

# The Application of NFC Verification System in Warehouse Management System

Fagui Liu<sup>1, a</sup>, Zheng Qin<sup>\*1, b</sup>, Yigong Zhang<sup>1, c</sup>, Xiao Hou<sup>1, d</sup>

<sup>1</sup>School of Computer Science and Engineering, South China University of Technology, Guangzhou, 510006, China

<sup>a</sup> email: fgliu@scut.edu.cn, <sup>b</sup> email: 503731351@qq.com,

<sup>c</sup> email: zhang\_1g@163.com, <sup>d</sup> email: houxiao2.0@qq.com

**Keywords:** NFC; Android; Warehouse Management System

**Abstract.** The commercial applications of NFC (Near Field Communication) have become increasingly mature. Many smartphones have become to carry NFC chip in default for communication. Warehouse management in the logistics industry has played a more and more important role in the current development of the electronic commerce. How to ensure the efficiency of warehousing in the most cost effective way is currently a difficult problem to be resolved. NFC technology application is a suitable solution for the verification module of the Warehouse Management System (WMS). We have designed and implemented the NFC picking verification system, which is mainly consisting of three parts: server, mobile client and tag printing system. Server uses the Spring architecture, and communicates with clients via HTTP protocol. Mobile client is an Android application using NFC technology to achieve verification steps. The tag printing system acquires SKU information from the logistics company and prints it to the NFC tag for verification. The NFC verification module is integrated into the activities of WMS, which can provide a new exploratory research for the commercial application of NFC.

## Introduction

The vigorous development of NFC technology in recent years as a new communication technology has a wide range of applications in the mobile payment, marketing and information-sharing field.

Warehouse management is the core part of the logistics supply chain management. The mobile network technologies and the WMS combined with verifying information by RFID (Radio Frequency Identification) [1] especially NFC technology will make a significant contribution to the logistic industry. Smartphone, as a mobile terminal, can access logistics information via the mobile Internet. Design a set of wireless identification technology to carry out the verification system, and integrate into the WMS to achieve the intellectualization, networking and informationization. NFC verification system can optimize the management processes with a low error rate to increase operability without sacrificing labor and resources efficiency, thereby enhances the company competitiveness.

The current research into NFC mobile phone or mobile phone with an external NFC reader to help the warehouse storage management is still at early stage, not for large-scale commercial applications. Compared to RFID technology, NFC technology has some unique advantages; for example, there is no need to order specialized handheld terminals. With the development of NFC technology commercialization applications, some companies use a fixed NFC terminal identifier to replace the fixed RFID verification terminal to scan product information tags [2]. However, such applications have not taken advantage of the convenience and practicality of NFC technology. In recent years, the ratio of mass-variety, small-volume, multi-batch, short-cycle distribution requirements have gradually increased which demands high efficiency in the logistics warehouse management. Mobile Internet and NFC technology application into storage management is an innovation in the logistics industry of research and exploration.

## NFC Verification System Related Work

The high security feature of NFC technology has ensured it an inevitable advantage in aspects of applications requiring a high degree of safety verification. NFC technology on access control systems to complete identity verification has been widely used in daily life. In recent years, experts and scholars has done further improvements in the security feature making it safer and more intelligent [3]; with NFC card emulation mode, the use of the NFC-enabled smartphone allows people to easily complete ticket information verification [4], raising the efficiency of travel. NFC verification system can reflect its fast, efficient and secure advantages in many aspects of production and daily life.

Compared to typical NFC verification system, with the great advantage of mobile phone application, the application of NFC calibration system in logistics supply chain, especially in warehouse management, is the innovation point of this paper.

## NFC Picking Verification System

NFC picking verification system is an NFC application example in the verification aspects. During inventory intake, picking and distribution, the warehouse management system needs to obtain the information related to product to process. By using NFC-enabled smartphone or mobile phone with external NFC reader to read the corresponding NFC tags, operator can easily access the commodity information.

