QR Code-Based Attendance System for Contact Tracking Post-Pandemic

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Abstract

The COVID-19 pandemic has brought about profound changes in daily life and introduced new challenges to public health maintenance. Despite ongoing uncertainties, with certain regions easing or completely lifting community activity restrictions, persistent concerns about the virus's continued threat prompt the need for robust health monitoring measures. In this context, the use of contact tracing apps becomes pivotal for organizing individuals' movements, monitoring social distancing, and ensuring adherence to health protocols. This study introduces a QR code-based attendance system, a meticulously designed web and Android application aimed at efficiently and accurately tracking individuals' whereabouts. The system leverages QR code scanning technology, and to enhance security, employs the Advanced Encryption Standard (AES) method for data encryption. This ensures the safe encryption of sensitive data, preserving its confidentiality and integrity during transmission and storage. The research outcome is a versatile application facilitating seamless access across diverse locations, allowing real-time tracking of individuals' presence. This capability proves crucial for contact tracing efforts in the event of positive cases, contributing to the implementation of post-pandemic security and surveillance policies. The system's design and features align with the evolving landscape of the pandemic, emphasizing adaptability and comprehensive support for public health initiatives.

Keywords— QR Code, AES (Advanced Encryption Standard), Contact Tracking

1. INTRODUCTION

In the new normal era, managing whereabouts in a building is becoming increasingly important to maintain the safety and health of residents or visitors. To face this challenge, the design of a web-based and Android-based presence system using a QR Code is an effective solution for monitoring and managing the presence of individuals in a building. In light of the global COVID-19 pandemic, various Governments and public health authorities across the globe are currently in the process of developing contact tracing applications to effectively monitor and impede the transmission of the virus [1]. Nevertheless, there exist prominent disparities among nations, namely between a "privacy first" approach that prioritizes the safeguarding of individuals' data albeit at the expense of limited accessibility for public health entities, and a "data first" approach that upholds copious amounts of information which holds immense value for epidemiologists.

These tools have the objective of implementing automation into epidemiological inquiries and facilitating the restriction of lockdown measures to limited regions instead of encompassing entire urban centers or nations [2]. With the emergence of numerous cases in numerous cities, the task of contact tracing has encountered heightened challenges [3].

Governments across the globe are making efforts to curtail the transmission of the COVID-19 virus. Consequently, the domain of digital contact tracing investigation has witnessed a rapid expansion, wherein numerous techniques have been suggested to assist in achieving this objective

[4]. Digital contact tracing entails the monitoring of individuals to ascertain the likelihood of interaction between infected individuals and users, employing mobile technologies like QR codes, Bluetooth, and GPS.

Apart from being used in the presence system in buildings, the QR Code also has a variety of other applications that can provide convenience and benefits in everyday life. Some common uses of QR Codes include mobile payment [5], marketing and promotion [6], electronic ticketing [7], identification and verification [8], and others. Barcodes serve as a prompt, facile, precise, and automated technique for the acquisition of data [9]. Their implementation enables the efficient and accurate tracking of products at a rapid pace that surpasses the capacity of manual data entry systems. It is noteworthy that barcode readers solely function to identify barcodes, and the acquisition of two-dimensional barcode readers is an expensive undertaking. As of late, mobile phones have been capable of realizing diverse forms of novel applications, such as photographing and filming, by utilizing embedded camera devices. Consequently, an intriguing approach encompasses seizing barcodes with mobile phone cameras and decoding them via software that operates on the mobile phones themselves.

This article will discuss the design of a web-based and Android presence system using QR codes in the new normal era. This system utilizes QR Code technology as an identification tool that allows users to safely record their whereabouts and comply with health protocols. In the new normal situation, it is important to pay attention to health and safety in buildings. With a web-based presence system, managers or security officers can easily monitor and manage individual presence data from an internet-connected computer device. This allows managers to take the necessary steps to maintain social distancing and maximum capacity within the building.

Previous research [10] By implementing this QR code-based attendance system, several advantages can be achieved, such as saving time in the classroom because the attendance process becomes automatic and fast. This system eliminates the need for manual attendance sheets and the time taken by instructors to record attendance manually. In another study [11], this study showed that a mobile app successfully enabled patients with IBD to collect and transfer PGHD using QR codes. It also demonstrated the app's effectiveness in facilitating data-centered and patient-centered medical care by providing doctors with timely and comprehensive insights into the patient's health status. A subsequent study [12] identified limitations of existing self-service payment methods and proposed a QR code-based payment solution to address these shortcomings, namely inefficiency, lack of convenience, or limitations in meeting evolving marketing and customer service needs.

According to [13], the QR code in this paper is used as part of a nutritional quality and safety traceability system. The system is designed and developed for full traceability of leafy vegetable quality. QR codes can be scanned by consumers to obtain information about the quality and safety of leafy vegetables online. This method can ensure food safety and hygiene through the control of key factors affecting food safety throughout the supply chain process. In addition, a study [14], this study presents the development of a system that aims to optimize the medical consultation process using QR codes in Peruvian hospitals. This paper presents a system that utilizes QR codes and mobile applications to optimize the medical consultation process in Peruvian hospitals.

Australia is considered to be the pioneering nation in launching its contact tracing application [15]. These contact tracing applications possess the capability to monitor each user who has come into proximity with one another. Moreover, they can promptly notify all affected users if one of them tests positive for the infection. Furthermore, some of these contact tracing apps can even alert users when they are close to an infected individual, thus aiding in the prevention of potential infection.

Through the implementation of a web and Android-based presence system, which utilizes QR codes, it is possible to enhance the overall health and safety measures within various buildings. Additionally, this system can effectively facilitate the management of individual presence. Furthermore, this insightful article possesses the capability to provide readers with valuable information regarding the development of similar presence systems that adhere to the health

protocols and applicable regulations within the new normal era.

In this article, we will discuss the design steps of a web-based and Android presence system using QR Codes in the new normal era. Starting from the design of the user interface with an emphasis on intuitive display and compatibility with health protocols, the development of web and Android applications that pay attention to data security and user privacy, to integration with database systems to store and manage presence data.

