Vehicle-to-Business Communication: The Example of Claims Assistance in Motor Insurance

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1 Introduction

Due to consequent policy making and research funding in Europe, the US, and Japan, Intelligent Transportation Systems (ITS) are gaining momentum and provide mature concepts for vehicular communications enabling vehicles to communicate among themselves (Vehicle-to-Vehicle, V2V) and their immediate vicinity (Vehicle-to-Infrastructure, V2I). Amongst others, the European research projects PRE-DRIVE C2X[1] and CVIS[2] as well as the German research project simTD[3] aim at improving road safety and traffic efficiency by facilitating a continuous information exchange between vehicles and their surrounding roadside infrastructure such as traffic lights or roadwork warning signs. In addition, the central consolidation initiative COMeSafety[4] fosters the harmonization and standardization of these research activities to achieve a pan-European communication architecture for co-operative intelligent road transport systems.

V2V and V2I communications are subject to large network effects. Due to the relative short range of the chosen wireless technology (IEEE 802.11 variants such as 802.11p (Jiang and Delgrossi 2008)) that features roughly 500-1000m coverage, a certain penetration of vehicles is required to run cooperative safety and efficiency applications like accident or traffic jam ahead warnings by multi-hop communications (Matheus et al. 2004, pp. 2-6). In recent years, the proliferation of powerful Broadband Wireless Access (BWA) technologies such as for instance UMTS, WiMAX, or LTE paves the way for a new generation of telematic services. One of

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[1] http://www.pre-drive-c2x.eu
[2] http://www.cvisproject.org
[3] http://www.simtd.de
[4] http://www.comesafety.org

the compelling features of such BWA technologies is the fact that the required infrastructure comes at no additional cost for the automotive sector. Moreover, as these technologies facilitate the interconnection of vehicles and diverse service providers, this generation of telematic services does not face the aforementioned network effects. Even more, as the in-vehicle communication units required for the new generation of telematic services could be directly equipped with the respective V2V and V2I communication functionalities, the former might be seen as an enabler of V2V and V2I communications as well as the related application scenarios.

Altogether, BWA technologies indeed indicate their potential in reviving the whole telematic services business. So is the number of telematics applications steadily rising in domains such as logistics, fleet management, or the insurance industry. Common to all application domains is the integration of real-world vehicle data into business applications in order to generate additional revenue by means of innovative services or to reduce costs based on business process improvements. As any of them is driven by a certain economic objective, we summarize them under the term Vehicle-to-Business (V2B), which reflects our general vision of integrating vehicles into business operations. As illustrated in Figure 1, the concept of V2B complements the previously introduced notions of V2V and V2I. While V2B applications are emerging, there is still a lack of well-defined and standardized integration platforms that allow for a reliable and scalable interconnection between vehicles and providers of telematic services. This paper addresses this issue by providing an analysis of the challenges and requirements for V2B communications. Further, a dedicated integration platform that enables the connection of vehicles with business systems is proposed. To illustrate our approach, we present the application scenario of claims assistance after car accidents.

The remainder of this paper is organized as follows: Section 2 provides an overview of related work from academia and industry. In section 3, we present the application scenario of "V2B-based Claims Assistance" after car accidents. In order to realize the application scenario, we analyze the challenges of V2B communications and propose an integration platform in section 4. Our paper concludes in section 5 with an outlook on future work.

