Near Field Communication Technology for AAL

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Abstract A common problem for ageing people is that they forget to take drugs at the correct moment. This can be a problem if they live in an independent way without other persons who can help them. In this work we propose the use of smartphones with Near Field Communication technology for medical care. The idea is to apply a tag in the box of the drug to be taken. The application in the smart phone indicates the time when the drug should be taken. When the user takes the drug, he approaches the smartphone to the box of the drug, and the smartphone tracks the event. With a simple interactions, which involves touching tags with the mobile phone, it is possible to manage the information easily. A user friendly application has been developed.

1 Introduction

The increment in Europe of the percentage of ageing people, the increment of the number of people with high disability, the reduction of the components in the family, cause a risk of a great degradation of the quality of the life of a great part of people and their exclusion in the active participation in the economy and in society. For many people the complexity and lack of utility, accessibility and usability of ICT is a major barrier.

This work is dedicated to my father. Massimo

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In EU research frameworks (FP7 and Horizon 2020) some guidelines are given to respond to these trends by mainstreaming and radically improving the accessibility and usability of new ICT solutions, especially for people with disabilities, functional limitations or lacking digital competences.

A great effort is spend in the creation of advanced prototypes of systemic solutions for independent living and active ageing, including reorganization of integrated care and rehabilitation processes, leading to a significant prolongation of personal autonomy.

Many EU projects have been developed and are under development in the field of ambient assisted living, between them:

- the initiative "Ambient Assited Living" (AAL) [1] aims to develop of a European Research Area in the field of "AAL for the Ageing";
- "eCAALYX" [2], is devoted to develop a wearable light device able to measure specific vital signs of the elderly;
- "SENSACTION-AAL" [3] worked on the development of ambulatory assisting devices for enhancing safety and security in balance and movement;
- "NETCARITY" [4] proposed a new integrated paradigm for supporting independence in elderly people living alone at their own home;
- "SMILING" FP7 and "Happy Ageing" [5], coordinated by INRCA of Ancona (IT), devoted to the definition of new instruments for rehabilitation.

An ambient for assisted living can be reached with a seamless integration and plug-and play operation of sensors, devices, sub-systems and integrated care services into cost-effective, self-maintaining, reliable, self-learning and adapting, privacy-respecting and trusted systems. A key point should be the simplicity to use in order to ensure the acceptability by the end user.

Near Field Communication (NFC) is a contactless or proximity communication medium, which is based on magnetic induction. The availability of smartphones and tablet at low cost with NFC facility allows the diffusion of this technology and the development of applications in many different fields, in particular in AAL and healthcare.

Vergara et al. [6] presented a proposal to enable patients getting prescriptions from home by using mobile phones and NFC, avoiding to go to the health-care center.

In [7] a model for the development of context awareness applications using NFC is presented. As an example, the authors presented an application in which the user in emergency situation could ask for help in an intuitive way, just by touching with the NFC smartphone an image with a tag associated, for example a picture of an ambulance.

In [8] the authors proposed an NFC-enabled medical devices to automatically collect clinical data. The doctor touches his NFC card to launch the application installed on the mobile phone. Then, he touches the medical device to obtain the measured data, and finally he touches the patient's NFC tag to identify the user.

In [9] NFC has been used to support Alzheimer patients. The patient measures his vital signs touching the monitoring device's NFC tag with the mobile phone. The

application on the mobile phone is automatically launched, it activates the monitoring device obtaining the measure through a Bluetooth connection. Then, the application analyzes the measure and, if necessary, it sends alert messages to the healthcare center.

In [10] a smartphone integrated with an NFC has been used to help the nurse to detect and update drug allergies and drug interactions during medication administration.

Many apps are available for smartphone related to drug assumptions, but they do not use NFC. Mainly the apps remind to the patient when medications need to be taken (e.g. Med Helper Pill Reminder [11]), or they give comprehensive drug information and they are used by doctors, nurses and other healthcare professionals for clinical information (e.g. Micromedex Drug Information [12] and Medscape [13]).

The application for smartphone with NFC, proposed in this work, helps the patients in taking drugs and records in the database the history of the drug assumption, signaling if the correct drug assumption is not followed.

Section 1 will briefly present the NFC technology and Sect. 3 will present the application developed.

