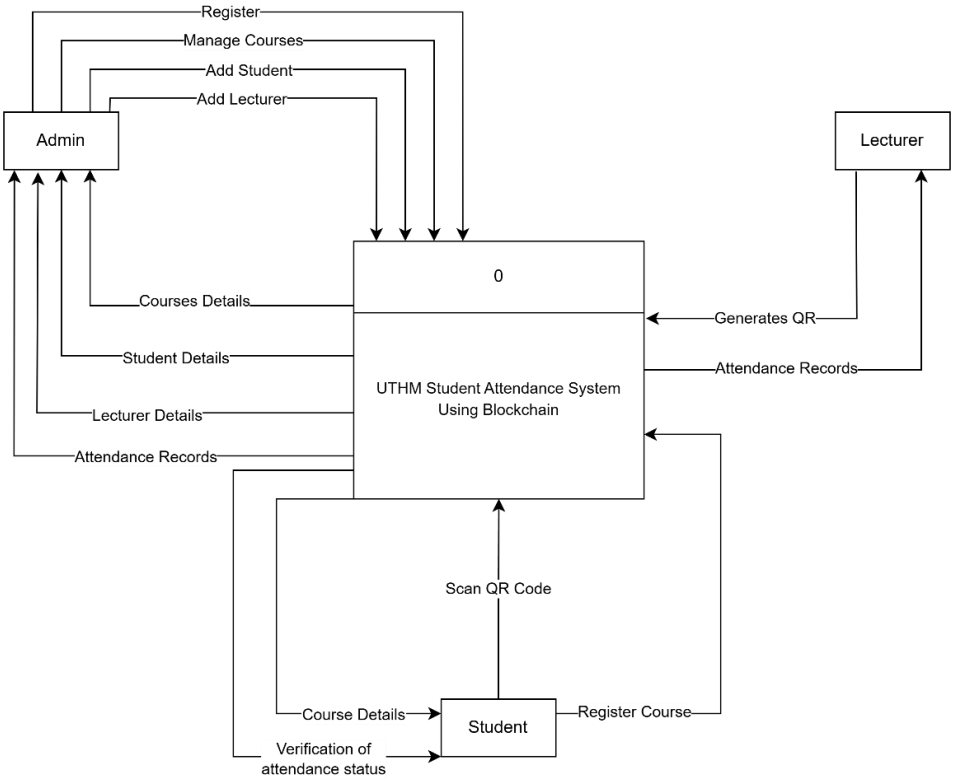


**Fig. 2** *Context Diagram*

## 4.3 Flowchart

The flowchart is a diagram of the sequence of movements or actions of the process involved in a complex system or activity. Flowcharts depict the system's data flow. In other words, data flowchart demonstrates where data goes, how it is processed, and how it is output. Fig. 3 shows the workflow of the UTHM Student Attendance System Using Blockchain.