2 Related Work

On a European level, the interconnection of vehicles and business applications is driven by the eSafety initiative of the European Commission (2009). This initiative incorporates the eCall technology, which enables automatic accident detection plus an emergency call including a combination of voice communication and data transfer. While the initiative aims at emergency response, the technical foundation can be used for other application domains as well. For example, the application of

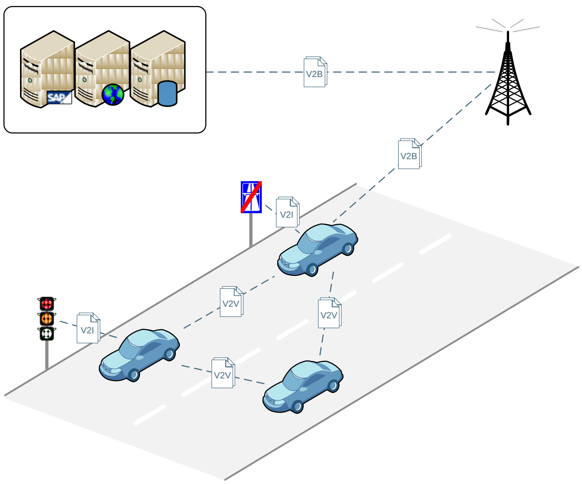

Figure 1: An all-embracing Intelligent Transportation System (ITS) consisting of V2V, V2I, and V2B communication concepts

BWA technologies and telematics gains significant grounds in the insurance industry (Coroama and Langheinrich 2006). Based on V2X communication technologies (Festag et al. 2008) and insurance telematics solutions, vehicles get connected to insurance enterprise systems. This enables new products and services. One example is the emergence of pay-as-you-drive (PAYD) pricing models (Litman 2008), where insurance premiums are calculated based on the actual driving behavior that is recorded and transmitted using dedicated on-board units. Examples from industry include Progressive Insurance, Liberty Mutual, GMAC, Uniqa, and many others.

As the relevance of V2B telematic services in the insurance industry steadily increases, companies that offer a broad range of insurance telematics are emerging (Octo Telematics 2009). Services in this domain include stolen vehicle recovery, automatic crash notification (eCall), and crash data recording. In this context, an area of particular importance to insurance companies is the management of insurance claims and the loss report after a car accident. For example, the "CrashRecorder" offered by Axa-Winterthur[5] facilitates recording data before and after a car accident. However, this product differs significantly from the solution proposed in this paper as data is read at a repair shop and not transmitted using BWA technologies. Similar applications based on mobile phones were recently launched by several insurance companies. As an example, the US insurance companies Nationwide[6] and Farmers[7] recently published two applications on the iTunes App Store,

[5] http://www.crash-recorder.ch

[6] http://www.nationwide.com/mobile/iPhone-support.jsp

[7] http://www.farmers.com/iclaim.html

which allow sending loss reports from an iPhone and offer subsequent value-added services. These products, however, require the user to manually collect input data and submit them via e-mail. Consequently, they differ from the proposed application, which is directly connected to the vehicle's on-board unit as well as to a commercial claims management enterprise system thus enabling an integration of comprehensive crash data into the claims management process.

3 V2B-based Claims Assistance

After a car accident, immediate emergency services are required. The eCall technology addresses this need with an automatic emergency call that includes the transmission of a basic set of data (e.g., current location of the vehicle) and the establishment of a voice connection to an emergency response center. Moreover, various additional services are possible. As an example, after car accidents people often lack adequate assistance as regards the arrangement of a tow truck or general support with the loss report (so-called *first notice of loss*) to their insurance company. V2B communications can be used at this point to establish a communication link between vehicles and insurance enterprise systems. This allows insurers to coordinate various services, which may partly be provided by their business partners (e.g., repair shops, tow truck companies). The early integration into the claims management process is beneficial for insurance companies, because they nowadays suffer from problems in terms of data quality, media breaks, and delayed loss reports, which eventually leads to both high operating costs and loss expenses. As of today, insurance companies use dedicated enterprise systems to support the overall claims management process. However, available solutions are poorly, if at all, connected with the physical insured objects and persons they are supposed to manage. As recent studies indicate, cost savings based on pro-active claims management can reach up to 15% (Accenture 2002; Bieber and Hoberg 2007; Mueller and Kuefner 2003). Against this background, we highlight the need for an integration platform that acts as a connecting bridge between vehicles and business systems such as claims management enterprise applications.

