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IWCM: Infrastructure Wireless Communication Module for Vehicle Communication with Recharge Infrastructure

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Abstract

CENIT VERDE was a R&D collaboration program focused on the development of a complete electrical vehicle, together with the appropriate infrastructure. This included the study of a reliable connection between recharge infrastructure and the PHEV / EV. The result was the development of a standardized communication interface module between the recharge infrastructure and the vehicle, named ICWM (Infrastructure Wireless Communication Module). This enables the implementation of a large number of specific services for electric vehicles in a cost-effective manner since it reuses components already available in the vehicle.

Keywords: Communication, Wireless, Infrastructure, Charging

1 Introduction

CENIT VERDE [1] was a R&D collaboration program funded by Spanish government, leaded by SEAT (VW Group) and with 16 partners located in Spain. The scope of the program was the advanced development of a complete electrical vehicle, together with the appropriate infrastructure (recharge points, integration in the power grid, etc).

The program started in September 2009 and ended in 2012 with the validation of the products developed in two demonstrators.

One of the main tasks was related to the study and design of charging infrastructure for reliable connection to PHEV / EV focusing on the two relevant aspects: (i) the bidirectional energy transfer and (ii) the control, handling and billing of the service, including communication between the vehicle and the infrastructure. One of the main objectives of the task has been the development of a common or standardized communication interface, between the recharge infrastructure and the vehicle. Two different interfaces have been implemented: PLC (power line communication) and wireless communication.

Wireless communication has been chosen because it allowed the integration of the functionality related to communication between the charging infrastructure and the vehicle with the internal vehicle network and other telematic services already available in the car.

This is done through an electronics module, named ICWM (Infrastructure Wireless Communication Module). The ICWM is the gateway between the vehicle and all the elements interacting with it: mainly the infrastructure, but also other elements such user mobile devices. This implementation permits the integration of a large number of services for electric vehicles in a cost-effective manner since it reuses components already available in the vehicle.

2 Requirements

The ICWM works as the main gateway for the vehicle. Therefore, it includes all required communication interfaces both to external and internal networks, namely:

- UMTS Communications (3G)
- GPRS / GSM (2G)
- GPS
- WLAN b/g, 54 Mbps (WI-FI)
- Digital Short Range Comm. (DRSC)
- Bluetooth (2.0 + ERC)

- CAN High Speed (1 Mbps)
- CAN Low Speed (125 Kbps)
- 1 x USB 2.0 (480 Mbps)
- 1 x USB 2.0 On-The-Go (480 Mbps)
- Ethernet Base 10/100 (up to 100 Mbps)

Figure 1 shows the communication interfaces embedded in the IWCM module.

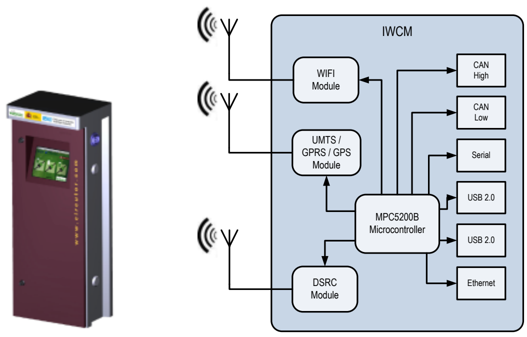

Figure1: Block Diagram of IWCM

DSRC protocol is seen as the most appropriate interface for the desired application. DSRC works at the 5.9GHz band with transfer rate of 18Mbps. The range is several km and works perfectly up to 160km/h [2].

3 Hardware

There are two hardware versions for the IWCM, one integrated in the vehicle and another one integrated in the recharge post. The vehicle version includes all the communication protocols mentioned above while the post version is a reduced or light version of the IWCM with only the DSRC and Ethernet interfaces.

Vehicle IWCM is supplied directly from vehicle battery. Internally, the various voltage rails required by the different modules are generated through SMPS to reduce power dissipation and enhance efficiency.

The core of the vehicle IWCM is a 32-bit microcontroller built on Power Architecture® technology for Automotive Applications that allows the implementation of the communication protocols while controlling the embedded sub-system.

The complete IWCM module packaging is shown in Figure 2. External dimensions are 232mm x 186mm x 33mm.

