Integrated Project - EUWB

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Definition of application scenario and definition of requirements

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Abstract

This report provides the definition of application scenario of Work Package 6 "UWB in Heterogeneous Access Networks". After to have described scenarios aiming at showing interworking and coexistence between UWB and other relevant technologies such as UMTS, WiMAX and ADSL, components of the demonstrators will be described. In the second part of the document it will be described the requirements of scenarios and of their components.

Keywords

Interworking, UWB, ADSL, UMTS, WiMAX, localisation, terminal, gateway.

Table of Contents

List of Figures

List of Tables

Abbreviations

ADSL	Asymmetric Digital Subscriber Line
DAA	Detect And Avoid
ECMA	European Computer Manufacturers Association
EUWB	CoExisting Short Range Radio by Advanced Ultra-WideBand Radio Technology
GPS	Global Positioning System
HD	High-Definition
HDMI	High-Definition Multimedia Interface
HDTV	High-Definition Television
HS(D)PA	High Speed (Downlink) Packet Access
IPTV	Internet Protocol Television
LDR-LT	Low Data Rate Localisation and Tracking
LTE	Long Term Evolution
MAC	Media Access Control
PCI	Peripheral Component Interconnect
PCMCIA	Personal Computer Memory Card International Association
QoS	Quality of Service
RRM	Radio Resource Management
RSSI	Received Signal Strength Indication
SDIO	Secure Digital Input/Output
TFC	Time-Frequency Code
TPC	Transmit Power Control
UMTS	Universal Mobile Telecommunications System
UWB-RT	Ultra-WideBand Radio-Technology
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
(V)HDR	(Very) High Data Rate
WAN	Wide Area Network
WiMAX	Worldwide Interoperability for Microwave Access

1 Executive summary

This report provides the definition of application scenario of Work Package 6 “UWB in Heterogeneous Access Networks”.

In order to demonstrate the interest of interworking and coexistence between UWB and other relevant technologies such as ADSL, UMTS and WiMAX, several scenarios will be developed in WP6:

- Localisation in shopping centre
- UWB localisation of firefighter in indoor environment
- IPTV over UWB

These demonstrators are composed of two mains components:

- Network access gateways (UWB/ADSL gateway, UWB/UMTS gateway, UWB/WiMAX gateway)
- Multiradios terminals (UWB/UMTS and UWB/WiMAX)

In the document it will be firstly described the scenarios and their components. And in the second part of the document it will be described the requirements of scenarios and of their components.

Of course, this is an on-going process subject to change and the scenarios described in this document could be modified during the following months, depending on the evolution of the UWB devices and the demonstration necessities of the project.

2 Definition of application scenario

2.1 UWB integration with up-to-date heterogeneous access networks

As a first step to include the UWB-RT in the up-to-date heterogeneous access networks, UWB commercial devices available at the beginning of the project will be integrated with the current network technologies such as HSPA, WiMAX and ADSL.

Figure 2-1 depicts the general scenario identified to perform this first stage of the integration process.

