Personalized Shopping Experience with
NFC Smartphone Apps and Electronic Shelf Label

Project Y-Mart

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Abstract—**Near Field Communication (NFC) capability has become a standard feature in majority of smartphones on the market today. As more users have adopted NFC enabled smartphones, systems are developed to utilize the NFC protocol for electronic payment and other convenient functions to improve personalized shopping experiences. However, most of the NFC enabled functions available today interact with shoppers at point of sale (POS) which only provide limited fraction of the rich customer benefit promised by this new technology. By integrating NFC capable smartphone applications with NFC enabled electronic shelf labels (ESL) and back-end web services, we can provide a more interactive, informed, efficient, fun and personalized shopping experience at a variety of retail environments.**

Keywords-NFC; Smartphone; RFID; Electronic Shopping Label; ESL.

I. INTRODUCTION

The retail industry has been advocating "smart shopping" for many years by adopting various technologies to enhance the shopping experience at the retail environment. The vision of smart shopping promises to provide on-the-spot production information at your fingertip such as specifications, reviews, promotions, recipes, related products, payment through the use of technologies. For example, some of the most recent attempts include the use of camera enabled smartphones and QR (Quick Response) code to provide on-the-spot information by visually scanning QR code which takes you to a website. However, the technologies have not quite lived up to the expectations and promises of the smart shopping vision.

Some of the reasons why smart shopping has not been widely adopted relate to cost and ease of use. For example, while QR code can be an excellent way to bring online content to a smartphone, the scanning process can be cumbersome and unreliable. The Electronic Shelf Labels (ESL) can potentially improve the on-the-spot interactivity with the shoppers, but the higher cost and lack of standardization hinder the wide adoption and applications. As lower cost and NFC compliant ESL become available, it could conceivably make it easier for the retailers to justify the investment if it could deliver the real smart shopping benefits to the shoppers.

Analysts have predicted that smartphones will play a bigger role in shopping [1]. As the use of NFC enabled smartphones become popular, the unique ID (UID) in each phone can become one's personal identification. This feature can further enhance and personalize the smart shopping experience by providing purchasing history, targeted promotions, loyalty rewards, and much more.

Project Y-Mart was designed and developed to leverage the latest NFC enabled smartphones and low cost ESL in conjunction with back-end web services to build a complete end-to-end prototype system. NFC enabled smartphone apps are developed on the Android and Windows Phone platform to demonstrate the working prototype. Web portal is also provided to allow retailers to manage and customize the system.

Current state of ESL systems will be reviewed in Section 2, followed by a system overview of Y-Mart in Section 3. The design detail and conclusion will be covered in Section 4 and 5, respectively.

II. RELATED RESEARCH

The increasing use of smartphone with Internet data services [2] has made augmented reality a reality in many fields of research and application [3], such as travel, library, and in some cases the retail industry. We have seen many attempts by the researchers and retail industry to enhance the shopping experience through the use of technologies, such as RFID, camera phones, QR code, smartphones, ESL and now NFC [4-8]. However, none seem to have provided a solution that the retailers are willing to implement at scale.

