Implementation of EDC Devices for Employee Field Activity Attendance Based on IoT Using ID Cards

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***Abstract*— This study presents the development and evaluation of an IoT-based attendance system using Electronic Data Capture (EDC) devices and QR-coded ID cards, aimed at improving attendance monitoring in decentralized field-based work environments. The system was designed with a thin-client architecture in which the EDC device, specifically the Advan Harvard model, functions solely as a data collector. It scans static QR Codes embedded in ID cards and transmits identity and timestamp data via Wi-Fi to a centralized server. The backend system, built using Visual Studio and MySQL, automatically validates the scanned data, stores it in the database, and sends real-time notifications through the Telegram Bot API. The entire process—from QR generation and scanning to data recording and notification—operates without manual intervention after initial setup. Test results show a 98% QR scan success rate under varying lighting and angle conditions, with data transmission occurring in under one second and notifications delivered within 1–3 seconds. The system proved stable across different network environments and supports secure data handling through encryption and restricted access. Compared to conventional manual methods, this approach enhances efficiency, minimizes manipulation risks, and enables real-time remote supervision. These findings confirm the feasibility of lightweight IoT-based attendance systems for use in flexible and infrastructure-limited settings.**

Keywords*— *attendance system, EDC device, ID Cards, Internet of Things (IoT), QR Code

I. INTRODUCTION

Employee attendance in field activities is one of the important aspects in human resource management, especially to ensure employee discipline, productivity, and performance accountability in various organizational sectors. However, conventional attendance systems that still use manual recording often face various problems, such as inaccurate recording time, potential fraud, and delays in processing attendance data [1], [2]. These problems lead to low administrative efficiency and data accuracy, which impacts the managerial decision-making process [3]-[5].

The development of Internet of Things (IoT) technology provides a great opportunity to digitally transform the employee attendance system. The implementation of IoT-based Electronic Data Capture (EDC) devices integrated with ID cards enables automatic, accurate, and real-time attendance recording, and can be accessed via the web or mobile applications [1], [6]. This system is also able to minimize the potential for fraud because each ID card has a unique code that can only be used by the owner [7].

out automatically by simply scanning the ID card, thereby reducing the potential for fraud and speeding up the attendance recording process. In addition, the recorded data can be directly sent to the server for further analysis [10]-[13].

The system can also automate the attendance recapitulation and reporting process, thus reducing administrative workload. Another advantage of IoT-based systems is their ability to integrate with payroll systems. Previous research developed an attendance system that is automatically connected to the payroll system, so that salary deductions due to tardiness can be made automatically and transparently. This improves fairness and discipline in the work environment [14].

To address these issues, this research focuses on using IoT by combining EDC devices and QR codes [15] to create a reliable and real-time attendance system that is simple to use and suitable for field workers.

II. METHOD

The use of EDC (Electronic Data Capture) devices integrated with RFID-based ID cards is one of the promising IoT implementations in the field of employee attendance [8], [9]. This system allows the attendance process to be carried.

A. Methodology

The method used in this research involves the stages of literature study, system design, implementation, testing, and evaluation of IoT-based attendance systems. Researchers started the process by reviewing various references related to digital attendance systems, EDC technology, and IoT integration to gain a comprehensive understanding of the problems and solutions that have been developed previously.

After the literature study stage, researchers conducted a system design that included requirements specifications, hardware and software architecture design, and attendance system workflows using EDC devices and ID cards. Researchers designed a flowchart to ensure that each attendance stage, from scanning the ID card to sending

notifications, runs clearly and measurably. This design process was carried out collaboratively by involving various related parties, such as the development team, operational managers, and field employees.

Next, researchers implemented the system in accordance with the design that had been made. Implementation includes application development, integration of EDC devices with the IoT system, and network connection settings to ensure attendance data can be sent and processed in real-time. Researchers also ensured that the system was able to accurately identify employees through ID cards, record attendance data, and send notifications to management through a digital platform.

After the system was implemented, researchers conducted system testing to assess the performance and reliability of the IoT-based attendance system. The test was conducted by simulating the attendance process by several field employees, monitoring the speed of data processing, and ensuring that notifications were received in a timely manner. Researchers also analyzed the test data to identify deficiencies and make system improvements if needed.

