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Need Of NFC Technology For Helping Blind And Short Come People

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***Abstract* — *Near field communication* is a short range wireless connectivity technology, which is mostly used in mobile phones. NFC is typically based on *RFID* at 13.56 MHz and NFC operating distance extends up to 10 cm. *NFC* does not require line of sight and works in dirty environments. *Near field communication* operates in both passive and active modes. Near field communication doesn't only necessarily have to be something that makes it easier for people like you and me to pay and a cool way for us to view advertisements, websites etc. it can also be used as a great way to make the lives of the blind and handicapped much easier. NFC could be a great way for someone in a wheelchair to be able to pay for their goods without rifling through a bag or purse or having to rely on someone else to follow them around with money NFC can also work when one of the devices is not powered by a battery (e.g. on a phone that may be turned off, a contactless smart credit card, etc.).*

Index Terms - List key index terms here. No mare than 5.

I. INTRODUCTION

Key words: Indoor Navigation Systems for the Blind, RFID-based navigation, NFC-enabled phones, Blind, Navigation, Mobile Computing, QR codes, Web-Services.

Near field communication doesn't only necessarily have to be something that makes it easier for people like you and me to pay and a cool way for us to view advertisements, websites etc. it can also be used as a great way to make the lives of the blind and handicapped much easier. NFC could be a great way for someone in a wheelchair to be able to pay for their goods without rifling through a bag or purse or having to rely on someone else to follow them around with money.

One of the most important limitations for people with visual impairment is the inability of unassisted navigation and orientation in unfamiliar buildings. A low-cost indoor navigation system, which is based on mobile terminals, supporting technology Near Field Communication (NFC), and Java program access to Radio Frequency Identification (RFID) tags, is developed.

The proposed navigation system enables users to imagine the map of the rooms (dimensions, relative position of points of interest). This information is stored in RFID tags in WAP Binary Extensible Mark-up Language (WBXML) format. The system allows leaving audio messages that are recorded in RFID tags in Adaptive Multi Rate (AMR) format. Voice enabled navigation that is familiar to users with visual disabilities, is used.

Blind Shopping is a mobile low-cost easily-deployable system devised to allow visually impaired people to do shopping autonomously within a supermarket. Its main contributions are:

a) A user navigation component combining an RFID reader on the tip of a white cane and mobile technology, and

b) A product recognition component that uses embossed QR codes placed on product shelves and an Android phone camera for their identification.

Furthermore, it provides a web-based management component to easily configure the system, generating and binding barcode tags for product shelves and RFID tag markers attached to the supermarket floor.

The concept of Audio-tactile Location Markers (ALMs) as a remedy to the lack of accessibility in current tag-based applications. ALMs are an auxiliary enhancement for existing real-world tags, which propagates their existence and purpose to blind and vision impaired people in the vicinity.

Users can activate an audible signal based on a pre-selection of available tags (pull) or choose to be constantly informed about nearby tags (push). We evaluated both methods with blind and vision-impaired people using an NFC-enabled smartphone. Participants experienced no problems locating the ALM based on the audible signal, but required assistance with touching the tag. Pull was favored to push in specific Situations.

II. IMPLEMENTATION ON NEAR FIELD COMMUNICATION TECHNOLOGY FOR BLIND AND SHORT COME PEOPLE

The number of people with visual disabilities is around 135 million, of which 45 million are blind. For people with visual disabilities navigation in unfamiliar buildings is more difficult than outdoors, where mainly they rely on guide dogs and white cane.

The main difficulties in the indoor navigation and orientation are: missing known landmarks, overcoming obstacles can be risky, not all the blind can read Braille tags, and the price of the existing systems for indoor navigation does not match the purchasing power of the people with visual disabilities.

One of the major disadvantages of the existing indoor navigation systems for the blind is the high price of hardware part, which in most cases is not consistent with the income of blind people. The indoor navigation system for the blind is proposed, that ensures widespread use thanks to the integration of mobile phones from the middle price segments, Java technologies, and passive RFID tags.

RELATED WORK

There are two basic methods for indoor navigation:

1) Navigation based on information from sensors, which determine the position of the blind (piloting methods)
2) Find the current position of the blind based on information for the previous position and an estimate of velocity and direction of movements (path integration methods or dead reckoning).

