NFC Based Equipment Management Inventory System

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ABSTRACT. *Traditional stocktaking is carried out manually using paper recording method. It takes time and labor, uneasy to be preserved and easy to be damaged. This study combines Android smart device platform with NFC technology, utilizing mobiles to read cards to conduct facility inventory management. Compared to traditional facility inventory control method, cards have advantages of uneasy to be dam-aged, easy to be preserved, etc., and meanwhile, it can combine with web page to add/edit facility list and management job of the maintainers. Thus, the electronic inventory control system developed by this study can not only be applied in the lab to manage facilities, but also widely applied in daily life and business.*
Keywords: NFC; RFID; NDEF; APP.

1. **Introduction.** Along with the popularity of the Internet and the enhancement of mobile's computing ability, the development of smart phones have become diverse, especially in data inquiry, data transmission, community network, etc. Thus, communication technologies such as Wi-Fi, Bluetooth, Near Field Communication (NFC), iBeacon, etc. have brought limitless business opportunities for mobile business applications. Amongst, NFC which allows non-contact-point data transmission between electronic devices over short distance has been seen as the important key technology to develop mobile payment in the future. Therefore, this study bases on NFC technology to develop an inventory control system which can be applied on smart phones [1] [2]. Facility management is an important but meanwhile complicated and time-consuming task. At present, inventory control system needs to be paper-based or using RFID to make electronic records. However, paper-based record has the disad-vantage of uneasy to be referred to, requiring manual work and consuming a lot of cost for labor and meanwhile time-consuming. Although RFID has the advantage which can electronize facility information and the complexity of manual work, being limited to the communication function, the signature data of RFID needs to be sent at fixed spots or after inventory work to backend management system

to be processed [3] [4] [5]. Thus, for large warehouse or complicated spatial layers, maintainers usually fail to control the immediate situation or obtain the information related to the products, lowering the efficiency of inventory work [6].

FIGURE 1. NFC sensing illustration

Facility management depends highly on the quality of the staff. Thus, using innovative technology to assist enterprises to do the job well is what enterprise should consider during their electronization and the ultimate goal of enterprise electronization. In view of this, this study utilizes NFC device built in Android smart phones and its sensing function to develop a set of NFC inventory control system. Combining Android phones and the APP developed by this study, we build information list for facilities in the database at servers. The data is transmitted through 3G/Wi-Fi, using NFC Tag as the ID for products. The related description can be obtained after using the mobile to read the Tag. Through the design and implementation in this study, students can save great manual stocktaking time and provide services enabling more convenient operation when users are using smart phones.

2. **Background.** NDEF format is the exchange standard for NFC card which can contain 4096 bytes data. Through this standard, devices with NFC can rapidly read the content in the NFC Tag. The information in the NFC Tag is not necessary to be much, instead, a segment of website or phone number will be enough to deliver the information to the users. The using method of NFC is similar to that of QR Code. But QR Code requires card reader to "scan" the card to read the content of the card. For NFC, users only need to "contact" the mobile with NFC Tag to directly read the information in the Tag. It is relatively convenient. The application of NFC can be divided into "Scenario Adjusting Mode", "NFC Tag Reading and Editing" and "data transmission." For example, when users write the information into the Tag and let other mobiles read its internal data such as phone number, web pages or simple text through the Tag, or using NFC Tab to avoid
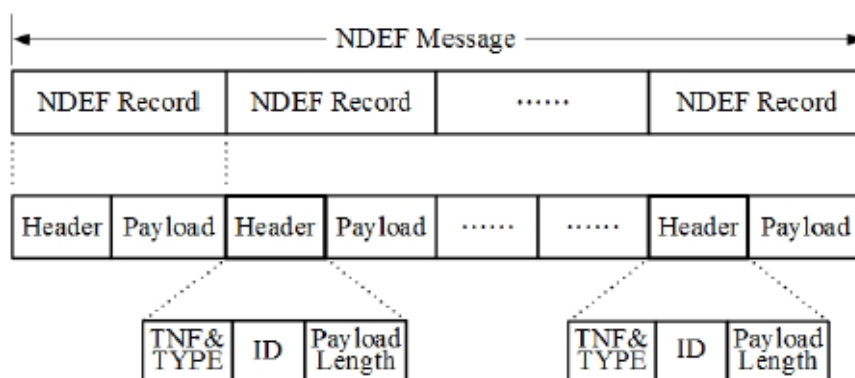

