IoT Based Smart Classroom System

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Abstract— **Internet of Things (IoT) is no doubt will be the new revolution in the era of Industry 4.0, where every object will be connected to the server or internet for data processing and control. The attendance system that we currently use now is recorded by signing our signature on a piece of paper, which makes tracking and processing troublesome. It will need to be digitalized by using various sensors and module on it. Besides, the current conventional classroom system does not implement any energy saving system, which contributed to the high cost in paying electrical bills. Thus, in this paper, an IoT based Smart Classroom System is presented. This system consists of two features; the autonomous attendance system as well as an energy saving technology implementation. As for the autonomous attendance system, the attendance that were taken from student matric card will be digitalized and send to the server to be processed, and then the attendance records are able to be viewed via a website. Meanwhile, through the energy saving technology, students or lecturer does not purposely need to switch off the air conditioning and lights each time they leave the class anymore. Overall, the whole system will increase efficiency in terms of attendance recording and processing and save huge amount of cost spend in electricity bill.**

Index Terms— **Autonomous Attendance Recording; Energy Saving System; Radio Frequency Identification (RFID); Smart Attendance System.**

I. INTRODUCTION

The rate of the student attendance is crucial as students will perform well in exams and practical lab if they go to classes consistently. Some of the students may not understand the importance of attending the class as they tend to skip the classes [1].

In University Teknlogi Malaysia (UTM), the attendance system is important as it will deter the rate of student skipping the class in which students are required to obtain at least 80% of the attendance in order to be eligible in taking the final exam of that particular subject. Thus, it is an obligation for lecturer to record student attendance in order to abide for this academic rule. However, the traditional attendance system that currently used in UTM could be improved, as it uses paper to record the student's attendance. Each of the students are required to sign the paper and the paper is passed around from one student to another just attendance record purpose. This action will cause distraction, where their attention is supposed to be at the lecturer. In consequences, the students may miss out some important facts and tips during the class. In addition, lecturers have to waste a huge amount of effort to calculate the attendance rate manually or by input typing [2]. This can put a great deal of stress in lecturers' workload. Furthermore, they have to bring the attendance sheet every day to the class.

This is where autonomous attendance system comes in. The purpose of this project is to create a platform in terms of a smart classroom system that will bring accessibility to students and especially to lecturers. This autonomous attendance system can be implemented in the university to track the percentage of attendance of each of the student automatically. Student will just need to scan their matric card onto radio frequency identification (RFID) reader and the data will be sent to the university server and be processed to ensure validity of the student in the correct class and time. Then the data will be visualized in terms of data and statistics in the website to be accessed by respective lecturer. Through the system, lecturer workload can be significantly reduced. At the same time, this system will encourage students to bring their matric cards whenever they attend classes.

Another feature of this project is the Wireless Sensor Network (WSN) energy saving technology that was implemented in it. WSN is a network of nodes (wireless sensor and actuator) that connected with each other. Through the network, the nodes pass the data from one to another to enable effective data transmission to main location. With this technology, the system can automatically shut down electrical appliances when no one in the classroom. Sensors will be installed at the ceiling of the classroom to detect human movement, whenever there is no one in the classroom in a certain period of time, the sensors will automatically send radio frequency (RF) signal to the microcontroller to switch off those appliances for energy saving.

II. RELATED WORKS

A. RFID Attendance System

Sutar has designed and implemented a RFID attendance system with some algorithm of taking in attendance data and put in to the correct database for user to view it [4]. There are five different levels of accesses which are the administrator, lecturer, student, university, administration and guest. Each of the users will have limited access and interfaces according to the user level as this is for security and privacy purposes.

Meanwhile, Costa has reviewed various hardware module to implement a low cost, but yet effective RFID attendance system to be implemented in class [5]. Various low cost development board and module such as Arduino Uno (a micro controller), real time clock module (to have a time parameter inside Arduino), Ethernet shield (to enable connection to the server via Ethernet) and RFID reader (to scan RFID tag) were used in the system.

