Design and Development of a NFC-Enabled Point Application System

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Abstract

Nowadays, users get points by stickers after they purchase some of products. However, to issue stickers and exchange points will be inconvenient to both store staffs and users. Moreover, the traditional way for point collection increases the business cost because of additional royalty cards and stickers. In this paper, we propose a novel, practical and integrated system to resolve above issue namely NFC-enabled Point Application System (NPAS). NPAS mainly consists of three subsystems including user-side application (APP), store-side APP and backend management system. The user-side APP allows the users to rapidly complete point management, for instance, they can accumulate points by communicating with the store-side APP through Near Field Communication (NFC) technique. The store-side APP calculates the points of each transaction and updates them to the backend management system. Therefore, the users can query their residual points, exchange details, available exchange commodities and so on. As the Android mobile operating system is the mainstream of smart phones, the Android-based APPs attracts more attention. Accordingly, we develop both Apps based on Java, XML, Android Software Development Kit (SDK) and Android Studio. The backend management system is composed of Apache server, PHP module, PHP files and MySQL database, which handles whole system management. The format of exchange information between backend management system and both APPs is JavaScript Object Notation (JSON). The interfaces of both APPs and backend management system are friendly and their operations are smooth. In a word, NPAS makes point collection and management more conveniently and smoothly.

Key Words: NFC, Application System, Android, MySQL

JEL Classification: L 86
1. Introduction

The appearance of smart phones has widely extended the usages of traditional mobile phones because they are not only a communication tool but also an essential equipment to the people’s daily life. A variety of applications have been developed, which make a convenience of people’s lives. Undoubtedly, the applications based on smart phones will play a key role in the future evolution of information technology. Android platform is becoming relatively popular than the iOS platform in the market of smart phones because it is open source and development tools are free. In addition, Android platform provides wide hardware architectures so that the developers can quickly realize their ideas by APPs [1-5]. In this study, both APPs are developed based on the Android platform. In the past, users collected points by using royalty cards and stickers after they purchased products. With the points, the users can exchange commodities without payment. However, most users often lose royalty cards or stickers and generally miss out the promotions. In store-side, they have to print royalty cards and stickers. In addition, they need to confirm that stickers are not counterfeits. Therefore, the traditional way of point management will increase additional costs and manpower. To speed up the point collection, Near Field Communication (NFC) technique is popular [6-10]. Accordingly, the users rapidly complete point collection. Also, the points can be added manually in our design.

In another word, NFC works as a bridge of information exchange. In a word, we develop a NFC-based point application system (NPAS) which is useful to users and stores. The NPAS consists of three main subsystems inclusive of user-side APP, store-side APP and backend management system. We utilize Java, XML, Android SDK and the Android Studio Integrated Development Environment (IDE) to develop both APPs. On user-side APP, the users can add points, exchange commodity and check related records by logging in their accounts. The store-side APP communicates with the user-side APP through NFC. With the exchange information, the stores can add points and exchange commodities for specific users. The main functions of backend management system include user management, store management, activity management and commodity management. The backed management system is implemented by Apache server, PHP module [11-12], PHP files and MySQL database [13-14]. The remainder of the paper is organized as follows: In Section 2, we review related work, and Section 3 explains the design details of the NPAS including user-side APP, store-side APP and backend management system. Subsequently, the development results for each subsystem are demonstrated in Section 4. Finally, Section 5 concludes the paper and future work.

2. Related Work

Android platform is a Linux-based operating system consisting of four components; Linux kernel, libraries and Android runtime, application framework and applications [15-18]. Each component provides interfaces to others. The kernel of Android is extended based on the Linux
kernel by adding few additional functions such as wake locks and other features that are more suitable for a resource-limited mobile platform. For libraries and Android runtime, Android runtime is composed of a Java libraries and Dalvik virtual machine. The Java libraries provides most functions for developing APPs. Dalvik virtual machine is used to execute APPs on mobile devices. Android system libraries are used to connect application framework and Kernel of Android, which are developed by C or C++ language. The application framework is generally used by application developers who can access all the API framework of core programs. With this framework, one APP can release some of functional components and the other APPs can access these components. All Android APPs belong to the Application component which contains contacts books, browser, games, email, and media player and so on. The main functionalities of APPs are developed by Java and the layout are developed by XML.