In the final stage, researchers evaluate the performance of the system that has been developed. The evaluation includes an assessment in terms of attendance recording accuracy, data processing speed, and user satisfaction with the IoT-based attendance system. The evaluation results become the basis for recommendations for improvement and further system development, so that this attendance system can support operational efficiency, increase transparency, and encourage the digitization of employee attendance management in the field. Flowchart in this study shown in the figure 1. describes the process flow of the IoT-based field employee attendance system using EDC devices and ID cards.

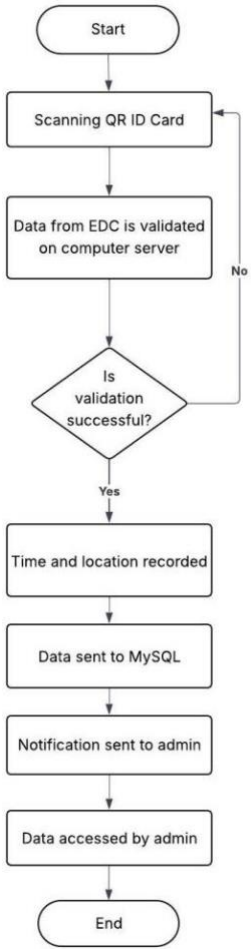

Figure 1. Proposed system employee field activity attendance

B. Flowchart Design System

With this structured system design, the process of presenting employee field activities becomes faster, more efficient, and easier to manage, and allows real-time supervision. The following is an explanation of the workflow visualized in Fig. 1.

1) *Start*
   The process begins when the EDC device is activated and ready for use.
2) *ID Card Scanning*
   Employees scan the QR code on their ID card using the scanner on the EDC device. This QR Code contains unique information such as the employee's name and NIP.
3) *Data Validation*
   The EDC device reads the data from the QR Code and sends it to the laptop server or computer for validation. The server checks whether the employee data matches what is registered in the database.
4) *Validation Successful*
   If the validation is successful, the data will be processed further and if it fails, the EDC device will display an error message, and the employee is asked to try again.
5) *Time and Location Logging*
   If the validation is successful, the EDC device automatically records the time of attendance using the real-time clock (RTC) and, if required, location data via the EDC's built-in GPS.
6) *Data Transmission to Laptop or Computer Server*
   Attendance data that includes employee identity, time, and location is sent to a laptop or computer server via an internet connection. The laptop or computer server processes and stores the data in a MySQL database.
7) *Notification to Admin*
   After the data is successfully stored, the laptop or computer server sends a notification to the admin or supervisor via Telegram. This notification contains information about employee attendance.
8) *Data Access by Admin*
   The stored attendance data can be accessed by the admin through a web-based application for monitoring and report generation.
9) *Finish*
   The process is complete after the data is successfully saved and the notification is sent.

C. Tools and Materials

Tools and materials that are used in this research are shown on the table 1.

TABLE I
TOOLS AND MATERIALS

No	Tools or Materials	Description and Function
1	ID card with QR code	As a medium for employee identification in the attendance system.
2	Power Supply (battery)	Provide power for EDC devices to operate autonomously in the field.
3	EDC Device (ElectronicData Capture)	As the main device for scanning QR codes from employee ID cards.
4	Laptop/PC	Required to perform programming on IoT devices and manage databases.
5	Wifi/Hotspot	Serves as a link between the EDC device and the internet so that it can send data to the laptop / PC server.

III. RESULTS AND DISCUSSION

The results of the research should be written clearly and concisely. Discussions consider outlines the importance of research, not repeat it. Avoid excessive uses quotations and discussions about literature published.

A. System Implementation

1) Employee Database Development and Management

The implementation of this research began with the creation of an employee database that would later be granted access to the attendance recording system developed in this study. The database in this system is the main foundation of the developed system. The employee data presented in the database will later become the single source of truth for all attendance processes in this system.

