Support for Visually Impaired through Mobile and NFC Technology

Pilar Castro Garrido*, Irene Luque Ruiz, and Miguel Ángel Gómez-Nieto

University of Córdoba, Department of Computing and Numerical Analysis
Albert Einstein Building, E-14071 Córdoba, Spain
{pcgarrido,iluque,mangel}@uco.es

Abstract. This paper describes a model based on an ontology for labeling context-awareness scenarios where blind or visually impaired people interact with embedded objects through mobile devices equipped with NFC technology. The augmented environment allows users to receive information and services from the tags disseminated, meliorating their experiences. Although this labeling is specially indicated for blind or visually impaired people, anyone can interact with this environment, obtaining tailored services and information from the tags. The solution proposed has been tested in a real environment: the Baena Olive-Grove and Olive Oil Museum, receiving a good acceptance from the users.

Keywords: Mobile phone, NFC, Context-awareness, Ontology, Handicap people.

1 Introduction

Visual impairment is the decrease in the volume of information collected by the eye from the environment, diminishing the amount of experiences that an individual might receive from the outside. Visual impairment ranges from low vision to blindness [1].

Technical assistance is the instrument, product, technical systems, etc., created in order to assist and improve the abilities of the person that uses it. The number of people that can benefit from this kind of devices has become higher and higher lately. The new technological developments can create devices that are able to compensate some of the features that otherwise, are difficult to achieve. By integrating these devices into the everyday life of the patient, they are capable of improve the patient's quality of life [2]. Thus, aids based on computer technology are making that people with disabilities could integrate perfectly in society. Clear examples of these aids are the studies related with the management of electronic equipment that help patients when accessing to reading and information processing, therefore, improving their quality of life.

Currently, the new technologies allow the integration of visually impaired people with the computational world, using the same operating systems than any person

* Corresponding author.

M.L. Reyes et al. (Eds.): IT Revolutions 2011, LNICST 82, pp. 116–126, 2012.

without a disability. This is achieved with programs or specific adaptations that help the impaired person to manage a computer normally [3]. When talking about new technologies, we are also including mobile phone technologies. Lately, mobile operators and designers are taking into account the specific needs of the blind and visually impaired people in order to allow them to access to the communication on equal terms, as communication is an essential element for achieving the integration of this collective.

Thus, researches and technological developments performed in recent years are based on the proposal of two types of solutions [4]:

- The development of special devices adjusted for disability people.
- The use of existing devices but incorporating specific applications in order to improve some aspects of the daily life of visually impaired people.

Among the solutions that considers the development of special devices, it must be highlighted, for example, the Owasys 22C [5], the first mobile phone designed for blind people. A phone without screen that warns the user by using phrases on the reception of messages, the existence of a call waiting or a missed call, who's calling, level of coverage and battery, etc. Other devices developed in this category include Braille keyboards for both PC and compatible mobile phones or PDAs using Bluetooth for the communication with mobile devices [6].

The software solutions are geared to the deployment of products that incorporate or not special equipment, supporting people with visual disabilities. In this group of solutions five categories could be differentiated:

- *Personal and Practices*: include applications that can be used in basic daily activities such as: organizing objects by color (i.e. clothes), performing basic calculations, recording voice memos, listening music on the mobile phone, etc.
- *Mobility Aids*: include applications that can help blind people to reach their destinations faster and to find the best route to it.
- *Reading "in process":* include applications that enable people with visual disabilities to read documents in specific formats.
- *Remote Access*: include computer applications that allow users to perform tasks remotely on their mobile phone even where a screen reader or a magnifier is not installed.
- *Fun and Learning*: include games enjoying the time or relax themselves, or to get more out of the skills.

Society is starting to notice that impairment depends more on the relationship of the individual with his physical environment and social and cultural background than on the physical handicap. It is the environment configuration which imposes barriers and limits; therefore, if those limits are removed by modifications, the obstacles that prevent the autonomy of individuals can be reduced or even annihilated.

In this paper we will describe how with the use of a tool for labeling objects within the environment, visually impaired people could perform tasks such as locating places in buildings or listening information from the posters (that are normally displayed in text mode but few times in Braille) just by the use of a mobile device equipped with Near Field Communication technology (NFC) [7]. Such tools should be included within the mobility aids and reading category.