2. RESEARCH METHODS

Currently, there exist numerous contact tracing applications that embrace and employ diverse contact tracing frameworks and methodologies [16]. Given the growing apprehension among users and developers regarding security and privacy concerns, a considerable number of these applications are opting to implement one of the myriad privacy protection protocols suggested and devised by researchers and industry experts. The design of this system exists in a building in the new normal era using the waterfall method. The waterfall model is a method in software development that is one of the classic life cycles. The stages of the waterfall model are communication, planning, modeling, construction, and deployment. The following is an overview of the waterfall model in the diagram shown in Figure 1 below.

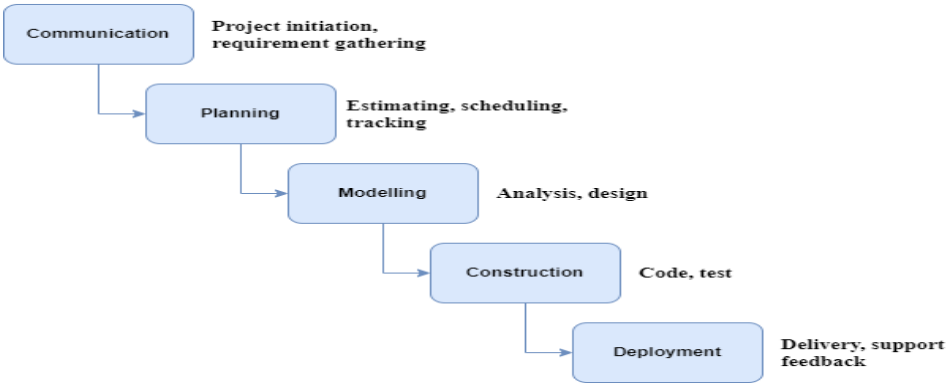

Figure 1. Waterfall Model

In the initial phase of research planning within the waterfall model, the emphasis is on meticulous planning for the attendance system. This involves defining clear objectives, scope, and approach for the research project. Key considerations at this stage include outlining research objectives, identifying pertinent questions, determining the project's scope, planning for data collection and analysis, addressing ethics and privacy concerns, allocating necessary resources, fostering collaboration and stakeholder engagement, conducting risk assessments and mitigation, undergoing ethical review, and obtaining necessary approvals.

Following the comprehensive research planning, the next stage is data collection, a crucial step in initiating research on the attendance system. This involves various methods:

Firstly, there is the collection of material sources, encompassing books and journals related to attendance management and systems. These sources delve into the methods, technologies, and theories underpinning attendance systems. Additionally, internal documents from the organization, such as policies, guidelines, or reports, provide valuable insights into the existing attendance system and areas for potential improvement.

Secondly, a relevant research search is conducted through scientific journals and conferences or seminars focused on attendance management and related technologies. The examination of research articles and conference papers aids in staying abreast of the latest developments in the field.

Proceeding to the system requirements analysis, this stage involves a meticulous examination of the attendance system utilizing QR Codes. The process includes identifying stakeholders, defining functional and non-functional requirements, conducting risk assessments,

and thorough documentation.

The subsequent phase, system design, focuses on creating a blueprint for the Android and web-based attendance system utilizing QR Codes. The design process encompasses system architecture, user interface design, QR code generation and scanning, data management, integration, data exchange, security and privacy measures, performance, scalability, error handling, recovery, testing, quality assurance, and documentation.

Moving forward, during the system implementation stage, dedicated efforts are directed toward developing the actual applications based on the design specifications. This involves setting up the development environment, Android application development, web application development, QR code generation and scanning, data management, integration, data exchange, security measures, testing, quality assurance, deployment, and comprehensive documentation and training.

In researching the attendance system, several considerations were used to design it. The system requires technology or methods that are good and easy to apply and implement. There are several methods used, namely, QR Code and AES. Both methods are technologies used to encrypt data on the system. By incorporating QR Code technology for data capture and AES encryption for data security, the attendance system aims to provide a user-friendly and secure solution for tracking and managing attendance-related information. These methods contribute to the system's effectiveness, ease of use, and data protection.

A. QR Code

The QR code, a type of trademarked bar code, is equipped with a machine-readable optical label that enables swift extraction of information upon scanning. Remarkably, the error correction feature of QR codes enables barcode readers to retrieve QR code data even when the code is defaced or damaged, without any loss [17]. The use of barcode readers enhances efficiency and ease of access to QR data. However, the public encoding of QR codes makes their stored information vulnerable to security breaches. To address this, scholars have proposed various security solutions.

QR codes, also known as Quick Response codes, were first introduced in 1994 by Denso-Wave, a subsidiary company of Toyota located in Japan. Initially, these codes were designed to serve as a means of tracking vehicle parts, but they have since gained widespread popularity in various Asian countries such as Japan, South Korea, China, and Taiwan. Furthermore, the use of these codes has been increasing steadily in Western countries over time. It is worth noting that QR codes are capable of encoding data both horizontally and vertically, allowing for the encoding of significantly more data than traditional bar codes [18]. The utilization of QR codes, which evolved from barcodes, is attributed to their ability to store diverse types of data, including numeric, alphanumeric, kanji/kana, and binary [19]. Additionally, QR codes possess a reduced display size due to their capacity to accommodate data both vertically and horizontally. A noteworthy feature of QR codes is their proficiency in scanning, as even in the case of partial data damage, they can still be scanned effectively. This characteristic renders QR codes highly prevalent, given their resilience to damage.

