# Enhancing the Restaurant Dining Experience with an NFC-Enabled Mobile User Interface

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**Abstract.** We provide a field study of a smartphone application and server-side software for improving the on-premises restaurant experience. To increase customer engagement, the smartphone client uses Near-Field Communication (NFC) to bootstrap the communication with the server and to localize customers to specific tables. The application further provides a complete end-to-end experience by allowing users to select food items, read micro-reviews of dishes, submit their order, and be alerted when the food is ready. We deployed our prototype system in a cafe-style restaurant in the dining commons of Stanford University and observed that the system was able to successfully streamline and enhance the dining experience for both customers and restaurant staff.

## 1 Introduction

The ubiquity of smartphones running mobile operating systems such as Android, iOS, and others has grown tremendously with smartphone global unit sales reaching 1.7 billion in 2012 [8]. This growth in hardware sales has co-occurred with the growth in mobile applications for business, gaming, and other domains. However, one area that has not been fully explored is the use of the smartphone in an on-premises retail business environment as an assistive platform to augment the customer experience.

In this paper we provide a work-in-progress field study of *in situ* smartphone usage in a restaurant dining scenario where the smartphone serves as an extension of the interface between customers and the restaurant's operational staff. We developed NapkiNotes, an Android smartphone application that interacts with a restaurant-side server. The application allows users to select dishes from a menu (thereby eliminating or reducing the need for paper-based physical menus), filter food selection based on ingredient preferences, look at high-granularity reviews of individual dishes, submit the order, and be alerted when the food is ready.

A key component of the system is the use of Near-Field Communication (NFC) [16] to bootstrap the communication between an NFC-enabled smartphone and the server by having the customer tap the smartphone against a restaurant-provided NFC tag affixed to dining tables. We encoded each tag with a unique (restaurant, table) tuple that uniquely identifies the location of the tag, thereby allowing the restaurant staff to find the user. Further, NFC improved

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the user experience by allowing a tap-to-start gesture that is easier to perform than other start-up methods such as taking a picture of a QR code.

We deployed our prototype in a cafe-style restaurant in the student dining commons of Stanford University and observed that the system was able to successfully streamline and enhance the dining experience for both the customers and the restaurant staff. In particular, customers found that NapkiNotes made ordering the food more convenient, while results suggested that the system helped reduce the restaurant's operational effort.

This paper is organized as follows: We discuss related work in Section 2, describe our system in Section 3, show field study results in Section 4, and conclude in Section 5.

## 2 Related Work

Our work focuses on a smartphone-based interface between users and a physical business, a topic explored by several companies. Foursquare [7] is a social smartphone application that allows users to "check in" at a store, thereby gaining social credibility points. Unlike Foursquare, our NapkiNotes focuses on improving the on-premises restaurant experience rather than just establishing user geo-presence. Yelp [22] has a mobile application that allows consumers to write reviews of businesses; NapkiNotes lets users write reviews of specific food dishes. Services like OpenTable [17] and SeatMe [18] provide smartphone-based restaurant table reservation for customers but not in-restaurant ordering.

Prior research has also looked at smartphone usage in physical stores. Mobile advertising [3,11,5] and mobile recommendation agents [15,12,13] look to facilitate an immediate, on-site purchase. NapkiNotes instead targets a more involved, ordered flow; unlike advertising where user interaction is potentially disconnected from subsequent in-store activities, the food selection and delivery process in a restaurant is sequentially connected, making this field study relevant to domains where time spent between the customer and the business is elongated.

To implement our tap-to-start feature, we used NFC, a low-power, short-range wireless technology used for contactless communication similar to RFID [21]. In many countries, NFC is already used for mobile ticketing and point-of-sale payment. In the USA at the time of this writing, Google is building out a mobile wallet for Android phones [9]. NFC has also been used in research scenarios, including device-spanning applications [6], automotive vehicles [19], tourism [2], sales management [10], and health care [14].

