Lecturer and Student Attendance System with RFID

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Abstract. Purpose: Manual recording of lecturer and student attendance at a university may potentially create inaccurate attendance recording. Particularly, manual attendance cannot accommodate the need for real-time attendance recording. Thus, this paper discusses on the design of a real-time attendance recording system by utilizing Radio Frequency Identification technology (RFID). Methodology: The proposed attendance recording system is built using Arduino Uno microcontroller, RFID reader MFRC522, and Node.js that runs on a personal computer. To identify each lecturer and student, every one of them is associated with a unique identifier called UID. Upon detection of valid UID, the system can determine whether a lecturer or a student comes late to the class or not in real-time. Any event of lateness will be identified as a violation of the university policy. In addition to that, the system is able to store various information related to the courses in the university, and also send email notifications through a PHP application. All necessary data required by the system is managed by MySQL. Results: Based on the tests conducted, data entry to the database, RFID reading, and lateness checking is determined to work as expected. RFID reading from the same card occasionally gives a different UID being read, which may be due to failure in the RFID reader or RFID tag. Time accuracy test on lateness recording gives only 80% accuracy, this inaccuracy is suspected to be the result of the unstable Internet connection between PC and database. Applications/Originality/Value: This attendance system is developed to conform with Pelita Harapan University’s policies on lecturer and student attendance in class. It is hoped that this system can be considered as an improvement to the current attendance system at Pelita Harapan University.

1. Introduction

There are many ways to improve quality of the teaching learning process in a university. Apart from the learning facilities that is provided, an attempt to achieve a better quality of education is done through ensuring that the lecturer and students attend the class on time. Research done by Banerjee [15] found that lecturer and student attendance are mutually reinforcing, as lecturer attendance is the most important determinant of student attendance, and student attendance is the most important determinant of lecturer attendance. Bati [21] conducted a study about student attendance and found that the factors preventing students from attending lectures are mainly individual, such as sleeplessness, ill health, and inefficiency of lectures in overcrowded halls.

By attending the class on time, lecturer can give teaching materials as planned before. For students, on time attendance is important so that student can participate the class since the beginning without missing the course materials given by the lecturer. From the perspective of study program, a good record of student and lecturer attendance improve the image of study
program. Several studies found that student attendance correlates to academic performance, progression, and degree classification [19, 20].

Pelita Harapan University places high importance in student on time attendance, as reflected in the university senate decree No.003/SK-Senat-UPH/IV/2013 about Standard Rules of Degree Program Education at Pelita Harapan University, Chapter 33 states that a student can only take the final exam if he or she attends at least 85% of all course meetings. Failure to fulfill the given criteria means that student is automatically exempted from the final exam. This is clarified further in senate decree No.015/SK-Senat-UPH/V/2016 about Revision of Standard Rules of Education at Pelita Harapan University, Chapter 57, which states that students must come on time to course meetings with grace period of 15 minutes. Students that arrive after the grace period will not have his or her attendance recorded for that course meeting, but still allowed to attend said course meeting. Regarding lecturer attendance, if a lecturer often attends after 15 minutes, then it affect the feedback given by students where through student feedback questionnaire where the required minimum score for lecturers is 4.5 out of 6.

Lecturer and student attendance at Pelita Harapan University is done by manual recording of student and lecturer attendance by signing the attendance list at every course meeting. The manual recording of attendance has drawbacks, namely it needs time for lecturer to verify the student attendance list. It also does not provide exact time of student and lecturer attendance. Inaccuracy of recording may also potentially occur because of human error.

To automate the student and lecturer attendance and to accommodate the need of real-time attendance recording system, this paper discusses the design of an attendance recording system by utilizing Radio Frequency Identification technology (RFID). Several automated attendance systems have been developed before, such as the one developed by Cahyadi et al. (2014), which uses client server-based fingerprint to take attendance. Another solution developed by Mansor (2012) uses readily available tools such as Google Forms and Google Spreadsheets to manage student grades and attendance records. Usage of RFID to manage student attendance has been done by Pireva et al. (2013), who designed a prototype of a system to track student attendance.

After introducing the problem, this paper discusses main components of the system. The system design and implementation are then elaborated consecutively in the next section. Afterwards, the system testing and evaluation is then discussed. Finally, the conclusion and future work section finalize the whole discussion.

