Mobility through Location-based Services at University

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***Abstract*—Location tracking systems are becoming more relevant in many new environments, due to the fact they the core of context aware applications. This new concept can improve the way universities provide services and a wide number of companies do business. Inside university area, users location (both students, teachers and staff) gives rise to a new kind of services based on their profile and on the area in which the user is in each moment, allowing a personalization of the offered contents. The present paper shows how location-based applications can be developed for mobile devices through a middleware that allows different location methods, such as Wi-Fi and RFID. Finally some location-based applications are given showing possible examples in different environments.**

***Index Terms*—Location-based services, Mobility, M-learning, RFID.**

I. INTRODUCTION

Nowadays mobile technologies are being applied on educational environments successfully. One of the main reasons of this success is the improvement of the technical features of the devices. New generations of mobile devices have wider screens with better resolution, built-in digital cameras, and connectivity not only with GPRS but also with Wi-Fi or UMTS. In some of them it is even possible to find GPS receivers, RFID readers or smartcards integrated.

All these new technologies inside a small and portable device are giving rise to a new generation of applications in all kind of environments. These kinds of applications are called M-Learning inside university environment. Here mobile devices are supporting collaborative and mobile work and enabling the students to learn anywhere and any moment, especially through games or courses designed for these small devices.

Location-based systems can now also find a place on this mobile and university environment thanks to the integration of GPS receivers. The motivation for the use of this kind of services at universities is because it allows knowing more information about the context. For example, a student in a cafeteria will have different needs than in a laboratory or in a secretary, or a teacher in a classroom will need different information than in an office. Knowing where the user is in every moment it is possible to offer personalized information through the mobile device depending not only on his/her profile but also on his/her location.

The present paper uses a real application developed by UNED (Spanish University for Distance Education) to show the evolution of location-based systems at university, making special emphasis on indoor location technologies, such as Wi-Fi and RFID.

II. OBJECTIVE

The result of this research is an application manager able to run different applications inside the mobile device of a user depending on his/her profile and the place where he/she is in.

In this way, a user entering into an area equipped with devices such as laptops, mobile phones or PDAs, will receive the pertinent information obtained from the information services of the organization. For example, a user in a conference hall will receive automatically the documentation related to it (slides of the presentation, additional documents, CV of the speaker, etc). In the same way, a student will receive the information about a practice entering or approaching to the corresponding laboratory.

III. ARCHITECTURE

In the design of the tool it had a great importance the construction of an open and modular architecture that allowed the integration on diverse environments depending on market requirements. The figure 1 represents the logical architecture of the system, showing the three main elements that constitute it: the location system, the adaptation middleware and the application manager. The location system is in charge of finding where the user is. Usually, there is a program installed in the mobile device that interacts with the location system obtaining the coordinates of the position.

The second layer in this architecture is an adaptation middleware that will ensure independence of the location system. Thanks to this middleware it will be possible to use several methods of location, for instance GPS, Wi-Fi or Radio Frequency Identification (RFID). It provides an abstract interface that must be implemented by every location system. In consequence, the application manager does not have to worry about what kind of location system is being used; it only has to interact with the adaptation middleware (Figure 1).

Finally the application manager will decide the application to show to the user depending on the user's location, the moment and the user's profile. This module will send a command to the mobile device to show the suitable application.