QR codes comprise 40 versions of symbols, wherein the configuration of the module or the number of modules differentiates each version. Furthermore, each version can rectify errors in the event of a malfunction. Each version of the QR code has an additional 4 modules in each level. The initial version of QR codes, version 1, consists of 21 x 21 modules, whilst version 2 is 25 x 25 modules, and version 40 comprises 177 x 177 modules. The size of the module corresponds to the amount of data that can be accommodated. A QR code can store up to 7,089 characters of numeric data, 4,296 alphanumeric characters, 2,953 binary characters, and 1,817 kanji characters. QR codes also feature 4 levels for correcting data errors, namely the L, M, Q, and H levels. The Q and H levels are the most widely used, as they offer superior data correction capabilities even when some modules are damaged. QR Code can accommodate 7,089 characters of numeric data, 4,296 alphanumeric characters, 2,953 binary characters, and 1,817 kanji characters. Then the QR Code has 4 different levels for correcting data errors. The levels start from the L, M, Q, and H levels. The most widely used levels are the Q and H levels because

they have good data correction capabilities even though some modules are damaged. In Table 1 below you can see the Different Levels for Correcting Data Errors.

Table 1. Different Levels for Correcting Data Errors

QR Code error correction level	
L Level	Can correct errors up to 7%
M Level	Can correct errors up to 15%
Q Level	Can correct errors up to 25%
H Level	Can correct errors up to 30%

B. AES

AES (Advanced Encryption Standard) is a symmetric encryption algorithm that is widely acknowledged for ensuring secure data encryption. In 2001, the U.S. National Institute of Standards and Technology (NIST) designated it as the standard for safeguarding sensitive information [20]. AES is broadly a block ciphertext or symmetrical algorithm, which uses the same key for encryption and decryption processes. AES is the result of the development of the previous method, namely Rijndael. Rijndael was designed by Vincent Rijmen and John Daemen. Rijndael was later adopted as the official cryptographic algorithm standard on May 22, 2002.

In cryptography, the cipher key of AES has three length variants, namely, 128 bits, 192 bits, and 256 bits. Each key length has an influence on the ground during the encryption or decryption process. The difference in the effect of key length on rounds is in Table 2.

Table 2. The Difference in the Effect of Key Length on Rounds

	Number of Keys	Block Size	Number of Rounds
AES - 128	4	4	10
AES – 192	6	4	12
AES – 256	8	4	14

The process of encryption and decryption through AES involves a series of sequential steps, namely, SubBytes, ShiftRows, MixColumns, and AddRoundKey. These four essential steps necessitate the use of plaintext, password, and key to successfully generate ciphertext during the encryption process or to perform decryption. Please refer to Figure 2 for a comprehensive demonstration of the requisite steps involved in AES encryption.

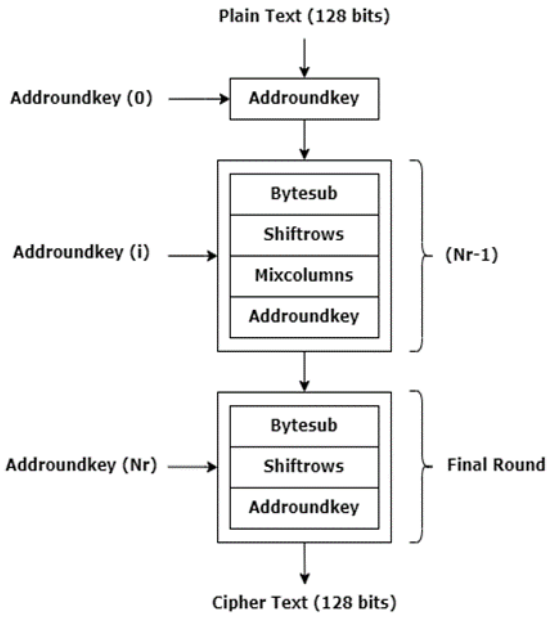

Figure 2. Steps AES Encryption

AES (Advanced Encryption Standard) encryption involves the following steps. First, the data to be encrypted is divided into blocks of appropriate length. Then, each block is encrypted separately using mathematical operations such as SubBytes, ShiftRows, MixColumns, and AddRoundKey. In the SubBytes step, each byte is changed using a specific substitution table. Next, in the ShiftRows step, the bytes in each row of the block are cyclically shifted to the left. The MixColumns step involves a matrix multiplication operation to change the values of the bytes in the columns of the block. Finally, the AddRoundKey step involves XOR between each byte in the block with the corresponding round key. This process is repeated in several rounds determined by the key length. Once all rounds are completed, the encrypted block is generated.

Those steps of AES encryption describe a series of mathematically powerful transformations and operations. The AES algorithm is widely used in various applications that require data security, due to its advantages in speed, efficiency, and resistance to cryptoanalysis attacks. Using AES, sensitive data can be securely encrypted to protect its confidentiality and integrity when transmitted or stored.

3. RESULT AND DISCUSSION

This segment delves into the requirements evaluation of the devised system. The analysis conducted was subsequently followed by the development of the system, database, and system interface. The final stage encompassed the system's implementation, culminating in the presentation of a screenshot displaying the COVID-19 tracking system.

3.1 Problem Analysis

The foundation of endeavors to surmount COVID-19 commences with the detection of suspected/probable cases. Subsequently, isolation measures and laboratory testing are implemented. If the test outcomes are affirmative and validated, treatment will be sustained by the SARS-CoV-2 protocol. Following this, tracing or tracking is conducted. Then, individuals in proximity will be subjected to a 14-day quarantine, and if symptoms emerge, they must be instantaneously isolated and subjected to further medical attention. The following is a depiction of Covid management in Figure 3.