Arulogun *et al.* has designed a RFID tracking attendance

system, by sending out notification to the mobile or an email to the students and lecturer [9]. Atabekov from Kennesaw State University has proposed a smart classroom system but with a different approach which used chairs in the classroom as attendance recording device [8]. The chairs all are connected to each other in the WSN, the data of the student is sent to the server for attendance tracking.

B. WSN Energy Saving System

Subramany has implemented a heating, ventilation and air conditioning (HVAC) control technique in an office environment by integrating with various sensors module to increase the accuracy to detect human presence in an indoor area [6]. The sensors used are temperature, humidity and carbon dioxide (CO_2) sensor module that were installed in each room. The sensors were connected to a wireless module to send necessary data to the base microcontroller to control the flow and temperature of air supplied into each room.

Aftab has revolutionized the traditional HVAC system that rely on wired temperature regulators and thermostats into a smarter form so that the system will have more optimized algorithm with minimum human supervision [7]. The proposed algorithm balancing the trade-off between communication frequency of wireless sensors and effectiveness of HVAC system so that to maintain thermal comfort and maximize the battery life of the wireless sensors. The algorithm is devised through multiple simulations to find out the pattern through different scenario i.e. different in average room temperature over time.

III. RESEARCH METHODOLOGY AND DESIGN

A. Project Work Flow

This smart classroom system project is divided into two main parts, the first is the RFID attendance system and second is the WSN Energy Saving System. The RFID attendance system can be divided into the prototype design and the web design part. The prototype design will grab out the RFID number from a RFID card to be sent to the server through Ethernet and save the information in the database. A web page is designed to visualize the information of the student as well as attendance statistical.

As for the WSN Energy Saving System, it is dealing with detecting any human movement in the classroom and the system will automatically switch "ON" or "OFF" the electrical appliances that are in the classroom depending on the situation.

B. RFID Attendance System

Figure 1 shows the flowchart for the process of RFID attendance system. The RFID attendance system can be divided into two parts; one is hardware, the other one is software. The hardware part consists of several low cost development shields and modules such Arduino Mega IC, RTC module, RFID reader, Ethernet module and etc. While the software part consists of MySQL database, server connection, webpage and etc.

In order to record student's attendance, students are required to tag their matric card onto the RFID attendance system, specifically to the RFID reader. After that, RTC module will record the time the student tagged their matric card and at the same time buzzer will be sounded two times

(to indicate that the student successfully tagged their matric card into the attendance system). Then the time and RFID number of that student will be sent to server through Ethernet module.
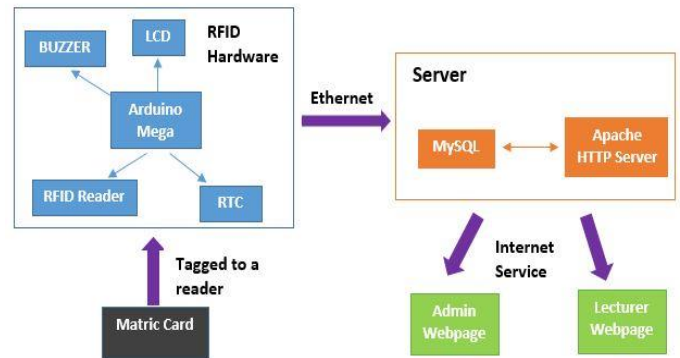

Figure 1: Process of RFID attendance system

The server will check the availability and validity of the student whether he or she is in the correct class, before the data is successfully saved in the MySQL database. If the attendance is successfully taken after checking all the information, a string of a welcome message together with the student name ('Welcome <name of the student>') will be displayed on the LCD display. Through this, the student can know that their attendance is successfully taken. This is necessary as students might cheat their way to scan in a different class but in the same time to take their attendance.

