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A Paho MQTT based IoT-RFID Attendance System using NodeMCU Firmware

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Abstract - *This paper aims to implement real time-small scale attendance system by merging NodeMCU WIFI module integrated with the RFID module and new trending lightweight MQTT protocol as IoT platform. It is designed to automate the attendance for covering all the shortcomings of the conventional manual pen paper method, which is very time consuming, space consuming, cost consuming, risk of data loss or damage of attendance sheet. The objective is to get accurate and reliable computerized attendance on the dynamic website with excel print for better utilization of faculty. Students are also capable to see attendance to improve academic performance. On the basis of unique RFID tags which gets fast and easily scanned in the proximity of the RFID reader. MySQL database has been used in order to access, manipulate and represent the student's attendance data in real time with appropriate security measures for data integrity. Finally, it quickly generates reports on the webpage. This proposed system is an entirely green and clean way and novel approach to flourishing in the IoT era.*

Key Words: RFID, ESP8266, MySQL, IoT, Paho MQTT, PHP.

1. INTRODUCTION

Attendance is a state of being present or an evidence of presence of the students in educational institutions, since penalty claimed for the students having below 80% present for that attendance record. This is a significant aspect to make future bright for students.

1.1 Existing scenario to the problems

Still today, attendance is taken by lecturers during lecture in 3 ways, which is insecure, inaccurate, leads to human error.

1) Calling name or roll number on the register, which is waste of teaching time.
2) Blank paper which is circulated by students during lecture. There may be chance of proxy intentionally or sometimes any student may forget to make attendance.
3) Attendance sheet which already having name, roll number needs to be signed by the students, which distract the students from the lecture concentration to find the name for making attendance.

Valuable time and work get wasted to organize and structure the attendance data in registers, needed to put and maintain that attendance data to proper location for future references. It requires more papers, registers and cost for it. Wasting valuable quality time of teaching leads to loss of education. This is not systematic as missing name of any student, proxy false attendance, chance of sheet loss or damage may possible. So, this pen paper work attendance method, impacted on four factors: time consuming, space consuming, cost consuming and data loss.

1.2 Solution

The proposed system is absolutely novel approach in IoT platform and implemented with four criteria for time, space and cost purpose.

- RFID technology has been used to reduce the effort of pen-paper.
- MySQL database has been employed in order to store and access the data easily.
- NodeMCU WIFI module has been implemented to connect with the system.
- MQTT protocol has been established for fast and simple communication without latency to build complete IoT system.

In a nutshell it provides a more efficient, effective way to automating attendance via website which allows the user to record the attendance faster and store in a safer place.

1.3 IoT Concept

IoT stands for Internet of Things. It is a technology for a system of interconnected smart devices over a wireless network without human involvement. The IoT devices maybe sensors, actuators, computer devices or software. IoT enables all devices to collect, transfer the data to the cloud, processes that data on a certain software program, and automate the tasks. So, it is a network of physical connected devices for exchanging data after being connected over the internet. So, it operates remotely at remote place.

There are 4 key components to integrate into the complete IoT:

- ✓ Devices or sensors: It maybe RFID, temperature Sensor.
- ✓ Connectivity: The sensors or devices connected to the cloud. It can be connected to the internet via cellular, WIFI, Bluetooth.
- ✓ Data processing: It processes the sensor's data in the cloud using certain software program.

- ✓ User interface: This will be the end user. It will work like an alert about the status or the situation of the devices or give the notification through texts or emails. So, in this way, IoT will work.

IoT gives 4 security measures for data transmitted and stored as per privacy and security concerns.

- ✓ Data confidentiality: unauthorized parties cannot have access to the data.
- ✓ Data integrity: corruption of data can be spotted.
- ✓ Non repudiation: It assures that the sender cannot refuse having sent a certain message.
- ✓ Data availability: reliability of access to and use the data available for authorized one.

1.4 MQTT Protocol

Message Queuing Telemetry Transport (abbreviated as MQTT) protocol is a simple lightweight publish-subscribe based messaging protocol, small code footprint, transports messages on the topic between devices with lesser bandwidth environments. This protocol is an open source, easily implementable and understandable client-server model, widely used in IoT for communication. It can be hosted in 3 ways - locally hosted server, virtual or cloud-based server and shared server application.

