Smart and Mobile Access to Cultural Heritage Resources: a Case Study on Ancient Italian Renaissance Villas

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Abstract— **Cultural Heritage Areas together Context-Aware Systems present a great opportunity where the Ambient Intelligence (AmI) paradigm can be successfully applied. This paper deals with the design of an AmI-based Information Systems, based on NFC (Near Field Communication) technology, developed to access Cultural Heritage Areas of particular interest, in which different objects of artistic interest can be interfaced in a proper virtual way without affecting the historical environment. The application of non-invasive technology NFC improves the context-awareness of the implemented system and allows users to receive customized information in a transparent way, through the most suitable device, allowing a realistic experience.**
The proposed AmI-based Information System is particular related to mobile and safe cultural access in the context of Villa Mondragone, an ancient Renaissance Villa. We outline a real system, called SMART VILLA, based on a set of mobile applets, each interfaced with a NFC based subsystem, related to particular sites (SMART BIBLIO for ancient books, SMART ROOM for particular rooms and SMART GARDEN for surrounding historical gardens).

Keywords—Cultural Heritage; Ambient intelligence (AmI); Context-aware; Near Field Communication (NFC); Pervasive Systems; AmI-based Information System.

I. INTRODUCTION

Mobile and Safe Access to Historical and Artistic Things in Cultural Areas such as Renaissance Villas require new information services based on smart phones and touch based user interfaces. Many of these services should be addressed by AmI infrastructure, by the touch of a mobile device instead of tradition application.

In this paper we analyze the impact of recent mobile technologies, like NFC (Near Field Communication) technology, on user interfaces that could be used in order to improve visitor accessibility in cultural area.

In many case researchers and visitors looking for ancient information need a mobile access to ancient documents and historical things embedded in the area in a pseudo-virtual manner. This type of mobile access requires the implementation of interaction methods by which the user can achieve his goals, such as acquiring information just by pointing or touching smart devices.

The user, when attracted by a specific item (for example a picture on the wall) he just brings his smartphone to access different services remotely located while keeping free to be immersed in the cultural context (Figure 4) without being annoyed by tedious keyboard operations. This will help the cultural understanding on the field thus improving learning capability level and allowing a better usage of cultural resources.

The system proposed is a kind of *smart pseudo virtual tour* especially tuned for cultural areas such a renaissance villa, with possibility, through NFC technology, to obtain further information with links and multimedia references.

II. AMBIENT INTELLIGENCE AND NFC TECHNOLOGY

The Ambient Intelligence (AmI) is a new research field, related to environments sensitive and responsive to the presence of people. AmI deals with the creation of intelligent environments where devices work according to the users' expectations in carrying out their tasks in easy and natural way using information and intelligence hidden in the network connecting these devices (Internet of Things).

The ambient intelligence paradigm builds upon pervasive computing, ubiquitous computing, profiling practices, context awareness, and human-centric computer interaction design and is characterized by systems and technologies that are:

- embedded: many networked devices are integrated into the environment;
- context aware: these devices can recognize you and your situational context;
- personalized: they can be tailored to your needs;
- adaptive: they can change in response to you;

In AmI the technologies are able to automate a platform embedding the required devices for powering context aware, personalized and adaptive services. The users, surrounded by ubiquitous resources embedded in augmented objects, interact in a natural and intuitive way with computational services like knowledge, work, home, eHealt, eCare, transport, mobility.

AmI requires the use of miniaturized communication infrastructures (including hardware unobtrusive like sensors, nanotechnology, etc..) and intelligent interfaces with which users can interact in a natural way.

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In addition, to ensure an adequate level of security it is necessary to use suitable software for the confidentiality of the information circulating within the AmI.

In this context the model of user interaction and information visualization play a very important role that has been studied by different authors where several models and paradigms have been proposed.

Figure 1: AmI - computational systems "placed all around us".

Near-**F**ield *Communication* (**NFC)** is an emerging technology that provides a natural way of interaction between the users and their environment. This characteristic makes it the preferred candidate for the development of intelligent environments. NFC technology is a combination of the contactless **R**adio **F**requency **ID**entification (RFID) technology and interconnection technologies that allows short-range wireless communication among mobile devices, personal computers, and intelligent objects.

NFC is a wireless bi-directional short-range technology (up to a maximum of 10 cm), it operates at the operative frequency of 13,56 MHz, it has a maximum transmission bitrate of 424 kbit/s, this technology allows communication between two devices called Initiator and Target, which are combined within a operation radius of 4 cm to create a peer-to-peer network for sending and receiving information between the two devices.

As regards the safety aspect, this is guaranteed, in the first place, by an **environmental characteristic**, the NCF technology provided, in fact, a very short communication distance between the two devices, this makes difficult the interception of the information exchanged; secondly, also, by the fact that these devices incorporate cryptographic functions through the use of Smart Card.

Near Field Communication technology overcomes the rigid distinctions between reader and tag and between active and passive devices, characteristics of technology RFID, incorporating safety features and convenience of the cards without contact.

