Enabling a Semantic Sensor Knowledge Approach for Quality Control Support in Cleanrooms

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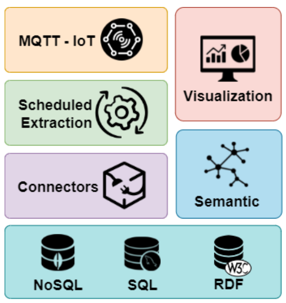
Abstract. With the explosion of big data technologies (BD), the possibility to integrate those tools into daily company operations is more affordable and straightforward. On the other hand, Knowledge-based approaches such as graphs and different semantic approaches, although those have not been so popular in the industry in the past years, nowadays, thanks to the high availability of heterogeneous data inside of the company context, those tools are being used more to enhance or enrich data and processes, and make more informed decisions about the business. The SEMT platform is presented; this system combines a Big Data recollection approach from a legacy/manual sensor environment to perform a knowledge enhancement process to support the semi-conductor development and production operations inside a cleanroom.

Keywords: Sensor Networks · Knowledge Base · Cleanrooms · Context Aware Systems.

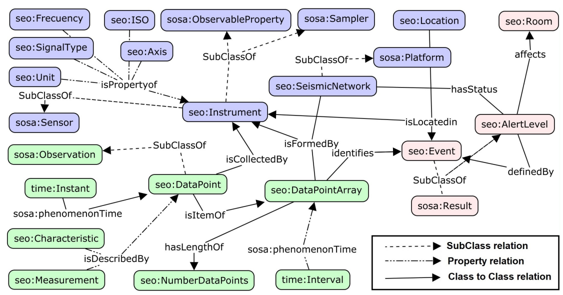
1 Introduction

The SEMT (Sensor Environment Monitoring Tool) proposed here was deployed in the company Leonardo SpA, in Rome headquarters, for monitoring a manufacturing environment, i.e., cleanroom. Cleanrooms are controlled R+D closed manufacturing environments that deliver controlled levels of particles, temperature, and other climate-related characteristics. The goal was to collect and analyze sensor environmental data over a production line, to support the cleanroom quality control process and the production of semi-conductors on this facility.

For these heterogeneous domains, semantic tools, such as Knowledge Base approaches [1], can boost the gathered data, providing context and enabling inference starting from the native data relations or external data sources, such as status reports or supply chain data. But, later arisen pattern discovery, interrogating the system to obtain contextual answers related to the status of a product using, e.g., SPARQL queries [2]. The motivation in this industry use-case scenario was to test a production-level usage for a semantic knowledge base schema to create the foundations of a contextual aware environmental sensor system inside of a limited and security-constrained environment.



(a) High Level Architecture view



(b) Knowledge-Base Schema

2 System Logical View

The system was designed to extract environmental data from heterogeneous sensors scattered in different laboratory segments. The general approach in this architecture was to create a data microservices-based supply chain; those services are divided into a set of layers grouped by functionalities at a higher level see Fig. 1a. All the components use HTTP REST messages allowing transparent and standard message interchange between the services in general. **Storage layer** provides persistence to the data, descriptors for sensors, collected data, and semantic data, The **Connectors layer** interacts directly with the device and his data; a connector for each device type should exist. The **Scheduled Extraction layer** provides the ability to coordinate the extraction from the sensor network, **Visualization layer** acts as a webapp for displays the dashboards, data reports, and device management interfaces. **MQTT IoT layer** can forward the recollected data via MQTT to the Leonardo 4.0 platform; the **Semantic Layer** will be debriefed in section 3.

3 The Semantic Layer

Some of the most compelling challenges at the design phase on this system were: (a) the inherent need to maintain historical data in an arbitrated way; for later trace, product quality control, and (b) usage of temporal data stored, both immediately and distant. For attending to these requirements, a simple adaptation of a contextual sensor network ontology [3] was used. The knowledge schema enhances the sensor data, mainly focusing on the collection model see Fig. 1b (Green Section), for this knowledge representation, two entities were exploited: (1) *DataPoint* and (2) *DataPointArray*, those are mainly focused on the live data collection.

A long-term purpose is to consider a later knowledge-discovery process to combine this data with product-related data, staff access and activity logs, and other context-aware relevant data. Initially, in this same way, the semantic layer is also used to query the temporal stored data to perform reports and predictive analysis on the different cleanroom internal locations, aiming to evaluate and assist a risk management procedure that could compromise the product viability.

4 Discussions and Future Work

This work's main intention was to develop the closest to an industry-grade solution that brings value into an existing production line implementing cutting-edge approaches and delivers a product complying with the standards of industry 4.0.

As controlled and restricted environments, cleanrooms require fast and efficient technologies to deliver real-time, contextual, and aware data of the room's reality, enabling further monitoring, tracing, controlling, and predicting product characteristics. With the development of this platform, it was possible to demonstrate that a fast semantic-data ecosystem can be set up in restrictive and productive spaces and contribute with an added value to the process.

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