NFC has also recently been used in limited dining scenarios. Cityvox deployed NFC tags at the windows of restaurants, allowing users to tap the tag and be directed to a Web site to read and write reviews [20]. In our work, NFC is affixed to individual restaurant tables to identify the user's seat, and our application allows users to order their meal. The CustomerIn concept [4] suggests per-table NFC localization but does not consider end-to-end meal ordering.

# 3 Design and Implementation

## 3.1 Overview

The NapkiNotes application addresses an important user need: improving the restaurant experience. For example, consider a scenario where a user is visiting an unfamiliar restaurant. The user sits down at the table, reads the menu, and then becomes daunted because there are too many unknown food item choices. Additionally, ordering food and requesting service can be frustrating at high-traffic restaurants where the waiters are busy, resulting in users flailing their hands in attempts to draw the attention of the staff. Therefore, we wanted to create an application that aims to make the restaurant experience more enjoyable.

The NapkiNotes system follows a client-server model. Users are required to download and install the NapkiNotes Android application onto their smartphone in order to access the restaurant functionality. Although a Web-based application was feasible, we chose to implement an Android application to more tightly control the user interface and to leverage the NFC feature. In our work we used a Samsung Nexus S smartphone running Android.

Upon visiting the restaurant and finding an NFC tag at a table, the user can tap his or her smartphone against the tag, which launches the application through Android's Intent application-dispatch system and bootstraps subsequent communication between the application and server over 802.11 Wi-Fi or 3G/4G. (We note, though, that throughout our experiments, the users accessed the network through Wi-Fi since the phones were not equipped with a 3G/4G SIM card.) When the user submits a food order, the information is sent to a restaurant server over HTTP with a custom application-layer payload and protocol. The restaurant can then prepare and serve the food to the customer.

## 3.2 Customer-Side Client Application

Our prototype's customer-facing features and interface derived from extensive usability tests and interviews involving seventeen Stanford undergraduate and graduate students. Screenshots are shown in Figure 1. The application provides:

- Tap-to-start: The user taps an NFC-enabled smartphone against NFC tags on the restaurant table to initiate communication with the server. Each NFC tag at a table contains, among other pieces of data, a unique restaurant identifier and a unique table identifier. The restaurant-side server is intended to provide online service to multiple restaurants, so this combination allows the tapping smartphone to be localized to a specific table.
- Setting preferences and filters: Preferences for select ingredients and meats can be set, thereby filtering the display of dishes. This capability allows customers with dietary restrictions to narrow down dishes.
- Menu browsing and food ordering: The user can view the available dishes, including full descriptions and pictures, and place an order.
- Reading and writing micro-reviews of dishes: Each dish can be reviewed and given a one-to-five star rating along with a pithy opinion.

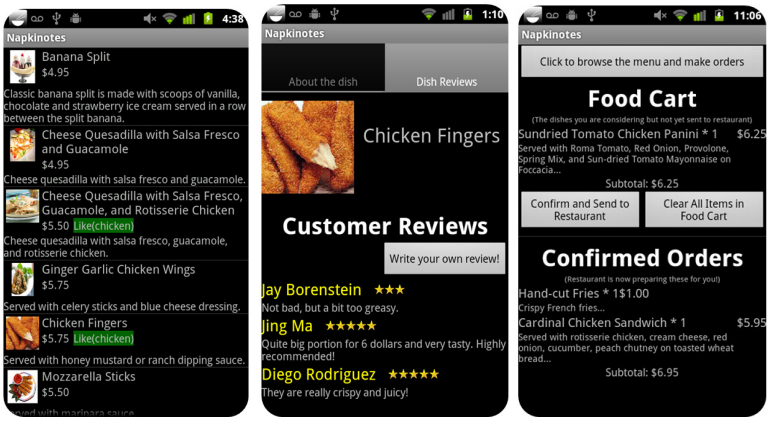


**Fig. 1.** Screenshots from the NapkiNotes smartphone application. Left: Users can browse through food on the restaurant's menu. Note that preferred items are highlighted. Center: Micro-reviews of individual dishes can be read and written. Right: Users can submit orders and then await notification of availability.

