Accident Detection in Vehicular Networks Using Android-based Smartphones

K.Chinna Rao and Charan Arur Panem

Abstract: : **The slow pace at which the automotive industry is making cars "smarter". On the contrary, the smartphone industry is advancing quickly. Existing smartphones are endowed with multiple wireless interfaces and high computational power, being able to perform a wide variety of tasks. By combining smartphones with existing vehicles through an appropriate interface we are able to move closer to the smart vehicle paradigm, offering the user new functionalities and services when driving. In this paper we propose an Android- based application that monitors the vehicle through an On Board Diagnostics (OBD-II) interface, being able to detect accidents. Our proposed application estimates the G force experienced by the passengers in case of a frontal collision, which is used together with airbag triggers to detect accidents. The application reacts to positive detection by sending details about the accident through either e-mail or SMS to pre-defined destinations, immediately followed by an automatic phone call to the emergency services.**

Keywords: **OBD-II; Android smartphone; testbed;performance analysis; vehicular security.**

I.INTRODUCTION

The widespread adoption of mobile telephony has remarkably improved interpersonal communications in our society. Nowadays mobile phones resemble small multifunction computers, being characterized by a CPU power and RAM size similar to that of laptop computers available only a few years ago. The future trend is that more and more users own these intelligent mobile terminals, and that their main use gradually shifts towards functionalities including web surfing, social networking, multimedia streaming, online games, domotic applications, and so on. Under these premises, it is possible to introduce novel services using smartphones in many different contexts.

At the same time, the automobile industry is undergoing a major strategical shift towards more ecological and secure vehicles, introducing also new vehicular services such as eco-driving support and Internet access. However, it will take many years until most of the vehicles in our streets are equipped with these novel functionalities. In the particular case of supporting safety and emergency services, any anticipation is clearly desirable since it may help at saving lives.

K.Chinna Rao is working as Assistant professor in CSE Dept at MRRITS ,Udayagiri,AP,India and Charan Arur Panem is working as Assistant professor in ECE Dept at MRRITS ,Udayagiri,AP,India, Emails: kchinnarao142@gmail.com, Panem.charan@gmail.com,

Currently, several European projects within the 7th framework program, like for example ASSET-ROAD [1], Cyber-Cars2 [2] and SAFETRIP [3], address safety on the road through vehicular networking. In the USA and in Asia we can find similar research activities and ITS projects, and several vehicle manufacturers are already working in this direction.

In this paper we propose combining existing vehicles with smartphones to achieve a solution able to improve security on the road. In our solution, smartphones are used as an alternative On-Board-Unit (OBU) within the vehicle, accessing the information in the vehicle's internal bus wirelessly. The only requirement to achieve this goal is that the vehicle supports the OBD-II standard [4]. Since this standard is mandatory since 2001, the solution is applicable to all vehicles aged 10 years or less (as of 2011). In this work, a specialized smartphone application was developed to provide support for emergency services based on the information available in the communications bus of the vehicle. In particular, the proposed application monitors the vehicle's speed and airbag triggers to detect when an accident has occurred. Positive accident detection is followed by any sequence of actions defined by the user, such as sending accident details via SMS or e-mail, or making an automated phone call to the emergency services.

II. RELATED WORK

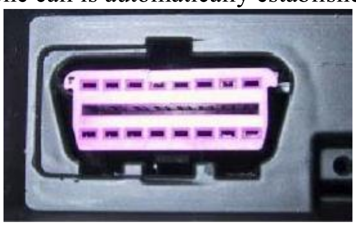
In the literature we can find some works that adopt Android based smartphones to support all sorts of in-vehicle services.

Al-Ani et al. [7] proposed using an Android-based terminal as a replacement to the vehicle's stereo system to provide a High Fidelity In-Vehicle Infotainment System (IVI). Such system provides informative and interactive material that will extend the driver experience by providing capabilities from a mobile-based operating system.