Facebook Messenger uses MQTT protocol (2011) to deliver messages in hundreds of milliseconds, and designed to use bandwidths and batteries sparingly. So, it overcomes the latency drawback of multiple seconds.

Ideal for constrained networks and QoS

MQTT comprises of single broker and multiple clients with multiple topics.

- ➢ Broker/Server – An MQTT broker is a server that receives all messages from the client and routes messages to the appropriate destined clients. It accepts all messages from clients and filters, delivers them to interested topic. Messages are organised in a hierarchy to topic.
- ➢ Clients – It may be devices, sensors, etc. could be one that either publishes or subscribes to a topic. Clients communicate with each other indirectly with the help of broker. Both publisher and subscriber are clients and runs on MQTT library.
- ➢ Topic – It is a name or place or namespace or entity titled for messages on the broker. Clients will subscribe and publish to a topic.

Each message consists of a fixed header, variable header and payload. Each control packet has a fixed header of 2 bytes, not compulsory to have variable headers and payload. A payload limited up to 256 MB of information and each connection to the broker contains a specified QoS (Quality of Service) level measures.

1) QoS 0 (At Most Once) – It is by default fasted setting mode. There is no follow up action as the client doesn't wait for acknowledgment (fire and forget).

2) QoS 1 (At Least Once) – The broker will resume responding to the messages, until acknowledgment is not received (acknowledged delivery).

3) QoS 2 (Exactly Once) – It is slower mode but a reliable QoS setting mode of two-tier handshake. This message is a one-time delivery. This ensures that the message is acquired and only delivered once (assured delivery).

2. LITERATURE REVIEW

It is recommended to use ESP8266 module for WIFI purpose in order to collect, record and process the data of participants of any event/conference as using MRF24WB0MA is three times more expensive [1]. When the RFID reader reads the tag and transmits the tag's data to the microcontroller. After comparing the stored ID, the attendance is then showed on the LCD (Liquid Crystal Display) and the data is transferred to the PC via RS232 port [2]. According to these papers [3][4], There are many attendance systems designed with RFID, which improve the manual method. It captures the attendance of the students by flashing the tags over the RFID reader.

The low-cost attendance monitoring system was implemented using RFID and IOT with the Cloud. To avoid proxy, the simple image comparison technique is used. It totally works on an image comparison algorithm by considering RGB values of the pixels. The student's attendance stored in the cloud database. Wi-Fi adapter and Cloud are less expensive than the Desktop computer and need less maintenance [5]. The concept of "IoT" has growing highly and attractively attention in education as well as industry while transmitting data over the network through computer communication without human interaction [6].

In this research project, making use of trending IoT fields, i.e. Wireless RFID technology and NodeMCU firmware has been used along with new MQTT protocol. To demonstrate our proposed system complete IoT, Paho MQTT is one of the types of protocol program is used. In this study, the result of the system is nothing more than to get attendance record of the students with downloadable excel sheets. This print of downloadable attendance excel sheet makes educational work excellent.

3. PROPOSED SYSTEM AND METHODOLOGY

RFID Technology – This technology permits devices to identify and capture the certain unique information recorded on a tag using radio waves.

Compared to the barcodes, RFID provides faster identification, no line of sight, reusable to rewrite or update,

higher data storage, higher read rate, multiple tag readings at a time, toughness, extreme distance reading without intrusion, cost effective. The best features of RFID are its speed, function, performance over bar code.

RFID module is used as input to the NodeMCU, which consists of RFID Reader and RFID Tags with antenna.

MFRC522 reader is used with features of low cost, compact size, low power consumption, portable and installable as needed. Students must need to enter in the class, so passive tags are used, which are powered through reader's electromagnetic fields to receive messages or ID data wirelessly from the reader. Because passive tags don't contain battery.

NodeMCU WIFI (Node Micro-Controller Unit Wireless Fidelity) Module – It is an easily available IoT firmware in addition with the development board. It is a cheap microcontroller with inbuilt ESP8266 WIFI capability to communicate and aid full TCP/IP stacks and assist to build easier on IoT platform. This module is interfaced with RFID.

