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Resumo This paper describes a new system support for urban computing, designated as RFIDcaching hunting game. The research focus on how the mobile users can interact with each other when they walk through a city with embedded RFID technologies. Situated displays are used to present graphical information collected by users and to motivate the interaction in the urban environment. Middleware infrastructure is minimized in order to achieve a high level of sustainability and is centred on webservices and d...

SYSTEM SUPPORT FOR URBAN COMPUTING AN RFIDCACHING HUNTING GAME

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Abstract: This paper describes a new system support for urban computing, designated as RFIDcaching hunting game. The research focus on how the mobile users can interact with each other when they walk through a city with embedded RFID technologies. Situated displays are used to present graphical information collected by users and to motivate the interaction in the urban environment. Middleware infrastructure is minimized in order to achieve a high level of sustainability and is centred on webservices and database systems, accessed from mobile devices.

Key-words: Urban Computing; RFID; Geocaching; Mobile Computing.

1 Introduction

Urban Computing (UC) main concepts arise from the need to improve life quality within cities. Taking advantage of technology, applications and services, available in urban environments, many forms of integrated interfaces can be afforded to citizens allowing then to interact with the city and with each other, within their social environment. Some cities already enclose a lot of technology and information systems, but they are still far from the ambient intelligence perspective[5]. The general ideas presented by Mark Weiser[17] when he describes

ambient intelligence can be applied to an urban environment, affording a new concept of urban computing[2]. Computing and social interactions on physical spaces in an urban environment can be achieved by a high level of physical-virtual integration[13]. The technologies associated with mobile computing[6] provide the user with the possibility to perform tasks in multiple locations, thus allowing users to achieve real mobility and introducing new scenarios that cut loose from the models used in the past. Most of the system supports for urban computing push the development of new frameworks that seamlessly configure the entire digital environment. Much work as been done already, developing a new meta-operating system or middleware skilled to integrate the heterogeneous systems arising from the presence of sensor networks, ubiquitous computing, wireless networking, wearable devices and Radio-Frequency Identification (RFID). This is a very hard task to be preformed, as can be seen from the state of the art report[10] previously submitted.

The main idea herein is the identification of emerging research topics, related to urban computing environment using a new approach based on RFID technologies, which allows the user to interact with the environment by using a Personal Digital Assistant (PDA) with a Global Positioning System (GPS) receiver and a RFID reader. The middleware infrastructure is simplified in order to facilitate the system deployment in a real environment. The tests implementation uses webservices and databases systems as core elements. The aim is to focus on new Human-Computer Interactions (HCI)[7], which can empower the user search activities related to the traditional geocaching game.

2 System Overview

One of the worldwide played games is Geocaching[1]. To play this game the user must have an Global Position System (GPS) or some cartographic map that helps him to find the containers, normally designated by geocach or caches. This caches are waterproof plastic boxes that contain a logbook or some little value trading items. There are 1675269[1] active geocaches spread around the world. This afforded the inspiration to search for new means to allow user to interact with the city sensing the environment with an RFID reader device to collect information from physical elements that are near to him, in what I define as a RFIDcaching Hunting Game.

As stated within the paradigm of pervasive computing, the RFID tags should be broadly disseminated throughout the city, every public space has a RFID tag associated, allowing users to read the tags on anything and everything, transforming the public space in a smart place[4]. Furthermore, as a result of the high level of integration with the physical environment, regarding the new concepts of physical hyperlinking[12], the RFID tags become embodied in the city in a ubiquitous manner. Some work is already done in the ubiquitous computer

network field in other to assist people in urban areas[9], which can also be viewed as an intelligent assisting location-aware service. The RFID technologies are very well developed and there are many applications which explore the interactions between users and physical objects, like augmented reality[16], or using the tags to annotate the physical environment[14] .

