

An In-vehicle eCall Platform for Efficient Road Safety

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ABSTRACT

eCall is an automatic in-vehicle emergency call service with the main objective is to reduce emergency response to reach an incident location (e.g. accident, crisis situation). When an incident occurs somewhere, the in-vehicle embedded device receives information from the sensors and calls the public safety answering point (PSAP) while sending the received information, such the location (GPS coordinates), the terminal identifier and driving direction for accidents. A voice connection between the vehicle occupants and the PSAP operator will be established aiming to quickly send an emergency unit to the incident location. However, existing eCall systems so far are special and professional purpose equipments. Furthermore, vehicles manufacturers are interested to collect information about the accident statistics and vehicles behavior from their equipments. To overcome this restriction of usage, this paper deals with the development of an eCall platform for large scale usage and for driving assistance in the case of accident. The developed platform is tested in urban and highway areas and some preliminary results are reported.

INTRODUCTION

The wide expansion of aftermarket personal navigation devices (PND), smart phones (3G phones), and the wide spread of GNSS (Global Navigation Satellite System) a broad range of different location based services (LBS) can be accessible by users anytime and anywhere. One of the most evident applications of LBS is the ability to locate a person who is either unaware of his/her exact location or is not able to reveal it because of an impediment or an emergency situation, such as vehicle breakdown in an unknown location. With the exact location, automatically transferred to the emergency services, the assistance can be provided quickly and efficiently [1, 2, 3].

Recently, several eCall systems have been developed to achieve this objective. These systems use so far embedded hardware components to allow wireless communications between vehicles and emergence agencies (i.e. V2I: Vehicle to Infrastructure communication), sending useful information such as airbag deployment as well as geographical coordinates from GPS module. Varieties of eCall systems from car makers, such as BMW, PSA, or from insurance companies exist already today and use SMS to communicate emergency calls [4]. However,

current eCall systems are embedded, centralized and stand-alone focusing mainly on a highly specialized task and a posteriori. Recall that such eCall systems are mainly automatic in-vehicle systems with the aim is to rapidly relaying important accident information, such as geographical location, time and accident strength. As they are proprietary systems, their performances are not really accessible. Because most of the driving-assistance software tools are proprietary and not accessible to all road drivers, the European commission would like to create an eCall software to be embedded on nomadic devices. More precisely, this software must allow access to the emergency call functions as easily as possible, while minimizing the risks during driving.

In this paper, an eCall platform developed for large scale usage is presented. This effort is a part of our work in the EU FP7 project, TeleFOT (Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles), where the main objective is to assess the impacts of functions provided by aftermarket and nomadic devices in vehicles with large scale field operational tests and raises wide awareness of these impacts [5].

The remainder of the paper is organized as follows. In section 2, we describe the proposed eCall platform. The experiment results are reported in the section 3. Conclusion and future work are presented in section 4.

ECALL PLATFORM

An eCall platform is developed to allow drivers to establish an eCall (voice and data transfer) with the PSAP. To report an event on the road, driver has two options, (i) calls the PSAP and sends a message at the same time or (ii) sends a textual message reporting the event. In the first case, the eCall application establishes a voice connection with an operator of PSAP, while sending at the same time a text data containing the geographical location of the event, a time stamp and other relevant information through the same channel that is being used to establish the voice call. Alternatively, the driver can also directly send text data to report an event. These events are stored into a server for further data analysis purpose. A server called “TeleFOT server” is established and used to store all collected data from different Nomadic Devices (NDs) embedded within vehicles. A client application is used by the PSAP operator to access particular events for emergency response. The same application is also used to analyze received data and to generate expected results.

ECALL ARCHITECTURE

When an event occurs (e.g. having an accident, seeing an accident, dangerous object deserted on the road...), the driver uses the embedded application on the ND to inform and send the event information to the server. The connection with PSAP is established according to the priority and the nature of the event (i.e. our eCall system gives priority to accidents). Therefore, in case of an event with priority and for safety reasons, the operator will contact

other safety actors (e.g. firemen, police and hospital) to prevent them and give all needed information (either if there are victims and injuries) to reach the event location.

