Ad Hoc and Sensor Networks Technical Committee Newsletter (AHSN TCN)

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PREFACE

The IEEE ComSoc Ad Hoc and Sensor Networks Technical Committee (AHSN TC) aims at sponsoring scientific and technical activities facilitating the dissemination of knowledge in the areas of ad hoc, sensor and mesh networks. In an attempt to make all the TC members as well as the AHSN worldwide community aware of what is going on within our main areas of concerns, this newsletter had been set up. The newsletter aims at inviting the authors of successful research projects and experts from all around the world with large vision about AHSN-related research activities to share their experience and knowledge by contributing in short news. So, the eight issue of the AHSN TC Newsletter features one high quality news item gently provided by Tarek Bouali (U. Burgundy, France), Sidi Mohammed Senouci (U. Burgundy, France), Michele Albano (CISTER/ISEP, Portugal), Arthur Lallet (Airbus DS, France), and Farid Benbadis (Thales, France). We thank them as well as all the previous contributors for their effort to make this newsletter successful towards fulfilling its objectives.

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NEWS RELATED TO AHSN TC

Platform for Smart Car-to-Car Communication

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Abstract

Modern vehicles are like a four-wheels computer which maintenance requires more computer skills than use of hammers, screwdrivers and spanners. Vehicles are aware of not only their operational state but also their surroundings through sensors, radars and GPS capabilities. The newest trend is to allow vehicles to exchange information thus making them networking. Therefore, the need for software-intensive in-vehicle applications and services is obvious. CarCoDe European project is the ICT experts' response to develop a software platform for automotive domain, which evokes the generation of the traffic service domain ecosystem. The project, mainly, aims to build cross-platform software enablers to support development of cooperative in-vehicle services. Therefore, cooperation between various tools (automotive, sensors and software systems) should be established to allow third party developers generate new innovative applications. In this brief article, we provide the main CarCoDe goals, depict its architecture and highlight potential achievements and realizations.

1. Introduction

Car-to-car (C2C) and car-to-infrastructure (C2I) communication and its support systems have progressed slowly both in standardization and in the automotive industry. Meanwhile, more and more electronic devices and systems have been brought to vehicles, especially to the professional sector, e.g. to taxis, trucks, excavators, or forest harvesters and forwarders. A common wireless band for IEEE802.11p/WAVE [1] systems was reserved recently both in Europe and in the U.S. but we still may need to wait for years before its deployment really begins. Currently, there is room for research and new innovation as none of the proposed approaches to C2C or C2I have reached wide acceptance or strong role in the market. The wireless communication of on-board vehicle systems and roadside stations may be based on alternative technologies. Currently, IEEE 802.11p has strong public support for the short range while cellular systems, 4G and LTE [2] are potential long-range solutions. Of these, LTE may get a stronger role soon and it could replace all others. Anyway, for offering appropriate user experience, on-board systems in vehicles should utilize different radio systems efficiently and seamlessly.

For the potential applications of the European project CarCoDe (2013-2015) the field is also quite open: the proliferation of electronics in automobiles has produced a huge volume of sensor data within the context of internal and external vehicle communication. The in-vehicle computing capability increase in storage and processing can be exploited to offer interfaces for vehicle driver and passengers to view and interact with this data. In the same trend of innovation, the combination of vehicle sensing and computing resources with wireless communications enables telemetric services also for remote diagnostics, fleet management and traffic monitoring that can provide benefits to drivers, fleet managers and public organisations to improve their maintenance operation, support services and mission critical assignments. But problems still exist in exploiting these computing capabilities and data processing:

(i) Accessing the essential data is not easy and assessing the status and operating condition of vehicles as well as installed aftermarket equipment is not efficient. This leads to situation where the owner of a vehicle may be unaware of conditions requiring maintenance, which may cause operating a vehicle with impending failures that can exacerbate the problem, leading to more costly repairs, downtime and major capital loss as well as safety concerns for drivers and other motorists,

(ii) Exploiting easily the operational status of vehicle fleet is rarely offered and leads to many errors of assessments. Collecting maintenance and operating costs information is not often a reliable process and often information is lost. This can affect purchasing and scheduling decisions and may impact the readiness of the vehicle fleet,

(iii) The security of embedded platforms is not adequate. A wide range of services is potentially interconnected in the car but they have very different protection levels. Moreover, most of them are reachable by the air, so that their (potential) vulnerabilities can be exploited without physical contact.