Piloting:

This type of navigation is used by systems with infrared, ultrasonic and radio-frequency (RF) beckoning and systems, based on visual pattern recognition and visual and RFID tags detection. IR based navigation systems require special hardware part, which can receive signals from the IR transmitters witch have a fixed position.

The determination of position is based on the ID code of the nearest transmitter. Better results are obtained when using ultrasonic beckoning. For example, navigation systems Drastic have 22cm position accuracy. To calculate the position of blind metric Time Difference of Arrival (TDOA) is used.

Dead reckoning:

For the realization of this type of navigation Micro-Electro-Mechanical Sensors (MEMS) are used, which give an estimate of velocity, direction and height (electronic accelerometers, magnetometers and barometers).

This type of navigation systems requires adjustment of the position after certain time interval. The correction is realized most often through (D) GPS, A-GPS or Wi-Fi positioning.

Mobile devices are increasingly equipped with sensors (such as cameras or RFID readers), which enable new ways of interacting with digital information in the physical world. In the last decade a multitude of technologies for real-world tagging has been investigated, including visual codes and Near Field Communication (NFC).

Typical application scenarios include interactive movie posters, which allow the purchase of tickets and museums equipped with tags for interactive exhibition guides. Both scenarios allow users to trigger an action by touching a tag in the physical environment with their mobile device (typically a mobile phone).

Since the introduction of NFC-equipped mobile devices on the mass market, a variety of commercial Applications have been deployed in the field.

For example, travelers on the Vienna underground are able to buy train tickets using their mobile phone1. A pilot project at the island of Sylt (Germany) enabled people to access a local information portal using NFC tags attached at various locations, such as bus stops, tourist information offices, and sights. These examples show that NFC applications have developed beyond custom-built solutions for a specified set of users, such as property management or manned guarding. Now that these types of applications are becoming more common, it is important to consider their accessibility.

Accessibility describes the degree to which a device or environment is available for every person. Nowadays, this term is more and more present in our society, as it is considered a fundamental right. On the other hand, technology seems to be invading every aspect of our lives, but it is also moving away from or not giving service to those collectives which most need it.

Mobile devices are transformed into sense enhancers giving a 6th sense to those who already enjoy their five functional senses, but more importantly, complementing those which have some sensorial impairment.

One of the concrete application domains targeted by PIRAmIDE is overcoming the difficulties blind people usually encounter whilst shopping in a supermarket without the help of someone else. This paper presents an inexpensive easily-deployable solution which makes use of off-the-shelf technology (mainly smart phones).

From our point of view, an accessible shopping solution has to fulfill the following requirements if a feasible and flexible wide deployment wants to be achieved: Blind Shopping

ENABLING ACCESSIBLE SHOPPING FOR BLIND PEOPLE

Conventional shopping behavior should not be altered.

Many available solutions require the user to establish her shopping list before initiating the purchasing process (planned shopping). In most cases, such an approach is more efficient but it is less enjoyable since the user, in this case the blind person, cannot actually browse the products of the supermarket, discover new brands or new product types, i.e. carry out opportunistic shopping. In fact, what we actually wish to do is mixed shopping, i.e. something in between planned and opportunistic shopping.

Minimal additional off-the-shelf infrastructure should be introduced in supermarkets.

Supermarkets are reluctant to introduce complex changes in their internal information management systems. Furthermore, only simple low-cost easily maintainable physical instrumentation of their purchasing surface including aisles and shelves is acceptable.

Any feasible solution should leave products as they are, i.e. such solution must be able of recognizing and deal with the standard UPC barcodes utilized in worldwide retail. It is a must that accessible shopping systems operate in actual supermarkets with all their restrictions.

Blind people should use their usual devices.

A blind person carries with her a white cane and a mobile phone. Therefore, if any, those are the elements that may be modified or enhanced in order to allow a blind person to safely and effectively carry out her shopping. Only inexpensive off-the-shelf already known technology by the blind should be considered to ensure wider acceptance.

