OPENWAVE ENGINE / WSU - A PLATFORM FOR C2C-CC

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Abstract

Field operational tests are seen as a key step in the further development of inter-vehicular communication. The combination of OpenWAVE Engine and WSU is an answer to the European demands for a communication platform that enables early prototyping and real life experiments with C2C-CC protocols and applications. The OpenWAVE Engine stack, which was initiated by the BMW Group Research and Technology, is based on a fully modular and extensible architecture. It provides the flexibility and scalability that is required for real world test scenarios, as well as for applications, as for the communication stack. Originally developed in the US and equipped with WAVE communication protocols, DENSO's Wireless Safety Unit (WSU) provides a hardware platform with a IEEE P802.11p radio interface plus the respective drivers, which perfectly integrates with OpenWAVE Engine.

This paper will show and discuss the requirements and design principles that have been taken into account building the OpenWAVE Engine / WSU communication platform.

Index Terms

Vehicular ad hoc networks (VANETs), Platform for V2x Communication, C2C-CC.

INTRODUCTION

The advantages of V2X communication have been recognized in many regions of the world. Research initiatives worldwide have started and already produced valuable results. Additional projects to solve the open issues are ongoing or are on their way.

Many regional efforts are taken to consolidate the results from research projects in industrial standards. For this purpose, industry consortia have been formed, namely the Car2Car Communication Consortium (C2C-CC) in Europe and the Vehicle Safety Communication Consortium (VSCC) in the US. In addition, standardization bodies started to work on and produce standards like the IEEE 1609.x series and IEEE P802.11p. Big field operational tests are planned or on the way to support the consolidation of V2X technology, e.g. German Sim-TD, Japanese Smartway, European FOT in FP7, US CAMP CICAS-V FOT, etc..

The regional variance of boundary conditions for the development of V2X communication are standing against an easy worldwide harmonization. For instance, while in the US, the development of V2X is strongly supported by infrastructure providers, which are focused on I2V communication and a nationwide infrastructure build-out was originally contemplated to be coordinated by the USDOT, in Europe, a common infrastructure seems hard to achieve due to the fragmentation with many national authorities. Therefore, it is no surprise that the resulting communication protocols and standards differ significantly.

Still, the mutual awareness of the world wide initiatives is growing. An increasing number of companies try to bridge the gaps between the regional developments. The reason is that, although, standards and communication systems worldwide have to respect local regulations and requirements, a common hardware platform has always been seen as key component for these communication systems to succeed in the market.

Consequently, already experimental communication platforms have to be flexible enough to support worldwide activities. These ideas were the starting point for the development of OpenWAVE Engine on top of DENSO's Wireless Safety Unit (WSU).

The remainder of this paper is organized as follows. The next section will introduce the principles that stand behind the development of a common communication platform for V2x communication. The follow

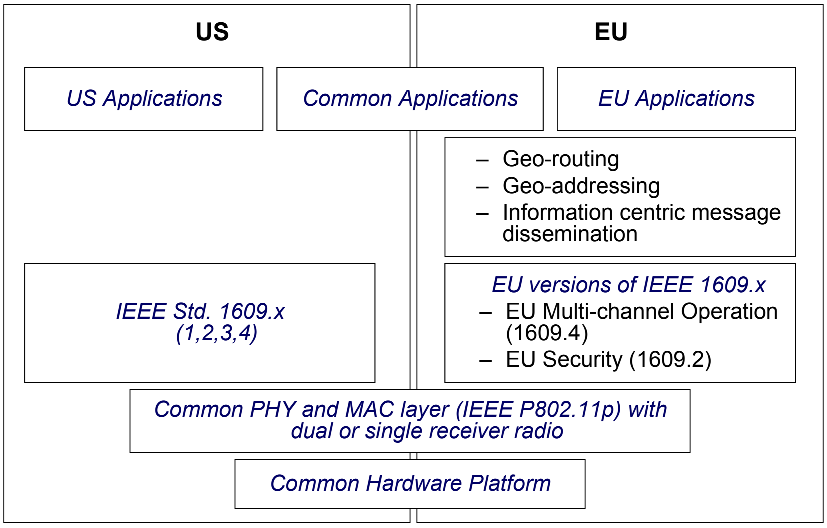

Fig. 1. Common Platform Concept

up section will provide detailed information on the OpenWAVE Engine framework, its architecture and its implementation. Finally, the last section will conclude this paper.