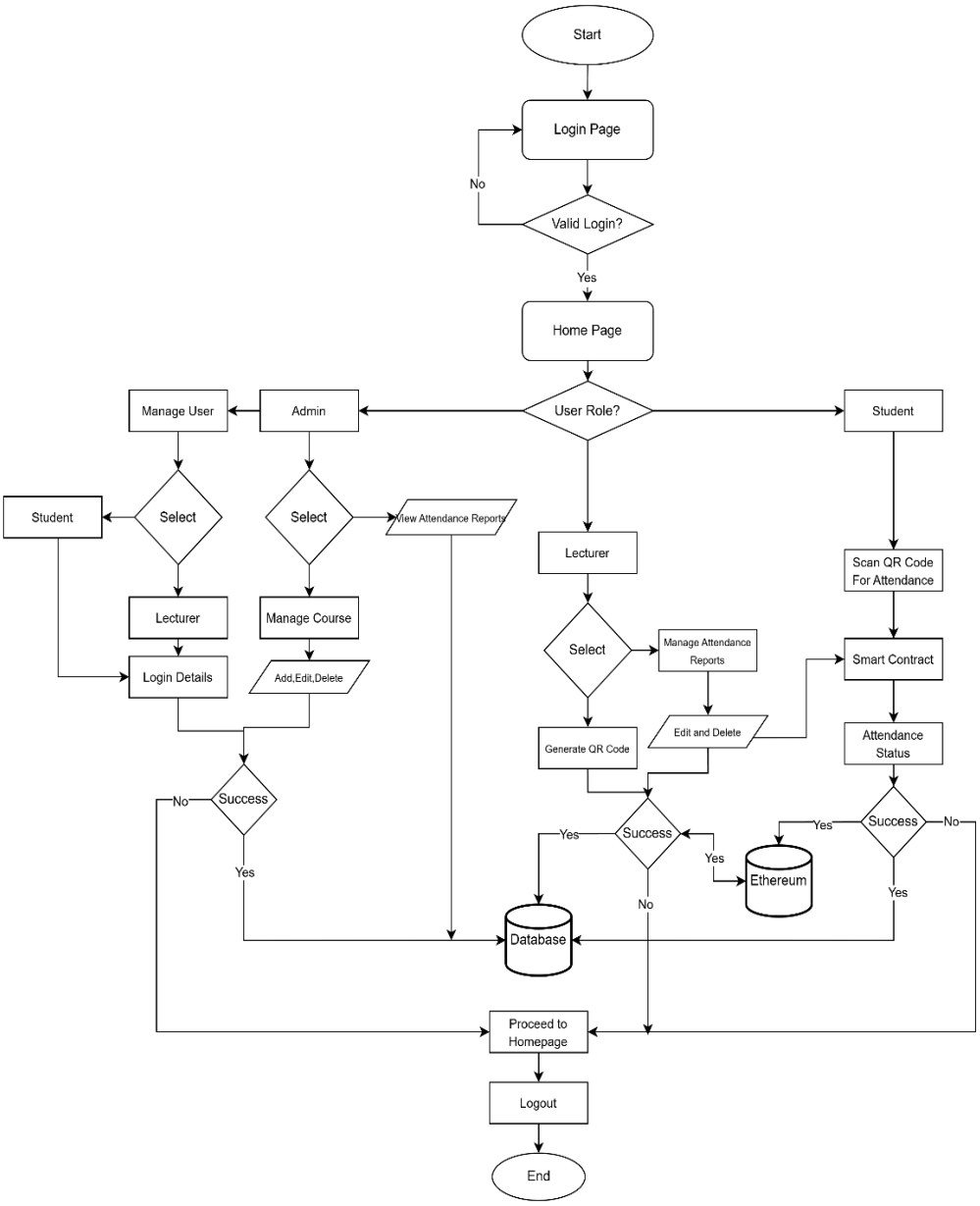


**Fig. 3** *Flowchart*

## 4.4 System Architecture

Fig. 4 illustrates how different components work together to create a secure and efficient attendance system. Lecturers generate unique QR codes for each class, which students scan to mark their attendance. Once scanned, the data is sent to the blockchain for validation through smart contracts, ensuring the records are accurate and protected from tampering.

After validation, attendance is securely stored on the blockchain, creating an unchangeable record that promotes transparency. Students can scan QR codes and check their attendance history, while lecturers can track and analyze attendance data. The decentralized blockchain system ensures data security and accessibility, reducing administrative tasks and providing a reliable way to manage student attendance at UTHM.

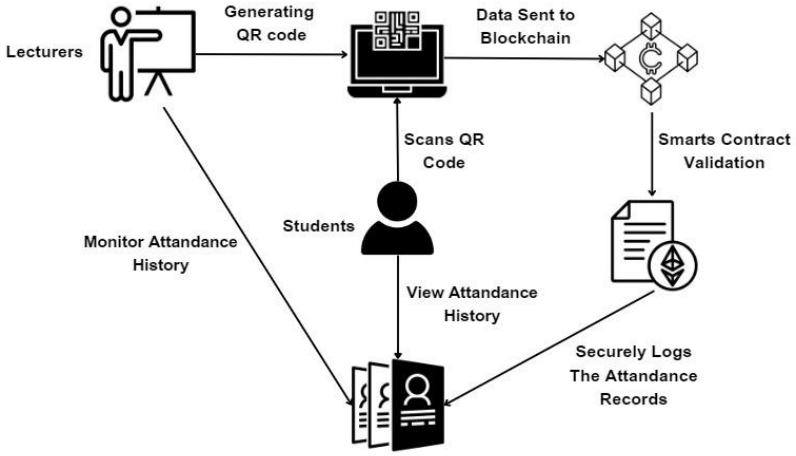


**Fig. 4** *System Architecture*

## 4.5 Entity Relationship Diagram (ERD)

Entity Relationship Diagram (ERD) is a type of structural diagram for use in database design. Fig. 5 shows the ERD for UTHM Student Attendance System Using Blockchain.

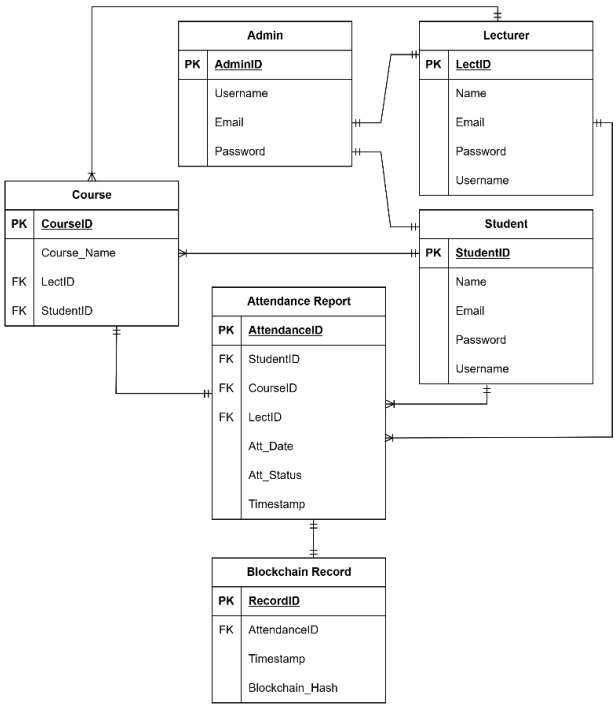


**Fig. 5** *ERD*

Fig. 5 represents the relationships between key entities in the system. Admin manages users, including Lecturers and Students. Lecturers generate QR codes and attendance reports, while Students scan the QR codes to mark attendance. The Course entity links lecturers and students, and all attendance data is securely stored in the Blockchain Record. The Attendance Report provides a summary of attendance details, ensuring a structured and secure system.

## 5. Implementation

This section discusses the implementation of UTHM Student Attendance System using Blockchain. The implementation of security modules, student modules, lecturer modules, admin modules, and blockchain environment will be described clearly.

## 5.1 Implementation of Security Module

The security module is a core component in ensuring the integrity and confidentiality of user data within the UTHM Student Attendance System Using Blockchain. This module implements several security best practices at both the client and server level, including input validation and sanitization, strong password enforcement, secure password storage, and a verification process for first-time logins.