In real-world scenarios at companies, this process is typically carried out by administrators or human resources departments who have authority over employee data. In addition to inputting data into the employee database, administrators or human resources departments will also verify data accuracy, update the database when new employees join or leave the company, and ensure that employee data and privacy are well protected. The information compiled in the employee database will be tailored to the needs of the company, particularly for personnel-related decision-making. The data may include: employee names, employee identification numbers, divisions, positions, or other necessary data such as the site where they are assigned if they are assigned to work in the field.

In this study, to simplify the simulation, only names and employee ID numbers were used. The data was organized in a simple table format and then prepared for further processing using Visual Studio.

2) Building Mysql Database and Generate Qr Code

The employee data that has been compiled in the previous stage is then input into the MySQL database. This MySQL database will later be used for validation when the employee attendance system developed in this study is implemented. The employee database is structured for easy access and consistent use by the developed attendance system. The database stored on this server will serve as a central repository. Employee identities that can access the attendance system are stored in a standardized format, enabling the system to easily retrieve stored data during the validation process. Data storage in MySQL is also designed to facilitate the update process, such as adding new employees or removing employees who are no longer working. The system is also designed to minimize duplication or the possibility of inconsistencies in employee data.

After the database is stored in MySQL, the data is then retrieved using an application developed with Visual Studio. The employee database is then processed to generate a unique QR code that represents each employee. Each employee whose data is stored in MySQL and whose QR code is generated will have one static QR code that can be used as their identification in the developed attendance system. Each employee will have one static QR code. Every new employee will receive one static QR code that can be printed on their ID card. The QR code generated using Visual Studio will be saved in image format for printing on the ID card. This stage is important because it translates the employee's administrative data, which was originally in text form, into a QR code that represents the database.

3) Printing ID Card with Static QR Code

The next step after the QR Code has been successfully generated is the process of printing employee ID cards. At this stage, the QR Code that has been created is combined with employee identity information in a card design. In general, ID cards contain elements such as the employee's name, employee identification number (NIP), photo, and company logo or identity. The QR Code is placed in an easily accessible area so that it can be scanned quickly using a scanning device.

In real-world scenarios, ID card designs typically follow company standards in terms of size, color, and information layout. ID cards not only serve as identification but also as an authentication tool for attendance in the developed system. Thus, each employee has a physical card integrated with the digital system, enabling more efficient attendance tracking.

Card printing is done using a specialized ID card printer with PVC or similar durable materials. In this study, the printing process is simulated as part of the system workflow, where the QR Code output is applied to a digital ID card template to demonstrate a practical implementation that can be applied in a company.

This stage marks an important transition from digital data to physical media that can be directly used by end-users, namely employees. With QR Code-enabled ID cards, the attendance process becomes more practical, secure, and minimizes the possibility of attendance data manipulation.

4) EDC Configuration

Before being used for recording employee attendance in the attendance system developed in this study, the EDC device must first be configured so that it can perform the function of

recording and transmitting employee attendance data. The first thing the researcher did in preparing the EDC device in this study was to set up the EDC device so that it could connect to the internet. The EDC devices used in this study were three units of Advan EDC devices of the Harvard variant. These EDC devices have a SIM card slot for internet access but also have the ability to connect to Wi-Fi facilities. In this study, the researchers utilized the Wi-Fi connection available at the device testing location. After ensuring that the EDC devices were connected to the internet, the researchers also ensured that the server computer was connected to the internet so that when the EDC devices recorded attendance, the recalled employee data could be sent to the MySQL database for validation.

In addition to configuring the internet connection from the EDC device, the researchers also set the local IP address of the server in the settings menu of the EDC device. The purpose of this IP configuration is to ensure that all attendance scan data is sent to the server storing the employee database for validation. Thus, the attendance validation process can be conducted accurately because the attendance data is sent to the correct endpoint.

To run the attendance system developed in this research, the EDC device does not require any additional applications to support this process. In the attendance system developed in this research, the EDC device's function is solely to scan QR codes and send data to the server according to the previously set IP. The EDC device does not perform any data processing or analysis.

5) Employee Attendance-Scanning ID

After the EDC device has been configured and is ready for use, the next step is the attendance process. In a real-world company setting, this process is carried out by employees who come to the workplace with their employee ID cards, which have personalized QR codes printed on them. These QR codes will then retrieve the employee data stored in the MySQL database.

