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Requirements and specification of services based on location awareness

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Abstract

This deliverable collects the requirements and the specification of services based on location awareness by means of the study of several use cases which take advantage of the location features provided by LDR-LT UWB technology in the context of heterogeneous networks. The report also gives an overview of the IMS specification and the management of the location information. Moreover, this document includes the description and the requirements of the two WP6 demonstrators envisaged to develop and test location-aware services in heterogeneous networks.

Keywords

IMS, LDR-LT UWB, location-awareness, requirement, service, use case.

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Abbreviations

3GPP	3rd Generation Partnership Project
AS	Application Server
CCF	Charging Collection Function
CSCF	Call Session Control Function
EUWB	CoExisting Short Range Radio by Advanced Ultra-WideBand Radio Technology
GLMS	Group and List Management Server
GPS	Global Positioning System
GSM	Global System for Mobile communications
HSPA	High Speed Packet Access
HSS	Home Subscriber Server
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LAES	Localization Application for Emergency Services
LBS	Location-Based Service
LCS	LoCation Services
LDR-LT	Low Data Rate-Location and Tracking
LOCSIP	LOCation in SIP/IP core network
LS	Location Server
MAC	Medium Access Control
MB-OFDM	MultiBand-Orthogonal Frequency Division Multiplexing
MLS	Mobile Location Service
NLOS	Non-Line-Of-Sight
OCS	On-line Charging System
OMA	Open Mobile Alliance
PDA	Personal Digital Assistant
PoC	Push to talk over Cellular
QoS	Quality of Service
RSSI	Received Signal Strength Indicator
SIP	Session Initiation Protocol
SUPL	Secure User Plane Location

TISPAN	Telecommunications and Internet converged Services and Protocols for Advanced Networking
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
UWB	Ultra WideBand
WAN	Wide Area Network
WG	Wireless Geophone
WGG	Wireless Geophone Gateway
WGN	Wireless Geophone Network
WMAN	Wireless Metropolitan Area Network
WSN	Wireless Sensor Network

1 Executive summary

The purpose of this document is the specification of services based on location awareness by identifying a set of requirements that will be extracted from the analysis of different use cases.

As a starting point, the report presents distinct definitions for location-based service (LBS) that have been given by important alliances and groups such as the Global System for Mobile communications (GSM) Association and the 3rd Generation Partnership Project (3GPP). Then, the basic components and the service models of the LBSs together with some examples of application are provided, mentioning the role of the location information in the heterogeneous networks.

After the study of several LBS use cases and the collection of the main requirements obtained, the text focuses on the IP Multimedia Subsystem (IMS) specification and proposes how to bring location information to the IMS.

Before the conclusions, the deliverable describes the envisaged platforms within WP6 for the development and test of location-aware services in heterogeneous networks and also specifies the requirements to be fulfilled by the corresponding demonstrators.

2 Introduction

With mobile penetration reaching saturation, intensified competition and regulations driving call prices down, mobile network operators increasingly seek new ways of maintaining revenue growth. Increased focus on delivering value added services, including location-based services, is one of the means of achieving this.

Location awareness will differentiate many mobile applications and services from PC applications and wired Internet services. Using mobile devices, LBSs leverage a user's physical location to provide enhanced services and experiences. LBSs enable a range of applications, such as navigation and mobile map services, workforce tracking, finding points of interest and obtaining weather information. Location awareness offers a compelling new business opportunity for application developers, operators and content producers.

Everyone seems to realize that the location market is a high potential industry. LBSs have undergone rapid growth. Factors driving this increase include higher availability of GPS-enabled phones, reduced prices and appearance of application stores. However, the popularity of the applications is still dependent on the region [1]. For example, in North America, navigation and family-safety solutions are the most popular. In Western Europe, navigation is the most used, followed by local search and friend finders, but there is no significant uptake in safety applications. These sorts of regional preferences will lead to a dynamic LBS market worldwide.

Many location-enhanced services do not need very high location accuracy to deliver a good user experience, but are instead more affected by availability of indoor location, which is not covered by satellite-based systems like GPS, and fast time to position fix. This fact opens the door to UWB as a key technology to be taken into account in the development of novel and promising location-aware services, due to its intrinsic features for providing accurate indoor localization.

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3 Location-aware services

Although location-based services have been an issue in the field of mobile communications for many years, recent years have seen rapid growth in the area of LBSs thanks to the advances in wireless communication and mobile Internet. LBSs, by delivering personalized information to mobile users based on their locations, are regarded as the killer application in mobile Internet. Nevertheless, there exists neither a common definition nor a common terminology for them. For example, the terms location-based service, location-aware service, location-related service, and location service are often interchangeably used [2].

In [3], LBSs are defined as services that integrate a mobile device's location or position with other information so as to provide added value to a user. The GSM Association simply defines LBSs as services that use the location of the target for adding value to the service. The GSM Association presents three examples where the added value is given by the filtering of information (for example, selecting nearby points of interest), showing the location of a target on a map, or automatically activating the service when a target enters or leaves a predefined location. Another similarly abstract definition of LBSs is given by the 3GPP [4]: a LBS is a service provided by a service provider that utilizes the available location information of the terminal. A similar definition for LBS is given by the international Open Geospatial Consortium [5]: A wireless-IP service that uses geographic information to serve a mobile user, any application service that exploits the position of a mobile terminal. These definitions describe LBS as an intersection of three technologies: New Information and Communication Technologies (NICTS) such as the mobile telecommunication system and hand held devices, Internet and Geographic Information Systems (GIS) with spatial databases [6].

In research, LBSs are often considered to be a special subset of the so-called context-aware services (from where the term location-aware service has its origin). Generally, context-aware services are defined to be services that automatically adapt their behaviour, for example, filtering or presenting information, to one or several parameters reflecting the context of a target. These parameters are termed context information. The set of potential context information is broadly categorized and may be subdivided into personal, technical, spatial, social, and physical contexts.

LBSs can be classified into reactive and proactive LBSs. A reactive LBS is always explicitly activated by the user. The interaction between LBS and user is roughly as follows: the user first invokes the service and establishes a service session, either via a mobile device or a desktop PC. S/he then requests for certain functions or information, whereupon the service gathers location data (either of themselves or of another target person), processes it, and returns the location-dependent result to the user, for example, a list of nearby restaurants. This request/response cycle may be repeated several times before the session is finally terminated. Thus, a reactive LBS is characterized by a synchronous interaction pattern between user and service. Proactive LBSs, on the other hand, are automatically initialized as soon as a predefined location event occurs, for example, if the user enters, approaches, or leaves a certain point of interest or if s/he approaches, meets, or leaves another target. As an example, consider an electronic tourist guide that notifies tourists via SMS as soon as they approach a landmark. 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 them in order to detect location events.

3.1 Components of Location-Based Services

If the user wants to use a location-based service different infrastructure elements are necessary. In Figure 3-1 the five basic components as used with an operator network in outdoor and their connections are shown [7]:

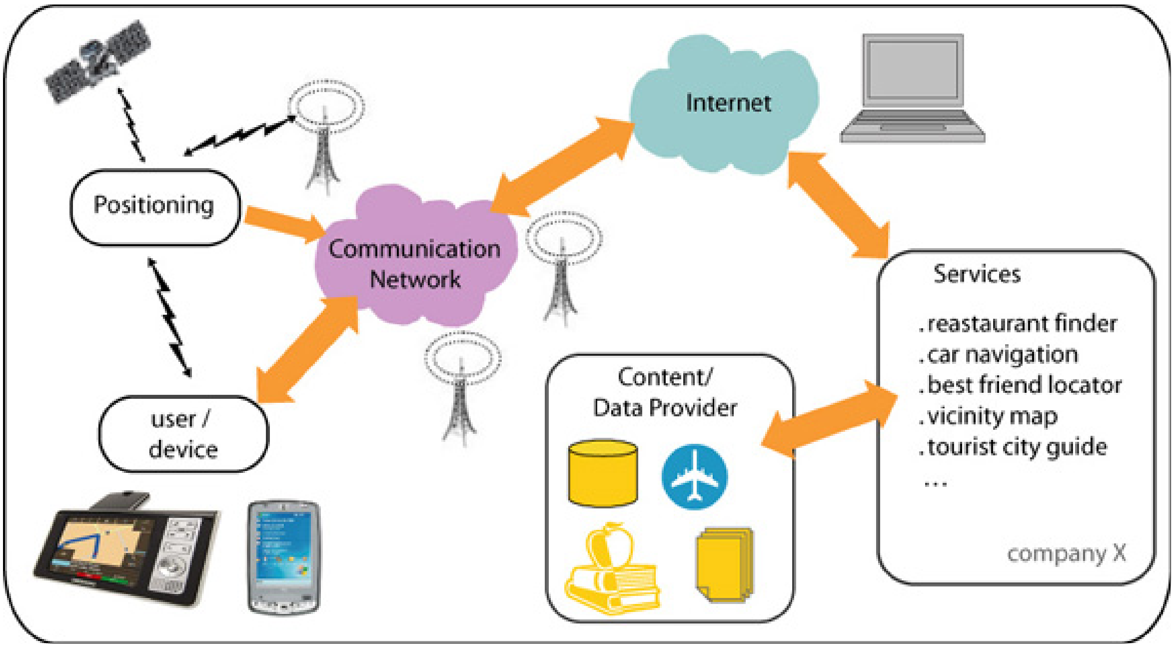

Figure 3-1: Components of LBS and their connections [7]

- 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 a 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 specific positioning systems such as the GPS and UWB. The former is widely used for outdoor navigation systems, while the latter can especially be used for indoor navigation.
- 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 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 a geographic data and location information data base will be usually requested from the maintaining authority (e.g. mapping agencies) or business and industry partners (e.g. yellow pages, traffic companies).

For indoor localization services using UWB, the user device will be part of an UWB network. Indeed, the UWB network by itself will provide the user localization. The localization could be performed with anchors deployed in the indoor environment or without anchors for applications that are deployed on the field as fire-fighter applications. The communication network will then be used to send the localization information in a longer range network or can be used to allow downloading the data and content provider.

3.2 Service models of Location-Based Services

Basically there are three types of service models for LBS: pull, poll and push [8]. Service models are depicted in Figure 3-2.

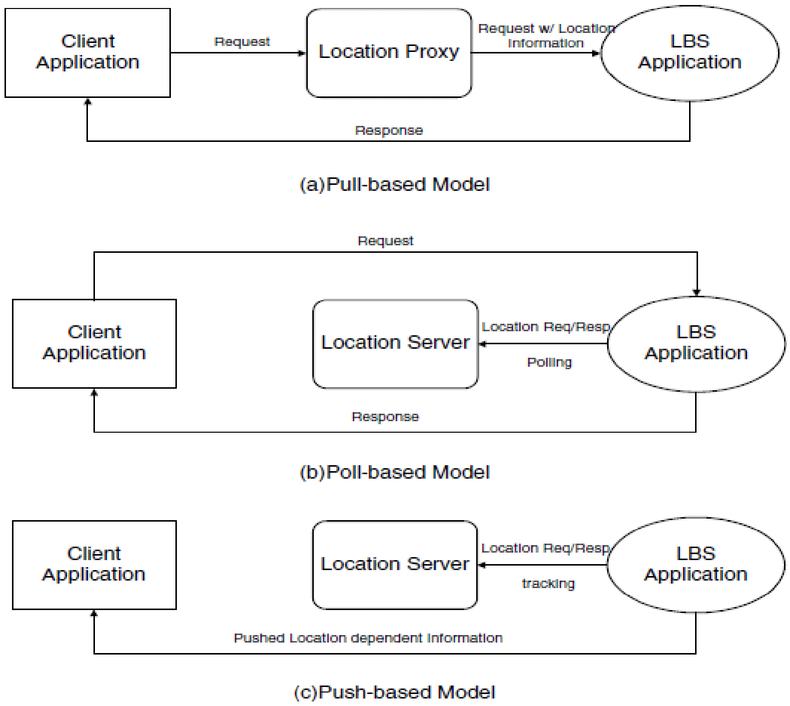

Figure 3-2: Service models for Location-Based Services [8]

In Pull-based model, the delivered information is directly requested from the user. A location proxy sits between client application and LBS application. When the client initiates LBS request to the LBS application, their location information is attached to the request by Location Proxy and then forwarded to LBS application. In this case, location-aware service is delivered while the client pulls the information from services. Usually Location Proxy is integrated into a middleware infrastructure upon which service is deployed. This model facilitates LBS developer in building and deploying LBS applications in the sense that the location retrieving is transparent and existing application could be converted to location-aware ones easily.

In Poll-based model, LBS application actively sends location request via well defined or industry standard location interface to location server (LS), which is responsible for getting the location of requested client. In this model, LBS application keeps polling LS or queries LS on demand in order to answer questions from client. The advantage of this model is that more advanced location functionalities could be supported and a standard location interface makes widely distributed location-aware computing possible.

In Push-based model, the delivered information is either not or indirectly requested from the user. The LBS application pushes location-aware information to client according to the user preference by tracking the position of mobile users. Push services are activated by an event, which could be triggered if a specific area is entered or triggered by a timer. Since push services are not bound on previous user interaction with the service, they are more complex to establish. Here, the background information like user needs and preferences has to be sensed by the push system.

3.3 Examples of Location-Based Service applications

There exist a broad range of different location-based services. Figure 3-3 gives an overview on the main categories of LBS applications [7].