Cheng et al. [8] proposed an Android-based mobile device platform which provides network management functionalities to guarantee the communication quality. In order to achieve ubiquitous computing, the proposed algorithm supports seamless handover via effective resource and handover management between heterogeneous networks.

Spelta et al. [9] implemented a system for a vehicle-to-driver and vehicle-to-environment communication, based on a smartphone core and Bluetooth communication. Since authors focus on motorcycles, they equip them with an embedded CAN-Bluetooth converter that is interfaced with the smartphone, which acts as a gateway toward an audio helmet and a web server.

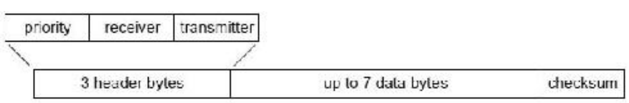
When focusing specifically on the support for accidents and emergency services using mobile phones, very few works are available. Thompson et al. [10] describe solutions to key issues associated with detecting traffic accidents, and detail how smartphone-based accident detection can reduce overall traffic congestion and improve the response time of emergency services. They also develop a smartphone-based accident detection system, and empirically analyze its ability to detect false positives, as well as its capabilities for accident reconstruction. However, they do not take advantage of any information from the vehicle's internal bus. In this work we develop an application that communicates with the vehicle's internal bus using the OBD-II interface and Bluetooth communication to determine whether accidents have occurred, and to estimate the severity of such accidents. The information retrieved is then submitted to emergency services, and an emergency phone call is automatically established.



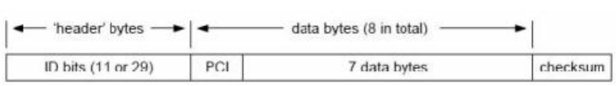
(a) Female connector

(b) Male connector.

Figure 1: Example of a) an in-vehicle OBD-II female connector, and b) a Bluetooth-enabled OBD-II device with male connector



(a) Frame format adopted by the SAE J1850, ISO 9141-2 and ISO 14230-4 standards.



(b) Frame format adopted by the ISO 15765-4 (CAN) standard.

Figure 2: OBD frame formats.

III. THE OBD-II STANDARD

The On-board Diagnostic (OBD) standards [4] were developed in the USA to detect car engine problems that can provoke an increase of the gas emission levels beyond acceptable limits. To achieve this purpose, the system is constantly monitoring the different elements related to gas emissions, including engine management functions, being a powerful tool to diagnose problems on vehicles' electrical systems. When a failure is detected, the system must store it in memory so that technicians may analyze it later on.

The first OBD standard, known as OBD-I, defined only a few parameters to monitor, and did not establish a specific emission level for vehicles. Thus, failures resulted in just a visual warning to the driver and the storage of the error. The second generation of OBD, known as OBD-II, standardizes different elements such as the connector used for diagnostic, the electrical signaling protocols, and the message format. Additionally, it defines a list of parameters that can be monitored, assigning a code to each parameter. A detailed list of DTCs (Diagnostic Trouble Codes) is also defined in the standard.

Several operating modes are defined by the OBD-II standard to allow for an easier interaction with the system, and defining the desired functionality. Most automobile manufacturers have introduced additional operation modes that are specific to their vehicles, thus offering a full control of the available functionality.

The European version of the OBD-II standard, known as EOBD, is mandatory for all gasoline and diesel vehicles since 2001 and 2003, respectively. Despite it introduces small improvements, EOBD strongly resembles OBD-II, sharing the same connectors and interfaces. Figure 1 shows an example of both male and female OBD- II connectors. In particular, the male connector shown in the figure is part of a Bluetooth-enabled OBD-II device that offers a bridge between the vehicle's internal bus and smartphone using a Bluetooth connection.

