Applying RFID Technology to Improve User Interaction in Novel Environments

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1. Introduction

At present our surrounding environment is constantly changing, the impact of new technologies and the information age is spreading dizzily in environments that were previously unthinkable. In order to take advantage of new technological developments we need solutions adapted to the rhythm of everyday life.

The interaction with applications has changed. Nowadays we aim to find new scenarios where the interaction between user and computer needs to be improved. We keep advancing, moving closer and closer to the idea of ubiquitous computing . All objects will be connected and the computer user will be involved. Thus, we will be closer to the natural way in which people interact with the environment. To achieve this type of scenarios we make use of the different advantages offered by mobile technologies, communication Wi-Fi (IEEE 802.11) and identification (RFID).

In this paper we describe the development and implementation of three different case studies, actually implementing the concept of context-awareness, location awareness and Internet of Things . In the first case, we describe GUIMUININ (Wireless Intelligent Museum Guides). This is a context-awareness project aim to improve the user experience in museums, so that users can see their location on any of the floors of the building and receive multimedia information on the museum item they select. In the second case, the project RCAR (Robotic Context Awareness by RFID) creates an environment sensitive to the location of a robot, which develops a tracking system and high resolution scanning for indoor or outdoor environments.The third case is the project Co-Interactive Table (Collaborative Interactive Table) that presents a digitalized table with RFID technology which executes collaborative tasks in a meeting room, face-to-face or remotely.

This article has six sections. Section 2 describes a RFID system and defines some concepts: context-awareness, Ubiquitous Computing, the Internet of Things and the types of interaction from user to new systems depending on the level attention. Section 4 presents the general infrastructure of RFID systems. In section 5, we describe our RFID systems and present their advantages and disadvantages. Finally, conclusions are set out in Section 6.

2. Related works

Technological developments in the miniaturization of microprocessors have opened up new possibilities for user services through the manipulation of information in their environment.

The major developments related to the computer field herald a new era where the systems should be adapted and integrated into the daily lives of people, occupying second place. This would ensure that the individual does not explicitly interact with the computer but in a passive way and implicitly dealing only with its target. This paradigm is defined by the term "Ubiquitous Computing" given by Mark Weiser from Xerox research center in Palo Alto in 1988 [2].

Weiser sees the technology as a means to an end based on the current user-computer interaction which he considers inadequate. The computer is a complex device and requires much concentration, thus distracting the attention of the user from the actual final task and he argues that the barriers between people and computers will disappear as we know them today, trying to provide ordinary physical objects with switching communication capacity, thus creating a large network of interconnected devices. The main objective is that the computer is hidden from the user, interacting with the user implicitly.

According to Bill Schilit [3] with the arrival of Ubiquitous Computing we will find a new way to interact with the system, the execution environments are constantly changing due to a very important factor is context. The context is defined by Dey as "any information that can be used to characterize the situation of an entity. An entity may be a person, place or object considered relevant to the interaction between a user and an application, including the user application [7]. Another concept closely related to the theory that explains Weiser is The Internet of Things, also known as the Internet of Objects, which refers to the networked interconnection of everyday objects.

Supporting these new environments requires the identification and communication technology which enables the user to work transparently. In the next section we briefly describe RFID technology. Specifically the Internet of Things is partly inspired by the success of this technology, which is now widely used for tracking objects, people, and animals. RFID system architecture is marked by a sharp dichotomy of simple tags and an extensive infrastructure of networked RFID readers. This approach optimally supports tracking physical objects within well-defined confines (such as warehouses) but limits the sensing capabilities and deployment flexibility that more challenging application scenarios require.

2.1 RFID technology

This section presents a detailed description of RFID technology. It is used to implement interactive, collaborative and context-awareness scenarios.

RFID (Radio Frequency Identification) is a system for storing and remotely retrieving data. This technology allows the identification of the object from the distance with no contact. An RFID system consists of:

- Reader or transceiver, which transmits request signals to the tags and receives the answers to these requests, it is a receiver / transmitter radio device. It needs one or more antennas to transmit the RF signal generated and receive the response. Readers may have an integrated antenna in their own hardware but it is not a requirement. Readers can range from card-sized PCM / CIA to fit a PDA to having a considerable size. Its main function is to communicate with the tags and facilitate the transfer of data to a control system.
- The RFID tag, label or transponder in the field of electronics, is an essential component of the RFID system, because of its operating scheme, it is capable of receiving and

transmitting signals, but these signals are only transmitted as a response to a request from a transceptor. The tag is a small chip or integrated circuit, adapted to a radio frequency antenna that enables communication via radio. According to their feeding mode, tags can be divided into: passive, obtaining the transmission power from the reader; active, using their own battery, and semi-active or semi-passive, using a battery to activate the chip circuitry but the energy to generate communication is that received from the reader´s radio waves, as passive ones. The most common type is passive tags, allowing the transponder device to work without its own power supply, making it cheaper, smaller and with an unlimited life cycle. As disadvantage, they present the distance limitation for identification.

- RNC (Reader Network Controller). This component is necessary to control the information received from the tags transforming it into useful information.
- Consumers. These are applications based on data received from RFID tags and will offer one service or another.

The operation of an RFID system is as follows: readers emit a magnetic, electric or electromagnetic field exciting the labels, they respond with the information they contain (unique id) via radio waves. When the reader receives the information, it is transmitted to the RNC that is responsible for pre-processing the data which will finally reach the customer.

2.2 The new interaction style with RFID

The new scenarios are generating new ways of the interaction between the user and the computer. The scenario where the user uses the mouse and keyboard to get a service has been replaced by others scenarios where the computation is implicit and user-directed. The new systems can provide information from the context which is captured by the system or by simple natural gestures. According to Ricardo Tesoriero in [1], the attention required from the user to use the new systems can be divided into two levels.

2.2.1 Lower level of attention

The user does not need to focus on the task to execute it. The system anticipates him/ her to provide a service. This is possible thanks to the context-aware applications. Some context-aware systems that use RFID technology are detailed next.

Then, it describes the context-aware systems developed with RFID technology to improve the cultural environment. eXspot is an RFID device evaluated in the Exploratorium museum in San Francisco (USA). Visitors have RFID tags and carry automatic cameras which take pictures depending on the preferences offered previously. The identification is used in a kiosk to view the captured images, creating custom web pages automatically [4,5,6,7].

