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Scenario description for automotive environment applications

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Abstract

Description of application scenarios for the automotive cluster, addressing the three UWB based functionalities “tag localization”, “detection and localization of passive objects” and “data communication”.

Keywords

Localization, detection, intrusion, data communication, UWB

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Abbreviations

EUWB	CoExisting Short Range Radio by Advanced Ultra-WideBand Radio Technology
VAI	Vehicle Ambient Intelligence
ECU	Electronic Control Unit

1 Executive summary

Three different functionalities, based on UWB technology, will be investigated in the automotive applications cluster within the EUWB project:

a) Localization of a dedicated tag

b) Detection and localization of passive non-cooperative objects

c) Two-way data communication

A number of application scenarios have been identified, based on the different functionalities described above. *This set of applications can be termed as "vehicle ambient intelligence"*.

For the localization of a dedicated tag, keyless entry is seen as the most important application scenario. It allows the introduction of enhanced comfort functions and customized multi-level authorization schemes. Fine grained customization allows a capabilities based authorization scheme for individual keys.

For the detection and localization of passive non-cooperative objects, intrusion sensing is identified as main application scenario to be addressed within the EUWB project. By detecting object movement inside the passenger compartment for example, unauthorized access can be detected. UWB technology allows fast, reliable and low-power operation for this type of application.

For two-way data-communication, two relevant application scenarios are identified. One scenario describes a generic sensor to electronic control unit (ECU) transmission in the motor compartment. In another scenario, the communication of user interface components in the passenger compartment to the body computer in the dashboard is described.

2 Introduction

The introduction of novel wireless technologies has been driven almost exclusively by consumer technology. Prominent application examples are the wireless interfacing of mobile phones or modern multimedia systems with Bluetooth connectivity. Only recently, generic automotive applications like car to car and car to infrastructure communication gained some traction. On the other hand, specific applications like keyless entry or tire pressure measurement employ only very simple, proprietary wireless data transmission techniques, using unlicensed frequency bands. Such narrowband solutions achieve only limited reliability in their given environment, because of the complex propagation channel in the car and at its surroundings.

Figure 2-1: The UWB propagation channel – reliable in the harsh automotive environment

Typically, the in-car environment is very tough for any wireless application. The metal shielding of the car body and the changing occupation with passengers or load leads to complex propagation characteristics. These characteristics have to be addressed, in order to achieve reliable functionality for wireless applications. With this knowledge and UWB as basic technology, a novel technical approach to wireless data communication and location tracking inside a car is possible.

Three different novel functionalities, based on UWB technology, have been identified and will be investigated in the automotive applications cluster within the EUWB project:

d) Localization of a dedicated tag

e) Detection and localization of passive non-cooperative objects

f) Two-way data communication

This document describes the application scenarios for the automotive environment, based on those functionalities.

3 Localization of a dedicated tag

The basic principle of localization using a dedicated tag shown in figure 3-1:

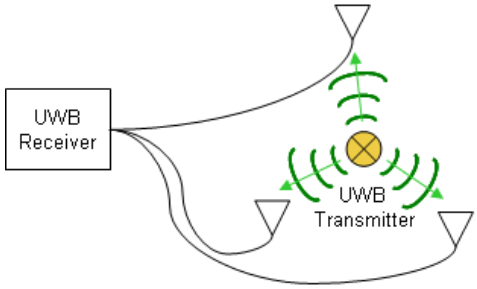

Figure 3-1: Typical location tracking system setup

The dedicated tag is an active transmitter, whose position is evaluated by an UWB receiver. Typically, the transmitter is a small low-power device and the receiver is realized as fixed infrastructure.

In the automotive environment, the UWB transmitter tag can be integrated or replace the keyfob (car key) and the UWB receiver is integrated in the car's fixed infrastructure.

For localization, more than one antenna is typically needed. The exact number of antennas depends on the required performance and the RF propagation characteristics of the wireless channel inside and around the car.

