VIP Access System for Server Room Based on Near Field Communication Technology

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***Abstract*—Nowadays, many smartphone products are bundled with a Near Field Communication (NFC) Module inside. In this research, it was used as a private key for high security server room in our institution. Generally, it consisted of three main subsystems. Those were security server, low cost embedded system, and NFC smartphone as a key. Smartphone was used in Host Card Emulation (HCE) Mode as an alternative ISO14443A interfaced to its shield. Low cost embedded system was used to control all of the magnetic keys at the door and all over the room. And every in-out activity to the room was recorded in the server. This system has quick time response and high success rate. Based on the result, it was analyzed that this system performed very well with high reliability. So, the system can be implemented in server room well.**

***Index Terms*—Near Field Communication (NFC); Access System; Host Card Emulation (HCE).**

I. INTRODUCTION

Smartphone becomes important for every person today. And currently, many smartphones are bundled with NFC (Near Field Communication) module inside. For example, in 2015 there are more than 150 million smartphone products bundled with NFC inside [1]. It can be used in many applications, such as digital payment, information change, security system, and more.

In NFC standard, it's only permitted to communicate in very close distance between two devices and in very short time. The transmission can be built in maximum 10 centimeters about 100-150ms [2]. So, it can be said that it's more secure and powerful than other protocol like infrared and blue-tooth [3]. And by this system, many types of applications using smartcard can be replaced. In detail, those are some advantages of NFC technology [2]:

- Provides high level security by establishing only two devices in close distance to reduce the interference.
- Reduce the risk of swiping card.
- Low power consumption for application.
- NFC provides two kind of general mode as RFID, can be used in passive or active mode.
- NFC provides higher data rate than RFID and bandwidth still can be increased.
- It doesn't require the external power.

First, NFC was introduced by Google in their Android 2.3 devices. In that time, it could only read the tags only. But they developed for the next version to increase the abilities to write and trade the data through Peer to Peer mode [4], [5]. Nowadays, current smartphones bundled with NFC can be used in three different modes. They are reader/writer mode, P2P mode, and Host-based Card Emulation (HCE) mode [6].

Table 1
Comparison of NFC and others [7]

Parameters	NFC	IRDA	Bluetooth
Network Type	Point to Point	Point to Point	Point to Multipoint
Set-up Time	<0,1 ms	~0,5 s	~6 s
Range	Up to 10 cm	Up to 5 m	Up to 30 m
Speed	424 kbps	115 kbps	721 kbps
Modes	Active-active, Active-passive	Active-active	Active-active
Usability	Human centric, easy, intuitive, fast	Data centric, easy	Data centric, medium
Selectitivity	High, given security	Line of sight	Who are you?
Use cases	Pay, get access, share, initiative service, easy set up	Control and exchange data	Network for data exchange headset
Consumer experience	Touch, wave simply connect	Easy	Configuration needed
Costs	Low	Low	Moderate

Since HCE mode has been introduced, smartphones can replace any smartcard-based application such as digital payment, security key, identity card, and more. in this mode, smartphones is read same as smartcard id tags by the card/NFC reader. In sort, data is routed into CPU directly from the reader [8][9].

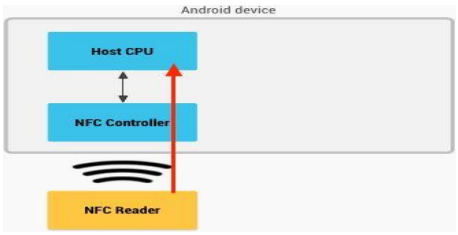

Figure 1: Host-based Card Emulation [8], [9]

NFC mainly used in digital payment and security system. Many smartcards and RFIDs usage have been replaced after the highly development of NFC technology. It's supported by bundling of NFC module in many smartphone product indeed. So, application user can bring their smartphones only without any cards. It becomes very practice.

For example, NFC was used in electronic ticketing such as train ticketing [4], airline ticketing [10], and e-ticketing system [11]. It turned ticketing system into paperless and payment method into digital way. Then in [2], it used in biomedical engineering to monitor heart rate and medical implant devices. Instead, in [12] NFC can be use for automated parking system. It also can be used in security system replacing the any other keys (conventional key through magnetic or RFID). It proposed more flexibility and security by using NFC technology especially bundled in smartphone.