2. Main Components
2.1. RFID
RFID (Radio Frequency Identification) is a device that transmits an identifier in the form of a sequence of numbers from an object using radio frequency. RFID is categorized as an automatic identification technology. RFID tag is comprised of a microchip that is embedded to a radio wave antenna and attached to a substrate. The microchip can store data up to two kilobytes. Information like a package’s delivery date can be stored on a RFID tag. Almost all RFID tags uses silicon-based microchip to store its unique identity number and other information. RFID tags can be divided in two categories, namely active and passive tags. Active RFID tag has its own power source and transmitter, while passive RFID tag does not have its own power source and only reflects radio wave that comes from the RFID reader. Because of its lack of power source, passive RFID tag has shorter operating range than active RFID tag, and only stores its identity number on the chip. Active tag is commonly used for long range identification, as its operating range can reach up to 300 feet away. RFID tags only works at specific frequencies, namely 445 MHz, 2.45 Ghz, or 5.8 Ghz.

To read data from RFID tag, a RFID reader is required. RFID reader is a device that has one or more antenna that transmits and receives radio waves from the RFID tag. RFID reader then sends the data from RFID tag to a computer to be processed further. Like RFID tag,
RFID reader can be divided into two categories, namely passive and active reader. Passive RFID reader can only receive radio wave from active RFID tag, while active RFID reader can transmit interrogator signal to RFID tag and receive authentication response from RFID tag [4].

2.2. Arduino Uno
Arduino Uno is a microcontroller board that uses ATmega328 as the microcontroller chip. Arduino Uno has 14 GPIO (General Purpose Input Output) pins with 6 of them capable to generate PWM (Pulse Width-Modulation) output, 6 analog inputs, USB connection, 16Mhz crystal oscillator, power jack, ICSP (In Circuit Serial Programmer) header, and a reset button. The anatomy of an Arduino Uno can be seen in Figure 1 below.

![Arduino Uno](image)

Figure 1: Arduino Uno

Arduino Uno can be connected to a computer using USB cable and can be powered with USB or external power supply using the power jack. The operating voltage of Arduino Uno board is rated at 6 to 20 Volts. However, if the supply voltage to Arduino is less than 6V, the 5V power pin may output less than 5V and may cause instability to the board. And if the supply voltage is more than 12V, voltage regulator may overheat and damage the board. Thus, the recommended voltage range is from 7 to 12 Volts. Arduino Uno can be programmed using Arduino IDE (Integrated Development Environment), a software that can be used to compile and upload code to Arduino board. Arduino IDE can download and include various libraries to interface and interact with various sensors and components connected the Arduino board [5].

2.3. PHP (Hypertext Preprocessor)
Initially, PHP stands for Personal Home Page, as it was designed to build a personal web page. In its development, PHP grows into a powerful web programming language that is used not only to create simple web sites, but also sophisticated web sites like Wikipedia, Wordpress or Joomla. Now PHP stands for PHP Hypertext Preprocessor, following GNU’s (GNU’s Not Unix) recursive naming convention. PHP can work with HTML (Hypertext Markup Language) and updated whenever the HTML page is viewed by visitors. PHP is run on web server side and the result is displayed on the HTML. PHP is an open source product. Several advantages of using PHP are high performance, can communicate with a wide range of database systems, has built-in library to handle various tasks and commands, relatively easy to learn, easily accessible source code, and free to use [6].
2.4. MySQL
MySQL is first developed by Michael "Monty" Widenius on 1979, who created a simple database system called UNIREG. MySQL is a RDBMS (Relational Database Management System) software that uses SQL (Structured Query Language) that is commonly used to interact with database. RDBMS is a database that contains one or more tables that are related to each other. Each table contains one or more rows and columns [7].

MySQL can be paired with PHP to connect a website to the MySQL database. The most common commands used in MySQL to interact with database are select, insert, update and delete. MySQL also provides commands to create database and indexing. Several advantages of using MySQL are high performance, free to use, can be used in multiple operating systems, relatively easy to learn, can be used without internet connection because it has built-in library, flexible and secure password system, and able to handle large-scale database [8].

2.5. CSS (Cascading Style Sheet)
CSS (Cascading Style Sheet) is a collection of code that is used to design and manage what is being displayed on a HTML web site, such as colour, layout, and font. By using CSS, a web developer can make a website that can adapt to various screen sizes. When a style is associated to an HTML element, the style formatting is applied to all instances of that specified element in the HTML file. CSS is usually paired with HTML, can be embedded directly to an HTML code or created as a separate file and referred to by the HTML file [9].

