Digital twin of heat generator systems as an enabler for the development of low-emission building energy technology (DZWi)

RWTH Aachen

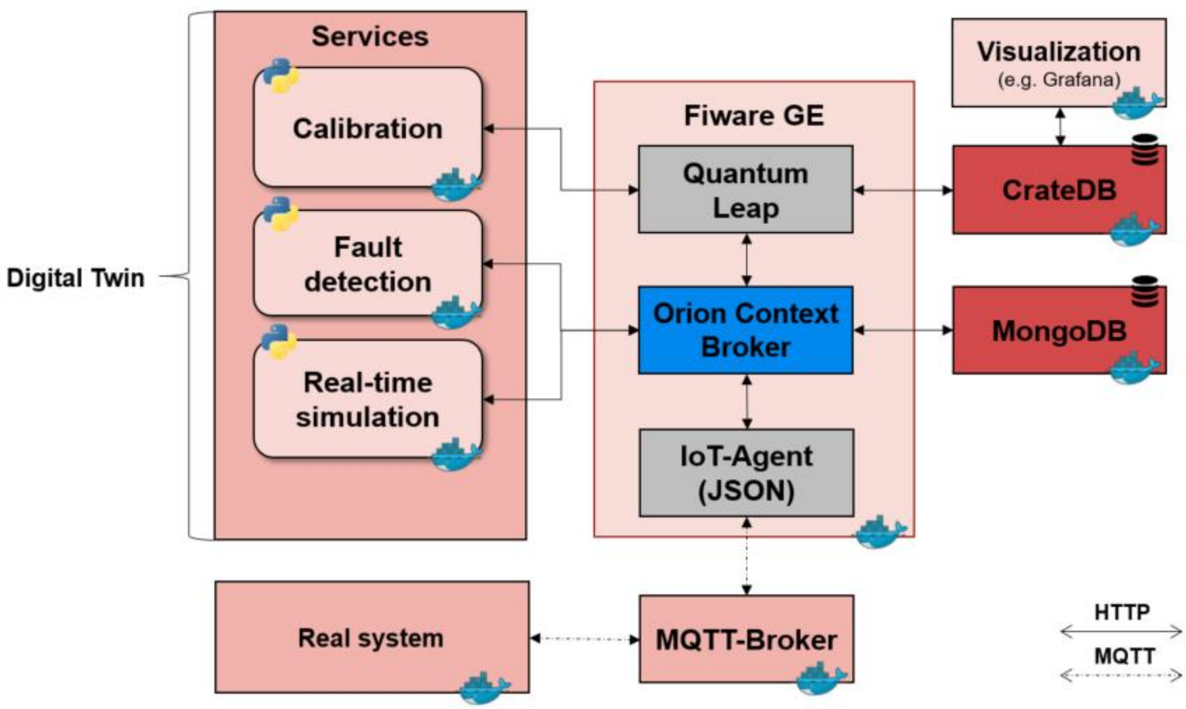

Figure 1: Fiware architecture for communication of virtual/real system and implemented services.

Summary of the project

Digitization is one of the most important challenges in energy technology in the coming years. In particular, its impact on critical system applications in building energy technology is currently being analyzed in various projects (e.g., National 5G Energy Hub). Previous projects focus on the control and regulation of complex energy systems of today and the future. However, the development process and operation of systems in building energy technology still need to be addressed. The current state of the art in this field is that development issues are dealt with in the R&D departments of the companies, and the results end up in a prototype, which then proceeds through various test phases. This development is complicated and time-consuming. Alternative development tools and paths are known from the automotive industry, among others, with which it is possible to accompany the entire development process digitally and only carry out the complex and cost-intensive measurements using prototypes at a very late stage. In addition, the digitization of devices offers the possibility of subjecting systems in operation to automated early fault detection and thus avoiding expensive repair costs. The DZWi project aims to transfer this approach to building energy technology.

In this context, the project's primary focus is to develop a digital representation of different energy conversion systems (heat pump/fuel cell) in detail, using which

R&D times can be shortened. The combination of scientific institutions and producers of modern heating technology is ideal, as the digital twins to be created can be tested directly on practically relevant products (high TRL8-9). Based on "Hardware-in-the-Loop" (HiL) tests (also known as field tests in the lab), fundamental parameters for heat pumps and fuel cells are to be determined. In addition to the analysis, an essential component is the description of the dynamic and static behavior, e.g., of the refrigeration cycle. Here, a generally applicable methodology is to be developed that also considers future refrigerants concerning the F-gas regulation. The core of all development work is a cloud environment, which should enable scalability of the results for the system's entire life cycle. Using the open-source middleware Fiware (fig. 1) to enable communication between real systems, virtual models, and integrated services like Fault Detection, we ensure a holistic approach to a digital twin replica. Detailed information on the project is provided on the project website: https://dzwi-waerme.de

Learnings and results

The effort to build a robust IoT infrastructure with open-source solutions often needs to be considered. For production environments, consideration may need to be given to commercial alternatives, which may be professionally maintained during operational phases to mitigate communication difficulties. If these prerequisites are met, integrating novel services, such as fault detection or calibration of the simulation models, is relatively simple. For modularity and synchronization of individual tasks, it is advisable to use tools that allow these tasks to be subdivided into individual modules. For example, one task could be the calculation of the root-mean-square-error (RMSE) as a metric of the deviation between simulated and measured data and subsequent calibration of the simulation model. The RMSE calculation is, thus, independent of the application and is also used for monitoring and fault detection. In this way, it is also possible for services to be executed within their environment.

FACTS ABOUT THE IOT CASE

IoT category: Optimize heat pump operation, Predictive maintenance, Installation and operation error analysis

Goal: Reduce costs and emissions during development and operation

Beneficiary: user, manufacturer, assembler (fault detection)

Data required: weather forcast, operation data

Analysis method: simulations, visualization, fault detection, alarming, energy balances, control engineering

Modelling requirements: dynamic models (Grey-box) as well as static models and Data-driven models

Quality-of-Service: daily near real-time

Project participants: Technische Universität Dresden, RWTH Aachen University, Viessmann Werke Allendorf GmbH, Glen Dimplex Deutschland

Time schedule: from 2020-2023

Technology availability: TRL 8-9

Link to webpage: https://dzwi-waerme.de/

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