IIot Platform for Agile Manufacturing in Plastic and Rubber Domain

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Abstract: In recent years, the concept of integration as a key to digital transformation has also been associated with the interconnection of hardware, software, data and information in Industry 4.0. One of the greatest challenges of Industry 4.0 is to be able to ingest massive amounts of data coming out from machines: the *eFactory* platform enable users to exploit innovative functionalities, experiment with disruptive approaches and develop custom solutions to maximise connectivity, interoperability and efficiency across the supply chains. To achieve this goal, it is necessary to work on standard communication protocols and architectures. By leveraging Industrial Internet of Things (IIoT) technologies, this feasibility study focuses on the design and implementation of an open source platform for plastic and rubber industry, that abstract data and functionalities provided by on-board machinery sensors, exposing relevant services outside the machines to external cloud-based applications. The federation of this new services related to the industrial scenario is supported by an interoperable 'Data Spine' that simplifies cross-platform communication and securely capture information on the multi-tier supply chain. The intent is to make the production process more automated, interconnected and moreover to support a Zero-Defect strategy thanks to digital technologies involved in the project.

1 INTRODUCTION

Industry 4.0 refers to the Fourth Industrial Revolution−the recent trend of automation and data exchange in manufacturing technologies. The key fundamental principles of Industry 4.0 include data integration, flexible adaptation, cloud/intranet, intelligent self-organizing, manufacturing process, optimization, interoperability, secure communication, and service orientation (Ji, et al., 2016) (Vogel-Heuser & Hess, 2016). These innovative technologies are used to create a “smart factory” where machines, systems and humans communicate with each other in order to coordinate, monitor progress and connect sensors to provide data, along the assembly line (Peralta, et al., 2017). The interconnectivity in this scenario is a challenge in terms of interoperability: accessibility, multilingualism, security, privacy, subsidiarity, use of open standards, open source software, and multilateral solutions, are definitely key concepts (Xu, Xu, & Li, 2018) (Branger & Pang, 2015). In this way manufacturers need to integrate connected, discrete operational systems and smart manufacturing assets of a factory and throughout the entire supply chain, providing a complete vision of Industry 4.0 (Lu, 2017).

To simplify system development and resource management, the ability to manage and maintain complex distributed systems, common industrial approaches based on the concept of Industrial Internet of Things (IIoT) have been adopted, also to implementing Industry 4.0 scenarios, such as: *Interconnected Factory* (complete production planning and machine management, production optimization), *Cyber Physical Systems (CPS)* (to know in real time every detail of the production process), *Decentralization* (ability of CPSs to make decisions on their own), *Internet of Things* (helps people and equipment to communicate each other), *Virtualization* (a virtual model of the factory to simulate the production process), *Real-time* (collect and analyse data in real time to make timely decisions), *Technical assistant and support systems* (intelligent process and production analysis tools to control the process and react automatically in case of problems) (Lom, Pribyl, & Svitek, 2016) (Schlick, Stephan, Loskyll, & Lappe, 2014).

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The scope of the feasibility study is to lay down guidelines regarding the crucial features for the management and the implementation of a IIoT platform and the connection of a new base open platform related to the Industry 4.0 scenario developed within the Regional project Pastic&Rubber4.0 (OpenPlast, 2018), to show the concrete possibility offered by the European project eFactory (eFactory, 2018) to promote interoperability between cross-domain platforms.

The study begins with an overview of the two projects mentioned, highlighting the aspects of interconnection and the challenges to be faced in order to implement in the future an ad hoc adapter to promote such binding. To endorse these aspects is proposed the general architecture for Industry 4.0 and quick outline of the different industrial communication standards and protocols supported by the machinery connected to the platform, followed by the presentation of the IoT gateway platform (OpenLink) implemented in Plastic&Rubber 4.0 project. Afterwards is described the core of this work related to the implementation through the Eclipse Kura gateway framework for the collection and processing of data from the various factory machines. Finally, the paper proposes the discussion and the conclusions of the first results obtained in terms of increasing the system flexibility and the performances of the cross-domain interoperability.

