Modularization of Mobile Shopping Assistance Systems

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***Abstract*—A customer shopping process consists of several essential and optional tasks like payment or information retrieval. This paper presents an overview of the possible solutions in the field of Mobile Interaction that can be applied in order to perform these tasks in future applications based on current and upcoming communication and interaction technologies. The tasks are represented by several modules, like shopping list management, shopping basket management and payment. These modules conceptually describe the available opportunities to realize specific parts of a customer shopping process based on several technologies and customer behavior. In particular, a deep insight into solutions based on Near Field Communication (NFC) is provided. For the first time, the modularization of shopping assistance systems has been considered. It is a substantial advantage for the retailer as it enables the analysis of the benefits and drawbacks of technologies and services. Furthermore, it allows the investigation independent from basic technologies like RFID and barcodes. Regardless of the used technology, the modules can be linked with each other which allows a simple integration of several modules in a retailer's infrastructure. Depending on the usage context, several combinations of modules are more applicable than others. Exemplarily, two implemented prototypes are described illustrating how modules can be combined to handle the specific needs of a market.**

I. Introduction

With the increasing proliferation of smartphones, the demand for applications has rapidly grown. More and more apps have found their way into the app stores. Apart from games, one can also find professional software and software for everyday life. The usage of smartphones in customer shopping processes, like shopping assistance or mobile payment, plays an increasing role. Especially the integration of NFC into smartphones will have substantial influence on the shopping process [1]. There are already several approaches using smartphones for payment purposes like Google Wallet [2] or the Starbucks App [3]. Most approaches make use of the smartphone for payment purposes. Other systems additionally integrate product information provision, e.g. the Starbucks App [3]. In addition to Mobile Payment and product information procurement, Wiechert et al. [1] mention loyalty applications and rebate coupons as possible applications for NFC in the customer shopping process. We furthermore add shopping list management, orientation inside the store and shopping basket management as available mobile shopping assistance systems. Besides different technologies like NFC or barcodes for implementing these processes, it is also taken into account where in the market the respective process takes place. As retail environments of different stakeholders or even different stores of the same stakeholder have their own individual structures, there is probably never one perfectly fitting system for all of them. Therefore, the components implementing the shopping process have to be modularized in order to make smartphone solutions applicable for every retail store.

II. Motivation and Ideas

Recently, a number of smartphones with built-in NFC support have emerged. Many new prototypes using this technology are coming up. Besides pure NFC solutions, also various transitional mobile solutions exist, e.g. based on QR codes. For example, the Touch&Travel system in Germany [4] applies both NFC and QR codes as well as positioning using wireless networks for determining the departure and destination stations of a train trip. The two latter technologies were added because not enough smartphones in Germany have built-in NFC support, yet. To determine the departure station and the destination station, the user scans the NFC chip or the QR code at a specific terminal (Touchpoint) or uses the location estimated by the smartphone. In the retail domain, there are also reasons why a full integration of NFC in the customer shopping process is not yet possible or useful. For example, the usage of NFC for self-scanning processes is only useful when every product is equipped with an RFID (Radio Frequency IDentification) or NFC tag, which is not the case yet. On the other hand, there are also shops which sell only a few and high-priced products, like fashion retailers who have already integrated RFID chips into all clothes [5]. This opens up a lot of opportunities for mobile interaction scenarios based on RFID/NFC technologies.

In a typical shopping scenario, the customer enters the store with his prepared shopping list. After he has orientated himself in the store, he informs himself about goods and puts the products he wants to buy in his shopping cart. At the Point of Sale (POS), the products are scanned by the personnel and the customer pays for his shopping. In order to simplify these shopping tasks and make them more convenient for the customer, mobile interaction techniques can be used. Which mobile interaction scenario fits best for a specific retail store always depends on the context, like size of the market, number and price margin of products and number of personnel. The modularization of mobile shopping assistance systems, like

product information procurement, product scanning and payment, allows us to pick the most applicable mobile interaction technique for each module. In this context, a module is defined as a conceptual description of a shopping task, including available technologies and use cases.