INDOOR NAVIGATION SYSTEM FOR BLIND AND SHORT COME PEOPLE

The blind users are equipped with two ultrasound receivers, located on their shoulders. Ultrasound technology, except for determining the position of the blind, can be used and to detect obstacles on the road. Most often detection is based on the conversion of the reflected ultrasound signal to modulated sound or vibration.

The greatest uses have RF beckoning techniques. In this case finding the position of the blind is based on analysis of signals from wireless networks, such as: Bluetooth™, Wi-Fi and Ultra Wide Band (UWB). Accuracy is from 1m to 50m.

There are indoor navigation systems for the blind in which position of the user is determined by the position of visual markers or objects. In order to reduce the price of the system mobile phones with built-in photo-camera may be used. As example, Rohs describe a system that recognizes the **Quick Response** (QR) markers. There are navigation systems in which information from the video frames is converted to modulated audio signals or to vibrations. Navigation systems based on visual pattern recognition, are still in an experimental stage.

RFID is a technology that has many applications, such as: navigation, building management, logistics, enterprise feedback control, clothing, food safety warranties, health systems, library services, museums, retailing, and etc. The most of existing RFID-based navigation systems for people with visual disabilities used a grid of tags.

Such a solution has the following disadvantages: requires a very large number of RFID tags if in the building has tens or hundreds of rooms; the integration of the tags in the floor or carpets require a lot of money; low speed of movement due to the low speed of RFID tags reading; additional hardware is needed - RFID reader, that can be integrated into the end of the white cane or shoes.

One of the major limitations in all indoor navigation systems described so far is the high price, which in most cases is not consistent with the financial income of the blind. Part of the existing indoor navigation systems are too complex and work with them requires long training.

1. System design

The design of the application takes into account the preferences of the control group of 20 users with visual disabilities. We used an interview to help to identify specific problems of the target user group. The choice of the user interface is very important for people with visual disabilities. Research in this area indicates that blind and visual impaired prefer to implement navigation with verbal commands.

The blind people prefer to walk along the walls than the middle of rooms. The number of changes of direction should be minimized. The route should be constructed by short straight segments with 90° angle between them. The blind users can easily identify doors, walls, and stairs with white cane. It is proposed to implement the navigation from room to room. For this purpose RFID tags are placed on each door. The system recognizes two types of tags: navi tags, that contain navigational information and audio tags that contain voice messages.

For easier localization RFID tags are placed above (navi tags) and under (audio tags) the door handle. This solution has the following advantages: minimum number of required tags; finding RFID tags is easier because it is limited to finding the door handle; each door is a reference point. RFID tag for each reference point contains information about the location of all other reference points within the room. To overcome any obstacles the blind rely on the white cane and messages in audio tags.

2. System architecture

The main features of the application are: Speech navigation in Bulgarian and English; Automatic activation of the application when mobile terminal comes close to the RFID tag; Working with two types of tags - navi and audio; Intuitive navigation from the current position of the user. The architecture of the application is shown in Figure below:

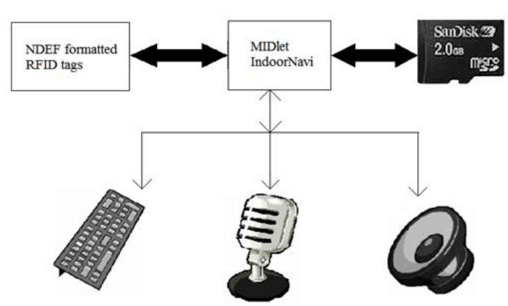

Figure 1 General view of application architecture

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Developed application uses the following access to hardware resources:

- NDEF formatted RFID tags, local FLASH disk of mobile terminal or external FLASH card, keyboard, microphone and speaker. To permit such access is necessary to deploy a signed MIDlet. The applications can be installed on mobile terminals that support: Profile MIDP 2.0/2.1 (JSR-118); File Connection API (JSR-75); Multi Media API (JSR-135) with enabled audio capture mode; Contactless Communication API (JSR-257).

- We use javax.microedition.contactless.ndef optional package to communicate with NDEFformatted RFID tags. The NDEF data transfer is selected because automatic activation (startup) of the application by the MIDP Push Registry is possible only for NDEF record types.