Matthias Lampe [11] built some models for smart box application, among which we find the following: an application displays a smart medicine cabinet which prevents the problems of medication by monitoring the use of medicines [8]. In this application, the bottles are equipped with RFID tags. The temperature of medicines is monitored constantly to prevent damaging substances. The Cabinet monitors if there are drugs that should not be combined to prevent dangerous situations. A variety of similar works focused on medical applications can be found in [9] and in the next chapter [10].These systems use RFID technology.

Smart Tool Box contains different tools equipped with RFID tags and a toolbox with an RFID reader included. The toolkit sends different warnings according to different situations

to workers in the workplace. It also monitors the time period that the tools have been used. It is designed for working environments such as maintenance air critical. [11].
Context-aware systems have also been implemented to improve house environment. An example developed for cooking is the RFIDChef [12] , a device equipped with RFID which read everyday products tagged with RFID. A suggestion is offered according to products, different dishes to be prepared depending on the products available.
Transnote [13] is a system based in RFID built to improve classroom teaching. It stores and shared notes default, using a PDA with an RFID reader, which are sent by students during the lesson.

2.2.2 Medium level of attention

It requires more attention from the user. Distinguishing between a low or medium level of attention from the user is difficult. This level includes the environments that contain digitized objects but a simple action is required, such as, a natural gesture or closer the mobile device to the object.
The advantage is that the user has total control about the functions executed by the system, because the functions will not be executed unless the user performs a natural gesture.
This level requires physical mobile interaction. It is an interaction paradigm that allows physical objects to be increasingly augmented and associated with digital information and on the other hand, mobile devices can provide increasing capabilities to ubiquitously acquire and process this information. This level uses mobile devices to extract information from augmented physical objects and to apply it for a more intuitive and convenient interaction with associated services. This approach optimally supports tracking physical objects within well-defined confines (such as warehouses) but limits the sensing capabilities and deployment flexibility that more challenging application scenarios require. Next some RFID systems using physical mobile interaction in different environments are described. They are also called the Internet of Things. There is also a description of a RFID system at this level.
Libraries where the books are digitized and can be electronically browsed by physically Mobile and RFID tags [14]. Scenarios and smart objects at airport [15]. The concept of smart packaging is real thanks to technologies like RFID [16] . The definition of AID (Appliance Interaction Device) is an environment in RFID Internet of Things.
The home, intelligent office and other scenarios specific additions to the environment using RFID tags [18-29]. Multiple platforms and tools for the development of physical interfaces including the Phidgets based on this technology [30,31]. Papier-mâché using RFID, computer vision with codes bars to create tangibles interfaces [32]. Sports equipment increased electronically with RFID and ubiquitous technologies [33]. In addition to these systems we can find more examples where the objects are digitalized by RFID to approach the future Internet of Things.

3. RFID systems architecture

The hardware and software architecture used to design and implement the RFID system adaptable to new context-awareness and collaborative scenarios is:

3.1 Hardware architecture

The general infrastructure is shown in Figure 1. It consists of physical objects that incorporate identification technology such as RFID, QR codes, Bidi codes, etc. The device in the client side includes a reader and a controller that is responsible for processing information received by the physical object and transform it into useful information, such as an XML message that is sent to the server, which will process the message and will trigger an action, such as the generation of user interfaces or the information requested at that time. To notify the customer with web services, the network technology is used, connecting the two components, the client and the server.

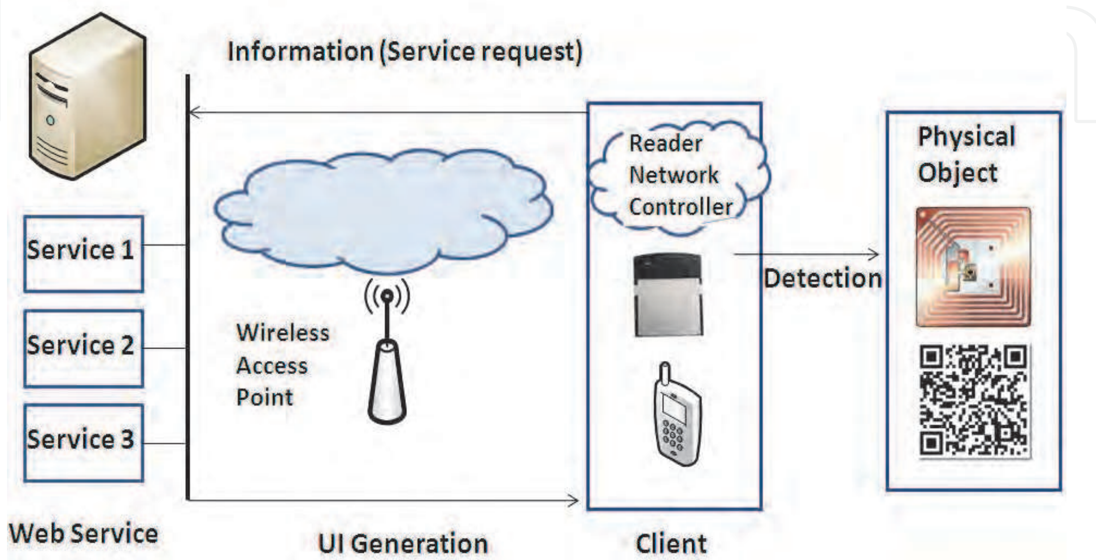

Fig. 1. Hardware architecture

To support the new systems we have used the following hardware devices:

- RFID-tags embedded in objects.
- RFID reader integrated into mobile devices or other object.
- RFID-Network Controller (RNC - RFID Network Controller) which is responsible for providing the necessary data to client applications.
- Server: it is a computer with functionality for hosting Web Services and Database.
- The communication network is responsible for connecting all the devices in the RFID system; the technology used in the systems is WiFi (IEEE 802.11).

3.2 Software architecture

We have used the Model-View-Controller to model the entities and actions that can execute in the described scenarios. It is a software architecture pattern that separates data from an application, user interface and control logic into three different components.

The general scheme covers several kinds of systems. These systems can be divided in two groups: The context-awareness system or location-awareness, which use the ID RFID to identify context or location information or digitalized objects that contain an id RFID associated to a service, it can generate an interface or execute a specific function.