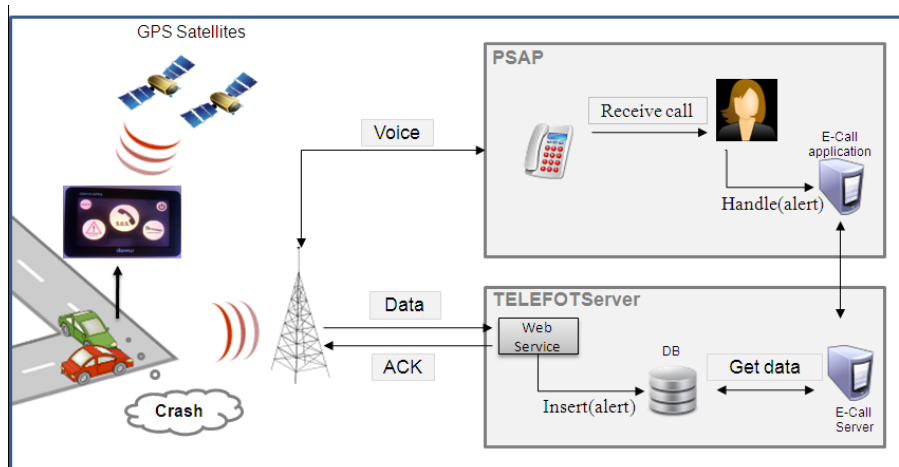


Figure 1. The eCall platform architecture

The system architecture is depicted in Figure 1. It describes all parts and actors participating to the realization of the eCall platform. It is composed of three parts. The eCall application embedded in the ND, TeleFOT server accessible via Internet, and finally the PSAP, which receives coming calls from drivers and manages all the registered events. These components are described in the rest of this section.

ECall application

The eCall application is embedded and run over the ND. It is developed by Microsoft c# and uses SQL Connector to allow communications between the ND software and database server. To secure the database access, the application invokes a web service that was implemented and deployed on the server side. This web service¹ is used as interface between the database and the software embedded on the ND.

The eCall application allows drivers to setup an eCall from in-vehicle ND to an emergency centre. This connection is done by pushing on an eCall button to send the GPS coordinates of the event using wireless communication technologies (e.g. 3G). The goal of this software is to create a user friendly interface, allowing the user to send alerts through the network. Alerts are notifications that are sent by the user about, for example, bad driving condition, car crash, etc. The alerts are sent to the server, which stores data about the user's identity, location, speed, time, and, the type of alert that has been sent.

¹ A web service is defined by W3C [6] as a software system to support interoperable machine-to-machine interaction over a network.

Furthermore, this software will allow better navigation management through the use of this information to compute an adequate itinerary, but also to improve the safety, by avoiding dangerous area (e.g. snow, fog).

TeleFOT server

The TeleFOT server consists of MySQL database, which is used to store users' data and the incoming alerts information. All users, using the eCall application, are registered at the beginning by specifying their name, address, phone number, etc. Alerts are stored via a web service invoked by the eCall application (into the ND), while an event is raised. It consists also of a web application that was developed using PHP language. The aim of this application is to manage the user registration, manage and display all events on the map by using Google Maps API. The map is especially used for visualizing the locations of events (as depicted in Figure 2). Also, we can get from each displayed alerts its corresponding user information. The use of a map is justified by the easy access to all information about received alerts. Therefore, the time required to process the user request could decrease as all the data of the events are provided at the same time as it is displayed on the map.