In addition, the lack of effective basic set of applications for cooperation between services, systems, and applications is a main road-block for the development and integration of new vehicle services interactions in C2X operations. We intend in the framework of CarCoDe project to fill this instrumented, interconnected and intelligent products and services both for on-board and off-board diagnostics, in relation with maintenance systems and support services.

The ITEA2 CarCoDe project is briefly introduced in Section II along with a definition of the goals defined to be fulfilled. After this, in Section III we highlight the project architecture. In Section IV, we go through the demonstrators developed along the project. We conclude with Section V where we outline future technological steps.

2. Project goals

CarCoDe (*Platform for Smart Car to Car Content Delivery*) is the ICT experts' response to develop a software platform for the automotive domain that evokes the generation of the traffic-service domain ecosystem. The project benefits from the increasing development in the automotive area regarding communication technologies and embedded devices for data collection to develop a platform that offers the possibility of inter-operability and cooperation of different tools (automotive, devices, software, etc.). The developed platform enables critical mass for large data usage and collection, supports the seamless use of alternative communication technologies and eases the exchange and use of essential information quickly and automatically. Provided information are used to enhance traffic safety, provide good driving conditions, better physical environment and response to emergencies and offer more entertainment for travellers. The main goals defined by the CarCoDe project are described as follows:

- Offer secure facilities for a safe, fast and efficient share of information in the vehicular network allowing measurements taking in real-time and favoring city traffic and pollution. This opens opportunities to develop real-time services to ease the monitoring of vehicles internal status and interaction of the driver with its environment,
- Enable the use of various available communication technologies based on a seamless and smooth handover within vehicles' on-board units. Developed techniques that are copmliant with the ETSI CALM (*Communications Access for Land Mobiles*) standard [3] in order to be able to manage multiple access mediums (Wi-Fi, WAVE, 2G/4G/4G, UMTS,

etc.) in on-board units (OBU) to always benefit from the always best-connected network characteristics,
- Enable vehicles with disrupted network links to communicate and exchange data with other vehicles and the infrastructure by providing services compatibles with delay tolerant networks and with direct communications between vehicles,
- Enhance data collection, analysis and security within vehicular networks by providing new routing protocols, security frameworks and techniques for data processing and analysis in the vehicle's on-board unit and infrastructure,
- Develop new efficient services and solutions for public safety, traffic monitoring, car diagnostics, data sharing between nodes and marketing. These services are based on the continuous and secure exchange and analysis of data from the vehicular environment,
- Support and enhance the deployment and use of content-centric networking architectures,
- Provide an open platform, which is interoperable and able to support new development and integration of services and applications by external developers and specialists.

3. Project architecture

CarCoDe have inherited from the vehicular network architecture to build an interoperable platform to support ITS-applications [4]. Therefore, the project includes vehicles moving in the network, infrastructure and a background server. Vehicles are equipped with embedded sensors, a display unit (embedded screen or Smartphone) and an In-Vehicle Infotainment (IVI) system. Sensors communicate their collected information to a data analysis and aggregation unit via the OBU. This unit is used to store data and display them on the screen, or send them through one of the best communication mediums available via the OBU (WAVE/DSRC, 4G, LTE, etc.). A vehicle can communicate with another one directly in a peer-to-peer manner (C2C) using IEEE 802.11p, or to the infrastructure using any wireless communication technology.

The infrastructure could be of different types and supports various communication capabilities; a road side unit (RSU) is able to communicate with vehicles in an opportunistic and short range mode based on IEEE802.11p/WAVE capability, a base station (BS) handles communications from vehicles connected via Wi-Fi and eNodeB exchanges data with vehicles which have 3G/4G or LTE capabilities. Infrastructures are mainly deployed in fixed positions in the vehicular network and represent the convergence medium used by vehicles to send their data to the background server. They are connected to the server either wirelessly or using a wired link.