The main research goal is to develop a new form of urban computing interaction, that works like a game where the users are hunting RFID tags associated with physical objects. These information data can be shared on-line directly to the web portal, manipulated my the mobile applications using web services or, if the user is off-line, collected data can be stored locally on a PDA for later synchronization.

2.1 System Architecture

The use of a system architecture approach which deploys sensors all-over the urban environment in order to assist the user is the common feature of most of the previously preformed work. The system architecture proposed wherein innovates by taking an opposite approach. The user is not identifiable by some RFID tag, instead the user owns the sensors in his mobile device and uses it to interact with the environment. Thus, the RFID reader is embodied in the user and not in the environment.

This infrastructure is very simple to deploy in the city and has a low cost of implementation to the city public administration, because the only prerequisite is the spread of RFID tags in public spaces.

If we just want to implement the game interaction mode, the system architecture could be as simple as Figure1:

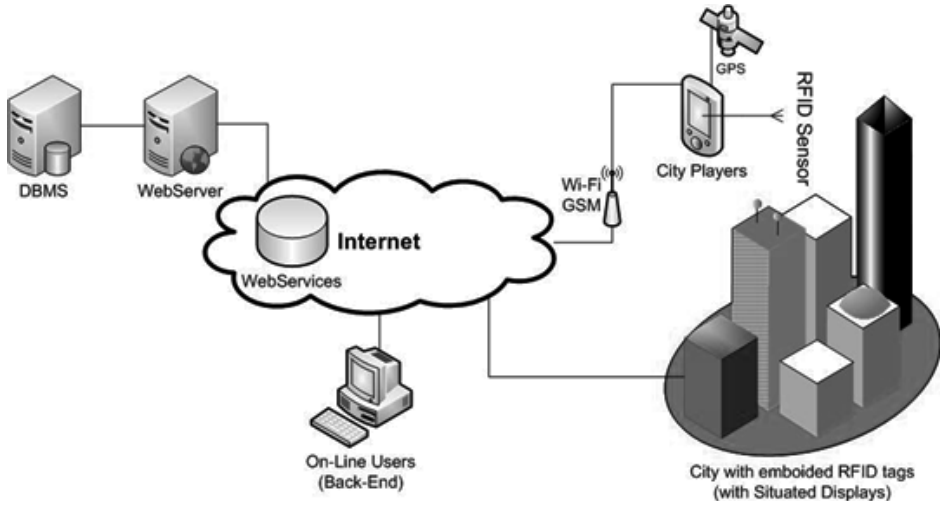

Fig. 1: System Architecture

The mobile user is represented by the city player with sensor capabilities (GPS+RFID), collecting information from the RFID tags, associating it with localization information received from the GPS (if available) and uploading the data to the information system. The main component of the information system is the Database Management System (DBMS) where all the information is stored, including the relationships between the physical spaces which have RFID tags, city players, virtual objects and situated displays[11] .

The PDA is capable of running the software which uses a context awareness application to help the user while is exploring the city environment. If the PDA has a available connection to the Internet using GSM or local Wi-Fi network, the software can invoke webservices to upload the collected information to the central system, according to the users preferences.

The web server provides access for online users to configure their profiles and to visualise their historical log. Users can also exchange experiences using a online forum discussion site.

2.2 Functionality

The minimal resource required to participate in this experience is the RFID reader, but to accelerate the searching processes a GPS can be very useful. A device with computational capabilities like a PDA, can help the user to manage information and interact with other on-line users. For a full compliant system a PDA with integrated GPS and RFID reader gives the user all the capabilities in just one device.

Unban interaction preformed by a high number of users, combining informations from GPS, RFIDs, virtual objects, on-line users and situated displays will reveal an ambiguous relation between real players, which can be explored from a social point of view.

The three main entities of the system: **City Players**, **Situated Displays** and **On-Line Users** are represented in Figure 2.

