Combining RFID and NFC Technologies in an AmI Conference Scenario

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The significance of sensing technologies in ambient intelligence is crucial. These technologies allow us to acquire context awareness automatically by knowing two basic features of context: who and where. They thus offer services in consonance with the characteristics of users and produce savings in the interactive effort. In this work we present an approach through a combination of: radiofrequency identification (RFID) and near field communication (NFC) technologies. We compare both, analyzing the requirements and the advantages of each one, defining processes that each technology offers. The first allows implicit user perception and triggering service, while by the second one we can have user localization on a point, and bring about an innovative way of interaction by contact.

1. Introduction

The vision of Ambient Intelligence (AmI), which is the evolution of Ubiquitous Computing, proposes the electronic perceiving of, and responding to, the single presence of the user. The electronic devices in these environments have to "disappear". This "disappearance" must be carried out in two dimensions: physical and mental [2]. The physical disappearances of devices are possible by absorbing or embedding them into the environment. The mental dimension is, basically, the interaction with them. That is to say, for them to disappear mentally we should not perceive that we are interacting with devices [1]. No previous learning is necessary; in other words, interacting with them should take place in the same way as we interact with other people or our environment.

To achieve the above-mentioned objectives, we have to reduce the necessary effort in the applications and computer inputs, step by step. Weiser [2] indicated that if a computer knew who and what was in its surroundings, it could be adapted and offer services without any requests being given. Sensing technologies have a crucial importance in AmI scenarios and much research work focus on adapting current technologies.

In previous work, we have looked at adapting the radiofrequency identification technology (RFID)so as to perceive inputs (localization and identification) in an implicit way, without requiring user effort [3] [4]. We have detected limitations in some contexts or situations. The present work looks for a RFID supplement with advantages offered by the Near Field Communication (NFC) technology.

Although NFC can be embedded in a variety of electronic devices such as: TV, digital/video cameras, microwave, etc., we focus only on the NFC-enabled cell phone, because it is an excellent device for accessing AmI services.

In the next section we describe some aspects related to visualization services in a conference scenario with NFC, providing examples of the use of NFC, and comparing it with RFID. We present the "touching interaction" concept that is involved in using NFC-enabled cell phones. Then we show a scenario where the combination of NFC and RFID-active is very useful in the saving of interactive effort. Finally, the first test carried out in the development of an application for this scenario is set out, along with our conclusions.

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2. AmI in a conference domain

The diversity of activities, user roles, rooms and services in a conference or workshop are ideal for implementing AmI ideas. The dynamic setting and the mobility there, is a good environment for using sensing technologies to capture context aspects that involve the user.

In a conference context we have different user roles: Speaker, Assistant or Audience, Chair, and Staff. A single user can carry out all of these throughout the conference. It is important to know about location, identification and role at all times. All those aspects give valuable information when offering services tailored to an appropriate moment.

The services are varied and we grouped them as follows:

- The Management of the Conference can be: Conference and session schedule, automatic trigger presentation of papers, statistics of attendance, conference delivery documentation and invoices.
- The Management of the Personal User Schedule. Although the conference schedule and a person's own schedule may be the same, there are different activities: finding a colleague, looking for meetings, finding a colleague that wishes to know you, exchanging business cards and so on..

A description of the user's role, services and databases can be seen in Figure 1.

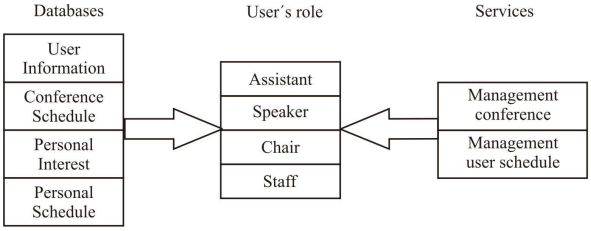

Figure 1. User's role, services and data in conference scenario

2.1 User Scenario

In the following scenario, we describe the activities at a conference, including the concept of "touching interaction". This scenario is the support for the application we are developing. In the first phase, we decided to test on a real case.

In the auditorium there are displays in different zones: at registration, in the lobby, the coffee break area, beside the doors of the workshop rooms, in the corridor, two of them inside the room: the main one for presentations of the papers and the secondary one for information on sessions.