Finding an appropriate interaction technique requires an overview of the existing modules including a detailed description of the available technologies and use cases. The range of these possible use cases is very wide and reaches from self-scanning processes using barcode technology to mobile payment using NFC technology. The mapping of shopping tasks to modules has the effect that all modules are independent of each other and replaceable using standardized input and output. This offers the possibility to e.g. use ordinary barcodes for product scanning and advanced technologies, like NFC, for the payment process at the POS.

According to current knowledge, it is already possible to define the future potentials for the usage of smartphones in retail environments. Several scientific articles have already described various kinds of NFC scenarios or prototypes for use in retail environments. These prototypes are mostly stand-alone solutions which e.g. only implement the payment process or an orientation task [1], [6]–[8]. However, there exists no complete overview of all modules belonging to the customer shopping process, including information about the available mobile interaction technologies and possibilities of use.

III. Technologies

Shopping tasks can be implemented using a set of different technologies. Overall, there are six options for using mobile interaction techniques in supermarkets: 1D barcodes, QR codes, RFID, NFC, wireless networks and image recognition.

A. 1D Barcode

1D barcodes [9] have already found their way into the shopping process [10]. They are printed on nearly every product, which is a substantial advantage for mobile interaction scenarios based on 1D barcodes. Another benefit of 1D barcodes is that they can be scanned at the most POS. Detecting barcodes with a reader requires a line of sight.

B. QR Code

QR codes [9] are a special form of 2D barcodes. The biggest advantage of using QR codes instead of 1D barcodes is that they have a higher data capacity. The amount of data which can be stored in the QR code depends on the size (number of rows and columns) of the code.

C. RFID

RFID [11], [12] is a very versatile technology. Assuming that every product will be equipped with an RFID tag in the future, which will probably be the case within the next decade, the technology can be used in nearly every shopping task. The advantage of this technology is that every single tag has a unique identifier. RFID has a range of several meters and does not require a line of sight.

D. NFC

NFC [11], [12] is an extension to the RFID technology which limits the reading range to a few centimeters. An NFC reader allows precise detection of tagged objects because usually only one tag is situated within the small reader range. This opens up a lot of new opportunities in shopping scenarios, especially for product identification and payment.

E. Wireless Network

Different scenarios can also make use of the wireless networks, e.g. Wireless LAN, 3G and Bluetooth. They can e.g. be used for logging in to the retailer's system or to submit bank account data in the payment process.

F. Image Recognition

Image recognition [13] can be used e.g. for product identification purposes. This requires that for each product pictures are available from every perspective so that they can be matched with product images taken during the shopping process.

IV. Shopping Modules

In our approach, the shopping tasks are represented by seven different modules. These modules encompass shopping list management, orientation, product information procurement, shopping basket management, customer loyalty reward, coupon redemption and payment. Shopping basket management and payment are the mandatory modules of a customer shopping process. Shopping list management, information procurement, customer loyalty reward and coupon redemption are only optional modules. Fig. 1 presents an overview of the defined modules including all available technologies and customer behaviors. The huge amount of available technologies which is presented, makes the modularization of the shopping tasks necessary as working with modules allows an easy exchange of technologies.

A. Shopping List Management

Studies revealed that shopping lists play a central role in grocery shopping [14]–[16]. Therefore, an easy way has to be found to make shopping lists available on mobile shopping assistants. There are mainly two types of shopping assistants. In the first scenario, the customer uses his own mobile phone for assistance during the shopping process. In the second scenario, the customer uses a mobile shopping assistant which is offered by the retailer, e.g. an interactive shopping cart like the IRL SmartCart [17]. This cart is amongst others equipped with a touch display showing user- and context-related information, such as the shopping list. For both opportunities, different interfaces can be used to make the personal shopping list available on the mobile shopping assistant.

