Integrated Project - EUWB

Contract No 215669

Deliverable

D8a.4

Test and verification of the demonstrator for public transport applications

Contractual data:	**M40**
Actual data:	**M41**
Authors:	**Thomas Feister, Thomas Bartzsch, Dirk Burggraf**
Participants:	**HTW, TESD, TESUK, EADS**
Work package:	**WP8a**
Security:	**PU**
Nature:	**R**
Version:	**1.0**
Total number of pages:	**26**

Abstract

Within D8a.4 the final demonstrator of the Public Transport Cluster of the EUWB project is described. The demonstrator consists of commercial FPGA boards. The PHY layer was developed by partner Wisair, the MAC software was developed by partners TESD/TESUK. A WLP layer to enable IP based traffic over WiMedia networks and a newly developed DME to control PHY, MAC and WLP layer were developed by partner HTW. In extensive tests the functionality of the demonstrator could be verified.

That leads to the final conclusion that the UWB network based on WiMedia compatible devices is now able to transport IP based data, i.e. the connection of the Internet and the high rate short range radio is available.

Keywords

ECMA-368, localization, public transportation

Table of Contents

List of Figures

Abbreviations

ASIE	Application Specific Information Element
CWUSB	Certified Wireless Universal Serial Bus
DME	Device Management Entity
DRP	Distributed Reservation Protocol
EUWB	CoExisting Short Range Radio by Advanced Ultra-WideBand Radio Technology
HDR	High Date Rate
LDR	Low Data Rate
LS	Least Squares
LT	Localization and Tracking
MABIE	Multicast Address Binding Information Element
MAC	Media Access Control
MB-OFDM	Multiband OFDM
OFDM	Orthogonal Frequency Division Multiplex
PDA	Personal Digital Assistant
RMSE	Root Mean Square Error
RSS	Received Signal Strength
RSSI	Received Signal Strength Indicators
SAP	Service Access Point
TOA	Time of Arrival
UWB	Ultra-Wideband
UWB-RT	Ultra-Wideband Radio Technology
WLAN	Wireless Local Area Networks
WLP	WiMedia Logical Link Control

1 Executive summary

The Public Transport Cluster is one out of the four clusters of the EUWB project, focussing on the aircraft cabin scenario. At the end of the project a demonstrator will be presented for verification of the functionality of the system. Furthermore, this demonstrator could be used as well for tests for system improvement. The test of this demonstrator and the functional verification will be described in this deliverable.

The demonstrator is based on commercial FPGA boards. These boards are equipped with a PHY layer daughter board developed by project partner Wisair. An alternative PHY solution is also available. Within the FPGA boards, the MAC software is running, developed by project partners TESD/TESUK. Using a proprietary protocol, the FPGA is connected with a host PC, where the higher layer software parts are running. The higher layers include a WLP layer to enable IP based traffic over WiMedia networks, developed by partner HTW. This layer is based on the draft WLP specification available from WiMedia Alliance, which was strongly improved. A newly developed DME to control PHY, MAC and WLP layer complements the architecture. Additionally, to be able to develop higher layer software without hardware a MAC emulator was developed by partner HTW.

The functionality of the developed software layers could be demonstrated by a series of tests, which are described in detail in this deliverable. That leads to the final conclusion that the UWB network based on WiMedia compatible devices is now able to transport IP based data, i.e. the connection of the Internet and the high rate short range radio is available.)

2 Introduction

One of the EUWB clusters is the Public Transport Cluster. Focused on the aircraft cabin scenario, the project partners want to develop a wireless communication system able to fulfill all requirements of such a system. Finally, the results of the development will be presented in a demonstrator, which allows the verification of the functionality of the system as well as enabling tests to further improve the system. In the following, the demonstrator will be described and the achieved results will be presented.

In section 3 a short overview of the system will be given. Based on deliverables from the beginning of the project, the structure of the wireless system and the main requirements will be summarized.

The demonstrator itself will be detailed in section 4. The hardware of the demonstrator will be shortly described. More attention will be given to the software. The structure of the software will be shown, every component will be shortly presented, including interfaces. Additionally, the MAC emulator will be mentioned, which allows the development of higher layer software without underlying hardware.

Finally, in section 5 test scenarios will be presented as well as the results obtained.

3 Public Transport Applications

3.1 System Overview

Within the EUWB project, the focus is on wireless communication systems within an aircraft. Beside this special scenario, there are a lot more options for introduction of such networks in public transport systems. The environmental conditions as well as the economic importance is e.g. for ferries or trains quite similar to the current situation inside an aircraft. So the EUWB scenario can be seen as a typical example for wireless communication in public transport systems in the future.

The Cabin Management System of an aircraft provides the core services and functions inside the cabin. The passenger's Inflight Entertainment System provides entertainment as well as information to the passengers. Mobile devices used by the cabin crew will further increase the service quality for the passengers and improve the working conditions for the crew. The use of wireless systems instead of wired systems will introduce much more flexibility in terms of re-configuration of the cabin as well as a substantial reduction of the weight due to the reduced cabling. Both aspects have a strong economical impact. A block diagram of a largely wireless Cabin Management System is shown in Figure 1. For more details please refer to [10].
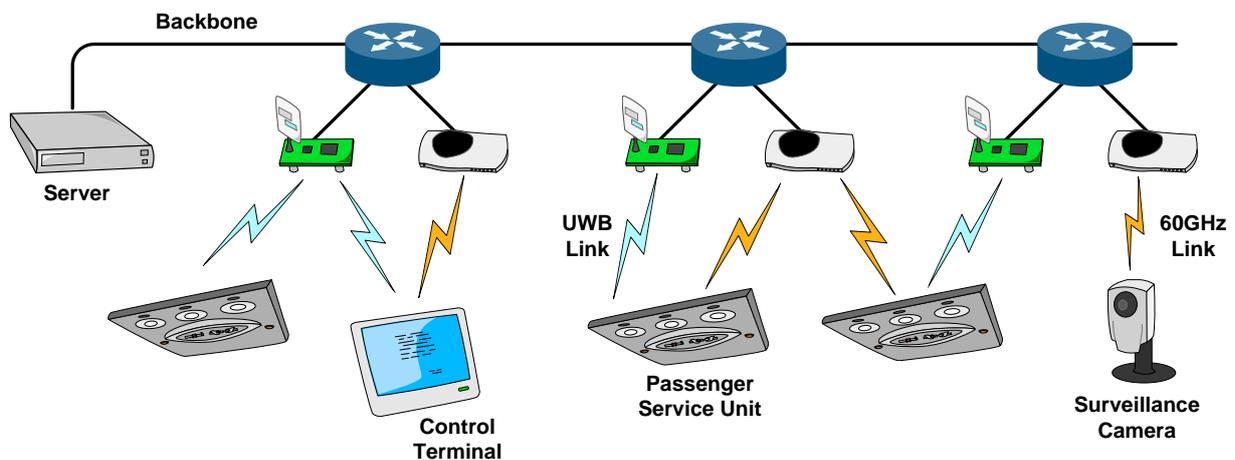
Figure 1: Block diagram of a wireless cabin management system

