

TOWARDS SIMPLE INTERACTION IN THE CLASSROOM: AN NFC APPROACH

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ABSTRACT

In a given environment, distributing different devices with computing capabilities around us opens up new possibilities. It allows simple and easy interaction between user and computer. In this work we propose an approach to make it easier to handle information in the educational context and to do so we have adapted Near Field Communication (NFC) technology, which provides a simple input to the system. The user only has to bring his/her mobile phone, equipped with a radiofrequency reader, near to a tag, obtaining services like localization, access, or presence. Most importantly for us, we present the visualization of information in what we have called a “*Visualization Mosaic*”.

KEYWORDS

Ubiquitous Computing, Ambient Intelligence, Everyday Computing, RFID, NFC.

1. INTRODUCTION

A great deal of researchers are setting store by the development of ambient intelligence. Their main proposal is to change our daily life support by small devices with different functionalities, situated in the environment placed around us. The system has to provide sensorial inputs which will give a context awareness that senses the users' presence.

Nowadays, the main input to the computer is in an explicit form by means of the usual devices. If we want to automate our everyday life (Everyday Computing), we can not ask the user for an additional interactive effort. A need for an easy and natural type of interaction thus arises, leading Schmidt to define the concept of implicit interaction (Schmidt 2002). This author argues that that kind of interaction allows the transparent use of the computer systems, enabling the user to concentrate on the task rather than on the tool. The interaction between the user and the system is provided by the physical environment itself. The system must have the capability to anticipate the actions of the user by getting the appropriate contextual information. This author's following step was to propose the concept of “embedded interaction” (Schmidt et al. 2005). This concept proposes the embedding of technology in devices of everyday use and, at a conceptual level, the embedding of interaction in the activity and tasks of our daily life.

In order to achieve these goals, technologies need to be adapted. These do not have to be new, but their functionalities certainly do, offering us implicit inputs to the system without the user's participation. To achieve this, we considered that RFID (Radio Frequency IDentification) technology is a good candidate, as it means the user may interact with the environment in the way that Schmidt proposes. There are some limitations in this method, however. The inflexible placement of devices, the small amount of information that can be stored in tags and, finally, the cost, are important aspects that have to be considered. For these reasons, in this work we present another possibility: NFC (Near Field Communication) technology. This combines an RFID reader with a mobile phone. So, as well as the identification process, other capabilities are added: storage, communication and process. We have put in practice both technologies (RFID & NFC) in modeling educational experiences (Hervás et al. 2006b) (Nava et al. 2007) and specifically in the traditional classroom (Bravo et al. 2005).

2. BACKGROUND

Identification by sensorial capabilities provides a wealth of services. The advantages of this process in intelligent environments are varied: localization within a context, visualization of specialized information, access to particular zones or places of a certain type of people and their presence in those areas, etc. These are examples of the benefits that we find coming from the simple act of identifying users.

Some authors have undertaken a search for mechanisms to carry out identification and tracking within an organization. Want and Hopper (Want et al. 1992) use a small infrared device which emits signals that are caught by various receivers located in different parts of a building. The experiment of Beigl and Gellersen “Mediacups” proposes identification by small devices embedded in objects of daily use (Beigl et al. 2001). We have focused on two technologies that are described in the next sections.

2.1 RFID Technology

This technology seems recent, although it came into being in World War II to identify objects. In the 60’s it began to be used commercially. We have employed this technology in different contexts (Bravo et al. 2006), thus supporting the users’ everyday life.

Basically, RFID technology consists of three elements:

- Readers or transceivers, which are in charge of mediating the flow of information between the computer and the tags.
- Antennas, which are responsible for sending and receiving the electromagnetic wave.
- Tags or transponders, consisting of a microchip that stores data, along with a microantenna.

The way in which this technology operates is as follows: the reader sends a series of waves to the tag and these are caught by the microantenna. These waves activate the microchip by means of the microantenna, with the aid of its circuit transponder; the energy is taken from the wave to transmit the unique identifier and the information contained in the tag.

The readers have an operation frequency and are divided generally into three basic ranks: low (125 KHz.), high (13.56 MHz.); these are the most widely-used; lastly, ultra-high frequency (UHF). This technology allows us to capture information from the environment in an implicit way, without any additional effort to the user. The services that are offered are obtained in the same way.

A fundamental and therefore important element, which at the same time limits the interaction with the context, is the storage capacity of tags. The maximum information that can be stored is just over 1Kb, although there are manufacturers who promise more capacity. This space on this memory size for storing the unique identifier should be made as small as possible but in any case, there is still only room for just a relatively small amount of information for the actual interaction with the environment.

