MYCAREVENT- Vehicular Communication Gateway for Car Maintenance and Remote Diagnosis

Erik Weiss, Guido Gehlen, Sven Lukas, Carl-Herbert Rokitansky
and Bernhard Walke

Communication Networks, Faculty 6, RWTH Aachen University
Kopernikusstr 16, 52071 Aachen, Germany
Tel.: +49 (0)241 8028575 *Email: erik.weiss@comnets.rwth-aachen.de*

Abstract

MobilitY and CollAboRative Work in European Vehicle Emergency NeTworks (MYCAREVENT)[1] is an European Project of the 6^{th} Framework Program [1]. MYCAREVENT aims to optimize the European market for automotive services and repair. MYCAREVENT develops and implements new applications and services which can be seamlessly and securely accessed using mobile communication. Maintenance situations like car breakdowns or minor failures will happen everywhere. Wherever such an unpleasant situation appears, the driver needs help and advice. The help most likely will be a roadside assistant. MYCAREVENT provides the roadside technician and the driver with mobile communication following an "always best connected" approach to facilitate the communication between the mobile users within a collaborative work environment. This paper presents the MYCAREVENT project and its communication architecture concept.

1. Introduction

The After Sales Market of the European Automotive Industry has become a very important market. The introduction of innovative mobile applications will enable new ways of working and collaboration among car manufacturers, workshops, road assistance services and the customer, who will all benefit from this. MYCAREVENT develops and implements new applications and services, which can be seamlessly and securely accessed by mobile devices. They will provide manufacturer specific car repair information according to the problems identified by the Off-/On-Board-Diagnosis systems. The mobile worker needs to interact with the service portals of the car manufacturers and independent services while performing the repair of the car.

The project also provides maintenance support for car drivers with self-services in situations where a little advice or a software fix is all that is needed. The results will be transferable to other industries which call for mobile remote ser-vices of manufactured consumer goods, using pan-European technical standards.

MYCAREVENT is strongly supported by car manufacturers, independent and dependent road assistances services, telecommunication providers, software developers, diagnostic tool manufacturers, and leading academics for a sufficient coverage of the competences needed to perform such a challenging task successfully [1].

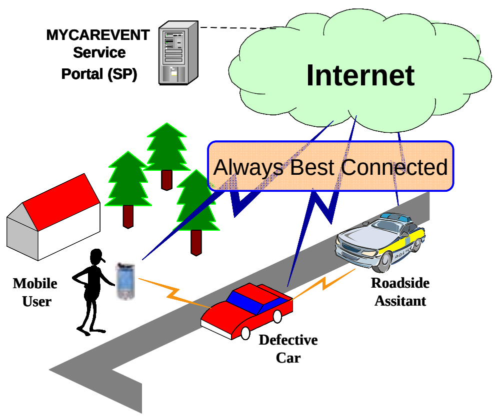

FIG. 1: METHODS
OF WIRELESS COMMUNICATIONS

MYCAREVENT will work with standardisation bodies like ISO (e.g. TC22 and TC204) to establish standards for the collaboration in the automotive industry and will support added value features by utilizing the potentials of mobile devices and the inter-operable use of service portals. Mobile communication will be used to communicate with the On-Board Diagnostic (OBD), to gather breakdown information (see Fig. 1) and to access web based services for repair information. This repair information will mainly guide the roadside assistant, but further services providing additional information for the driver are conceivable.

---

[1] http://www.mycarevent.com

1.1 Mobile Communication

Mobile communication enables the exchange of fault messages (with error codes) and repair information. Thus, mobile communication is a main enabler to allow complex repairs at the roadside. Fig. 2 shows the flow of information. The car reports a failure, this message and subsequent information are transmitted using mobile communication to a service provider. The service provider analyses this error message with an existing information database and provides guidance and repair information, and if necessary, a process to deliver additional spare parts is initiated.

The repair guidance is transmitted to the roadside assistant, who is now able to execute the repair. Taking into account such repair and maintenance situations, difficulties arise. Fast movement or rural countryside environments are a substantial challenge for the perfor-

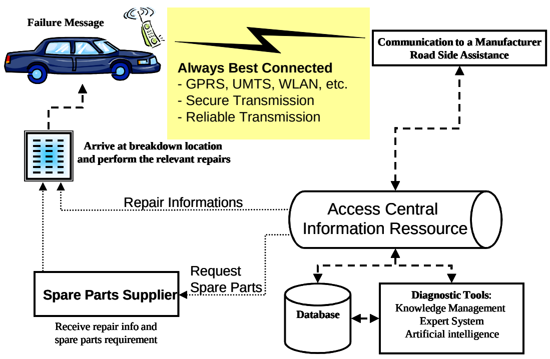

FIG. 2: EXAMPLE INFORMATION FLOW

mance of mobile communication networks. Different mobile communication systems can be considered, like GSM, implying GPRS or UMTS, as well as short range communication like WLAN or DSRC. If none of those classical communication systems is available, vehicle-to-vehicle communication and/or satellite communications will be used.