NFC will generate the contactless revolution, offering ubiquitous services and information to users in different moments and places, and making possible the Internet of Things. Some projects developed have been developed under this pervasive vision. For instance, in [8], a social networks, allows to any people to get the user's location, a system devotes to delivery meal service for handicapped [9], or the use of NFC in schools, offering games, services for absences control and students follow-up, information or teaching [10].

The paper is structured in the following way: an Introduction section with the description of the scope of the manuscript, followed by section 2, which provides a brief description of the characteristics of NFC technology. In section 3 the proposed model for the definition and building of smart and augmented scenarios is described; showing the main elements of the proposed ontology that is the basis of the model. Section 4 presents a specific application: the labeling of a museum. Finally there is a discussion about how NFC and mobile technology could improve the everyday life of visually impaired people, allowing them to have and swift and customized interaction with augmented environments.

2 Near Field Communications for Touch Interactions

NFC is an easy-to-use short range wireless communication technology that was jointly developed by Philips and Sony, and it is based on Radio Frequency Identification technology (RFID). NFC is a combination of contactless identification and interconnection technologies which enables secure short-range communications between electronic devices, such as mobile phones, PDAs, computers or payment terminals through a fast and easy wireless connection [11].

NFC operates in the 13.56 MHz frequency range, on a distance of typically a few centimeters and combines the functions of a contactless reader, a contactless card and peer-to-peer functionality on a single chip. NFC devices working with the standard NFCIP-1 [12] can operate in active mode (like an RFID reader) and passive (such as a tag), operating at speeds between 106 and 424 Kbit / s. NFC technology can be found on devices like mobile phones, and is able to interact with other NFC devices and RFID tags.

RFID tags are small devices, similar to a sticker that can be attached or incorporated into a product, animal or person. Tags contain antennas that enable them to receive and answer to requests by radio from an RFID transmitter-receiver. Passive tags require no internal power, while active ones need it. NFC has settled a standard by a consortium of companies and public and private organizations, this is the NFC-Forum [13] which standards have been recently developed and published.

In the last years, the use of mobile devices (phones, PDAs, etc.) has increased notably, hence, applications to achieve the full use of these device are being developed massively. Nowadays, a mobile phone is more that a tool to make calls, it could be used for many different tasks such as information exchange, access to public services like payment and so on.

By using NFC technology and the amount of resources provided by mobile devices (sound, video, data processing, etc.) users can interact with the real environment just by touching real objects previously augmented by tags. Thus, enabling in and easy and friendly way complex procedures which provide information and services to the users.

The elements that must be found in any stage of the "touch interaction" are the following:

- The augmented objects: items labeled with RFID tags. Users interact with these objects by touching them with their NFC device, receiving afterwards the information and services needed.
- The NFC mobile device: a device used for the interaction between the user and the augmented objects disseminated through the scenario.
- The software installed on the mobile phone device: software used for guiding the interaction process and which is called MIDlet and is usually developed in Java.

3 A Model for the Definition of Augmented Scenarios

The proposed model is based on the creation of scenarios through the definition of a set of objects augmented with RFID tags that offer a wide range of services to users when they interact with them [14].

The tags assigned to objects contain information and services tailored to them by a set of rules that match the users' preferences and context interaction. These rules are in charge of the customization of the interaction of the user with the scenario. Therefore, even when two users interact with the scenario using the same object, the response given to each one will be different as it depends on the interaction context and user's preferences.

