Proceedings of the 2020 Winter Simulation Conference
K.-H. Bae, B. Feng, S. Kim, S. Lazarova-Molnar, Z. Zheng, T. Roeder, and R. Thiesing, eds.

A FRAMEWORK FOR THE SIMULATION OF TOMORROW'S MOBILITY

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ABSTRACT

The mobility sector is broad and linked to various other domains such as communication, energy, or society in general. Simulation can help to invent, test, and evaluate solutions for cross-domain mobility problems. However, the modeling and simulation of elaborate scenarios brings many challenges in itself. Therefore, a framework is proposed that can be utilized by different kinds of users in order to create mobility simulations.

1 INTRODUCTION

In the field of mobility, we are facing social, ecological, and economical challenges. Some demanding problems are environmental pollution, demographic changes, and limited urban space, while the population is growing and people are moving from rural areas to urban cities. These issues and a change in people's attitudes are enabling new technologies such as electrified vehicles and scooters, or concepts such as ride sharing and hailing. Nevertheless, solutions bring new challenges themselves that must be taken into account. For instance, an electric scooter is a typical mode of transport for *the last mile*. Therefore, the need for coordinated multi-modal transport system may rise with the use of scooters and with it the complexity and dependencies of the overall transportation system. From another perspective, there is rapid technological progress. Processors, sensors, and radios allow i.a. for autonomous driving. Communication between traffic participants is enabling accident warning systems or platooning. In addition, the road infrastructure is being connected, allowing adaptive traffic light programs or dynamic lane closings. Combining communication and sensors, futuristic concepts (e.g. autonomous taxi fleets) are not inconceivable. Therefore, associated terms such as CAVS (Connected and Autonomous Vehicles) or ITS (Intelligent Transport Systems) are established and widely researched. Besides theoretical ideas, the development, testing, and evaluation of related algorithms, technologies, and products require a lot of resources. Naturally, simulation offers indisputable benefits in this stage. However, the complexity of the modeling itself and the simulation implementation effort grows with the number of involved domains, tools, and data sources. Many specialized off-the-shelf tools related to mobility do exist, but no high-level interoperability standards are established.

2 MOBILITY SIMULATION FRAMEWORK

The priorities and requirements for a simulation vary with the use case. A mechanical engineer may need detailed simulations that run magnitudes faster than wall clock time in order to realize a massive amount of virtual test kilometers. A traffic engineer may want to run a simulation based on household surveys and estimate the acceptance of a new line. In the latter case, the performance and the level of detail may not be top priority, but techniques to ingest heterogeneous data into a simulation. In general, domain experts may not have the required knowledge in terms of implementing (co-)simulations. There is the need for a framework that allows modeling and simulation of tomorrow's mobility - without the burden of doing

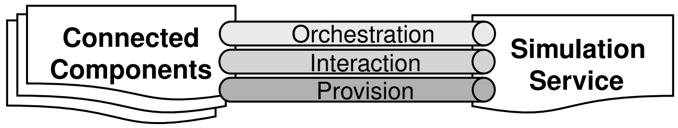

Figure 1: Architectural concept.

this on a low-level layer or getting locked in by a vendor. The author is working towards a framework that takes care of the low-level work by integrating different state-of-the-art simulators. Supported by a GUI, a user can create and run distributed co-simulations that are fed by various data input sources. At the same time, the framework aims to be extendable and offers open interfaces for additional components. Three main questions arise: How to combine different levels and instances of traffic simulation? How to form co-simulations? How to incorporate real world traffic measures? One of the core ideas is based on the data domain and layer concepts presented by Gütlein and Djanatliev (2019). An abstraction layer that allows the seamless integration, interplay and exchange of various simulation tools is introduced. Based on this abstraction, generic traffic interfaces are defined in order to empower the integration of external models, tools, data pools, and real-world components. In order to meet performance related requirements, distributing the simulations is possible by partitioning scenarios spatially. While the simulator instances run in Docker containers, load balancing mechanisms can be applied. Data analytics methods such as machine learning or stream processing are hyped since many years. Support for these and other data driven techniques should be provided by giving access to the simulation states and outputs. To achieve that, while sticking to loose couplings and extendability, customized point-to-point connections between simulators and/or other components are not suitable. Thus, the communication will be realized via a publish/subscribe messaging system: Apache Kafka, which is well known in the field of big data pipeline processing. This allows for real-time processing of the simulation data (e.g. online detection of collisions by stream analysis of simulated positions, turning angles, and speeds). Since the simulator coupling is also implemented on top of the same messaging system, the architecture's complexity is reduced (see Figure 1). Time synchronization is done in a (semi-)decentralized conservative manner. Furthermore, an exchange of the underlying messaging platform is possible. More information about the architecture can be found in (Gütlein and Djanatliev 2020). Another major point is the ingestion of real data. The presented communication mode facilitates data driven simulations. Different calibration modules monitor and control a traffic simulation. Based on the deviation between input streams (e.g. real-world trajectories or count data) and simulated measures, the simulation is calibrated online.

3 CONCLUSIONS AND OUTLOOK

A framework for the simulation of future mobility was proposed. The architecture, the tool couplings, and the time synchronization are already implemented. Further work includes the data ingestion and calibration algorithms. Enhancements on the translation components between different layers/levels of traffic simulation will be done. An optimistic time synchronization mechanism could be implemented and evaluated. Especially in sparse traffic scenarios, an optimistic version should outperform the conservative approach. Finally, the quality of the calibration methods and the overall performance needs to be evaluated.

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