TABLE II
PERFORMANCE OF QR CODE SCANNING

Date	Total Trials	Successful Scan	Failed Scan
14-Jul	6	5	1
16-Jul	8	7	1
17-Jul	11	11	0
21-Jul	1	1	0
22-Jul	4	4	0
23-Jul	11	11	0
29-Jul	14	14	0
30-Jul	12	12	0
10-Aug	3	3	0
Total	70	68	2
Percentage		97.10%	2.90%

The attendance process is carried out by pointing the ID card at the EDC device. If the scan is successful and the QR code is read by the EDC device, the EDC device will capture the data stored in the QR code and send it to the previously designated server using the pre- configured internet connection. The data captured by the EDC device is sent in digital form and processed by the server to be validated against the employee database previously stored in the MySQL database.

In this study, using 3 dummy employee cards and 3 EDC machines, 70 card scanning experiments were conducted using the EDC device that are shown in Table 2 and Fig. 2. Out of the 70 scanning experiments, 2 failed to scan. The scanning failure was caused by an improper scanning angle and distance. Thus, the success rate of the ID card scanning test in this study is 97%.

From the employee's perspective, in addition to ensuring that scanning is performed at the appropriate distance and angle, cardholders must also ensure that their cards are readable, clean, not faded, folded, or damaged in any way that prevents the QR code on the employee card from being scanned properly.

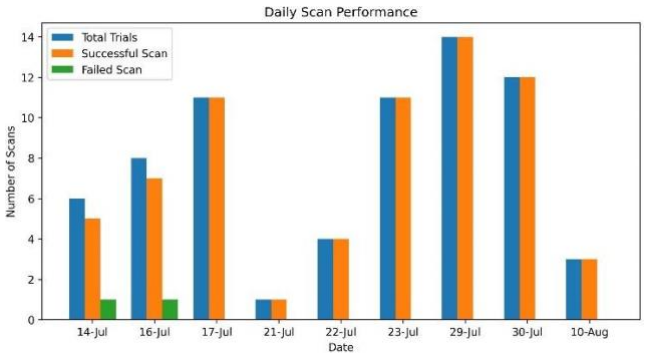

Figure 2. Daily Scan Performance

The occurrence of several failed QR code scans in this study was primarily influenced by non-optimal scanning angles and distances during the scanning process. These failures were not caused by system malfunction, but rather by operational factors related to how the QR code was positioned relative to the EDC scanner. This indicates that visual-based attendance systems remain sensitive to alignment and environmental conditions during data acquisition.

Similar findings were reported by Atmaja et al., who emphasized that failed detection events highlight the importance of proper alignment and sufficient lighting conditions for visual recognition components to function correctly. Their study also underlined the importance of mechanisms that separate and store failed detection data, as such records provide a valuable audit trail for administrators to review rejected attempts and verify attendance data manually when necessary. This approach ensures that attendance records are not entirely lost due to technical anomalies or recognition errors [8].

Although the recognition technologies used was different, both systems demonstrate that environmental and operational factors play a critical role in determining the reliability of IoT-based attendance systems. Therefore, the failed scan cases

observed in this study can be considered an inherent limitation of visual recognition processes rather than a deficiency of the proposed system.

6) Network and IoT Integration Setup

The attendance system developed in this study relies on network integration and inter-device connectivity that supports the principles of the Internet of Things (IoT). EDC devices are configured to connect to a local server via a wireless network (Wi-Fi) available at the test site. This configuration enables the devices to send scan data directly and automatically without local storage, as well as enabling real-time data processing on the server side.

Network settings are configured by assigning a static IP address to the computer functioning as the server. This address is entered as the destination endpoint within the EDC system, so that every time a device performs a scan, the data is forwarded to that address via the HTTP protocol. Testing is conducted in a closed local network environment, without involving public internet access, thereby minimizing latency and facilitating the maintenance of connection stability.

The local server used in this system runs a backend application developed using Visual Studio and connected to a MySQL database. The application receives data from the EDC device, records time and identity information in the database, and activates the notification system via the Telegram API. This architecture forms a one-way communication path from the EDC to the server, with system logic processing performed entirely on the server side.