A shopping list can be generated using a mobile device, which can be used later on in the retail context, or a stationary system, like a desktop computer. Using a stationary system for creating the shopping list requires an internet connection and an online user profile as it is only possible to have

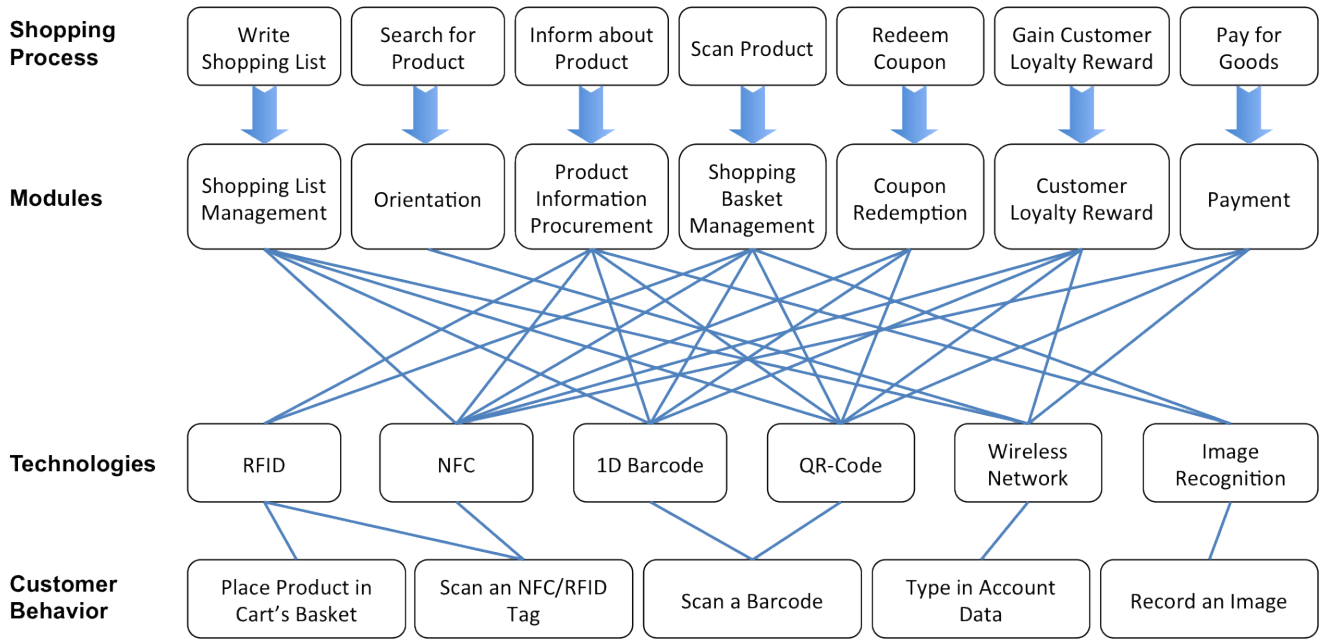

Fig. 1. Mobile Shopping Assistance Modules and available Technologies in a Customer Shopping Process.

access to a previously created shopping list inside the market if the information is available at the backend system of the market. The generation of the shopping list on the customer's smartphone can be done actively or passively using a specific application of the market. By using his own smartphone, the customer can generate his shopping list independent of his location. There are several ways to create a shopping list actively, e.g. by typing in product names, by using speech [18] or by a pen and paper approach [19]. The most common technique is typing in product names. An application which has been implemented for a specific market can also make product suggestions while typing. The second possibility is the usage of speech. Using this possibility, the customer can add products to the shopping list by uttering the product names. It is also possible to use a pen and paper approach, e.g. by using the Anoto digital pen and paper to generate a shopping list on the smartphone. A shopping list can also be created passively based on the shopping habits of the customer. Collected information about previously purchased products allows the generation of suggestions for the next shopping list.

