COM2REACT: V2V COMMUNICATION FOR COOPERATIVE LOCAL TRAFFIC MANAGEMENT

Arnaud de la Fortelle, Claude Laurgeau, Paul Muhlethaler, Yasser Toor

COM2REACT: V2V COMMUNICATION FOR COOPERATIVE LOCAL TRAFFIC MANAGEMENT

Arnaud de La Fortelle[1,2], Claude Laurgeau[1], Paul Muhlethaler[2], Yasser Toor[2]

ABSTRACT

The European project COM2REACT aims at building a local cooperative traffic management system through a peer-to-peer application, the Virtual Sub-Center (VSC), based on vehicle-to-vehicle (V2V) communication. COM2REACT is an enhancement of the REACT system, which relies on a central server that gathers data from probe vehicles, aggregates and analyzes them by an integrated set of models, and generates both vehicle-specific recommendations and information for relevant authorities. This additional collaborative layer will increase the reactivity of the system and avoid an overload of communication and of the central server with information only relevant at a local level. The goal of this paper is to give the reader an overview of the new technologies developed to reach the ambitious goals of COM2REACT: V2V communication, VSC and local traffic applications.

KEY TOPICS

4.8 Wireless Communications to/from/among Vehicles

Secondary: 10.4 Probe Data Processing

KEYWORDS

V2V Communication, collaborative system, Traffic management.

Secondary: Traffic, safety, efficiency, sensors, probe vehicles, communication, intelligent transportation systems (ITS), peer-to-peer application, Virtual Sub-Center (VSC).

PAPER TYPE

Scientific

REGION

Europe

---

[1] Mines Paris, 60, Boulevard Saint Michel 75272 Paris cedex 06, France, {Claude.Laurgeau, Arnaud.de_La_Fortelle}@ensmp.fr

[2] INRIA, Domaine de Voluceau, Voluceau, Rocquencourt BP 105, 78153 Le Chesnay Cedex, France, {Paul.Muhlethaler,Yasser.Toor}@inria.fr

1 INTRODUCTION

Effective large-scale control of traffic, geared to address both efficiency and safety, requires a system incorporating a hierarchy of control levels:

1. High control level over an urban, metropolitan or regional area provided by a Regional Control Centre (RCC) that acts as a strategic controller
2. Middle control level provided by local sub-centres, each operating over a limited number of nodes and links in the road network
3. Low control level implemented within an individual vehicle

COM2REACT's (COoperative CoMmunication System TO Realise Enhanced Safety And EffiCiency In European Road Transport) overall objective is to establish the feasibility of such a three-layer, scalable, cooperative system. Its implementation will involve the deployment of two two-way communication systems: vehicle to vehicle (V2V), and vehicle to infrastructure (V2I). This structure will facilitate significant improvement in the flow of information acquired by moving vehicles and in its quality and reliability, thereby enhancing road efficiency and traffic safety on urban, intercity arterials and rural roads.

A key objective of COM2REACT is the implementation of the middle control level by means of a virtual traffic control sub-centre, which manages a moving group of vehicles in close proximity. The virtual subcentre (VSC) functions locally via the V2V communication system. It obtains and processes data acquired by the vehicles and rapidly provides instructions related to local traffic and safety situations. It also transmits, by means of the V2I communication, selective data to an RCC and receives, in return, instructions to distribute to the vehicles. The role of VSC is set, unnoticeable by the driver, to one of the vehicles in the group according to rules imbedded in all COM2REACT vehicles.

The COM2REACT system will build upon the DG Research REACT project to create the high level and the low level layers of the system. REACT comprises RCC, V2I communication and sensor-equipped vehicles. COM2REACT's newly developed VSC will interface with REACT's RCC, utilizing REACT's V2I communication, with the appropriate adaptations. At the low layer REACT's vehicles will be used, complemented with additional sensors, in order to test the COM2REACT system and confirm its feasibility under the conditions pertinent to traffic safety: vehicle state, driver state, road state and intervehicle situations.

Hence the most significant developments that are developed hereafter are:

- A V2V ad hoc network using WiFi communication.
- The VSC: a peer-to-peer layer enabling local cooperative traffic applications.
- The integration of the COM2REACT system within vehicles and applications tests.

