Medicines Identification for African Illiterate Patients using Near Field Communication

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Abstract. This paper presents the application of Near Field Communication (NFC) to the healthcare sector. Although a number of papers have been written to discuss different NFC applications in the healthcare sector, none of them address the potential challenges facing illiterate patients worldwide. According to UNESCO institute for statistics, the Sub-Saharan African region has the highest percentage of illiterate people compared to other regions in the world. NFC can be used in conjunction with other technologies, especially mobile communications which provide high data speeds at cheap rates. The proposed NFC application consists of a NFC sticker placed on the medicine container, the NFC phone with an Android application that reads the sticker ID, connects to a Medicine Information Server and retrieves relevant instructions for medicine in audio form. Some of the advantages for this solution are that the NFC stickers can be recycled.

Keywords: NFC, GPRS, EDGE, 3G, mutual inductance and Electronic Health Records.

1 Introduction

1.1 What is NFC

Near Field Communication (NFC) is a set of standards used to establish radio communications between NFC abled devices by bringing them into close proximity. There are many NFC devices in the market including latest smartphones. NFC standards including ISO/IEC 14443 and Felica are derived from Radio Frequency Identification (RFID) .The latest ISO/IEC 18092 standards were defined in 2004 by Nokia, Phillips and Semiconductors. The NFC standards are now overseen by NFC Forum with about 60 members. [1]

1.2 NFC Application

The use of Near Field Communication (NFC) has been adoption in a variety of payment systems, including bus fare, train and tickets in stadiums [2]. More implementations are expected due to its secure transaction process as a result of the short range of operation, i.e. the range is less than 10 cm. Moreover, a number of smart phones embedded with NFC technology is increasing at an exponential rate. As the prices of smart phones are also expected to drop due to high competition in smartphone industry, many people in developing countries are likely to afford at least one NFC smart phone per family.

NFC applications in different part of the world include but not limited to the following:

- Public transport
- Mobile payment
- Loyalty program
- Commercial services
- Mobile shopping
- Access control
- Employee payment
- Event ticketing
- Home healthcare
- Field Services

1.3 UNESCO Literacy Statistics

Good healthcare systems are necessary for wellbeing of all the people including the African population which is estimated at 863 million as per 2010 UNESCO general facts about Sub-Saharan Africa [3]. Table 1 shows the statistics regarding the world distribution of adults and youth literacy. From table 1, Sub-Sahara Africa has the lowest per cent of literate population compared to other regions of the world: 63 per cent of adults are literate and 72 per cent of youths are literate.

Table 1: The 2010 Global distribution of adults and youths literacy in per cent.

Region	Adult	Youth
World	84	90
Arab States	75	89
Europe	98	99
Central Asia	99	100
East Asia and the Pacific	94	99
Latin and the Caribbean	91	97
South and West Asia	63	81
Sub-Sahara Africa	63	72

The mobile phone signal coverage in Africa consists of a number of technologies that complement each other. These technologies are general packet radio services (GPRS), which offers data speeds of 56 to 114Kbit/s. The next technology is enhanced data rates for GSM evolution (EDGE) what supports speeds of up to 296Kbit/s. The latest technology that is available in rural areas is 3G and it can support speeds of up to 56Mbit/s. These technologies have enabled mobile devices to communicate with higher speeds and hence increased the amount of data that can be transmitted from one location to the other. The response time between the mobile devices when they exchange data has also increased due to new technologies in mobile communication.
The main purpose of this paper is to address medication identification challenges facing illiterate Africa patients using a combination of NFC and smart mobile phone technologies.
The rest of the paper is structured as follows; section 2 discusses Near Field Communication theory, active and passive modes of communication and modes of operation. Section 3 discusses a literature review of NFC applications in the healthcare sector, while section 4 discusses the proposed NFC medication identification for illiterate African patients and finally the conclusions are made in section 5.