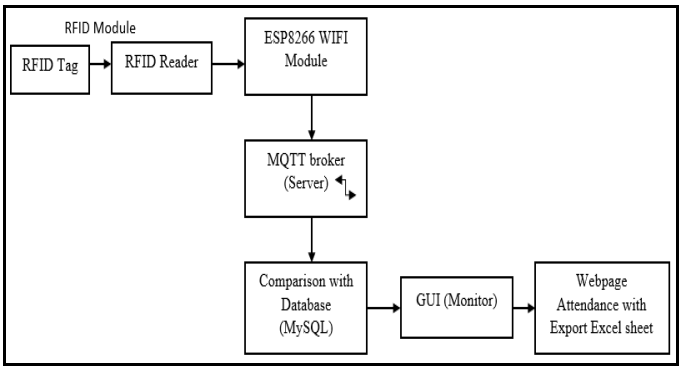

Fig -1: Proposed system

In website design, the frond end system is implemented through MySQL database and PHP. PHP, HTML with CSS languages are used to develop the web pages and to connect with database. Attendance data processed with PHP as server-side scripting language through HTML forms and creates queries for the data and the database will ultimately be effective. Localhost is activated by creating a database connection with MySQL tool i.e. phpMyAdmin.

Paho MQTT publish subscribe architecture

Eclipse Paho provides an open source client class implementation using Paho MQTT Python client library, which employs to transmit information across devices.

To integrate the RFID tags in IoT, this publish subscribe pattern has been employed (Fig-2). When the RFID client wants to broadcast, send or publish data of topic ID to the broker. This needs to establish a connection with ESP8266 broker. The RFID reader acts as sensor, captures ID from tag. The RFID clients can publish the topic to the broker, after connection establishment between them. The broker then receives and publishes that available ID to destined computer client. The computer client requests to ESP8266 broker to connect, after which the broker sends the acknowledgment to the destined client for that connection request. The broker continuously sends updated current messages of topic to the subscribed computer client.

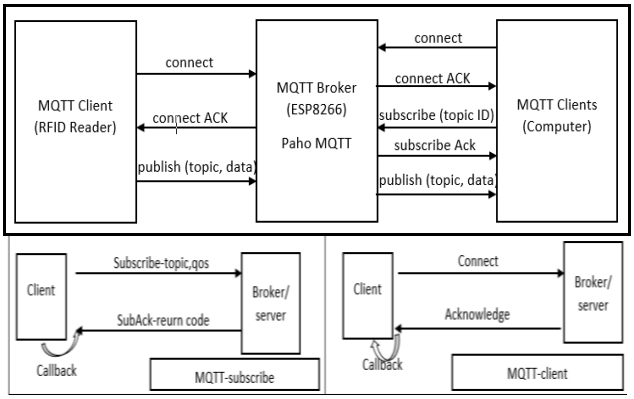

Fig - 2: Simple Paho MQTT service module with callback

All Paho MQTT communication is accomplished with subscribe and publish code scripted in python code. Paho MQTT client offers several main methods nothing but control packets with their callback: 1) connect() and disconnect() ; 2) subscribe() and unsubscribe(); 3) publish()

Connect – This is the first packet dispatched from the client to the broker to establish a connection.
Disconnect – This is the final packet dispatched from the client to the broker for connection is being shut.
Publish – A client sends a message to the broker using topic.
Subscribe – A client request to the broker with interested topic to subscribe. After receiving the subscribe acknowledgement, the broker sends published messages to that topic. Clients are capable to subscribe multiple topics.
Unsubscribe – The broker will stop publishing message on subscribed topic. Clients can subscribe to the broker for any topic of interest, being able to unsubscribe, when bored.

3.1 Methodology

The proposed system methodology (Fig-3) involves four phases.

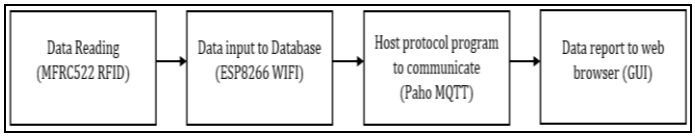

Fig -3: Proposed methodology

1) RFID data reading - RFID reader (RC522), RFID tag (student's ID card) and NodeMCU development board (ESP8266 WIFI module) are included.