2 eFactory PROJECT

The eFactory project realises a federated smart factory ecosystem by primarily interlinking 4 smart factory platforms from the FoF-11-2016 cluster [COMPOSITION, DIGICOR, NIMBLE, vf-OS], with their integrated toolsets and services through an open and interoperable Data Spine. The eFactory platform allows users to take advantage of the wealth of Industry4.0, Internet of Things (IoT), Artificial Intelligence, Big Data Analytics and Digital Manufacturing solutions displayed in the project ecosystem. The eFactory federation is offered to the manufacturing and logistic companies as an open platform to utilise the offered functionality, experiment with innovation approaches and develop custom solutions based on specific needs.

As shows in Figure 1, the core of eFactory ecosystem is the 'Data Spine', an interoperability mechanism that provide support for secure and interoperable data exchange (between internal and external platforms), service calls and API integrations across multiple systems and platforms. To help users create their own software applications and services, eFactory is equipped with an open Software Development Kit (SDK) and a development environment (Studio). The SDK uses Data Spine as an integration layer and allows users to compose applications or integrate services based on their specific needs. The eFactory Marketplace Framework uses the Data Spine to interlink the marketplaces of multiple platforms in the eFactory ecosystem. The Data Spine, that streamlines cross-platform communication and securely captures multi-tier supply chain intelligence, which is then propagated within the platform (through interfaces and a dashboard), is proposed as a bridge for protocol heterogeneity and provide uniform access to services between base platforms and apps/tools.

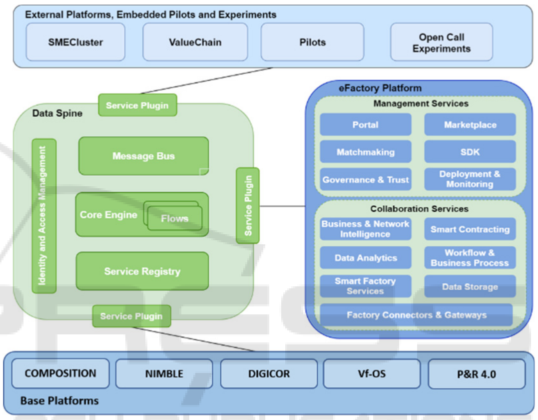


Figure 1: eFactory concept architecture.

Using these implementation features of the eFactory platform, it is therefore possible to connect throw the Data Spine new platforms built for different domains, in the specific case treated in this paper, a complete, open and security trusted base platform related to rubber and plastic industrial domain is taken as a feasibility study reference.

The use of common (de-facto) standards for communication and data exchange at the shop-floor, systems and business/enterprise levels is one of the best practices of distributed systems development: in this way, project partners would develop standardised solutions to enable the interoperation of heterogeneous and distributed solutions in the eFactory federation. Standardisation is of special importance in supporting the digital transformation of industry. In this way, the eFactory project as also the focus to inviting manufacturing companies, digital solution providers, software developers and researchers to carry out experiments related to the development, prototyping, integration and validation of innovative solutions using eFactory platform.

3 P&R 4.0 PROJECT

This paper is also based on the use cases carried out during the Regional project Pastic&Rubber4.0 (which for the market is renamed OPEN PLAST) that focuses on implementing a real scenario of technological innovation through defining, developing and experimenting in real plastic and rubber factory use cases new models and organizational tools borrowed from Information and Communications Technology (ICT) world.

The regional project focuses on three fundamental objectives: the increase in performance at the process level (in terms of processing times and overall quality), the flexibility of the processing systems (in terms of working conditions and autonomy) and the rapid diffusion of the information for the involvement of users in the process.