3.2 Structure and Requirements of the Communication System (incl. Location Awareness)

In detail descriptions of the structure and requirements for Cabin Management Systems are given in [10] and [11].

The following functions and applications are seen as potential candidates to be provided and supported by the Cabin Management System's wireless extension:

1. Wireless PSU (Passenger Service Unit) including

- PA (passenger address) and audio

- Reading Light

- PAX (passenger) call

- Signs and PAX Information Display

2. Wireless illumination-/ light control units including

    - Control & Monitoring of general illumination units (IBU´s)

    - Spot lights, signs, stairs

    - Monuments (light dome, bar, mobile office corner, lavatories, galleys)

    - Emergency Lighting (Floor path marking, Exit Signs, etc…)

3. Wireless sensors (smoke detection, doors, etc.)

4. Wireless info displays

5. Wireless crew services

    - Crew intercom and cockpit alert

6. Cabin security system including

    - Wireless cabin video monitoring system

    - A/C (Aircraft) access control, staff location & tracking

7. Contact-less passenger seat or other electronic devices

The most important requirements given in [11], to be seen as nice-to-have assumptions, should be summarised in the following table. Due to the underlying radio standard, especially the data rate is a maximum value, which will be distributed among the devices within one group, i.e. among the devices connected to a given access point.

	HDR	LDR
Data rate	480 Mbps (up to more than 1 Gbps for VHDR)	50 Mbps
Range	10 m (6 m VHDR)	25 m
Ranging accuracy	10 cm	
Ranging update rate	20 Hz	

Table 1: Requirements of the wireless communication system

Furthermore, it is important to note the device density in a cabin. There might be up to 300 devices active. So the system should be carefully designed to avoid interference between LDR and HDR devices as well as between different groups of LDR/HDR devices.

4 Demonstrator

4.1 Hardware

The hardware developed in WP7 consists of an FPGA board and a PHY board attached to it. The FPGA board comes from Xilinx and is a freely available ML507, containing an Virtex-5 FPGA XC5VFX70 and a lot of peripheral hardware. Especially important is the availability of USB2 and Gb-Ethernet interfaces for communication with the platform. The FPGA itself provides 11.200 Virtex-5 slices (a Virtex-5 slice is composed of 4 LUTs and 4 flip-flops) and one hardware PowerPC block. There are two PHY boards available. Partner Wisair newly released the Wisair 612 Module, which now provides also ranging capabilities. Figure 2shows this configuration. A second PHY is using the Realtek RTU 7012 chip. The PHY modules communicate with the TES MAC according to ECMA639 interface.

Figure 2: FPGA board Xilinx ML507 and UWB PHY

4.2 Software

4.2.1 Overview

The software includes all layers above the PHY. On the PowerPC within the FPGA, there is the MAC software running. On the host PC, connected to the FPGA board by means of a Gb-Ethernet, there is the WLP/DME running as well as the application software, which for demonstration purposes might be reduced to a test application. In a final device, MAC and WLP/DME have to run on the same

platform. But due to the limited resources of the demo platform this was not possible to realise for the demonstrator. Nevertheless, the correct function of the implemented software can be demonstrated.

4.2.2 Interfaces

The interfaces between the layers are illustrated in Figure 3. WLP SAP, ALME SAP and WLME SAP are in detail described in [7]. These interfaces are organized in the same way as MAC SAP and MLME SAP, which are part of the ECMA-368 standard.
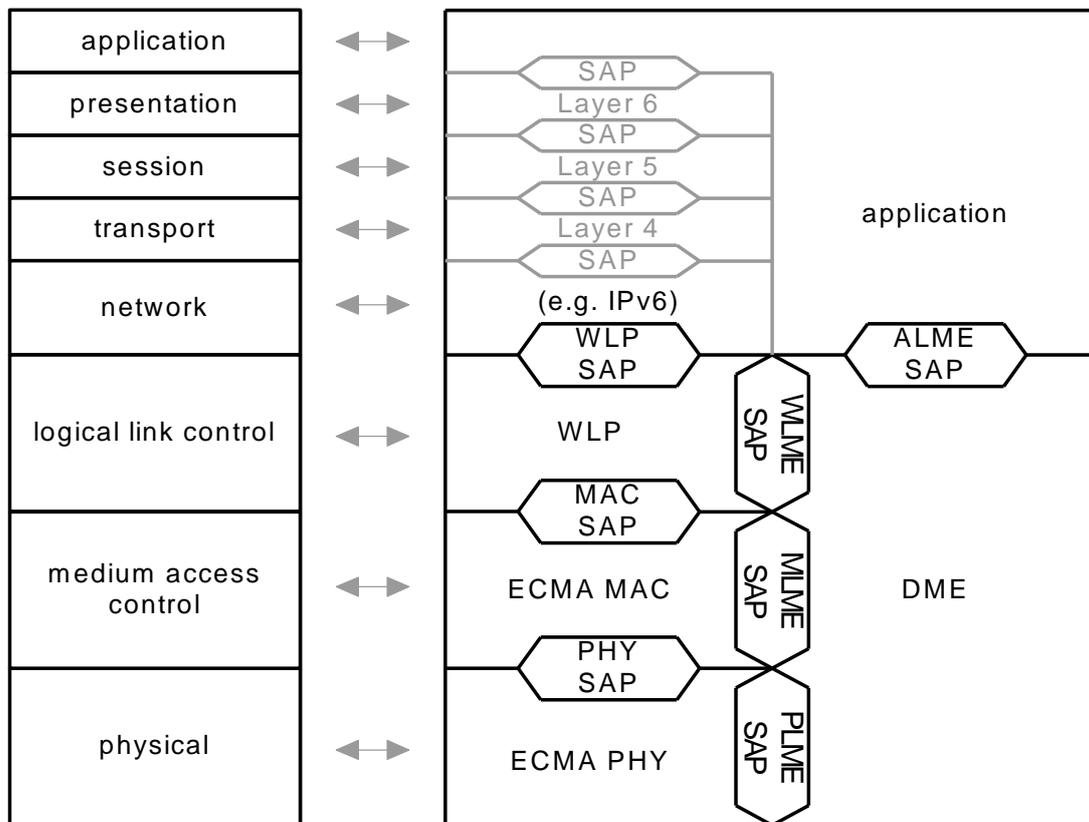

