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NEAR-FIELD COMMUNICATION TECHNOLOGY FOR INFORMING BLIND AND VISUALLY IMPAIRED PERSONS WHEN MOVING THROUGH TRAFFIC INTERSECTIONS

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Today's development of services for mobile terminal devices based on Near-Field communication technology (NFC) are mainly used for payment models in the systems of e-commerce, data transfer or identification. Due to its technological specifications and user-friendliness, NFC technology can also be applied in the function of providing information to the blind and visually impaired persons. By transferring relevant information to the blind or visually impaired persons by using mobile terminal devices, the user receives accurate information, thus increasing the feeling of safety. Apart from the theory about NFC technology, this paper defines the architecture of information provided by the information service about the user environment. The information service is provided by means of development application solution for Android 4.3 and higher mobile operating systems, having done at the same time also the analysis of the security threats.

Keywords: assistive technology application, NFC tag, NFC, mobile terminal device, ICT

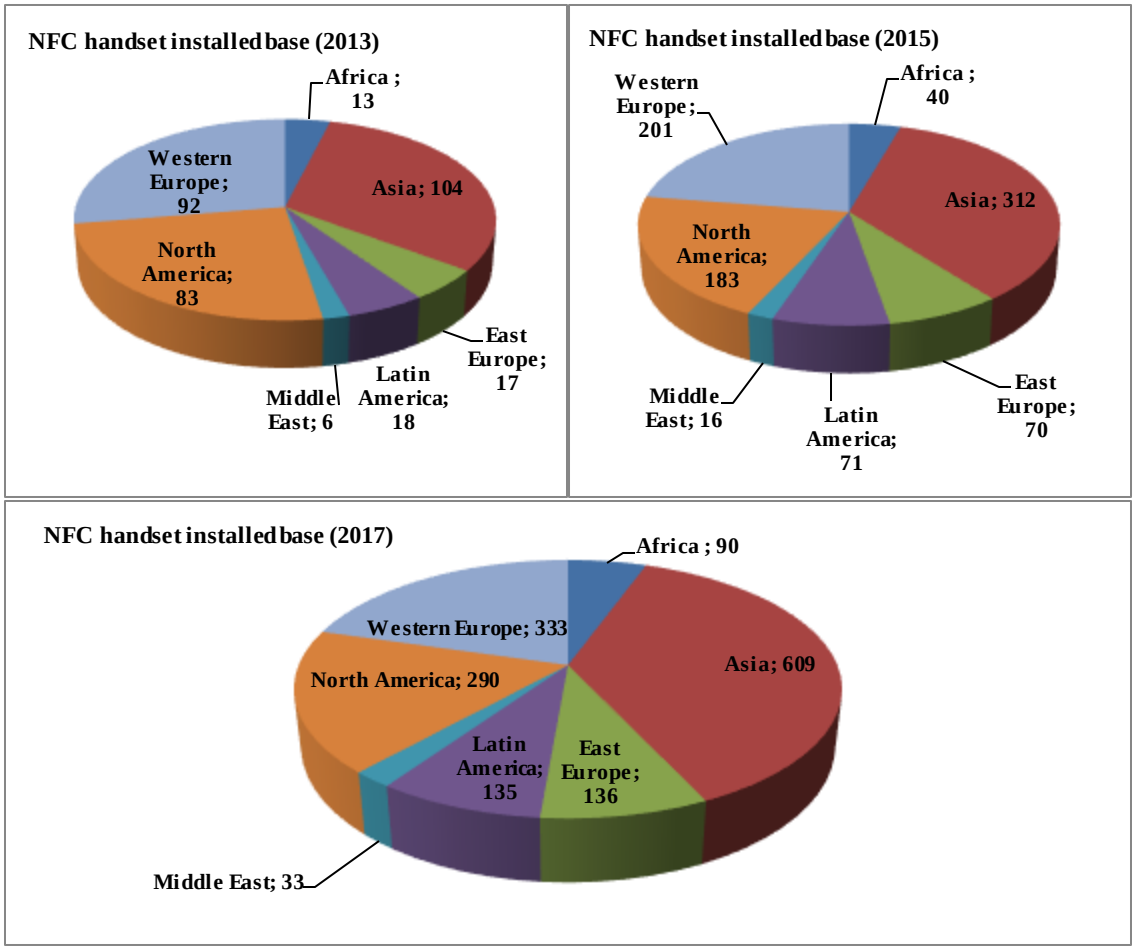
1. Introduction

Near-Field communication technology (NFC) represents a standard in two-way interaction between the devices, access to digital contents and connection of electronic devices with a single touch. NFC technology supplements many wireless technologies by means of key elements in the already existing standards (ISO / IEC 14443 A & B and ZIS-X 6319-4). In accordance with the mentioned standards the users can use their mobile terminal devices in different systems [Dudwadkar et al., 2013].