TOWARDS A COMMON APPROACH

Simplified, the principles when defining a common communication platform are the following. The hardware platform has to be the same, the software implementation fulfills the different local communication protocols. This approach is shown in figure 1, sketching the development of a platform for the US and Europe. The figure shows a platform that is based on a common hardware platform and contains also a common radio layer, IEEE 802.11p (1). Above this layer, the designated protocols differ significantly. Whereas the US platform implements the IEEE 1609.x (2; 3; 4; 3) standard series, the EU counterpart implements adapted functionalities. In addition, the EU platform needs to support protocols that are currently under discussion in European standardization, such as geo-routing, geo-addressing, relevance-based forwarding, etc..

The OpenWAVE Engine framework described in the next section realizes the European communication protocol in addition to the US stack on top of the WSU hardware platform.

OPENWAVE ENGINE

Considering the various parties that are involved in the development of the European version of a inter vehicle communication system, many valuable ideas and concepts already exist, which have to be brought together. It seems to be a challenging approach to harmonize all that concepts and solve the existing dependencies. It is important for the European work to come up with their own view of an V2X communication stack as it already exists in the US and in Japan. To speed up the standardization work a consistent evaluation and integration process for existing concepts and algorithms is needed. It is important to concentrate on the optimization of existing parts and get a first impression how several components have impact on the other parts of a communication system. Therefore the development of the OpenWAVE Engine framework has been started.

Originally, OpenWAVE Engine was initiated as ACUp (AKTIV Communication Unit - 802.11p) by BMW Group Research and Technology within the German research project AKTIV. The ongoing further development (named OpenWAVE Engine) aims at speeding up the European standardization activities. It is therefore intended to be provided to interested projects and partners as a highly efficient and easily extendible communication platform.