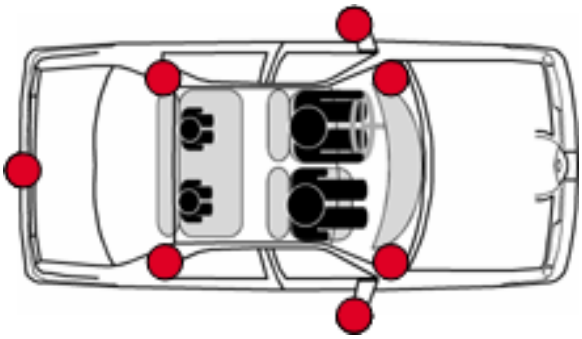

Figure 3-2: Example of one possible antenna placement

For the scenarios described in this document, two different spatial regions with their specific set of applications were identified:

- In close proximity to the car body on the outside of the car
- Inside the car chassis in the passenger compartment

3.1 Outside of car

When an authorized person comes in close proximity of the car (< 2m), the keyfob (car key) will be detected and located. On envisioned application is light dimming, where the interior lights are turned on, when the driver approaches the car. If the driver reaches the car and reaches for the door handle, the door will be unlocked.

Figure 3-3: Keyfob location tracking in close proximity of the car

The location tracking has to work in complex RF environments like:

- parking lot or garage, where the car is surrounded by other cars and concrete
- in presence of RF interferers like mobile phones, WLAN, WiMAX or airport radar

The distance range for locating the keyfob is

- door authorization.: 1-1.2 m
- light dimming: 2 m with 50 cm cell resolution

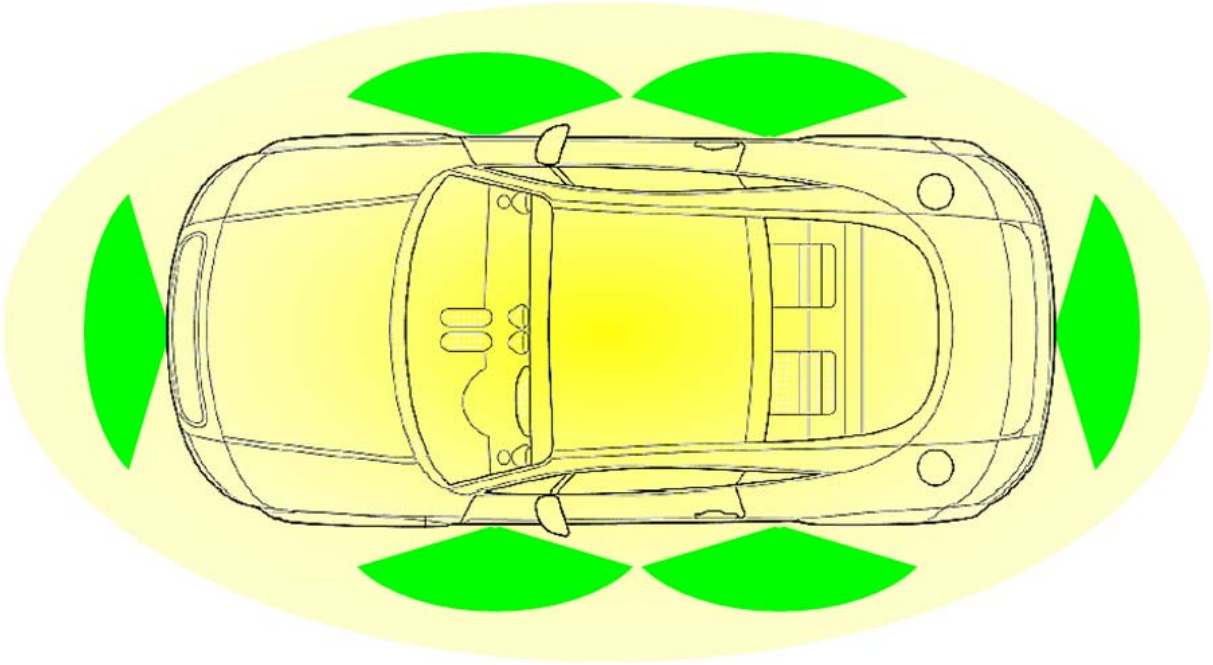

Figure 3-4: detection zones for car access authorization

Figure 3-4 shows the detection zones around the car, where door handles are placed:

- Passenger doors
- Fuel door
- Trunk and engine compartment

Passenger door access using keyfob location tracking will be investigated in WP8b.

3.2 Inside car

Using the localization functionality of the keyfob, two basic scenarios are considered. When the driver is sitting in his seat, the push-button engine-start functionality is enabled. Also, personalized settings can be automatically set, according to the driver:

1) Individual seat position setup
2) Entertainment and car system setup, climate control

Personalized driver authorization also allows for extended functionality like setting a maximum vehicle speed, limiting the allowed navigation range of the car or allowing only vehicle access without engine start authorization.

