Industrial Control with Knowledge Graphs

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Context and Motivation With the rise of an Industrial Internet of Things (IIoT) and the increased connectivity of industrial equipment, of sensors and of actuators, industrial control now is at the intersection between information technologies (IT) and operational technologies (OT). Industrial processes can be controlled with agility and efficiency by remote software components.

The objective of SIRAM (Integrated Systems for Mobile Assistant Robots), a regional project involving Mecaconcept, Creative'IT and Mines Saint-Étienne, is to develop an interoperable, adaptive information system that integrates mobile assistant robots (RAM) in the Industry 4.0 environment of IT'm Factory.

The prototype developed in SIRAM aims at showing how a control system can automatically adapt to contextual evolution and deal with heterogeneous objects on the same factory floor, including production equipment equipped with a pre-programmed industrial controller, low-power connected devices mounted on that equipment and industrial robotic arms.

Objective The objective of the internship is to extend an existing Knowledge Graph (KG) describing the IT'm Factory, such that a remote agent-based control system can observe the real-time state of the factory and act on it in a unified manner. KGs are particular kinds of databases designed to capture knowledge from various sources, represented as a set of interlinked entities [1]. In addition to the explicitly stated knowledge, KGs often include logical rules to derive implicit knowledge, which makes them a relevant abstraction to represent factory lines in Industry 4.0 scenarios. Industrial equipment, sensors and actuators are represented as entities that are related to each other via spatial relationships ('is adjacent to', 'contains', etc.) and structural relationships in terms of system engineering ('is part of', 'connects to').

The existing KG for the IT'm factory already includes such entities (see online entry point) but it is not sufficient for industrial control. In particular, it does not include interdependencies (as rules) between the different properties of the overall production system ('if an optical sensor mounted on a conveyor belt indicates a presence, then some workpiece is on the conveyor belt'). The concrete objective of the internship is therefore to extend the KG, such that the full state of the system can be derived from an evaluation of its (partially) observable properties.

The technologies involved in the internship are the Resource Description Framework (RDF), typically used to model KGs, and a data model standardized by the Open Platform Communications (OPC) foundation: OPC Unified Architecture (OPC UA). The intern will transform several pre-existing models expressed in OPC-UA (see online repository) to RDF, for integration in the KG. He will also implement a prototype to dynamically read real-time property values from the IT'm Factory and derive a full description of the system. Concepts from the Robot Operating System (ROS) may also be included, to model parts of a RAM.

Expected results The following results should be delivered at the end of the internship:

- an extension to the existing KG for the IT'm Factory, following knowledge engineering best practices

- a technical specification to transform OPC UA information models to RDF
- a software prototype to interact with OPC UA servers (and, optionally with ROS nodes) and perform rule derivation

Prerequisites

- good programming level in an object-oriented programming language (preferred: Java)
- basics of RDF and Semantic Web technologies
- basics of logical inference
- (optional) basics of logic programming

Keywords: Knowledge Graph, Semantic Web, Industry 4.0, OPC UA

Application Applications must include:

- CV and a cover letter
- Transcript of past 2 years (optional)
- Reference letter (optional)
- Contact information

References

[1] A. Hogan, E. Blomqvist, M. Cochez, C. D'amato, G. D. Melo, C. Gutierrez, S. Kirrane, J. E. L. Gayo, R. Navigli, S. Neumaier, A.-C. N. Ngomo, A. Polleres, S. M. Rashid, A. Rula, L. Schmelzeisen, J. Sequeda, S. Staab, and A. Zimmermann, "Knowledge Graphs," *ACM Computing Surveys*, vol. 54, pp. 71:1–71:37, July 2021.