2 Near Field Communications Theory

2.1 Basic

NFC is a short range wireless technology that operates at a distance less than 10cm. This short range mode of operation is considered very secure and as a result transactions are exchanged between devices using NFC. The basic working principle for NFC is based on the induced current between two coils placed next to each other. When a coil is placed in an area covered by a changing magnetic field produced by the first coil, a changing current gets induced in the second coil. The higher the coupling coefficient (as per equation 1) between the two coils results in more current being induced in the second coil [4].

$$K = \frac{M}{\sqrt{(L_f * L_s)}} \quad . \qquad \textbf{(1)}$$

where, M is mutual inductance between the two coils, and L_f and L_s are inductive values of the first and second coils respectively.
The application discussed in the previous paragraph is only true when the NFC devices operate in a passive mode. Only one device has power supply and its magnetic fields power the second device. The data communication between the devices in both directions is accomplished by using the magnetic field established between them [5], [6], [7].

2.2 NFC Active and Passive Modes of Communication

NFC employs two different coding to transfer data. If an active device transfers data at 106 kbit/s, a modified Miller coding with 100% modulation is used. In all other cases Manchester coding is used with a modulation ratio of 10%.

NFC devices are able to receive and transmit data at the same time. Thus, they can check for potential collisions, if the received signal frequency does not match with the transmitted signal's frequency.

Table 2 shows the relationship between coding scheme and NFC device communication mode.

Active Mode: in this mode both initiator and target devices provide their own power supply and create a magnetic field to transfer data between each other. Any device can be the initiator while the other will be the target. One device creates magnetic fields and the other device transfers data back to the initiator [8], [9] and [10].

Passive Mode: in this mode of operation only one device (initiator) has its own power supply to power the device and creates magnetic fields for the target device (tag) as well. Upon reaching the target, the magnetic fields induce current which gets rectified and powers the target circuit. The target transfers data back to the initiator using the magnetic field channel [8], [9] and [10].

Table 2: NFC active and passive device mode speed

Speed	Active Device	Passive Device
424 kbit/s	Manchester	Manchester
212 kbit/s	Manchester	Manchester
106 kbit/s	Modified Miller	Manchester

2.3 NFC Standards

NFC technology utilises the 13.56MHz frequency and is governed by ISO 18092 and EMCA 340 standards [1].

NFC Forum has defined four Tag types that are interoperable between NFC technologies and devices [11]. Table 2 shows the NFC types, corresponding standards they support and the maximum internal memory each NFC tag can accommodate.

Table 3: NFC standards and tag memory

Forum Type	Standard	Memory Size
Type 1	ISO/ IEC 14443A	2Kb
Type 2	ISO/ IEC 14443A	2Kb
Type 3	FeliCa	1Mb
Type 4	ISO/ IEC 14443A	32Kb

2.4 NFC Modes of Operation

NFC can operate in one of three following modes; Card Emulator mode, Peer to Peer mode and Reader mode [12].

- **Card Emulator mode**; in this mode mobile phone is used as a tag for external readers. This is applicable when mobile phone is used as a payment card.
- **Peer to Peer mode**; in this mode mobile phone interact with another mobile phone for transacting.
- **Reader mode**; in this mode mobile phone is used to read / write to external tags. This is applicable when mobile phone is used as a point of sale (POS) terminal.

3 NFC Related Work in Health Care

NFC technology has gained slow inroads in the healthcare industry. In this section, different healthcare applications based on NFC will be reviewed.

Devendran, Bhuvaneswari and Krishnan identified a need to use NFC technology in conjunction with an Electronic Medium Records (EMR) system. They proposed system can make the process of patient record keeping easier, more accurate and more efficient. Each patient is issued with a NFC tag that is read via a NFC reader connected to a computer for uploading patient information into an EMR system when the patient arrives at the hospital or clinic. The NFC data is uploaded with EMR information each time the patient leaves the hospital [13].

In addition, Devendran and Bhuvaneswari in their study of NFC and healthcare proposed a basic architecture for m-health services using NFC to facilitate the provisioning of healthcare to people using mobile phones. They highlighted that NFC and mobile phone technology can be used to allow individuals to report the following:

- Room, bed or medication identity using low cost NFC tags.
- Time, place or care giver identity by mobile phone
- Quick filling of multiple choice forms as an option for additional information.

These applications provide real-time feedback for personal care and help improve quality assurance in the healthcare sector [14]. In their paper, the authors suggested that their proposed solution can improve quality assurance in the healthcare sector by reducing clinical errors. However, errors in most cases are human by nature rather than system oriented. That means than no technology can eliminate errors entirely if the human users are not trained to use a technological system correctly. Despite having said that, one advantage with the proposed system is that it offers systematically quick information saving and searching.