While NFC-based applications have come a long way and promised to enhance personal experience [9], the implementations at retail environment currently seem to be limited to electronic payment at the point of sale (POS). One of the main reasons is that the NFC enabled on-the-spot product information and smart shopping experience would require ESL to interact with the personal smartphones. The current state of the art of ESL systems are the commercial systems provided by Pricer and Store Electronic System [10-
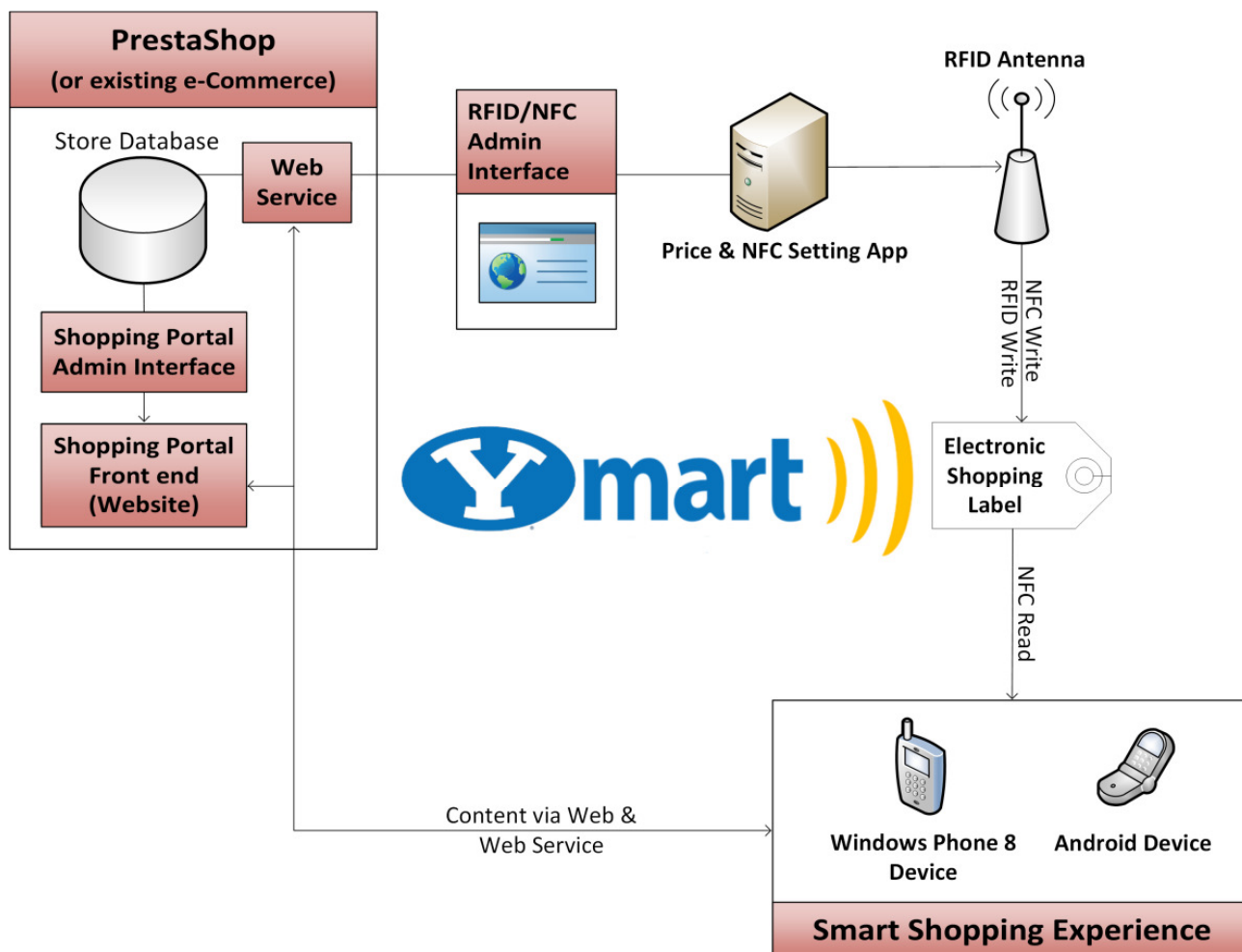
Figure 1. Y-Mart System Overview Diagram

11], which are too expansive and based on proprietary systems. While they were originally designed for store management and not for smart shopping, some have begun to advertise NFC capabilities in the new ESL products. A startup RFID/NFC vendor Jogtek Corp. has developed a new class of ESL that is low cost, battery-less, RFID ISO 15693 and NFC compliant [12]. The Y-Mart system is designed and implemented based on the Jogtek ESL and standard RFID and NFC protocols in conjunction with NFC compliant Android [13] and Windows Phone [14] mobile devices.

III. SYSTEM OVERVIEW

In order to provide end-to-end solution in this prototype, the Y-Mart system includes the following components as shown in Fig. 1.

- A back-end server with product database, smart shopping content (specification, promotion, recipe, etc.), user data (gender, age group, history, loyalty reward, etc.), RESTful web service interface, and web management portal.
- Battery-less ESLs that contain NFC ID that can be mapped to product ID or SKU and product information in either hypertext or URL. The ESLs can be programmed through RFID ISO 15963 and read through NFC protocols.
- RFID driver and antenna that programs the ESLs.
- Mobile apps that run on NFC capable smartphones and tablets including Windows Phone 8 phone, Android phone, Android tablet.

