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Design and Implementation of an IOT-Based Smart Attendance Monitoring System Using Dynamic QR Codes

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Abstract

In educational institutions, efficient and accurate attendance monitoring is crucial for maintaining academic integrity and student engagement. Traditional attendance systems are often time-consuming, prone to manipulation, and inefficient for large classrooms. This paper proposes Design and Implementation of an IoT-based Smart Attendance Monitoring System utilizing QR code technology to streamline and automate the attendance process. The system uses a mobile application and a Raspberry Pi- based display unit to present dynamic QR codes. The system uses also a cloud-based backened firebase. The system integrates a QR code generator and scanner with a cloud-based backend, allowing students to mark their attendance by scanning unique, time-sensitive QR codes displayed during each lecture. The QR codes are dynamically generated to prevent proxy attendance and can be linked with student identification to ensure authenticity. Attendance data is captured in real-time and stored securely on the cloud, enabling faculty and administrative staff to access and analyze attendance records effortlessly. The use of IoT devices ensures connectivity, scalability, and automation while enhancing transparency and reducing human error. This system promotes accountability, enhances classroom management, and provides a reliable, user-friendly solution for attendance tracking in modern educational environments. The preliminary results show a 90% accuracy rate in attendance logging with positive feedback from the faculty

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Introduction

In recent years, the integration of Internet of Things (IoT) technology into educational institutions has opened new avenues for enhancing operational efficiency and academic oversight. One area where technology can provide substantial benefits is in the management of student attendance during lectures. Traditional attendance recording methods such as roll calls or paper-based sign-in sheets are not only inefficient but also susceptible to manipulation, such as proxy marking (Amritha *et al*., 2019). These methods consume valuable teaching time and often fail to provide accurate real-time data (Alghamdi *et al.,* 2017). In most educational institutions he attendance is taken manually. It is not only time-consuming it is also insecure and unreliable and it can be lost. Some institutions are using attendance sheets for attendance why this will be difficult for teachers to keep track of many students because by taking or writing for them a student can help other students or his friend to mark their attendance even the other students may be absent or come late in class so it is not reliable (Dey *et al.*, 2015).

To address these limitations, we propose an IoT-based Smart Monitoring System that utilizes Quick Response (QR) code technology. In this system, each student is assigned a unique, encrypted QR code linked to their identity and course schedule (Alhasson *et al*.,2020). At the beginning of each lecture, the QR code is scanned using an IoT-enabled device or mobile application. The scanned data is transmitted over the internet to a centralized cloud database where it is authenticated and logged instantly. This process significantly reduces the chance of proxy attendance and ensures that only present students are marked.The system is designed to be user-friendly, secure, and scalable. It supports real-time data processing, automated attendance reporting, and integration with institutional learning management systems (LMS). Thus, the system is scalable ad can be integrated with existing learning Management Systems. Additionally, it offers analytical tools for faculty and administration to monitor student engagement and identify patterns of absenteeism (Ali *et al*., 2018).

This paper discusses the system architecture, components, implementation strategy, and security considerations. By automating attendance tracking and integrating it with cloud computing and IoT, the proposed solution aims to modernize lecture

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monitoring in educational institutions and promote a more accountable and efficient academic environment. The proposed system can be achieved with these objectives: Collection of data of students in the department for a particular level of study, using the data to generate and design QR code using a python program, connecting the data to the design system and simulation and test run the designed QR code management System.

There are several methods used for smart attendance systems and they include (Bhise, 2022); QR code, RFID tag, Biometric Fingerprint, Facial Recognition.

QR code: A Quick Response (QR) is a type of matrix barcode (or two-dimensional barcode) first designed in 1994 for the automotive industry in Japan. A barcode is a machine-readable optical label that contains information about the item to which it is attached (Norouzi and Addeh ,2020). In practice, QR code offers data for a locator, identifier, or tracker that points to a website or application. A QR code uses four standardized encoding modes (numeric, alphanumeric, byte/binary) to store efficiently; an extension may also be used.

