ORIGINAL ARTICLE

NFC Tags-Based Notification System for Medical Appointments

Quratulain Masud[1], Munazza Fatima[2], Razi Iqbal[3] *, and Awais Ahmad[4]

[1,2]*University of Engineering and Technology, Pakistan*
[3]*Lahore Leads University, Lahore, Pakistan*
[4]*Al-Khawarizmi Institute of Computer Science, University of Engineering and Technology, Pakistan*
(**Received** 23 May 2014; **Accepted** 16 July 2014; **Published on line** 1 December 2014)
*E-mail: razi.iqbal@leads.edu.pk
DOI: 10.5875/ausmt.v4i4.742

Abstract: In clinics and hospitals, whenever a patient visits a doctor, usually he arranges an appointment for his next visit. It can be quite difficult for some patients to keep track of these appointments, especially if they're irregular and widely spaced. Failure of the patient to keep the appointment is disruptive to the doctor's schedule. This paper adapts Near Field Communication (NFC) tags to automatically create alarms and notifications in the patient's NFC-enabled devices (tablet, cell phone, etc.). In the process, the physician or physician's assistant enters the appointment data to a database. This information is then wirelessly sent to the tag via an NFC read/write device. The patient then touches his NFC-enabled device against the tag to create notifications in the device.

Keywords: Near Field Communication; Passive Tags; QR Codes; RFID

Introduction

Near Field Communication (NFC) is a wireless communication technology that is used for transmitting information from one device to another at a very short ranges of around 10cm [1]. NFC is based on RFID, which is used to read information from a tag (passive or active) using a reading device. NFC provides excellent security and privacy by working in three different modes [2]:

- Read/write mode
- Peer to peer mode
- Card emulation mode

Hospitals and clinics are increasingly turning to modern technology to facilitate treatment and optimize patient management. Examples include the use of QR codes and RFID tags [3]. This paper explains a practical implementation of NFC devices in clinics and hospitals for improved patient appointment management. Effective patient management is critical to maintaining a high level of efficiency and safety in healthcare centers. Patients can usually be differentiated into two groups based on the nature of their visit: Frequent patients who rely on schedule appointments, and first-time patients or those without prescheduled appointments [4].

Patients frequently forget and miss doctor's appointments, disrupting both the doctor's clinical schedule and the patient's treatment schedule, and this break in treatment can be exacerbated if the doctor cannot quickly arrange for a replacement appointment. Multiplying these disruptions by multiple patients can easily produce chaos. Despite these issues, few innovations have been made in appointment scheduling systems, and today paper-based schedules are still the norm [5].

Certain technologies have been used to maintain continuity between doctor visits and minimizing strain on the patients who need to make frequent visits. Appointment systems based on QR codes assign each

patient a QR code tag providing quick access to specific information, including appointment times and locations. However, such systems can be rendered unusable by damage to the QR tag, and such tags can't be overwritten for reuse. NFC devices, by contrast, can provide such information in a safe and economic way, but can also be overwritten and recycled, thus reducing overall operating costs.

Quratulain Masud is a graduate student in Mechatronics & Control Engineering at the University of Engineering & Technology, Lahore, Pakistan (2010-2014). She is currently working on her final project related to the analysis and design of a mechanical finger with active force feedback capability.

Munazza Fatima is a graduate student of Mechatronics & Control Engineering in University of Engineering & Technology, Lahore, Pakistan. Her undergraduate final project, "Analysis & Design of a mechanical finger with active force feedback capability", was conducted in collaboration with faculty at the University of Texas at Arlington.

Razi Iqbal completed his undergraduate training the University of Central Punjab, Lahore, Pakistan, and received his Masters and Ph.D. in Computer Science and Engineering from Akita University, Japan. He currently serves as Assistant Professor and Researcher at Lahore Leads University, where he pursues research in applications of wireless technologies in agriculture, education and transportation.

Awais Ahmad graduated from Department of Mechatronics and Control Engineering, University of Engineering and Technology, Lahore in 2013. He joined Al' Khawarizmi Institute of Computer Science in July 2013 as Research Officer III. He is currently working on projects related to near field communication with Dr. Razi Iqbal. His research interests focus on robotics, embedded systems, software systems, wireless technologies, bio-medical engineering and entrepreneurship.

System Architecture

Traditionally, when arranging a follow-up visit for a patient, the doctor communicates the time of the next visit either verbally or by writing on a card or form. However, this traditional way of arranging appointments is very inefficient because people tend to forget the appointments. In some cases, the doctor's assistant will telephone the patient with a reminder, which is somewhat more efficient but increases the overall cost and hassle for the clinic or hospital.