3. Navigational data encoding

```
<?xml version="1.0"?>
<tag>
     <pos>entrance</pos>
    <to>leaving-room</to>
     <dim>5.5x4</dim>
<object>
    <name>bedroom</name>
    <navi>L1 L3 R0.5</navi>
</object>
<object>
     <name>terrace</name>
     <navi>L1 L4.5 L3</navi>
</object>
</tag>
```

To enable description of any reference point in navi tags a self-describing data representation is sought. This implies the use of meta language which can describe any data types. Extensible Markup Language (XML) is most widely used language when platform independent transfer is needed. It allows the description of any type of user data and will therefore be used.

The main problem with XML in particular application is the limited size of the memory of RFID tags. XML would not allow compact data representation. To compress XML data WAP Binary XML (WBXML) format is used. The WBXML enables information for approximately 35-40 reference points to be stored in Mifare 4K tag.

Navigation is from current reference point to the target reference point. For this purpose we use the following commands: forward (F), left (L), right (R), backward (B), and staircase (S±n, where n is the number of floors). When L and R commands are used direction is changed 90° from the current user orientation and 180° - when command B is used. In the navigation process three metrics can be used: meters (command Um), steps (Us) and number of rooms (Ur).

By default, meters are used. For example, navigation string "F5.5 Ur L R5" means: go straight ahead for 5.5 meters, turn 90° left, and desired rooms the fifth in right side of the corridor.

The equivalent voice command is:

1) Go straight 5.5m;
2) Turn left;
3) Right side of corridor;
4) Count 5 doors.

Each navi tag contains the following information:

1. Current position of the user (XML tag <pos>);
2. Name of the room (tag <to>);
3. Dimensions of the room in meters (tag <dim>);
4. Name of reference points and navigational information to reach it (tags <object>, <name>, <navi>).

Example content, stored in the navi tags, is shown in Figure.

4. Program architecture

- Program architecture of the application in Unified Modeling Diagram (UML) format is shown in Figure.

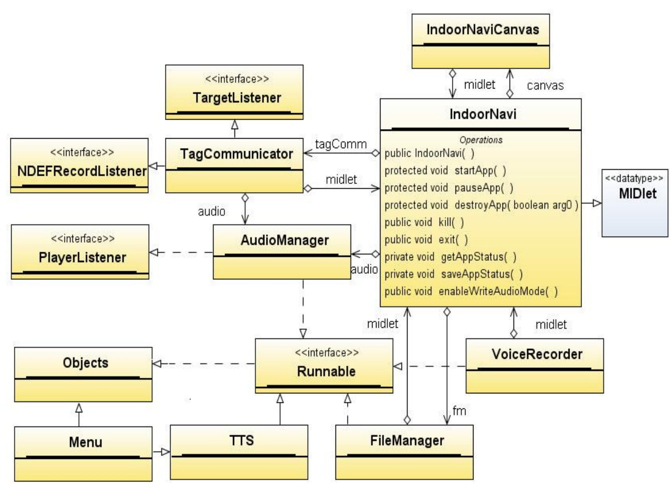

Diagram 1 UML class diagram

The description of the most important classes and interfaces is follows:

IndoorNavi base class is used for initialization and registration of the application. It is realized in body of the method startApp. Initially an object of class TagCommunicator is created. Then all other necessary objects, for the functioning of the application, are created.

Communication with RFID tags is implemented through class **TagCommunicator**. Its main task is registration of the application in the Push Registry if it has not yet been made. When RFID tag is detected method targetDetected is called. If the mode "audio recording" is enabled, and if tag is Mifare 4K and audio message is available, it content is saved on audio tag.

When NDEF record is recognized method recordDetected is activated. If the tag is navi type its content is read and decoded. This is realized through internal class **ParseXML**. Information for all reference points in the room is described by objects of class **Objects** (name of the reference point and navigation to it).

If the tag is audio type the user can: hear the voice message and date and time leaving, and delete message if he/she has necessary rights.

Speech navigation is realized by class **TTS**, which calls the necessary methods of class **AudioManager**. Class TTS provides static methods for word, sentence and digit to speech conversion. To each word, which the application support, corresponds resource AMR audio file. File specifications, corresponding to words, are saved in queue and wait for their processing. It is implemented in a separate thread.

