OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG | INF | FACULTY OF COMPUTER SCIENCE | Communication and Networked Systems

Bachelor Thesis
Lightweight Digital Twin Framework for IoT Applications

Motivation

Digital Twins (DTs) are virtual representations of physical systems that enable real-time monitoring, analysis, and control. In the context of the Internet of Things (IoT), Digital Twins offer tremendous potential for improving system reliability, maintenance, and decision-making. However, traditional DT frameworks are resource-intensive, making them impractical for IoT devices that operate under strict power and computation constraints.
The challenge lies in designing a DT framework that is lightweight enough to run on resource-constrained IoT devices, while still providing the necessary functionality for synchronization, data processing, and control. This thesis explores approaches to minimize latency and resource usage while maintaining accurate and reliable Digital Twin operations.

Objective

The goal of this thesis is to propose and evaluate a lightweight Digital Twin architecture tailored for IoT environments. The work involves modeling synchronization latency, analyzing energy and resource trade-offs, and validating the design through simulation.
Steps to be completed:

- **Step 1 – Literature Review:** Analyze existing Digital Twin frameworks, especially for IoT and Edge Computing.
- **Step 2 – Modeling:** Define mathematical models for latency, energy usage, and communication overhead.
- **Step 3 – Evaluation:** Compare the proposed DT framework with baseline architectures.

Prerequisites

- Basic knowledge of IoT systems.
- Familiarity with simulation tools (e.g., NS-3/OMNeT++) is a plus but not mandatory.
- Experience with modeling and performance analysis

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Expected Outcomes

- A theoretical model and simulation of a lightweight DT architecture
- Performance metrics: latency, energy efficiency, synchronization accuracy
- Comparison between edge, cloud, and hybrid DT approaches
- A thesis report and possible publication based on results

References

[1] **A. Fuller, Z. Fan, C. Day, C. Barlow**, "Digital Twin: Enabling Technologies, Challenges, and Open Research," *IEEE Access*, 2020.

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[3] **L. Tao, H. Zhang**, "Edge Computing for Digital Twin in IoT: A Survey," *Journal of IoT Research*, 2022.

[4] **P. Mell, T. Grance**, "The NIST Definition of Cloud Computing," *NIST Special Publication*, 2011.

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