Smart Guide: Mid-Scale NFC Navigation System

Nicolas Bonzani, Edward Kang, Chen-Hsiang Yu, and Mira Yun
Department of Computer Science and Networking
Wentworth Institute of Technology
Boston, MA 02115, USA
{bonzanin, kange1, yuj6, yunm}@wit.edu

***Abstract*— Existing navigation systems that utilize GPS are unreliable on any smaller scales ventures such as on or within a campus and generally are unstable within buildings or other structures. We found a need to have a more reliable way to access directions when GPS systems were inaccurate or inaccessible. Since NFC readers are not uncommon in mobile phones nowadays, we propose a new portable system, *Smart Guide*, to utilize this underused technology in a new way. In this paper, we present Smart Guide that is an Android application using NFC to aid a user in mid-scale navigation.**

Keywords—NFC; Android development; mid-scale navigation system;

I. INTRODUCTION

Existing navigation systems which utilize Global Positioning System (GPS) are unreliable on any smaller scales ventures such as on or within a campus and generally are unstable within buildings or other structures. Based on the observations, we found that there is a need to have a more reliable way to access directions, especially when GPS systems are inaccurate or inaccessible. Because Near Field Communication (NFC) readers have become more and more common in mobile phones nowadays, we decided to utilize this underused technology in a new way. NFC tags are relatively cheap and they have very flexible placement options in the real world. In addition, the ways one can utilize the tags to inform users of various types of data are very robust.

Within this paper, we present our experience learning how to develop an Android application which utilizes the NFC capabilities found in many popular mobile devices of the time. Our original idea was to create a functional application which could aid a user in navigating a maze using the NFC tags as sort of "checkpoints." When the user taps their phone to a tag within the maze, a corresponding map would appear on their device, alerting them to the quickest and most optimal path out of the maze.

Smart Guide is a system we propose to demonstrate the idea of mid-scale navigation purpose. The system is a "proof-of-concept" at current stage, but it can be used in the future on more mid-scale projects. For example, our application can be expanded to create a very precise directional navigation system on a campus using NFC tags placed throughout the area. In addition, *Smart Guide* is an excellent stepping stone for teaching new students how to connect to and utilize the NFC reader in mobile devices when beginning to create Android applications.

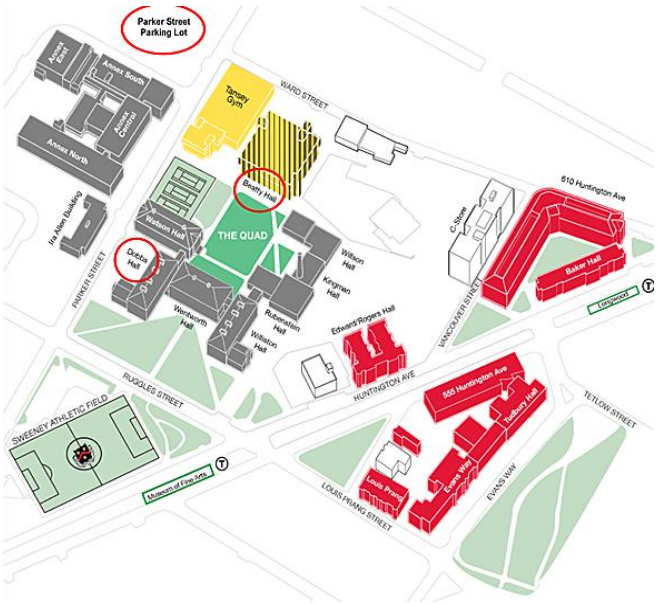

Fig. 1. Wentworth Campus Map

Currently, navigation systems found on mobile phones comprise of an application which uses your GPS-based location to approximate your position in the world. While this information is often useful in providing driving directions, it is not precise enough to adequately deliver directions on a smaller scale. Take the Wentworth Institute of Technology campus, as an example. In Figure 1, we can see that the campus is not very large, perhaps a quarter of a mile by a quarter of a mile at most. A

traditional GPS based navigation system would be nearly useless in helping a prospective student or someone unfamiliar with the area with traversing the campus and getting to their desired destination. *Smart Guide* eliminates that obstacle by allowing a user to precisely know where they are and giving step by step directions each time they approach a tag.

II. NFC AND ITS UTILIZATION

NFC was our platform of choice as it is the most easily accessible technology for beginner Android developers. In addition, there is little to no barrier to entry with the technology, as the tags are decently inexpensive and relatively easy to work with and program.

NFC is a new short-range, standards based wireless connectivity technology that uses magnetic field induction to enable communication between electronic devices in close proximity [1]. Nokia, Philips, and Sony established the NFC Forum in 2004 [2]. This technology is currently used for many different services such as Google Wallet, Apple Pay, and Nintendo Amiibo.