During the testing process, data transmission from the EDC to the server ran without significant disruptions. The system was able to record attendance times with a transmission delay of less than one second. This success was supported by the stability of the local network used. No connectivity issues were encountered during the simulation scan within a sufficient Wi-Fi signal range.

This integration model illustrates the application of IoT concepts on a local scale, where edge devices are tasked with collecting data and sending it to a processing center without executing internal logic functions. This approach is considered relevant for the needs of automatic attendance recording in limited work environments, with simple infrastructure that can handle processes efficiently.

7) Telegram Notification Integration

After the QR Code scanning process is successful and the data received from the EDC device is declared valid, the system automatically sends a notification to the Telegram account that has been previously configured as the receiving channel. This notification is sent using the Telegram Bot API, which has been integrated into the system's backend application. This feature is designed to provide real-time notifications to administrators or managers regarding user attendance activities.

The message format sent via Telegram includes information sourced from database matching results, such as the user's name, ID code, location, and scan time. This data is retrieved from QR code scanning results and has been validated against existing entries in the database. The notification sending function is triggered automatically after the data storage process is successfully completed in the system.

During testing, notifications were successfully received by the designated Telegram account, with a time lag varying between 1 and 3 seconds from when the data was received by the server. No delivery issues were encountered as long as the internet connection remained stable. The system demonstrated a sufficiently good level of responsiveness in delivering notifications sequentially, in accordance with the order of scans that occurred.

The implementation of this notification feature aims to provide instant feedback to system administrators, as well as support transparency and real-time monitoring of activities. Additionally, the presence of digital logs in Telegram can serve as a temporary backup in case access to the main database is disrupted.

This function is part of the architecture connecting end devices with the processing center and external user interfaces. Through this integration, the attendance system not only records attendance data but also establishes a decentralized and easily accessible reporting mechanism.

8) Web-based Monitoring Interface

This system provides a web-based interface that is directly connected to the MySQL database. The interface is used by administrators to view attendance data that is automatically recorded each time a scan is successfully performed by the EDC device.

The web interface displays information such as the user's name, ID code, attendance time, and location if available. The data displayed is sourced from tables that are updated in real-time by the system. Through this interface, administrators can monitor and summarize attendance data without needing to manually input data or directly access the database.

The interface can be accessed via a browser as long as the device is connected to the same network as the server. During testing, attendance data appeared in real-time after the scanning process, indicating that the system was running as intended and capable of providing quick visual feedback.

This interface is accessed via a browser using a local address or pre-configured server IP. No additional installation is required on the user side, as all functions are executed on the server side and presented in the form of a responsive web page. This model also allows access to be distributed to multiple devices simultaneously, provided that users are on the same network as the server.

During testing, the web interface was able to display attendance data immediately after the scanning process was completed. This demonstrates that the system maintains continuity between data input from the EDC and visual output to the user interface. With this feature, the attendance monitoring process becomes more practical, centralized, and can be accessed simultaneously by multiple users if needed.

B. Implementation Scenario and Workflow

The system implementation scenario is designed to describe the operational flow of attendance from start to notification received by the admin. The process begins when the user scans their ID card equipped with a QR code using an EDC device. After a successful scan, the data obtained— in the form of an identity code and time—is immediately sent via Wi-Fi to the specified server.

Upon arrival at the server, the data is processed by the backend application, which validates it by comparing the received code with entries in the database. If the data matches, the attendance information is stored in the attendance table within the MySQL database system. After successful storage, the system automatically sends a notification to the registered Telegram account via the Telegram Bot API. This notification serves as real-time attendance notification and includes important data such as the user's name and the time of recording.

C. Testing and Evaluation

Testing and evaluation of the attendance system developed in this study are necessary to determine whether the developed attendance system can be used properly and accurately, can show the appropriate attendance location, have reliable connection stability, and ensures the security of employees' personal data stored in the database. Testing and evaluation were conducted on the developed system using 3 dummy cards and 3 EDC devices. The tests were conducted from July 14 to August 10, with a total of 70 trials.