Figure 2 shows the interface UTM attendance system website. User need to log in first in order to able to access the contents of the website. Currently, only two level of users is provided; one for the administrator, the second one for lecturer. A username and password was provided in order to access the website.
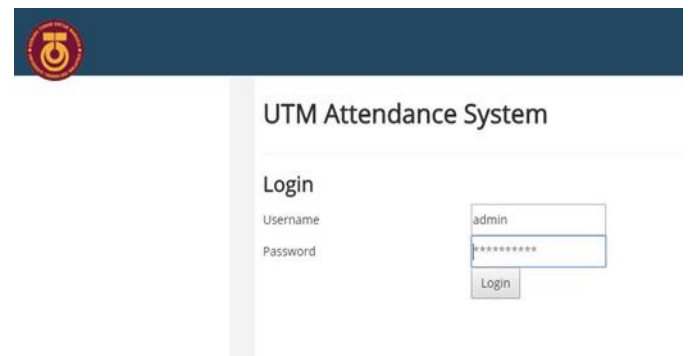

Figure 2: Design of the Website

The administrator is able to create a user account, register subject to time table, student registration and attendance table in the server. They can have direct access to all the settings and configurations of the server and database system. Whenever a modification of the system is needed, admin can log in with their account to do their work.

Besides, admin also can create a new ID and password to access the website, able to register any new student with Name, RFID number and Matric Number, able to register the subjects taken by the students, able to register any new

subjects with necessary info like ID, Name, Day, Time Start and End, Class ID and Name of lecturer and create an attendance table in the database from selecting the subject and day of the subject.

Meanwhile, lecturer can log into their account to check their student attendance data and details. The system will automatically calculate all the necessary attendance information without the lecturer to do it manually. Lecturer also could re-check the status of student attendance, and are able to change the status of attendance in case of medical leave.

C. WSN Energy Saving System

Figure 3 shows the flowchart for the process of WSN Energy Saving System. The WSN Energy Saving System were divided into two mechanisms: the human movement detection and off-working hour mechanism. In the design, there will be two nodes with the Arduino Pro Mini as their microcontroller (MCU), they are called PIR node and relay node. PIR node will be dealing with detecting human movement in the class while relay node serves to switch "ON" or "OFF" the electrical appliance depending on the PIR node's signal. The PIR node will be connected to a PIR sensor and a nRF24L01 wireless communication module while the relay node will be connected to 1 channel relay, a RTC mode and a nRF24L01.
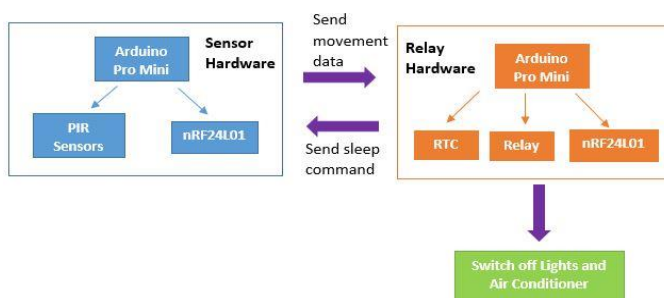

Figure 3: Process of WSN energy saving system

For human movement detection, whenever there is no human movement in the classroom, the PIR sensor will trigger the MCU in the PIR node to wait for a period of a time; during the waiting period, if there is still no human movement detected, then the nRF24L01 will send a trigger message to relay node to indicate that there was no human in the classroom. The relay node will receive the message and automatically switch "OFF" the electrical appliance in the room by controlling the input-output (IO) of 1 channel relay. Vice versa, if there is a constant human movement detected in a period of time, thus it confirms there are human in the class. The nRF24L01 will send a message to the relay node to switch "ON" the lights or other electrical appliance.

As for off-working hours mechanism, the RTC module becomes the most important tool in order to determine whether the current time is falls on the weekend or it is after 6pm in the weekdays (last class of the day). Whenever the current time on the RTC falls in these off-working hours period, a signal will be sent to relay node in order to activate the sleep mode function. Note that, the sleep times are different from the one on weekdays and weekends. Before

the relay node goes to sleep mode, it will send a RF signal to the PIR node to ask it to activate the sleep function; all of the electrical appliances connected to PIR node will be switched "OFF". At 8.00am of the next day, both of the nodes will wake up automatically and resume its routine operation.