User inputs such as full name and IC number are checked both on the browser JavaScript and on the server PHP. The system makes sure names only have valid characters and checks for mistakes or unwanted spaces. For IC numbers, it checks the format and confirms the month and day are correct. Fig. 6(a) illustrates for validating and sanitizing full name input while Fig. 6(b) shows JavaScript validation for Malaysian IC number and date. All inputs are cleaned on the server to block dangerous data or attacks.

```php
function validateFullName($name) {
    // Sanitize input
    $name = trim($name);
    $name = filter_var($name, FILTER_SANITIZE_STRING, FILTER_FLAG_NO_ENCODE_QUOTES);
    // Check length
    if (strlen($name) < 2 || strlen($name) > 100) {
        return "Full name must be between 2 and 100 characters.";
    }
    // Check for valid characters (letters, spaces, apostrophes, hyphens)
    if (!preg_match("/^[a-zA-Z\s'\-]+$/u", $name)) {
        return "Full name can only contain letters, spaces, apostrophes, and hyphens.";
    }
    // Check for consecutive spaces
    if (preg_match("/\s{2,}/", $name)) {
        return "Full name cannot contain consecutive spaces.";
    }
    // Check for special characters at beginning or end
    if (preg_match("/^[\s'\-]|[\s'\-]$/", $name)) {
        return "Full name cannot start or end with spaces, apostrophes, or hyphens.";
    }
    // Additional security check for potential XSS
    if ($name !== strip_tags($name)) {
        return "Full name contains invalid characters.";
    }
```

**Fig.6(a)** Validating and sanitizing full name *input*

```javascript
function validateIdNumber() {
  const input = document.getElementById("id_number");
  const value = input.value.trim();
  const idType = document.getElementById("id_type").value;
  clearFieldValidation(input);
  if (idType === 'IC') {
    if (!/^[0-9]{6}\-[0-9]{2}\-[0-9]{4}$/.test(value)) {
      showFieldError(input, "Invalid IC format. Use: YYMMDD-PB-GGGG");
      return false;
    }
    // Additional IC validation
    const parts = value.split('-');
    const month = parseInt(parts[0].substring(2, 4));
    const day = parseInt(parts[0].substring(4, 6));
    if (month < 1 || month > 12) {
      showFieldError(input, "Invalid month in IC number.");
      return false;
    }
    if (day < 1 || day > 31) {
      showFieldError(input, "Invalid day in IC number.");
      return false;
    }
```

**Fig.6(b)** *JavaScript validation*

The system checks the strength of every new password entered by the user. On the front-end, a JavaScript function measures if the password meets security rules, such as being at least 8 characters and including uppercase letters, lowercase letters, numbers, and special symbols. If the password is strong, a message is shown to the user. This helps users pick better passwords and keeps their accounts safe from simple attacks. Fig. 7(a) shows JavaScript function to check and display password strength on the registration form.

```javascript
const val = passwordInput.value;
let strength = '';
if (val.length < 8 || !val.match(/[A-Z]/) || !val.match(/[a-z]/) || !val.match(/[0-9]/) || !val.match(/[^a-zA-Z0-9]/)) {
    strength = 'Weak';
    strengthMessage.className = 'strength weak';
} else if (val.length >= 10 && val.match(/[A-Z]/) && val.match(/[a-z]/) && val.match(/[0-9]/) && val.match(/[^a-zA-Z0-9]/)) {
    strength = 'Strong';
    strengthMessage.className = 'strength strong';
```

**Fig. 7 (a)** *JavaScript function to check and display password strength*

After a user sets a password, the system never stores it as plain text. Instead, the password is encrypted using PHP's password_hash() function before saving it in the database. This way, even if someone gets access to the database, they cannot read any user's actual password. This practice protects users and follows standard security guidelines. Fig. 7(b) shows PHP code for hashing the user's password and Fig. 7(c) shows the hashing password stored in the database.

```php
$hashedPassword = password_hash($newPassword, PASSWORD_DEFAULT);
```

**Fig. 7 (b)** *PHP code for hashing the user's password*

| Email | Password | UserID |
|---|---|---|
| ai220185@student.uthm.edu.my | $2y$10$NXoar17IOQ5iWLCWvB6vOOCQGZBVov96ijFVA7tIiDZ... | AI11 |

**Fig. 7 (c)** *Result of password hashing*

For extra security, the system requires all new users to change their password on their first login. When a user logs in for the first time, they will see a screen asking them to check their email for a secure password reset link. The user must open the email, click the link, and set a new strong password that follows the password policy. This process makes sure that default passwords are not used and helps protect accounts from being easily hacked. Fig. 8(a) shows page for email verification to change password and Fig. 8(b) shows email receive for set new password.