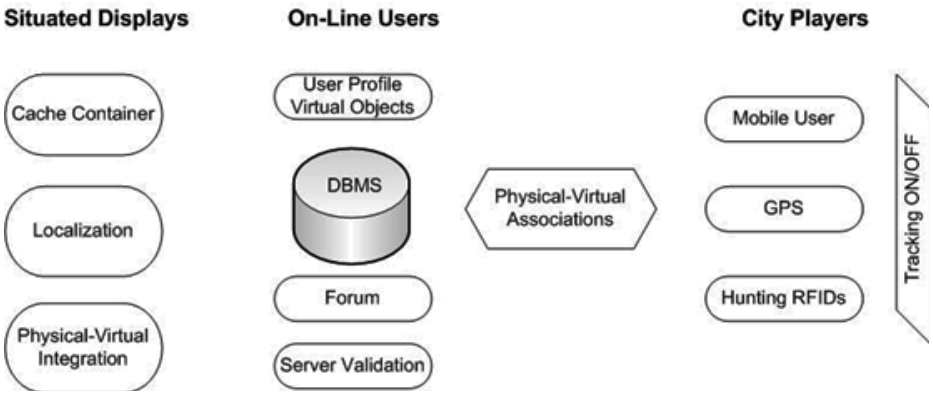

Fig. 2: System Functionality

The database has photos from the city associated with every RFID tag. Photos can also be submitted by on-line users and turned available at the situated displays after scrutiny of the most voted one.

Apart from personal information and configuration, the user profile will also have limited virtual objects that act as an user avatar and could related to virtual-physical associations.

For each RFID tag collected by the user, the system will preserve the last virtual objects associated between the tag and the user avatar. A rank of the most collected tags can be establish and the aggregated information sent to situated displays.

2.3 Environment

Some cities already deployed RFID technologies in smart places, such as the experience made in the city of Kobe, where Japanese government build a new IT infrastructure with RFID tags embedded in streets, electric poles, residence indication signs and information services for mobile multimedia devices that assist people to navigate and find facilities in cities.

It is also very easy to tag physical caches which are simple plastic boxes. With a waterproof RFID (Figure 3) attached inside the box, which would be able to resist to weather conditions at the external environment. The physical container allows a limited number of objects inside but can be associated with several virtual objects.

Fig. 3: RFID Label

In the USA the Food and Drug Administration (FDA) government agency approved the VeriChip's implantable RFID chips (Figure 4)for use in humans. About twice the length of a dime, the device is typically implanted between the shoulder and elbow area of an individuals right arm. Human RFID chips cannot

track someone in real time as GPS does, but can provide information like: the user was inside some building or if he has passed near a scanner antenna. This approach was avoided because of the security weaknesses related to privacy and human rights. The same functional goals can be achieved by placing RFID tags in public places, resulting in less risk of user privacy loss.

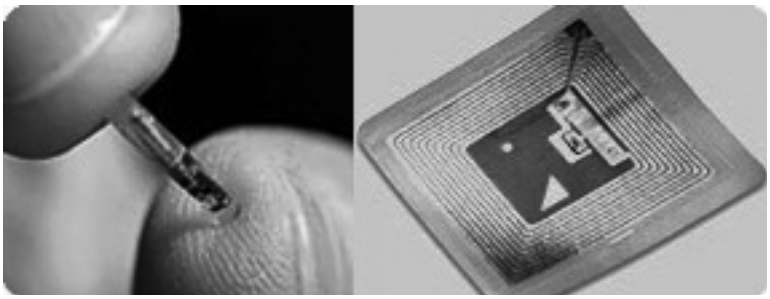

Fig. 4: RFID Human Implant

Large displays are being increasingly placed in public places in order to support community and social activities. The users can socialize around large situated displays which generated graphics result from users movements within the city environment. Research as already been preformed for context-aware public displays[3] which can be useful to map the user interaction with the environment. The situated displays can retrieve location data from the database and generate filter views only for neighbour users and physical places.

