Industrial IoT applications

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Abstract: In this paper, we present three industrial-oriented IoT applications from industrial robotic, intralogistics and smart water management domains. They utilize Fiware open source IoT platform. We present architecture diagrams of the developed IoT platform applications and share our experiences of the implementation.

1 Introduction

Cloud computing platforms offer new possibilities for data analytics applications. Microsoft Azure and Siemens Mindsphere are examples of commercial cloud computing platforms that offer extensive possibilities for application development and deployment in the cloud, especially in big data storage, analysis and visualization. IoT platforms based on edge computing or fog computing offer possibilities for real-time data streaming, analytics, and visualization in the local networks.

Fiware is an open source platform offering components for analyzing and visualization of data from Internet of Things (IoT) sources. The Orion Context Broker component and the Next Generation Services Interface (NGSI) are the core of Fiware. Orion Context Broker (OCB) provides an NGSI API. OCB publishes context information from entities (virtual real-world objects). Entities can be IoT sensors or application components, etc. OCB publishes context information from context producers (IoT sensors etc.) to context consumers (visualization, analysis components etc.), and supports two-way communication.

Especially SMEs can benefit from Fiware due to its open source approach and ease of deployment of the components. Fiware has a strong European background and is favored by the European Union in many projects funded by EU.

VTT has implemented advanced industrial IoT applications. In this paper, we present three industrial oriented applications from industrial robotic, intralogistics and smart water management domains. They utilize Fiware components.

2 Intralogistics application

Digitalization of the manufacturing industry has created growing interest in digital technologies such as IoT and how the manufacturing floor can be more integrated. The European project Logistics for Manufacturing in SMEs (L4MS) aims to tackle this need by accelerating the automation of intra-factory logistics for SMEs and Mid-Caps. The goal is to reduce the time and installation costs of mobile robots by helping manufacturing SMEs and Mid-caps to develop new, smart intra-factory logistics solutions. The deployment of exceptionally small and flexible logistics solutions requiring no infrastructure change, no production downtime and no in-house expertise aims to make investment in logistics automation more attractive (www.project.l4ms.eu/).

One of the main results that the L4MS project provides is an IoT platform called Open Platform for Innovation in Logistics (OPIL). The OPIL platform will contain the latest navigation, localization, mapping and traffic management services for rapid and cost-effective deployment of logistics solutions. OPIL also enables manufacturing SMEs to conceive highly autonomous, configurable and human-robot logistics solutions according to their business needs.

OPIL architecture consists of three layers: IoT Nodes layer, Cyper-Physical middleware layer and Software systems layer. Components in the IoT node layer interact with the physical world, whereas software applications operate at the level of software systems layer control and monitor OPIL functions. These components communicate with each other by exchanging messages with the middleware layer that decouples components interacting with the outside world, pure software components, and enterprise applications from each other. Components can either directly operate according to these messages or translate them into a suitable format for internal usage. Here we concentrate on the functionalities of the middleware layer containing the FIWARE components.

Role of Fiware

OPIL utilizes FIWARE in its Cyper-Physical middleware layer, which provides the means for exchanging context information between different modules and functions. This message/context-oriented communication is managed by FIWARE's generic enabler Orion Context Broker (OCB). Communication is managed with HTTP requests. OCB enables the OPIL system to gather, publish, exchange, process and analyze context data. OCB manages information with a publish/subscribe pattern and brokerage of contexts (www.fiware-orion.readthedocs.io/). For maintaining context data OCB uses MongoDB as a database, in which data is stored in Next Generation Services Interface (NGSI) data format. NGSI includes data in entities that hold registrations and subscriptions. The data itself is produced by IoT sources such as sensors, cameras and mobile robots.

Coarsely, mobile robots can be divided into ROS- *(*Robot Operating System) and non-ROS driven. As a way to enable communication between OCB and mobile robots, OPIL uses FIROS. FIROS is an open source ROS module, which translates ROS messages into FIWARE's NGSI entities. This convention also works from entities to ROS messages (www.wiki.ros.org/firos). In order to avoid duplicate information, a timestamp is also included in the entity. With non-ROS based mobile robots, OPIL uses a custom component to convert ROS messages into a suitable format for the robot.