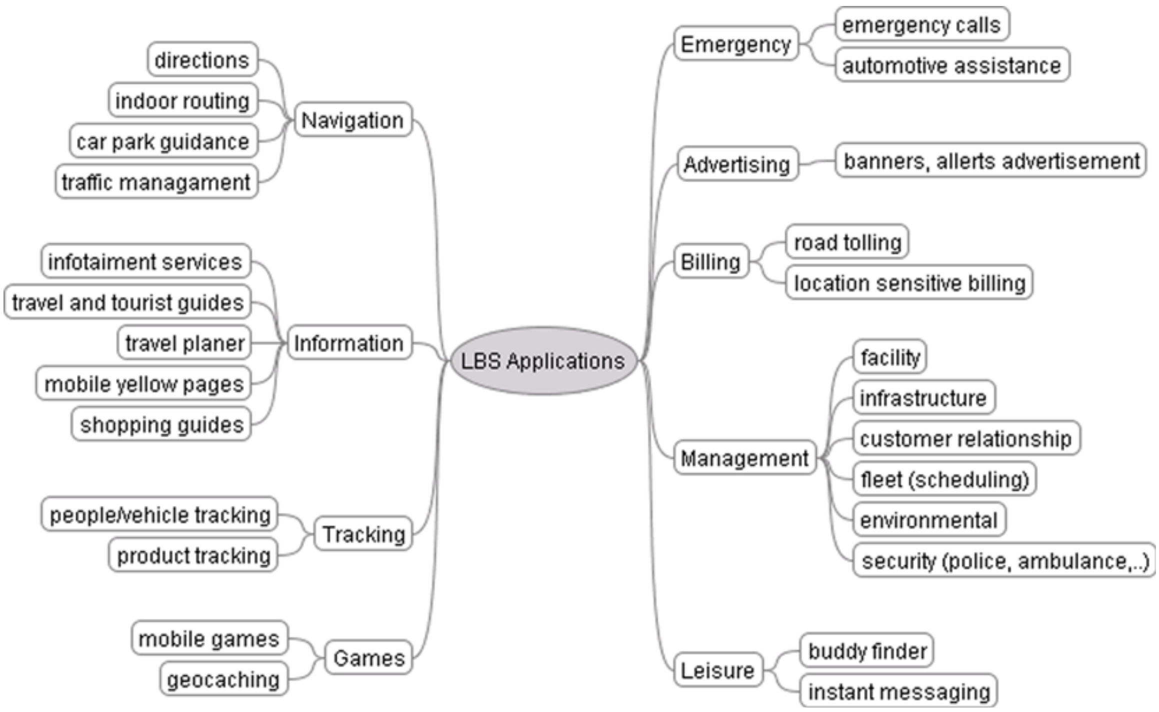

Figure 3-3: LBS application categories [7]

3.3.1 Emergency services

One of the most evident applications of LBS is the ability to locate an individual who is either unaware of their exact location or is not able to reveal it because of an emergency situation (injury, criminal attack, and so on). With the exact location automatically transferred to the emergency services the assistance can be provided quickly and efficiently. This category includes public and private emergency services for both pedestrians and drivers. While public emergency services for calling out fire-fighters, medical teams, etc., are currently being mostly regulated by public organisations, the emergency roadside assistance for drivers appears to be one of the most promising of the assistance services in terms of operator revenue.

The emergency services can also be the fire-fighters or policemen by themselves. Indeed using UWB system in indoor environment can allow rescuers to locate themselves in order to avoid incidents and to allow going in difficult environment knowing that they can be located each other.

3.3.2 Navigation services

Navigation services are based on mobile users needs for directions within their current geographical location. The ability of a mobile network to locate the exact position of a mobile user can be manifested in a series of navigation-based services. By positioning a mobile phone, an operator can let the user know exactly where they are as well as give them detailed directions about how to get to a desired destination.

3.3.3 Information services

Finding the nearest service, accessing traffic news, getting help with navigating in an unfamiliar city, obtaining a local street map – these are just a few of the many location-based services. Location-sensitive information services mostly refer to the digital distribution of information based on device location, time specificity and user behaviour. Services such as guided tours (either automated or operator-assisted), notification about nearby places of interest (monuments etc.) and transportation can be identified within this category.

3.3.4 Tracking and Management services

Tracking services can be equally applicable both to the consumer and the corporate markets. One popular example refers to tracking postal packages so that companies know where their goods are at any time. Vehicle tracking can also be applied to locating and dispatching an ambulance that is nearest to a given call. A similar application allows companies to locate their field personnel (for example, sales people and repair engineers) so that they are able, for example, to dispatch the nearest engineer and provide their customers with accurate personnel arrival times. Finally, the new found opportunity to provide accurate product tracking within the supply chain offers new possibilities to mobile supply chain management.

3.3.5 Billing services

Location-sensitive billing refers to the ability of a mobile location service provider to dynamically charge users of a particular service depending on their location when using or accessing the service.

3.4 Location-aware services in heterogeneous networks

In the last few years, extensive effort from network operators, manufacturers and research entities is being directed to integrate multiple technologies into heterogeneous access networks and multi-interface user devices in order to provide always the best connection depending on the service requirements in terms of range, mobility, data rate or power consumption. In this context, location capabilities of technologies such as GPS or UWB allow the network operators to upgrade services like product placement or Internet access and developing novel services exploiting the information of accurate user position.

As it is shown in Figure 3-4, cellular and wireless technologies such as UMTS/HSPA, WiMAX and 802.11 are commonly used to provide network access in different conditions. On the other hand, in order to retrieve the position of the device, satellite systems as GPS or Galileo may be used. But these systems are limited to outdoor environments, which is an important restriction as in many cases the devices will be indoors. Another possibility would be using the available information in the access network (e.g. RSSI) to estimate position, but this would be very inaccurate in indoor environments due to wall attenuation and multipath effect.

At this point UWB arises as a very good alternative to provide this positioning information to the network in indoor environments. LDR-LT UWB technology allows localising and tracking the users at every moment with a very high accuracy even in indoor environments due to the specific characteristics of UWB systems. Once the users' position is known, the users could receive information of their interest via UWB or other access technology (UMTS, WiMAX...).

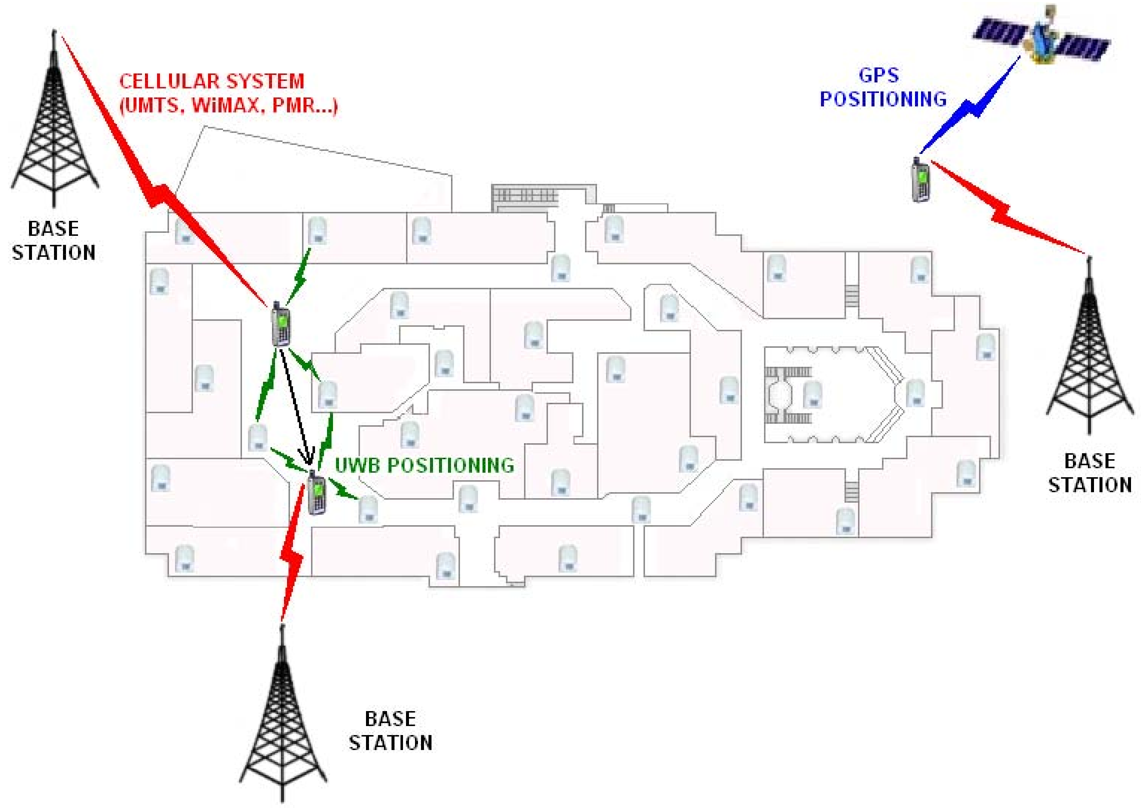

Figure 3-4: Location-aware services in heterogeneous networks

UWB localization systems could be deployed in a variety of scenarios such as shopping malls, train stations, airports, exhibition centres, sports stadiums... in order to provide users with dual cellular/UWB devices with positioning information. This would allow the user to position themselves on their device in the same way as car navigation systems and locate the place he wants to go (a shop, check-in desk, their seat...). But location information could also be forwarded to the access network operator, which would allow the development of location-aware services. Therefore, the users could get information of interest (special offers, arrival times, match statistics, etc.) both through the UWB network or through the access network. In Section 4 several use cases of location-based services in heterogeneous networks where UWB could be applied to provide localization in indoor environments are analysed. Two demonstration platforms will be deployed (see Section 6) as a test-bed for the implementation of location-aware services.

Besides the development of location-aware services, the location information provided by UWB can also be used by the operators in order to enhance their networks, for example, aiding network planning. The operator may be able to locate calls in certain areas to estimate the distribution of calls and user mobility for network planning purposes. These applications may be utilized for hot spot detection and user behaviour modelling. Moreover, focusing on the QoS of the network, the UWB positioning system may be employed to track dropped calls to identify problematic and poor quality areas. Finally, the location information can be used by the operator to improve Radio Resource Management, with more intelligent handovers and more efficient channel allocation techniques based on localization prediction. The conceptual research for the improvement of Radio Resource Management in Heterogeneous Networks through location awareness will be performed within WP4, in particular in Task 4.5 “Study of new system concepts with location awareness”. In Task 6.3 these concepts will applied to an UWB access network and improvements in handover and access point mapping when multiple UWB access point are present will be studied and developed.

It has to be noticed that in most applications described before for commercial usage, anchors can be deployed and anchor-based localization algorithms can so be applied. For these algorithms as detailed in WP4, some anchors are deployed for example in the supermarket for WP6 scenarios. The target node which has to be located has an unknown position. For anchor-based localization algorithms, ranging measurements are performed between the target node and the anchors only as the anchors are at fixed location. For WP6 scenario, there are multi hops in the network and WP4 took this parameter into account for optimising positioning algorithms.

For some applications however, anchors can’t be used and anchor free algorithms have to be used. This is the case for fireman deployment scenario and also most of sensor networks scenarios. Indeed, for these scenarios, people are coming in a place and deploy their UWB equipments for a limited amount of time and are not using indoor infrastructure. Most of the time indoor infrastructure could be also broken due to fire. Localization has so to be performed without anchors.

4 Use cases of location services

4.1 Use Case A: Indoor Positioning System (IPS)

4.1.1 Description

The objective of this service is to provide users with a navigation tool similar to car navigation systems but aimed to indoor environments. Car navigation systems are based on GPS (Global Positioning System), but its use is limited to outdoor environments due to the inability of GPS signals to penetrate obstacles. At this point UWB arises as a very good alternative to provide this positioning information in indoor environments, due to its high accuracy, low cost and power consumption and good performance in multipath and even NLOS conditions.

Some interesting scenarios for this application are shopping malls, train stations, airports, exhibition centres, sports stadiums, hospitals, museums etc. In this kind of scenario, a set of fixed UWB anchors would be distributed in known positions in order to provide user's dual WAN/UWB devices with location information. On the other hand, the user would be connected through the WAN access to the navigation service provider, which would provide periodically updated maps according to user's position. Users could also request the navigation service to guide them to a certain place (a shop, check-in desk, their seat...) or get information of interest (special offers, arrival times, match statistics, etc.).

4.1.2 Requirements

Table 4-1: Indoor navigation technical requirements

ID	Name	Description
IPS.1	Tracking	Mobile user's position will be provided by a LDR-LT UWB system with an accuracy better than 1 meter
IPS.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS (100 meters in LOS) for a suitable system deployment over large areas
IPS.3	Mobility	The tracking system will be able to track mobile users at walking pace, so position must be updated every second
IPS.4	Deployment area	The LDR-LT UWB network must cover large indoor areas over 100m x 100m
IPS.5	Network topology	LDR-LT UWB network topology, tracking algorithms and information distribution strategies must be able to cope with large scale networks (more than 100 nodes). Ad-hoc topology and relaying for communication between anchors are advisable
IPS.6	User device	User device must integrate both LDR-LT UWB and WAN interfaces

IPS.7	WAN access	Mobile users devices must have wireless access to the Internet in order to connect with the service provider
IPS.8	Throughput	WAN access throughput must support the transmission of maps updated every second (at least 1 Mb/s)
IPS.9	Service provider	Service provider will have a public IP address, so clients can access the navigation service through Internet
IPS.10	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.2 Use Case B: Location-based search

4.2.1 Description

The objective of this service is to provide users with customized search results ordered according to user's location. This can be useful for requesting the nearest business or service, such as an ATM or restaurant.

With GPS as positioning system outdoors, a LDR-LT UWB network would provide mobile phone users with location information in wide indoor environments such as shopping malls, train stations, airports, exhibition centres, sports stadiums, etc. The use of UWB embedded in a device like GSM should provide a seamless connection from GPS to UWB network. User's search request includes user's position, so search provider can order search results according to proximity to the user. For example, when a user in a shopping centre looks for a restaurant, the search results would show the closest restaurants. With this purpose, information in search databases should also include location information. The application inside shopping malls, airports and train stations can also be used to help blind people.

Figure 4-1 illustrates this kind of application.

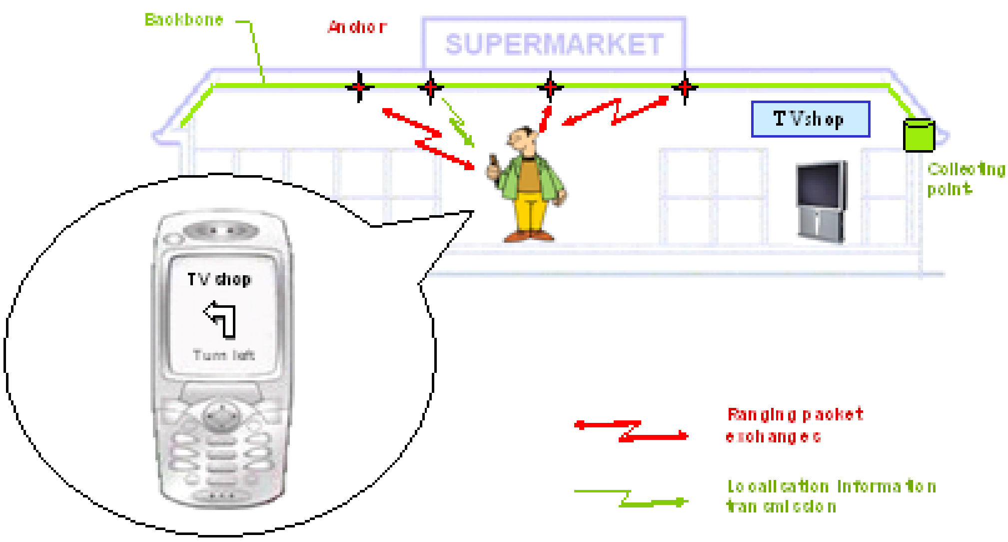

Figure 4-1: Location-based search

4.2.2 Requirements

Table 4-2: Location-based search technical requirements

ID	Name	Description
LB-SEA.1	Localization	The LDR-LT UWB network will be able to localize service users with an accuracy better than 1 meter
LB-SEA.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS (100 meters in LOS) for a suitable system deployment over large areas
LB-SEA.3	Deployment area	The LDR-LT UWB network must cover large indoor areas over 100m x 100m
LB-SEA.4	Network topology	LDR-LT UWB network topology, tracking algorithms and information distribution strategies must be able to cope with large scale networks (more than 100 nodes). Ad-hoc topology and relaying for communication between anchors are advisable
LB-SEA.5	User device	User device must integrate both LDR-LT UWB and WAN interfaces
LB-SEA.6	WAN access	Mobile users devices must have wireless access to the Internet in order to connect with the service provider
LB-SEA.7	Throughput	WAN access throughput must support web-browsing (at least 300 kb/s)
LB-SEA.8	Service provider	Service provider will have a public IP address, so clients can access the search service through Internet
LB-SEA.9	Search requests	User’s search request must include user’s position
LB-SEA.10	Search database	Information included in the search database should include location information
LB-SEA.11	Search results	Search results will be ordered according to user’s location
LB-SEA.12	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.3 Use Case C: Proximity marketing

4.3.1 Description

The objective of this service is to provide users with information such as latest bargains, special offers, discounts coupons, etc. of the shops and business nearby.

