Mobile Identification: NFC in the Healthcare Sector

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***Abstract*— In the midterm future Near Field Communications (NFC) is expected to spread up within the healthcare sector. This article reviews the use of NFC in the healthcare sector. Application areas, use cases, potential benefits and barriers, will be presented. The present study provides guidance for researchers in adopting and deploying NFC in medical sector. The main healthcare and security applications are patient's identification and medication control. NFC can also be used in deploying resource control, management and data acquisition and remote delivery applications. The main benefits of NFC are: improvement of care quality, existence of standards and applications with friendly human interface. The main barriers are: limited availability of mobile phones with NFC, deployment costs, security, technology limitations and support of the health centre staff.**

***Index Terms*— Near Field Communication, healthcare, Mobile Identification.**

I. INTRODUCTION

Nowadays there is a general orientation towards the Information and Communication Technologies' (ICT) extensive usage at the productive and services sectors. The healthcare is between those sectors. One of the booming TIC-based healthcare services is the remote monitoring of patients. This healthcare service is accomplished by the deployment of personal area networks (PAN) or body area networks (BAN) using sensors and mobile phones [1]. The PAN and BAN systems consist of a device with several sensors for monitoring blood pressure, weight, blood glucose level, oxygen level in the blood, etc. The monitoring data is sent through wireless communication (such as Wi-Fi or Bluetooth) to the mobile phone [2].

Wi-Fi and Bluetooth are license-free 2.4 GHz frequency band technologies. Wi-Fi provides up to 300 Mbps links with around 30 mts of indoor reach [2]. Bluetooth it's a widely used technology in PAN. It provides up to 100 m reach and maximum link speed of 24 Mbps. Both technologies are normally available in a broad range of mobile phones and require user configuration [1].

Radio Frequency IDentification (RFID) represents another PAN technology. RFID was developed as an identification technology, but it has evolved towards monitoring and inventory management systems [3]. RFID works at several frequency bands. Thus the identification range varies within: centimeters for 125 kHz and 13.56 MHz and up to 10 m for 2.4 GHz. The RFID operation requires that a terminal device energizes a label; the energized label will be able to send its identification code. Therefore RFID can only be deployed in mobile phones when the 13.56 MHz is used.

The healthcare sector has been using different means for patients and medical devices identification. Today, identification is generally done manually, which is why identification errors occur. Such errors frequently result in serious mistakes when carrying out vital activities such as medication, blood transfusions, clinical trials, surgery, and a variety of other medical procedures. The use of automatic means as graphic one-dimensional (1D) codes, RFID, two-dimensional (2D) graphic codes has been tested and implemented in some healthcare centers to mitigate these errors [4]. A new possibility is the use of NFC as identification mechanism.

Near field communication (NFC) is an emerging technology which operates at the 13.56 MHz band. This technology is penetrating the healthcare sector driven by the mobile phones boom. NFC allows the short range information exchange between two devices and the terminal identification based on the ISO/IEC 14443 standard, supported also by RFID. NFC applications are oriented towards auto configuration of terminal devices. Thus, NFC facilitates and encourages their terminal devices usage by non-technical users, through technological barriers elimination [1]. In recent years NFC has been primarily deployed in access control systems, users' identification and as electronic or mobile payment (also known as mobile money, mobile wallet and mobile transfer) [5]. In this article applications, use cases and the main drawbacks of NFC in the healthcare sector, will be presented.

II. NEAR FIELD COMMUNICATIONS (NFC)

A. Review Stage

NFC is an RFID evolution, specifically contactless smart cards and interconnection technologies. NFC operates in the 13.56 MHz frequency band with transmission rates up to 464 Kbps. It works with very low power levels; thus, devices must be in a very short-range (less than 10 cm). Current mobile phones already have NFC technologies; therefore, its usage has been driven by the mobile market boom [6].

NFC devices have three operation modes:

- Peer to peer mode: used for bidirectional

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communications between NFC devices; e.g., personal data exchange between two mobile phones with NFC.

- Card emulation mode: the device behaves as a contactless smart card, and it is not possible for the reader to differentiate between a smart card and the NFC device. This is achieved by meeting with ISO / IEC 14443 standard for contactless smart cards [7]. The card emulation has been used for payment application and the development of "virtual money".
- NFC read/write mode: it allows for reading and writing the content in the labels or transponders. This mode is widely used for customer loyalty and geographic localization by locating NFC labels in some points of the customer path [8].

The NFC operation modes are depicted in Fig. 1

Figure 1 NFC operation modes.

As there is an NFC operation mode which emulates RFID, Table I shows a comparison between both technologies.