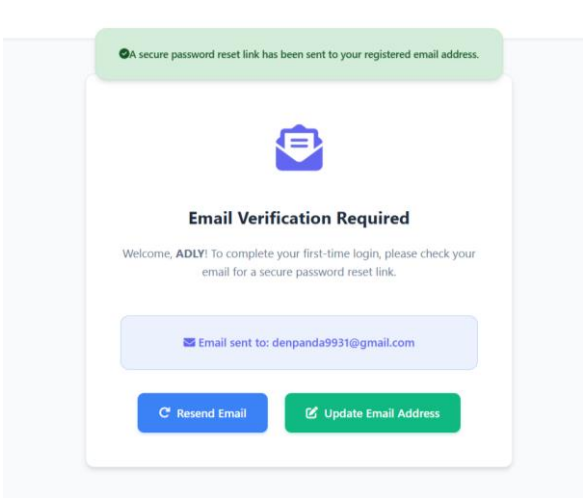


**Fig.8(a)** *Send Email verification page*

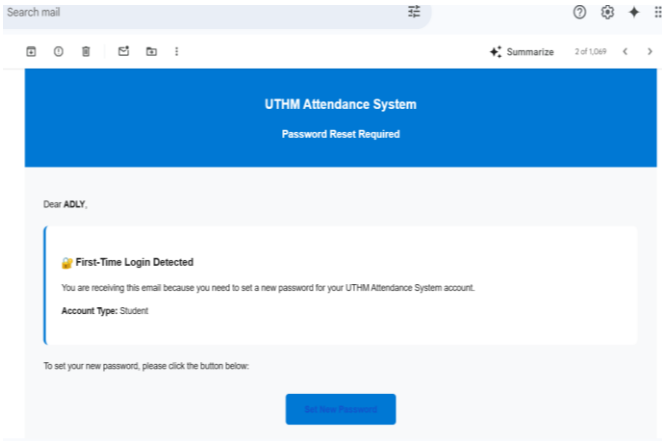


**Fig.8(b)** *Email received for set new password*

## 5.2 Implementation of Student Modules

The student module is built to give students full control over their attendance and course activities in a simple and secure way. With this module, students can register for courses, scan QR codes to mark their attendance, view detailed attendance records, and update their personal profile information whenever needed. Before students can scan their attendance, they need to register for courses first. Students can register for courses offered by lecturers through the system. The available courses are shown in a list, and students can easily add them to their own profile. Fig. 9 shows registration courses page.

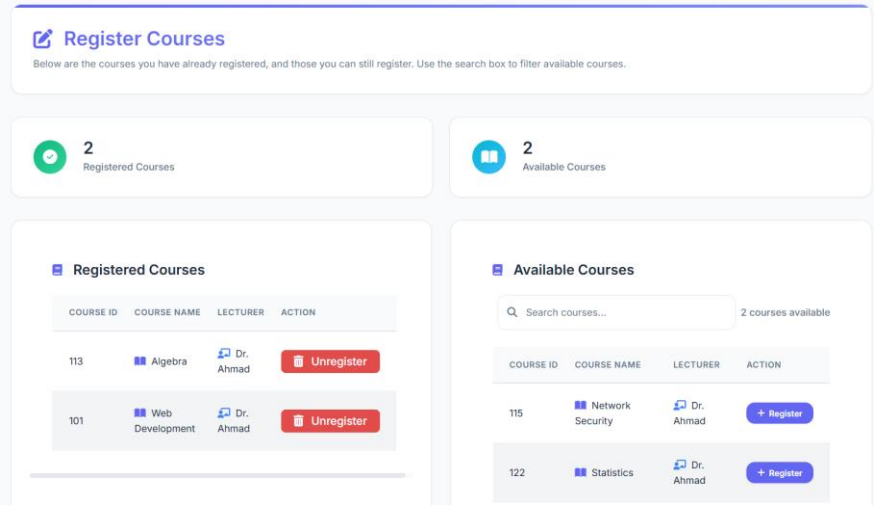


**Fig.9** *Register courses page*

The student can scan the lecturer's QR code to mark their attendance for a class session. This is done by using the "Scan QR Code" page in the student dashboard shown in Fig. 10 (a). After scanning, the system will show confirmation and connect with the student's MetaMask wallet. Fig. 10 (b) and (c) shows that students must approve the transaction in MetaMask, which will record the attendance securely on the blockchain. Once the transaction is confirmed, the student receives a final message showing that their attendance is successfully stored on the blockchain, along with the transaction hash and block number shown in Fig. 10 (d). This process ensures that all attendance records are tamper-proof and can be verified at any time.