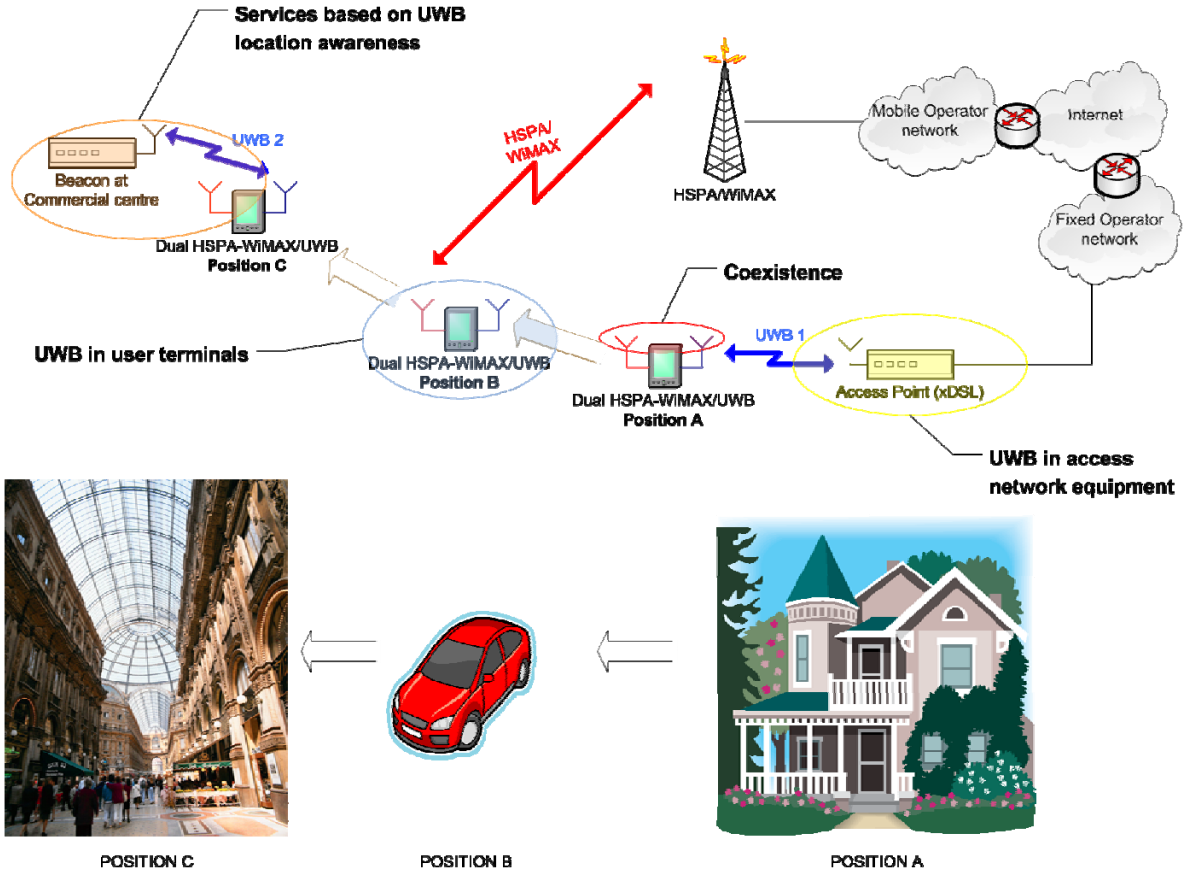

Figure 2-1: Scenario for UWB integration with up-to-date heterogeneous access network

In Position A the user is at home and accesses to the Internet by means of a UWB link (5 m, 200 Mbps) that connects with an ADSL access point. Later when the user is outside and wants to connect again to the Internet, s/he uses the same device, but this time by means of a HSPA link because both wireless technologies are integrated in a dual device. Finally, the user is in a commercial centre and the UWB network is aware of the location of the user. This information can be used for improving the access and roaming between the UWB beacons/access points, but also for sending relevant advertisements depending on the user's location. Additionally, UWB integration has to be accompanied by the guarantee of no interfering in other wireless technologies.

2.1.1 Multi-radio interface user devices

2.1.1.1 UWB/WiMAX user device

The UWB/WiMAX user device will be able to be connected to WiMAX network and to HDR UWB networks in order to offer to the user the best connection possible. In this first step, the user device will integrate component available on the market.

2.1.1.2 UWB/UMTS user device

The UWB/UMTS user device can be connected to UMTS network or to HDR UWB networks depending on the user's needs or the availability of the preferred network coverage. Within the UWB inclusion in up-to-date heterogeneous access networks stage, as far as possible, the utilized devices will be commercially available and provide both radio technologies integrated.

2.1.2 Access network equipment

2.1.2.1 UWB/ADSL gateway

The development of UWB access points providing access to the Internet by means of an ADSL connection could be an interesting approach aiming to the convergence of networks, with homogeneity in the core and heterogeneity in the access.

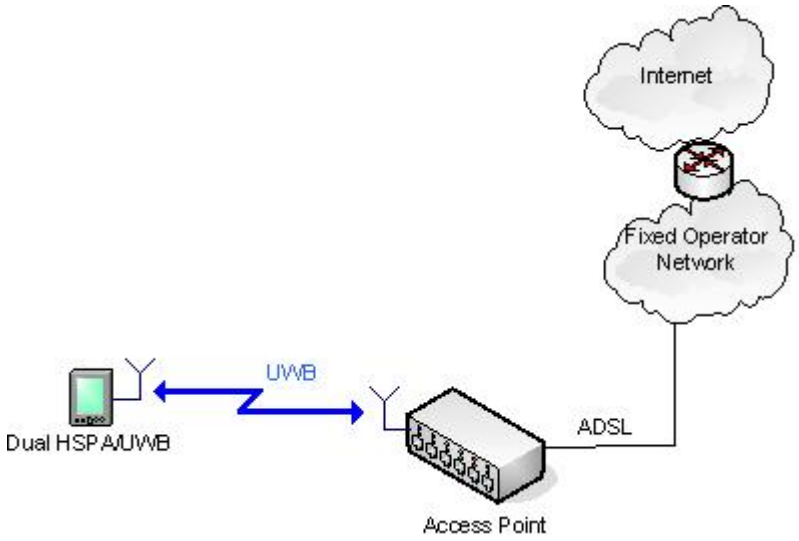

Figure 2-2: UWB/ADSL gateway

The UWB/ADSL gateway will also allow accessing multimedia content or services. As it will be detailed at 2.1.4.3, the provision of Triple-Play service (telephone, high-speed internet access and television) is one of the key products offered by an integrated operator, having at the moment a great attractive to the customer. UWB is appropriate to be used as a wireless technology to transmit the television signal to the decoder.

2.1.2.2 UWB/WiMAX gateway

The UWB/WiMAX gateway aims to provide an interconnection between HDR UWB and WiMAX networks. This gateway aims to perform the convergence between these two different types of networks what permit to offer a power safe high data rate Internet access.

