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Vehicular Communication Gateway

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The Success Story of the Vehicular Communication Gateway

MYCAREVENT develops and implements new applications and services, which can be accessed seamlessly and securely. These services will provide the customers with manufacturer specific repair information according to the problems identified by diagnosis systems.

Mobile communication will be used to communicate with the On-Board Diagnostic (OBD), to gather breakdown information and to access web based services for repair information.

This information will primarily support the technicians. Still, additional services providing drivers with specific information are another aim of MYCAREVENT. Using pan-European technical standards, the results will be transferable to other industries, which call for mobile services.

Mobile communication enables the exchange of fault messages (via error codes) and repair information and thus allows complex repairs at the roadside. The Chair of Communication Networks (ComNets) at the RWTH Aachen University leads the work in 'Mobile Communication' and is the inventor of an innovative vehicular communication gateway.

This gateway bridges the gap between the demands at the roadside and the repair information stored at different companies. The work in 'Mobile Communication' investigated the potential of various mobile devices and communication networks and designed an "always best connected" communication platform for the roadside patrol and the driver.

"The envisaged communication solution aims at facilitating today's communication systems as well as future mobile communication concepts such as Long Term Evolution (LTE), inter-vehicle communication and hybrid systems."

Facing repair and maintenance situations, fast movement or rural countryside environments are substantial challenges for the performance of mobile communication networks. Furthermore, different mobile communication systems can be applied, like GSM, implying GPRS or UMTS/HSDPA, as well as short range communication like WLAN or DSRC.

The envisaged communication solution aims at facilitating today's communication systems as well as mobile communication concepts such as Beyond 3G, inter-vehicle communication and hybrid systems.

In the course of the project a Vehicular Communication Gateway (VCG) testbed demonstrating "always best connected" communication has been developed and is now transformed into a prototype of the latter product.

Use Case

MYCAREVENT addresses different technical areas, such as manufacturer dependent and independent workshops and roadside assistance and aims at providing these with case specific services. Particularly for the use case involving roadside assistance, mobile

Figure 1: Product Prototype of the Vehicular Communication Gateway

communication is one mandatory enabler, which demands primarily for mobility, see figure on Roadside Assistance requesting additional repair information. The same goes for the technician who should as well be able to work mobile in the workshop. Thus, his laptop will be attached to WLAN or Ethernet in the garage, and to WLAN or GPRS/UMTS in order to access the repair instructions on site. The technician experiences only the performance change of the new communication medium. While attached to WLAN, the technician can be supported with multimedia information guiding through the repair, by using e.g. video streams showing the detailed assembly process of spare parts or interactive circuit diagrams. While on the move and attached to GPRS/UMTS, the service will be tailored to available transmission resources, waiving of video or large animation transmissions and focusing on plain information.

Special attention must be paid to the roadside assistance (RA), or in general, to the technician not implicitly being able to configure the communication device in case of technological changes. As communication centre, a mobile vehicular communication gateway (VCG) is integrated to the RA's car. The VCG manages all communication related issues, e.g. deciding about the best communication system. The VCG is configured and maintained from the backend. The backend is able to change settings and modify/add the contracts with new operators. Hence, the RA is the user of the VCG and not the maintainer being involved in the configuration of the gateway.

Beside the depicted use case, the gateway might also be placed in a common car. In this case the gateway is not only responsible for communicating error codes or repair guidance, but also manages car internal communication (infotainment).

Business Modelling for VCG

The vehicle communication gateway supports the application of MYCAREVENT services and products and offers significant advantages compared to conventional communication technologies. A new business opportunity for network operators or "virtual" network operators with different radio access networks arises, as they can offer this gateway to customers in order to fulfil the "Always Best and Secure Connected" requirement. Yet, the use of VCG requires an investment, which needs to be compensated by an appropriate value for the investor. The VCG itself may not offer an adequate argumentation to justify the expenses; but set in relation to the extensive options offered by MYCAREVENT services and products, a large benefit for the use of VCG can be presented.

