# Runtime Infrastructure for simulating Vehicle-2-X Communication Scenarios

Tobias Queck

Outline for his Master of Science Thesis in Software Engineering

## I. MOTIVATION

The vehicle manufacturing industry plans to integrate vehicle to vehicle and vehicle to infrastructure communication (V2X) into their products in the near future. As consequence of the additional investments, research in the area of vehicular communication has already increased considerably. Due to the industry's demands, the research community has to substantiate their research results in real-world use cases and applications.

Vehicle-2-X Communication provides the foundation for new applications that enhance both safety and traffic efficiency. The applications have to support or even replace the driver in regular or critical traffic situations. When the integration of Vehicle-2-X Communication components in new vehicles is started, it must be considered that it will take an undefined period of time until all vehicles are covered with the necessary components. The length of this period is essentially affected by the additional costs for the communication equipment. Consequently, applications must already generate measurable benefits for the driver when only a small amount of vehicles is covered with the new hardware.

During the last years, the research in V2X communication has been focused amongst others on hardware requirements, security, communication, and routing protocols; and on application, trust, and privacy concepts. The results have been evaluated and proofed mainly by simulations. Specific simulation tools for either traffic or networks are available and fulfil the necessary requirements. Currently, one aim of the automotive research is the development of V2X applications. To evaluate the improvements of Vehicle-2-X Communication applications, scenarios are defined and field tests are carried out. However, the realization of field tests is rather complex and expensive. The first meaningful field test is planned as part of the SIM TD project in 2008. Hence, simulations are essential to prepare the tests in the real world and reduce their costs. In "Realistic Simulation of Vehicular Communication and Vehicle-2-X Applications", Schünemann et al. show that different kinds of simulators have to be combined to provide a simulation environment for a realistic simulation of Vehicle-2-X Communication scenarios. Based on this requirement, a challenging problem is to run simulators synchronous. Indeed, each simulator manages its own internal simulation time and data. However, the clocks of the simulators have to be synchronized and moreover, simulation data has to be exchanged among simulators.

There are already several existing simulator couplings specified for particular simulation tools: TraNS, Multiple Simulator Interlinking Environment for C2CC in VANETs, and VANET Simulation Environment. However, they do not offer the opportunity to exchange simulators at a later stage or to integrate application implementations developed for real vehicles without the need of adaptation. A further problem is that Vehicle-2-X Communication applications developed for real vehicles need the same interfaces for interaction with their environment both at runtime of the simulation and when embedded in a vehicle. Consequently, a complex data model for the simulation of V2X applications is necessary.

## II. OBJECTIVES AND SCOPE

- *This thesis aims to discuss different simulation techniques being usable for simulating Vehicle-2-X communication scenarios.*

The fundamental background of simulation techniques is introduced. Commonly used simulation concepts are explained. Furthermore, different approaches and algorithms for combining different simulation tools are discussed and their strengths and weaknesses are analysed.

- *This thesis aims to define a concept to integrate real Vehicle-2-X communication applications unmodified into Vehicle-2-X communication scenario simulations.*

Independent of the simulation concept, the core of a Vehicle-2-X communication scenario consists of the vehicles and their running applications. For the simulation of Vehicle-2-X communication scenarios, vehicles can be categorized by their ability to participate in the communication. Based on their category, several simulators are necessary to simulate all properties of a vehicle. The main objective of Vehicle-2-X communication scenario simulations is to evaluate applications that are developed to be embedded in real vehicles. Consequently, real Vehicle-2-X Communication applications are to be integrated in the simulated scenario without modification.

- *This thesis aims to develop a runtime infrastructure for simulating Vehicle-2-X communication scenarios.*

The main purpose of this master thesis is to design and implement a runtime infrastructure for simulating Vehicle-2-X communication scenarios. The simulation infrastructure offers interfaces for the integration of arbitrary simulation tools, e.g. for network, traffic, and environment simulation. Besides, it allows the coupling of approved simulators and provides the flexibility to exchange simulation tools without changing the infrastructure. Simulators for V2X Communication related fields are studied and useful examples are enhances with all functions necessary to interact with the runtime infrastructure. The proposed infrastructure is a distributed simulation system that allows the communication among different simulators regardless of their scope. Furthermore, it provides interfaces that are used by applications embedded in vehicles to interacted with their environment. Hence, no modifications are necessary to run applications of real vehicles within this runtime infrastructure.

- *Finally, in this thesis, the defined application integration concept and the runtime infrastructure is proved with an example Vehicle-2-X communication simulation.*

As proof of concept, it is shown with an example V2X communication application that an intended user of this simulation runtime infrastructure is able to define a simulation run using a road network, a number of vehicles and their routes, and a ratio between classic, equipped, and application supported vehicles. The generated results contain vehicle specific statistics about waiting times, trip duration, and speed changes as well as traffic related statistics. Based on this results the impact of the tested applications on a traffic situation with different equipped vehicle coverages is illustrated.

### III. THESIS STATEMENT

I propose the following thesis:
*A runtime infrastructure to integrate arbitrary simulators for different research areas of Vehicle-2-X communication creates the possibility to run complex and realistic simulations of Vehicle-2-X communication scenarios.*