Next, we review related work. An automatic Fall Detection Systems (FDS) was developed by using built-in sensors and multiplicity of wireless interfaces of Android-based smart phones [5]. Also, the authors present a complete analysis on existing fall detection systems that are based on Android platform. This study systematically takes the different ideas of the literatures into account including system architecture, sensors, detection algorithms and the response time of fall alarms. Moreover, the analysis of evaluation methods is used to assess the performance of detection processes. Finally, they concluded that most studies do not evaluate the actual applicability of Android platform to fall detection solutions.

Next, we study various applications of the NFC technique. In the past, several indoors navigation systems were proposed to eliminate deficiencies. Unfortunately, they encounter several technical issues. Accordingly, they propose a Near Field Communication (NFC)-based indoor navigation system which enables users to navigate through a building or a house by touching NFC tags. The tags are spread around so that the users can be navigated to their destinations [8]. In this study, they present system requirements, design details and the viability of NFC Internal with a prototype application and a case study. The performance of the system was evaluated and compared with existing indoor navigation systems. The comparisons show that NFC Internal has considerable advantages to existing indoor navigation systems in terms of security, cost, robustness, simplicity and commercial availability. Mobile payment is an emerging technology, which can fill the gap between the potential and usage. MobiPag, an integrated mobile service solution based on the NFC was developed [9]. The Mobipag is open architectural model that allows multiple partners to become part of the payment value-chain. Moreover, this study describes an architecture and a mobile payment trial. They further consider the usage experiences associated with real-world payment situations with NFC-enabled smart phones. Based on analysis, they conclude the future versions of NFC-based payment systems. A WebTag solution that allows direct access to sensor tags over NFC technique for secure applications was proposed [10]. This solution is feasible because the advances of information
and communication technologies have overcome many challenges related to wireless sensor monitoring. With WebTag, the data transmission in wireless sensor monitoring could be improved. The upstream communication link is based on open IP technologies. However, the downstream communication link is masked with proprietary protocols used for the wireless link such as ZigBee, Bluetooth and RFID. Moreover, WebTag can read the sensor data, configure the sampling rate and implement IP-based security policies.

In the end, we continue to review work related to PHP and MySQL. PHP is a dynamic language used in server-side of Web development [12]. A PHP file contains codes to be executed for multiple configurations. The dynamism and multi-configuration nature leads to dangling references. When a configuration is executed, a reference to a variable or a call to a function is dangling if corresponding declarations missed out. The authors confirm that the existence of such dangling reference errors include dangling cross-language and embedded references in the client-side HTML/JavaScript codes and data-accessing SQL codes. In order to prevent data loss and damage in MySQL database and ensure the efficiency of normal operations of information systems, a reasonable backup and recovery strategies was proposed to build a highly available and highly reliable MySQL database backup and recovery system [13]. Using MySQL master-slave replication technology, the system implements real-time synchronization of data and automatic switching between master and slave database servers, which ensures the high availability of database usage. When master database fails, this system achieves full recovery of data that ensures the high reliability of database by using logical backup technology.

3. Design of NFC-Enabled Point Application System

3.1 Overview of System Architecture

The system architecture of the NPAS includes user-side APP, store-side APP and backend management system depicted in Figure 1. First of all, users utilize the user-side APP to register accounts by filling personal information. When the registrations have been completed, the users can sign in their accounts hereafter. Then, the users can utilize the user-side APP to accumulate points after purchasing products. Moreover, the users can query the residual points and rehearsal exchange list by communicating with the backend management system through 3G/4G or Wi-Fi network. The users may forget bringing or not using smart phones and therefore they can inform their accounts to the store staff instead. Finally, the store staff adds new points to the user accounts. In order to realize NFC communication, the user-side APP has to implement the function of card emulation and the store-side APP has to implement the function of card reader. NFC is a set of communication protocols that make two electronic devices communicate each other by bringing them within range about 4 cm. Each NFC device can work in one of three modes. First, card emulation mode enables NFC-enabled devices such
as smartphones to act like smart cards, allowing users to perform transactions such as payment or point accumulation. Second, reader/writer mode enables NFC-enabled devices to read information stored on NFC tags or smart phones. Lastly, NFC peer-to-peer mode enables two NFC-enabled devices to exchange information in an ad-hoc style.