- Interaction between customer and staff: In fast-food restaurants, the staff can signal to the user's smartphone when the food is ready, and in more formal restaurants, the user can signal the restaurant for service by the waiter.

In our prototype we used the NFC capability provided by the Nexus S smartphone and the Android NFC API to read NFC NDEF messages stored on MIFARE tags. Data containing restaurant and table information was written beforehand onto the tag running tag-writing Android software. For use in the restaurant, we used NFC as an initiator to invoke the application and to bootstrap subsequent Wi-Fi or cellular communication between the application and the server. This initiation can be performed by the user with a convenient tap between the phone and the tag. Android's NFC API provides two modes of activation: intent dispatch, where an application is invoked by the runtime system, or foreground dispatch, where a foreground activity is required. In our system we used intent dispatching.

### 3.3 Restaurant-Side Server

We implemented a prototype design where multiple restaurants can be provisioned through one server, with the restaurant instances being branches of the same corporate family or separate entities. The NapkiNotes Android application communicates with the server through NapkiNotes Data Transfer (NNDX), a custom protocol that defines data types and handshaking with the data payload delivered in an HTTP POST message. The restaurant's system management interface is Web-based for ease of accessibility and use, comprising three major parts: the order monitor, the service request monitor, and the menu editor.

The **order monitor** is the most important part of the server. The NNDX server receives orders from the clients and places keys with an order number

into the current session's entry, where the monitor finds them, reads the keys with its order information, and displays them to the staff. The **service request monitor** is a webpage table that shows service requests coming in from their respective tables. The **menu editor** allows menu entries to be entered into the restaurant database, including item name, description, prices, and so on.

## 4 Field Trial Evaluation and Results

To test NapkiNotes we deployed our system at The Dish At Stern, a fast-food eatery on the Stanford University campus that is open to the public but primarily serves undergraduate and graduate students. Typical fare includes made-to-order pizzas, sandwiches, and paninis. A patron waits in line to place an order and then returns to a table to await the completion of the food, which is vocally called out by a member of the staff.

We initially set up our server-side database with the restaurant's dish inventory using the menu editor system described earlier. Once the data input was finished, we invited random customers, all of whom were students, on a weekend day to use NapkiNotes with our phones. As mentioned before, we used the Samsung Nexus S smartphone running Android with WiFi connectivity.

This section discusses the results of the field trial and projects our findings for the domain of on-premises mobile applications in general.

### 4.1 Time to Complete Order Submission

One of the primary benefits of NapkiNotes is that the user can order food while at a table without having to wait in line. On average, customers took less than two minutes to look through the menu items on the application and then place an order. We contrast that with the amount of time a customer must wait in line at a cafe or restaurant that does not have a service like NapkiNotes.

**Table 1.** Empirical measurements of customer waiting times at restaurants around the Bay Area, all taken on the same day. Duration times are stated as minutes:seconds. Durations were measured for each customer from entrance to exit from the queue.

| Eatery | Location | Time of day | Mean queue duration | Median | Max |
|---|---|---|---|---|---|
| In-N-Out Burger | San Francisco | 10:00 AM | 2:18 | 2:12 | 3:02 |
| Subway Sandwiches | Stanford | 1:00 PM | 11:46 | 10:21 | 16:53 |
| Pho Vi Hoa Restaurant | Mountain View | 7:00 PM | 8:56 | 11:46 | 12:34 |

For completeness we found other eateries in the Bay Area that had a similar serving style to The Dish At Stern and took empirical measurements there, as shown in Table 1. Depending on the time of day, customers can potentially wait in line for over ten minutes. The last two eateries had only one cashier at the time, exacerbating the wait times. We noted that some people chose to depart the eatery immediately when seeing how long the line was in front of them. A system like NapkiNotes can alleviate this queuing time to place an order by allowing the customer to perform the ordering action on the premises with the convenience of his or her own smartphone.

### 4.2 User Satisfaction

Among the customers who used NapkiNotes, 16 elected to fill out a paper-based questionnaire to evaluate our system, where feedback scaled from 1 to 5 (highest). Table 2 shows user satisfaction results for the system's features, Table 3 shows user satisfaction with the Android application's interface, and Table 4 shows user interest in future deployment to other restaurants and cafes. In general, users were satisfied with the system, with all features scoring above 4.0 except for the user interface for selecting food preferences, which we explain below.