Always Best Connected for Next Generation Vehicular Communication

Vehicular communication has been a research topic for many years. It comprises car-to-car (C2C) and car-to-infrastructure (C2X) communication. MYCAREVENT focuses on C2X and needs a vehicular communication gateway, which is able to incorporate today's communication systems and approaching techniques of the next generation as well. The requirements for the car-to-infrastructure communication of the gateway contain some important differences compared to the published work of session mobility protocols.

1. The car gateway always connects to only one Service Portal, and the requested information is hosted there or at least in the referred service network.
2. Both, the service network and the driver control the behaviour of the car gateway. The car gateway usually does not act autonomously but is assisted by the network.
3. The reasons for a system change might vary from only loss of coverage or availability.
   a. Security requirements
   b. Reliability requirements
   c. QoS constraints
   d. Service requirements

Furthermore, the car gateway does not only manage the mobility for its own traffic; the gateway manages the mobility of all attached devices within the car. This could be the roadside patrol's laptop, the drivers PDA or the in-car telematics unit, as well. The centre part of the figure on Gateway Functionality gives an overview of the functionality of the communication gateway. The gateway incorporates several communication systems to connect the car with the service provider, e.g. UMTS/ GPRS and WLAN.

On the right hand side of the figure on Gateway Functionality the communication towards the service provider is depicted. Several communication media are envisaged. A dynamic network selection chooses the most suitable communication medium. Moreover, this could also be a combination of two or more parallel communication technologies. The functions mobility management (MM), encryption, authentication, QoS mapping, enhanced reliability and routing are shown in the middle of the figure on

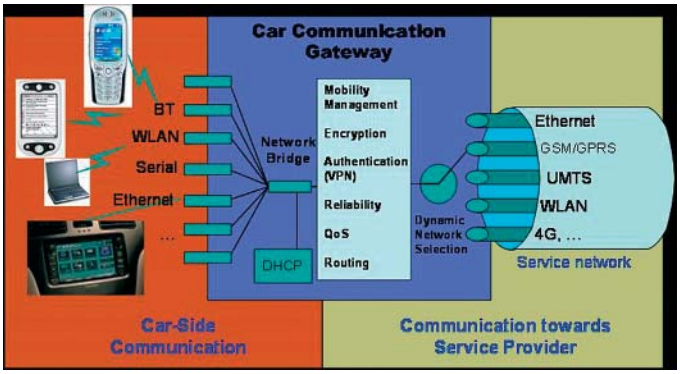

Figure 2: Gateway Functionality

Gateway Functionality.

The left part describes a classical gateway design, except that many different technologies can be used to attach to the gateway as the central point of communication. Mobile devices, such as the roadside patrol's laptop, driver's PDA or in-car telematics units will be able to connect to the gateway. Thus, the gateway offers an advanced communication service.

Vehicle Communication Gateway (VCG) Protocol Architecture

The protocol architecture of the VCG is related to the IEEE 802.21 Media Independent Handover (MIH) reference model. Information

services to various arbitrary link layer protocols, like GPRS, UMTS, 802.11 (WLAN), DVB-T, 802.16 (WIMAX) are foreseen. The current prototype consists of GPRS, UMTS/HSDPA, and WLAN. The Mobility Management and Network Selector base on a messaging process that is oriented on the MIH information services and provides the application layer and the operation and maintenance centre (OMC) with an interface to control the behavior of the network selection.

The gateway establishes an encrypted UDP tunnel to the security gateway. The UDP tunnel switches between different communication systems, depending on the required QoS and the allowed costs for communication. This layer is tightly coupled with the IP protocol. The address of the IP layer is the never changing virtual IP address of the communication tunnel endpoint, which is connected to the security gateway at the service provider. Thus, the application on top only uses the virtual address of the tunnel endpoint. The algorithms to determine the communication system and to handle the mobility are described in the next sections.