Today the development of NFC technology is used exclusively for the purpose of making the payments in the models of e-commerce, data transfer, management of web contents, etc. The application of NFC technology in mobile terminal devices and the possibilities it provides is described by the authors who clearly define the theory of NFC technology, as well as the data security protection methods [Dudwadkar et al., 2013]. The designing of applications for mobile terminal devices used in e-commerce has been described in the mentioned research where authors introduce a new paradigm of mobile cloud (SmartWorks) [Hong Youn et al., 2014]. The management of personalized services of multi-media contents is also possible by using the combination of NFC and Bluetooth technology which brings to the fore the contactless technology [Marilly et al., 2011]. In the traffic environment NFC technology is represented in case of: taxi transport, time announcement in case of buses and trams, tourist travel offers, peer-to-peer data transfer, emergency calls and location-relevant data [Burden, 2006], [Finzgar, and Trebar, 2011], [Widmann et al., 2012]. The penetration of NFC technology according to ABI research consortium is presented in Graph 1.

It shows clearly the expected share up to the year 2017.– clear explanation of the essence of the problem, previous work, purpose of the research and contribution. According to the latest official data from February 2014 in the city of Zagreb there are 1,961 persons of impaired vision, and out of this figure 171 users are employed and move independently along the traffic network of the city of Zagreb. For the purpose of this research 101 users out of the mentioned figure were included, which is 59% thus rendering the

sample relevant, whereas 84% of the users independently use the basic functions of the mobile terminal devices.



Graph 1. Share of NFC technology and its penetration up to 2017 [ABI Research, April 2013]

Information of the blind and visually impaired persons (users) is the basic principle in achieving an increase in the level of mobility for moving along the traffic network. In the City of Zagreb, as of 31 October 2012, there were 76 traffic intersections equipped with audio signalling, and there is a total of 698 signalling devices. The function of user information about how to manage a traffic intersection consists of audio and tactile information, and not all traffic intersections are equipped with these. The problem of the mentioned methods of information is incorrect information (turning off of the sound during night hours or during peak hours and tactile bands that fail to be in satisfactory condition). For this purpose this paper proposes the application of NFC technology in the function of informing the users about the environment and the architecture of relevant information provided to the user by the mobile application. The application has been developed with the NFC development KIT and tested on Samsung S4 mobile terminal device.

2. Near-Field communication technology

NFC Forum was founded in 2004 as result of promotion, implementation and standardisation of the new wireless technology of three companies Sony, Philips and Nokia. The development of NFC technology followed the globally accepted standards such as ISO, ECMA and ETSI standard. NFC is compatible with ISO/IEC 14443 and ISO/IEC 15693, Sony FeliCa contactless smart cards and with Philips MIFARE® (ISO 14443 A), and described by standard ISO18092. It represents the short-range technology (maximally up to 20 [cm]) resulting from RFID technology (ISO14443A/MIFARE/FeliCa) and Contactless Payment system. In this way, NFC can use the current RFID infrastructure without the need for additional technical specifications or requirements.

NFC supports in a standard manner different data transfer rates, in order to ensure compatibility between the existing infrastructure. Current data transfer rates are 106 kbps, 212 kbps and 424 kbps.

Near-Field communication technology represents a group of wireless short-range technologies presented along with other contactless technologies in Table 1.

Table 1. This is an example of a Table [Ali et al., 2014]

	NFC	**RFID**	**Bluetooth V2.1**	**IrDA**
Setup time	<0.1 [s]	<0.1 [s]	~6 [s]	~0.5 [s]
Transmission range	0.04-0.1 [m]	Up to 1 [m]*	10-100 [m]	0 -2 [m]
Communication	Two way	One way	Two way	One way
Maximum data rate	424 kbps	128 kbps	2.1 Mbps	16 Mbps
Security	Unsecured unless protected	Unsecured unless protected	Less secure	Very secure

(*Depending on the model: active passive, where the distances are then also bigger)

The basic advantage of NFC technology is the two-way data transfer which is reflected in establishing connection between two devices enabling automatic sending and receiving of data. Bluetooth technology also has the possibility of two-way communication, but for this it requires pairing of devices. The RFID and IrDA technologies in this sense represent one-way communication for sending of certain information.

