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- Título del trabajo: Integration of wireless communications in a GIS platform
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- Resumen: This paper presents a new developed platform for the Commercialisation of Advanced Services of Geographical Information, focussed in portables devices, and that makes use of the telecommunication networks available today: Internet as the backbone and cellular networks (GSM + GPRS) as access networks.

  The platform implements a system for commercialising cartographic information in form of vectorial maps for different amount of time, guarantying property rights of the provided information. The problem with vectorial maps is that they have additional information, as points of interest or street names, that is very important to have them updated. So it is more interesting, for both the provider and the customer, to rent the maps for a small period of time, and also for a low fee, than selling them for ever and for a big amount of money.

  The client accesses to the service using a vectorial map player, that runs over PC or PDA (Personal Digital Assistant) platforms, and using a GPS receiver, it has navigation facilities. Before accessing to the information the player will request authorization to the server. Mobile devices will access Internet, where the server is connected, using WLAN, circuit switched cellular network (GSM) or packet switched cellular network (GPRS). The server side will control user access and download required maps.

  The platform includes also a system to improve GPS localization (Differential GPS). The communication between the client and the server uses SMS messages of GSM system, one for the request and another for the answer. This operation is very sensitive to response delay and it has been optimised in order to work properly.

Integration of wireless communications in a GIS platform

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Abstract – This paper presents a new developed platform for the Commercialisation of Advanced Services of Geographical Information, focussed in portables devices, and that makes use of the telecommunication networks available today: Internet as the backbone and cellular networks (GSM + GPRS) as access networks.

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I. INTRODUCTION

Nowadays, the technological evolution has lead to a situation where the user can reach several advanced devices and systems but there is a lack of applications that make use of their whole potential. We can mention:

a) Global Positioning System (GPS): this system has proved his reliability and continuity since mid 90's. Moreover, there is the Differential GPS, in this case a server sends a correction vector using the RASANT system via FM radio broadcasting. The receiver decodes the incoming information and using the RTCM format sends it to the GPS receiver that with this additional information can give a more accurate position.

b) Consolidation of personal mobile communications with already mature systems like Global System for Mobile communications (GSM) or emerging ones like General Packet Radio Service (GPRS), that is much efficient in data transmissions.
c) Internet: this global network is increasing its size and capacity every day, and what's more, the user has different ways to access it: fixed and wireless, and with different bandwidths.
d) Mobile computers: Laptops that have high performance and Personal Digital Assistants (PDA) that are emerging with strength. Also its operating systems that support more and more applications, as Windows CE. In that point we also should bear in mind that one of the drawbacks of PDAs was the way in which they could be connected to the network. Nowadays, there are several manufacturers that have recently shipped PC cards that implement the main radio communication protocols: Bluetooth, IEEE 802.11b, GSM and GPRS. The present application is mainly focused to the use of them.
e) Geographic Information Systems (GIS): These systems are able to represent maps and their topographic information, and together with navigation facilities have a great potential on new services in different fields as geographic prospections, vehicle fleet control, patient surveillance, ...

The aim of the platform presented in this paper is to provide a global application that combines all these systems in order to offer to the user, a set of services that include: localization, improvement of this localization and access to geographic information servers that provide digital cartography with relevant associated information that permits to navigate through them. This system works through a client – server model, where the server is an HTTP server (Apache Server in the first prototype) with additional functionalities for authenticate and authorize clients and control radio devices as RASANT and GSM receiver. The system supports two types of clients: browsers and a proprietary application. The client's hardware platform may be a PC or a PDA connected through wired network, or through a wireless interface as WLAN, GSM or GPRS. It also needs a GPS receiver.

All these services are intended to be paying services, in that case the server logs all user operations and the client will be billed according to the server utilization. Different tariffs may be applied depending on the user, but the most relevant will be that where information is sold for a short period of time (from several hours to several weeks), after that period the client should buy the information again. This mechanism makes possible to charge a small amount of money for service utilization, and user will only pay for the use he really needs. It is envisaged that these form of micro-payments increases server utilization and therefore company's benefits.