The systems built are highly distributed. Figure 2 shows the three parts: Controller, View and Model.

Controller. This part is on the client side and consists of the following entities: **RFIDReader**, which is the RFID reader. It will inform the **Context Model** that an Identifier from any tag has been detected. The **ContextModel** will transmit the identifier to the server through a proxy, represented by the **ServerProxy** class. Such identifier is processed by the server running the Web Service . There is only one identifier and it is associated with the class command which is referred to a command or service. The server component contains the **WebService**, it is a software component that communicates with other applications by coding the XML message and sending this message via standard Internet protocols such as HTTP (Hypertext Transfer Protocol). Web Services are a set of protocols and standards used to exchange data between applications in order to offer services. They facilitate interoperability and offer automated services to be invoked, causing the generation of user interfaces automatically, thus allowing the user consistency and transparency in using the technology. There are two possibilities depending on the request made. The first case when it is only necessary to view some information, we just need to send the identifier of the RFID tag. The second case when the function requested is more complex, as the generation of a new interface, sharing files, etc., it is also necessary to pass the corresponding parameter.

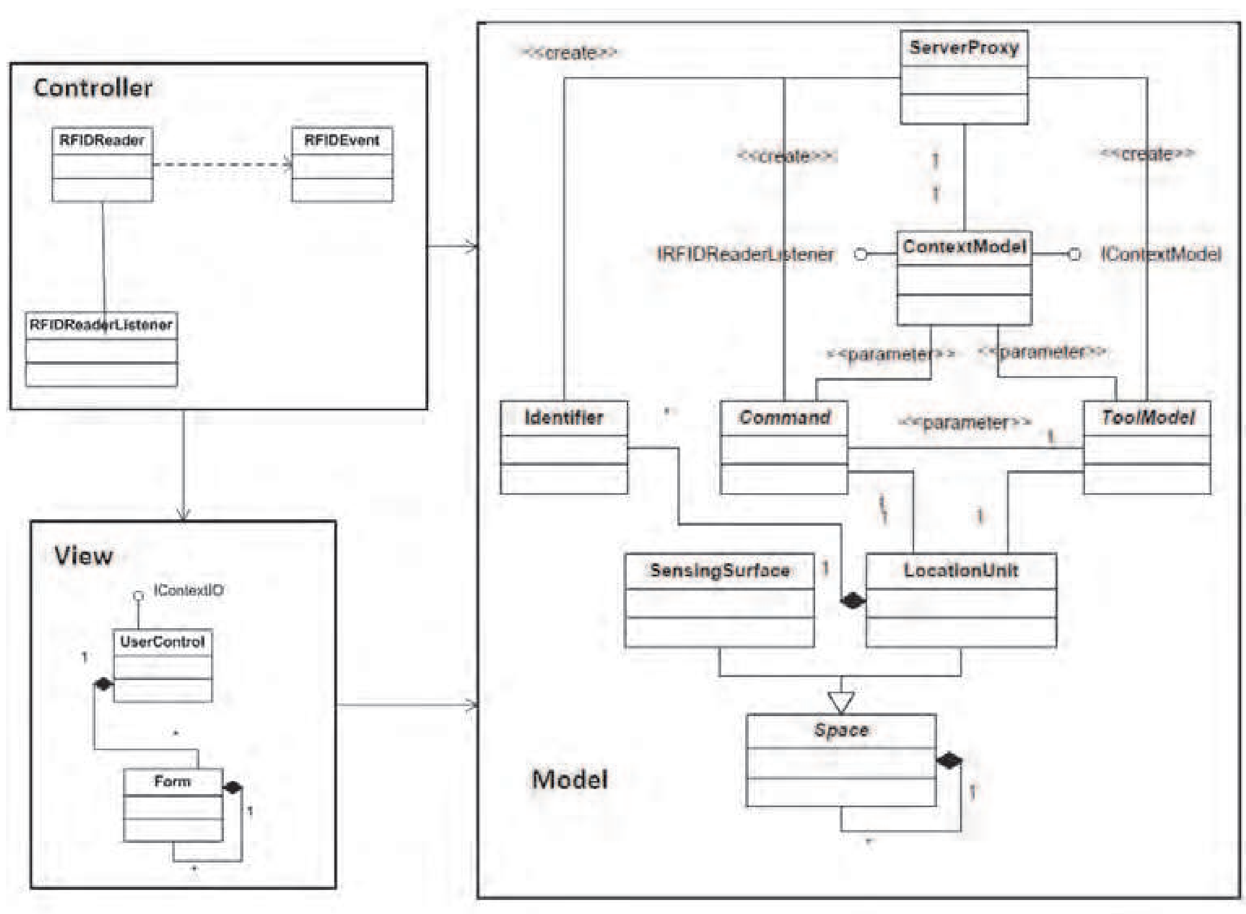

Fig. 2. Software architecture

4. Case studies developed by using RFID technology

In this section we describe three systems built in the University of Castilla-La Mancha (Albacete). The main objective is to take advantage of RFID technology to built systems that improve the user experience.

4.1 A context-aware system in cultural environments (GUIMUININM)

Modern museums offer visitors devices to guide them and help them to enjoy their visit. Often, these electronic guides provide visitors with audio information about the pieces exhibited in the museum. These devices require a higher level of attention from users; we attempt to address this problem by converting the environment in a context-aware place. Thus, we make the users' interaction with the system invisible, allowing them to enjoy the experience in the cultural environments.

GUIMUININ (Wireless Intelligent museum guides) is a context-aware project aimed to improving the user experience in museums in which the system may know his/her location on any of the floors of the building and retrieve multimedia information about the museum pieces near the user.

We have used technology based on mobile devices and RFID to implement the system. An art object or piece displayed along with extra information. Active RFID tags to identify a showcase and passive RFID tags to identify a piece in the showcase. A positioning subsystem is responsible for giving the mobile devices an identification to locate the device according to a relative or absolute position. On the other hand, the mobile device is able to detect automatically the position of the user in the museum and retrieve the correct information according to the user location in the museum.