3.1 Scenario Overview

In the insurance scenario "V2B-based Claims Assistance", as shown in Figure 2, a vehicle submits a loss report to an insurance company after a minor car accident and drivers benefit from value-added services. Triggered for example by the deployment of the airbag unit, the in-vehicle insurance application places an emergency call, which establishes a voice connection to an emergency center. This application behavior is closely related to the functionality proposed as part of the eCall system and could also be integrated into existing eCall implementations (European Commission 2009). In addition, the current position of the vehicle, personal as well as insurance-specific data about the driver, and crash sensor data is sent to the insurance carrier. To enhance privacy and give drivers maximum control over their personal data, the information can be submitted either manually or automatically. Furthermore, the loss report can be enriched with crash sensor data that enables the insurance carrier to perform a first assessment of the situation.

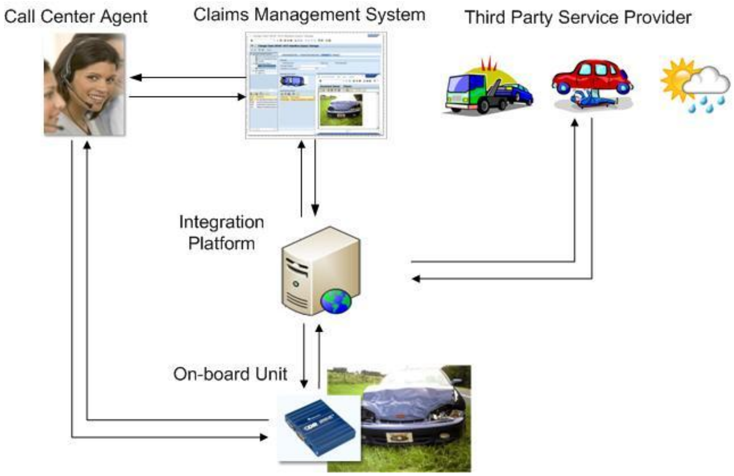

Figure 2: Application Scenario "V2B-based Claims Assistance"

After the claim was submitted to the claims management enterprise system, the insurance company uses the transmitted position of the vehicle to offer additional location-based services to the driver. Services are displayed to the driver using the in-vehicle Human-Machine Interface (HMI). For example, the driver can request a tow truck or, in case the car is still roadworthy, use the navigation system to find the way to the closest authorized repair shop. The application also provides helpful information like a driver's eligibility for a rental car as well as the arrival time of a requested tow truck. Finally, the transmitted information can be reviewed in the claims management enterprise system from the perspective of claim personnel at an insurance company. As an example, the claim file holds information about the business partners that offer the different third party services.

3.2 Application Concepts

To realize the scenario outlined in section 3.1, an application deployed on the vehicle's on-board unit plus an integration platform facilitating the communication with business applications are required. The integration platform interfaces with a claims management enterprise system as well as with systems of third party service providers. In addition, it interfaces with the application residing on the on-board unit of a vehicle. This application needs to access vehicle-specific data such as crash sensor data and GPS data. At the same time, it needs to be able to communicate with the integration platform that facilitates the access to the aforementioned enterprise systems. Consequently, the scenario includes a communication flow from the in-vehicle application to the claims management enterprise system and vice versa:

- *Vehicle-to-Business*: The in-vehicle application collects data stemming from vehicle sensors and the GPS module and reacts to pre-configured exceptional situations indicating a crash condition, such as the deployment of the airbag unit. In this case, the application starts actively collecting information to submit an emergency call together with a loss report to the integration platform that forwards the information to the respective enterprise systems.
- *Business-to-Vehicle*: The invocation of the in-vehicle application is necessary to provide the driver with available value-added services in the aftermath of an accident. That means the service invocation is mainly used to provide the user with information and services that are displayed on the in-vehicle HMI.

Hence, the new generation of telematic services and the related V2B-enabled application scenarios require a dedicated integration platform, which copes with the specific challenges of V2B communications and allows for a reliable and scalable interconnection of vehicles and business systems.