TABLE I
NFC AND RFID COMPARISON

	RFID	NFC
Operations Modes	Half Duplex o Full Duplex	Full Duplex
Information Exchanged	Only one code, prerecorded or user definable	Variable, depending on the operating mode of application
Frequency Operating Range	125 KHz, 134.2 KHz, 13.56 MHz, 433 MHz, 860-960 MHz, 2.45 GHz	13.56 MHz
Exchanging Distance	From 10 cms and 1000 cms	10 cms Maximum
Standards	ISO, Transmision Interface Only	ISO, Transmission and Protocol and Protocols and Protocol Testing Interface
Terminals	Specific frequency range and manufacturer	Mobile Phone with NFC
Cost	Medium- High	Medium-Low
Transmission Rates	80 Kbps, 160 Kbps, 320 Kbps o 650 Kbps	Between 106 Kbps and 464 Kbps

From Table I, it can be seen that the main difference is between the information to be exchanged. In RFID the information exchanged consist of a unique code, while in NFC the information exchanged depends on the operation mode. Normalization process and the technology usage are promoted by the NFC Forum, through ECMA INTERNATIONAL [9], through ISO (International Standards Organization) and ETSI (European Telecommunications Standards Institute). Table II lists the NFC standards developed until today.

III. NFC APPLICATION AREAS

A summary of NFC healthcare applications gathered during this work is shown in Fig. 2. The application where arranged based on the following objective functions: Healthcare and security, administration and inventory, and data acquisition.

A. Main healthcare and security applications

Patient's Identification: involve placing a tagged-wristband in the patients. Medical staff can access patient's information stored in the tagged-wristband using a mobile phone. Another approach is to access patient's information stored in a centralized server [11]. NFC is used for identification of newborn babies and patients undergoing surgery [12]. Patient's identification is also used for nursing students. In this case; based on doctor instructions, a mobile phone application gives specific cares and attentions for each patient to the students [13].

TABLE II
NFC STANDARDS [9] [10]

Subject	Date	ISO Standard	ETSI Standard	ECMA Standard
NFC- Interface and Protocol (NFCIP-1)	2004 (2d. Edition)	ISO/IEC 18092	TS 102 190	ECMA-340
NFC- Interface and Protocol (NFCIP-2)	2005	ISO/IEC 21481	TS 102 312	ECMA-352
NFCIP-1 Testing Methods RF Interface	2005	ISO/IEC 22536	TS 102 346	ECMA-356
NFCIP-1 Testing Methods Protocol	2005 (2d. Edition)	ISO/IEC 23917	TS 102 394	ECMA-362
NFC- Wired Interface (NFC-WI)	2007	ISO/IEC 28361	TS 102 541	ECMA-373
NFC-SEC: NFCIP-1 Security Services and Protocol	2010	ISO/IEC 13157-1		ECMA-385
NFC-SEC-01:NFC-SEC Cryptography Standard using ECDH and AES	2010	ISO/IEC 13157-2		ECMA-386
Front-End Configuration Command for NFC-WI (NFC-FEC)	2011	ISO/IEC 16353		ECMA-390
Memory-Spot Interface and Protocol (MSIP-1)	2009			ECMA-391

Medication's Control: several proposals have been done within this objective. In [14] is proposed an NFC-based prescription system for elderly patients. The system uses simple drawings console and the patient mobile phone to send the medication request. The doctor receives the request information, and based on the patient's medical history sends the new prescription. At the drugstore the pharmacist can access to the elderly patient's prescription.

Another medication's control proposal is presented in [15]. The authors propose to tag the drugs with NFC labels. By using a mobile phone the drug's information is presented to the user graphically and audibly. This is achieved by a mobile phone application which converts text to voice. The former proposal is complemented by a system to determine; based on patient's medical history, if any component of the drug selected by the patient may cause allergies or other damage [16].

B. Resource control and management applications

Access control: it consists in the access control to specific area, based on the NFC contactless card function (e.g., a patient's room with forbidden visits).

C. Data Acquisition Applications

Terminal Exchange: it is proposed to reduce the data exchange time at the medical staff shift changes [11].

Data Collection for Remote Delivery: data can be collected form sensors (passive or active sensors) using sensor networks. The collected data can be transmitted by the mobile phone networks to central servers for future use or analysis [17]. The sensors send the information to a mobile phone terminal and it can be access only by the medical staff using another mobile phone with NFC [18]. Sometimes, the information from sensors is send using higher reach technologies like Bluetooth [1]. It has established a standard for sending information from a mobile phone to a central server [5].

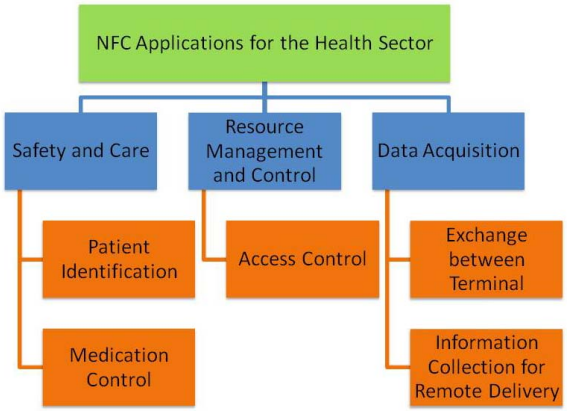

Figure 2 Healthcare sector applications.