The Quick Response system became popular outside the automotive industry due to its fast readability and greater storage capacity compared to standard UPC barcodes. Applications include product tracking, item identification, time tracking, document management, and general marketing. A QR code can be read by an imaging device such as a camera and processed using Reed-Solomon error correction until the image can be appropriately interpreted. The required data is then extracted from patterns that are present that are present in both horizontal and vertical components of the image. QR code data entry is at least 100 times faster and more accurate than traditional manual keyboard entry.

RFID Tag: RFID is an acronym for "radio-frequency identification" and refers to a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves (Das, 2019) opined that RFID is similar to coding in that data from a tag or label are captured by a device that stores the data in a database. RFID, however, has several advantages over systems that use barcode asset tracking software. The most notable is that RFID tag data can be read outside the line of sight, whereas barcodes must be aligned with an optical scanner.

Biometric Fingerprint: Biometrics are body measurements and calculations related to human characteristics. Biometric authentication (or realistic authentication) is used in computer science as a form of identification and access control. It is also used to identify individuals in groups that are under surveillance (Gómez *et al.*, 2016).

Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals. Biometric identifiers are often categorized as physiological characteristics which are related to the shape of the body. Examples include, but are not limited to fingerprint, palm veins, face recognition, DNA, palm print, hand geometry, iris recognition, retina, odour scent, voice, the shape of ears and gait. Behavioural characteristics are related to the pattern of behavioural of a person, including but not limited to mouse movement, typing rhythm, gait, signature, behavioural profiling, and credentials (Dey *et al.,* 2015).

Materials and Methods

Materials and Software Used

QR Attendance Software**:** It is a mobile application created by Daniel R. Helmfelt and released on Jan. 18, 2018. Barcode Scanner**:** It is a mobile application created by ZXing Team and released on Sept. 9, 2018

Visual Studio Code: Is a code editor redefined and optimized for building and debugging modern web and cloud applications. Figure 1 shows the visual studio code.

Fig 1: Visual Studio Code Logo

Fusion 360: Is a cloud-based 3D modeling, CAD, CAM, CAE, and PCB software platform for professional product design and manufacturing.Figure 2 shows Fusion 360

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Fig 2: Fusion 360 Logo

Blender: Is a free and open-source 3D computer graphics software tool set used for creating animated films, visual effects, art, 3D-printed models, motion graphics, interactive 3D applications, virtual reality, and, formerly, video games. Figure 3 shows the Blender Logo.

Fig. 3: Blender Logo

Canva: Is a free-to-use online graphic design tool. Use it to create social media posts, presentations, posters, videos, logos and more. Figure 4 shows the canvas logo.

Fig. 4: Canva Logo

Hardware Used: Smart Device, Smart phone or a tablet), ID card, 3D printed (Tablet Wall mount)

Methodology

The method involved the QR design, ID design, attendance system and the tablet wall mount design

System Components: The system components include: a QR Code Scanner (e.g., USB barcode reader), Microcontroller (e.g., Arduino Uno), Wi-Fi Module (e.g., ESP8266), Database (e.g., MySQL), Power Supply (e.g., 5V, 1A)

System Equation: The system can be represented by the following equation (Guo *et al*., 2021):

$$A = (Q \times S) + (W \times D) \quad (1)$$

Where:

A = Attendance Status (0 = absent, 1 = present)
Q = QR Code Scan Result (0 = invalid, 1 = valid)
S = Student ID (unique identifier)
W = Wi-Fi Connectivity Status (0 = disconnected, 1 = connected)
D = Database Update Status (0 = failed, 1 = successful)

Explanation

1. The QR Code Scanner reads the QR code presented by the student.
2. The Microcontroller processes the QR code scan result and checks if it matches the Student ID in the database.
3. If the QR code is valid, the Microcontroller sends a signal to the Wi-Fi Module to update the attendance status in the database.
4. The Wi-Fi Module connects to the internet and updates the attendance status in the database.
5. The Database updates the attendance status, and the Microcontroller receives confirmation of the update.

