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LOCATION-BASED SERVICE PLATFORM ARCHITECTURE FOR WIRELESS MOBILE USERS IN
CONVERGENT NETWORKS

THESIS

PRESENTED AS A PARTIAL FULLFILLMENT TO OBTAIN
THE ACADEMIC DEGREE OF

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BY:

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Management

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Dedication

To my parents, Miriam and Ezra,
To my sisters, Ada and Hanna,
To my grannies, Ruth and Graciela,
And the rest of my family,
Whose unconditional support, love and guidance
Has always been there
To not let me give in or give up and always to step forward

We made it!

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To my parents, Miriam and Ezra, for their love, support, guidance and courage,

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Jaciel, Lulu, Emiliano, Franz, Carlos, Brian, Izchel, Jessica and Gaby,

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Yetna, Dulce, Inti, Rafa, Ruben, Viss, Blanca, Luis, Joaquin, Mayra, Rocio, Carolina, Juanma, and all my friends I met when I came to this city, in the CET and ITESM,

Thank you very much!!!

Todah Rabah la Jem!!!

Abstract

Current communications are not only by voice but also carriers are capable to use their networks to transmit data and video, resources that customers are using more and integrating phenomenally fast to their daily lives. Wireless companies have a trouble in their hands, competition and technologies are cheaper than what they were in the 90's, so, increasing fees are not on the table for discussion. Then, they have to offer other services without impacting their customers, attracting them and add value to their networks.

Current cellular customers demand new features delivered by their cellular companies. Different services have been deployed over the years to satisfy customer's needs, such as SMS, mobile Internet, mobile TV, etc. Other kinds of services that have appeared on the market are those named as LBS (Location-Based Services). LBS are beginning to show that they may increase the value perceived by customers when they choose a company. Moreover, they are deployed to satisfy existent requirements and capable to be personalized according to user preferences through applications contained in mobile devices. These services are based on positioning information gathered by mobile networks and delivered to service providers, the owners of technological platforms in charge to process data and requests and deliver value-added information in return.

The increasing LBS market has been aided by the use of the Internet Protocol (IP) and the development of application protocols such as SMPP, SUPL and MLP. These protocols are beginning to be used not only inside the carriers' core networks but also on users' mobile terminals, increasing not only market penetration but also the development of different content. Furthermore, we can mention that IP is merely an ally and not the final solution for the LBS platform in our case.

Mobile providers in some cases prefer to become merely carriers and establish agreements with service providers instead of deploying these services in home and invest capital that they are not willing to spend either. Nevertheless, carriers have the advantage to be able to add to their network a wide variety of services because they can get agreements with many services providers. This is also possible thanks to the compatibility of certain technologies and protocols existing in the market.

This work shows a platform developed to attend different requests from different networks, accepting interfaces as SMS, WAP and HTTP. The general concept proposed considers storing information and flow control over the service provisioning, different characteristics to others proposed by other authors. This work's main characteristics are inner flow control and profiling done by an entity named Central Control Unit (CCU) helping storing useful data considered for further service provisioning managed and controlled by a server named MCS (Management and Control Server). The MCS is also defined for gathering information gotten from the carriers' databases. This information is accessed by the SEE (Service Execution Environment) using clients defined to request the necessary information managed by the MCS and be used by the SEE to deliver value-added information results to mobile users.

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Chapter 1: Introduction

Preface

The present chapter describes the methodology used for the compilation of this thesis. It pretends to give an initial overview of the work and tries to prepare the readers to know what the work is about.

1.1 Background

Cellular networks are widespread around the world, these networks have attracted a huge quantity of users in the last 20 years and in some cases, they can sum three times the quantity of traditional telephony. Not only its growth has been dramatically fast, but also the development of new capabilities, faster networks, better quality and added services are present in the cell phone companies.

Cell phones in current times are not only devices to communicate using voice, we can now send and receive data, images and navigate in the internet and have access to diverse services thanks to the advances and development in this field of communications. Cellular network carriers has also begun to realized that in order to make a difference with competitors and attract more customer, they have seen the need to develop more services to satisfy niches present in the market.

These niches can be satisfied deploying technological platform to offer LBS or location-based services which are classified as VAS (value-added services) for the mobile carriers, useful to increase revenues and getting advantages in relation to the competition.

1.2 Objective

The objective of the present work is to determine the technological elements required to the implementation of a LBS (Location-Based Service) platform in convergent networks or 4th Generation Network totally based on the Internet Protocol. We also consider a definition of the possible interaction (technologically and businesslike speaking) that the mobile carriers and the service platform provider must have. The elements are considered separated entities that interact and establish a relationship where the platform provider possesses the infrastructure and the elements to deliver LBS services. On the other hand, the mobile carrier has those elements to reach mobile users and calculate their position and location. The communication between both entities is possible using internet connections between the carrier network elements and the platform elements, obeying the trend of convergence present in the market.

1.3 Justification

Tipper (2006) explains that wireless communications and wireless systems have experienced phenomenal growth over the past decade and have become part of the infrastructure. The use of wireless devices such as cell phones, PDAs, and laptops (in general mobile stations – MSs) has become the enabler of viable location based services and applications that need position location information.

There are several techniques (Tipper, 2006) such as Cell ID, observed time difference of arrival, advanced forward link trilateration, etc. that are used to determine the position of the MS in cellular networks. In cellular wireless systems, the normal infrastructure for transporting voice and data traffic is leveraged in a location service (LCS) architecture for transporting the location sensing information and query management for location-based services.

Current cell networks have diverse capabilities delivered to mobile users through cell phones. Ordinarily, cell phones were created to offer voice services but after some years on the mobile market, cell network providers have incorporated other services. The first service aggregated to the system was SMS (Short Message Service), a service to send and receive short messages. More recently, data delivery and sending accessing using an especial browser, known as WAP (Wireless Access Protocol) browser incorporated to devices, have converted cell phones in a complete tool to offer value-added services, such as LBS.

Cellular technologies are seen today as a way to communicate many people fast and easy. However, today's trends point that users and wireless network providers have changed. Now, users demand more services besides the voice. This was first seen when the SMS were deployed and today's messaging is widely used among persons. The cellular network infrastructure has changed a lot since the first phones appeared which used analogical systems to communicate to those we use today that has become digital.

Digitalization and improvement in technologies have permitted the development of more services. When the internet appeared for the first time, many people never thought even once that the internet would be a useful tool in communications. Today's core devices in cellular networks use a lot the internet to communicate with external entities, such as servers where applications reside.

These applications have been developed to be compatible and capable to offer the services using technologies that in some cases were especially developed to function in cell networks. Remote servers that communicate to elements in the carriers' core networks and obviously with the mobile users have allowed the appearance of LBS (Location-Based Services).

LBS are based on LCS (Location Services) which most of the time are delivered by the mobile carriers who are the owners of this information and consist to know in what part of the coverage area the users are and in some cases when required, to calculate the accurate position using coordinates. These LCS are possible thanks to location schemas and positioning technologies done by mobile devices or in the carriers' networks. These technologies will be explained in detail in Chapter 3: and Chapter 2:.

Services based on location have awaken certain interest and have been already seen as an excellent way to deliver value-added services (VAS) to mobile users through wireless network

providers, in our case, cell phone companies. These kinds of services are of particular interest because they can satisfy necessities of every user. The VAS are important to mobile carriers because is a way to increase their revenues in times where voice services have been dropping in cost in the market.

Some of the most important fields of development are those belonging to the security and safety family (see section 2.5). This is clearly seen on the United States, where the FCC (Federal Communications Commission), has increased the exigencies in accuracy in locating users even when just dialing 911, the national emergency attendance number. This project was named E-911, and its main purpose is to increased levels of security and to reduce time of response in contingencies that citizens report to the 911 without even asking where they are calling from.

Another criterion is taken in consideration in the European Union, where homologation for the 112 in every member state of the union is searched with the same exigencies and requirements, especially on wireless providers. In this case the service is known as E-112, and it tries to be the equivalent in functioning to the E-911.

We can underline that not only E-911 or E-112 are present on mobile markets, we can find diverse services such as monitoring of moving personnel in emergencies, finding help security personnel like firemen and police men, finding missing people, intruder detection an even alert on fire or terrorist attacks. Further information is described on section 2.5.

Currently, when we want to measure the magnitude of what cellular networks mean, we only have to see the trend of growth in the mobile market that indicates an important niche to satisfy. In 2006, The GSM (Global System for Mobile Communications) Forum estimated that in the world there were almost 2.5 billion users of cell technologies, and GSM represented the 74% of the market that year, reaching the 1.8 billion users.

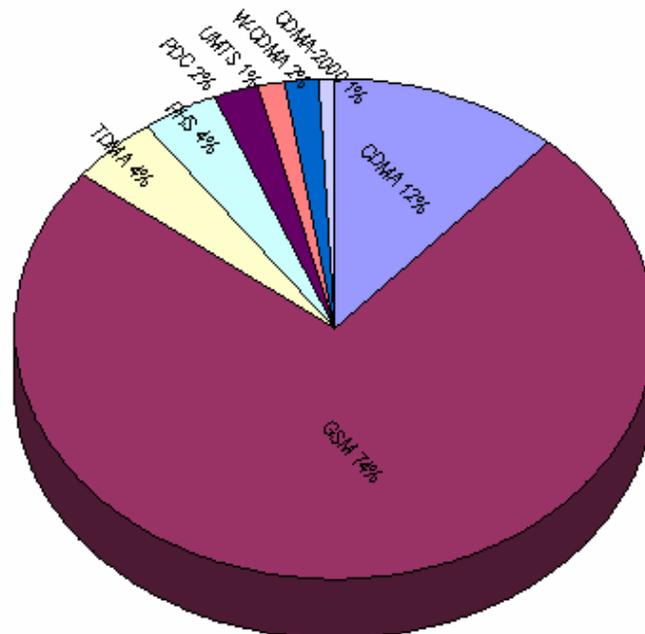


Figure 1: User penetration of cellular technologies (3G Americas, 2006)

A similar trend has been presenting in Mexico with the fast growth and acceptance of the population, aided by reduces in costs of equipments with more capabilities inherent in the devices. In Mexico, there were almost 50 million users (2006), the 50% of the total population, whose GSM users are almost 57% of the domestic market. This is shown in the next figure.

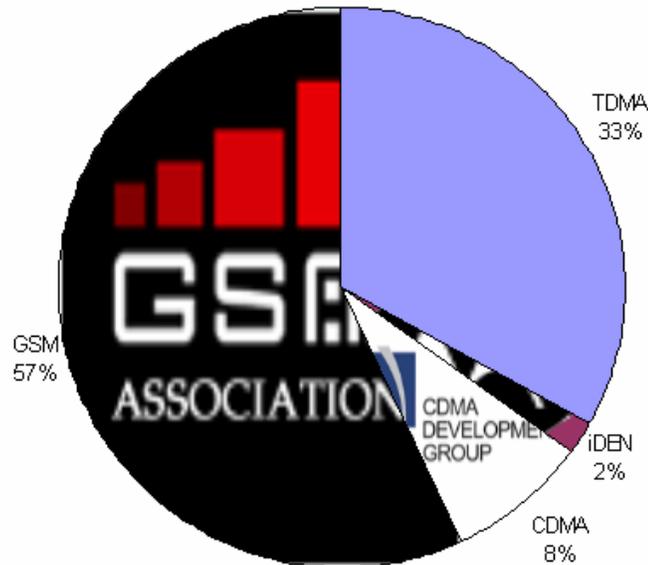


Figure 2: Percentage of usage of technologies in the market (2006)

The last figures, justify the study of GSM networks, which are, as we can see, the more spreaded as much in the domestic market as the international market. After getting the technology chosen, LBS criteria must be analyzed to determine what kind of services are demanding.

GSM networks have been constantly evolving since their origins and they are widely used around the world. This is why the focus of this work is based on GSM, taking in consideration that GSM and its evolution technologies such as UMTS are used in Latin America and Europe and statistically, the numbers of users are high.

Furthermore, some companies with tradition of using other cellular technologies such as CDMA are taking in consideration to use the LTE, the evolution of UMTS for 4th Generation Networks. One example of this is Verizon in the United States (Verizon, 2007) which has chosen this technology to step forward into the convergent trend present in the market, even though it is a long traditional CDMA based company.

This 4th Generation Networks are convergent and mostly based on the Internet Protocol and according to what we mentioned above, in current times, the existence of platforms to offer and deliver added services to customers are imperative. LBS usage is spreading fast and the development of platforms is an issue to take in consideration because of its potential to attract new customers and satisfy those requirements to current ones.

LBS platforms must be capable to process geographic information and users' data and deliver what customer requires. All this can be achieved using a platform well deployed and designed. The present work pretends to give an overview of the technological elements necessary for a platform that can offer services remotely following a trend of convergence, based on the functioning

using internet connections to establish the communications links between users and platform, using the infrastructure of the carriers' networks.

1.4 Structure of the work

In this work it is pretended to present a definition of the elements required for a LBS platform that works on GSM networks but with capabilities to be used in the future for 4th Generation Networks. In Chapter 2:, LBS are described, their requirements, capabilities and diverse location and positioning methods that can be used in specific devices inside the GSM networks. An overview of Cellular systems is described in Chapter 3:, as we mentioned, based on technologies GSM. Chapter 4: shows the trend and the technological advances that can be used in the future for the platform. Chapter 5: describes the elements of the platform that can be deployed to offer a service attending requests from different users, no matter what access technology they use. Finally, Chapter 6: presents conclusions and future works.

Chapter 2: Location-Based Services

Preface

LBSs are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device (Virranti, 2001). Angelides (2000) refers to LBS as an advantage when most individuals can think of several ways in which wireless location could benefit them personally or professionally. Whether it involves location of loved ones, receiving a personalized traffic report, or receiving information on the nearest restaurant or theater, it is easy for consumers to see how these applications can provide them with greater levels of convenience and productivity.

The top three priorities (Angelides, 2000) identified by survey respondents were location-based services for: emergency assistance, navigation, and concierge services, outweighing the incumbent value-added service leaders such as voice mail and caller ID. Supporting to this priorities, in the last decade, health assistance have become a very important issue to attend, especially because user's life can be in danger.

Applications such as child tracking, stolen vehicle recovery, and personal emergency alerts are high-value location-sensitive services, but are challenging for security organizations to deploy and maintain. If available, they typically rely on specialized location technologies that are cost prohibitive, and limit subscription to customers with a high disposable income. The introduction of high-accuracy location technology into the market is expected to provide security organizations with the increased performance and reduced cost necessary to enable such services and expand their business and customer base dramatically (Angelides, 2000).

2.1 Classification of LBS

Betayneh (2006) comments that LBSs can be classified as Reactive LBSs and Proactive LBSs, however, other authors classifies LBS as Push LBS (equivalent to reactive LBS, activated by users) and Pull (equivalent to proactive LBS, activated by service providers), which it is more common classification to find.

- **Reactive LBS (PUSH):** Reactive LBSs are always explicitly activated by the user. The interaction between LBS and users is roughly as follows: the user first invokes the service and establishes a service session, either via a mobile device or a desktop PC. The user then requests for certain functions or information whereupon the service gathers location data (either of the user or of another target person), processes it, and returns the location-dependent result to the user. This request/response cycle may be repeated several times

before the session is finally terminated. Thus, reactive LBS are characterized by a synchronous interaction pattern between user and service.

- **Proactive LBS (PULL):** Proactive LBSs are automatically initialized as soon as a predefined location event occurs, for example, if a user enters, approaches, or leaves a certain point of interest or if he/she approaches, meets, or leaves another target. Thus, proactive services are not explicitly requested by the user, but the interaction between them happens asynchronously. In contrast to reactive LBSs where the user is only located once, proactive LBSs require to permanently track a user in order to detect location events.

As we see on Table 1, LBS are divided in families of services that can be sub classified as push or pull kind. These services listed on Table 1 are seen from different points of view, it means that the push services are seen on the view that users activate before obtaining information, and pull services delivers information without any direct interaction from users but accepting them or rejecting them. Besides, the services are listed from order of appearance and development in the market according to some author from different sources.

Table 1: Push and Pull Services

Family Service	Pull Service Example	Push Service Example
Call Routing	Incoming call notification	Dialing a friend
Information and Entertainment	Notification of offers and discounts in the mall	Finding the closest Chinese restaurant
Tracking and Tracing	Notification when a company car is moving outside the location area	Finding a company car close to your location
Safety and Security	Notification of fire or evacuation	Requesting to find the closest police station

2.2 Processes involved in LBS

LBS involve some processes inside the networks of the wireless providers. The first processes are position and location determination, in which the network provider calculates the coordinates where every user is. A second process related to location is mobility management, which involves the updating of databases inside the provider's networks, to know in what part of the network the users are connected to.

2.2.1 Position and location determination

Location and position are terms used indistinctively, however, for not causing more confusion in this work; it can be made a small difference among these two concepts. Location can be assumed as the knowledge of what base station the mobile users are connected to inside the network. On the other hand position can be the determination of the coordinates in a plane to find users in a more accurate way. Location is recorded in the HLR (Home Location Register) and VLR (Visitor Location

Register) databases and the position can be recorded in databases of the GMLC (Gateway Mobile Location Center).

However, in order to be able to determine position, LBS Clients or LBS Applications need to request to the network (especially the GMLC) where a certain user is. After that, the GMLC demands the location and just after the network knows the location of users, it sends a request to the serving SMLC to calculate the position. Right after it sends this request forward to a serving LMU according to the user's location; very useful to avoid repeating search procedures in every cell in the network and making the process faster. This process inside networks is known as "LM schemes", which depend absolutely on the policies of the network providers decide to deploy in its network

Betayneh (2006) says that LM schemes are essentially based on users' mobility and incoming call rate characteristics. The main task of LM is to keep track of a users' location all the time while operating and on the move so that incoming messages, calls or other requests can be routed to the intended recipient. LM consists mainly of:

- Location Tracking and Updating (Registration): A process in which an end-point initiates a change in the Location Database according to its new location. This procedure allows the main system to keep track of a user's location so that for example an incoming call could be forwarded to the intended mobile user when a call exists or maybe bring a user's profile near to its current location so that it could provide a user with his/her subscribed services. This is much related to mobility management in section 2.2.2. This is divided in two different techniques:
 - Static Update Strategies – Beytaneh (2005) explains that there are specific areas in which an update could take place. Two different approaches can be inferred:
 - Location Areas (LAs): Also referred to as Paging Areas or Registration Areas. In this scheme, service areas are created with each area considered a LA. Only when a mobile host moves from one LA to another that an update to its location in the Location Database is taken place.
 - Reporting Cells: Also referred to as Reporting Centers. In this scheme, updates take place at specific centers (cells) in the network. Only when a mobile host gets re-located to one of these centers that an update takes place.
 - Dynamic Update Strategies – according to Beytaneh (2005) says that these schemes take place when mobile host determines when an update should take place based on its movement, frequency of incoming messages, signal strength and other factors. These can be:
 - Depending on the incoming call arrival rate and mobility, the size of a mobile hosts LA is determined. Analytical results for this approach have shown that this strategy is an improvement over Static Update Strategies when call arrival rates are user-dependent or time-dependent.
 - An asymmetric distance-based cell boundary system with cell search order optimization that uses a combination of information of the most recent update that took place along with the direction of motion.

- Time-based location updates that take place every T seconds.
 - Movement-based location updates that take place after every M cell crossings.
 - Distance-based location updates that take place whenever the distance covered exceeds D . This kind of strategy is the toughest to implement since it requires information about the topology of the wireless network.
- Location Finding (Paging): The process of which the network initiates a query for an endpoint's location. This process is implemented by the system sending beacons to all cells so that one of the cells could locate the user. This might also result in an update to the location register. There are several paging methods (Beytaneh, 2005):
- A method for balancing both Location Updating and Paging. Probability distribution techniques along with the lower bounds on the average cost of paging and Poisson incoming-call arrival model are used to formulate the paging and registration optimization problem in terms of timeout parameters.
 - Minimizing the amount of bandwidth expanded in locating a mobile host by using probability distribution on user location.
 - A mobile user mechanism that incorporates a distance-based location updates scheme and a paging mechanism that satisfies predefined delay requirements.
 - A mobility tracking mechanism that combines a movement-based location update policy with a Selective Paging scheme. The Selective Paging scheme decreases the location tracking cost under a small increase in the allowable paging delay.
 - The application of multiple steps paging strategy.
 - Locating mobile users by using paging costs and delay bounds. Paging costs are associated with bandwidth utilization while delay bounds influences call setup time. Reverse, semi-reverse, and uniform paging schemes provide a simple way for portioning the service area and decrease the paging costs based on each mobile user's location probability distribution.
 - Reverse Paging is a scheme designed for a situation where the called mobile host is most likely a few PAs away.
 - Semi-reverse Paging is a scheme where a set of PAs is created in a non-increasing order of location probabilities.
 - Uniform Paging is a scheme in which a LA is partitioned into a series of PAs with each PA consisting of approximately equal number of mobile cells.
 - Intelligent Paging is a scheme that it is mathematically proven that the movement of mobile hosts is modeled according to a probability process called the Ergodic Stochastic Process.

Also, Beytaneh (2006) explains that for LM purposes, a wireless network usually consists of Location Areas (LAs) and Paging Areas (PAs). While LAs are a set of areas over which location updates take place, PAs are a set of areas over which paging updates take place. Usually, LAs and

PAs are contiguous, but that's not the case always. In addition, a LA usually contains several PAs. Location and paging design integrate the Location Management of the Network.

2.2.2 Mobility

Even though, networks are capable to keep trace on user through their infrastructure, in most cases, most of the location requests are begun to attend to a demand initiated by users or by LBS clients to satisfy a service and an updated location estimated is required all the time, especially on this platform.

However, every process is initiated in some time, especially when devices are turned on. This process is very simple, because the mobile device sends registration information to the VLR and HLR which are databases inside the network that will be utilize to find user in the correct coverage area and demand the correct information to the serving devices present in the area where the device is located. The initiating process is shown on Figure 3:

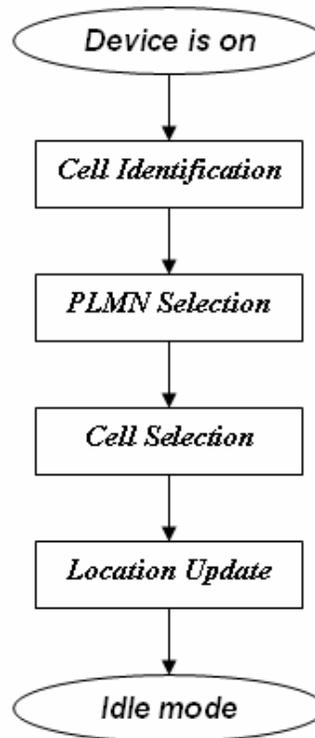


Figure 3: Initiating location process (Arora, 2008)

After the cell is turned on, an initiating process begins. The first step is to do what is called cell identification. In this process, the cell phone measure the strongest BCCH channels, it means, the downlink channels which contain specific parameters needed by a mobile so it can identify what network to connect to be able to access to the services available on it.

This information is recorded in internal registers of the mobile and this is: LAC (Location Area Code, which identifies a determinate coverage area), RAC (Routing Area Code, shows how to reach

the mobile in a specific area inside the location area), the LAC and the RAC form the RAI (Routing Area Identity) which serve as a paging resource to locate users, and finally the MNC or "Mobile Location Code" which is used for the second process to identify a wireless provider. The MNC is an international agreement developed to keep control among cellular networks providers, no matter what technology they use.

Secondly, PLMN (Public Land Mobile Network) selection, it means to choose a network provider. This is possible only by the coverage services areas reached by services providers, and cell phones are limited to those zones where cell companies have installed infrastructures of their own, so users can or cannot have access to communications service, an issue that can be solved if the users' service provider has agreements with other PLMN to offer what is called roaming, which is a tracing capability to keep offering the service to those that moves even out of the area or country where service provider has their cell network.

Third, when recognizing the PLMN, the cell phone chooses a cell in the network which can offer it the best quality in signal strength and guarantee the provisioning of the service. Distance determines signal strength, and those are some of the most important parameters taken in consideration to decide what cell to connect to and make the proper registration.

After deciding all this, an information exchange is made. Cell phone literally informs the serving VLR that he is in its coverage area. Then, the VLR records its identity and presence, and right away informs the HLR, a master database that contains all the information of every subscriber of the PLMN, to help in locations requests demand that can be asked by other devices such as GMLC, LBS client or some others, in order to have more efficiency and velocity to the position calculation process and demand this kind of information to the correct cell instead of asking every cell present in the network.

These processes described above guarantees mobility and the whole process made continuously is known as mobility management which lies on the databases, the VLR and the HLR mostly.

2.3 Applications of LBS

Betayneh (2006) mentions that LBS have three typical uses: military and government industries, emergency services, and the commercial sector. The military and government industry services include all the applications used by soldiers which in most cases were developed by the US army. One example is the GPS satellites that permit to find users with an accuracy of three meters and more recently, part of the systems has been released to offer it to civilians.

The LBS in general terms can be developed to satisfy specific services that respond to a criterion of interest. These criteria are associated of certain actions such as orientation and localization, navigation, search, identification and event check, as example. When LBS are developed, designers must focus on what the users may demand, it means, what problems a customer would like to get answered when they face a location or position problem.

Chapter 2: Location-Based Services

We have to emphasize that LBS are very useful not only in anyone's hometown, they are really important when someone needs information of unknown places or simply to help moving faster when traffic conditions in the city requires extra help for not getting stocked in traffic.

According to the action, they require some specific operations and every action is different to the other, because the cause of the problem is not the same. Some of these actions only require a few operations to be completed, like the event check, as accessing to an information database may be enough to satisfy what the client requested. However, some other, require more resources, even on the mobile to deliver the necessary information for the case. An example of this may be the navigation, when real-time information and interactive applications on mobile are demanded for service provisioning. Table 2 shows different cases that might be present.

Table 2: LBS actions and operations (Steiniger, 2006)

	Actions	Example	Operations
	Orientation and localization	Where am I? Where is my friend?	Positioning, geocoding and geodecoding
	Navigation	How do I get to city downtown?	Positioning, geocoding, geodecoding, and routing
	Search	Where is the closest restaurant?	Positioning, geocoding, and calculating distance and area.
	Identification	What is this place?	Positioning, directory, selection search.
	Event check	Where is the city parade?	Event directory

Emergency services are especially deployed in Europe, Asia and United States where users dials 911 only, and automatically the systems requests its position to network provider to respond fast to emergency calls (Betayneh, 2006).

This can be seen as a value-added service to users and they are the most demanding accuracy requestors, just the same to the military services. Finally, commercial services are used by marketers to offer, sell and promote services, assets, whose accuracy it's not very important.

The applications of LBS have to be integrated in technological platform with the interaction between elements proper to the platform and with some others from the carrier networks. Table 3 shows different examples and the accuracy requirements recommended for service provisioning. These services are categorized in different families of services with similar applications.

As we can see in Table 3, every family of services has a requirement of accuracy. Those that focus on finding, tracking and tracing routes demand special levels of accuracy because they are used for safety and security situations or simply because the assets that use them are of important value for the owners.

In any case, this is something that the LBS providers have to deal with, especially when they don't own the technologies for finding, locating and calculating the position of users. They have to be conscious on what kind of service want to deploy and who to do agreements with. Capabilities of service provisioning depend on high measure of the networks' resources that carriers own and how willing they are to improve them gradually.

Table 3: Examples of LBS applications

Service Family	Application	Accuracy
Information and Entertainment	Traffic Information	Medium
	Driving Conditions	Medium
	Traffic Information	High
	Road Maps	High
	Gaming and Gambling	Low
	Closest POI	Medium
	Time Zone Determination	Low
	Advertisement	Low
	Information Broadcasting and News	Medium
Tracking and Tracing	Allocation Management	High
	Personnel Location	High
	Inventory Tracking	High
	Car Fee Payment and Control	High
	Insurance Assistance	Medium
	Fleet Management	Medium
	Restricted Area Determination	Low
Call Routing	Tracing Calls	High
	Mobile Communication Stablishment	Low
	Call Fee Charging	Low
	Service Provider Selection	Low
Safety and Security	Personnel Monitoring	High
	Emergency Movement Monitoring	High
	Intruder Detection	High
	Emergency Service	High

2.4 Technological components of the Location-Based Services

According to Steiniger (2006), LBS architecture has the following components in order to offer these services (see Figure 4):

- **Mobile Devices:** A tool for the user to request the needed information. The results can be given by speech, using pictures, text and so on. Possible devices are PDA's, Mobile Phones, Laptops, but the device can also be a navigation unit of car or a toll box for road pricing in a truck.
- **Communication Network:** The second component is the mobile network which transfers the user data and service request from the mobile terminal to the service provider and then the requested information back to the user.
- **Positioning Component:** For the processing of a service usually the user position has to be determined. The user position can be obtained either by using the mobile communication network or by using the Global Positioning System (GPS). Further possibilities to determine the position are WLAN stations, active badges or radio beacons. The latter positioning methods can especially be used for indoor navigation like in a museum. If the position is not determined automatically it can be also specified manually by the user.
- **Service and Application Provider:** The service provider offers a number of different services to the user and is responsible for the service request processing. Such services offer the calculation of the position, finding a route, searching yellow pages with respect to position or searching specific information on objects of user interest (e.g. a bird in wild life park) and so forth.
- **Data and Content Provider:** Service providers will usually not store and maintain all the information which can be requested by users. Therefore geographic base data and location information data will be usually requested from the maintaining authority or business and industry partners (e.g. yellow pages, traffic companies)

The elements mentioned in Figure 4 can be the base for functioning procedures of the platform illustrated on Figure 39. The components mentioned before can be considered the columns where the platform is supported and absolutely necessary for the development of a platform, but, in most cases not necessarily interrelated directly by the same owner.

The relationship mentioned before involves that in all cases, referring to network providers, these are independent from the application or LBS platform provider most of the time, they only share information when required and they own all data about user's location and obviously, all the devices to get it. Further information will be explained in the following chapters.

On the other hand we have two more elements known as application provider and content provider. The first is responsible for application development, maintenance and establishing agreements with wireless providers, they have a one-on-one relationship. The second, the content provider, owns every data of places, information and data that helps to increase the value of the services. They can be one or only exchange data and keep certain independence to each other. This can be seen as a business model (see Annex B)

In general terms, the platform as a complete entity in our case, will manage two different databases. One of these databases is absolutely for information related to users, such as name, preferences, services requested, position, and other information exclusively from users and billing purposes. On the other side, the content server manages geographic-related information such as places of interest, reference points, restaurants and other information of this kind. So, even though both servers can be integrated in similar ways, information contained in them is different by source.

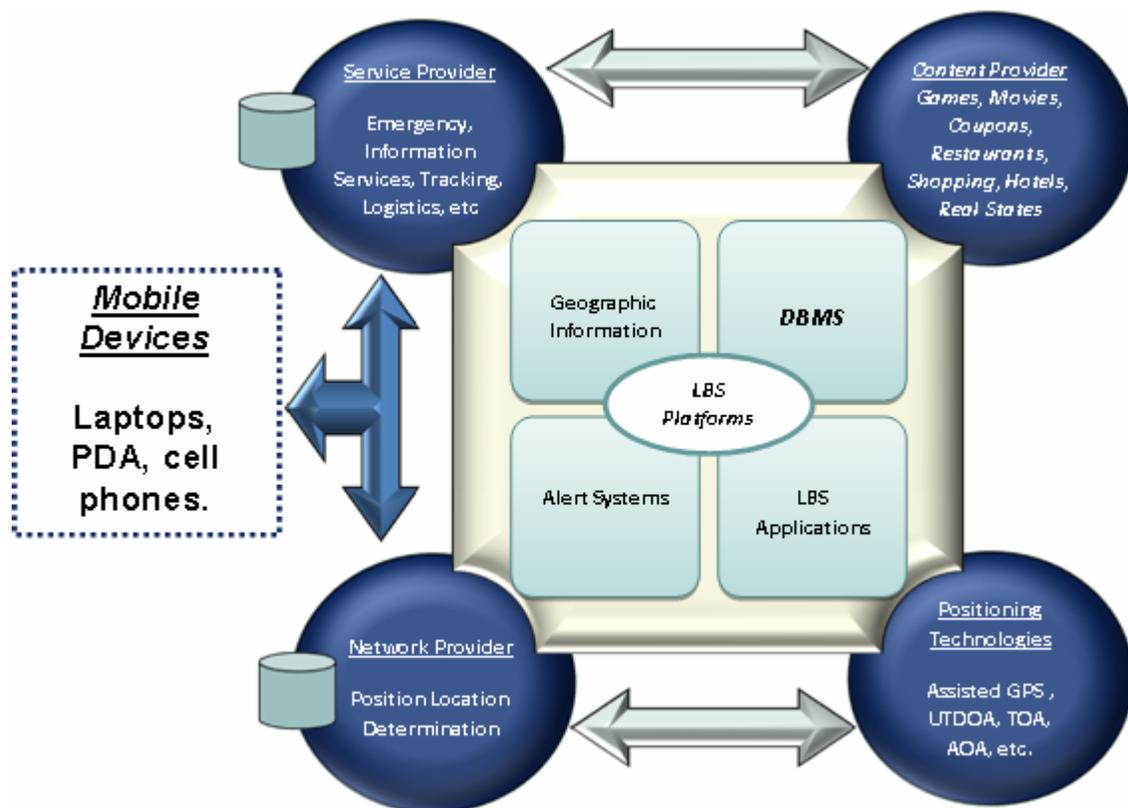


Figure 4: Components of an LBS Platform

In this field, the platform needs a total cooperation with network providers who own not only the access media to used, but also, location devices and transport devices for information. Cellular network in current days have been developed to offer three different services: voice, data and video, however, voice and data, especially data transfers are being considered.

The three different devices used to reach user are those involved to location determination (SMLC and GMLC where location request are delivered and calculation are done), data transfers (GGSN and SGSN, including WAP gateway to send information and websites to the browsers in mobile devices), messaging (SMSC, a gateway to send, store and forward messages from and to users) and obviously, every core device used to interconnect them with the base station where mobile device connect to the network. More about this can be consulted on Chapter 3:.

2.4.1 General requirements

There are different things that have to be reviewed before designing a LBS platform, and these are LBS requirements. LBS must be seen in several points of view which, according to Tsalgatiidou (2006), are: users, usability, reliability, privacy, location infrastructure, and service interoperability. The next paragraphs list what Tsalgatiidou (2006) considers important to take in consideration. Practically, all of these, except the users, connect the service providers with the network provider, so, a business model is proposed along to the platform design.

Among the functional requirements related to users we can find: browsing of spatial information (e.g. city maps); navigation (e.g. acquiring directions and guidance to POI); access to catalogue data (e.g. restaurants and their menus, etc); location-based access (e.g. accessing information according to his or her location); personalized access (e.g. profile mechanisms in likes, concurrent places, etc); fast, easy and friendly access to the service; geographical view as maps and information like textual descriptions; graphical representation or routes and guidance instruction, etc.

About usability, have to be considered, on one side, properties of mobile networks such as: bandwidth variability, latency, unpredictable disconnections and communication autonomy; and in other side the properties of mobile terminals such as: small and low-resolution displays, limited input capabilities, limited computing power, limited power and small memory size. And, adding to the last ones, we need to consider a not very intensive use of mobile network and minimal volume of transmitted data, possibility to offline operation, and user interface should be very simple and user friendly and the amount of presented information content limited and well specified.

Meanwhile reliability, considers expectation of users when, for example, requiring information when traveling, ask for information of where to go and wrong information is not allowed for wrong decisions. These concerns involve: data reliability (correct and valid data); software reliability; appropriateness and precision of exploited algorithms and methods, etc.

In privacy we can find the terms of privacy handling consolidate issues like ownership of location information, use of location information, disclosure to service providers, etc. In present work we consider a scenario where the network provider and its core elements (HLR, VLR, etc) have control on location information. This is explained in the business model.