After entering the physical store, the user has the possibility to use his own smartphone or the system offered by the retailer for shopping assistance. Using the mobile shopping assistant of the retailer requires the transmission of the shopping list to this system. Several opportunities exist to make the shopping list available on the retailer's system. The first possibility requires a customer account. In this case, after successful login to the system, the shopping list which has been created beforehand and stored at the retailer's backend is loaded. The login can be performed using several identification mechanisms, like user name and password, barcode, QR code or NFC. The second way to send the personal shopping list to the retailer's mobile shopping assistant is to transmit it via NFC or Bluetooth from the customer's own mobile phone. This requires a specific smartphone application provided by the market.

B. Orientation

Searching for rarely purchased products can be a tedious task, especially in hypermarkets. To assist customers in this task, several stand-alone indoor navigation systems have been developed [20], [21]. In order to help customers to orientate themselves inside the market, the shopping assistant at least has to display a map of the market. Additionally, the locations of searched products can be displayed on this map. Using wireless networks to determine the position of the customer allows the visualization of his position inside the market. For navigation purposes, additionally the shortest path between the current location and the destination location can be visualized.

C. Product Information Procurement

Inside the supermarket environment, there are various possibilities to retrieve information about specific products using mobile interaction techniques. Similar to the previously described shopping list scenario, the customer again has the possibility to use his own smartphone or the mobile shopping assistant of the retailer. This also allows customers without own mobile phones to make use of mobile interaction techniques inside the market.

By working with a mobile assistant, the customer can make use of NFC, barcodes, QR codes or image recognition to retrieve information about products if appropriate services are provided. Nowadays, it is already possible to scan the barcode (EAN) of a product and obtain information about the specific product from the internet. In the future, when

TABLE I
PAYMENT SCENARIOS

	Mobile Device	Phone2Terminal	Phone2Phone
Technologies	Wireless network	NFC, Barcode, QR code	NFC
Location	Everywhere	POS	Everywhere

every product will be equipped with an RFID tag, it will also be possible to scan the product information by holding the NFC-equipped smartphone against the product. Fitting each product with a QR code also enables information procurement through scanning this code. At last, there is the possibility to retain information by making use of image recognition. The system running on the smartphone recognizes the picture and displays the product information, e.g. as an overlay of the camera stream.

If the retailer offers smart shopping carts, RFID technology can also be used for product information retrieval. The IRL SmartCart [17] e.g. scans products which are equipped with RFID tags immedately when they are placed into the cart's basket. This is possible through an RFID antenna which is attached to the shopping cart. When a product is recognized by the shopping cart, specific information about the product can be displayed on the monitor mounted at the handlebar of the cart.

The product information procurement process can also be personalized. For this purpose, the user profile can be transferred to the interaction device in the same way as the shopping list. This profile can e.g. include personal preferences or allergy information.

D. Shopping Basket Management

Shopping basket management is one of the two mandatory tasks of the shopping process. The different possibilities to add products to the shopping basket depend on the type of shopping assistant and its implemented technologies.

For shopping basket management processes inside the market, there are several opportunities. Analogous to the product information procurement process described beforehand, NFC, barcodes, QR codes or image retrieval can be used for scanning products with the mobile assistant. These technologies demand an explicit acting of the user who has to actively scan the product.

Another possibility to add products to the shopping basket during the customer shopping process is to make use of implicit behavior-based scanning. This means that the customer does not have to scan the products actively, but this is done through his normal acting inside the market. An example for behavior-based scanning is scanning of RFID equipped products when they are placed inside the shopping cart. Another example is implicit adding of products to the shopping basket by taking products out of the shelf. Products are deleted from the shopping basket again when they are put back to the shelf.

E. Coupon Redemption

Another module of the customer shopping process is coupon redemption. Coupon redemption using mobile interaction techniques requires digital coupons which are stored on the customer's smartphone. These coupons can be available in terms of barcodes or QR codes or can also be ready for transmission via NFC. A customer can receive coupons e.g. by email or by a specific application of the retailer. By scanning digital coupons stored on the smartphone, the retailer can grant the customer the specific discount before payment.

