Activities and Applications of the Car 2 Car Communication: The Renault vision

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SUMMARY

The road transport is at the origin of 40.000 fatalities per year in Europe and 1,700,000 injuries. In the scope of its e.Safety program, the European Commission with the support of national authorities targets to divide by two the number of road fatalities by 2010 with a vision to have a "zero fatalities" by 2020. Of course the European car manufacturers strongly support this objective and are convinced that this can be reached only through a combination of means including an efficient co-operation between vehicles and between them and an "intelligent" road side infrastructure. These objectives and convictions led to the development of European activities and projects which are summarized in this contribution. The European C2C (Car to Car) Communication Consortium in relation with the US VSC (Vehicle Safety Communication) project has been playing a key role in the development of the concepts and technologies which are now at the origin of the standardization activities and research projects (GST, PREVENT, SAFESPOT, CVIS) being introduced here below. Many safety applications (some of them being summarized here) will use this standard infrastructure for contributing to a safer road environment.

1. CAR 2 CAR COMMUNICATION CONTEXT

The development of Wireless LAN from IEEE 802 committee has been enabling the development of new services based on the Car to Car (C2C) Communication capabilities and Cars to road side infrastructure (C2I) communication capabilities. However, initially these IEEE 802 standards were not developed for the communication between mobiles at high speed, though the IEEE 802.11b has been demonstrating some capabilities for that. Consequently the IEEE 802 committee, in co-operation with the US car manufacturers has been developing a new standard, the IEEE 802.11p, targeting mobile applications. This standard recommends the use of bandwidth in the 5.8 GHz band. In Europe, due to the diversity of national frequency regulations, it seems that the less constrained band being compatible with the US standard is the 5.885 to 5.905 band (2x10 MHz channels). As it will be demonstrated later on, for safety services requiring some real time performances and a high reliability, it is necessary to have a dedicated wireless LAN. Moreover, to allow in the future, all vehicles of all makers being equipped, it is necessary to select a low cost, mass produced technology such the ones proposed by IEEE 802. This lower layers standard is not enough for the building of Ad Hoc networks and Mesh networks. We need some efficient network layers able to dynamically build a communicating community composed of mobiles being close to each others (for example : for a given vehicle with all others being in a radius of 500 meters to one Kilometer). In this context, it is clear that the IPv6 protocol is a major player, but for some real time applications, this protocol could not be the right one. It is then an important task to identify in what extend IPv6 is relevant for the coverage of all C2C and C2I needs, what are its intrinsic limits and how this protocol could be enhanced, complemented to obtain a 100% coverage of the C2C / C2I needs and requirements. As it is clear that the C2C / C2I infrastructure must be adapted to support the various targeted safety applications, the needs and requirements for this infrastructure will be emerging from the development and experiment of these applications (see the section 4 of this paper).

2. CAR TO CAR COMMUNICATION CONSORTIUM

The Car2Car Communication Consortium is a non-profit organisation initiated by European vehicle manufacturers which is open for suppliers, research organisations and other partners. Its mission is to:

- establish an open European industry standard for Car2Car and Car2Infrastructure communication systems to guarantee European-wide inter-vehicle-road side infrastructure interoperability.
- promote the allocation of an European wide exclusive frequency band for Car2Car and Car2Road side infrastructure safety applications.
- encourage the harmonisation of these Communication standard worldwide.

To achieve this mission, the C2C-C Consortium has been fixing its objectives as:

- Creating an open European industry standard for inter-vehicles and vehicles-Infrastructure communication systems based on off-the shelf wireless LAN components .
- Taking into consideration worldwide related activities.
- Promoting the allocation of a royalty-free European-wide frequency band for Car2Car applications.
- Enabling the development of active safety applications by specifying, prototyping and demonstrating the C2C system.
- Developing realistic deployment strategies and business models to speed-up the market penetration.

Currently, the C2C-C Consortium is constituted of the six following car manufacturers :

- AUDI
- BMW
- DAIMLER CHRYSLER
- FIAT
- RENAULT
- VOLKSWAGEN

However, this Consortium is open to other European car manufacturers and the main stakeholders of the European transport system which are interested by this considered domain.