2 VEHICLE-TO-VEHICLE COMMUNICATION

COM2REACT did not undertake new communication development, but to overcome current limitation, e.g. range limitation. The project performed extensive testing to choose the best available wireless technologies (focusing on 802.11 devices). The goal is to enable experiments of the whole COM2REACT system while keeping modularity: e.g. WiFi 802.11b/g cards can easily be replaced in the future by 802.11p. The same conception lead to remain untouched subjacent layers, such as MAC or physical layer.

The network operation is ensured at a higher level by routing protocols, adaptable to mobility situations. The implementation is based on the existing Optimized Link State Routing Protocol (OLSR), which is especially developed for mobile ad-hoc networks. It operates as a table driven and proactive protocol, thus exchanges topology information with other nodes of the network regularly. The COM2REACT consortium is well aware that routing algorithms and models for vehicle and mobile ad-hoc networks are already offered today by research consortiums projects such as Network on Wheels (NoW), CarToCar or IETF (MANETs). However, these protocols do not meet the requirements of the project. Some of them are not yet available while other do not offer the required parameters (e.g. the communication topology is necessary for the VSC). Hence OLSR has been chosen and a special version that satisfies COM2REACT needs is being implemented. OLSR has been developed by INRIA

and standardized at IETF, is already well recognized by the industry (OLSR is implemented on CISCO routers) and will be proposed in other European projects (Cyvercars2, CVIS…). Besides, the protocol does not require reliable transmission of control messages. Some other topic have been addressed such as:

Geographic id vs. IP id.

Type of communications: Unicast vs. multicast communications (geo-cast routing).

Dynamic initialization.

Finally, at the intersection between communication and application, negotiation algorithms are being developed to assign the roles of each entity behind a local area network, within the VSC.

3 VSC : P2P LOCAL TRAFFIC MANAGEMENT

A main objective of COM2REACT is the design and analysis the different options for the communication and control process that is needed for the functioning of the novel VSC-concept. In the current developments, and excepting the functionalities covered by the REACT system (V2I), the principles underlying the VSC are as follows:

• All COM2REACT vehicles are equipped with compatible communication and processing systems and identical capabilities and can function as either VSC or an individual vehicle.

• V2V module detects neighbouring vehicles, as soon as vehicles are in communication range. There the adapted ad-hoc protocol links the vehicles: a group is formed. A signal will be send to the VSC host so that it takes into account the arriving vehicle. This holds for departing vehicles. Special cases are group creation, host departure and group destruction. These cases are handled by the routing protocol, but it is necessary to ensure the correct communication between the routing layer and the VSC layer.

• Vehicles in a group communicate with their VSC (using V2V) (1) routinely, informing it of their location, destination and status (communication rate to be determined) and (2) upon the occurrence of special events, as detected by their in-car sensors. Such events could be related to vehicle status, road conditions, state of the driver or neighbouring vehicles.

• Vehicles are capable of direct communication (V2V) with each other but avoid it except for emergencies such as collision avoidance.

• Vehicles association with a group is done according to prescribed rules that depend on parameters such as range and local vehicle density. These parameters will be periodically continually observed by the vehicles, which will join with, or depart from groups of vehicles accordingly.

There are a variety of open issues that will be investigated in more detail, e.g. the frequencies for communication and positioning information, the decision process to direct communication to the VSC or to other vehicles, the synchronization of different information flows, the dynamic adjustment process dealing with a constantly changing constellation of moving vehicles etc.

