Networking Needs and Solutions for Road Vehicles at Imara

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Areas of interest: In-Vehicle, Inter-Vehicle and Infrastructure to Vehicle Communications; ITS Architecture, Interoperability and Standards; Mobile IP and Network Mobility in IPv6.
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The Imara team has been working on transport systems innovations for more than 10 years and is involved in several european projects in this field (CyberCars 2, COM2REACT, CVIS, etc.). Trying to provide safer and more efficient transportation solutions, several axes are explored, such as driver information systems, collaborative road data collection or even fully driverless vehicles. In this context, the need for reliable and efficient communications is increasingly present.

Basing the physical layer on off-the-shelf solutions like Wifi or GPRS, various techniques are developed and used to achieve communication between the involved entities. Due to its generality and wide availability, IP (either v4 or v6) is used as the network layer.

This paper proposes a survey of the methods employed at Imara to try and provide a stable communication environment allowing driverless vehicles to interact with each other in several types of driving situations where information sharing is needed. An account of how the solutions are integrated and, finally, how well they behave together in live experiments is given.

1 Communication needs

Depending on the desired goal, both communication with closeby peers and with remote installations are necessary. We identify three example communication scenarii requiring specific connections with other networked components.

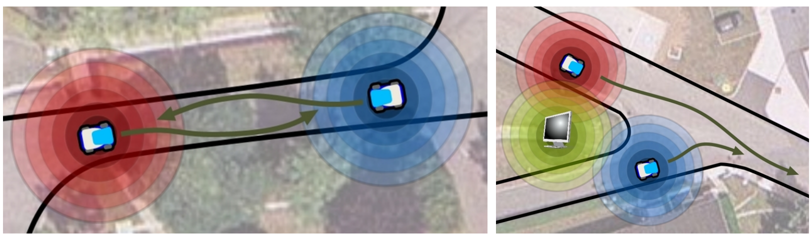

Figure 1: Two driving situations where communication is desirable for the vehicles to collaborate: trajectory planning and exchange (left) and passing of a supervised crossroads (right).

Vehicle to vehicle It is usual to be in such a situation that two vehicles, going into different directions, have to share the same road segment. In this case, collaboration is highly desirable to

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allow a better path planning. By exchanging trajectories and intentions information (Fig. 1, left), the vehicles can elaborate paths (using, for example, PMP [1]) together which can be safer and more efficient for both vehicles.

Vehicle to infrastructure In some situations, communication with neighboring vehicles is insufficient to provide interesting information. It may be necessary to communicate with the infrastructure to get information about a crossroads, in order to pass it safely (Fig. 1, right), or to report traffic information (*e.g.* road congestion or heavy rain) to a central server in order to warn other drivers.

Service announcement On a more general basis, one can see every vehicle and parts of the infrastructure as subnetworks providing one or more services. It is necessary to have a network-independent method to allow every entity to discover what its neighbor can provide in terms of services. This is an important part of the communication system as it is not reasonnable to assume every entity to be similar. Indeed, each vehicle may provide heterogeneous informations and algorithms. Two peers first have to know which of these services they have in common in order to be able to cooperate. Then, they should elect the best common service as the one they'll use in this case. Finally, they can work together to achieve the most efficient actions for both of them.

2 Technical proposals and systems

Trying to address the situations given above, some technologies have been chosen and are currently, or in the process of being, implemented in our vehicles and infrastructures.

OLSR mesh networks In the case of neighboring vehicles needing to communicate, local ad-hoc wireless networks can be used. The use of OLSR to build multi-hop mesh networks allows to extend the range of the basic physical layer and form larger clusters of interconnected vehicles. This permits the vehicles and infrastructures to have information from distant nodes more in advance and plan their own decisions with more knowledge about the supposed future.

IPv6 mobility When communicating with a remote infrastructure, it may be desirable to reach a vehicle which attachement point to the network topology changes. Providing a mobility layer (integrating MANET and NEMO [2]) therefore seems highly necessary. An experimental IPv6 testbed has been developed at Imara to provide IPv6 and a mobility mechanism to the test vehicles. With this technology, both pure road-management- and leasure-oriented traffics can be seamlessly exchanged with a mobile vehicle.

Zeroconf Based on Apple's Bonjour protocol, several Zeroconf implementations for various software platforms have been implemented. Using Multicast DNS services and services announcements seems to be an efficient way to inform peers in the network, be it meshed or more regular, about which information (*e.g.* sensors readings) or services (*e.g.* algorithms) every entity can provide.

References

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