A Near Field Communication Tool for Building Intelligent Environment using Smart Posters

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Abstract— NFC is becoming one of the most important advances in wireless communications technologies because it allows the incorporation of the RFID technology into mobile devices. This technology is used in ubiquitous computing to obtain different kinds of information and services from different sources anytime and anywhere. In order to build smart environments, in which we are able to obtain information from the objects surrounding us using NFC, the development of a tool that provides all the basics options for defining, storing and retrieving this information and services is mandatory. In addition, the tool has to use different standards defined by the NFC-Forum in order to interact with different devices and RFID tags. This paper describes the tool and its applications to the university environment. With this aim, several types of Smart Posters have been developed, such as a Department and Faculty Smart Poster.

Keywords— Intelligent Environments, Mobile Phones, NFC, RFID, Ubiquitous Computing.

I. INTRODUCTION

TODAY, thanks to the advances in the information and communication technologies, everyone can access the information quickly, accurately and at any place and everywhere. All of this can be possible through ubiquitous computing systems. These systems are composed by a network of interconnected computers and sensors, embedded in daily objects. Users can interact with these objects in a natural way without being aware of all the elements that are involved in computations. This paradigm is also called Ambient Intelligence.

Previous to the arrival of ubiquitous computing systems, society had a large amount of information that could get to us through elements like the internet. However, the needs of the 21st century society demand information accessible at anytime and anywhere.

This has given the impulse for the rising of a new type of systems that, interacting with the appropriate elements, are able to obtain information from everything around us. This has promoted the pervasive computing systems, which are able to obtain information from everything that surrounds us, using the proper interaction elements.

The elements needed for developing pervasive computing systems are those elements related to radio frequency identification (RFID) systems such as RFID tags that store the information and data needed for the interaction or RFID readers capable of establishing the communication.

In order to establish an effective interaction with environmental elements it is necessary to incorporate the capability of obtaining information into devices widely spread in society and commonly used by citizens, such as mobile devices.

Near Field Communication (NFC) technology is a simple extension of RFID, supported by the leading mobile device, infrastructure and technology manufacturers, as well as by all major payment providers.

NFC is a new short-range high frequency wireless communication technology that allows a bidirectional communication and a exchange of data between devices over a distance of about 5-10 centimeters. It operates at 13,56 MHz and permits data transfer at a rate up to 424 Kbits/s. Lately, the number of devices that incorporate NFC has grown considerably. Mainly in those mobile devices that can be used as phones or PDAs. NFC offers three different operation modes: passive tag (like a card emulation), active (where the device acts as a reader for writing or reading a tag) and the peer to peer mode (where both devices involved in the communication act in active mode).

NFC allows users to interact in an easy and intuitive way, not only with other NFC devices but also to interact in those intelligent and pervasive environments where everyday objects have been augmented with tags that provide information and services. NFC has a lot of different applications.

This technology was originally designed for applications like payment and ticketing [1] but it could also be applied in entertainment and social applications, accessing control, content distribution, peer to peer data/money model transfer, smart advertising, tourism applications, healthcare and Ambient Assisted Living, etc. Possibilities are almost endless.

The NFC-Forum [2] is a non-profit organization whose mission is to promote the use of NFC technology by developing standard specifications, ensuring interoperability among devices and services, and educating the market about NFC technology. NFC Forum organization is responsible for providing the NFC standards [3] that make it possible for successful communication between devices and tags, and enable any company to create NFC-Forum compliant solutions that will be interoperable with other company's devices and solutions.

Among these specifications we can highlight: NFC Data Exchange Format (NDEF), four Tag Type Operation

Specification based on ISO 14443 [4] (Type 1, 2, 3, 4 Tag), NFC Recording Type Definition (RTD), NFC, Text Record Type Definition, NFC Uniform Resource Identifier (URI) Record Type Definition, NFC Smart Poster Record Type Definition, NFC Generic Control Record Type Definition, NFC Forum Connection Handover Technical Specification and NFC Logical Link Control Protocol (LLCP) Technical Specification. Currently, the definition of these standard is not closed and there is people working on them, adapting them to the new technologies, new ways of NFC interaction and new features and applications of this technology.