With this purpose, the user’s mobile phone should have integrated a LDR-LT UWB interface. When a LDR-LT UWB device in the shop/business detects the presence of a user nearby, it will send an advertisement to the user's mobile phone, for instance an SMS. The advertisements could be targeted only to certain users according to characteristics such as age, user profile, etc. Advertisements are pushed to the user without any previous request from the user, therefore it is necessary a previous acceptance of the service by the user in order to protect non-users from receiving unsolicited messages.

4.3.2 Requirements

Table 4-3: Proximity marketing technical requirements

ID	Name	Description
P-MKT.1	Proximity detection	The LDR-LT UWB sensor in each shop must detect the presence of other LDR-LT UWB devices close to it
P-MKT.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS
P-MKT.3	User device	LDR-LT UWB will be integrated into user's mobile phone
P-MKT.4	Advertisements	The user will get an advertisement from the shop nearby on their mobile phone
P-MKT.5	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.4 Use Case D: Children security

4.4.1 Description

The goal of this application is to detect if a person is going out of a security zone. As an example a teacher could use this new service in order to detect if a student is going out of the authorised zone (in the schoolyard, in a zone defined outside the school when they are going out...).

All students are equipped with LDR-LT UWB radio (on watches or wristbands). The teacher has the relative position of each student on its terminal (GSM, UMTS) and when a student is going out of the security zone an alarm (SMS) is sent to the teacher.

In this solution there is no anchors used for the localization. Some distance measurement messages are sent and relayed to the teacher terminal. All the students are not directly connected to the teacher and some relaying is needed in order to obtain the distance from each student.

This solution can also be deployed in other environments for example for elderly people in an old people's home.

Another possible application is to support parents when visiting amusement parks, shopping centres, multiscreen movie complexes, museums, family entertainment centres, etc. Through a LDR-LT UWB enabled mobile phone, parents would get a notification (SMS) when children move apart from them. Furthermore, a LDR-LT UWB network would provide accurate tracking of children's location, so in case the child has moved apart they could locate them through a map tracking children's position.

Figure 4-2 illustrates this kind of application.

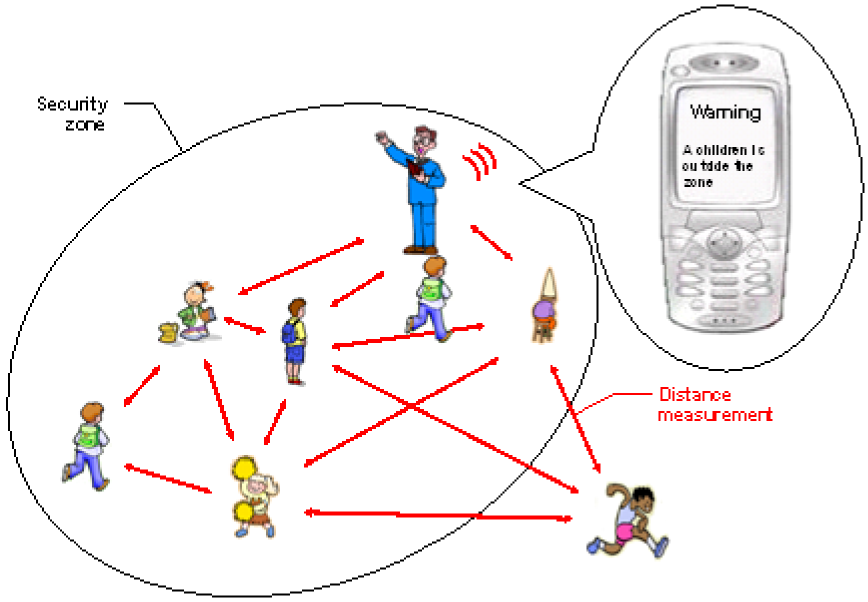

Figure 4-2: Children security

4.4.2 Requirements

Table 4-4: Children surveillance technical requirements

ID	Name	Description
CS.1	Tracking	Children's location will be tracked by a LDR-LT UWB system with an accuracy better than 1 meter
CS.2	Range	LDR-LT UWB devices range must be at least 30 meters in NLOS (100 meters in LOS) for a suitable system deployment over large areas
CS.3	Mobility	The tracking system will be able to track mobile users at walking pace, so position must be updated every second
CS.4	Deployment area	The LDR-LT UWB network must cover large indoor areas over 500 meters
CS.5	Network topology	LDR-LT UWB network topology, tracking algorithms and information distribution strategies must be able to cope with large scale networks (more than 100 nodes). Ad-hoc topology and relaying functionality must be used as all children can't have a direct link with the teacher
CS.6	Children's device	Children will wear a watch or wristband with an integrated LDR-LT UWB transceiver
CS.7	Parents device	LDR-LT UWB will be integrated into teacher's mobile phone or PDA

CS.8	WAN access	Teacher's mobile phones must have wireless access to the Internet in order to connect with the service provider
CS.9	Throughput	WAN access throughput must support the transmission of maps updated every second (at least 1 Mb/s)
CS.10	Notifications	Teachers will get notified on their mobile phones when students go out of the security zone
CS.11	Map	Teachers will be able to access a map with children's location
CS.12	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.5 Use Case E: Buddy-finder

4.5.1 Description

The objective of this service is to notify users about the proximity of other service users that are linked to their (buddies). This way, a user entering a shopping mall, leisure centre, disco, etc. would receive a notification if any of the contacts on their mobile phone directory or instant messaging application contact list are in the same location.

With this purpose, a LDR-LT UWB network should be deployed in the scenario, although not very high accuracy is required, so less UWB transceivers could be used compared to other use cases. User's mobile phone should have integrated a LDR-LT UWB interface. Users would only be able to locate users on their contact list that have this service and therefore have explicitly agreed to be found by their buddies. Users would start the buddy-finder service (most likely integrated in an instant messaging application) on their mobiles and a connection would be established with the service provider that would notify the users about the status of their buddies.

4.5.2 Requirements

Table 4-5: Buddy-finder technical requirements

ID	Name	Description
BF.1	Localization	The LDR-LT UWB network will detect the presence of service users and will be able to localize them with an accuracy better than 1 meter
BF.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS for a suitable system deployment over medium-size areas
BF.3	Deployment area	The LDR-LT UWB network must cover large indoor areas over 100m x 100m

BF.4	Network topology	LDR-LT UWB network topology, tracking algorithms and information distribution strategies must be able to cope with large scale networks (more than 100 nodes). Ad-hoc topology and relaying for communication between anchors are advisable
BF.5	User device	LDR-LT UWB will be integrated into user's mobile phone
BF.6	WAN access	Mobile users' devices must have access to the Internet in order to connect with the service provider
BF.7	Notifications	Users will get notified on their mobile phones when a buddy is located near them
BF.8	Service provider	Service provider will have a public IP address, so clients can access the buddy-finder service through Internet
BF.9	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.6 Use Case F: Proximity payments

4.6.1 Description

The objective of this service is to allow users to make small monetary transactions with their mobile phones or other handheld devices just by placing it near a kiosk or payment station. Proximity payments are already being applied in multiple scenarios such as vending machines, ticketing, parking meters, public transportation (bus, subway, train…), road tolling, etc.

With this purpose, the kiosk or payment station would have a LDR-LT UWB transceiver that would detect the proximity of user's UWB-enabled mobile phone or a smartcard with a UWB transceiver. There are many possibilities for the payment platform architecture, which can be based on the mobile operator, on credit card or financial companies, on Internet payment third parties or on prepaid smartcards. The payment platform can be contacted either by the kiosk (in that case the kiosk should have connection to Internet) or by the user's mobile phone. The payment can be charged to the user's bank account, mobile account or to a prepaid account.

4.6.2 Requirements

Table 4-6: Proximity payments technical requirements

ID	Name	Description
P-PAY.1	Proximity detection	The LDR-LT UWB sensor in the kiosk must detect the presence of other LDR-LT UWB devices close to it. The in/out decision must be taken by the system based on sub 30 cm resolution
P-PAY.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS
P-PAY.3	User device	LDR-LT UWB will be integrated into user's mobile phone

P-PAY.4	Payment platform	The payment platform will be contacted either by the kiosk or by the user’s mobile phone
P-PAY.5	Transactions	The user will be able to order/accept transactions using their mobile phone
P-PAY.6	Payment	The payment will be charged either to the user’s bank account, mobile account or a prepaid account
P-PAY.7	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.7 Use Case G: Customized multimedia guide

4.7.1 Description

The objective of this service is to provide museum visitors with an interactive location-aware multimedia guide. The guide would provide the visitor with the multimedia content (audio, pictures, text, video) according to user’s location, so the users would automatically get the corresponding explanations as s/he is approaching a work of art. Furthermore, the application could have a navigation tool to guide the user through the museum. The user could choose between different available tours or even customize the rooms or works s/he wants to visit.

With this purpose, a set of fixed UWB anchors would be distributed in known positions in order to provide user’s dual WAN/UWB devices with location information. On the other hand, the user would be connected through the WAN access to the service provider, which would provide the multimedia content corresponding to user’s location.

4.7.2 Requirements

Table 4-7: Customized multimedia guide technical requirements

ID	Name	Description
CMG.1	Tracking	Mobile user’s position will be provided by a LDR-LT UWB system with an accuracy better than 1 meter
CMG.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS for a suitable system deployment over large areas
CMG.3	Mobility	The tracking system will be able to track mobile users at walking pace, so position must be updated every second
CMG.4	Deployment area	The LDR-LT UWB network must cover large indoor areas over 100m x 100m
CMG.5	Network topology	LDR-LT UWB network topology, tracking algorithms and information distribution strategies must be able to cope with large scale networks (more than 100 nodes). Ad-hoc topology and relaying for communication between anchors are advisable

CMG.6	User device	User device must integrate both LDR-LT UWB and WAN interfaces
CMG.7	WAN access	Mobile users devices must have wireless access to the Internet in order to connect with the service provider
CMG.8	Throughput	WAN access throughput must support transmission of multimedia (audio, pictures, video) content (at least 1 Mb/s)
CMG.9	Service provider	Service provider will have a public IP address, so clients can access the multimedia guide service through Internet
CMG.10	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.8 Use Case H: Parking space finder

4.8.1 Description

Parking of cars comprises one of the most acute and growing problems of big modern cities. Indoor parking garages are the way to save space in cities. Compared to outdoor parking, indoor parking garages occupy a smaller space, because they are expanded vertically to multiple floors; therefore they can contain thousand of cars. The disadvantage of the indoor parking garage is that it takes time to find a parking space and of course wastes gas, becoming stressful and infuriating on more than one occasion.

The parking space finder service helps drivers to find available spaces when entering an indoor parking garage. This service will save drivers time and money.

Firstly, the user sends a service request via an SMS, through a call or by means of an application on their dual WAN/UWB mobile phone. The user position, which is obtained from a UWB-based location system, is also included in the service request. Then, the operator/service provider sends a query to a database of available parking bays, which is continuously updated thanks to the information from a UWB sensor network deployed in the indoor garage. The sensors will be interconnected and connected to the operator’s network too. Finally, the network sends the user the geo-referred information about available parking spaces via an SMS or through a data connection and the application stored in the user device calculates the best route to the nearest parking spot. The information is displayed on a browser-type cartographic system. The database will be updated until the user disconnects from the finder service after parking.

4.8.2 Requirements

Table 4-8: Parking space finder requirements

ID	Name	Description
PSF.1	Tracking	Mobile user’s position will be provided by a LDR-LT UWB system with an accuracy better than 1 meter

PSF.2	Range	LDR-LT UWB devices range must be at least 20 meters in NLOS for a suitable system deployment over large areas
PSF.3	Mobility	The tracking system will be able to track mobile users at slow-driving pace, so position must be updated every second
PSF.4	Deployment area	The LDR-LT UWB network must be cover large indoor areas over 100m x 100m
PSF.5	Network topology	LDR-LT UWB network topology, tracking algorithms and information distribution strategies must be able to cope with large scale networks (more than 100 nodes). Ad-hoc topology and relaying for communication between anchors are advisable
PSF.6	User device	User device must integrate both LDR-LT UWB and WAN interfaces
PSF.7	WAN access	Mobile users devices must have wireless access to the Internet in order to connect with the service provider
PSF.8	Throughput	WAN access throughput must support transmission of multimedia content (at least 1 Mb/s)
PSF.9	Service provider	Service provider will have a public IP address, so clients can access the finder service through Internet
PSF.10	Finder requests	User’s parking space finder request must include user’s position
PSF.11	Finder database	Information included in the database of available parking places should include location information
PSF.12	Finder results	Finder results will be sorted according to user’s position
PSF.13	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.9 Use Case I: Oil exploration

4.9.1 Description

An application for oil-gas exploration focused on a sensor network seismograph system was presented to the EUWB project by Wisygeo [9], which is a new company (established in 2009) to develop and market wireless solutions for high-speed battery-powered monitoring for environmental and oil exploration.

As shown in Figure 4-3, the proposed Wireless Geophone Network (WGN)-based system should replace the actual cabled systems used in high density (approximately 2000 sensors/km^2) on-shore seismic acquisition, since current systems require hundreds of kilometres of cabling that cause delays and high logistic costs.