In order to guarantee intellectual property of the information, all files are encrypted with a personal key, and only the authenticated user has access to it. Also, before to display the critical information the client will contact with the server and ask if it can show the map, the better way to reach the server by mobile

clients is using GPRS network. The file may be already stored on the client or can be downloaded when required from the server.

II. GEOGRAPHIC DATA FILES (GDF)

In GIS there exist two basic map formats: raster and vectorial. First one stores the map like an image, in file formats as bitmap, JPEG, TIFF, ... Vectorial formats are more interesting because they store map information as a group of coordinates linked by vectors and permit to store points of interest and other kind of information like street names, number of lanes of a route, forbidden directions, ... and make the map navigable for the user. It is in these format that the presented application works with.

In the market there exist different vectorial map formats, and most of them are proprietary of companies that sell also the respective viewers. This is the case of AutoCAD, MapInfo, ESRI, ...

In order to develop an application that was not dependant of a proprietary format it was decided to work with an open GIS file format. This is the case of Geographic Data Files (GDF).

GDF is a European standard [1], that is used to describe and transfer road networks and road related data. It is much more than a generic GIS standard, because GDF gives rules how to capture the data, how the features, attributes and relations have been defined. In Europe, GDF is promoted by the major digital road data suppliers: EGT, Bosch, ETAK and Tele Atlas. These companies have committed themselves to build their databases according to the GDF specifications. This implies that complete Europe will be available in GDF in the coming years.

The main drawback of GDF is the fact that its files are in text format. This represents an inefficient way of storing digital information because it occupies more memory and are slower to read. There is also the option to store files compressed, this will solve the issue about memory, but not reading speed.

III. APPLICATION FUNCTIONALITIES

The service has two kind of clients in order to satisfy different user requirements: particular and professional.

The first one is a low featured navigation application that uses a conventional browser ran in any type of platform (PC or PDA, Windows or Linux) [2]. The user will access to a HTTPS server that will build the required maps from a GDF file and send them to the user. The most relevant functionalities of the server are: to display maps and its points of interest, to display associate information (streets names), to calculate distances over the map, to look up specific streets, to make zooms, to view the map at different scales, localize points on the map and represent its coordinates in UTM and in WGS84 coordinates systems. In this application it is possible to have public and restricted areas.

The second one is the GDF electronic commerce viewer, with navigation functionalities and interfaces of GSM and GPS, that integrates all the points explained in the introduction of this paper. Its main features are:

a) Representation of vectorial maps in GDF format: the GDF format provides three different levels of representation. The implemented player represents the first level, because it is the most powerful. This level provides topological information and also gives real sense to the represented elements. In this way, the user has access to the characteristics of the map, as its points of interest and streets and parks names. The player displays maps and offers several functionalities. It displays its points of interest and the information associated to any element of the map. It is able to generate and display multimedia information associated to any point of the map (audio, video and images). The player calculates distances over the cartography, makes zooms, shows the map at different scales, draws a grid over the map and offers the possibility of using a magnifying glass over the map.

b) The player can display GDF files that the user already owns or maps that had been bought for an amount of time from the server. These last files will be encrypted with the DES algorithm and compressed with the ZIP60 algorithm. The key used for the encryption is different for each client application and unknown for the user. When trying to load a map, the player will firstly look up in the local memory (hard disc or compact flash) and if it can not bee found there, the player will contact the server and download it automatically using a HTTPS connection. After that, the file will remain encrypted at the user's local disk.

c) When the player has found the encrypted map, it has to verify if the user has the right to use it. To do so, it will contact again to the server who will have this information. If the user has permission to see it, all this process will be transparent for him and the map will be displayed. If not, the player will show a popup window requesting the user to buy the map for some amount of time. When the user confirms this request the map will be displayed, and the server database updated with the new user parameters. It is interesting to remark that in order to make this operation (verifying user rights for the map) the client has to be connected to Internet where the server will also be. This verification can be done very fast using GPRS access. Instead, the operation of downloading the map is much more bandwidth consuming. Consequently, it would be preferable that the client already has all the encrypted maps in his memory. This can be done in an indoors environment using a WLAN or with an already recorded compact flash memory. In this way, when requiring to access the system from outdoors, the amount of data transmission with the server will be reduced to the minimum.