Figure 3: Interfaces between layers

To realize the communication between a PC running the layers above the MAC and the MAC itself, which is running at the PowerPC of the FPGA platform, a special protocol called *Chekmate* was implemented; Figure 4 shows the block diagram.
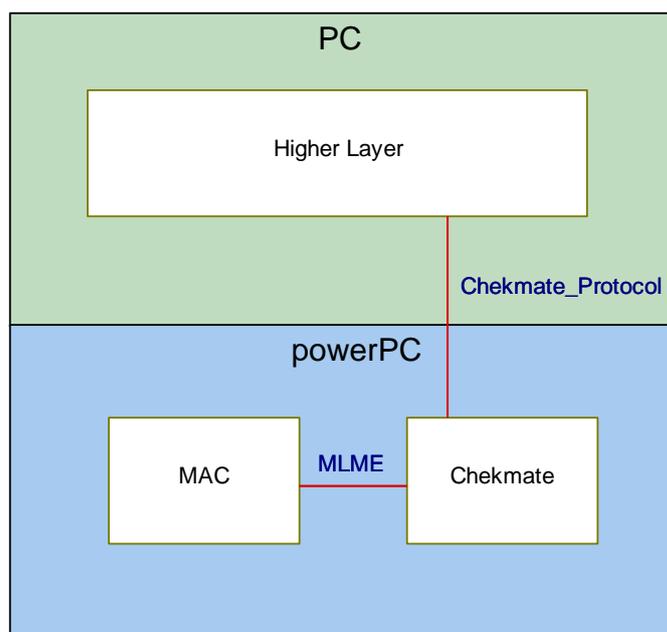
Figure 4: Chekmate block diagram

Using this protocol, the primitives defined in ECMA-368 are used for communication between the WLP/DME and the MAC layer. For more details about *Chekmate* refer to [9].

The interfaces

4.2.3 MAC

The MAC layer includes a huge sub-set of the functionality and primitives described in ECMA-368. In this section the most important features of the MAC implementation with respect to the application scenario will be shortly addressed. For more detailed descriptions and test results please refer to [9].

P2MP

Whereas the initial demonstrator was only capable to form beacon groups of 2 devices and communicate only point to point, the current release supports beacon groups of more then 2 members and the reservation of MAS slots from every member of the beacon group.

This feature is tested with the platform test setup, which enables a device to communicate with multiple devices. On reception of a beacon from any remote device, a device will initiate reservation negotiation. Such an automatic reservation of time-slots has to be handled with care for multiple device communication.

If the negotiation is denied, or no answer from the remote device is received, the negotiation is considered as failure. The device will not retry again. The application has to initiate explicitly the negotiation again with specific remote device. A device may play a different role with different devices, as a Target with one remote device and as an Initiator with another remote device

Multicast

To control the channel load and to make the data transfer more efficient, the multicast feature is important also for radio devices. Therefore, in the current release the multicast feature is supported. One device will register the multicast address, i.e. multicast address binding, thus initiating a multicast

group. Other devices can then register to that group. From that point in time this multicast address or multicast group is ready to get activated, the devices can receive data sent by the initiator.

In the current platform test implementation, device D1 acts as initiator which registers a multicast address by sending a MAB-IE in its beacon. The devices which are acting as targets (D2, D3), activate themselves on reception of the MAB-IE and get ready to receive the data. The initiator might now address the data packets using the multicast address, and the devices which are activated will be able to receive the data packets.
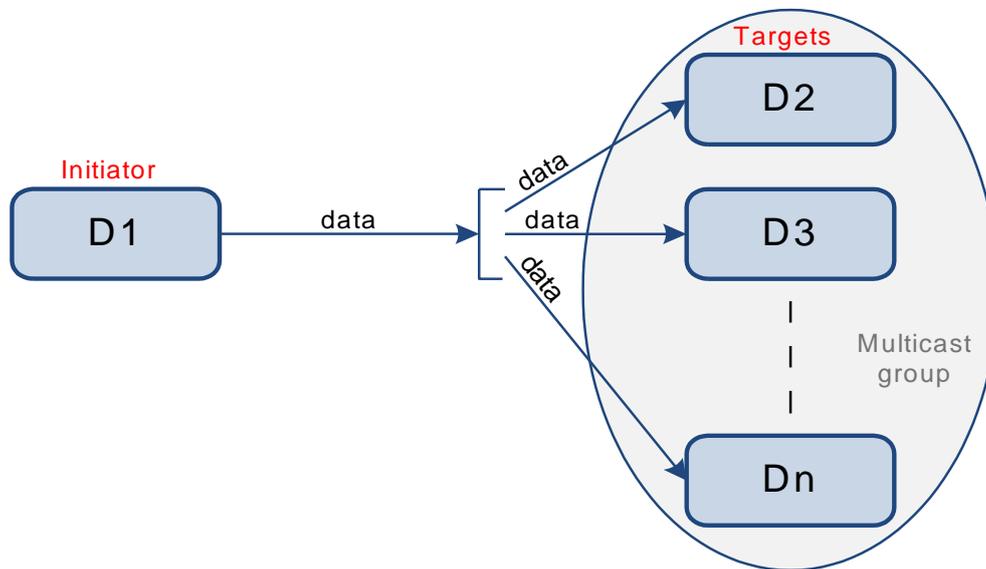
Figure 5: Multicast Group