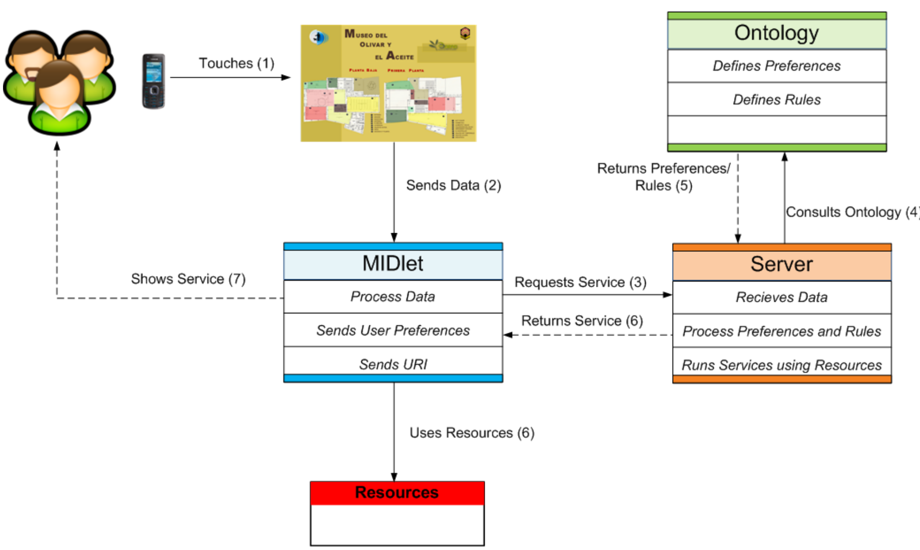

Fig. 1. A model for the development of context-awareness scenarios

Fig. 1 shows the way to personalize the interaction. When a user interacts with the objects in the scenario, the MIDlet installed in the mobile phone receives information from the tag associated to the object. Then, the MIDlet processes the received information (i.e. an URI), and sends it, as well as local user information stored in the NFC device to the services server.

In the next step, the services server reviews the defined ontology, extracts it and executes the rules defined that are in charge of the awareness of the user interaction. These rules define the services to be executed and the resources needed in that execution. Finally, services and information are returned to the mobile device of the user, being the MIDlet the one that receives and executes them.

In order to ease the context definition, an ontology was developed. Through this ontology the device, RFID tags and the back-end server can communicate without losing information. This ontology contains information about the user's preferences, the scenario, the context, etc. as well as a set of rules in charge of dispatching the services fully tailored to the user.

3.1 Ontology for Modeled Awareness NFC Interactions

An ontology is an explicit and formal description of concepts in a domain [15]. Inside an ontology, classes or concepts can be distinguished, as well as slots, roles or properties, which can have facets or restrictions. The main goal of the ontology developed is the sharing of common understanding of the information structure between people and software agents, being this one of the most important goals within the development of ontologies [16][17].

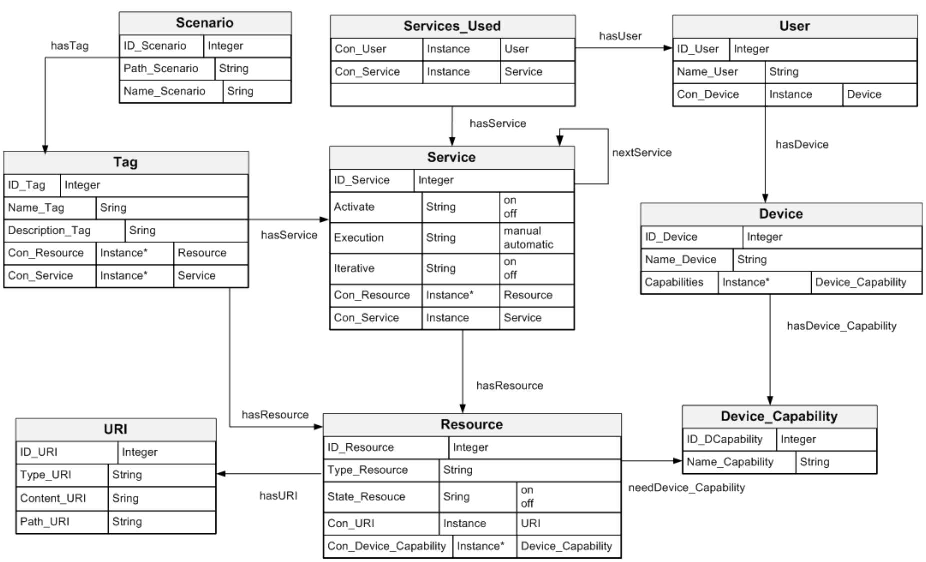

Fig. 2. Summary of the main elements of the proposed ontology

Fig. 2 shows some of the main classes considered in the proposed ontology, the relationships among them and their main attributes or slots describing those classes.

