A Near Field Communication Framework for Indoor Navigation

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Abstract - Navigating indoors has resulted in a variety of research. However, the existing methods are complex and time consuming resulting in a high cost solution. Existing research has not been able to address these issues; this makes the usability of indoor navigation doubtful in developing countries. This paper presents a cost-effective method of navigating indoors using Near Field Communication (NFC) and adopting the Universal Design principles. The proposed system enables users to navigate indoors by tapping an NFC embedded mobile phone to an NFC tag. This study has profound implications for future studies of NFC and has potential to make indoor navigation ubiquitous.

Keywords - Indoor Environments, Indoor Navigation, Mobile Agents, Near Field Communication, Radio-frequency Identification, RFID tags

I. INTRODUCTION

With the advent of the mobile phone, computing has become increasingly mobile, ubiquitous and context-aware. Navigation is an interesting aspect of computing and mobility. It involves an individual finding his/her way around, in order to arrive at a desired destination. Global Positioning System (GPS) is widely adopted for outdoor navigation but has one flaw, it does not support indoor navigation [1]. Mobile indoor navigation systems guide users inside buildings by taking into consideration the current position of the user, the most suitable path and the destination of the user. Without proper guidance, a new student or visitor at a university campus may try to locate an office for a long time. With a good interactive indoor navigation system, locating their destination becomes easier. However, for physically challenged persons, navigating is not so easy. It is important that the navigation infrastructure be developed with them in mind. Research in indoor navigation explicitly points out the importance of navigation in our daily activities.

Indoor positioning systems are classified into six categories: Infrared, Ultrasonic, Radio-Frequency (RF), Magnetic, Optical and Audible sound [2]. RF positioning systems consist of Radio Frequency Identification (RFID), Wireless Local Area Network (WLAN), Bluetooth, Ultra-Wide Band (UWB) and sensor networks. WLAN technology for positioning seems to be more preferred. However, due to the high cost of these technologies [3], indoor usability in developing countries seems impractical.

RF-based indoor positioning technique determines object position using Received Signal Strength (RSS). The fingerprinting based positioning systems are carried out in two phases - offline and online phase. However, a serious shortcoming was that it is costly and time-consuming [4]. Because the positioning techniques based on RSS could sometimes be less accurate, Sayrafian-Pour and Perez [5] focused their research work on providing robust methodologies that could be implemented on a low cost infrastructure.

Ozdenizci et al [3] proposed an alternative, innovative, low cost indoor navigation system using NFC. Accuracy, usability and context-awareness are very vital in such systems. However, the design seems to be more focused on the navigation system than the user.

In this work, an indoor navigation system with voice, text and path integration is considered using the Universal Design (UD) principles. The Center for Universal Design defines UD as “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” [6]. The seven principles are: 1) Equitable Use 2) Flexibility in Use 3) Simple and Intuitive Use 4) Perceptible Information 5) Tolerance for Error 6) Low Physical Effort 7) Size and Space for Approach and Use. In addition, the proposed system can increase the mobility of users in developing countries when navigating in campuses, hospitals, shopping malls and large buildings. Increased mobility will make navigation for the physically challenged more bearable. This will be important since the use of wireless devices and services is still emerging in developing countries.

II. PROPOSED SOLUTION

NFC is an emerging technology that provides a seamless way of interaction between a user and his/her environment. It works in four ways: phone to phone, phone to device, phone to tag and phone to reader [7]. NFC has three main operating modes: card emulation, Peer-to-Peer (P2P) and reader/writer modes. The transmission range is so short that separating two devices breaks the communication between them. This suggests inherent security in the technology. Since the technology has a very short range of operation, it is considered hard to eavesdrop.

The goal of this work is to be able to navigate indoors using an NFC enabled mobile phone and a system that can be used by the physically challenged without trading flexibility for usability and vice versa. As denoted in figure 1, by tapping the mobile phone to the NFC sticker/tag at the entrance of the building, the Uniform Resource Identifier (URI), which contains the location of the map data, is read as noted in [3]. The map data is downloaded via mobile network. As soon as the navigation application in the mobile phone starts, it loads the map information and tells the user his/her current location (which is the location of the tag) and asks for the destination. As the user moves towards the destination following the path within the navigation application, he/she can tap any tag along the path to know his/her current location and if he/she is still on the right path.