2) Data Acquisition/Data input to database - ESP8266 is programmed in Arduino sketch code. Then this code processed for the data input to MySQL database system by using PHP via XAMPP web server.
3) Hosting MQTT broker (Communication protocol) – Paho MQTT is implemented and coded in python 2.7 software. This protocol communicates with ESP8266 and computer system.
4) Data report to web browser/Dynamic website – To visualize the interface at the front end, CSS, JavaScript and PHP server scripting languages are used in the backend for data report to the web server.

3.2 Flowchart framework

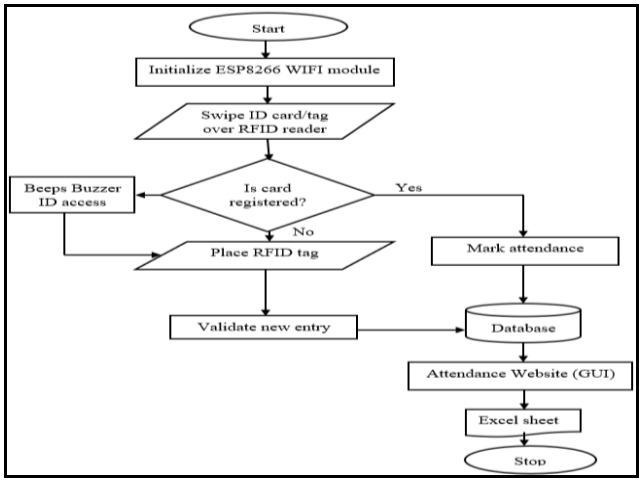

Fig - 4: Attendance flowchart

As per flowchart, it will initialize ESP8266, then capture and read tags whenever get scanned over reader. It will check the condition that card is registered or not, a) if not registered, then buzzer will beep for incorrect entry. After that, place the RFID card and validate the new entry for the new card in the database. b) If the condition is true and the card is registered. Then it will mark the attendance automatically in the database, which will be displayed on the attendance website with printable excel sheet format.

4. RESULTS AND DISCUSSIONS

In Arduino IDE coding, enter the SSID along with the password of WIFI credential using available hotspot, enter the IP address of the computer system on which the server is running to see attendance on the webpage in web browser of computer system. If all connections are proper, then ESP8266 and RC522 will blink up and generates the output of the attendance. The data from hardware side is sent to the MySQL database software system in computer with micro USB cable.

4.1 Testing (Backend Operations)

Several RFID tags were tested to input the student's data and the details were updated in the database by using RFID tags swiped over the reader for registering. The buzzer will beep for unregistered students, which are not stored in the database. The attendance record of every student is performed during testing. Each tag is detected with unique ID. The ESP8266 sends the student ID for comparison with the database and displays that student's card ID number using serial communication through Arduino coding and is displayed on the serial monitor of Arduino IDE (Fig-5) and also shows IP address of NodeMCU ESP8266. For working of the broker with clients, Paho MQTT has been established. So, scanned ID is shown on the python shell (Fig-5), with showing message that MQTT connected. During execution, Python code must need to be run in parallel to the Arduino code for complete backend operations.

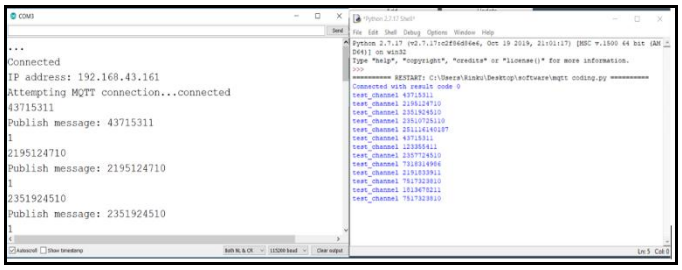

Fig -5: Outputs on Serial monitor of Arduino IDE & Python Shell in python IDE

This data was detected and matched successfully with that registered ID, then sent and stored in the MySQL database with student details and DateLog. The stored data table can be checked in phpMyAdmin page (Fig-6).