Although each tag has associated a set of predefined services, the user will receive a personalized subset of services depending of some aspects of the context like:

- Whether the user have already used the service or not.
- Interactions history.
- Whether the service is active or not.
- Whether the device has the resources needed to provide the service, and if the user has activated the service.
- User’s preferences.
- Other context information gathered from previous interactions.

Thus, the services received by the user depend on contextual information as much as on the specific preferences of the user and the device used in the interaction. So, for instance, when the different services associated to a tag are defined, an execution sequence of those services is provided; however depending of the context and the user preferences, some of the services are not offered to the user or not even executed. This change in the properties of the predefined scenario can be achieved thanks to the use of a slot in each service that is used for indicating the next service to be executed.

The preferences of each user are stored in the mobile service in a XML file. During the interaction with the environment those preferences are transformed into specific instances of the ontology available on the server.

In addition to the ontology, a set of rules is defined. The rules are used for the customization of the services offered to the users. Table 1 shows, as an example, two of the defined rules. The first rule is a simple rule that informs about the next service that must be performed taking into account previous interactions of the user.

The second rule is a more complex one. It returns the list of services available for a specific user depending on the services that he has requested previously as well as the resources available on the mobile device.

Table 1. An example of two rules defined

RULE 1: ***Next Service***	**RULE 2:** ***Available Resources for the User***

`User(?u)^`
`Service(?s)^`
`hasNextService(?s, ?next)^`
`Services_Used(?su)^`
`hasUser(?su, ?u)^`
`hasService(?su, ?s)`
`→ sqwrl:select(?next)`
	`Resource(?r)^`
	`User(?u)^`
	`Device(?d)^`
	`Device_Capability(?dc)^`
	`hasStateResource(?r, ?state)^`
	`swrlb:containsIgnoreCase(?state, "on")^`
	`needDevice_Capability(?r, ?dc)^`
	`hasDevice(?u, ?d)^`
	`hasDevice_Capability(?d, ?dc)`
	`→ sqwrl:select(?r)`

3.2 A Tool for the Development of Augmented Scenarios

NFCSC (NFC Scenario Creator) is a tool fully developed in Java for the definition of scenarios under the described mode. This tool allows the integration of the scenario's definition in the MIDlet executed in the NFC device for the interpretation of the interaction. This tool uses a model for the definition of the scenarios and an ontology for the definition of the knowledge used by devices and objects.

Fig. 3 shows, through the example of labeling a museum, the application's interface. The tool permits the definition of different scenarios (named projects) consisting of a set of tags. Each tag will have a set of services or functionality associated, and each service will consists on a set of resources.

The full list of tags that define the scenario, general properties of the project and information about the services defined for the tags are shown in Fig. 3. The services shown belong to the tags of the stage called "*El Molino*", which main functionality is to notify with a sound the exact location of the place and to explain how to get there, among others such as display museum information by a connection to the website.

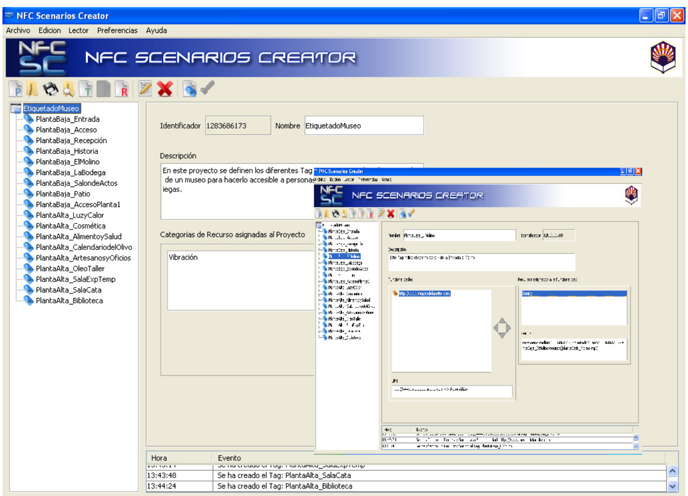

Fig. 3. A snapshot of the tool for the development of augmented scenarios

It is clear that for a blind person, visual information has no value at all, so in the user preferences it is set that all the services offered must be in sound mode with no visual information. A person with no visual handicap could wish to receive only visual information or both visual and sound, so those preferences are taken into account when the user touches a tag. In that moment the ontology is consulted and the interaction context is analyzed so the answer given to the user is tailored to him.