2 Near Field Communication

In recent years, new standards related to Radio-frequency Identification (RFId) technology have been defined, among them the Near Field Communication (NFC) is extremely important. NFC protocol is defined by the NFC Forum [14], created in 2004 by Nokia , Philips and Sony. Today NFC Forum has more than 160 members and partners among which Samsung, Visa, MasterCard , Google , Intel etc.

NFC is a radio technology that allows two devices to communicate at short distance, about 4 cm. The two devices are called respectively “Iniziator” and “Target”:

- **Initiator**: it starts the commutation and controls and manages the data exchange, for example a reader.
- **Target**: the device that responds to the requirements of the initiator, for example a card or a tag.

NFC devices operate in two modes, passive or active.

- **Passive mode**: in this mode, the reader generates an electromagnetic field and the passive tag responds by modulating the antenna load for data transmission. In addition, NFC technology allows a smart phone to emulate a passive tag, or it can act as a reader of tags.
- **Active mode**: both devices generate a magnetic field and modulate the opposite magnetic field. A communication between a reader and a smartphone, or between two smartphones can be established.

The NFC protocol and message formats are based on standards that are already in use for RFId to maintain compatibility with them (allowing applications such as reading information from food labels), but they seek to extend the operational capabilities thanks to peer-to-peer among "intelligent" devices, for example two smartphones.

The standard of communication between NFC tags and reader works at a single operating frequency of 13.56 MHz, with a bandwidth of 2 MHz. The reasons that led to the choice of such frequency are related to the fact that the size of the tag antenna decreases as the frequency increases. Furthermore, the transmission at higher frequencies than 13.56 MHz requires more energy. The speed of data exchange can reach an intermediate value between 106 Kbit/s and the maximum peak of 424 Kbit/s.

The standards [15, 16] are defined in ISO, ECMA and ETSI, are divided into:

- The NFC IP-1 describes the radio interface, initialization, anti-collision, a texture format and a protocol for exchanging data block with error handling. Both active communication and passive communication are defined. The standards ETSI TS 102.190 , ISO/IEC 18092 and ECMA 340 define (in the same way) NFC IP-1.
- The NFC IP-2 specifies a mechanism for selection between different modes of communication. This protocol refers to the fact that the same devices can communicate as NFC IP-1, or as ISO/IEC 14443 or as ISO/IEC 15693, in all cases operating at 13.56 MHz.
- The NFC-WI (wired interface) controls the exchange of data between NFC device and the "front-end" of the apparatus in which the NFC device is located.

Using NFC, the communication between smartphone and tag automatically starts when the mobile phone gets close to the tag. The interaction between user and the object is therefore fast and intuitive. This is a fundamental requirement in many different applications [17]. The NFC technology allows cover a fundamental requirement imposed by AAL: the ease of use especially for elderly people.

3 Farm Alert Application

The idea to design an application for the management of drugs is born from the observation that the majority of people, even young people, do not easily remember to take the prescribed drugs. Many people, especially elderly persons or person with disability, need to take often many drugs. In these cases, it usually happens that the person forget to take the drug in the correct moment or he is not sure that he has already taken the drug.

The application, that we named "FarmAlert", proposed in this work, helps the patients in taking drugs in extremely easy way. The idea is the use of smartphone with NFC to assist at home people who must take drugs, as shown in Fig. 1. The application of the smartphone will remind the person that he must take the drug and it will trace the drugs that the user has already taken.

Fig. 1 FarmAlert: application on smartphone with NFC and drug with RFId NFC

The application is partitioned in two sections: everyday use and drug list update. This allows the use to persons not skilled at all in mobile phones.

- **Everyday use**: the procedures, that are used everyday, are performed in an extremely easy way: the user just touches the RFId tag placed in the box of the drug with the smartphone with NFC in different moments of the day to know which of them must be taken and when, and the application registers in the smartphone that the drug has been taken.
- **Update drug database**: The critical procedure are writing the tag and writing or changing the drug prescription database on the smartphone. These procedures are performed only when a change in the prescription is needed and they can be performed by the user itself, if skilled enough, or by a person with a normal knowledge on smartphone helping the person in the normal life, or by the doctor who makes the prescription. These procedures are protected by password so that a not skilled users cannot modify the prescription.

The application has been developed on a low cost Samsung Nexus S smartphone with NFC and Android OS using the NetBeans development environment, used by Oracle. Other smartphones with NFC or development environment, such as Eclipse, can be used. The Android platform gives free tools and library, allowing and easy and fast development of the desired application.