Warehouse management systems mostly use pallet as SKU (Stock Keeping Unit, the amount of stock units). The number of Pallets is fixed and usually less in number compared to boxes packaging of goods. This application mode can reduce the number of NFC tags and thus reduce costs. The NFC tag is rewritable. If we pair the tag and pallet, tag can be rewritten to reflect change goods on the pallet through the NFC picking verification system. In the early stage of NFC technology into warehouse management, this model is the easiest way to realize.

## System Architecture

NFC picking verification system uses two design patterns (C/S and B/S) on the frame design [5]. Mobile client and Web client are both client terminal to access the server, but their scope and functions of communication are different. Mobile client can communicate with system server via 3G/4G mobile network or base stations through a wireless router. Web clients can connect to the router via a wired or wireless network connection to access the server. The picking verification system needs the access to the server for logistics information. In the warehouse management application scenario, we are using multiple clients, including mobile client and Web client, single server corresponding mode.

The communication framework of NFC picking verification system is shown in Figure 1.

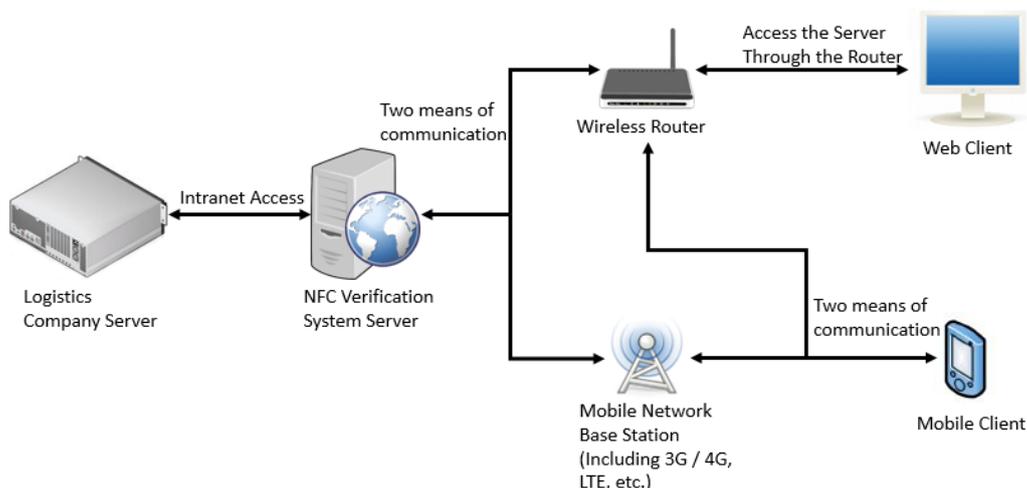


Fig.1. NFC picking verification system communication framework

Mobile client and Web client are also different in function. Mobile client is mainly for information verification, timely access to verify and upload information, and inquiry about the customer order information. Web client can manage mobile client devices and check the information and status.

In addition, NFC picking verification system also includes a separate tag printing system module. The system has agreed with the mobile client on the tag-reading format. In accordance with the SKU information, logistics companies need to print on tag, which is a separate but very important part.

The flow chart of label printing system is shown in Figure 2.