A. Retailers' Perspective

From the retailers' perspective, the back-end server is the heart of the system which includes:

- A typical e-commerce product database that supports all the traditional services such as inventory and pricing.
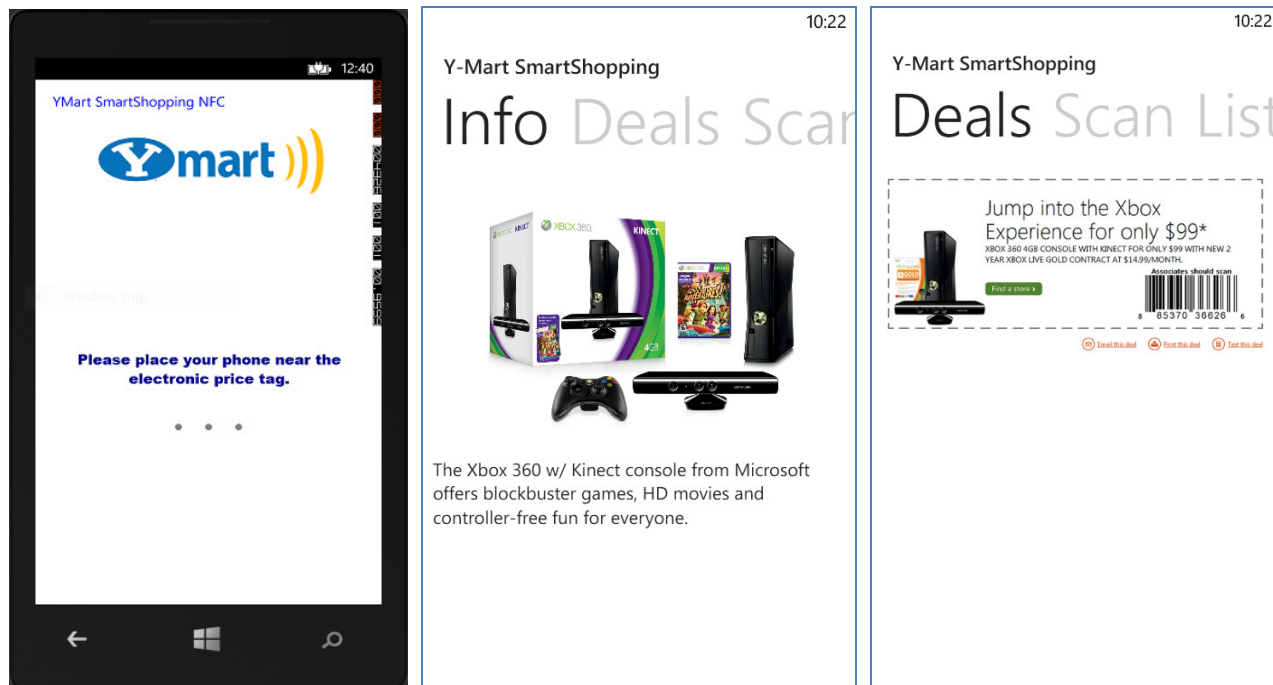
Figure 2. Screenshots of current prototype Y-Mart Windows Phone app. (Xbox and Kinect are trademarks of Microsoft Corp.)

- A user database which may track users' product queries and product purchases based on the smartphone NFC ID. For registered loyalty program customer, the database can potentially has more information, such as gender, age group, loyalty rewards, etc. The user information and/or history can be mined to provide targeted promotion, product suggestion, or advertisement through the smartphone apps.
- A smart shopping database that contains the enriched smart shopping content such as product details, (user

Figure 3. Jogtek Battery-less ESL Prototype

and expert) reviews, recipes (for food), and related products. The related products can be items in a recipe, accessories for electronics or many other scenarios.
- RESTful web services that provide programming access to the data mentioned above.

B. Shoppers' perspective

From the shoppers' perspective, the smartphone (or tablet) app is the heart of the system that makes the shopping experience informative, personal, and fun. For the shoppers to enjoy the full benefit of personalized smart shopping, they simply need to install the apps for their smart mobile device. The apps are developed by the retailers and post on the app distribution service for the mobile platform.

The common user scenario this system intends to address is when the shopper is at the product shelves in a retail store where they would simply need to tap the smartphone on the ESL to bring up the product information on the screen; any additional information, such as review and recipes, are just a finger tap away on the smartphone. The app will also inform shoppers of relevant products that are on sale based on user's product query, history, and personal information. Fig. 2 shows examples of screenshots from the current prototype Y-Mart app for Windows Phone 8 device, where special promotion is prompted when user scanned a product item.

IV. IMPLEMENTATION

A complete end-to-end functioning prototype of the Y-Mart system was implemented for proof of concept and feasibility. Implementation details for some of the components are described below.

Figure 4. Y-Mart customized PrestaShop server example screenshot.

A. ESL

The NFC enabled ESL is the component that facilitates the personal interaction at the product shelf, for large scale retailers that have tens or hundreds of thousands SKUs in a store. The cost and manageability of store ESLs are obviously major concerns. We prototyped the system based on a battery-less, low cost ESL technology (shown in Fig. 3) that can dramatically reduce the initial capital to install the ESLs on the product shelf. One additional benefit for the retailers is that an automated ESL update process can reflect more accurately the price labels, which can potentially lead to less overhead in regulatory compliance with consumer or government agencies.