1) Identification Accuracy

The identification accuracy parameter in this study is intended to evaluate the ability of the EDC-based attendance system developed in this research to read, validate, and correctly recognize the identity of the card owner and then record it in the web-based database. In this study, the researcher used 3 dummy cards for the simulation. The simulation was conducted using four EDC devices with a total of 70 trials from July 14 to August 10.

Out of the 70 experiments conducted during that time period, 67 scans were successfully sent to the server. Of the 67 data received by the server, all data correctly identified the cardholder's identity, thus proving that the attendance system developed in this study can reliably read and verify the identity of the cardholder. This aligns with previous studies indicating that QR code scanning generally achieves high success rates even under varying lighting conditions or scanning angles. Thus, the developed system possesses the capability for reliable cardholder identification and can be utilized in employee attendance recording processes [9].

2) Location Precision

The location precision parameter in this study was tested to evaluate the accuracy of the attendance system utilizing this EDC device in recording location information accurately. Testing of the level of location precision reported by the EDC device to the system was conducted on 67 simulations that were successfully recorded on the server out of a total of 70 trials. The simulation results from the 67 data received by the server showed that all 67 successfully transmitted data matched the actual location coordinates.

In this experiment, the researchers used two different locations from the 70 trials. The attendance system successfully provided sufficiently accurate location information. This ability to provide location information is due to the EDC devices used having active GPS features during attendance tracking. Although it has a GPS feature, it will not function if it is not activated. Additionally, the GPS also depends on an internet signal. If both conditions are met, valid location information can be received by the server and utilized according to the company's needs.

To verify the accuracy of the location sent to the server by the EDC device, the researcher cross-checked the recorded location using coordinates provided by Google Maps. The cross-check of the location coordinates sent to the server by the EDC device showed that the recorded location was accurate. The precise location recording function in the attendance system developed in this research is highly beneficial in practical use, for example, for companies with field projects spanning multiple sites. Different EDC devices can be used at each field project location, and the attendance system will be able to recognize the location coordinates of the field workers who are clocking in.

These results are consistent with previous studies showing that electronic device-based attendance systems with GPS integration are capable of accurately displaying locations, provided that the devices are within adequate signal range.

3) Connection Stability

In this study, researchers also examined the connection stability of the attendance system developed to determine whether this attendance system is reliable, especially in recording employee attendance in the field or at project sites outside the office. The connection stability parameter examines whether the EDC device used can maintain a stable connection between the EDC device and the server during the transmission and validation of attendance data. Connection stability testing was conducted using a Wi-Fi network at the testing location.

The researchers conducted 70 trials, and out of the 70 scanning trials, 2 were unsuccessful due to inaccuracies in distance and angle. Out of the 68 successful scans, one failed to be sent to the server due to temporary connectivity issues (signal loss). This indicates that the success rate depends on the quality of the network at the testing location. Overall, the success rate of data transmission to the server exceeds 98%, demonstrating that the developed attendance system can maintain a stable connection while within the range of an adequate network.

4) Data Security

Data security parameters in this study are important parameters to be tested. Researchers ensure that employee

personal information and privacy remain protected. Attendance data sent from the EDC machine to the server is expected to remain intact and not leaked during the transmission process from the EDC device to the server. The system developed using a MySQL database in this employee attendance recording system guarantees that the data sent is secure. Additionally, the system is designed to restrict database access through user-level authentication, ensuring that only authorized parties can manage the data. During the simulations conducted in this study, no suspicious activities were detected, nor were any security vulnerabilities identified that could potentially allow manipulation of attendance data.

The results of the tests conducted by the researchers indicate that the attendance system developed in this study can maintain data security and integrity. This system is reliable in operational contexts that require control over employee information protection.

D. Discussion of Result

1) Comparison with Conventional System

The attendance system implemented in this study replaces the manual recording method that has been used in various work environments. Conventional systems such as attendance lists with signatures have limitations in terms of recording speed, data accuracy, and authentication control. In this method, there is no automatic validation mechanism that can ensure that the recording is done directly by the individual concerned. This opens the potential for manipulation, such as double recording or fictitious attendance.

