How Mobile Communications Improve Car Maintenance and the Aftersales Sector

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***Abstract** - **M**obilit**Y** and **C**oll**A**bo**R**ative Work in **E**uropean **V**ehicle **E**mergency **N**e**T**-works (MYCAREVENT)[i] is a European Project of the 6th Framework Program [1]. MYCAREVENT aims to improve and significantly modernise the European market for automotive services and repair, and helps the aftersales sector to deal with European Regulations. The After Sales Market of the European Automotive Industry has become a very important market. MYCAREVENT develops and implements new applications and services [4][2] which can be seamlessly and securely accessed using mobile communications. One of the critical points here is to ensure easy access to the various maintenance and repair applications and services anywhere and anytime. Repair situations, like car breakdowns or minor failures can happen anywhere. Wherever such an unpleasant situation occurs, the driver needs help and advise. This help will most likely be from a roadside assistant. In order to facilitate permanent repairs at the roadside the technician needs information and guidance. The MYCAREVENT consortium develops the technological concept to provide the roadside technician and the driver with mobile communication following an "always best connected" approach, which will facilitate the communication between the mobile users within a collaborative work environment.*

Introducing

The MYCAREVENT consortia discovered four crucial research / application areas.

- The Aftermarket Repair Sector, accessing repair information relevant for different car model and manufactures is one of the key challenges being faced by the car garages [2].
- The mobile communication first enables the access of repair information when away from the garage. Thus, (in-)dependent roadside assistants can receive repair information when requested.
- Onboard Diagnostic (OBD) Systems in the automotive industry have already been used for many years for brake and engine control. More advanced OBD systems, provide guidance to the repair technician by means of a diagnostic scan tool connected to the vehicle through a diagnostic connector.
- Furthermore, Standards for Automotive Repair & Diagnostic Information have to be defined.

Mobile communication will be used to communicate with the OBD, to gather (standardized) breakdown information 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 driver are conceivable.

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

Mobile Communications

Mobile communication enables the exchange of error messages and repair information. Thus, mobile communication is a main enabler to allow complex repairs at the roadside. Fig. 1 shows the flow of information. The car reports a failure, this message and subsequent information are transmitted using mobile communication towards a service provider. The service provider analyses the described 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 information is transmitted to the roadside assistant who is now able to execute the repair (after delivery of spare parts, if any). Taking into account such repair and maintenance situations, difficulties arise. Fast movement or rural countryside environments represent a substantial challenge for the performance of mobile commu-nication networks. Different mobile communication systems can be considered, such as cellular systems, like GSM, implying GPRS or UMTS, as well as short range communication like WLAN or DSRC [3]. If none of these communication systems is available at a certain location the employment of (new) vehicle-to-vehicle communication systems or satellite communication is foreseen. The envisaged communication solution aims at facilitating today's communication systems, as well as mobile communication concepts beyond 3G and hybrid systems. Additionally, localization in mobile communication systems and localization improvements are investigated. The MYCAREVENT consortium investigates the potential of various mobile devices and communication networks and designs the self-configuring "always best connected" network. A prototype demonstration will be developed and, among other things, the "always best connected" network will be demonstrated. MYCAREVENT connects to the Service Portal (SP) using a car communication gateway. The gateway uses several communication systems to connect to the service portal. MYCAREVENT identified three major communication requirements, choosing the right network, transmission reliability and security. Those three functions together form an 'intelligent connection' (INCO) (see Fig. 2). The Network Selection (NS) is responsible for the management of different communication interfaces based on user and service profiles. On top of the network selection an entity is needed to ensure a secure communication. This will be realized within the Security block. The third functionality required is a reliable transport (Transport Reliability, TR). TR protects the connection up to a certain packet error rate (PER). Since each communication interface itself already ensures a certain PER the TR block has to choose the reliability degree in accordance with the used communication interface. Hence, a change of the communication interface requires also the adaptation of the reli-

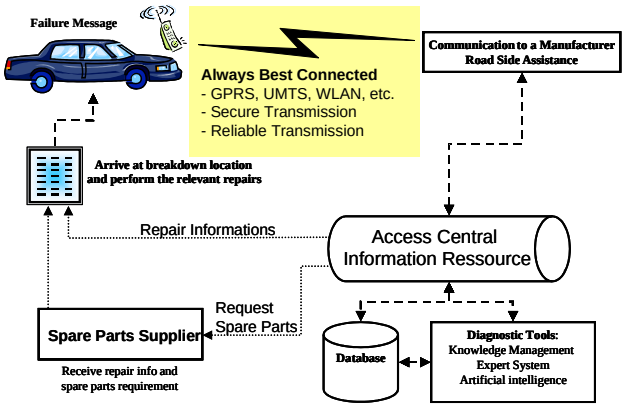

Fig. 1: Example Information Flow

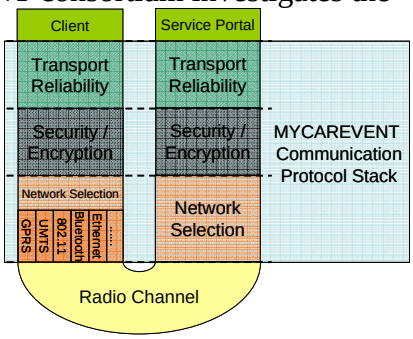

Fig. 2: Intelligence Connection (INCO)

ability mechanisms. The degree of reliability is adaptable from the application e.g. for downloads, video streams or voice calls.