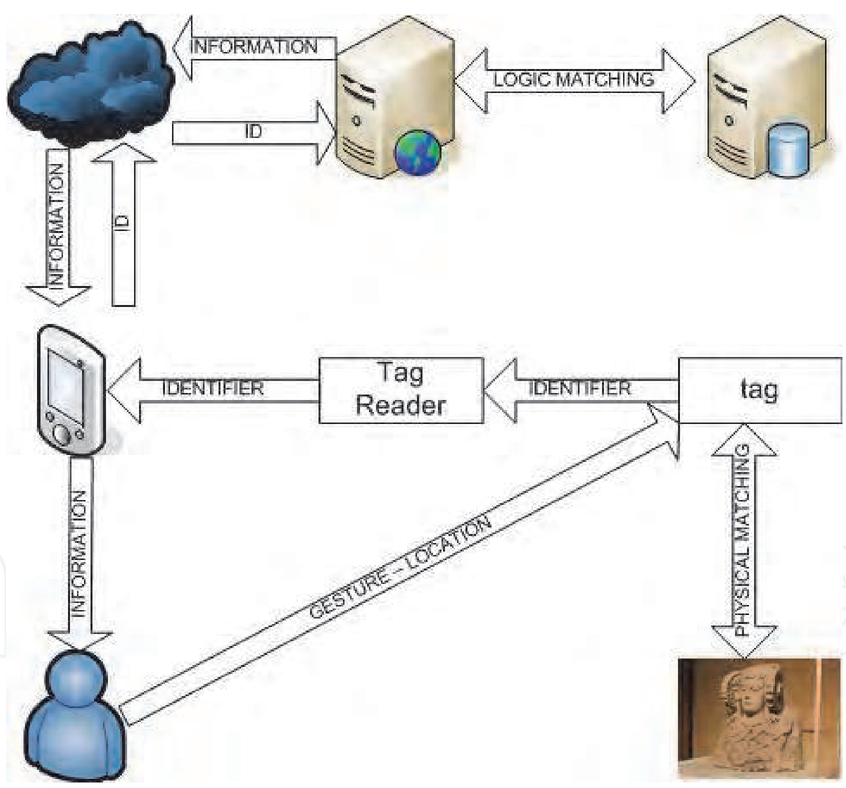

Fig. 3. Active(location) and passive (gesture) RFID scheme. The RFID reader is installed on the mobile devices.

4.2 System based on location awareness (RCAR)

The location of the entities (user, robots...) is necessary to build context-aware systems. Currently the development of systems for outdoor location seems to be solved by Global Positioning Systems (GPS). However, this technology is not enough in indoor environments, where the satellite signal undergoes a total attenuation, or rather where the accuracy and precision are very low. To solve this problem we have built the system RCAR (Robot context awareness by RFID).

RCAR is an indoor tracking system. It is capable of locating and track autonomous entities inside buildings. To achieve this goal we propose awareness surfaces using passive RFID tags.

Sensitized surfaces are physical surfaces where an autonomous system can be located (floors, walls, ceilings, tables, etc.). This surface consists of tracking units, which have at least one single identifier associated. For the identification code of a paging unit, physically we have to assign an identification code to a physical area and implement a mechanism to get that ID.

A tag represents a paging unit and a mesh of tags a sensitized surface. The mechanism used to obtain information from the tags is a passive RFID reader which is integrated into the autonomous entity. A robotNXT is chosen to incorporate the PDA and RFID reader. The PDA is connected via Wi-Fi (IEEE 802.11) to a wireless service control. The location manager is responsible for mapping the identifier to the corresponding physical surfaces.

Figure 4 shows a schematic representation of the location system, Lego Mindstorm NXT robot built with PDA and the surface used to sensitize with RFID.

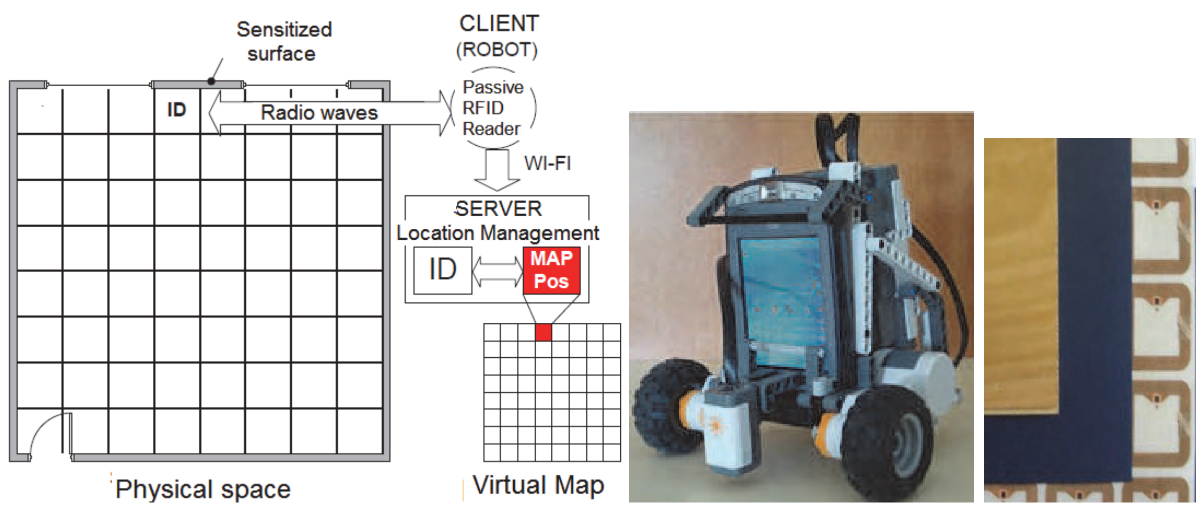

Fig. 4. Schematic representation of the location system. Lego Mindstorm NXT robot built with PDA and sensitized with RFID.

4.3 The co-interactive table: RFID system to improve collaborative meetings

Most activities performed in our life present a high degree of collaboration. One of the critical points of this process is the lack of information which may lead to waste users' time, thus increasing the feeling of frustration in the tasks. Some distributed collaborative applications may allow users to perform some tasks as videoconferences, chats, e-mail, etc., but in some other situations it is necessary to perform such tasks face-to-face to obtain better results.

The Co-Interactive Table is a system designed and built to facilitate collaborative tasks necessary in any meeting, such as sharing information and files among the participants, using simple, natural and intuitive gestures.