The location infrastructure is owned by the network provider. This can mean that those procedures related to the functioning of this equipment involve not only determining the position of the customer but also providing service or contents based on the position.

The following requirements are also relevant: accuracy by the location method requested by the application; wide area of location, even in every coverage area of the network; fast in location procedures, especially considering that the platform proposed in this work is related to emergencies and health attendance; possibilities to locate all mobile devices irrespective of their type and whether they are roaming or not and even locate in groups at the same time; and consumer privacy.

In last place, interoperability includes allowance of using several types of terminals and positioning infrastructures; and being able to utilize geographic data available in existing GIS databases, mostly.

2.4.2 Positioning Technologies

LBS depend on some location methods implemented in wireless devices or directly on the network without any dependence on them that's why they can be classified as: network-based method; mobile-based method; and/or mobile-assisted method.

2.4.2.1 Network-based technologies

Network-based technologies are widely used in the wireless market because they are very scalable and their implementation is cheaper than other location technologies such as mobile-based or mobile-assisted methods. Mobile-assisted methods require several devices very expensive in the cells or in subscribers' mobiles. Network-based technologies reduce costs helping providers to offer several LBSs, and subscribers to consume those services at a better cost.

In network-based implementation one or several base stations (BSs) make the necessary measurements and send the results to a location centre (SMLC) where the position is calculated. Network-based implementation does not require any changes to existing handsets, which is a significant advantage compared to mobile-based or mobile-assisted solutions. However, the MS must be in active mode to enable location measurements and thus positioning in idle mode is impossible.

Many existing location-based applications rely on global positioning devices or specialized RF transmitters for location. These technologies are both expensive and somewhat limited in their ability to provide reliable location information. With network-based location technologies, the same technology used to calculate the location of a wireless phone can be used to calculate the whereabouts of a location device. The devices, which are essentially stripped down phones, can be extremely compact and cost effective, and allow application providers to enable widespread applications at a much more attractive price point. (Angelides, 2000)

Steiniger (2006) called this group of technologies network-based positioning. Here a tracking and evaluation of the user location is done by using the base station network. Therefore the mobile device sends either a signal or is sensed by the network. Some of these devices may be: pager, on-board units, navigation systems, transceiver, laptops, cell phones, PDAs and pocket pc.

In order to understand how LBS are possible, we need to check out different network-based location methods, such as TOA with its improvement TDOA method and the variation U-TDOA method and AOA, which will be explained below. The primary reason of why these technologies were selected it's because these ones are compatible to any network-based technology and they can be used in a design of such wireless communication networks.

Caffery (1998) explains that radiolocation systems can be implemented based on either signal strength, angle of arrival (AOA), or time of arrival (TOA) measurements, or their combinations. The signal measurements are used to determine the length or direction of the radio paths to/from an MS from/to multiple BSs.

AOA y TOA utilizes the same mathematical triangulation principles to calculate locations by measuring the difference in time it takes for a signal to reach a set of known objects. The primary difference between the technologies lies in the place the location is calculated, in the equipment that is needed to perform the calculation, and in how these differences affect the performance that a given location technology can deliver (Angelides, 2000).

Angelides also mentions that wireless location technologies performance must be evaluated according to accuracy and yield. Accuracy relates to the ability of the location technologies to pinpoint a caller or location devices (usually an average measure in meters), while yield is a measure of the ability of the technologies to actually calculate a location (usually measured as a percentage of

successful locations per 100). And yield is equally valued in the commercial services world, as the capability to process a location is of critical importance for a large percentage of applications, such as medical notification and stolen vehicle recovery (Angelides, 2000).

2.4.2.1.1 AOA or “Angle of Arrival” method

AOA techniques estimate the MS location by first measuring the AOAs of a signal from an MS at several BSs through the use of antenna arrays. Scattering near and around the MS and BS will alter the measured AOA. In the absence of an LOS signal component, the antenna array will lock on to a reflected signal that may not be coming from the direction of the MS. Even if an LOS component is present, multipath will still interfere with the angle measurement. The accuracy of the AOA method diminishes with increasing distance between the MS and BS due to fundamental limitations of the devices used to measure the arrival angles as well as changing scattering characteristics (Caffery, 1998). A general functioning procedure is illustrated on Figure 5.

Steiniger (2006) establishes that AOA it is possible by using antennas with direction characteristics the angle of arrival in the mobile device can be detected. Because of a moving mobile device this is not very exact. Another possibility is that many base stations have segment antennas (usually 2-4) which divide the circum-circle of the base station in segments of 90, 120 or 180 degrees.

Besides, Chalamalasetti (2003) says that the multiple element arrays require calibration, and the phase and amplitude response of each element and cables, switches, etc. must be known and stable for measurement accuracy. Alternately, a single antenna may be moved to synthesize an array. The angle resolution is limited by the size of the array and the limitations of the processing algorithm, and many implementations of this method are very slow.

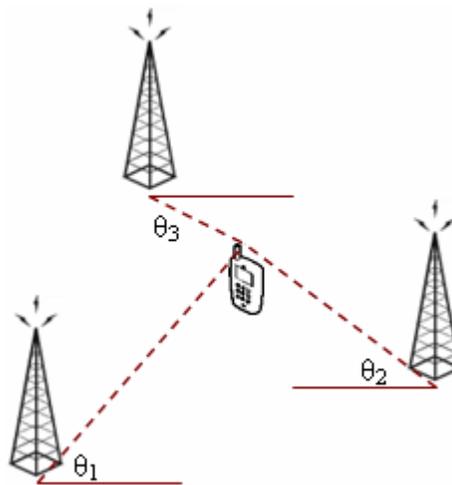


Figure 5: Angle of Arrival Method

Chalamalasetti (2003) declares on his report that direct measurement of AOA is possible using a rotating directional antenna. Resolution depends on the antenna beamwidth, which in turn depends on antenna size in terms of wavelength, and antenna travel during the measurement.

Antenna front to back ratio will also limit the dynamic range of the measurement. The rotating antenna method, combined with a wide band channel sounder, has the attraction of being direct and reasonably fast.

Davies (2004) remarks that the angle of arrival systems are considerably more accurate than signal strength based methods, although the technique clearly requires line of sight propagation conditions between mobile station and base station for correct location estimates. In situations where no line of sight signal component is present, the antenna array will lock onto a reflected signal that may not be coming from the mobile station. Where a line of sight component is present, multi-path propagation in the form of scattering around the mobile and base stations affects the measured angle of arrival.

2.4.2.1.2 Time-based methods

Caffery (1998) defines these techniques as those based on estimating the TOAs of a signal transmitted by the MS and received at multiple BSs or the time differences of arrival (TDOAs) of a signal received at multiple pairs of BSs. In the TOA approach, the distance between an MS and a BS is measured by finding the one-way propagation time between an MS and a BS. Geometrically, this provides a circle, centered at the BS, on which the MS must lie.

By using at least three BSs to resolve ambiguities, the MS's position is given by the intersection of the circles. In the TDOA approach, differences in the TOAs are used. Since the hyperbola is a curve of constant time difference of arrival for two BSs, the time differences define hyperbolae, with foci at the BSs, on which the MS must lie. Hence, the location of the MS is at the intersection of the hyperbolae. The essential ingredient for the timebased approaches are high-resolution timing measurements. A deeper definition of these location methods will be given in the next paragraphs.

TOA or "Time of Arrival" method

Reza (2000) declares that the Time of Arrival technique exploits triangulation to determine positions of the mobile users. Position estimation by the triangulation is based on knowing the distance from the mobile to at least three base stations in the line of sight (LOS). The base stations determine the time signal takes from the source to the receiver either on the uplink or on the downlink.

The way this triangulation is done is by calculating the total time elapsed from the instant the command is transmitted to the instant the mobile responds is detected. This time consists of the sum of the round trip signal delay, and any processing and response delay within the mobile unit. When the processing delay is subtracted from the total measured time, total round trip delay is found. Half of the quantity would be the estimate of the signal in one direction. Multiplying this time with the traveling velocity of the electromagnetic waves would give the approximate distance of the mobile from the base station. The approximate distance to the mobile determined by two additional receivers

could be used to determine the mobile position at the intersection of circles from multiple TOA measurements (Reza, 2000). This is shown on Figure 6.

Woodacre (2003) proposed TOA advantages as follows: a) synchronization with transmitter is not needed; b) only inter-RN synchronization needed; c) it has a lot of advantages for TX; d) it's a very simple technology; e) it has an infrastructure independent to the mobile devices; and finally, f) it consumes low power.

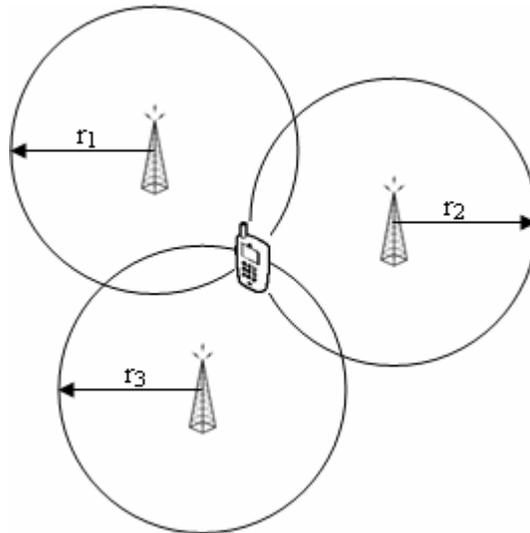


Figure 6: Time of Arrival Method

TDOA or "Time Difference of Arrival" method

Reza (2000) considers TDOA as a hyperbolic PL technique. Two distinct stages are involved in the hyperbolic position estimation technique. In the first stage, time delay estimation is used to find the time difference of arrival (TDOA) of acknowledgement signals from MSs to BSs are determined. This TDOA estimate is used to calculate the range difference measurements between the base stations. In the second stage, an efficient algorithm is used to determine the position location estimation by solving the nonlinear hyperbolic equations resulting from the first stage. TDOA can be estimated by two methods: A) Subtracting the TOA measurements from the two BSs; and B) Correlating two versions of the acknowledgement signal at the two BSs. For further comprehension refer to Figure 7.

Murphy (2007) tells that TDOA uses signals that are normally transmitted by the mobile phone such as a voice phone call. No special "burst" signals have to be transmitted for TDOA to operate. This allows TDOA to work with current handsets with no modification. The base stations must be updated to calculate the time difference, but no changes are required in the handset.

According to Murphy (2007), TDOA can also provide better reception in low signal environments, because the receive signal is much more powerful than in the case of GPS. In-building location determination is difficult with any system, because there is no direct line of sight to the transmitter, but a TDOA unit is more likely to receive a signal than a GPS unit.

However, Murphy (2007) also refers to some of the problems this technology may have, mentioning that since TDOA operates by measuring the time that it takes signals to travel from the handset to the cell tower, multipath can be a big problem. The more the signal reflects off structures before it arrives at the tower, the longer it will take for that signal to get there. This is particularly a problem in urban environments. When a signal is transmitted from within a large grouping of buildings, it is almost certain that it will be reflected multiple times before it arrives at the tower.

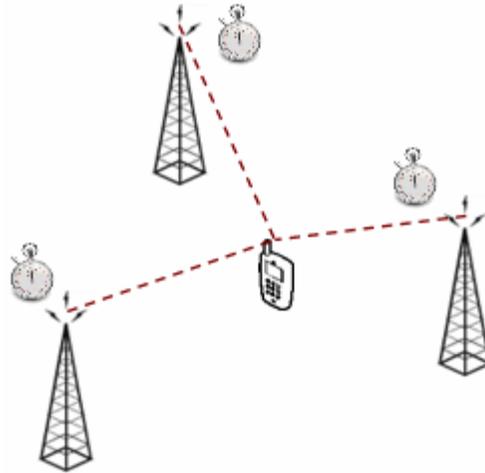


Figure 7: Time Difference of Arrival Method

Furthermore, Murphy (2007) also considers that TDOA is not able to provide the accuracy of GPS. Multipath causes errors as discussed above, but the altitude of the handset relative to the tower is also a problem. If one tower is located high on a mountain and another in a valley the distance can be highly skewed by the relative altitudes of the towers.

Furthermore, Chalamalasetti (2003) considers that the differences in the arrival times of a signal at spatially separated sensors can be used to estimate the angle of arrival of the signal. Due to noise or sensor malfunction, the time difference estimates may be erroneous and thus the angle of arrival estimate may be inaccurate. If the signal to noise ratio is high enough, these differences, i.e. time delays, can be estimated by simple methods, e.g. polarity coincidence correlation.

U-TOA or “Uplink Time Difference of Arrival” method

This is one of the most common location technologies in the market not only because it is widely used in the GSM market but also because it is a network-based technology that allows it to be used in other kinds of wireless networks. Even some authors like Martinez (2006) consider this technology as a network-based location method very useful in order to get information.

The U-TDOA method employs a process similar to radio signal triangulation used on TOA and TDOA methods: it calculates the location of a transmitting mobile phone by measuring the difference in time of arrival of signals at different receiver sites (called Location Measurement Units or LMUs). When the mobile phone transmits, antennas at a number of different base stations receive the signal. The time that an individual LMU detects the signal is a function of the distance of the

transmission path between the mobile phone and each LMU antenna. The U-TDOA method uses digital signal processing to match up the signals at pairs of LMU receivers and determine the difference in reception time. The U-TDOA equipment then computes the latitude and longitude of the phone based on these differences. This is shown on Figure 8.

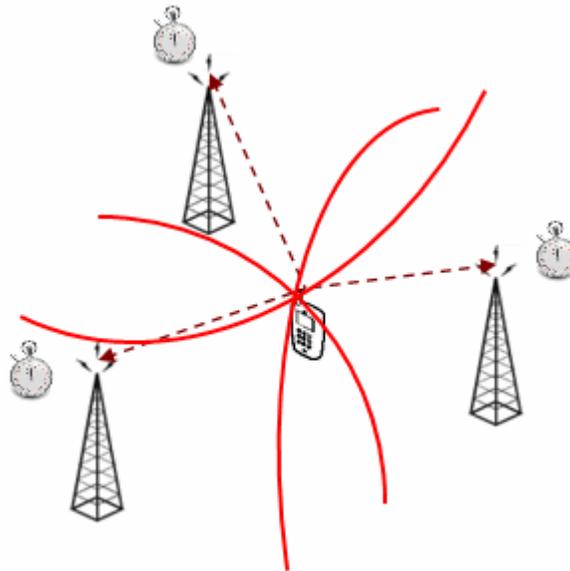


Figure 8: Uplink Time Difference of Arrival Method

The triangulation implemented by U-TDOA produces very accurate measurements, typically in the range of ± 50 meters. U-TDOA technology can achieve these results in situations where GPS (and even A-GPS) simply fails to function, particularly indoors or in dense urban environments. Also, with U-TDOA, accuracy can be scaled by adjusting the number of LMUs in the network and the latency a U-TDOA systems is about 10 seconds from the initiation of the call and the delivery of requests.

Angelides (2000) also mentioned that U-TDOA shows substantial potential for enabling a wide variety of location-based services while permitting operators to deploy such services with a minimum amount of risk. U-TDOA offers a key advantage to commercial services: the ability to locate all existing wireless phones. It also performs well in a wide variety of environments and can be scaled to meet the demands of the operator, end user, and service provider.

U-TDOA's counts on consistent performance across a wireless subscriber's network in a variety of conditions. Unlike handset-based solutions that rely on specialized technology in the handset to do location, network technologies like U-TDOA rely entirely on equipment placed within the wireless network to do the location calculation. Because of this, network technologies are not limited by the processing capacity of the phone and have the ability to devote substantially greater processing power to the calculation of a location. This allows U-TDOA to provide extremely high performance even in difficult radio environments such as in dense urban areas and inside buildings (Angelides, 2000).

U-TDOA (Angelides, 2000) is a technology that can be widely used by providers and subscribers because is a network-based technology which permits to locate all existing and future

phones on the operators' network and thanks to the lack of special handsets which limit the provision of location services to those who are willing to replace their phones.

U-TDOA (Angelides, 2000) is also a highly scalable technology. It can be deployed in varying densities and configurations to provide different levels of performance and service depending on market and application requirements. This gives wireless operators the flexibility to deploy location technologies in a highly controlled manner and eliminates much of the risk associated with implementing a new technology. It is also the only solution that is currently compatible with all of the major global air interfaces.

And as it was mentioned previously, Angelides (2000) also considers that because the location equipment is independent of the mobile device, U-TDOA can be easily configured to support alternate location methods.

Angelides (2000) explains that by allowing U-TDOA to be combined with lower accuracy cell ID technologies, users can receive uninterrupted location service even when they are in areas where high-accuracy systems are not deployed. And also, going forward, U-TDOA can also be combined with complementary location technologies such as E-OTD and A-GPS as they penetrate the subscriber base over time to leverage each technology's strengths and maximize the LBS revenue opportunity.

2.4.2.1.3 Cell identification methods

Davies (2004) believes this is the most basic technique for determining the location of a mobile for provision of location services and applications is Cell Identification (Cell-ID), or Cell of Origin (COO). The approximate position of a mobile handset can be identified as it connects to the network via a physically locatable base station transmitter, and is assumed to be located geographically within the area predicted to be best served by this base station. Accurate maps of the base station coverage area are required, as this method relies on the hypothesis that geographical coverage of a cell corresponds to that predicted by radio coverage studies.

This bilateral location principle can be implemented as a network-based technique or as a mobile-based technique where the network continuously transmits the coordinates on a control channel (Davies, 2005).

There are three different methods, all of them can be considered as once, although, because two of them are improvements of the authentic Cell-ID method. As we mentioned, the following technologies are part of this tech-family: Cell Identity (CI), CID+TA or "Cell-ID + Timing Advance (TA)", and Strength of Signals received by the handset (RXLEVs).

C-Id o "Cell Identification" method

Spirito (2001) mentions about this technology that in cellular networks base stations serve only a limited geographical area; thus the identity of the base station serving a mobile provides the simplest positioning information. In GSM the serving BTS identity is available with the parameter

known as CI. In case of omni-directional serving cell, the CI-based location estimate is at the serving cell's antenna coordinates. For a sector cell the CI method can be configured to calculate the location estimate by taking into account antenna azimuth, and size of the cell as well (refer to Figure 9)

Laitinen (2001) considers that the main advantage of Cell-ID technology is the low cost of deployment and operation, as it is an inherent feature of all cellular systems and requires minimal changes to existing systems. Additionally it can be implemented across the whole population of users as it can be supported by all mobile handsets. Cell-ID based location is fast as no calculations are required to obtain location information, making it suitable for applications requiring high capacity.

Accuracy is generally low as it is directly dependent on cell radius, which can range from hundreds of meters in urban areas to tens of kilometers in rural areas. Generally accuracy is greater in densely covered urban areas due to the small cell radius of micro-cells and pico-cells, and considerably lower in rural environments. The main difficulty with the Cell-ID technique is correctly predicting the coverage of the cells, as the location of the base station a mobile unit is currently using may not be the closest physically. This is particularly the case in third generation systems where a mobile terminal can be in communication with several different base stations in soft handover situations, or where the active base station can change several times a second (Davies, 2004).



Figure 9: Cell Identification Method + Sectorization Method

C-Id+TA o "Cell ID & Timing Advance" method

Spirito (2001) also raises that besides CI method, also TA for the serving BTS is available in GSM. TA is an integer number ranging from 0 to 63 introduced in the GSM system to avoid overlapping of bursts at the BTS side. It is proportional to the distance between MS and serving BTS estimated by the system.

This method is used in cellular networks as GSM and it has been included on the standard where it specifies that GSM uses CI and TA to define a circle (in a 2-dimensional scenario) centered at the serving BTS site on which the MS location is estimated. In case of omni-directional serving cell, the CI+TA location estimate is at the serving cell's antenna coordinates. If the cell is a sector cell, the

CI+TA method determines the location estimate in the direction of the serving cell's antenna azimuth, at a distance estimated from the TA (Spirito, 2001). Further graphical explanation, refer to Figure 10.



Figure 10: Cell Identification + Time Advanced Method

Cell ID by Signal Strength

Caffery (1998) believes that radiolocation using signal strength is a well known location method that uses a known mathematical model describing the path loss attenuation with distance. Since a measurement of signal strength provides a distance estimate between the MS and BS, the MS must lie on a circle centered at the BS. By using multiple BSs, the location of the MS can be determined.

This member of this technological family is named CID+TA+RXLEV or "Cell Identification and Timing Advanced and RELEVs. It's more complex than any other member of the same family for many reasons and advantages, its accuracy is better but infrastructure is more complex and it also depends on mobile devices (see Figure 11).

The CI+TA+RXLEV method estimates the handset's coordinates by combining CI, TA (used to estimate the distance between MS and serving BTS), and RXLEV information. RXLEVs are measurements of the strength (i.e., power) of signals received by the MS from the serving cell and from up to the six strongest neighbor cells. The level of a signal received by an MS, or more precisely the attenuation the signal has experienced, depends on the reciprocal position of the MS and the BTS from which the signal was transmitted. Attenuation values from multiple neighbor cells are modeled by the CI+TA+RXLEV location method through basic propagation models and used to estimate the location of the MS. Optionally, the method can use propagation models tuned to best fit the propagation phenomena in specific environments and it can be left the possibility to use only a subset of the information available (e.g., TA only or RXLEVs only) to estimate the handset's coordinates (Spirito, 2001).

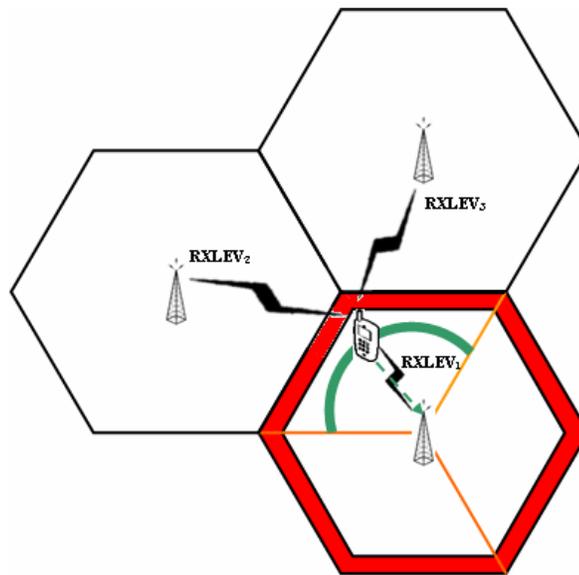


Figure 11: Cell ID + TA + RXLEV Method

2.4.2.2 Mobile-based technologies

On the contrary to last methods, mobile-based technologies offer some advantages in contrast. One and the most important is that network based technologies don't offer a very accurate measurement of the users' location, so, when designing LBS, we need to take in consideration this parameter of how accurate we need to find our user.

In mobile-based implementation the MS makes measurements and position determination. This allows positioning even in idle mode by measuring control channels which are continuously transmitted. Some assisting information like BS coordinates might be needed from the network to enable location determination in the MS. The two main methods found in the market are the EOTD (Enhanced Observed Time Difference) and OTDOA (Observed Time Difference of Arrival) which are based on the TOA and TDOA calculations with the difference that they are done in the mobile devices. These methods require changes in the mobiles and special units of calculation inside the devices.

Both methods, EOTD and OTDOA are based on TOA or TDOA methods respectively, and they are considered the mobile versions of those methods. As much the EOTD as the OTDOA requires the installation of devices that receive the measurements done by mobile. Networks also require units specialized on sending a signal continuously to mobile to allow calculation in the software inside the telephones.

Enhanced Observed Time Difference

The E-OTD positioning method (Wylie-Green, 2001) is a handset-based technology that requires a GSM terminal to measure the Time Difference of Arrival (TDOA) between the radio signals received on the Broadcast Control Channel (BCCH) frequency of its own serving base station and at least two of the neighboring base stations in its candidate list. Given the coordinates of the measured sites and the offset in transmission time between their BCCHs, the system can use the observed time difference measurements (OTDs) made by the mobile to estimate its coordinates.

There are many different factors that can affect the accuracy of an OTD estimate (Wylie-Green, 2001): the radio environment itself presents many challenges, most notable of which may be the multipath problem; network planning issues that affect OTD estimation; and, topological characteristics may also affect OTD estimation accuracy. This method uses LMU (Location Measurement Units) in disperse geographic points. The density of LMU will determine the accuracy of the system; that is why carriers install one for every two base stations.

The mobile devices are EOTD-enabled software entities and they measure periodically the signals from three or more base stations. The time differences of the signal arrival to the two points (LMU and mobile) combine to produce hyperbolic lines that intercept in the place where the mobile is. The last allows offering a two-dimension location method. In the case of EOTD, the mobile measure the time difference of arrival of the bursts of two close base stations. This is known as Observed Time Difference (OTD) measurements.

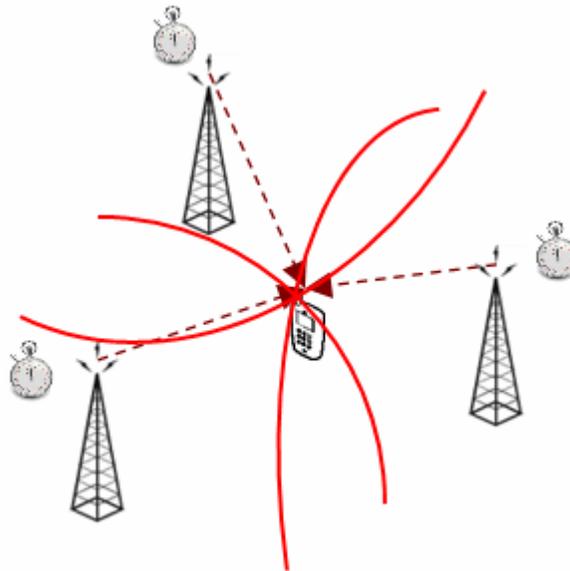


Figure 12: Enhanced Observed Time Difference

A disadvantage the EOTD has is that base stations must be synchronized and extra calculation must be done. This calculation is called Relative Time Difference (RTD) and it refers to the difference in time among them to allow estimating the differences in real times. In order to increase the accuracy, OTD and RTD measurements must be obtained from three pairs of base stations. The OTD measurements are done by the mobile, while the base stations deliver coordinates

and RTD values among them to allow mobile calculating its position. Otherwise, the mobile measures the OTD and delivers it to the network that calculates the position of the mobile user in the network. This is shown in Figure 12.

Observed Time Difference of Arrival

The Observed Time Difference Of Arrival (OTDOA) method is implemented in the UMTS standardization, and is based on measuring the difference in time of arrival of the downlink signals received at the mobile station (Laitinen, 2001). OTDOA operation in mobile assisted mode, where the serving radio network controller performs the position calculation, is mandatory and available in all UMTS mobile terminals. The availability of mobile-based implementations depends on the position calculating capabilities of the mobile station and the operator, as base station position information and Relative Time Differences (RTDs) have to be sent to the mobile station. (Davies, 2004)

According to Wegdam (2004), the observed time difference of arrival (OTDOA) positioning method uses observed time differences between mobile phone and close-by base stations (of which the exact location is known) to determine the location. The measurements of different base stations are used to triangulate the location. The accuracy of the OTDOA positioning method varies depending on the actual location of the mobile phone within the cell; especially if a mobile phone is close to one of the base stations, it may be difficult to hear the two other base stations needed for the triangulation. Although some controller products implement this method, it is not yet widely deployed. The OTDOA is mostly used in UMTS networks and is very similar to the EOTD method in calculations, with the difference of the usage of a different air interface, the Uu deployed exclusively for UMTS.

2.4.2.3 Mobile-assisted technologies

These technologies are a complement to latter technologies mentioned above. These methods include solutions where the MS makes measurements and sends the results to a location centre in the network for further processing. A clear example of these one is what we know as A-GPS, which continuously sends measurements reports to a processing unit in cellular networks to estimate its position obtaining calculations between results in mobiles and network infrastructure.

A-GPS or “Assisted GPS”

We need to see how its former technology works: the GPS. The GPS (Global Positioning System) is a constellation of 24 satellites that orbit the earth in 6 orbital planes (at 10,600 miles above the earth) of four satellites each. It offers location accuracy from 100 to 10 m, in some cases reaching 1 meter. This is achieved using GPS-enabled terminal and ground stations at the same time with satellites, creating calculation to triangulate its position. GPS satellites cover all earth but the Arctic and the Antarctic areas, because they travel in an East-West pattern. Its main errors are because of atmospheric conditions, mostly in the ionosphere and troposphere. Other sources of

errors may be the environment and obstacles around the receiver producing multi-path delays (Williams, 2005).

Accurate time information is required for GPS receivers to calculate distances using propagation time from satellite to receiver, requiring a relatively strong received satellite signal. To overcome this limitation Assisted-GPS (A-GPS) allows reception of GPS satellite data at signal levels below known thresholds, and in some cases location estimation when indoors. A-GPS is a hybrid technology that utilizes GPS satellites in conjunction with the cellular network infrastructures to their best advantage. This technology requires mobile stations with partial GPS receivers, which introduces additional circuitry although the size, weight, memory and power requirements are significantly less than for full GPS receivers. (Davies, 2004)

The procedure is as follows. Firstly, the network coarsely locates the MT using a cell-based technique. This location, combined with the GPS signals at the transmitter, reduces the search space for the GPS triangulation calculations by predicating the received signals, thus saving time. The MU itself has a partial GPS receiver that clocks onto a satellite and transmits the received data back to the ground station for processing. Since the scaled-down GPS receiver is used, the size, weight, memory and power requirements are much less. This hybrid solution can get an accuracy of about 15m, only slightly worse than full-scale GPS. Normal GPS fails when the satellite signals become blocked, but A-GPS survives at a lower resolution since it has the network methods to fall back on. (Dibdin, 2001) This is shown in Figure 13.

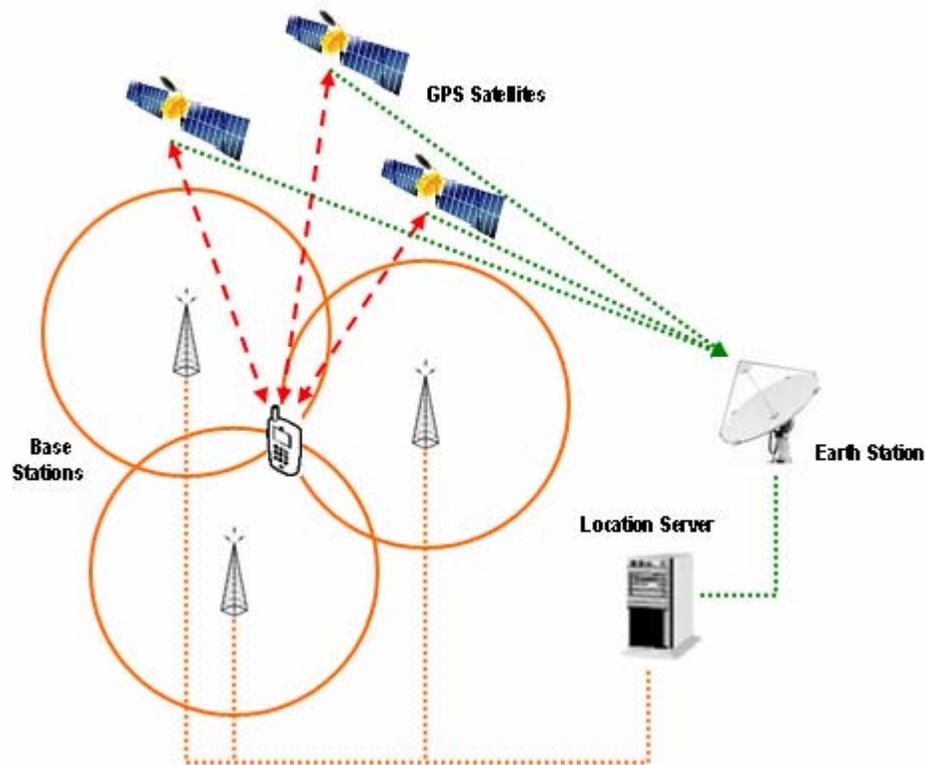


Figure 13: Assisted GPS Method

Traditionally, the A-GPS measurement can be done using a location server where measurements from the networks and the satellites are used to find users; other alternatives lie

absolutely on mobiles. In some cases, the A-GPS considers the existence of other positioning methods to make more accurate the measurements. Sometimes the GPS and the AFLT methods are used together. The AFLT method consists in measuring the down link signal to mobiles where a client resides and calculate its position. It requires changes in the mobile to be able to make calculations in CDMS networks. Similar solutions exist on GMS-based networks.

2.5 Feasibility and accuracy

When deciding to design LBS platform, we have to take in consideration two parameters which are considered the most important to make recommendations on services providers to implement them as part of the services they have to offer. The first parameter is accuracy. This one is related to the type of service we want to offer and we have to concentrate to take a decision on how much accurate we want our service and see if the network can offer it. Accuracy varies from LBS to LBS. LBS can be classified in groups named families. Every family requires different range of accuracy.

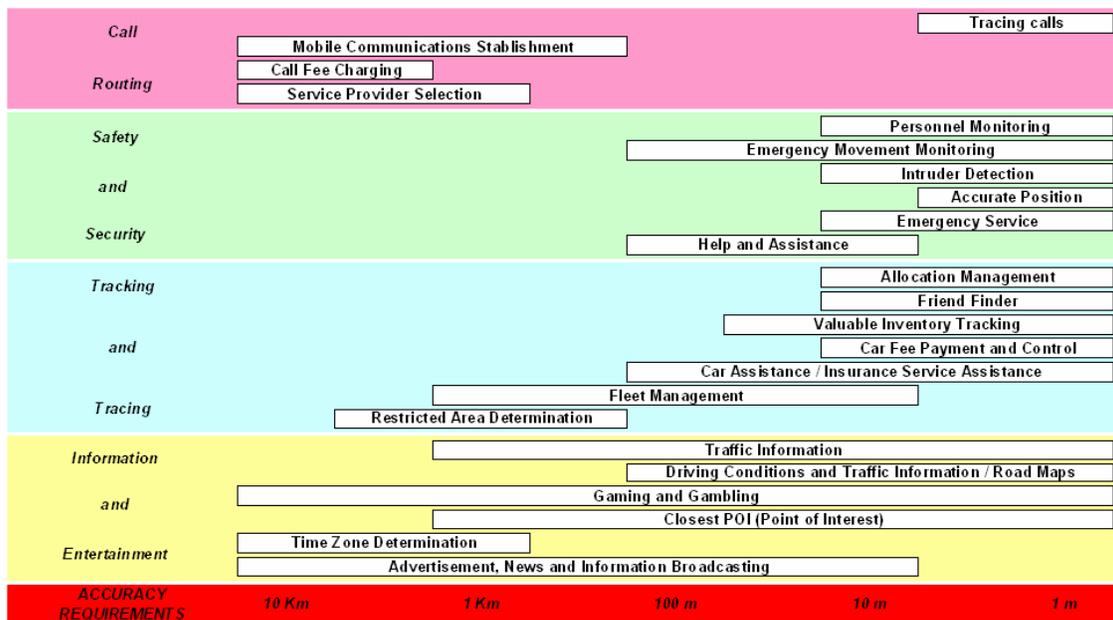


Figure 14: Accuracy requirement and LBS families

We can classify LBS in four major families (Figure 14): Call Routing, Safety and Security, Tracking and Tracing, and Information and Entertainment. The “Call Routing” family refers to those services necessary to offer basic services in cell networks such as call establishment, call fee charging and provider selection when turning on cell phones. This family requires the less accuracy, except for tracing call services, which can also be associated to security in some specific cases.

A second family, “Safety and Security” is considered the most demanding family in respect to accuracy. These kinds of services requires very accurate measurement results because this services are focuses on persons and their integrity, which in many cases, can involved even their lives. We can find services such as Personnel Monitoring, Emergency Movement Monitoring, Emergency

Services and others. Telemedicine services, including emergency attendance can be considered in this family.