QR Design: The proposed system used a mobile application and a QR code creator created using a python program for taking student attendance. In the proposed system a database of all the students admitted was collected from the admission details. The student's attendance in the lecture hall was taken by scanning the QR code which contains the student's details.

The algorithm used for the work is as follows:

Step 1: Convert the student's details to a Quick Response (QR) code using Python via Visual Studio Code. Figure 5 shows students details. Figure 6 and Figure 7 show the visual studio code and QR code respectively.

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```
# NAME:
# MATRICULATION NUMBER:
# DEPARTMENT:
# FACULTY:
# LEVEL:
```

Fig 5: Students Details *Source: Student fieldwork, 2023*

```
1  import qrcode
2  input_data = "FUO/16/EEE/2548"
3  qr =qrcode.QRCode(
4      version=1,
5      box_size=10,
6      border=5,
7  )
8  qr.add_data(input_data)
9  qr.make(fit=True)
10 img= qr.make_image(fill ='green', back_color='green')
11 img.save('QR.png')
```

Fig.6: Visual Studio Code

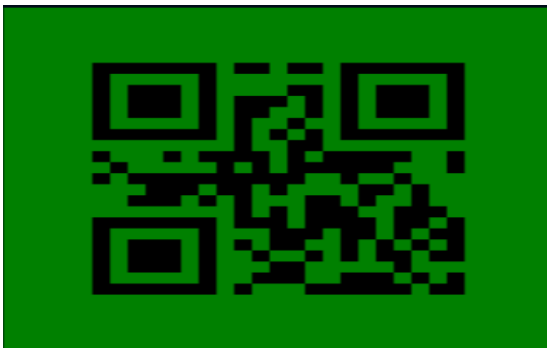

Fig.7: QR code

ID Design**:** The design of the ID in Figure 8 was created using the canvas application, the QR code created above was then merged with the ID

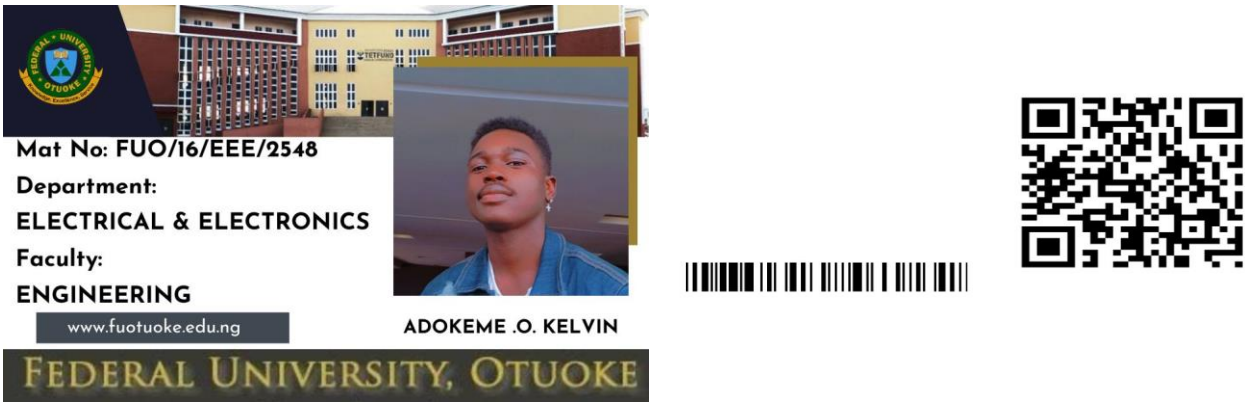

Fig.8: ID Design with Canva

Attendance System: Step 2: Download the Barcode. Scanner and QR Attendance Control to Scan, Read and record the arrival and departure times of students from the QR code created

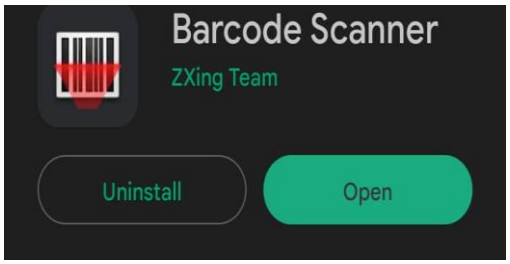

FIG 9: Barcode Scanner

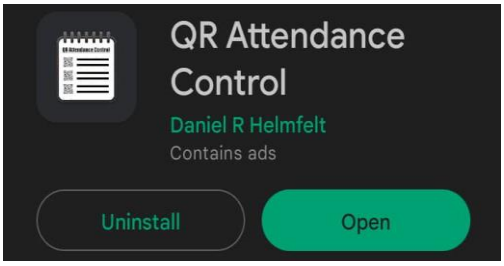

Fig10: QR Attendance Control

Fig. 11: Arrival and Departure

Step 3: Download the CSV attendance file for record keeping purpose

Fig.12: Obtaining the CSV

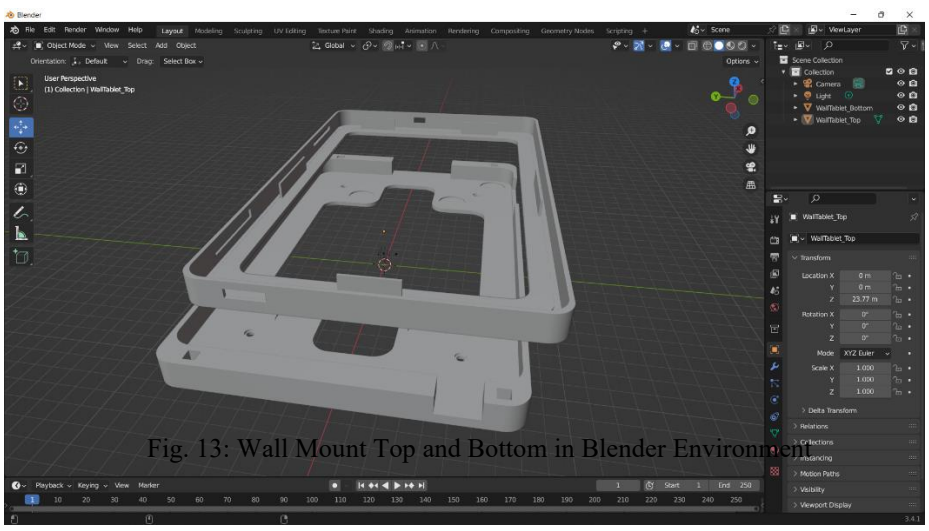

Fig. 13: Wall Mount Top and Bottom in Blender Environment

Mathematical Equation

The overall attendance rate is given in equation (2)

(He *et al.,* 2023)

$$OVR = \Sigma(DA) \div \Sigma(DC) \quad (2)$$

Where: OVR= Overall Attendance Rate

DA= Days Attended

DC= Days of Classes

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QR Code Generation

The QR code content Q is generated as Hester *et al*. 2017)

Q= H(U||E||T|S)

- H(x): Cryptographic hash function (e.g., SHA-256).
- *U:* User ID (a unique identifier for each attendee).
- *E*: Event/Session ID (a unique identifier for the session).