We have used technology based on mobile devices and RFID to implement the system, which is composed of several panels (one per user) forming the interactive table. A projector connected to a PC updates instantly important information such as ideas, notes and specific user information. The Co-Interactive Table client application runs on mobile devices with RFID reader. The system can recognize and offer the service required by the user with a gesture as simple and natural as placing the mobile device near the interactive table to select the desired action.

The interactive table is composed of different panels. The size of each panel is 210x297 mm, the same as a din-A4 paper. Its interface shows the operations that a user may perform in the meeting. These operations are graphically represented by attractive and intuitive metaphors. RFID tags that provide the functionality to the panels are hidden under the external interface

Each user has a panel and a mobile device with an RFID reader. Each mobile device has the application client running in it. This application shows the information necessary to use the interactive table. All the devices are connected by a Wi-Fi access point to the server that stores the important data, files and methods necessary for the operation of the system. In addition, the room has a projector connected to a PC that shows the users connected at each moment and the post-it notes that they have sent during the meeting through their panels. It can also support remote meetings where users are distributed in different geographical locations connected to the same server.

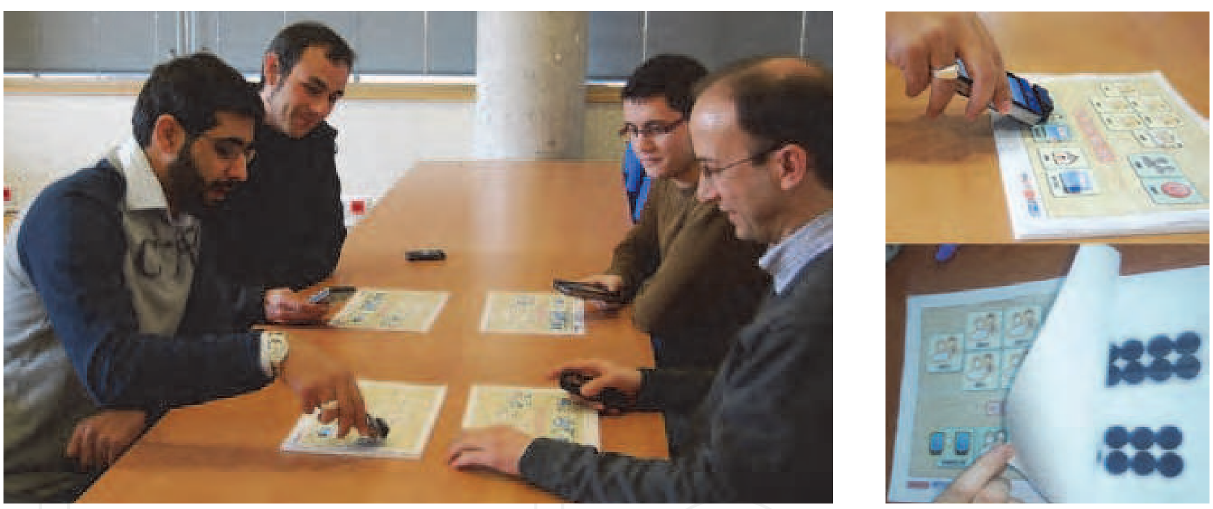

Fig. 5. The image on the left hand side shows a meeting room that incorporates the "Co-Interactive system". The image on the right shows the natural gesture required to run a function by interactive panels and the tags RFID integrated under the interface.

As an example of use, figure 5 shows a specific scenario in which four users participate in a meeting using the Co-Interactive Table. Each participant has a panel with all the functionalities available depicted on it and a mobile device with an integrated RFID reader.

The interactive panel (See figure 6) shows visual metaphors that represent a specific operation. The available functions are the following:

- Log in: It suggests the user to log in. At this moment the system panel is associated with the user.
- Transfer File: This function allows users to share files with the participants in the meetings, this way you can share and save information easily in a few seconds. Depending on the metaphor selected, the file can be shared with a particular user or with all the users in the meeting.

- View User Information and Files: This metaphor shows the users´ academic and professional information. This function facilitates communication in meetings where people do not know each other previously. In addition they can see the files uploaded by other users.
- Returns to the main screen: This function returns to the main screen.
- View my files: This metaphor shows the files received during the meeting.
- Select user: Selecting a user is always necessary to carry out a collaborative activity. In our case it will be necessary to transfer and view files and information from another user.
- Exit: The user logs out. This function removes the association between the panel and the user.