IV. Advantages of NFC Adoption in Healthcare Sector

In this section the areas benefited from the use of NFC in the health sector are presented:

D. *Patient's Security and care*

Improves in patient's security and care translates to real-time automated tracking in healthcare centers. Thus, an important error reduction is achieved in treatments and medication applications, improving the provided care quality. NFC technology allows the creation of a monitoring tool that allows keeping the quality of care regardless of the people who provide it.

E. *Leadership in Healthcare*

A current need is the creation of an action-based leadership, where quality represents the leader's main support. Thus in the short to medium term, improvements in health indicators using new technologies; particularly NFC, are expected to spread up.

F. *Existence of Standard*

Recognized standards and interoperability between NFC and more powerful current technologies, makes easier to use and incorporate NFC applications in the health sector. The fact that ISO, ECMA and ETSI endorse the NFC standards strengthens the development and adoption of this technology.

G. *Friendly Human Interface*

The human interface used by NFC is highly simple and intuitive. This is based on the fact that for fast and user friendly operation a mobile phone application must be simple and easy to operate. Mentioned advantages for the use of NFC are shown in Fig. 3.

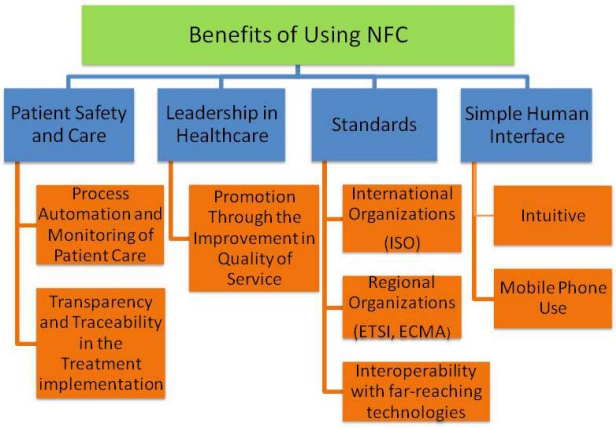

Figure 3. NFC benefits

V. Negative Aspects of NFC Adoption in Healthcare Sector

Despite of advantages of using NFC, there are delay factors for the intensive deployment of NFC applications in the healthcare sector. Some factors can be categorized as obstacles. Other factors create uncertainties about whether or not the emergent expectations will be cope by NFC. Obstacles and uncertainties are shown in Fig.4.

A. *Obstacles*

The main obstacle is the Information and Communication (ICT) Technology Infrastructure in health centers and its related costs.

Within the ICT infrastructure as the first problem emerges the limited availability of terminal devices with NFC. Some mobile phone manufacturers have been reluctant to NFC incorporation. However, in 2011, major manufacturers like Apple, Blackberry and Samsung have made announcements of NFC incorporations as part of their terminals [19]. It is just a matter of time for the Common use of NFC.

An important point is the incorporation of the NFC-acquired information to the different systems and records of the sector. This incorporation involves the creation and modification of current applications. Thus it represents additional costs to be considered for the NFC future use.

B. *Uncertainties*

Due to NFC is a novel technology, there are several concerns about the technology and its use (e.g., the information security and its related impact on the healthcare sector's culture). Regarding security, to read the information NFC requires bringing devices almost touching. Thus it gives a relative safety perception. However, there is still no way to prevent the information reading and modification by

unauthorized users.

It is important to have the support of all the health center staff. This is a necessity to achieve a correct use of the system, and to perceive it as a quality improving tool for the healthcare center. This last point is perhaps the most complex uncertainty in considering implementation of a NFC system. However, there are experiments which show that this problem can be overcome with proper preparation [12].

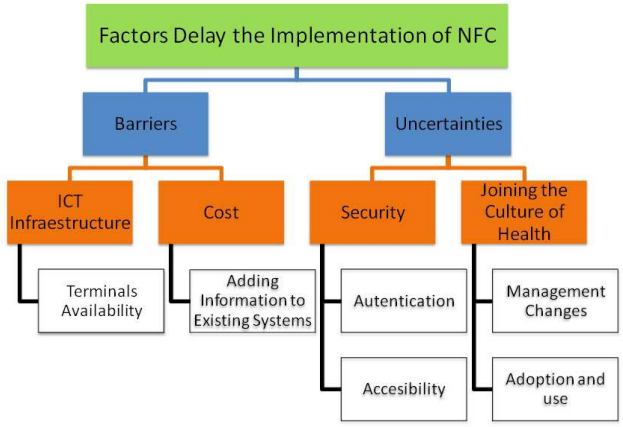

Figure 4 Delay Factors for Deployment of NFC Applications in the Healthcare Sector.

VI. CONCLUSION

Several experiences developed by using NFC technology in the healthcare sector have been successful. Those experiences have allowed foreseeing a significant improvement in the quality of services using this technology. However, until the introduction of NFC technology in mobile phones is final, no benefits can be maximized.

The main advantages in the implementation of NFC in the health sector are: Safety and Patient's Care, Leadership in industry, Existence of Standards and Interoperability with far-reaching Technologies.

The lack of terminal and industry-oriented applications represents a barrier for the use of NFC. Uncertainties about its security and technological limitations by the medical staff are serious barriers to the successful implementations of NFC applications in the healthcare sector.

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