To speed up the communication with RFID tags, data is cached on the local disk of the mobile terminal. When the application is started for the first time, the following folders are created: IndoorNavi/cache/audio and IndoorNavi/cache/navi. Caching is implemented by the methods of class **FileManager**.

When RFID tag with NDEF record is detected, the following information is extracted:

The record identification code (RID) the record date and time (eTag) and MIME type. The file specification is based on RID, eTag and MIME type. Audio messages are created by the methods of class **VoiceRecorder**. The mobile terminal must support Multi Media API and audio capture mode.

Interface is implemented by class **IndoorNaviCanvas**. It is maximally simplified and intuitive. By Left or Right Soft key application's menu is called. The menu is constructed using static methods of class **Menu**. Menu items are changed adaptively depending on the operation mode and events from RFID tags (Tag detected, Record detected).

In order to evaluate the performance of the application a series of experiments in hospital is conducted. RFID tags are placed on the doors of all rooms to which visitors have access (doctor's offices, manipulation, registration, toilets), including the entry-exit doors. The doctors can leave messages for their patients in audio tags.

The Concept of Floor –plan of the building

One of the most important limitations for people with visual impairment is the inability of unassisted navigation and orientation in unfamiliar buildings.

A low-cost indoor navigation system, which is based on mobile terminals, supporting technology Near Field Communication (NFC), and Java program access to Radio Frequency Identification (RFID) tags, is developed. The number of people with visual disabilities is around 135 million, of which 45 million are blind.

In every field blind people have to face some problems for finding any kind of information from the resources like from the person, internet, shopping mall, hospital, school, colleges and to reach the exact location every time blind person need the another person who is not blind.

For helping blind people there is an indoor navigation system though which blind people can easily go everywhere or catch the information without facing any kind of problems.

In indoor navigation system there is a floor-plan in which magnetic objects are fixed in every 5 cm distance on the floor of the building.

Now while entering in the building, with the use of white cane blind people can fetch those magnetic objects fixed in the building.

And also there is a sensor system though which blind people can easily find the exact location using audio clips.

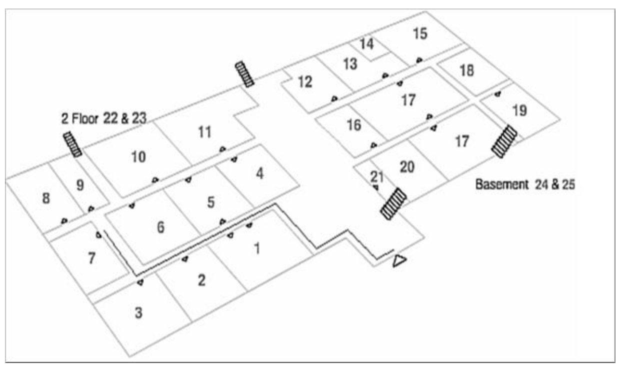

Figure 2 Floor-plan of the building

THE BLIND SHOPPING PLATFORM

Our solution aims to offer eyes-free technological support for blind people to shop around as if they saw, without altering conventional shopping patterns. It is designed to avoid overloading the visually-impaired person with additional new

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gadgets and enforcing a supermarket to go through heavy and costly, both in price and time, installation and maintenance processes.

The assumptions taken by Blind Shopping regarding a supermarket organization are as follows. First, it is considered that all products are grouped into different product categories (e.g. drinks), and these are divided into product types (e.g. drinks/cola) which again are divided into concrete brand products (e.g. Pepsi can).

Apart from that, the supermarket is divided into cells of two main types: cells containing shelves and passageway cells. Thus, internally, Blind Shopping maps the IDs of the RFID tags within a cell to navigation and product location information such as the type of a given cell, its neighbor cell types, and in case of being shelf type cells, the product category, types and concrete products located in that area.

Blind Shopping offers infrastructural support for the whole purchasing process within a supermarket, understood as a four step cyclic process:

1. **Product category navigation**
2. **Product search**
3. **Product identification**
4. **Product selection.**

Such cycle is broken when the user decides to go to the cash till to pay for her purchases. Consequently,

Blind Shopping offers a **navigation component** driving the user through voice messages to the aisle where a product category previously dictated to her smartphone is located. Once there, Blind Shopping also offers support for **product recognition** by either shelf section identification or product own identification by means of **QR** or **UPC** code scanning, respectively.