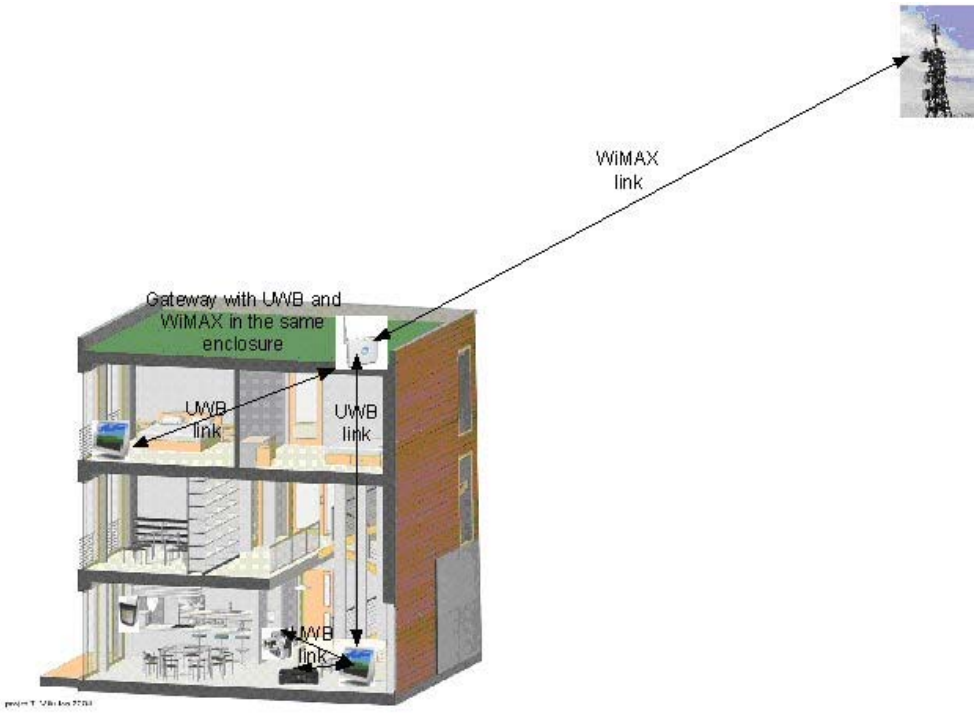

Figure 2-3: UWB gateway using WiMAX access in a residential environment

2.1.2.3 UWB/UMTS gateway

The UWB/UMTS gateway will provide an interconnection between HDR UWB and UMTS networks. The gateway will adapt the UMTS signal to HDR UWB communication and vice versa. This allows deploying a HDR UWB network at user's premises and enables the possibility of accessing to the Internet via UMTS network.

2.1.3 Location-aware services

Task 6.3 "Location-aware services in Heterogeneous Networks" tackles with the usage of location information to upgrade services like product placement or Internet access. Location capabilities will allow the operators to develop novel services exploiting the information of accurate user position.

In order to retrieve the position of the device, satellite systems as GPS or Galileo may be used. But these systems are limited to outdoors 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 environment 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 indoors environment. 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...).

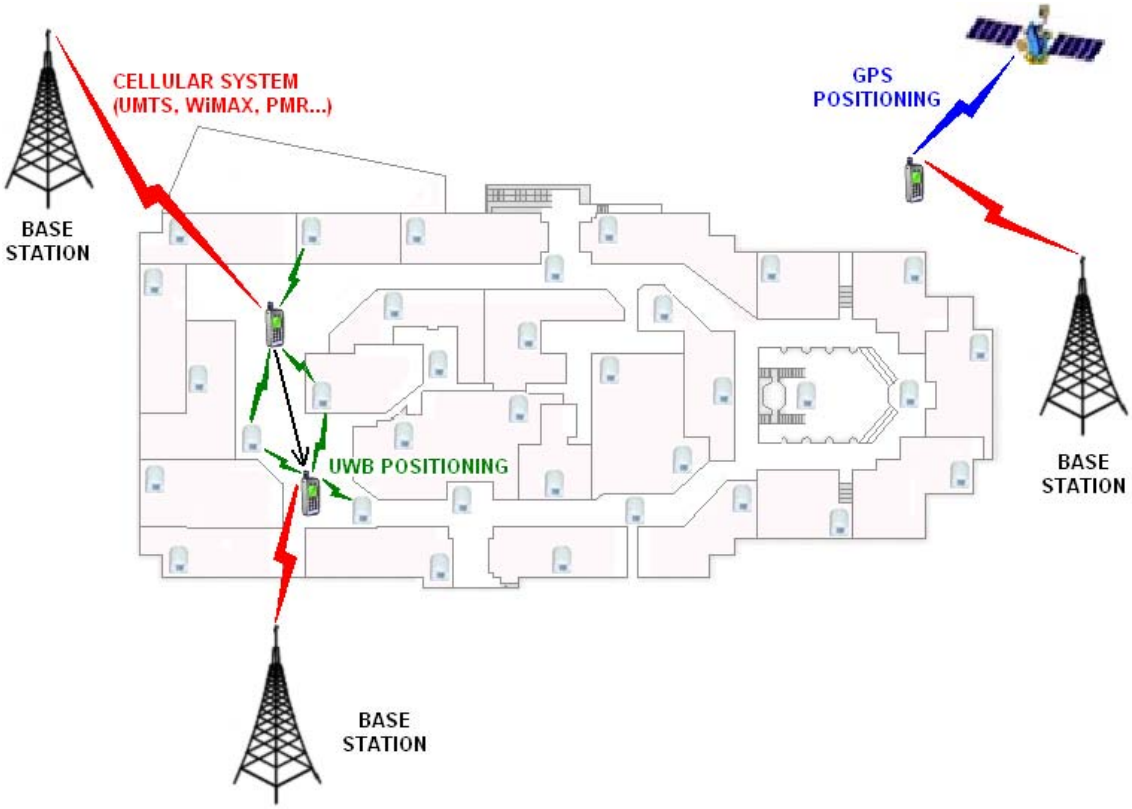

Figure 2-4: Location aware services in heterogeneous networks

Possible scenarios of application are shopping malls, train stations, airports, exhibition centres, sports stadiums, etc. These places could have a UWB network providing users with dual cellular/UWB devices with positioning information. In this kind of scenario, a set of fixed UWB anchors would be distributed in known positions in order to provide with location information to the users devices.