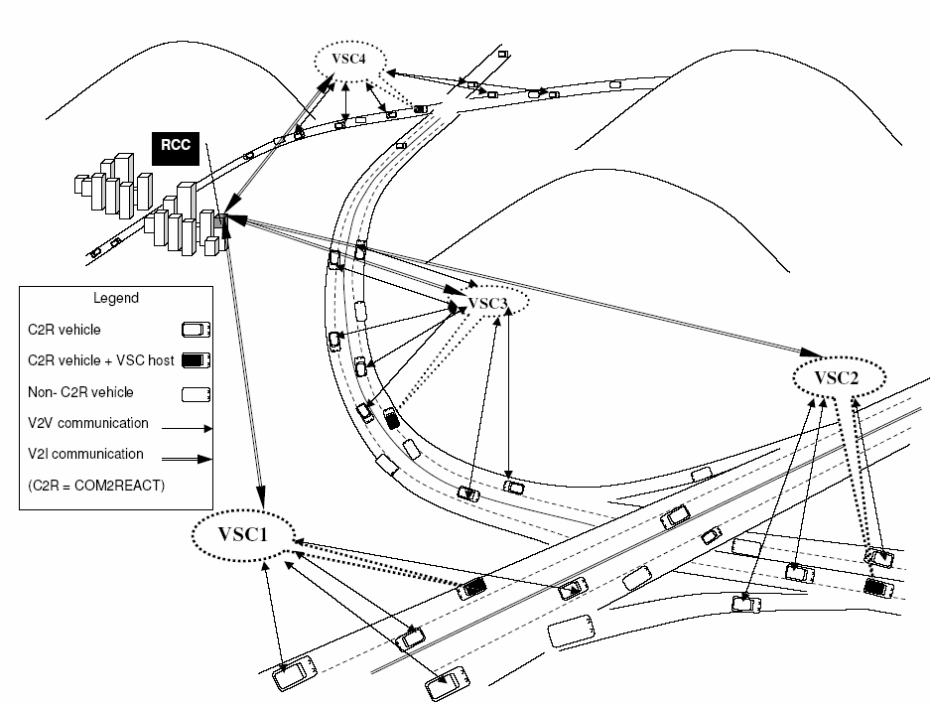

Figure 1 The COM2REACT system and VSC concept

Traffic models are also being developed to fit the COM2REACT system. They will provide the data and decisions necessary for the 4 applications that have been defined:

- Local navigation system
- Traffic flow control
- Collision warning by locating “hazards” (static obstacle or inattentive driver)
- Traffic state assessment and fusion

Since the beginning of 2007, a lot of experiments have been conducted in order to test the concept of VSC and the technological specification of such a system. Concerning V2V communication, the system uses a standard 802.11b card with 9 dB antennas on top of the roof. With such hardware, ranges of 700m on motorways and 300m in cities can be achieved with a sufficient stability.

The networking layer based on the routing standard OLSR ensures the diffusion of the messages inside a VANET. Here, again, the concept has been refined. Originally, it was thought that the whole VANET (the topologically OLSR-connected component) would be the VSC cluster. In fact, it is only necessary that the VSC cluster is a *subset* of the VANET, constituted by vehicle sharing the same informational need (e.g. vehicles driving in the same direction). Experiments prove that OLSR is not currently entirely satisfactory since it increases some latency (at reconfiguration times), but it is sufficient for the current system.

VSC layer experiments have proved the system is functional. The information in all vehicles is exactly the same with a very small latency. With the same information, all vehicles decide for themselves with exactly the same algorithms, hence decisions are consistent. Moreover, with the same information (similar to the Safespot *local map*), more applications can be easily designed without much strain on the communication links.

4 EXPERIMENTS & CONCLUSION

All the technologies will be integrated into 5 cars: 4 identical C3 cars from Mines Paris and one additional C3 from Sphericon (integrating the DAISY Sensor). Figure 3 shows the C3 at INRIA: these vehicles are part of the Joint Research Unit “LaRA” (www.lara.prd.fr) between Mines Paris and INRIA. The in-car architecture is derived from REACT, with extension in communication, maps calculation (ADAS-RP), sensing and local application (VSC).

Figure 2. REACT sensor vehicles: 4 LaRA C3.

Several tests will take place. WiFi is being tested to chose the hardware. Then VSC tests will validate the VSC basic functionality (formation, dynamic management…). A third step is a system test combining the VSC capabilities with the Regional Control Center (RCC, centralized management). A last set of experiments will prove that VSC can be deployed without a RCC. Finally a public demonstration will take place by the end of October in Paris, France. The last two sets of experiments will demonstrate that the COM2REACT system is operational and easily deployable for the next generation of traffic management systems.

ACKNOWLEDGEMENTS

COM2REACT (www.com2react-project.org) is a project funded by the European Commission within the Sixth Framework Program.