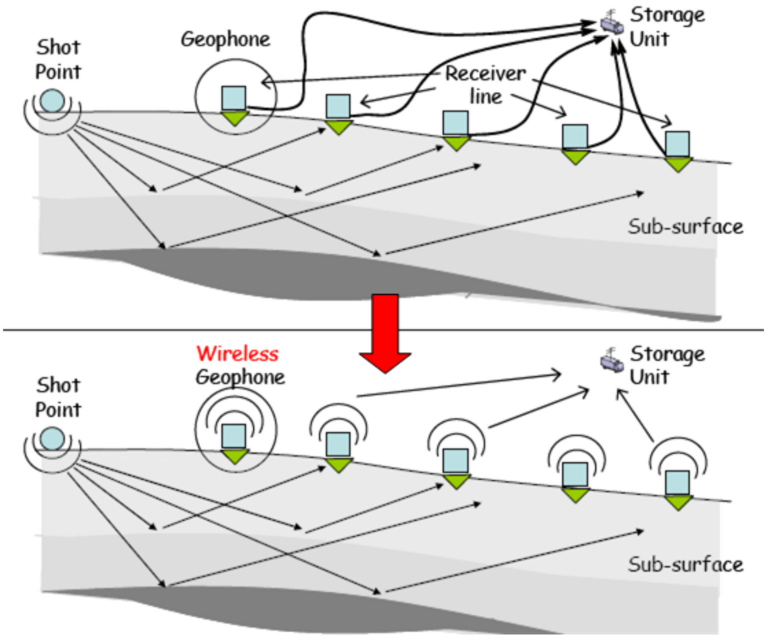

Figure 4-3: Wireless Geophone Network for high density land acquisitions

A WGN might consist of units (receivers or Wireless Geophones, WGs) that are in charge of sending their own recording data or forwarding (relaying) the data of other WGs. Each WG is battery-powered and is typically equipped with a radio transceiver (for radio transmission and reception), small microcontroller and storage unit to handle processing, digitalization and buffering of seismic data. As for cable-based system, real-time data delivery needs to be guaranteed so that geophone digital data readings could be conveyed to storage unit with stringent delay constraints. Moreover, the control/storage unit provides the necessary functions of timing and monitoring of each (wireless) geophone.

The large field extension and receiver density require the WGN to exploit sophisticated radio transmission technologies to efficiently handle either short-range transmissions (e.g., for receiver-to-receiver short-distance communication within one group interval) and long-range transmissions (for seismic data delivery to storage unit and geophone remote monitoring) that must cover distances of several kilometres.

From a communication perspective, a WGN can be based on a mixture of network technologies that are working in cooperation: groups of WGs (e.g., within a group line) are forming independent Wireless Sensor Networks (WSN, see Figure 4-4) that are simultaneously operating (e.g., sensing and transmitting using different frequencies/channels). At the same time, each network of sensors is interconnected by long-range wireless links to form what is usually referenced as scalable Wireless Metropolitan Area Network (WMAN). WMAN network must support long-range links to collect the data traffic generated by each WSN for propagation toward the central control/storage unit.

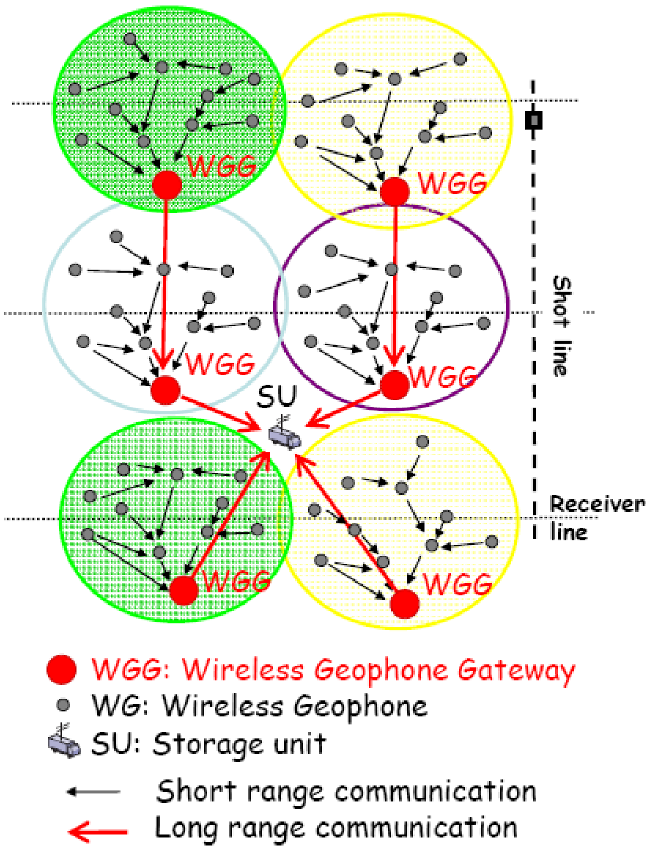

Figure 4-4: WGN-based scheme for high density on-shore seismic acquisition

The accuracy of localization information plays a key role in the seismic acquisition procedure, since position errors can significantly degrade the quality of the imaging process required to get subsoil maps from the geophone data. UWB radio technology provides excellent location estimation quality, with error below 0.5 meters. Its use can allow for acquiring both location information and synchronization without the need of deploying GPS-equipped WGN (with savings in terms of costs and battery-use due to the low power consumption of UWB devices). UWB is one of the most suitable technologies for the short-range communications required in the WSN, with the best characteristics in terms of data rate, number of devices, consumption and protocol overhead among current mature technologies like Bluetooth, Wi-Fi and ZigBee.

Concerning the long-range transmissions, WiMAX and Wi-Fi are outlined as the most optimum candidates due to their support of mesh networking, high data rate and long range.

Gateways are equipped with the necessary technology and radio circuitry to handle both short-range and long-range transmission/reception (as illustrated in Figure 4-5). Gateways have the capability of i) receiving data readings transmitted by WGs in short-range; ii) buffering and forwarding seismic digital data; iii) maintaining long-range (bidirectional) connections with other Wireless Geophone Gateways (WGGs) and storage unit; iv) propagating control commands to WGs for acquisition localization and synchronization. A WGG (Wireless Geophone Gateway) has therefore the role of interconnecting a number of low-power geophones transmitting at short-range distances with the storage unit by forwarding their data over multiple long-hops across a number of gateways (as in mesh mode operation).

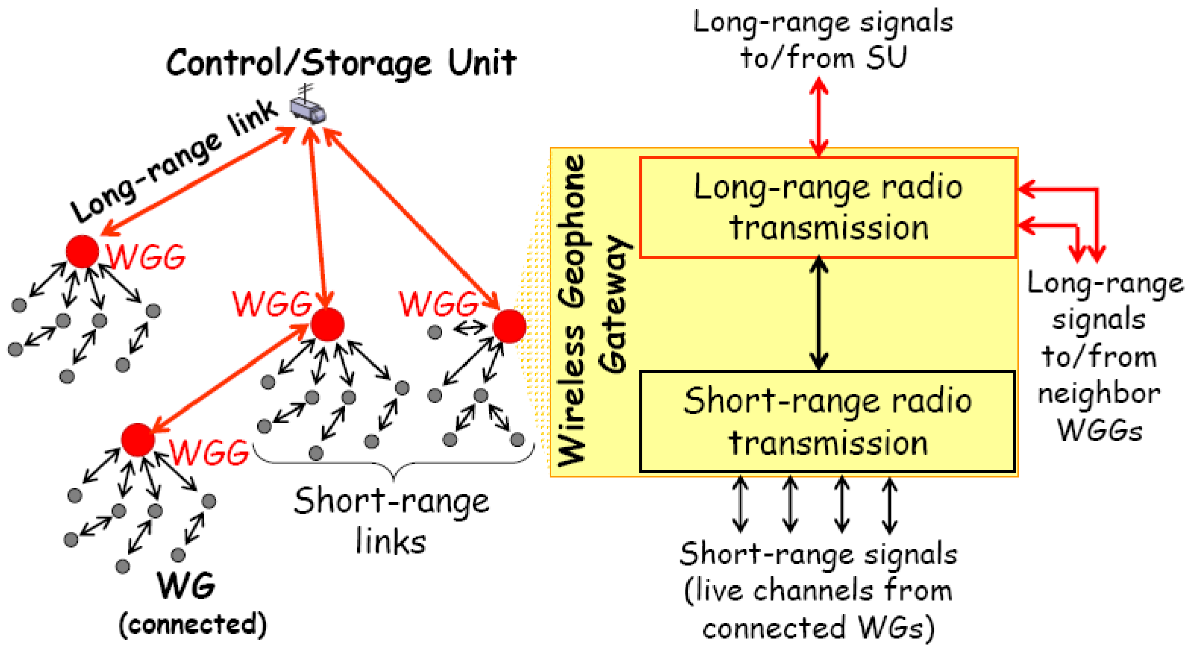

Figure 4-5: Wireless Geophone Gateway

As a summary, this application shows a heterogeneous environment, where Wi-Fi/WiMAX standards and UWB technology interwork in order to provide a control/storage unit with the necessary information to identify the areas that can contain hydrocarbon deposits beneath the Earth's surface. Although this use case gets off the “typical” definition of location-based service, it has been included in this deliverable due to the great importance of the location information provided by the UWB-enabled geophones to draw the subsoil maps and make the final decision on the places where the exploring wells should be drilled.

4.9.2 Requirements

Table 4-9: Oil exploration requirements

ID	Name	Description
OE.1	Localization	Localization accuracy better than 50 cm
OE.2	Range	Short range: 20-30 meters Long range: several kilometres (mesh networking)
OE.3	Large-scale network	At least 15000 UWB-enabled geophones (MB-OFDM and IR) for one survey
OE.4	User device	PC/laptop with Internet connection to access the storage unit (out of the scope of the described application)
OE.5	WAN access	Wi-Fi/WiMAX access is required for communication among WGGs and with the storage unit
OE.6	Throughput	Per geophone: 50 kbps; Aggregated traffic: 100 Mb/s

OE.7	Power consumption	Low power consumption is required (2-3 days full operation/node)
OE.8	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

4.10 Use Case J: Location Application for Emergency Services (LAES)

4.10.1 Description

The proposed system will be used in situations where lives are at risk, from a small house fire up to major disasters. The applications are used temporarily by emergency services in all aspects of disaster situations, including disaster prevention.

Most deployments will be for the kind of small-scale emergencies that occur every day, and are dealt with by the emergency services almost as a matter of routine. However, in such emergency situations, particularly within smoke filled, partially or completely collapsed large buildings, communications with rescue personnel can be difficult. Safety and coordination of the operations are hampered by a lack of knowledge of the location of emergency staff.

The use of UWB radio, to allow the precise location of personnel to be measured and displayed in a control centre, will make a real contribution to save lives. It can also support an increase in the communication between emergency personnel, where the system is able to handle localization and communications.

The main benefits for those authorities who use them are:

- high indoor availability within buildings affected by disaster;
- high positioning accuracy even in this indoor environment;
- no fixed installations required (only ad-hoc reference stations);
- high positioning accuracy for sensor networks deployed in critical situations.

One scenario that is foreseen for fire-fighter users is a building that has collapsed due to fire (which will be the most common case), terrorist attack or earthquake. Each emergency worker is equipped with a small unit which allows transmission and reception of UWB signals and allows the localization of the rescuers even in indoor harsh environment.

Figure 4-6 illustrates the scenario for fire-fighters.

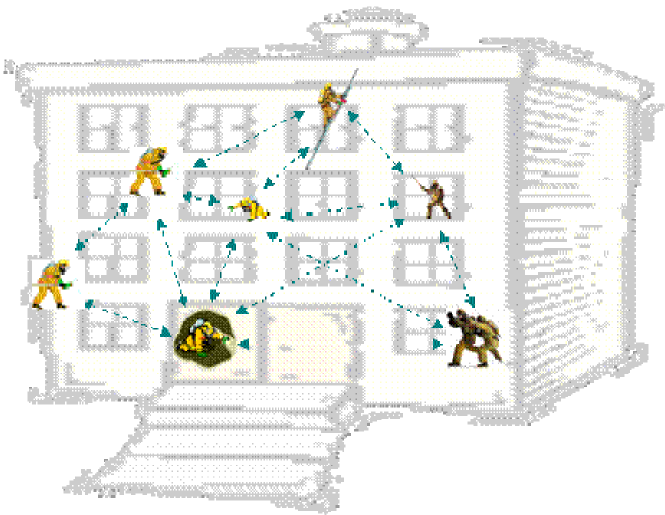

Figure 4-6: Fire-fighters in a building that has collapsed due to fire, terrorist attack or earthquake

The fire-fighter who is in danger can be precisely located in relative positioning thanks to the ranging information that is transmitted in the UWB network. In order to have an absolute positioning, several solutions can be envisaged:

- with an Anchor-Based Localization (ABL) system. In this case, anchor nodes can be put outside the building in rescue vehicles or just at the entrance of the building if anchor nodes are dropped portable UWB units. The absolute position can be obtained thanks to Global Navigation Satellite Systems (GNSS) information;
- with an Anchor Free Localization (AFL) system. In this case, all rescuers have a relative 3D positioning. As an example, they are able to know if there is a fireman behind a wall and to rescue him if necessary.

For this first scenario, UWB devices are used mainly indoor. Fire-fighters need to go in a deep indoor environment in which propagation is difficult and need to have localization information in all cases.

4.10.2 Requirements

Table 4-10: LAES requirements

ID	Name	Description
LAES.1	Localization	Localization accuracy better than 1 meter in a harsh environment
LAES.2	Range	LAES devices link distance must be 50 meters in NLOS in indoor environment (500 meters in LOS conditions) for a typical deployment
LAES.3	Deployment area	Based on information received from some users (fire-fighters), the deployment area is a reduced one. In case of damaged buildings or houses the concerning area doesn’t have an area more than 10000m² = 0.01 km². For damaged industrial areas the concerning area contents approximately up to 2 km² (petrochemical companies), airports and shunting yards content an area up to 12 km²

LAES.4	Network topology	The network topology is an ad-hoc topology. No infrastructure is required for such system
LAES.5	User device	PC/laptop with Internet connection to access the storage unit (out of the scope of the described application)
LAES.6	WAN access	Wi-Fi/WiMAX access is required for communication from the building to the control unit (in the vehicle) if LDR-LT link is possible or from the vehicle to the headquarters
LAES.7	Throughput	Per fire-fighter device, the throughput must be sufficient in case of AFL. Indeed if tracking is performed at a rate of 1 measure per second among all users (up to 20) it is estimated that a radio data rate of 500 kbps is needed (250 kbps for the useful data rate)
LAES.8	Power consumption	Low power consumption is required
LAES.9	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

5 IP Multimedia Subsystem

A noteworthy example of convergence is IMS, aiming to specify an architecture that enables interoperability for service provision independently of the access technology.

After the analysis of different use cases of location services performed in section 4, requirements for advanced and innovative service platforms have been extracted in terms of localization/tracking accuracy, range, mobility, user device, WAN access, throughput, service provider, coexistence… These requirements could be considered as interesting and valuable contributions to the technical specifications of the 3GPP, for instance, completing the information collected in [10] about the description of location services.

5.1 Overview

IMS is an international standard for advanced multimedia service delivery in next generation converged networks (homogeneity in the core and heterogeneity in the access). Originally designed to evolve UMTS networks to deliver Internet Protocol (IP) multimedia to mobile users, IMS has become the core component within 3G, cable TV and next generation fixed telecoms networks.