Figure 1 illustrates the proposed NFC-based alarm activation for appointments. Upon completing the current checkup, if a subsequent appointment is needed, the doctor enters the date and time of the follow-up appointment in a central database. The doctor's receptionist can access this information and transfer it to a fixed NFC passive tag at the reception desk through the NFC read/write device. The patient then taps his smart phone against the read/write device to automatically set a schedule alert in the patient's calendar, with the option to set multiple reminders, thus freeing the patient from the responsibility of actively tracking future appointments.

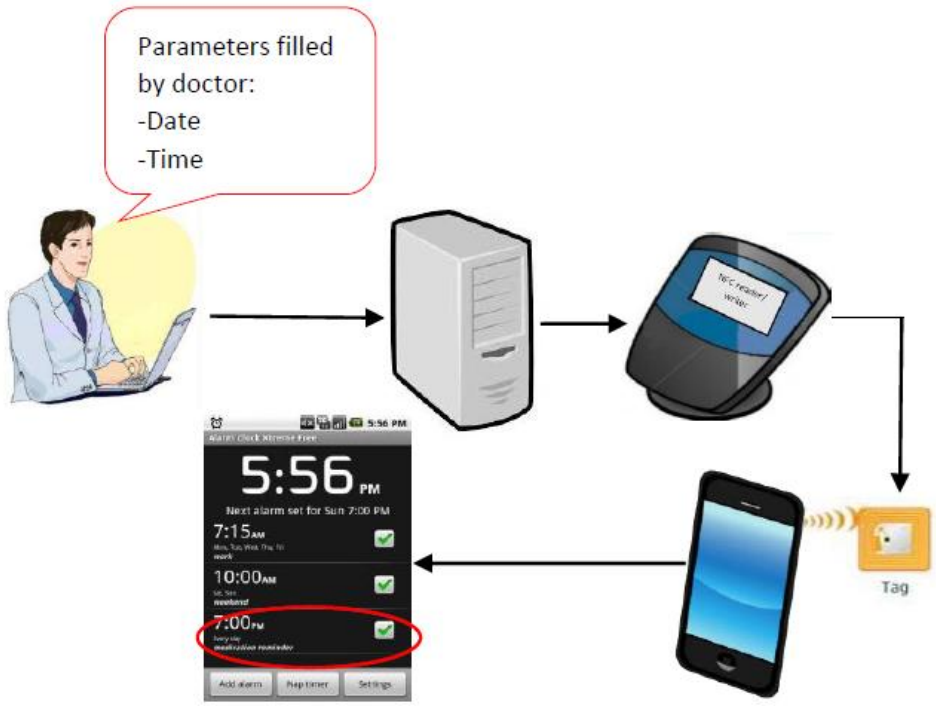

Figure 1. NFC tag-based alarm activation for medical appointment.

System Flow

The proposed system is divided into two parts: writing information to the NFC tag and retrieving information from the NFC tag and setting the alarm.

Figure 2 illustrates the process of writing information to the passive NFC tag. First, either the doctor or receptionist enters the appointment time and date in the central database. This information is then transferred to the server. An Android-based application was created on a virtual device which enables the server to write the required parameters to the passive NFC tag or the user's smart phone. The NFC read/write device is only activated, if the patient has already been notified about the previous appointment. When the previous information is transmitted, the NFC read/write device is activated and rewrites the required parameters to the tag. The information thus now exists both in the central database as well as on passive tag and can be retrieved from both the ends.

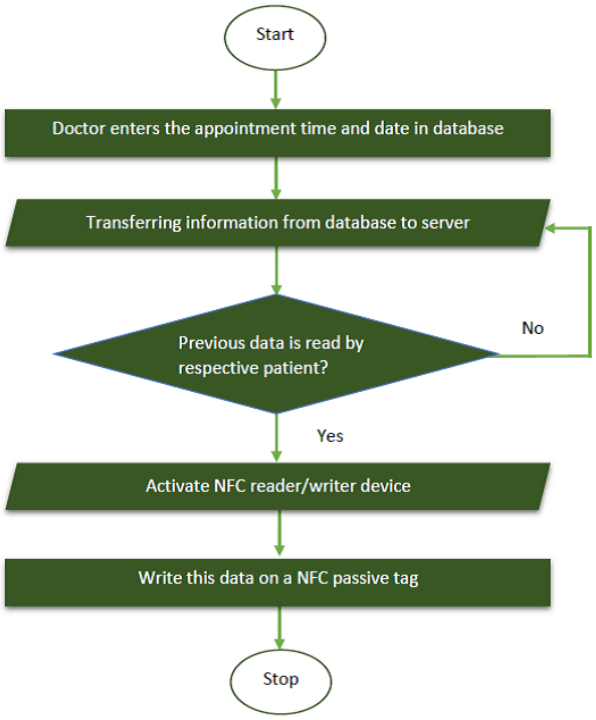

Figure 2. Flow diagram for writing information to the NFC tag.