It is needed to take into account the resources of the NFC mobile device, since will be the device where the interaction takes place. Currently, most used phones as the Nokia 6212 Classic [18] have many restrictions in terms of available resources.

When the project is finished, the tags are recorded using the USB reader Omnikey 5230 reader / writer [19]. Besides, the files needed for using the MIDlet are also created.

4 Application to Smart Labeling of a Museum

Using the tool aforementioned different physical spaces of a museum were tagged with the aim of promoting mobility and access to the museum's information to people with visual impairment. The tool can be used in any space, no matter whether it is a public one as museums, health centers, public buildings, or a private one as private residences. In our scenario, two types of sites labeled for blind or visually impaired people were established. The first one corresponds to a map of the place, which has been augmented so each room in the map contains instructions to get there such as: *"Fist floor, second door on the right"* (see Fig. 4).

The second one corresponds to each of the rooms and items (objects) placed there. Therefore, when a person enters a room without using the map, he/she can interact with a poster at the entrance of the room. When the user touches the poster with his mobile device, he/she receives information about the room in sound form, i.e.: *"You are on the first floor, second door. This is an exhibition hall"*.

Fig. 4. Museum map and an example of the user's NFC interaction

The labeling of the main objects of each room is included in this second category. In this case, the user can listen to a description of the object or to its history; being this information the one that a non-visually impaired person would read on the object's tag. In this way, a blind or visually impaired person would be able to move across the museum and gather the same information as anyone else.

This labeling is called non-intrusive labeling of the environment because there is no need to physically change any of the existing facilities. The RFID tags [20] that are associated with objects are a kind of invisible embedded hardware that can be placed in any existing poster.

The real scenario where we tested this model and labeled the environment was the Baena Olive and Olive Oil-Grove Museum, located in the town of Baena, in the province of Cordoba. The aim of this City Museum is to provide a lively and interactive demonstration of the most important aspects of the harvesting and production of olive oil as well as to describe the way of living of the people involved in it. The building where the Museum is located was the mill of Don José Alcalá Santaella and most of the machinery dates from mid of the 19th century [21]. Nowadays, the building has more than 800 square meters of exhibition space, divided in two floors (see Fig. 4).

The first part of the labeling, as mentioned above, is the creation of smarts posters for the museum's entrance. Each room that appears in the map will contain a RFID tag with information about how to get to it (see Fig. 5 left). When a user interacts with the map, a vibration is displayed to help him to get to the tag, later and depending of the user preferences stored in the mobile device, the phone will play a reproduction indicating the room, how to get to it and a set of advices, i.e. if the user will have to climb stairs, to take a lift or to pass through a door.

Of course, all the questions posed to the user will be reproduced in sound, with an indication of how to answer to the question through the mobile keypad, for example: *"Click the right button for yes and the left button for no"*. Besides a person with no visual impairment can also use the system, he/she can also change the preferences of his/her device and change the display mode of the information into visual. The system allows the user to customize the way he receives the information from the environment.

The second part of the labeling process is to tag each room (see Fig. 5). In this example, at the entrance of each room a smart poster has been placed. When the user brings his mobile device close to the poster, the device vibrates indicating that a tag has been found and plays a recording with information of the room.

The same process takes place inside each room with the main objects. Each object has a tag with some information. This information is played by the NFC mobile device to the user, who gathers the same information than a non-visually impaired person (Fig. 5 right).

Fig. 5. Some snapshots of the NFC interaction in the room "*El Molino*"

5 Discussion and Remarks

We have described in this paper how the use of new technologies can help blind or visually impaired people to move around different rooms in a museum and obtain information about the objects that surround them in a simple way: touching the objects with their NFC mobile device. NFC is one of the most important emerging technologies for the upcoming years because of its simplicity, reliability and security. In the interaction process the user just has to touch the tagged object.