FIGURE 2. NDEF format

the complicated steps for scenario mode setting. Besides, NFC technology allows mobiles to directly transmit files mutually. Mobiles only need to start NFC sensing function to transmit graphics, web pages, files, etc. to another NFC mobile, greatly simplifying the complicated matching process in the past, and making the data transmission between mobiles more convenient.

In the past, the application of NFC is similar as that of tradition RFID functions except

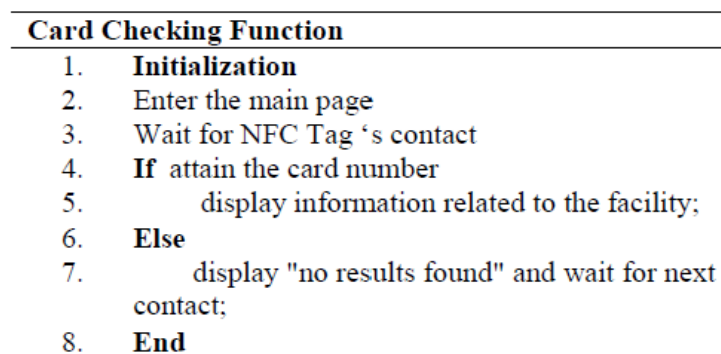| Card Checking Function |
| --- |
| 1. **Initialization** |
| 2. Enter the main page |
| 3. Wait for NFC Tag 's contact |
| 4. **If** attain the card number |
| 5. display information related to the facility; |
| 6. **Else** |
| 7. display "no results found" and wait for next contact; |
| 8. **End** |

FIGURE 3. Flow chart of the card checking function

for e-purse function. In entrance guard system, mass transportation system, convenience store payment, etc., using smart phones to replace traditional plastic cards can reduce the trouble of carrying a lot of cards. Some people apply NFC to class roll call to replace online/paper-based roll call used in the past and save the time for roll call. For payment transaction in the parking lots, in the past, there were long lines in front of auto payment machines. Using NFC electronic payment can avoid waiting in line and the loss of IC token.

QR Code is a widely applied coding technology. Compared to two-dimensional bar codes, QR Code can store more data and does not require the scanner to sweep across in a straight line, and therefore, it is widely applied in object identification, document management, marketing, etc. Although QR Code has wider support and popularity and is generally supported by mobiles [6], QR Code needs to insert poster ads or text or links of videos and redo the graphic of the QR Code, increasing its convenience of usage.

NFC provides a faster, more convenient and safer data access method. The advantage is its better flexibility to use, and it can store different types of messages. If users want to change the content, they do not recreate a new NFC tag. Instead, they simply have to remove the previous one and write new message into the tag. In addition to the easy setting, NFC can send messages between mobiles and tags in a contactless way, greatly reducing the time to launch an application or waiting for the analysis. The communication between the tag and the reader is fast and can accomplish the complicated information transaction. NFC and Bluetooth are both short-range communication technologies that are integrated into mobile phones. NFC operates at slower speeds than Bluetooth, but consumes far less power and does not require pairing [7].

NFC sets up more quickly than standard Bluetooth, but has a lower transfer rate than Bluetooth low energy. With NFC, instead of performing manual configurations to identify devices, the connection between two NFC devices is automatically established in less than a tenth of a second. The maximum data transfer rate of NFC (424 kbit/s) is slower than that of Bluetooth V2.1 (2.1 Mbit/s).