d) Navigation facilities: The player gets input from a GPS receiver and is able to position the user over the cartography. To achieve this, it is necessary to convert the WGS84 coordinates, proportioned by the GPS receiver, into UTM coordinates, used by GDF maps. Moreover, if the user moves and its

position exceeds the dimensions of the displayed map, it will try to load the correct map automatically, looking up at local directories or downloading it from the server, always verifying user rights over the map first.

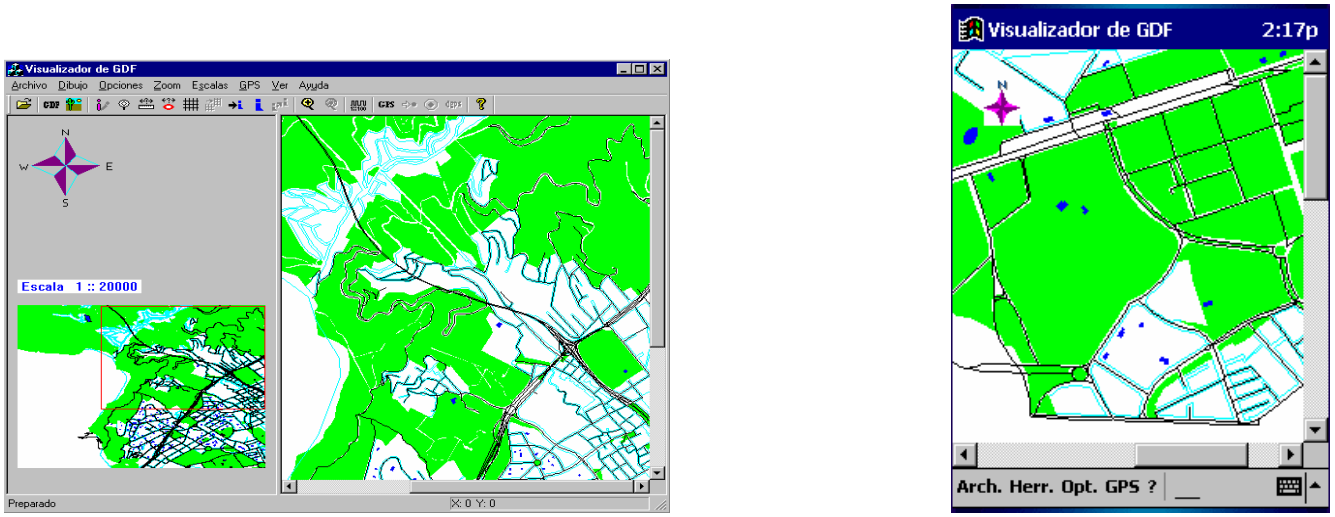

Figure 1. GDF electronic commerce player for PC and PDA.

e) The GDF electronic commerce player offers the possibility to correct the position provided by the GPS using the improvement position server. In order to do that, the player sends a request of correction using a SMS message to the server. After a few seconds, it receives a SMS with the answer, builds a RTCM frame and sends it to the to the GPS receiver. The GPS receiver, with the just arrived information will apply the DGPS algorithm and correct its position, which will be presented to the user through the GPS display or through the player window.

The GDF electronic commerce player is available for PC and for PDA (figure 1). The most relevant functionalities are the same in both platforms but there are two main performance differences due to the PDA's hardware limitations. The first of them is the quantity of information displayed simultaneously in the screen and the second the amount of time needed for downloading, reading and displaying the map, that is higher in a PDA than in a PC.

IV. ARCHITECHTURE AND REQUIREMENTS

In the figure 2 it can be seen the global architecture of the system. We can distinguish 3 well differentiated parts: the client side in different platforms, the server side with 4 servers (HTTP, database, authorization and positioning improvement) that can be run in the same or different computers, and the transport network that combine Internet with different access methods and GSM / GPRS. Although in the figure GSM / GPRS appear as mobile telephones a better solution will be to have PCMCIA cards directly connected to the device.

