Contribution ID: **12** Type: **Oral**

Fusion Middleware. A comparison of state of the art systems in research, industrial manufacturing and cloud.

Thursday 11 December 2025 14:30 (25 minutes)

Middleware is the connective layer that fuses data, models, and control across heterogeneous systems, enabling end-to-end workflows across a large number of systems. This talk compares the state of the art in middleware across three domains, large-scale experimental laser and MCF facilities, industrial manufacturing, and cloud platform, highlighting similarities and differences. We also discuss the main technologies behind these middleware platforms and the conceptual frameworks behind these systems.

In research settings, middleware emphasizes agility and reproducibility. Software systems such as EPICS and TANGO coordinate large-scale sensor and actuator networks while being easily extensible. The data generated in these platforms is typically extremely high volume due to the resolution needed in order to capture plasma effects. This puts demanding requirements on the data transfer mechanism, the networking backbone as well as control loop systems. The challenge is that academic stacks often optimize flexibility over operational determinism and long-horizon lifecycle management.

Industrial manufacturing focuses on different problems. Integrating OT and IT with strict requirements for reliability, real-time performance, and safety. Here, middleware centers on deterministic messaging, standardized industrial protocols, and secure edge gateways bridging brownfield equipment. Systems are becoming increasingly hybrid between cloud and edge computing. The challenge is balancing vendor ecosystems and lock-in against interoperability while meeting certification, maintenance, and uptime SLAs.

Cloud-native middleware privileges elasticity, global reach, and managed governance. This domain is largely driven by zero-trust infrastructure, which enables secure systems on a global scale. In this area, hybrid patterns (edge preprocessing combined with in-cloud analytics) emerge as the default. However, typically the data inside global applications is often not as volatile, unstructured and dense as compared to manufacturing systems or large-scale research setups.
Across domains, common patterns include publish–subscribe messaging, schema-first contracts, central orchestration systems, and ETL data pipelines with lifecycle-managed schemas. Event-driven architectures enable data extraction and archiving in large database systems for structured and unstructured data. We discuss a common set of technologies and patterns used in all domains and survey convergence trends, for example OPC UA and MQTT bridging to cloud-native streams. Attendees will leave with a general taxonomy of middleware, a clearer overview of current open-source projects, and a review of common trends across all discussed domains.

Country or International Organisation

Germany

Affiliation

Chair for Lasertechnology RWTH Aachen

Speaker's email address

moritz.kroeger@llt.rwth-aachen.de

Author: KRÖGER, Moritz

Presenter: KRÖGER, Moritz

Session Classification: Simulation and Modelling Techniques

Track Classification: Data Techniques