2.2 NFC Technology

NFC technology totally changes the way of understanding traditional RFID installations. The reader is now mobile and the tag can be fixed or mobile. The tag will contain contextual information, solving the problem of the small amount of space that was available for the information storage in RFID.

The change of direction towards a mobile reader logically comes from the need for a contact interaction. This process is very simple because the only action required is to bring a mobile phone near the tag. In addition, this tag may be embedded anywhere, allowing different services to be activated in the environment.

NFC technology was developed by Philips and Sony in 2002 and is being propagated by Nokia, Samsung and the Philips Company itself. Consisting of the integration of mobile telephony with identification by radiofrequency, it provides an intuitive communication between electronic devices, which is at the same time simple and secure. It works at a distance of between 5 – 10 cm. to 13.56 MHz and transfers data up to 424 Kbits/sec. (NFC Forum 2006).

NFC technology consists of two elements:

- Initiator, as its name indicates, it begins and controls the information exchange.
- Target, this is the device that replies to the initiator’s requests.

Two forms of operation exist in an NFC system: passive or active. In the passive form (figure 1a), only one of the devices generates the short range radiofrequency field, providing energy to a tag that was inactive, allowing it to be able to read or write data in its memory. In the active form (figure 1b), both devices generate their own radiofrequency field to broadcast the data, recognizing each other automatically (Harold 2005). In addition Figure 1 shows the four NFC modes of operation.

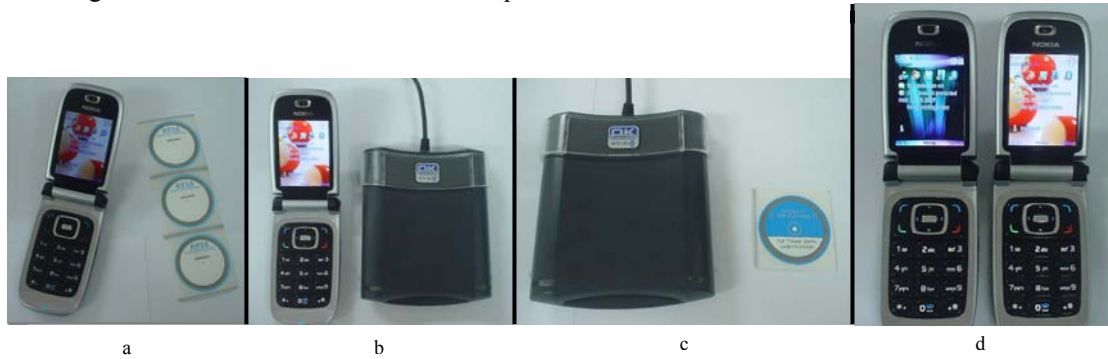


Figure 1. Passive and active forms and four modes of operation

In Figure 1a, a mobile telephone with NFC technology can be observed (the one in charge of generating the radiofrequency field of short reach), and to its right the electronic tags that are used with this technology. Figure 1b shows two devices that generate the short range radiofrequency field, a mobile telephone with NFC technology and to its right a reader.

Two characteristics which distinguish NFC technology from RFID technology are that:

- An NFC device can function as Initiator or Target (figure 1c).
- Two NFC devices which recognize each other automatically can only work at a short distance from each other (figure 1d).

In Figure 1c we can see an initiator device (reader) and a target device (tag), and in Figure 1d, two NFC devices that recognize each other automatically, by just bringing them close together. A similar case would be that of a reader and a mobile with NFC technology, as we have shown in Figure 1b.

2.3 Analyzing Both Technologies

In RFID technology explicit interaction within the context does not exist. The user only has to wear a tag and pass within the radius of the wave that is emitted by the reader. The information stored in the tag and its unique identifier are then taken and read in order to begin the necessary processes and offer services. As we said previously, certain devices need to be available with the computer system (figure 2a). NFC technology, on the other hand, requires an explicit interaction. However, due the capabilities of the mobile phone, some services can be offered without the server support. An example of its use can be observed in Figure 2b.

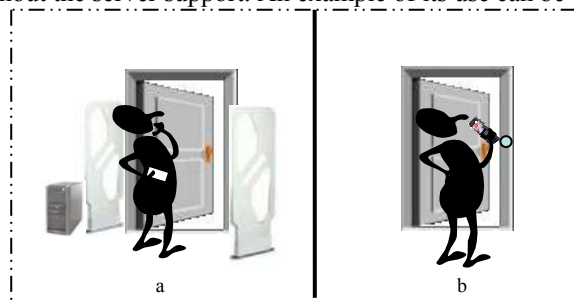


Figure 2. Differences between RFID (a) and NFC (b) technologies

In Figure 2a we can see the devices that are required to open and access a particular place, in this case, a classroom. The devices are the tag carried by the user; the antennas and readers that are near the door are managed by a computer which also controls the electronic lock. However, in Figure 2b the user just has to

bring his/her mobile phone close to the tag that is embedded in the doorframe and the information needed to open the electronic lock is sent to the autonomous device via Bluetooth.