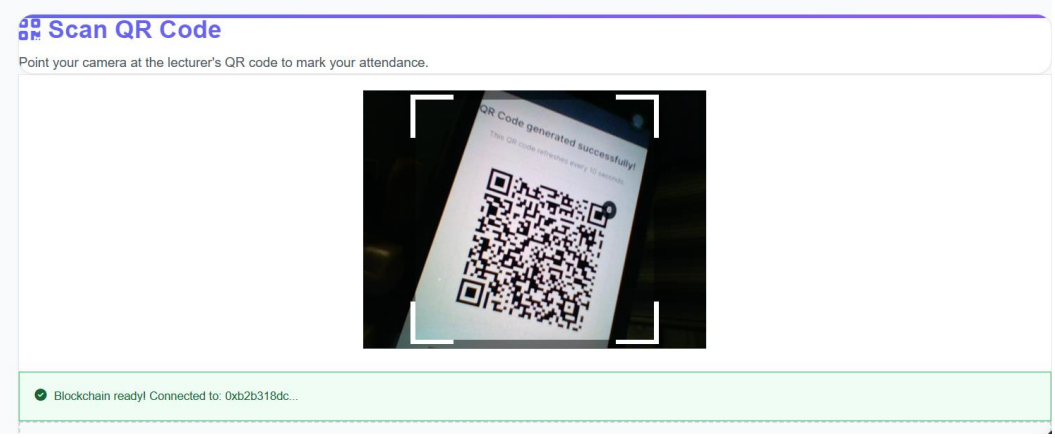


**Fig.10(a)** *Scan QR Code Function*

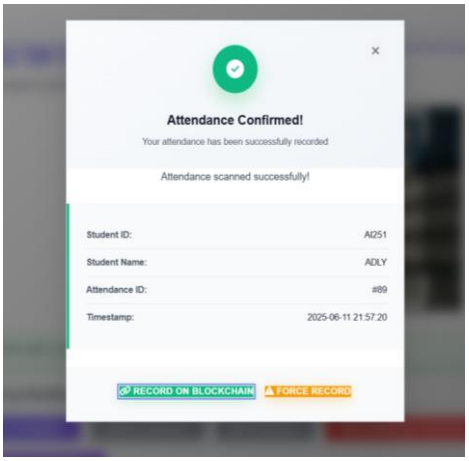


**Fig.10(b)** *Output Attendance Confirmed*

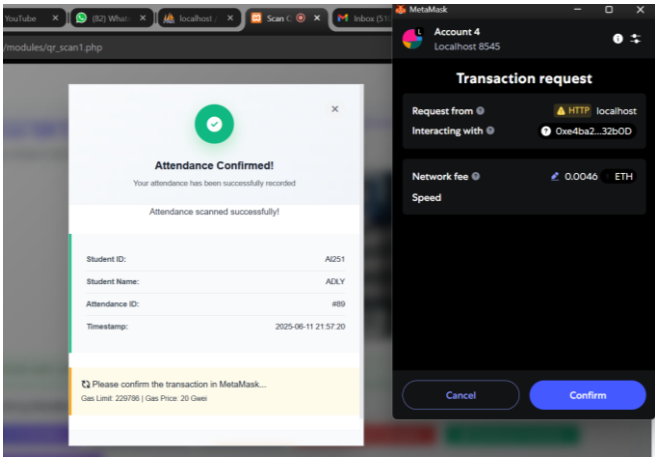


**Fig.10(c)** *Metamask Transaction Request*

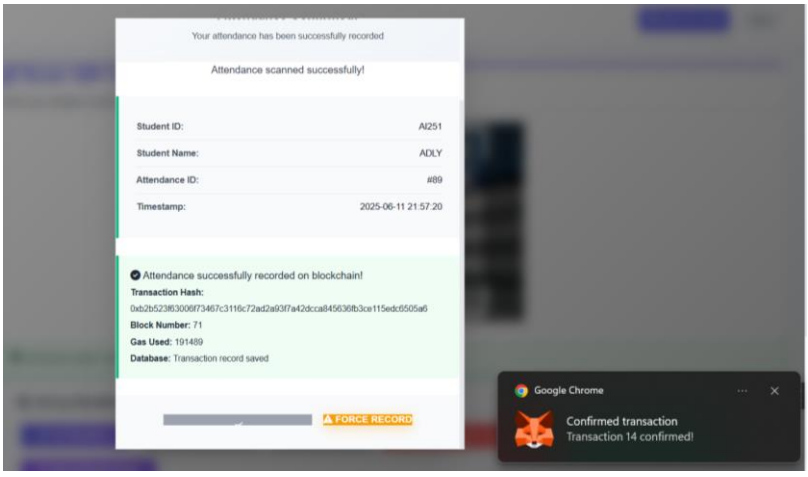


**Fig.10(d)** *Attendance Successful Record on Blockchain*

## 5.3 Implementation of Lecturer Modules

The lecturer module provides tools for lecturers to manage attendance in a secure and efficient way. Lecturers can generate a unique QR code for every class session. The QR code contains information about the course, date, and session, and it refreshes automatically after 10 seconds to prevent students from sharing or reusing old codes. This feature helps to reduce proxy attendance and makes sure only students in the class can scan for that session. Fig. 11(a) shows a generated QR Code for attendance.

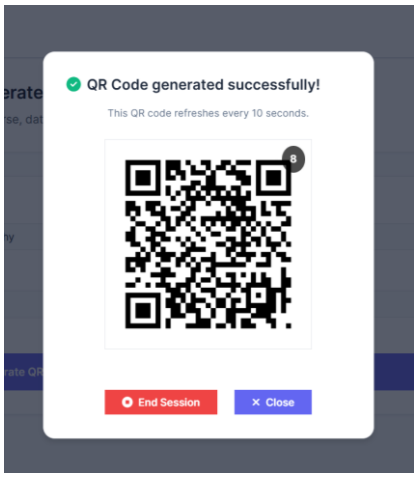


**Fig.11(a)** *QR Code generate*

Lecturers can monitor which students have attended each session in real-time. The system shows a list of students who have scanned the QR code and the time of their attendance. Lecturers can also see overall attendance summaries and trends for each course. Lecturers can update or correct a student's attendance status. All changes are tracked up and can be reviewed later. Lecturers can upload an absent letter to database and generate warning letters for students directly to student emails. Fig. 11(b) shows attendance report for lecturer.

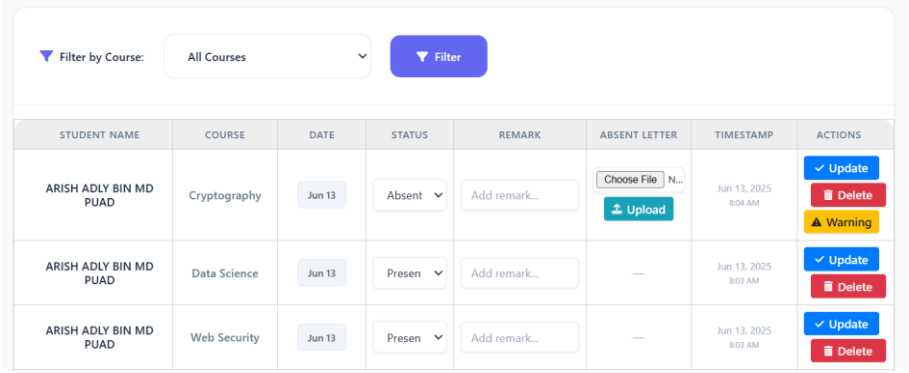


**Fig.11(b)** *Lecturer Attendance Report*

## 5.4 Implementation of Blockchain Environment

The blockchain environment for the UTHM Student Attendance System was set up using a combination of Ganache and MetaMask setup, Truffle configuration, Solidity and Smart Contract. Ganache is used as a local Ethereum blockchain for testing and development. It provides a private blockchain network where transactions can be processed quickly and without real cryptocurrency. The system connects to Ganache using the host IP address and port number as configured in the Truffle framework. Fig. 12(a) shows a server configuration on ganache.