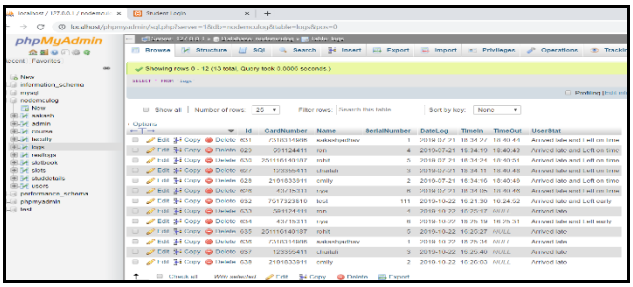

Fig -6: phpMyAdmin database

4.2 Dynamic Website Output (Front-End Design)

In order to access the home page of the website portal (Fig-7), user authentication is provided by the admin, to prevent unauthorized access to the credential data. Homepage of website has four main integral tabs: Admin, faculty, student validation and student login.

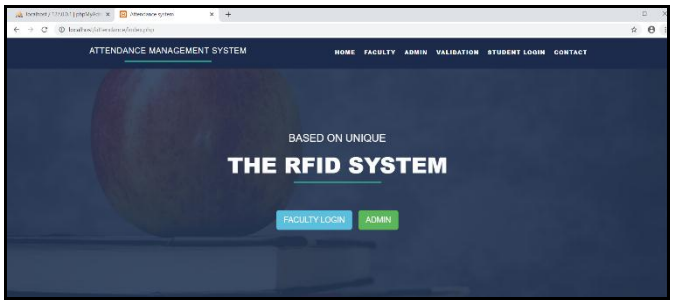

Fig -7: Homepage of dynamic Website

Admin, faculty and student (Overall login page as Fig-8) modules are required to register and login for secure access. During login, providing any wrong data, the website shows a pop-up message saying that 'incorrect data'. User authentication has been verified through a username and password during unit testing. This data is matched and stored in the system database. When the login process is successful, then the user is automatically redirected to see the basic information and able to see attendance record with date and timestamp.

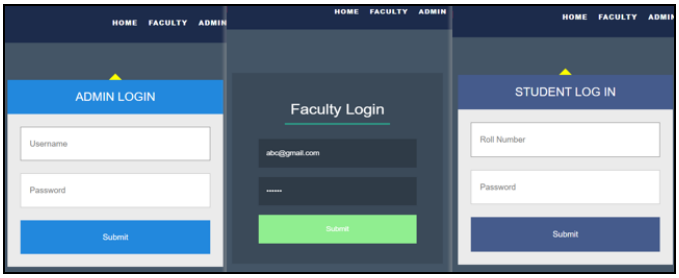

Fig -8: login page for admin, faculty and student

4.3 Attendance Result

Faculty can see attendance of the students for their session using faculty module and the students able to see attendance using student module. Export to excel tab is useful feature to print by selecting proper date on the date tab (Fig-9). This downloadable excel sheet (Fig-10) is useful to faculty for superior work.

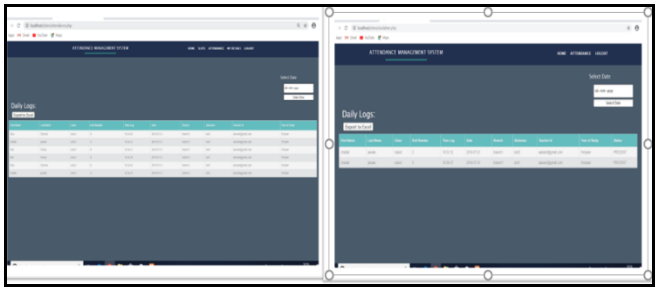

Fig -9: Attendance on webpage: Faculty and Student

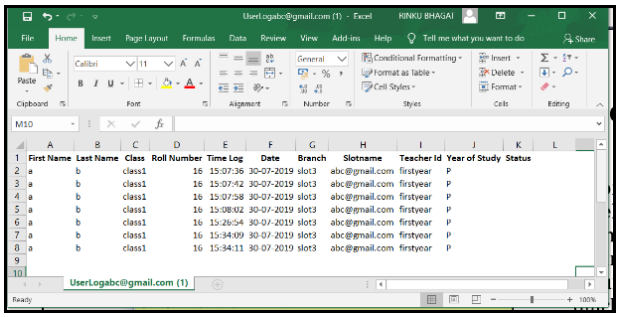

Fig -10: Excel Sheet attendance

Our motive is to see computerized attendance on webpage with a downloadable excel sheet has been implemented successfully with Paho MQTT on small scale.