A. Client requirements

The main objective of the project is to provide a tool that enables mobile users to use dynamic navigable cartography by staying permanently in contact with the system server which will provide the required information and user control. So the preferred client hardware platform are laptop PCs and PDAs. The advantage of laptops are its major performance and the drawback its bigger size. On the contrary, PDA are much smaller but have the problem of hardware limitations. Nowadays, the most advanced PDAs have CPUs at 206 MHz and RAM of 64 Mbytes with typical display resolution of 240 x 320 pixels. This will require to optimize applications in CPU and memory.

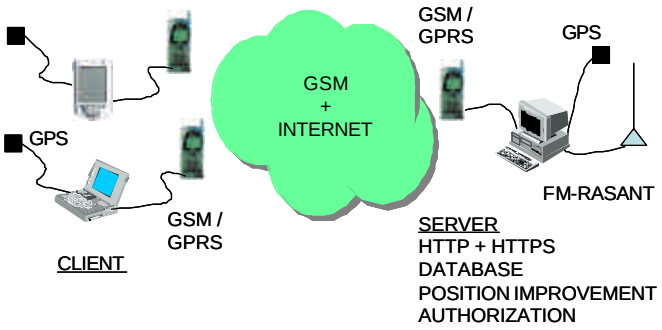

Figure 2. System Architecture.

The way to connect these devices to the network will be different depending on the wireless system coverage. Usually in indoors environment, the connection will be done through a wireless LAN, IEEE 802.11b standard at 11 Mbps. In outdoors environments, there will not be WLAN coverage and the connection will be through circuit switched cellular networks (GSM) or better, through packet switched cellular networks (GPRS). At present time, GSM is widely available in Europe and GPRS infrastructure is being developed very fast.

In the first prototype, GSM Wavecom modems connected to the serial port have been used to access the GSM network and to send SMS (Short Messages Service) messages. The GPRS connection has been tested using a GPRS mobile telephone.

The client platform will require also a GPS that can be connected through the serial port or implemented in a PC card.

B. Server requirements

The server has to implement several tasks and needs some hardware and software, these requirements are:

a) To build HTML pages for clients that access with a browser: This is done using an Apache server on a Linux platform, programming with PHP language and using HTTPS connection to increase system security.

b) To send GDF maps of specific areas to clients accessing with the proprietary application: Using PHP pages, the Apache server consults a database (in the prototype is an Oracle Server with the Spatial module), builds the required map and sends it to the client.
c) To protect the information: Before to send the map, the server will encrypt it with a preconfigured user key and using DES algorithm. In order to make the connection more efficient the file is also compressed with ZIP algorithm.
d) To authenticate the users: Previous to access any information, each request is validated with a login and password by the Apache Server. User passwords are maintained in a MySQL database.
e) To authorize user requests: When a client application wants to display a map, firstly it must ask for permission. In this case, it establishes a TCP/IP connexion with a specific authorization server that consults a MySQL database where information of available maps for a particular user is stored.
f) To improve user position using DGPS: In this service the server will receive requests of clients and with the information obtained with a RASANT receiver, connected to its serial port, it will build specific messages and send them back to the client so it can correct its position. Due to the fact that this service needs to send a very few amount of data (200 bytes approximately) it was implemented with SMS messages because it is cheaper for the client than having to establish a GSM data connection. Therefore, the server needs a GSM PC card or modem in order to receive and send this messages. Although this service is integrated in the presented application it can be used independently.

C. Network requirements

This application is using Internet as the main backbone and since it is focussed to mobile clients these should use wireless access methods. Therefore, primary restrictions will be in the access network. As it has been said before, four access standard mechanisms have been envisaged: IEEE 802.11b, GSM, GPRS and in a particular case SMS of GMS.