Figure 3 illustrates the system flow by which the appointment alerts are set. The patient first activates the NFC application on her smart phone and then swipes the smart phone against the passive NFC tag to retrieve the appointment data. The information is then displayed on the smart phone and is used to arrange alerts.

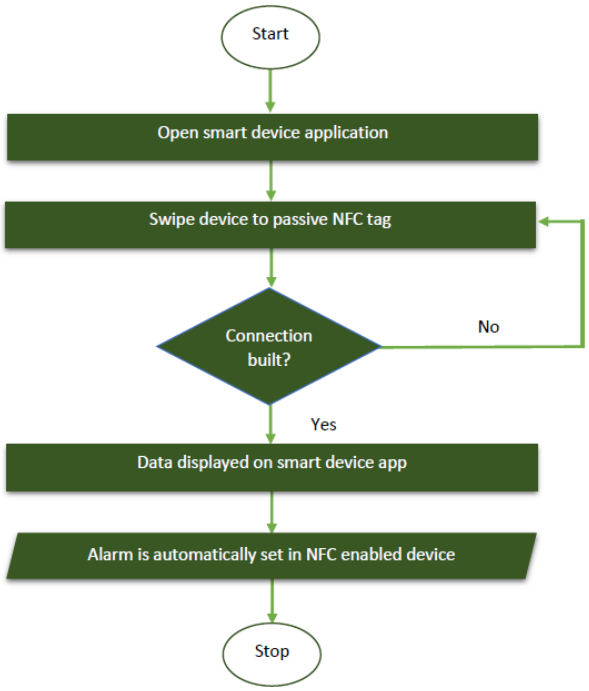

Figure 3. Flow diagram for information retrieval from the NFC tag and alert setting.

Figure 4 shows the interface of the Android application. The information displayed is read from a passive tag and is stored in phone's internal memory for later use.

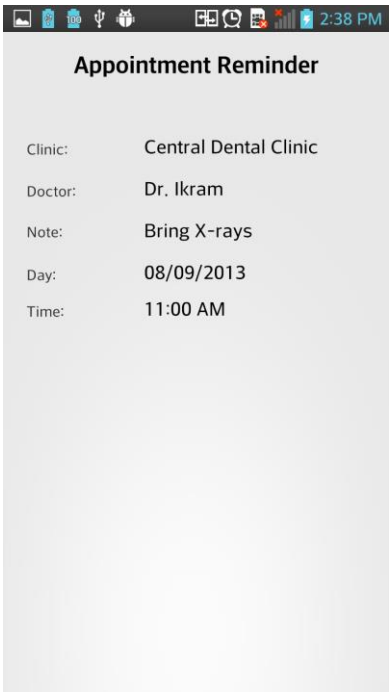

Figure 4. Appointment reminder app for Android device

As shown in Fig. 4 above, the information is retrieved from the passive NFC tag and is stored in the phone for later notification. While different types of NFC tags are available with different data capacities, the

proposed solution was developed using NFC tags with internal storage of 128 bytes, enough to store Clinic Name, Doctor Name and Notes along with time and date of the appointment. The application then arranges periodic notifications as shown in Fig. 5.

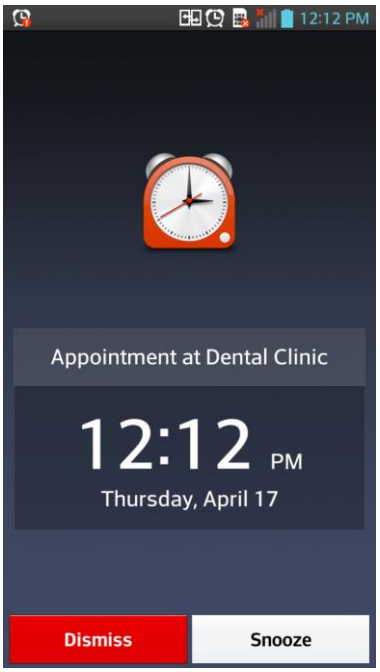

Figure 5. Appointment reminder.

Comparison between NFC and other communication techniques

NFC vs. QR Code

In addition to NFC tags, appointment information can be stored in various formats to trigger alerts. QR codes provide efficient and fast information storage and retrieval. [6]. However, they are not always reliable. QR codes can be rendered inoperable by physical damage to the tag, and even working tags have very limited data storage capacity [7].

The NFC approach optimizes ease of use. It can be operated without opening an application, and information is transferred simply by waving the smart phone near the NFC tag. QR codes require pre-processing and an active application for data transfer to take place. NFC tag-based data transfer also enjoys an advantage over QR codes in terms of flexibility in that QR codes cannot be modified once printed, but the information contained in NFC tags can be modified and updated at will [8]. Given that doctor's appointments frequently must be changed, this advantage alone makes the NFC–based system more suitable for storing medical appointment data.