4 V2B Communications

4.1 Challenges of V2B Communications

The intermittent connectivity of vehicles caused by their high mobility and the incomplete network coverage of existing BWA technologies constitutes a major challenge of V2B communications. Vehicles will regularly lose and attempt to reestablish their Internet connection, e.g., when driving in a tunnel. Consequently, the infrastructure must provide appropriate discovery, monitoring, and identity management mechanisms to maintain the vehicles' changing IP addresses (e.g., by applying the concept of Network Mobility, NEMO).

The non-permanent connectivity of vehicles further affects the reliability of the actual message transmission. In a disconnection phase, there may be vehicle applications trying to send messages to business systems. In case of a critical message, which has to be transmitted within a certain period of time (e.g., a system error that is to be sent to the related vehicle manufacturer), the infrastructure must be able to deliver it prior to all other queued messages as soon as the connection is reestablished. To allow for such a form of Quality of Service (QoS), dedicated in-vehicle functionality for priority-based queuing and scheduling of message transmission is required.

As V2B communications envision diverse service providers to exchange information with millions of vehicles (Kraftfahrt-Bundesamt 2009), the overall scalability of the communication architecture constitutes a further critical challenge. Consequently, an infrastructure for V2B communications must not only provide appropriate components and mechanisms to enable an efficient and reliable message exchange. It must further be able to process an enormous amount of data exchanged between vehicles and business systems and scale properly with an increasing number of vehicles, service providers, and messages.

Finally, the heterogeneity of hardware and software components provided by different vehicle manufacturers requires a dedicated in-vehicle abstraction layer covering interfaces and protocols used within a vehicle to exchange information. This encompasses the in-vehicle data access (e.g., to read the status of the engine or the current position using GPS) as well as the interaction with the driver via an appropriate HMI.

To enable diverse providers to offer their services to vehicles and request life cycle data from the latter (e.g., to allow a vehicle manufacturer for providing proactive and predictive maintenance services, cp. (Miche and Bohnert 2009, p. 45)), an appropriate *V2B integration platform* is required, which facilitates a reliable and scalable exchange of information between vehicles and business systems. In addition, a dedicated in-vehicle abstraction layer is needed that enables a cost-effective development of vehicle applications by minimizing the adaptations required for deploying applications on different vehicles.

4.2 V2B Integration Platform

According to section 4.1, V2B communications covers an n:m relation between vehicles and business systems. As many evaluations of distributed systems have proven, a huge amount of point-to-point connections results in an inflexible and hardly manageable overall system structure (Schroth et al. 2008). For that reason, our V2B integration platform comprises a dedicated component, the *Vehicle Integration Platform (VIP)*, which enables a loosely coupled, asynchronous communication between vehicles and business systems (derived from (Souza et al 2008)). An instance of the VIP may either be operated directly by a stakeholder that intends to interconnect its systems with vehicles (e.g., a provider of a location-based service) or by a third-party service provider offering the platform as a service according to the Software as a Service (SaaS) model (Chou D. and Chou A. 2007). Consequently, as depicted in Figure 3, a vehicle may exchange information with several service providers via multiple instances of the VIP (e.g., operated by the vehicle manufacturer and the insurance company, respectively).