IV. RESULTS AND DISCUSSION

A. Smart RFID Attendance System (Lecturer)

When lecturer log into the system with their username and the password, the home interface that they will see includes some necessary info of the subject (refer Figure 4). A welcome message with the subject name they are lecturing, the lecture name, number of student under their section and the overall percentage of attendance for all of the student will appear on webpage screen. At the left side of the webpage, they will see some navigation bar which consists of General Details, Student Details and Date Details.
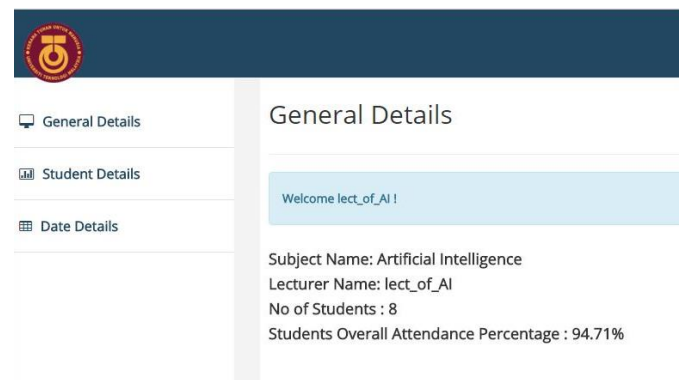

Figure 4: Web Page of the Home Interface for Lecturers

1) Student Details

Under the Student Details navigation bar, lecturers are able to check and track each of the student overall attendance as shown in Figure 5. Lecturers can see all of the student details and current percentage attendance for each of the students. Besides that, lecturers also able to change the status of the attendance; i.e. form "absent" to "present" in case of medical leave or other specific reasons (see Figure 6). This can be done by clicking the name of the student that the attendance need to be modified, then select the date and choose the status of attendance. Once the submit button is clicked, the attendance status will straight away be updated in the server.
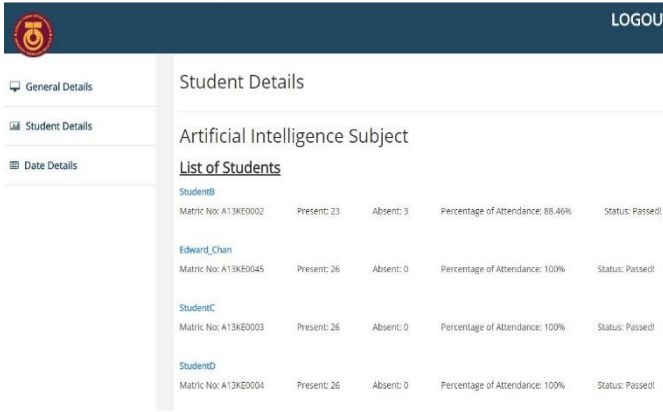
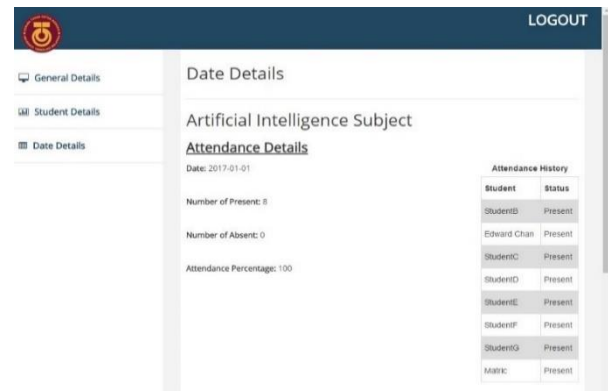Figure 5: Web Page of all the Student Details for Lecturers

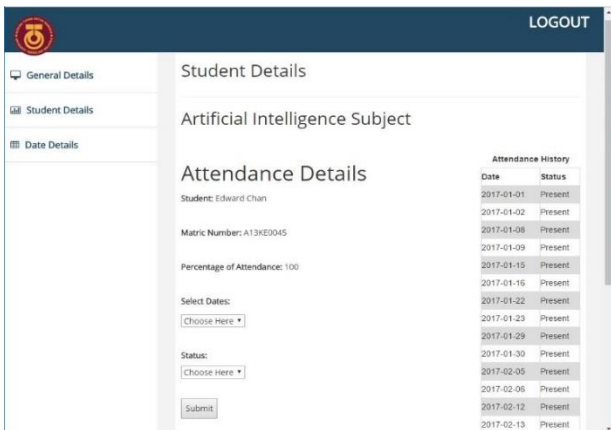Figure 6: Web Page of Selected Student Details for Lecturers