The “Tracking and Tracing” family includes services of locating and finding assets, such as cars, containers, or controlling traffic and automatic fee payment. This can be considered a “balanced family” because not all of them need to be as accurate as those belonging to the latter family. This is why these services are used for controlling devices of entertainment (e.g. appointment or finding a friend) and they are not considered of high importance and there’s no risk to users.

The last but not least important is the “Information and Entertainment” family. This one is very similar to the “Tracking and Tracing” family in respect to accuracy requirements. Accuracy is not a strong requirement to satisfy, even a few kilometers are acceptable when designing like this ones. Gaming and Gambling, Time Zone Determination and Traffic information are clear examples of this LBS family.

After describing LBS families, we have to compare technologies available in the market. These technologies visible on the following image are present in current cell technologies.

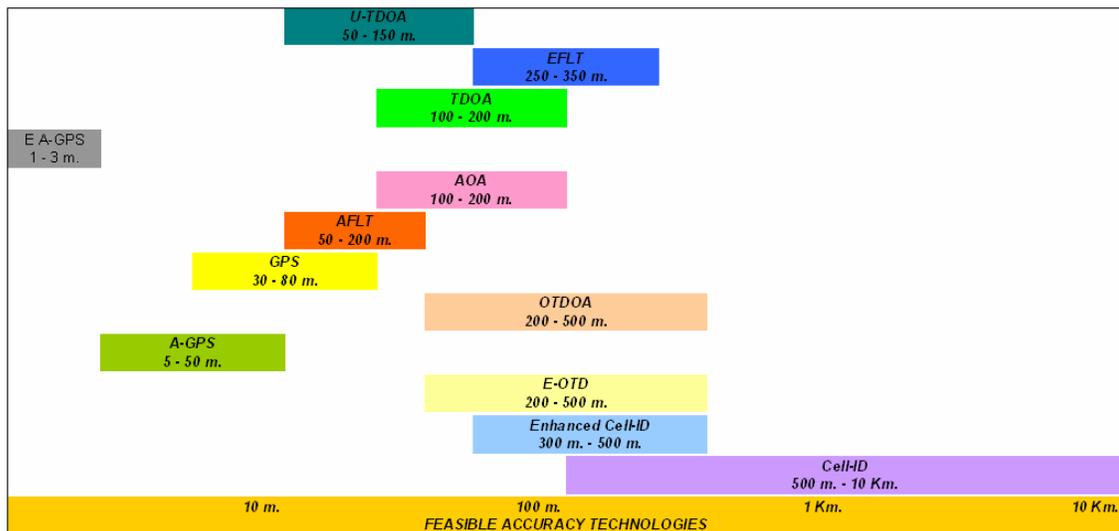


Figure 15: Feasibility of technologies

Our focus on the systems, LBS applied to health services, indicates that we demand services with high accuracy and feasibility. Health Services, especially Telemedicine, needs to manage location and position information of users in a very accurate and feasible manner, which determinates the quality of the service delivered to mobile clients.

An average of 10 to 50 meters of accuracy are demanded in this kind of services, especially because they can be classified in the “Safety and Security” family, so, the technologies more recommended for this platform are U-TDOA, GPS, A-GPS or E-A-GPS, which is and improvement of the A-GPS. Those technologies mentioned before are compatible to GSM Systems and the derived platforms in the market.

Summary

Location-Based Services are all the service based on the user's position determination. Two main processes are involved on the side of the networks providers: position and location determination and mobility. The former involves the estimation, calculation and measurements to determinate where the users are located inside the networks and aided by position algorithms, the establishment of the coordinates to obtain a more accurate determination. The latter, the processes of updating inner databases, all that in order to keep recorded the behavior of movement and connectivity that the users can present and accelerate the location of users for further position estimations.

Every LBS platform lies on four pillars: positioning technologies, mobile carriers' networks, service provider application servers and content provider servers. These four elements are necessary to be able to deliver an end service with value to customers and they support the platform itself. The platform is mainly formed by DBMS, LBS application servers, geographic information servers and alert engines support, with their respective control politics and devices.

Positioning technologies can be of three different kinds: network-based technologies (measurements done by devices in the carriers' networks), mobile-based technologies (measurement done completely inside the mobile devices) and mobile-assisted technologies (measurements done partially by elements inside the carriers' networks and the mobile devices and the same time to acquire more accurate measurements).

Finally, when designing a service, two main requirements must be taken in consideration as potentials of success or failure: accuracy and feasibility. The choice of any positioning technology depends on the kind of service we want to offer, and what technologies the carriers are able to support. Accuracy varies from service to service and not all the positioning technologies can offer the same accuracy required to attend the requests.

LBS are so diverse and they can be used to provide almost all kind of information but they need technological platform that compute some data to accomplish this goal. The final purpose of this document is to provide a design of a technological platform whose functionalities be implemented in any wireless networks for first instance, taking in consideration that the most advanced and spread networks are those used for cellular communication. This platform must be focused on the objective to deliver location-based services through any kind of wireless network, using different application protocols for communications whose backbone may be the Internet Protocol as communication media.

We depart from the point that wireless operators own the infrastructure and the capabilities to locate and calculate an accurate position of wireless users in their coverage area; at the same time they can provide an access media as much to the providers of the service as the users that request any deployable service in the platform. However, well-designed platforms are demanding to offer high-valued services, with good capabilities and new characteristics for increasing feasibility and trust in their results.

As we can see, the main content of this document is to explain the interaction of both sides (providers and carriers) and the necessary resources and elements inside and outside a technological platform for a data information processing service for wireless network users.

Currently, wireless networks provide several resources for LBS delivery, even remotely, but certain information surges from some elements in the networks. These elements in the market are deployed thinking in compatibility achieved by manufacturers using world-recognized protocols and standards which in some cases are reachable by LBS developers. However, the communication media and patterns are delivered and deployed but the research of inner elements on a platform are necessary. These elements must provide feasibility, trust, flow control and more requirements to create a reliable processing environment for LBS attendance. So, this is why the interest of this work focused on researching these elements to propose them in future developments.

Even though LBS platforms exist, efficiency is searched on this work trying to achieve it providing two functionalities to succeed in LBS market: user information managing by creating profiling and inner flow control in their algorithms. These two requirements must be, in a personal context, inherent and present in platforms to help providers to deploy more functionalities and capabilities to offer high value added service to customer from wireless networks and create reliable contexts of information processing.

So, basically, the core of the thesis involves defining those elements closely related to the platform such as DBMS, application servers and Geographic information servers aided by content provider servers. This is considered to create an autonomic environment between the two main elements, the service provider and the network provider.

Chapter 3: Cellular System Overview

Preface

This chapter explains how the systems can deliver a service originated by users' mobile devices. The platform system may involve the usage of technologies such as SMS, WAP, Internet and diverse standards to attend requests. These technologies add special capabilities to satisfy necessities even from IP-based devices in prior technologies according to the technology evolution trends existing in the communications market.

There are some elements in common in the functioning of the different services offered in the cell phone networks. Processes involved in their functionalities are explained graphically using diagrams in this chapter, putting the final user on the right and the final entities involved on the left. Devices in cell networks will be divided in four groups of interest in this work: common architecture, data transference, positioning, and messaging. These devices are listed next.

3.1 Common architecture

Devices included in the common architecture are those that support devices that remain in three categories: data transference, messaging and positioning. These elements are mainly control devices and/or managers of internal databases of the carrier. In this category we include the mobile terminal, for being the root of any service delivered by a wireless network and the cellular networks are not the exception to this.

For instance, the architecture considered in this case is the UMTS, which is a technological evolution of the GSM, following the choice done in advance in section 1.3. However, the UMTS architectures can be of two versions, R99 and R4, being the latter the newest, but we will explain the R99 because it is considered the basis of the newest ones.

There are other elements in the core network used to authenticate and keep control of authorized users in the network. One of these elements is known as AuC or Authentication Center. The AuC is responsible to check out the status of the users and providing authentication parameters aided by another device named EIR.

The EIR or Equipment Identity Registry, which is responsible to catalogue devices according to their status, it also allows network providers to identify users whose mobile are not legal, enlisting them in a black list and the rest to allow them to keep using the network in a safety way. The process of these devices is as follows:

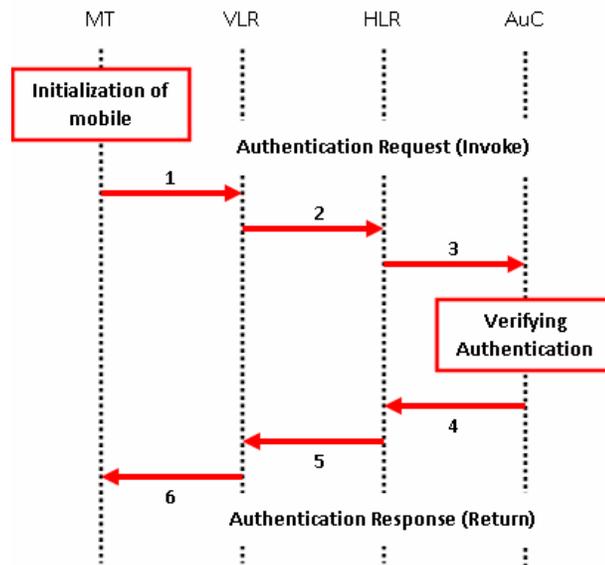


Figure 16: Authentication process

These devices in the network, especially the VLR and the HLR, are responsible to do what we call Roaming. According to Lin (2001), Roaming has two basic operations: registration, the process whereby an MT informs the system of its current location, and location tracking, the process during which system locates the MT. The Roaming is useful to deliver services, including voice and data. The procedure is as follows:

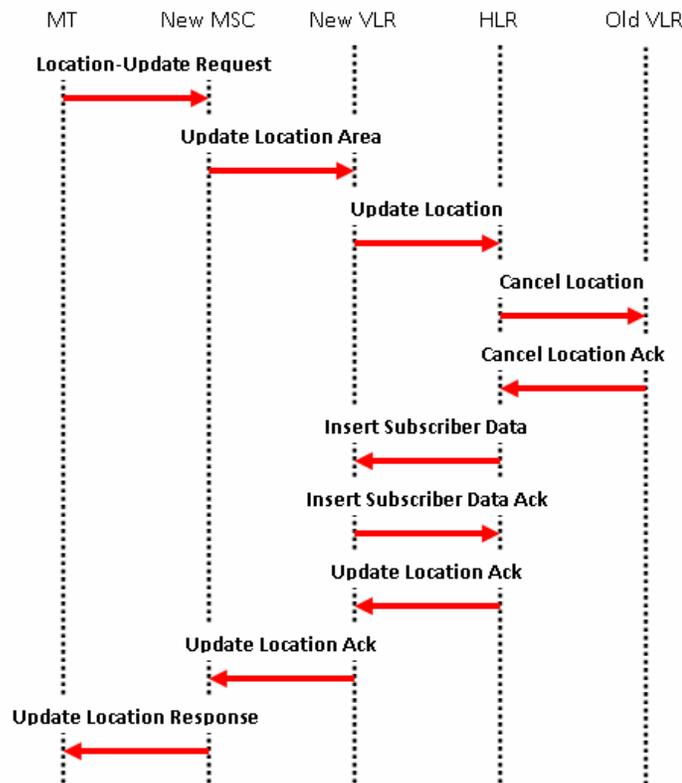


Figure 17: Roaming procedure

3.1.1 MT – Mobile Terminal

MT is also known as cell phone or any mobile device capable to use the cell network. MT must be a SMS-enabled device to access to this kind of service. The only thing users need to do is to access to their applications to write and select the phone number of destination. This is a key element to our system which it'll be explained later.

3.1.2 UTRAN – UMTS Terrestrial Radio Area Network

The UMTS Terrestrial Radio Area Network (UTRAN) defines in the R99 the air interface and the base station. According to some authors like Budgor (2006), the difference that UMTS has with a GSM/GPRS core are the base stations and the air interface (Uu) they use to communicate, located in the UTRAN, nevertheless, the core network is practically the same between the R99 and R4 architecture, or almost minimally changed.

Basically, the difference between the R99 and the R4 is the way they manage voice in their core systems. The R99 manages voice with traditional signaling SS7 and the R4 architecture, introduces elements known as Circuit Switched Media Gateway (CS-MGW) which conveys voice in IP packets within the core networks without making voice become VoIP (Voice Over IP) (Bugdor, 2006). Besides, the R4 architecture, and later releases, introduces elements to transport voice with a trend to used IP to send it, but we will not discuss this part because we want to focus in the data transference devices. The UTRAN is form by several RNS (Radio Network System).

RNS is defined in UMTS technologies and is constituted by several RNC (Radio Network Controller) which at the same time are constituted by a certain number of Nodes-Bs, which are in charge of deliver the service to mobile users. RNC is defined (Budgor, 2006) as a device in charge of the control of several nodes B to multiplex and de-multiplex packages, which is a key factor we'll be explained in more details when system's functionality is developed.

3.1.3 HLR – Home Location Register

The HLR is (Lin, 2001) a network database that stores and manages all mobile subscriptions of a specific operator and is the location register to which an MT identity is assigned for record purposes, such as directory number, profile information, current location, and validation period.

According to Siebert (2006), the HLR is the location register that administers all important permanent subscriber information, including temporary subscriber information such as the currently serving VLR. Furthermore, HLR device is responsible to support roaming and macro-mobility.

Every service provider possesses a HLR which is a huge database that contains users' information permanently as mentioned before and helps to locate users automatically when required

with a non-very accurate estimation. The HLR receives information from VLR in order to keep its databases updated continuously.

HLR subscriber information includes: the International Mobile Subscriber Identity (IMSI), service subscription information, location information (the identity of the currently serving Visitor Location Register (VLR) to enable the routing of mobile-terminated calls), service restrictions and supplementary services information. All this information is exchanged between the network elements using SS7 transactions with both Mobile Switching Centers (MSCs) and VLR nodes.

The information contained in the HLR follows the following structure: the International Mobile Subscriber Identity (IMSI) Number is a unique non-dialable number allocated to each mobile subscriber in the GSM system that identifies the subscriber and his or her subscription within the GSM network. It resides in the Subscriber Identity Module (SIM), which is transportable across Mobile Station Equipment (MSE). This number is made up of three parts: the mobile country code (MCC) consisting of three digits, the Mobile Network Code (MNC) consisting of two digits, and the Mobile Subscriber Identity Number (MSIN) with up to 10 digits. Meanwhile, the Mobile Subscriber ISDN (MSISDN) Number is the dialable number that callers use to reach a mobile subscriber.

Table 4: The IMSI Format

Mobile Station Equipment (MSE) Subscription Services			
	MCC	MNC	MSIN
Unit #1	334	03	44510000
Unit #1000	334	03	44510999

Table 5: The information in the HLR

Users' Information		
IMSI	MSISDN	Other subscriber data
334-03-44510000	81-2364-8657	-----
334-03-44510999	81-3465-2365	-----

3.1.4 VLR – Visitor Location Register

Lin (2001), explains that a VLR is a database used the customers visits another part of the network, doing a temporary record where subscription information is stored so the service can be provided. Siebert (2006) mentions that a VLR is the location register for circuit switched services used for MSC controlled roaming for delivering wireless services to or from mobile stations currently located in its area. Positioning is supported on location area basis comprising one or more cells.

Every time a cell phone enters in a new coverage area, it needs to register in the new VLR attached to the MSC which provides the service to the user in the location area, and afterwards, the VLR reports users' new location to the HLR to enable roaming and update the database to help location procedure when needed, but at the same time the HLR reports the old VLR to erase from its register, that's why the type of information contained on it is temporary, it lasts until the MT leaves its coverage area. When a mobile subscriber roams away from his home location and into a remote location, SS7 messages are used to obtain information about the subscriber from the HLR, and to create a temporary record for the subscriber in the VLR.

Every network has a coverage area which is the zone that subscriber have access to the network. This zone is divided in location area which allows managing location more accurately and easily. These location areas are recognized in the entire world and every mobile, may be associated to one location area at the time but a location area can be associated to many mobile. The information is formed by a country code (3 digits), a mobile network code (2 digits) and a location area code (5 digits).

3.1.5 MSC – Mobile Switching Center

The MSC is the core of the systems. It switches functions to the correct RNC which can contact the correct user. It receives information from other devices such as SMSC or RNS and coordinates the correct functions requested by the network or by mobile users. Besides, it can control several RNC and aided by its VLR and the service provider's HLR, finds and delivers what it was requested.

3.2 Data transference architecture

In the data transference, we classify only two main elements introduced the GSM networks were developed and evolved into GPRS capabilities: the GGSN and the SGSN. It does not mean that they don't use other elements, on the contrary, they use one or several devices classified as common architecture to find users when they have to deliver information and data to a user that requested. This is shown as follows:

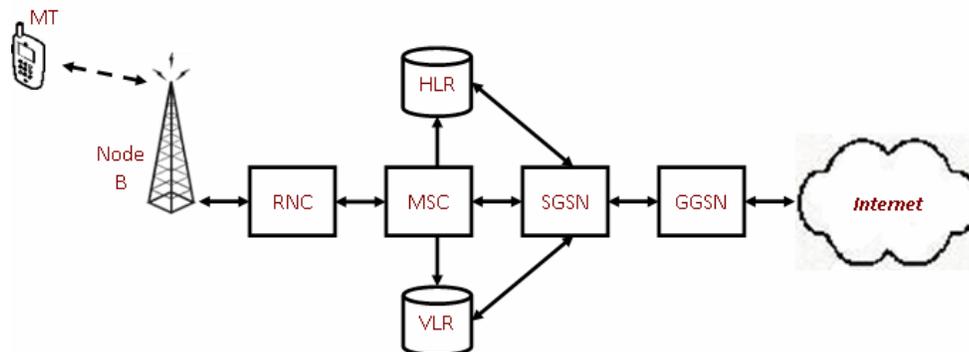


Figure 18: Data transference architecture

Figure 18 shows the devices that form part of the elements in charge of data transference in the cellular networks. As we can see, they share common elements with the functionalities of messaging and positioning to work correctly, these are: the MSC, the RNC, the VLR, the HLR and the Node B. Without the common elements, the data transference elements would not be able to locate the users that want information exchange.

3.2.1 SGSN – Serving GPRS Support Node

Serving GPRS Support Node (SGSN) (Budgor, 2006) is responsible for session management, participation in the PDP context creation and the setting of QoS parameters. It is also responsible for producing charging information and routing packets to the correct RNC.

The SGSN is able to relate a MT with an IP address. The GGSN routes every IP package and deliver them to the SGSN in order to find where the MT is. In order to find MT, the SGSN ask for it to the HLR and in some cases to the VLR to keep it traced. When it finds it, it sends the information to the MSC who take the package and delivers it to the correct MT through the RNC.

Several SGSN interconnected one to each other can form a GPRS network in the wireless carrier and this group of SGSN has to be connected to at least one GGSN to get access to Internet.

3.2.2 GGSN – Gateway GPRS Support Node

The Gateway GPRS Support Node (GGSN) (Budgor, 2006) connects the packet-switched domain to the Internet. It creates the PDP context assigning an IP address to a user terminal, can forward requests to connect to ISPs, and generates charging records.

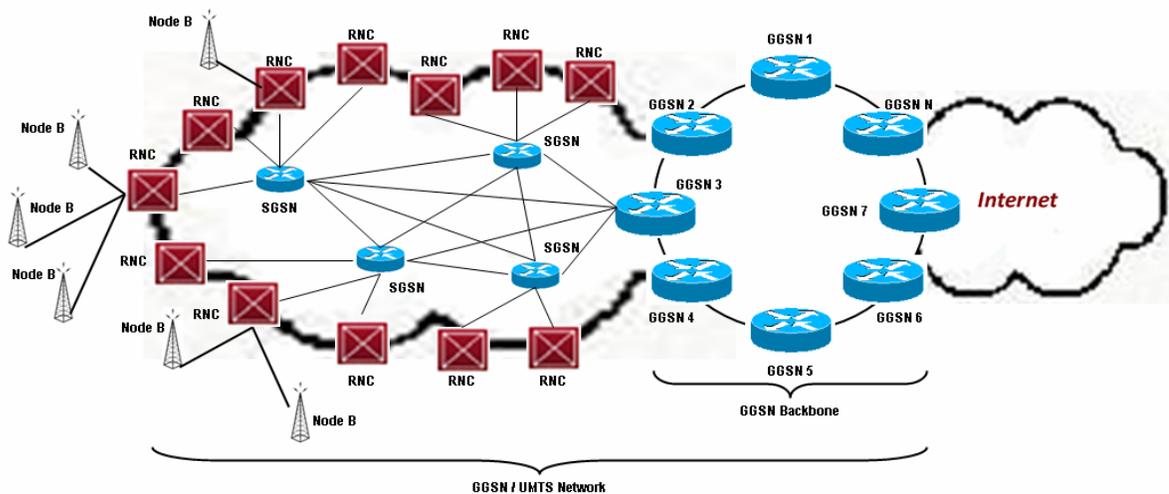


Figure 19: GPRS / UMTS Network

GGSN can form a backbone for the wireless carrier and they can be interconnected, however, the architectures demand a GGSN controller for the entire backbone. These devices, besides being

able to interconnect it with others GGSN, it also has the capabilities to interconnect several SGSN to it, meaning that a GGSN can take control on several SGSN. The union of SGSN and GGSN form the GPRS Network, the data capability entities of the UMTS networks as Figure 19 shows.

3.2.2.1 Wireless Application Protocol

Better known as WAP, is a protocol designed and implemented as default in mobile devices from second generation and on, especially on cell phone and its main purpose is to provide information delivery to wireless users using a WAP navigator similar to Internet Explorer in Windows or Mozilla Firefox in Linux versions, but with certain differences.

The WAP as Dao (2002) mentions has given as a result the Mobile/Wireless Internet. The Mobile/Wireless Internet must be compatible with GSM, and CDMA. Secondly, the small size of mobile devices means a restricted user interface, less powerful CPU and comparatively low memory capacity. Moreover, standard Internet content will not be interpreted correctly by the micro-browsers found in mobile devices. Therefore new mobile Internet standards are needed, such as the Wireless Application Protocol (WAP) and the Wireless Markup Language (WML).

WAP can facilitate to use mobile Internet access using cell phone providers' networks, which are capable to connect to the Internet and exchange, send and receive information from and to this global network. WAP is designed to operate over many wireless networks. It is a stack of protocols, which are similar to the standard Internet on PCs. (Dao, 2002). As it is shown on Figure 20, the WAP protocol can be used to deliver information and data from an application server to the mobile device using a WAP browser to get access to that information.

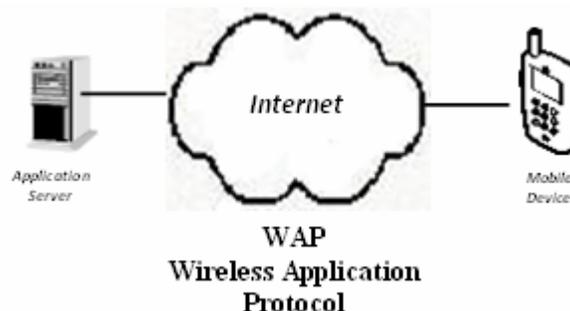


Figure 20: Interaction between Application Server and Mobiles

WAP was developed to help mobile to display content according to their capabilities and processing resources, which in most cases, are limited. This creates a model of three main entities interacting every time mobile users want to use the WAP Browser to navigate in the internet.

This WAP Browser requests the website of interest and establishes a connection with the web server; however the response won't reach the mobile directly. The response and the content of the website have to pass through a WAP Gateway in the provider's core network. This is made to adapt the website and transform it in a WML-based website. After passing through the WAP Gateway, the mobile's WAP Browser receive the information and displays the website, in most cases, it looks different from the one we can be used to watching. This is shown in

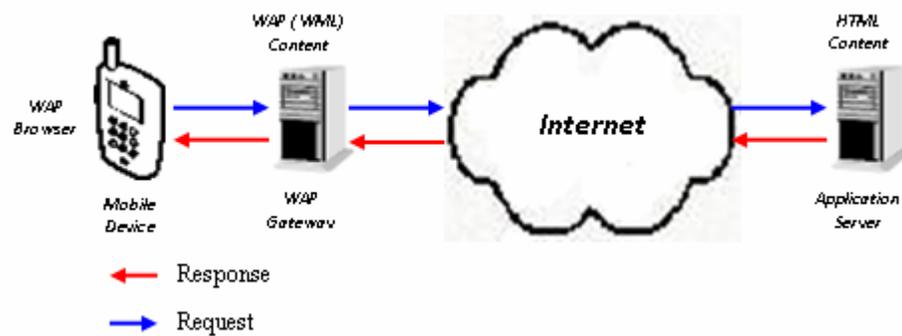


Figure 21: Wireless Application Protocol working

Wireless Markup Language

Dao (2002) specifies that WML is based on the eXtensible Markup Language (XML), which is a markup language developed for delivering database contents via the standard Internet. WML is therefore similar to HyperText Markup Language (HTML), but is designed for the efficient delivery of data across limited bandwidth mobile telephony networks. A WML page is called a 'deck', and in one WML page it is possible to have many sub-pages, referred to as 'cards'. Each WML card is identified by an Internet-standard Uniform Resource Locator (URL). Users navigate with the WML browser through the WML cards.

WAP Browser

A WAP Browser is an application in the mobiles that allows connecting and watch websites in the cell phones. This browser is especially designed to have access to several applications common to other browsers. However, this browser required especial websites in order to be able to show them, this is because mobiles are memory limited and resources are not very high. WAP Browsers shows website that are on WML and receives them using a WAP gateway.

WAP Gateway

A WAP gateway is a device in the core network of the carrier and allows mobile through a WAP browser to show websites especially designed in WML. There are several WAP servers that allow "transparent connections" to the mobile devices. It does not mean that every website has to be programmed in WML, a WAP gateway has the capabilities to "translate" the web site into WML and send it back to requesters, and vice versa.

WAP gateways provide efficient wireless access to the Internet, and handle requests from WAP-enabled handsets, and pass requests to, and receive data from, a server (because handsets

cannot communicate directly with the server). Moreover, the gateway translates WAP to the TCP/IP Internet protocol for application servers which do not support WAP. (Dao, 2002)

3.3 Positioning Architecture

These possibilities are recent and very important for the development of the platform mentioned in this work in the next sections. To locate user is a very important issue, however, we won't take it deeply because, and this is related to the infrastructure belonging to network providers. The selection of the devices and the technologies to implement on the network to locate users depends on providers but recommendations relative to the issue can be consulted in section 2.5.

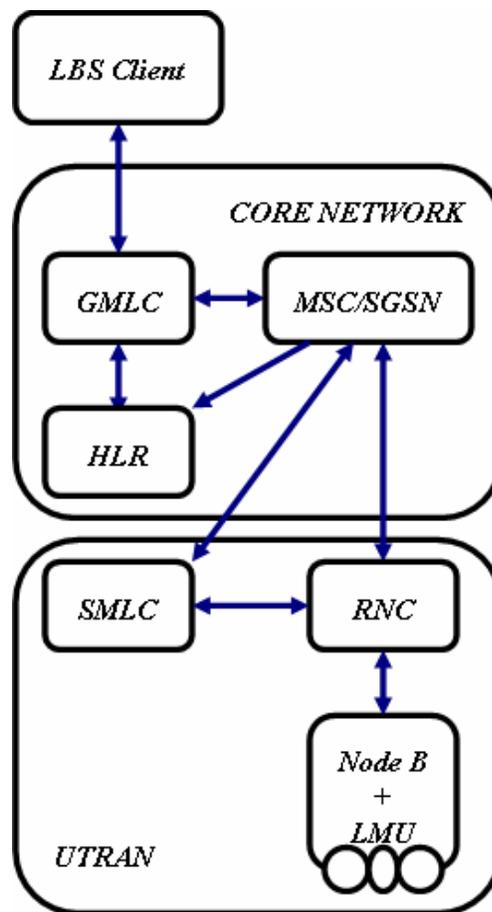


Figure 22: Location Determination Devices (Bravo, 2004)

The location infrastructure shares some common elements to others services, like the MT, RNS, HLR, VLR, and the MSC, further information of them can be consulted in section 3.1. Nevertheless, location architecture possesses specific devices in its architecture which will be explained in brief. In the last Figure 22 are shown interconnections among these devices.

3.3.1 SMLC – Serving Mobile Location Centre

According to Montilla (2004), an SMLC can be integrated into a BSC (Base Station Controller in GSM networks) or a RNC (Radio Network Controller in UMTS networks) and manages the coordination and scheduling of resources required for locating mobile devices. It calculates the position estimation and has control over several LMU, creating serving areas.

This entity is called the location server and it is the software entity used to calculate position or provide assistance data or participate in the positioning process. Different location technologies require different location server functionality. (Williams, 2005)

3.3.2 GMLC – Gateway Mobile Location Centre

Montilla (2004) explains that a GMLC contains the functionality to support the location services and gets support from the HLR or VLR for routing of information which is done by the MSC together with the SGSN. This entity is considered the front door to the cell network. It sends location services requests to the appropriate application server even through the Internet and it also receives these responses from the application server to be delivered to mobile requesting users. Williams (2005) mentions that the services delivered by the GMLC include:

- Authentication of location requests,
- Authorization using subscriber data and password verification,
- Administration keeping a TDR (Transaction Detail Records) for billing and reporting systems,
- Privacy allowing a subscriber-level positioning privacy control and privacy management,
- Security using encryption thanks to application protocols such as the MLP.

Figure 23 shows the process that follows a request initiated by a mobile user. Formerly, the mobile device sends the request to an application server where the service resides (1). After receiving the request, the application server processes the request and gathers the information necessary to attend to the service. Then, the GIS is demanded for geographic information (2) but in case of not having the position of requester, the GIS must ask for this information to the GMLC in the network carrier communicating through the MLP protocol (3).

The GMLC receive the MLP request message and checks for authentication and privacy of the user and the service provider (4). After knowing the identity of the service provider and the privacy preferences of users, the GMLC ask for the measurements required to calculate the position coordinates of requester (5). The GMLC responds using a MLP response message (6) where the positioning information is contained. This information is used to geocode and deliver the information requested (7) and later the results are sent to the application server (8) for a last processing and manipulation of formats. Finally, the response is sent back to the wireless user in a format supported by this device (9).

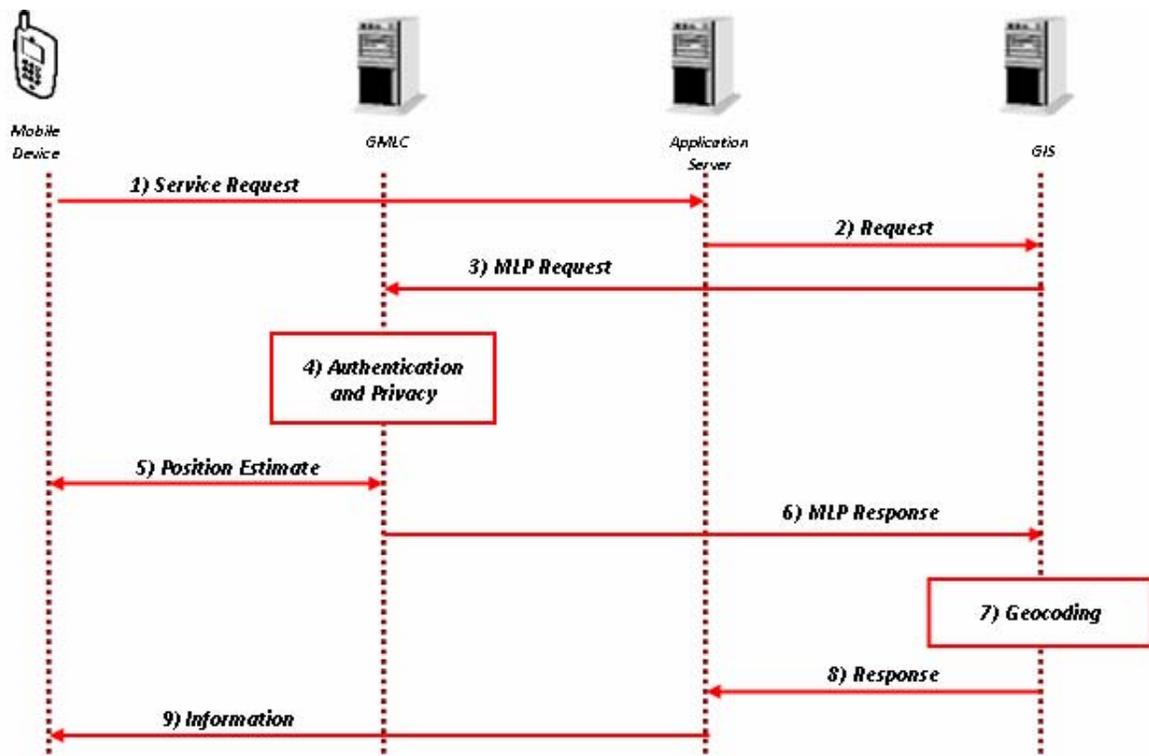


Figure 23: Position determination procedure

According to Faggion (2006), the current GMLC can communicate with different location server from different technologies, like cellular networks (our case), Bluetooth and WLAN. It can also use databases containing users' profiles and exchange the position data to GIS servers using a protocol known as MLP. On the other hand, there is another protocol used to locate the users inside the network of the provider known as SUPL.

3.3.2.1 Mobile Location Protocol

The mobile location protocol or MLP (Tipper, 2007) is an example of an application level mechanism used by a location services client to obtain position information about a MS from a location server (such as the MPC or GMLC). This protocol can also be used for emergency services. The goal of the MLP specification was to develop standard methods (using XML) for Internet applications to obtain position information from cellular network entities.

The purpose of Mobile Location Protocol is to deliver a simple and secure access method that allows Internet applications to query location information from a wireless network, irrespective of its underlying air interface technologies and positioning methods. To achieve this goal, MLP works as an API between location server and location client (usually an application).

The location server is a logical unit, which means that the actual implementations vary from GMLC (Gateway Mobile Location Center in GSM/UMTS) to MPC (Mobile Positioning Center standardized by ANSI). (Koskela, 2005)

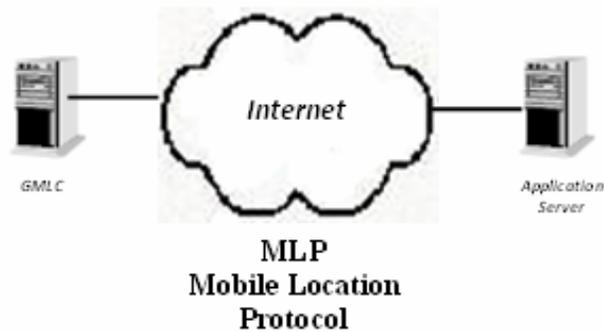


Figure 24: Interaction between application server and GMLC

The way the MLP operates (Tipper, 2007) is fairly simple. An LCS client requests position information from a location service using an MLP request, which may, for example, be transported using XML in HTTP and SSL. The location request is an XML document that could include the MS's identification in either the North American mobile identification number format or the GSM mobile subscriber identifier format, the age of the position information, the response time, and accuracy. The response from the location server is also delivered to the LCS client using MLP. The location response is also an XML document, which provides information such as the accuracy, response time, and so on.

MLP is based on well-known Internet technologies, such as HTTP/1.1, SSL/TLS and XML. MLP is an XML interface that enables communication between location-based services and location infrastructure. Because MLP includes the user ID and password as clear text in the MLP header, it is standard practice to use SSL or VPNs for security. Supporting MLP is important as it ensures the widest possible compatibility in the industry. (Koskela, 2005)

3.4 Messaging Architecture

Cell phones were originally created for communicating persons wirelessly transmitting just voice; however, through time these communications networks have been developed to offer customers diverse facilities to improve the way they communicate.