Joe arrives at the lobby of the auditorium where he is to present his work. He takes his NFC-enabled cell phone, onto which he has previously downloaded the application that the workshop organizers have sent him by email. The application offers him an option to configure his interests (researchers he wants to contact, notes to comment on with some colleagues, etc.) and his availability (his schedule during the congress, meetings, meals, etc.). When he arrives at the registration area he goes to the desk labeled "pre-registered with NFC" and he places his cell phone near the NFC service point. From this moment the application executes and a display in front of him indicates that he has to wait for the identification badge (with an RFID tag) and the workshop documentation. He receives another series of notices regarding the event (state of the session where he participates, location of people of interest to him and so on).

Joe goes to the conference room and finds a person he is interested in meeting. If this person agrees, they exchange their "business card". At this moment he selects an available option for scheduling a meeting.

When the user arrives at the room door he is looking for, he observes on the display beside the door, which people are already inside the room. He also sees the presentation that is in progress, the modifications to the schedule, the exhibitions, etc. Meanwhile, inside the room, the chair observes on the secondary display that the next speaker is already in the room but that his presentation is not yet on the server's database, so he has decided to send an automatic SMS.

During the presentation's Q&A session the relevant data of the person asking the question appear (on a secondary display) as well as the time left before the next session. Lastly, when Joe approaches the presentation area, the data of his paper appear on the room's main screen. In addition, an option for downloading his presentation is available. To transmit the file he puts his cell phone on the service point.

3. Sensing Technologies

In an AmI context, sensing technologies are very important, perceiving some characteristics of the environment without any action required on the part of the user. Sometimes it is not necessary to wait for new technologies. We can adapt the existing ones by innovations to them, using their advantages, as Weiser's vision recommends [2].

We propose a combination of the "old" technology like RFID, with a "new" one, NFC, with the aim of covering three important elements in an AmI:

Localization (wide and pinpoint), Identification, and finally, Ubiquitous services to the user. Some important characteristics of these technologies are described in the following points, comparing the features of both, and analyzing the way in which they can complement each other.

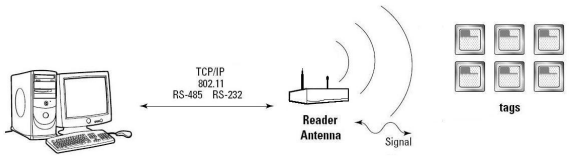

Figure 2. Elements of a RFID system.

3.1 RFID

This technology is commonly used to identify objects, but its characteristics make adaptability for AmI use possible. RFID technology allows us to capture information from the environment in an implicit way without any user effort, offering services in an implicit way too [5] [6] [7].

In RFID systems there are basically two elements [8] (fig. 2):

- Tags or transponders, which consist of a microchip that stores data, and antenna (coupling element). That is packaged in such a way that it can be installed in an object; it also has a unique series number.
- Readers or interrogators have one or more antennas, which emit radio waves and receive signals back from the tag. The "interrogation" signal activates all the tags that are within its reach.

RFID systems are classified as active and according to the kind of tag used. In this work we use only active tags: they are those that have own power supply (battery) and their reach can be of up to 100 m.

Readers have a frequency of operation and are usually divided into three basic ranges: Low (125Khz.), High (13.56 MHz), which is the standard one, and Ultra High Frequency (UHF).

A characteristic that defines the RFID area is the computer-reader connection, which is carried out physically. In this, the antenna is located in one place and the tags are completely mobile.

3.2 NFC

The great variety of devices that surround us and the multi-functionality of each one have created the need for interconnection between them. In order for this to be carried out by the user in a way that is clear to him or her, the" near field communication" (NFC) standard has been created [9]. This technology was developed by Philips and Sony in 2002. It is a short range wireless connectivity technology combining RFID and interconnection technologies.

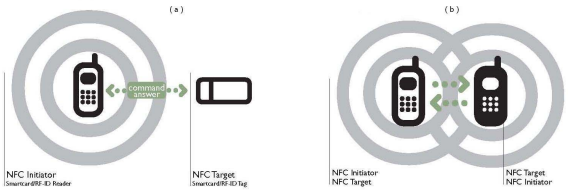

Figure 3. (a) NFC device emits a sign of RF to activate a target (b) Two NFC devices establish an active communication among them [11].

NFC uses a high frequency band of up 13.56 MHz, with a data transmission speed of 424 Kbits/s and a reach of 10 cm. It was deliberately designed to be compatible with the RFID tags operating in this band (ISO 14443), but incompatible with the standards of EPC global [10]. In 2002, international ECMA published the open standard 340 "NFC Interface and Protocol", which was adopted by ISO/IEC with the number 18092 one year later.

NFC systems consist of two elements:

- The Initiator; as its name indicates it begins and controls the information exchange (called reader in RFID); and
- The Target is the device that responds to the requirement of the initiator (called tag in RFID).