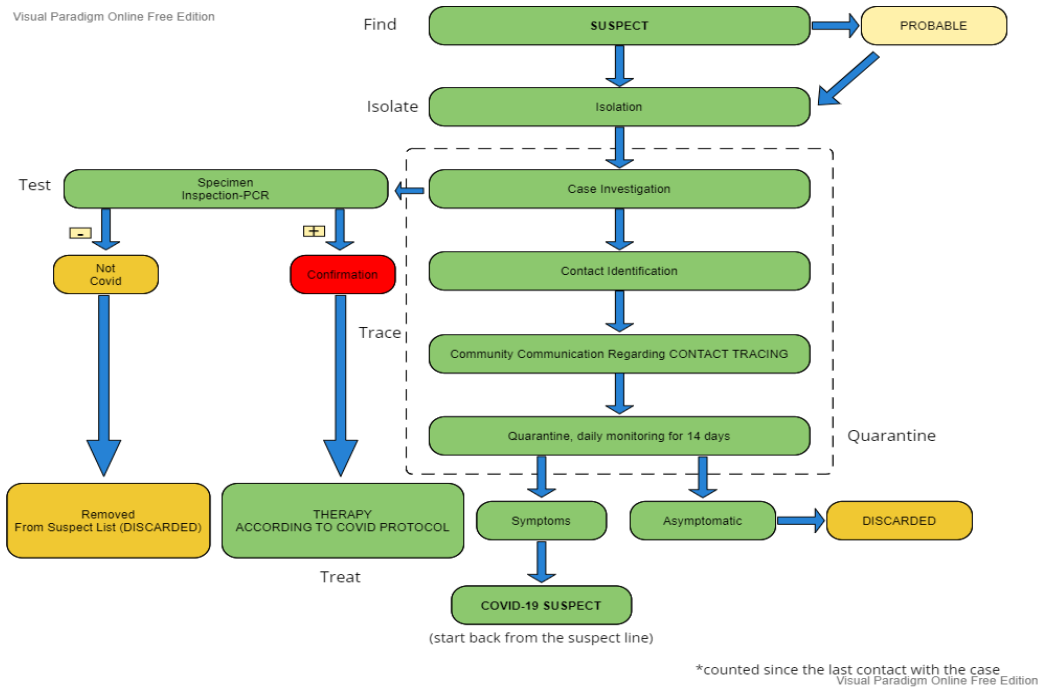

Figure 3. New Normal Era Management

After COVID-19 and the entry of the new normal era, an attendance system using QR codes was created as an effort to track a person's presence. This system was developed with the main purpose of ensuring better control and supervision of individual attendance in various places, such as offices, schools, or shopping centers. Attendance systems using QR codes are an effective solution because QR codes can be easily scanned using mobile devices without requiring physical contact. Users only need to use their phone's camera to scan the QR code that has been provided at the place visited. Upon successful scanning, the system will record the user's attendance in real time.

The main advantage of a QR code-based attendance system is the efficiency and accuracy in tracking the presence of individuals. In new normal situations that demand the implementation of strict health protocols, this system allows managers to monitor the maximum capacity of the room, set the required social distancing, and ensure that only individuals who have scanned the QR code are allowed to enter a certain area. In addition, attendance systems using QR codes also provide advantages in terms of data collection. Information related to individual attendance can be collected and stored in a database, which can later be used for contact tracing purposes in case of COVID-19 or for further data analysis related to room usage.

With a QR code attendance system in place, managers can have better visibility into the number of visitors, ensure compliance with health protocols, and improve security and surveillance in the various places visited. The system also provides a sense of security and comfort for users, as they can track their attendance accurately and hassle-free.

3.2 Solution to the problem

Drawing from the exposition of issues encountered in the management of attendance, where the initial approach was less discriminating, it becomes imperative to undertake measures aimed at addressing or mitigating the extant challenges. In this regard, scholars proffer remedies with a view to monitoring and curtailing the cases. Such remedies include the employment of a QR Code method fortified by AES method security, which can be implemented on both web and Android mobile platforms.

3.2.1. System Design

The system built in this research can perform QR Code creation and scan or scan QR Code accompanied by validation and tracking. The system must be run to run properly.

1) QR Code creation process

In the process of making a QR Code, several steps must be taken. The ongoing process has two subjects that play a role in it. The subjects are users and admins. The process is depicted in Figure 4, using the initials A and B, A as the process carried out by the user, and B as the process carried out by the admin. Steps for Creating QR Codes by Users and Admins can be seen in Figure 4.

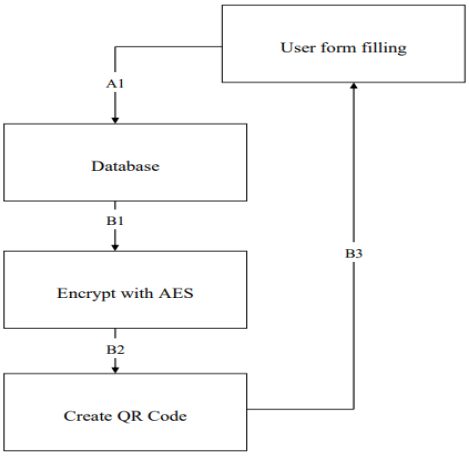

Figure 4. QR Code Creation Steps by User and Admin

In this process, several steps are carried out by admins and users. The admin performs the process of making a QR Code from the input form that is filled in by the user. In making this QR Code, the data obtained from the user will be used for validation and tracking. Therefore, it is necessary to encrypt data using the AES method, so that the data has security. The following diagram shows the relationship between QR Code creation and AES encryption. More details can be seen in Figure 5.

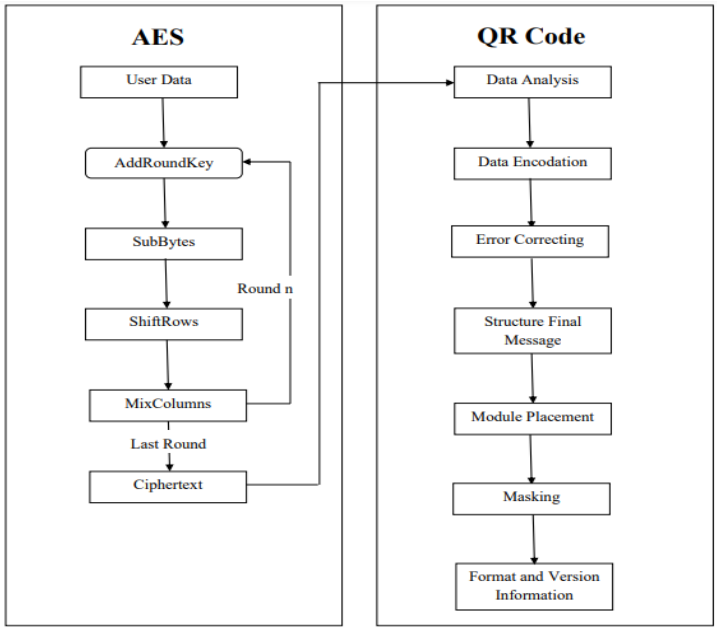

Figure 5. Diagram between QR Code Generation and AES Encryption.