TABLE I. NFC VS RFID

	RFID	*NFC*
Operating Frequency	13.56 MHz	13.56 MHz
Communication	One Way	Two Way
Standards	ISO 14443, 15693, 18000	ISO 14443
Scan Distance	Up to 1 m (3.2 ft)	Up to 4 cm (1 in)

NFC is a subset of another technology called RFID (Radio Frequency Identification). As seen in Table 1, NFC has a shorter physical range than RFID [3]. This allows for less chance of interference with another NFC device. As such, NFC is a much more viable technology than RFID for the purposes of our system. In addition, due to its shorter scan distance, NFC has the benefit of being more secure. Since the radio that connects to the tag only has to go approximately 4cm, there is less chance of a malicious individual connecting to your device wirelessly.

The project starts with no experience in mobile application development. As such, we needed to not only learn how to employ and take advantage of the NFC technology within the phones, but we also needed to study how to create a basic Android application from scratch.

For a while, we attempted to create our own programs which would allow us to customize the data we would store on a tag, but nothing we managed to create did what we needed to do. In order to get a tag to store custom data, we realized that you have to essentially create and store a 'Mime Type' on the tag. This is the custom data that allows for variation between tags. Each tag must have a unique Mime Type in order for the application to react appropriately upon discovery of the tag. Eventually, we discovered an application on the Google Play store called Custon NFCTagWrite [4]. This application allowed us to customize a MIME Type and write it directly to a tag.

In order to effectively use the data on the tag, we figured out a way to quickly and efficiently distinguish between different MIME Types, while also pulling up a specific image or direction based on that MIME Type. We discovered the best way to do this is to utilize a feature of the Android libraries called Intent Filters. Android applications are essentially a set of programs that are woven together nearly seamlessly. Each individual piece of the application is referred to as an 'activity,' which provides a screen for users to interact with to do actions. By utilizing intent filters, we were able to rapidly swap between activities on the fly, pulling up the appropriate images of the maze each time a tag is tapped. As seen in Figure 2, each MIME Type we stored on a tag corresponded to a specific activity which would be called upon discovery of that MIME Type.

The intent filter would automatically open the corresponding activity due to the <action> and the <data> lines. When an NDEF formatted tag (the industry standard for NFC) is discovered, the data on it is checked. If the data found matches a MIME Type corresponding to an activity, the <action> line is called and the intent is pushed forward, opening the activity. This would cause an image of the map at the point you are to show on the screen.

These specifics are something a beginning Android developer likely would not be privy to, and as such learning how to utilize these features of the libraries creates an excellent learning opportunity for new programmers.

III. SMART GUIDE

The current incarnation of our application is a very basic version, but could easily be expanded upon. In this section, we present our implementation in detail.

```
<activity
    android:name=".MapActivity"
    android:label="@string/title_activity_map" >
    <intent-filter>
        <action android:name="android.nfc.action.NDEF_DISCOVERED" />
        <category android:name="android.intent.category.DEFAULT" />
        <data android:mimeType="application/nfc.smartguide.mapactivitytrigger" />
    </intent-filter>
</activity>
<activity
    android:name=".TapActivity"
    android:label="@string/title_activity_tap" >
    <intent-filter>
        <action android:name="android.nfc.action.TAG_DISCOVERED" />
        <category android:name="android.intent.category.DEFAULT" />
        <data android:mimeType="text/plain" />
    </intent-filter>
</activity>
```

Fig 2. Intent Filters and Mime Types

Currently, our application works as such; A user opens the application, and taps their device to any nearby tag, or can open the map directly from the screen, as seen in Figures 3.

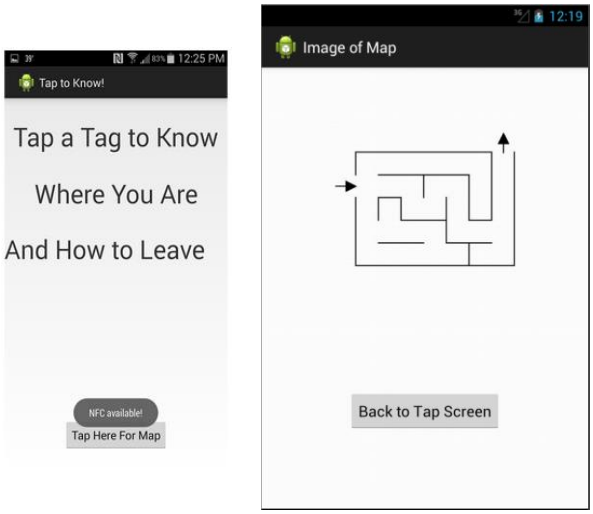

Fig.3. Tap Screen and Map Screen

The application then shows the user a path to their desired destination, in our case to the exit of the maze as seen in Figure 4. When a user gets to their destination, they can tap the tag placed at the destination and the application will alert them they have arrived appropriately at their end point. In future versions of the system, it could possibly show the user step-by-step directions to their destination, similar to current GPS systems. Each time the user would tap a nearby NFC tag, the system would register the tapped tag, and show the proper direction the user must walk. This allows for a user to more accurately navigate a tight area, such as a large building on campus. Furthermore, our system allows for travel in three dimensional space, whereas GPS systems only allow for travel in two dimensions. Our system would allow for tags on multiple floors of a building, and could be used to point a user towards a specific room on a specific floor.