An NFC device can be interrogated and interrogate and can operate in either active or passive mode that depends on how the devices they operate, if mode active or passive.
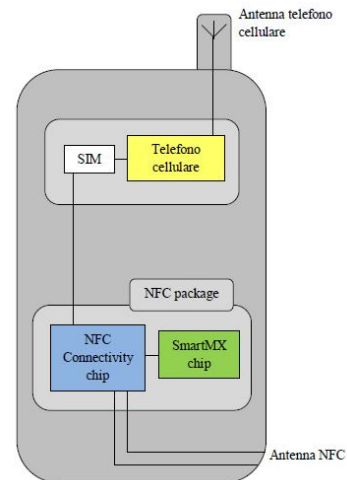

Figure 2: internal structure of an NFC device

The standards for the NFC's communication protocols are defined in the same way in ISO and ECMA and also in ETSI.

The main standard are:

- **Near Field Communication Interface and Protocol-1 (NFCIP-1)**: describes the radio interface, initialization, collision avoidance, a frame format and protocol for the exchange of blocks of data with error handling.
- **Near Field Communication Interface and Protocol-2 (NFCIP-2)**: it specifies a selection mechanism between various communication modes.
- **Near Field Communication Wired Interface (NFC-WI)** : this standard governs the exchange of data across the elements enabling the NFC technology and the "front end" of the device which are integrated.
- Other standards specify test methods for **NFCIP-1**: ECMA-356 and ISO/IEC 22536, ECMA-362 and ISO/IEC 23917.

The view of the possible applications of NFC technology is widespread and is difficult to provide an accurate list.

The most important classes of applications of NFC technology are [4]:

- Information about objects (**Reader mode**);
- Ticketing/Mobile Payments (**Contactless Card**);
- Coupling devices (**Device Pairing**);

The object of this paper refers specifically to the first class of applications.

This particular category covers all applications involving the use of NFC devices to obtain information from devices with passive behaviour, so called "passive token", without the need for physical contact. Approaching the NFC device

311

in a passive token, you can read the information contained therein.

NFC offers a simple solution based on the ''touching paradigm'' that makes possible the information exchange and access to content and services in an intuitive way. Besides, it simplifies people's interaction with the environment, resulting in the ''Touch Computing'' paradigm, where users get their mobile device close to everyday life objects, provided with visual marks and RFID Tags or other NFC devices, with the aim of triggering the intelligent services offered by those objects. Therefore, this combination of RFID and visual tagging of physical objects and NFC devices available, have contributed to the development of the ''Internet-of-Things'' [7], where all the resources, that surround us and their associated services, are available through any connection (GPRS/UMTS, Bluetooth, etc.).

A possible application area of the Ambient Intelligence and the development of pervasive systems is the tourism, which is always growing.

Nowadays, different investigations are studying the use of NFC in a wide spectrum of problems, including commerce, ticketing and payment, transportation, tourism, identification and security.

In the next section we focus on its applicability to reach smart accessibility for cultural areas in which there are strong requirements together the need to increase user participation.

III. CULTURAL AMBIENT INTELLIGENCE THROUGH SMART MOBILE TECHNOLOGIES

Cultural Heritage knowledge requires advanced information services often carried in a mobile scenario. Cultural and natural heritage applications have proved to be an attractive vehicle for researchers. Several projects have developed data collection tools, museum or city visitor guides as a means of demonstrating various concepts including location and context awareness and smart building environments. Together, these represent two ends of the 'production' process of bringing cultural and natural heritage from the research environment to its consumers.

This leads to consider a new model of Mobile User Interface   in which there is the integration between recent mobile internet technologies (e.g. Web 2.0 with mobile adaptation) and sensor based interfaces (RFID and NFC tag systems). The main issues are:

- Smart Location Services. Huge information associated to cultural areas could be accessed in a location dependent way thus avoiding to download big files but kept location or even physical particular object dependent (e.g. a particular shape in a picture).
- Contactless Services. Active tags could enhance particular transactions otherwise impossible while visiting cultural areas. This can improve user engagement even for novice users. For example a smart notification system could help visitor to be

alerted on the cultural added value about things in a room before to start a tour.
- Etc.

IV. CASE STUDY: SMART BIBLIO SYSTEM ON THE ITALIAN'S HISTORICAL VILLA "MONDRAGONE"

"SMART VILLA" is an experimental integrated mobile information system based on a mobile web application developed to interface user with a dynamic image gallery enriched with touch based operations that will contribute to access historical documents while visiting ancient villas.

We have realized an implementation of the system "SMART VILLA" for "Villa Mondragone" (Figure 3), that is the representative office (International Conference Center) of University of Rome "Tor Vergata".

Villa Mondragone is one of the twelve Tusculum villas built in the sixteenth century by papal nobility, located in the south-east of Rome near the ancient city of Tusculum in the Castelli Romani area. Villa Mondragone is a building of over 80.000 cubic meters for which the use of this technology allows easy access for such a wide dislocation of cultural and historical resources.