3. CAR 2 CAR RELEVANT EUROPEAN PROJECTS

In term of activities, the C2C-C Consortium partners have started to develop their C2C and C2I visions into several European Research projects, being supported by the European Commission, in the scope of the 6° PCRD (R&D Framework Program). The safety issue is now well understand by the car manufacturers who are contributing to both type safety (as represented on the following 3.1 figure) : active safety (avoiding an accident) and passive safety (mitigating the impact of an accident). This figure allows also to position the contribution of three European Integrated projects which are summarized below :

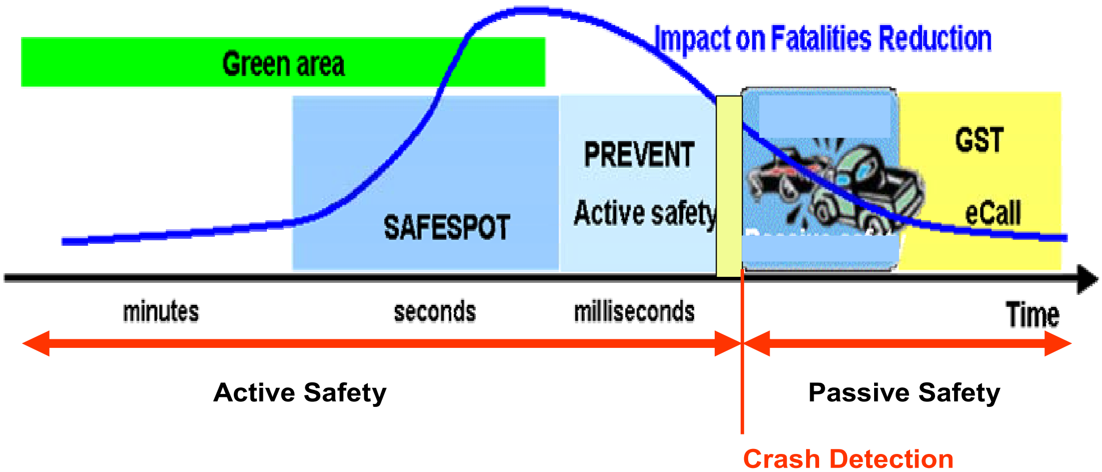

Figure 3.1 : Active and passive safety

3.1 GST Contribution

The GST (Global System for Telematics) Integrated Project (started one year ago for a total three years) is not mainly focusing on Car to Car or Car to Infrastructure communications and applications. However, some of its subprojects are still related to the domain of C2 C and C2I. This is the case for the four following subprojects.

- **Open System** is working on the development of standard protocols (mainly application protocols for telematic services). This is achieved with the vision of obtaining a common open telematic system facilitating the interoperability between the cars and all servers supporting the targeted services. Such objective is of course common with the ones defined by the C2C-C Consortium and many of the upper layer protocols defined by GST could be re-used for some C2C and C2I applications.
- **SEC (Security)** is working on the specification of security mechanisms to be used as well at the In-Vehicle telematic platform level, as for the exchange of information between the In-Vehicle telematic platform and off board servers. Some of these security mechanisms could also be used in the context of C2C and C2I communications.
- **CERTECS (Certification for Telematics Components & Services)** is developing a global approach for the Certification of Telematic Components and Services. This includes conformance testing, interoperability testing, security testing, EMC testing,...etc., with some design inspections including the approach followed by the supplier to manage the risks of dysfunctions (caused by a failure, a fault, a security attack) of the proposed implementations. Standard Conformance and Interoperability are at the centre of C2C and C2I implementations as all cars from different makes, different models and all road side

infrastructure units must conform to the selected standards and be able to safely interoperate between themselves to fulfill their missions and services.

- **RESCUE** is proposing several C2C services (Warning Triangle, Blue Corridor or Blue Wave, Virtual Cones) which are described in the section 4 of this paper.

3.2 PREVENT Project

This four-year Integrated Project has been started in 2004 and will be developing, testing and validating Preventive (active) safety applications using advanced sensors and communication devices integrated into In-Vehicle systems for driver assistance.
The objective of the project is to help drivers avoiding accident by sensing the nature and significance of an imminent danger, while taking the driver's state and status into account. Depending on the importance and timing of the foreseeable danger, the system will alert the driver as early as possible, warn him / her and, if there is no reaction on the part of the driver, actively assist or ultimately intervene in order to avoid and mitigate the accident.
PREVENT is not centered on C2C and proposes a combination of means including specific sensors (e.g. anti-collision radars). However, the WLDW (Wireless Local Danger Warning) subproject of PREVENT is focusing on a C2C communication system development and validation.