2). QR Code scan process

In the process of scanning the QR Code, it is a step of the system. In this process, there is a very important step, namely user validation. The following is a depiction of the QR Code scanning process in Figure 6 which is marked by the process carried out by the officer given the letter A and the process carried out by the user given the letter B.

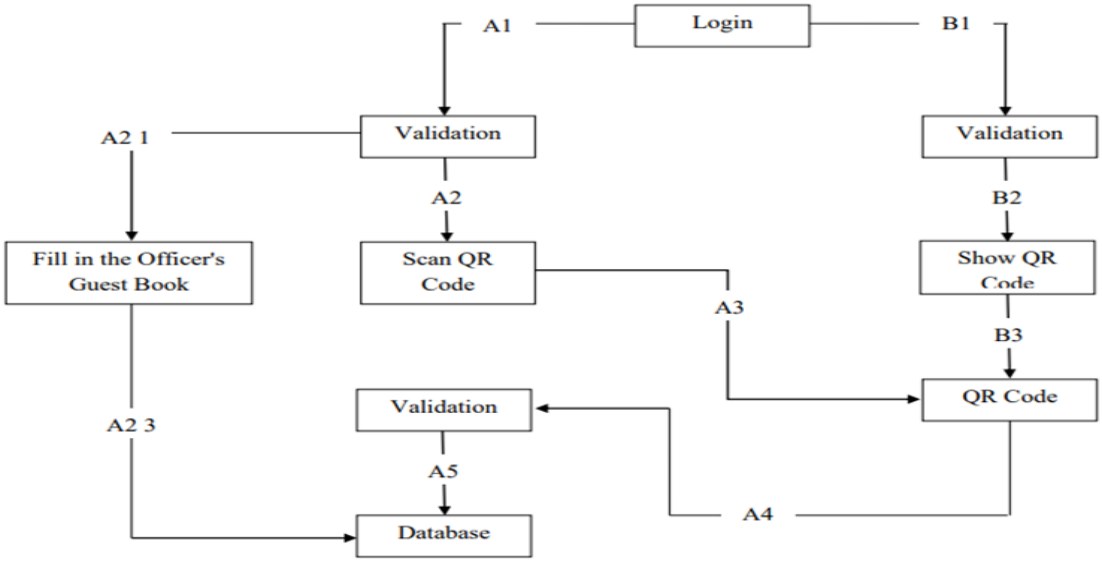

Figure 6. QR Code Scanning Process

In this process, there is a QR Code scan step and then validation. Among these steps are the QR Code scanning process and AES decryption. The process is depicted in Figure 7.

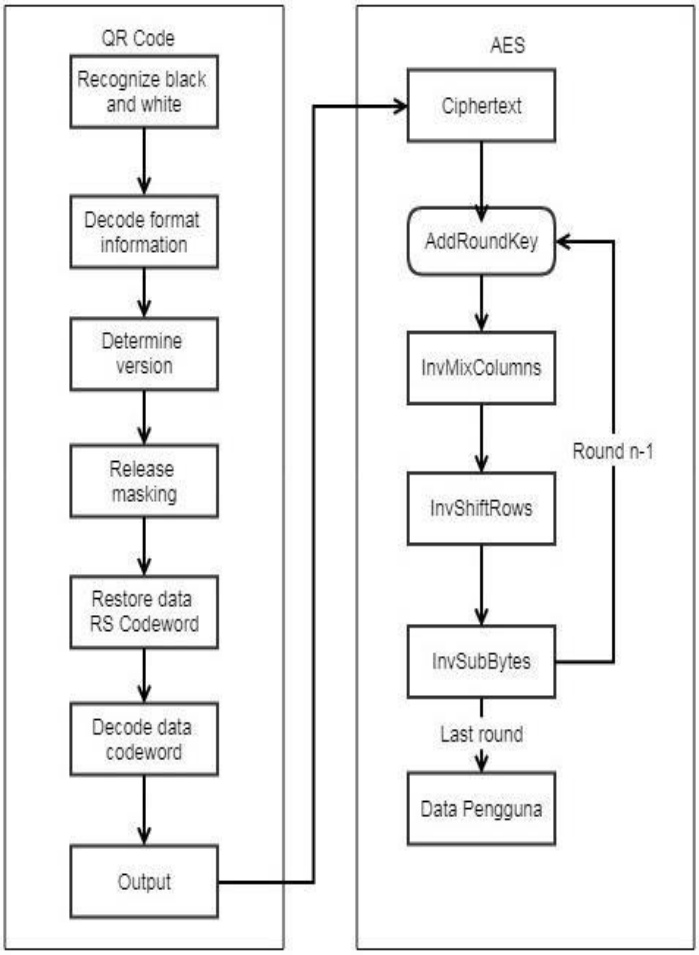

Figure 7. QR Code Scan Step Validation

In the two processes above, there are main keys in the running of the system, namely, AES and QR Code. In AES, the system uses 128-bit AES to secure or encrypt data. Then the QR Code uses error correction level H, to provide convenience when scanning because users show the QR Code to officers using devices that have different levels of light intensity so that an adequate level is needed for the system.

The system uses two processes in AES, namely encryption and decryption. The encryption and decryption process in AES is not much different. In the encryption process that occurs in the system, namely securing the key from the data. The key used is the user's username. In the first AES process, which is to add around the key, because the system uses AES-128, 10 rounds are used. After getting the number of rounds, SubBytes, ShiftRows, and MixColumns are performed. Because the AES process repeats itself, the process will stop at round 10. If you use 192 bits, it will perform up to the 12th round and 256 bits will perform until the 14th round.