There are currently two operation methods of NFC technology, passive (one-way) and active (two-way), the third method of operation (development one) in which the NFC handset is expected to communicate with the receiver which operates without powering, i.e. which will receive energy at the moment when the signal is brought to the receiver.

NFC technology is used for reading and writing data. Communication between two compatible NFC devices is possible when these are at a distance of about 5 [cm] from each other. When these two devices are in immediate proximity, or touch, NFC connection is established. This touch is not necessary because of the physical contact of two devices but it rather represents the method how to enable communication set-up. By bringing one device into proximity of the other, i.e. by their touch at the place marked for the touch the set-up connection protocol is opened and the connection is realized with the exchange of all the foreseen data in the exchange field which should not be outside the limits of 10 [cm].

NFC Forum has defined three basic communication operations of NFC standard: Peer-to-peer, Read/Write and NFC card emulation [Finkenzeller and Muller, 2010].

Peer-to-peer communication represents the way of communication between NFC devices. This method does not support contactless API communication.

Read/Write method of operation allows application exchange of messages that are defined as part of the NFC Forum standard. This part of communication has security drawbacks and as such represents the method which can applicatively be upgraded mainly regarding security. This method supports contactless API communication.

NFC Card emulation is a method which allows NFC mobile terminal devices to behave as standard smart cards. This part of communication is safe and supported by contactless API communication.

3. Information of users based on Near field communication technology

Today’s development of applications based on NFC technology can be divided into several categories: Touch and Go, Touch and Confirm, Touch and Capture, Touch and Link, Touch and Connect, and Touch and Explore [Finkenzeller and Muller, 2010].

Touch and Go - in this category we find applications such as access control systems, logistics reporting systems or security technology as well as ticketing systems. Here the NFC device behaves like a contactless smart card that contains an access code or ticket and has only to move quickly past the reader.

Touch and Confirm applications such as mobile payment where the user has to confirm the interaction by pressing a button or entering a PIN into the NFC device.

Touch and Capture here, the NFC device is located close to the transponder (smart label) which for instance can be attached to a smart poster. The NFC device can search transponders for information such as phone numbers or a URL for further information.

Touch and Link applications that require online connection of the NFC device. Data read by the NFC interface are forwarded via an online connection (GPRS, UMTS) to a server. The server can process these data and send back information to the NFC device where it is shown on the display.

Touch and Connect - a connection of two NFC devices for transmitting images, MP3 files simply for matching phone directories of two NFC-enabled mobile phones.

Touch and Explore - it is possible to randomly combine the above categories. Touch and Explore allows the user to intuitively 'find and explore' new applications.

The mentioned possibilities of applicative solutions for mobile terminal devices are the starting point for the development of applicative solution for information of users about their location and environment.

3.1. The Modules of applicative solutions

Modules of applicative solution represent basic functionalities of mobile applications with the aim of informing and leading the user from the starting to the desired point. The modules are characterized by adaptability to the users' requests that are interconnected and represent the basis of the applicative solution.

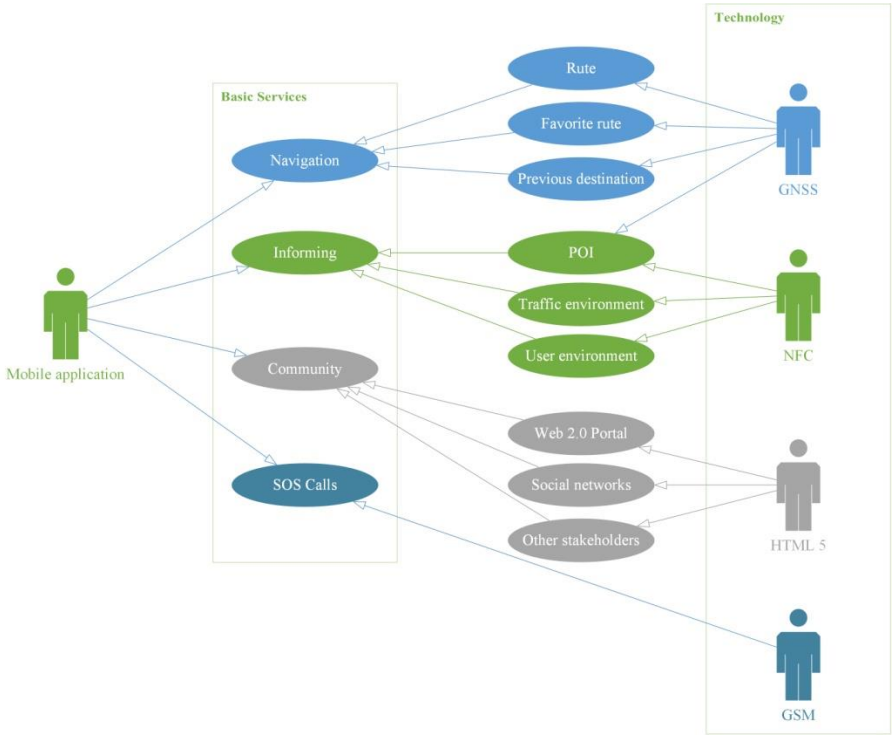


Figure 1. Modules of application and connection technologies

The modules are characterized by the following items:

- adaptability to the users' needs by configuring the module parameters;
- user-friendliness;
- standardized appearance of display and functions based on the elements of universal design;
- reliability as integrity of data established at the level of relation base of data connected with the dynamic Web 2.0 portal, and
- connection with the citizens information system.

According to data provided by the surveyed users, the users' requirements are directed to the following functions:

- possibility of offline/online operation of application (in offline operation the real-time user information is turned off);
- automatic recognition of the usage mode pedestrian/vehicle;
- voice control;
- input of interest points;
- elements of assistive technologies (colour, font, etc.);
- method of creating routes, and

- possibility of automatic creation of the return route.

The mentioned functionalities are the basic characteristics in the function of guiding and navigation of the users whereas the basic requirements for user information about their environment have to provide:

- accurate and understandable information about the environment that depends on the location of the user;
- information about further movement guidelines, determining the direction of movement;
- information has to satisfy all the elements from the process of performing the training of orientation and movement, and
- information about the traffic environment, intersection, or part of the network used by the user.

In the case of mentioned functionalities NFC technology has been planned for the methods and possibilities of informing the users. Figure 1 presents the modules of application of this connection technology which depend on the users' requests. The user uses NFC technology to obtain the information about the navigation at the traffic intersection and about the environment while moving along the traffic network. Information is contained in the NFC tag which can be found on the housing of the audio signalling indicator. The elements marked on the user movement section can also contain NFC tags and information important for the user – in this case the users get information about their environment. The mentioned method of information increases the users' level of safety and orientation. The points of interest (POI) are also important for user information; they mark all the major elements on the movement route that the user has defined by web interface or while creating their own routes based on GPS technology.

3.2. Information architecture of providing user information service

The architecture of information that is provided to the user depends on the users' requirements. Users' requirements create the priority information important for safe and independent movement of the users. Proper architecture of information provides the user with faster and easier search of relevant information, creation of movement routes, methods of information while moving along the traffic network elements and customized contents.

Information provided by the user information service contains all the elements of universal design which is the basic principle for independent participation of the users in everyday life. This refers to the unbiased possibility of usage, equal methods of usage for all users, flexibility, conspicuity, low physical or mental effort and toleration of errors.

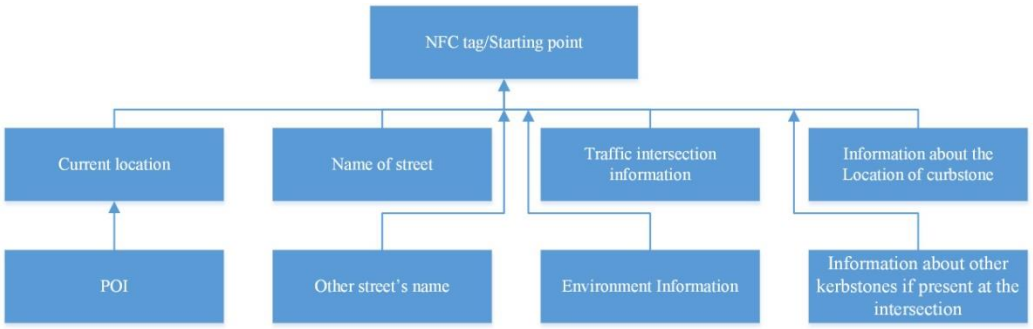


Figure 2. Architecture of information in NFC tag

By using their mobile terminal devices the users receive information in the following form:

Direction of movement north-south Šubićeva street, oblique pedestrian crossing, body posture 30° to the right, three lanes east-west, two lanes of tramway tracks, pedestrian island, three lanes west-east.