Figure 7: Design of the Website for Lecturers

2) Date Details

Under the Date Details navigation bar, lecturers are able to check back the attendance history of each of the students in that class for each of the particular dates as shown in Figure 7. After a specific day is clicked inside, an information regarding the attendance history of the students will be displayed such as; which student is present and absent, some information on the number of present, absent and percentage of attendance as shown in Figure 8.

Figure 8: Web Page of Selected Date Details for Lecturers

B. Smart RFID Attendance System(Admin)

When administrator log into the system with their username and password, a welcome message and some includes some necessary links to the database will be displayed (see Figure 9). At the left side of the web page, a navigation bars which consists of Login Info, Student Info, Student-Subject Info, Subject Info and Attendance Table Details can be found.

There are a lot of functionality of the web page provided to the admin for the sake of maintaining and upgrading the attendance system and database. Below are some features available for admin.

1) Home Dashboard

Under the home dashboard, admin able to have access each and every table in the MySQL as shown in Figure 9.
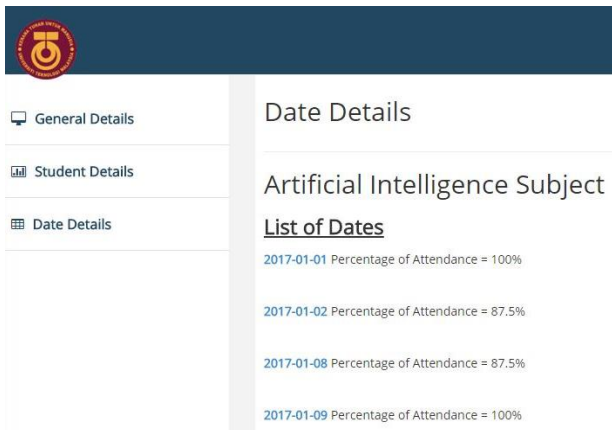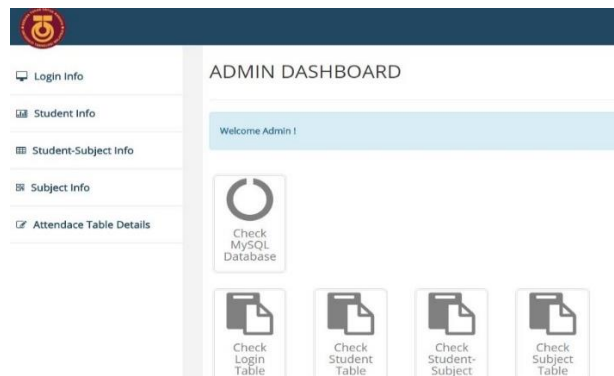

Figure 9: Web Page of Home Dashboard for Admins

2) Login Info

Under the Login Info navigation bar, admin able to create a new username and password for lecturers to access the website as shown in Figure 10. Necessary information such username, password and subject to teach should be provided before the new user account is created.

Figure 10: Web Page of the Login Info for Admins

3) Student Info

Under the Student Info navigation bar, admin can register new student to the database with name, RFID number and matric number should be provided upon registering new student so that he or she could use the RFID attendance system as shown in Figure 11.

Figure 11: Web Page of the Student Info for Admins

4) Student-Subject Info

Under the Student Info navigation bar, admin can register the subjects taken by the students as shown in Figure 12. He or she first have to key in the matric of the student. Then the system will direct the admin to another page to let them select the subject to be registered. Under that web page, necessary details of the student will be displayed such student name, student ID as well as student's matric number (see Figure 13).