This feature is used in the home entertainment and in the public transportation application demonstrator for video streaming. In the future there are more applications imaginable, which will make use of this feature.

ASIE

A device may include an ASIE in its beacon for each of its applications which have made the request. The scope of the ASIE is dependent on the application that requested the inclusion of the ASIE. The current release has adding of new ASIE in its beacon and updating the same when ever required.

MLME-ASIE-ADD.request and MLME-ASIE-REMOVE.request has been added.

This feature is needed for higher layer synchronization (D8a.3.6), Multiband/Multimode (D8a.3.7) and the implementation of the WLP PAL for the public transportation deliverable (D8a.4).

4.2.4 WLP

The WiMedia Logical Link Control Layer (WLP) started to be developed by the WiMedia Alliance in 2007, aiming at connecting the IP world (i.e. the internet) and the short range HDR radio devices according to the WiMedia standards (i.e. ECMA-368). But the development was not continued after a first approved draft. Within the EUWB project, the partners continued the development and finalised a first version of the WLP specification [7]. According to this specification the implementation of the WLP layer was done. Especially for the Public Transport application the features offered by WLP are of great importance.

The WLP layer is a kind of protocol adaption layer, which has to handle the address translation between IP and the EMCA-368 network. In the OSI model, the WLP layer is the logical link control, located between media access control and network, as illustrated in Figure 3.
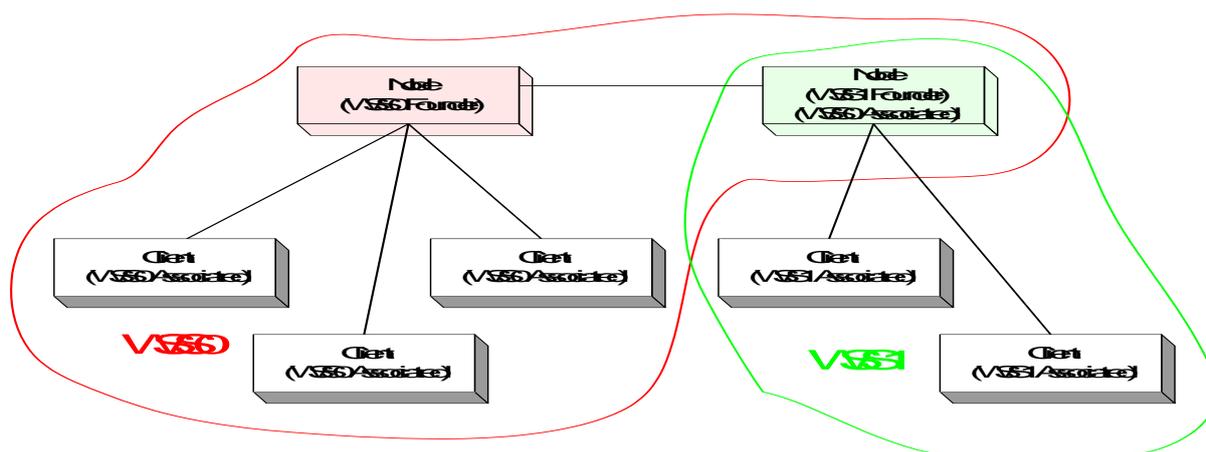

Figure 6: WLP WSS

WLP defines WLP Service Sets (WSS) to group the devices within radio range. Communication is allowed only between devices, which are member of the same WSS. This principle is shown in Figure 6. The functionality to create and destroy WSS, to associate to and disassociate from a WSS, as well as the translation of addresses is comprised in the WLP layer, which was developed in the project.

4.2.5 DME

As shown in Figure 3, the Device Management Entity (DME) is located beside the PHY, MAC and WLP layer. The DME interfaces these layers by means of their management entity SAPs. In [7] there is a complete specification available, defining the functionality of a DME for ECMA-368 compatible devices and WLP.

The DME is essentially controlling the behaviour of the device. It collects information from the PHY, MAC and WLP layer as well as from the application. Based on this information, it controls the other layers by generating of commands and monitoring of the results. Furthermore, it informs the application about the current status of the network or the link resp.

4.3 Information Elements

4.3.1 Standardised Information Elements

The ECMA-368 defines a number of information elements for several purposes. Currently, there are a few of them available in the demonstration platform, supporting the essential transmission capabilities to be demonstrated. In detail, information elements available comprise:

- Distributed Reservation Protocol (DRP) IE: When communicating by means of reserved MAS, the devices have to be aware of the current reservation situation within the beacon group. A device willing to initiate a communication link has to announce the intended reservation to other devices. The device(s) addressed has/have to approve this reservation. This procedure is especially important due to the hidden-node problem – one device might receive different signals than the other, which necessitates the announcement-and-approval procedure for MAS. This procedure is done using the DRP IEs, which beside other information mainly includes bitmaps to identify the MAS in question.

- DRP Availability IE: To enable a device to select MAS to be used for its communication, it is meaningful to provide information about the current status of the MAS usage in the beacon group. The device itself might not be able to obtain this information by itself due to the hidden-node problem mentioned above. Therefore, this IE is used to inform other devices about a device's view regarding the MAS utilisation, enabling the initiating device to pre-select free MAS and to ease the announcement-and-approval procedure to agree on MAS to be used for communication between devices.