With a maximum working distance of less than 20 cm, NFC has a shorter range, which reduces the likelihood of unwanted interception. That makes NFC particularly suitable for crowded areas where correlating a signal with its transmitting physical device (and

by extension, its user) becomes difficult. In contrast to Bluetooth, NFC is compatible with existing passive RFID (13.56 MHz ISO/IEC 18000-3) infrastructures. NFC which is similar to the Bluetooth V4.0 low energy protocol requires comparatively low power. When NFC works with an unpowered device (e.g., on a phone that may be turned off, a contactless smart credit card, a smart poster, etc.), however, the NFC power consumption is greater than that of Bluetooth V4.0 low energy protocol since illuminating the passive tag needs extra power.

3. **System Implementation.**

3.1. **NFC Card Checking Function.** In the past, when checking facilities, we always need paper-based records and facility number to conduct matching. And sometimes stickers on the facility may be worn away. When the number of facilities increase, managers will feel traditional inventory control method waste time and labor; therefore, if we could replace traditional manual work by electronic work, the time and cost in manual work can be saved. In view of this, this study designs a function module using NFC sensing to replace traditional paper-based checking. The operation flow chart of card checking function is shown in Figure 3. After executing APP, the program will start the initialization and enter the main page to read NFC Tag. If there are matching data for the reader card number, the layout will dis-play the information related to the facility. On the contrary, when it display "no results found", it will wait for read the next data. Through this

Search Function
1. **Initialization**
2. **Enter the main page**
3. Executing facility search function and enter query;
4. **If** search results are not empty
5.   display all matching facility items;
6.   **If** click on the facility name
7.   display information related to the facility;
8.   **End**
9. **End**

FIGURE 4. Executing flow of search function

operation method, the manager just needs to stick the Tag with pre-entered information to the facility. And then contact mobile/tablet with NFC function with the Tag. The App will automatically start to conduct matching and display the matching results on the screen for users' reference. This way, the facility control process can be greatly simplified to save labor, time and cost.

3.2. **Data Search Function.** The time for checking facilities is directly proportional to the number of facilities. This time, the inquiry for facility information and search function will become relatively important. Furthermore, facilities can be lent or transferred. Therefore, when designing data search function, in addition to the common items such as type, number, name or other detailed specification, the facility management and using status should be also considered to enable facility maintainers to rapidly understand the status of the facility. Figure 4 shows the operation flow chart of data search function. When system maintainers use data search function, they can select facility search icon and enter the keywords to be searched for after entering the APP main page. The APP
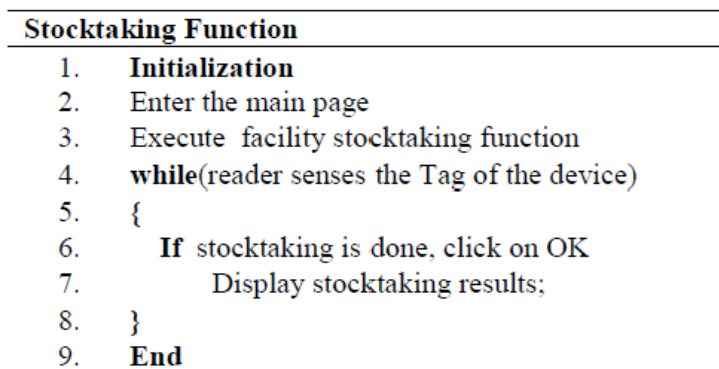
Stocktaking Function

1.	**Initialization**
2.	Enter the main page
3.	Execute facility stocktaking function
4.	**while**(reader senses the Tag of the device)
5.	{
6.	**If** stocktaking is done, click on OK
7.	Display stocktaking results;
8.	}
9.	**End**

FIGURE 5. Execution flow chart of search function

will list the facilities matching the keywords achieving the goal of rapid search.