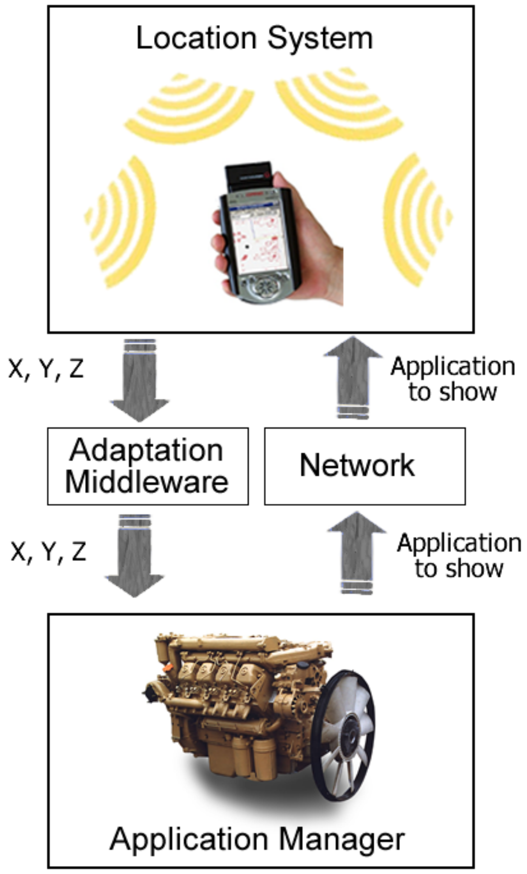

Figure 1. Logical architecture of the system

IV. EVOLUTION THROUGH LOCATION TECHNOLOGIES IN MOBILE DEVICES

For a long time, the most famous positioning method has been GPS (Global Positioning System), but other systems have emerged in the last years, fundamentally based on wireless technologies. Some examples are the Wi-Fi networks, Bluetooth or the Infrared sensors. In addition, other Radio based technology such as RFID can also be used to locate any kind of things: people, goods, animals, etc.

A. GPS: Used worldwide

It is a fact that the main and more widely used location method in mobile devices is the Global Positioning System (GPS). This technology offers a quite reasonable accuracy in outdoor environments.

Each GPS satellite transmits data that indicates its location and the current time. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are farther away than others. The distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions (Figure 2).

Although four satellites are required for normal operation, fewer may be needed in some special cases. If one variable is

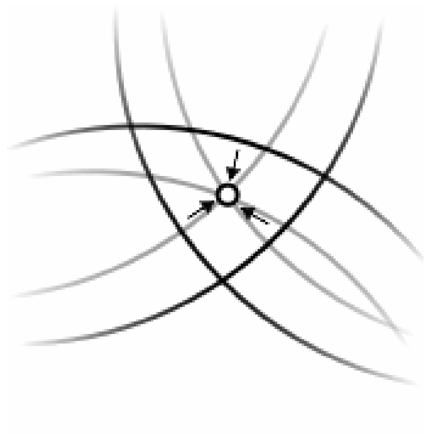

Figure 2. How GPS works

already known (for example, a sea-going ship knows its altitude is 0), a receiver can determine its position using only three satellites. Also, in practice, receivers use additional clues (Doppler shift of satellite signals, last known position, dead reckoning, inertial navigation, and so on) to give degraded answers when fewer than four satellites are visible.

The position calculated by a GPS receiver requires the current time, the position of the satellite and the measured delay of the received signal. The position accuracy is primarily dependent on the satellite position and signal delay.

To measure the delay, the receiver compares the bit sequence received from the satellite with an internally generated version. By comparing the rising and trailing edges of the bit transitions, modern electronics can measure signal offset to within about 1% of a bit time, or approximately 10 nanoseconds for the Coarse/Acquisition code. Since GPS signals propagate at the speed of light, this represents an error of about 3 meters.

However, the use of this technology inside buildings is not possible because the receiver needs to have direct contact with the satellites. For that reason, technologies such as Wi-Fi or RFID are appearing in location systems for indoor environments.

B. Wi-Fi location for mobile devices

Wi-Fi based location uses a small program installed in the mobile device that will recollect the powers received from the access points every 250 ms, and it will send them to a server where they will be processed to obtain the user's coordinates. The inconveniency of this method is that it requires a previous calibration of the system.

The location manager is based on a positioning engine able to locate wireless clients, such as mobile devices, PDAs, laptops or others devices that fulfil the standard 802.11b with a reasonable precision (currently the most advanced system have an error margin of one meter, enough to the application that we use).

In first place, the system requires the installation of at least three wireless access points in the covered area, which will emit in different channels. Once the access points are working properly, it is necessary to calibrate the application measuring the power and noise in several points of the map (Figure 3).