The EDC-based system in this study works by scanning a QR Code containing the employee's identity code. After scanning, the data is sent to the server via a Wi-Fi connection and immediately recorded in the MySQL database. Each attendance entry is accompanied by time information and, if configured, location data. The received data then triggers the sending of notifications to Telegram through integration with the Bot API. With this workflow, attendance recording runs automatically and can be monitored without manual involvement at each stage.

The use of a structured database allows the recapitulation process to be performed directly from the system, without the need to process data from physical documents. Recorded attendance information can be searched, filtered by time, or exported for routine reporting purposes. This supports more organized, auditable, and tamper-proof data management.

The EDC devices used have dimensions and specifications that allow for use in remote work locations or field areas with minimal network support. Since it does not require complex applications or local storage, the device can function as a standalone scanner that only sends data to the server. This architecture is suitable for implementation in distributed work units, including field projects, guard posts, or temporary locations with limited resources.

Notifications using Telegram function as an information conduit, delivering attendance summaries directly to managers or administrative personnel. This functionality permits real-time remote surveillance without interfacing with the primary system panel. Consequently, the system not only logs attendance but also enables the prompt and precise dissemination of information to pertinent parties.

The created system presents numerous practical advantages over manual methods, such as time efficiency, recording dependability, and operating flexibility under diverse geographical situations.

2) Analysis of Advantages and Limitation Advantages

The proposed attendance system offers several advantages that improve the efficiency and reliability of attendance management. One of its primary strengths is real-time monitoring. Attendance data are transmitted immediately after a QR code is scanned, allowing administrators to access the information through the web interface or receive instant notifications via Telegram. This enables remote monitoring of employee attendance without requiring direct access to the main system. According to Ganesh et al., real-time monitoring systems can reduce attendance recording delays by up to 50% compared to conventional manual methods.

Another significant advantage is the high recording accuracy achieved using QR codes generated from pre-validated employee data. Because employee information is verified before QR code generation, the scanning process minimizes manual data entry and reduces the likelihood of human error. Rahmawati et al. reported that QR code-based attendance systems can achieve an accuracy rate of over 95% under normal operating conditions. This level of accuracy contributes to more reliable attendance records and reduces the need for manual corrections.

In addition, the system provides efficient integration of multiple processes within a single workflow. It combines QR code scanning, backend verification, automatic data storage in a MySQL database, and real-time notifications through both the web application and Telegram. By integrating these functions into one automated process, the system streamlines attendance management, reduces administrative workload, and improves the overall flow and accessibility of attendance data.

Despite these advantages, the system has several limitations that should be considered. First, the system is highly dependent on network connectivity. Attendance data must be transmitted through a Wi-Fi or hotspot connection to the server, making reliable internet access essential for normal operation. When the network is unstable or unavailable, data transmission may be delayed or temporarily interrupted, which can affect the timeliness of attendance records.

Another limitation involves QR code readability. The effectiveness of the scanning process depends on the physical condition and quality of the printed QR code. Damaged codes, poor print quality, or excessive glare on the card surface can interfere with optical recognition and reduce scanning performance. Previous studies on QR code printing have shown that reflective or glossy materials can significantly decrease scan reliability due to light reflections and image distortions. Therefore, matte or semi-gloss printing materials are generally recommended because they minimize glare and improve scanning accuracy.

IV. CONCLUSION

This study successfully developed an IoT-based attendance system using QR code scanning through an EDC device connected via Wi-Fi. The system operates automatically, transmitting identity and timestamp data to a backend server built with Visual Studio and MySQL. Test results showed a 98% success rate in QR scanning and stable real-time performance, including Telegram notifications within 1–3 seconds. The system remained reliable under various lighting and network conditions, with data security ensured through encryption and restricted access. Overall, the system meets its objectives and is suitable for field-based work environments.

Future research can focus on optimizing the system for use in remote areas with unstable network coverage by adding dual-network support or automatic fallback mechanisms, as well as ensuring power availability through portable power sources. Further development may also explore extending the system's functionality beyond attendance tracking to include work time logging, overtime calculation, payroll integration, and location-based monitoring for mobile employees. Additionally, to improve system security and user verification, future studies may incorporate advanced authentication methods such as biometric recognition (fingerprint or facial), RFID, or NFC technologies.

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