Data Search Function

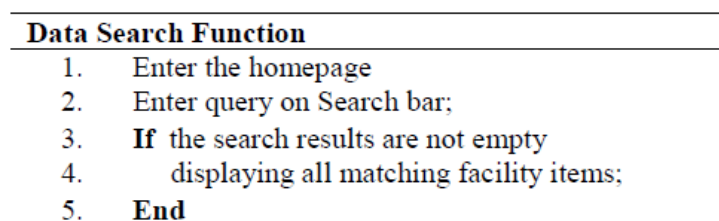|	
1.	Enter the homepage
2.	Enter query on Search bar;
3.	**If** the search results are not empty
4.	displaying all matching facility items;
5.	**End**

FIGURE 6. Flow chart of data search

3.3. **Stocktaking Function.** To implement NFC stocktaking function, the data should be imported to the database and matched with the corresponding cards to get the advance preparation of NFC stocktaking done. Then, we can execute device stocktaking through the registered information in the database and the NFC function on mobile devices. During the stocktaking process, we can obtain the current stocktaking status from the screen of the device. After the stocktaking is done, the device will notify which properties are not found.

The operation flow chart of stocktaking function is shown in Figure 5. After entering APP main page, click on facility stocktaking and take devices to sense the Tag of the device to execute facility stocktaking. After stocktaking is done, click on OK and the stocktaking results will be displayed on the screen.

Data Add/Edit Function

1.	Enter the web page homepage
2.	**If click on the** "Add" button
3.	Enter the data and send ;
4.	**Else** click on the "Edit " button
5.	Edit data and send;
6.	**End**

FIGURE 7. Operation flow chart of data add/edit function

3.4. **Data Search and Edit Function.** Although smart handheld devices can execute functions such as checking E-mail, browsing community websites, reading news, etc., but when entering massive data, personal computer is a better option. In view of this, this project also plans to develop a web operation interface for traditional personal computer. System maintainers can execute add, edit and search functions through web management interface (this can be applied on smart handheld devices as well). The operation flow chart of web search function is shown in Figure 6. When users enter web homepage, users can conduct searching according to the query they enter, checking the common items such as maintainer, number, model, etc. to conduct the matching. If the matching results are not empty, the matching facilities will be displayed on the web interface. Figure 7 shows

FIGURE 8. Application architecture

the operation flow chart of data add/edit function. Users can click on "Add" button after entering the page to add new data to the database or click on "Edit" button to edit the existing data.

3.5. **Operation Flow Chart of the System.** Figure 8 is the operation flow chart of the App. The App is composed of three functions: "device (or property) stocktaking function", "device search functio" and "device card matching function". When users execute the App, it will first perform initialization and enter the main page. On the main page, it can sense the Tag to obtain the related information of the device. On the upper right of the main page, users can switch to the pages of "device stocktaking function", "device search function" and "device card matching function". The operation steps of device stocktaking function are as follows. After entering the corresponding pages, we can sense the NFC Tag to execute stocktaking. After the stocktaking is done, click on OK and it will display the stocktaking results and list the properties which are not found. For device search function, click on the search function and a dialog widow will pop up. After entering the keywords and click on OK, the device list matching the inquiries will be displayed on the screen for users' reference. For device matching function, after entering the matched corresponding pages and select the device to be matched, we can click on the match button and take blank NFC Tags to approach smart handheld devices to complete the matching. Later, the sensing cards are able to obtain the related information of the device.

FIGURE 9. APP initialization layout

FIGURE 10. Device information layout

FIGURE 11. Facility search layout

FIGURE 12. Facility search results

FIGURE 13. The tag matching and notification message

FIGURE 14. The tag matching layout

4. **Application operation interface and function display.** The following we will show the APP operation interface and each function.

4.1. **Data Stocktaking Function of NFC Device.** As shown in Figure 9, after starting the card checking function of the APP, it will start to read NFC Tag; as shown in Figure 10, if we enter the information to the NFC Tag in advance, the mobile communication devices will display the information related to the facility in the Tag. On the contrary, the mobile will display notification message and wait for next contact.