FIROS is also supplied with sensors in OPIL, but additionally IoT Agent UL 2.0 is used. This agent converts Ultralight 2.0 protocol messages such as HTTP and MQTT into NGSI messages, making it possible for devices using Ultralight 2.0 protocol to communicate with OCB (www.github.com/telefonicaid/iotagent-ul). With device provisioning, IoT Agent can find a specific context entity from Intelligence Data Advanced Solution platform (IDAS).

IDAS is FIWARE's Backend Device Management generic enabler implementation. IDAS implements protocol agents for NGSI entities to allow intercommunication between OCB and generic wireless sensors and actuators. These agents include the above-mentioned IoT Agent UL 2.0 and are part of the IDAS platform (www.forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/IDAS). In OPIL, IDAS is concerned with NGSI context entity management regarding sensors.

Architecture

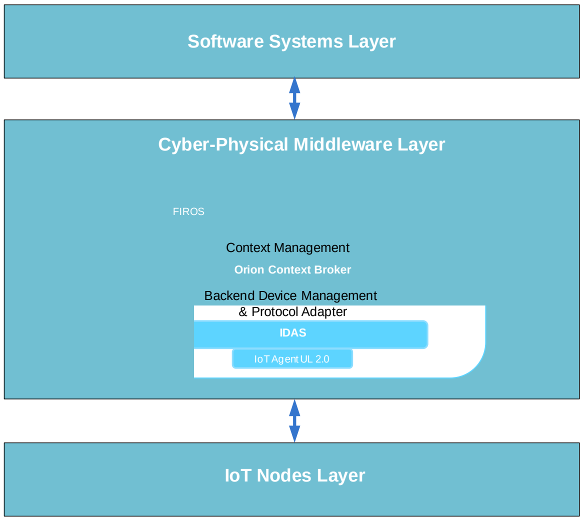

Figure 1. Simplification of OPIL architecture with highlighted FIWARE components.

FIWARE offers a platform with diverse resources to innovate IoT-based technologies. FIWARE's generic enablers are relatively easy to use and understand. In order to get started with OCB and MongoDB, it is necessary to have sufficient hardware. The critical resource regarding MongoDB is RAM memory, as MongoDB performance is related to the amount of available RAM to map database files into memory. Because of the NGSI entity structure, it is up to the user to take care of saving historical data, as entities are always overwritten. In addition, FIWARE is under continuous development, and so some enablers are removed and new ones are brought up. This is both a pro and a con.

3 Robotic application

MIDIH Reference architecture

In the industrial robotic application, the IoT computing platform is based on the MIDIH reference architecture model (http://midih.eu/) (Figure 2). The model provides guidelines for designing of architectures for Cyber Physical System/IoT systems. The functionalities provided by the architecture model are mapped into software components.

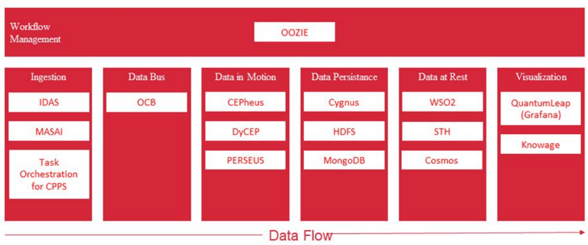

Figure2. MIDIH Industrial IoT and Analytics Platform Architecture (FIWARE4Industry Pipeline) (Benedicto Jesús, 2019, Atos, Internal project document, [Accessed 13.3.2019])

The MIDIH architecture offers two lanes for implementing applications: FIWARE4Industry and APACHE lanes. FIWARE4Industry is an ecosystem that offers FIWARE-based software (open source) components for the manufacturing domain (www.fiware4industry.com). Apache has similar components as the Fiware for developing IoT platforms. APAHCE is also an open source software ecosystem (www.apache.org) and it is supported by the Apache foundation.

The IoT computing platform for the robotics application is based on FIWARE lane.