- Multicast Address Binding (MAB) IE: There are different addressing schemes used for IP traffic e.g. in Ethernet connections and in radio systems according ECMA-368, the length of the addresses is not identical. Therefore, an address mapping has to be done to enable IP communication through an ECMA-368 network. For P2P IP traffic, this is related to the WLP topic (see below). For multicast traffic, there is a special IE defined, which informs devices about the mapping of multicast IP addresses to network internal multicast addresses to be used for communication in the radio network.

4.3.2 Application Specific Information Elements

A device may include an ASIE in its beacon for each of its applications which have made the request. The scope of the ASIE is dependent on the application that requested the inclusion of the ASIE. The current release enables the application to add new ASIE to its beacon and to update the information whenever necessary.

- MLME-ASIE-ADD.request sends an ASIE to the MAC layer, which will be added to the device's beacons. Also a modification of the information contained in the ASIE is possible using this primitive.

- MLME-ASIE-REMOVE.request allows the application to stop the transmission of the ASIE and to free the memory.

This feature is needed for higher layer synchronization (D8a.3.6), Multiband/Multimode (D8a.3.7) and the implementation of the WLP PAL for the public transportation deliverable (D8a.4).

4.4 MAC Emulator

The HDR Demonstrator provides two modes. At first, of course the utilization of real hardware is possible, enabling demonstrator set-ups as described above. On the other hand, a MAC emulator was developed by partner HTW, which allows the verification of functionalities from upper layers without the need of using FPGA Hardware. The development of higher layer software can be done independently from the hardware development. The devices are connected via Ethernet, which substitutes the physical layer of UWB radio except for the timing constraints, which are not of importance for the higher layers. The emulator uses ECMA-368 primitives for the communication between the layers in the same way as the real hardware does, an easy switch between emulator and real hardware is possible by a simple modification in one of the header (for more details refer to [8]). Beside the MAC layer, which is switched to be the emulator or the real MAC, all other parts of the software will work in both scenarios, as shown in Figure 7.
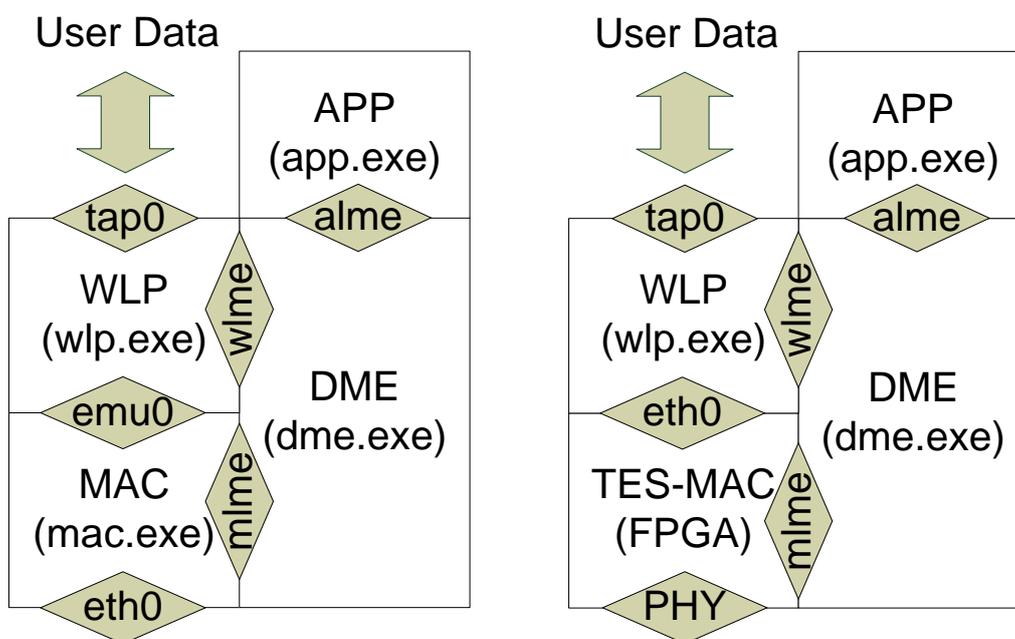
Figure 7: Demo structure with MAC Emulator (left) and real hardware (right)

The communication between the layer-processes is managed by message queues. The user data exchange with upper user layers is provided by the virtual interface "tap0" in the WLP process (for more details concerning all used processes and software issues refer to [8]).

The MAC emulator was successfully tested with 4 devices, the implementation is intended to be used with up to 7 devices.

4.5 Demonstrator set-up

As described in 4.4 the demonstrator supports two modes. Both modes consist of different set-up procedures, which will be declared briefly in the following subchapters (for more details refer to [8] and D7.4.2b).

4.5.1 Demonstrator with FPGA Hardware

The demonstrator consists of 1 Wisair 612 radios and 2, respectively 3 Realtek RTU 7012 radios, which are all connected to Xilinx ML507 boards. The demonstrator works

Xilinx board Setup

	Xilinx Board	**PC**
IP address	192.168.23.11	192.168.23.1
EUI	00:11:22:33:44:01	
IP address	192.168.23.22	192.168.23.2
EUI	00:11:22:33:44:02	
IP address	192.168.23.33	192.168.23.3
EUI	00:11:22:33:44:03	
IP address	192.168.23.44	192.168.23.4
EUI	00:11:22:33:44:44	

Table 2: Source address setup

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0	0	0	0	0	0	0	0

Table 3: Source setup SW8 for device 1

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0	0	0	1	0	0	1

Table 4: Source setup SW8 for device 2

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0	0	1	0	0	1	0

Table 5: Source setup SW8 for device 3

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0	0	1	1	0	1	1

Table 6: Source setup SW8 for device 4

PC Setup

The PC uses the IP address of the Xilinx board as gateway address to send IP packets over the wireless link. To setup the route refer to information in [8].