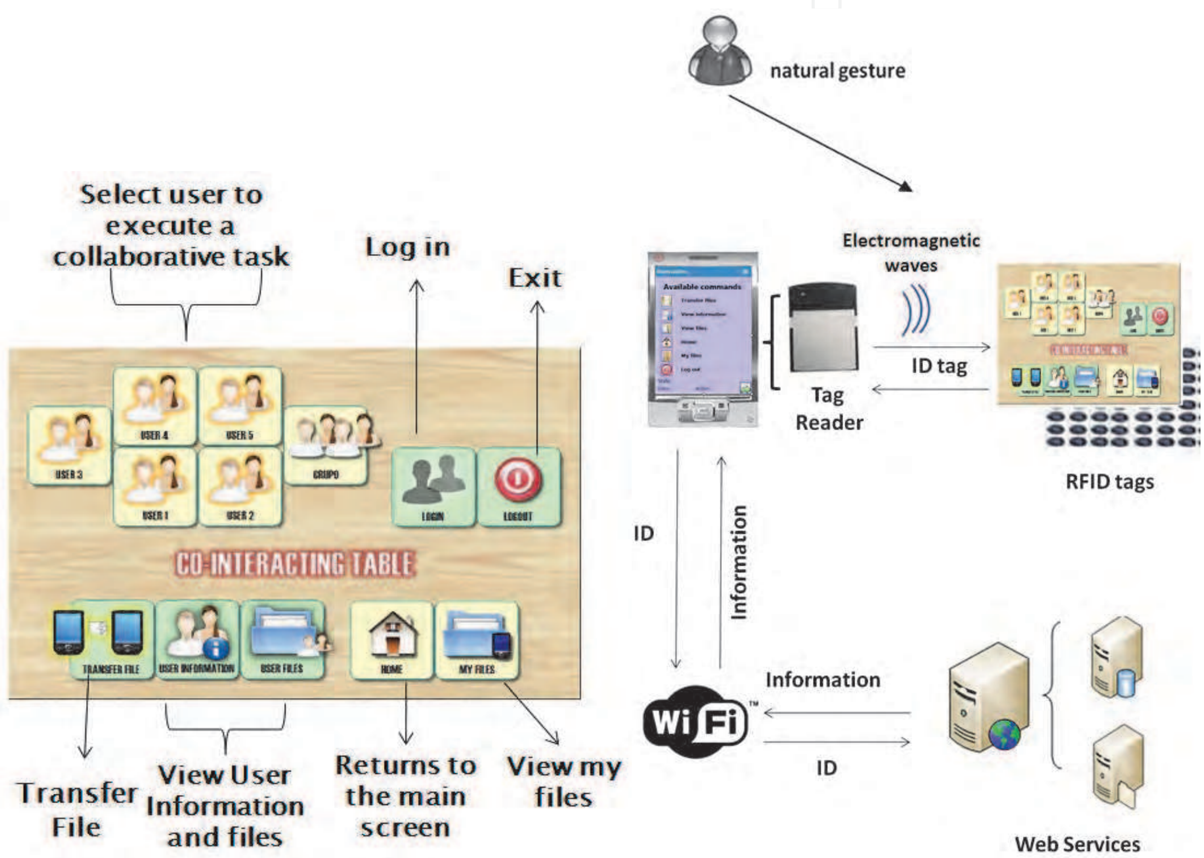

Fig. 6. User interface interactive panel: it shows the functions offered by the intelligent object and scheme showing the operation of the panels incorporating RFID technology with the mobile device and Web Services.

The system architecture is client-server, where the processing capacity is shared between both. Its operation is very simple: the client, which in our case is the application running on the mobile device, makes requests for a service from the server which provides the response. As shown in Figure 6, from the client side we can see the scanned physical object (interactive panel) that communicates with the mobile device using RFID technology. Both the mobile device and the PC are responsible for implementing the services offered by the server via Wi-Fi wireless technology.
The server runs on a PC that is connected to an access point via Wi-Fi. Its main objective is to provide the shared resources and the services required to the customer.

The server content has been divided into two parts: one is responsible for hosting the files from the meeting and the other one stores the database.
The hardware components used to build the system are the following:

- The interactive panel is a lightweight and portable rectangular object of 210x297 mm. Its interface contains visual metaphors that indicate the functions that can be carried out using the panel. Under the interface RFID tags are hidden, as seen in the right image of Figure 5, thus providing functionality to panels. Altogether the object is made up by 48 tags.
- RFID-Tags are under the interactive panel interface. The tags used are passive, i.e. no external battery is required to operate.
- RFID Readers contain CompactFlash connectivity. The maximum reading range is 10 meters and can accommodate multi-tag (anti-collision), i.e. they can read multiple tags at a time without causing any conflict or loss of information read. It is easy to connect to computers and PDA handheld readers.
- The Access Point, also called WAP, (Wireless Access Point), is a terminal that connects devices to form a wireless network, thus allowing communication among them. It is always ready to serve new customers we serve and its main function is to receive, store and transmit information to the corresponding device. Its use has allowed us to create a high performance safe and reliable wireless LAN.
- The Webcam is a small digital camera connected to a computer which can capture images and transmit them through the network to users who are located elsewhere; therefore, meetings can be held remotely, because the interactive panel functionality is not lost despite users not being in the same room. In our case it is optional; it would only be used in specific cases.
- Mobile devices, also known as handheld, PDA, Palmtop or just handheld devices are small, with some processing capabilities, permanently connected to the network. This is the device the user will use to interact with the panel.
- The Projector: Its function is to receive a video signal and project the corresponding image on a projection screen. In our case it is used to project the image of an application whose function is to show users present at the meeting and the important information. It is connected to the server and is constantly updated.
- The PC: Its function is to run the application to be displayed on the projector. The server is contained in the PC, as well as all its resources and optionally the web cam which is incorporated can be connected when wishing to hold a meeting remotely. The PC is always connected to the access point to provide the services required by the user.

The software components that allow the operation of all the functions required are:

- The "controller." It is located on the mobile device and its main function is to control communication between the mobile device and the interactive table, supported with RFID technology. For communication to be perfect the component is continuously waiting for the execution of an event as the ID reading of the RFID tags contained in the panel and then it will send the information to the web server to run the specific operation.
- The "web Service". Its function is to receive the identifier read by the RFID reader and check it with the database in order to return the corresponding data to the client running on the mobile device.
- The "co-it". It runs on the mobile device and its main objective is to display the information corresponding to the function selected in the interactive table. This component communicates via Wi-Fi with the Web service.

- The "post-it system". It runs on a PC and its function is to verify if there is a new user or event in the meeting, as sending a "post-it type" note to the public folder, and subsequently inform all users of the meeting by displaying the updated information on the projector. The "post-it" system incorporated allows people to expose their ideas easily, facilitating the exchange of information at the meeting.

The communication process is as follows: (See Figure 6). The user makes a gesture as simple and intuitive as approaching the device to the metaphor selected; this is the event that triggers the next action:

The RFID reader incorporated on the mobile device emits electromagnetic waves that excite the RFID tags. The reader will read a single ID, and then sends it to the RNC (Controller) which is responsible for pre-processing data to be sent to the server. Using wireless technology the reader sends the ID and the panel ID to the server, the ID is then mapped to the database for the action to be executed. This information is sent via Wi-Fi to the client´s mobile device, which is responsible for implementing one window or another depending on such information, thus triggering the interface automatic change without requiring the use of a pen.

5. Benefits and drawbacks - lessons learned

In this section we will discuss the advantages offered by the integration of RFID technology in the new scenarios.

The benefits about RFID tags are that they can be hidden allowing users to work in a natural way without being aware of them.

The execution of functions is easier, this depends on the context or on simple natural gestures. In this way this is actually the definition given by Weiser on Ubiquitous Computing, which describes a technology that runs implicitly to the user, ensuring that the user has complete control over the application without concentrating on it.