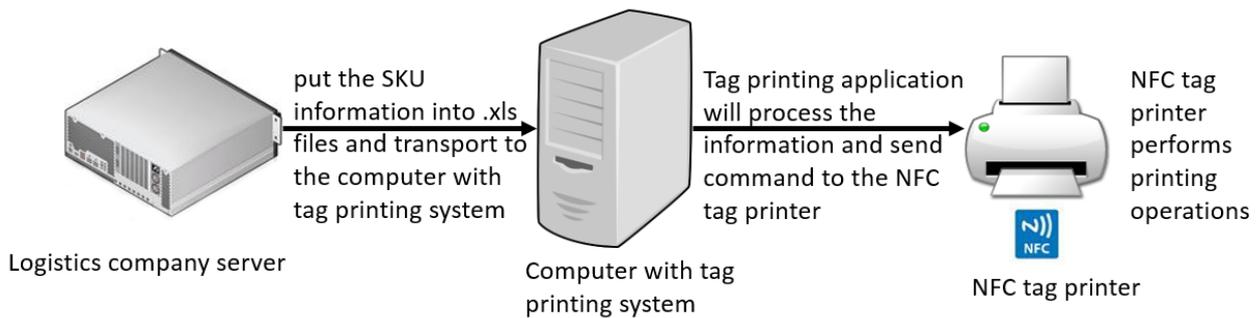


Fig.2. NFC tag printing system flow chart

Verification process is divided into storage and picking stage. In the stage of storage, the information management of the cargo is the core. The information of cargo will be printed to the NFC tags to attach to the corresponding cargo tray. The picking stage is divided into three steps, namely, mobile device authentication and acquisition order, SKU verification and APP information upload. Mobile phone authentication and acquisition order is used to check the phone for registration management. Mobile client sends requests to server to obtain the order information. SKU verification is used for NFC verification of mobile phones to carry out the NFC verification procedure, and feedback the results to the user. APP information upload is that the mobile client will verify the results and send them to the server for information query and statistics when there is network connection.

### NFC-enabled Smartphone Verification

By using the NFC APIs, developer can easily develop NFC verification function on Android smartphones [6].

OrderNFCActivity class implementations contain NFC induction order detail screen. By importing the system packages, developer can develop related functions.

Rewrite Activity method *onNewIntent* can prompt NFC module on the phone to capture intent generated upon sensing NFC tags and operate accordingly to obtain the corresponding tag method.

After judging whether the tag can be used, we call *nfcProcess* method, which contains local operations for verifying data.

When right or wrong in the verification is detected, the appropriate message will appear, accompanied by appropriate sound alerts enable users to clearly perceive the results of verification.

Each tag scan action will have a verification information, and the local SQLite database entry verification information, using unique constraints during insertion, so that the correct and incorrect verification information in the database is stored only once preventing to store redundant information and errors.

After each verification information item has been obtained, it will conduct a verification of SKU information within an order, if the information verification is completed, the order status will be changed to “to-be-uploaded”, and the user would receive a pop-up window prompt reminder.

## **NFC External Reader Verification**

There are still a large number of Android mobile phones are not equipped with NFC module despite the rising awareness of the convenience it has provided in daily life verification steps. Therefore, the use of an external NFC reader for non-NFC Android phone is of an important practical value.

Some companies are already onto the market of external NFC reader for Android phone. The reader is mainly for data transmission through audio channels of mobile phone. There are some external NFC devices for data transmission via Bluetooth, i.e. an NFC-enabled smart watch. These external readers can also read NFC tags.

The demand for customized functions has urged the API reference documentation and the tag structure both important to consider during the development of the external readers.

The external NFC reader used in NFC picking verification system is from Advanced Card Systems Holdings Limited. The company produced ACR35 external reader, which is compatible with Android systems and iOS phone system. ACS has provided appropriate development kit `acsaj-1.0.0.jar` used for application development [7].

According to the reference documents and Demo code provided by ACS company, there are three operation stages respectively, Reset, Power On and Transmit. Reset is to initialize the external reader, set the predetermined parameters. After the stage is completed, the external reader can work normally. Power On is to enable the relevant function modules of the external reader to carry out the work. Transmit is to obtain the data in the tag by using NFC and send it to the mobile phone. After completed these three stages, we can achieve the function of obtaining data from the NFC tag.

## **Design and Implementation of Server**

Server uses Spring framework for data operations and information processing in integrated application of the MVC design pattern. Use Controller to handle requests from HTTP client or mobile clients.

In the Spring framework, it is through `@RequestMapping` (value = "/ ...", method = GET / POST) syntax in the Controller to process the Http GET or POST request the server received and process and respond the request via `@ResponseBody`.

Http request response operation needs to be applied to the Spring Framework Service layer. Service layer is the specific business operation process. Service layer may need to obtain or store data from a database with involvement of DAO layer.

