A Concept for an Adaptive Communication Middleware for Car-2-Cloud Applications

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I. Introduction

The connectivity of vehicles is already omnipresent in luxury cars and transportation. Applications like remote diagnostic management, emergency calls, or traffic jam avoidance are only possible through Car-2-Cloud communication. The connectivity of vehicles will become even more important in the future due to autonomous driving and other connected-car services. However, the availability of existing and future mobile radio networks cannot be guaranteed everywhere, especially in rural areas, car parks, and tunnels. Depending on the network connectivity and quality, applications should adapt their communication behavior and distinguish between safety-critical, necessary, and less important data traffic. This paper introduces our concept of a middleware which adapts the communication behavior of vehicular applications and switches between different communication protocols and transfer media. A more detailed description of the approach, a discussion of the relevant applications and their requirements, as well as an extensive review of related work can be found in [1].

II. Vehicular Communication

We identify four communication channels which are depicted in Figure 1. First, at home or in public areas WiFis can be used for transmission. Second, a connection could be established via mobile radio networks such as 3G, 4G or even 5G. Third, fixed communication stations deployed along the road – so called *Road Side Units (RSUs)* – can be used for communication. Lastly, data can also be transmitted via hop-based communication across other vehicles.

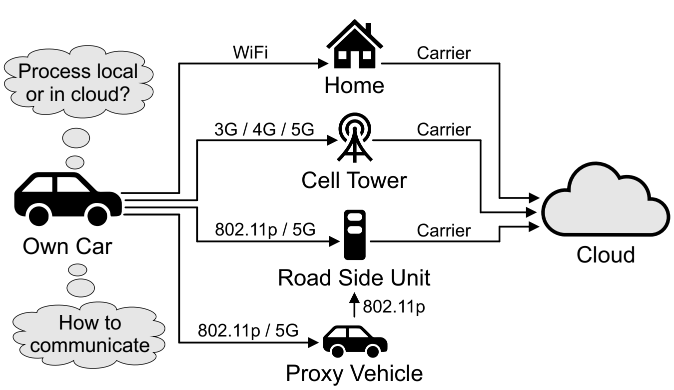

Fig. 1. Communication Types for Car-2-Cloud Transmission.

III. Applications

Car-2-Cloud applications have different requirements and can be classified among others by the following characteristics [1]:

- Online (while driving) or offline data exchange.
- High or low priority traffic.
- Required bandwidth.
- Frequency of transmission.
- Applicability for smart cities and/or highways.
- Compliance with real-time requirements.
- Bidirectional or unidirectional.

Example applications which differ in their requirements are real-time navigation, parking lot search, charging station management, remote control of autonomous vehicles, machine learning for autonomic driving, vehicle as an office, insurance profiling, tolling, and platooning coordination.

IV. Adaptive Approach

We are working on an application-aware middleware which selects an appropriate communication channel meeting the requirements of an application If no sufficient or suitable communication channel is available, data may be buffered for later dispatch. Applications such as route planners should be advised to perform calculations locally or in the cloud.

Currently, we are developing a simulation environment for Car-to-Cloud communication. The environment integrates a vehicle driving simulator and a network vehicle-to-cloud simulator. We will complement the simulation environment with a middleware for adaptive Car-to-Cloud communication, e.g., for choosing the best parameters and protocols for different use cases. This integrates self-adaptation into the communication as well as the placement of applications.

In addition to the simulation environment, we plan to apply our approach in a testbed for benchmarking in cooperation with an industry partner. The aim of the testbed is the verification of the simulation results as well as executing tests on real hardware, including real driving scenarios.

References

[1] S. Herrnleben, M. Pfannemüller, C. Krupitzer, S. Kounev, M. Segata, F. Fastnacht, and M. Nigmann, "Towards Adaptive Car-to-Cloud Communication," in *IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom)*, (Kyoto, Japan), 2019.