The first value-added service integrated in cell phones was the message exchange among users, that's why current cell technologies are able to send and receive short messages in mobile terminals.

This service is named SMS (Short Message Service) which can be accessed from any cell phone. Nomadic users can send these messages using their phones and the phone number of the person they want to communicate to, but with some equipment adapted to current cell networks. A basic architecture is as follows:

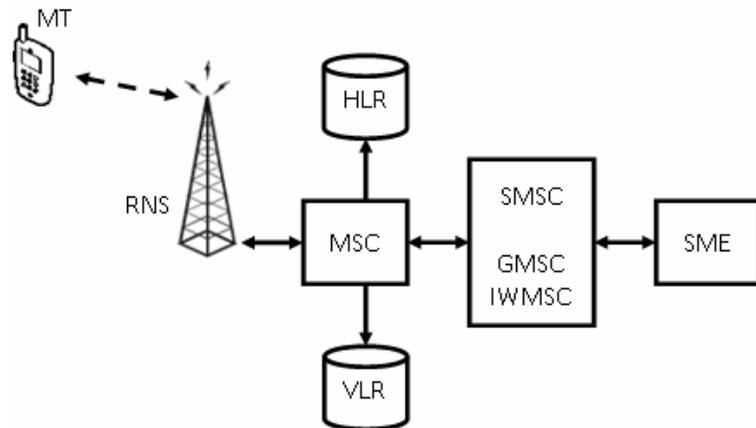


Figure 25: SMS Architecture

In the instance that a SMS need to be sent using cellular networks the procedures is shown on Figure 26 and explained below it.

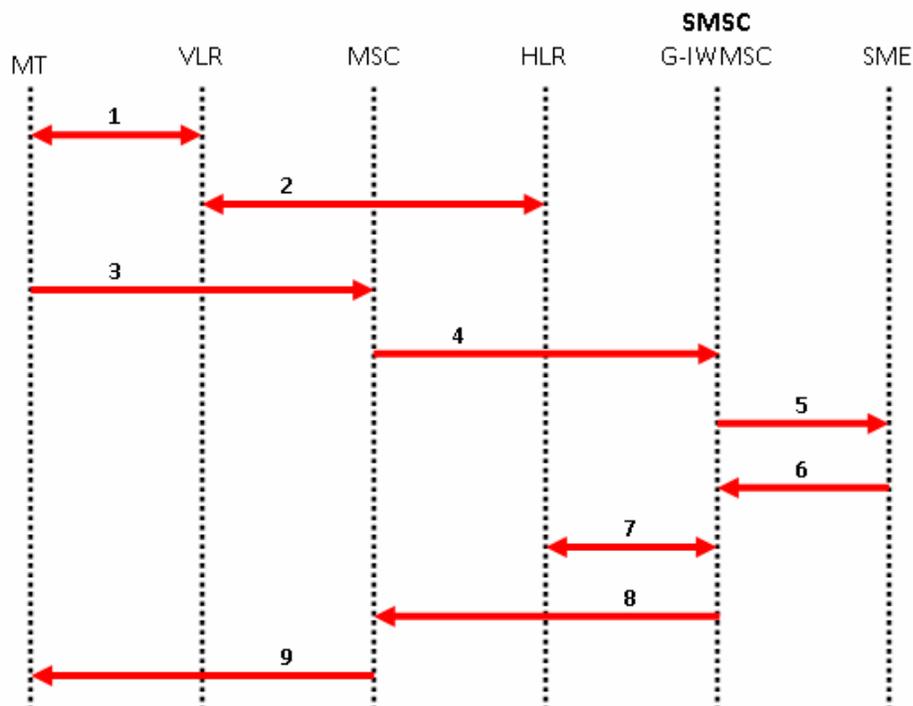


Figure 26: SMS System Functioning

The system as a complete entity needs to do the following tasks to do what is necessary in these procedures:

1. MT asks authentication to the service provider's VLR which registers its position in the database.
2. VLR informs the HLR about the current position of the MT, so the network provider knows where to send messages in return.

3. MT sends a message which is received by the MSC.
4. MSC sends it to the SMSC who will be in charge to store it and forward it to the correct destination.
5. SMSC identifies that the message needs to be routed to the ESME in charge to respond the message to make the MT capable to download the application using its WAP portal.
6. ESME responds to request and sends a message back to the MT source containing a link to download and install application, the SMSC stores this message after send it back to destination phone.
7. SMSC uses its two functionalities to know where to send the message it has stored, the GMSC detects if destination source in inside the network, otherwise, IWMSC routes where it belongs.
8. SMSC receives the message from the ESME and switch it to the MSC source.
9. MSC identifies destination user and switch it back to it.

3.4.1 SMSC – Short Message Service Center

ADC Telecommunication (1999) explains that the SMSC is responsible for the relying and store and forwarding of a short message between an SME and a mobile station using the information stored in the VLR and HLR to route it. This device has two functionalities known as the SMS-GMSC and the SMS-IWMSC that are typically integrated with it. The configuration of this device is a crucial part of the complete solution.

ADC Telecommunication (1999) says that the SMS gateway MSC (SMS-GMSC) is an MSC capable of receiving a short message from an SMSC, interrogating a home location register (HLR) for routing information, and delivering the short message to the MSC of the recipient mobile station, it means, inside the same network where the message is originated. This device can route messages to several MSC inside the network provider coverage.

The SMS Interworking MSC (SMS-IWMSC) (ADC Telecommunication, 1999) is an MSC capable of receiving a short message from the mobile network and submitting it to the appropriate SMSC outside the network where the message was originated. This can be used to reach users from subscribed to different service providers.

3.4.1.1 Short Message Peer-to-Peer Protocol

One of the most important protocols related to the platform is the SMPP. This protocol was defined to establish communication between an ESME and the SMSC and vice versa using this application protocol at the same time with the TCP/IP to reach both sides. This is shown in the next picture.

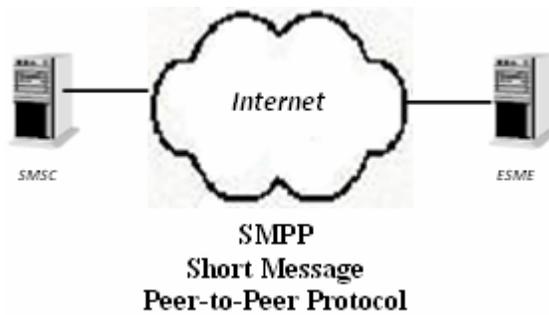


Figure 27: Interaction between ESME and SMSC

This protocol (3GPP Group, 1999) defines a series of different messages dividing them into two classes: SMSC to ESME and ESME to SMSC. In the first group there are only three of interests, and these are:

- **submit_sm_resp**
 - Response indicating that a short message has been accepted successfully or not. Messages submitted with this command id will include the status indicating success or failure of the corresponding "submit_sm".
- **submit_multi_resp**
 - Response indicating that a short message has been accepted successfully or not. Messages submitted with this command id will include the status indicating success or failure of the corresponding "submit_multi".
- **deliver_sm**
 - This command is issued by the SMSC to submit a short message to the ESME for delivery. It may also be used to return a delivery receipt for a message which had been submitted with the delivery receipt flag set.

On the other hand, we have the following ESME messages that are used to establish a communication the serving SMSC:

- **submit_sm**
 - This command is issued by the ESME to submit a short message to the SMSC for transmission to a specified subscriber.
- **submit_multi**
 - This command is issued by the ESME to submit a short message to the SMSC for transmission to a specified subscriber or Distribution List or Multiple Recipients.
- **deliver_sm_resp**
 - This command is issued by the ESME to acknowledge the receipt of a deliver_sm.

The flux of messages between both entities is continuous and it can be exemplified in the next figure. Only two messages have relative importance for the functioning of the system: deliver_sm and its response and submit_sm and its response, because on these messages the

information can be transferred from one side to another. The following figure shows a flux focusing on mobile user, because this one is responsible of asking the service.

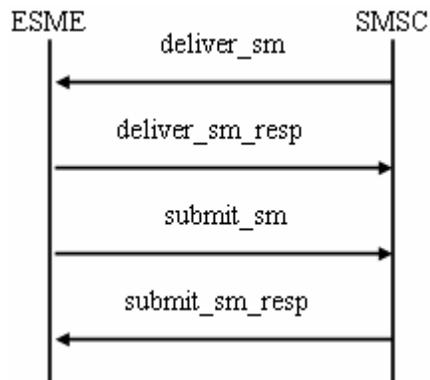


Figure 28: Message Exchange between SMSC and ESME

3.4.2 SME – Short Message Entity

A SME is an entity that can be integrated into a cellular system, especially on an SMSC, however, in some instances; a SME can be interconnected to the SMSC through an Internet connection receiving the name of “ESME” or “External Short Message Entity”.

An ESME is any entity capable to send and receive message using the protocol SMS, however, it does not mean that only can communicate with other technologies. In this work, for reasons of the standard, the platform can be considered an ESME for one of its functionalities but it can also get communications with other devices besides the SMS.

Summary

Cellular networks have certain devices with specific functionalities, and they may be divided in four groups: common architecture, data transference, positioning, and messaging. The common architecture devices are those in charge of the elementary functionalities like connection, mobility and service provisioning such as: MT, UTRAN, RNS, RNC and MSC, and their databases where users are registered, the HLR and the VLR. Control devices like EIR and AuC are considered in this group as well.

The data transference elements are used for provisioning data connections to users. These devices make possible to get in the internet and have access to some functionalities that need internet connections and data transference. They provide not only connectivity, but also the resources to adapt the information format to the capabilities of the mobile device. The positioning elements are those in charge to calculate the coordinates of mobile users, all this after knowing where the users are connected with the help of the common architecture. Positioning algorithms are

stored in these elements, especially in the SMLC and they have a direct interaction with the application server to provide a service based on positioning and location.

The messaging elements are used to exchange short messages among mobile users. They can also be used to deliver information through messages directly to the mobile devices using SMS. Finally, we need to make clear that all these elements get certain interaction with the application server and they can communicate directly using specific application protocols that use the Internet Protocol as a transporter, allowing offering the service remotely.

As we mentioned before, cellular networks are very well positioned in the wireless communications market and attend a quite considerable quantity of customers, domestically and internationally, who have access to this communication way. Therefore, multiple companies have invested to integrate complete networks and decrease prices to attract more clients continuously. Adding extra services help companies to obtain extra incomes and keep balance of their assets. These services try to attract clients while they increase the sensation of value perceived by users.

Every element mentioned above is crucial for any service provider. Knowing their functional procedures is useful to develop functional capabilities inside the platform. The way they communicate and work give the opportunity to develop a remote service-provider platform using IP connections only. Besides, the cellular network architecture of interest is based on GSM and all the specifications and details explained were based on this kind of wireless network. This is because it is one of the cellular architectures with high market penetration and highly developed.

All services, LBS included, are founded over technological platforms that connect to communications networks to reach users. So, this work is focused on finding those technological elements necessary to deploy a platform that can process geographical information to deliver information services. These services may be used by cellular network clients for first instance, but at the same time, we focus on being prepared for the future. In order to be prepared to the future, a design of a platform must consider the changes that are around the corner and be able for these changes, especially those involved in the convergence trend toward IP-based networks.

Chapter 4: IP-Based Networks

Preface

We mentioned before that today's networks are becoming closer and closer everyday and most of them are seen as complementary to the rest. They are beginning to converge into a common communication backbone: the internet protocol. Voice, data and video are some of the traditional services that can be transported from side to side using this protocol. This is why, in this chapter, we try to explain some of these changes that may have an impact over the design of the platform to offer services through wireless networks.

4.1 The background of the convergence of the networks

The Internet, as Odlyzko (2000) said, is the latest in a long succession of communication technologies. Leiner (2003) explained that Internet was based on the idea that there would be multiple independent networks of rather arbitrary design, beginning with the ARPANET as the pioneering packet switching network, but soon to include packet satellite networks, ground-based packet radio networks and other networks. The Internet as we now know it embodies a key underlying technical idea, namely that of open architecture networking.

Besides, Leiner (2003) thought and believed that the Internet has revolutionized the computer and communications world like nothing before. The invention of the telegraph, telephone, radio, and computer set the stage for this unprecedented integration of capabilities. The Internet is at once a worldwide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals and their computers without regard for geographic location.

The Internet is widely predicted to produce "digital convergence," in which computing, communications, and broadcasting all merge into a single stream of discrete bits carried on the same ubiquitous network (Odlyzko, 2000).

New technologies have often facilitated changes, but they were seldom the sole factors. Precise predictions have seldom been correct. Society has adopted the tools that were offered to it in a variety of often unexpected ways. The one factor that is undeniable, though, is that apparent from the tables in this section. Historically communication has been extremely highly valued. Individuals and enterprises have been devoting increasingly large fractions of their resources to it, and consuming rapidly rising volumes of it. The growth in volume of information has led to a change in how we react to it. Over the last two centuries we have moved from scarcity to surfeit. (Odlyzko, 2000)

Leiner (2003) said the Internet today is a widespread information infrastructure, the initial prototype of what is often called the National (or Global or Galactic) Information Infrastructure. Its history is complex and involves many aspects - technological, organizational, and community. And its influence reaches not only to the technical fields of computer communications but throughout society as we move toward increasing use of online tools to accomplish electronic commerce, information acquisition, and community operations.

The explosive rise of the Internet, according to Odlyzko (2000), is only the most recent chapter in a remarkable history of humanity becoming increasingly connected, the "annihilation of space and time," in a phrase going back at least to the early 19th century. The volume of messages addressed individually to each one of us has increased about a thousand-fold over the last two centuries. Much of this growth has been slow, and accomplished through the power of compounding. However, growth rates rivaling that of the Internet have been observed occasionally before, for example in the development of the telegraph. The wireless industry is experiencing similar growth even now.

One reason for the sharp increase in broadband subscribers is the growing demand for faster Internet speeds. Broadband services provide Internet connections that are at least five times faster than earlier dial-up technologies, enabling users to play online games and download music and videos, as well as share files and access information much faster and more efficiently than before (ITU, 2004).

ITU (2004) considered that following the introduction of commercial broadband services, many economies have enjoyed a continued period of growth in broadband subscriber numbers, with these numbers rising impressively since 1999. In certain markets, broadband is predicted to be one of the fastest-growing communications-based consumer services.

Broadband is increasingly regarded as a catalyst for economic success in the information economy. And more and more economies are focused on ensuring that access to broadband is both available and affordable to their population. In most economies, the availability of affordable broadband access has been driven largely by the private sector — particularly where effective competition is present in the market — and supported by government intervention (ITU, 2004).

Furthermore, Flament (1999) considered that this tendency is becoming not only in those users who have access at home, but also many users have changed their connections into mobile ones. Today's mobile communication systems are primarily designed to provide cost efficient wide area coverage for a rather limited number of users with moderate bandwidth demands.

Regardless, mobile companies have done an effort to fulfill market expectations; their evolution hasn't been as expected, especially because of high costs in deployment by companies which need to offer the service to user at high prices, resulting unaffordable for many of users. Some others previous studies have identified key limiting factors as spectrum shortage, power consumption and infrastructure costs (Flament, 1999).

Evolving 3G networks is more expensive in network investment than previous generations as they are far more complex and sensitive to poor configuration (Forge, 2004). But the reasons for slow take-off of 3G services lie not just in the barrier of network costs of a new generation of technology that the main suppliers have yet to master

The 4th Generation Technologies will integrate earlier technology such as cellular 2G, 2.5G, 3G, and WI-FI, rather than replace them. It is designed for heterogeneous network access, not just standalone mobile services. Although the technical challenges of 4G are even more daunting than 3G, whether 4G succeeds is more a politic-economic question of what it competes with than a technical one, as it rivals both fixed and mobiles network services (Forge, 2004).

In the forthcoming 4th generation era, the mobile user will expect to be able to access the same services from a variety of terminals with highly diverse characteristics (e.g. cellular phone, PDA, laptop computer) in terms of processing power, availability of persistent storage and content visualization capabilities, even preferences. These technically demanding expectations raise the need for a flexible service provisions process that accommodates these disparate concerns and undertakes all necessary interactions with the underlying network infrastructure and the application-boosting servers (Gazis, 2002).

The provision of quality of service (QoS) guarantees for user traffic streams is intrinsically bound to the application of differentiated pricing and billing schemes. Besides, to achieve mass scale deployment over millions of mobile terminals from different manufacturers and with disparate characteristics, application architectures should adopt the write “write once, run anywhere” paradigm (Gazis, 2002).

4.2 IP-based wireless networks

Li (2002) indicates that the combination of the growth of internet and the success of wireless networks births the trend: an increasing demand for wireless internet. Besides, he also emphasizes that wireless networks will evolve in 2010 into IPv6-based networks named 4G networks or 4th Generation Networks. He also points that these networks are future broadband and ubiquitous wireless networks, with high bit rate around 20Mbps to 100 Mbps.

Li (2002) also mentions that these networks will pursue to offer fully converged services and ubiquitous mobile access, to support diverse user devices and its functioning will be very autonomous and automatic and they'll be highly software dependable using mobile agents that could manage an individual user's content preferences and/or to organize and reconfiguring major elements of networks.

As it can be seen in the last picture, networks are directing to work all together and interacting one to each other. In current times, networks can work in several way using internet connections, no matter if we talk about a WIMAX network or a cellular networks, the unique difference is how much depends on internet to communicate each other. In today's networks, IPv4 is supported in many elements of the cellular networks to send voice, data and video and even location devices, on 3G networks present on the market in many countries around the globe, use it to send information to each other. This allows creating platform to offers services remotely and permits to enable the creation of diver value-adding services useful to mobile users.

Nevertheless, today's networks only interact in the core network level using IP in cellular networks, mobile devices are still using traditional signaling to send and receive information. Even though, current devices were capable to function at 100% using an IP-based connections, our technology is still on the way to support all the incredible quantity of wireless networks. Only in

Mexico, we are talking about more than 60 million cell users, 60% of population, but in countries like Japan probably we are talking about an 80 or 85% of the population. Let's imagine how many users there are all around the world.

Bravo (2004) considers that 4th generation networks are planned to satisfy: mobility, handover, paging, broadband access, etc. Most of these advantages are offered because the IETF (Bravo, 2004), a general research of 4G mobile networks, include the support for Mobile IPv6 and Hierarchical Mobile IPv6, the mobility protocols; and Thongthammachart (2003) considers that the Internet and the telecommunication networks are emerging into a unified multimedia infrastructure, and furthermore, to give chance to access all communication services easily from anywhere at any time and using any terminal.

This is why a new technology, IPv6, an evolution of IPv4, it's being deployed. IPv6, according to Li (2002) is surely the core network of the future wireless Internet infrastructure. He also mentions that IPv6 has been designed to enable high-performance, scalable Internet works that should as needed for decades. It is hard to imagine 3G networks to be exploited without the gradual introduction of IPv6. It has to be mentioned that IPv6 will mark a trend that characterizes to converge many wireless networks into the same backbone: IPv6 creating 4G networks. This is shown in Figure 29.

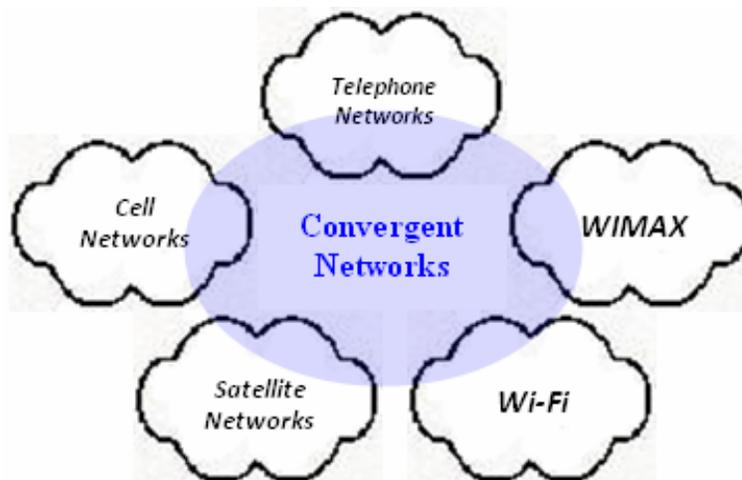


Figure 29: Convergent Networks

According to Bria (2001), the 4G networks will offer telepresence, information availability everywhere, security, mobile shopping, public and private access, multi-terminal support, and some other services.

The convergence trend and the development of internet technologies offer deployment capabilities for assuring and improving services over the Internet Protocol. Using IP, with some application protocols mentioned before, can ease the communications of entities to satisfy LBS demand remotely. Today's providers can implement GIS servers and deliver geographic information using remote connections to contact users in almost any kind of networks. Even though these parts of technologies are not completely developed, they are on their way to offer, probably in some years, complete, enhanced LBS solutions to satisfy requests. This is shown graphically on Figure 30.

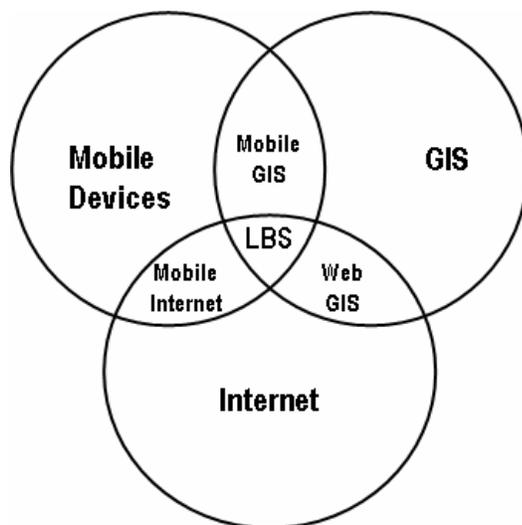


Figure 30: Convergence capabilities

In order to be prepared to support a convergence trend, the functional model proposed is based on the usage of messages defined as part of application protocols transported by the Internet Protocol. Interfaces in the platform must be ready to receive these messages and used them to afford a service in return. Besides, applications on the mobile must be also considered to guarantee the provision of useful information even though users keep moving after requesting the service. Both considerations are important to guarantee service provisioning.

4.3 General architecture overview

Even though, IP-based networks offer different capabilities, they maintain a strong similitude with traditional networks and many of their core elements remain being similar to those precedents. Paging is also a resource that can be provided by convergent networks. Announces, new networks entrance notifications and more capabilities can be done in these networks. Xie (2003) refers to the Home Agent (HA), Foreign Agent (FA) and MT as the entities involves in these procedures.

4.3.1 Mobility

According to Thongthammachart (2003), the Mobile IPv6 (MIPv6) involves that the mobile terminal identifies itself with a unique static home address' regardless of its point of attachment. The mobile terminal identifies itself with a unique static home address' regardless of its point of attachment. When the mobile terminal moves from its home network to a foreign network, a new temporary address belonging to the foreign network will be allocated, in addition to the static home address called the "care-of-address".

The current location of mobile users will be recognized by this temporary address; and the Mobile IPv6 terminals periodically send updates of their current point of attachment on the IPv6 core

network to their home network, thus the current position of mobile users will be provided automatically. This is shown on Figure 31.

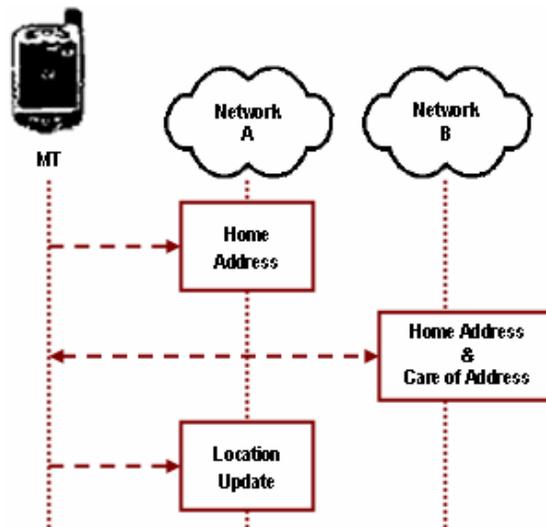


Figure 31: Mobile IP version 6 paging

As a MT is turned on, immediately the mobile connects to the closest network or to its home network. The MT registers on the Home Agent (Network A) using its default IP address and it will stay connected until the coverage area is not reachable or the mobile is turned off. When the MT moves away from its home network, the MT has to connect and look for a new network to be connected to.

Finally, when the MT finds a new network (Network B), the MT delivers its Home Address. In this case the, the Home Address is renamed as "Care of Address" and the Network B provides a new Home Address using a Foreign Agent (FA). The mobile automatically informs the new care of address to its home network and a location update takes place, helping its home network to know where its mobiles are connected to. The "Care of Address" is used to keep identified the network of origin of the mobile and keep mobility in case of service delivery and trace mobility.

4.3.2 Paging

Xie (2003) comments that this helps when packets for an MN are sent to its permanent address, i.e., its home address first. The HA intercepts all the IP packets destined to the MN and tunnels them to the serving FA of the MN. The FA decapsulates and forwards these packets to the MN.

According to Xie (2003), currently, there are three major paging protocols proposed for Mobile IP. In home agent paging, the HA acts as the paging initiator and buffers the data packets to MNs before paging. When an MN registers with its HA, it also sends a multicast address of all the FAs in its current paging area to the HA. This multicast address is used for HA to send paging requests. After receiving paging requests, all the FAs, in a paging area, broadcast paging messages to MNs in their subnets, through wireless links. The paged MN sends a paging reply to the paging

initiator through its serving FA. The HA updates the current location of the MN and forwards all the buffered packets to the MN.

In foreign agent paging the paging initiator is the registered FA, which is the FA that an MN registers with when entering a new paging area. Note that the registered FA of an MN is not necessarily to be the current serving FA of the subnet the MN is residing. The registered FA buffers data packets destined to an MN in idle mode and sends paging requests to all other FAs in the paging area.

Domain paging is a distributed paging architecture, where the paging initiator is dynamically selected from the routers along the path from the domain root router to the last serving FA of the MN. The decision of the paging initiator depends on the paging load of each router.

4.3.3 Power saving

Another issue attended in convergent networks is power saving in mobiles. This is why Xie (2003) explains that these devices are capable to be in two states: idle and active, using paging. Xie agreeing with Haverinen (2000) indicates that under Mobile IP paging, an MN is allowed to enter a power saving idle mode when it is inactive for a period of time. During the idle mode, the system knows the location of the MN with coarse accuracy defined by a paging area which is composed of several subnets.

The MN may also deactivate some of its components for energy-saving purpose. An MN in idle mode does not need to register its location when moving within a paging area. It performs location update only when it changes paging areas. When packets are destined to an MN in idle mode, they are terminated at a paging initiator. The paging initiator buffers the packets and locates the MN by sending out paging requests within the paging area. After known the exact location of the MN, i.e., the subnet where the MN is residing, the paging initiator forwards the data packets to the serving FA of the subnet and further to the MN. When an MN is in active transmission mode, it operates in the same manner as in Mobile IP and the system keeps the exact updated location information of the MN. This can be resumed in the Figure 32.

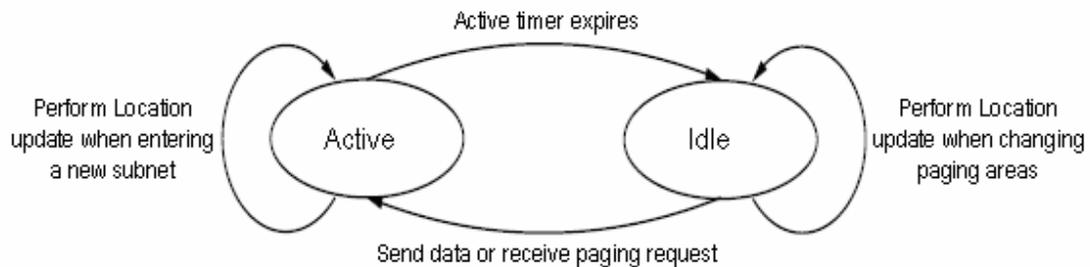


Figure 32: Idle and Active Mode Transition (Xie, 2003)

4.3.4 Roaming

Roaming is another issue very related to convergent networks, but at the same time very evolved. According to Mei (2005), basic components of LBS architecture can be transformed to service providers in Web Services. Each provider publishes the service description to UDDI business registry on UDDI server. Users or other providers discover services from marketplaces, search engines or business applications. According to the description in the business registry, they facilitate integration with each other over the Web.

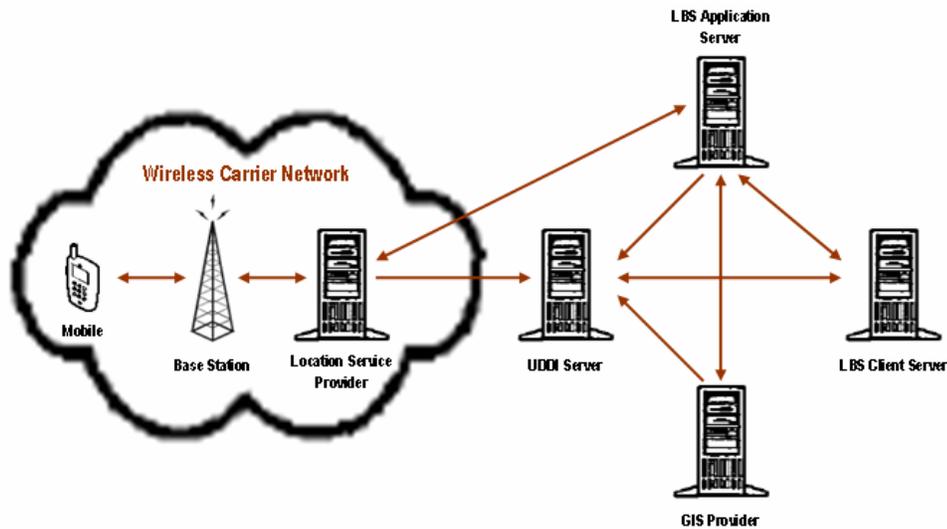


Figure 33: Network Components over Internet (Mei, 2005)

Mei (2005) also mentions that are five elements involved directly in IP-based roaming: Location Service Provider Server (LCS-PS), Geographic Information Service Provider Server (GIS-PS), Location-Based-Service Client Server (LBS-CS), Location-Based-Service Application Server (LBS-AS) and UDDI Server.

The LCS-PS (Mei, 2005) accepts requests, estimates location, and returns locations to clients. Clients specify user name, password and one or more MSIDs in positioning requests. Then, LCS server shall translate geographical location into a well-defined universal format. It is part of the wireless carrier network and may be accessed remotely. Billing issues are managed by carriers in what they name "Call Detail Record" (CDR). Privacy also lies on this server and they must considered users' privacy preferences.

Mei (2005) refers as a GIS-PS as an entity that receives search requests and returns geographical information with standardized format. After receiving requests, the provider process spatial data according to locations in the requests. The core of any GIS is a database which holds and describes spatial data.

The LBS-CS (Mei, 2005) needs to specify essential information when client applications communicate with LBS. The information includes user identity, user password and located objects. User identity and password may be stored in client's storage. The located objects are dependent on

services types. All these information are stored in client applications and automatically sent to servers when the client uses LBS.

The LBS-AS is a server where all the services are processed. This server returns back a service with valuable information according to what users requested. The logics and all the programs are loaded in this unit and the owners of these one are specialized in development of more applications.

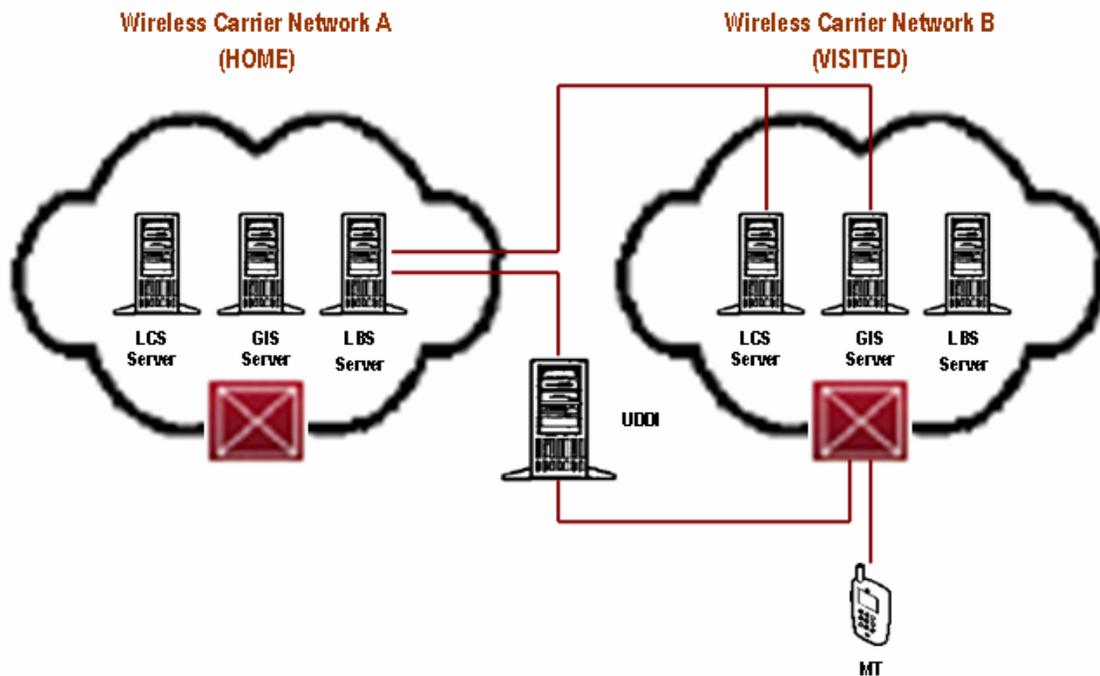


Figure 34: UDDI Server and roaming (Mei, 2005)

The UDDI server (Mei, 2005) is an entity mostly for registering and recording information from providers. Registries in this server include all of the above to allow users choose different application providers, gathering information from different networks and have an easiest access to a wide gamma of services. Users can find service providers using a portal to do it. Provider can announce the development of new applications to inform users rapidly. In abstract, an UDDI is a web directory full of registry where last elements can be announced.

The UDDI allows users receiving descriptions of their original LBS provider and have access to them no matter where they are (Figure 34). This is possible because they only need the access from other providers to access to the portal and be findable in roaming areas. The only information that has to be local is the location and geographic information that may be requested form the original LBS server to the other operator. (Mei, 2005)

4.3.5 Privacy

Privacy is another issue that concerns in convergent networks. In difference to the cellular networks which possesses specific devices in its core network to control and manage privacy, the IP networks also has them. Privacy can be managed directly with the location server or any other device focused on this issue (Thongthammachart, 2003). A similitude with cellular networks is present in convergent networks, the source of location data. Just as the cellular networks, the convergent wireless carriers are the owners of this information and of the devices responsible for measurements and calculation of the positioning information. The whole procedure can be as follows in Figure 35 (Thongthammachart, 2003).