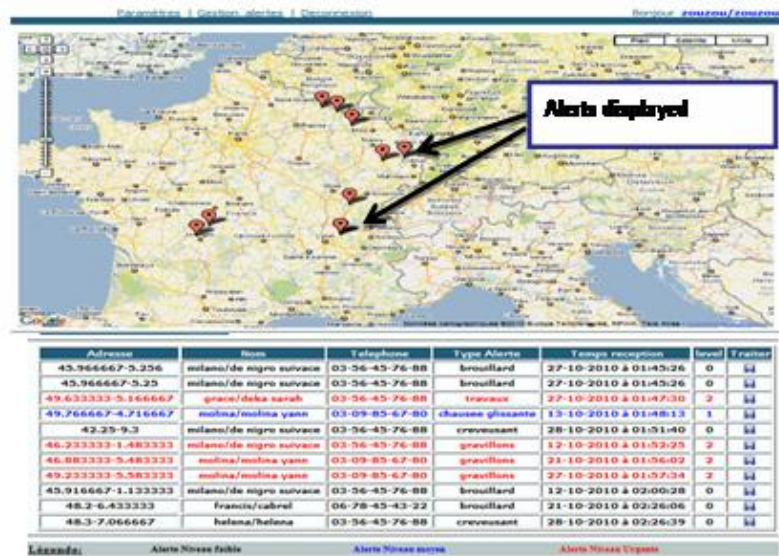


Figure 2. Received alerts displayed on the map

Public Safety Answering Point (PSAP)

For the PSAP, there is an operator (mainly a person) who handles the received alerts and the incoming calls, and has access to the TeleFOT server application. Then if necessary, the operator will contact the authorities by providing the required information (e.g. the event address and nature).

EXPERIMENTAL RESULTS

EXPERIMENTS ENVIRONEMENT

The experiments have been conducted in Belfort/Montbéliard city both in urban and highway environments. The purpose of these experiments is to measure and evaluate the communication time between the vehicle and the server. As described in section (which one), the aim of this platform is to reduce the intervention time of emergency units in order to save lives in the case dangerous events. Furthermore, the location of such events has to be as accurate as possible.

The experiments have been done by using Danew devices, especially the model GS410GPRS [7], with 3G features (please check), and uses a dual-core ARM processor with 1GB of internal memory. It is compatible with the most mobile networks and features that run on Windows CE .Net 5.0 operating system.

SCENARIO DESCRIPTION

In these experiments, two vehicles equipped with Danew devices are used. Several trials have been conducted and results, essentially the latency, are reported by evaluating three techniques. The first technique consists in sending alerts without making a call. The second technique, called synchronous parallel eCall, consists in sending, at the same time (simultaneously maybe better), the alert and the call (multi threading). Finally, the third technique, called asynchronous sequential eCall, consists in sending first alerts followed by the call.

RESULTS DESCRIPTION

During the experiments, the vehicle speed and the locations are also collected. We have measured driving patterns by collecting the vehicle's speed and position from GPS Data logger to get the time delay and the distance from TeleFOT server (located at UTBM-Belfort). To compute latency, we have processed as follows; from the Danew devices, events are sent to the server by specifying, the alert type, the current position, the timestamp, the device id. These data are received by the server and stored in the database. The server replies to each event by sending an ACK message (a signal to acknowledge the receipt of the event) to the vehicle. After receiving the ACK message, the latency is computed, which measures the amount of time delay the system spent in processing the message, i.e. the time delay when the vehicle sends an alert until it receives the ACK message.