The application has to send different kind of data that have different network requirements:

a) When accessing to the server through a HTML browser the information with more volume will be maps coded as JPEG images. The range of data volume will vary between 50 Kbytes to 200 Kbytes. In this case GSM has very few bandwidth and it is more convenient to use WLAN or GPRS.
b) When downloading maps for the proprietary application: If the user has not the map to display it has to be downloaded from the server. GDF maps can have very different sizes, from less of 100 Kbytes to several Mbytes. Network requirements will be similar to the previous case, but having into account that the server should not send maps above 300 Kbytes.
c) When asking for authorisation the amount of information to be transferred is about 1 Kbyte, therefore bandwidth is not critical and it doesn't represent any problem the use of GSM.

d) When requesting improvement of position: This operation only requires to send 2 packets: one for the request and one for the response, and both have less than 200 bytes. In this case the transport was implemented using SMS.

V. MEASUREMENTS

One of the most critical factors for the application success is the response time to information access. In order to evaluate this parameter some tests have been done. Table 1 presents the obtained access times in seconds. Client devices are an iPAQ 3660 by Compaq and a PC laptop Pentium III at 500 MHz with 320 Mbytes of RAM. The downloaded encrypted map has a size of 172 Kbytes without compression and 53.9 Kbytes compressed (the map is always sent compressed).

Situation	WLAN	GPRS	GSM
The PDA client asks for authorisation	2	23	24
The PDA client downloads the map	9	81	94
The laptop client asks for authorisation	1	9	11
The laptop client downloads the map	8	35	40

Table 1. Measured access times.

All measured times include server response times. The server response time for authorisation is practically null (about 200 ms) when compared with transmission times. Instead, the time to build the map is bigger, and in the measured situation is of 7.5 s. We also have to bear in mind that this time is very variable and depends on the computer that hosts the server database and the size of this database.

Another point to remark is the connection time. In a GSM access, the time that the mobile terminal needs to connect with its Internet Service Provider is approximately 26 s, and it has to connect and disconnect every time that the user needs some additional map not stored in its hard disc. Instead, with a GPRS access, the connection time is about 7 s, and what is more important, the user doesn't need to connect and disconnect continuously because it is possible to use the "always connected" GPRS option.

These response times are critical from the point of view of the user, but depending on his requirements can be more or less tolerant. However, in the improving position service the response time is much more decisive because the GPS receiver will usually not accept data older than 20 s, although it is not critical until a delay of 30 s [3].

In this service, the server answer is transported through GSM's short messages. But in order to get the fastest response, all needed data is included in a single message: The client sends a correction request for those satellites that it really needs. The server, then, looks the RTCM flow provided by the RASANT system, and extracts the required information. It codifies this data and sends to the client in a single message. The client extracts the received information and it builds several RTCM frames that are

introduced to the GPS receiver, who displays the corrected position. Several measurements of service response time have been done, and more than 95% of answers where younger than 20 s.

VI. CONCLUSIONS

Nowadays, there is an increasing interest on localization services using the GPS system. Some manufacturers as Magellan, Garmin or Trimble have proposals of equipment that have cartography already loaded in their devices, but for global services this solution seems inefficient. On the other hand, mobile telephony manufacturers as Ericsson, Trium, Nokia, Benefon or Motorola are shipping terminals with advanced graphical capacities. Finally, PDAs manufacturers as Compaq, Casio + Siemens, Palm or Psion are investigating the possibility of incorporating cellular communications (GSM / GPRS) and GPS to their terminals. In this context, there is a lack of commercial applications or solutions that make use of the global facilities provided by the mobile communications and localization systems.

This paper presents a system that provides services of localization and navigation over vectorial cartography on mobile devices with wireless capabilities (WLAN, GSM, GPRS, SMS), for use in multiples fields from chronic patient control to vehicle fleet management or tourist information . Mobile communications are required because clients devices need to interact with a centralized server which tasks are to authorize clients the access to restricted information and to download the required maps. Authorizing information needs to transfer very few, but critical information and therefore a data circuit switched GSM connection or GPRS would be sufficient. When having to download a new map to the client, the volume of information will be about some hundreds of KBytes, consequently a GPRS or WLAN will be required.

VII. ACKNOWLEDGEMENTS

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