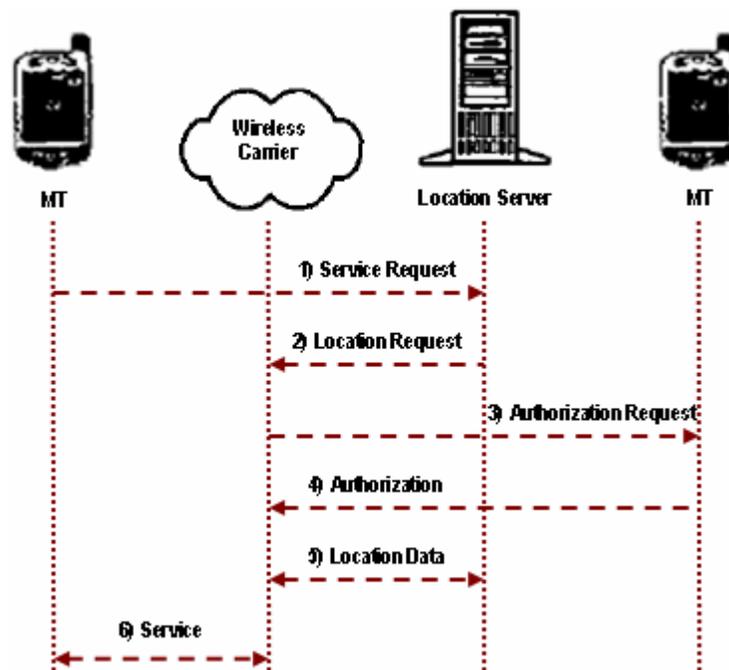


Figure 35: Privacy and positioning in convergent networks

In certain application where a person can be located by someone else, privacy is a very important concern. One example of a service like this is the Friend Finder (Schiller, 2004). An MT sends a service request to locate someone (1). The location server, after receiving the incoming request, asks for the user's privacy preferences to the carrier's wireless network (2). Before making the measures and gathers the location data from the user of interest, the network provider ask for authorization (3). When the user receives the authorization request, it depends on it to accept or reject the positioning request. In an affirmative case, the MT accepts and responds to the authorization request (4). Until then, the location data is gathered by the network and the location server and sent to the requester to provide the service. Most of the acceptances and rejections are made using specific applications residing on mobiles.

4.3.6 Positioning

Positioning initiation, information obtaining and procedures can be controlled and exchanged using a protocol named SUPL and can be considered for future development in case of getting IP-enabled networks to work in. This protocol was thought to work not only with current networks, but also, with convergent networks in the next years. This protocol can help assisting the service from side to side when an application server asks for the users' positioning information. It can form a complete system that work from the application server to the user's mobile, initiating and/or activating positioning services inside the carriers' networks. We have to consider that this protocol is based in the MLP, using its message structures for communicating.

SUPL (Secure User Plane Location) employs User Plane data bearers for transferring location information, and for carrying positioning technology-related protocols between a SET (SUPL Enabled Terminal) and the network. SUPL is considered to be an effective way of transferring location information required for computing the SET's location. The effects of deploying SUPL are mostly restricted to providing a SUPL Location Platform (SLP) and SET to support SUPL. To serve a location service to a client, considerable signaling and position information is transferred between actors such as a SET and a location server. (Open Mobile Alliance, 2007)

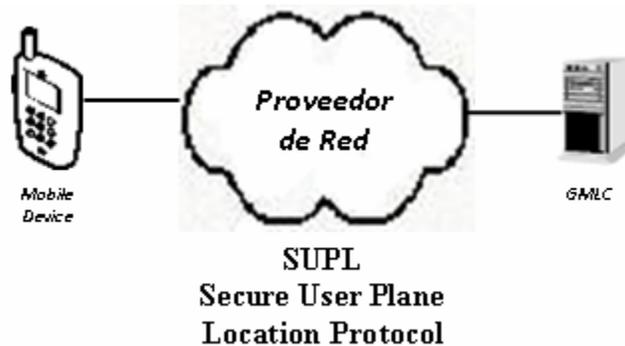


Figure 36: The SUPL Entities

The SUPL Location Platform functionality is within the GMLC, which is the Location Server defined in GSM and UMTS, and the MPC, which is defined in ANSI standards. Since the SUPL Location Platform should be regarded as a logical entity, other implementations are possible (Open Mobile Alliance, 2007).

The SUPL was designed to do the following services: immediate location service (LCS) for commercial services or emergency services, deferred location service (after the request) and periodic location services for keeping location information always updated. This protocol has the faculty to be able to be initiated by network or set (SUPL Enable Terminal). (Open Mobile Alliance, 2007)

This protocol requires small changes in terminal and most of its positioning information is calculated and based on mobile-based technologies. IP connections are necessary for its functioning; however it supports current, traditional networks for transferring information in case of a SUPL Network Initiated Service, the SUPL network starts the SUPL transaction by using one of the

following methods: WAP Push Access Protocol (PAP) or SMS directly. This protocol is used to create entire platform for service provisioning which are formed of (Open Mobile Alliance, 2007):

- SUPL Location Center (SLC) that coordinates the operations of SUPL in the network and performs the following functions as it interacts with the SUPL Enabled Terminal (SET) over User Plane bearer: privacy, initiation, security, roaming, charging, and service management.
- SUPL Positioning Center in charge of positioning calculation.

4.4 IP-based core network elements

Bravo (2004) mentions that the key elements in MIP (Mobile IP) location developed by Geopriv Working Group of IETF are:

- Location Generator (LG) – obtains the user's location, creates the LO and publish it.
- Location Server (LS) – receives announcements and subscriptions requests from LBS clients. Applies rules to the received LO and sends it to the appropriate clients.
- Location Receiver (LR) – the client receiving the Location Object.
- Rules Holder (RH) – maintains the rules for reception, filtering and distribution of location objects.

However, Bravo (2004) mentions that an IP-based core network for LBS provisioning must be integrated by an Location Service Server (LSC-S), a Position Determination Entity (PDE), a Location Management Unit (LMU), Authentication and Authorization entity (AAA), mobility management nodes (HA – Home Agent, PA – Paging Agent and MAP – Mobility Anchor Point), the radio Gateway and mobile stations.

Bravo (2004) mentions that Location Services Server (LSC-S) is responsible to communicate with clients through a standard interface, with the ability to manage them. It attends Mobile Station's request to location and announces services to the MS and Positioning Elements, and lies on information delivered by the AAA to proceed to attend requests. The AAA (Authentication and Authorization) manages user profiles in a database in order to provide authentication and authorization Information to the LCS-S. The information contained in this database is similar to that in the HLR in the cellular networks.

PDE or Position Determination Entity is responsible to calculate position using positioning algorithms based on measurements taken by the MS and LMU (Location Management Unit). It also exchanges location information keeping communication with MS using SLP. It announces location methods supported by the network. Another unit that works together with this unit is the LMU. The LMU or Location Management Unit is responsible to measure signal parameters over the radio interface to deliver to PDE enough position estimation data to calculate an accurate position (Bravo, 2004).

Meanwhile, Bravo (2004) defines the core elements in the network as the mobility nodes explained before: Home Agent (HA), Mobility Anchor Point (MAP) and Paging Agent (PA). The HA and MAP direct messages to the users using the MIPv6 (Mobile IP version 6). They also are in

charge of requesting paging the mobile to make them change their state from idle to active if that is the case.

Finally, Bravo (2004) indicates that the Radio Gateway contains the Base Station functions and Access Router (AR) over IP to direct the messages to the appropriate users. It also enlists announcements of the LCS-S and PDE. The Mobile Station coordinates requests in the network serving as a bridge between LCS-S (core network) and PDE (RAN).

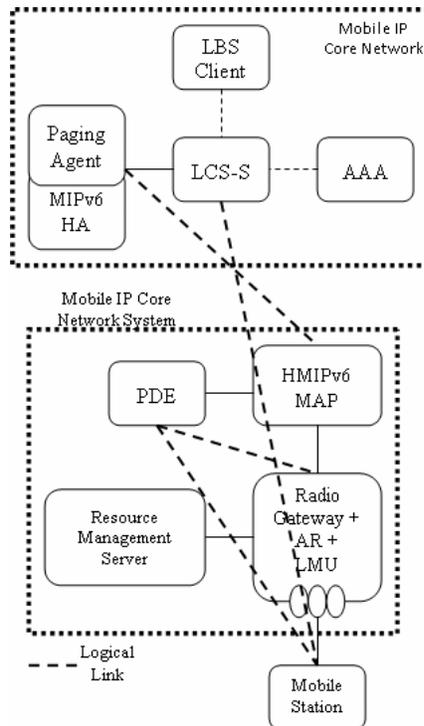


Figure 37: IP-based position location determination architecture (Bravo, 2004)

Summary

Today's networks are characterized by evolving phenomenally fast. Recent technologies in domestic markets such as internet are making big changes and giving good advantages for the development and evolution of new technologies.

One of these core technologies is the IPv4 which has created more services than any other technologies in the past. However, this has created the need to make it evolve to allow more services and functionalities to the World Wide Web. IP has allowed integrating communications and reduce costs for providers and the opportunities to create more services to reach an increasing, demanding market, whose broadband connections with new services are present on the market.

It is considered that in the future, our communications technologies will evolve in a way that their backbone will be an IP technology. Even today, mostly wireless technologies, they use it to reach sides in the communications networks and communicate devices inside the core using application protocols to do it. However, this will change because companies are considering doing

this, even at the user level and making the mobile device to be totally IP-based to establish communications.

IP-based networks offers advantages such as improvement in mobility and diversification of services, nevertheless, they are similar in functioning and capabilities with traditional networks at some level, mostly pricing, which is relatively lower. They offer mobility management schemes, roaming and other capabilities that unify communications and allow users to have access to their services in a more friendly way than before. Moreover, advantages of the roaming in IP-based networks are considerable. Complex platforms can be conceived without being connected directly one to each other. Every component mentioned above can be an entity separated with the capabilities of interacting remotely and being part of different providers which in any case, might be specialized in what they own.

Besides, convergent networks will remain sharing an issue to make customers confident: owning the location and positioning information of customers. This creates an environment of reliance and trust to the carrier and the satisfaction of clients that see this as good and positive.

Chapter 5: Technological Platform Proposed

Preface

Development in wireless networks can be increased by adding services. These services must satisfy clients' needs and add value to the carriers' networks. Current technological development help carrier choosing whether to invest in developing these services in home, however, they decide to get helped by the obtained expertise by service providers. Service providers develop platform with specific capabilities to process information. This information processed is used to deliver a service back to user using carriers' networks.

These service providers focus on platform deployments which are capable to deliver value-added services (VAS) to customer of wireless carriers. We explained how the IP-based networks and cellular networks work, but in this chapter we explain a specific architecture and its elements.

The platform needs interaction with the wireless networks and the development of this platform was focused on cellular networks. Moreover, it does not mean that the development of the platform doesn't consider the interaction with IP-based networks.

The elements of the platform are thought to work based on internet connections and identify and used application protocols to communicate with wireless networks, allowing creating an environment for further applications development in 4th Generation Networks.

5.1 Value-Added Services

A value-added service (VAS) is a term used in Information Technologies to classify every service that can be offered to users to increase the value delivered and perceived of the carrier's networks. The VAS can be developed adding elements inside the carriers' networks or remotely through the creation of technological platforms. The VAS have the following characteristics (mobileIN.com, 2004):

- Add value total service offering
- Stand alone in terms of profitability and/or stimulates incremental demand for core service(s)
- Can sometimes stand alone operationally
- Does not cannibalize basic service unless clearly favorable
- Can be an add-on to basic service, and as such, may be sold at a premium price
- Can be deployed in-home or remotely.

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- Can create a differentiation among carriers, which is perceived by users.

Current wireless networks use a lot of VAS in their offer of services. One of the first was the SMS, however, roaming, push-to-talk, call management, location sensitive billing, mobile data services (location-based services included) can be classified as VAS as well.

These services are the focus of this work because they contain the LBS. Besides, mobile data services are utilized to obtain information, content, and to perform transactions. All of these activities are more meaningful if they are tailored to the individual. Location-based services add value by way of putting the data into a location context for the user and allow personal profiles further enhance the value through Personalization (mobileIN.com, 2004). Location-Based Services are classified as mobile data services because:

- Stand-alone,
- Can be offered at a premium price,
- Provide differentiation,
- Can coexist with the rest of the services
- Can used some common elements to reach users,
- And, consist of the transfer of information.

These services as many other can be classified into categories. There are currently two types of VAS (mobileIN.com, 2004):

- **Stand-alone services** – are those value-added services that stand alone from an operational perspective. These types of services need not be coupled with other services, but they can be. Many non-voice services fall into this category. They are often provided as an optional service along with voice services, but they could be offered and used by themselves without the voice service. For example, SMS could be offered and used as a service without voice calling.
- **Not-stand-alone services** – are more numerous and important type of VAS, are those services that do not stand-alone. Instead, this category adds value to existing services. While it seems implicit in the definition of value-added, this is an important principle that makes value-added services stand apart from other services.

The development of VAS platform is thanks to the increasing development of the Internet on one side, and in the other side, the increasing deployment effort for institutions like the OGC (Open GIS Consortium), the LIF (Location Interoperability Forum) and the OMA (Open Mobile Alliance), for mentioning some. These organizations make standards and recommendations that providers must pay attention to achieve the development of a platform useful and compatible with the networks and technologies in the current market.

5.2 General Platform Elements

This chapter considers every element necessary for the technological platform. The main purpose is to offer VAS to customers and use its geographic information to deliver information of

Chapter 5: Technological Platform Proposed

interest. This platform is focused to work over cellular networks in order to satisfy users' requests. Figure 38 shows a general overview of the platform which will be explained in detail.

The proposed platform (see Figure 38) is formed by five elements in the side of the service provider: geographic information server, management and control server, application server, DBMS and content servers.

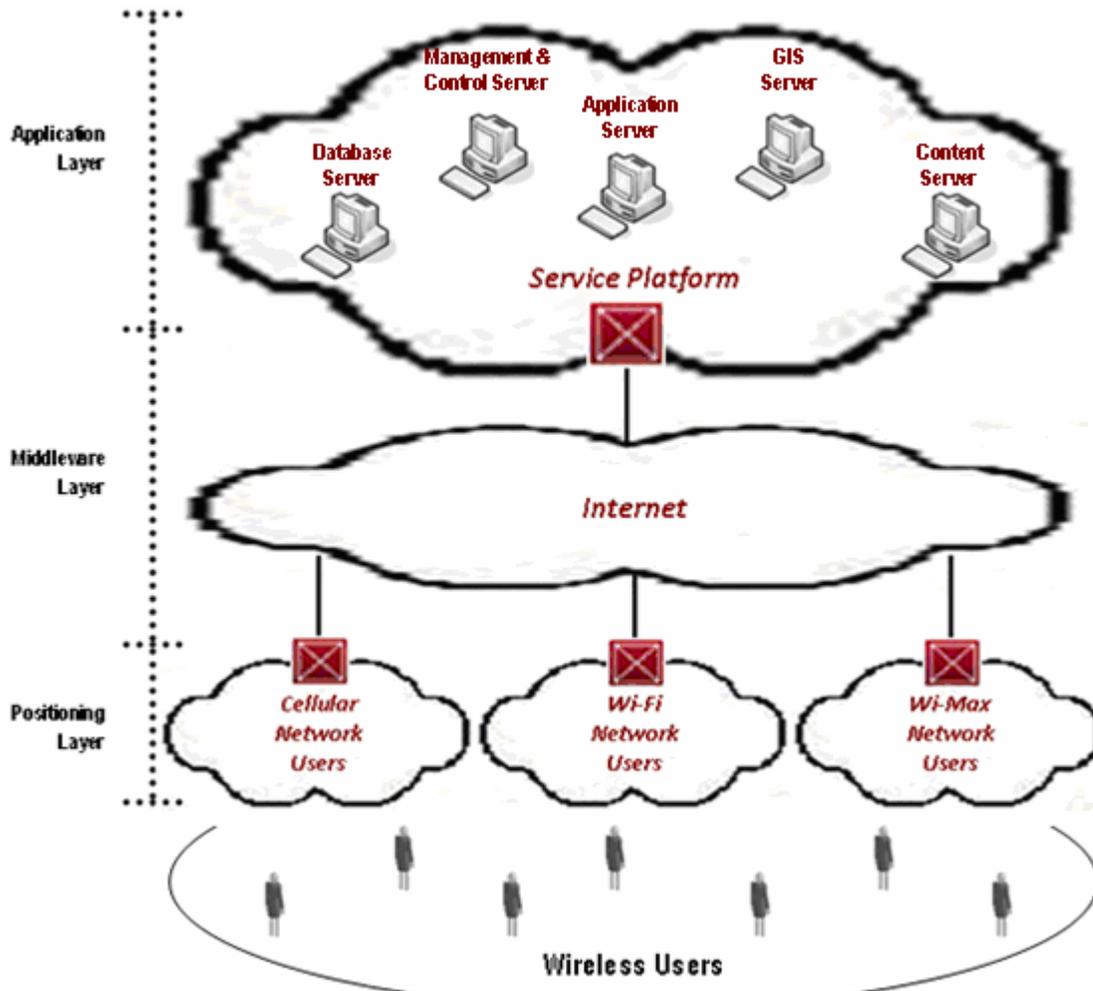


Figure 38: Architecture of the platform

Figure 38 shows a complete platform which can be divided mostly in three communications layers (Schiller, 2004): the first layer, the positioning layer comprises all the elements responsible of calculating the position of the customers and finding the location of the users in the network.

The middleware layer is the next one, which is in charge to control and comprises the elements for safety and those in charge of exchanging information. This layer guarantees security and establishes the parameters for communicating, such as connections, access policies, intruder detection, etc. Most of the time, the middleware layer resides on the carrier's network, but some control devices (firewalls, control and management servers) can also be integrated in LBS platform to make a more secure link.

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Finally, the application layer comprises all the services created in platform server to satisfy the service provisioning after the request and obtaining the required information for doing it. This part is the focus of this work which, in following chapters, will be explained in detail.

After surveying wireless technologies of interest, we have to define key elements in consideration of the platform. Every LBS platform is formed by five primary elements: DBMS, LBS Applications, Content Providers, Geographic Information Systems and Management and Control Servers.

DBMS, "Database Management Systems" (Blazewicz, 2003) are large shared data banks stored in a SAN (Storage Area Networks). This information is crucial for the functioning of the platform because it will contain all the information necessary to attend requests when required. The main difference between the database server and the content server is the kind of information both server have. The Content Server is geographical information such as maps, places of interest and some other reference points to establish a connection between the users' coordinates and the place where they are. On the other hand, the Database server stores all the personal information about users, like profile, preferences, background, etc.

A LBS application architecture is a complex issue that will receive request via WAP, SMS or HTTP. The platform possesses different interfaces to receive requests and to send responses. This ability make the platform become an ESME o "External Short Message Entities" when is capable to receive short messages. An ESME possesses a number registered on the SMSC (Short Message Service Center) of the network provider, (see section 3.4.2) which is capable of receiving, processing and sending back messages with information. But also, it can have interfaces to support WEB and WAP that help to offer the service as well to cell phone users as PC and PDA users.

As we can see, the platform basis of communication lies on internet connections and probably this one of the best way to reach users because of the convergence trend present in current days. Besides, according to Crane (2005) services must be available to the user via any access network, be it 3G, WLAN or WIMAX; and services must be available on any device from a mobile telephone, PDA or PC.

5.3 Architectural principles

As we mentioned before, the core platform is planned to satisfy different kind of users. This is possible because in the present, wireless service providers are being capable to offer services using the TCP/IP protocol and in their network contain gateways capable to interconnect them with the Worldwide Network. Even though this is possible and according to the focus of this work, IP is not seen as a final solution but as an ally and complementary resource to send and receive request from users. This is because cellular networks are still on the way to be totally deployed as IP-based networks but the core platform, being IP-based, in the future may be capable to attend end-to-end IP-based services, like those in WIFI or WIMAX.

Another point of interest is that, in any case, the three networks mentioned above are wireless. Wireless network are increasing its number of users in current days. Even more, in Mexico, cell phone users are three times more than PSTN users in just ten years and this trend is similar in

several countries in the world, so this is why a platform to interact with these networks are demanding.

The platform, as we will define next, has a main focus which is to attend requests using SMS, HTTP and WAP interfaces to communicate to users in cellular networks. The applications are focused on position and location determination will be provided by network carriers and processed by geoinformation servers. Furthermore, information is crucial in the platform so DBMS platform are another resource which must interact with the API server, because being informed with high-valued information is what a customer might be interested in.

IT technologies are based on international standard for compatibility compliance in order to have a flexible platform to be compatible to providers and technology suppliers which follow these regulations. An example of this is to have WAP or SMS interfaces to receive the request which work with SMPP or WAP protocols, normalized worldwide.

5.4 Platform elements

The Remote Service Assistance Platform will be contained in a server named RESAP Server (RESAPS). The RESAPS is based on the work of Zhang (2003) and Spanoudakis (2004) for being considered two optimal architectures for the platform; however more new features were added to increase the advantages as offering LBS to customers. Refer to Figure 39 whose arrows indicate flows of information.

This work adds an element crucial to the monitoring of the provisioning of the requests centered on the CCU (Central Controller Unit), changes in the RM (Request Module) to create the requirements and make changes for creating a processing environment, and the interaction between the platform server and a server named Management and Control Server (MCS), in charge of controlling the information flow and data storage.

This platform was developed with the purpose to be one that may satisfy diverse kind of LBS in the future, and be compatible to any wireless existing network. This platform is different from others because it introduces the development of two elements inside the application server and the improvement of a third. Further explanation of new features and comparison is given on section 5.7.

One of these elements is a part known as CCU or "Central Control Unit" responsible to monitor and control the flow of information inside the application server. It also checks processes and interaction among entities of the server. Moreover, the CCU creates users' preference profile storing them in databases outside the application server by sending the information in small messages based on an xml language.

On the other side, the SEE, in difference to other platforms, integrates a specific client to get information from an outside server known as MCS, plus a GIS client to geocode information. These two elements are considered to create a reliable, advanced platform to offer LBS to users in mobile networks.

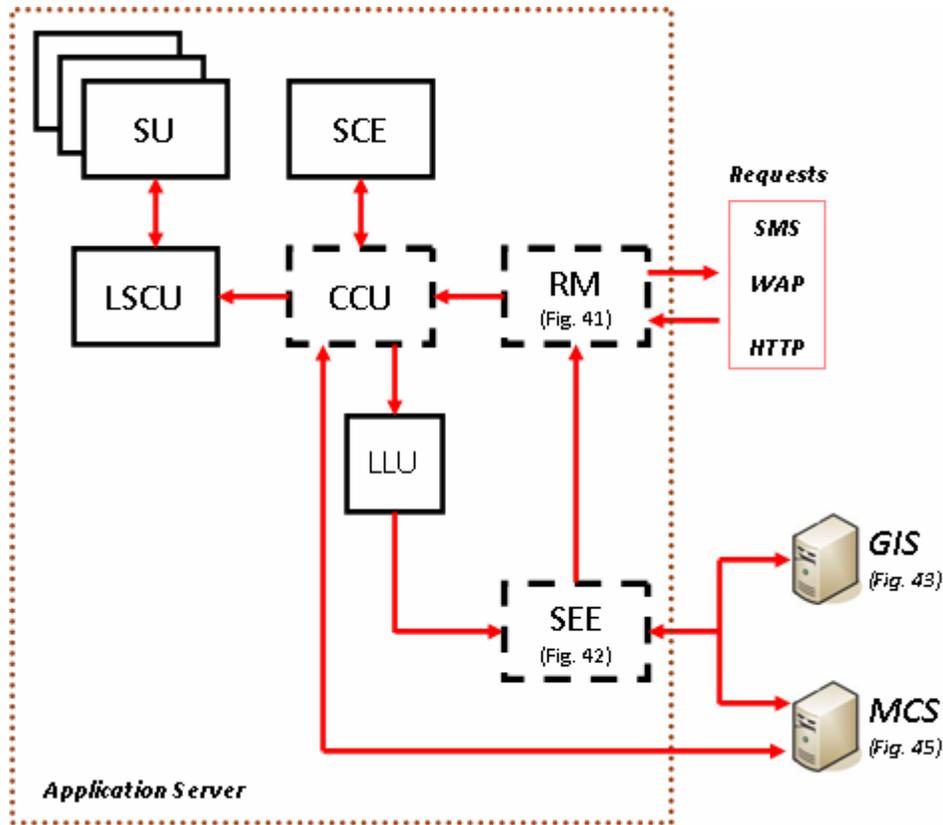


Figure 39: Elements of the core of the platform

As we mentioned before, a platform requires a central server to process the information and complete the incoming requests to deliver information, however, this platform lays on the information gathered, stored and managed by carriers and their technologies supported in their networks. Further explanation is given on section 2.4 and with Figure 4.

We saw before that Steiniger mentioned some technological elements for such a platform. These elements are considered in different ways. Then, diverse mobile devices are considered according to the kind of request message they can send, be it a WAP, SMS or HTTP structured message. Those messages can be transported using the Internet Protocol to reach sides, to send and deliver the service in certain level in wireless networks of the carrier.

The design was founded on the idea that carriers own the position and location information, so a specialized server named MCS is responsible to gather and request this information to the carrier when required. Such information is stored in inner databases and can be accessed to process requests and attend to user's demands. We have to remark that the functioning of the platform is activated after receiving request messages which are structured according to standardized application protocols. These protocols define datagrams or messages structured that can be interpreted by the application server after some adaptations to be understood inside the platform.

The most recommendable for a LBS platform is to be based on languages like XML and their inner protocols of communication as well. This allows taking advantage of the flexibility and capabilities allowed by XML such as manipulation of data and images at the same time. (Zhang, 2003 and Spanoudakis, 2004)

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The platform is formed by three major servers (Figure 39): Application Server (AS), Management and Control Server (MCS) and Geographic Information Server (GIS). The AS is the principal and the responsible for processing and delivering information after receiving requests. These elements of the core work based on XML-based languages and its elements are classified into two categories: service processing elements and Service Execution Environment (SEE). The Service Processing Elements include those parts for:

- Receiving requests and translating them into xml-based languages and vice versa for delivery (Request Module – RM);
- Deciding and choosing the correct procedures to attend an specific request (Logic Service Choice Unit – LSCU) and the parts that contains these logic procedures (Service Units – SU);
- Controlling and monitoring the programs and messages inside the platform (Central Controller Unit – CCU). This control allows the platform to manage resources and create users' profiles that might be stored for further usage in the future.
- Creating and manipulating the programs and logic, to adapt what it is contained in SU (Service Creation environment – SCE). This is done to satisfy every request and personalize it.
- Controlling and monitoring the loading of these programs and resources into the heart of the platform (Logic Loader Unit – LLU): the Service Execution Environment (SEE).

On the other hand, the SEE is the unit responsible to communicate with the GIS and the MCS using two different clients. These clients allow gathering information such as positioning data, user's profile and other.

As much the GIS as the MCS store information and they need Database Management Systems (DBMS which create a way to manage information in a more organized, effective way. These DBMS are defined as Object Relational for the nature of the information needed to attend Location-Based Services (LBS). The next paragraphs explain these elements in detail.

5.4.1 Core elements

The server where the core elements reside should be developed on JEE (Java Platform Enterprise Edition). The JEE is a very useful tool to create servers for LBS applications and the environment is very flexible to work using xml-based languages and manipulate data and information from different databases and outside servers to process information.

The server is the most important entity. A solution very recommendable is the use of J2EE or Java Enterprise Edition that allow creating software module to program different process and logics. The J2EE allows creating xml-based protocols as well, and controlling DBMS and interacting with external services as a GIS and DBMS.

This server is a union of applications modules denominated units whose flow of processes is controlled by Java Beans and it is very compatible with DBMS and GIS. The JEE development allows

creating XML-based protocol which are very recommendable to use in LBS platforms to support web-based services and databases, through messages created by it and based on the protocol and XML.

5.4.1.1 Service Processing Elements

The Service Processing Elements involve every unit that will determine the logic procedures to load to the SEE. The elements belonging to this classification are: Request Module, Logic Service Choice, Logic Units, Central Controller, Service Creation Environment, and Logic Loader.

Request Module

The Request Module (RM) enables the platform to receive requests and communicate with other entities of the platform to proceed to attend requests and give the appropriate response to users. It checks requests and communicates directly with the SMSC, another web server or WAP server. It is responsible to make the first analysis and directs the request to the correct entities involved in execution. It communicates with the rest of the core elements.

The Request Module obeys to the trend of convergence. The RM is capable to receive messages in WAP, HTTP or SMS format, every one of them in its own format according to the protocol. RM is formed of six parts. The first, "the Gate" (GT), is responsible to receive, store and send inside and outside the platform to change the request into languages based on xml for manipulation and check the received formats are valid.

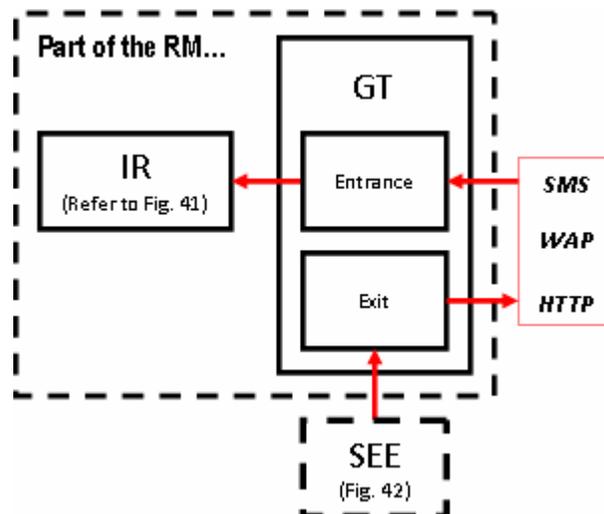


Figure 40: The Gate in the Request Module

The GT is divided in two modules (Figure 40), an Entrance and an Exit. Both modules have a buffer each for storing and creating service tails. Every service tail will be controlled by priorities defined by the application residing in the mobile and not manipulated by users. This service tail will

control the flow from and to the outside of the platform. When a message with a highest priority arrives, they will be put in the front of the tail for being attended first.

The Entrance receives from the outside and communicates with the IR for further processing. In contrary, the Exit may receive the responses processed by the SEE to final delivery to service requesters. The GT is a smart entity with classification capabilities using priorities and storing faculties to help improving the resources of the platform. This is proposed to try avoiding congestion and bottlenecks when attending the requests by the service processing elements.

The "Identifier" (IR) is responsible to receive the request from the GT and identify what logics are needed to follow to change into xml from SMS, WAP or HTTP formats. The "Compiler" (CR) and the "Sintaxis Checker" (SC) are the next entities. These units, following the logic given by the IR, are capable to change the incoming formats into xml and viceversa. In the case of an incoming request, the SC sends the results to an "Inner Sender" (IS) that transmits it to the CCU. The complete elements of the RM are shown on Figure 41.

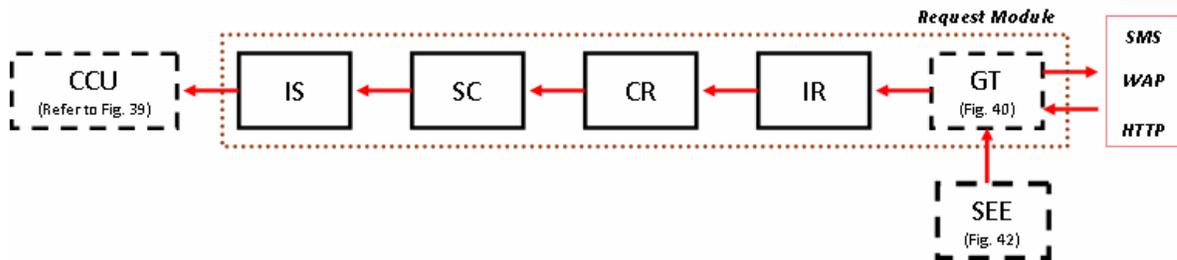


Figure 41: Components of the Request Module

The SEE sends the results to the GT and no further manipulation are taken in considerations because the SEE has the capabilities to deliver the final formats of the response which are ready for delivery to final users.

Logic Service Choice Unit

The Logic Service Choice Unit (LSCU) is responsible to decide what to do in the best logically way according to the incoming request. It analyses the xml message delivered by the CCU and detects what logic must proceed. After that, the LSCU decides what services will be loaded in the SCE and invokes processes and programs stored in the LU. In our RESAP, we have defined three different services which we will call Service Units (SU).

Service Units

The Service Units are defined as containers of the logic and procedures to attend certain requests. These units store all the logic to proceed to attend requests and follow the indications to activate the correct service, all given by the LSCU. The service units are activated when the LSCU

choices which to activate and invoke programs and processes. The SU delivers the logic contained in them to the LSCU who passes it to the CCU for delivery to the SCE for further processing.

Central Controller Unit

The CCU is proposed in order to satisfy the control requirements that a platform must have. A platform like this may be deployed to satisfy different requests of any nature; this is why the control and the flow of information inside it must be monitored. The information flows from the outside to the inside and vice versa and keeping control should guarantee the service provisioning.

The CCU may also help to identify information from requesters and allow creating profiles that may be stored in databases for further usage in automatic service provisioning circumstances in the future. This is gotten by accessing the MCS to obtain crucial information for access allowance and allow proceeding to the request attendance.

The Central Controller Unit (CCU) is the heart of the Service Processing Elements. This unit receives the request translated by the RM into XML-based language and directs it to the LSCU to detect what SU must invoke.

After the last process, the LSCU sends the programs and the logics to the CCU and this controls the flow directly to the SCE which will execute some changes and create the programs necessary for the SEE. The SCE delivers the programs to the CCU who has to take them to the LLU to proceed to the load in the SEE for the rest of the procedures.

The CCU is a unit in charge not only to control the flow of information inside the platform, but is also responsible to gather information and store it in a database to use it to create users' preference profiles for further usage in the future. The information is sent to a database server using an xml-based language supported by a database system, e.g. Oracle. This is where the interaction between the application platform and the MCS is involved in first place. Another interaction is done when the SEE has to process the request, this interaction is explained in details later.

Service Creation Environment

This entity is the responsible for the creation of service for service provider. These authors agree that a SCE must contain a Service Editor, a Service Compiler and a Code Generator.

The Service Editor receives the information from the LSCU, and creates a document based on an xml language. The Service Compiler checks the document's lexical and syntax and when it is right, the Code Generator creates a program that will be loaded by the LLU. This program as the rest of the platform is based on a Java language. (Zhang (2003) and Spanoudakis (2004))

Logic Loader Unit

The Logic Loader Unit (LLU) has the obligation to receive what the CCU has from the SCE and loading, unloading, and any process for the correct functioning of the SEE. The SEE receives all the instruction through the LLU who controls and watch for the correct execution and development of the procedures besides being the responsible to activate the SEE correctly.

5.4.1.2 Service Execution Environment

The Service Execution Environment (SEE) is every element in charge to process all the information. This unit will receive all the information from the processing elements will deliver the logic; after that, SEE will require direct interaction with the GIS through a client to exchange information and proceeding to response to request. In other words, it will unite the logic and the information in the same result, in some case. In other scenarios, the SEE will only deliver result without consulting the GIS. According to specific logic, the SEE must request position information to the GIS for several persons at the same time to let SEE do its job.

It also interacts with the MCS to obtain information related to the service like user's profile, position and location, billing and others. For doing this it requires a client that gathers this data whose process are determined by the internal logic that might be in JAVA. The SEE communicates with the RM only when it has responses to send properly to requesters.

About the delivery, the SEE has a third client only to send and receive the request and responses, the SEED or SEE Door. The SEED communicates with the LLU and the RM (IR or Identifier) to proceed to choose how to change the xml-based protocols into the delivery format requested by end users. In the RM, the CR and the SC do what it has to be done and the IS becomes and OS (Out Sender) communicating directly to the GT to deliver the requests to users.

GIS Client

The GIS Client (GISC) it is used to communicate the core with the GIS. It sends the requests coming from the SEE (Service Execution Environment) and receiving the answers of the GIS, using the OpenLS protocol to do it. (Spanoudakis, 2005)

MCS Client

The MCS Client is merely a requester. It is only activated when additional information is required for request attendance. The SEE may use this interface to request user's position to send

the information to the GIS or user's UAPProf to determine the correct format to deliver the responses and indicates to the RM.