In this paper, we tried to focus on implementation of security system by using NFC technology in server room. Generally, it was like keyless entry but propose more security. By using smartphone, some seperate systems such as NFC id and user data id can be generated into one system. All of the record also can be saved as logs in the server by integrating those system with the cloud server.

We divide the paper into four main parts, the first contain introduction of NFC technology and its usability. In second section, it provides the reserach method and general system design. Then, in the third will be discussed about the result. It consist the testing and evaluation of the system design. And the last section contain the conclusion and the next reserach plan in developing the current system.

II. System Design and Implementation

This VIP access system is divided into three main parts. The first part is mainly used for reading the identity of the user tags which is established at the room entry. It consists of main controler as the brain of the system., ethernet module to connect the system to the cloud, solenoid key, NFC reader, and PIR sensor used for turning on the system from sleep mode. The second part is a server used for saving the logs and reporting to the client. And the last part is the application established in the smartphone. Smartphone application was established on android platform. The application is functionally used to assemble the NFC tags code and the user identity and route them to the reader when connected.

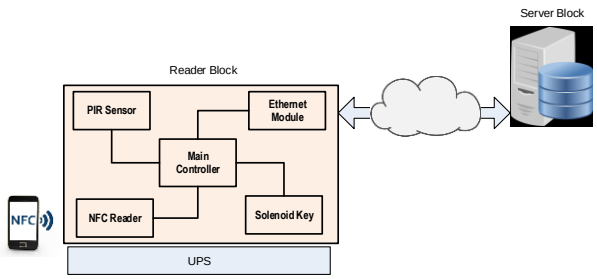

Figure 2: General System Design

NFC Smartphone is used as main key for entering the server room. There are limited access only given to the server administrator and engineer. In each NFC smartphone, installed the application to read the tags from its NFC module and implan the identity of the smartphone owner. It's used to identify the user who has the VIP access or not. It will keep the server room from ilegal access. Smartphone is used in HCE Mode, so it's read as the ISO14443A card.

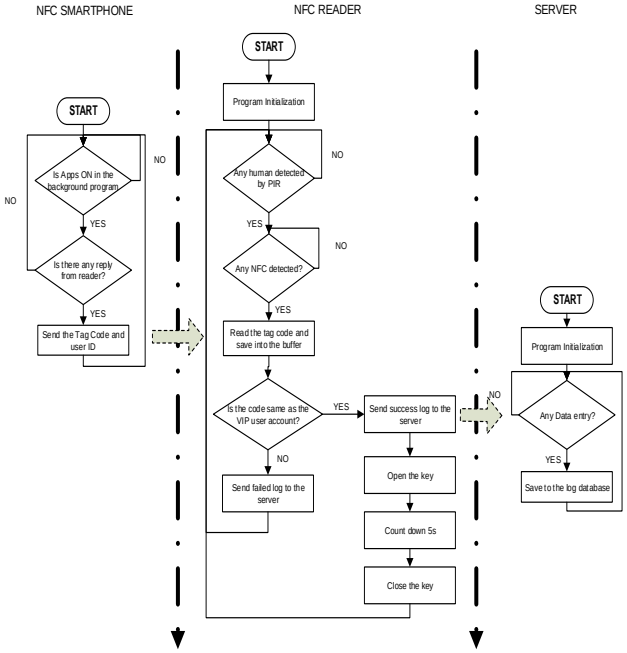

Figure 3: Simple Flowchart Design

The performance are measured by some parameters, such as success rate of reading tags, time response for lock-unlock the key, log report on the server and to the administrator. The result of the test are discussed on the next section below.

III. Results and Analysis

In this section, it is explained the results of performance testing. There are four types of performance tests. The tests are used to know the reliabilities of the designed system. First test is by measuring the success rate of NFC tagging on the reader. It has been done by variables, they are distance between NFC and reader, angle and the result can be shown below.

Table 2
The Results of Distance Testing

No	Distance (cm)	Smartphone Types	
		Xperia Z LTE Android 4.4	Samsung Note Android 5.0
1	0	Success	Success
2	0.5	Success	Success
3	1	Success	Success
4	1.5	Success	Success
5	2	Success	Success
6	2.5	Success	Success
7	3	Success	Success
8	3.5	Success	Success
9	4	Success	Success
10	4.5	Success	Success

The system was tested by using two kind of smartphone, Sony Xperia and Samsung Note. They have different type of NFC module and Operating System. So, it's purposed to make sure that designed the system can work properly by using any types of smartphone. And based on the table above, the reader can effectively communicate maximum in distance 4.5 cm from NFC smartphone. As we know that NFC module is installed in different position in each smartphone. In this case, it is set in HCE mode in order to make the UID in fix number. There were also tested the time response in 3 cm distance for fifteen times. The average of the time is about 0.261 s for Sony Xperia and 0.248 s for Samsung Note.