The NFC Forum Tag is a contactless tag that can operate according to one of the four NFC forum tag platforms called NFC Forum type 1-4 Tag Platforms. Its specification defines the data mapping and how the NFC Forum Device detects, reads, and writes NDEF data into the Type tag platform in order to achieve and maintain interchangeability and interoperability.

The application data stored inside an NFC Forum Tag is encapsulated firstly into an NDEF message and secondly into a data structure specified by the NFC Forum Type Tag Platform. The NDEF message and the NFC Forum Type Tag Platform encapsulation are used to identify the type of application data; e.g. a URL, a v-Card or a Jpeg image and to guarantee the interoperability and the co-existence between applications.

The application data is any kind of information that can be stored into a NFC Forum Tag, for example a URI, Text, Smart Poster (Text + URI), Handover Parameters (Bluetooth parameters: PIN, address or Wi-Fi parameters: SSID, WEP Key), Business Card (vCard), signature, etc.

NDEF is a lightweight, binary message format that can be used to encapsulate one or more application-defined payloads of arbitrary type and size into a single construct called NDEF message. An application-defined payload is encapsulated inside one single NDEF record, or chunked into two or more NDEF records.

One or more application-defined payload contains the Application Data. Each application-defined payload is described by a Type, and an Optional Identifier. Type identifiers may be URIs, MIME media types, or NFC-specific types (NDEF, NFC RTD-URI, Text, Smart Poster). Optional Identifier enables association of multiple payloads and cross-referencing between them.

Through NFC, tags become physical hyperlinks that can be further associated with actions. This physical hyperlinking feature is greatly enhanced by the increased resource availability on most NFC phones, for example their support for embedded Java virtual machines, which allows the automatic launch and execution of applications relating to the interpretation of the collected URI.

For example, this facility of NFC can be used to transform smart phones into a tangible interface for pervasive computing applications that automatically identify and retrieve information relating to particular objects or locations

A. Smart poster and v-Card Tags

One of the most interesting formats because of the possibilities it offers is the defined by the NFC Forum as a Smart Poster RTD. In the Smart Poster use case, information about an object, event, etc., is somehow attached onto a physical object. It defines an NFC Forum Well-known Type on how to put URLs, SMSs, or phone numbers on an NFC Forum Tag or how to transport them between devices defining a superstructure that associates this kind of URIs with various types of metadata. The design goal of the Smart Poster was to provide a simple way to access a remote service by using the touch paradigm [5].

The vCard use case consists of an NFC Forum Tag embedded into a business card that contains an electronic vCard (vCARD21, RFC 2425, RFC 2426) with the person details. Reading the tag using an NFC Forum device like a mobile phone or a notebook, the user can retrieve and save the vCard information into his address book.

Once the information is correctly stored and saved, the user can use it as desired. This saves the user from manually typing the person details of the business card. If the memory space of the NFC Forum Tag is big enough even a Jpeg image can be stored in the electronic vCard.

Thus, Smart Posters is one of the key use cases for NFC technology [6]. The idea is that an object can be made "smart", i.e., it is capable of storing additional information about itself in the form of an NFC Forum Tag.

Hence, touching the object with a NFC device, this information can be read and displayed to the user through the NFC device. The Smart Poster can also contain actions that will trigger an application in the device; for example, launching a browser to view a web site, or sending an SMS to a premium service to receive a ring tone.

The Smart Poster concept is built around URIs (Uniform Resource Identifiers [RFC 3986]), which have become the standard for referencing information around the Internet. Therefore, these posters include several RFID tags that allow to the users interact with the environment, providing information or launching applications or services. The creation of these tags is not a trivial process.