Low cost deployment as mobile devices will incorporate this technology in the short term, passive RFID tags are very inexpensive, thus offering very cheap and affordable systems. Greater flexibility in the dynamic content of the system. The application can update their information quickly and effectively, thanks to the existing interconnection network. This type of systems offer the possibility to work in different physical environments, presenting fewer limitations than other systems such as infrared or ultrasound, which suffer greater attenuation level to consistent materials. Tags or passive tags do not require additional batteries, thus providing easy maintenance and high resistance.

Thanks to this technology the implementation of new interfaces can be developed for any mobile device, allowing the system usability and user-friendly interaction, thus improving user satisfaction.

Some possible limitations are: It requires connectivity to another network interconnection. The server needs to contain all the data from RFID tags, so in very complex systems we can find a lot of data, which might be difficult to manage.

6. Conclusions

The computer human interaction currently undergoing is not yet as natural as desired. The user must pay too much attention to the computer.The main objective is for users to focus on their tasks and not on the system performance. This type of systems, implicit by the user, also called context-awareness or the Internet of Things are difficult to develop. The use of embedded technologies into the objects is required to implement them, in addition to the network wireless and server requirements to manage all the information. In this chapter we present three projects, one of them is focused on improving the user visit the cultural environments, the system captures the user's context information and sends back information on works of art that are near the user at that moment. Another project has focused on improving indoor tracking systems for objects that have been sensitized with RFID tags. The last project improves collaborative tasks carried out at the meetings. In order to facilitate such tasks, we have digitized panels. RFID technology has been used because of the advantages it offers. We can see that RFID is a technology with far more profits than previously thought, which has moved from being the star product identification, to be able to scan simple objects and scenarios, providing intelligent environments where information is readily available. It facilitates human interaction with the environment through mobile devices and overcomes the limitations of mobile phones by providing a new type of interface that is easily adaptable.

7. Acknowledgements

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8. References

[1] Tesoriero, R., Gallud. J. A., Lozano, M. D. and Penichet, V.M. R. (2009). Supporting New Ways of Interaction in Cultural Environments, *Human-Computer Interaction*, Inaki Maurtua (Ed.), ISBN: 978-953-307-022-3, InTech, Available from: http://www.intechopen.com/articles/show/title/supporting-new-ways-of-interaction-in-cultural-environments

[2] Weiser, M. (1991) The Computer for the 21st Century, Sci Amer., *ISSN*: 1064-4326

[3] Schilit, B., Adams, N., Want, R. (1994). Context-aware Computing Applications.1994 First Workshop on Mobile Computing Systems and Applications, ISBN: 978-0-7695-3451-0, Santa Cruz, CA, USA.

[4] Sherry, H., Holly, F., RFID enhances visitors' museum experience at the Exploratorium, Communications of the ACM, ISSN:0001-0782, v.48 n.9, September 2005 - 240.

[5] Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., and Spasojevic, M. (2002) Rememberer: A tool for capturing museum visits, ISBN:3-540-44267-7 Tech. Rep. HPL-2002-187, Hewlett Packard Laboratories, July 17 2002.

[6] Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., and Spasojevic, M. From informing to remembering: Ubiquitous systems in interactive museums, *IEEE Pervasive Computing*, vol. 1, no. 2, pp. 13–21, 2002. ISSN:1536-1268

[7] Hsi, S. (2004).I-guides in progress: Two prototype applications for museum educators andvisitors using wireless technologies to support informal science learning, in *WMTE'04: Proceedings of the 2nd IEEE International Workshop on Wireless and Mobile*

Technologies in Education (WMTE'04), ISBN:0-7695-1989-X (Washington, DC, USA), p. 187, IEEE ComputerSociety, 2004.
[8] Wan, D. (1999). Magic medicine cabinet: A situated portal for consumer healthcare, *Lecture Notes in Computer Science*, vol. 1707, pp. 352–355, 1999. ISBN:3-540-66550-1.
[9] Fuhrer, P., Guinard, D. (2006). Building a Smart Hospital using RFID technologies: Use Cases and Implementation October 12 - 13, 2006, Fribourg, Switzerland and will be published in its proceedings in the Lecture Notes in Informatics. ISBN: 978-0-7695-3336-0.
[10] Benelli, G., Parrino, S. and Pozzebon A. (2010). RFID Applications for Sanitary Environments, Sustainable Radio Frequency Identification Solutions, Cristina Turcu (Ed.), ISBN: 978-953-7619-74-9, InTech, Available from: http://www.intechopen.com/articles/show/title/rfid-applications-for-sanitary-environments
[11] Floerkemeier, C., Lampe, M., and Schoch, T. (2003). The Smart Box Concept for Ubiquitous Computing Environments. Presented at Smart Objects Conference (Grenoble, 2003).
[12] Langheinrich, M., Mattern, F., Romer, K., Vogt, H. (2001). First steps towards an event based infrastructure for smart things, Dec. 15 2001.
[13] Miura, M., Kunifuji, S., Shizuki, B. and Tanaka, J. (2005). Airtransnote: Augmented classrooms with digital pen devices and RFID tags, " in *WMTE*, pp. 56–58, IEEE Computer Society, 2005. ISBN: 0-7695-2385-4.
[14] Salcedo, R. M., Ogata, H. and Yano, Y. (2005).Towards a new digital library infrastructure with RFID for mobile ELearning, in *WMTE*, pp. 261–263, IEEE Computer Society, 2005.ISBN: 0-7695-2385-4.
[15] McCoy, T., Bullock, R. J. and Brennan, P. V. (2005). Rfid for airport security and efficiency, in *Proc. IEE Seminar on (Ref Signal Processing Solutions for Homeland Security No. 2005/11108)*, pp. 9 pp.–, 2005., ISBN: 0-86341-564-4.
[16] Pala, Z. and Inanc, N.(2007). Smart parking applications using rfid technology, in *Proc. 1st Annual RFID Eurasia*, pp. 1–3, Sept. 5–6, 2007. ISBN: 978-975-01566-0-1.
[17] Roduner, C., Langheinrich, M., Floerkemeier, C. and Schwarzentrub, B. (2007). Operating appliances with mobile phones - strengths and limits of a universal interaction device, "in *Pervasive Computing, 5th International Conference, PERVASIVE 2007, Toronto, Canada, May 13-16, 2007, Proceedings* (A. LaMarca, M. Langheinrich, and K. N. Truong, eds.), vol. 4480 of *Lecture Notes in Computer Science*, pp. 198–215, Springer, 2007. ISBN: 978-3-540-72036-2.
[18] Jung, K. K., Son, D. S. and Eom, K. H. (2009). Rfid footwear and floor system, in *Proc. WRI World Congress on Computer Science and Information Engineering*, vol. 3, pp. 72–75, Mar. 2009. ISBN:978-0-7695-3507-4.
[19] Ha, S., Jung, H. and. Oh, Y. (2006).Method to analyze user behavior in home environment, *Personal Ubiquitous Comput.*, vol. 10, no. 2-3, pp. 110–121, 2006. ISSN:1617-4909.
[20] Barrett, R. and Maglio, P. P. (1998).Informative things: how to attach information to the real world, " in *UIST '98: Proceedings of the 11th annual ACM symposium on User interface software and technology*, (New York, NY, USA), pp. 81–88, ACM, 1998. ISBN:1-58113-034-1.