Differently, the store accounts and passwords are assigned by the administrators of the NPAS. With the default settings, the store staffs can sign in the store-side APP. In the NPAS, the store-side APP is installed in an Android device such as tablet. After purchasing products, the users put their smart phones close to the tablet and then the new points will be added to the backend management system after NFC connection or manual operations. Besides, the users can inform the store staffs what commodities they would like to exchange. Next, the store staffs click the required commodity items and the points are reduced automatically. The backend management system is in charge of handling store management, user management, activity management and commodity management, which is the core of the NPAS. All management functions are implemented by PHP files. Both user-side APP and store-side APP connect to the Apache server on the corresponding PHP files are parsed by the PHP module. Next, the messages are dispatched to the MySQL database and the required information is retrieved. Finally, the Apache server returns results and both APPs resolve the results according to JSON format. In a word, NPAS is a useful and practical application system while integrating with NFC capability.

![Figure.1: System Architecture of the NPAS](image-url)
3.2 Design of User-Side APP

When a user activates the user-side APP, the first operation is to input existing account with password or register a new account with password on the sigh-in screen. The detailed flowchart of the user-side APP is illustrated in Figure 2. If the user input wrong account or password, the operation will go back to the sign-in screen. If the number of wrong inputs exceeds three times, the APP will be terminated. Similarly, if the user does not fill required or correct registration information, the operation still goes through the same procedures as the above mention. After logging in the user account, there are five main functions such as commodity exchange, promotional activities, exchange list, personal settings and open NFC. The user can exchange favorite commodities by checking the commodity exchange. Moreover, the promotional activities provide the latest promotion information. After exchanging commodities, the user can check historical exchange records by checking out the exchange list. Personal settings are used to maintain user information. When the user would like to communicate with the store-side APP, the NFC should be activated first by open NFC.

Figure. 2: Flowchart of the User-Side APP

3.3 Design of Store-Side APP

When the store staff activates the store-side APP, the first operation is similar to the user-side APP. The detailed flowchart of the store-side APP is illustrated in Figure 3. On the sign-in screen, the store staff has to input account and password which are assigned by the NPAS administrator. However, the store staff can change password on demand. The store staff asks the users to tape their smart phones to the tablet with store-side APP and then the account information is transferred through NFC communication. Besides, the users can inform their accounts to the staff if no smart phone is on hand. If the users purchase products, the operation
will go through to the add points. The store staff inputs the amount of money which will be automatically transformed into corresponding points. Finally, the new points will be updated to MySQL database in the backend management system. On the other hand, the staff can enter the commodity exchange page when the users would like to exchange free commodities. The store staff selects the required commodities from the commodity list and relative points will be reduced.

**Fig. 3: Flowchart of the Store-Side APP**

3.4 Design of Backend Management System

The backend management system mainly manages the stores, users, activities and commodities which are implemented by PHP files. The detailed flowchart of the backend management system is illustrated in Figure 4. The administrator can add a new store with default account and password. Also, the administrator can check the available stores by accessing the store list. Moreover, the administrator can add a user when needed. More importantly, the administrator can add new activity related to various promotions. According to store requirements, the administrator can add new exchange commodities.
4. Conclusion

We introduced the detailed design and implementation of an application system that specializes in point management by integrating with NFC technique namely NPAS. The NPAS is an attractive system which are composed of three subsystems such as user-side APP, store-side APP and backend management system. Moreover, two APPs of the NPAS were developed by using Java language, XML language, Android SDK and the Android Studio IDE. They both communicate by NFC and hence the point management can be completed automatically. However, we still provide a manual interface to manage points when the users do not carry their smart phones. The backend management system consists of Apache server, PHP module, PHP files and MySQL database, which provides user management, activity management, store management and commodity management. By using the NPAS, the users can manage their points efficiently and the store staffs can simplify the management procedures of point exchange and management. More importantly, they can greatly reduce their costs. In a word, the NPAS is a useful and practical application system which benefits to the users and stores.

Acknowledgments

The author acknowledges the financial support from the Ministry of Science and Technology in Taiwan, under the grant number MOST 107-2221-E-158-001.

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Proceedings of the 15th International Conference on Education, Technology, 
E-Learning & Society (ICE19 Hong Kong Conference) 
Hong Kong - SAR. August 9-11, 2019. Paper ID: HE920