The background server represents the higher authority and global monitoring entity with the highest privileges in the CarCoDe architecture. It holds all the data collected from vehicles and exchanged with the infrastructure. It has in charge the data storage and analysis and services enabling. In fact, all data are analyzed in this server depending on the application requirements and services are enabled to clients via a secure service enabler.

CarCoDe architecture is detailed by Figure 1 where all involved components and stakeholders should cooperate to collect real-time information to offer the most efficient and reliable services to potential clients (driver, passengers, police, fire-fighter, fleet manager, etc.).

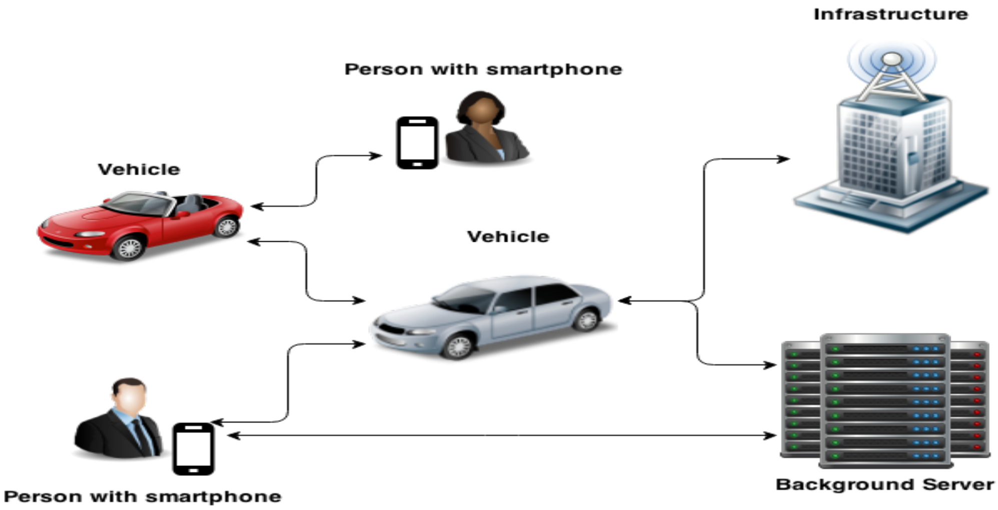

Figure 1: CarCoDe Architecture

4. Demonstrators

This section is devoted to describe some of the developed demonstrators during the CarCoDe project, which consist in applications complying with the proposed architecture and are more likely related to public safety, city parking and remote car diagnostic.

A. Public safety: Itinerary Planning

Itinerary Planning is an application service developed to allow a potentially huge number of users to plan their route. It is very beneficial for individuals and companies owning fleets of vehicles, to decrease their expenses and preserve the environment by providing the most economic itinerary for a trip. Fire-fighters and police agents also benefit greatly from this service when planning tracking and rescue missions. The proposed service is based on data collection from different sources and their analysis to provide the best itinerary to a destination. Therefore, information about road topologies, weather conditions, traffic and vehicle's internal diagnostics are gathered and analyzed to calculate the fuel consumption of a vehicle from one point to another. For fire-fighters and police agents, data are also analyzed to offer the fastest route to an incident scene. In some cases, the emergency services can also have an onboard signalling system which changes the traffic lights in a favourable way for the emergency vehicles to pass, and which must be taken into account as an influence on the environment while planning the itinerary. The background server, which has access to other information sources in the Internet and also responsible of the storage and management of data collected from moving vehicles, offers the application service. The application is accessible via mobile equipments (e.g. smart phone, tablet, etc.) using an application interface where information about trip and passengers are introduced to be sent in a request to the background server. The client does not require Internet connection to benefit from the service because all computing complexities are handled by the server, which has more privileges and a more general view about the network.