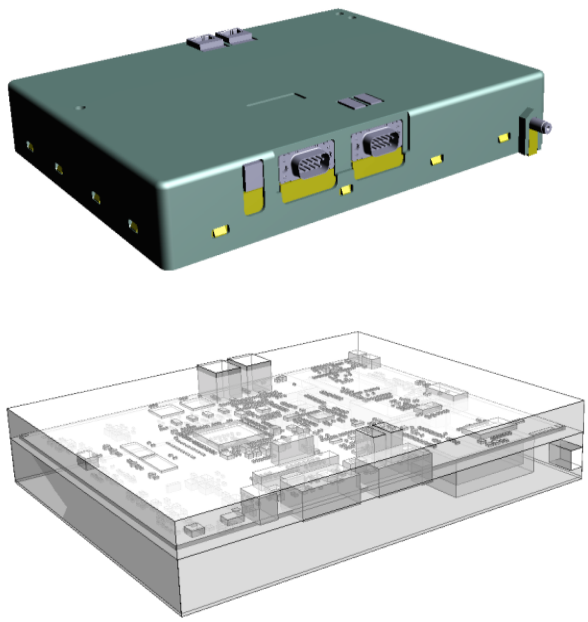

Figure 2: CAD Model of IWCM showing external packaging and internal components

Both vehicle IWCM and post IWCM integrate a DSRC module embedding a IEEE 1609 / 802.11p radio and a 300 MHz MIPS II 32-bit network processor and 10/100 Fast Ethernet.

4 Software

One of the main objectives for system software design of the IWCM is to achieve system energy efficiency.

To realize this purpose, we have designed a modular system of software based on Linux as operating system but using the specific implementation for automotive applications or (AGL) Automotive Grade Linux [3] with kernel 2.6-22. The AGL implements Real Time characteristics needed for the automotive environment.

Taking the advantages of the modularity of the operating system, the device drivers were designed specially adapted to allow the system energy efficiency.

The software architecture used is the standard architecture for embedded systems containing a Linux operating system as shown in Figure 3. At the bottom layer, the firmware is the responsible of the low level access to the microcontroller. The boot loader allows rewriting and run the images of the operating system,

The operating system performs the management of processes and memory, includes the libraries providing the encryption and communication routines.

Finally, on top of the stack, a shell-interpreter provides interact with the system. This shell-interpreter runs in debug mode and it is only available for the developer, and is not accessible by the user.

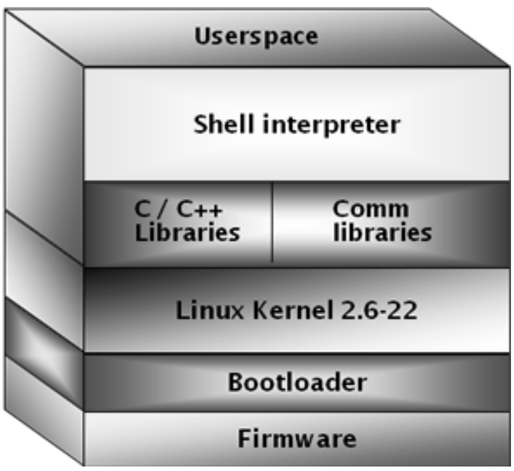

Figure 3: Software stack of ICWM processor

The communication libraries allow the system to implement secure communications through SSL and SSH, using a 256-bit encryption algorithm with shared keys.

5 Application

The wireless communication between the EV and the recharge system is currently a hot topic. Of course, interoperability, privacy, and security are key concepts [4].

As part of the development of communication interface, LEAR leaded the development of the high-level protocol for handling the communication between the vehicle and the recharge station for the CENIT VERDE project. Figure 4 shows the UML communication diagram of this process.

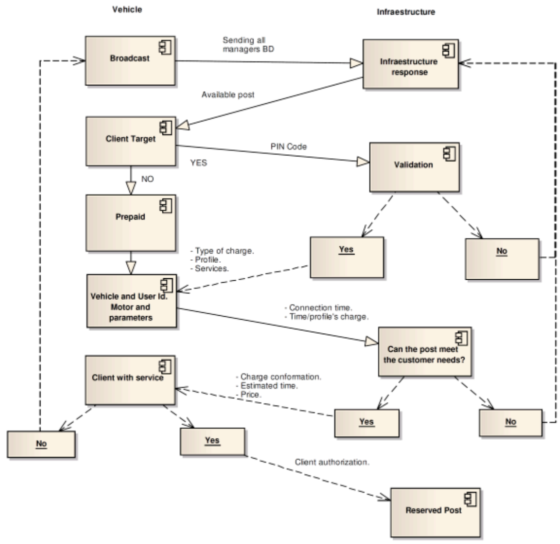

Figure 4: High-level Communication Diagram

The security protocol included was implemented using asymmetric or public key encryption. The RSA algorithm used a 1024-bit key.

Using the auxiliary display of the vehicle, a dedicated HMI was created for demonstrative purposes.

The system was tested in a demonstrator vehicle up to speeds of 60Km/h without any issue.

6 Conclusions

A specific wireless communication module, named ICWM, has been developed focusing on the standardization of communication between the vehicle and the recharge station. The system reuses several communication interfaces already integrated in the vehicle, mainly DRSC and Ethernet. This enables the implementation of a large number of services for electric vehicles in a cost-effective manner.

The two components needed (for the vehicle and for the recharge station) have been implemented and satisfactorily tested in real conditions.

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