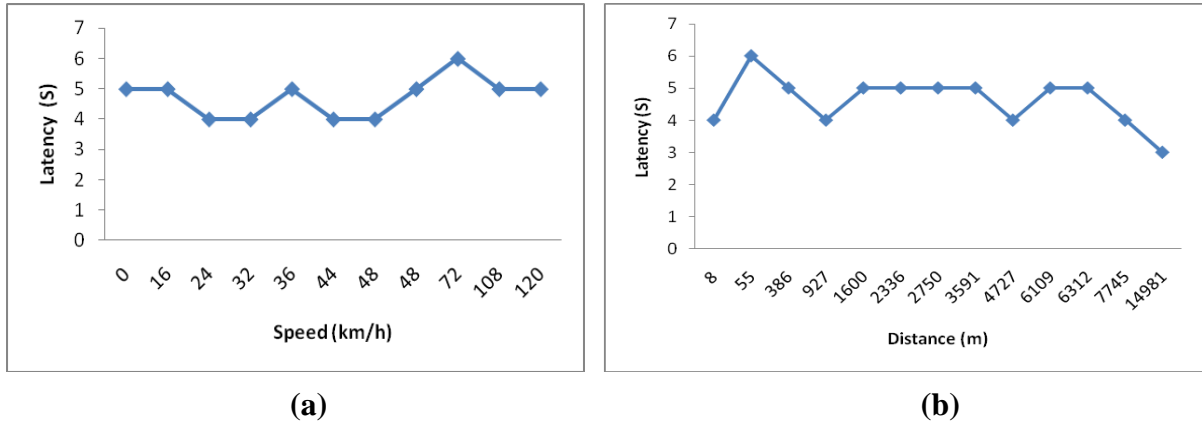


Figure 3. Latency versus (a) Speed and (b) Distance when sending only alerts

Figures 3 (a) and (b) illustrate the vehicle latency variation according to the speed and distance in the case of simple alerts without calling. For the two curves, regardless the distance and the speed, the latency is around 4.69 s (in average).

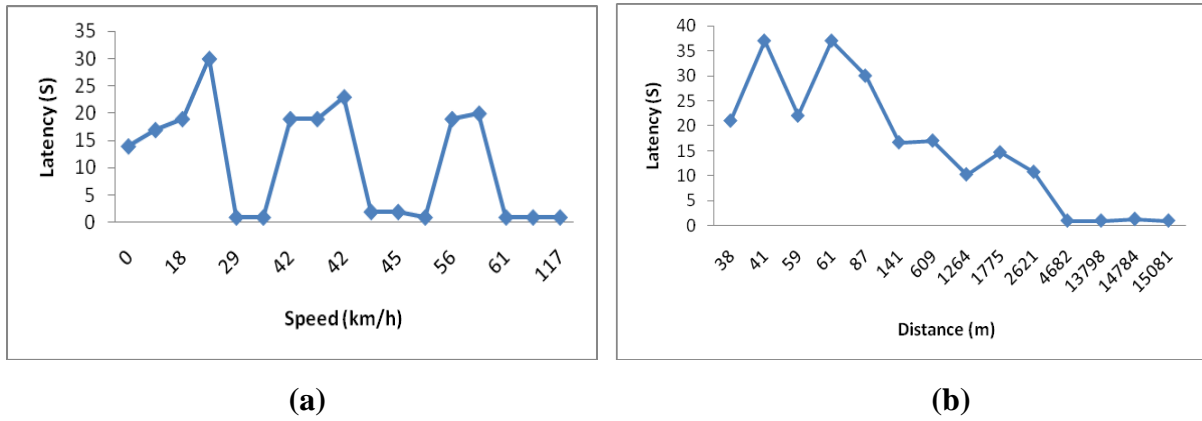


Figure 4. Latency versus (a) Speed and (b) Distance when using parallel eCall technique

Figures 4 (a) and (b) show respectively the variation of the vehicle latency according to the speed and distance in the case of synchronous parallel eCall. In these figures, we remark that the latency is increased comparing to the first case (Figure 3) because of the connection mode (sending and alert and making a call simultaneously) from the vehicle to the PSAP. For this case, the average latency is approximatively 13.46 s.