With a small increase in interaction, explicit vs. implicit, we obtain a great variety of benefits from NFC technology. In the following table, a comparative study of both of the afore-mentioned technologies can be seen.

Table 1. RFID and NFC interaction

	RFID	NFC	Interaction	
			RFID	NFC
Devices	Computer system, readers, tags	Mobile phone, tags	Implicit	Explicit
Reader	Fixed in the environment	Continuous movement, embedded in the mobile phone	Implicit	Explicit
Tag	Continuous movement	Fixed in the environment or mobile	Natural interaction	Explicit interaction
Storage of data	Limited capacity, 64 bytes	Greater capacity, 760 bytes. Use of the memory of the mobile telephone	-	-
Cost	High	Reasonable	-	-

3. DESCRIBING THE SCENARIO: AN EDUCATIONAL CONTEXT

The context is a rich source of information that up until recently was barely used in computer systems. Interaction between humans is reinforced by the richness of language, gestures, rules of coexistence and social interaction. The context-environment in which this interaction develops involves an implicit understanding in many situations, something that does not happen in our interaction with the computer. Here, explicit interaction is required, along with an adaptation to the computer context. Dey and Abowd define the context as “*any information that can be used to characterize the situation of an entity; an entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves*” (Dey and Abowd 1999).

Visualization is a service that is needed to express the knowledge that is required. To achieve this, the user has to be identified when he/she is giving a presentation about the subjects that he has investigated. Our starting-out point corresponds to groups of students who are doing Teacher-Training. In a cooperative approach, students are often required to investigate a specific subject and submit a presentation or report on it. They themselves divide up the tasks that other members of their group will later present. In addition, they have to compile and organize the information. Finally, they have to make an additional effort to put together a presentation and show the knowledge acquired to members of other groups.

The different users participating in this educative environment have to build different actions with electronic devices so that they can project and explain the presentation that they have organized. These activities require additional time and can be solved in a simple way. For that to happen, the support of the corresponding identification technology is required.

In the previous section, we mentioned different mechanisms for user identification and localization. The identification technologies which optimize the advantages that NFC offers over RFID are described and the context of the users has to be tagged. This means getting an awareness of the acts and actions that have to be performed in any given place. The actions have to satisfy two different profiles: that of teacher and that of student, respectively. The information stored in the tags depends on the place where they are found, namely on doors, notices, boards, etc. The tag fixed on the door gives access and, at the same time, is used to control the attendance and students' location. Teachers can adapt their class contexts as well as location service whenever necessary. One of the most important services deriving from identification in the classroom is visualization. In the next section we present two approaches.

3.1 Visualization by RFID

The first experience that we have focused on with the RFID technology in the educational context is the visualization service as Figure 3 shows. To obtain this, and as implicit output to be carried out, the teacher has to wear a tag and place it near the reader next to the board. The data stored in the tag are read and the presentation that has been prepared before for the class is automatically taken from a data base for its projection. Similarly, information about the students present, along with the teacher's plan for that class, proposed exercises, documents, links and a map of the building appear on the mosaic of visualization.

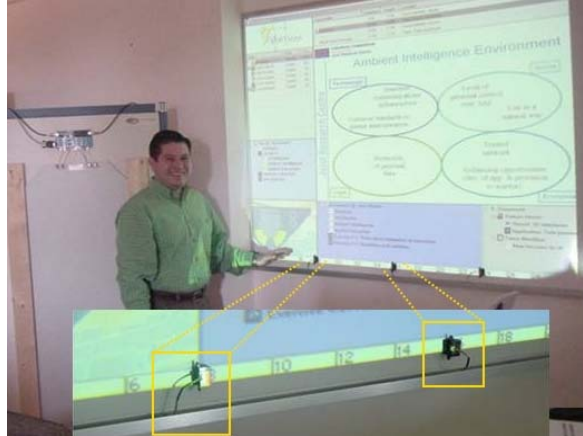


Figure 3. Visualization service provided to the teacher by RFID

To enable the above function, we have a reader, as well as a computer, to organize the visualization server (Hervás et al. 2006a). In our visualization approach by RFID, we have four sensors with different functionalities, for example passing a slide and going back to a previous one, taking control, etc. In addition, there are two kinds of interaction with sensors: passing a hand near sensors quickly or keeping it steady there for a few seconds. With this set of RFID-sensors, it is possible to manage the different parts of the mosaic by just providing each sensor with the user's requirements.