This would allow the user to position himself on his device in the same way as car navigation systems and locate the place he wants to go (a shop, check-in desk, his 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.

It should be taken into account that the size of the location network can be very large, so efficient algorithms able to cope with large networks will be needed. In that sense, the distribution of the location information (distances and positions) is also an important topic in order to optimize the resources of the network. Both centralised (positions are calculated by a location server) or distributed (each device calculates its position) approaches can be considered.

Concerning the accuracy required for this kind of scenario, positioning error should be less than 1 metre. Another important parameter is the position update rate, which should be enough to allow the correct tracking of the mobile nodes at walking pace.

A demonstration platform will be deployed (see Section 2.1.4.1) as a test-bed for the implementation of location-aware services.

2.1.4 Description of demonstrators

2.1.4.1 Shopping centre

The main objective of this demonstrator is to build a platform for the development and testing of location-aware services in heterogeneous networks. The scenario is a scaled representation of real indoor environment, for instance a shopping centre.

The main elements of the demonstrator are:

- Dual UWB LDR-LT/UMTS device: The dual device gets its position from the location server through the UWB LDR-LT interface. On the other hand, the device accesses different services through the UMTS interface, including location-aware services.
- UWB LDR-LT piconet: It implements a location system which tracks the position of the dual device
- Location server: Connected to the LDR-LT UWB piconet coordinator, it receives the ranging information from every node and applies the tracking algorithms in order to determine the position of the dual device.
- Service provider: The services provider is connected to Internet and can be physically anywhere. The dual device connects to the provider through the UMTS network, asking for a service and providing its position. The provider will process the request and send the information according to the device position.

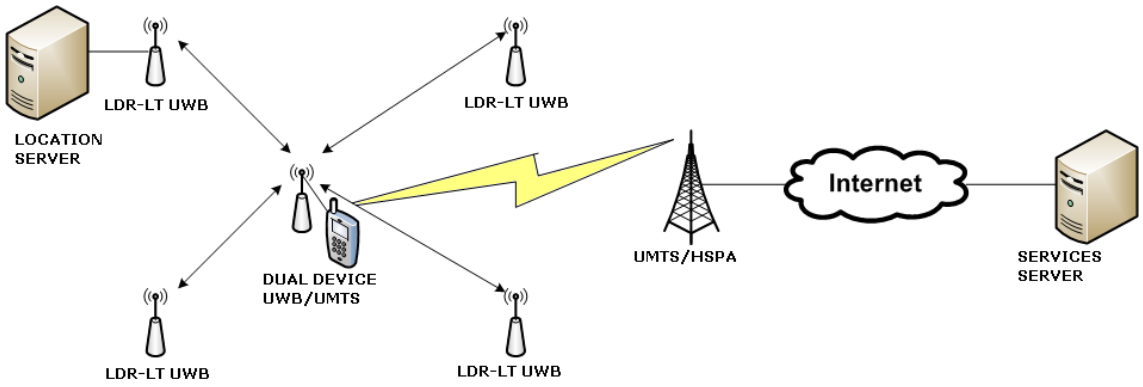

Figure 2-5: Location-aware services demonstrator

On this demonstration platform, multiple location-aware services could be implemented. For example a navigation application, that would provide the dual device with a map of the shopping centre. Then the user could ask the application to guide him to a selected place, access to information of the different shops/businesses, etc. Another possible location-aware service would be related to location-aware marketing. The operator could provide the user with information of the shops/businesses when he comes near, for example last bargains when getting near a shop or scheduled films when passing near a cinema.

It also allows implementing different tracking algorithms and ranging information exchange strategies that will be studied in Tasks 4.1 and 4.2.

2.1.4.2 UWB localisation of firefighter in indoor environment

This demonstration platform aims to illustrate a use case of location aware service in heterogeneous network. Indeed, the use of UWB allows localisation in indoor environment what can be very useful for some users as firefighters.

The main elements of this demonstration platform are:

- Dual UWB LDR-LT/WiMAX device: The dual device gets its position from the location server thanks to its UWB LDR-LT interface. This dual interface transmit in real-time the position of nodes of the network.
- UWB LDR-LT nodes: These nodes implement a location system, which gives the position of each node of the UWB LDR-LT piconet.
- Headquarters: Headquarters is connected to Internet and can be physically anywhere. It is connected to the dual UWB LDR-LT WiMAX device thanks to a VPN, which secures the link between it and the dual UWB LDR-LT 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).

2.1.4.3 IPTV over UWB

An attractive demonstration scenario for a global operator would be represented in Figure 2-6, which shows a possible configuration to provide Triple-Play service.