Figure 3: Villa Mondragone

The area considered for this case study, is related to the congress and cultural activities and includes:

- the Swiss Hall, used as a large conference room for about 150 seats;
- the Hall of the Theatre, with 120 seats;
- four meeting rooms for parallel sessions with 50 seats each (Hall Garden, Green Room, the Terrace Room, Room SS. Peter and Paul);
- the Belvedere Room on the second floor;
- the Internet Point Secretariat, equipped for congresses;
- the Hall of the Caryatids, the Red Room and the Hall Borghese, halls of high representation;
- the Library;
- the Gallery for exhibition stands;
- the Portico of the Accoglienza.

Villa Mondragone, externally, has the Inner Court, the Portico of Vasanzio, the Secret Garden and the Garden of the Windmill Theatre of the Waters.

The implemented system[10] is composed of a mobile web image gallery for library and historical areas, tuned for smart phones and tablet with a wireless connection to radio

tags, that could be easily inserted over ancient things without changing the original historical environment.

This requires a new software and wireless mobile system based on radio tags communication protocols available on existing smart phones and tablet (WIFI TAG protocols). In such a way, visitors equipped with standard smart phone (iPhone, Android, etc.) could easily navigate through web library interface. In addition, when they are close to ancient paintings, books or other masterpieces a notification system could alert by means of suitable multimedia messages.

The artistic works (eg. smart poster) are equipped with NFC tags, in particular, tag type 4 is defined to be compatible with ISO 14443A and B standards. These NFC tags are pre-configured at manufacture and they can be either read / re-writable, or read-only. The memory capacity can be up to 32 kbytes and between the communication speed is 106 kbit/s and 424 kbit/s [7];

- Regarding the choice of the type of tag, the state of the art provides for a classification of tags, and we have identified the fourth class, both for the reader compatible with the mode-only required for our system, both for the capacity of data storage, equivalent to a maximum theoretical of 32 kbytes, suitable for saving the URL.
- As local web server is used a laptop with linux distribution and XAMPP;
- for each opera of art was created a html page containing the following information content:
  o Author;
  o Size of the artist object;
  o Title and Description;
  o Thumbnails with captions and links to high resolution images;
  o Information, when present, containing references to the historical period and cultural object;
  o Potential stores;
  o Location of the opera inside "Villa Mondragone".
- install WIFI network for the sharing of content available on the XAMPP server;
- use an Android device (eg, model Samsung Galaxy S II) with a NFC interface for displaying the properly URL.

In the present case-study, we report the case of a particular application of SMART VILLA, that is the System called SMART ROOM, in reference to the use of NFC technology for the extrapolation of information detectable by the various objects exposed in the Villa.

The basic **functional scheme, that implements "SMART ROOM"**, consists of the following steps:

1. The user must enable **the NFC on the Samsung device** through the internal *menu*;
2. The user needs to **activate the WIFI network** via internal menu;

3. Now, the user can hold the device to the respective tags;
4. The user approaches the **device to the tag within a radius of 4 cm**, so he can view the web page that describes the object on his screen.
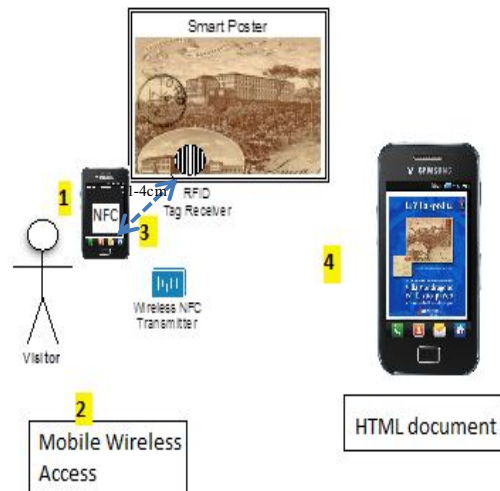

Figure 4: SMART VILLA Overview

Figure 3 shows the four substantial steps above referred and outlines the System Organization by showing usage and operations carried out by visitors. Users looking for documents and information in "SMART ROOM", can access to wireless information system by connecting their **smartphone to a wireless RFID TAG located on suitable smart Panel or smart Poster** holding radio receiver embedded in the picture.

V. CONCLUSIONS

This paper addressed the impact of Ambient Intelligence (AmI), on Cultural Heritage Information Systems, showing how this evolutionary paradigm, by means of numerous sensors, is useful for the development of Smart Context-Aware System, providing more advanced services.

In particular the paper has shown the design of a AmI-based Information Systems, where NFC technology is embedded into the background, suitable to access cultural areas of particular interest.

The proposed system is related to mobile and safe cultural access in the context of ancient Renaissance Villas, where different sources of cultural things are interfaced in a proper virtual way without affecting the historical environment. We outlined a real system, called SMART VILLA, based on a set of mobile applets, each interfaced with a NFC based subsystem, related to particular sites (SMART BIBLIO for ancient libraries, SMART ROOM for

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