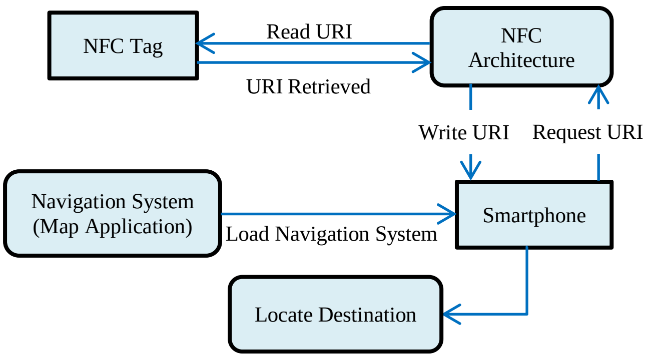

Figure 1: Flow diagram of conceptual framework

A. Methodology

This study will be organized in three parts:

1. Map Generation: OpenStreetMap (OSM) - an open source platform - is considered for the implementation of this work. In order to develop the map data, map matching is done using OSM. The map of the test bed building is in OSM, and porting applications and tools with OSM will be easily achievable. Java OpenStreetMap (JOSM) editor is a tool that can be used to create and edit indoor maps; another is Potlatch. The piclayer plugin has been installed and used to ease creating of indoor maps. The floor plan of the test bed building is uploaded to JOSM and the edges are matched and aligned to the OSM map. Thus, nodes and links can be computed and the map data created. This map data will present details about rooms, doors, corridor and stairs. Physically challenged people can easily navigate indoors when they have a good map data. The map can be reused at any time, as it can be easily accessible on OSM.

2. Landmark-based method for positioning using NFC: This involves route calculation, presentation and communication. Various indoor navigation systems have been developed using existing technologies, however these technologies are quite complex and costly. Also, positioning accuracy is still an issue. Passive NFC tags are simple, cheap and accurate in positioning. NFC tags and toolkit will be used in this work. NFC Data Exchange Format (NDEF) will be used in writing data to the tags. This will be the next step in the implementation.

3. Navigation Framework: Navigation can involve the use of text, audio and visual path integration. Navigating with text is not interactive enough. Due to language barrier, navigating with audio alone may not be user friendly enough. This framework will use text, voice and path integration. The framework will use the Java and Android SDKs. It also includes using existing NFC APIs such as the OpenNFC, LinuxNFC, NFCpy and libNFC.

B. Equipment and Technologies

The NFC Forum has issued various specifications for NFC. These include NDEF, Record Type Definition (RTD), Logical Link Control Protocol (LLCP), connection handover and operations specifications for four tag types. The NDEF defines a common data format between NFC-compliant devices and tags. The RTD specifies rules for building standard record types. Five specific RTDs (Text, URI, Smart Poster, Generic Control, and Signature) are used to build standard record types. The NDEF, RTD and operations specifications for tag types will be used in this work. PandaBoard with its expansion board will be used to test the application. NFC tags or stickers will be used for location sensing. Pandaboard with an NFC dongle attached to it will be used as an end-user device. The NFC dongle will communicate with nearby NFC tags and location information will be displayed on the Pandaboard touch screen. Other devices (Tablet, PCs and mobile phones) that support NFC will also be used in the testing. Hence, the sensitivity of the various NFC devices will be reported.

C. Testing and Evaluation

This work will be tested for performance index considering technical, non-technical and human factors. In the technical factor, proximity performance of phone to tag will be observed, sensitivity of various devices and NFC tags will be noted. UD principle 5 will be used here. In the non-technical part, usability and flexibility of the system will be noted. In the human factor, the responses, views, adaptation and limitation of people to the technology will be observed. All UD principles will be used in evaluating the non-technical and human factors.

III. Conclusion

The aim of this research is to implement a cost-effective framework for Indoor Navigation. This approach needs extensive testing and development to consolidate its viability. A cost-effective NFC solution is beneficial for developing countries. A framework will be developed and implemented. The design will focus on a good user interaction in order to increase usability but not at the expense of flexibility. The next challenge of this research will be to create the indoor map of the test bed building with JOSM and OSM. Work with NFC tags and development of the navigation application will follow.

Acknowledgement

This work is based on the research supported by the National Research Foundation. Any opinion, finding and conclusion or recommendation expressed in this material is that of the author(s) and the NRF does not accept any liability in this regard.

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Wilson Sakpere received his B.Eng (Hons) degree in 2007 from the University of Ilorin, Nigeria and is presently studying towards his Master of Technology degree at the Cape Peninsula University of Technology, Cape Town. His research interests include Near Field Communication, Positioning and Mobile Navigation.