The AES-128 encryption process on the system is found in the creation of the QR Code, the part of storing form data in the database. The display of the form to be encrypted and the database is shown in Figure 8 and Figure 9.

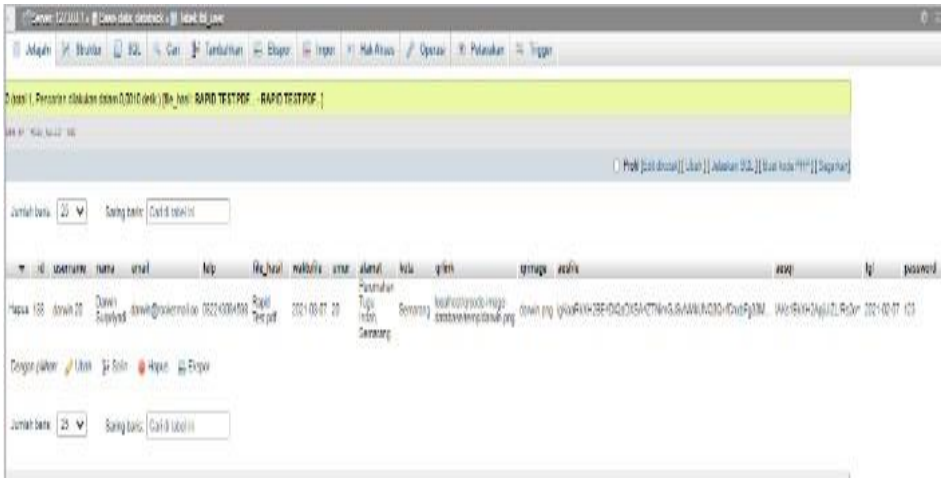

Figure 8. Database Form

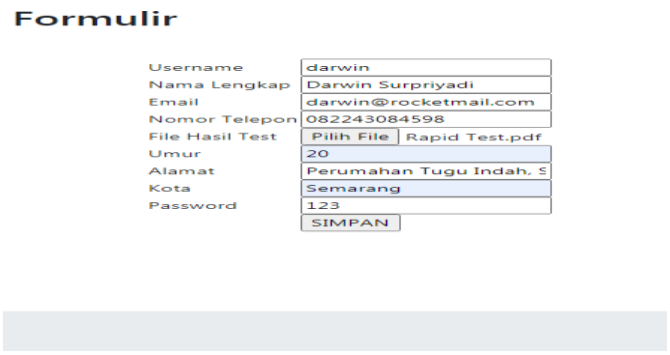

Figure 9. Form to be Encrypted

Upon the conclusion of the document submitted by the potential user, the subsequent measure entails engendering a QR Code. The construction of a QR Code involves an encryption algorithm utilizing a 2-dimensional barcode. In the realm of production, procedures entailing visuals or imagery are imperative, including module placement and masking, to facilitate the generation of an appropriate version and level of the QR Code.

3.3 *Ways of making*

The utilization of a QR Code necessitates a QR Code Scanner, commonly referred to as a scanner. This instrument can also be obtained in the form of an application on mobile devices like Android and iPhone. Presently, the QR Code is employed to simplify the process of retrieving information. In the context of attendance control, it is utilized to facilitate the process through two main procedures: 1. Scanning the QR Code, and 2. Verifying the QR Code scanner tool. The latter process involves scanning and confirming the manufacturing process, which incorporates coding that activates the scanner solely for verification and scanning purposes.

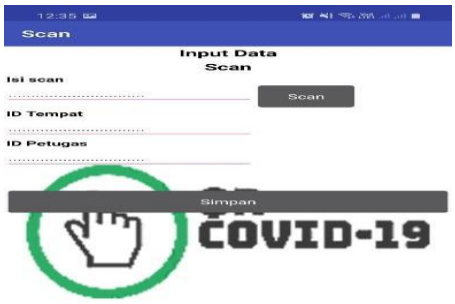

Figure 10. Scanner for staff or Member Officers

In Figure 10, the scanner is only used for staff or members or officers who understand and are committed, so that the implementation of tasks to achieve goals can be achieved. Then to make a QR Code, it is necessary to carry out a registration procedure for officers, in this case, the Covid-19 task force. Figure 11 show the Officer Registration Procedures.

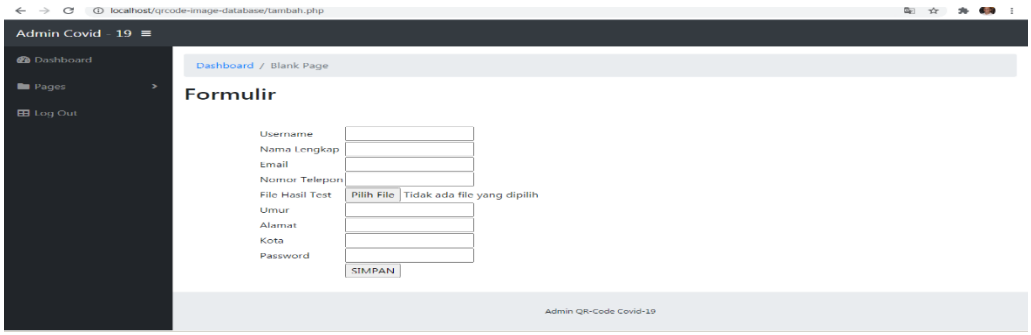

Figure 11. Registration Procedure for Officer

3.4 Program Listing

Figure 12 show several blocks that interconnect and combine functions to create a mobile-based scanner application. Each of these blocks has an important role in building an effective and user-friendly application. With these interconnected blocks, the mobile-based scanner application can provide a better user experience in scanning and managing documents efficiently and practically.