3.2 Visualization by NFC

The visualization service with NFC technology is also controlled by a computer. In this case it is structured in 3 zones (figure 4). In the top left the teacher's syllabus, which he/she distributes for the course, is shown. On the bottom left hand side, there are the documents for supporting the subject that is being dealt with by this group. Finally the large zone, on the right, visualizes the topic that is being explained at that moment.

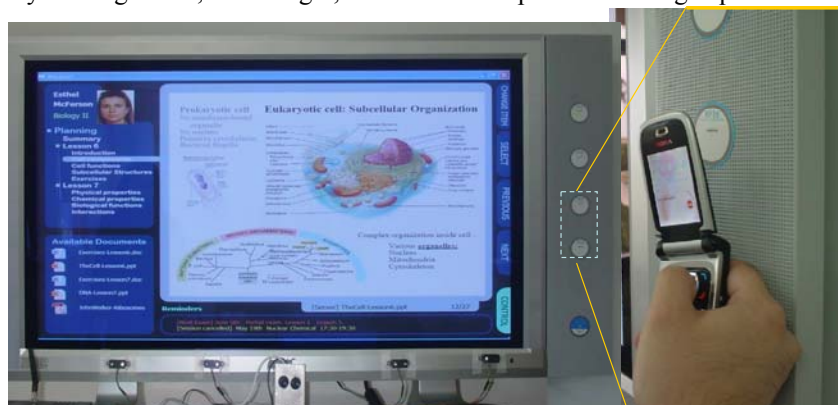


Figure 4. Use of tags embedded in the screen

This mosaic is similar to the previous one, although we have reduced the part of attendance, due to the fact that each student has to touch the tag when entering with the mobile phone and, in some cases, this can

be problematic. The operation is very simple; once the teacher brings his/her mobile phone close to the control tag, embedded in the screen (figure 4), the class begins. The information that is stored in the mobile phone initiates its transference and the presentation, which has been prepared beforehand, is ready to visualize. Other tags exist for supporting the interaction of the presentations. In order to pass slides, all that we need is to handle is the corresponding tag. The teacher has the option of changing subjects, selecting one of these, going forward or back. Another way to interact with the presentation is with the mobile phone, that is to say, through its keyboard. To do so, a program has to be downloaded and this can be done by just touching the control tag.

4. EXPERIENCE AND EVALUATION

The educational setting is very rich in interactions that are carried out by the users in this environment, but up to recently these interactions have not been fully taken advantage of. Sharing information by means of papers, displays and so on are the normal forms chosen by users.

Developing new interfaces to speed up the process and to help in everyday activities presents a new challenge: the evaluation of the systems. This assessment is a multidisciplinary set. There needs to be experimentation and observation of the actions and reactions that the users and computer devices share. Certain steps or methodologies for supporting the construction of different applications have to be followed if this process is to take place. In this sense, Schmidt proposes to verify the following points in the production of these guidelines (Schmidt and Van Laerhoven 2001):

- Identify the contexts to study.
- Build and Assess a prototype.
- Integrate signals of processing and context abstraction.
- Build applications.

It is important to take note that the students have not seen the computerless scenario before, as Figure 5 shows. The presentation of each student is activated by the tag when it is detected by the reader (figure 5a) or when they touch the tag with the mobile phone (figure 5b).



Figure 5. Experience using RFID technology (a) and Experience using NFC technology (b)

The assessment of the devices and systems was carried out in the main hall of the School of Computer Science of Castilla-La Mancha University. We set up the devices needed to make it possible to carry out the experience where the Teacher-Training took place. The devices that were involved were the computer, readers, tags and mobile phones. In the following sections we explain how this works.

The information that the students wanted to present to their companions was organized by a computer system that we developed to that end. This program allows simple slides to be constructed by just keying in the principal text (title) and secondary text (contents). It is also possible to attach images and graphs. The tool finally generates an exit XML that represents the knowledge of the user and, for us, the information that is stored in the database. This allowed students to produce their presentations in a simple way, avoiding unnecessary distractions in their activities. The students did not physically use the computer in the environment where the experience was conducted. It was not necessary to run a program such as Power Point to show their presentation. The use of the mouse was not necessary either, as just a natural movement with their hand over a given sensor or touching the control tags was enough.