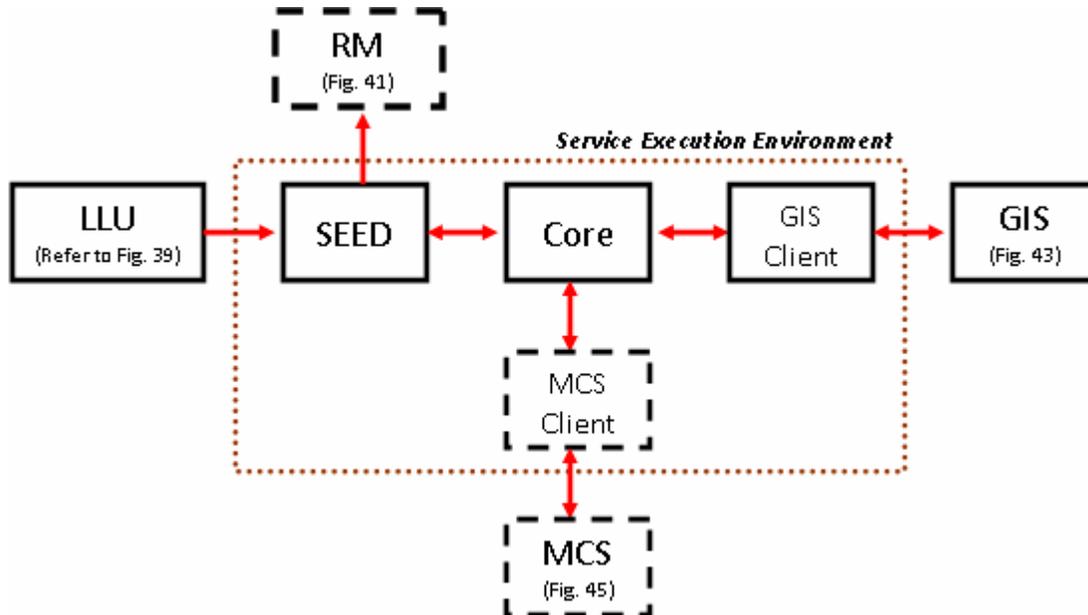


Figure 42: SEE Elements

5.4.2 Management and Control Server

Agreeing with Crane (2005), there are a few elements related to management in the platform, these element can be in a specialized server named Management and Control Server (MCS). These elements are listed next. The MCS is a server formed by a few unit described next.

Location and Positioning

It is a unit responsible to request the wireless provider to location of users if highly important in the platform in order to send it to the GIS server in the platform. This unit must connect to the GMLC, a location server in the provider network, but it also has to know who to locate to, a task that has to be delivered by the incoming request receiver interface.

Mobility

This feature may not be deployed for the time being because we are talking about a service provide to cell network users. However, it is considered for futures deployment because it is expected even cell networks evolve into IP-based-core networks in some years.

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This feature include the possibility to have interaction with an internet entity called UDDI which is a server that can be accessed though internet to see every service provider listed in the server using WAP connection or internet browsers so, users can locate their services providers and access to them without caring of the country where they are in. This, as Crane (2005) explains, opens the opportunity to develop user-centric services.

Profile

Profile refers to the idea to contain user's identities. Profiles can be contained in databases in the platform which is the case of study. Here, authorization and service level profiles are stored in a component of the platform so the platform owns the information, so, in every scenario has to query and collect information from users.

Session Control

Services in the platform are not being considered if they need to establish longing connections. Services can be dynamics and short periods are enough for the platform because it only needs to receive and send information in a fast way. However, in the future, the platform can be scalable and some other specification can be added in this feature.

Authentication

Every incoming request has to be recognized as permitted, it means that the part of the platform responsible to receives requests has to query a central database where every user will be listed and recognized. This can be possible because in the incoming messages and execution of the service, key information must be exchange between them like phone number and/or SIM information in mobile, mostly to be able to recognized users.

Connectivity resources

This is specified as a part that involves mechanism for transport policy enforcement (interaction one-to-one to network provider), firewall control, interfaces used, etc. This can make the application server become the gateway. However this part is not widely discuss in this document for not being the focus of it.

Adapter

The adapter is responsible for getting the capability of the handset just like UAPProf (User Agent Profile) defined by WAP Forum. UAPProf is mainly used to describe the capability of handset. It is also define to enable the end-to-end flow of a UAPProf between handset and the intermediate network points such as WAP Gateway and WAP Server.

A full UAPProf file describes the hardware feature, software feature, application feature and network feature. Using UAPProf, network nodes can deliver information as handset's features. This allows the platform to deliver appropriate picture created by GIS to terminal. This component communicates directly with WAP Gateway. (Zhang, 2003)

5.4.3 Geographic Information Server

A Geographical Information System (GIS) refers to the computer-based capability to manipulate geographical data (i.e. all data that has a spatial attribute associated with it). A GIS includes functions to support the operations of acquisition, compilation, storage, update, management, retrieval, presentation and analysis of data. Spatial data in the form of maps or images can be stored in vector format or raster format. All GIS data are 'geo-referenced', so that all coordinate information is in a well-defined reference framework (or 'datum'). (Dao, 2002)

Dao (2002) mentions that data in GIS is spatial, and refers to a unique location on the earth's surface – its geographical location with respect to a datum. A spatial object must have following four characteristics defined:

1. Location – it exists at a known point on the earth's surface.
2. Form – it has a geometric representation, with any geographical feature being represented by one of three basic geometric types: point, line and polygon. Points represent objects with discrete locations, lines represent directions or streets, and polygons or areas represent big places like parks.
3. Attribute – properties that describe the nature of the object. Location, height, ownership, tenants, commercial classification, and facilities are some example of attributes.
4. Spatial relationships with other objects – some basic relationships are boundary of an area, adjacent areas, distance between any two geometric objects, and distance buffer of an object.

GIS is (Spanoudakis, 2005) responsible for covering all aspects concerning visual and textual information retrieval and preparation in order to create representations (e.g., maps) for a certain area. We have to take in considerations that the proficiency of the GIS component will depend on the information on the content server, which in most cases, must be updated continuously to prevent failure and wrong information delivered to users.

The information in a GIS is a representation of the world. There are two mechanisms of how the information can be encoded: the vector model and the raster model. In the vector model, information about GIS features (points, lines, and polygons) is encoded and stored as a collection of

(x,y) coordinates. A point is represented as a single x/y combination. Depending on its path, a line is represented as two or more sets of x/y coordinates. The representation of a polygon is stored as a series of (x,y) coordinates that form a closed loop. This creates representation very much alike to real maps. (Williams, 2005)

In a raster model, data are comprised of a grid of cells covering an area. A difference with the last model is that the vector model represents a series of nodes (x/y points) interconnected by lines, which represent lines and/or the edges of a feature that is a polygonal shape. In contrast, the raster representation of the real-world figure consists of series of cells. Individual cells represent individual features in the case of a point. A series of cells represent line data. A clustering of cells represents polygonal data. Raster data modeling provides a simple data structure, which is easy to manage and requires less powerful computing equipment than vector data modeling. In addition, raster data is very compatible with various techniques for gathering data, such as the conversion of imagery to GIS data. (Williams, 2005)

In comparison, the raster model is less accurate than the vector model because the grills offer low resolution. Resolution refers to the fact that fineness of the graphic representation of data (Williams, 2005).

The GIS component implements algorithms like navigation routing and geo-coding, which render it capable of answering both simple and sophisticated requests. It is proposed to base the communication between the GIS and the core of the platform using OpenLS. The GIS can get positioning information from carriers directly communicating to the GMLC or the positioning element in the platform, specifically in the MCS. This server gets more information to process from external entities named content servers. The main functionalities of the GIS component are (Schiller, 2004):

- Geocoding and reverse geocoding – converts a street address to a latitude/longitude (x, y pair of coordinates) position. And it is also able to receive coordinates and translate them into street address to deliver it to users being placed on a map.
- Routing – calculates the optimal course, based on specific criteria, between origin and destination. Shorter paths, traffic conditions and weather status are some of the parameters taken in consideration for determining the best routes. In some cases, this functionality becomes more interactive using real-time images and voices indications to direct users to get to destination, using an application residing in the mobile device.
- Proximity searches – use POI database information to find businesses or landmarks near a specified location or coordinates of users. Gas stations, restaurants, hotels and other places are some examples of this functionality.

5.4.3.1 OpenLS

OpenGIS Location Services (OpenLS) is (Koskela, 2005) an OGC specification for a platform of open location services, known as GeoMobility Server (GMS). OpenLS defines access to GMS which consists of core services and abstract data types. The five core services that GMS offers, and the location-based applications are built on, are directory, gateway, location utility, presentation and

route services. Additionally, there is a navigation service, an enhanced route service, which is an independent specification.

Koskela (2005) mentions that every GMS uses open interfaces to access core network's positioning entity (GMLC) and provides a set of interfaces allowing applications to access the OpenLS Core Services. The GMS also provides content, such as maps, routes, addresses, POIs and traffic info. The request/response messages and associated abstract data types for the GeoMobility Server are encoded in XML for Location Services (XLS), which is a XML-based language. This author also mentions that the protocol defines two interfaces, the WFS and the WMS.

Web Feature Service

Web Feature Service (WFS) specifies interfaces for describing data manipulation operations on geographic features using HTTP as the distributed computing platform. Data manipulation operations include both query features based on spatial and non-spatial constraints (basic WFS), and the ability to create, update and delete feature instances (WFS with transactions). WFS request consists of a description of query or data transformation operations that are to be applied to one or more features. The request is generated on the client and is posted to a web feature server using HTTP. The web feature server then reads and executes the request. Web Feature Service returns GML encoded data to the client, which decides how to further process it (Koskela, 2005).

Web Map Service

In the work of Koskela (2005) explains that WMS specification standardizes the way in which maps are requested by clients and the way that servers describe their data holdings. WMS defines three operations:

- GetCapabilities: Obtain service-level metadata, which is a description of the service's information content and acceptable request parameters
- GetMap: Obtain a map image whose geospatial and dimensional parameters are well-defined. A client may specify the information to be shown on the map (one or more layers), possibly the styles of those layers, what portion of the earth is to be mapped (bounding box), the coordinate reference system to be used (SRS), the desired output format, the output size (width and height), and background transparency and color.
- GetFeatureInfo: Ask for information about particular features shown on a map.

Koskela (2005) also considers that the WMS protocol defines a simple interface for web based mapping applications, based on simple query syntax for posting a request and getting a map as a standard rudimentary picture format (GIF, PNG, SVG, etc.) in return. In this case, the Styled Layer Descriptor (SLD) is used for encoding for how the Web Map Server specification can be extended to allow user-defined symbolization of feature data.

5.4.3.2 Geography Markup Language

Geography Markup Language (GML) is an XML encoding for modeling, transport, and storage of geographic information. The GML specification defines XML Schema syntax to describe the grammar of conformant GML data instances to pick out only those schemas or schema components that apply to their needs.

GML provides different kinds of objects for describing geography including coordinate reference systems, geometry, topology, time and features. A geographic feature is an abstraction of a real world phenomenon, thus a digital representation of the real world can be thought of as a set of features. The benefits of using GML include interoperability (vast support from vendors), XML based, flexible visualization of data and effective querying capabilities. (Koskela, 2005)

The GML is easy to use and databases can be modeled in the same way. Some of the content that the GIS database may possess is as follows (Schiller, 2004):

Table 6: GIS database schema (Schiller, 2004)

Characteristic	Attribute
element	elementID, length
connection	elementID(fk), descriptive attributes
elementConnection	elementID(fk), connectionID(fk), distance
road	roadPartID(fk), roadID, partID
kilometerPost	roadPartID(fk), post
roadElement	roadPartID(fk), elementID(fk), eStart, eEnd
postElement	elementID(fk), eStart, eEnd, roadPartID(fk), post(fk), offset
node	nodeID, representationID
link	linkID, nodeIDBegin(fk), nodeIDEnd(fk), length
linkElement	linked(fk), elementID(fk), eStart, eEnd
coordinates	elementID(fk), eStart, eEnd, xStar, xEnd, yStart, yEnd, accuracy

5.4.4 Content Servers

Extra servers are necessary for managing information additional to personal information managed in the data servers. This information can be map, announces and other necessary for the functioning of the platform and some elements such as the GIS server. The DBMS can be seen as a content provider because it stores every personal data of users. Interaction with content provider is defined as being part of the same owner of the platform; however it will interact using other server with the application server.

Examples of these servers may be: Map and Driving Directions Provider (city maps, routes and destinations) and POI Providers (health clinics, hospitals, emergency centers, animal control centers, paramedics, lifeguards, police, coast patrol, and fire department, just to mention some.

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The content servers are merely database that stores information useful for the GIS so, a object-relational database is the most recommendable to implement in these servers. The GIS needs to get supported by content providers to get graphical data which interact while GIS works with the information originating of them. The three providers are:

1. POI Provider – it contains a list of every enlisted hospital, health center, clinics and every center of health service attention attached to coordinate data. Every available center needs to be recorded in this database, which we'll be interrogated by the GIS to deliver the services requested.
2. MAP Provider – it contains graphical information, including map and diverse images that can be sent to users' mobiles. Images are selected by querying interrelated fields of information by the GIS.
3. Driving Direction Provider – this service delivers information that can orient users to get to some places with the most optimal route, in order to reduce time of traveling and avoiding traffic and road problems.

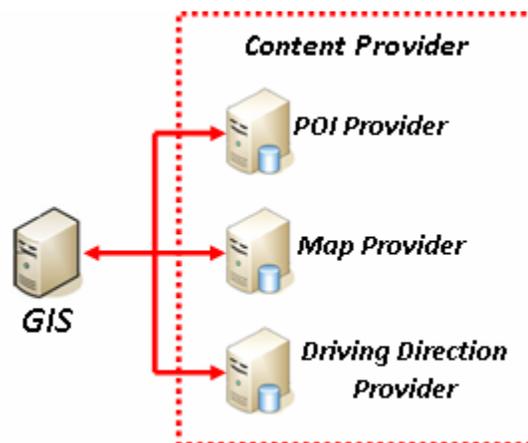


Figure 43: GIS and Content Server

In many cases, content providers are merely databases that contain information from different sources and they are available for the GIS to use them. Dao (2002) considers that Relational Database Management Systems (RDBMS) are generally used to store spatial data. However, a RDBMS is designed only for transactions involving comparatively simple data types such as characters and numeric data. Spatial data are usually complex objects that require more than one data structure to describe them, and their spatial relationships.

Dao, agreeing with Syafi'i (2000), comments that a new generation DBMS, known as the Object Relational Database Management System (ORDBMS) has been developed. The ORDBMS merges the object-oriented management system that allows the storage of complex data as objects, and the relational database management system to offer the ability to manage the relationships between objects. A Structure Query Language (SQL3) can support all database management operations, as well as object-oriented data modeling.

ORDBMS offers facilities such as user-defined data types (UDT) and user-defined functions (UDF). These enable users to store and manage complex spatial data, as an object, along with data from other sources such as CAD (Computer Aided Designs) and images in the same database. More

importantly, ORDBMS allows spatial analysis to be performed in the database server using SQL commands instead of in the application. Oracle Spatial Cartridge is an example of a spatial database that stores geometric objects as Abstract Data Types (ADT), a user-defined data type, in feature-based tables, within the RDBMS. Most LBS developers, such as AirFlash, AutoDesk, CellPoint, GeoTouch, IntelliWhere, Webraska, Xmarc, currently use Oracle to store their spatial data (Dao, 2002). Current Oracle is version 11.

5.4.5 Database Management Systems

An application platform uses information, which in most cases, is must be stored to be used in a later process for other results as reports, informs, and others. This information is stored in SAN (Storage Area Network) which are managed by DBMS (Database Management System) that can be different to those the content providers have because they can be external entities and for management applications, the service providers must consider to store some of the information used to attend past requests.

A DBMS, according to Blazewicz (2003), is a system used to store, manage, manipulate, analyze, and visualize the data in various forms such as: records, documents, scientific and business data, voice, videos and images. Following to this author, the applications of the databases are very diverse and providers can use them several application.

Referring to DBMS, the system must be capable to have several characteristics in order to satisfy systems requirements, such as: spatial data information (management of geographic and spatial data), support management of non-traditional data types such as texts or images, support the management of data types defined by users (especially if the system has an option of privacy configuration by users), OLAP capabilities, messaging option to users and web application server capabilities.

Blazewicz (2003) recommends two different database systems to satisfy these capabilities in this system: DB2 and Oracle. These DBMS were recommended by this author because of their functionalities and capabilities they allow such as supporting different kinds of information (voice, data, images, text, etc) and even manipulating information supporting XML, a tool very useful for the functioning of the entire platform.

Blazewics (2003) considers that modern database systems are mostly client server systems where a database server is responding to request coming from other clients, which can be applications servers. The service platform contents an application server which is responsible to receive and send back responses using information from the outside, the databases and some other entities as databases and content provider servers.

Blazewics (2003) indicates that a database represents the properties common to all applications but it's also independent to it, so, that's why it has to be seen as an entity separated from the platform but at the same time complementary.

Considering our platform will be web-enabled, it cannot even work properly without database support (Blazewicz, 2003). So, that's why to define its functioning as not only a web-based, database-supported platform but also an XML-based platform.

The major strength of database systems (Blazewicz, 2003) is the ability to provide fast and unprocedural concurrent access to data while ensuring reliable storage and accurate maintainability of data. Besides, this author considers that the database systems have evolved from the simple business-data processing systems that operate on well-structured traditional data such as numbers and characters strings, to more complex object-relational systems that operate on multimedia documents, videos, geographic-spatial data, time-series, voice, etc. The following picture shows how the platform is connected to the database server.

There are different kinds of database in the market; however, one of the most recommended is the relational database, what's more, on this platform we need to define our database as a relational database system (Blazewicz, 2003). According to Blazewicz agreeing with Ramakrishnam indicate that in a relational database, data are organized into table format.

However, a specialized database is required to accomplish the goals to offer a complete service. Our database, and of course of the platform itself, need to manage temporal and spatial data (because LBS need to know where to find people), and transactions with other entities. Besides object-relational systems allow defining data of vastly any type, including text, audio data, video data, images, pictures, and more recently XML; moreover they support the storage and manipulation of such data, and are hence suited for the emerging area of multimedia and Internet application.

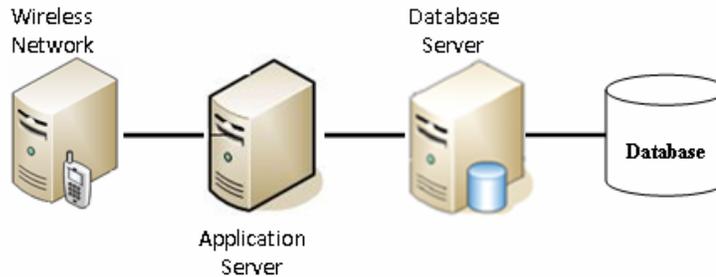


Figure 44: The platform and the database server

Just equals to the ORDBMS in the GIS, a similar DBMS might be deployed for the system. This database is related to the CCU and the MCS, meaning that the CCU may send it information to store and the MCS may request information from it to proceed attending the requests (Blazewicz, 2003)

5.4.5.1 Storage Area Network

The Storage Area Network or SAN is, as its name says, a junction of servers to store data information to be accessed using a DBMS Server that through queries sent from the application server, gathers the information and delivers it to the application server.

Following the last, it will be formed of the last tables above which will store in a SAN (Storage Area Network) and they will be accessed by the application server using queries. Between the SAN and the application server, there has to be a database server in charge to make all logical procedures to deliver correct information to the application server in certain activities.

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According to Holmes (2004), SAN were developed for situations where engineers have tended to associate long-term storage with any other component associated to processor, doing this a complex task to achieve. This is because, when more capacities of processing power or storage are imperative, buy new devices were the only solution. This is why large-scale move towards to networked storage named SANs. The last picture shows a simple but efficient SAN. It is formed by three Storage Subsystem which are mainly disks controlled by a disk controller.

The SAN switch is deployed to control accesses where two or more storage subsystems are used. Finally, the last two elements refer to the database server and the client server. The first is in charge and where the analytical machine is installed and especial software is required, such oracle and other database specialized software. The client server is where the application resides. The next picture shows the components of a SAN:

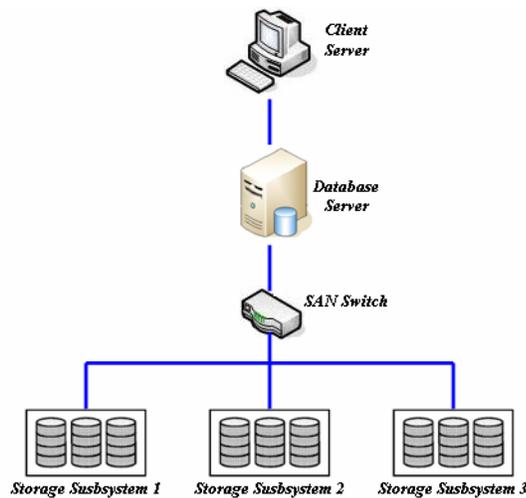


Figure 45: Storage Area Network Architecture

During operations, only the client server and the database server will be exchanging information when the client server demands information using queries compatible to the database software. The database server receives the order and proceeds to find the information in the storage subsystem aided with the SAN switch to locate the correct information in the proper disks.

Holmes (2004) signs that one of the advantages SANs offer is that extra storage can be added to the storage subsystem as it is required, making it easy to upgrade and low first investment.

5.4.5.2 RAID Architecture

As we mentioned before, SAN are very useful to store information and they are considered to be implemented in the platform because they can be security measurements to guarantee the integrity of the information.

Blazewicz (2003) on his book comments that RAID architectures are used to organize data on these disks to speed-up in processing time, especially, because quantity grows with the amount of data stored in a SAN and only if disks are uniform technically (e.g. same access times and storage

capacities). RAID means “Redundant Array Inexpensive Disks” and it permits an adaptable balance between efficiency and safety.

There are a few RAID architectures. The basic is RAID 0 where a single disk controller accesses to the disks. However, for the nature of the platform, we have to use another architecture which is also based on the last one but with different capabilities (Blazewicz, 2003). Its bases it's a parallel access with no redundancy at all. In this architecture, all data is divided in blocks and distributed in multiple disks, this is why it is called “stripping”. These strips most of the time are the size of a disk sector (CONSENSYS, 1997)

Even though RAID 0 is the basic RAID architecture, the RESAP needs security, integrity and backup only achievable with RAID 1. Blazewicz (2003) refers to RAID 1 as an architecture that uses mirror disks, so that only half of the available disks can be used for storing data, and the other half is a copy of the first. They are considered a logical disk; no matter how many we have because they are all together. Besides, they provide redundancy by writing identical copies, that's why they always must be installed in pairs.

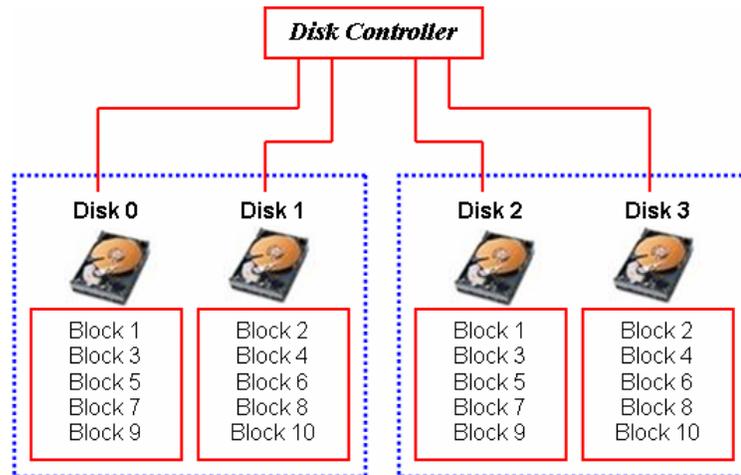


Figure 46: RAID 10

Moreover, both are very common to find in the market, and there are some combinations valid to such applications like ours. CONSENSYS (1997), a SAN and RAID provider since the eighties, mentions that RAID 10 can be used as a source to get storage disks. RAID 10 was chosen for being a correct architecture that can help improve the data storage.

According to CONSENSYS (1997), RAID 10 means the combination of RAID 0 (stripping) and RAID 1 (mirroring). Disks are mirrored in pairs for redundancy and improved performance, and then data is striped across multiple disks for maximum performance. The following diagram shows it:

5.5 Functional model

The general concept of the platform is based on an interaction model from a functional view. It is defined from two sides: the service provider with the carrier's network and the three serves that forms it. The former, is explained in details in section 5.5.2, meanwhile the latter in section 5.5.3. The

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interaction model consist as Coulouris (2002) mentions, in recognizing the elements involved in the functioning of a system, their interaction among them and specific characteristics that make them unique in their behavior alone and with the rest of the platform.

We need to consider that the interaction involves passing messages when some process does something and pass it to another process for completeness, resulting in communication and coordination (Coulouris, 2002).

Some of these elements are in the control of the platform designers but some others escape from their control because they interact but don't belong to the platform. These external entities are part of the network from cellular provider or any other wireless network provider in the market willing to consider interacting with a service provider to add value to their networks.

Returning to the interaction model, we can consider that this platform is a model where multiple servers' processes may cooperate with one another to provide a service to complete a specific task. Every element inside the platform server is a process with a specific algorithm to complete a task.

The Application Platform, being formed by few processes, it is considered a distributed system. In our specific case, its core element, the CCU, must contain a definition of steps to be taken by each of the processes that compose the system, including transmission of messages, in order to transfer information and coordinate their activity (Coulouris, 2002).

This can be seen in Figure 47 where the elements of the platform are seen as a single entity that integrates the whole functionality as one. The platform processes and delivers results in a more transparent and friendly way where the relationship with the service provider becomes direct and one to one, offering the advantage to the network's provider to be a mean of delivery and transport of information in its own infrastructure. In this model the platform is a union of servers that contain singles processes that work to achieve a goal but, functionally, they are the same entity.

A strong effort has to be focused on the CCU, however the rest entities must not be lost of sight, because the CCU can be a strong algorithm very reliable but, this core algorithm depends of the success and processing of the rest of the processes.

Interacting processes perform all of the activity in a distributed system, and one thing has to be considered that each process has its own state, consisting of the set of data that it can access and update, including variables in its program. This is private and it can be accessed or updated by any other process (Coulouris, 2002).

The CCU has to take in consideration two factors: ordering of processes and ordering or arrival. The first one is controlled entirely by the CCU which monitors the flow of information inside the platform. However, finalized processes have to be identified to help the CCU to take control of the information; this is what we call ordering of processes.

The CCU knows what to do (section 5.5.4), and the sequence of processes but identifying the completed steps can improve proficiency and create a reliable environment. The second is controlled by the GT in the RM; this control the flow inside and outside the platform receiving priorities declared by mobile users and by the SEE at the time of delivery, so, high-prioritized requests will be finalized first.

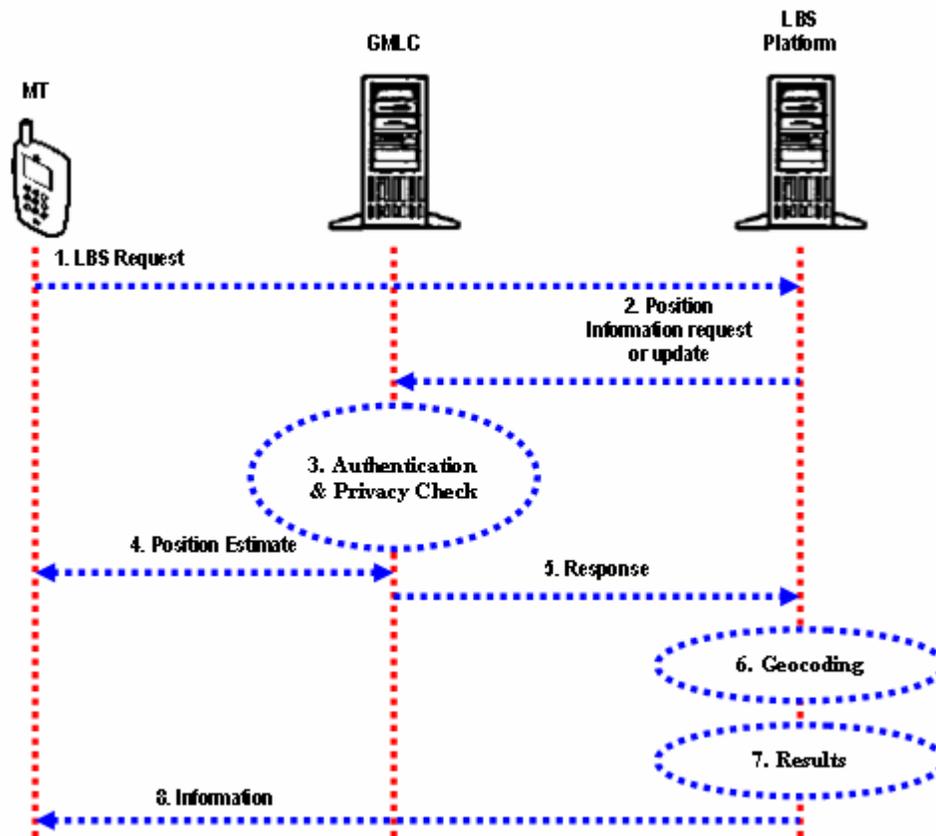


Figure 47: The LBS platform as a single functional entity

5.5.1 General features of the system

Coulouris (2002) explain that there are some challenges a platform must satisfy to be considered a solid system. One of the challenges satisfied by the platform is heterogeneity. Platform is designed to identify internally different formats of requests sent by mobile users with cellular phones or traditional web browsers with HTTP. After they're received, they are translated into formats understandable by the platform using xml-based languages to manipulate and create a standardized environment.

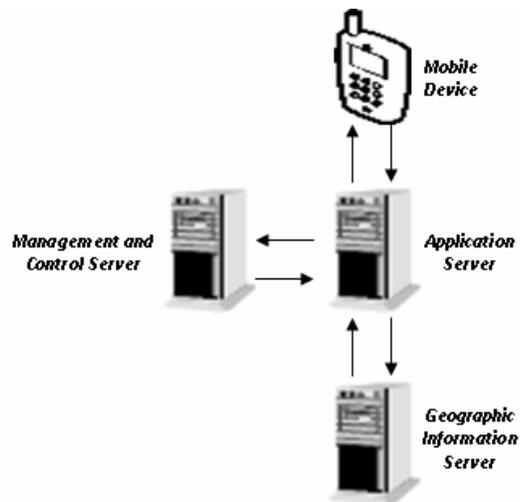


Figure 48: Service provided by multiple servers

The second, openness, is satisfied to allow the platform be extended into new services. We need to focus on the idea that the platform contains Service Units (SU), where the logics and all the procedures are stored and accessed by the LSCU when the service is identified. In this case when new services are demanded to be integrated in the platform, small logical choice decision has to be incorporated into the LSCU and the resources introduced and stored in the SU, to be able to deliver the resources to the SEE for processing the requests.

On the other side, the same occurs with the RM, especially on the IR (Identifier) and the CR (Compiler). In the former, new logics to change format into new service has to be loaded in order to allow the CR to follow the correct steps to make changes that can be used by the rest of the platform to attend a new request.

Security, on the other hand, is an issue of interest. The security lies on the mobile itself. As we know, many LBS require a residing application on the mobile devices to provide the services and enable users to have access to the service. Moreover, applications allows users to personalize with preferences what they would like to receive and when. This is where users have to decide about their security of their information. In few words, if users don't allow being located, they cannot be located in normal conditions.

On the other hand, the platform has only one interface for gathering information of users directly to the carrier's networks, the MCS. This can allow focusing on security policies and devices on one server. Access, privacy and security is managed by this server and the protection of the platform's information guards this server using firewalls and tools for intruder detection and other issues of security.

Scalability, as the name says, refers to how big it can get when time goes by. The application server is done by separated entities that work together to accomplish a result. However, if the capacity of them is over, the platform can be upgraded by introducing more entities with the same functionalities to enrich and make more robust the system.

The first issue taken in consideration was the separation of the Gate (GT) in the RM (Request Module), by doing the GT in two modules, one for reception and one for delivery, both of them with

buffers for storing and control de entrance of request inside the platform. In the future, more modules can be added progressively.

Failure handling is controlled directly by the Gate (GT). This entity in the RM has buffers for storing. The GT is programmed to received and sent using different application protocols. Application protocols (such as SMPP) consider acknowledgement messages, in order to notify a successful arrival, or retransmit it when necessary. The GT has two wait until the acknowledge message is sent back by the entity responsible for delivery in the carrier's network, in cellular networks, or by the user's device in case of convergent networks. The buffer can also be integrated with duplication capabilities for further reliability. Inside the platform, the CCU, as a monitor it is, it's responsible for assuring service providing and guarantee the efficacy of the system. It has to check the flow of information and data through the platform and see that every entity is doing what they have to do in the correct order.

Concurrency is controlled by the buffer in the GT. These buffers receive the requests and order them by arrival, and release them gradually to avoid saturation of the system. However, there can be some inner control by priorities declared by the residing application in mobile to process this request before other of lower priority. This can benefit in emergency applications when certain events are more important than others.

Transparency involves every aspect mentioned above. Any requester can access by using HTTP, SMS or WAP interfaces because the platform can recognize them. Entities for standardized these message are inside the platform and all the information has a format based on xml. This included the MCS and the GIS, so the information is understandable by every one of the entities of the entire platform.

The flow inside the platform and outside the platform assures that the request will be attended and creates reliability because the platform can process gradually the requests and avoid saturation. Besides, the SDK chosen for the platform is flexible and allow integrating more entities for strengthen the platform in the future, taking advantage of the heterogeneity of the languages used to work.

Finally, we have to mention that our platform offers a service provided by multiple servers that interact as necessary. They are separated host and their function changes from one to another. For example, the application server receives and delivers requests, giving information to the GIS for transforming the coordinates in valuable information. These coordinates and extra data are managed and controlled by the MCS, the entity in charge of all data storing and management and the application server demands the information to the MCS for deliver it to the GIS creating an environment shown on Figure 48

5.5.2 Information flow interaction among entities

In general terms, Figure 49 shows an overview of the process that has to be done in order to provide this service. The process will be explained next. LBS lies on the statement that they need to be invoked to give a response in return, in case of being pull services. In other case, they can be completely automatically initiated by the service provider or by applications developed to generate requests and send them to the application server. In any case, mobile ought to be located.

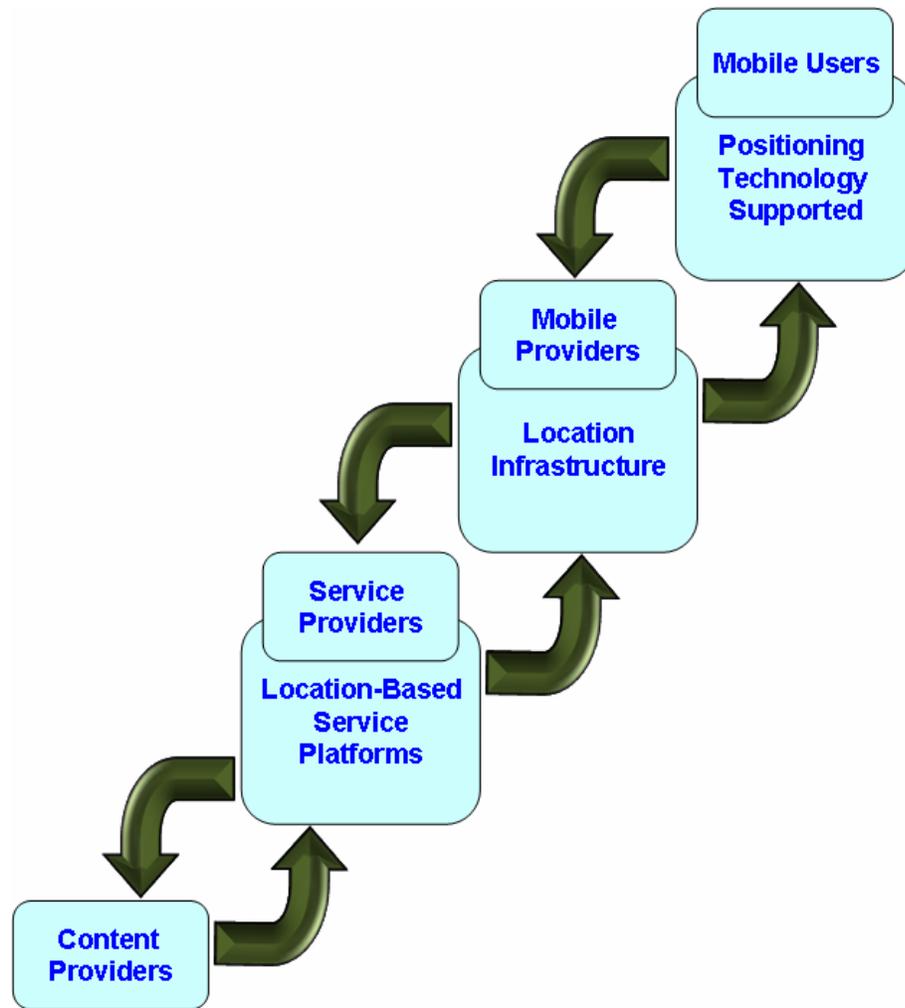


Figure 49: General processes

Network providers, as we saw before, control over location infrastructure, and they don't depend on LBS client to do these procedures. They store information location of their users inside their coverage area in a database contained in the GMLC after being calculating by the SMLC. They can do this previously even after there is any location request initiated by user or LBS clients, so that's why this specific task is considered as one of the most independent because the real owners of this information are the network providers which have to guarantee privacy to their mobile users, even the decision of when to do them when they're not required is taken by the service provider.