Unlike traditional navigation applications, *Smart Guide* requires no internet connection to be used. Currently, the design of the system would store the map and all the navigation data locally. This would allow for a new student to be prepared before getting to the campus should they not be able to access Wi-Fi or a cellular network.

Throughout the development of the system, we realized that not only does our project have a useful application as a more precise mid-scale navigation system, it also has a use as an introductory programming challenge for students and others interested in utilizing NFC in a custom Android application.

IV. Future Plan

As a result of our endeavors, we successfully develop a system, *Smart Guilde*, which is a functional Android application utilizing the NFC features in mobile devices. This was our main goal for this research, as this is essentially a “proof of concept” for a larger, more comprehensive application. Given time, this research could be compounded into a much more comprehensive and useful application. After much testing of the system,

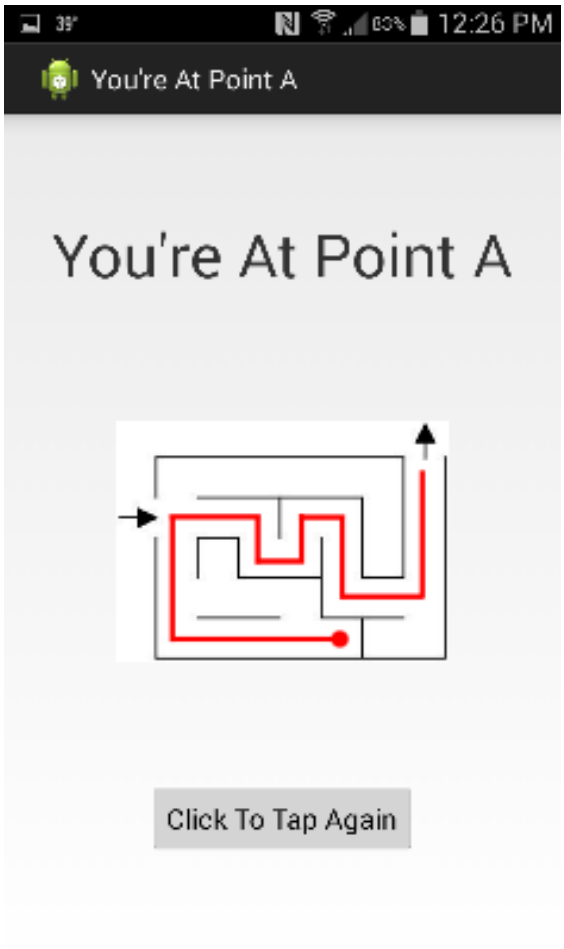

Fig. 4. Point A Screen

we were happy with how responsive the app was and how quickly it did its work.

For now, the system is a mostly static jump between activities and images. Our next feature to be implemented is dynamically created directions. This would allow our ultimate idea to take shape, by creating an application which would guide the user from one point to another, no matter the point. Creating the directions dynamically allows for a much less bloated application, as all the data would not need to be stored on the device. This is something we have taken into consideration when developing the system.

The interface currently is very simple, by design. There are few buttons and no menus, in order to create a straight forward and functional system for now. As the system grows and evolves, we plan on creating a unique and useful interface which allows users to easily and quickly use the system when they need it.

REFERENCES

[1] Near Field Communication (NFC) Technology and Measurements - White Paper, Rohde & Schwarz, June 2011.

[2] The Near Field Communication (NFC) Forum, NFC-forum, March 2004. http://nfc-forum.org/

[3] The Difference Between NFC and RFID-Explained, RapidNFC, April 2013. https://rapidnfc.com/blog/72/the_difference_between_nfc_and_rfid_explained

[4] Paulus Schoutsen. NFC Tag Writer (GitHub Project), April 2013. https://github.com/balloob/Android-NFC-Tag-Writer

[5] Shane Tully. Writing Custom Data to NFC Tags With Android Example, December 2012. https://shanetully.com/2012/12/writing-custom-data-to-nfc-tags-with-android-example/

[6] Ralf Wondratschek. Reading NFC Tags with Android, May 2013. http://code.tutsplus.com/tutorials/reading-nfc-tags-with-android--mobile-17278