Decisions such as type and technology of the chosen tag, or the type and information format stored are very important. Moreover if we want that all the NFC enabled devices can recognize and retrieve information stored on the tags, they must be recorded under certain guidelines and according to international standards promoted and disseminated by the NFC Forum.

Therefore, it seems necessary the development of a open tool devoted to the building of smart real life scenarios through Smart Posters, where augmented objects thanks to added tags supply information and services to any users provide with NFC device.

This paper present an open tool devoted to management of Tags based NFC-Forum for the development of smarts environments. This paper is organized as follows: after this

introduction, in section two, we describe the TagMan application, showing its characteristics, architecture, interface and the advantages it offers in the construction of smarts environments. In section 3 we described some of our current works in the NFC application in the university environment using this tool. Finally we discuss the result and conclusion of this and our out coming works.

II. A TOOL FOR BUILDING SMART POSTERS

A poster can include tags that use any of the aforementioned formats. The recording of information in the tags should be done with ad-hoc application programs done taking into account the reader used to record the data, the type and technology of the tag (there are different types that show different internal structure in the storage distribution and access to it) and, of course, information to be stored.

This is a complex process in which it is necessary to perfectly know the structure of the target tag, the conditions and restrictions to access to it and store data in it, the handling APIs, and the used devices/readers APIs.

Moreover, the novel state of NFC is the reason that there are no high-level tools designed to the user for this purpose, which reduces the expansion of this technology and its application to ubiquitous computing; there are only few and deficient proprietary tools that are difficult to obtain.

Besides, these applications only allow the recording of the tags, but not the management of them as a whole project. This is, i.e. allowing the management of all the tags contained in a smart poster in a uniform and unified way.

For this reason, our goal was to develop an open, user-oriented and service-oriented tool (TagMan) that enables creation, record and the management of tags (any kind) for the building of smart environments, making use of the most popular types of tags and devices in the market and compliant with the NFC Forum specifications.

Furthermore, this tool allows the project management for the building of tags associated with different environments or applications for which they are built.

TagMan provides the foundation for new and innovative NFC applications that are based on the new NFC-Forum standardized technology architecture. TagMan is a software application that provides a platform for programming NFC tags with standards based NFC data that enable users to access content and information services with their NFC enabled devices in an easy and intuitive way. Specifically architected to support current and future NFC-forum standards, TagMan provides a unique tool for encoding and decoding of NFC tags. NFC TagMan provides a complete support for all NFC-forum Mandated Tag formats (ISO 14443 A, B) from leading manufacturers.

The operation with the tool is extremely simple. Its intuitive interface allows any user to create a smart poster without issues. Therefore, the user does not have to be a expert in the subject, or to have any knowledge about the standards defined by the NFC Forum. Thus, the user does not have to learn how to store information in the tags. The only thing the user has to know is which and what kind of information he wants to offer to the other users and how to do it (via sms, web, service or so).

Hence, TagMan enables users to design and parse NFC tags data records such as Text, URI, VCard, Smart Posters and custom RTDs just by filling different forms and follow simple steps.

So, keeping it brief, the process that follows any TagMan user would be: first, the user has to decide what information he wants to store in the tag, second, the users has to select and fill out the relevant form provided by the tool, and finally the user has to proceed to the recording of the tags. Internally TagMan will ensure that the data entered by the user is properly processed, encoded and is compliant with the standards.

The tool also encapsulates it in records under the corresponding Record Type Definition (RTD) and codifies those records in a single NDEF message that can be automatically encoded in one of the NFC-Forum tags compatible format.

TagMan also offers to the users another set of facilities for the handling of tags, even after they have already been recorded for the first time. Thus, the users can read their content if wish to verify, modify or add any information.

The tool also offers the possibility of using advanced specific tags manufacturer features such as locking the tag after being encoded. This feature allows the user to prevent anyone else to change the initial content of the tag once inserted into the smart poster, either from another reader or NFC device.