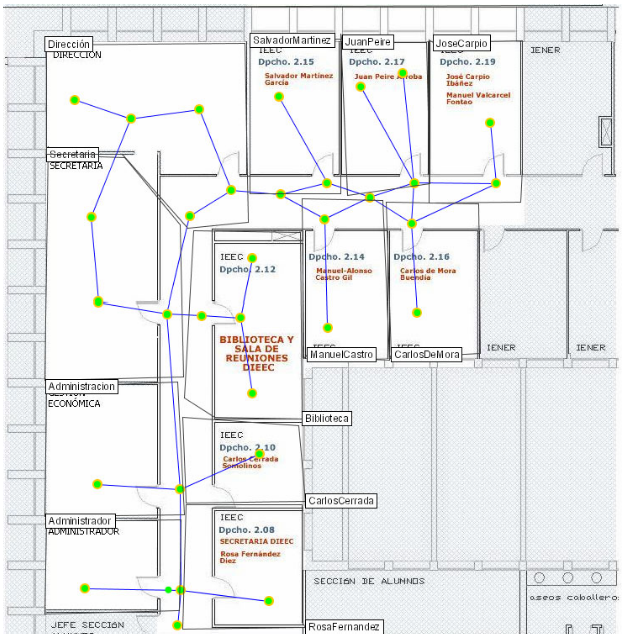

Figure 3. Measuring the power in the covered map.

These measurements will give as a result the optimal position of the access points in the covered area. It will also be used to setup and calibrate the neuronal networks.

For this calibration, a positioning pattern will be used with the more significant geographic points of every room, which will register the received powers of each access point.

Another aspect to consider is the definition of areas in the map, which allows deciding the application showed to the user depending of his/her position. The definition of the areas also guarantees the integrity of the system controlling the access to these areas and allowing the compilation of statistics of movements of the users.

Ideally, the precision of location would be perfect, however, the received power by the access points is not constant and can be affected by electrical fields (for example a microwave), physics (walls in rooms, offices and zones of step that contain isolation materials) or thermal effects (people affluence).

C. RFID location for mobile devices

On the other hand, Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. This identification is usually used for identification, as the substitute of bar codes, tracking any kind of products or even animals or people. Some tags can be read from several meters away and beyond the line of sight of the reader. In addition this identification method can also be used to locate people in an area. But it only locates people when the RFID reader reads the tag that the user carries.

Nowadays it is possible to find RFID readers integrated in many mobile phones. This system is being used together with smartcards mainly to allow payments. But it also opens a wide mosaic of applications in the location field. Inside RFID-based location there are two kinds of systems, depending on if the user carries the tag and is identified by several readers in the building (Passive location) or if what the user carries is the reader, and he/she reads the tags integrated in the environment (Active location). Both will be described in the following points.

1) Passive RFID location

In this case, there is no need of any action by the user to be identified. The tag that the user carries will be read and the user identified only crossing a door. If the system has several RFID readers it is possible to track the movements of the user by a map, knowing in which room the user is at every moment and in which rooms he/she has been in the past.

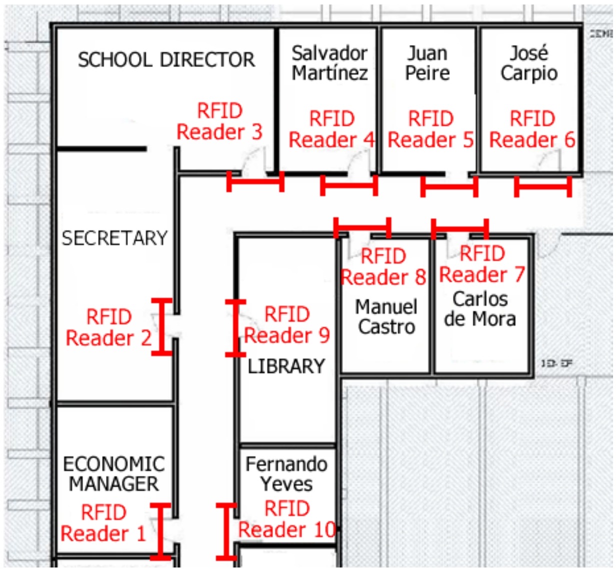

Figure 4. RFID readers at the entrance of every room

As it can be seen in the figure 4, every time the user enters in a room he/she will be identified and located through the RFID readers integrated at the entrance of every room.

Once the system knows where and who is the user it is possible to offer him personalized contents thanks to the application manager that will decide the most suitable application to be shown.

2) Active RFID location

Active location requires the user carry out some action. In this case there will be several RFID tags spread along the map, for example at the entrance of rooms, on informative panels, etcetera.

When the user approaches his/her mobile phone to some RFID tags it will read the information stored into the tag, what will be used to know where the user is this moment (Figure 5).

Once the tag is read, the mobile phone will be able to connect to a server and obtain personalized information depending on its profile and its location inside the map.

Figure 5. An RFID reader in a mobile phone.

V. APPLICATIONS ON UNIVERSITY ENVIRONMENT

Inside the location field with mobile devices, UNED has developed a system to offer personalized information depending on where and who the user is (Figure 6).