If the user disables PDA Software tracking information, he will not send his location information to the central database but he can still interact with the system as an anonymous user. Under these conditions, virtual objects associated with the user will not be related with RFID information collect by the PDA software. Situated displays don't show private information, only a statistical graphical view will be present.

When tracking is enabled by the user, situated displays and online users can visualise all information collect by the mobile sensors during city walks, and represent geographic information using Google Maps API. Figure 5 is an example where the information collected from mobile radio amateur stations (that broadcast the GPS data to a digipeater) is aggregated with the geographical information using the Google Maps API.

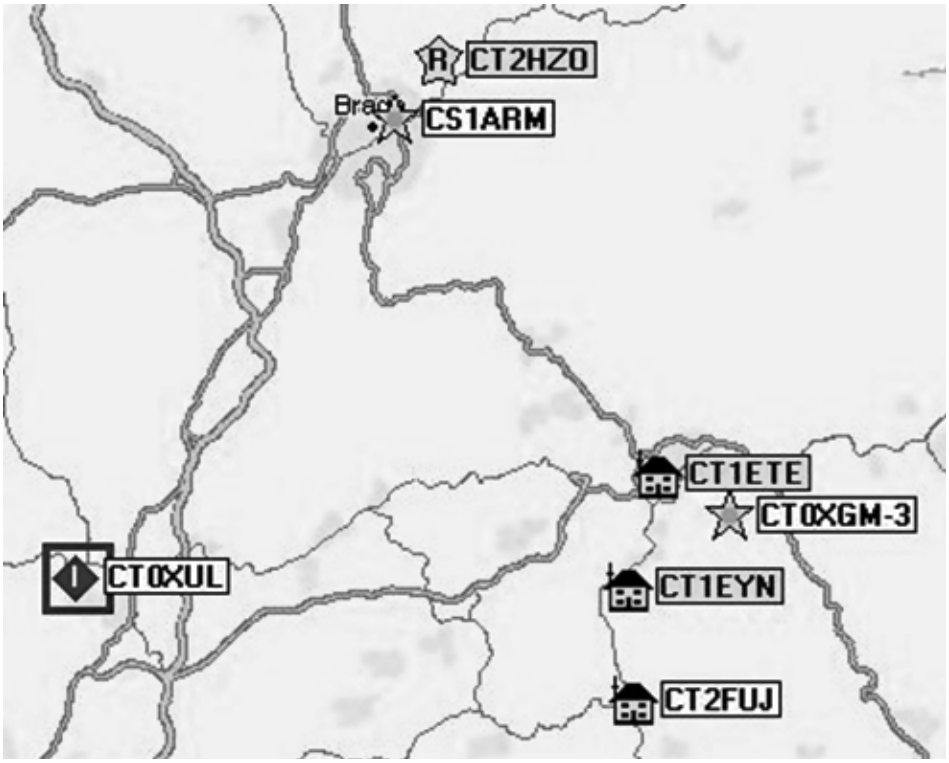

Fig. 5: Situated Display - User Location Information

2.4 Security

The system middleware uses encryption security measures to ensure the user is reading the tag information and not simply trying to forge his presence as if he was in the physical place, by submitting the codes directly to the central system. The sector 0 is public and only available for reading where the tag serial number is stored. In order to access to the private sector a password must be sent by the user. The middlware generate a new password for each user and ensure that the new key is stored inside the RFID label. This way, the code associated with the physical location changes every time the user submits the tag.

2.5 How can be used ?

This system can be explored in several different ways. The most interesting one is preformed without no explicit action taken by the user. Implicit interaction can be achieved because the perception of what surrounds the city player can be done automatic and there is no need for user attention. The city player walks through the city, while the PDA software reports the collected tags to the central

database, resulting an pro-active interaction with the situated displays.