2.6. JavaScript
JavaScript is a programming language used to add interactivity to a website, for example adding dynamic effect, animation or web-based game. JavaScript can be paired with HTML to create an interactive website. JavaScript is invented by Brendan Eich, who was a member of the Mozilla project team. JavaScript is a complex but very flexible language, as many developers has provided many useful tools such as API (Application Programming Interface), third party framework, and libraries. JavaScript is an interpreted language, thus does not require a compiler. JavaScript can be used to create an event-driven website, receive text variable, validate data, detect user web browser, and work together with various additional components such as node.js [10].

2.7. Node.js
Node.js is a platform designed for web server. Node.js was initially developed by Ryan Lienhart Dahl on 2008, who has a vision to develop a web server that is able to manage real-time interaction like Google’s Gmail. Node.js can work with various operating systems and has its own HTTP server library so it can run a web server without using additional software such as Apache or Nginx [11]. Node.js is written in JavaScript programming language and is event driven. Unlike most JavaScript programs, which is executed on client-side, node.js is executed on server-side. Node.js has better memory efficiency when working under heavy load. When using Node.js, user does not need to worry about deadlock, which is a condition that occurs when two or more processes are waiting for each other to release the resources that are currently in use. Node.js has both synchronous and asynchronous operations, but Node.js’s main advantage lies on its asynchronous capabilities [12].

NPM (Node Package Manager) is a package manager for Node.js. The function of NPM is to manage, search, and install various packages to node.js to add various specific functionalities, such to working with database and Arduino [13].
3. System Design

To run attendance recording system using RFID, there are several preliminary processes that are accomplished. The process consists of course schedule creation and course enrolment. Course schedule creation is performed by administrative staff. To record their attendance, students and lecturers need to be registered in the course according to their respective roles. When the class starts then all students and lecturers will do tapping. If the lecturers or students present in a class after 15 minutes or more then it will be counted as lateness. A corresponding email will be sent to the administrative staff.

3.1. Hardware design

The attendance recording system uses an RFID reader to read the UID data stored on the student or lecturer identity card. Data is then sent to Arduino. Arduino processes the data and sent it to a computer that runs the Node.js process. Afterwards, data is sent to the database server. Hardware design of the system is depicted in the following figure 2:

![System Block Diagram](image)

**Figure 2:** System Block Diagram

The RFID reader used in the system is the MFRC522 RFID reader. This RFID reader has four SPI (Serial Peripheral Interface) pins, namely the Master Out Slave In (MOSI), Master In Slave Out (MISO), Serial Clock (SCK), and Serial Data (SDA) or Slave Select (SS). In addition, the RFID reader has a 3.3V supply voltage pin, a ground reference voltage pin, and a reset pin. These pins can be directly connected to the Arduino, the pin connections between the RFID reader and the Arduino microcontroller can be seen in Figure 3. Students will use their student ID card for attendance, which contains an RFID tag. The RFID tag used is a passive RFID tag which operates in the 125KHz frequency, and adheres to ISO Standard 14443-3A. When the student ID card is tapped to the RFID reader, the card data will be read by the reader and sent to Arduino to be stored in the database server.

Arduino needs to communicate with the computer in order to send data to the database. This is accomplished using Node.js. Arduino sends data to the serial port with baud rate 9600, which is read using Node.js. To be able to read serial data, Node.js requires an additional library called serialport, which can be obtained and installed using Node Package Manager (NPM). Communication to the database is actualized using Node.js, PHP and MySQL. System uses class library that is provided by CodeIgniter framework to send email notification [14].

3.2. Software Design

The system designed must be able to implement the following functions: insert and delete user, insert and delete student data, insert and delete schedule data, display attendance time for students and lecturers, and display notification of lateness or missed attendance.
4. MFRC522 and Arduino Connection Schema

Figure 4 describes the flow diagram for student registration process. Students must fill their student ID, full name, username, password, and UID on a web form. UID data will be autofilled when student taps their student ID card to the RFID reader. After student has finished inputting the data, administration staff must validate the data, if the data is valid then the data is stored in the database and the web form displays message that data is successfully stored. If there are any fields that are left blank, the system will show a message to ask the student to fill the empty fields.