Thanks to these features, and others such as the ability to create any kind of tags using the current existing standards or the ability to manage several projects for the creation of smart poster, turn TagMan into a powerful, complete and very useful tool that facilitates the creation of pervasive ambient.

A. TagMan implementation

TagMan has been fully developed in Java using Eclipse as IDE. For the correct construction of the NDEF messages and the records contained in them we have used the Contactless Communication API Java specification, led by Nokia and defined under the Java Community Process as JSR-257.

This API defines a set of APIs for proximity, contactless-based communication and allows us to discover and exchange data with contactless targets such as NDEF tags or RFID tags.

The enabling of the communication of the application with the different supported tag readers / writers has been more complex. The actual communication with the ISO14443 compliant smart cards is done using Application Protocol Data Units (APDU) commands. For this reason it was necessary to create different packages of Java classes that implement these APDUs commands. [7].

TagMan permits the use of several of the most used NFC readers/writers with its unique features, such as Omnikey 5321 USB or ACS. To achieve this, TagMan incorporates the DLLs files of all those readers compatible with the tool.

B. TagMan architecture

Fig. 1 shows the class diagram for TagMan. The main class TagMan Manager is in charge of managing and conducting all operations can be carried out on the existing projects in the application and the contained elements (tags). Also it allows the direct access to editing, recording and reading the tags.

Through the class diagram shown in Figure 1, we can understand the architecture of TagMan. The main class is TagMan Manager. This class allows access to all functionality offered by the tool. On one hand it allows the management and execution of all the possible operations of creation, modification and deletion of projects, and those operations on the elements that compose them, in other words, the tags.

Besides, the management of the communication between the tool and the class responsible for sending the information entered and stored via the graphical interface so that the reader can record it in the tags.
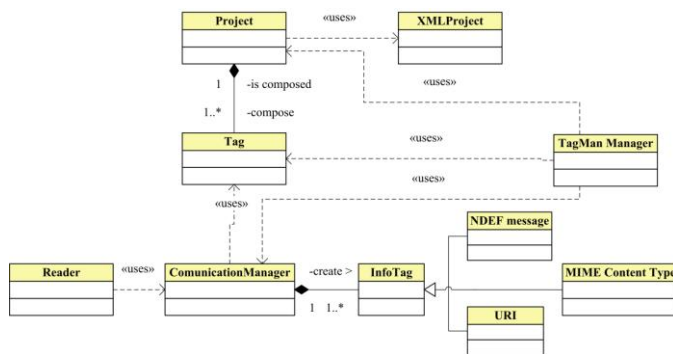

Fig. 1 TagMan Class Diagram

As can be observed in Fig. 1, the tool defines the Smart Poster as a set of projects. This configuration will allow that from a single application it would be possible to manage several smart posters. A smart poster or project consists of one or more tags.

These tags might be classified according to their type and content. The information stored in the tag determines the structure and information provided by the smart poster. That information could be entered manually by the users through the graphical interface, however, TagMan also has an alternative way to do it: by defining the tags through an XML file.

TagMan defines all projects via an XML file that stores the tag definition and its content. Hence, by knowing the XML structure of the projects, users can insert or update the file information, being this information directly uploaded into the tool to be managed graphically later on.

The *XMLProject* class is the responsible for carrying out these actions. This class also allows the generation of an XML file from any of the existing projects. This feature permits the definition of each project to be easily exported to other applications.

The *Tag* class provides the methods needed for building tags elements, allowing the user to differentiate among the different types defined; and also noticing the user about what

information can be stored in each type. The content stored in the tags is specified by the *InfoTag* class. Basically, the content can be one of the following three types: a MIME Content Type (which includes de vCard format), a URI or a NDEF message that might be made by one or more identical or different records.

The recording and reading of tags can be done thanks to the *ComunicationManager* class. This class is responsible for establishing the connection between the application and editing, writing and reading of them. Finally, the *Reader* class facilitates the recording of the tag, representing and allowing the correct management and operation of the tag reader/writer.