Even though, location procedures are independent and directed by politics in mobile carriers, they have to take care of what devices they need to implement in their networks, according not only to network standardized technology but also to the technology supported by most of their users and to demands on accuracy and feasibility required to satisfy several kinds of services provided by LBS clients. More on these recommendations were explained on section 2.5.

Services providers and users exchange information continuously, giving users the possibilities to be always located in case of the existence of requests and the network providers are those that control this information and use it to obtain some benefits from it. However, privacy politics have to be taken in consideration for not to violate rights of users.

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Mobile providers stores the information, and when this information is required to be sent to an specific LBS client, the GMLC controls the flow of it and needs to have registries of the existence of valid clients after delivering any location information. LBS client and GMLC don't have to be interconnected physically to exchange information, they can use the application protocol MLP to do this. A wider explanation was given on section 3.3.2.1.

However, we have to discuss that this protocol is only used to send and receives location requests and responses, when the service itself is sent by the LBS client, the use of WAP, IP and HTTP protocols are necessary. This is done by devices known as WAP Gateway and GGSN which manages the flow of data from and to the Internet.

After obtaining position information from service providers, LBS clients through an application or LBS platform can use it to deliver a VAS (Value Added Service) which is a set of images, text and data that can be used by requesters in a useful manner. The platform might depend seriously on information stored in a database to proceed to attend a request. Some of these databases can be only data managed by DBMS or external content providers, useful to the GIS to manipulate geographic data to be delivered to users.

After processing this, the LBS platform delivers information back to the user through its own gateway which can use HTTP, WAP or even SMS to deliver what it was requested. These interfaces are considered in the development of the platform to activate a series of processes.

In most cases, depending on the kind of service, LBS platform may require using what is called a GIS application server. In a general concept, a GIS server is an entity capable to manage coordinates and translated in value-added information, mainly images and other information types using data bases with this information.

In our specific case, a GIS and a LBS platform need to interact in junction to offer a complete solution. On one hand, the platform needs to follow a series of steps to notify, activate and send the correct procedures to the request activated and make the GIS send proper geographic information.

5.5.3 Concurrency control

One of the methods for designing a better distributed system is using threads to increase system performance and create a multi-threaded context in an execution environment. A thread is the operating system abstraction of an activity. An execution environment is the unit of resource management: a collection of local kernel-managed resource to which a thread has access. An execution environment consists of: an address space, thread synchronization and communication resources (communication interface) and higher-level resources (open files, etc). (Coulouris, 2002)

This allows the system to receive concurrent executions and avoid having strange effects. The use of threads also allows reducing interference from concurrent operations. This is what it is called atomic operations.

The environment of the system is synchronized, it mean, one process after another for the same request. This forces the execution of threads to be separated in time and ensures that the instance variables of a single object are accessed in a consistent manner; this ensures that the

operations are accomplished successfully. One of the advantages to create this in the platform is that is based on Java, which can make possible the use of synchronized method. (Coulouris, 2002)

5.5.4 Functioning of the application server

A mobile user sends a request to the application server, which is received by the RM. The procedures that the platform considered are the following and explained on Figure 50.

The RM not only receives the request, but also identifies (1) what format the request has and the way to translated into an xml-based language to make it compatible with the rest of the inner communication protocols of the platform.

When the RM finishes translating the request, it sends it to the CCU (2) for control and recording the user's information of the incoming request in a database to allow creating preference profiles for further services in the future. The CCU send the request to the LSCU (3) to identify what kind of request it is and ask for the logic contained in the SU (4 and 5). The LSCU delivers the logic and necessary programs back to the CCU (6).

The CCU controls the flow of information directly to the SCE (7). The SCE compiles, create, personalize and adapt the programs and logics to the requester (8). Then, the CCU sends the results from the SCE to the LLU (9) for loading, controlling and preparing all the processes required for the attendance and execution of the service initiated by the request (10).

The SEE receives all the necessary programs and logics and gathers information from the MCS (11 and 13). The MCS must contain information related to the user's mobile technical capabilities (AUPProf) and positioning information, or any other data necessary for processing. In a contrary case, the MCS must communicate with the mobile carrier's network (12).

After getting all the necessary information, the SEE sends the positioning information and requests the results to the GIS (14). The GIS processes this information and deliver value-added information to the SEE (15). The SEE, with the information of the user's mobile capabilities adapts these results to make them compatible to the user's mobile and sends these results to the RM (16), the unit responsible to deliver the service to the user's mobile and make the final arrangements for the delivery (17).

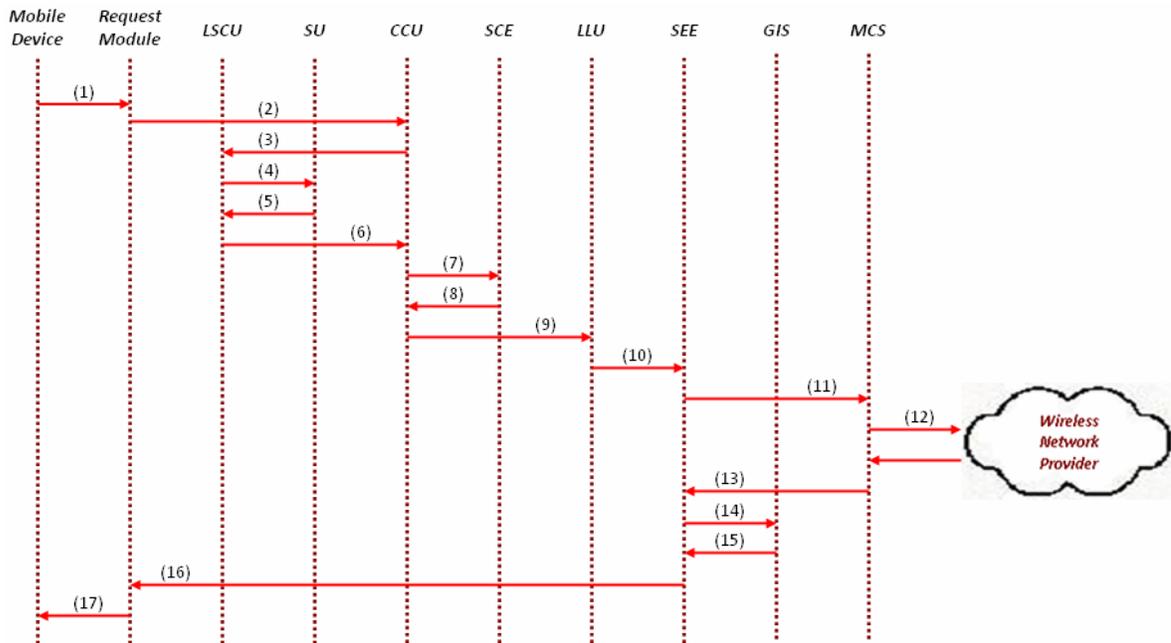


Figure 50: Functioning of the application server

5.6 Advantages and personal contribution of the platform proposed

The platform proposed has advantages in comparison to prior platform. One and the most important are the profiling resources that can stores and used in future. This advantage can make the platform generate push services based on the users' preferences after requesting pull services. These resources are stored in a master server, named Management and Control Server which is responsible to store, analyze and create the statistical information to achieve the delivery of further services.

The absence of a server like the MCS in prior platforms is considered as a weakness for not allowing developing more services and creating more sources of benefits not only for the users, but also for the carrier and the service provider as well. Information is a highly appreciated and valuable thing.

Gathering information and using it in good directions allows being one step forward and offering to users the commodity to receive information of interest in the future. This server also allows the application server to focus only in processing information and not wasting resources in requests of information to remote entities in the carriers' networks. The MCS in few words is the information processing brain of the system that gives results to the application server to make efficient and faster.

On the other hand, considerations of privacy must be of concerned to avoid falling in opposed reactions from users that may consider this as an invasion of privacy. In this case, the information can be used to personalized the information requested and make things fasters because the service providers knows exactly what the users prefer and consider as beneficial for them.

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Multiple scenarios are considered on the platform, besides, multi-platform support is considered for further applications. Convergent network is the arrow of motivation to develop such a platform. Mobile or stationary users can get access to this, because the most important factor considered is the way the position and location information is obtained. This information lies on the deployment of carriers and the resources they invest for obtaining the best and most accurate information to deliver high-value-added services.

Another issue of the advantage is the usage of open application protocols which are highly standardized world widely. These protocols can be transported by the Internet Protocol, allowing creating low-priced, fast connections. Besides, component manufacturers in the wireless market have incorporated these protocols in their functionalities, allowing compatibility among manufacturers and providers in a high scale.

The use of XML-based languages is another issue that allows declaring the advantage of this platform. These languages are compatible with many technologies, not only those LBS-related ones, but also with IP-based technologies, WAP included.

The architecture proposed is beneficial as well. The components are flexible and the server is scalable. On one side, the server that manages the information uses SAN (Storage Area Networks) to store the information which is scalable and the quantity of information considerable. Its elements (disks) can be added continuously, depending on the necessities of storage.

On the other side, the SDK proposed to be employed for the platform offers a flexible environment for future growth originated by an increasing users market. One example is the RM proposed. This unit, at the beginning, will have an entrance and an exit interface for receiving and delivering requests and responses respectively. For example, if the numbers of users grow, more interfaces can be added and new policies of tailing can be deployed. In both cases, we have a buffer to store data and introduce it or send it back gradually using priorities defined in the platform and/or by the application residing in mobile devices, allowing constant flows of information and avoiding overflows.

In respect to information, the platform can support different kind of requests (SMS, HTTP or SMS) and deliver the information in the same manner. Besides, all the information schemas (databases included) are proposed to be based on xml to avoid misunderstandings and errors, using not only languages compatible but also DBMS that support xml.

5.7 Differences and new features among the platform proposed and others

We mentioned before that the present work was based on the research done by Spanoudakis (2003) and Zhang (2003), however in comparison to those platforms developed by them, we have different capabilities and features proposed.

Both authors recommend the usage of xml-based languages to establish communications between inner modules inside the application platform, besides, they also consider that any LBS platform requires being strong enough to receive and attend request through SMS, HTTP and/or WAP interfaces. At the same time both authors developed a Geographic Information Server. This server is used to analyze and transform the positioning data into valuable information.

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Besides both authors recommend interfaces to obtain positioning, charging, billing information, and UAProof file with information of users' mobiles. However, at first sight, this is a huge quantity of information if we consider that this kind of platform serves to attend several requestors at the same time so, one major difference is proposed. In this case, we named it MCS, "Management and Control Server", whose main functioning capabilities focus on storing, managing and controlling this information using a database management system such as Oracle.

In this server is where we introduce those capabilities mentioned by Spanoudakis and Zhang (2003) but with a complete database system to improve information management and be able to deploy more capabilities using the analysis, profiling capabilities and compatibilities among these technologies such as xml support and presentation to final users. This server is proposed as an autonomous server that requests this information constantly, keeping it updated and available when the application server requires it.

The MCS is recommended not only to be used to store all the information and manage it but also recommended to be used as an ally to reduce consume of resources in the main server, the application server. This is useful to allow server to focus on specific tasks and not waste valuable kernel resources in different activities during the processing of the request.

Then, the application server counts on two servers, the GIS and the MCS to manipulate data and help it to collect it and deliver final result with information. So, to be able to receive this information, a new client is proposed in the SEE, a module present in the works mentioned before. Besides the GIS client, a MCS client in the SEE is responsible to ask for information to the MCS and take it inside the SEE in the application server. In conclusion, the Zhang and Spanoudakis' platform seems not considering the information storing and further processing capabilities of it in the future, so, this capability was personally considered as important and necessary.

The second difference in the platform proposed is the central module named CCU. This module is an entity that manages all the information flow inside the application server. Both platforms mentioned before trust the functioning of each module separately. Every module is programmed to follow a process in an independently way from one to another. Every process is an independent algorithm that knows what steps form it; however there is no control entity that guarantees that the exchange of result among inner entities is done correctly.

That is why the CCU is proposed; in the same way every module of the application platform keeps an algorithm to deliver a result, the CCU manages the flow following a series of steps in a master algorithm that control the exchange of information among entities. This is something that was not seen on former platforms, and it is proposed to keep an information exchange control that monitors the functioning of the applications server.

Finally, the third change proposed is contained in the RM or Request Module, the module that has the interfaces for receiving and delivering requests. This entity is different because, in comparison to the other platforms, the RM has an entrance module named GT or "Gate" which is divided in two parts: an entrance and an exit. These parts are conceived as buffers with storing capabilities of the results delivered by the SEE and/or by the arriving requests. These buffers store the requests from outside and the results from inside and they can classify and create service attention queues. This can be achieved providing identifiers in the messages that can help the modules to classify them according to priorities and importance.

These changes in the SEE and the RM, and the new module, the CCU, and the creation of the MCS, were proposed to increase the reliability of the entire platform and make some improvement to those platforms present in research done before by Spanoudakis and Zhang in 2003.

5.8 Motivational example

In today's world, concerns about health assistance increase, that's why we explain an example of an application that can be deployed using our platform proposed satisfying these concerns. The application lies on the mobile devices and sensors that are connected using a personalized application residing on the mobile.

This application stores information from the sensors that monitors vital signs of patients. This information is also analyzed continuously and in case that some parameters predefined escape from the limits allowed, an alert is sent with the information stored to inform the platform about the emergency. This is done without the user contacts or sends the notification. In response, the platform processes the information and creates an attendance environment informing the required help about the position and location of the user. Paramedics, doctors and/or hospitals can be informed using their information stored in databases.

In case of no emergency, the application in the mobile can deliver notifications to the application server which in this case, only stores the information and creates informs that can deliver to patient's doctor for records. More information about this example and all the process and information involved are given on Annex A below.

Summary

The last chapter explained the elements necessary for the creation of a technological platform to attend users request in wireless convergent networks. The platform is planned to work using application protocols over IP connections to allow remote connections. The platform is formed by 5 servers: a database server, a management and control server, an application server, a GIS server and content servers.

The MCS and the database server work closely and they can be integrated in the same server. Most of the information resides in some platform database servers; however some of this information has to be gotten from other elements, mostly residing in the providers' network. This information is stored and controlled by a server named MCS which is responsible to obtaining this information and process what the application server delivers for further applications. All the policies of privacy, users' information and profiling are also in charge of this server.

The application server is the core element of the platform and it contains the modules and units that process, collect and deliver a response after receiving request. This server has interfaces to receive request from different format and delivering in the same manner. It contains units that store different logics and other in charge to gather the programs required to create the correct elements according to the request.

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Finally, the last two elements, the GIS server and the content servers, are element related closely. Both servers are generate responses according what the application requires, The GIS server changes the coordinate information into understandable information with possibilities of location, orienting directions and routing users.. This is only possible with the help of content server which store in databases pictures, map and information of point of interest. This platform offers many advantages in comparison to those before, because it gives chances to profile creation, storing and managing information, and the elements used to created can be very scalable in the future in case the demand of service provisioning increases with time. Besides, the usage of xml languages offers flexibility and with every element standardized creates a reliable environment. The platform is ruled by the convergence trend and according to what is it planned, the platform can attend request from different users in different wireless mobile networks.

Chapter 6: Conclusions and future works

Location-Based Services offer considerable benefits and can ease people's lives. The increase of the Internet open the door of considerable functionalities, developments and creation of new market niches to reach more persons, that's why service providers must focus on the business environment to create what people really demand.

Service providers depend on high scale on the capabilities that networks' providers deploy on their infrastructure. Negotiations must be done to establish the policies of information exchange to guarantee service provisioning on the service provider's side; and on the side of carriers, to add value to their networks and obtain extra revenues with these services.

Technologically speaking, the trends indicate the existence of a convergence oriented to a common backbone technology: the Internet Protocol. This protocol was designed to establish remote communications and share information, but today, this protocol is used not only as a transfer protocol for information, but also for more services, including the location-based services.

The IP protocol is a carrier, and many institutions and organizations have been developing compatible standards to add more functionality to the Internet. These standards are application-level protocols. These protocols have enabled the creation of new services and added potential to networks all around the world. We have to emphasize that without these protocols, the development of the Internet wouldn't have been possible to the current level. Besides, the communications get better and easier because they establish the patterns to universal understanding that make possible that different manufacturers can interact and communicate with no relative problem.

One impressive thing is that this trend is guiding different technologies (that began single and isolated to satisfy a specific function) into a common association where all of them may work together, interconnecting different users from different networks in a more transparent way, using the same backbone protocol.

Taking in consideration the creation of more services and the trend of convergence in the market, the decision of designing a platform that obeys both requirements was taken. Currently, the convergent networks are being created and it will take a little until current providers update their network into the new technology. However this does not mean that new proposals cannot be done.

The platform proposed on the work tries to be a complete, reliable solution that can be deployed currently and offer the services to traditional users, especially to those in cellular networks. Moreover, independently on how the networks evolve in the future, the platform was thought to attend requests from user in cellular networks or by those in IP-based networks.

A developer, to be successful, needs to be conscious of three things: the convergence trend, the uses of international standards and multi-interface capabilities. The first is obvious, everything in this world evolves and to be successful, someone has to evolve and keep stepping forward. Then, we can mention that without standards, communications would be hard, even impossible and in some cases, expensive.

Standards allow providers to choose and compare equipment and take advantage of the different capabilities a manufacturer can offer and interconnected different equipment from different providers without being afraid of incompatibility among them. In the same manner, a platform provider must be conscious that these standards are present and exist and the platform must be capable of understanding them to be capable of exchanging information with these networks. Besides, mobile carriers provide position and location schemas and technologies, at the same time with privacy policies and security devices on their side, and they decide what technologies for calculation of users' position they offer. These measurements have to be considered by service providers and accept them when they decide to create platform to offer LBS remotely.

In few words, being capable of receiving and answering requests are not only sufficient. Information homologation is helpful and the inner standardization make possible to have a reliable, stable platform. After saying the last, the platform presented tries to be capable of offering services from cellular and IP-based networks today and in the future.

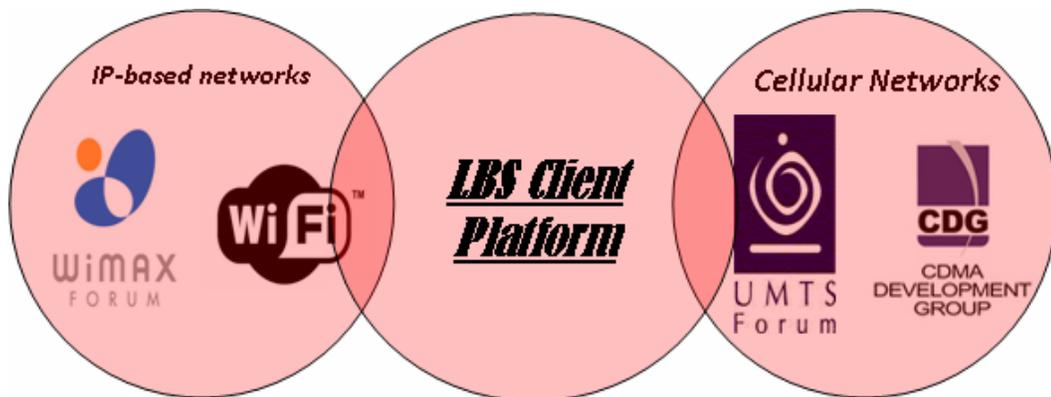


Figure 51: Capabilities of the platform

A platform for Location-Based Services is a multidisciplinary activity where a group of specialists have to be gathered. These experts must cover the following fields of knowledge: location technologies and methods, wireless networks, IP-based technologies, communications protocols, distributed servers developers, xml-language programming and database programmers and modelers. As we can see it is a complex task that can obtain optimal results if the group of correct persons is chosen.

In global terms, a platform has to be seen in a perspective of resources: the client needs a service but also want privacy and security, so, location and position information belongs to the carrier and we, as the platform, are third parties that require having access to that information. In that case, our platform has to be secure and consider privacy policies.

As future work we must consider the following issues that were not developed in the thesis, but they are considered for future employment:

1. Designing privacy policies and security means to preserve privacy and trust in the LBS platform.
2. Improvement of positioning calculation algorithms.
3. Creating xml-based languages compatible with the different entities mentioned in the platform.
4. Designing of mobile applications for devices.

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5. Physical deployment of the servers, such as the application, the databases and the geographic information servers.
6. Integrating in a server object relational databases.
7. Creation of methods for recognizing market niches applicable to Location-Based Services.
8. Determining methods to create agreements of which capabilities must own both sides to offer such services.
9. Designing efficient position and location schemas to locate users.
10. Studies of the effects in the network's carrier with the transfer of information of this kind.

Annex A. Motivational example

The following figure shows an example of what a platform can be in order to offer Location-Based Services. In general terms is a platform based on wireless networks and mobile devices, in this case, we are explaining a platform used on cellular networks for different reasons.

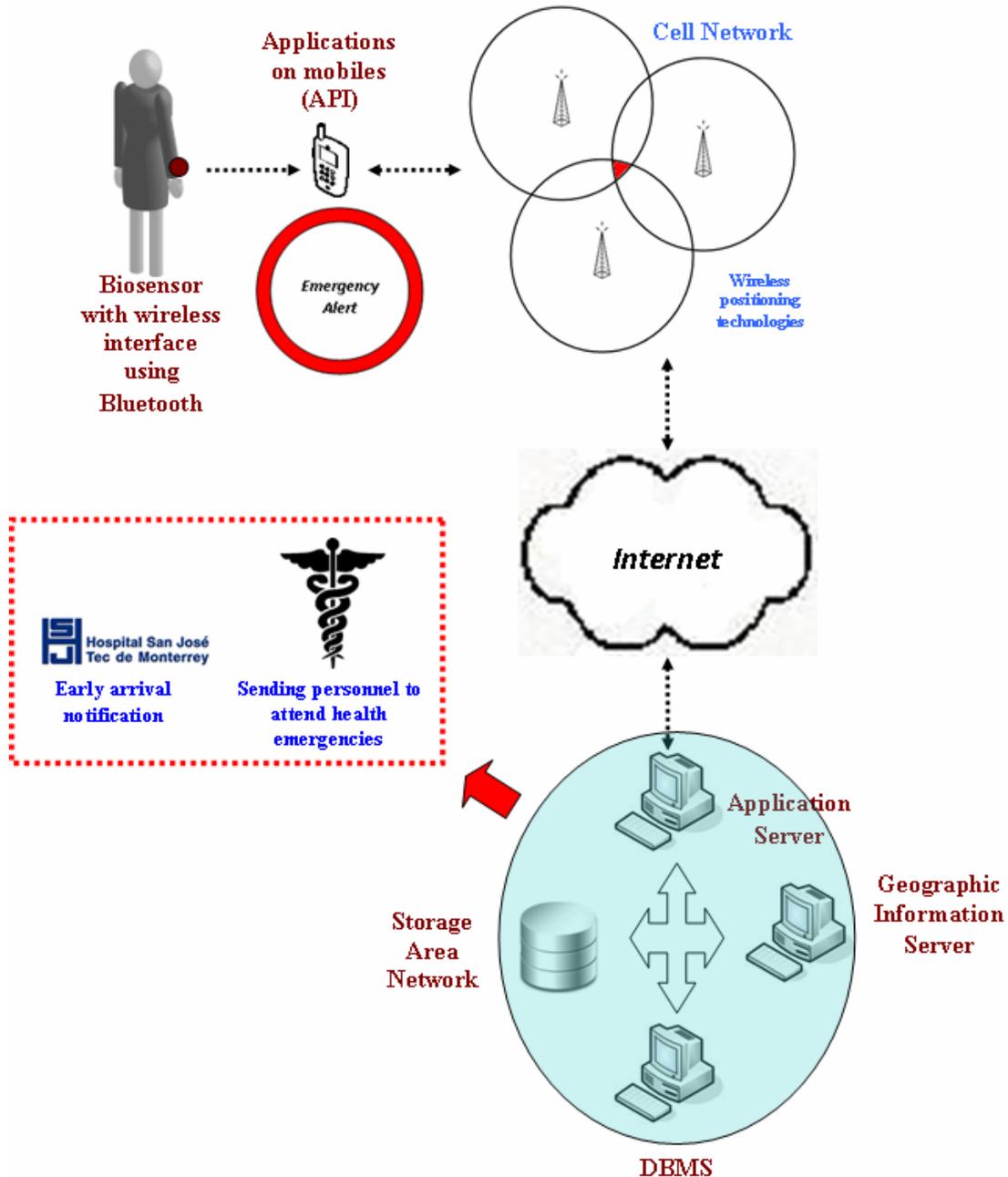


Figure 52: General Overview of an Application

a. General Description

The platform is based on applications residing on mobile devices that can be deployed using J2MN, a Java Platform for development of applications for mobiles. This application may be related to sensors that monitor vital signs of patients and send the information to the mobile device with the application where the information is stored and after a period of time the information is sent through the cellular network to reach the platform, and the information can be sent using two main ideas: emergency and non emergency situations, using SMS and/or WAP to request the service and receiving response in the same manner.

The platform as we mentioned in later chapters, is a multi-protocol supported platform where user can request services through many different protocols like HTTP, SMS or WAP. The platform has some elements that were explained in Chapter 5; however some of these elements will be described in the next paragraphs because we will try to explain an example of a platform focused on health emergencies.

b. Database Elements in Health Emergencies

The database necessary for the platform needs to be formed of several tables which contain information and data continuously accessed by the health attendance application. The following figure shows the different tables that need to be created for storing all the information required to deliver an end-to-end service.

As we can see, every table is related to medical information; it means that it will contain only information related to information to help to assist mobile users when they may have a health problem. The circle in the center indicates what databases are considered more important in the system because they need to be accessed continuously and in some cases, updated periodically, especially the vital signs table, which through an application server and the database server, will receive information from time to time that need to be updated and monitored according to users' demands.

The database will be formed of the following tables which will be stored in a SAN (Storage Area Network) and they'll be accessed by the application server. When the application server needs to access to the information stored inside the SAN, a database server will exist and will be in charge to make all logical procedures to deliver correct information to the application server in certain activities.

A Database Updater Controller (DUC) is a proposed entity in the MCS. It has the faculties to monitor, to schedule, receive and send information to the correct entities of the platform and if necessary, from wireless network providers, in order to keep the databases with the correct information updated as much as possible. It is a complex function that involves an application to receive the information sent directly from the CCU, after receiving the requests. This can be done using an HTTP interface to send and update the database.

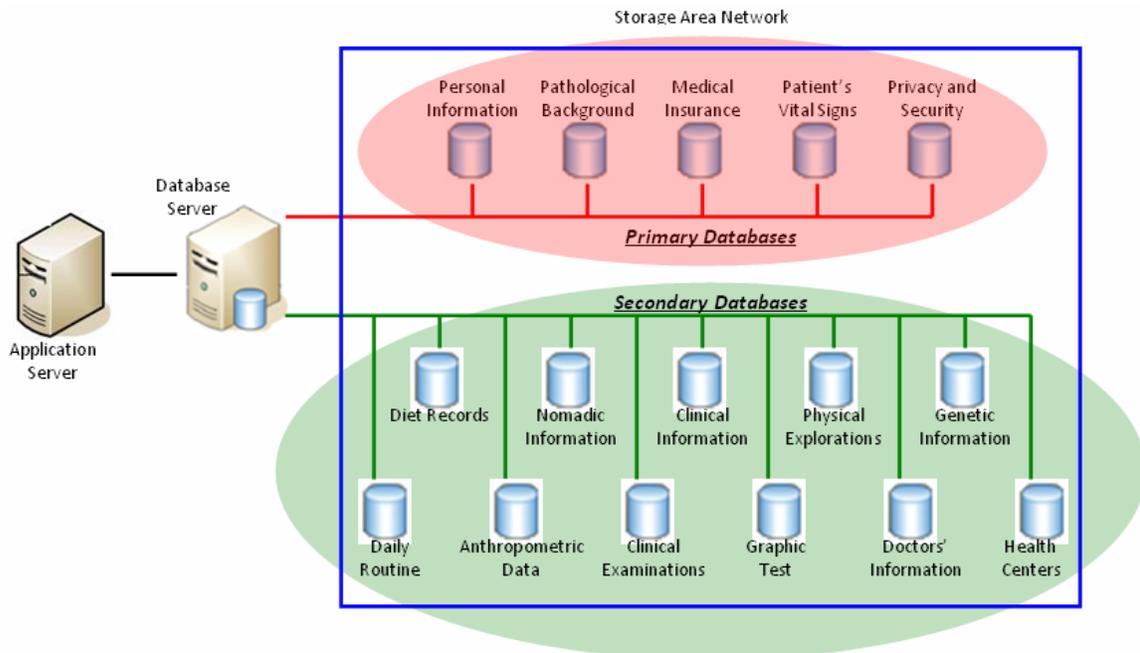


Figure 53: Database and health attendance

Its core process focuses on the fact of receiving messages from the mobile application directly to it. This application receives, analyzes and stores the xml-based message. This is why it is very important that programmer when designing the API for mobiles, consider the fact to include pointers in the structure of the message that the API will send to request for services so the application on the platform can proceed to what it must.

c. Functioning of the platform

The present paragraphs explain the processes the platform has to do in order to work and deliver a service to users when requested. According to Betayneh (2006), Location-based services must be defined in two contexts. Primary contexts involve: time (when?), location and position (where?), identity (who?) and activities (what?), while secondary contexts define several contexts such as: personal (social security number, address, spouse, etc), technical (location devices, mobile devices, web server, wap servers, etc), spatial (restaurants?, hospitals?, avenues?, etc), social (meetings?, proms?) and physical (SMS?, web browser? wap browser?). But there is a big importance especially on spatial context. In general, definitions or classifications must be done; certain keys can be defined to identify the service required by the message sent by the mobile user's device. For example:

Table 7: Services of the platform

Service Key	Meaning
TELEMEDICINE	Sending a WAP Push message to download the application. No more information required
ASSISTANCE	Users may request contact doctors for attendance voluntarily and the information have to be sent to the person requested. Every process is done inside the network to locate users and deliver this request to doctors.
HELP	Requesting attendance to an emergency where user cannot do more. Information stored in device needs to be attached in the message.
UPDATE	Information sent need to be queried to the database in order to be updated. This capability needs to content more information, in order to make possible query the DB server. Every data stored in mobile has to be sent to the application.

The last table shows four different services in the beginning. The first two, "TELEMEDICINE" and "ASSISTANCE" are mobile originated, it means that they are done by users and they absolutely depend on them, even though the process to ask them is the same, the functioning of logics varies.

The "HELP" and the "UPDATE" services are automatic. They depend on the logics of functioning residing in the application installed in the mobile devices and both will keep communications sending datagram or several datagrams through a WAP connection in periodic times.

Downloading the application and sending SMS

In order to understand this section, refer to 3.4 and Figure 54 at the end of Annex A. Cell phones have messaging capabilities. In order to have access to the platform, mobile users have to send messaging to install an application necessary for monitoring their vital signs.

Furthermore, the first step is simple: using a mobile, someone needs to send a message to an ESME number. E.g. the service can be activated just sending "TELEMEDICINE" to 11200. In this case we are talking about a mobile-originated message which reaches the SMSC who forwards it right after to the proper ESME registered on the SMSC directory.

Table 8: Example of a PDU message

91OC255521321501910C251831993876910925551102F0010080604180000027000 C74656C656D65646963696E61
--

Table 9: Example of a message sent to the SMSC

Field	Meaning
91	International telephone number standard
0C	Indicate that the source is a 12 digit long phone number
255521321501	The SMSC phone number swapped. In Mexico, e.g. Telefonica is +525512235110
91	International telephone number standard
0C	Indicate that the source is a 12 digit long phone number
251831993876	My phone number swapped. The number is +528113998367.
91	International telephone number standard
09	Indicate that the source is a 9 digit long phone number
25551102F0	Example what it can be an ESME phone number. In our case may be +525511200
01	Indicates is a delivery message
00	Indicates a reference number
80604180000027	Date of the message (2008 Junio 14 20:00:00 GMT-6)
00	Indicates it is an Short Message
0C	Length of the message sent (12 letters in this case)
74656C656D65646963696E61	Text "telemedicina" (in English "Telemedicine") in hex.

Every ESME is associated to a phone number, which in the example is the phone number 11200. This number is recognized by the network and the message is sent to the RNS, the base stations in UMTS. In the RNS, the RNC receives the message and sends it the serving MSC. The MSC interrogates the HLR and the VLR about the destination number. After this, the MSC can find out where the destination number is and knows that have to send it the SMSC. The message travels inside the cell network using the signaling SS7 and its MAP protocol.

When the message reaches the SMSC, SMSC determines that the destination number is an ESME, so, SMSC needs to get integrated a SMPP gateway that will get the message and send it through an internet connection to get the remote ESME. The message will reach the ESME identified with the phone number +525511200, which will have to take the message content and identify what the message is all about. However, every message will be received by an ESME Agent in charge to identify what the request is.

An ESME is responsible to answer to this message. In this case, it is part of the SMS interface integrated in the Request Module Entity (RME). In any case, this part of the RME can be considered an ESME, because it can communicate to the SMSC of the wireless provider using an application protocol known as SMPP. This protocol, as we saw before, can be packed using TCP/IP to reach a remote ESME using the Internet.

Core platform is based on the works of Zhang (2003) and Spanoudakis (2004) who agree in many of the same units. After receiving, analyzing and determining what kind of request is (see Table

7), the RME send the request to the core platform to proceed to respond using the correct logic. Meanwhile, the SMSC and the mobile will be exchanging point-to-point messages for control which are in PDU format. The structure of the message sent to ask the URL to download the application can be as shown on Table 8 and Table 9.

Then the SMSC sends the message back to its destination, our platform. The platform after receiving this message, it identifies the arrival format, determining that is based on the SMS protocol. After that, the RM adapts the message into an xml-based one, discarding unnecessary elements of the PDU format, taking the following form:

Table 10: The SMS changed to xml

Message element	Meaning
<?xml version="1.0" encoding="utf-8"?>	Indicates the format of the xml
<sms>	Indicates the beginning of the message
<src>528113998367</src>	Indicates the source number
<svc>Telemedicine</svc>	Indicates the text of the message, translated in a kind of service
</sms>	Indicates the ending of the message

After receiving a message from the SMSC, the application platform will deliver a WAP Push message through an SMS used as carrier for response. These messages are a kind of SMS used to access to a web site without introducing a web address in the cell phone browser. The response message done by the platform, after receiving the last SMS, can look like similar to the following code:

Table 11: Example of a WAP Push message

Message element	Meaning
<?xml version="1.0" encoding="utf-8"?>	Indicates the format of the xml
<sms>	Indicates the beginning of the message
<dest><num>+52818116596213</num></dest>	Indicates the destination number
<text>Click n the following link to download application to your mobile:</text>	Indicates a small text for indications of what to do
<p>DESCARGAR</p>	Indicates the links for the WAP push message
</sms>	Indicates the ending of the message

The last message is completely on an xml code, and we have to mention that in this way a user cannot receive it so changes and adaptation must be done by the application server to adapt it into an SMS-supported format. After that, we see that these messages contain a web address which has to be clicked on it only. In the way we see, it seems a simple short message however it contains a more complex programming.