The services offered, that can be deployed as a service in the Data Spine of the eFactory project, may include integration with company Enterprise Resource Planning (ERP) systems, shop monitoring, scheduling and optimization of production planning, energy management and optimization, remote and predictive maintenance, control of feeding and cooling systems, the integration of automated warehouses up to augmented reality systems (e.g. in the maintenance field). Benefiting from the above, Industry 4.0 Factories – or simply "Smart Factories"– will be able to perform prognoses such as health management of machine tools, enhancing productivity and increasing the quality of processes and services. The advanced elements of this project are related to the possibility of implementing an open source platform for plastic and rubber factories with a modular IoT architecture for the management of applications and an advanced data repository for shop floor monitoring. In order to implement the hardware and software components of this platform for the retrofit of the existing machine, the researches exploit new standard communication protocols (such as OPC UA, Euromap 77/83, etc) and a multi-protocol platform open to market standards.

This paper also focuses on the management and software implementation of the various industrial communication protocols used to describe a single Data Model that allows correct storage of data from the different factory machines on the Data Spine (or generic Cloud platform). The common Data Model will describe all the events, variables and resources that could indicate quality issues, exploiting it to reduce defects, the respective causes and the strategies to avoid the propagation of the errors along the shop floor.

In the implemented IoT architecture, in order to provide the capability to offload computationally expensive data processing from the Cloud to the Edge (minimizing additional latency and operational expenses) (Peralta, et al., 2017), a core role is assigned to the Low Power Gateway (LPG). Edge computing is mainly considered an extension of cloud computing to the edge of the network, which enables new applications and services related to a huge number of heterogeneous IoT devices (Vaquero & Rodero-Merino, 2014). Edge computing brings significant benefits in terms of: low latency, geographical and large-scale distribution, mobility and location awareness, flexibility, heterogeneity and scalability (Bonomi, Milito, Zhu, & Addepalli, 2012) (Barcelo, et al., 2016). As an edge node, the Low Power Gateway will have the capability of data pre-processing (acquiring data directly from the machines or trough adapters), conversion between protocols, communication through IoT protocols and send data to the Data Spine (as the Open Platform), using the imposed requirements.

With the functionalities of filtering and pre-processing on board of LPG, proposed as new project implementations, it is also possible to monitor the status of the manufacturing process in real time. This provides the possibility to define new strategies based on real data acquisition able to detect and prevent the generation of errors and defects along the shop floor. In case an error occurs, instead of wasting the part, corrective actions are suggested based on correlations and decision support mechanism. In this way, to develop a Zero-Defect strategy to cope with increasing competition and sustainability related issues, plants should be designed and managed using best practices from emerging key enabling ICT technologies (May & Kiritsis, 2019).

4 INDUSTRY 4.0 GENERAL ARCHITECTURE

Several architectures and conceptual platforms have been proposed to develop Industry 4.0 applications. As proposed by numerous studies, there are three major types of integration: *horizontal integration*, *vertical integration* and *end-to-end integration* (Qin, Liu, & Grosvenor, 2016) (Oliveira & Alvares, 2016); all this integration formats require changes in enterprise architecture, ICT integration and processes (GTAI, 2014). Liao et al. (Liao, Deschamps, Loures, & Ramos, 2017) have specified these three types of integrations in Industry 4.0 as (1) *Horizontal*

Integration: integration of the different Information Technology (IT) systems used in the various stages of the manufacturing and business planning processes within and between companies (e.g. inbound logistics, production, outbound logistics, marketing, value networks) (Kusiak, 2017); (2) *Vertical Integration*: integration of the various IT systems at the different hierarchical levels to deliver an end-to-end solution (e.g. actuator and sensor level, manufacturing and execution level, production management and corporate planning levels); and (3) *End-to-End Digital Integration*: the digital and real worlds are integrated across a product's entire value chain and across different companies, whereas incorporating customer requirements. Industry 4.0 is expected to achieve all three major integrations as described above, plus hardware integration, software integration, and information integration. Efficient real-time integration of data in Industry 4.0 production processes needs to be ensured, as the support of automation in Industry 4.0 requires such integration (Xu, Xu, & Li, 2018).