C. TagMan main interface

The TagMan main interface, shown in Fig. 2, is divided into four sections or frames. At the top of the screen is the menu bar through which we can access to most of the functionality offered by the tool like the creation, modification, or deletion of a project; or to create, delete or copy a tag, choose the language of the interface, activate the reader mode or select the type of the reader, etc.

The left side window is for the project and tag management. The information is shown with a tree structure allowing the easy access to different opened projects and the corresponding defined tags classified by their corresponding NFC types. Thus, there are three levels in the hierarchy when a project is defined., The first level defines the project, the second level has as many branches as different types of tags are included in the project; and the third level locates all the tags belonging to each type.
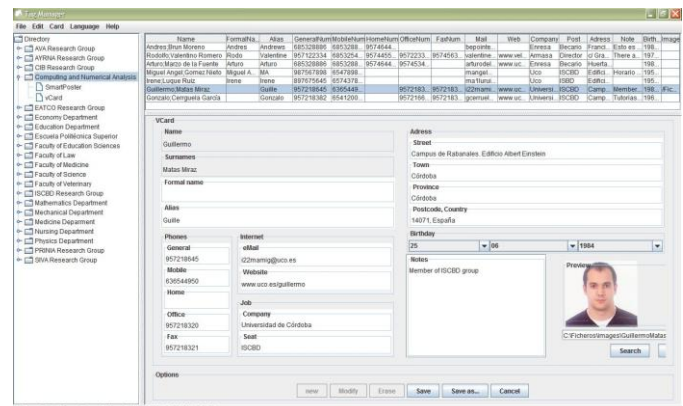

Fig. 2 TagMan main interface

The two frames on the right side of the main windows are designed to display and edit the information that will be included on the tag located on each smart poster. At the top are displayed as a list each of the tags of a certain selected type and project. The contents of any tag is editable from the lower area, where according to its type will be shown all those associated fields that can be edited.

Fig. 2 shows an example of the use of the interface. In this case it can be observed how the user is editing a vCard tag

belonging to the project *"Numerical Analysis and Computer Department"*.

On the left side of the window the selected project and type of the tag are noted. In the right area it can be seen the tag selected (upper frame), and the possible editable fields for this kind of tag (lower frame) such as personal and contact information, picture, notes, etc.

TagMan also uses these same two right frames when the user tries to create a new tag. To perform this action, users just need to select the project (poster) in which the tag will be included and click the option Edit –>Add new Tag. Then we must choose the tag type to edit. TagMan easily makes the process by providing the user with a list of possible types that can be created by the application such us vCard or Smart Poster with different kinds of URIs like http://www, https://www, tlf, mail_to, ftp://ftp, telnet://, imap:, pop:, file:// and so on.

TagMan lets you copy, cut and paste tags from one project to another, which can greatly facilitate the creation of new smart posters. Once edited and completed its content, the recording of the tag is simple and consisting in to specify the tag or the tags to recording and selecting Card–>Write Tag option and choosing the lock option or not.

III. AN EXAMPLE OF APPLICATION: THE DEVELOPMENT OF UNIVERSITY SCENARIOS

With the aim of providing new services to the directives for European universities and to improve the quality of existing university services, we have worked in the development of smarts environments in the university ambient [8, 9]. The quality is so important in education, that some authors have developed tools for monitor and assure quality in schools [10].

Although the use of new technologies in the teaching-learning process is needed, that is not enough [11], so it is also necessary to take into account the circumstances in which the teaching-learning process is performed in order to improve the offering of new facilities to all the included agents (students, teachers, organization, services, etc.).

Thus, and taking advantage of features and facilities that NFC technology offers, emerge the idea of providing to the university users access to university information and services using Smart Posters.

The location of Smart Posters in anywhere on the campus or university building, allows that anyone (students, teachers, or people not related with the university) with a NFC enabled device may access to this information and services at anytime and anywhere without rather than touching the tags located in the Smarts Poster with a NFC device.