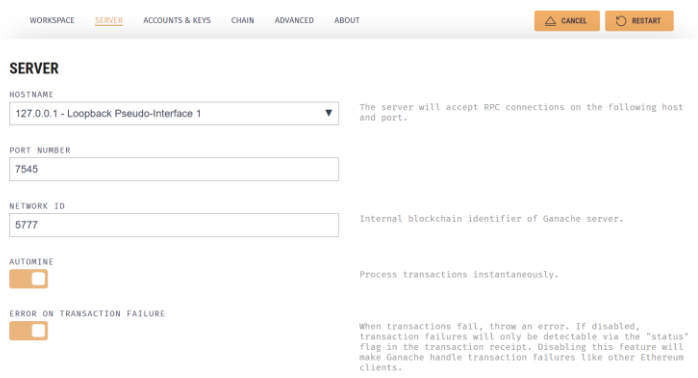


**Fig.12(a)** *Ganache server configuration*

Truffle must be installed in Visual Studio code using npm commands. Truffle is a development framework for Ethereum, used here to compile, deploy, and test the smart contracts. The truffle-config.js file is used to tell Truffle how to connect to the Ethereum blockchain network for developing and testing smart contracts. In this setup, it configures Truffle to connect to a local Ganache blockchain running on localhost webpage. Fig. 12(b) demonstrates the connection configuration for ganache.

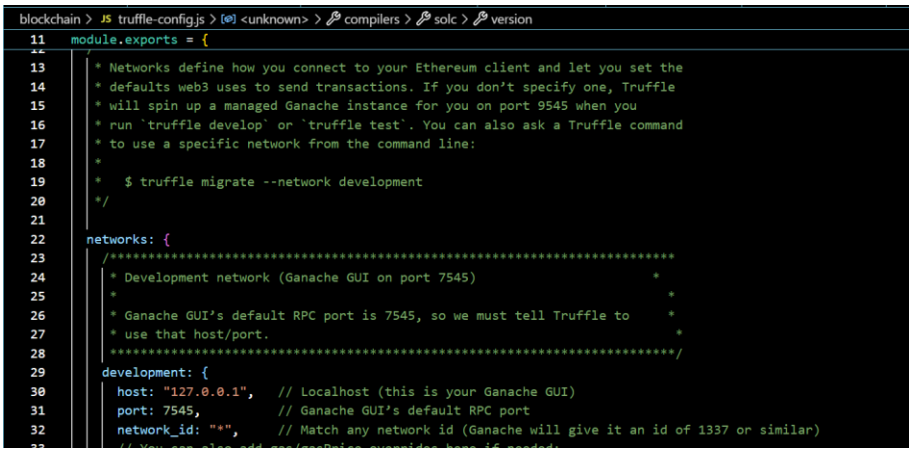


**Fig.12(b)** *Ganache Connection to Localhost Configuration*

MetaMask provides features to allow users to import accounts from the Ganache. In Ganache, it provides a list of testing accounts which consist of public address and private key. An account is selected, and its private key is imported into the MetaMask to build the connection between MetaMask and selected account in Ganache. It is important as it provides the testing environment to launch the transaction without paying the gas fees. Fig. 12(c) shows the imported account from ganache and Fig. 12(d) shows account information for the imported account.

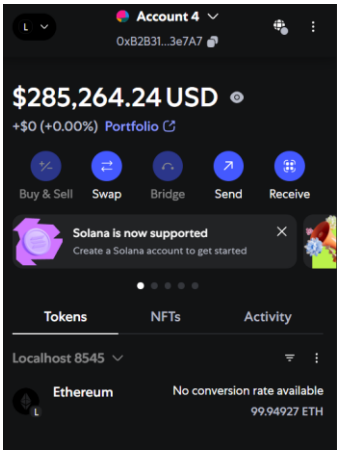


**Fig.12(c)** *Imported account from Ganache*


**Fig.12(d)** *Account information on Ganache*

A smart contract is a program on the blockchain that runs automatically and securely handles transactions. It ensures transparency and cannot be changed by anyone. The contract stores every attendance record, including the student's wallet address, student ID, course ID, and timestamp. It also makes sure that a student cannot mark attendance more than once for the same session. When a student scans the QR code and confirms the transaction, the contract saves the record permanently on the blockchain and emits an event for easy tracking. This ensures all attendance data is secure, transparent, and cannot be changed by anyone. It also prevents double attendance and saves all data permanently on the blockchain. Fig.12(e) shows part of contract that builds for the proposed systems.

```
blockchain > contracts > Attendance.sol > ...
contract Attendance {
    struct Record {
        address student;    // the wallet that submitted
        string  studentID;  // e.g. "AI250"
        string  studentName;
        uint256 courseId;
        string  courseName;
        uint256 timestamp;
    }

    // courseId → keccak256(matric) → whether already marked
    mapping(uint256 => mapping(bytes32 => bool)) public hasAttended;

    // chronological attendance logs
    Record[] public records;

    event AttendanceRecorded(
        address indexed student,
        string  indexed studentID,
        uint256 indexed courseId,
        string  studentName,
        string  courseName,
        uint256 timestamp
    );
```