IMS specification began in 3GPP Release 5 as part of the core network evolution from circuit-switching to packet-switching, representing an approach to delivering "Internet services" over GPRS. This vision was later updated by 3GPP, 3GPP2 and TISPAN by requiring support of networks other than GPRS, such as Wireless LAN, CDMA2000 and fixed line.

3GPP works closely with experts in the Internet Engineering Task Force (IETF) to ensure maximum re-usability of internet standards, preventing fragmentation of IMS standards. IETF is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.

Figure 5-1 represents the IMS reference architecture [11] including interfaces towards legacy networks and other IP-based multimedia systems.

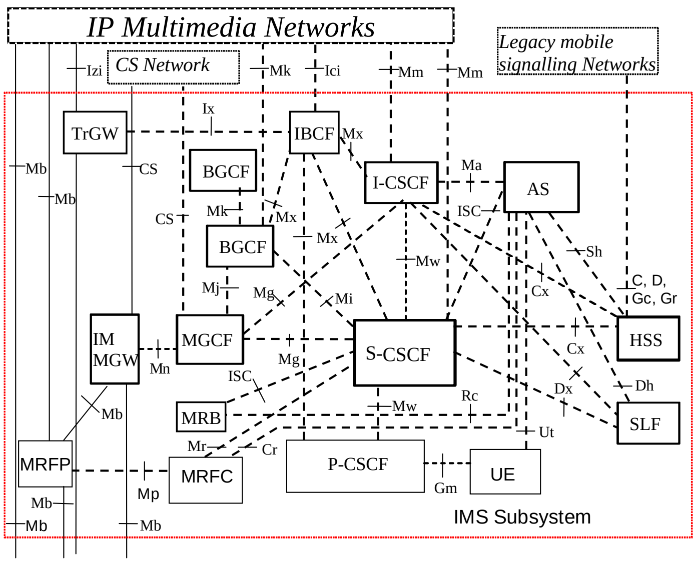

Figure 5-1: Reference Architecture of the IP Multimedia Core Network Subsystem

The detailed description of the functional entities and nodes presented above is out of the scope of this deliverable and can be found in [11], [12]. A simplified IMS architecture is depicted in Figure 5-2.

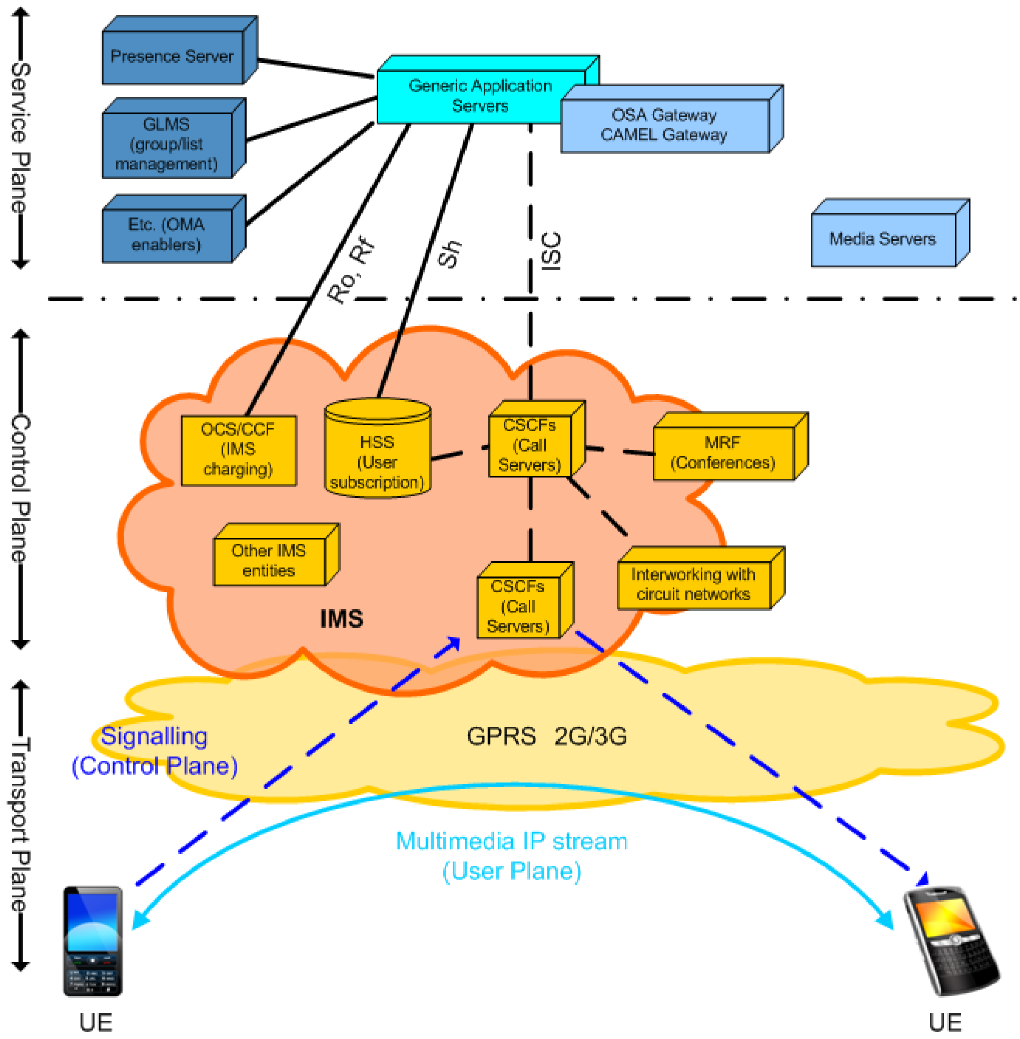

Figure 5-2: Simplified IMS Architecture

As shown in Figure 5-2, the IMS consists of three logical planes: Service Plane, Control Plane and Transport Plane. Of the most significant protocols used in the IMS, the Session Initiation Protocol (SIP) must be highlighted, which was chosen by 3GPP for session establishment, modification, and release. It is the signalling mechanism for IMS, thereby allowing voice, text and multimedia services to traverse all connected networks.

The Service Plane comprises application and content servers to execute value-added services for the user. The IMS allows for generic and common functions -implemented as services in SIP Application Servers (AS) - to be reused as building blocks for multiple applications and services. This implies the introduction of new services offering rich user experiences, with fast time-to-market and a simplified service creation and delivery process.

The Presence Server (PS) collects information about the availability of user and services. The Group and List Management Server (GLMS) manages the lists of identifiers for users and services.

The Open Mobile Alliance (OMA) is an international organization [13], developing open, market driven interoperable specifications for global adoption of data services. It was created in June 2002 by leading mobile operators, device and network suppliers, information technology companies, content and service providers with nearly 225 Global Members. More than 40 enablers have been published and there are over 100 active work items for OMA enablers. One of its working groups is focused on the IMS topic, specifying a framework for enablers that use IMS capabilities.

Thanks to the Customized Applications for Mobile network Enhanced Logic (CAMEL) gateway, the IMS functionalities are offered to be used by CAMEL services, allowing the Intelligent Network to control IMS sessions. By means of the Open Service Access (OSA) gateway, the IMS functionalities are presented to third parties.

The Media Servers and Processors are in charge of capturing, playing and mixing media streams (audio/video).

The Control Plane comprises network control servers for managing call or session set-up, modification and release. The key IMS entity in the Control Layer is the Call Session Control Function (CSCF), which is responsible for session control and processing of signalling traffic. The Home Subscriber Server (HSS) is a user database, which maintains each end-user's profile. The Media Resource Function (MRF) is responsible for the manipulation of multimedia streams. The On-line Charging System (OCS) and the Charging Collection Function (CCF) deal with the IMS billing. Integrated voice, data and video services increase demands on charging modes. OCS requires real-time interaction between IMS entities and the billing system, and the OCS interacts with users' accounts in real-time to control or monitor service-related charges. Concerning the offline billing, CCF receives charging information from IMS entities, which it pre-processes. Offline charging collects charging information after a session has been completed, which does not affect the service process.

The Transport Plane transmits user data and conveys signalling to the Control Plane, providing a core Quality of Service (QoS)-enabled IPv6 network with access from user equipment (UE) over mobile, Wi-Fi and broadband networks. This layer comprises routers and switches, both for the backbone and the access network.

5.2 IMS and location-aware services

Extending IMS with support for location-aware services will enhance such services with value-added features provided by IMS architecture, including: QoS support securing enhanced service quality, service integration by defining standard interfaces over an IP-based infrastructure and support for flexible charging depending on the type of services being used by a client. Based on a horizontally layered architecture, the IMS provides an open call/session control architecture with interfaces to the service and transport planes adopted in both wireless and wireline industries. Moreover, new revenues to operators and service providers will be offered.

5.2.1 Location server

Based on the results obtained after the search performed in the literature, the inclusion of a location server in the IMS Service Plane would be an interesting proposal for bringing location information to the IMS and also connecting the IMS with a real positioning system [14], [15].

The location server would be designed as a generic SIP AS located in the IMS Service Layer. The method for determining user position would not be implemented within the location server; rather, the location server would be responsible for delegating the location request to a positioning system, which would consist of a UWB network that would take advantage of the location features inherent to the LDR-UWB technology.

Using the terminology proposed in [4], the location server would take the role of a LoCation Services (LCS) Client and would obtain location information from a LCS Server. A suitable protocol (e.g., Mobile Location Protocol (MLP) [16]) would provide the means of conveying such information. As explained in 5.1, all other AS requiring location data could send requests to the location server via a SIP interface. Such a concept would provide a central location in the IMS Service Plane that would give location data, rather than having each AS separately requesting data from a LCS Server.

By implementing the location server, acting as an interface towards the UWB positioning system to retrieve user location information, existing and emerging IMS-based services (Push to Talk Over Cellular (PoC), Messaging, Conferencing, Multimedia Telephony...) would be able to extend their capabilities becoming location-aware and taking into account end-user position.

The architecture integrating the location server into IMS and connected with a UWB positioning system is shown in Figure 5-3.

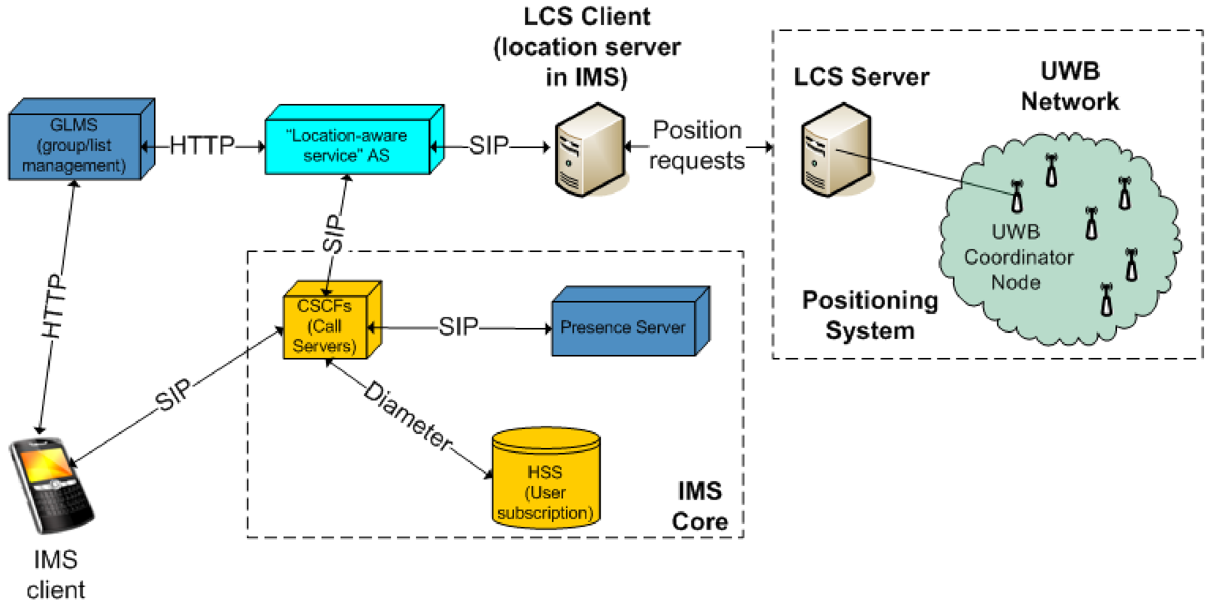

Figure 5-3: Location server integration into IMS architecture

The "Location-aware service" AS and the location server (LCS client) are the two new components in comparison with Figure 5-2. The proposed solution in Figure 5-3 would develop a "Location-aware service". The user would be notified when other user, which belongs to a group, entered a certain area (shopping centre, office…) in order to establish, for example, a PoC session or sending a multimedia message.

The location server would receive location inquiries through a SIP interface. The SIP location requests could carry location filters that would be necessary to specify events that would trigger notifications to users in order to avoid flooding the network with responses carrying location information.

To establish a "Location-aware service" session, after receiving a SIP request for a group session, the "Location-aware service" AS would contact the GLMS via HTTP to retrieve a group member list. Then, for each member of the group the server would check their presence status by contacting the Presence Server, checking whether they are online, offline, or busy. Finally, the "Location-aware service" AS would retrieve location information from the location server for available users, to determine whether they are within range from the session originator.

5.2.2 Location in SIP/IP core Specification

OMA, as described in 5.1, is designed to be the centre of mobile service enabler specification work, helping the creation of interoperable services across countries, operators and mobile terminals that will meet the needs of the user. SIP-based OMA enablers use the services of an underlying SIP/IP core infrastructure, e.g. IMS. Focusing on one of the Working Groups (WG) identified in OMA, the Location WG (LOC) has been created to develop specifications to ensure interoperability of Mobile Location Services on an end-to-end basis. As a result of the work performed within OMA LOC group, a new enabler, the LOCSIP v1.0, has been approved as Candidate [17] (information update: August 2009).

Previously, OMA has developed various enablers related to location. The Mobile Location Service (MLS) enabler has the main purpose to define protocols for exposure of terminal location to applications but does not define any positioning determination mechanisms. SUPL (Secure User Plane Location) on the other hand defines procedures and protocols for positioning determination of a terminal utilizing an IP connection between server and terminal. Both enablers are to some extent prepared for use in a SIP context e.g. by allowing use of SIP-URI (Uniform Resource Identifier) identities. None of them do however support the exposure of terminal location to an application within a SIP/IP core network (one example of such a network is an IP Multimedia Subsystem). The implication of this is that a SIP application server needing location information to enhance its services needs to implement one or more non-SIP interfaces to location servers. By instead defining an interface and procedure using SIP, additional interface technologies can be avoided and routing and addressing mechanisms in the SIP/IP core as well as existing SIP-based OMA enablers can be reused.