Smart Posters have been proved as quite useful in environments such as elder care, like other developed systems such as System using Welfare Information Technology [12]. Therefore we can assume that they would be welcomed in the university environment.

Different types of Smarts Posters can be created in the university environment, depending on organization or service

to be targeted: a) research groups, b) departments, centers, services, etc.

In any case, the information and services that Smart Posters can offer is very similar regardless of the organization and university service to which they are directed: a) information about people (teachers, university managers, etc.), b) information about services and organizations, c) information about qualifications, courses, subjects, etc., d) information about places or units and services locations (maps), and e) access to several services that may be offered by the administrative units and academic management (access to secretary of the faculties and services, access to departments, access to teachers, enrollment, etc.).

In short, any kind of content can be coded based on formats such as MIME content type, URIs or Smart Poster, which are supported by TagMan. In this way the personal information could be stored in a tag with vCard format, or web pages, call requests, messaging, GPRS connection, access to websites or starting applications (among others) in a tag with Smart Poster format.

Fig. 3 User interaction with Department Smart Poster

TagMan has been used in the University of Cordoba environment for the construction of Smarts Posters for various Departments and Faculties. In this paper we describe two different types of Smarts Posters created thanks to TagMan.

The first scenario provides the users information about the department of Computing and Numerical Analysis at the University of Córdoba (see Fig. 3) .The left area of the poster is dedicated to the teachers.

We can find an icon with the image of each of the teachers belonging to the department. Behind each icon a tag has been placed. This tag stores information in vCard format about the teacher.

So, anyone who approaches his NFC enabled device to the poster can retrieve information such as the address and office location, contact information such as: telephone number and email, tutorial dates, website, etc.

The second area is dedicated to the department management staff. It follows the same functional philosophy, however in this case the information stored is different (working hours, contact information, etc.).

The last area is for the research groups. As in previous cases, there is an icon representing each of the groups and behind each icon a tag with information stored in Smart Poster format has been placed. In this case the stored information is their location, website, members and person responsible, a brief note about their research topics, etc.

Another scenario provides information about the Escuela Politécnica Superior of the University of Cordoba (see Fig. 4). This smart poster provides very detailed information about this University faculty.

In this poster we can find four areas providing different information to users. One of those areas allows the users to know the organizational structure of the staff, providing them information about each one of its members. Another area provides information about the academic qualifications that can be studied, as well as data for each individual course.

Thus, for each academic qualification and each course, users can obtain information about it, the name and number of credits for each subject, description, syllabus, teachers, schedules, etc.

Fig. 4 User interaction with Faculty Smart Poster

A third area of the poster is dedicated to provide information about the Faculty departments. In the tags dedicated to each of the departments information such as location, research groups, and contact information and so on is stored.

The last area of the poster (Fig. 4) hosts two tags that deserve special mention. The first allow users to obtain a campus map with the location of the center and its secretary. To solve this issue, it was enough to store in the tag a NDEF Message with a record in a smart poster format containing a URI storing the *url* assigned to the map in a server, then through a WAP/GPRS connection the NFC phone will download the map.

The second of the tags implements the most interesting service in this poster: the possibility of getting a turn to be attended at the faculty secretariat.

In order to implement this functionality it is necessary to consider three issues: a special tag on the poster is needed; a service in charge of dispatching the turn tickets in response to the user requests is also needed; as well as a MIDlet application installed on the mobile phone in charge of the turn requesting, to receive and store the dispatched turn in the phone's secure element (so the MIDlet should be signed).

Behind the icon of the turns request there is placed a tag containing a NDEF message with an external NDEF record type, with the task to start automatically the MIDlet stored in the mobile phone and initiate the process of requesting and storing the turn without any user intervention.