**Fig.12(e)** *Attendance Smart Contract*

Web3.js is a JavaScript library that allows websites and web applications to communicate directly with the Ethereum blockchain. By using Web3.js, the attendance system can connect to blockchain networks, interact with smart contracts, and handle blockchain transactions from the browser. For this proposed system, Web3.js is used together with MetaMask to let students and lecturers sign transactions securely. For example, when a student scans a QR code to mark attendance, Web3.js connects the web page to the student's MetaMask wallet. The student can then confirm the transaction, and Web3.js will send the attendance data to the smart contract on the blockchain. This makes it possible to write and read blockchain data in real time, ensuring that every attendance record is secure, transparent, and tamper-proof. Web3.js also helps the system check account balances, listen for blockchain events, and verify transaction status, making blockchain integration smooth and user-friendly in the web application. Fig. 12(f) shows a Web3.js JavaScript library.

```
<script src="https://cdn.jsdelivr.net/npm/web3/dist/web3.min.js"></script>
```

**Fig.12(f)** *Web3.js Library*

Fig. 12(g) shows the details of a blockchain transaction for recording attendance. The transaction includes the contract address, function name, and all input data such as course ID, student ID, student name, and course name. The record is stored on the blockchain together with important information like the gas used, transaction hash, and block number. This provides full transparency and proof that the attendance was successfully saved and cannot be changed by anyone.

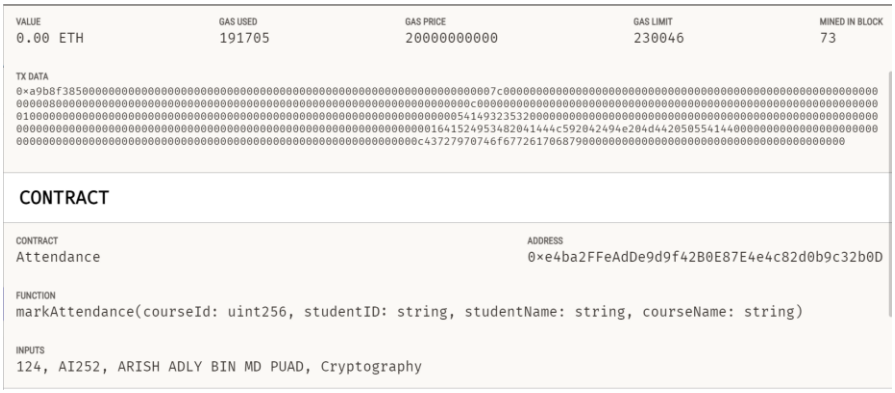


**Fig.12(g)** *Transactions details on Ganache*

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## 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 Resul | Actual Result |
|---|---|---|
| User Login Validation (Enter corrects credentials and Click "Login") | User successfully logs in | Pass |
| Invalid Login Attempt (Enter incorrect credentials and Click "Login") | System displays "Invalid Login" message | Pass |
| Generate QR Code (Lecturer selects a course and Click "Generate QR Code") | QR code is successfully generated | Pass |
| Students scan the QR code and system validates QR code | Display message: “Attendance Record Successfully” | Pass |
| View Attendance Report (Student navigates To “Attendance Report” page | Attendance records are displayed | Pass |
| Monitor Attendance Report (Lecturer accesses Attendance reports and selects a specific course) | Display message: “Feedback sent successfully” | Pass |
| User interact with Metamask (Student scan Lecturer edit attendance) | Metamask interface shown. | Pass |

**Table 6** *Results of the security test plan*

| Check List | Actual Result |
|---|---|
| Student and Lecturer should be able to login with valid ID and password only | Pass |
| Student, Lecturer and Admin should be able to login based on their role | Pass |
| Users are prevented from using expired or reused password reset links | Pass |
| Session is destroyed after logout | Pass |
| Enforce strong password policy with minimum 8 characters, uppercase, number, and symbol | 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 Student Module

A user acceptance test was conducted with 10 students to evaluate the student module of the blockchain-based attendance system. The feedback was collected using a 7-point satisfaction scale for each feature. Fig. 13(a) shows all students were able to log in to the system without problems, and every first-time login successfully received a link to set a new password. The system displayed messages that were easy to understand. Fig. 13(b) Students could update their profiles, register for courses, and view their registered courses, with all 10 users reporting complete satisfaction for these features.


**Fig.13(a)** *Result Login page*

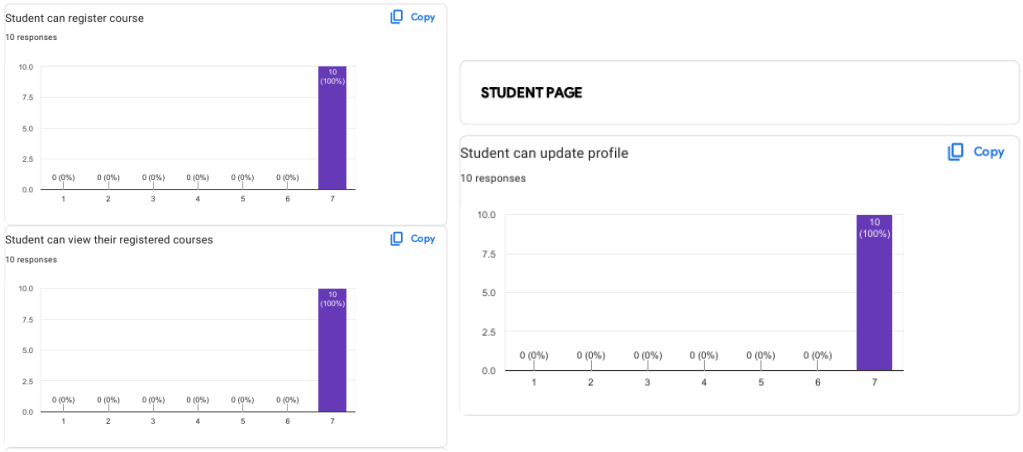


**Fig.13(b)** *Result Student page*

Fig. 13(c) shows result for QR scan and blockchain features, all students were able to scan the QR code for attendance, receive the MetaMask transaction prompt, and view the transaction details on the blockchain. Fig. 13(d) shows every student also reported that they could use the system without issues, found the interface easy to understand, and agreed that the system was straightforward to use.