B. Back-end server

The Y-Mart store back-end server is developed with the open-source PrestaShop e-commerce software [15] to provide a presentation and logic layer for the smartphone app and management web portal. The PrestaShop component represents an existing store platform, which most retailers would already have. The smart shopping system would simply be an extension to the existing system. An example screenshot of the currently running Y-Mart customized PrestaShop prototype server is shown in Fig. 4, where stores can manage the additional smart shopping content.

RESTful web services were also developed as API (Application Programming Interface) for the management web portal and mobile apps to access product information, user data and smart shopping content. The web services are designed to be scalable in case of a large retail store where there could be hundreds of customer at a time.

Each UID on the NFC ESL is stored in the database and linked to a product ID (or SKU). Each UID on the NFC smartphone is also stored and linked to a user. When a customer scans an ESL for a product, the smartphone app reads the UID and calls the web services to retrieve the product information. At the same time, the mobile app will also use the UID of the NFC smartphone to retrieve the user information. The server can then use the combination of the product and user to present personalized content on the smartphone.

C. Price update server

The pricing data and smart shopping content on the ESL are updated wirelessly through RFID 15693 protocol. The Y-Mart prototype consists of a small power RFID driver and antenna which is connected to a price update server via USB. The price update process will run periodically to check changes in the PrestaShop server and update the ESL through the driver.

D. Mobile apps

A few popular NFC capable mobile devices were chosen to develop prototype Y-Mart apps.

- Nokia Windows Phone 8 phone
- Google Nexus One Android phone
- Google Nexus 7 Android tablet

The apps use the standard NFC APIs provided by the operating systems to read the NFC tags and use the HTTP protocols to call the back-end web services. Some example screenshots are shown in Fig. 2 and Fig. 5.

V. CONCLUSION AND FUTURE WORK

The Y-Mart project successfully implemented a personalized smart shopping experience with the latest NFC technologies. While only limited usability test were conducted, the preliminary result has shown that, comparing to scanning QR code, the users can more easily and reliably interact with the ESL through their smartphone to access the rich and personalized smart shopping content right at their fingertips.

There are certainly many features that we would like to add to the system; for example, shopping list, shopping cart, integration with payment, etc. Additional tests of usability and at scale are necessary as we continue to develop. As the ESL technology continues to advance, exciting personalized smart shopping experience could be here in the near future.
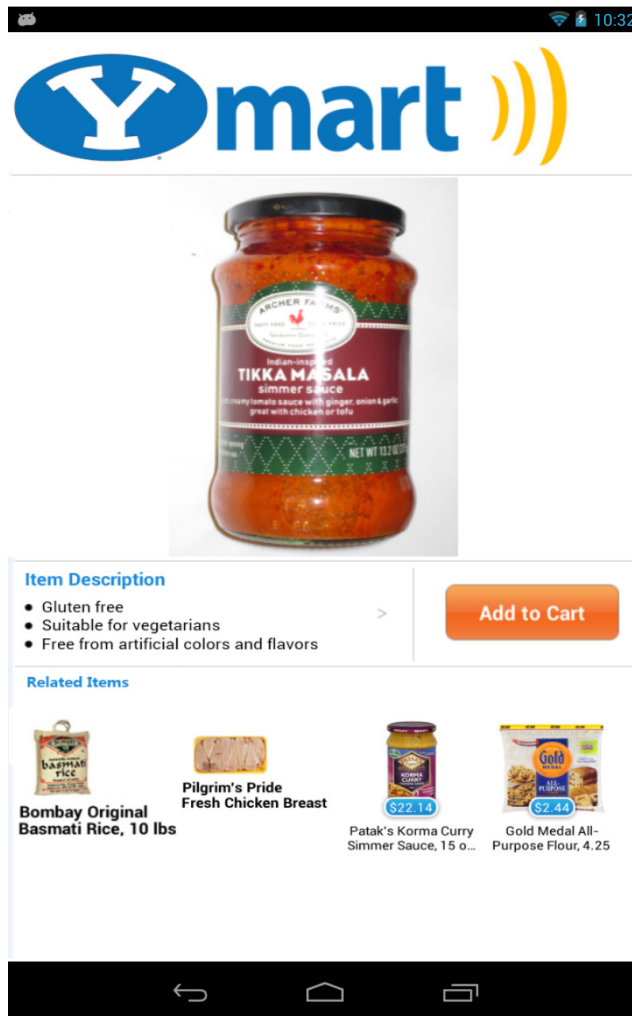

Figure 5. Example of Android app screenshot

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