If the city player just wants to explore the system as a RFIDCaching Hunting Game, some of the basic rules are:

- If he takes something from the cache, he must leave something of an equal or greater value (geocaching)
- He should associate some personal message to the on-line logbook.
- Publish his experience in the WEBportal
- He can enable/disable tracking information
- He can attach a virtual object to the cache

The user is not limited to searching the RFIDcache, he can also create new ones and place (hide) them in the urban environment. Then upload the localization, RFID tag and some complementary informations (user help), to the system.

3 Research Challenges

The main goal of the project is to prove that RFID can be a reliably infrastructure for identification in physical public spaces and can be helpful to the user while exploring the city, making it possible to play a city hunting game.

At the beginning the RFID technologies were seen as a replacement for barcodes labels used to identify objects. Then many applications were developed to identify, localize people and associate it with other resources. Those type of architectures have a big problem concerning the right to user privacy. When the user has an RFID with him, he can be tracked like a marathon runner. Trust in the system will be affected and so, legislation recommendations related to privacy must be followed. More research must inevitably be preformed in order to solve this privacy problems related to RFID.

The architecture proposed allow the user to stay anonymous, since only the public spaces or physical objects have RFID tags.

If the uses doesn't want to stay anonymous, information about his actions passes on the situated displays. The city players can use this information to extend their capabilities. An indoor scenario, where many tags are placed in a small area, the graphical representation of those tags will overlap, so research must be done to find a better solutions to data representation.

Reading multiple tags that are available in the city will cause problems subject to radio jamming and similarly electromagnetic impulses can permanently damage radio devices.

In the traditional game it is not possible to track the user since this function is not available by GPS, but with on-line connection to the Internet some experiences can take place, with the user consent, when tracking information is available at the system. This will be a research challenge as the city players that

are near or are doing activities in the same place can interact with each others.

One of most reference work on location system using RFID is SpotON[8]. It uses an algorithm for three dimensional location sensing based on radio signal strength analysis, but no complete system as been made available yet. This research can also address challenges related to location inside buildings.

The use of public displays has been researched in various contexts, but one of the main question is how the city players will interact with them. Information from different users must be visible to the others and the display is shared by on-line users too. This creates many research challenges related to sharing resources over a network.

Questions and problems such as: what type of virtual objects can be created by the users to be putted inside the virtual container cache; if the virtual objects will also appear on the situated displays and what kind of social consequences it will make to the relations between people, must be answered before the system can be fully operational.

4 Methodology

The methodology approach is based on a distributed participatory model[15] where the end-users enters into the world of the researchers and developers. Since the research is to be applied in an urban computer environment, the users can have a chance to propose changes in the system features, in order to achieve a hight level of appropriation of the system. This can be seen as an iterative and incremental approach which emphasises continuous user involvement.

In the first stage, the pre-project ensured the project commitment. Then the research project entered on a traditional life-cycle regarding stages as: study, functional model iteration, design, build iteration and implementation. The final steps of the methodology uses several methods to study the principal concepts and describe the research activities, that are related to the game exploration in a urban computing environment.

Observation methods can collect information on how the city players interact with the situated displays that are present in public spaces, like plazas or inside buildings. Information about mobile devices that are used by the city players must be retrieved and a external perception on the strategics used during the game explored. The forum also works as an external observer, when the system enters at the production phase, since all users can send suggestions in order to optimize the system.

Analysis methods were implemented in order to retrieve information from data collected by the city players. The data was analysed recurring to statistics tools which make possible visual representations in the situated displays and apply some metrics that can characterized the level of liability and robustness of the RFID infrastructure. Its very important to know how long an RFID infrastructure

deployed in a public place will be operative and the number of false detections that may happen.

4.1 Evaluation

Many aspects should be evaluated because it is very difficult to build models for city players, showing how they build expertise and knowledge related to this specific game. The rejection of the system by the users can be minimised if evaluation is used to find some mistakes in the design and expose the lack of correctness against the functional requirements. The final goal is to deploy this game in a unban environment and the economic evaluation is very important since the project deploy will be massive in the urban environment. Evaluation the software using a lab testbed is a cheaper solution and was a fist step approach. Qualitative and quantitative methods were also used to evaluate and measure the user value and the requirements of all entities.