As a first step, in each box containing the drugs an RFId tag is inserted. In some cases this tag is already inserted in the box for traceability reason during the production and storage of the drug. If the tag is not already present, it can be inserted in the box by the user, it is programmed by an expert user using the application TagWriter in the smartphone so that the tag contains the name of the drug, expiration date and other information.

As a second step the person who must take drugs, or somebody who take care of him/her, will create a list of drugs to be taken and the time schedule during the day. The creation of the list of drugs is very easy.

Finally, the user places the mobile the smartphone over the drug tag to verify if it is the correct time and the smartphone register that the drug has been taken.

The functionalities of the application can be activated through the NFC (NFC activation) or manually activating the application in the smartphone (Menu).

3.1 NFC Activation

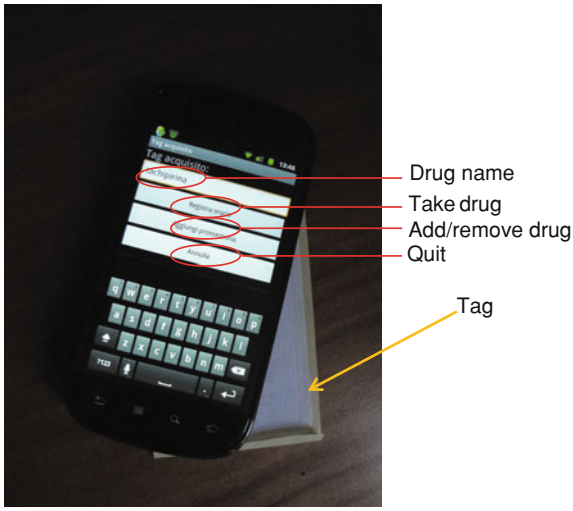
As soon as the smartphone is placed over the drug box, the menu shown in Fig. 2 will appear with the name of the drug written in the tag. Then the user can press:

- **Take drug**: This functionality is activated only if the drug is already present in the database, a password is not required. This procedure is performed in the everyday use. If the actual time is close (with a tolerance that can be fixed, for example: 10 min before and 30 min after) to the one registered in the database for that drug, a new menu will appear, and the actual date and time will be written in the database, registering that the drug has been taken and when. If the actual time is not in the range allowed or the drug has already been taken in that time period another menu will appear, indicating an error.
- **Add/remove drug**: a password is required, to avoid that a drug could be inserted by mistake. Provided the password, the menu of Fig. 3 is shown. The name of the drug written in the tag is shown, the user can insert the name of the drug that will be shown in the list and at what time the drug must be taken. Then the data inserted can be saved pressing “save” or discarded pressing “delete”.
- **Quit**: the registration procedure of the drug is discarded.

The flow diagram of the NFC activation procedure is summarized in Fig. 4.

Once the drug list has been filled, a short time (e.g. 5 min) after the prescription time, the smartphone will inform the user with an acoustic signal that he must take the drug. The acoustic signal will be repeated periodically (for example every 5 min for the successive 30 min), if the user does not perform the procedure “take drug”.

Fig. 2 NFC activation menu



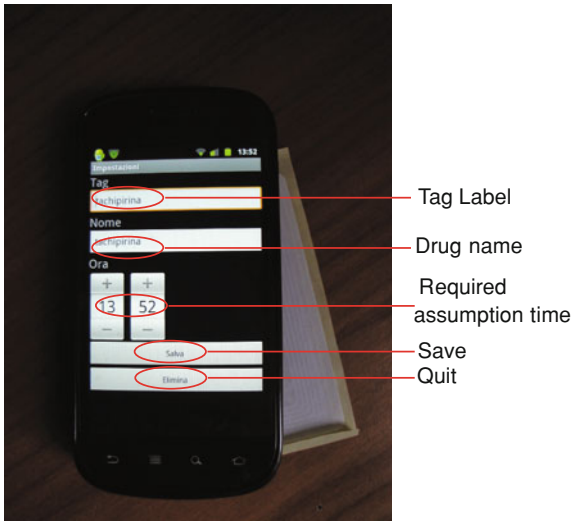


Fig. 3 Menu to add a new drug

3.2 Menu Activation

At any time, with a click on the main application, without the use of the NFC of the drug box, the user can visualize the menu shown in Fig. 5, with the following procedures:

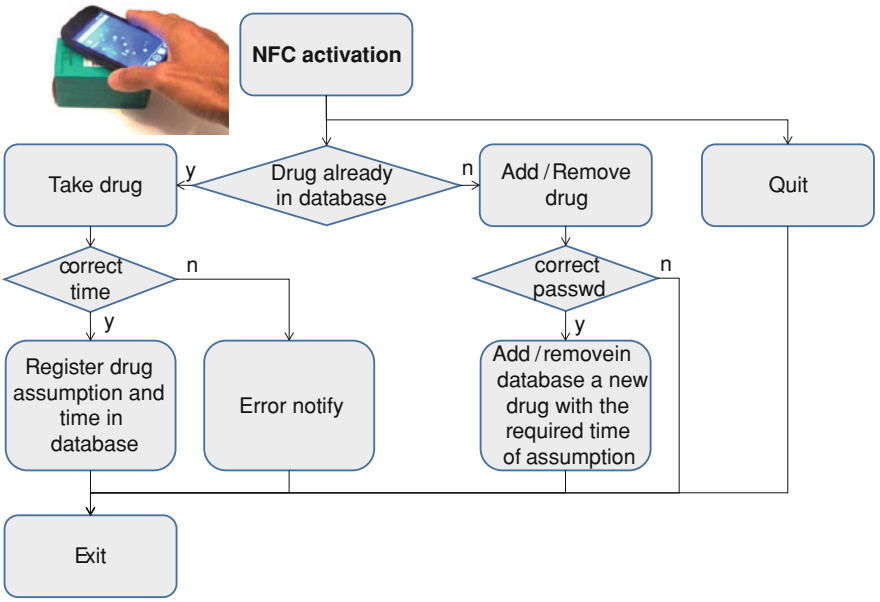


Fig. 4 Flow diagram of the NFC activation procedure

Fig. 5 Main menu

- **Add/remove drug**: open a page for the manual insertion or removal of a drug in the user database, this page is protected by a password.
- **Reset**: delete the entire drug database, this page is protected by a password.
- **Change password**: allows to change the password, provided the old password.
- **Enable alarm**: enable the acoustic alarm at the time the drugs must be taken.
- **Disable alarm**: disable the acoustic alarm.

The flow diagram of the Menu activation procedure is summarized in Fig. 6.

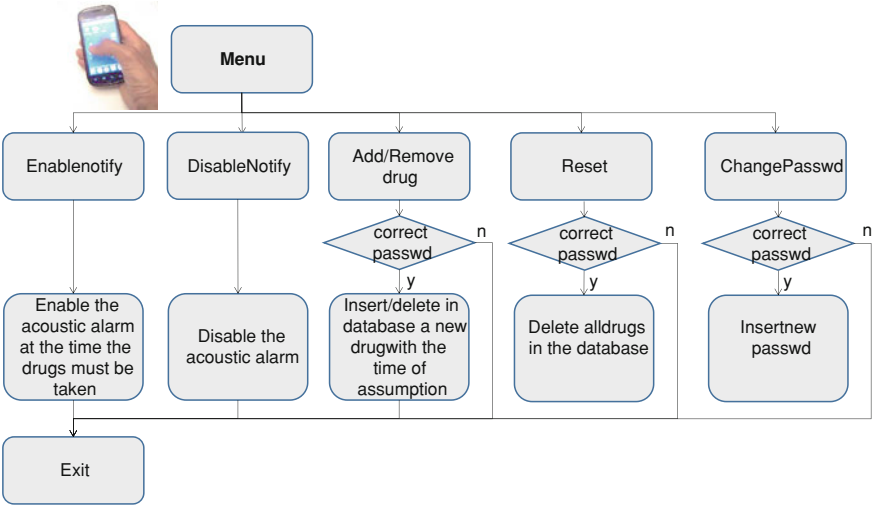


Fig. 6 Flow diagram of the menu procedure

Fig. 7 Interaction of FarmAlert with external environment

4 Conclusions

We proposed an easy to use application on smartphone for drug assumption at home, just touching the drug with the smartphone the user can:

- know when he must take the drug,
- the last time he has taken the drug,
- register that he is taking the drug.

The smartphone signal will remind the drug assumption, if necessary, and register in the database the history of the drug assumption, signaling if the correct drug assumption is not followed.

The application developed is under test with elderly people to improve the easiness of use with users not skilled with smartphones.

Further development of the application will be the connection of the smartphone with a remote superuser (a familiar of the user, a doctor, a pharmacy or the hospital) to send the information on drug assumption and to notify immediately if something wrong happens in the drug assumption, as summarized in Fig. 7.

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