4.5.2 Demonstrator with MAC Emulator

PC-Setup

The Demonstrator with MAC-Emulator is suitable for up to 7 devices. Figure 8 shows the set-up.
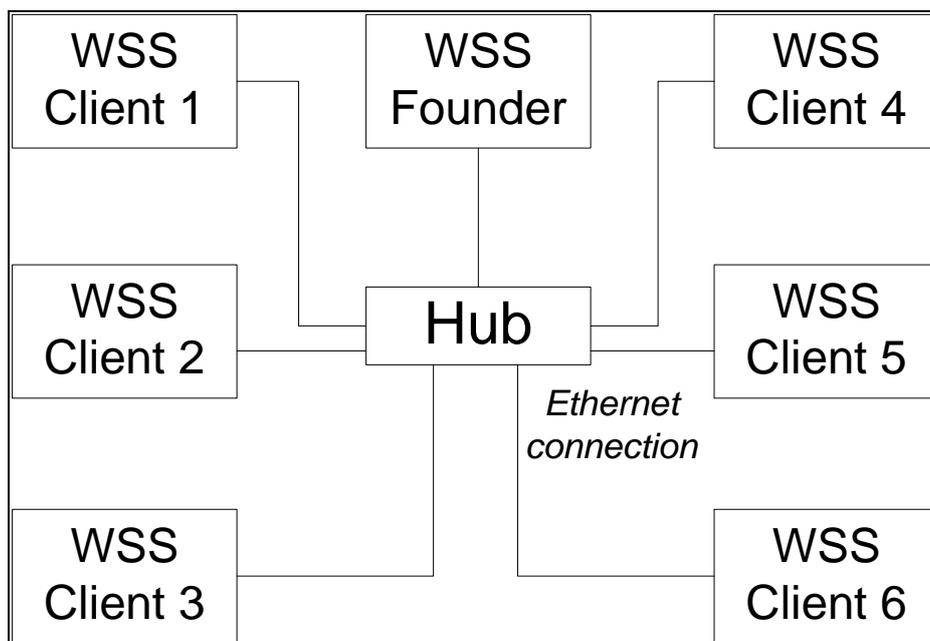

Figure 8: Emulator set-up

The set-up consists of one WSS created by one WSS founder and up to 6 WSS clients which are associated to that WSS. Each device consists of four software c++-processes: DME, WLP, MAC and Application. The user can get information and can control the processes via unix terminals. After all processes for all devices are set-up the user has to define the IP address of the virtual interface "tap0" to allow communication between the WLP layer and upper layers. After all configuration issues are done the all devices are able to exchange data. For more information concerning supported refer to [8].

The HDR Demonstrator supports the following tested features shown with the appropriate mode:

Features (Primitives, IEs, misc.)	Supported mode (Emulator, FPGA hardware)
MLME_BEACON_START	both
MLME_BEACON_STOP	both
MLME_MULTICAST_REGISTER	both
MLME_MULTICAST_ACTIVATE	both
MLME_ASIE_ADD	both
MLME_ASIE_REMOVE	both
DRP Support	Only Hardware (FPGA) mode
MABIE	both
DRP IE	Only Hardware (FPGA) mode
ASIE	both
Supports up to 7 devices (with MAC emulator) and 5 devices (with FPGA)	both
WLME_WSS_CREATE	Both
WLME_WSS_DESTROY	Both
WLME_WSS_ASSOCIATE	Both
WLME_WSS_DISASSOCIATE	Both
WLPIE List + Remote List	Both
Multicast	Both
ALME_BEACON_CHANGE_BAND	Only Hardware (FPGA) mode

Table 7: Demonstrator features

For more detail refer to [7] and [8].

5 Test Scenarios and Results

5.1 DRP Reservation

Reservation is based on the Distributed Reservation Protocol (DRP) and is in charge of the DME. To exchange reservation information between devices Information Elements (IE) will be used. To negotiate a reservation DRP Information Elements (DRP IE) are attached to the Beacon Frame of the MAC; this procedure is called "Implicit Negotiation". To inform the devices about the slots which are for disposal, user configured Medium Access Slot (MAS) Maps are transmitted via Beacon Frames. To determine any reservation, several types of reservation bitmaps will be used, each is 216 bit, where each bit represents the allocation of one MAS. Figure 9 shows the DRP procedure for two Devices, which can be extended logically to up to 4 devices.
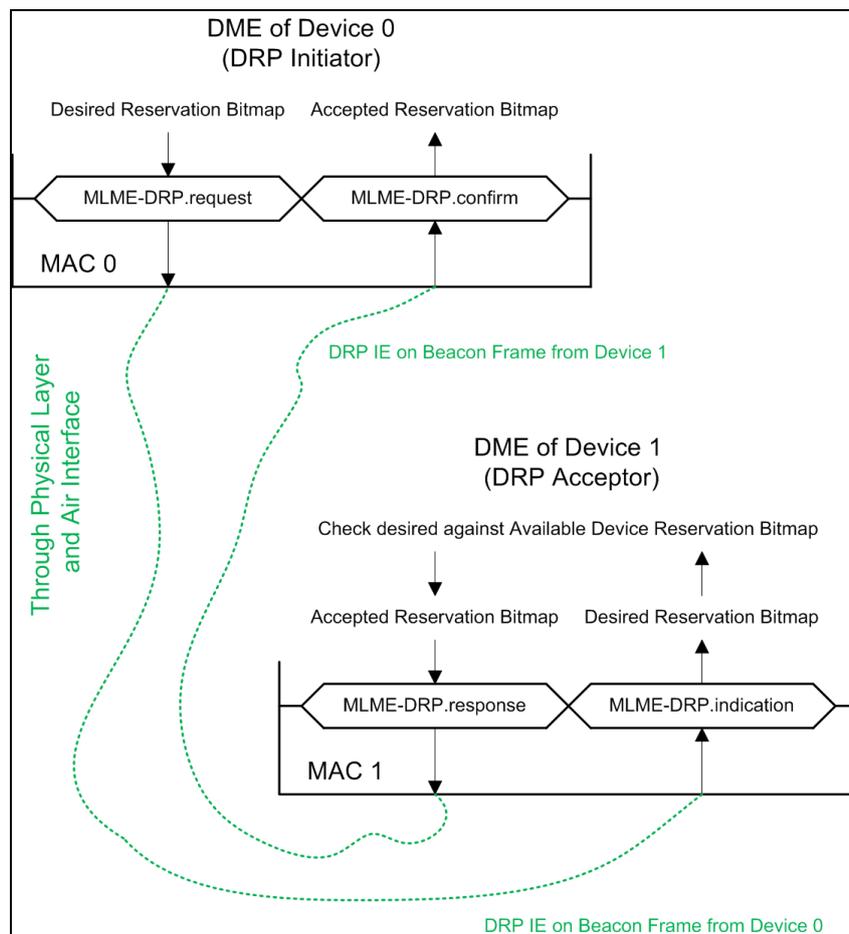
Figure 9: DRP procedure