F. Customer Loyalty Reward

Mobile interaction techniques can also support the usage of loyalty programs. Loyalty programs always require an authentication of the customer. This can be realized in analogy to the authentication during the payment process described below either by transmitting a personalized code via NFC, by generating a personalized barcode or QR code at the customer's phone or by logging in to the retailer's system using user name and password. Once authenticated, the customer can retain specific bonuses or collect loyalty points.

G. Payment

Payment is the second mandatory task of the shopping process. Apart from the traditional payment methods, like payment in cash, by credit card or by debit card, there are already a few approaches using the customer's own smartphone for payment purposes. Prominent examples are Google Wallet [2] or the Starbucks App [3]. Google Wallet allows payment through card data which is stored on the phone and transmitted via NFC. In contrast to that, Starbucks makes use of the loyalty program to allow customers to pay for goods. The Starbucks application allows a registered customer to generate a personal QR code on his smartphone, which authenticates him when it is scanned at the POS. The purchase price is then deducted from the customers account.

Using mobile interaction for payment requires either a customer's account at the retailer's system or the transmission of bank data via NFC or other wireless technologies. Payment can take place inside the market using wireless technologies for login or transmission of bank account data if the own smartphone is used. Working with customer accounts requires a registration at the retailer's and the provision of the personal bank account data. The customer has to authenticate himself at the retailer's system to pay using his customer account. This can be realized by generating customer specific barcodes or QR codes on the smartphone which unambiguously identify the customer when being scanned at the POS. Furthermore,

NFC technologies can also be used for authentication. Apart from authentication, NFC can also be used for securely transmitting bank account data for payment.

Payment can take place either anywhere inside the market or only at the POS. Table I presents an overview of possible payment scenarios. The first possibility is to use a mobile shopping assistant, either from the retailer or the own smartphone. After login to the retailer's system, which can be done using a specific application or a webpage, the user can confirm the transaction. This scenario is independent of the location inside the market and requires that the information about scanned products is transmitted to the mobile device beforehand, e.g. by scanning a QR code with the specific information, or that it is already available on the mobile device, e.g. through the self-scanning process. The Phone2Terminal payment in contrast can only be applied at the POS. The customer can pay e.g. by using his bank account data which is stored on his mobile phone and transfer it through NFC to the terminal. Another option is the generation of a personalized barcode/QR code at the customer's own mobile phone. This allows the authentication of the customer by scanning the code at the POS. The last option is the Phone2Phone payment. The customer can pay with the smartphone at the retailer's phone by transmitting the relevant bank account data through NFC to the retailer's phone which then executes the transaction. This requires holding the phones together during the payment process. It is independent of the location within the market. The described system is similar to the pilot project girogo enrolled in Germany this year where customers do not pay with their phones but with NFC-equipped bank cards in combination with the retailer's smartphone [22].

V. Prototypical Implementation

A shopping process consists of several tasks represented in the modules which have been described in the last section. These modules can be freely combined to be most applicable for the specific usage context of a market. In the following, two implemented prototypes are presented that illustrate how the modules can be linked together to handle the needs of a specific market.

A. Smart Shopping Cart and Phone Payment via Wireless Network

The first prototype combines the modules shopping list management, shopping basket management and payment. For this prototype, the different modules have been implemented using different technologies, like RFID, NFC, QR codes and wireless networks. Both, a smartphone and a smart cart provided by the retailer have been used in the implementation.

Shopping List Management: The customer generates the shopping list, e.g. at home, using a smartphone application of the retailer. When he arrives at the retailer's, he can submit this shopping list to the retailer's smart cart. For the transmission of the data to the shopping cart, NFC technology is used because it is fast and secure. This requires that the customer has an NFC-equipped smartphone. An NFC reader which is integrated into the handlebar of the shopping cart, recognizes the phone when it is placed near the reader. The shopping list is read and displayed on a screen attached to the cart.