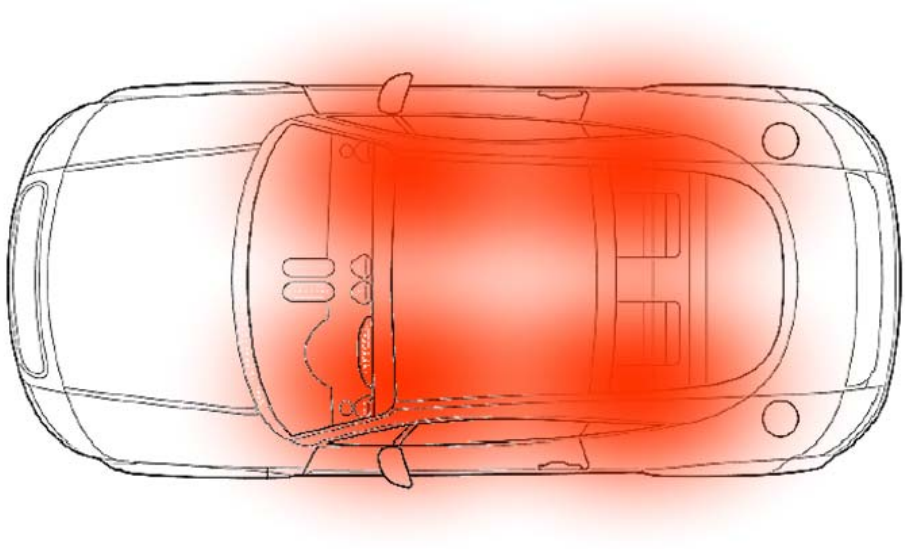

Figure 3-5: Simplified field distribution inside a car, when the antennas sit in the A and C pillars

One important constraint for this kind of location tracking applications is the reliable and exact determination of the position of the driver (or the key for that matter). Together with additional safety measures, e.g. pressing the brake pedal, the push-button engine-start functionality can be realized.

4 Detection and localization of passive non-cooperative objects

A passive non-cooperative object is any object which is not involved in the UWB system. The detection and localization of such objects is a major challenge due to the absence of a tag. However, there are various applications basing on the detection and localization of such objects.

4.1 Intrusion sensing

The first kind of applications where passive non-cooperative objects have to be detected and localized is intrusion sensing. In this application the sensor is only active while the vehicle is parked (not in operation) and locked.

Envisioned application scenarios are:

- Burglar alarm

In this case the sensor should detect a person trying to enter car or trying to take something out of car. Movement inside the passenger compartment will be detected. The discrimination between inside and outside of the car is crucial for the performance of the system. For convertibles, a virtual safety zone above the passenger compartment is created. For pick-up cars, the virtual safety zone is located above the loading area. For trucks, especially the storage area has to be protected. Generally speaking, this application covers the surveillance of the passenger compartment, storage areas and trunks.

A UWB intrusion sensing demonstrator will be presented in this project.

Figure 4-1: Intrusion sensing (Source: Bosch)

- Children and dog protection

The same UWB sensor can be applied to a application scenario, where children or dogs are left behind in the car. When the temperature inside the passenger compartment exceeds a certain limit and movement is detected, an alarm sounds.

- Marter detection

Marters love the warmth in the engine compartment of a recently parked car as well as the taste of cables and rubber parts of the engine. Damage due to marters is becoming more and more common. With an UWB intrusion sensor movement inside the engine compartment is detected and a marter protection actuator (e.g. high voltage source) can be turned on.

- Trunk sensor

A person may be locked in a trunk unintentionally. In this case, movement inside the trunk is detected by an UWB sensor and the trunk door can be unlocked automatically. If the trunk door is opened without prior movement inside, an alarm is raised (intrusion) .

4.2 Occupancy sensing

Another kind of application is occupancy sensing. The passengers are assumed as passive non-cooperative objects, hence no tag is necessary.

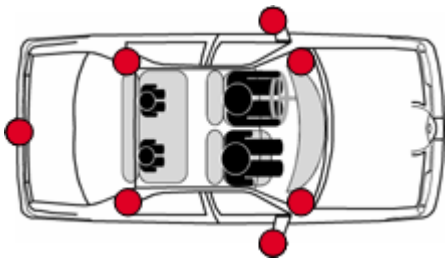

Figure 4-2: UWB sensor mounting positions for car access authorization and occupation sensing

For e.g. the seat belt pretensioner, it has to be detected whether a seat is occupied or not. The UWB sensor is applied to detect the seat occupancy of the front seats as well as the back seats.