Use Cases

MYCAREVENT works in many different technical areas. The car manufacturers focus is mainly to provide manufacturer dependent and independent workshops and roadside assistants with case specific information. Mobile communication is one of the mandatory enablers for the use case involving the roadside assistant. One main challenge is mobility. The technician 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 multi-media 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 could be tailored to available transmission resources, waiving transmissions 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 to some extend control the behavior of the car gateway.One advanced possibility is to connect the in-car telematics unit or the on-board 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 minor problems by himself. Otherwise the failure report and additional guidance is forwarded to the closest roadside assistant patrol.

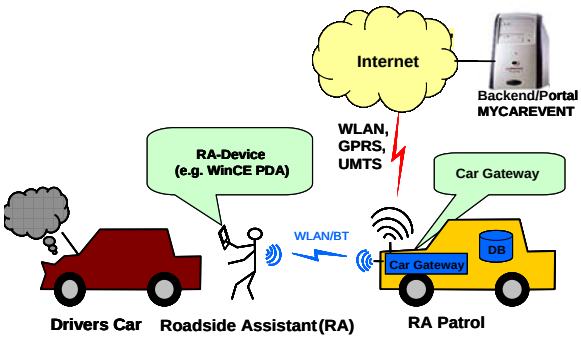

Fig. 3: Roadside Assistant requests additional repair information

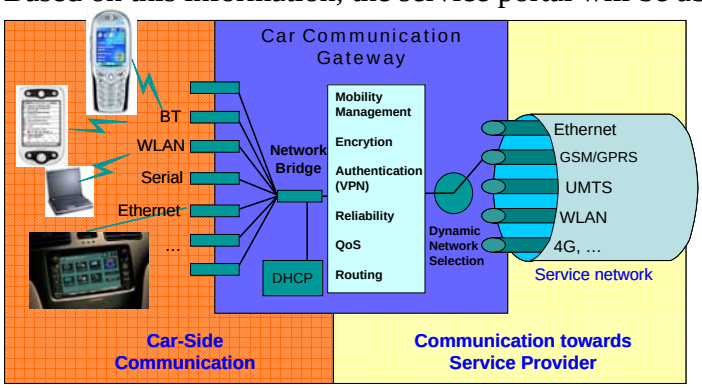

Fig. 4: Gateway Functionality

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 pa-

rameters.
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.

Always Best Connected for 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 within this service network.
2. The service network and the driver together control the behavior 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 middle 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 media 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 [5] 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.

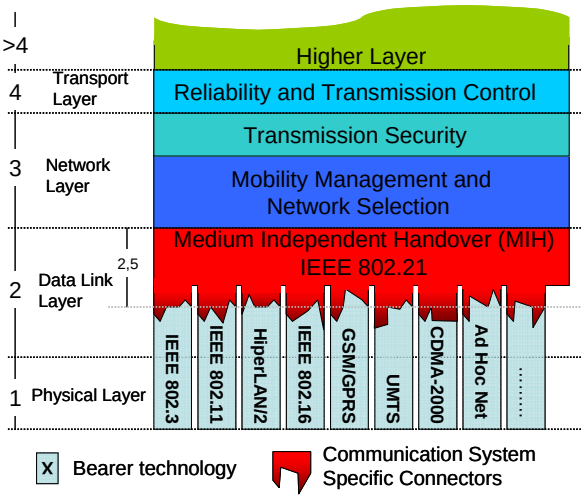

Fig. 5: Communication Architecture to the Service Provider

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 behavior 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 behavior of lower layers by carrying the upper layer decisions to the local or the remote entities in the lower layers.

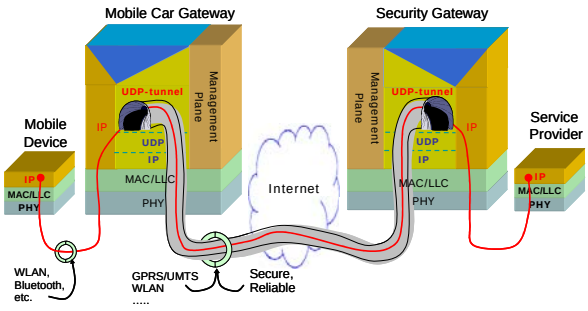

FIG. 6 DATA FLOW FROM MOBILE TERMINAL VIA CAR GATEWAY AND UDP TUNNEL TO THE SERVICE PROVIDER.

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 decides to perform handovers.

Conclusions and Outlook

This paper presents the mobile communication goals in the MYCAREVENT project and the developed car communication gateway. The addressed use 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. The MYCAREVENT project is driven by the end users. The project aims at developing mobile communication solutions and services which adapt to people and business needs and not vice versa. This places highly stringent conditions for enabling an "always best connected" and low cost communication network [3]. MYCAREVENT creates the communication architecture and develops a prototype to demonstrate a complete communication solution, providing the roadside assistant or the driver with the best suited connection to repair and maintain the car.

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References

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