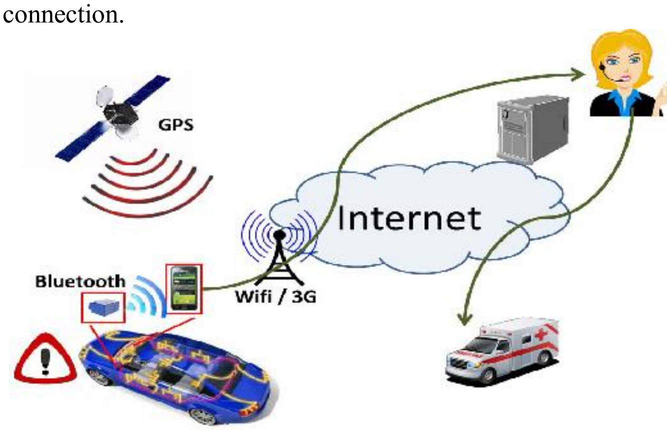


Figure3: Elements in the scope
the proposed application

A. Communication protocols

Although the physical interface is well defined, the communications protocol varies depending on the manufacturer. The available protocols are: (i) SAE J1850 PWM (Pulse-Width Modulation) [11], (ii) SAE J1850 VPW (Variable Pulse Width) [11], (iii) ISO 9141-2 [12], (iv) ISO 14230 KWP2000 (Keyword Protocol 2000) [13], and (v) ISO 15765 CAN [4]; these protocols present significant differences between them in terms of the electrical pin assignments. Notice that most vehicles implement only one of these protocols. For instance, Chrysler uses the ISO 9141-2 protocol, General Motors uses SAE J1850 VPW, and Ford uses SAE J1850 PWM.

B. Diagnostic Trouble Codes (DTCs)

Diagnostic Trouble Codes were standardized in document

ISO 15031-6 [14], and allows engine technicians to easily determine why a vehicle is malfunctioning using generic scanners. The proposed format assigns alphanumeric codes to the different causes of failure, although extensions to the standard are allowed to support manufacturer-specific failures.

C. OBD message formats

The OBD system was designed to offer a flexible communications system. Message delivery among different devices requires defining the type of message to be delivered, along with the transmitter and the receiver devices. The adoption of different message priorities is also supported in order to make sure that critical information is processed first.

However, depending on the protocol used, the format of this message may vary slightly (see figure 2). Notice that both frame formats allow up to 7 data bytes, and they include a checksum field in order to detect any transmission errors.

IV. PERFORMANCE EVALUATION

The first issue we address is the sampling rate performance when varying the number of sensors monitored. Notice that the CAN bus used for in- vehicle communications is shared, and different data sources will compete for bandwidth. This means that the number of samples received per sensor will vary depending on the number of sensors monitored.

In our application, both vehicle speed and airbag sensor data are continuously being retrieved. Thus, at least two sensors are always monitored. In case the user wishes to monitor other sensors as well, the extra traffic in the network associated with this additional sensing will cause the sample rate of all sensors to degrade. . In fact, we find that not only does the individual sensor sampling rate decrease, but the total sampling rate also diminishes due to contention on the bus. Thus, in order to maintain the per-sensor sampling rate above one sample per second, we should avoid monitoring more that four sensors overall. Since our application allows defining exactly which sensors are monitored, this requirement is easy to fulfill.

V. CONCLUSIONS AND FUTURE WORK

Current research efforts aim at developing solutions to enable a future where the networked vehicle plays a central services server that is able to integrate the information automatically delivered by the vehicle with information manually introduced by the operator.

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K.Chinnarao.Now doing Ph.D. He did M.Tech (CSE) and B.Tech(CSE).Now working as a Assistant Professor in CSE department at MRRITS,Udayagiri,AP,India. Doing Research Work on Information Security.

Panem Charan Arur. He did M.Tech (VLSI System Design) and B.Tech(ECE).Now working as a Assistant Professor in ECE department at MRRITS,Udayagiri,AP,India.Doing Research Work on Low Power VLSI. Published Two InterNational Journal,Attended one InterNational conference and Three national level conference and two national level technical seminars,two national level workshops.Professional Association member ships IAENG,CSIT,IACSIT. He has a review committee member in three International Journals.Now he doing research on advanced technologies in VLSI and Embedded systems.