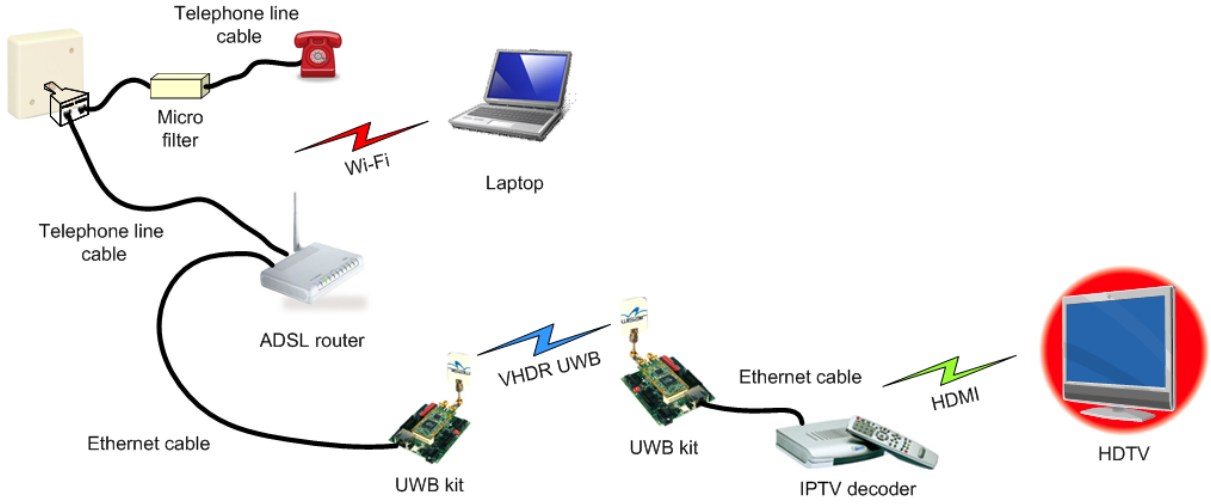

Figure 2-6: IPTV over UWB scenario

The Triple-Play service is a marketing term for the provisioning of two broadband services, high-speed Internet access and television, and one narrowband service, telephone, over a single broadband connection (ADSL technology in the figure above).

In this case, the high-speed Internet access is performed by means of a Wi-Fi link, whereas through a VHDR UWB link, the high-definition (HD) television signal reaches the IPTV decoder. UWB-RT is the most suitable wireless technology to transport HD signals due to its inherent capability to transmit the information at extremely high data rates.

At the moment, Triple-Play technology does not allow the transmission of HD signals but operators are announcing the provision of that kind of contents. Therefore, an alternative demonstrator that will

be tested is depicted at Figure 2-7, where the PC accesses the HD contents located in the remote server by means of a UWB link. Moreover, the PC could be replaced by a multimedia player connected to a HDTV, as shown in Figure 2-8.

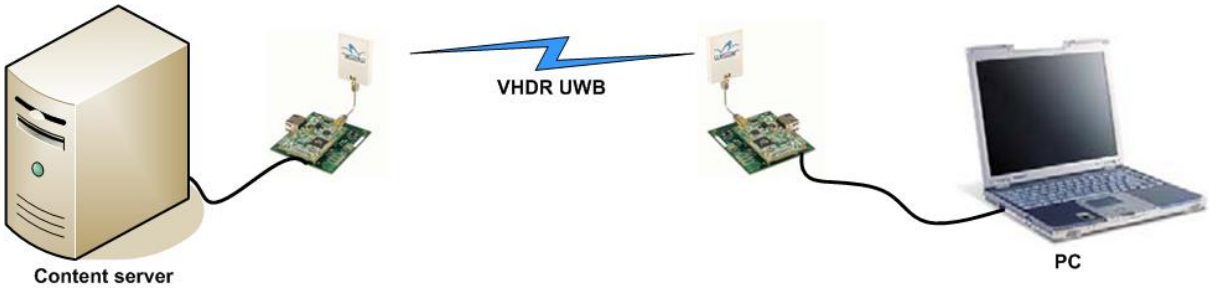

Figure 2-7: Transmission of HD signals over UWB (1)

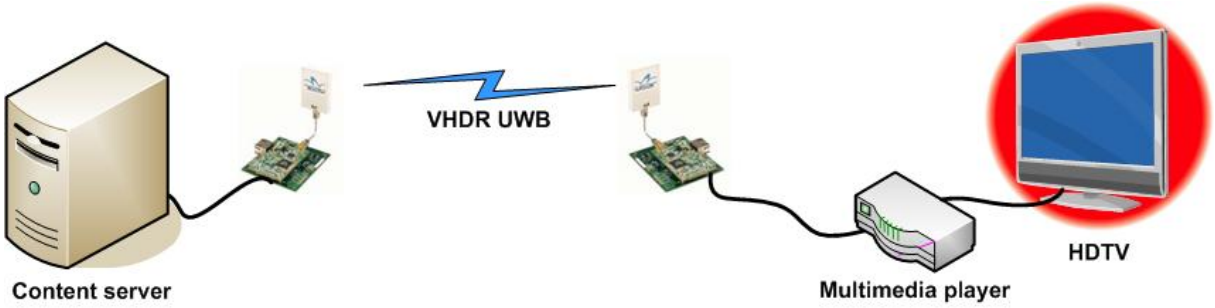

Figure 2-8: Transmission of HD signals over UWB (2)

2.2 UWB integration in long-term heterogeneous access network

The second stage to fulfil the main purpose of WP6 is the study of the UWB integration into a future heterogeneous network access (see Figure 2-9). Whereas in section 2.1 the stress is put on achieving UWB integration with deployed networks, the focus in this second step is to analyse and propose UWB for being part of future access to converged network. Thus the first approach covers mainly the implementation activities and the second one will focus on the study of capabilities of using UWB in pico-cells, the specification of usage of location awareness in service platforms, the evaluation of UWB coexistence with future wireless networks, as well as the assessment of collaborative mechanisms among UWB and other wireless access technologies.