Figure 3 Navigation system (left), UPC code recognition (middle) and QR-code recognition

Blind Shopping Architecture

- The distributed component architecture of Blind Shopping is composed of the following three components:

1. **Navigation system.**
2. **Product recognition**
3. **System management**

1. Navigation system.

It is in charge of guiding the blind user inside the supermarket. It provides through a headphone connected to her smartphone simple verbal navigation instructions. It combines a white cane with a portable RFID reader attached to its tip, a set of road mark-like RFID tag lines distributed throughout the corridors of the supermarket and a smartphone application processing the RFID readings received though Bluetooth and generating user navigation verbal commands as result.

RFID tag marking (top), Motorola Milestone and HTC Desire Android devices (left), Baracoda's Pencil2 barcode recognizer and IDBlue RFID reader (middle), NFC 6131 NFC device (right) and QR-Code and standard UPC barcode (bottom center)

2. Product recognition

Once the user reaches the target product section, she points with her camera phone to an embossed QR or UPC code attached to a shelf section or product. The smartphone camera recognizes that code and then informs verbally about the product main features. Note that a QR code can encode up-to 4296 alphanumeric characters, and its redundancy makes successful reading possible even when partial images of them are captured.

3. System management

Blind Shopping includes a web front-end for Blind Shopping RFID and QR code infrastructure management. It allows the registration of the collection of RFID tags scattered though the supermarket floor and the QR codes attached to products or shelf sections.

<u>IMPLEMENTATION DETAILS</u>

A Nokia 6131 NFC was used, initially, for reading RFID tag floor markings and delivers them through a Java ME Bluetooth application to a user-carrying Android phone. An alternative implementation using the autonomous Baracoda Tagrunner1 RFID Bluetooth reader has then been used.

The mobile application in an Android phone allows the blind person to choose an action through a gesture interface or by issuing a voice command. Concretely, the navigation system operation is requested by drawing an "L" or issuing the "Location" voice command (see Fig. 3). Drawing a "P" or issuing a "Product" voice command, the user will access the product recognition component that allows obtaining information about a product.

A backend server contains the system data and business logic of the Blind Shopping platform. In a real deployment, this back-end should be integrated with the inventory management system of the supermarket.

Figure 4 User drawing a "P" (left) on Motorola Milestone, Nokia 6131 NFC to read HF RFID tag for navigation and supermarket mock-up for testing (right)

An exhaustive comparative study of existing accessible shopping systems for blind and visually impaired people was carried out by Kulyukin and Kutiyanawala in 2010. ShopTalk is a wearable solution that requires the user to carry a barcode scanner and a UMPC in a backpack. Verbal route instructions are issued through a headphone connected to the UMPC at the blind person's backpack.

Although the supermarket does not need to install and maintain any hardware, the system requires access to the supermarket's inventory control system and binding of product barcodes into supermarket locations so that guiding can be accomplished.

The advantage of Blind Shopping is that it only demands a lightweight smart phone equipped with a camera to read QR Codes attached to shelf sections and the very blind person's white cane enhanced with an off-the-shelf RFID reader.

A cost effective, RFID-based mobile indoor navigation application for the people with visual disabilities has been developed. Application combines the capabilities of modern mobile phones, allowing the creation of multi-modal interfaces and low cost passive RFID tags. It can be used for indoor navigation of people with visual disabilities (from room to room in hospitals, schools, universities, and etc.).

- The main advantages of the application are:
  - Low cost and widely accessible.
  - Simplified and intuitive user interface.
  - Automatic activation of the application.
  - Local info caching to speed up response.
  - Audio-enabled navigation.
  - User can leave audio messages.
  - Floor-plan of a building and communication with WEB server are not required.

Navigational information must be corrected if the user stray from the route between two reference points or get lost. This is easily feasible, if the mobile phone supports program access to an electronic compass and accelerometer. Currently there is no NFC enabled mobile phone, which has built-in compass and accelerometer. A prospective module "Electronic compass and accelerometer", which will communicate with mobile phone via Bluetooth™ interface, will be developed.