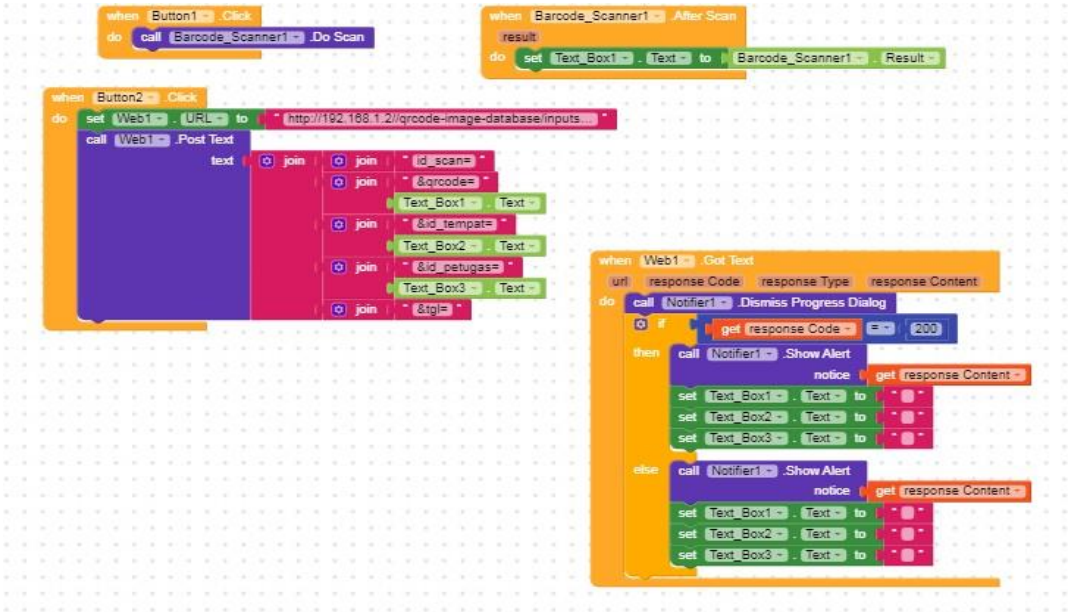

Figure 12. Application Building Function Block

In Figure 13, there is a PHP listing that aims to run the database function in the scanner application. This listing has an important role in entering data related to the scanner application into the database. In this context, the database function refers to the process of storing the data required by the scanner application in a database. The PHP listing in Figure 14 helps in carrying out this task. By using a suitable PHP listing, the data generated from document scanning by the application can be stored in a structured manner in the database. This allows users of the application to perform more efficient and effective data searching, management, and analysis.

```php
<?php
include 'koneksi.php';
$id_scan=$_POST['id_scan'];
$qrcode=$_POST['qrcode'];
$id_tempat=$_POST['id_tempat'];
$id_petugas=$_POST['id_petugas'];

date_default_timezone_set("Asia/Jakarta");
$tgl = date("Y:m:d");


$sql=mysqli_query($db1,"INSERT INTO hasil_scan VALUES('','$id_tempat','$id_petugas','$qrcode','$tgl')");
if($sql === true){
    echo "sukses";
}else{
    echo "gagal";
}
?>
```

Figure 13. PHP Listing Database

It is important to maintain the security and accuracy of the data entered into the database. Therefore, the use of appropriate data security and validation methods also needs to be applied in this PHP listing. Overall, through the PHP listing in Figure 14, the scanner application can store data related to document scanning into the database. Thus, users can easily manage and access the data for further purposes. The listing above is a process to display the QR Code on the application for verification. The listing above also needs to access the database, namely user data.

3.5 Implementation

The application of the QR Code as a system for tracking attendance.

Figure 14. Display User Mobile Application

In Figure 14, show the appearance of a mobile-based user application designed for the Android operating system. This application has been equipped with a QR Code feature and a residence permit extension warning limit. The QR Code feature in this application allows users to read and scan QR codes found on various objects or documents. Users can use their mobile device camera to point at the QR code, and the application will read and extract the information contained in the code.

The app provides a reminder to users regarding the deadline for renewal of their residence letter. When approaching the extension deadline, the application will provide a warning so that users can extend their residence letter by applicable regulations. The user interface of this application is designed to be responsive and easy to use on mobile devices with the Android operating system. The intuitive interface design allows users to easily access and utilize the QR Code feature and get clear residence permit extension warnings. The application of the QR Code feature and residence permit extension warning limit in this mobile-based user application aims to provide convenience and comfort for users in accessing important information and maintaining the validity of their residence permit by the applicable provisions in their place of residence.

Figure 15 displays a table that serves as a recapitulation of all QR Code scan results. This table is designed to provide a comprehensive overview of the scan results. The table contains information related to each QR Code scanned, such as username, name, email, test letter, remaining test time, address, age, QR code, city, or other identification data. With this recap, the

admin staff has access to the information collected from the various QR Code scans that have been conducted.

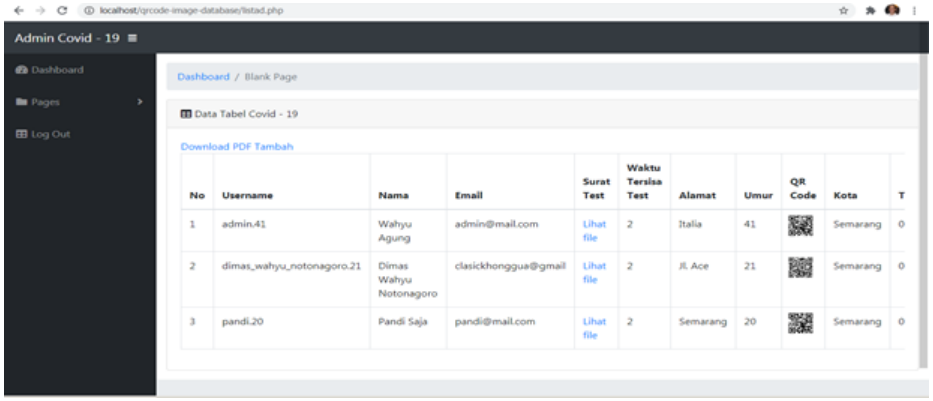

Figure 15. Table Recapitulation

However, it is important to note that the recap can only be viewed by admin staff. This shows that access to the recap table is restricted to users with special access rights, in this case, the application or system admin staff. This access restriction aims to maintain the confidentiality and security of the information contained in the recap table. By giving limited access rights to admin staff, it can be ensured that sensitive or personal data collected from QR Code scanning results remains protected and can only be accessed by authorized parties.