Krishna, Sreevard, Karun and Kumar are of the opinion that NFC technology can be used for real time hospital patient management. They have considered an architecture that can be used across different departments of multi specialities in hospitals. The patient's information written on the NFC tag is read by the reader when the patient enters certain doors within the hospital. This approach saves time and cost with regards to opening a new paper based file each time a patient visits different healthcare facilities [15]. This solution is considered to have positive effect when patients go to emergency departments.

Jara, Zamora and Skarmeta presented the deployment of services in medical environments that can be carried out with NFC technology also. They highlighted the following NFC services in medical environments;

- External applications to the human body; these refer to mobile phones that manage electronic health records (EHR), collecting of data from medical devices.
- Internal applications to the human body (implants); these refer to NFC devices that communicate with implant devices to collect data, setting up parameters and power supply to recharge batteries. These are possible since the NFC works at 13.56MHz which is considered harmless to health and NFC operating frequency of 13.56MHz is common for all countries.

They concluded their paper by stating that in an effort to make NFC technology safe, cryptographic tags must be used to protect data stored in the NFC tags [16].

During their study regarding suitability of NFC for medical devices, Freudenthal etc. conducted a series of experiments using 15.56MHz tags [17]. They implanted tags within human cadavec and took measurements. Table 3 shows the dimensions of the tags that were successfully read.

Table 4: Dimensions of tags

Label	Length(mm)	Width (mm)	Area (mm^2)
Q	22	38	836
O	45	45	2025
C	65	34	2210
M	76	45	3420

Their experiments furthermore determined by implant depths within which the tag information could be read accurately are shown in Table 5.

Table 5: Results

Location	Depth (mm)
Below dermal fat	11
Below ribs	27 (including 11mm of dermal fat)
With skull	15 (including 6.5 mm skin and superficial fascia

Despite the successful experiments using implanted devices, the authors noted that for distributed systems the unintended personal disclosure for private information and corruption of data integrity can occur.

Morak, Schwarz, Hayn and Schreier discussed the feasibility of using m-health and NFC based medication adherence monitoring system [18]. Their system consists of smart medication blister, a NFC phone that connects to remote tele-monitoring service which passed data to physician’s phone via https protocol. Their system is depicted in figure 1.

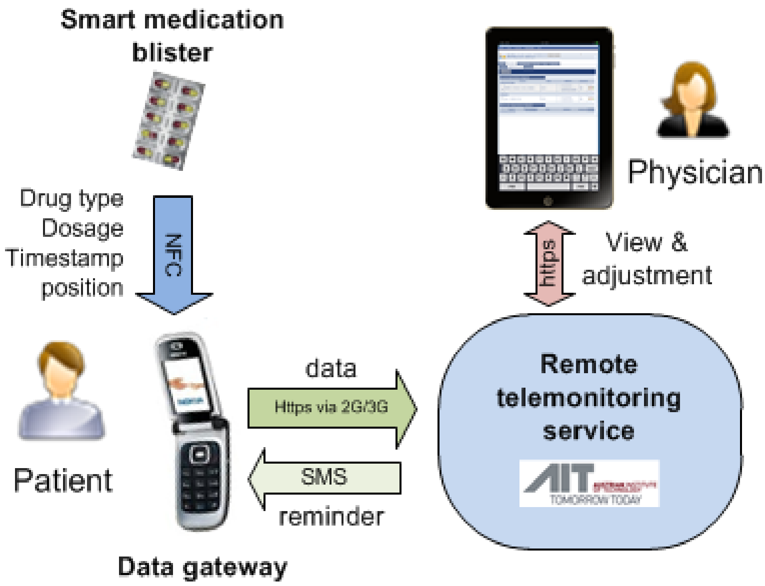

Fig.1. Medication adherence monitoring system

Based on the obtained results, they concluded that medication adherence monitoring based on NFC enabled medication blisters and mobile phone is feasible. However, they indicated that some improvements with respect to blister and the recycling processes are required before the system can be completely adopted in the industry.

4 Proposed Solution

The previous section has covered the different healthcare applications based on NFC technology. However, none of the applications cater for illiterate patients, which can be an issue when it comes to following the correct medication regimen.