3.3 New EUCAR Supported Projects Overview

Two project proposals supported by EUCAR (Technical committee of ACEA (Association des Constructeurs Européens d'Automobiles)) and the C2C-C Consortium are currently under development and evaluation. They are :
The SafeSpot IP proposal – This project proposed by EUCAR is aiming at specifying, developing and validating C2C and C2I applications supported by C2C and C2I standard communication infrastructures such as currently promoted by the C2C-C Consortium. Some generic applications (e.g. accurate local relative cars positioning, local dynamic map) will be used for the support of other safety applications (see some synthesis in section 4 of this document).
The CVIS IP proposal – This project proposed by ERTICO is focusing on Cars to Road side Infrastructure co-operation. This proposal contains some road safety contributions, but is more focusing on increasing the efficiency of transport systems.

Indeed these two projects (proposed within the scope of the E.C call on Transport co-operative systems) shall be relying on a common standard C2C and C2I infrastructures. It is why a strong co-operation has been started between the two project consortium leading to some compatible organizations, especially for the standardization and deployment of common technologies and common communication / application standards.

4. SOME CAR 2 CAR APPLICATIONS

This section provides some synthesis of safety applications which are considered by the various activities and projects which have been introduced here before. This is certainly a not exhaustive list of applications:

4.1 Accurate local relative cars positioning

This is a generic application to be used by other applications (e.g. Driver advice on safety margin) based on the capabilities for a given vehicle to detect some accident risks. Such capabilities rely on the definition of some logical rules taking into account the surrounding vehicles respective local relative positioning, their respective speeds, road conditions,...etc. The need for such an application arises because the position information provided by GPS/Galileo systems does not meet general requirements set by safety applications. As a matter of fact, such applications need a highly accurate and reliable relative position information, rather than an absolute indication. Hence, a specific solution, based on the co-operation between vehicles and infrastructure has to be developed comprising:

- relative vehicle location via ad-hoc network
- vehicle location via landmarks
- techniques for location accuracy enhancement
- …etc.

4.2 Local Dynamic MAP

All intelligent vehicle functionalities rely on the vehicle's knowledge of its surrounding environment. The "knowledge" is represented as a dynamically updated world model (**local dynamic map**). Inputs to the model are (fused) sensor data, data exchanged with other surrounding vehicles and static data (e.g. digital map data). Output from the model is real-time data to be used in control algorithms (e.g. for the driver advice on safety margin application). An advanced version of a local dynamic map will not only have an accurate road map but a map where the own vehicle data and data from the other vehicles and external infrastructural components are integrated. This world model is a generic component that is needed for co-operative applications and it fills the gap between sensors/sensor data fusion, static data and applications. It has to be emphasized that such local dynamic MAP maintenance will require a strong real time co-operation (and then communication) between all the cars which are moving locally and between these cars and the road side infrastructure.

4.3 Driver advice on safety margin

The so called "SAFETY MARGIN" has been built during the definition of the SafeSpot proposal and can be described as following:

The vehicle (or the infrastructure) collects all the available information about traffic (road users in the surroundings), state of the road, vehicle types, geometry of the road, weather/visibility conditions, traffic rules, etc. Based on these information it will be possible to define what are the best conditions for the driver/vehicle in order **to travel through that specific road segment safely** (fig 4.1 below). Obviously the main parameter is the vehicle speed, but also other characteristics will be considered (distance from preceding vehicles, lane, etc.).

Figure 4.1 : Advice to the driver according to an assessed local situation

The safety margin will be defined considering :

- the possible dangerous situation that could happen in that specific road segments;
- the dynamic capabilities of the vehicle, taking into account the road status;
- the driver status, its capability to manage emergency manoeuvres correctly.

The concept of the SAFETY MARGIN is today left to the driver subjective analysis of the traffic condition. With the cooperative systems approach it will be possible to have all the necessary information to suggest a more “objective” Safety Margin to the driver.

4.4 Local Danger Warning

The local danger warning application is the capability provided to a given vehicle to signal in real time to all other surrounding vehicles any danger which can be automatically detected. Local danger can be :

- Some vehicles in accident. In this case, it is the vehicle(s) in accident which is / are issuing a “local danger warning” (e.g. the GST – RESCUE warning triangle).
- An immobilized vehicle due to a breakdown situation. The concerned vehicle will then issue a local danger warning.
- A vehicle in Fire, particularly in risky areas (e.g. in a tunnel or a parking). In this case, the concerned vehicle can start the broadcasting of a local danger warning as soon as an excessive temperature is detected. Such alert can then be repeated by the infrastructure or by other vehicles.
- When a bad weather condition is detected (e.g. some slippery icy condition) by a given vehicle .