The envisaged communication solution aims at facilitating today's communication systems as well as mobile communication concepts beyond 3G and hybrid systems. The MYCAREVENT consortium investigates the potential of various mobile devices and communication networks and designs an "always best connected" network for the roadside assistant and the driver. A prototype demonstrating this "always best connected" network will be developed.

2 Use Cases

MYCAREVENT works in many different technical areas. The car manufacturers focus mainly to provide manufacturer dependent and independent workshops and roadside assistants with case specific information.

Mobile communication is one of the mandatory enabler for the use case involving the roadside assistant. One main challenge is mobility. The tech-

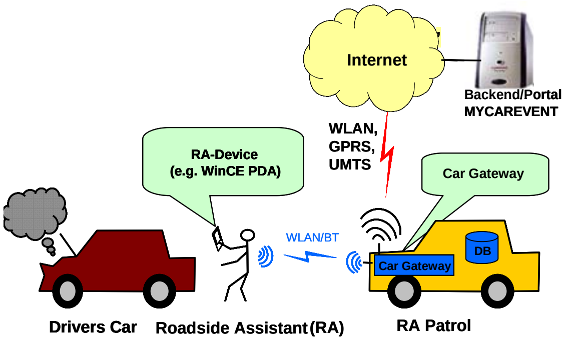

FIG. 3: ROADSIDE ASSISTANT REQUESTS ADDITIONAL REPAIR INFORMATION

nician in the workshop should be able to work mobile. His laptop will be attached to WLAN or Ethernet in the garage, and on the move to WLAN or GPRS/UMTS in order to access the repair guidelines. 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 him during the repair.

That might even include a video stream showing the detailed assembly process of spare parts or interactive circuit diagrams. While on the move (see Fig. 3) and attached to GPRS/UMTS, the service will be tailored to available transmission resources, waiving transmis-

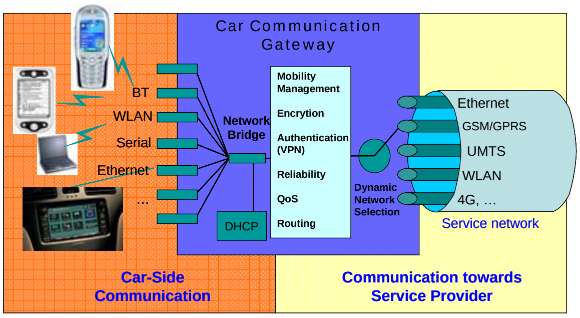

FIG. 4: GATEWAY FUNCTIONALITY

sions of videos or large animations and focusing on plain information. Therefore, it is important that the gateway as well as the network side is up to date about the transmission conditions. Based on this information, the service portal will be able to configure, and partly to control the behaviour of the car gateway.

One advanced possibility is to connect the in-car telematics unit or the onboard diagnostic (OBD) system to the gateway to provide additional information, describing the failure or symptoms to the service provider. Based on that information, the service provider elaborates if the driver is able and willing to fix the problem by himself. Otherwise the failure report and additional guidance is forwarded to the closest roadside assistant patrol.

3 Communication Requirements

The previous section has described in brief some of the use cases addressed by MYCAREVENT. In particular, the use cases supporting the roadside technician contain challenging requirements for the mobile communication. Some major requirements are listed below:

1. The gateway has to choose the most suitable communication system. The decision to use a certain communication system will be based on user profiles and service parameters.
2. The communication has to be secured, if required.
3. The QoS of the connection should be monitored, adapted and switched if the connection performance falls below the required quality of service parameters.
4. Switching the wireless network should be transparent and seamless for the application.
5. To ensure reliable transmission of critical information or software, the connection should not exceed a certain configurable packet error rate.