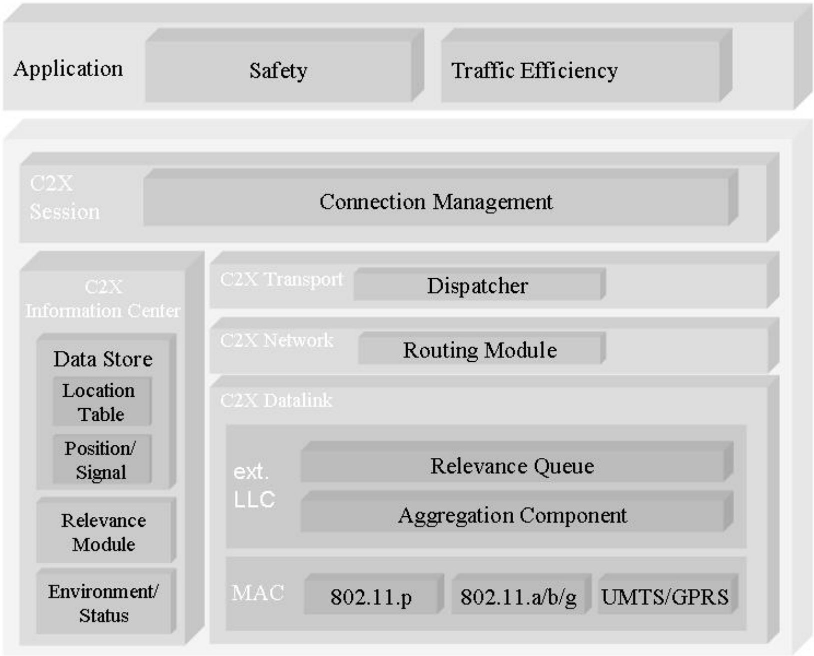

Fig. 2. OpenWAVE Engine Software Architecture

Architecture

The European ideas for a V2X communication architecture deals also with the efficient usage of small communication bandwidth. It has to meet the claim of a crowded area where various cars and roadside units are exchanging numerous of information with high data rates. In addition, in Europe only $30MHz$ for safety and traffic efficiency application are available yet. Hence, concerning the US approach for congestion control, which is based on channel switching, in Europe different strategies have to be developed to guarantee a defined level of service for information of high importance. Therefore, in addition to a packet centric message dissemination (5) which is done by using intelligent routing algorithms, a information centric (6; 7; 8) dissemination strategy is needed. In particular this means that calculation of the specific importance respectively relevance of each message will be done before sending it to the neighbor vehicles. This approach has to assure that the most important message will be sent first to the neighbor vehicles even when it has been put later into the queue. The calculation is based on specific information about the vehicle and its environment. The quality of the calculation increases the better the algorithm are and the more information are available in the vehicle's data store which is integrated in the OpenWAVE Engine's Information Center Component. The Information Center will store all data that has been provided by application messages, incoming messages form neighbor vehicles or messages form a specific OpenWAVE Engine Data Provider e.g. for positioning or vehicle signals. Hence, the information centric approach obviously increases the overall quality of information in a vehicular network related to the current traffic situation.

To minimize access to the medium, an aggregation of messages is intended. The aggregation merges a specific number of messages, that are stored in the relevance queue and send them as just one message. This has the effect, that communication medium is used more efficiently and that congestion is tried to be avoided. Furthermore the message aggregation approach allows to minimize overhead by adding just one message header and one certificate per message cluster. It also avoids that messages which are smaller than the minimum network packet size are sent over the network. Thus, the network capacity is used more efficiently. The number of aggregated messages is regulated dynamically e.g. by the current number of neighbors and the channel congestion.

Concerning security aspects, the framework has been designed for the implementation of different hooks which can be realized as a special security layer e.g. a firewall. Further, components can be integrated where different pseudonymity and authenticity strategies are implemented. This guarantees that security can be plugged in afterwards with low effort and different concepts can be tested, compared and rated.

In addition for an evaluation framework an easy to use and low performance logging functionality is important and has been implemented. This enables as well tracking for evaluation purpose during a test run as error searching for development reasons. To summarize this subsection, figure 2 gives overview on the The OpenWAVE Engine software architecture.

Implementation

To guarantee the required flexibility and extensibility for evaluation and fast prototyping the OpenWAVE Engine Framework is completely based on a plug-in approach. This ensures a fast redesign of the communication stack and the internal workflow for test reasons.

Plug-ins are implemented as layers and components. Layers typically are used for the V2X communication layers and are characterized by a standardized interface. This enables the unlimited linking of layers and their flexible order in the communication stack. Components usually are parts of a pursuant layer and can be used to exchange specific algorithms e.g. message aggregation, routing strategies or relevance calculation. To ensure a flexible workflow within the communication stack a message oriented approach has been used. This means that all data exchange between applications and the framework is done by using different types of messages. Each application defines its own message format or derives it from an already existing one. By using message inheritance e.g. version compatibility of applications can be realized. In addition to the message flags, meta information can be defined. A meta information describes how to access a specific message data e.g. speed or position without knowing the whole message format. This enables the separation of the applications and the framework and will be used for storing information in the OpenWAVE Engine's Information Center.

CONCLUSIONS

The OpenWAVE Engine / WSU platform for inter-vehicle communication is a response to the demands of European research projects and the C2C-CC. The OpenWAVE Engine architecture is fully modular and designed for fast prototyping and testing. It has been developed as a framework to speed up the European V2X standardization process. The wireless safety unit (WSU) provides the ideal communication platform for OpenWAVE Engine. Amongst others, it consists of an IEEE P802.11p compatible radio module with a WAVE communication stack. The result of this combination is common platform that can be used in the US and in Europe.

OpenWAVE Engine / WSU will help in early rapid prototyping of new communication protocols and applications. It will serve as stable platform for demonstration activities in various research projects and activities. These demonstrations are a key step in the further development of V2X communication in Europe, but also worldwide.

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