The proposed solution as depicted in figure 2, consists of each medicine container having an NFC sticker with data stored in it. An illiterate patient with a NFC Android smartphone can tap the NFC sticker with the phone after activating a Medicine ID application from the phone. Then the NFC application reads the NFC sticker, connects to the Medicine Info Server via either of the channels (GPRS, EDGE or 3G) and Internet connections. The sticker ID is mapped to medicine ID and the corresponding wave file gets downloaded to the phone and plays the medicine dosage and instruction information.

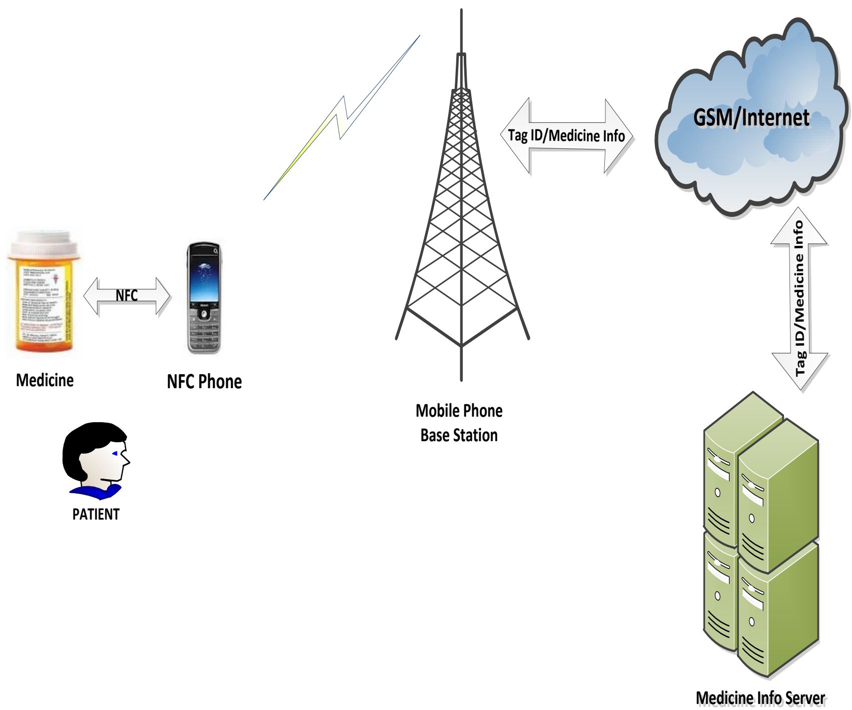

Fig.2. Overview of NFC based solution for illiterate patients using remote audio instructions.

The proposed solution can be very effective to illiterate patients since it can eliminate medication errors due to instruction and correct dosage. Moreover, the solution is flexible because the NFC sticker can be reused for other medicines and is easy to use. However, the patients have to take used medicine containers back to the healthcare centres. Lastly, the solution is cheap since it uses data rather than voice call charges.
In an effort to minimise the error of patients taking wrong medicines despite this system, the locally stored wave files in the smartphone will have to have the correct and appropriate logo.

5 Conclusions

According to UNESCO Institute for Statistics, Sub-Sahara Africa population is 863 million and has the highest per-cent of illiterate people in the world (37% and 28% for adults and youth, respectively). Based on the study of NFC and its application in healthcare, the following conclusions can be made. The NFC applications predominately used in payment systems is slowly getting relevance in the healthcare sector. The decreasing cost of smart phones and data usage are two major factors contributing to the increasing usage of applications in the mobile healthcare sector.
The benefits of the proposed solution can be summarized as follows;

- The solution will be useful for illiterate patients.

– The solution is simple and can eliminate medication intake errors.
– The solution is flexible since the NFC sticker can be reused for other medicines by updating the relevant information in the database.
– The solution is easy to use.
– The solution is cheap since it uses data rather than Voice calls. Moreover, mobile operators can be encouraged to offer free data connectivity to the Medicine Info Server as part of their social responsibility initiative.

Challenges and improvements of the proposed solution can be summarised as follows;

– The wave files stored in the smart phones can be replayed again and again without re-downloading them. But care must be taken so that correct files are played else the system will be counter effective. This issue can be resolved by using a wave file naming approach and logo.
– The patients will have to be incentivized to take back old medication containers to the healthcare centres so that NFC stickers can be reused.
– The major challenge is to design and populate the database with the medicines available in the country of application; however, that will be done once and only add new medicines when the need arises.

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