Server uses MySQL for data storage. It needs to get order information from the logistics company server and set the SKUs for filtering, and then store in the database. It also needs to store the verification information returned from various client terminals and client settings etc...

Java source code package on the server needs to build web package for the appropriate request.

## **Evaluation**

We have tested the functionality and performance of NFC Picking verification system in storage environments over a period of time. The outcome has proved the consistency and stableness of our solution.

The Ntag 213 type tags is to test the NFC verifying speed. Galaxy J5(NFC-enabled) finishes a information verification in 0.26 seconds, among which the establishment of connection takes 0.1 seconds, 0.16 seconds for information processing. The log is shown in Figure 3. With an external NFC reader, it takes 3.38 seconds with checking the status 0.01 seconds, using the ACR35 obtain tag information 3.21 seconds, information processing 0.16 seconds; the log is shown in Figure 4.

L...	Time	PID	TID	Application	Tag	Text
D	08-12 14:41:00.499	30384	30384	com.qinzheng.apptest	myDebug	_id = 1, orderid = 20160812243841166, status dateend = 0, primarykey =
D	08-12 14:41:04.239	30384	30384	com.qinzheng.apptest	myDebug	----Get TAG Start----
D	08-12 14:41:04.339	30384	30384	com.qinzheng.apptest	myDebug	----Get TAG End----
D	08-12 14:41:04.339	30384	30384	com.qinzheng.apptest	myDebug	----nfcProcess Start----
D	08-12 14:41:04.389	30384	30384	com.qinzheng.apptest	myDebug	--10000410--
D	08-12 14:41:04.409	30384	30384	com.qinzheng.apptest	myDebug	10000410
D	08-12 14:41:04.449	30384	30384	com.qinzheng.apptest	myDebug	----nfcProcess End----

Fig.3. Verification test with NFC-enabled mobile phone

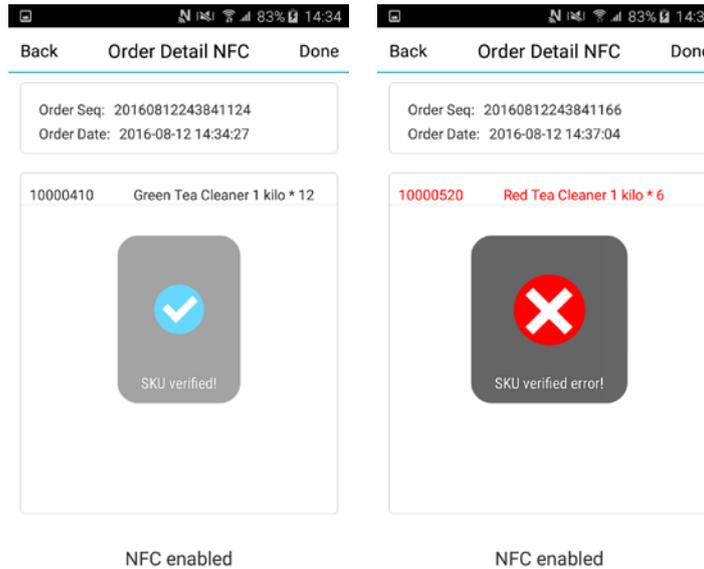
D	03-21 10:35:42.623	13243	13568	com.qinzheng.apptest	myDebug	----reset restart----
D	03-21 10:35:42.623	13243	13568	com.qinzheng.apptest	myDebug	----reset running----
D	03-21 10:35:42.633	13243	13689	com.qinzheng.apptest	myDebug	----APP status is true----
D	03-21 10:35:44.633	13243	13689	com.qinzheng.apptest	myDebug	----poweron running----
D	03-21 10:35:45.333	13243	13695	com.qinzheng.apptest	myDebug	----transmit running----
D	03-21 10:35:45.333	13243	13697	com.qinzheng.apptest	myDebug	FF B0 00 07 10
D	03-21 10:35:45.983	13243	13697	com.qinzheng.apptest	myDebug	31303030303431300000000000000000
D	03-21 10:35:45.983	13243	13697	com.qinzheng.apptest	myDebug	data1:31303030303431300000000000000000
D	03-21 10:35:45.983	13243	13697	com.qinzheng.apptest	myDebug	data1:10000410
D	03-21 10:35:45.983	13243	13697	com.qinzheng.apptest	myDebug	----transmit interrupted----
D	03-21 10:35:45.983	13243	13695	com.qinzheng.apptest	myDebug	----poweron interrupted----
D	03-21 10:35:45.983	13243	13689	com.qinzheng.apptest	myDebug	----reset interrupted----