Evaluation questionnaires were created to measure also the important characteristics of usability or user satisfaction, and measure the levels of usefulness of prototyping approaches.

Since there is no mobile PDA with RFID sensor, the evaluation was made using a prototyping strategic that regards the utilization of the RFID Reader/ Writer that have a SD Card interface (Figure 6) that can read tags up to 12.5 cm in range.

Fig. 6: SDiD - First Low Frequency RFID R/W SD Card

4.2 Simulation

The prototype created is very important to make a physical simulation of the system architecture regarding also the software and hardware components. A testbed simulation can be achieved by lunching an event day game in the University Campus, where a limited number or users can interact in a ubicom environment. The simulation for the interoperability of technologies all uses a

small scale system, based on the developer AVR32 GNU Toolchain in which the first tests were made and resulting this boot sequence (Figure 7).

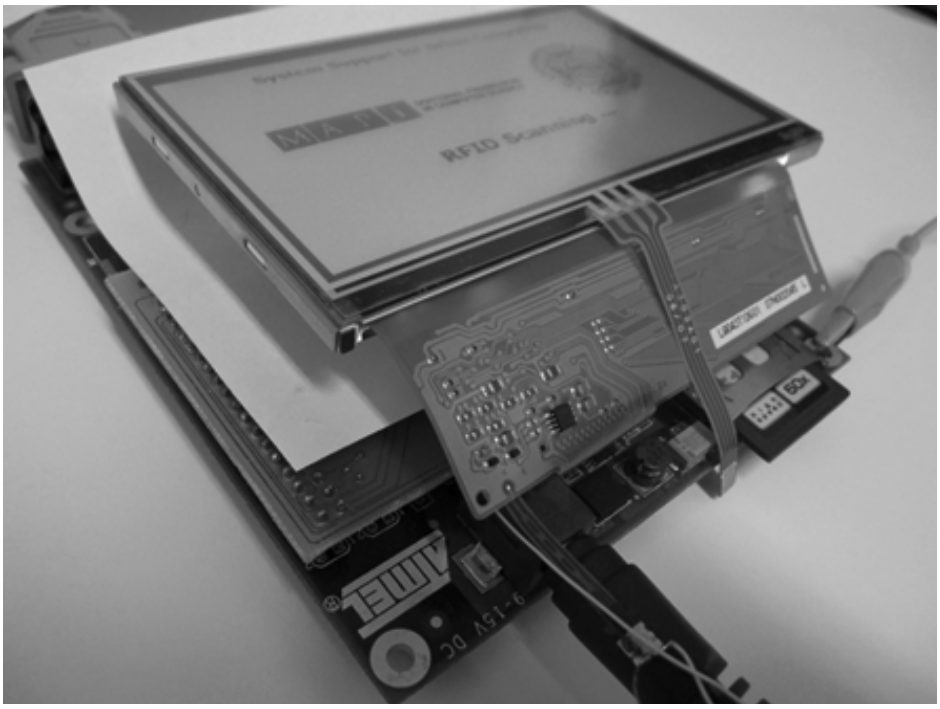

Fig. 7: Boot Sequence

5 Conclusions and Expected Results

The research presented in this system report describes a new approach for system support in urban computing environment, where the user can sense the environment using an RFID reader device and GPS.

User privacy is a main concern in this project, enabling the user to stay anonymous while interacting within the environment.

Some guidelines were established for the deployment of the RFIDcaching game as a prototype, to evaluate the system in multiple scenarios.

Expected results from the research planing are:

- System support for anonymous user interaction.
- Evaluation of the system adoption.
- RFIDgeochacing game deployment.
- Testing the liability of the system.

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