Media Independent Handover (MIH) Layer

The Mobility Management and Network Selector of the Vehicle Communication Gateway uses events from the MIH layer. The MIH layer couples within the Control Plane to layer 2 functions of each specific communication system and within the user plane to the IP layer of each system. The Network Selector function bridges the QoS requirements coming from the application with the current condition of all available networks. The application and configuration interface provide policies covering the required QoS, security, and reliability demands regarding the communication and contractual limitations. This policy will be applied to the available communication modes to form the respective rule tables. The Network Selector evaluates these rule tables according to the triggers coming from the MIH layer.

Mobility Management & Network Selector

The decision about the used network is based on communication modes. Each mode contains technical details, like MAC address, frequency, bitrate and contractual agreements, e.g. cost model, or roaming agreements. The important differences regarding a certain communication technology are stored as one mode to operate. In addition, the OMC at the service portal, which configures the VCG might update the list of possible communication modes. This list serves as basis and contains all allowed communication modes. Each communication technology has certain indicators describing the performance of a network, e.g. typical information for WLAN is the used bitrate (PHYMode). Other parameters are the used frequency or the exact MAC address of an AP.

Generation of the Mode Database

The basis for the network selector is the generation, maintenance and monitoring of the basic communication modes and rules. Each VCG has a predefined list of possible/acceptable modes, this list is kept up to date by the operator. The VCG compares the acceptable nodes with the existing ones at the current position. All acceptable modes together form a complete list of basic modes. WLAN modes contain provider name, communication cost, WLAN technique, frequency, bitrate and MAC address. The MAC address and the frequency are stored to allow a fast change and a focused scan method. However, the most important parameter is the experienced bitrate, which depends on the applied PHYMode. A certain service might require a data rate that cannot be served with low bitrates. The list of possible modes is distributed by the OMC and only depends on the available communication interfaces of the VCG.

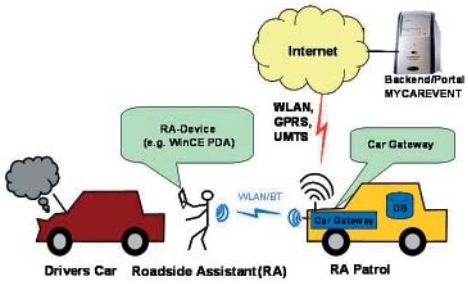

Figure 3: Roadside Assistance requests additional repair information

The VCG scans all interfaces and searches for available communication systems and mobile operators. Based on the found communication modes, the VCG controls the list of possible communication modes and compares which modes are allowed from the OMC and which modes are currently available. This step reduces the list of possible communication modes to the available modes, which serves as basis for the decision at the current position. The VCG scans permanently with all unused interfaces to monitor the list of available modes, adds the modes of new detected providers and eliminates modes that are not longer available. The VCG correlates the list of available modes with the policies describing the required QoS. The correlation result is the excellence of a mode with regard to the requested QoS. The excellence describes the accordance of a mode with the required QoS. The combination of mode and excellence is called a rule. The table of achievable modes (Basic modes) is correlated with service specific QoS parameters (throughout, delay, etc.) and the excellence of each mode is calculated.

Conclusion and Outlook

This article presents the role of ComNets, AU in the MYCAREVENT project and the developed car communication gateway. The addressed use cases are outlined and the requirements for mobile communication and the mobile vehicular communication gateway are described. Based on the use cases and requirements an advanced car communication gateway has been developed and the different functions are explained. The VCG will be configured remotely and allows e.g. roadside patrols to concentrate on their repair job while always using the best communication. Within the MYCAREVENT consortium, ComNets develops a prototypical product (see the figure on Product Prototype of the Vehicular Communication Gateway) of the VCG to show the benefits and efficiency of mobile communication for automotive after sales services. After the project runtime the VCG will be used during lectures, to explain the complexity of the network convergence and will be further extended within in follow-up projects.

Summary
ComNets developed a Vehicular Communication Gateway (VCG) prototype demonstrating "always best connected" communication. The VCG serves as remotely controlled communication centre integrated to the roadside patrol allowing the technician to concentrate on their repair job while always using the optimum communication.