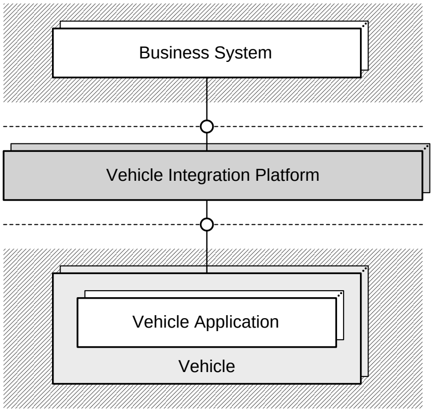

Figure 3: V2B Integration Platform - Overall Structure

The VIP facilitates a loosely coupled integration of vehicles and business systems by providing an event-based message broker, which facilitates an asynchronous communication according to the interaction style publish/ subscribe. This allows both vehicles and business systems to subscribe to and retrieve information about events of interest using either a push or a pull delivery as well as the application of dedicated transmission policies (e.g., time-to-live). To address the scalability challenges outlined in section 4.1, vehicles are represented as encapsulated modules within the VIP. Consequently, vehicles have to provide mechanisms for locally disseminating messages received from the VIP to the respective vehicle applications and for delivering events to the addressed VIP, respectively. In addition to the enforced decoupling, this results in a reduced number of messages exchanged between vehicles and the VIP. By limiting the content of the messages to the actual information provided by vehicles, the communication scalability is further enhanced. All additional parameters required by the receiving business systems are included by system-specific connectors of the VIP. Thus, the V2B integration platform decreases the number as well as the payload of messages exchanged between vehicles and the VIP and extensively addresses the scalability challenges V2B communications will face.

To account for the mobility and the resulting intermittent availability of vehicles, the V2B integration platform provides a discovery mechanism, which is independent from the actual network architecture. This functionality can be realized either by the VIP broadcasting probe messages or by vehicles notifying the VIP about any changes regarding their network connectivity. Hence, the discovery functionality provides the basis for the required identity management and enables the VIP to monitor vehicles and their applications.

Moreover, the VIP facilitates the remote invocation of vehicle applications. For that purpose, it provides a dedicated buffering mechanism required due to the intermittent connectivity of vehicles and makes use of the vehicle monitor described above to verify the availability plus the endpoint of the vehicle whose applications are to be invoked. Eventually, the actual information exchanged between vehicles and enterprise applications may include sensitive and person-related data (cp. for instance the usage-based insurance model PAYD). To cope with this challenge, the V2B integration platform includes message encryption and authentication features, and provides mechanisms for the storage and maintenance of respective certificates.

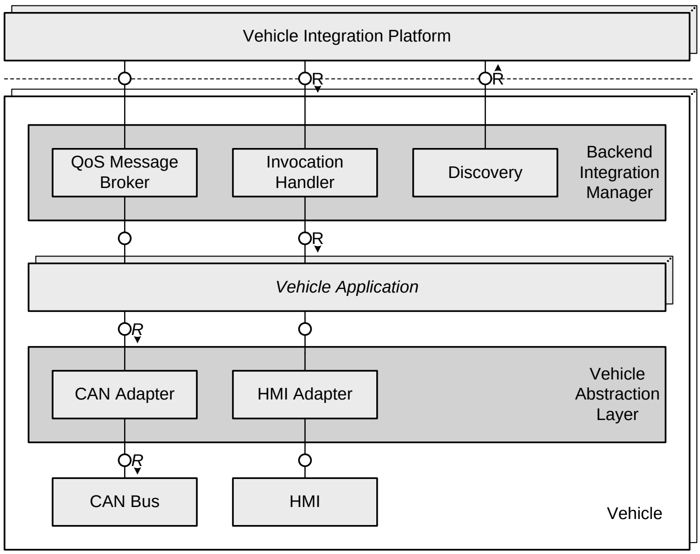

Figure 4: In-Vehicle Integration Architecture

In addition to the aforementioned *n:m* relation between vehicles and business systems, also vehicles encapsulate diverse systems running on separate hardware platforms. Thus, vehicles consist of diverse Electronic Control Units (ECUs) that are interconnected via specific Controller Area Network (CAN) buses, an in-vehicle HMI that facilitates the interaction with the driver, and several vehicle applications such as the in-vehicle insurance application presented in section 3. To effectively interconnect vehicles and business systems and to allow for a cost effective development of vehicle applications, our V2B integration platform encompasses a dedicated in-vehicle communication component that complements the VIP, the *Back-end Integration Manager (BIM)*, and a vehicle abstraction layer with vehicle-specific adapters (cp. Figure 4).