We have also described a tool that allows the labeling of different scenarios and its application to the Baena Olive and Olive-Oil Grove Museum. This tool is based on the ontology proposed. This ontology allows us to define and build augmented scenarios composed by smart objects, offering tailored services to the users. Services with associated resources are provided to the users in a customized way thanks to the definition of a set of rules considered in the ontology. Those rules permit the customization of the interaction through a set of preferences defined by the users and the study of previous interactions of the user.

Although this tool is still in an early version and the types of services offered to the tags/object are limited, we are working in its development in order to include more complex services such as GPS navigation, ticketing, payment, activation of other devices, etc. Always bearing in mind that those services must be offered to the user in a context-awareness way.

For this purpose, we are extending the ontology, defining new rules, taking into account more information gathered in the history of the user's interaction, and also considering more preferences as well as more of the resources available in the mobile phones.

Acknowledgments. This work was supported by the Ministry of Science and Innovation of Spain (MICINN) and FEDER (Project: TIN2011-24312). Our thanks to City Council of Baena and the Baena Olive-Grove and Olive Oil Museum for their collaboration in the development of this research.

References

1. American Optometric Association, http://www.aoa.org/low-vision.xml (last accessed July 2010)
2. Department of Health and Human Services in North Carolina, http://info.dhhs.state.nc.us/olm/manuals/dsb/VR/man/Definitions.htm (last accessed July 2010)
3. IST Results, Technology To Improve Learning For Visually-impaired Children. ScienceDaily (April 27, 2006), http://www.sciencedaily.com/releases/2006/04/060427093628.htm (last accessed August 2010)
4. Hinton Sr., D.E.: Research and technological aids for people who are deaf-blind. American Rehabilitation (1989)
5. Screenless Phone, http://screenlessphone.com/ (last accessed June 2010)
6. Code Factory: Making mobile phones and PDAs accessible to the blind and visually impaired, http://www.codefactory.es/en/products.asp?id=326 (last accessed May 2010)
7. NFC Forum Technical Specifications, http://www.nfc-forum.org/specs (last accessed August 2010)
8. Siira, E., Törmänen, V.: The impact of NFC on multimodal social media application. In: Proceeding of Second International Workshop on Near Field Communication, Monaco, pp. 51–56 (2010)
9. Siira, E., Haikio, J.: Experiences from Near-Field Communication (NFC) in a Meal Service System. In: Proceeding of 1st Annual RFID Eurasia, Istanbul, pp. 1–6 (2007)
10. Ervasti, M., Isomursu, M., Kinnula, M.: Experiences from NFC Supported School Attendance Supervision for Children. In: Proceeding of Third International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, Malta, pp. 22–30 (2009)

11. NXP, http://www.nxp.com/news/content/file_1237.html (last accessed July 2010)
12. International Organization for Standardization: Near Field Communication – Interface and Protocol (NFCIP-1). ISO/IEC 18092 (2004) (last accessed January 2010)
13. NFC Forum, http://www.nfc-forum.org (last accessed July 2010)
14. Castro Garrido, P., Matas Miraz, G., Luque Ruiz, I., Gómez-Nieto, M.A.: A Model for the Development of NFC Context-Awareness Applications on Internet of Things. In: Proceedings of 2nd International Workshop on Near Field Communication – NFC, Monaco, pp. 9–14 (2010)
15. Colomb, R.M.: Ontology and the Semantic Web. IOS Press (2007)
16. Musen, M.A.: Dimensions of Knowledge Sharing and Reuse. Computers and Biomedical Research 25, 435–467 (1992)
17. Gruber, T.R.: A Translation Approach to Portable Ontology Specifications. Knowledge Acquisition 5, 199–220 (1993)
18. Nokia 6131, http://europe.nokia.com/find-products/devices/nokia-6131-nfc/technical-specifications (last accessed September 2009)
19. OMNIKEY 5321, http://omnikey.aaitg.com/index.php?id=products&tx_okprod_pi1%5Bproduct%5D=4 (last accessed January 2010)
20. Smart Label, http://en.wikipedia.org/wiki/Smart_label (last accessed July 2010)
21. Baena Olive-Grove and Olive Oil Museum, http://www.museoaceite.com/ (last accessed September 2010)