This functionally is implemented using MIDP 2.0 Push Registry [13]. This feature enables MIDlets to set themselves up to be launched automatically, without the user initiation.
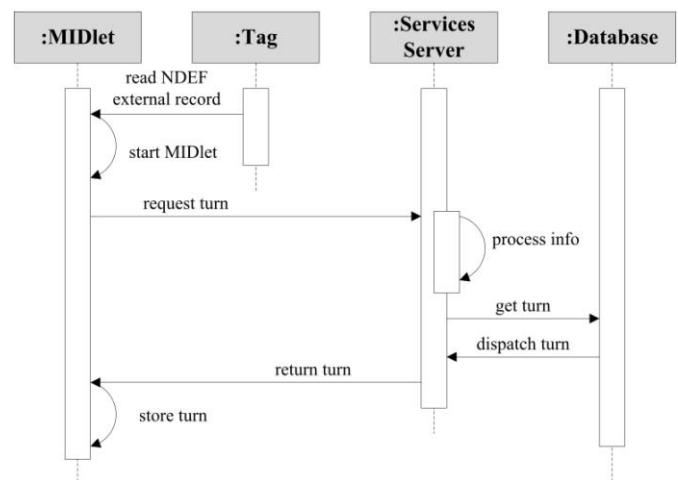

Fig. 5 Turn request process

The service in charge of receiving the user requests and dispatching the turns has been implemented using the NFC business platform developed by Nexperts [14].

This service is just a procedure that determines when and where each user can go to the secretariat taking into account important aspects like opening hours, the number of desks and staff available at any time and the average time needed for the public attention among others.

In order to use the turn service it is mandatory to have a MIDlet specially created for that purpose installed in the user device.

This application provides four main functionalities for those who use it: a) requests a turn from the faculty secretary, b) receives the information related to the turn and stores it in the device secure element, c) provides the user with the ability of consulting, sharing or changing his turns at any moment, and d) deletes the stored turns.

As can be observed in the sequence diagram of Fig. 5, the final process is very simple, the user just has to bring his device close to the poster and the launching process, turn

requesting and turn storage is performed automatically and transparently to the user.

Fig. 6 User interaction with Guide Smart Poster in the Campus

A. Other Smart Poster of Interest

Besides, there are other Smart Posters at the University, developed to guide the students through the Campus (see Fig. 6) providing them a route to help them for going from one building to another, simply getting their mobile device close to the location they want to visit.

Once the location is chosen, it automatically launches the MIDlet installed on the mobile device, offering a full menu of actions to perform. The most important is to see the map showing the selected route. The path that the system returns is one that allows us to go from the current to the selected position in the Smart Poster.

For this NFC application a GPRS connection is needed through which the server gets the correct route and provides a map which is displayed on the mobile device. The information stored in the tags of these Smart Posters is the name and coordinates of the current location and the different locations to which to move, in order to build the route.

When the device touches the Tag in the picture, first the system asks the user whether he/she wants it to be downloaded, it detects it and automatically starts up the MIDlet that retrieves and decodes the content in order to identify the scenario.

Finally The MIDlet shows the list of services for that Tag. For example, "Recover Map", an option where a map with the route from his/her current location to the selected/touched interest point is shown by the MIDlet. The information can be stored for future accesses and requests, and once finished, it ends the application.

IV. REMARKS AND DISCUSSION

In this paper we have presented a software tool that makes easier the creation of smarts environments through the construction of NFC Smart Posters.

TagMan considers multiple standards for the construction of the smart poster tags enabled to TagMan linking any kind of information or services to them. This allows to apply this technology to many application scenarios, such us the university scenario described in this paper, in order to provide to the users more and better information and services or even to improve the quality of the existing ones. For example, locating a smart poster with information about a course in a student cafe in the city will allow students to enroll in the course without having to move to the Faculty.

Hence, and due to the generic nature of TagMan and the large number of tag formats supported, TagMan allows the construction of practically any type of smart poster without the need to develop a specific application for it.

This characteristic simplifies, standardizes, speeds up and unifies the creation of such environments.

Moreover, TagMan manages all project information as XML standard format allowing easily import and export all information for its possible interaction with other applications.

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