The purpose of LOCSIP is to expose location information to user equipment/application servers connected to a SIP/IP core network (e.g. an IP Multimedia Subsystem). This service enabler is specified as a reusable network component in a SIP/IP core network, capable of receiving and responding to location subscriptions over a standardised SIP-based interface. Handling of the location specific functions within a SIP/IP core is defined but positioning determination functions within SIP/IP core is out of scope.

LOCSIP V1.0 enables a Location Client to subscribe to location information from a Location Server, exposing the location information of Targets. The subscription may include filters defining temporal or spatial criteria for when location information shall be delivered. The subscription may also include a list of targets.

Figure 5-4 presents an example of location request for an entity registered in the IMS core through SUBSCRIBE-NOTIFY messages. The procedure is defined in the following points:

1. A SUBSCRIBE message is generated by a Location Client requesting location information about a Target. A Feature tag for location service should be included in the SUBSCRIBE request to allow SIP/IP core (Serving Call Session Control Function – S-CSCF) to route the request directly to the Location Sever. This mechanism is used to distinguish location service requests from presence service requests.
2. The Location Server initiates the location procedure of Target. This process is out of the scope of LOCSIP and depends on the type of network where Target is registered.
3. "200 OK" from the Location Server to the Location Client: response for successful subscription.
4. Once the location information is obtained after finishing the location procedure, it is encoded in a Presence Information Data Format Location Object (PIDF-LO) [17] and enclosed to a NOTIFY message (from Location Server to Location Client).

5. "200 OK" from the Location Client to the Location Server: response for successful notification.

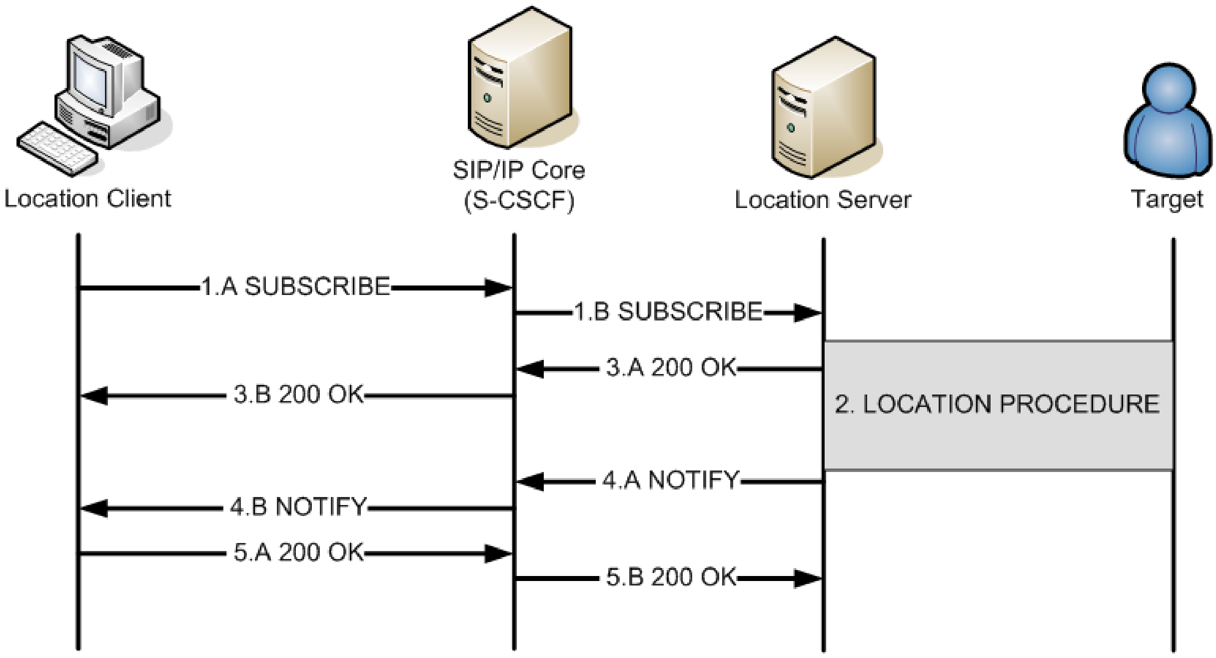

Figure 5-4: LOCSIP procedure for target location request

6 Demonstrators of location-aware services

6.1 Shopping centre

6.1.1 Description

The main objective of the shopping centre demonstrator is to build a platform for the development and test of location-aware services in heterogeneous networks.

Due to the unmatched features of impulse-based UWB-RT concerning Time-Of-Arrival measurement and distance estimation, UWB is a good candidate to provide wireless users with location information on indoor environments, which are not covered by satellite-based systems like GPS. Furthermore, thanks to the simultaneous data transmission and location capabilities of UWB, a single UWB network could be used to interconnect different sensors (e.g. fire detection sensors) and provide mobile users with location information. Besides user's positioning itself, localization information could be used by wireless/cellular access networks to develop location-based services or to improve radio resources management.

Some scenarios for this application are relatively wide indoor environments such as shopping malls, train stations, airports, exhibition centres, sports stadiums, etc. Interesting applications in these scenarios are: advertising the last bargains of a shop to mobile users around, providing information about schedules and the way to the platform/gate in stations and airports, or guiding and providing the visitors with information in museums or tourist areas.

The most important elements of the demonstrator are shown in Figure 6-1.

- Dual LDR-LT UWB/HSPA device: the dual device gets its position from the location server through the LDR-LT UWB interface. On the other hand, the device accesses different services through the UMTS-HSPA interface, including new developed services based on location-awareness.
- LDR-LT UWB picocell: it is composed of at least 4 fixed nodes, one of them acting as a picocell coordinator. The distance between the mobile and each fixed node is estimated and transmitted to the location server.
- Location server: the location server application runs on a laptop connected to the LDR-LT UWB picocell coordinator. It receives the ranging information from every node and applies the tracking algorithm to obtain the position of the dual device.
- Services server: the service provider application runs on a computer that can be physically anywhere, as far as it is connected to the Internet with a public IP address. It must have stored the geographical information about the shopping centre (shops, walls, corridors, etc.). It receives information requests from the dual device, which include the device's position. The application processes the request and sends the requested information according to the device position.

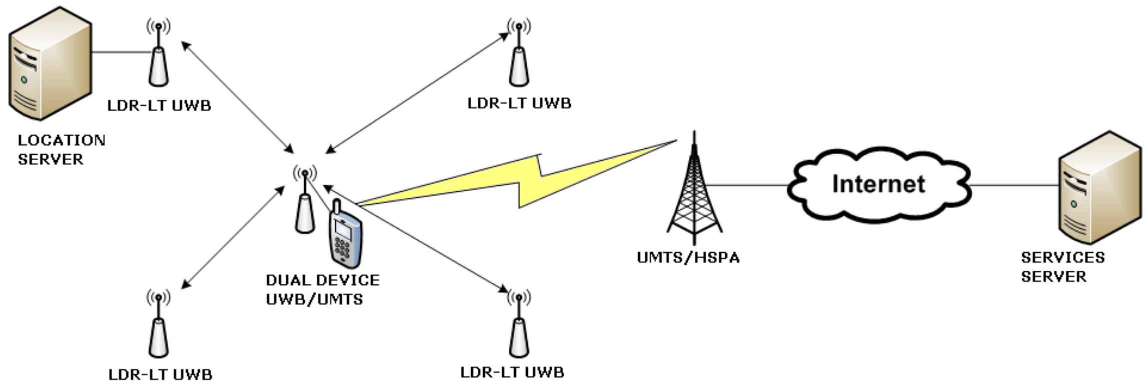

Figure 6-1: Location-aware services demonstrator

The LDR-LT UWB network will be deployed in a reduced area of few meters length, which will be a scaled representation of a real indoor environment, for instance a shopping centre. The dual device will move across the area and the position provided by the LT system will be converted into a position in the real shopping centre.

On this demonstration platform, multiple location-aware services will be implemented. Firstly, a navigation application that will provide the dual device with a map of the shopping centre. It will track the user's movement, being automatically updated according to the user's position. The user will be able to zoom in/out and scroll the map, ask the application to guide them to a selected place, access information of the different shops/businesses, etc. Another service that will be implemented is location-based search. Information about the shops will be stored in the service provider database together with their position. When the user searches for some kind of business (restaurants, fashion shops, grocery stores...), the search results will be ordered according to the distance to the user. Finally, another possible location-aware service is related to location-aware marketing. The operator will provide the user with information of the shops/businesses when s/he comes near, for example last bargains when getting near a shop or scheduled films when passing near a cinema.

The access to the services will be designed with a view to compatibility with the existing service platforms, for instance IMS (IP Multimedia Subsystem). Necessary enhancements to these platforms will be proposed in order to take advantage of location-aware information.

Although the main objective of the platform is the development and test of location-based services, it can also be used to test different tracking algorithms and location information acquisition and distribution strategies in the LDR-LT UWB location system.

Following, a further description of each element is included.

6.1.1.1 LDR-LT UWB piconet

The LDR UWB piconet is composed of at least 4 fixed LDR UWB nodes, plus the dual LDR-LT UWB/HSPA mobile node. One of the fixed nodes will act as the piconet coordinator. Furthermore, the piconet coordinator will be connected to the location server. Physically, the piconet coordinator will be connected to a laptop executing an application which controls both functionalities (piconet configuration and localization).

For the implementation of the LDR-LT UWB piconet, LDR platform developed within EUWB WP7 will be used (see Figure 6-2). This platform includes a complete protocol stack:

- Application layer (APPL)
- Network layer (NWK)
- Medium Access Control layer (MAC), split into SoftWare MAC (SW-MAC) and HardWare MAC (HW-MAC)
- Physical layer (PHY)

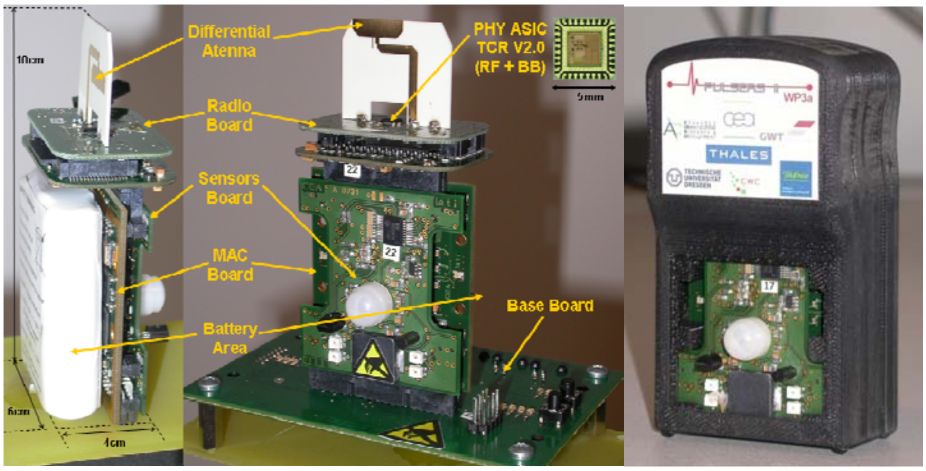

Figure 6-2: Physical view of the IR-UWB LDR-LT platform (profile/front/packaged)

From the implementation point of view, the Application, Network, and SW-MAC layers are part of a software package whereas the HW-MAC and PHY layers are part of a hardware package. The complete stack is implemented into each physical node, including the part of the application in charge of local elementary computations (e.g. for positioning purposes), all except for the part of the application that is hosted on the user device and responsible of advanced tasks (e.g. the Graphical User Interface).

A more detailed description of EUWB LDR-LT platforms can be found in [18].

6.1.1.2 Dual LDR-LT UWB/HSPA device

The dual LDR-LT UWB/HSPA device represents the mobile user device, which would be in general a mobile phone, smartphone or PDA. Nevertheless, for demonstration purposes the dual UWB/HSPA will be implemented in a laptop. A UMTS/HSPA PCMCIA card will provide the device with HSPA access. On the other hand, a EUWB LDR-LT platform will be also connected to the laptop. Finally, the services client application will run in the laptop, providing the user with access to location-aware services.

The interface provided by the EUWB LDR-LT platforms is a RS-232 serial port. A RS-232 to USB converter will be used to provide a more extended USB interface that is likely to be available in most of user devices. Depending on the targeted user device and interface, other possible converters can be used, such as CompactFlash cards and PCMCIA cards featuring a RS-232 serial port, which are provided by different manufacturers.

Summarizing, the integrated LDR UWB/HSPA user device will be composed of:

- User device
    - Laptop with HSPA card (optionally smartphone or PDA)

- EUWB LDR-LT platform
    - Interface converter: USB to RS-232 adapter (optionally PCMCIA RS-232 card or Compact Flash RS-232 card)
- Client application

6.1.1.3 Location server

The function of the location server is to collect the distances estimated by the fixed LDR-LT UWB nodes and compute the position of the mobile UWB/HSPA node. Physically, it is implemented in a laptop/PC connected to the LDR-LT UWB piconet coordinator. The interface between the LDR-LT platform and the laptop is represented in Figure 6-3:

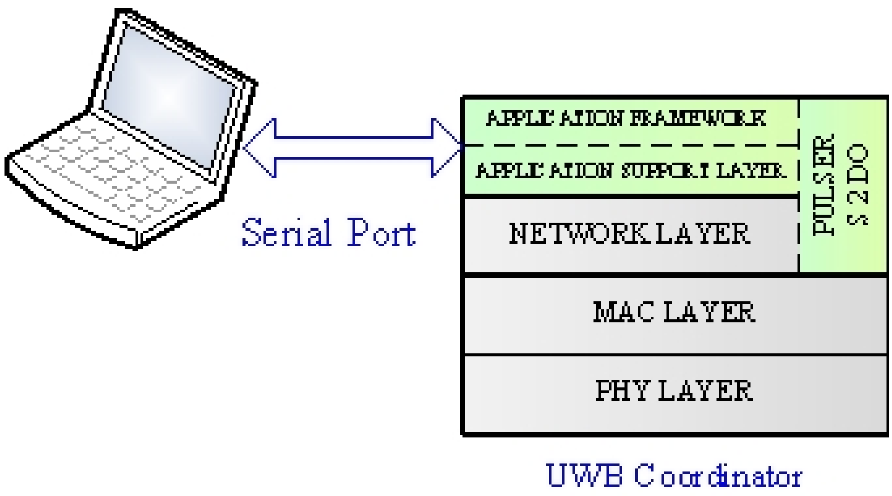

Figure 6-3: Interface between the GUI and the network

As it is depicted in the previous figure, the communication between the location server and the physical platform is made through a serial port interface. The EUWB platform Graphical User Interface will provide both localization and network configuration functionalities, so it will be used in the location server with minor modifications if needed.

