Check-In Location System Using NFC Technology

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Abstract. In COVID19 pandemic, new norms have been introduced, including, to leave a record when checking-in to a particular place. This new norm is regulated in order to trace locations that have been visited by someone with positive COVID-19. This paper presents a work on development of check-in location system. The system implemented Near Field Communication (NFC) technology which is mainly utilized two NFC compatible devices where an identification card (IC) is used as a smart object (NFC tag) and the NFC detector as an NFC reader to exchange information. Testing has been conducted in order to observe the system performance, and, the results showed that this system is able to collect information of users who were coming to premise. Also, the information can be checked by authority in order to track someone with positive COVID-19. As conclusion, this system can be an alternative to MySejahtera App.

1. Introduction

The global health event of the twenty-first century caused by an infectious disease known as the coronavirus disease 2019 (Covid-19) mounted severe societal and economic disruptions. Interventions such as wearing of face masks and social distancing measures were taken to dampen the transmission [1]. However, it was not enough to stop the transmission of the infectious disease as it was difficult to track cases and contacts between the infected travellers in the early stages. Public health responses to reinforce case detection, contact tracing and quarantine with targeted communities to reduce further spread and strengthen systems to detect transmission resurgence.

In order to implement contact tracing among the public, it is important to leave a record when checking-in to a particular place. After some time, it was found that checking-in to a certain premise requires a series of steps and it could be difficult and inconvenient especially towards senior citizens. In today’s age of information, a robust advantage of global connectivity is given to combat against the infectious disease. [2] Hence, an easier check-in system with fewer steps and without any Wi-Fi connectivity needed is proposed using NFC as the main point of invention [3].

Digital technologies usage has been enhanced since the outbreak of the pandemic [4]. With these technologies, development and advancement in digital technologies such as the internet of things (IoT) and cloud computing can be applied to undertake measures that are beneficial to curb the pandemic.
NFC is a short-range, high-frequency wireless communication technology that enables the exchange of data over a distance of 10cm without the need of the internet. NFC as the combination of contactless identification and interconnection technologies can be achieved by bringing two NFC compatible devices close together. Such devices can be a smart object similar to NFC tag or NFC reader or NFC enabled device which can later make use of the exchange of data to provide mobile services such as mobile application and web service page [5].

This paper proposes a check-in system using NFC technology which mainly utilize two NFC compatible devices where an identification card (IC) is used as a smart object (NFC tag) and the NFC detector as an NFC reader to exchange information. The identification card (IC) and the NFC detector exchange data when brought to a distance together utilizing the near field technology. Each IC containing their individual UID code serves as a smart object to be read by the NFC detector and the data can be then posted into the NoSQL or real-time database.

A strong advantage of using this system is the simplicity and contactless communication with ease of use and does not require any internet connection. Convenient, easy and almost instantaneous check-in process saves users time and provides high efficiency and reliability for operators at the same time. With this user-friendly system, users would not need to get their IC to be scanned directly to the NFC detector as it allows a communication distance within 10cm. Users can tap their IC as they enter any premises equipped with the NFC detector. This checking system also includes a mobile application for users’ registration, history display for premises owners and also related authorities to track down users that have been to infected areas.

2. Methodology
In Malaysia, the identification card also known as MyKad, is used as personal identification and citizens are required to carry them at all times. Hence, the project is made use of the embedded chip in the card as an access key to check-in to a location. Each identification card will have an individual UID code which can be read by the NFC detector [6]. The detector will try to match the scanned UID code with the one that has registered into the NFC App. If the UID is matched, the user is permitted to check-in to the location. However, if the UID code is not matched, the buzzer will be alarmed to alert the premise owner that the user has not registered through the application and at the same time, the LCD will also display the string of UID code where the user can then enter the code in the registration app for registration. Checking-in to different premises is important especially during this pandemic as it leaves a record and helps contact tracing among the infected population.

This project consists of three stages of works, i. Hardware development, ii. Software development, and iii. Testing. For the software development, it is involved an Arduino programming and Apps development. Figure 1 shows a general flow of the check-in location system using NFC technology.