Fig.4. Verification test with ACR35 external reader

From the efficiency point of view, the use of NFC-enabled mobile phones is quicker and more efficient. The functional limitations of external NFC reader have resulted in the slowness of validation process.

After NFC picking verification system applied in WMS, the probability of picking errors has reduced to 0% to ensure the normal operation of warehousing and logistics work.

Figure 5 shows the reminder on the mobile client whether the verification is right or not.



(a) SKU verified

(b) SKU verified error

Fig.5. NFC verification reminder

In addition, we put forward the proposed NFC picking verification system with several traditional warehouse management and information verification systems for comparison, as shown in Table 1.

Tab.1. Comparison of verification systems in WMS

Item	Manual	RFID verification system	Barcode verification system	NFC verification system
Speed	Slow	Fast	Fast	Fast
Scalability	None	Low, unable to use smartphone to complete the verification	High	High
Device	None	Need sensors	Need smartphone or sensors	Need NFC-enabled smartphone or NFC external reader
Sensing distance	Short	Long	Short	Very short
Error rate	High	Low, long sensing distance easily sense multi tags	No error	No error

In comparison with many other verification information systems in warehouse environment, the NFC picking verification system has the advantages of fast verification speed, high scalability and getting no verification error.

## Conclusion

NFC technology is a non-contact near-field communication technology. The use of NFC reader mode in built-in module or an external NFC reader with the phone identification tag is incorporated in the warehouse management picking verification. It is an innovative NFC application in warehouse management. The advantages of NFC technology combine with the use of smart phones as a carrier for the logistics industry can serve to increase efficiency in warehouse management segment as well as cost savings and other effects on the further development of the logistics industry.

## Acknowledgement

This paper is supported by the 3th strategic rising industry program of Guangdong Province, (Project no. 2012556003); International Cooperation Special Program for platform, (Project no. 2012J510018); the key lab of cloud computing and big data in Guangzhou (Project no. SITGZ[2013]268-6); Engineering & Technology Research Center of Guangdong Province for Big Data Intelligent Processing (Project no. GDDST[2013]1589); Engineering & Technology Research Center of Guangdong Province for Big Data Intelligent Processing (Project no. DDST[2013]1513-1-11); Provincial Science and Technology Project in Guangdong Province under Grant (No. 2013B090200055).

## References

- [1] Choy K L, Ho G T S, Lee C K H. A RFID-based storage assignment system for enhancing the efficiency of order picking[J]. *Journal of Intelligent Manufacturing*, 2014:1-19.
- [2] Kefalakis N, Leontiadis N, Soldatos J, et al. Supply chain management and NFC picking demonstrations using the AspireRfid middleware platform[C]//*Proceedings of the ACM/IFIP/USENIX Middleware'08 Conference Companion*. ACM, 2008: 66-69.
- [3] Chan D C, Benjapolakul W. NFC-enabled Android Smartphone Application Development to Hide 4 Digits Passcode for Access Control System[J]. *Procedia Computer Science*, 2016, 86(2016):429-432.

- [4] Čavdek M. NFC smart phones in a ticket verification system[J]. 2014.
- [5] Pavlu V C. Client/Server Application[J]. 2003.
- [6] Coskun V, Ok K, Ozdenizci B. Professional NFC Application Development for Android[J]. Wiley John + Sons, 2013.
- [7] Advanced Card Systems Holdings Limited. Driver/Manuals/DataSheets[EB/OL]. <http://www.acs.com.hk/en/drivers/>, 2016-04-25.