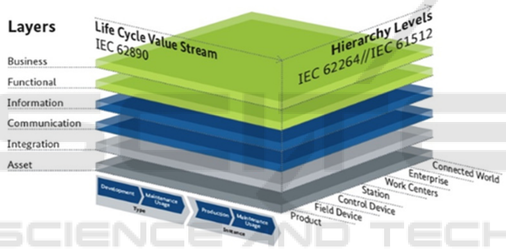


Figure 2: RAMI general concept architecture.

The German Electrical and Electronic Manufacturers' Association and its partners have developed the Reference Architecture Model Industrie 4.0 (RAMI 4.0) (Rojko, 2017) which is now supported by Platform Industrie 4.0 and is considered a key standard for Industry 4.0. RAMI 4.0 groups the main components of Industry 4.0 into a single three-dimensional model that describes the space in which Industry 4.0 manifests itself (see Figure 2). The three axes of RAMI 4.0 represent the hierarchical levels of a networked production plant, the life cycle of plants and products and the IT representation of an Industry 4.0 component.

This 3D architecture and the concepts related to RAMI 4.0, become the starting point for the implementation of the IIoT platforms related to the eFactory and Plastic & Rubber 4.0 projects, to demonstrate how this platforms can be approached to the features explained into RAMI 4.0 in order to have an architectural model that can be replicated in different production contexts, which is also one of the objectives of the project.

5 STANDARD AND PROTOCOLS INDUSTRY 4.0

In the last few years, another hurdle for both IoT and Industry 4.0 has been the lack of standards. Standardisation in IoT mainly aims at improving the interoperability of different applications/systems (Da Xu, He, & Li, 2014). Standardisation efforts are needed to ensure devices and applications from different countries to be able to exchange information. Various standards such as communication/identification/security standards, used in IoT might be the major drivers for the spread of IoT technologies (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012).

The companies that join the OPC Foundation (OLE for Process Control) (OPC, 2020) have addressed the problem and have created a standard protocol for the operation of the machines and software systems that can now communicate with each other using information models that enable a large volume of data to be represented in a structured manner and transferred in a standardized form.

With the introduction of service-oriented architectures in manufacturing systems, the OPC Foundation developed the OPC Unified Architecture (OPC UA): a set of specifications to address challenges in security and data modelling and at the same time provide a feature-rich technology open-platform architecture that was future-proof, scalable and extensible (OPCFoundation, 2018).

The main reasons related to the adoption and the greater use of the OPC-UA standard in the plastic and rubber industrial sector, are the following: allows Smart Manufacturing, contributes to reducing the complexity of communication between devices and machinery (thus improving the overall efficiency of the systems), it is compatible with legacy systems, new machinery and product lines, it is multi-platform, it is not a proprietary format, it is able to receive and interpret multiple data points from different sources.

Furthermore, Euromap, the organization that joins plastic and rubber processing machinery manufacturers' associations at European level, has been involved for years in the development of an interface for Industry 4.0 (EUROMAP, 2020). The recent standard that describes the interface between injection moulding machines and Manufacturing Execution System (MES) for data exchange is called

Euromap 77: this standard is based on OPC UA and replaces Euromap 63, which is an obsolete text file-based data transfer standard, but due to the longevity of machine tools, Euromap 63 will still be of interest for the next few years. The longevity of machine tools is a fundamental challenge for the digitalization of factories because new standards and old standards have to be considered and those data has to be harmonized (Behnke, Müller, Bök, & Bonnet, 2018). With Euromap 77, machines from different manufacturers can be easily networked for monitoring the quality of the process and acquisition of production data. In the Plastic&Rubber 4.0 project, the focus is also related to the use of the new standards (such as Euromap 77) to create a Data Model concerning to the factory machine that is as homogeneous as possible, however remembering that inside the factories for plastic moulding and rubber machinery may be present with more obsolete standards and protocols (e.g. Modbus, S7, Euromap63, Euromap83 etc).