Concerning airbags, the passenger dimensions have to be measured by the UWB sensor. Further on, it has to be detected whether the person is out of the usual sitting position or whether there is any other object on the seat, e.g. a child safety seat.

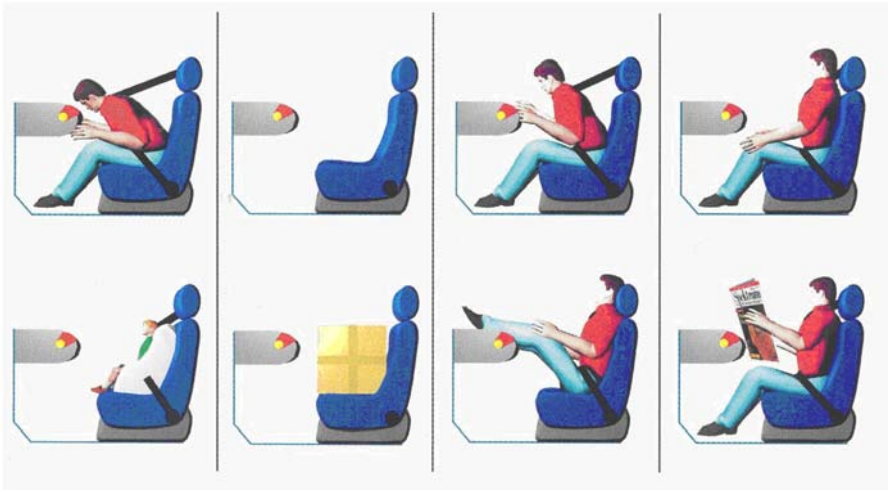

Figure 4-3: Possible cases which have to be covered by occupation sensing (Source: Bosch)

4.3 Physiological parameters

In principle, UWB could be used to measure physiological parameters, e.g. the driver's heart beat. These applications are not to be addressed.

5 Data communication

Wireless data communication is the most widespread application area for Ultrawideband systems. In this chapter, only pure data transmission applications will be described. The combination of data transmission with other Ultrawideband functionalities like location tracking or object detection was handled in the previous chapters.

Within the EUWB project WP8b, only short range communication inside the car is investigated, leading to a maximum communication distance of up to four meters. As the presented use cases will show, the typical communication distances is even smaller, more in the range of 0.5 to 2 meters. Also, communications is mostly only interesting within on compartment, be it the engine compartment, the passenger compartment or the trunk.

The most important feature expected from an Ultrawideband communication channel is reliability. Because of the difficult propagation characteristics inside a car (metallic surroundings, complex obstacles, changing loads, moving passengers), an important part of the project will focus on channel measurement and modelling.

Two application scenarios will be described in this chapter:

a) remote connection of user interface elements to the body computer (“Remote UI”) sitting in the dashboard

b) sensor to electronic control unit communication

5.1 Remote UI

In a modern car, a large number of knobs and controls are available. Figure 5-1 shows a typical car entertainment and climate control centre, with a large number push buttons and control wheels. Other examples are side doors window opener buttons or a back seat climate control centre.

As each user interface element needs to be connected to a control unit or body computer, typically located in the dashboard, a large cable harness is required, providing a pair of wires to each element.

Figure 5-1: Typical user interface controls (Photo: Bosch)

Wireless communication between the remotely mounted user interface elements, scattered everywhere in the passenger cabin, and its corresponding control unit located in the dashboard leads to a reduced cabling effort. Also customization of car models is much simpler and retrofit equipment can be easily installed.

Power supply for the remote user interface components is still needed; however alternative supply means like common supply cabling or power harvesting are possible. User interaction will only occur very sparsely and the information content to be passed to the control unit will be extremely small.

Although most of the user interface consists of such very simple components like push-buttons, others might have more elaborate elements like display to provide additional information. Therefore two-way communication is necessary to achieve a satisfying remote control solution.