Figure 12: Web Page of the Student-Subject Info for Admins

Figure 13: Web Page to register Subject for Selected Student for Admins

5) Subject Info

Under the Subject Info navigation bar, admin can register any new subjects to be add to the database subject to provide necessary info of the new subject such subject ID, subject name, subject time table (day of class, time start and end), class ID and name of lecturer that will teach the subject as shown in Figure 14.

Figure 14: Web Page of the Subject Info for Admins

6) Attendance Table Details

Under the Attendance Table Details navigation bar, admin can create an attendance table based on the subject time table (see Figure 15). Before the attendance table is created, admin should select subject or class name and click the day of the subject (based on the subject's time table) and then click submit button. The server will straight away create a new table for attendance for the particular subject and was saved in the database. Finally, the attendance table for that subject is ready to be used.
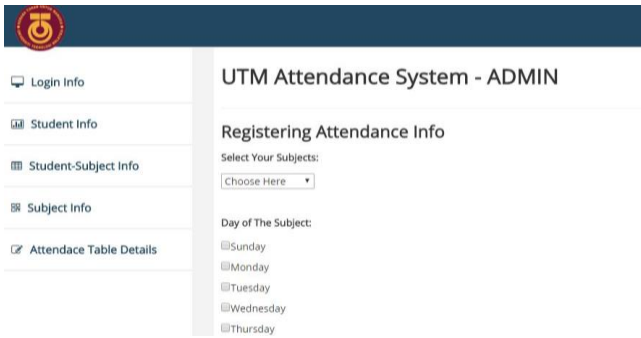
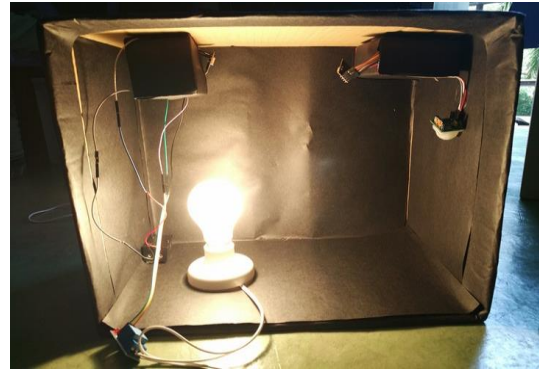Figure 15: Web Page of the Attendance Table Info for Admins

Figure 18: Picture of the prototype of Human Movement present

C. WSN based Energy Saving System

The system is implemented in Arduino connected with PIR sensor and communicate using nRF24L01 RF module. When there is a continuous no human movement in 4 seconds waiting time, then the PIR node will send a message to the relay node to switch "OFF" the electrical appliance. However, when there are human movements during those periods, PIR node will tell the relay node to switch "ON" electrical appliances.

1) No human movement

When there is no movement, the Arduino will keep on counting for 4 more seconds (refers to Figure 16), if still no human movement, then it will send a message to the relay node to switch "OFF" the lights.

Figure 16: Web Page of the Attendance Table Info for Admins

2) Human movement

When there is no movement, the Arduino will keep on counting for 4 more seconds (refers to Figure 17), if there is a sudden human movement detected, then it will tell the relay node to switch "ON" the lights as shown in Figure 18.

Figure 17: Case Results of Human Movement in Class

V. CONCLUSION

From the results we found that, the IoT based smart classroom system that consist of the smart RFID attendance system and WSN energy saving technology will be successful and can be worked out inside of any classroom. Further development in the design of the system will be needed to enable full system to be ready to be implemented in every classroom throughout the university. With the introduction of the WSN energy saving system, we hope that the energy consumption spent in classroom for air conditioned and lights will be significantly reduced in terms of energy used as well as the energy bills. So that it could channel more fund in research and other facilities. This smart attendance system will benefit not only for students, but for lecturers especially in reducing their daily workout. When their work is reduced, they can concentrate more on their research and bringing knowledge to every student.

There are lots of aspect for improvement needed in this project, especially for the web interface for the administrator as well as lecturers. The interface should be clear, concise and attractive. For the RFID attendance system and WSN energy saving prototype, the system currently is running in sequential order, it should be improved to be run in parallel sequence so that it would not be depending on every code block in running the system.

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