In an NFC system there are two modes of operation: Active and Passive (fig. 3). In the active one, both devices generate their own field of radio frequency to transmit data (peer to peer). In the passive one, only one of these devices generates the radiofrequency field, while the other is used to load modulation for data transfers.

It is important to mention that, although the NFC protocol can be installed in any electronic device, our interest will be centered on NFC-enabled cell phones.

3.2.1 NFC applications. In the last two years the research into NFC-enabled cell phones has received a strong impulse from several companies through different programs such as: Paypass of Mastercard, Visa Mobile, and Mobile J/Speedy of JCB. The reports of investigations into NFC can be summarized in two points:

- The use is mainly for payment, ticketing and "smart poster".
- Only one application has been launched commercially.

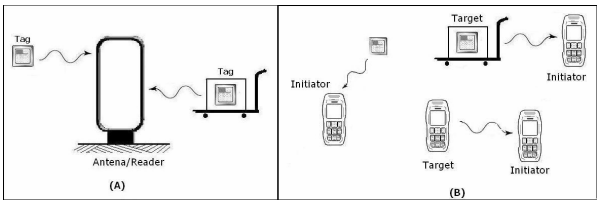

Figure 4. Comparison of mobility between NFC and RFID.

The first application of NFC launched commercially is in the public transportation company "Rhein-Main Verkehrsverbund" in the City of Hanau, Germany; with the name of "NFC-Handy Ticketing". It enables customers who use Nokia 3220 mobile phones to pay for their ticket by just bringing it close to the targets placed in buses.

In New York City, from January to April of 2007, they have been carrying out the program "NYC Mobile Trial" (www.rmvplus.de) in which users will have been able to: pay in some establishments, access information through smart posters and pay for their ticket on subway lines.

The Philips Arena of Atlanta, Georgia in the United States carried out a pilot program, in which 150 season ticket holders of the hockey and basketball teams were equipped with Nokia 3220 cell phones. They could use them to purchase in stores, as well as to access videos and pictures through smart posters that were placed throughout the arena. Although the program obtained favorable answers, they decided not to broaden it out because there was only one NFC-enabled cell phone model available in the United States, made by Nokia.

In November of 2006 the Upper Austria University of Applied Sciences began the project "I want you" (www.nfc-research.at) which allows the use of NFC-enabled cell phones for buying at automatic dispensers and campus coffee-shops. They also function as a key to enter rooms and buildings.

4. Our proposal combining NFC & RFID

In previous work [3] [6], we used RFID to know two main aspects of context awareness automatically: Identification and Services. The problems within these works were to do with exact localization of users (the RFID locates users in an area) and that the services offered did not require the user's confirmation.

Bearing in mind our main aim, which is to be closer to implicit services, we began to explore NFC technology. There are two characteristics that distinguish NFC from RFID:

- NFC devices can work as Initiators or Targets.
- Two NFC devices are recognized automatically at only a short distance from each other (contactless).

The distance required to detect a NFC device (target or initiator) is quite small compared to an active RFID tag but, at the same time, this in itself is a security factor. It ensures that we can always be aware of our proximity to a device and that the signal can not be intercepted without our realizing it. An RFID system can detect tags that enter the reader's field action, which we call Reader-fixed vs. Tag-mobile (Fig. 4a). The reader is "fixed" and so requires a physical connection to the computer that contains the application. It limits the extent to which a change of place can be carried out. In the NFC systems the initiator and the target can be mobile, however. We refer to this as Initiator-mobile vs. Target-mobile (Fig. 4b). In this case, the application can be contained within the initiator itself or, in the case of a cell phone; it can be accessed through the cell phone's signals.

If only a RFID system exists, without NFC, there are a series of limitations. These can be overcome by NFC. RFID technology allows the capturing of two important aspects of the user: localization and identification. This is done in a very implicit way, but there are three limitations:

- Localization; at present, this is given within a quite a big area, and
- Cost of spreading readers;
- Memory capacity of the tags.

These limitations can be solved by NFC technology:

- An NFC initiator device can move to any place.
- The localization will be on a point because of the need to bring the target and the initiator very close together.
- The initiator/objective can use the memory device.

We consider that in some circumstances an application combining RFID and NFC will mean a step towards invisible interaction.

5. AmI-conference processes whit NFC-RFID

AmI is a sensitive environment that responds to the presence of individuals according to their characteristics and preferences, in an easy, intuitive way which does not require a learning process [12] [13].