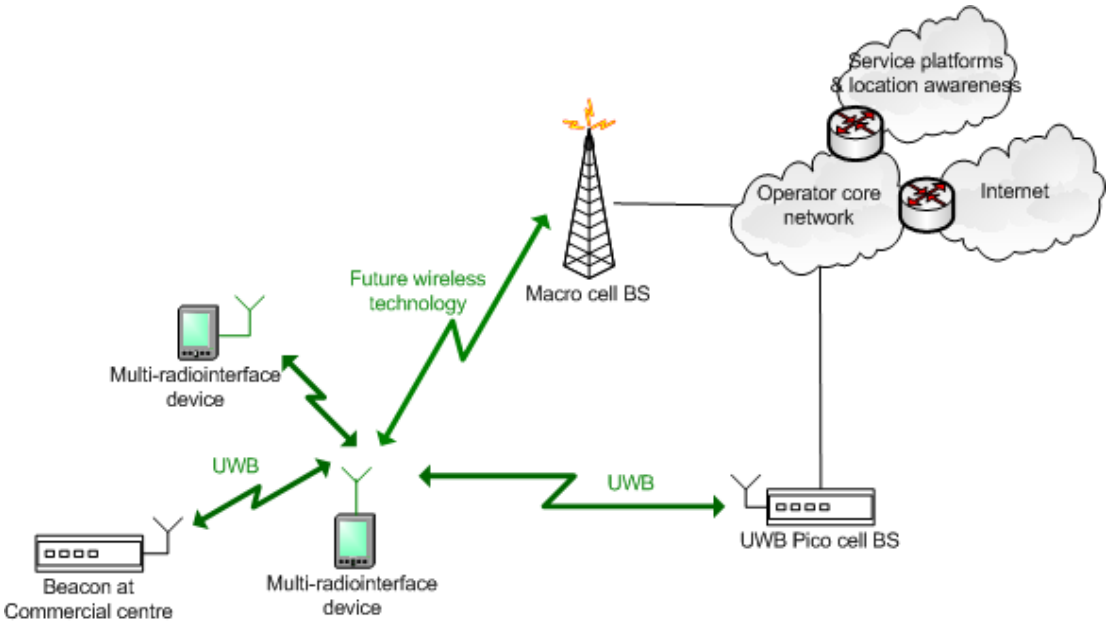

Figure 2-9: UWB in long-term heterogeneous access network scenario

2.2.1 Advanced multi-radio interface user devices

The advanced multi-radio interface user device will integrate on a same user device two types of Radios:

- UWB radios developed in the Work Package 7 of the project
  - HDR UWB interface
  - LDR-LT UWB interface
- Broadband access radio
  - WiMAX interface
  - UMTS interface
  - LTE interface

This user device will integrate components developed by Work Package 7. Some optimisation mechanism will be implemented in order to minimize power consumption and to provide the best connection possible depending on the available connection.

2.2.2 Advanced access network equipment

2.2.2.1 Multi-radio interface node: collaborative mechanisms

Bearing in mind the concept of homogeneity in the core and heterogeneity in the access to a converged network, from the point of view of the operator and also for the user's satisfaction, it would be very attractive that the different access radio technologies (current and advanced ones) collaborated among them giving the most suitable and reliable connection required for the provision of the most services as possible.

2.2.2.2 Foreseen evolution of UWB/WiMAX gateway

The UWB/WiMAX gateway will integrate on a same device a WiMAX subscriber station, an HDR UWB interface and a LDR-LT subscriber station. Due to the interference risks but also connectivity advantages of three radios integrated in a same device, it will be study how to maximise the QoS for network's users (Low power consumption, best data rate as possible etc…).

2.2.2.3 Capability studies of UWB in pico-cells

Due to the modulation techniques used in the UWB systems, such as MB-OFDM, that are characterised by low power consumption, high data rates and low level of intrusiveness, it has been envisaged the study of the capability of UWB as a radio technology to be integrated in the pico-cells belonging to the Radio Access Network of a converged network.

In order to face the constraint of the limited coverage of the UWB devices, another interesting topic of study would be the increase of the coverage range by means of UWB repeaters.

2.2.3 Advanced location-aware services

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.

The main 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 this concepts will applied to an UWB access network. 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 presented in Section 2.1.4.1 could be further enhanced with the inclusion of HDR UWB as access network, making use of the EUWB access network equipment. The UWB access points would be used to access location-aware services through Internet in the same way that in the previous demonstrator, but also to demonstrate some concepts related to the usage of location information to improve radio resource management. 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 EUWB Access Points.

