The Challenge

New digital ecosystems that combine existing products and processes via software and data are currently emerging in all areas of our lives.

One central challenge in this respect is the integration of components and systems, which increasingly takes place dynamically and at runtime. Particularly systems that make safety-relevant decisions in an automated manner and on which, in extreme cases, human lives may depend must then be validated and tested in a particular way. This includes, for instance, automotive platforms that are able to dynamically receive and integrate driving functions. With Industrie 4.0, industrial production is facing similar issues when it comes to dynamically integrating new devices and processes into an existing plant.

Typical Issues

Together with our project partners, we have been able to successfully use virtual prototypes in the past to answer classical questions regarding architecture decisions or system design:

■ How to remotely control safety-relevant vehicle functions via smartphone without violating safety properties?

■ Is the new automotive platform safe from cyber-attacks?

■ Which network technology offers enough bandwidth for my automotive platform/industrial plant?

■ How to automatically plan my Industrie 4.0 production?

■ What impact does the introduction of a new type of robot have in my industrial plant?

■ How to realize software lockstep for controlling industrial plants?

■ How to add open interfaces to an existing system and how to validate these?

■ Will the new component fit into the existing infrastructure?

■ Have all requirements been taken into account in the system architecture?

The Solution

The FERAL solution by Fraunhofer IESE is a simulation platform with various components. They allow integrating even complex, heterogeneous scenarios into a test scenario and systematically checking properties in a protected virtual space with the help of digital twins. Such a scenario might be the correct functioning of a pedestrian recognition system or the faultless interaction of two functions from different manufacturers.

The Benefits of Virtual Engineering

■ Cost and time savings in strategic developments and when system concepts (control units, networks, etc.) are changed

■ Early detection of misdevelopments

■ Validation of decisions with measurable results

■ Consideration of the requirements of different stakeholders (marketing, developers, users, project management, etc.)

■ Focus on solution concepts instead of on problems

■ Testing of system concepts in the context of defects and attacks (e.g., hacker attacks)
Autonomous driving presents great challenges for the automotive industry. These include technical challenges such as “How does the vehicle reliably recognize pedestrians crossing the road?” or “Which decision does Artificial Intelligence have to make?”. The greatest challenge regards functional safety – it must be guaranteed that the autonomous vehicle is as safe as or safer than a vehicle with a human driver.

Due to the increased complexity of autonomous vehicles, classical validation techniques quickly reach their limits. Experts from TÜV Süd believe that 100 million critical situations must be tested in order to sufficiently test a single vehicle function. Classical field tests could never achieve the necessary coverage, as a number of critical situations arise too rarely in real driving situations. This is why BMW assumes that 95% of the tests for autonomous vehicles have to be performed virtually with the help of simulations.

The advantage: Simulations can adapt existing scenarios through variations so that critical situations will occur frequently. Let’s look at the testing of an intersection assistant as an example: In real driving situations, it seldom happens that two vehicles arrive at an intersection at the same time and that the assistance system has to perform emergency braking. Accordingly, it would be very effort-intensive to perform field tests in real driving situations.

In such cases, simulation offers the possibility to generate virtual vehicles that trigger this critical situation and thus ensure that the intersection system can be validated.

In the virtual validation of autonomous systems, it is not enough, however, to merely look at sensor data processing and the correctness of the Artificial Intelligence. The processors used or the abilities of the network technologies used in the vehicles can form a bottleneck that prevents timely reaction. For this reason, the validation of an autonomous system can only be done via a simulation containing the entire vehicle as a digital twin with sensors, control units, and actuators, as well as the network technology connecting them. This requires different simulation models to be coupled.

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Our Technology

The FERAL simulation framework developed by Fraunhofer IESE creates virtual prototypes by coupling simulation models and simulators, existing code, and virtual hardware platforms. This enables the impact of decisions to be reviewed at an early stage.

At a very early stage of development, the simulation may be based purely on models; this is called Model-in-the-Loop (MiL) simulation. For that purpose, FERAL supports, e.g., UML state machines, activity diagrams, and coupling with other simulators such as Matlab Simulink. In these early phases, critical design decisions are often made that can be validated with the help of these simulations. If first implementations of the software are already available, they can be combined with the existing models in a Software-in-the-Loop (SiL) simulation. This enables making more accurate predictions about the system behavior or testing compliance with previously developed models in back-to-back tests. In parallel to the design of the software, the design of the hardware is advanced in the classical V-model. FERAL supports this step by providing virtual hardware platforms, i.e., processor and network models to which the software components can be deployed in a virtual Hardware-in-the-Loop (vHiL) simulation. All these simulations (MiL, SiL, and vHiL) serve to detect defects in early development phases, if possible, which allows reducing the number of expensive Hardware-in-the-Loop-(HiL) simulations and integration tests.

Our Services

With our expertise we will gladly support you in the development of new system and software concepts. We will cooperate with your engineers to validate decisions, optimize systems, or create something completely new.

Customers who want to use virtual prototypes themselves get support from us in the development of customized simulations solutions as well as in the implementation of their own simulator coupling concepts. Do you have any questions about virtual simulation with FERAL? Then get in touch with us!
Fraunhofer IESE

The Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern has been one of the world’s leading research institutes in the area of software and systems engineering for more than 20 years. Its researchers have contributed their expertise in the areas of Processes, Architecture, Security, Safety, Requirements Engineering, and User Experience in more than 1,200 projects. The institute is working on innovative topics related to digital ecosystems, such as Industrie 4.0, Big Data, and Cyber-Security. It is a technology and innovation partner for the digital transformation in the areas of Autonomous & Cyber-Physical Systems and Digital Services, and its research focuses on the interaction between embedded systems and information systems in digital ecosystems.

Fraunhofer IESE is one of 72 institutes and research units of the Fraunhofer-Gesellschaft. Together they have a major impact on shaping applied research in Europe and contribute to Germany’s competitiveness in international markets.

Fraunhofer Institute for Experimental Software Engineering IESE
Fraunhofer-Platz 1
67663 Kaiserslautern
Germany