[21] Want, R., Fishkin, K. P., Gujar, A. and Harrison, B. L. (1999).Bridging physical and virtual worlds with electronic tags, ” in *CHI ’99: Proceedings of the SIGCHI conference on Human factors in computing systems*, (New York, NY, USA), pp. 370–377, ACM, 1999. ISBN:0-201-48559-1.

[22] Kindberg, T., Barton, J., Morgan, J., Becker, G., Caswell, D., Debaty, P., Gopal, G., Frid, V. Krishnan, M., Morris, H., Schettino, J. and Serra, B. (2000). People, places, things: Web presence for the real world, ” Tech. Rep. HPL-2000-16, Hewlett Packard Laboratories, Feb. 13 2000. ISSN:1383-469X.

[23] Ljungstrand, P., Redstr¨om, J. and Holmquist, L. E. (2000). Webstickers: using physical tokens to access, manage and share bookmarks to the web, ” in *Designing Augmented RealityEnvironments*, pp. 23–31, 2000.

[24] Rekimoto, J., Ayatsuka, Y. and Hayashi, K. (1998). Augment-able reality: Situated communication through physical and digital spaces, in *ISWC*, pp. 68–75, 1998. ISBN:0-8186-9074-7.

[25] Rohs, M. and Bohn, J. (2003).Entry points into a smart campus environment - overview of the ETHOC system, ” in *ICDCS Workshops*, p. 260, IEEE Computer Society, 2003. ISBN:0-7695-1921-0.

[26] Smith, M. A., Davenport, D., Hwa, H. and Turner, T. (2004). Object auras: a mobile retail and product annotation system, ” in *Proceedings of the 5th ACM conference on Electronic commerce (EC-04)*, (New York), pp. 240–241, ACM Press, May 1–8 2004. ISBN:1-58113-771-0.

[27] Riekki, J., Salminen, T. and Alak¨arpp¨a, I. (2006). Requesting Pervasive Services by Touching RFID Tags, *IEEE Pervasive Computing*, vol. 5, no. 1, pp. 40–46, 2006. ISSN:1536-1268.

[28] Ailisto, H., Pohjanheimo, L., V¨alkkynen, P., Str¨ommer, E., Tuomisto, T. and Korhonen, I. (2006).Bridging the physical and virtual worlds by local connectivity-based physical selection, ” *Personal and Ubiquitous Computing*, vol. 10, no. 6, pp. 333–344, 2006. ISSN:1617-4909.

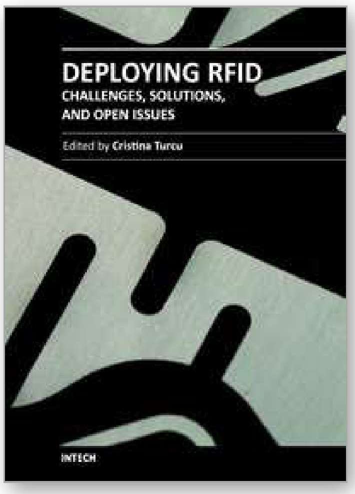
[29] Wagner, D., Pintaric, T., Ledermann, F. and Schmalstieg, D. (2005). Towards massively multiuser augmented reality on handheld devices, ” in *Pervasive Computing, Third InternationalConference, PERVASIVE 2005, Munich, Germany, May 8-13, 2005, Proceedings*(H.-W. Gellersen, R. Want, and A. Schmidt, eds.), vol. 3468 of *Lecture Notes in Computer Science*, pp. 208–219, Springer, 2005.ISBN: 3-540-26008-0.

[30] Marquardt, N. and Greenberg, S. (2007) Distributed physical interfaces with shared phidgets, ” in *Tangible and Embedded Interaction* (B. Ullmer and A. Schmidt, eds.), pp. 13–20, ACM, 2007. ISBN: 978-1-59593-619-6.

[31] Greenberg, Saul and Fitchett, Chester, (2001). Phidgets: easy development of physical interfaces through physical widgets, in *Proceedings of the ACM Symposium on User Interface Software and Technology*, Papers: Tactile user interface, pp. 209–218, 2001. ISBN:1-58113-438-X.

[32] Klemmer, S. R., J. Li, J. Lin, Landay, and J. A., (2004) Papier-mache: toolkit support for tangible input, in *Proceedings of ACM CHI 2004 Conference on Human Factors in Computing Systems*, vol. 1, pp. 399–406. ISBN 1-58113-702-8, Vienna, April, 2004.

[33] M. Kranz, Spiessl, W. and Schmidt, A. (2007). Designing ubiquitous computing systems for Sports equipment, in *PerCom*, pp. 79–86, IEEE Computer Society, 2007. ISBN:0-7695-2787-6.



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Radio frequency identification (RFID) is a technology that is rapidly gaining popularity due to its several benefits in a wide area of applications like inventory tracking, supply chain management, automated manufacturing, healthcare, etc. The benefits of implementing RFID technologies can be seen in terms of efficiency (increased speed in production, reduced shrinkage, lower error rates, improved asset tracking etc.) or effectiveness (services that companies provide to the customers). Leading to considerable operational and strategic benefits, RFID technology continues to bring new levels of intelligence and information, strengthening the experience of all participants in this research domain, and serving as a valuable authentication technology. We hope this book will be useful for engineers, researchers and industry personnel, and provide them with some new ideas to address current and future issues they might be facing.