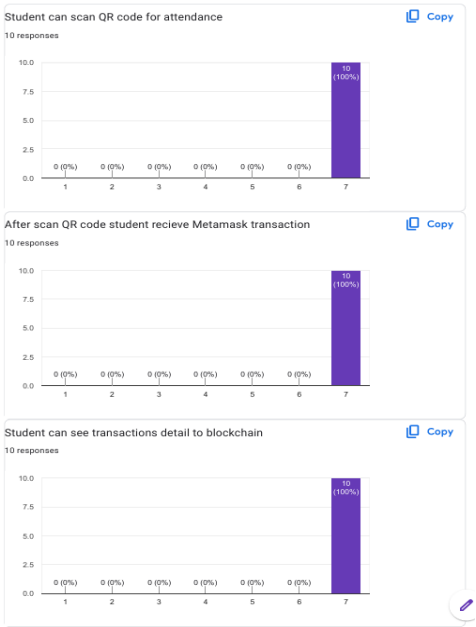


**Fig.13(c)** *Result for QR scan modules*


**Fig.13(d)** *Result Overall System*

## 6.3 User Acceptance Form Result for Lecturer Module

A user acceptance test was conducted with lecturers to evaluate the lecturer module. Table 7 shows lecturers were able to log in and found system messages easy to understand. Most lecturers were satisfied with profile management and course management features, including updating profiles, viewing course details, and generating QR codes for attendance. The attendance report page allowed lecturers to view and manage reports, check blockchain records, and upload supporting documents. Overall, the lecturer module was rated as user-friendly and easy to use, with scores of 5 or above for all tested features. The user acceptance test for the lecturer module was conducted by Dr. Nasarudin from the Fakulti Sains Komputer dan Teknologi Maklumat.

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

| Question | Result (Dissatisfied 1 – 7 Satisfied) |
|---|---|
| **Login Page** | |
| 1. Lecturer can login without problem. | 7 |
| 2. Display message easy to understand | 7 |
| **Profile Page** | |
| 1. Lecturer can update profile. | 7 |
| 2. Lecturer can view profile details. | 5 |
| 3. Lecturer can view course details. | 6 |
| **QR Code Module** | |
| 1. Lecturer can generate QR code for attendance. | 5 |
| **Attendance Report Page** | |
| 1. Lecturer can manage attendance report | 5 |
| 2. Lecturer can edit or change status attendance. | 6 |
| 3. Lecturer can see attendance blockchain record. | 6 |
| 4. Lecturer can generate warning letter. | 6 |
| 5. Lecturer can upload student absent letter | 6 |
| **Overall System** | |
| 1. Lecturer can use the system without problem. | 5 |
| 2. The interface easy to understand. | 5 |
| 3. The System easy to understand | 5 |

## 6.4 User Acceptance Form Result for Admin Module

The admin module was also tested for user acceptance as shown in Table 8. The user acceptance test was conducted by Mr. Shahril Nazim, a system analyst from PTM (Pusat Teknologi Maklumat). He was able to log in, register new students and lecturers, and manage courses without issues. Viewing lists of users and course registrations was straightforward. All features scored between 5 and 7 on the satisfaction scale, indicating that the admin found the system effective and easy to understand. Overall, the admin module provides a smooth experience for managing users and course information.

**Table 8** *User Acceptance Form Result for Admin Module*

| Question | Result (Dissatisfied 1 – 7 Satisfied) |
|---|---|
| **Login Page** | |
| 1. Admin can login without problems. | 7 |
| 2. Display message easy to understand. | 7 |
| **Registration Page** | |
| 1. Admin can register for students. | 6 |
| 2. Admin can register for lecturer. | 6 |
| **Courses Page** | |
| 1. Admin can manage courses for lecturers and students. | 5 |
| 2. Admin can view list of existing course registration. | 5 |
| 3. Admin can view list of existing users. | 5 |
| **Overall System** | |
| 1. Admin can use the system without problems. | 5 |
| 2. The interface easy to understand. | 5 |

## 7. Conclusions

In summary, the UTHM Student Attendance System using Blockchain has been developed and tested with complete functionality. The system achieves the main objectives set out in the project scope, including secure attendance recording, tamper-proof data storage, and improved transparency for all users. This system provides several key advantages. Attendance records are stored on the blockchain, ensuring they cannot be changed or deleted. Security is further enhanced through password hashing, strong password policies, and a first-time login verification process. The use of QR codes and MetaMask wallet integration makes the attendance process fast, secure, and easy to verify. Students and lecturers can confidently track attendance history, knowing that the data is protected from manipulation.

However, there are still areas for improvement. Blockchain transaction confirmation can take a few extra seconds compared to traditional systems, and using a local blockchain (Ganache) limits real-world deployment until migrated to a public or institutional blockchain. Some users may find MetaMask interaction less familiar at first.

To enhance the system in the future, transaction speed and user experience can be improved, and the system can be integrated with a live Ethereum testnet or mainnet for larger-scale use. Adding more automation and reporting features could also benefit administrators and users. Overall, this project demonstrates that blockchain technology is a reliable solution for secure and transparent attendance management in higher education.

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## Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *A. D. A. Md Puad, N. Z. Harun;* ***data collection:*** *A. D. A. Md Puad, N. Z. Harun;* ***analysis and interpretation of results:*** *A. D. A. Md Puad, N. Z. Harun;* ***draft manuscript preparation:*** *A. D. A. Md Puad, N. Z. Harun. All authors reviewed the results and approved the final version of the manuscript.*

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