4.1 RFID Experience & Evaluation

The students who participated in this experience have to carry tags with the appropriate instructions referring to the presentations they had given previously. They obtain the stored data as they passed near the antenna (over 80 cm.). The reader was continually transmitting waves of low frequency (125 Khz.), detecting tags and transmitting information in order to project the presentations automatically (figure 5a).

Table 2. Evaluation of the use of RFID technology

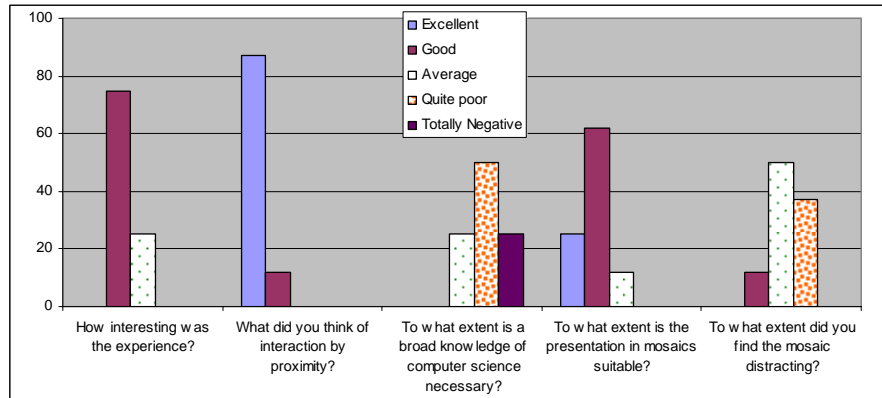
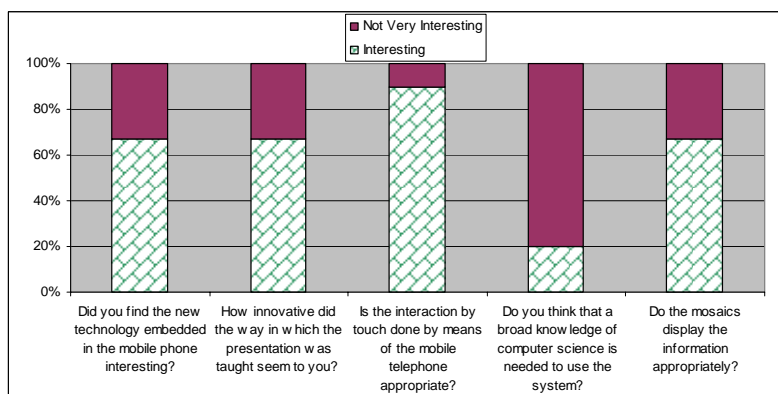


Table 2 shows that the acceptance of this experience was positive. The natural interaction by proximity received an excellent valuation in students' assessment; that is, the simple action of approaching the screen and the automatic projection of each presentation satisfied the students. They believed that special knowledge of using computers is not necessary. Finally, they thought that the idea of showing the information structured in mosaics was a good one.

4.2 NFC Experience & Evaluation

The experience that was presented had an approach that was different from the previous one. We took the advantage of this environment to carry out an evaluation, bringing with us a mobile NFC phone (figure 5b). Thus, by simply bringing this device close to a tag, their presentation was activated. The students who participated in this experience touched the control tag that contained the instruction about their presentations which they had produced previously. When touching the tag with the mobile phone (2 cm.) the presentation is visualized.

Table 3. Evaluation of the use of the NFC technology



The results that we obtained from this evaluation can be appreciated in Table 3. The great interest in, and novelty of, the technology embedded in the mobile phone found great acceptance. The success of the automatic projection of their presentation by just bringing the mobile telephone near to the control tag must be underlined. The interaction with sensors and tags was satisfactory (moving slides, navigation, etc.).

5. CONCLUSIONS

New forms of interaction with technologies and devices embedded in the environment allow the users to become involved in Ambient Intelligence. In this particular case, we see how this occurs in the field of education. The ease of having devices with computer capacities, communication and storage allows users to handle information, documents, and presentations, in other words, all that is necessary in an educative context. In this work we have demonstrated how integrating RFID technology into the mobile phone as NFC allows us to make the users' daily life easier and more efficient. With RFID technology services are obtained in an implicit way. For that to happen, electronic devices that are dispersed in the environment are needed. But the cost of these devices is rising considerably and the possibilities of interacting with the context are centralized in the server, which assumes a lot of responsibilities. The use of the mobile phone is a part of the everyday life of students and other people, so the students that participated in this scenario felt very much identified with this technology. In addition to the technology just mentioned, we have introduced a complement for implicit or embedded interaction, with a set of sensors placed near the visualization devices, which are put into action by just passing a hand by them.

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