**Table 2.** User satisfaction results for overall NapkiNotes usage

| Feature | Rating |
|---|---|
| Tap-to-start using NFC | 4.69 |
| Viewing the menu | 4.35 |
| Ordering food | 4.62 |
| Read/write dish reviews | 4.27 |
| Food-ready notification | 4.50 |

**Table 3.** User satisfaction results for the NapkiNotes smartphone user interface

| User interface | Rating |
|---|---|
| Application start | 4.65 |
| Menu | 4.54 |
| Menu item details | 4.15 |
| Ordering food | 4.54 |
| Food-ready notification | 4.46 |
| Setting user preferences | 3.92 |

**Table 4.** User interest results for NapkiNotes future deployment to other restaurants and cafes in the future

| Future deployment focus | Rating |
|---|---|
| Viewing the menu | 4.62 |
| Ordering food | 4.15 |
| Reading per-dish review | 4.23 |
| Food-ready notification | 4.85 |

In addition to the ratings, users wrote their opinions on the features and interface. The results of these comments and the ratings are summarized below.

**Tap-to-Start:** The use of NFC to allow users to initiate the application by tapping on an NFC tag was found to be the most useful feature. NFC receives much of the popular press' attention in the USA for its potential to replace credit cards in point-of-sale payments [1], but we have found that using it as a bootstrapping mechanism for subsequent communication is already very valuable because the tapping motion for the customer is easy to understand and quick to perform. Its use can replace taking photos of QR codes, which is not as intuitive as tapping and requires more user interaction in aiming a camera.

**Customization of Orders and User Preferences:** From the questionnaire comments and the low rating on "setting user preferences," it was seen that the customers were disappointed in the application's inability to capture customization of food orders, which prevented them from ordering something not on the menu or making special requests on a specific dish, such as no pickles

on a burger. Furthermore, we did not implement a means to allow the user to inquire about vegetarian variations, such as replacing beef with tofu. The root cause of this problem is that communicating such details over the smartphone is not as efficient as having a verbal exchange with human staff. Although we can potentially add a text field to allow users to specify food customization, some customers already mentioned that, in general, working with the virtual keyboard on the smartphone was difficult.

**Ordering via the Smartphone Rather than via Interactive Human Discourse:** Some customers enjoyed the experience of casually browsing through the detailed information presented on the smartphone because it let them look through the items at their own pace. Others mentioned that it was impersonal because one would then not get to know the restaurant staff members.

**More Information for Display:** In general, the customers wanted more information displayed in the application, not less, in order to let them make informed food-selection decisions. Suggestions included adding information to denote vegetarian dishes and nutrition facts.

### 4.3 Restaurant Staff Feedback

The management responded positively to the system and stated that they were interested in using the system further. In general, they were appreciative of the interface, the restaurant-side order management system, and the benefit of customers submitting orders directly, bypassing the service staff. Importantly, they were enthusiastic about the use of NFC that allowed customers to become more quickly engaged with the menu and ordering system while also providing immediate localization of these customers to specific tables. The management further wanted to expand upon the system to collect statistical information on the number of customers using NapkiNotes and to have access to the history of orders and service requests in order to improve their service. Long-term benefits for the restaurant would be faster throughput of customer order processing and improved customer satisfaction, resulting in more customer visits and purchases.

## 5 Conclusion

We provided an initial evaluation of our in-progress work on NapkiNotes, an NFC-enabled smartphone application and server-side system that looks to improve the on-premises restaurant experience by streamlining the interaction between the customer and staff. Our field study of a real-world deployment at a Stanford campus eatery shows that users responded positively to the system. In general, our findings reveal the potential for using mobile user handhelds as a replacement for paper-based informational content as well as an assistive communicative channel between customers and staff in a physical store location. In the future, we look to improve the server-side software by running on a provisioned, secure service.

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