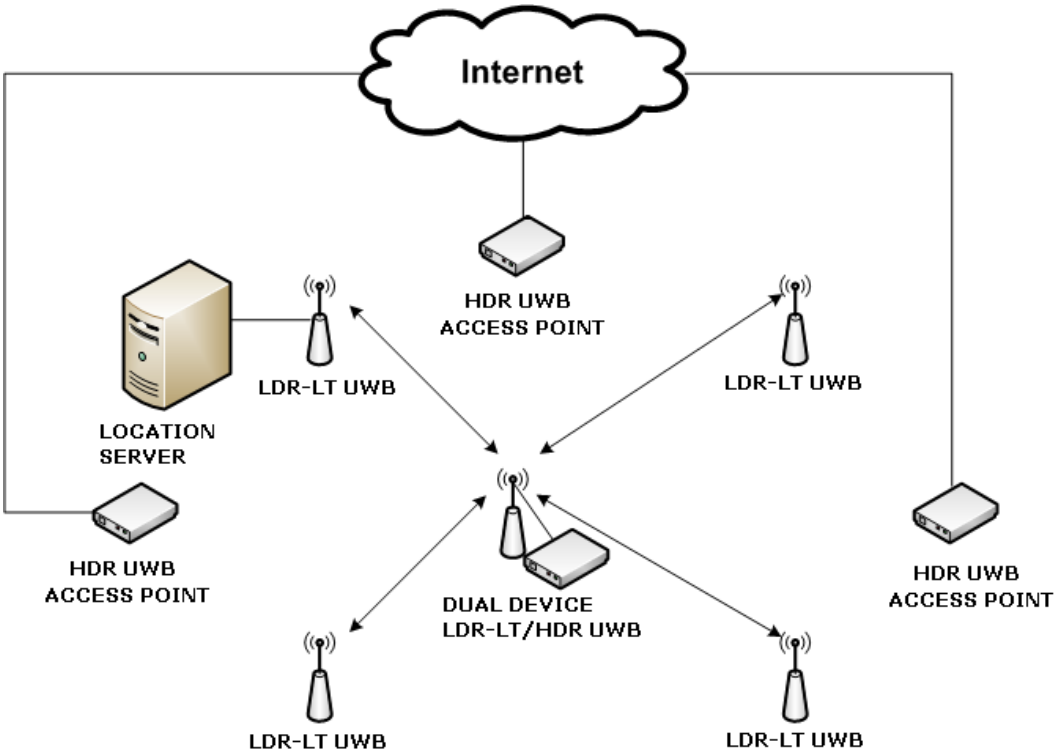

Figure 2-10: Location-aware services demonstrator enhanced with HDR UWB access points

3 Definition of requirements

In order to better define EUWB WP6 scope, a list of requirements has been collected. They will better clarify EUWB target, according to the definition of application scenarios. These requirements have been split into two main classes, as it is shown in the following table.

Table 3-1: Definition of requirements

Class	Field	Description
Technical requirements	Multi-radio interface user devices	Requirements on multi-radio interface user devices
	Access network equipment	Technical requirements specific for access network elements
	WAN equipment	Requirements linked to WAN equipment
	UWB equipment	Requirements demanded to the UWB equipment
Scenario requirements	Up-to-date scenario	Requirements related to up-to-date scenario
	Long-term scenario	Expected requirements for long-term scenario

3.1 Technical requirements

3.1.1 Multi-radio interface user devices

Table 3-2: Multi-radio interface user device requirements

ID	Name	Description
MRIUD.1	Multi-band	Frequencies required to support different technologies (UWB, WiMAX, UMTS/HSPA, Wi-Fi)
MRIUD.2	Data rate	Data speed required to support different applications
MRIUD.3	Power-aware	Devices will be power-aware for extending battery lifetime, e.g. switching off not used radio-interface
MRIUD.4	Form factor	Terminals must be as small and compact as possible
MRIUD.5	Multi-port	USB, PCMCIA, SD, USIM…
MRIUD.6	Antenna	If possible, built-in antenna
MRIUD.7	High processing capacity	Real-time video transmission supported
MRIUD.8	Sensitivity	User terminals must guarantee correct working at low level of received signal

3.1.2 Access network equipment

Table 3-3: Access network equipment requirements

ID	Name	Description
ANE.1	Coexistence	Appropriate working must be ensured independently on the application scenario
ANE.2	Power-aware	Devices will be power-aware for saving power consumption
ANE.3	Data rate	Data speed required to support different applications
ANE.4	Form factor	Equipment at user premises must be as small and compact as possible
ANE.5	Multi-port	Several ports in order to allow the most different connections as possible
ANE.6	Antenna	If possible, built-in antenna

3.1.3 WAN equipment

Table 3-4: WAN equipment requirements

ID	Name	Description
WAN.1	Data rate	Data speed required to support different applications
WAN.2	Form factor	Equipment must be as small and compact as possible
WAN.3	Antenna	Integrated antenna, if possible
WAN.4	Sensitivity	Equipment must guarantee correct working at low level of received signal