4.2. **Facility Search Function.** When users want to use the facility search function, they only need to click on the upper right button on the APP homepage (Please refer to Figure 9). As shown in Figure 11, the APP will display a search window allowing users to enter the queries. After they click on OK, the APP will check whether there is any information matching the query in the column of facility name, number, model or keeper in order. If there is, it will display the matching information as shown in Figure 12.

4.3. **Facility Search Function.** When stocktaking the equipments, equipments which are diagnosed as requiring maintenance, the notification function of the App can be launched; as shown in Figure 13, the "Report" on the upper right of the screen can be clicked on when equipments needs to be reported maintenance. At this moment, the layout as shown in Figure 14 can be seen asking whether adding the equipment information to the notification record. After clicking on OK, related problems of out-of-order equipments can be filled in on the window and send the content to the system manager as shown in Figure 15.

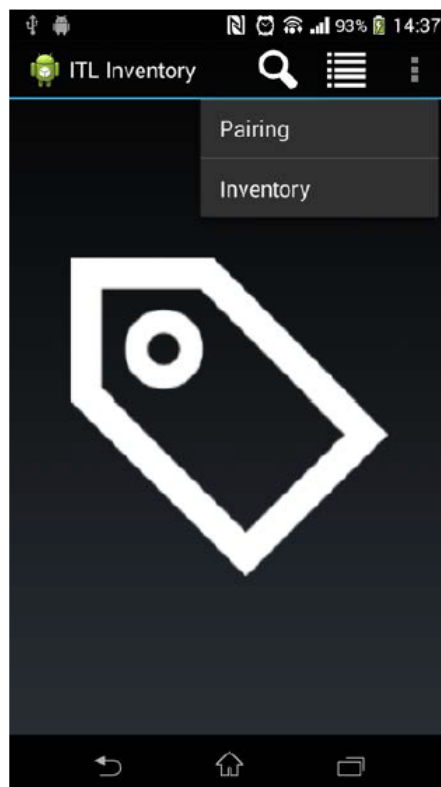FIGURE 15. The problem report layout

FIGURE 16. Device stocktaking layout

FIGURE 17. Stocktaking status layout

FIGURE 18. Stocktaking results

FIGURE 19. Stocktaking results

FIGURE 20. Facility list (Homepage)

4.4. **Stocktaking Function.** To use NFC stocktaking function, we should first to select "Inventory" on the upper right in Figure 16. After entering the stocktaking layout as shown in Figure 17, the Tag of the device can be sensed via NFC phones. The device which is stocktaken will be marked by a check as shown in Figure 17. Repeat the sensing until the stocktaking is finished. Click OK to display the stocktaking results when it is done. The number of successes and failures of stocktaking and unfound properties will be shown as in Figure 18. As illustrated in Figure 18, through this inventory system, users are able to quickly check equipments haven't been stocktaken, e.g. checked equipments and unchecked equipments. Among checked equipments, users can click on a drop down list on the left of each major item as shown in Figure 18 to obtain the detailed information of individual items as shown in Figure 19.

4.5. **Web Page Function.** Web page data search function is consisted of three parts including add, edit and search; the search bar is on the upper right of the web page, facility adding function is on the left upper side and the edit button is on the right side of every facility. Figure 20 is the user operation interface. Figure 21 is the layout of search results. Users can find the facilities matching the entered keywords; Figure 22 is the add/edit layout. After sending the entered data, the adding/editing is done.

5. **Conclusion.** In recent years, the development of smart handheld devices has been booming. Most people are using smart phones. Amongst, Android phones have more market share and most of the new phones have NFC function, making the data exchange between phones easier and able to read Tag; this study shows the approach to use NFC function which can be read by smart phones to implement an inventory control system. Through NFC Tag and the assistance of the inventory control system implemented by this study, users just need to contact their phones with NFC Tag on facilities. The handheld

FIGURE 21. Web search results (Keyword: iphone)

FIGURE 22. Add/edit layout

devices will display the information related to the facility. It can save more time and labor cost compared to traditional paper-based checking or RFID.

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