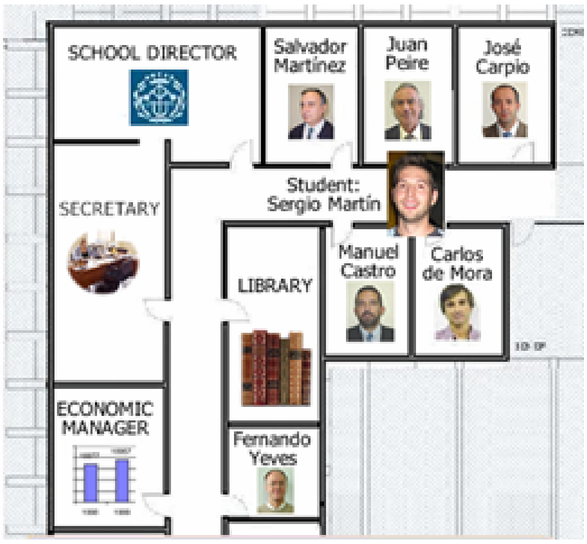

Figure 6. A student approaching the office of a teacher.

Figure 7. A sample screen of the application

Basically, the system obtains the information about the location of the user thanks to the geographic location system that offers the coordinates (X, Y, Z) of all the devices connected to the system. From them, it is possible to determine in which area or room of the building are these terminals. With this data, the tool determines what information must be offered to each terminal and is possible to track the user's movements.

In figure 7 can be seen a screen of the application, showing the associated information to the area in which the user is in this moment, in this case, it is information related to a teacher.

Figure 8. Information in a PDA screen.

In this case, due to the fact the system is a prototype the information associated is very simple, only the information related to the teacher: subjects, timetables, curriculum vitae, e-mail, and etcetera. This view is for a mobile device with a wide screen, such as Ultra Mobile PC (UMPC) or a laptop.

The application gives also support to more reduced devices such as mobile phones or PDAs in order to provide access to anyone anywhere. In figures 7 and 8, it is possible to see a screen of the application in a PDA, showing the information related to the room where the user is this moment. In this case it is the information of a teacher because the user is close to this teacher's room.

VI. OTHER APPLICATIONS

One of the main advantages of location-based tools is the great capacity of integration in diverse areas:

- Security (emergency, attendance in highway, forest monitoring, etc.).
- Services search (vehicles, people).
- Tourist information points (museums, art galleries, etc.)

- Routing of calls to the closest centre (shipments of food, services of technical attendance, etc.).
- Customized information services (yellow pages, tourist information, located publicity, etc.).
- Hospitals can improve patient care by keeping constant track of doctors, nurses, support staff and other medical resources;
- Retail stores, stadiums, and other service-oriented facilities can adjust staffing levels and product inventory to best accommodate consumer patterns;
- Corporations can track assets more effectively.

As an example of this versatility and great capacity of integration in other environments, in the development of the prototype were prepared two more environments in addition to the university: an Egyptian museum and a hospital.

In the Egyptian museum environment were developed several information pages about the art pieces in every room, such as "Box with Carved Scenes of King Tutankhamun and His Queen" shown in figure 9, that were shown in the user's mobile device every time he/she accessed to the room.

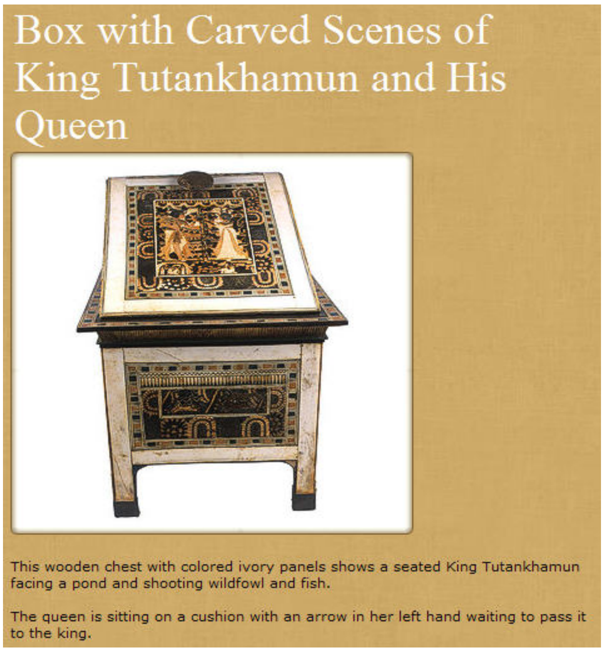

Figure 9. One of the applications in the Egyptian museum environment.

