A Tool Chain for UML-based Modeling and Simulation of VANET Scenarios with Realistic Mobility Models

Christoph Sommer, Isabel Dietrich, Falko Dressler, Winfried Dulz, Reinhard German*
Computer Networks and Communication Systems
Department of Computer Science, University of Erlangen, Germany
{christoph.sommer,isabel.dietrich,german,dulz,dressler}@informatik.uni-erlangen.de

ABSTRACT

We show the advantages of integrated tool support for evaluating Vehicular Ad Hoc Network (VANET) scenarios. This includes three primary aspects. First, we provide support for convenient graphical modeling using UML diagrams and automated model transformation into executable simulation code using the *Syntony* framework. Secondly, a bidirectional coupling of network simulation and road traffic microsimulation provides realistic mobility models. The *Veins* system supports manifold interactions between the Inter Vehicle Communication (IVC) protocols and the microsimulation based road traffic. Finally, the developed integrated simulation framework is based on the state-of-the-art network simulation core OMNeT++ which also provides a comprehensive library of well-tested simulation models for communication networks. We demonstrate the feasibility and the advantages of this integrated modeling and simulation based on a traffic information system that is investigated in the context of the CoCar research project.

1. MOTIVATION

The development of Inter Vehicle Communication (IVC) protocols for Vehicular Ad Hoc Network (VANET) scenarios is in the main focus of such simulations [1], e.g. for incident detection such as traffic jam and accident detection. Simulation models used to evaluate VANET scenarios are usually implemented in C++ or JAVA for a particular simulation framework. Also, the employed mobility model is mostly either a simple model provided by the network simulator or an (online generated or observed) trace of road traffic [2]. Based on this observation, we identified three major issues that need to be considered for future developments, i.e. there is tool support needed in three dimensions:

- *Modeling* – The development of simulation models is very time expensive and error prone. Therefore, the modeling of simulation scenarios needs to be supported by standardized modeling languages such as the Unified Modeling Language (UML). *Syntony* (Section 2) is such an approach that is completely integrated into the Eclipse framework.

- *Mobility model* – The evaluation of realistic road traffic requires accurate mobility models rather than simple random waypoint models. Also, IVC protocols must be able to directly interact with the road traffic simulation. Therefore, bidirectionally-coupled road traffic and network simulation is needed – as supported by *Veins* (Section 3).

- *Model library* – To support the quick and comprehensive modeling of VANET scenarios, access to an extensive library of well-tested models, e.g. the TCP/IP suite, in a standard simulation framework is needed. In particular, we are using the OMNeT++ simulator [3].

In particular, we use our *Syntony*[1] and *Veins*[2] tool-chain to evaluate IVC protocols within the CoCar project.

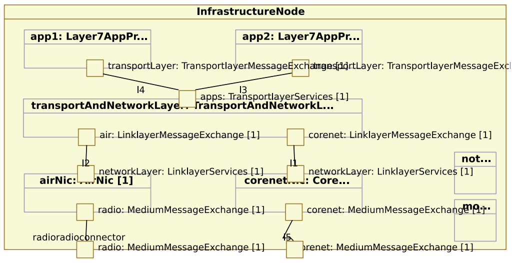

Figure 1: Exemplary composite structure diagram

2. SYNTONY

We are using the well-known modeling standard UML 2.1 to specify the structure and behavior of networked systems. In particular, composite structures and state machines are used for this purpose. In addition, activity diagrams are employed to specify actions in detail. The model is then annotated with quantitative elements and performance metrics using the standardized UML profile for Modeling and Analysis of Real-Time and Embedded Systems (MARTE). In this way, a fully standard compliant model of a system can be developed. *Syntony* [4] provides a mechanism for the automated translation of such standard compliant UML models into discrete event simulations. Currently, *Syntony* generates simulation code executable within the network simulation framework OMNeT++. To simplify the exchange with existing tools and models, the tool is based on the open source platform Eclipse. A sample diagram depicting the composition of a node in the demonstrated case study is shown in Figure 1.

*Syntony is supported by Fraunhofer IIS, department for Communication Networks. Veins is supported by Vodafone R&D Germany in the context of the CoCar project funded by the BMBF under grant number 01BU0692

[1] `http://www7.informatik.uni-erlangen.de/syntony/`
[2] `http://www7.informatik.uni-erlangen.de/veins/`

3. VEINS

For optimal simulation of IVC protocols, the influence of road traffic on the network and vice versa needs to be considered. For this purpose, we developed a special simulation framework, *Veins* (Vehicles in Network Simulation) [5], which provides bidirectionally-coupled road traffic and network simulation using well-established simulators from both communities. In particular, we employ OMNeT++ for modeling realistic communication patterns of VANET nodes. Traffic simulation is performed by the microscopic road traffic simulation package SUMO [6]. Because it is in widespread use in the research community, results from different network simulations can be easily compared. Traffic scenarios can be configured by importing detailed road layouts from a Geographic Information System (GIS) and inserting traffic flows according to inductive loop measurements. A screenshot of the bidirectionally-coupled simulation is shown in Figure 2.