The DRP procedure has been successfully tested and verified with up to 4 devices. For more information refer to [7], [8] and D7.4.2b.

5.2 WLP Service Sets

As defined in [7] the functionality of WLP service sets is provided by several primitives, which will be declared in the following subchapter. WLP service sets implementations are suitable for the demonstrator with MAC emulator and with real hardware. The following functionalities have been tested successfully and are suitable for the set-up specified in Figure 8, which consists of one WSS with one WSS founder and up to 6 WSS clients.

5.2.1 Creation

This primitive is generated by the DME to create a new WSS. Creating a new WSS is only possible if the device is a WSS founder. The WLP Layer initiates the creation of a new WSS. The tag for the WSS will be created randomly between 0 and 254 but must not be a tag of an already existent WSS. The WSS will be immediately activated and the WLP Device will announce that WSS in its WLP IE.

5.2.2 Association and Disassociation Frames

As defined in detail in [7] this subchapter gives a brief description of the association and disassociation frame types and their functionalities.

AssociationSubtype	Short Name	Description
0x00	A0	requests association in a WSS; sent by a client or node to the WSS founder
0x01	A1	confirms an A0 frame; sent by the WSS founder to accept or deny association
0x10	D0	requests disassociation from a WSS; sent by the WSS founder to a WSS client
0x11	D1	confirms an D0 frame; sent by the device that will be disassociate from a WSS

Table 8: Association/Disassociation frame types

The A0 Association Frame is sent by a Client or Node Device to request association in a certain WSS. The destination has to be the WSS Founder. The WSS Founder replies that request with the concerning A1 Frame indicating a grant to access the WSS or a denial.

The D0 Frame can be sent by the WSS Founder to a WSS Client if the WSS Founder wants to remove the WSS Client from its WSS. The WSS Client confirms that request with a D1 Frame. Does the WSS Client deny disassociation, the WSS Founder should retry several times. If the WSS Client doesn't grant the disassociation, anyway the WSS Founder has the right to remove the WSS Client from the WSS. If there is no D1 Frame from the WSS Client during several retries of request, the WSS Founder removes also the WSS Client.

If the WSS Client sends the D0 Frame to the WSS Founder then the WSS Client wants to leave the WSS. The WSS Founder sends a D1 Frame in response to D0. If the WSS Founder denies the request, the WSS Client should retry periodically the request. The WSS Client doesn't have the right to leave the WSS without acceptance of the WSS Founder, except the WSS Founder doesn't confirms the D0

Frames of several request retries. In the latter case the WSS Client can assume that the WSS Founder is dead an should leave the WSS unauthorized.

5.2.3 Association

This primitive is generated by the DME to request association to a specific WSS. The WLP Layer initiates the association process (see Figure 10 for association and disassociation process) to the WSS.
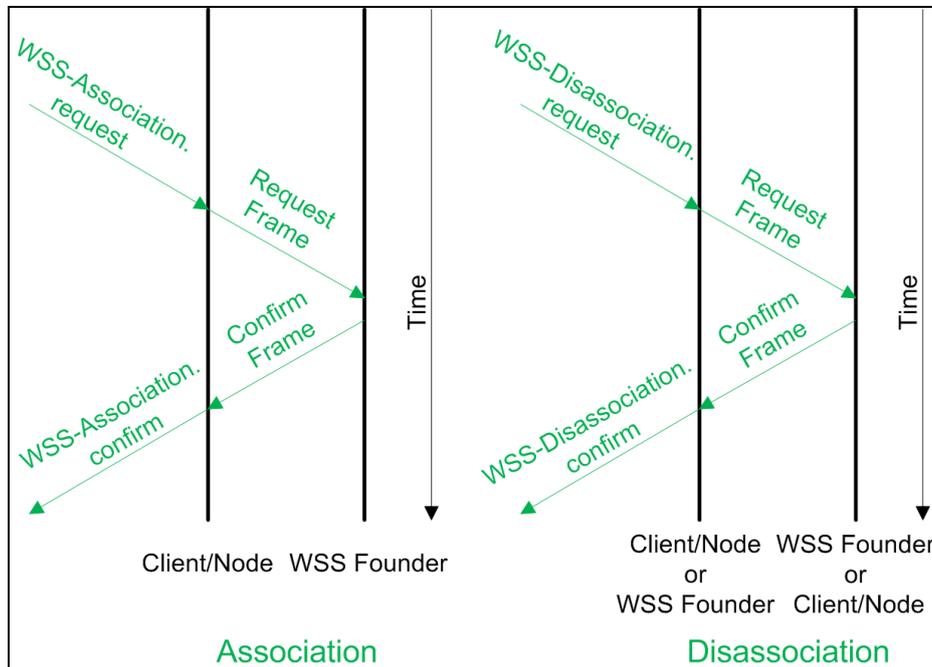

Figure 10: Association and Disassociation process

5.2.4 Disassociation

This primitive is generated by the DME to request disassociation from a specific WSS. There are two scenarios. On one side the WSS Founder wants to disassociate an associated WSS Client (e.g. before destruction of the WSS) and on the other side a WSS Client wants to leave a WSS represented by the WSS Founder. The WLP Layer initiates the disassociation process from the WSS by sending a D0 Frame to the WSS Founder or the WLP Client.