- ➢ When a bad road condition is detected by a given car (e.g. signaling some oil on the road making it slippery: use of the ESP car function for such detection).
- ➢ ....etc.

Possible local dangers are numerous and when detected, can be at the origin of broadcasted messages to all vehicle which are surrounding the detecting vehicle. Such messages can also be relayed by other vehicles (Ad Hoc networks) and by the road side infrastructure.

4.5 Road side Information display

Road side information which are not always visible from drivers due to some obstacles (e.g. trucks) between them and the road side signs can be advantageously broadcasted and then be displayed by all the drivers (see the following 4.2 figure below) HMI.

Figure 4.2 : Head up display of road signs

This is typically a road side infrastructure – car communication allowing to supply a lot of information as well static (directions, permanent dangers, proximity of point of interest,...etc.) as dynamic.(actual speed limit, temporary dangers, traffic information, weather condition information, ...etc.).

4.6 Relaying safety related information

The Europe telecommunication coverage is not absolute. A lot of communication black spots are sill existing (Tunnels, underground parking, rural areas, ...etc.) and will continue to exist for a long time. This situation can be improved by using Ad Hoc or Mesh networks created through the C2C and C2I communications. These mobile networks will be complementing the existing global networks and adding some supplementary bandwidth to compensate for in case where the existing telecommunication infrastructures is not capable to provide the requested service. Then these mobile networks will be used to relay and propagate urgent information until finding an available global network access point (e.g. GSM / GPRS, UMTS, WiMax,...etc.). A typical example would be the e.Call propagation until finding a GSM access point.

4.7 Right of Way Vehicles Routing

During emergency situations, it is necessary to give way in priority to emergency vehicles (Police, Fire vehicles, ambulances,...etc.). For this purpose, the GST RESCUE has been defining the two following services :

- The “blue corridor” or “blue wave” which consist for an emergency vehicle to require to all vehicle ahead to give way and free some emergency corridors. Such broadcasted message can give some precisions on the corridor to be released.
- The “virtual cone” is replacing the physical orange cone which are put on the road to signal some problem or some work. This broadcasted virtual cone message will be used to guide surrounding vehicles in order for them to avoid these problems and leave some specific corridor reserved for the necessary interventions which are going on.

4.8 Abnormal situation alerts

Abnormal situations can be detected by an intelligent road side infrastructure when exchanging with the cars which are using it (e.g. the access by a given vehicle of a road portion which is not authorized) or can be detected and signaled by the car itself (e.g. stolen vehicle). Under such abnormal situation two different car - road side infrastructure behavior can be found:

- If a vehicle is entering a forbidden area for it (in the forbidden direction of a one way road, exceeding a tunnel limited height, transported payload or vehicle size not allowed,...etc.). In such case, upon detection of the abnormal situation, the road side infrastructure will signal it to the concerned driver and then may alert the road authorities if this abnormal situation is creating some dangers.
- If a vehicle detects itself an abnormal situation (e.g. stolen vehicle, driver in difficulty,...etc.), it can signal it to other vehicles and to the road side infrastructure in order to alert the police / emergency services to act and solve the identified problem. This is also a way for police vehicle to interrogate vehicles and detect those which are stolen.

5. MAIN REQUIREMENTS & CONCLUSIONS

This article proposes some innovative applications, based on C2C and C2I, to increase the road safety. As it can be derived from these various applications which are proposed here, one essential requirement is the development of common communication standards being used between all the cars whatever their makers, their models and versions , but also between these cars and the road side infrastructures being developed in Europe. The C2C consortium has been identifying the need for 2 x 10MHz channels being necessary to maintain an accurate dynamic map of the vehicles progressing in the same local area.

This bandwidth is justified by the necessity of a tight coupling between cars (at 100 Kms / hour, a car progresses of about 27 meters per second) and by the number of cars which may be using simultaneously this bandwidth (several hundreds in a local area of 500 meters radius).

The main problem will be the fast deployment of these technologies allowing to take a real profit of these new services. Such fast deployment could be only possible if the cost of the telematic system to be used reaches an acceptable low level. Moreover, the proposed standards shall be the same across Europe in order to avoid generating an unnecessary complexity. All these requirements led the C2C-C Consortium and other actors of the standardization to support the allocation of a road transport dedicated Wireless communication system in the 5.885 to 5.905 GHz band. This band which is compatible with IEEE 802.11p standard proposal will be reserved for road safety applications, so offering the expected quality of service.

The strategic deployment of these services shall be achieved in strong co-operation between all the stakeholders of the road transport including of course the public authorities which are directly responsible for the safety of their European citizens.