![Figure 1 General block diagram of the check-in location system using NFC technology](image)
2.1. Hardware Design and Development

The main electronic component in this project is NodeMCU ESP32 [7]. It is a micro controller with integrated Wi-Fi and dual-mode Bluetooth. Also, it is known as relatively inexpensive and low power consumption device. Here, NodeMCU is used to control the flow of the check-in location system. It acted as a middle person between the NFC detector and NFC App. Table 1 shows its function description.

Apart of NodeMCU ESP32, the circuit involved with LCD (16 x 2), a rechargeable battery, buzzer and button. The buzzer is used to alarm the result, while button is used to turn ON/OFF the device. Next, the completed circuit was placed in the customized container as shown in figure 2. The customized container is designed using Solidwork software. Later, it is printed using 3D printer with PLA material.

Table 1 NodeMCU ESP32 functions

| No | NFC detector | NFC App |
|----|--------------|---------|
| 1  | Read the UID code | Compare the UID code in the NoSQL/real-time database |
| 2  | Establish NFC module (MFRC 522) | |
| 3  | Send the UID code to Apps | |
| 4  | Send the result to LCD | |
| 5  | Display result at LCD | |
| 6  | Turn ON/OFF the buzzer | |

2.2. Arduino Programming

The Arduino programming is created based on the functions that required by the system as shown in Table 1. Here, the main function is described as pseudo code and it is shown in figure 3.
2.3. Apps Development

In the mobile application, there are three parts which are included three different end-users. For first-time users, registration can be done through the mobile application by providing their name, IC number and UID code. Users are able to obtain their individual UID code by tapping their MyKad near to the NFC detector which will be provided at different premises. After the premise owner completes signing up for this check-in system, they will receive an account with their own password. Premises’ owners are able to monitor people who have been to their remises by selecting a certain date and time. Thus, if the place has been infected, premises’ owners can inform relevant end-users immediately. Related authorities will receive an account that can acquire the information of the registered users. When an investigation is required, the authorities can perform contact tracing almost immediately to acquire the information needed and prevent the infected travellers from increasing the area of transmission. Figure 4 to figure 6 show the pseudo code of the user’s registration, premise’s owner and authority.

### Pseudo code of the main program for check-in location system
1. Start
2. Initialize the system
3. Read UID code through the MyKad
4. Compare UID code in database
5. If UID code == database
6. Display welcome at LCD and record information
7. Buzzer alarm 1 time
8. Else, write UID code in database
9. Buzzer alarm 3 times
10. End

Figure 3 Pseudo code of the main program

### Pseudo code of the user registration
1. Start
2. Initialize the system
3. If user already in database
4. Successfully registered
5. Else, user fill the form
6. New user registered
7. End

Figure 4 Pseudo code for the user registration

### Pseudo code of the premise’s owner
1. Start
2. Initialize the system
3. Enter password
4. If password correct
5. Select date and time
6. Message to selected customers
7. Else, re-enter password
8. End

Figure 5 Pseudo code for the premise’s owner
2.4. Testing
Testing is conducted once the system is completed. Four categories of testing have been carried out in order to ensure the system is able to work accordingly. The testing is involved initial condition, user/customer part, premise’s owner part and authority part. The conducted test description is shown in table 2.

| Category          | Test description                                                                 | Expected result                                                                 |
|-------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Initial condition | 1. The check-in location device can turn ON and OFF.                             | 1. Press ON button, LCD display “Scan your card here”. Press OFF button, LCD turn OFF. |
|                   | 2. The check-in Apps can connect to internet.                                    | 2. Database can be displayed                                                     |
| User/customer     | 1. Placing an unregistered MyKad near to the check-in location device.           | 1. Buzzer alarm for 3 times. LCD display “please register”. Customer requires to fill registration form using check-in location App. Then, customer information saves in database. |
|                   | 2. Placing a registered MyKad near to the check-in location device.              | 2. Buzzer alarm 1 time only and customer information save in database. LCD display “welcome”. |
| Premise’s owner   | 1. Access premise’s owner check-in App and enter correct password.              | 1. App display selection of date and time. Then, owner can select date and particular time. After that, a set of recorded data will be displayed. |
|                   | 2. Owner select particular data to send message                                  | 2. A message is delivered and state “Hi, you have been suspected interacted with the infected population. Please move to your nearest clinical or hospital to carry your swab test/Covid-test. Thank you”. |
|                   | 3. Access premise’s owner check-in App and enter incorrect password             | 3. App display main menu and request password.                                   |
| Authority         | 1. Access authority check-in App and enter correct password.                    | 1. App display selection of date and time. Then, authority can select premise, date and particular time. After that, a set of recorded data will be displayed. |
2. Authority selects particular data to send message
2. A message is delivered and state “Hi, you have been suspected interacted with the infected population. Please move to your nearest clinical or hospital to carry your swab test/Covid-test. Thank you”.