- T: Timestamp of QR code generation.
- S: Secret key for securing the QR code.
- ||: Concatenation operator.

QR Code Validation

To validate the QR code during scanning (Hossan *et al.*, 2017):

K = H(U|E|T|S)

(3)K=Q and $|T_{scan} - T| \leq d$ (4)

- K: Recomputed hash using the scanned data
- Q: Hash embedded in the QR code.
- T scan: Time the QR code was scanned.
- d: Maximum allowed time deviation for attendance validation.

Punctuality Scoring (Optional)

To measure punctuality, the score P is computed as (Gomez et al., 2016):

$$P = max(0,1 - \frac{|T_{scan} - T|}{d}) \quad (5)$$

Result and Discussion

Analysis of Existing System

The drawback of the existing attendance system is it takes up valuable time to collect and record data, its bulky in terms of paperwork especially for higher institute. This situation will lead to inaccurate entry errors.

Analysis of Proposed System

The proposed system saves time, it is fast, efficient and reliable.Its methods require little or no experience to operate

Advantages of proposed system

i. Eliminate duplicate data entry and errors in time and attendance entries.
ii. Eliminate paperwork and save time
iii. High Accuracy

Conclusion

The use of QR codes in attendance systems has been a growing trend in recent years. QR codes offer a fast and secure way to track attendance, providing accurate and up-to-date records. Not only do they provide a more efficient way to manage attendance, but they also offer a more secure and convenient way for students and staff to check-in. The implementation of QR codes in attendance systems has many advantages. It is cost-effective, easy to use, and can be used to track attendance easily. Additionally, it offers a secure way to keep records and can be used to track attendance even when students are absent.

In conclusion, QR code is a great way to improve attendance systems. It is cost-effective, easy to use, and provides a secure and convenient way to track attendance. With its many advantages, it is no surprise that QR codes have become a popular choice for attendance systems.

References

Alghamdi, S., Alfarraj, O., Altowaijri, A., and Qadir, J. (2017). Smart attendance system using QR code. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 2886-2891).

Alhasson, A., and Abuamara, M. (2015). A secure mutual authentication RFID protocol for internet of things. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 2290-2295).