6 FRAMEWORK ARCHITECTURE FOR OPENLINK IoT GATEWAY

The IoT eco-system will involve machines, factory network and surrounding devices related to IoT, with an attention to diffuse information rapidly on the involvement of users in the industrial process, increase the performance at the job level and the system flexibility.

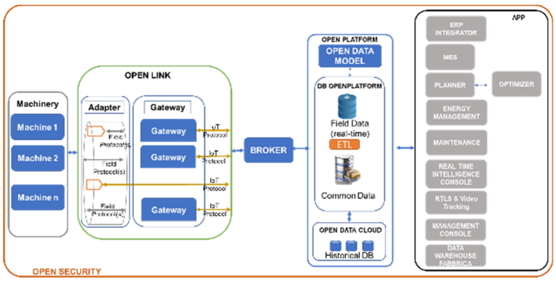


Figure 3: Plastic & Rubber 4.0 Open Platform.

Regarding the designed IoT architecture (Open Plast Platform) as described in Figure 3, can be seen as a set of four macro blocks:

- **Machinery:** representing different types of machines (presses, chillers, drying systems, etc.) that will be connected and integrated to the OpenPlatform using the IoT Subsystem.
- **OpenLink** (IoT Subsystem)**:** represents IoT devices (Gateway and Adapter) that allow the machines to communicate with the Open Platform.
- **OpenPlatform:** includes within it a series of databases that will be used differently by the applications and by the IoT Subsystem (OpenLink). Moreover, some mechanisms will be implemented for managing access and issuing certificates.
- **Applications:** this macro-block represents all the applications that will be developed in Plastic & Rubber 4.0 (Manufacturing Execution System (MES), Planner and Optimizer, Energy Management, Maintenance, Management and Real Time Intelligence Console, RTLS & Video Tracking and Factory Data Warehouse). While the Machinery and the Open Link (IoT Subsystem) will be physically located within the factories, the Open Platform and applications can reside both within individual factories and in the Data Spine.

In the OpenLink block, the smart IoT gateway framework is a software solution that bridges the semantic gaps between the raw machine sensor data and the information context that is interested by high-level applications. The Low Power Gateway (LPG) implements an IoT platform that acts as an aggregation point coordinating the connectivity between the devices and the machines, and with the different subsystems, as well as with networks and external devices. Furthermore, it has the functionality of IoT middleware, interfacing heterogeneous physical devices (such as sensors and actuators) and machinery, exposing data and features to the Open Platform database and the Open Data Cloud.

For the design and the implementation of the Low Power Gateway, some fundamental requirements related to Industry 4.0, to the concept of interoperability and cross-federation, have been taken into account (Figure 4):

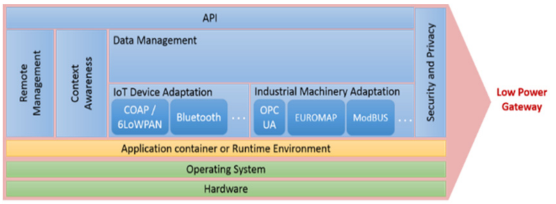


Figure 4: Development view Low Power Gateway.

- **Interoperability:** the LPG must be able to interact (exchange of data and services transparently) with heterogeneous devices, technologies, machinery and applications, without the need for further adaptations by the developer of application or service. Interoperability can be understood from a communication, syntactic or semantic perspective.

- *Communication Interoperability*: allows the platform to transparently transfer information between sensor and actuator networks, devices, machinery and subsystems that use different transport protocols.

- *Syntactic Interoperability:* must allow the harmonization of formatting and coding structures of any information and service.

- *Semantic Interoperability*: refers to the meaning of information or services and must allow the correct interpretation of information exchanged between sets of devices and services connected to the platform.

• **Service-based:** the LPG will offer maximum flexibility if new and advanced features are added (such as support for a new machine). These and other services can be designed, implemented and integrated into an application container or runtime environment that is a service-based framework (such as Java-OSGi, Python, ROS, Node.js) that offers a flexible, modular and simple application development environment.