The mentioned information consists of the current location which is indicated by the cardinal points of compass (north, south, east, west and derivatives) and the name of the street which is within the user's environment. The information about the traffic intersection describes all the elements of which the traffic intersection consists with the description of the direction of the vehicle movement. The direction of the vehicle is also described by using the cardinal points of compass. If the intersection configuration has a certain trigonometric form or the pedestrian crossing is set at an angle then these data also have to be

included in the information provided to the user. The distance of the kerbstone is defined by the users using the aids (white cane or guide dog), where the mentioned information in NFC tag is of informative significance. All the mentioned information is presented in Figure 2, which shows the basic information necessary for safe orientation of the users at the traffic intersection.

The solution has been developed by NFC Solutions Development package [IdentiveNFC.com, 2014]. The development package consists of software applications based on SCM Microsystems thus enabling the development of applicative solutions based on ISO14443, Mifare and Felica standards. Cards and tags that were used during the development and testing are:

- TOPAZ;
- NTAG 203 Mifare Ultralight C;
- DESFire EV1, and
- SLE66R32P.

The data were recorded through software solution, whereas the applicative solution has been developed on Eclipse ADT bundle development environment for Android operating systems. The application was tested using Samsung Galaxy S4 mobile terminal device. The system architecture is presented in Figure 3.

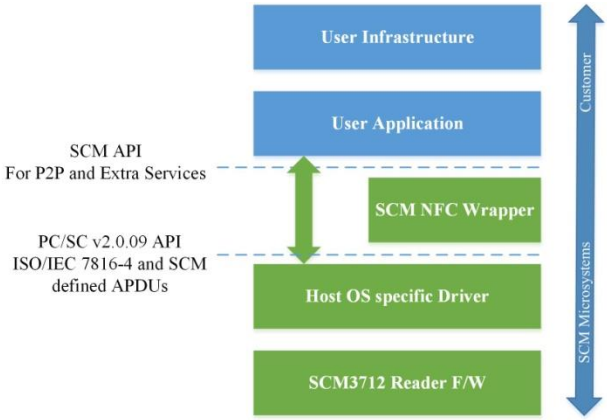


Figure 3. Architecture of the system based on NFC technology

The mentioned architecture allows data to be recorded into all the mentioned NFC tags and their reading for all the devices that are prescribed by the NFC Forum. The applicative solution uses all the elements of assistive technologies and their accessibility and suitability was tested by the users.

4. Security of NFC tag data

NFC technology represents *short-range* communication protocol which is also faced by security threats. The possibilities of attacking NFC technology can be performed by interfering with the RF signals which represents physical attack or unauthorised entry to an NFC tag [Infosec institute resources, 2014].

Today's tags install security certificates into the chips, and they are not part of the major NFC specifications that define the tag itself. The main objectives of data protection include: authenticity, integrity, and confidentiality. Data confidentiality is achieved through the use of encryption of the very algorithm, whereas authenticity and integrity are realized through adopting the signature process. Satisfying the degree of authenticity and integrity as such requires satisfaction of NDEF (NFC Data Exchange Format) structure prescribed by the NFC Forum. The methods of attacking NFC technology are divided into: Eavesdropping, Data Modification, Relay Attack, Data Corruption, Spoofing, Man in the Middle attack and NFC Protocol Stack Fuzzing.

When developing an applicative solution the authors have used protection methods for the attacks such as: Data Modification and Data Corruption.

Data Modification – the attacker attacks the data by using Radiofrequency - RF device thus stopping data exchange. The attack is of short duration but nevertheless sufficiently long to change the binary coding. The mentioned attack is very difficult to perform and it belongs to the group of rare cases.

The most frequent method of disturbing or interfering with NFC data exchange is by using RFID jammers. The change of data can be discovered by introducing a code in the device which uses NFC technology by measuring the power of frequency of NFC source of signal thus allowing verification of RF field which reads the possibilities of attack. The other possibility refers to the change of data via receivers which is the carrier of certain RF signal bits. The success of the mentioned attack depends on several factors such as the forces of amplitude modulation.

Data Corruption – form of attack by denying the requested service or DoS attack in which the attacker disturbs data transfer by blocking the flow by not performing data decoding. The attacker in this case sends radio signals that destroy the information content within the communication protocol. As protection the verification of RF signals during data transfer is introduced which makes it possible to automatically stop data transfer in case of attack.

5. Conclusions

In the mentioned research the possibilities of NFC technologies are analysed from the aspect of informing the users about their environment by using applicative solution for Android mobile operating system. According to statistical indicators an increasing use of NFC technology is predicted and therefore in further development the mentioned solution is expected to find its application in real environment. While testing the applicative solution the users were provided with the requested information in a defined format, thus allowing accurate and clear information. Accurate information raises the level of security during the movement of the users along a part of the traffic network which is equipped by solutions based on new technologies.

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