The in-vehicle module BIM encapsulates all communication functionalities required for enabling vehicles to exchange information with business systems (via the VIP). The well-defined and programming language-independent interfaces of the BIM enable diverse providers to develop vehicle applications that make use of this facility. As outline above, the BIM consists of a discovery component, which enables vehicles to register with multiple instances of the VIP. Moreover, it includes an invocation handler, e.g., a Web Service bridge, facilitating the remote invocation of vehicle applications. Finally, the BIM provides a lightweight QoS message broker that realizes the vehicle-internal distribution of events and the data exchange with the VIP according to the interaction style publish/ subscribe. To account for the uncertain and intermittent network connectivity of vehicles, the BIM applies a priority-based message queue and a related scheduler, which manages the delivery of queued messages according to their priority.

Finally, our V2B integration platform resolves the issue of existing, heterogeneous in-vehicle platforms by an appropriate adapter concept. First, this includes a CAN adapter that complies with the adapter design pattern. It encapsulates any specific interfaces of the CAN bus and provides a standard interface for receiving information about connected ECUs, e.g. to retrieve the current mileage. Secondly, the abstraction layer provides a generic interface to the in-vehicle HMI. According to the architectural pattern model-view-controller, the HMI adapter abstracts from any layout or input modality specifics and is limited to the elements to be displayed (e.g., input field, label) as well as the information expected from the driver. That way, each vehicle manufacturer can provide an optimized rendering engine, which facilitates the adaptation and optimization of the Graphical User Interface (GUI) to the display capabilities and input modalities of the HMI.

Hence, vehicle applications neither have to deal with the communication functionality nor with any hardware specifics of different vehicles. This improves not only the maintenance and further developments of vehicle applications, but also the deployment of the latter on different vehicles. Finally, the HMI adapter allows vehicle manufacturers to apply a common look-and-feel to all applications running on their vehicles thus enhancing the user experience of drivers.

5 Conclusions

In this paper, we presented the concept of Vehicle-to-Business communications as a complement to V2V and V2I communications. Due to the evolution and the new possibilities enabled by state-of-the-art BWA technologies, the integration of vehicles and business systems will overcome technical issues that were dominant in the last decade. However, we observed a lack of adequate communication and integration concepts because of an insufficient understanding of the challenges of V2B communications. Consequently, the contribution of this paper is an analysis of the challenges of V2B communications. A V2B integration platform tackling these challenges is proposed, which facilitates a reliable, scalable, and secure information exchange between vehicles and business systems. This platform includes dedicated communication facilities plus an in-vehicle hardware abstraction layer to allow for a cost-effective development of vehicle applications. In order to link our theoretical concept to a real-world example, we chose an application scenario from the insurance industry that deals with claims assistance.

To demonstrate and prove our concepts, we are currently developing a prototype of our V2B integration platform. The complementary message brokers of VIP and BIM facilitate a topic-based publish/ subscribe interaction according to the OASIS Web Services Notification (WSN) standard[8], which we extended due to the QoS requirements outlined in section 4.1. For the in-vehicle HMI adapter, we defined a dedicated XML schema plus the related interfaces to allow for a programming language-independent HMI access. Moreover, the required discovery functionality is realized by a registration interface provided by the VIP, which allows vehicles to notify the latter about any changes regarding their addresses or available vehicle applications.

To demonstrate our architecture and showcase the potential of V2B communications, future work includes the implementation of the insurance scenario "V2B-based Claims Assistance" described in section 3.1. For that purpose, we will implement a vehicle application that makes use of our infrastructure to submit a loss report enhanced by vehicle data to the insurer's claims management system and to display value-added services on the HMI. In the medium term, field tests are planned in order to ensure the real-world feasibility of our approach. Finally, the security and privacy related challenges of V2B communications are subject to further research and have to be tackled to lower the barrier for both service providers and consumers to step into the emerging V2B market.

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