The EUWB platform Graphical User Interface will be based in PULSERS II GUI, which provides support for localization, but it also includes some other functionalities like network configuration, monitor and set-up tasks of all the sensors and actuators included in the boards. A snapshot of the PULSERS II GUI main window is shown in Figure 6-4. The main functionalities of EUWB GUI are:

- Network configuration: network initiation, showing the routing table, binding process...
- Status: monitoring the status of the network. The user can see how many devices are connected, their type, and detailed information about them.
- Location: device configuration, range measurement and access to different information such as the neighbourhood table, ranging information and calculated positions.

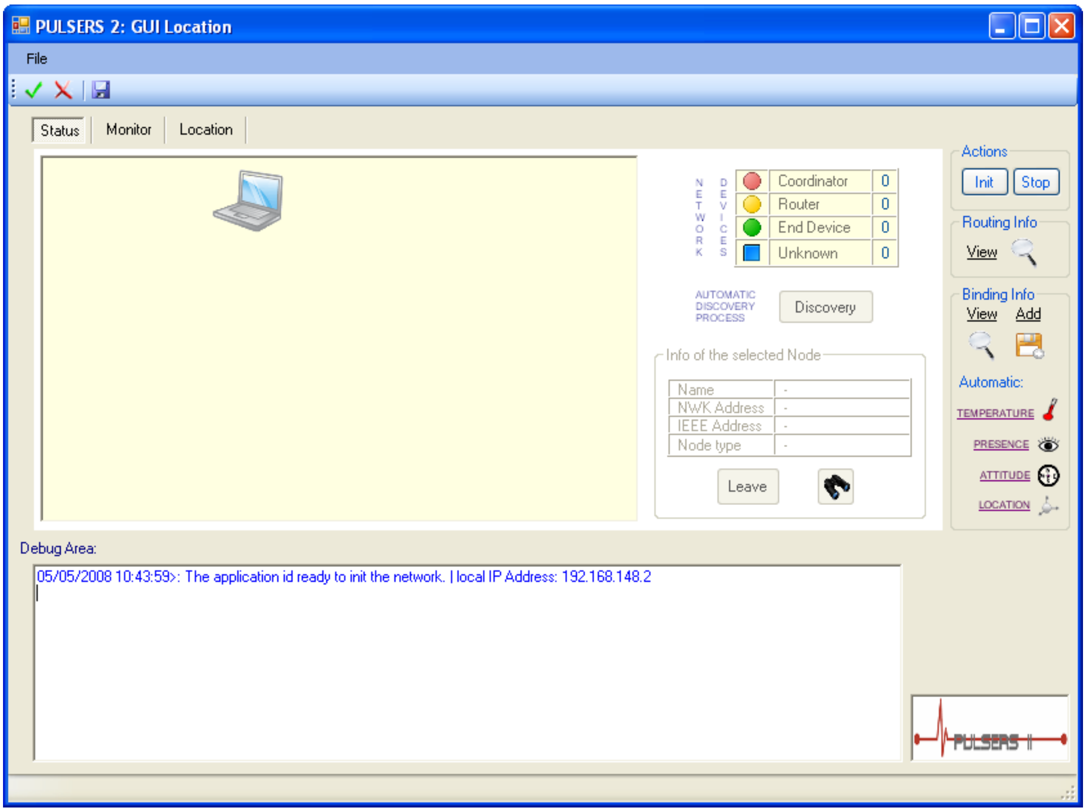

Figure 6-4 : PULSERS 2 GUI main window

6.1.1.4 Client application

The client application runs in the dual UWB/HSPA device and provides the user with all the information concerning the shopping centre: map, shop list, shop information, bargains, etc. The information is adapted according to user's position. Through the client application, the user is able to access location-aware services such as shopping centre navigation, location-aware search or bargain advertisement. The client application gets access to the services server through the HSPA interface, and retrieves user's position through the LDR-LT UWB interface.

The server application is composed of different modules:

- Communication module: this module implements the communication with the server application through TCP/UDP sockets. Different sockets are used for each service. In the set-up procedure, the client attempts to establish connection with the server sockets. Once the connection is established, both client and server can exchange TCP packets. In case of UDP links the connection procedure is not necessary.
- Session control module: this module is in charge of the session set-up and the exchange of session information between client and server.
- Localization module: this module controls the LDR-LT UWB interface and retrieves user's position periodically from the location server.
- Map client module: periodically, the client sends a map request to the map server including user's position and other information (zoom, scroll, etc.). When the map information is received, it is processed and displayed. Therefore the map tracks the user's movement, being automatically updated according to the user's position. The user is able to zoom in/out and scroll the map

through the zoom and scroll controls. The user can also access to shop information by clicking a shop in the map or selecting it from the shop list.

- Route client module: the user can ask the application to guide them to a selected shop. This module requests the route to the route server and then displays the route provided by the server.
- Ads client module: this module displays the advertisements sent by the ads server when the user approaches certain shops.
- Search client module: when the users selects a search by type, it sends the search request with the selected type and user's position and displays the shop list received with the distances estimated to each shop. If any shop is selected, it displays shop information and highlights the shop in the map.
- Graphical User Interface: it is in charge of the interaction with the user. It displays the information from the different services and allows the user to configure the application settings and to control the different services. A snapshot of the GUI is shown in Figure 6-5.

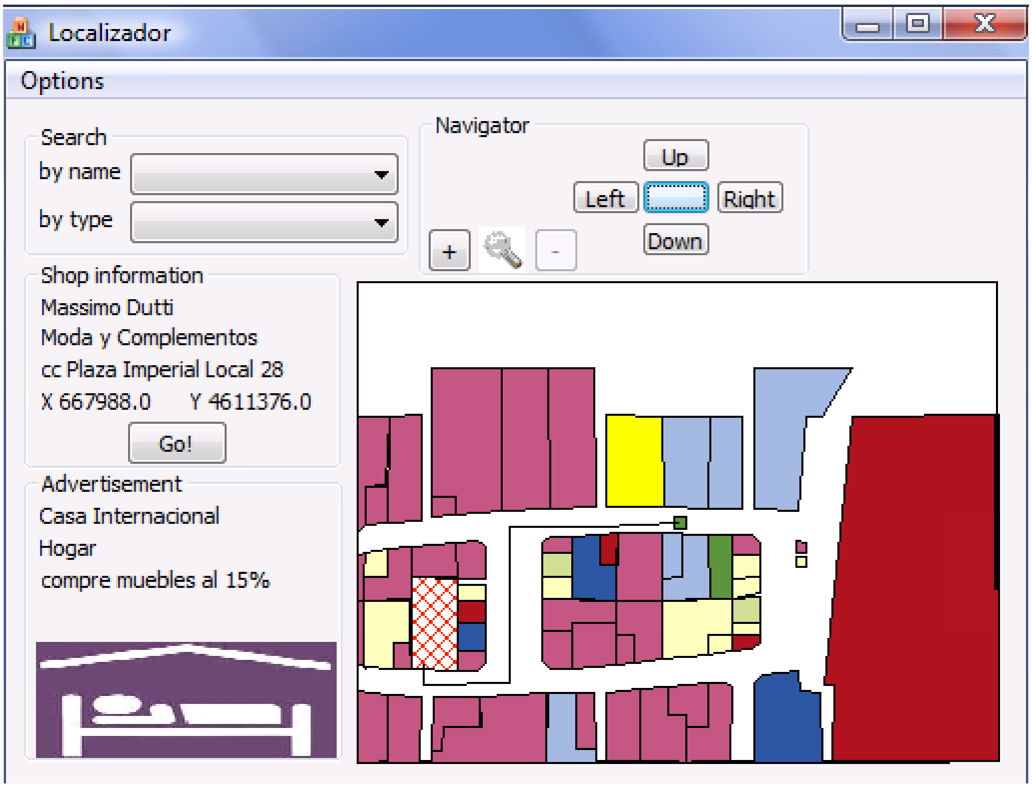

Figure 6-5: Client application main window

6.1.1.5 Services server

The function of the services server is to provide the requested information to the mobile user according to its position. It is physically located in a computer that must be connected to Internet with a public IP. The services server runs the server application that communicates with the client application on the mobile node.

The server application is composed of different modules:

- Communication module: this module implements the communication with the client application through TCP/UDP sockets. Different sockets are used for each service. In the set-up procedure, the server sockets are listening for connection attempts from the client. Once the connection is established, both client and server can exchange TCP packets. In case of UDP links the connection procedure is not necessary.

- Session control module: this module is in charge of the session set-up and the exchange of session information between client and server.
- Map server module: it receives the map requests from the client, generates the map information according to the client's position, zoom and scroll state and sends it to the client.
- Route server module: it receives the route requests from the client and computes the optimal route to the selected shop and sends it to the client.
- Ads server module: periodically it requests the client to provide its position. Once the client's position is received it computes which advertisement should be sent and sends it to the client.
- Search server module: it receives the search requests from the client, searches for the shops of the selected type and sends the search results to the user ordered according to the distance to the user.
- Shopping centre database: it stores all the information concerning the shopping centre, including the shop list with the position, vertexes and walls of each shop and the corridor segments and nodes lists for routing functionality.

6.1.1.5.1 Advanced demonstrator

As well as the development of location-aware services, Task 6.3 "Location-aware services in Heterogeneous Networks" also considers the use of location information provided by UWB to study and develop improvements in handover and access point mapping when multiple UWB access point are present. Although this task mainly focuses on theoretical and simulation studies, some basic concepts may be tested in a demonstration platform.

With that purpose, the location-aware services demonstrator will be enhanced with the inclusion of HDR UWB as network access technology, as it is shown in Figure 6-6. The HDR UWB access points will be used to access location-aware services through the Internet in the same way that in the main demonstrator, but also to demonstrate some concepts related to the usage of location information to improve radio resource management, for example enhanced handover techniques between UWB access points based on localization prediction. That was not feasible on the first version of the demonstrator, as it would entail the modification of radio resource management procedures on the cellular network, UMTS for instance. Some basic concepts could be demonstrated on the enhanced demonstrator depending on the capabilities of the advanced access network equipment.

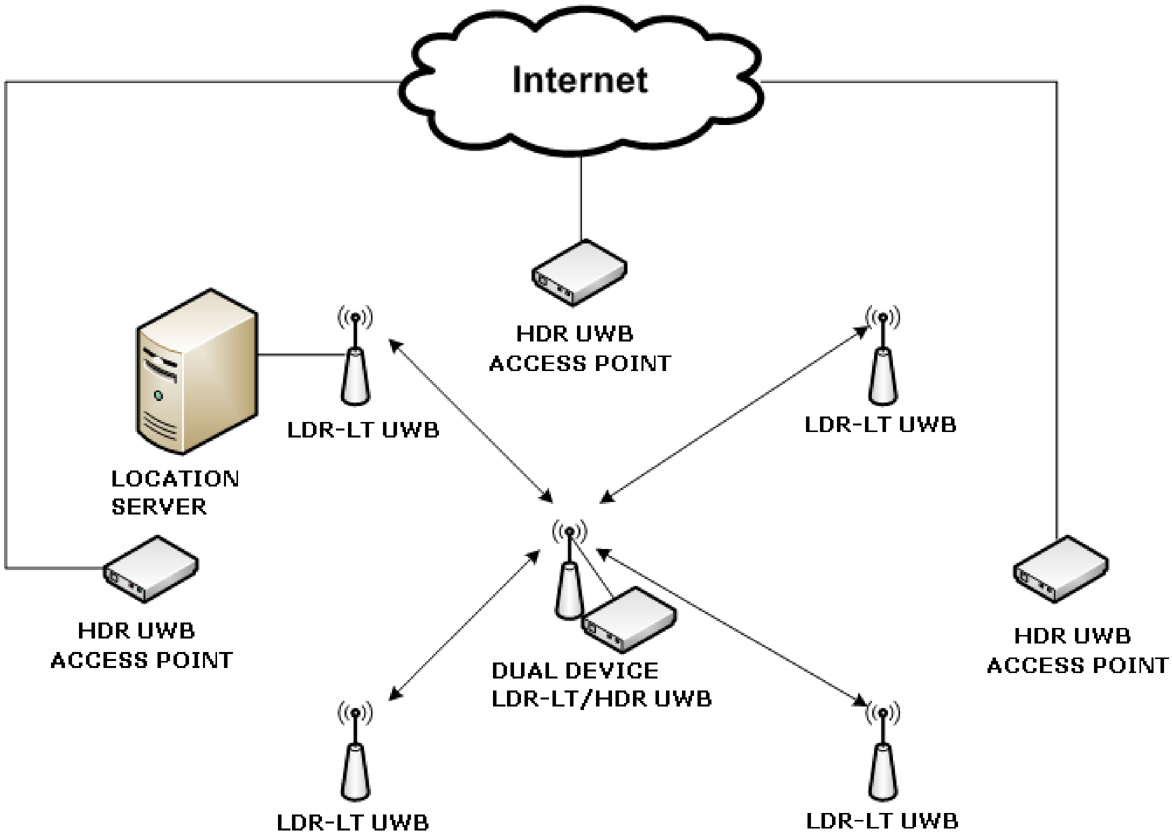

Figure 6-6: Location-aware services demonstrator enhanced with HDR UWB access points

There are two main changes in the demonstrator architecture:

- The dual device implements both LDR and HDR UWB interfaces.
- HDR UWB access points are introduced to provide Internet access. With this purpose, either UWB/HSPA or UWB/xDSL access points developed within Task 6.2 may be used.

The UWB/xDSL and UWB/HSPA access points consist of the following hardware and software components:

- Hardware elements
  - Desktop/laptop with Ethernet, USB & PCMCIA interfaces
  - EUWB HDR boards
  - xDSL router/HSPA PCMCIA card
- Software elements
  - UWB equipment & Ethernet/HSPA card drivers
  - Interoperability software

6.1.2 Specification and requirements of location-based services for shopping centre scenario

The following location-based services will be implemented in the shopping centre demonstrator scenario:

- Navigation

The navigation service allows the user to position themselves in the shopping centre map, explore the map and shops and ask for the shortest route to any shop. The service follows a pull scheme, as exchanges are always initiated by the client with a map or route request, which is processed by the server that sends the consequent response. The service is automatically started after the user starts the application and is authorized by the server. Shopping centre information including a list of shops with shops information is initially sent to the client. Then the client sends a map request to the server. The map requests must include different parameters such as the window size, zoom level, scroll state and, depending on the scroll state, the user's position or the origin coordinates. Therefore, there are two possible operation modes. When scroll is not active, a request is sent periodically and the generated map is centred on user's position and sized according to window size and zoom level. When scroll is active, a request is sent each time the user clicks on a scroll button and the map is generated according to the origin coordinates, window size and zoom level. The map is sent as a shop list with a list of vertexes and walls for each shop. Then the map is drawn in the client window and the user is able to select any shop just by clicking on it. Concerning the route functionality, when the user clicks on the button to ask the way to a certain shop, a route request is sent to the server including user's position and shop index. Then the server computes the shortest way to the shop and sends a response with the route represented as a list of segments and nodes. Finally the client draws the segments in the map and periodically requests route updates.