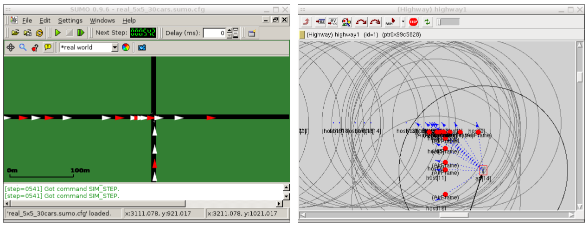

Figure 2: Bidirectionally-coupled simulation

4. DEMO SETUP

The demo shows the CoCar IVC example[3] as depicted in Figure 3. In this example, cars are communicating with a fixed, UMTS-based network infrastructure to submit new traffic information as well as to query the current traffic state. IVC is directly influencing the route selection of the cars, i.e. they have an inherent influence on the road traffic and finally on future IVC.

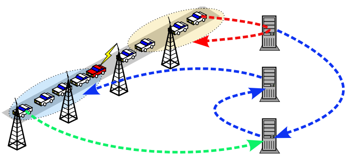

Figure 3: Overview of the CoCar system

Requirements and specifications of IVC systems have been modeled in UML. These UML diagrams, together with standard OMNeT++ network models, are the basis for the automatic transformation into executable OMNeT++ simulation code.

The simulation is using *Veins*, i.e. the bidirectionally-coupled network and road traffic simulation. After running the simulation, the simulation results are imported back into *Syntony* to be graphically analyzed as depicted in Figure 4.

The demo is presented on a laptop computer that runs *Syntony* as well as OMNeT++ and SUMO. The main focus is to show the integrated modeling of the IVC application protocol using the UML and the automatic transformation into executable simulation code. Also, using the graphical interfaces of OMNeT++ and SUMO, the bidirectional coupling of network and road traffic simulation is demonstrated. Finally, it is shown how to collect the simulation results within *Syntony* and to analyze the protocol behavior.

[3]The cooperative cars project is aiming at basic research for Car-to-Car (C2C) and Car-to-Infrastructure (C2I)

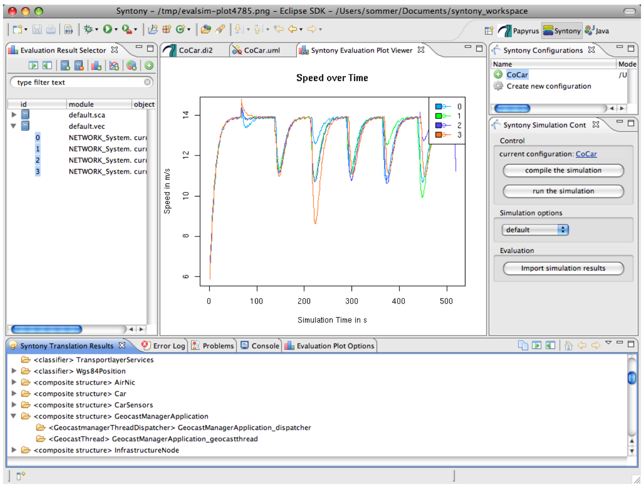

Figure 4: Graphical analysis of simulation results

5. REFERENCES

[1] J. J. Blum, A. Eskandarian, and L. J. Hoffman, “Challenges of Intervehicle Ad Hoc Networks,” *IEEE Transactions on Intelligent Transportation Systems*, vol. 5, no. 4, pp. 347–351, December 2004.

[2] C. Lochert, A. Barthels, A. Cervantes, M. Mauve, and M. Caliskan, “Multiple simulator interlinking environment for IVC,” in *2nd ACM International Workshop on Vehicular Ad hoc Networks (VANET 2005), Poster Session*. Cologne, Germany: ACM, September 2005, pp. 87–88.

[3] A. Varga, “The OMNeT++ Discrete Event Simulation System,” in *European Simulation Multiconference (ESM 2001)*, Prague, Czech Republic, 2001.

[4] I. Dietrich, V. Schmitt, F. Dressler, and R. German, “SYNTONY: Network Protocol Simulation based on Standard-conform UML 2 Models,” in *2nd ACM/ICST International Conference on Performance Evaluation Methodologies and Tools (ValueTools 2007): 1st ACM International Workshop on Network Simulation Tools (NSTools 2007)*. Nantes, France: ICST, October 2007.

[5] C. Sommer, Z. Yao, R. German, and F. Dressler, “Simulating the Influence of IVC on Road Traffic using Bidirectionally Coupled Simulators,” in *27th IEEE Conference on Computer Communications (IEEE INFOCOM 2008): Mobile Networking for Vehicular Environments (MOVE 2008)*. Phoenix, AZ: IEEE, April 2008, submitted.

[6] D. Krajzewicz, G. Hertkorn, C. Rössel, and P. Wagner, “SUMO (Simulation of Urban MObility); An open-source traffic simulation,” in *4th Middle East Symposium on Simulation and Modelling (MESM2002)*, Sharjah, United Arab Emirates, September 2002, pp. 183–187.