4 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 develops a vehicular communication gateway able to incorporate today's communication systems and approaching techniques of the next generation as well. The requirements for the car to infrastructure communication side (cf. Fig. 4) 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 this service network.
2. The service network and the driver together 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 an exchange of systems might be different 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 assistant's laptop, the drivers PDA or the in-car telematics unit, as well. The center

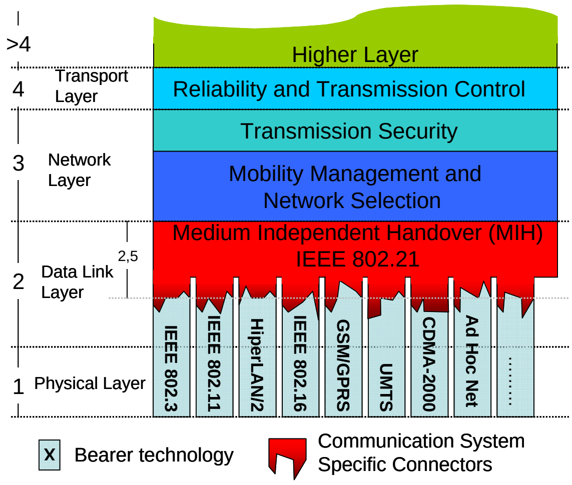

Fig. 5: COMMUNICATION ARCHITECTURE TO THE SERVICE PROVIDER

part of Fig. 4 gives an overview of the functionality of the communication gateway. The gateway incorporates several communication systems to connect the car with the service provider; among them are UMTS/ GPRS and WLAN. On the right hand side of Fig. 4 the communication towards the service provider is depicted. Several communication medias are envisaged.

A dynamic network selection chooses the most suitable communication medium. Furthermore, this could also be a combination of two or more parallel communication technologies. The functions mobility management (MM), encryption, authentication, quality of service (QoS) mapping, enhanced reliability and routing are shown in the middle of Fig. 4. 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, like the roadside assistant's laptop, driver's PDA or in-car telematics unit will be able to connect to the gateway. The gateway offers an advanced communication service. Fig. 5 shows the layer structure for the communication towards the service provider (cp. Fig. 4). The proposed solution includes a generic convergence layer. The convergence layer contains adaptation interfaces for each technology in order to compare the measurements and peculiarities of different systems, e.g. WLAN and GPRS signal strength is not comparable. Each interface employs triggers to inform about current values of the data link or physical layer. Some of these parameters are comparable and some are unique for each. A convergence layer is needed to normalize and evaluate the triggers and to derive clear status information for the mobility management, e.g. link is going down. The IEEE 802 task group 21 [2] spends much effort in the development of a medium independent handover (MIH). The core piece of work in 802.21 is the MIH function (MIHF). MIH introduces additional communication services to exchange state information between lower layers and MIH peer entities.

Fig. 5 denotes these unique parts using communication system specific connectors to attach to each interface. The overall goal is the provision of parameters, trigger values and any useful information from each interface to control the usage and data flow in the most beneficial way. IEEE 802.21 proposes to include a MIH peer entity in the network part. IEEE 802.21 supports the media independent handover, but MIH neither controls the handover nor manages the mobility itself. It reports and allows a holistic view over all network interfaces and the respective radio conditions.

4.1 IEEE 802.21 Media Independent Handover

The means to obtain this goal are MIH Function Services. There are three different services provided: Event Service, Command Service and Information Service. Event Service uses a push model for information transfer. It is an asynchronous service indicating changes in state and transmission behaviour of L2 data links, e.g. a Link Down event.

The destination of an event is the MIH Function of the local stack, the MIH Function of the remote stack (network side), or both. A MIH Function registers for events of interest. Command Service is implemented in the way of a query/response mechanism. It refers to the commands sent from upper layers to lower layers. These commands control the behaviour of lower layers by carrying the upper layer decisions to the local or the remote entities in the lower layers. Information Service also uses a query/response type of mechanism for information transfer.

It is used to obtain static and dynamic network information such as link layer parameters. MM protocols may use the Event service, Command service and Information service to manage, determine and control the state of the underlying interfaces. Owing to the MIH Function Service events, the mobility protocol might decide to perform a handover.

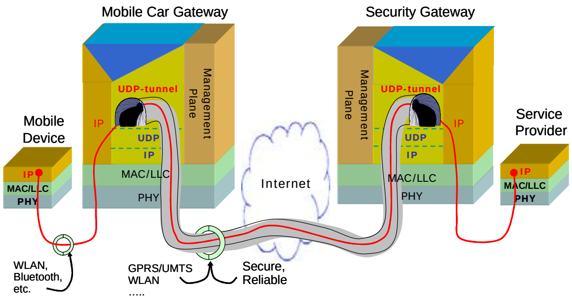

FIG. 6 DATA FLOW FROM MOBILE TERMINAL VIA CAR GATEWAY AND UDP TUNNEL TO THE SERVICE PROVIDER.