5.2.5 Destroy

This primitive is generated by the DME to destroy a WSS. The WLP Layer initiates the destruction of a WSS. The destruction of a WSS is bound to several points. If the device is a Node Device and the WSS Founder it has to disassociate all Client Devices and Node Devices within the WSS, afterwards the WSS should be destroyed. If there are any problems during disassociation procedure, the WLP Layer should destroy the WSS at latest after the timeout had passed. If the device is a Node Device and not the WSS Founder or a Client Device, the request should be denied using the appropriate ResultCode within the confirm primitive.

5.3 WLP-Unicast

The WLP-Unicast is a simple, successfully verified, point to point communication specified in [7].

5.4 WLP-Multicast

As defined in [7] the WLP-Multicast consists of several primitives and functionalities, which will be declared in the following subchapters. WLP Multicast implementations are suitable for the demonstrator with MAC emulator and for the one with real hardware. The following functionalities have been tested successfully and are suitable for the set-up specified in Figure 8, which consists of one WSS with one WSS founder and up to 6 WSS clients.

5.4.1 Indication

This primitive is created by the WLP layer to inform the DME that there is an interest of multicast traffic in the network. Before multicast traffic is available in the subnet, the multicast source has to register the Multicast EUI48 (MEUI48) and tell all clients in the network about the availability of this address. Then clients can activate the multicast address to receive this traffic. The WLME-Multicast. Indication consists of the parameter "Multicast-Code" which distinguishes between the four tasks: Register, Deregister, Activate and Deactivate, which are explained in the next subchapters.

5.4.2 Register

This primitive is generated by the WLP layer of the multicast source when there is an interest for this multicast traffic in the network. The WLP layer builds an MEUI48 and sent it to the DME. The MEUI48 has to be registered before it can be activated. The DME registers the MEUI48 and sends a Multicast Address Binding Information Element (MABIE) with the MEUI48 to inform all clients in the network about the availability of this address.

5.4.3 Deregister

This primitive is generated when no client is interested in receiving this multicast traffic or the multicast source can no longer provide this traffic. The DME deregisters the MEUI48 at the MAC layer so that no more packets can be sent to this address.

5.4.4 Activate

This primitive is generated by the WLP layer of a client who wants to receive a specific multicast traffic. The WLP builds an MEUI48 and sends it to the DME. DME tries to activate the submitted MEUI48 at the MAC layer. When successful the MAC will pass through all packets which are addressed to this multicast address.

5.4.5 Deactivate

This primitive is used to inform the DME that the client is not longer interested in this multicast traffic. The DME deactivates the MEUI48 at the MAC layer so that packets to this address are now discarded. If the MEUI48 is the address FF:FF:FF:FF:FF:FF all MEUI48s are deactivated.

6 Conclusions

More than three years of development work finally led to the demonstrator described above. The demonstrator is meant to show the successful inclusion of a high rate short range radio network in a public transport scenario. The requirements from the management system regarding security, the monitoring and control of parameters and the co-ordination of services are included as well as the passengers comfort, i.e. entertainment systems and information. Within EUWB, the Public Transport Cluster was focussed on a scenario of an aircraft, lead by partner EADS. Nevertheless, the results of the project will be used also in other areas of public transport. In trains, intercity buses or ferries one will find similar conditions as inside an aircraft.

By means of the demonstrator, the connection between the IP based communications in the Internet with a radio system based on the WiMedia standards is shown. This will offer great opportunities in the future to realise more comfort for the passengers as well as to enable business cases for innovative companies. Therefore, using the results from WP8a, which are integrated in the verification platform described in this deliverable, there is a chance to change parts of the commonly known appearance of public transport systems.

References

[1] S. Zeisberg, V. Schreiber, "EUWB - Coexisting Short Range Radio by Advanced Ultra-Wideband RadioTechnology", *ICT Mobile and Wireless Communications Summit*, Stockholm, 2008.

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

[3] S. Wang et al., "Localisation using ECMA 368 platform," deliverable D8a.3.5 of the integrated project – EUWB, 215669, 2010.

[4] L. Decelis et al., "Implementation of the enhanced LT engine with mobility management (LDR and HDR)," deliverable D4.3.2b of the integrated project – EUWB, 215669, 2010.

[5] W. P. Siriwongpairat et al.: "Multiband-OFDM MIMO Coding Framework for UWB Communication Systems," *IEEE transactions on signal processing*, vol. 54, 2005, pp. 214–224.

[6] ECMA 368 MAC and PHY Specification

[7] HTW Dresden (University of Applied Sciences), "WLP/DME Specification",2010/2011, contact: zeisberg@htw-dresden.de

[8] HTW Dresden (University of Applied Sciences), "HDR demonstrator manual", 2011 contact: zeisberg@htw-dresden.de

[9] D. Radović et Al."(V)HDR platform (HW/SW) provision to different activity clusters (initial /final)", deliverable D7.4.2b of the integrated project – EUWB, 215669, 2011

[10] S. Bovelli, F. Leipold, "Scenario description for public transport applications", deliverable D8a.1 of the integrated project – EUWB, 215669, 2008

[11] S. Bovelli, F. Leipold, "Requirements for public transport applications", deliverable D8a.2 of the integrated project – EUWB, 215669, 2008

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

[13] R. S. Thomä, O. Hirsch, J. Sachs, and R. Zetik, "UWB sensor networks for position location and imaging of objects and environments," in Proc. Second European Conf. Antennas and Propagation EuCAP 2007, 2007, pp. 1–9.

Acknowledgement