NFC vs. Barcode

NFCs can be used even if the user's smart phone is switched off or out of power, whereas barcode-based applications require consistent power. NFC chips incorporate RFID (Radio-Frequency Identification) technology, in which data is transferred from a passive tag to the NFC enabled device via radio waves. One essential component of any functional RFID system is a read/write device used to store or retrieve from the RFID tag [8]. A major advantage of RFID tags is that the reader can operate at relatively large distances from the tag and out of direct line of sight [9].

Experimental Results

Different experiments were conducted to assess the suitability of NFC tags for the proposed system. The results of these experiments are presented below:

Table 1. NFC data transmission between active and passive tags.

No. of Bytes	Error %	No. of Disconnections
28 Bytes	0%	0
64 Bytes	0%	0
128 Bytes	0%	0
Overall Error %	0%	0

Table 1 summarizes data transmission tests for different volumes of data. Transmission using the proposed NFC system was found to be very efficient, with no errors or disconnections between the active (phone) and passive (tag) devices.

Table 2. NFC data transmission at different ranges.

Distance	No. of Trials	Success Rate
10mm	10	0 %
5mm	10	60 %
Touch	10	100 %

Table 2 summarizes test results for data transmission at different distances between the active and the passive devices. Data transmission was very efficient when the devices were touching. However, as the distance increased to 5mm, the success rate dropped to 60%, and dropped to 0% at 10mm.

Conclusion

Ensuring that patients remember their doctor's appointments is a critical issue both for healthcare productivity and outcomes, but conventional methods of arranging appointments are prone to error. This paper proposes a system using passive NFC tags to automatically set appointment alerts in the patient's

smart phone. Experiments find that the proposed system allows for the effective and reliable storage of appointment information. The concept can be extended to other fields which require accurate recall of distant events, such as banking and public administration.

References

[1] J. Patel and B. Kothari, "Near field communication - the future technology for an interactive world," *International Journal of Engineering Research and Science & Technology,* vol. 2, no. 2, pp. 55-59, 2013. Available: http://ijerst.com/download.php?file=ijerstadmin/upload/IJEETC_518299068c8a9.pdf&iid=27

[2] K. Ok, V. Coskun, M. N. Aydin, and B. Ozdenizci, "Current benefits and future directions of nfc services," in *International Conference on Education and Management Technology (ICEMT)*, 2010, pp. 334-338. doi: 10.1109/ICEMT.2010.5657642

[3] C. Li-Chuan, L. Chen-Lin, and W. Chang-Jer, "Applying qr code technology to facilitate hospital medical equipment repair management," in *International Conference on Control Engineering and Communication Technology (ICCECT)*, 2012, pp. 856-859. doi: 10.1109/ICCECT.2012.31

[4] U. S. Premarathne, H. Fengling, I. Khalil, and Z. Tari, "Preference based load balancing as an outpatient appointment scheduling aid," in *35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2013, pp. 1298-1301. doi: 10.1109/EMBC.2013.6609746

[5] M. Yeo Sy and S. Sankaranarayanan, "Near field communication based patient appointment," in *2013 International Conference on Cloud & Ubiquitous Computing & Emerging Technologies (CUBE)*, 2013, pp. 98-103. doi: 10.1109/CUBE.2013.27

[6] M. Vazquez-Briseno, F. I. Hirata, J. d. D. Sanchez-Lopez, E. Jimenez-Garcia, C. Navarro-Cota, and J. I. Nieto-Hipolito, "Using rfid/nfc and qr-code in mobile phones to link the physical and the digital world," InTech, 2012. Available: http://www.intechopen.com/articles/show/title/using-rfid-nfc-and-qr-code-in-mobile-phones-to-link-the-physical-and-the-digital-world

[7] R. Iqbal, A. Ahmad, and A. Gilani, "Nfc based inventory control system for secure and efficient communication," *Computer Engineering and Applications Journal,* vol. 3, no. 1, 2014. Available: http://comengapp.com/index.php/comengapp/article/view/50

[8] P. D. N. Hebert, A. Cywinska, S. L. Ball, and J. R. deWaard, "Biological identifications through DNA barcodes," *Proceedings of the Royal Society of London. Series B: Biological Sciences,* vol. 270, no. 1512, pp. 313-321, 2003. doi: http://dx.doi.org/10.1098/rspb.2002.2218

[9] R. Singh, *Nfc v/s qr code v/s barcode*, 2014, [Online]. Available: http://www.rakeshsingh.me/nfc-vs-qr-code-vs-bar-code/ [Accessed: May 23]