4.2 Mobility Management and Network Selection

On top of IEEE 802.21 a mobility management (MM) function is deployed, which is based on the events and triggers received from the MIH layer and on rules and QoS constraints for each service. These rules are maintained and adapted from the car gateway user and the service provider. Based on these rules and the information from the MIHF, the MM chooses the best set of communication systems.

If required, the connection is secured using off-the-shelf security protocols. We currently envisage using IPsec to encrypt the traffic and to authenticate the car gateway. The applied security could be modified depending on the service, e.g. it is not essential to protect open web information, while advanced repair information is confidential. For this reason transmitting such information needs to be encrypted. After setting up an IPv4 connection, the use of already existing internet services is possible according to the capabilities of the access technology used. By moving out of the coverage of an access technology, a connection break will be caused. The terminal might be able to anticipate the upcoming break, due to the descent of data rate and the rising of packet error rate. The terminal reacts by redirecting the traffic over another IPv4 connection utilizing the next best suited interface, if available.

To handle this in a seamless way, the MM forecasts when the connection will be interrupted. The prediction is based on the supplied information from the 802.21 sublayer. It is always possible that the connection is interrupted immediately without any service degradation in advance. In this case the MM sets up new connections choosing for the interfaces, depending on the desired service class. To establish a connection, we have to authenticate to the MYCAREVENT secure access gateway. With respect to the not-to-be-trusted Internet, the security gateway authenticates to the car gateway, too. After this process, a session key must be established to encrypt the subsequent traffic. Last but not least we need to get a connection record from the security gateway, including essential communication information, like a routable IPv4 address. All this is done securely by a 3 way handshake protocol. Afterwards, the car gateway has got a fixed IPv4 address and any communication is directed through a *"tunnel"* by encapsulating the user data into datagrams with dynamically changing source IPv4 addresses directed to the security gateway. With respect to the scarcity of IPv4 addresses, most network providers provide private (only locally routable) IPv4 addresses to their attached clients.

This causes additional complexity, since gateways have to perform Network Address Translation (NAT) to allow terminals with private IP addresses access to specified services. The NAT gateway performs the matching of actual port numbers and private IP addresses to a few public IP addresses and a large number of port numbers. This technique requires the knowledge of upper layer protocols (i.e. TCP, UDP, ICMP) by the gateway. Handling other protocols is not standardized. The solution to overcome a NAT is the encapsulation of the IPv4 datagram within a UDP datagram (cf. Fig. 6).

5 Conclusion and Outlook

This paper presents the MYCAREVENT project and the developed car communication gateway. The addressed business cases are outlined and the requirements for mobile communication are described. Based on the use cases and requirements an advanced car communication gateway has been developed and the different functions are described within this paper. The project group develops a live demonstrator to show the advances of mobile communication in car maintenance.

6 Acknowledgement

This work was funded by the European Research project MYCAREVENT (IST-004402). The authors would like to thank the members of the project for the valuable discussion.

7 References

[1] MobilitY and CollAboRative Work in European Vehicle Emergency NeTworks, 6th Framework European Project, IST-004403; www.mycarevent.com,

[2] IEEE P802.21/D00.01, Draft IEEE Standard for Local and Metropolitan Area Networks: Media Independent Handover Services; Available at www.ieee802.org/21/ July 2005.

[3] G. Gehlen, E. Weiss, S. Lukas, C. Rokitansky, B. Walke. "*Architecture of a Vehicle Communication Gateway for Media Independent Handover*" 3rd International Workshop on Intelligent Transportation, WIT 2006, March 2006

[4] E. Weiss, G. Gehlen, C. Rokitansky, B. Walke. „*How Mobile Communications Improve Car Maintenance and the After-sales Sector"*, 12th IEEE Benelux Symposium on Communications and Vehicular Technology in the Benelux, SCVT 2005,

[5] E. Weiss, G. Gehlen, A. Kemper. „*Always Best Connected (ABC) in Wireless Car Communications*". 1st Workshop on Wireless Vehicular Communications and Services for Breakdown Support and Car Maintenance (W-CarsCare)