A basic usability study with a blind person has been carried out. She was requested to navigate through different sections of our emulated supermarket surface by using her white cane with an attached BT RFID reader and an Android application on an HTC Desire. Her main comment was that navigation was very intuitive since locating the RFID tag markings was very easy and the navigation vocal commands very useful to reach the desired target. She was then requested to assess whether locating embossed.

UPC barcodes and using a Baracoda Pencil2 device to recognize them (see center of Fig. 1) was easier or harder than using the Android phone camera to point to embossed QR codes located over products (see right hand side of Fig. 1).

She judged that the latter was much more plausible. Besides, QR code recognition using a camera phone is much faster and reliable. Blind Shopping is a low-cost easily deployable solution which makes a supermarket accessible to visually-impaired people through two core components:

a) An RFID and mobile phone based indoor navigation system and
b) A mobile QR-code based product recognizer. Future work will undertake a fully fledge evaluation in a real supermarket.

III. ALGORITHM

```
If (person enters into the building)
    If (RFID fetch the various locations)
        Person select shops or information about a choice of
        direction to various destinations through the objects
        fixed on the floor of building
            If (person enters into the shop)
                With the use of QR code person identify
                product and Use NFC Phone
                    If (tag data are in cache)

                        Read it
                    Else

                        Read payload data and decode to
                        XML format and write to cache

                    End if

                        Parse XML data and create
                        description object

                    If (delete command is selected)
```

Delete NDEF message from cache and tag

Else

Read the NDEF message

End if

End if

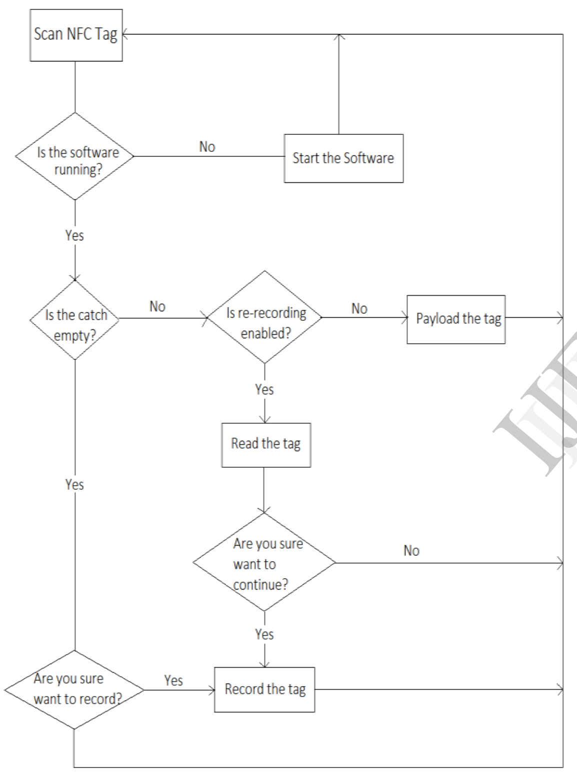
End if

Else

Person does not identify location

End if

IV. FUNCTIONAL FLOWCHART



Flowchart 1 Flow of NFC

V. NEXUS S NFC HARDWARE

Figure 5 NFC Devices and Chips

VII. CONCLUSION AND FUTURE WORKS

A cost effective, RFID-based mobile indoor navigation application for the people with visual disabilities has been developed. Application combines the capabilities of modern mobile phones, allowing the creation of multi-modal interfaces and low cost passive RFID tags. It can be used for indoor navigation of people with visual disabilities (from room to room in hospitals, schools, universities, and etc.). Blind Shopping is demands a lightweight smart phone equipped with a camera to read QR Codes attached to shelf sections and the very blind person's white cane enhanced with an off-the-shelf RFID reader. Real-world tags allow for a multitude of applications and are already being applied in commercial applications, such as ticketing and payment. However, they currently lack accessibility for blind and vision-impaired users due to their small size and visually driven affordance. To propagate the existence, location, and functionality of real-world tags, we developed the concept of NFC.

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