• **Context-awareness:** for building adaptive applications and services, as well as for reading detected values. The IoT subsystem must be aware of the context through a model to be used for the development of effective intelligent services that operate in a specific way based on the context. To enable context awareness, layered architecture has been used to build frameworks for devices, raw data storage and processing, context management, and applications.

• **Data Management:** the LPG can provide applications with data management services: these include data acquisition and processing, data fusion at the "peripheral" level and a local data storage capacity to manage network latency and reliability.

• **Event management, Analytics & UI:** the LPG is able to handle events with near real-time constraints. The platform can have analysis capabilities and expose processed and improved data to the Open Data Cloud.

• **Remote Management:** the possibility of instantiating, configuring, updating, monitoring, starting and closing remotely all the different software components (i.e. services and applications) running on the platform.

• **Security and Privacy:** security must be implemented both at the device and application level. Functions such as authentication, encryption and authorization must be part of the software architecture. Furthermore, each block of LPG that uses personal information must preserve the privacy of the user who owns it.

• **Open Standards:** communication within and outside the LPG must be based on documented open standards to ensure interoperability.

• **APIs:** Providing Application Program Interfaces (APIs) for application developers is an important feature. The APIs allow easy integration with existing applications and integration with other IoT solutions and cloud services. The programming paradigm (e.g. publish/subscribe, REST, etc.) concerns the model for the development or programming of apps or services.

7 GATEWAY IMPLEMENTATION

As highlighted in the previous section on the design of the Open Platform, the various machinery (directly or through adapters) send the data to the OpenLink which, after some procedures of filtering and processing, exposes the processed data, through a MQTT Broker, directly to the applications and services on the Data Spine. The first tests in lab were conducted using the Cloud available on Eclipse: Kapua™ is a modular, integrated, interoperable IoT cloud platform to manage and integrate devices and their data and provide a solid foundation for IoT services for any IoT application.

To implement the gateway/client framework, it is chosen to use an Eclipse tool that basically acts as a proxy between the field devices and the data centres. Eclipse Kura™ is an extensible open source IoT Edge Framework based on Java/OSGi (Open Service Gateway initiative), that provides a platform for building IoT gateways. Kura offers API access to the hardware interfaces of IoT Gateways (e.g. serial ports, GPS, watchdog, GPIOs, I2C, etc.). It features ready-to-use field protocols (including Modbus, OPC UA, S7), an application container, and a web-based visual data flow programming to acquire data from the field, process it at the edge, and publish it to leading IoT Cloud platforms through MQTT connectivity (Kura, 2020).

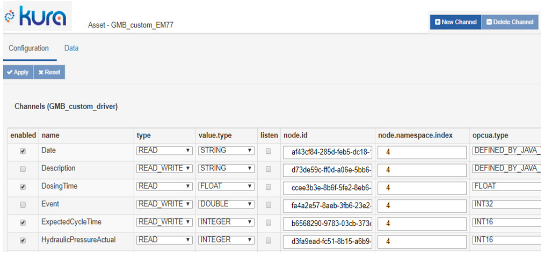
Kura (in particular, at the moment in which this paper is written, it is suggested to use version 4.0) has a user accessible web console that provides several important features available out-of-the-box: the ability to configure the gateway, connect to a remote cloud and even a visual data flow programming tool to dictate the data collection and processing pipelines of devices connected to it (Lee & Nair, 2016).

The application implemented in Kura is provided as an OSGi module and performed inside the container together with the other Kura components. Applications can be remotely implemented as OSGi packages and their configuration can be imported (or exported) via a snapshot service.