The WAP Push uses the SMS as a transport method to reach users. When we click on the link, the WAP browser opens the site and establishes the connection showing a website. This website can be seen only because we visited the website using a WAP Gateway which transforms the format from html or xml to wml, a programming language compatible to mobile devices and the websites we can browse on our telephones. To understand how the SMS works, go to section 3.4.

This website has to be mounted in a WAP Server or WEB server. The second one is more recommendable to be able to offer user of PC and palms the content as well. This WAP or WEB Server is an APACHE server which can support XML or HTML content. The WAP Geteway can be integrated into a GGSN, the device responsible to the internet connections. When we click on the website in our mobile, the connection is established and the GGSN/WAP Gateway send the info through the Internet. This is possible because in the UMTS, the air interface was developed to deliver IP-based packages into mobile users.

After finishing the download procedure, the mobile itself begins installation process. It's very recommendable to have a Java-based application because of the compatibility mobile devices have form manufacturer. They even possess a utility known as AMS or "Application Management System" loaded on the operative system of the phone. The AMS detects new applications installation and begins the process automatically and compatible with JAVA programs. This application can be developed using the J2ME or "Java 2 Micro Edition" and it was essentially developed to enable API for small devices as PDA and cell phones mostly. Furthermore, the interface of the client application residing in the phone has to be user-friendly.

During the installation process, application will interrogate mobile owners some details to internal functioning, including personal information like Social Security Number (SSN), name and others because in functioning this data are necessary to send them with the information that will be monitoring the sensors. It has also to be considered what vital signs will be monitored to store the valued data and discard those with no value at all for users.

There are two devices that need to be present on the phone: a Bluetooth interface and the sensor. First ones are integrated in some phone so it's very important that users buy phone with this technology integrated. During application installation process, the API needs to detect the existence of this device and send an error message in case there's not one. In contrary, it has to be able to activate the Bluetooth interface permanently. Right after, a negotiation for association between the API in the cell phone and the sensor has to be done. More details in this part will not be considered from now on about the architecture in detail of both devices, only the logic is a part of interest in the present work as well as the API interface.

The last paragraphs explained the procedure necessary to ask the link to download the application into the mobile; however, a second service can be initiated in the same way. A message containing "ASSISTANCE" can be sent to the ESME, but, the logics to attend is as follows:

1. The process of sending a message is equal to the service "TELEMEDICINE".
2. The message is received by the RME which detects the new service: "ASSISTANCE".
3. The service is requested to the platform and the correct service is selected.
4. Platform gathers information about the user which is identified using his or her phone number stored in the database.

5. The logics establishes to locate users first, so that's why the request is resent to the GIS server which ask the location of the users through the MLP protocol to the location server in the network, the GMLC and the location is begun (for more information see section 2.2)
6. After receiving the information, the GIS translates the coordinates into graphic information which is sent back to the platform which processes and creates a code to be sent to the correct personnel.
7. The platform queries the database to know what personnel is related to the user. So, it proceeds to create SMS and WAP Push messages to be sent.
8. The information created will be sent to the health personnel related to the user using the resources created to notify them where their services are requested.

Functioning of the sensors

We mentioned before, the sensors are in charge of monitoring vital signs declared in the installation process. The sensors and the cell phone with the API will be in contact continuously, where sensor will be constantly sending data gathered from users and the API storing information. This can be defined as a "semi-endless process" and not only because it will have to be constantly storing data but also analyzing the parameters.

The API has to be programmed with certain analysis capabilities to identify certain parameters in an acceptable range, in which monitoring will continue as normal. The following figure describes procedures in case this is not happening. When there is a parameter out of normal, a message of emergency has to be done; in other case, the process continuous as normal. When we refer as normal, it has to be considered that no anomaly appears and the sensors keep monitoring the patient's status until a period of time is out, is then when the process goes on. For understanding these paragraphs, refer to Figure 55 at the end of Annex A.

Emergency attendance

The complete procedure is shown graphically on Figure 56 at the end of Annex A. The API gathers all the information sent by sensors and has to create datagrams in order to be able to send them to the platform. This one may receive the message in formats based on xml. The message may be sent using WAP connections from the mobile to reach the platform, whose IP address is known by the application with priority. Arrival messages are structured in xml to ease the platform to process the information and can look like the following message:

Table 12: Example of a message produced by the API in mobiles

Message part	Meaning
<?xml version="1.0" encoding="utf-8"?>	Indicates the formats of the xml language
<sms>	Indicates the beginning of the message
<user>65835200489</user>	Indicates the users identification
<pswd>19830706</pswd>	Indicates a password for security
<stt>0</stt>	Indicates the kind of message
<sgn>0</sgn>	Indicates the vital sign monitored
<sgn_val>36</sgn_val>	Indicates the value of the vital sign
<id_msg>0000000001</id_msg>	Indicate a message identification for control
</sms>	Indicates the end of the message

However, the message emitted by the API on the mobile must contain pointers to help the web server to identify this incoming message contains not only information to be sent to a database server, but also request to the application server. The application server, using its interface WAP in the RMU, will receive the request from the web server and the process to attend begins. In order to send response to the request, it is determined that is a health emergency.

The application server, according to what Spanoudakis (2004) mentions about the core of the platform, the SEE or Service Execution Environment, will follow a logic that indicates it has to get the stored information contained in the MCS. In case of not having the information, the MCS has to contact the positioning component of the platform that will contact the GMLC and communicate using the Mobile Location Protocol to exchange message of request and response using HTTP connections.

Right after the GMLC contacted the mobile to locate it (even using the Secure User Plane Location Protocol) and received the information requested; it sends it back to the positioning component of the platform. The SEE recovers the information from the MCS and sends it to the Geographic Information Server (GIS) using a GIS Client to communicate to this server. This GIS client may use the OpenLS protocol.

The GIS responds locating what it was requested, and sends the information back to the core of the platform. The core platform, the SEE, can determine the formats to send this to the user using a component, defined by Zhang (2003), as an "Adapter". This adapter allows recovering information about the mobile devices that the carrier has to determine which capabilities the mobile devices have. The UAProf (User Agent Profile) is obtained and the Adapter can obtain it using the WAP gateway of the carrier. All this process is followed to locate the user in troubles.

The information queried by the GIS is not only the one stores in the content servers, the GIS has also to request information stored in the database where the Social Security Information is, in order to make a relation of location and position of hospital and health centers where the patients are registered and/or finding their doctors.

The application server, having a response back, has to check the user's profile, communicating to the database server using its HTTP interface and gathers information about the user and selects the correct personnel to attend the emergency, and proceeds to do the same steps to locate them, but in contrary to the users needs, the GIS must be requested not only to locate them but to proceed to determine where the closest hospital are using content provider as resource.

Then, the information about the location of the patient and the closest POI (hospital, clinical, etc) are sent to the personnel found, using WAP (to send images) and SMS (to send addresses) interfaces if the UAProf indicates they have mobile devices, in other instances, the HTTP might be used. In contrary, the information about the location of emergency personnel is sent in the same way to the patient's device.

Functioning without emergencies

In this last case, the procedures are quite simple. The first procedure is similar to what the API has to do when sending information in case of emergency. The message is sent to a web server that recognizes the message and queries the database server that stores information.

The database server integrates OLAP capabilities which allow generating analysis of information and making reports that can be sent using HTTP interfaces, even by e-mail to those medical personnel involved with certain patients in order to keep them informed about the status of their patients. For understanding this section, refer to Figure 57 at the end of Annex A.

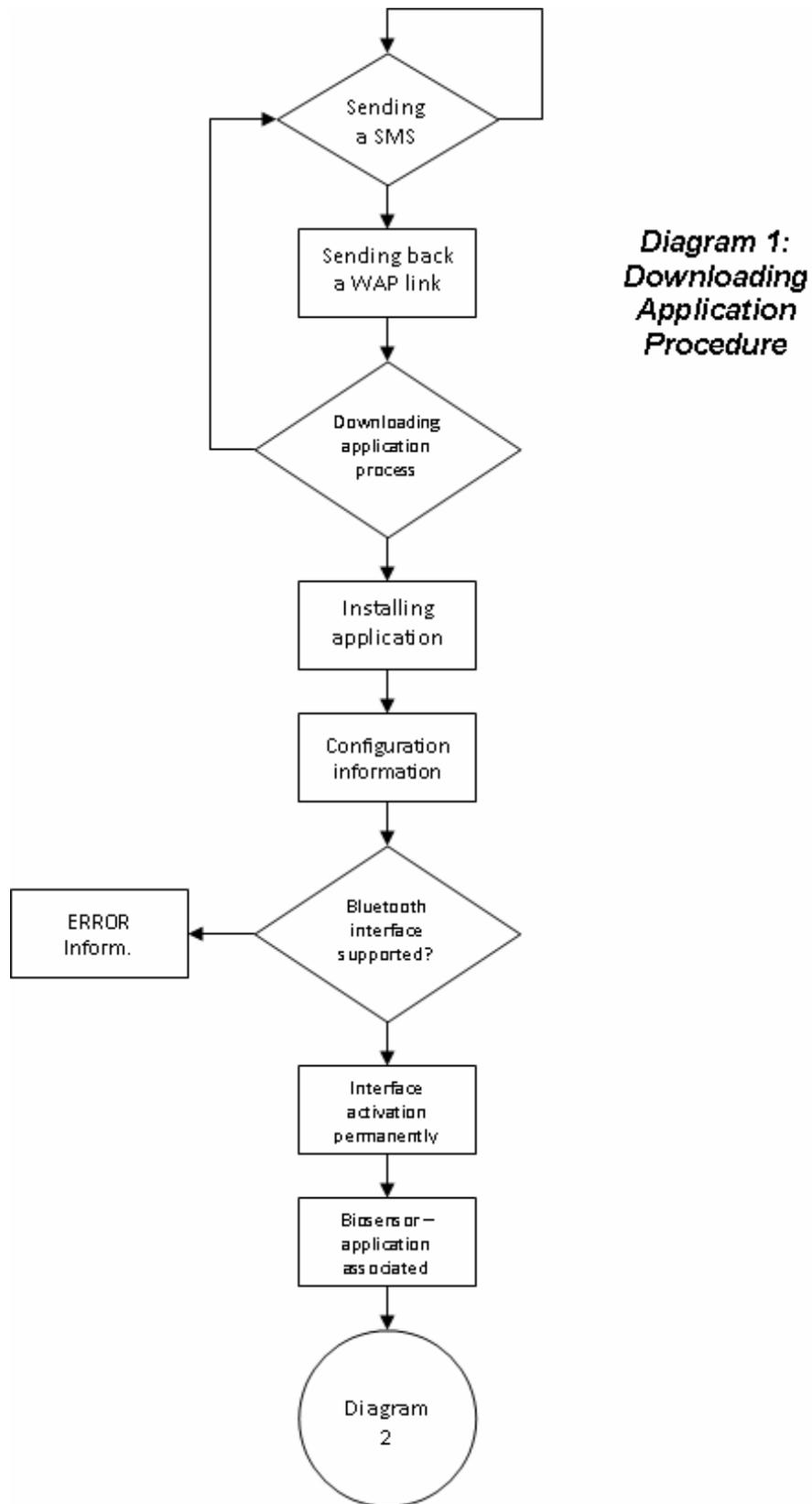


Figure 54: Functioning Process Beginning

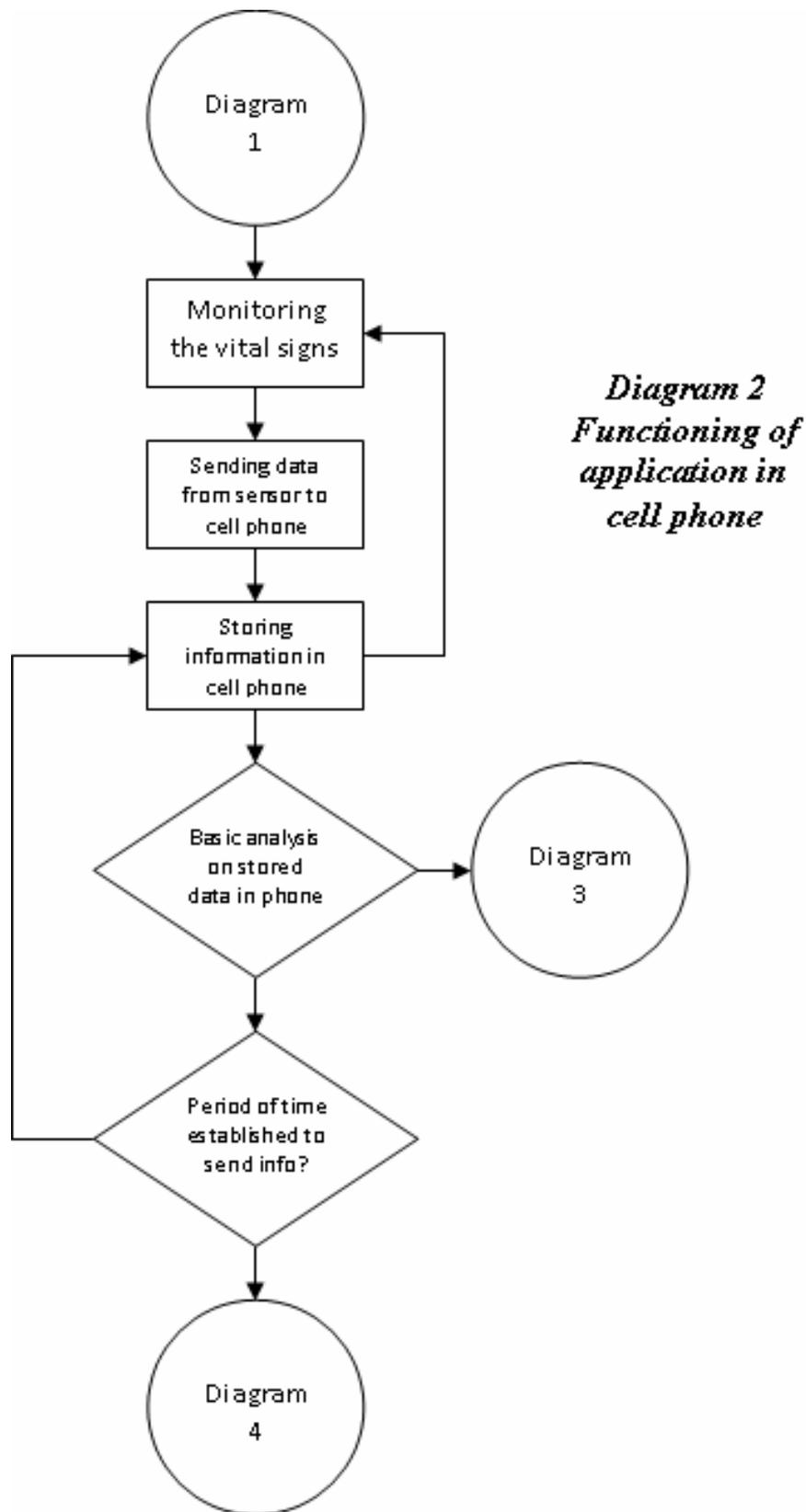
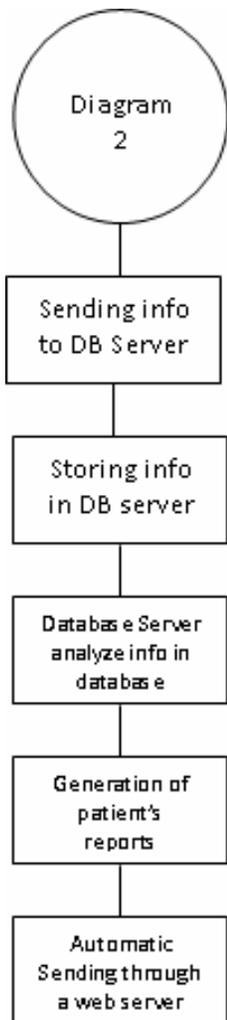


Figure 55: Sensor Functioning Process



*Diagrama 3
Emergencia
Médica*

Figure 56: Emergency Case



*Diagram 4
Functioning
without health
emergencies*

Figure 57: Normal Case

Annex B. Business Model

a. Issues of the business model

Current communications are not just about calling someone using our voice to do it. There are a lot of different ways to do it so; besides, we live in a time where our lifestyle demands continuously some way to improve our daily life. Our life is very different to that our great-grandparents and grandparent and even our parents once ever had.

Persons may always be worried about their health conditions and, for over one century, our conditions in health medication and attendance have increased the level. Flu, chicken pops, scarlet fever, and other diseases have been eradicated in a big part of the planet and mortality has diminished in considerably levels. However, this is not enough in today's world.

Seamless, our lives have be improved in quantity but not in quality. Stress, pollution, fast-food-based feeding and some other issues have made our health to decline and suffer illness that haves to be monitored regularly.

Heart attacks, asthma, blood pressure are some of the most common illness we can suffers, either by genetic inheritance or daily life. Although this problems are common and many persons get them, they produce several deaths a year but with proper assistance.

It has also to be considered that our communications media has been developed in the last thirty years. Some of these communications media that have developed in very high rates are those that transmit wirelessly. Some of these are the cellular networks. Only in Mexico, we can find more that 60 million users in a total population of 100 million (Mundo Contact, 2008). This shows the impact and demand of this kind of service.

A market niche is found related to both issues: telemedicine. Telemedicine, and the word says, is about medicine at distance. One way to satisfy this niche is to develop what we call LBS. According to Unni (2003), LBS are broadly defined as services that are enhanced by and depend on information about a mobile device's position. Location information is used to filter out irrelevant information and provide the context for different services. These services could be offered and executed both within and outside the mobile operator's network.

As we mentioned before, the platform explained has the main purpose to help users in health emergencies monitoring their vital signs and sending information to the platform using carriers to reach both sides.

This is why the platform to assist in emergency cases was considered as a topic to develop. But considering that the platform itself is not completely enough, we have to declare some statements as business proposals.

b. Definition of the service

The service that is tried to be delivered to users is considered a value-added service (VAS). A VAS is every service that gives a plus to the services supported by networks and clients benefits from them. In the chapter where we described the platform, we considered the VAS as a LBS client, capable to receive requests using different interfaces to do it and in return, emergency attendance given by specialist in health problem like doctors, paramedics and competent personnel.

Service requires accuracy and feasibility because, as we saw in chapter 2, telemedicine can be considered as an emergency-service-family member. All of the LBS rely on location and position data which must not be expensive.

There are three different methods: network-based, mobile-based and mobile-assisted, being the latter the more accurate ones. There are different technologies that offer different level of the parameters mentioned before but the more accurate are those mobile-assisted methods like E-OTD, TDOA and A-GPS, as we can see in the next table with their cellular technologies:

Table 13: Location methods comparison

Technology	Networks	Requirements	Accuracy
Cell-ID / Enhanced Cell-ID	All	None	300 m to 10 Km
EFLT	CDMA	None	250 to 350 m
TDOA	All	None	50 to 200 m
AOA	All	None	100 to 200 m
AFLT	CDMA	None	50 to 200 m
U-TDOA	All	Changes in mobile	50-150 m
OTDOA	GSM	Changes in mobile	200 to 500 m
EOTD	GSM	Changes in mobile	100 to 500 m
GPS / A-GPS	All	Changes in mobile	3 to 80 m

c. Background of the business model

The platform mentioned before will constitute a technological platform belonging to a Service Provider. Previously we have described technologically the elements that form part of infrastructure but we have not described its business relationships with the mobile carrier and vice versa. A general model is shown next.



Figure 58: Value chain

In this figure we can identify three important suppliers in the service: service provider (owner of the platform), mobile carriers (owner of the position location capabilities, users' profile databases, billing access technologies) and finally, mobile users' (owners of terminals where applications run and demanding agents when required).

For instance, these elements have to be listed in order to understand where the importance resides in, and the answer is: in every of these elements. This is because a service provider cannot access to client without an appropriate delivery infrastructure and vice versa, so it has to establish agreement to mobile carriers.

On the other hand, mobile carriers cannot differentiate from others without having services that add value to what it is capable of. Today's users don't doubt and hesitate to change the company whether this doesn't satisfy his or her increasing demands on value-added services. Today's carriers cannot stay static in a changing world, especially on one of the specialty: communications.

The business model relies on the assumption when the mobile users demand the services and ask for it. Those users that want to have access to the service require to be subscribed, especially because gathering information is demanding. Mobile users will ask the service in two ways: push and pull.

Push refers to the way persons related to attend emergency will be informed. In case of requiring a paramedic, messages of location of users, places, images and any other resource to make possible the arrival of paramedic to the place where the emergency is, will be processed and delivered to the correct persons. And, Pull refers to the option to ask them by the user.

Two scenarios are previewed: an scenario where for different reasons a mobile user asks the service sending a message to ask for help and other where the person is monitored by sensors which, using applications in the mobile device, send this information of vital signs to a application server the it will compute them and deliver the necessary help.

d. Business model entities

In this business model, we are defining an assisted business scenario. Such a scenario relies on the assumption that network operators have exclusive control over location data. This is done because, for security, safety and privacy reasons, users can trust more in the usage of LBS.

Besides, network operators are widely known and persons can relate in an easier way services with wireless companies not LBS companies. And trust in big companies is more viable instead of small companies; no matter if the infrastructure is awesome and very complicated the face of the business are network operators.

Mobile carriers in this case, will determine what kind of infrastructure they can deploy, the location method supported according to its core network (CDMA or GSM and their evolutions). Policies of privacy may be discussed, especially with whom they will exchange the data of their users. In some degree, mobile carriers are responsible of this information and of the safety, privacy and security of their users, this is why network operator must establish strong relationships with the services providers to determine the level of privacy they manage and the capabilities users will manage to feel more comfortable. This has to be done to gain acceptance by users that trust their information is safe and not everyone will know where they are and what time.

In this structure, mobile providers become mobile carriers, because they act merely as transporters of voice, data and content, they generate revenues through selling location data and through increased airtime usage and/or data package volume. Even though many companies can offer VAS in-house, in order to reduce cost, they can give up control over location data to provide meaningful content to their customers (Unni, 2003).

By opening the network and relinquishing control over location data (Unni, 2003), operators would attract more marketers of these services to the network. Marketers would have the potential to capture greater value, because they would be dealing directly with customers. Customers would benefit through greater choice and the ability to deal directly with marketers. Market forces would determine which services survive in the marketplace.

Billing is another issue to concern. In order to reduce confusion, it is proposed that every fee is paid by customers directly to the mobile carrier, who manages prepaid and fee users. Then, agreements of cost, prices and payments need to be established only between the mobile carrier and the service provider. This can help to develop a structure where a mobile carrier can establish relationships to several service providers without affecting their customers and obtain revenues from different resources and make itself different from competence.

Having enabled mobile device with proper applications, agreements with the mobile carrier, service provider must consider that they cannot be owner of all the information. This is something they see in relation to mobile carriers' location information, for instance. So, a fourth player enters to the scenario that may be related or not directly with the service provider: the content provider.

Content provider, as we mentioned, may or may not be related to the service provider because in this case, this providers owns huge quantities of information, be it images, text, ads, POI,

all of that contained in databases which can be accessed querying the content provider by the service provider to obtain what it needs.

The relationships between the service provider and content provider may be one to many, it means, according to the complexity of the platform, a service provider may consider agreements with many information and data resource providers. Both relationships can create long relationships chains that can add a value to the mobile carriers, this is shown as follows:

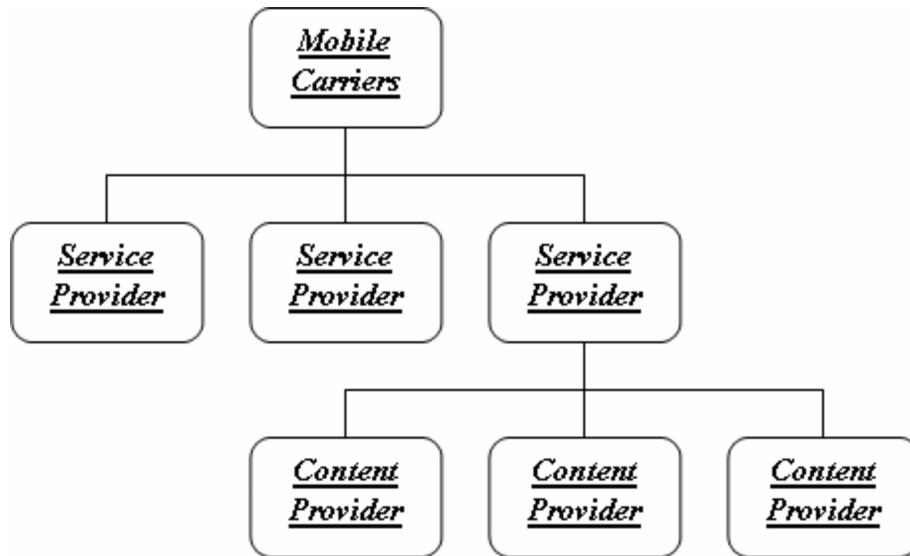


Figure 59: One-to-many relationship chains in the business model

e. Assumptions of involved entities

There are certain issues that have to be reviewed whether mobile carriers and service providers want to make successful businesses delivering LBS to customers. Practically, this relies on three entities: network providers, service providers and customers.

Network providers are seen as the mobile carrier and their ally are the providers of the services. One advantage mobile carriers has is that today's network are evolving into 3G networks which means that more capabilities can be developed because of the data rates that can be gotten and mobile devices counts on a lot of different capabilities from those previous devices had. The issues that network providers must focus are:

1. Focusing on demands of customers.
 - a. This issue considers that network providers are those in charge to see what the clients want. They are the front door to these services and thanks to this contact they can be those who line the demand and the offer of services. Attending to what clients want they can provide a fore vision to make differences and establish the bases to a solid business. In this case the have to make alliances to specialist like the service providers to consider any change that can be done on the service providers' platform

or development requirements for new ones. Doing it so, network provider, as marketers, will offer services acceptable and demanded by clients with the needs that the service can satisfy. This can also result in detection of needs uncovered by the market and produce more information “merchantable” according to law regulations that can produce a new business unit in the mobile carrier.

2. Billing.

- a. Services are (Unni, 2003) paid using charging models as flat rate and user per-minute for voice but data is different. Some models presented by Unni (2003) include pay-per-use, prepaid usage, service specific subscription fees, time of day rates and volume rate. However, for the kind of the service that will be provided, the service specific subscription fees are considered one of the most adequate because the quantity of information sent by the mobile to the service provider platform cannot be easily determined because of the differences in needs that customers can have according to their diseases.

3. Pricing.

- a. It exist a strong relation between the price we pay and the value we see. Services must be developed according to the needs of the market, which will determine an offer and a demand. Mobile carriers must be really sure that the service they offer may be a success and the customers see that every penny they pay for it really it is worth it. Economical studies of feasibility and return of investment must be taken to determine a viable service. In resume, a well diagnosed service can attract good customer.
- b. A strong relationship between cost and benefit plays an important role in pricing determination. In order to attract customers, the benefits perceived by them must be high, but operative cost must be low to the carrier, in order to gain high revenues to benefit the company.

4. Privacy

- a. According to Unni (2003) acceptance of location-based services would depend to a great degree on how well operators allay privacy concerns of consumers, especially when sharing information to third parties.
- b. Every privacy policy must be well understood by users and indicate step by step what privacy is about and the limits of it.
- c. Providers together with the service provider must let the customers to determine the level of privacy they would like to receive and in some case, deactivate the functions, in order to receive what the consumer really wants to avoid a rejection from him/her.
- d. The providers and the carrier, in some cases, will have to evaluate how much privacy will allow in some LBS, especially to those that are supported or government mandatory.

On other side, service providers must focus on a few issues that must be taken in consideration:

1. Technological infrastructure
 - a. Service provider depend on measurements given by mobile carriers, this is why service providers and mobile carriers must define together both side's capabilities when technology is involved. LBS are much related to accuracy given by the different methods used to position consumers. No service platform must be deployed if service provider doesn't know those that will make possible to reach consumers
2. Determination of market niches
 - a. Even though the mobile carriers are the front, service provider can interact and support mobile carriers to make field studies, surveys and any other study to find market niches to determine.
 - b. Clients demand and service providers must offer what the market really wants, not what we think they want. When carriers and providers find niches they can develop an application that can be perceived as a very high value-added service and consumers can proceed to use it.
3. Pricing
 - a. Similar to network providers, prices must be determined by arrangements between the carrier and the provider. Parameters such as accuracy, demand, information delivered and some others must be taken in consideration to establish fees where both, carrier and providers obtain revenues and consumers accept them. As we mention, the more attractive the service seems to consumer, the faster it will be accepted by them because consumers will consider the price as correct.
4. Privacy
 - a. Policies of privacy involved service providers, too. As a third party, opposition from consumers is present, even rejection of it. This is why service providers must establish strong relationships with carriers and establish security and integrity of the information exchanged with the carrier. They must assure that information is safe with them and guarantee that it will be used in correct procedures.
 - b. Carriers, as the owners of the information and trustful entities by consumers, may be an ally to accomplish this target. Carriers only deliver information to those recognized by the positioning server, so statements and agreements of information exchanged must be in order.

Finally, consumer only has three as we mentioned before: privacy (integrity of personal data?, third parties involved?, information required?), value and pricing of the service (necessary? how much does it cost? does it worth it? is the right price? is it useful? do I use it?).

f. Cost determination

According to Strüker (2003), cost includes those generated by the obtaining of information, negotiation between the owner of the information and the service provider, transaction and exchange

of data, reevaluation and inspections of contracts celebrated between the owner of the information and the services provider and enforcement in changes of increasing statements in contracts.

Strüker (2003) also mentions that, besides the last consideration, the carrier and the service provider must take in consideration the infrastructure of both. He divided these costs in three layers:

1. The first one, network infrastructure, involves all equipment required to offer these services, and any modification in the network necessary to adequate the system to technical requirements of the platform. Operational costs as transfer rates are included.
2. The second one, basic services, include all the management services to process, like positioning, authentication, billing, broadcast, processing, etc, to control the procedures of the service.
3. The last one, economic services, include those related to content providers such as: traffic controls, POI, and other external databases.

g. Strategies of the model

In order to make a high-valued location-based service attractive to consumer in wireless networks or any other communications network, we consider two of the three entities to follow the following strategies:

1. Mobile-carrier related strategies:
 - a. Marketing to make LBS of public knowledge
 - b. Field studies, analysis of consumer behaviors, and other to recognize market niches
 - c. Gain trust of consumers by policies of "client first" and "offering what client demands".
 - d. Establishing pricing and revenue in agreement with the service providers.
 - e. Being open to new advances and changes in services.
 - f. Strengthen relationships with services providers.
 - g. Improving networks to be able to support even the most demanding service.
 - h. Developing services together with the service providers and exchange information about capabilities from both of them.
 - i. Ownership of position location determination technologies and its information.
 - j. Facilitate acquisition of new equipment to consumers.
 - k. Creating offers to attract consumers.
2. Service-provider related strategies:
 - a. Dialoging with carriers about technological capabilities.

- b. Creating projects to determine niches of the market together with carriers to find real needs to satisfy.
- c. Establishing strong relationships with carriers.
- d. Adequate privacy policies according to those taken by the carriers.
- e. Agreements in pricing and revenues must be discussed by their allies.
- f. Establishing agreement with several content providers to be able to get as many information resources as possible.
- g. Developing platforms to be able to attend demands on services from different devices (internet browser, wap portal, SMS, etc).

Annex C. Acronyms

<i>Acronym</i>	<i>Meaning</i>
3G	3rd Generation
3GPP	Third Generation Partnership Project
AAA	Authentication, Authorization, and Accounting
A-GPS	Assisted Global Positioning System
ANSI	American National Standards Institute
AOA	Angle of Arrival
API	Application Programming Interface
AS	Application Server
AuC	Authentication Center
BSC	Base Station Center
BSS	Base Station Subsystem
CCU	Central Controller Unit
CDMA	Code Division Multiple Access
C-ID	Cell Identifier
CS-MGW	Circuit Switch Media Gateway
DBMS	Database Management System
E-911	Enhanced 911 (USA Emergency Service)
EIR	Equipment Identity Registry
E-OTD	Enhanced Observed Time Difference
ESME	External Short Message Entity
ETSI	European Telecommunications Standardization Institute
FA	Foreign Agent
FCC	Federal Communications Commission
GGSN	Gateway GPRS Support Node
GIS	Geographic Information Server
GIS-PS	GIS Provider Server
GML	Geography Markup Language
GMLC	Gateway Mobile Location Center
GMSC	Gateway MSC
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HA	Home Agent
HLR	Home Location Register
HTTP	Hypertext Transfer Protocol
IETF	Internet Engineering Taskforce
ITU	International Telecommunications Union
IWMSC	Interworking MSC
JEE	Java Platform Enterprise Edition
LA	Location Area
LAC	Location Area Code

LBS	Location-Based Services
LBS-AS	LBS Application Server
LBS-CS	LBS Client Server
LCS	Location Service
LCS-PS	LCS Provider Server
LG	Location Generator
LIF	Location Interoperability Forum
LLU	Logic Loader Unit
LM	Location Management
LMU	Location Measurement Unit
LR	Location Receiver
LS	Location Server
LSCU	Logic Service Choice Unit
MCS	Management and Control Server
MLP	Mobile Location Protocol
MNC	Mobile Location Code
MPC	Mobile Positioning Center
MS	Mobile Station
MSC	Mobile Switching Center
MT	Mobile Terminal
NGN	Next-Generation Network
OGC	Open GIS Consortium
OMA	Open Mobile Alliance
OpenLS	Open Location Services
ORDBMS	Object Relational Database Management System
OTDOA	Observed Time Difference of Arrival
PA	Paging Area
PDA	Personal Digital Assistant
PDE	Position Determining Entity
PLMN	Public Land Mobile Network
POI	Point of Interest
QoS	Quality of Service
RAC	Routing Area Code
RAI	Routing Area Identity
RESAP	Remote Service Assistance Platform
RF	Radio Frequency
RH	Rules Holder
RM	Request Module
RNC	Radio Network Controller
RXLEV	Received Signal Level
SAI	Service Area Identifier
SAN	Storage Area Network
SCE	Service Creation Environment
SEE	Service Execution Environment
SEED	Service Execution Environment Door
SGSN	Serving GPRS Support Node

SIM	Subscriber Identity Module
SMLC	Serving Mobile Location Center
SMPP	Short Message Peer-to-Peer Protocol
SMS	Short Message Service
SMSC	Short Message Service Center
SS7	Signalling System number 7
SU	Service Units
SUPL	Secure User Plane Location Protocol
TA	Timing Advance
TCP/IP	Transfer Control Protocol / Internet Protocol
TDOA	Time Difference of Arrival
TOA	Time of Arrival
UAProf	User Agent Profile
UMTS	Universal Mobile Telecommunications System
U-TDOA	Uplink Time Difference of Arrival
UTRAN	UMTS Terrestrial Radio Area Network
VAS	Value-Added Services
VLR	Visitor Location Register
VoIP	Voice Over IP
WAP	Wireless Access Protocol
WFS	Web Feature Service
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WML	Wireless Markup Language
WMS	Web Map Service
XLS	XML for Location Services
XML	Extensible Markup Language

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