As regards processes carried out in AmI, our work will be focused on two groups:

a) Perceiving/Locating users, and

b) Offering services to users.

Our proposal is to provide sensitivity to the environment by means of a combination of RFID-active and NFC. To do this we get users to wear RFID-active tags and NFC-enabled cell phones. In section 4 we explain the advantages offered by RFID and NFC

complementing each other in one single system. The operation modes of these technologies generate two different forms of user detection: RFID *perceives* users in an area and NFC *locates* them in a point.

Table 1. Perceive vs. locate

	Technology	User's action	Description
Perceive users in a sensitive area or service	RFID	Implicit	It perceives the user that carries the label within the reader's reach
Locate users at a service point	NFC	Explicit	The users have to bring the NFC devices close to each other.

The operation of a RFID tag and NFC device is such that when either one is detected, the first information that is sent is the user Id, which is unique to each user. When perceiving or locating users, we identify them automatically. We conclude that there are two processes being carried out: Perceive (and identify) and Locate (and identify).

5.1 Perceive and locate

A RFID active system has a range of approximately over 80 m. With this we define the "service or sensitive area" as a function of the reader position, but we only know users who are within this area, not the pinpoint localization of them. That is, we "perceive" the user is inside the service area, without knowing their localization.

NFC's operating range is just 10 cm. This fact allows us to provide services when the initiator and target are closer. We are interested in bringing two devices close together in order to obtain services, more than in the physical position. With NFC we have located the user, at a "point of service", in order to deliver the services. So, with the RFID technology we perceive users within a service area; and with the NFC one, we locate them at a service point. This can be observed in Table 1.

The combination of both technologies does not limit the use of NFC in an intelligent environment. We can establish service points outside an RFID-defined area.

5.2 Services

Although there are a great variety of services in an intelligent environment, our interest focuses on those produced by identification from RFID and NFC technologies. Each one generates a type of services: RFID generate "Services in the area" and NFC brings four "services at a point".

Table 2. Implicit service by RFID

Services in area service	Data necessary
Visualization The mosaics show information according to the characteristics and preferences of the users.	- Id User
Attendance The system registers the time of entering or exiting the service area.	- Id User
Location The system knows who is in the service area.	- Id User
Note to comment The user carries out notes that he/she wants to comment on with somebody when they meet. The system then also detects them and the note in a service area.	- Id User looked - Note

1) Area services

The user will be able to receive a series of services when within the area of the RFID reader's reach (service area) depending on his/her characteristics, preferences and availability of devices. We can mention some of these services next (Table 2):

- ***Visualization***. The information that is displayed on the screens located in the corridor, as well as on those used for a user's particular characteristics and functions [3] [4].
- ***Attendance***. The system stores a list of the users remaining in the different areas.
- ***Location***. Showing the users inside the environment and service area.
- ***Note to Comment***. The user carries some comments about things he needs to talk about to other users in the RFID tag. These comments will be displaying when he enters the area (if the other relevant user or users is, or are, there).

2) Services in a point

When a user brings his NFC device near to another, it will be with the purpose of obtaining services. This service point can be fixed (if is part of the infrastructure of AmI) or mobile (if is carried by other user). The different services at a point are (table 3):

- ***Explicit sure identification***. The Id contained in the cell phone allows the user to be recognized in a safe, sure and precise way. For instance, on opening a door, getting documentation, etc.
- ***Presentation Card.*** When two users meet they can exchange their presentation card by bringing their phones near each other.
- ***Scheduling appointment/meeting***. Users interested in scheduling a meeting with others only have to bring their cell phones near and the system searches for a suitable appointment for both.

- ***Carrying files***. Taking files in the tag or cell phone memory in order to exchange data make a presentation or use another computer.

Table 3. Explicit service by NFC.

Services in point services	Data necessary
Business/Presentation card Bringing cell phones near each other in order to exchange the presentation card.	- Id User - Name - Address - e-mail - Tel & cell,
Scheduling date The user selects an option of looking for a meeting with another. By just putting the cell phones close to each other, the system looks for and selects a suitable meeting arrangement.	- Id User - Cell phone agenda
Explicit sure identification The secure user identification at a "point of service". Example: Open a door.	- Id User
Carry files Take files into the tag or cell phone memory so as to exchange data	- Id User -File destination - File

For each process mentioned before it is necessary to carry information in tags or cell phone. The technology which generates the service in either the RFID-tag or the NFC device will be what stores the data. One example of this can be seen in Figure 5.

