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Plant-wide communication architecture enabling online life cycle assessment

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Industrial processes can be very energy-intensive and consume resources during the production of essential materials and goods. Many of these processes are large-scale and may include distributed production steps. The suboptimal control of these processes can significantly increase the use of resources and energy as well as environmental impacts.

The plant-wide control of large processes can be difficult. Process control decisions at geographically distributed subunits and plants may contradict with the global optimum if the necessary information is not available. Furthermore, the impact of local decisions to the overall process is not always clear. This calls for plant-wide control strategies on the coordinating supervisory level. In order to improve such monitoring and control methods, new information exchange practices and integration architectures are required.

Integration of information and control systems in production is challenging both from a scalability and interoperability point of view. Most integrations still rely on point-to-point connections, i.e., systems directly requesting information and services or setting new operating set points. Although the production systems are rather stable, the development of new control procedures is laborious due to the number of necessary integrations for accessing the distributed data. This may also cause performance issues for some systems providing data for these advanced control applications spanning several production units. The integration of external constraints, such as logistics or resource costs, to the control optimisation further increases the necessary effort.

With information systems from different decades, vendor-specific interface implementations and application-specific data structures, the integration is further complicated. Despite successful technologies, such as OPC UA, the use of the agreed information models has not yet been established to the point of plug-and-play connectivity. Commonly agreed information models are required as well as adaptation layers connecting incompatible interfaces and legacy systems.

The Horizon2020 funded COCOP project (Coordinating Optimisation of Complex Industrial Processes) aims to enable plant-wide monitoring and control by using the model-based, predictive, coordinating optimisation concept in integration with automation systems. For the control, the intention is to decompose the entire optimisation problem into sub-problems. The concept relies on the fact that truly large systems typically have some definite structure arising from a linking of independent subunits. This structure can be utilised while decomposing the control problem.

An integration and communication architecture has been developed that supports this control approach in a scalable and interoperable manner. The COCOP communication architecture is based on the concept of a message bus as a broker for data and events. This scalable broker acts as a dataflow hub onto which data is sent from information producers and from which information consumers subscribe to process the data. Still, data can even be delivered “on request”, which is desirable for historical data.

The communication principle promotes event-driven information exchange, therefore facilitating the development of applications that react timely to production-related events. To improve interoperability, standards-based message structures have been chosen and composed to form the basis of data semantics for process measurements and events.

To support development, a software development kit (SDK) has been implemented. This SDK guides and facilitates the integration of existing systems. Using the SDK, it is easy to create adapters conforming to the agreed messaging semantics. Still, integration to the standards-based communication protocols is possible even without the SDK.

In this paper, we demonstrate the use of the COCOP architecture with an Online LCA case. LCA or Life Cycle Assessment is a standardized (ISO 14040-44: 2006) methodology to assess the environmental impacts throughout the life cycle of a product or service. Traditionally, this has been conducted on a yearly time resolution with averaged data. In contrast, Online LCA uses real-time data that is available in the control systems, thus providing real-time environmental decision support to plant operators and managers. The case process is a distillation process for water-ethanol mixture located at TUT’s teaching laboratory. The Online LCA model is integrated to the control system via OPC UA and AMQP (Advanced Message Queueing Protocol), and the LCA results are visualized in Outotec ACT (see Fig. 1). AMQP is suitable for large data volumes, thus enabling even data-driven solutions, such as machine learning, in future tasks.

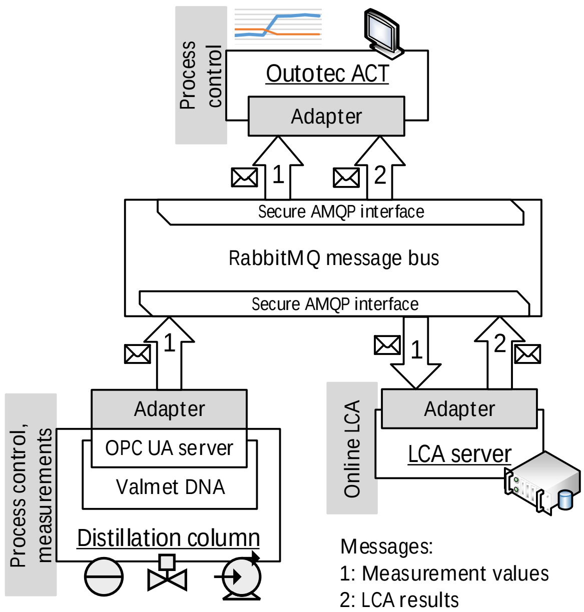

Fig. 1. The implementation of the online LCA utilising COCOP communication architecture.