B. Public safety: AVL, video transmission and Public Safety LTE/3G access demonstrator

This demonstrator enables the enhanced AVL (Automatic Vehicle Location) service, video transmission and Public Safety LTE/3G access. The AVL provides the vehicle location with the CAN bus data such as the vehicle speed and sensor values. The video transmission enables a control room operator to receive the live video from the public safety vehicle through the LTE/3G network and Internet. This demonstrator is made of the following components: Vehicle equipped with a rugged PC, a video system for live video transmission and video recording, a Broadband Vehicular Router with high-power modem that operates in the 400MHz spectrum and which is fully compliant with the 3rd Generation Partnership Project (3GPP) LTE (Long

Term Evolution), an OBU allows the monitoring and remote control of the vehicle systems and sensors. A LTE network is also deployed in this demonstrator and provides wide area wireless network coverage for the public safety vehicles. A Control Room Application is used to provide a video viewing and recording and a mapping application with vehicle position and CAN data.

C. City parking

Passive traffic, which is the vehicular traffic caused by the searches for free parking spaces, leads to a strong increase of the total traffic in cities. In fact, recent studies [5] showed that searching for free parking spaces in cities takes 6 to 14 minutes. Compared to typical travel lengths in urban scenarios, the drawn conclusion is that searching for a parking space greatly contributes to fuel consumption, to pollution and to the hours lost by drivers when running their errands in the city. Nowadays, a number of strategies have been developed to reduce the time/fuel spent searching for a parking space [6] and some strategies leverage on ICT systems to collect real-time data about parking space usage. The scenario targeted by the application service City Parking (CP) aims to reduce the passive traffic. The complexity of this application service mainly resides in its server side within the background server since both the OBU-CP, which runs on the OBU, and the EXT-CP, which runs on external entities such as parking lots, are straightforward. The CP application service considers instrumenting a reasonable number of parking lots and roadside parking spaces and computing the profile of their utilization indexed by date, time, location, kind of parking space, price, etc. Later on, this service uses the profile to forecast the presence of free parking spaces in a specific area. So, when a driver requests a parking space close to a destination, he is informed about the most probable locations to find a free parking space that responds to his query in terms of hourly cost, maximum distance from the destination, etc.

D. Remote car diagnostic

Remote Car Diagnostics (RCD) is an application service offering to its clients an online monitoring system that takes care of notifying and predicting malfunctioning of the vehicle. The RCD application service is mainly composed by a logical part running in the background server and an OBU-RCD part, which is internal to the vehicles on board unit. The OBU is continuously querying sensors embedded in the vehicle through a communication CAN bus to collect a high-fidelity view of the scenario at hand. Collected data are transferred to the background server through an M2M platform to be analyzed, stored and used by the RCD application service to build profiles about the functioning of different brands/kinds of vehicles that are in a healthy condition. In the meantime, the RCD application service analyzes the distance of the current vehicle's behaviour from its 'healthy' profile to predict potential malfunctioning and suggest maintenance operations to the user. Moreover, the application service will take care of contacting tow trucks/ambulances when a serious problem occurs.

E. DTN data transmission in vehicular context

In the scope of the Remote Car Diagnostic (RCD) demonstrator, we have used a content dissemination and synchronisation framework (FeedSync[1]) capable of handling content transfer in delay/disruption tolerant networks. For this purpose, we have integrated the RCD system to this framework, which has allowed us to transfer data from a vehicle to the backend server, by routing the content through other vehicles and road side unit. For this purpose, the integration required to add a FeedSync proxy on each vehicle and to bridge it with a DTN module. The FeedSync proxy stores the content and transmits to the DTN module, which encapsulates the content in DTN bundles and routes it to other DTN nodes. When received by other DTN nodes, the same module handles bundling decapsulation and transmission to the next FeedSync proxy. When a road side unit receives the content, it transfers it to the remote car diagnostic server.

[1] Submitted paper currently under revision.

5. Conclusion

The CarCoDe project provides a new platform for secure and efficient vehicular communications and data gathering and analysis, thus fitting the increasing requirements of ITS-applications. The project enhances the cooperation between all vehicular network stakeholders and investigates new solutions to increase the security and comfort of drivers and passengers by exploiting new equipments and technologies. The developed platform supports and eases the development and exploitation of new services and applications by external third parties. New applications have also seen the light during the project, which mainly target public safety, city parking and remote car diagnostics.

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