Based on the spesification in [7], NFC can be read between 0 – 10 cm. But, in this case it only can be read for maximum distance 4,5 cm. Of course, it could be caused by some reasons like signal interference from the device. Smartphones not only generate NFC frequency, but also other frequencies such as GSM/3G/HSDPA/LTE signals and more. Besides, external frequencies could also interfere the NFC signal.

Based on the graph below, it's shown that there are no significant correlation betwen angle and read time response. However, there are some exception between 140-220 degree which NFC can be read by the reader. It was caused by the position of NFC module in the smartphone located in the center of the phone. So, it caused the failure of reading the UID from smartphone HCE mode.

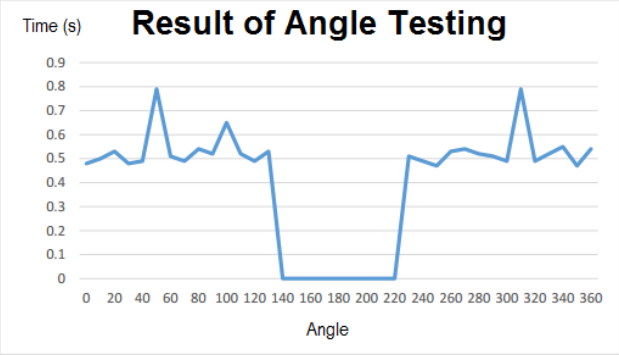

Figure 4: The Result of Angle Testing and Read Time Response [13]

They were also tested the validity of VIP access. In the system, it designed that the VIP user can unlock the door by tagging their NFC smartphone to the reader. The log will be reported to the server in the same time. Meanwhile, non VIP user who tagged their NFC smartphone to the reader can not unlock the door. They only will be give the buzzer sound as the sign that they can not access the server room. By the thirty times testing, it's proved that the system 100% success.

To verify all of system performance, it has been tested from the beginning of the system work until the last processes on the server record te logs and send the SMS messages to admin. At the first, NFC has to be enclosed to the reader. But, the system should detect the human movement by PIR sensor to activate the reader. the testing used only the VIP key only for example. The result has shown below.

The testing shown above was done by only using the VIP account and tested from approximately 3 cm distance in normal position (0-30º). From forty times testing, it can be said that the success rate is 100% because there's no failure. And the average time process is approximately 1.9 s. Quick time process and response means tha system reliable to be implemented in real condition. User can access for opening or closing the door quickly without waiting. Moreover, HCE mode in smartphone devices can replace the rfid card as the secure key. So, It means that the system still reliable to be implemented. Besides, the security can be guaranteed by the NFC standard system.

IV. Conclusion

Based on the previous section discussed, we can conclude that generally all of the designed system is success to be implemented as VIP access system. In HCE mode, it replaced the conventional RFID or any smartcard implementation by using NFC smartphone. It also improve the security by combine the tag codes (UID) with the smartphone owner identities. By implementing the server to record the logs, administrator can know all of the people entered the room. It makes security tracing easier than conventional method.

In the future, it can be improved by adding the CCTV system to monitor who is inside the room. By using cctv system, can be implemented face recognition method to match the UID with the owner face. We believe that there will be more improvement in security system research day by day arround the world. However, the main point of those are to make the guaranteed system in security and other reliability performance variables as like the power consumption, cost, etc.

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Table 3
The Results of System Testing

Description	PIR Status	Reader Status	Buzzer Sign	Solenoid Key	Server Logs	SMS Status	Process Time (s)
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	3.45
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	3.22
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.08
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.08
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.45
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.38
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.2
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	3.7
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.46
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.5
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.86
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.8
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.5
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.14
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.1
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.3
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.3
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.25
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.04
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.08
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.1
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.4
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	0.8
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	0.85
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.86
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.4
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.4
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	3.04
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.75
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	1.9
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.1
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.2
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	3.08
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	3.24
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	2.24
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	0.76
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	0.7
Any movement, NFC enclose to	Detected	On	On	Unlock	Recorded	Sent	0.98