Overview of Workflow

1) The hardware needs to be connected to the computer through USB cable.
2) Setup NodeMCU WIFI setting on available hotspot. Run the computer as a server using IP address of the system on Arduino IDE sketch. Similarly, run the python program at the same time. Then, connection will be established.
3) Firstly, scan RFID tags over RFID reader, then ESP8266 reads that scanned and captured ID and will be displayed on the serial monitor of Arduino IDE.
4) If 'Attempting MQTT connection...connected' message is displayed on that serial monitor, then MQTT connection is established, so that we can see ID number on both serial monitor of Arduino IDE and python shell of Python IDE at the same instance.
5) During execution, ESP8266 has WIFI capability, so it will send ID data to the database.
6) Attendance results will be displayed on the computer's web browser. XAMPP is web server which enables and runs PHP scripting on an open source PhpMyAdmin tool.
7) If the python code is running properly, then ESP8266 will process that data on a dynamic website.
8) This website displays all the important details as per attendance. Finally, student's attendance will be displayed accordingly.

Website Workflow

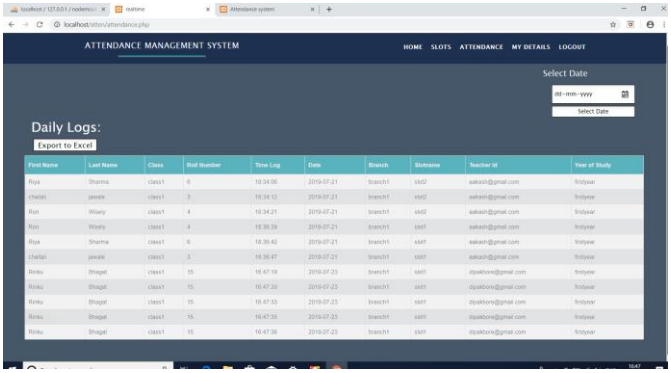

Fig -11: Attendance with faculty name

1) Go to the Admin module. Admin will login through username and password.
2) Admin will do two tasks. Add new students by RFID cards and register new faculty members by using add student tab and add faculty tab respectively.
3) Then the admin will logout.
4) For newly allotted students need to validate details like branch, class, active academic year, birthdate, etc. using student validation tab.
5) For Faculty module, faculty will login with email ID along with password, add book slots, subject, time, etc. and will logout.
6) If the validated student hover the card on RFID, and if current slot is going. The student will be marked as a present for that particular branch, lecture time and date with username of faculty (Fig-11).
7) Faculty will login and check present students for their conducted lectures.
8) For Student module, student will login using roll number and password.
9) Student will see attendance using student module. Also, will update personal details as per need. That's the flow for website.

5. CONCLUSIONS

This paper has presented the proposed system with hosting Paho MQTT implementation properly for communication and its interfacing successfully accompanied with booming RFID technology. In order to accomplish effective and environment friendly time-saving automated computerized attendance in real time with ready excel sheet to maintain attendance records in IoT trends has been done. As regular pen-paper methods require more papers, registers, space to store and the cost involved. Hence, this proposed system improves in four factors: 1) Time 2) Space 3) Cost and 4) data integrity.

The system provides more accurate and high identification in quick and rapid way and verification speed in seconds. I conclude that this user-friendly proposed system would prove to be in characteristics like easy and fast report generation, ease of installation design, cost efficient, time saving, less tedious, portable and analyses data in real time. To overcome unreliable and inaccurate manual work, this proposed system gets improved with less effort and yet generates the results with high accuracy and qualitative one. Ultimately, improves academic performance for student achievement with encourage as quality time of teaching saves.

Future scope:

- Mobile app can be developed.
- SD card Modem can be used for backup memory.
- Thingspeak as a cloud server can be used for data analysis.
- Hadoop software can be used for massive data storage and processing.

Security and privacy - Use of unique identity with biometric technology such as iris sensor or fingerprint sensor or image processing improves more authorization for RFID tag misuse, as tag is prone to manipulation.

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