Ali, M., Chowdhury, M., Rahman, M. M., and Mahmud, S. (2018). Smart attendance system using face recognition. *7th International Conference on Informatics, Electronics and Vision (ICIEV)* (pp. 69-73).

Amritha, A., Haripriya, R., and Sindhuja, R. (2019). Smart attendance system using face recognition. *3rd International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 689-692).

Bhise, K. S. (2022). Wildlife animal tracking using RFID and GSM technology. *International Journal of Scientific and Engineering Research, 7*, (pp. 1–2)

[

Das, P. (2019). Fingerprint-based smart attendance system for educational institutions. *International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST)* (pp. 1-4).

Dey, S., Pratihar, D. K., and Nandi, P. (2015). Fingerprint recognition for attendance management system. *Procedia Computer Science*, 45, (pp.364-371)

Garfinkel, S. L. (2007). An evaluation of extended attributes in an advanced file system. *ACM Transactions on Computer Systems*, 25(3), (pp. 1-26)

Ghiasi, S., and Rahbar, G. (2019). Design and development of a smart classroom attendance system using face recognition. *3rd International Conference on Computer and Communication Systems (ICCCS)* (pp. 53-57).

Gómez, V., Sánchez, G., Guzmán, E., and Guzmán, V. (2016). A smart attendance system for classroom using face recognition. *5th IEEE International Conference on MOOCs, Innovation and Technology in Education (MITE)* (pp. 1-4)

Guo, Y., Wu, J., and Wu, D. (2016). An efficient RFID anti-collision protocol with a dynamic frame length. *IEEE Transactions on Industrial Informatics,* 12(1), (pp.186-194).

He, D., Bu, J., Han, G., and Zhuang, L. (2014). Efficient RFID authentication with forward privacy. *IEEE Transactions on Dependable and Secure Computing*, 11(3), (pp.241-253).

Hester, J. G. D., and Tentzeris, M. M. (2017). A mm-wave ultra-long-range energy-autonomous printed RFID-enabled Van Atta wireless sensor: At the crossroads of 5G IoT, Tactile IoT, and Industry 4.0. *IEEE Transactions on Microwave Theory and Techniques, 65*(12), (pp.5485–5496).

Hossain, M. D., and Hossain, M. A. (2017). Smart attendance management system (SAMS) using QR code. *International Conference on Green Energy and Technology (ICGET)* (pp. 1-6).

Norouzi, A. and Addeh, J. (2020). A novel approach for student attendance system via QR code. *4th International Conference on Control, Engineering and Information Technology (CEIT)* (pp. 1-6).