The QR Code scan results recap table in Figure 19 is a useful tool for admin staff to track and monitor scanning activities performed. By having an in-depth understanding of the scan results, the admin staff can take appropriate steps for analysis, reporting, or necessary follow-up actions based on the information collected in the recap table.

4. CONCLUSION

The integration of QR codes into attendance tracking systems has proven effective in reducing the spread of Covid-19. This approach increases the efficiency of attendance tracking, providing comprehensive data to accurately determine user traffic records. The use of QR codes enables monitoring of attendance patterns, identification of congestion situations, and implementation of measures to maintain distance protocols. In addition, the integration of QR codes with AES 128 encryption enhances system security by securely transmitting and storing data collected through QR code scanning. This combination not only enhances security but also simplifies system maintenance, reducing manual data entry errors. Overall, this integrated solution offers a safe and efficient way to manage and control the spread of infectious diseases in various settings, including educational institutions, workplaces, and public places.

REFERENCES

[1] B. Sowmiya, V. S. Abhijith, S. Sudersan, R. Sakthi Jaya Sundar, M. Thangavel, and P. Varalakshmi, “A survey on security and privacy issues in contact tracing application of COVID-19,” *SN Comput Sci*, vol. 2, pp. 1–11, 2021.

[2] Y. Gvili, “Security analysis of the COVID-19 contact tracing specifications by Apple Inc. and Google Inc.,” *Cryptology ePrint Archive*, 2020.

[3] B. Chappell, “Coronavirus: Sacramento county gives up on automatic 14-Day quarantines.” 2020.

[4] R. Flood, S. C. Chan, W. Chen, and D. Aspinall, "Checking Contact Tracing App Implementations with Bespoke Static Analysis," *SN Comput Sci*, vol. 3, no. 6, p. 496, 2022.

[5] L.-Y. Yan, G. W.-H. Tan, X.-M. Loh, J.-J. Hew, and K.-B. Ooi, "QR code and mobile payment: The disruptive forces in retail," *Journal of Retailing and Consumer Services*, vol. 58, p. 102300, 2021.

[6] A. Ateka and T. Kwanya, "Using QR codes to Promote Information Services and Products in Academic Libraries in Kenya," 2019.

[7] T. Kuncara, A. S. Putra, N. Aisyah, and V. H. Valentino, "Effectiveness of the E-Ticket System Using QR Codes For Smart Transportation Systems," *International Journal of Science, Technology & Management*, vol. 2, no. 3, pp. 900–907, 2021.

[8] X. Yu *et al.*, "Positioning, navigation, and book accessing/returning in an autonomous library robot using integrated binocular vision and QR code identification systems," *Sensors*, vol. 19, no. 4, p. 783, 2019.

[9] Y. Liu, J. Yang, and M. Liu, "Recognition of QR Code with mobile phones," in *2008 Chinese Control and Decision Conference*, IEEE, 2008, pp. 203–206.

[10] S. V. S. H. Reddy *et al.*, "Design of QR Based Smart Student Attendance System," in *2023 IEEE 2nd International Conference on AI in Cybersecurity (ICAIC)*, 2023, pp. 1–4. doi: 10.1109/ICAIC57335.2023.10044175.

[11] C. Song *et al.*, "Collection of patient-generated health data with a mobile application and transfer to hospital information system via QR codes," *Computer Methods and Programs in Biomedicine Update*, vol. 3, 2023, doi: 10.1016/j.cmpbup.2023.100099.

[12] L. Yingli, "Design and Implementation of QR Code Payment in Power Self-service Payment Terminal," in *2021 6th International Symposium on Computer and Information Processing Technology (ISCIPT)*, 2021, pp. 432–435. doi: 10.1109/ISCIPT53667.2021.00093.

[13] Y. Dong, Z. Fu, S. Stankovski, S. Wang, and X. Li, "Nutritional Quality and Safety Traceability System for China's Leafy Vegetable Supply Chain Based on Fault Tree Analysis and QR Code," *IEEE Access*, vol. 8, 2020, doi: 10.1109/ACCESS.2020.3019593.

[14] G. Custodio-Chavarría, R. P. Soldán-Araujo, and D. Burga-Durango, "System to Optimize the Process of Medical Consultations Using QR Codes in the Hospitals of Peru," in *2022 Congreso Internacional de Innovación y Tendencias en Ingeniería (CONIITI)*, 2022, pp. 1–4. doi: 10.1109/CONIITI57704.2022.9953670.

[15] M. A. Azad *et al.*, "A first look at privacy analysis of COVID-19 contact-tracing mobile applications," *IEEE Internet Things J*, vol. 8, no. 21, pp. 15796–15806, 2020.

[16] C. Troncoso *et al.*, "Decentralized privacy-preserving proximity tracing," *arXiv preprint arXiv:2005.12273*, 2020.

[17] Y.-J. Chiang, P.-Y. Lin, R.-Z. Wang, and Y.-H. Chen, "Blind QR Code Steganographic Approach Based upon Error Correction Capability.," *KSII Transactions on Internet & Information Systems*, vol. 7, no. 10, 2013.

[18] M. M. S. Rani and K. R. Euphrasia, "Data security through QR code encryption and steganography," *Advanced Computing: An International Journal (ACIJ)*, vol. 7, no. 1/2, pp. 1–7, 2016.

[19] J. Rouillard, "Contextual QR codes," in *2008 The Third International Multi-Conference on Computing in the Global Information Technology (ICCGI 2008)*, IEEE, 2008, pp. 50–55.

[20] D. Joan and R. Vincent, "The design of Rijndael: AES-the advanced encryption standard," *Information Security and Cryptography*, 2002.