Fig. 2. Prototype: Scanning of Products via RFID.

Shopping Basket Management: Product scanning takes place using RFID technology. All products are equipped with RFID tags which are recognized when the products are placed inside the shopping cart. The recognition of the products is realized using an RFID antenna which scans the basket's content. When the products are scanned, they are displayed on the cart's monitor including price information next to the shopping list (s. Fig. 2).

Payment: All products that are placed inside the shopping cart provide information about their price. Additionally, the purchase price is also shown on the cart's display. The transaction of the purchase amount is realized using the mobile phone of the customer. This enables the customer to pay at the retailer's without forwarding the personal bank account data to him. When the customer wants to pay for the products in his basket, he has the possibility to generate a QR code, including information about the products placed inside the shopping cart, which is presented on the cart's display. Now this code is scanned by the customer's mobile phone which then displays all payment information. To complete the payment process, the customer has to confirm the transaction and type in the PIN code of the bank account he has stored on his smartphone. After successful transmission, the mobile phone has to be placed at the shopping carts handle again to synchronize it via NFC with the shopping cart. This synchronization informs the cart which products have been sold and removes the security protection of these products. Afterwards, the customer is able to leave the market without triggering an alarm. The whole bank transaction process takes place on the smartphone. The separation of the payment module and the scanning module which is running on the retailer's smart cart makes the prototype more secure. The customer does not have to submit his bank account data to the retailer and no personal data is shared between the customer's smartphone and the retailer's system.

B. Self-Scanning and Phone2Phone Payment via NFC

In the second prototype, the modules product information procurement, shopping basket management and payment are combined. In this case, NFC technology is used in all modules. Similar to the previously described prototype, this requires that every product is equipped with an NFC or RFID tag.

Product Information Procurement: The customer has the opportunity to obtain product information by scanning the products with his NFC-equipped smartphone. When holding the phone against the product's tag, information about the product is displayed on the phone.

Shopping Basket Management: Product scanning takes place parallel to the product information module. After the product information has been displayed, the customer can add the product to his virtual basket of goods by clicking a specific button on the mobile phone's display. For every product which is scanned for the first time the product information is displayed. Scanning a product for the second time directly adds the product to the shopping basket.

Payment: The payment procedure takes place at the POS between the retailer's and the customer's NFC-equipped smartphones. To start the payment process, the customer holds his phone against the retailer's mobile phone. In this step, the basket of goods is transmitted via NFC to the retailer's mobile phone. Next, the customer has to confirm the payment by typing in his PIN code on his own mobile phone. Both, bank account information and PIN code are sent via NFC to the retailer's mobile phone which then accomplishes the transaction via an available wireless network. An advantage of this system is that the customer can hold the instrument of payment in his hands and does not have to give away his bank card.

VI. Conclusion

This paper presented an overview of the customer shopping tasks which have been mapped to modules. These modules include shopping list management, orientation, product information procurement, shopping basket management, coupon redemption, customer loyalty reward and payment. Each module can be implemented using a set of different technologies and requires certain customer behavior. As the modules are independent of each other, it is possible for the retailer to implement a solution that fits the market's needs. For example, it can combine scanning of barcodes on products for the shopping basket management and NFC technology for the payment process. The overview of the modules including the available technologies aims at helping retailers to identify possible benefits or drawbacks of technologies or services for their stores. After deciding which modules they want to implement in their markets and which technologies they want to use, the retailers can easily integrate them into their infrastructure. Even if the available technologies change in the future, e.g. through the integration of sensors into the shopping environment, which can e.g. identify the customer and his behavior, the seven modules will retain, just the technologies and the customer's behavior will change. It is planned to implement all described modules including all mentioned technologies and use cases. Having this shopping framework, several studies will be conducted which shall identify which technologies and use cases customers prefer for each shopping task.

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