Using the Kura tutorial, the first steps were taken to configure Kura 4.0 on a Raspberry (Pi4), which will be used as an IoT gateway and which provides client interface with the factory machinery. Eclipse Kura introduces a model based on the concepts of Drivers and Assets to simplify the communication with the field devices attached to a gateway. The Driver encapsulates the communication protocol and its configuration parameters, while the Asset, which is generic across Drivers, models the information data channels towards the device. When an Asset is created, a “virtual” device is automatically available for on-demand read and writes via Java APIs or via Cloud though remote messages. In this Client/Server model, the different standards and protocols managed by the machines (e.g. Modbus, S7, OPC UA, Euromap 63, Euromap 77, etc.) defines sets of services that the servers can provide, and each server indicates its own group of services that it makes available. Information is exchanged using DataTypes defined by the standards or by producers, while servers use Data Models that clients can identify dynamically by requesting metadata containing the description of the format used.

For example, OPC UA can be mapped on various protocols and supports several types of data encoding allowing users to choose in order to optimize applications in terms of portability and efficiency. It should also be noted that the available Channels can be set to read/write the values from the machines: for this reason it is possible (retroactively, thanks to the pre-processing on the gateway or possibly to new configurations identified on the Cloud) set or block some machine data, avoiding sudden breakages.

In Plastic&Rubber 4.0 project, a set of variables from the rubber moulding and plastic extrusion machinery has been defined, some of which are related to the implementation set provided by the Euromap consortium, but others are customized directly by the owners of the factory machinery.



Channels (GMB_custom_driver)

enabled	name	type	value.type	listen	node.id	node.namespace.index	opcua.type
☑	Date	READ	STRING	☐	af43cf84-285d-feb5-dc18-	4	DEFINED_BY_JAVA_
☐	Description	READ_WRITE	STRING	☐	d73de59c-ff0d-a06e-5bb6-	4	DEFINED_BY_JAVA_
☑	DosingTime	READ	FLOAT	☐	ccee3b3e-8b6f-5fe2-8eb6-	4	FLOAT
☐	Event	READ_WRITE	DOUBLE	☐	fa4a2e57-8aeb-3fb6-23e2-	4	INT32
☑	ExpectedCycleTime	READ_WRITE	INTEGER	☐	b6568290-9783-03cb-373	4	INT16
☑	HydraulicPressureActual	READ	INTEGER	☐	d3fa9ead-fc51-8b15-a6b9-	4	INT16

Figure 5: Kura GUI Channels.

Figure 5, shows the implementation of the variables received from the various machines (the values in Channels/Assets are updated in real-time), via Kura's Graphic User Interface (GUI).

Since at present, an implementation bundle relating to the Euromap 77 specifications does not exist on the Eclipse Marketplace (from Eclipse Kura Marketplace is possible to download additional Wires components that can be installed into personal Kura runtime with a simple drag-and-drop approach), a comparison was made between the pre-existing Kura package for the OPC-UA driver and the implemented package which fulfils the requirements of the Euromap protocol. Using this approach, during the implementation of the Low Power Gateway, the structure of the Kura bundle relating to OPC UA has been partially extended to support the features related to machines compatible with Euromap 77, especially regarding the acquisition of customized variables. To improve this, new classes have been implemented, following the development line proposed by the OSGi framework with the characteristics and DataType referring to Euromap 77.

With the aim of having modular and visual data flow tool, the Kura Wire Ghaph (Figure 6) define data collection and processing pipelines at the edge by simply selecting components from a palette and wiring them together. With this tool users can: configure an Asset, periodically acquire data from its Channels, store them in the gateway, filter or aggregate them using powerful SQL queries, and send the results to the Cloud.

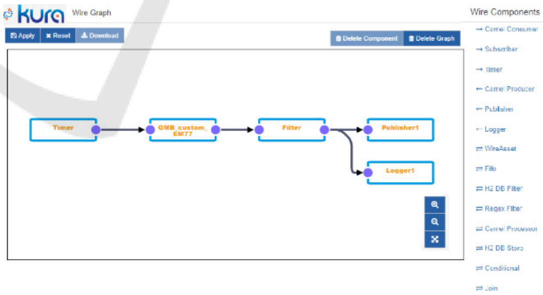


Figure 6: Kura Wires GUI.