3.1.4 UWB equipment

3.1.4.1 LDR-LT UWB equipment

Table 3-5: LDR UWB equipment requirements

ID	Name	Description
LDR.1	Piconet creation	LDR equipment will be able to create a piconet
LDR.2	Joining a piconet	LDR equipment will be able to join an existing piconet
LDR.3	Ranging	LDR equipment will be able to estimate the distance to any other device in its piconet
LDR.4	Data communication	LDR equipment will be able to transmit data to any other device in its piconet
LDR.5	Transmission parameters	LDR equipment will be able to offer the users the possibility of choosing different parameters related to the transmission, such as data rate or transmission power.
LDR.6	Ranging parameters	LDR equipment will be able to offer the users the possibility of choosing different parameters related to the ranging procedure, such as ranging update rate or number of pulses used for each range measurement.
LDR.7	Operation mode	LDR equipment will be able to operate autonomously (without being connected to a computer) by embedding an application
LDR.8	Control mode	LDR equipment will be able to be controlled by a computer via an Ethernet, RS-232 or USB interface
LDR.9	PHY, MAC and NWK	LDR equipment will implement physical, MAC and network layers
LDR.10	Upper layers	Software implementation of upper layers will be provided to run either on a computer or embedded in the device
LDR.11	Antenna	In-built antenna, if possible
LDR.12	Range	Range should exceed 20 meters in LOS situation at least, although a higher range (50 meters) would be desirable.
LDR.13	Ranging accuracy	Ranging accuracy must be at least 50 cm in the whole range.
LDR.14	PHY data rate	PHY data rate should exceed 300 kbps
LDR.14	Quantity	Number of required platforms: to be determined

3.1.4.2 (V)HDR UWB equipment

Table 3-6: (V)HDR UWB equipment requirements

ID	Name	Description
UWB.1	PHY data rate	Regarding different applications where different data throughputs are required, (V)HDR equipment will have the ability to adapt its data rate to several throughputs when required, being the minimum expected PHY data rate 200 Mbps
UWB.2	Transmitted power	(V)HDR equipment will be able to adjust the power to be transmitted (Transmit Power Control, TPC)
UWB.3	Working band	WiMedia Band Group #1 and WiMedia Band Group #2
UWB.4	TFC channel	(V)HDR equipment will be able to offer users the possibility of choosing different working frequencies manually or automatically (when mitigation techniques are included)
UWB.5	Duty cycle	(V) HDR equipment will be able to change the percentage of the bandwidth dedicated to uplink and downlink, if possible
UWB.6	Mitigation techniques	DAA provision
UWB.7	Distance	Room-range coverage: up to 10 meters
UWB.8	Network topology	Point-to-multipoint communication
UWB.9	Operation mode	(V)HDR equipment will be able to operate autonomously (without being connected to a computer) by embedding an application
UWB.10	Control mode	(V)HDR equipment will be able to be controlled remotely by a computer via an Ethernet, RS-232 or USB interface
UWB.11	Data interface	Ethernet, PCMCIA, PCI Express Mini Card or half mini card, USB, SDIO
UWB.12	Standard compliant	ECMA 368/369 and WiMedia
UWB.13	Antenna	In-built antenna, if possible
UWB.14	Quantity	Number of required platforms: to be determined

3.2 Scenario requirements

3.2.1 Up-to-date scenario

Table 3-7: Up-to-date scenario requirements

ID	Name	Description
UTDS.1	QoS	Minimum QoS must be ensured depending on the application
UTDS.2	Coexistence	Peaceful interoperation must be guaranteed, with no interference among the different radio technologies involved
UTDS.3	Reliability	Connection will be maintained until the end of the communication
UTDS.4	Connectivity	“Always the best connection” will be provided
UTDS.5	Throughput	Adaptive data rate depending on the application
UTDS.6	Positioning	User’s position will be provided by means of an LDR UWB location & tracking system
UTDS.7	Location accuracy	Accuracy provided by the UWB location system must be better than 1 meter
UTDS.8	Large-scale location	Location and tracking algorithms and information distribution strategies must be able to cope with large scale networks
UTDS.9	Tracking	The location and tracking system will be able to track mobile users at walking pace

3.2.2 Long-term scenario

Table 3-8: Long-term scenario requirements

ID	Name	Description
LTS.1	QoS	Minimum QoS must be ensured depending on the application
LTS.2	Coexistence	Peaceful interoperation must be guaranteed, with no interference among the different radio technologies involved, existing and future ones
LTS.3	Hand-over	Capability of transferring an ongoing call or data session from one UWB access point to another
LTS.4	Collaboration	Cooperation between the different available technologies to provide users with the most valuable services in the best conditions in any situation

LTS.5	Connectivity	“Always the best connection” will be provided
LTS.6	Throughput	Higher data rates for evolved applications will be required
LTS.7	Positioning	User’s position will be provided by means of an LDR UWB location & tracking system
LTS.8	Location accuracy	Accuracy provided by the UWB location system must be better than 1 meter
LTS.9	Large-scale location	Location and tracking algorithms and information distribution strategies must be able to cope with large scale networks
LTS.10	Tracking	The location and tracking system will be able to track mobile users at walking pace
LTS.11	Location-aware RRM	Radio Resource Management in the heterogeneous network will take advance of the location information

4 Conclusion

This report has provided the definition of application scenario of Work Package 6 “UWB in Heterogeneous Access Networks”. The two phases approach (up to date equipments integration scenario and long term scenarios) of WP6 were described in this document.

In this document, it was described several scenarios what will be developed in WP6:

- Localisation in shopping centre
- UWB localisation of firefighter in indoor environment
- IPTV over UWB

The second part of the document described the requirements of the scenario themselves and the High and Low Data Rate UWB equipments requirements induced on development of Work package 7 of EUWB.

References

[1] Zeisberg, S., Schreiber, V.: “EUWB - Coexisting Short Range Radio by Advanced Ultra-Wideband RadioTechnology”, ICT Mobile and Wireless Communications Summit, Stockholm, June 2008, accepted for publication

[2] URL of EUWB consortium: http://www.euwb.eu

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