The other environment developed to show the versatility of the system was a Hospital, where doctors and nurses were located inside the building to improve the efficiency.

In addition, when doctors were visiting their patients they obtained their medical history in the mobile device just approaching to them. In figure 10 a sample of a patient's medical history shown to a doctor can be seen.

VII. PRIVACY ISSUES

While all of these applications and services promise enormous consumer benefit, privacy concerns abound, and must be addressed if new services and applications are going to be accepted by consumers [16].

Figure 10. One of the applications in the Hospital environment.

Location-sensing technology raises interesting problems, such as the expectations users have for privacy in particular places or while engaged in specific activities [17]. For example, some people will not mind to be monitored at work but they will prefer a higher level of privacy in his private life, or sometimes they will not want to be monitored when they are in a bar or in the bathroom.

In addition, to the location aspect of place, the social context of place also has some affect on their willingness to share location information. Some studies reveal that people is far more willing to share location information when they are alone. The influence of being with friends is statistically stronger when people are at home or in the library. These studies suggest that when people are at home or in the library are more interested in enabling social contact- that is, having others find them-and possibly less concerned about privacy, even when they were at home [17].

In the case of RFID technology, a primary security concern is the illicit tracking of RFID tags. Tags which are world-readable pose a risk to personal location privacy [18]. This case is deeply different from Wi-Fi or GPS location privacy problems, because it is possible not only to know who and where the user is, but also other information such as what kind of clothes he wears, due to the fact not only humans can wear RFID tags, but also any kind of products. This means that if a user enters a store with a pack of gum in his/her pocket, the reader can identify that pack of gum, the time and date he/she bought it, where he/she bought it, and how frequently he/she comes into the store. If the user used a credit card or a frequent shopper card to purchase it, the manufacturer and store could also tie that information to his/her name, address, and e-mail. He/she could then receive targeted advertisements by gum companies as he/she walks down the aisle, or receive mailings through e-mail or regular mail about other products [19]. For that reason there are several kinds of mechanism to avoid reading and writing in the RFID tags, such as Faraday Cages (Figure 11).

These techniques block the electromagnetic signals sent by the reader to power the RFID tag. A manifestation of the increasing fear that is appearing in this sense is that it is possible to find these Faraday Cages embedded into wallets and even trousers (Figure 12) to prevent not allowed readings from malicious users.

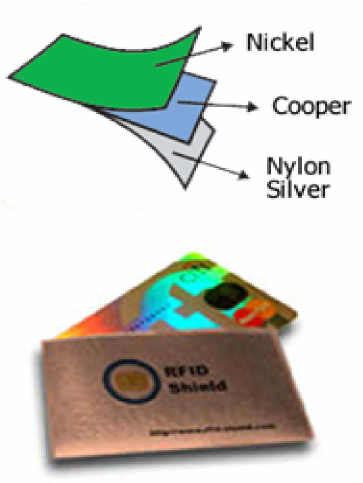

Figure 11. The Faraday's cage acts as an RFID Shield intercepting the electromagnetic signal which normally powers the RFID tag.

Figure 12. A Faraday's cage embedded in a pair of trousers and a shield protector for passports.

In summary, location-aware systems must develop privacy policies that will clearly inform the users about how their personal information will be used, who is going to manipulate it and the purpose. All this information should be specified in a contract signed by the user and the company in charge of the personal information. In any case, this information can be read without the explicit permission of users and must be only used for the specified purposes.

VIII. CONCLUSIONS

Location technologies embedded into mobile devices are nowadays a reality. Users can easily purchase PDAs or mobile phones with full connectivity: 3G, GPS, Infrared, Wi-Fi and Bluetooth; and in a near future they will also offer other technologies such as Wi-Max or ZigBee. The use of these technologies will allow location-aware systems become more popular and spread in everyday life, reaching other areas of the society, such as the sanitary environment, museums, monitoring of buildings, tourist information points, conferences, customer service departments, and etcetera.

On the other hand, there are some privacy issues that must be addressed in order to ensure users trust these systems, what means location-aware technologies will have a very promising future.

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