Regarding the task of acquisition and processing of the raw data from the various machines, it was decided to carry out a decoding step of the machine status (on/off) and a pre-filtering (evaluation of the change in values acquired over the time) to ensure that the data can be sent smoothly and according to certain pre-established timings to the MQTT Broker and subsequently to the Data Spine. Once the main structure has been defined to collect all the raw data from the sensors on the machine, the bundles developed on Kura can be used to proceed with the publication of the data on an MQTT broker.

As mentioned during the description of the eFactory architecture, the Data Spine interlinks the APIs of the participating base platforms so that each platform's functionality is at least, visible and accessible at the level of eFactory. This needs to offer interoperation services at the level of protocols, message formats, data structures, data models, software services, and processes ranging from field level control to business process performing.

Thanks to the possibility of pre-processing inside the gateway (edge level computing), the security model is simplified and improved. For example, it is an advantage that despite many devices in the field, the number of gateways that must be connected to the Cloud is reduced. Obviously, the relationship between device and gateway must be "trusted".

This solution is also required to reduce as much as possible the defects, the respective causes and the strategies to avoid the propagation along the line. Decision Support Systems (DSS) are considered as a robust technology able to provide an advantage to several manufacturing companies, also to increase Zero Defect Manufacturing strategy. The scope is to facilitate real-time inspection, condition monitoring and control - diagnosis at the shop-floor, utilizing continuously mine multiple data streams and run the suitable models to monitor operations and quality performance, to classify products on the basis of quality metrics, as well to predict occurrence of defects and deviations from production and quality requirements.

8 CONCLUSION & FUTURE WORKS

This feasibility study has presented some strategies for the implementation of an IIoT platform interconnected to the deployment of the cross-domain eFactory platform, contributing towards the creation of an ecosystem of connected smart factories in Europe: in this Industrial IoT scenario, connected machinery, plants and production lines continuously collect data "on the field", that can be pre-processed and shared within wireless or wired corporate networks to better synchronize processes.

The federated eFactory platform delivers enhances value and reduces the barrier to innovation by providing seamless access to services and solutions that are currently dispersed. In parallel the IIoT platform provides the necessary infrastructure, tools and support for novel service creation and validations by third parties. The expected result due to the implemented IIoT platform is to translate into a technological and competitive improvement of the production system, an increase in the general production capacity, as well as in an improvement in the performance of the machines and processes, reducing both economic and environmental costs and also energy consumption of production plants.

A further result concerns the expansion of communication protocols in the middleware based on standard interfaces for interoperability (platform independent), the safe and reliable exchange of data between the machines and MES: the implementation of advanced planning/optimization algorithms applied to the production cycles of a 4.0 manufacturing plant, also provides the design and development of a robust early stage data knowledge-based inference engine to support Zero Defect strategies in manufacturing environment.

The suggested implementation of the Low Power Gateway promotes the adoption of common standards for the development, the management and security of systems, guaranteeing a certain level of transparency, which is essential to reduce complexity and increase the trust of both developers and end users. To further expand the experimental part and for a better analysis of the results, additional experiments and some comparisons with the deployments of the other cross-domain platforms on the eFactory Data Spine could be planned as next steps.

Regarding the use of the Kura framework for the implementation of the LPG software, as future work it is possible to improve the proposed bundles in order to extend and uniform the Data Model that foresees the input values from different machines (with different protocols) and then analyse themselves on the Data Spine to offer various services. With this architecture, the transfers required from IIoT devices may be reduced, since the publishers would only need to update in the Data Spine the predicted data in case of mismatching: the progress of eFactory will be to ensure that a whole federation of platforms can be deployed in different cloud environments with minimal reconfiguration.

In conclusion, this study highlights that cross-domain platform level interoperation challenges are about interoperability between various platform layers, i.e. devices, network, middleware, application, data and semantics. Next steps related to this feasibility study in the plastic and rubber domain, could provide validation scenario to demonstrate the seamless access and utilisation of the 3rd party system/application by eFactory services and users.

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