![System Flow Diagram for Student Registration](image)

Figure 3: System Flow Diagram for Student Registration

Figure 5 describes the system flow diagram for attendance taking process. When the student taps his or her student ID card to the RFID reader at the beginning of the class, the UID data is received and the system checks to the database to verify and match the UID for the student’s
ID number. If the student ID number is enrolled in the course, the ID number is sent to the microcontroller to be processed for the time attendance and compared to the specified start time of the class. The time of attendance is then recorded to the system.

Figure 4: System Flow Diagram for Attendance Taking

Figure 6 describes the system flow diagram for lateness checking process. Following the process from figure 5, the time of attendance is recorded and compared to the start time of the class. If the time of attendance is more than 15 minutes after start time of the class, the time of attendance is recorded, and the student is marked as late to class. If the end time of class has passed, attendance for the said class is closed and students who do not do the attendance process will be marked as not present. The system then sends notification to the administration staff for the students that are late or missed the class.

The database design is described in Figure 7. The attendance system is comprised of several data, such as data for class, schedule, room, lecturer, students, attendance and admin. The class schedule data has fields for day, date, start time and end time. Attendance data is built from data from schedule and students.
5. System Implementation

This section contains implementation and evaluation of the system. Hardware design can be seen in Figure 8. There is an RFID reader which is connected to an Arduino UNO. This RFID will be associated with a PC (Personal Computer) that is connected to a serial port.

In this system, there are main parts of the web page namely log in, home, master menu, student data and course schedule. At the login session, administrative staff is asked to enter a
username and password to authenticate whether he or she has access to the web page. If access is granted, the administrative staff is able to manage master data, such as courses, students, lecturers and rooms. To input students and lecturers data, the UID of RFID is required to be inputted. According to the master data, administrative staff is able to compose schedule of class. With the existing schedule, the staff is able to enroll students as participants of the class and also assign lecturers to teach class. When students and lecturers do tapping their RFID to RFID reader, the staff is able to receive notifications whether the student or lecturer attends, absent or late in the class. An example of screenshot that shows a process to add class schedule is depicted in the following Figure 9.

The staff is required to input date, start and end time of the class. Data about room, course and lecturer is retrieved from the master data. After all the column is filled, the staff submits
the data to the database. After room, course, schedule and lecturer data has been inputted to the system, administration staff inputs student data which comprises of Student ID, name, username, password, and the UID from the student’s RFID card. The student data input screen can be seen in Figure 10.

![Formulir Tambah Mahasiswa](image)

**Figure 9:** Screenshot of adding student data

Notification of lateness is sent by email to the administration staff, the format of the email can be seen in Figure 11. The email shows the student ID, student name, class name, class date and minutes being late to the class after the grace period.

![Laporan Keterlambatan Mahasiswa](image)

**Figure 10:** Email Notification

6. System and Evaluation
Four tests were conducted to test whether the system works as intended or not. Each test will be conducted multiple times and the success and failure rate will be recorded. The result and analysis of each test are discussed in the sub-sections below.

6.1. Data Input Testing
The purpose of this testing is to test whether inputted data is properly received and stored in the database. This testing is done by inputting the class schedule data from the web interface. The testing is done ten times and the result in Table 1 shows that all ten tests were successful in correctly inputting and storing into the database.
Table 1: Data Input Testing Result

| Test No. | Status |
|----------|--------|
| 1        | Success|
| 2        | Success|
| 3        | Success|
| 4        | Success|
| 5        | Success|
| 6        | Success|
| 7        | Success|
| 8        | Success|
| 9        | Success|
| 10       | Success|
|          | Success Rate 100% |
|          | Failure Rate 0%   |

6.2. RFID Reader Testing
Testing of the RFID reader is divided into two different testing scenarios. The first testing is done by using ten different RFID cards to check whether the system can read those cards properly and differentiate them from one another. The result can be seen in Table 2, where the table shows that all ten cards were properly identified and differentiated from one another.