6. Touching Interaction

The use of NFC involves at least one explicit action: "touch", on the part of two NFC devices; sometimes, it involves a bit more to confirm the fulfillment process, by pressing a button on the initiator. This interaction that can contain one or two steps is being called: "touching interaction", which we can define as *"The deliberate bringing together of two devices, for the purpose of obtaining services"*.

"Touch", is an explicit task that produces the "touching interaction" – it does take away from the ideal of implicit or invisible interaction. At the same time it generates a saving of effort, compared with the traditional way of interacting with electronic devices.

At the moment, the NFC-enabled cell phone is beginning to be distributed and its applications focus on two categories: Pay and Smart poster. As it is a device of widespread use, however, the challenge is there to provide more implicit services within the same device.

In NFC-enabled cell phones, "touching interaction" will mean the substitution of more than one explicit action, (as we are doing at present) by only one single explicit action- bringing the NFC-enabled devices next to each other and sometimes pressing the button to confirm the service. For example: If two users exchange their business card, when they arrive at their office they will type into their computer all the information; while, with the proposed system, they will just bring near their cell phone close to press a button.

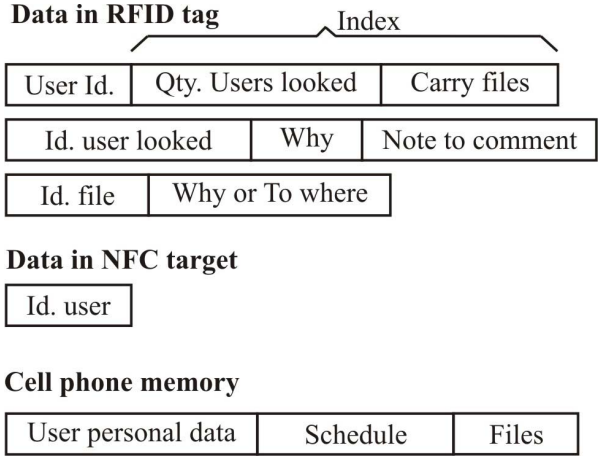

Figure 5. Data in NFC and RFID.

7. Case studies

We have partially partiallydeveloped an application for the scenario described above. We decided to produce a test to know users' reactions during the "2nd International Workshop on Ubiquitous Computing & Ambient Intelligence" (wUCAmI '06).

Days before beginning the workshop, we asked the authors for their presentation files and assigned each a number. This number was stored on NFC tags, which was in turn added to the accreditation badge of all the attendees and collaborators of the workshop. When each one picked up his documentation we explained what they were to do for presentation. In addition, all the coordinators were equipped with an NFC-enabled cell phone.

Before and during the session, the main display of the conference room where the workshop is taking place shows a series of notices which will be of interest to those attending. When the event begins, the chair places his cell phone on his accreditation badge and when he has heard the sound indicating that the reading had been correct, the presentation prepared before shows on the display. Then he then passes his cell phone by his tag in a similar way to before and the information about the session and the first paper are displayed. Next, when the first speaker stands up and approaches the presentation board, one of the workshop assistants (fig. 6) passes his cell phone by the speaker's accreditation badge. The presentation starts to be displayed.

Figure 6. Read the NFC target with cell phone.

It's important to mention that the system is not it affected if, at a given point in time, some user wishes to use his own computer to offer his presentation. The next user can give his presentation in the usual way.

To deploy the presentations, the tag contains a url that includes the number assigned to the coordinator or speaker of the presentation. On pressing the "OK" key, the cell phone modifies a database by means of the link; the application that controls the display detects the change and starts the presentation.

Before ending the workshop a survey is carried out amongst the attendees, to find out their opinion and level of knowledge of NFC. Among the results we should mention: more than 90% of the attendees considered that it was excellent that the applications were carried out in the workshop. All of them thought that the application was very simple to use and more than 80% considered that the application represents a reduction in interaction effort.

8. Conclusions and further work

The characteristics of NFC get around the shortcomings of RFID. NFC contributes with memory and pinpoint localization, which are what RFID lacks.

It offers implicit services by means of a device that is in daily use and this implies a saving of interactive effort. These two characteristics assure us of immediate acceptance on the part of users.

We suggest the concept of "touching interaction", giving this name to the process of bringing two NFC-enabled devices near to each other, in order to obtain services in an ambient intelligence environment. We have described a scenario and the corresponding evaluation of it in a real case.

Our scenario shows us that a combination of RFID and NFC is a better option than using both separately. At the moment, we are developing the next stages of our application and envisaging other environments where an RFID-NFC combination could be applied.

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