Report Dagstuhl Seminar 10402
Working Group on Communication Patterns

Claudio Casetti
Falko Dressler (Moderator)
Lars Eggert
Felix Schmidt-Eisenlohr
Jérôme Härri
Ozan Tonguz
Jörg Ott
Lars Wischhoff

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1 Introduction and Motivation

The objective of the working group communication patterns during the Dagstuhl Seminar on Vehicular Networks has been to review the current status of the communication patterns and principles and discuss the upcoming challenges the community will face in the near future. This is an executive summary of the discussions during the sessions.

2 Communication Principles

An important discussion took place in the context of the future heterogeneous vehicular networks. Beside the IEEE 802.11p basic access technology, cellular technologies such as 3GPP Long Term Evolution (LTE) is taking an increasing popularity as a complementary access technology to compete for the three major communication patterns found in vehicular networks: Vehicle-to-Vehicle (V2), Vehicle-to-Infrastructure (V2I), and Infrastructure-to-Vehicle (I2V). Another particularity of vehicular networks to be considered for the different access technologies is the predominant role of the broadcasting, or geo-broadcasting, principle compared to traditional networks.

Investigating the capabilities of the two major access technologies to cover these communication patterns and principles, IEEE 802.11p has initially been selected for its capability to natively fulfill all communication patterns, for its high bandwidth and for its low latency, particularly in the case of V2V for traffic safety applications. However,

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the newest evolutions of LTE rel. 11, also known as LTE-Advanced, will also allow dedicated communication bypassing a Base Station. Considering the current work in a new research paradigm called Machine-2-Machine communication and its strict low latency requirements, it is expected from LTE and LTE-A to also reduce their servicing delay.

On the communication principles side, it is well known that cellular networks have not been designed for broadcast communications. In particular, when information is required to be broadcast in a small area, potentially spanning over different cells, IEEE 802.11p and its native dedicated broadcast capabilities is particularly adapted, and although IEEE 802.11p is expected to lose its predominant role in the future, it will remain a strong competitor notably for localized low delay broadcast communications and services. For larger unicast coverage, LTE is expected to appear as a critical player.

It would however also be wrong to consider LTE as capable of transporting any traffic required for vehicular networks. Although LTE and LTE-A will provide competing bandwidth, unlike IEEE 802.11p, they will also have to service high demanding commercial traffic such as online gaming or mobile television. As it is already the case now with UMTS networks and WLAN, IEEE 802.11p will play a critical role in off-loading traffic from cellular networks. Generalizing, considering the various frequency bands available nowadays, using them in a seamless way and regardless of the employed technology following cognitive networking principles, will probably be a major research challenge in the upcoming years. It is therefore expected to see various technologies, such as LTE, LTE-A or IEEE 802.11p to cooperate instead of compete as function of the user, application or network operator preference. The traditional boundaries related to access technology and communication patterns are expected to disappear in the near future.

As previously mentioned, a key communication pattern in vehicular network is the one-hop broadcast, which role is to make other vehicles aware of the presence of the transmitter and the potential danger that could appear. A major paradigm shift can be observed in vehicular networks: whereas cellular or WLAN networks seek high broadcast bandwidth with limited reliability, vehicular network require a very high reliability, low delay but mostly low bandwidth. Despite its simplistic access, IEEE 802.11p, as any open-loop channel access principle, has not been defined to this objective. A critical but basic challenge should therefore aim at developing innovative broadcast mechanisms aiming at providing a low latency and high reliability 1-hop broadcast in highly dynamic topologies.

So far, the discussions were limited to homogeneous vehicular populations. Vehicular network are expected to be a part of a future heterogeneous and ubiquitous network of pedestrians, buses, bicycles, trams and vehicles. In this perspective, the interoperability and cooperative technologies should be investigated. Can we use IEEE 802.11p to also inter-network pedestrians using their smart phones? Should we use RFID or IEEE 802.15 technology? More generally, how can we detect and contact any mobile player in an area irrespectively to its technology, operator and mobility aspect? These are just brief examples of the future challenges of ubiquitous vehicular networking.

Finally, vehicular networks are also expected to influence future applications. Assuming vehicles being ubiquitously connected, considering their processing and storage capabilities, challenging directions in cloud computing and adding vehicles into the cloud

will appear in the near future. A key observation for the success of applications to vehicular networks is that they should be easily deployable and should already work at low deployment rate. The identity of vehicular network is also expected to evolve. Two major tendencies may already now be found: vehicles are driven by human being therefore showing social aspects. Also, vehicles, therefore machines, communicate to assist drivers thus creating networks of machines. Both trends show different patterns, as social networking connects vehicles with similar social features, is oriented toward high bandwidth but is delay tolerant. Machine-to-Machine (M2M) networks on the other hand connect vehicles without any social context, have low bandwidth requirements but strong delay requirements. Whereas social and mache-2-machine networking is two different research paradigms, it can be jointly found in vehicular networks.

3 Conclusion

Concluding, future communication patterns in vehicular networks will we independent from the available access technologies (IEEE 802.11p, LTE-A, WiMAX), but before developing elaborated communication mechanisms over multiple hops or technologies, the basic one-hop broadcast paradigm should be solved. It is also expected to find novel patterns and paradigm such a social or machine-2-machine patterns jointly being employed and optimized. Finally, a critical aspect is the identification of the role of vehicles in the future numerical infrastructure society, where heterogeneous services and service patterns might become more crucial than the communication patterns themselves. The existence of vehicular network depends on this.