Table 2: RFID Reader Testing Result with Different RFID Cards

| Test No. | Card No. | Status |
|----------|----------|--------|
| 1        | 1        | Success|
| 2        | 2        | Success|
| 3        | 3        | Success|
| 4        | 4        | Success|
| 5        | 5        | Success|
| 6        | 6        | Success|
| 7        | 7        | Success|
| 8        | 8        | Success|
| 9        | 9        | Success|
| 10       | 10       | Success|
|          |          | Success Rate 100% |
|          |          | Failure Rate 0%   |

The second testing is done by tapping one RFID card ten times and check the data read by the system. It is expected that all ten tests should yield the same UID number read from the card. However, testing result in Table 3 shows that occasionally, the UID number read from the RFID card gives a different number in tests number 4, 5, and 6. This is suspected to be due to the failure either in the RFID reader, RFID tag, or both.

The purpose of this testing is to test whether the system can properly detect whether an attendance is determined to be late because the tapping is done after the grace period of the class, and whether an email notification is properly sent for the late attendance. The testing is done by tapping the RFID card at ten times after the grace period, and the result can be seen
Table 3: RFID Reader Testing Result with the Same RFID Card

| Test No. | Status |
|----------|--------|
| 1        | Success |
| 2        | Success |
| 3        | Success |
| 4        | Fail    |
| 5        | Fail    |
| 6        | Fail    |
| 7        | Success |
| 8        | Success |
| 9        | Success |
| 10       | Success |

Success Rate 70%
Failure Rate 30%

Table 4: Lateness Check Testing Result

| Test No. | Status |
|----------|--------|
| 1        | Success |
| 2        | Success |
| 3        | Success |
| 4        | Success |
| 5        | Success |
| 6        | Success |
| 7        | Success |
| 8        | Success |
| 9        | Success |
| 10       | Success |

Success Rate 100%
Failure Rate 0%

in Table 4. The table shows that all ten tests successfully detects if the tapping is late and sends the proper email notification.

6.3. Time Recording Accuracy Testing

The purpose of this testing is to measure and compare the accuracy of the actual time of tapping the RFID card, and the attendance time recorded by the system. The card is tapped at five different times after the grace period of the class with the time of tapping recorded and compared to the time read by the system and the lateness time reported in the notification email. The result can be seen in Table 5, it shows that tests number 1,2,3 and 5 yields an accurate time, however test number 4 shows a discrepancy of 1 minute between tapping time and time recorded in the system. In this Table 5, several symbol that used are: \( T \): Class Start Time, \( R \): RFID Tapping Time, \( S \): System Read Time, \( M \): Minutes Late in the Notification Sent. This is suspected to be caused by connection and latency issues between RFID reader and database, and this could be significant in cases where students arrive very close to the end of the grace period as it could make a difference between being marked as late or not.
Table 5: Time Attendance Recording Result

| Test No. | T   | R   | S   | M   | Status       |
|---------|-----|-----|-----|-----|--------------|
| 1       | 7.15| 7.40| 7.40| 25  | Accurate     |
| 2       | 7.15| 7.43| 7.43| 28  | Accurate     |
| 3       | 7.15| 7.45| 7.45| 30  | Accurate     |
| 4       | 7.15| 7.47| 7.48| 33  | Off ~1 minute|
| 5       | 7.15| 7.49| 7.49| 34  | Accurate     |

Success Rate 80%  
Failure Rate 20%

7. Conclusion and Future Work

After designing and testing of the system, there are several conclusions that can be drawn regarding the Lecturer and Student Attendance System with RFID. Data input testing to the database from website has 100% success rate where all data successfully enters the database with no data loss or problem. RFID reader testing to read 10 different UIDs or RFID tags has 100% success rate, where the RFID reader was able to successfully identify and distinguish the different UIDs. However, testing the RFID reader to read the same RFID tag 10 times has 70% success rate, as there are several tests that yields a different UID number from the same RFID tag, which might be caused by faulty RFID reader or RFID tag. Lateness check testing has 100% success rate, where system successfully detects when the tapping of RFID tag is done after the grace period of lateness, which is set to 15 minutes after start time of class. Upon lateness, the system successfully sends notification to the administration staff’s email addresses that are stored in the database. Time recording accuracy testing has 80% success rate, as there are tests that has time discrepancy of 1 minute between actual tapping time and the time read by the system, which might be caused by connection and latency issues between the RFID reader and database.

The system can be improved and refined further by adding more roles in the system, such as roles for student, lecturer, and academic advisor, where each role can be defined to have specific privileges and actions available to them. Additionally, the notification sent out from the system can be improved to be able to send images, attachments, audio or video files in addition to text message. And lastly, the system can be integrated to be a part of a larger system such as a smart classroom or smart campus.

Acknowledgments

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