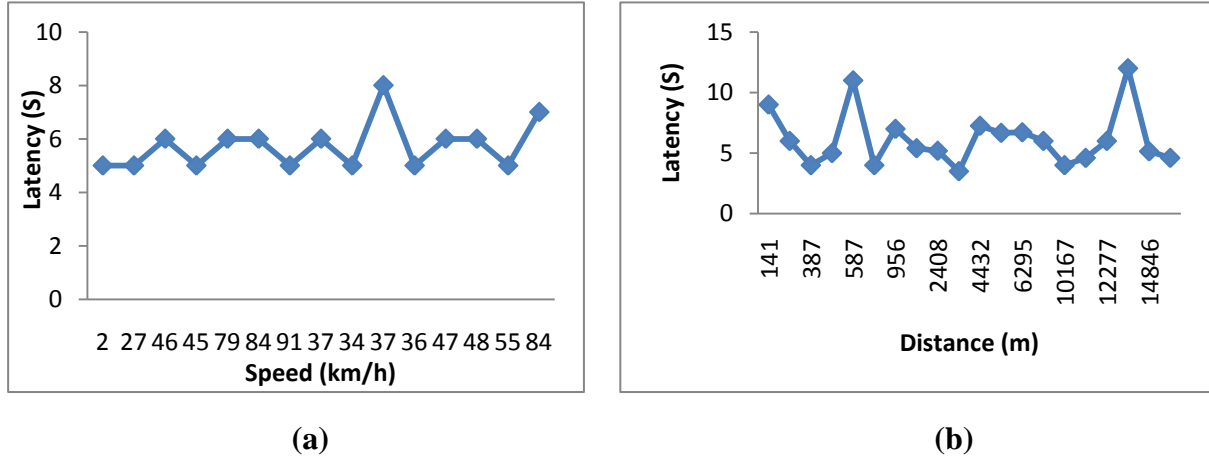


Figure 5. Latency versus (a) Speed and (b) Distance when using sequential eCall

Figures 5 (a) and (b) show the vehicle latency variation according to the speed and distance when using asynchronous sequential eCall technique. Unlike (please check) in Figure 3, for this connection mode between vehicle and PSAP, the latency increases slightly and it is around 6 s in average for the Figure 5(a), and around 7 s (in average) for the Figure 5(b) whatever the speed or distance.

For these three communication modes, we conducted experiments on the highway and urban road of 15 kms in the same conditions. As we can see from these results, the delay, to send out information from the in-vehicle ND to the server and to receive an ACK message, is neither sensitive to the vehicle speed, nor to the distance between the vehicle and the server location. By the way, Figures 3(b), 4(b), and 5(b) show that when the distance from the server increases the latency decreases. This might depend on the cellular network (i.e. GPRS network) conditions and locations (i.e. distance between the vehicle and the relay station, network overload).

Communication mode	Average latency	Location accuracy
Simple alerts	4.69 s	47 m
Synchronous parallel eCall	13.46 s	71 m
Asynchronous sequential eCall	6 s	65 m

Table 1. Average latency and location accuracy for the three communication modes

Table 1 summarizes the average delay and location accuracy for the three communication modes used in our experiments. The location accuracy is the distance between the location when the vehicle sends the alert and the location when it receives the ACK message. This accuracy will help to have a precise address of the vehicle.

CONCLUSIONS AND FUTURE WORK

In this paper, an eCall platform developed under TeleFOT project is presented. Preliminary experiments are conducted and results show the possibility of decreasing emergency time

which in turn could save lives and reduce the impact of injuries. Preliminary results show the importance of in-vehicle eCall using NDs. Future work addresses the comparison of communications techniques with another technique that use in-band Qualcomm modem for eCall data transfer, in which the communication channel is shared between data and voice.

Developed functions and services will also be tested using large population instance. More than 300 vehicles equipped with mobile devices fixed in the cockpit will be used to compare, in one hand, the impact of using these embedded devices on the users' behavior, such as the easy use and the quality of the information they receive. In other hand, the efficiency of the system such as the rapidity to really bring to users the relevant information in a reasonable time and at a precise area, and the rescue delay will be performed.

ACKNOWLEDGEMENT

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