IoT platform

The IoT platform is running in a virtual machine (Ubuntu 18.04). The architecture is shown in Figure 3. The platform consists of the following Fiware components:

- Orion Context Broker: OCB receives requests from subscribers. It delivers data from sources (sensors) to subscribers/context consumers. (https://fiware-orion.readthedocs.io/en/master/)
- MongoDB: OCB uses MongoDB for storing information about NGSI data entities (registrations, subscriptions). An entity is a virtual representation of real-world objects with attributes.
- Quantum Leap: This component is an OCB subscriber. When a new value arrives to the OCB, Quantum Leap parses and validates the data and stores it in a time-series database. (https://smartsdk.github.io/ngsi-timeseries-api/)
- Crate DB: Crate DB is an SQL Data Base Management System, which supports real time querying and time series data. Crate supports NGSI v2 format. (https://crate.io/)
- Grafana: This is an analytics tool for visualization of time-series data (Figure 4). It supports basic analytics functions such as maximum/minimum, average, smoothing etc. Grafana uses CrateDB (grafana.com)

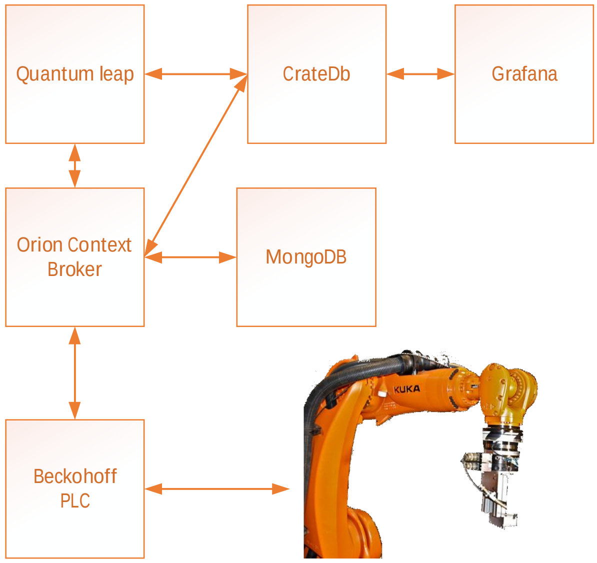

Figure 3. Architecture of the edge computing platform

Figure 4. Visualization of the force sensor data from Grafana

The first implementation was running as Docker containers in Docker desktop application. In this version we had some instability issues. The problem was solved by installing the software from source codes (a virtual machine with Ubuntu 18.04.). With this setup the stable performance was achieved (real time visualization of the sensor data).

4 Smart water management application

The objective of the SWAMP (swamp-project.org) project is to develop an IoT-based smart water management platform for precision irrigation in agriculture. Up to 70% of annual freshwater consumption is related to agriculture, making it one of the fundamental global challenges. The SWAMP platform supports farmers in using water more efficiently, avoiding over- and under-irrigation, as well as decreasing costs and energy consumption. The

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platform makes use of measurements made by local weather stations, soil probes, drones, and water monitors, as well as external services such as satellite imagery, to provide the farmer with an optimized plan on how to control each valve and sprinkler head of the irrigation system. With four pilot sites in Europe and Brazil, the project approach is pragmatic and solution-oriented.

The SWAMP Platform development is still ongoing, and the system currently consists of the mainstream components of FIWARE: Orion Context Broker/NGSI-LD Context Broker, IoT Agents, Mosquitto MQTT broker, MongoDB, QuantumLeap, and CrateDB. These components can be deployed with a number of possible configurations, depending on the used IoT devices and communication technologies. The system architecture is categorized into five layers (Figure 5).

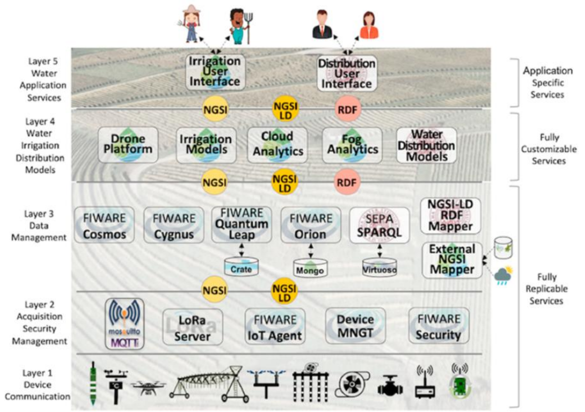

Figure 5. Preliminary Swamp architecture layers.

When the planning of the SWAMP Platform was initiated, a performance analysis for the core FIWARE components was performed. In general, the results suggested that FIWARE should be able to deliver the performance required. The pilots aim for high scalability, which may however require re-engineering of some components as well as special configurations for deployment. The SWAMP Platform is currently under development, and the first version of the system is planned to be launched during autumn 2019.