- Location-based search

Location-based search allows the user to look for shops of a certain type, getting the search results ordered according to the distance from the user. The service follows either a pull or poll scheme, depending on whether user's position is provided by the user itself in the search request or retrieved from the location server by the server, respectively. The service is started when the user queries the application for shops of a certain type (restaurants, fashion, etc.). The client application then sends a search request to the server with the selected type and, in case of pull scheme, user's position. If position is not included (poll scheme) the server connects to the location server to retrieve user's position. Then the server collects the shops belonging to that type, computes the distance to the user for each shop and sends the shop list to the client application. The client application displays the shop list and distances so the user is able to select a shop, which will be shown in the shop information area and highlighted in the map.

- Proximity marketing

The objective of proximity marketing is providing the user with relevant information of the shops s/he is approaching, such as bargains, special offers, etc. without any previous request of the user. The proximity marketing service is started in the application setup as the navigation service is started. Previously, there would be an implicit or explicit agreement of the user when installing the application. The service follows a push scheme, as the server sends the advertisements without a previous request from the user. Periodically, the server requests user's position from the user or from the location server. Then the server computes the distance from the user to the different shops featuring this service, selects the closest shop and, if it is under a certain threshold and it is different from the previously selected shop, sends the advertisement to the user. Finally, the advertisement is displayed in the advertisement area of the client application and the shop is highlighted in the map.

Concerning the requirements, the technical requirements of the scenario and the demonstrator applications (client and server) requirements can be distinguished.

6.1.2.1 Demonstrator technical requirements

Table 6-1: Shopping centre demonstrator requirements

ID	Name	Description
SC-DEM.1	Tracking	Mobile user’s position will be provided by a LDR-LT UWB system with an accuracy better than 1 meter
SC-DEM.2	Range	LDR-LT UWB devices range must be at least 20 meters
SC-DEM.3	Mobility	The tracking system will be able to track mobile users at walking pace
SC-DEM.4	LDR-LT network configuration	The LDR-LT UWB network will be configured through a GUI connected to the network coordinator
SC-DEM.5	LDR-LT operation	Once the network is configured, the LDR-LT UWB nodes will operate autonomously without any user interaction
SC-DEM.6	User device	User device must integrate both LDR-LT UWB and HSPA interfaces
SC-DEM.7	HSPA access	User device must have HSPA access to the Internet in order to connect with the service provider
SC-DEM.8	Throughput	HSPA access throughput must support the location-based services (at least 1 Mb/s)
SC-DEM.9	Service provider	Service provider will have a public IP address, so clients can access location-aware services through Internet
SC-DEM.10	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

6.1.2.2 Client application requirements

Table 6-2: Client application requirements

ID	Name	Description
CAPP.1	LDR-LT UWB interface	The application will be able to interact with the LDR-LT UWB interface in order to retrieve user’s position
CAPP.2	TCP/IP sockets	The client application will communicate with the server application through TCP/IP sockets
CAPP.3	Message exchanging	All the messages exchanged between client and server will be xml formatted

CAPP.4	Login	The client application will ask the user's login and password to get access to the services
CAPP.5	Authentication and set-up	The application will set-up a connection with the server application in order to authenticate the user and start the services
CAPP.6	Settings	The application will allow setting different parameters such as map refresh rate, server IP and port, etc.
CAPP.7	Statistics	The application will display traffic statistics for each service
CAPP.8	Map	The application will be able to display a map of the shopping centre and will provide zoom and scroll functions
CAPP.9	Search	The user will be able to search a shop by name or by type. The application will display the results of the search by type ordered by distance to the user
CAPP.10	Shop information	The application will show a shop's information when the user clicks on it or selects it in the shop list
CAPP.11	Routing	The user will be able to ask for the route to the selected shop, which will be displayed on the map
CAPP.12	Advertisements	The application will be able to display advertisements received from the server
CAPP.13	GUI	The application will have a Graphical User Interface to interact with the user

6.1.2.3 Server application requirements

Table 6-3: Server application requirements

ID	Name	Description
SAPP.1	TCP/IP sockets	The server application will communicate with the client application through TCP/IP sockets. Service sockets will be listening for connection attempts from the client
SAPP.2	Message exchanging	All the messages exchanged between client and server will be xml formatted
SAPP.3	Authentication and set-up	The server application will authenticate the user's login and password in order to allow access to the services. Then it will send the shopping centre and shops information to the client

SAPP.4	Map provider	Upon client's request, the server application will create and send to the client a list of shops and walls adapted to the client display (size and zoom). Two modes will be supported: map centred on user's position or map with origin in reference coordinates provided by the client
SAPP.5	Search by type	Upon client request, the server application will provide a list of shops of the given type ordered by distance to the user
SAPP.6	Routing	Upon client request, the server application will compute the shortest route to the selected shop and provide it to the client
SAPP.7	Advertisements	The application will request client's position periodically and send advertisements from the closest shops
SAPP.8	Shopping centre database	All the topological information concerning the shopping centre and shops will be stored in a binary file

6.2 UWB localization of fire-fighter in indoor environment (LAES)

6.2.1 Description

The objective of this demonstrator is also to build a platform for the development and test of location-aware services in heterogeneous networks. Low Data Rate UWB technology will allow provisioning fire-fighter localization services in indoor environment, what is very useful during emergency situations.

This scenario is illustrated in Figure 6-7.

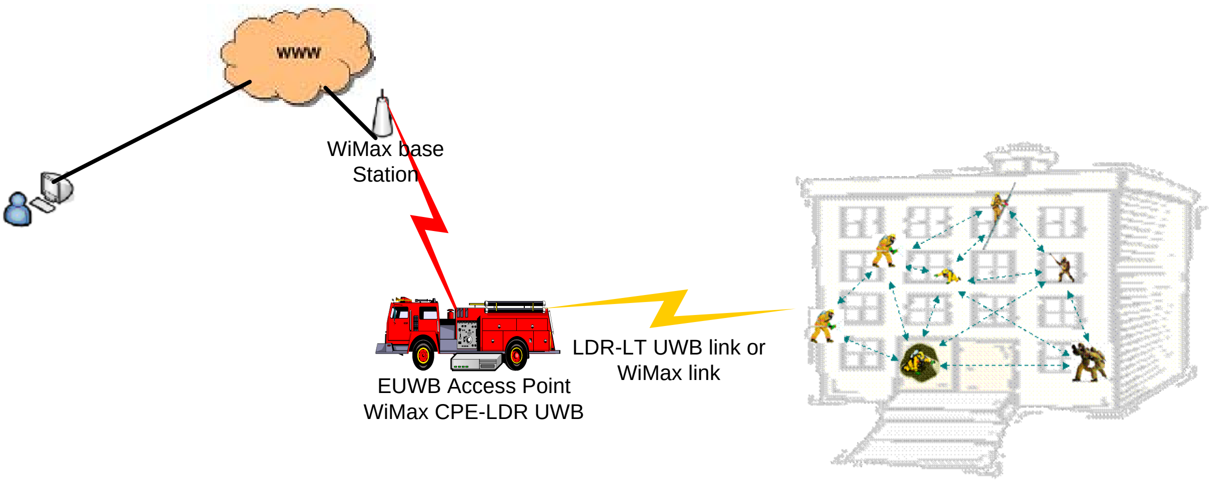

Figure 6-7 : UWB localization of fire-fighter in indoor environment

The main elements of this demonstration platform are:

- Dual LDR-LT UWB/WiMAX device: it is installed on a truck and allows the interconnection between fire-fighters and headquarters. It transmits real time position of fire-fighters (LDR-LT UWB) and video (HDR UWB).

- LDR-LT UWB nodes: these nodes are held by the fire-fighters and implement a location system, which gives the position of each node of the LDR-LT UWB piconet.
- Headquarters: the headquarters is connected to the Internet and can be physically anywhere. It is connected to the dual LDR-LT UWB/WiMAX device thanks to a VPN (Virtual Private Network), which secures the link between the headquarters and the dual LDR-LT UWB/WiMAX device. The headquarters will be able to track in real time each node of the network and will be able to send useful information to the nodes on the field (map of the building, position of the victims).

For other scenario related to security (site survey applications), it would be needed to have LDR-LT devices (low data rate sensors) but also HRD UWB devices in order to have HD video transmission. For this kind of application, LDR-LT information as well as HDR information is forwarded to a headquarters thanks to WiMAX links for a wider range. Even if HDR link is not a strong requirement for fire-fighter scenario, this will be added in the demonstration platform in order to evaluate also site survey applications. The use of LDR-LT, HDR and WiMAX technologies in the Gateway will so be studied in the scope of WP6. Furthermore, the difference of data rate between HDR UWB and WiMAX link will be studied and some solutions will be found for the demonstrator (smart compression algorithms).

The UWB/WiMAX demonstration platform is so focused on the interconnection of different radio technologies and equipments. It will show through a unique gateway, connected with both LDR and HDR UWB interfaces, that the information carried by UWB signals can be transmitted through a WiMAX network without weakening.

A possible scheme of the WiMAX reference platform is presented in Figure 6-8.

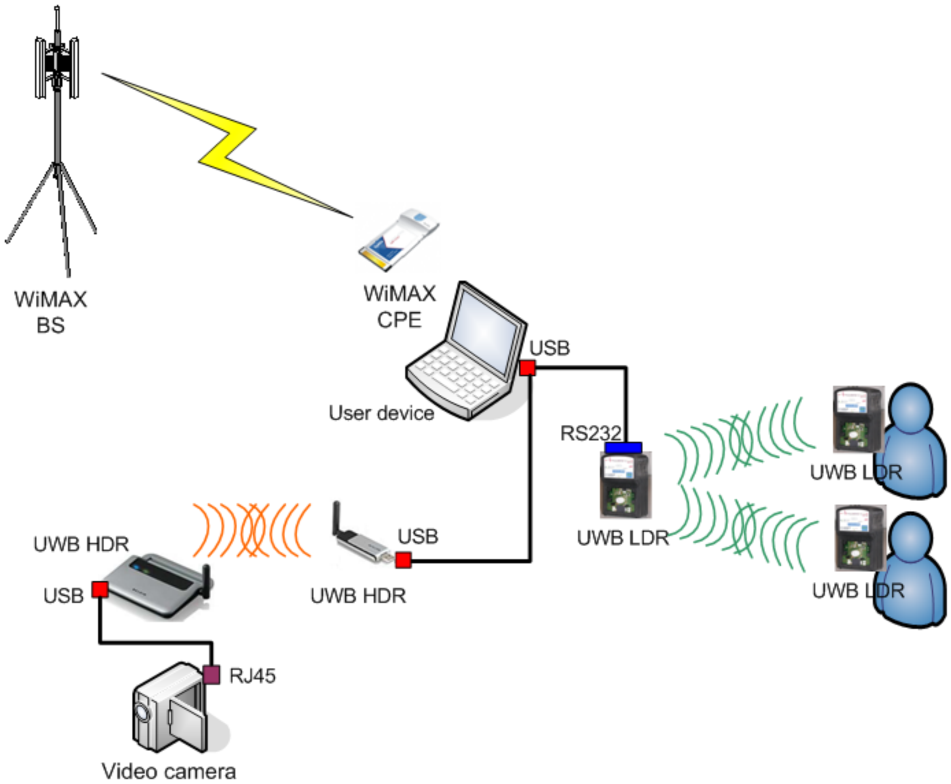

Figure 6-8: WiMAX and UWB interconnection

6.2.2 Specification and requirements of location-based services for fire-fighter localization

This scenario requires high accuracy of positioning information and must be independent of classical positioning systems, like GPS, that are not suitable in indoor environment. Moreover, a HDR link with a guaranteed quality of service is required in order to transmit real time video and to be able to receive information from the headquarters (20 Mb/s per node). Systems need to implement relaying mechanism to extend the range of the network.

The main requirements of the fire-fighter localization demonstrator are collected in Table 6-4:

Table 6-4: Fire-fighter localization demonstrator requirements

ID	Name	Description
FL-DEM.1	Tracking	Mobile user's position will be provided by a LDR-LT UWB system with an accuracy better than 1 meter. Ranging is performed between all nodes as Anchors are not mandatory for this scenario
FL-DEM.2	Range	LDR-LT UWB devices range must be 50 meters in NLOS in indoor environment (500 meters in LOS conditions) for a typical deployment. Relaying mechanisms are necessary for range extension
FL-DEM.3	Mobility	The tracking system will be able to track mobile users at walking pace
FL-DEM.4	LDR-LT network configuration	The LDR-LT UWB network will be configured through a GUI
FL-DEM.5	LDR-LT operation	Once the network is configured, the LDR-LT UWB nodes will operate autonomously without any user interaction
FL-DEM.6	UWB/WiMAX gateway	UWB/WIMAX gateway must integrate HDR&LDR-LT UWB and WiMAX interfaces. A HDR UWB interface can be added in case of sensor network scenario but it is not mandatory for fire-fighters scenario
FL-DEM.7	UWB nodes	LDR-LT UWB nodes must be held by fire-fighters, implementing a location system
FL-DEM.8	WiMAX access	UWB/WiMAX gateway must have WiMAX access to the Internet in order to connect with the headquarters
FL-DEM.9	Throughput	HDR UWB throughputs must be at least 20 Mb/s/node (real time video transmission and communication with the headquarters). HDR links are not a requirement for fire-fighters scenario but are added to the demonstration platform in order to cover other scenario such as site survey with Low Data Rate and High Data rate sensors

FL-DEM.10	Security	A VPN (Virtual Private Network) is required to secure the link between the headquarters and the UWB/WiMAX gateway
FL-DEM.11	Coexistence	Peaceful interoperation must be guaranteed between the different radio technologies involved

7 Conclusions

In this deliverable, five main infrastructure elements to use a LBS have been identified: mobile devices, communication network, positioning component, service-application provider and data-content provider; three LBS service models have been explained: pull, poll and push; and five examples of LBS applications have been highlighted: emergency, navigation, information, tracking-management and billing.

Different use cases of LBSs have been described and are summarized in the following list:

- Indoor Positioning System
- Location-based search
- Proximity marketing
- Children security
- Buddy-finder
- Proximity payments
- Customized multimedia guide
- Parking place finder
- Oil exploration
- Localization Application for Emergency Services

From the analysis of these use cases, important requirements have been obtained that could be considered as interesting and valuable contributions to the technical specifications of the 3GPP.

An overview of the most significant elements of the IMS architecture has been given, detailing how to include a location server in the IMS Service Plane. Three enablers related to location and developed by OMA have been presented: MLS, SUPL and LOCSIP.

Two demonstrators have then been considered as platforms to develop and test location-aware services in heterogeneous networks within WP6:

- The shopping centre corresponding to the indoor navigation, location-based search and proximity marketing LBSs
- and the localization of fire-fighter in indoor environment corresponding to the Localization Application for Emergency Services.

The main requirements to be fulfilled by both demonstrators have also been identified.

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