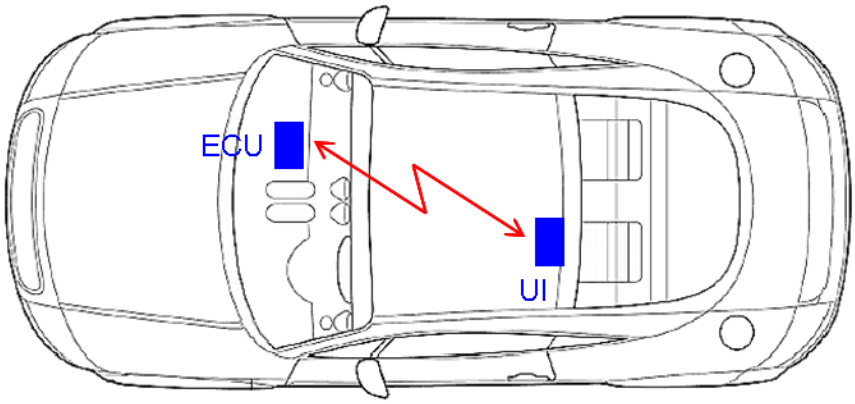

Figure 5-2: Communication inside the passenger cabin

5.2 Sensor to control unit

There is a lot of data communication inside the motor compartment between different sensors and their corresponding ECU. In order to reduce the cabling effort, achieve higher flexibility in mounting positions and installation of after-market devices, wireless data communication is desired.

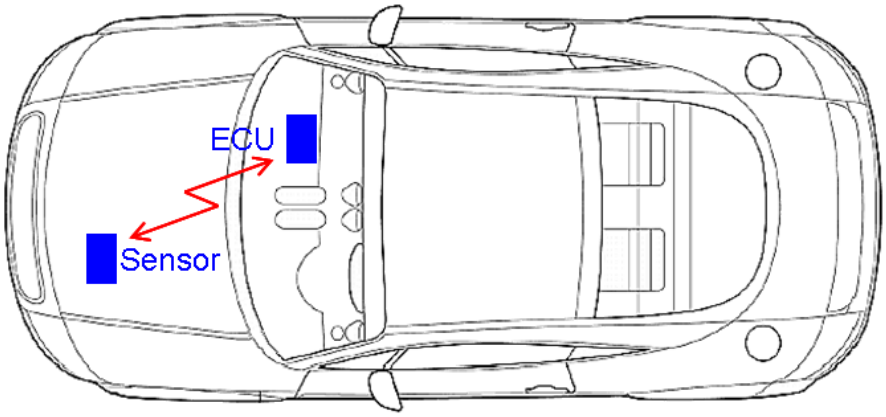

Figure 5-3: Communication inside the motor compartment

Within WP8b, two applications will be investigated specifically. The first application is a simple communication between the car battery and an ECU, providing its charge state to the electronic control unit. This type of data communication is typically realized using a wired LIN bus.

The second application will address a CAN bus type communication.

Figure 5-3 shows a typical electrical field distribution of a high frequency signal at 433 MHz in the engine department. Because of the metallic surroundings and the complex geometry of the compartment, a number of arbitrarily shaped field minima and maxima can be observed.

Figure 5-4: Typical distribution of the electrical field of a high frequency signal in the engine compartment

6 Conclusions

This document provides an overview of possible UWB application in the automotive environment. For selected applications, the feasibility will be demonstrated within the EUWB project.

Based on a single UWB technology platform, synergy between the different applications allows to sharply reduced system costs and application effort in a vehicle for the applications now addressed by UWB technology.

Easy customization is possible by wireless data communication, by easily positioning or replacing components without additional cabling.

Enhanced security is achieved by combining active elements for driver access and authorization functionality with passive detection capabilities for intrusion detection.

However, there are several challenges, which can be identified:

- Power consumption of the system is critical, especially in the case of the key, which has to work for several years out of a coin cell battery. Also intrusion detection lays strict requirements on power consumption, as it will only be active when the car is parked.
- Cost is another critical challenge, especially for applications where products based on a different technology are already introduced in the market. Synergy between the different applications based on UWB technology is the key element for market success.
- The Reliability of the wireless components is the key attribute of all addressed applications. Without a reliable localization, detection and data transmission performance there will be no customer acceptance.

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

[3] Berens, F. Dunger, H. Czarnecki, S. Bock, T. Reuter, R. Zeisberg, S. Weber, J. Guasch, J.F. : "UWB car attenuation measurements", ICT Mobile and Wireless Communications Summit, 2007

[4] Bosch: Automotive Electrics/Automotive Electronics, 5th Edition

[5] Bosch: Automotive Sensors

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