3. Access authority check-in App and enter incorrect password
3. App display main menu and request password.

3. Results and Discussion
After the test procedures were carried out for the system, the performance has met with 100% of the required specifications. However, it still has some limitations which are difficult to control. First, the MyKad is embedded with the 4K Mifare Classic tag type, which is the same as market use such as Watson Cards, Credit cards, Student cards etc. Hence, MyKad is selected as the smart tag for NFC as every citizen in Malaysia is required to carry them at all times. The second limitation is the occurrence of the miss of margin and alignment display on the LCD. Therefore, the system has to be operated once after switching it on before allowing the users for check-in. The third limitation is the purchasing of the NFC detector system where premises’ owners are required to purchase the system with an account through providing verification of business type and other details. The registration “Premise Owner” page cannot be done by themselves as an account is needed to be set up by us. After an account of the premise owner is created, they are able to log-in and view the users’ checked-in history. The fourth limitation is the limitation of viewing users’ history where after the users checked-in, they are not able to trace back their history as this application is only used for registration purposes.

The mobile application for the check-in system is used for users’ registration, history of checked-in users for premises’ owners and also related authorities to track down users that have been to infected areas. Whenever a registered premise has been found contaminated by Covid-19, the premise owner can send a message to relevant checked-in users via this mobile application. This is to inform the users that they might have a close contact with an infected person. The personal details of the user can only be viewed by related authorities such as Ministry of Health Malaysia (MOH) but not the premises’ owners.

The NFC system performs well and is stable after the test procedures. However, it may face some inconsistency if the physical connection is loosened. Hence, in order to provide a stable system, the cable connections have to be fixed and tightened to the board and components. The NFC system does not consume a lot of power and Wi-Fi connection is required to be used by the premises’ owners only. The users would only need Wi-Fi connection for the first time of registration through the mobile application and there is no mobile data or Wi-Fi connection when checking-in to a location.

Figure 7 shows the prototype check-in location device. Figure 7(a) shows the initial condition of LCD which is displayed “scan your IC”. Then, Figure 7(b) shows an unregistered MyKad scanned result, which is the LCD displayed “Register required”. While, Figure 7(c), a registered MyKad scanned result, and showed “Welcome, customer’s name”.

Figure 8 shows the check-in location Apps. Figure 8(a) shows the registration form that required to fill by unregistered customer. Next, Figure 8(b) and 8(c) shows the main menu for premise’s owner and authority to access the database, respectively. Figure 8(d) shows the selection menu of dates for the premise owner to view the recorded data. Figure 9 and Figure 10 show the list of recorded data and message that sent to relevant customer for COVID19 awareness, respectively.
Figure 7 Prototype testing (a) Initial display, waiting to be scanned (b) Scan by MyKad, before registering at the system, and (c) Scan by MyKad, after registering at the system.

Figure 8 The view of check-in location Apps. (a) Registration Page for User in the Application, (b) Sign-in Page for Premises’ Owners in the Application, (c) Sign-in Page for Related Authorities in the Application, and (d) Page for Premises’ Owners to Select Date to View Users’ History.

Figure 9 Data of user shown for related authorities.
4. Conclusion

Contact tracing is vital to reduce and help stop the transmission of Covid-19 by tracking cases and contacts between the infected travelers. To implement contact tracing, we have successfully developed a convenient check-in system using Near Field Communication (NFC) and the Internet of Things (IoT) as the medium of invention. The NFC detector prototype designed in this project is compact and lightweight, and is able to be operated with a rechargeable battery. Therefore, it is very portable to be placed on the entrance of the premises. This system is also highly efficient to contact people who might be at risk of the infectious disease but also easily accessible especially to communities living at a poor internet connectivity area and senior citizens because it does not require a smartphone for every check-in. The system can also be utilized for further use such as NFC-based attendance system or door-lock security system. We hope that the system proposed can deploy a more convenient contact tracing system for users, vendors and related authorities.

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