A MAAS PLATFORM ARCHITECTURE WHICH SUPPORTS DATA SOVEREIGNTY IN MANUFACTURING SYSTEM SUSTAINABILITY ASSESSMENT

HARA PRASAD TRIPATHY, PRIYABRATAPATTANAIK & SUSHANTA KUMAR KAMILLA

Department of Management, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha

ABSTRACT

The digitalization of industrial processes, along with the large incorporation of IoT infrastructures through production systems, has a dramatic effect on the value chains of manufacturing and the business models that are built on top. Starting with the concept of dematerializing production capital and supporting servitization, this paper describes the architecture behind a Manufacturing as a Service (MaaS) network, establishing an ecosystem that functions as a virtual marketplace taking untapped production capacity, as well as other virtual and physical assets, closer to the demand for production, in order to obtain their optimum production ability. The portal provides a clear link between the manufacturing services suppliers, the technology they incorporate, and the consumers requesting the products / resources. As a critical element in the service / product selection process is the assessment of the sustainability output of goods and businesses, the platform supports the automated acquisition of manufacturing data, their production through an LCA-based engine and aggregation into indicators. These metrics are used to identify suppliers into the sustainability perspective and/or provide means of communication of manufacturing-generated impacts. It incorporates the INTERNATIONAL DATA SPACES (IDS) connector as a data rich platform to link different entities through safe data exchange and trusted data sharing, thereby promoting data sovereignty. Integrating the IDS reference model forms the basis for data privacy and protection that provides trust between participants in the network and guarantees data owners, respect for who uses their data, how long, for which purpose, how many times and under what terms and conditions.

KEYWORDS: *Manufacturing Service, Sustainable Manufacturing, Industrial Data Space*

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INTRODUCTION

International Data Spaces Approach to Industrial Data Management

Servitization is now a popular practice embraced by businesses operating in a wide variety of industrial sectors, moving revenue generation from the selling of physical goods to charging consumers for the availability of the service or functionality provided by the product. That model extends to both consumer and capital goods, as businesses are increasingly able to sell (and buy) production resources rather than new machinery, thereby establishing the Production as a Service (MaaS) model. To achieve the MaaS paradigm in its entirety, aggregation and information sharing points are required to give visibility to the manufacturing ability that any business may wish to make available at any location and field [1], [2]. Digital networks have shown the ability to resolve this need by building digital environments capable of serving consumer and supplier needs internationally and across multiple sectors facilitating the transition of business models to service-oriented approaches.

As digital industrial platforms manage an extensive amount of customers' and suppliers' data to provide value-added services, the trust in the infrastructure supporting the secure management of data becomes instrumental to platform acceptance. In fact, although there are very good examples of how the exchange of data between business ecosystems can work, the overwhelming majority of businesses are still struggling with the uncertainty around technical and legal issues, as well as with actual technical and legal barriers [3]–[5]. The uncertainty showed by companies in managing the transition towards the data economy is also reflected by very limited initiatives supporting a univocal, technology-based approach to trust and security management in data transfer within value networks.

In this context, an outstanding experience is represented by the Industrial Data Space (IDS), i.e. an initiative driven forward by Fraunhofer, together with over 60 key industrial players, that makes digital sovereignty over industrial data and trust in data sharing, key issues addressed by their reference architecture model. The IDS aims at creating a virtual data space that leverages existing standards and technologies, to facilitate the secure and standardized exchange and easy linkage of data in a trusted business ecosystem, providing a basis for cross-company business processes, while guaranteeing data sovereignty for the participating data owners[6]–[8]. The developed Reference Architecture Model, as well as the designed communication interfaces are meant to establish an international standard which considers the following user requirements:

- Trust: at the basis of IDS, trust is supported by a comprehensive identity management focusing on the identification of participants and providing information about the participant based on the organizational evaluation.
- Security and data sovereignty: Components of the IDS rely on current security measures, more a data owner in the Industrial Data Space attaches usage restriction information to its data before it is transferred to a data consumer. The data consumer may use this data only if it fully accepts the data owner's usage policy.
- Ecosystem of data: The IDS architecture pursues the idea of decentralization of data storage, which means that data physically remains with the respective data owner until it is transferred to a trusted party.
- Standardized interoperability: The IDS Connector (communication interface to other participants in the network), is implemented in different variants and vendors, still being able to communicate with every other connector.
- Value adding apps: The IDS enables app injection to connectors to add services on top of the pure data exchange. This includes services for data processing as well as the alignment of data formats and data exchange protocols, but also enables analytics on data by the remote execution of algorithms.
- Data markets: The Industrial Data Space enables the creation of novel, data-driven services that make use of data apps, also fostering new business models.

One of the most interesting aspect about the IDS business reference architecture is the opportunity to support multiple implementations and to combine them with open source enablers. One of the currently more accredited implementations of the IDS reference architecture is carried out using the Generic Enablers provided by theFIWARE architecture. FIWARE is an open source initiative defining a universal set of standards for context data management which facilitate the development of Smart Solutions for different domains. In particular, it covers the need to gather and manage context information, processing that information and informing external actors, enabling them to actuate and therefore alter

or enrich the current context. This is managed by the FIWARE Generic Enablers that constitute a set of building blocks that offer reusable and common shared functions to be deployed in multiple use cases[9]–[11]. The FIWARE Foundation is working towards making sure that core FIWARE Generic Enablers can be integrated together to build a valid open source implementation of the IDS Architecture. Both organizations are collaborating on the development of domain data models and communicating about the development of their respective specifications and architectures to keep them compatible.

Lifecycle Assessment in the IOT Domain

In the challenge of transforming manufacturing towards a low-carbon, resource efficient and sustainable economy, the European manufacturing sector is undergoing a process of evolution impacting the way products are manufactured, supplied and sold. Advancements in the context of the Industry 4.0 framework provide relevant opportunities for achieving sustainable manufacturing by providing sustainability-oriented organization with the technological enablers addressing the efficient management of products, materials, energy, water and wastes. On the other end, Life Cycle Assessment (LCA) provides a widely accepted methodology able to assesses the environmental impacts throughout a product life cycle, and exploit the acquired data to address process optimization or sustainability impact communication. The measurement of the sustainability performances of products and companies has been largely recognized as a focal pre-requisite for the actual translation of these strategies into operations. For these reasons, proper metrics must be adopted enabling the standardized calculation of appropriate indicators measuring the environmental performances at product and company levels. Monitored data empower: performance optimization, support to guarantee standardization and legal compliance, sustainability communication and marketing.

Enabling the possibility to uniquely identify and track everything, anywhere, and anytime, the emergence of Internet of Things (IoT) and Digital Twin concepts introduce a further level of detail of the assessment focus that is the lot-wise or batch-wise evaluation. This is meant to address a single product produced in a specific moment, following a specific manufacturing path. Traditional LCA methodologies provide average values not keeping into account each item performances; this means that a product or a batch processed in a given production line results in a set of pre-calculated (and average) impacts. Should users monitor sustainability performances of each single batch, they would also be able to dramatically increase the amount of information used to improve the overall performances of a company or to be communicated to their customers. However, the acquisition of Lifecycle data (Lifecycle Inventory) is universally recognized as the most time- and resource-consuming phase in the whole LCA implementation path, and data gathering from the different entities along the supply chain is probably the most critical issue to be solved, also considering that completeness and quality of gathered data is fundamental for the reliability and repeatability of the calculated impacts. The coordinated but automatic collection of sustainability-related data coming directly from single production machines and lines of the supply chain via IoT, or coming from the simulation performed within the Digital Twin environment or, again, from other company software, is meant to drastically reduce the time needed to obtain a reliable and real-time evaluation of the single item and/or of the entire supply chain.

Beyond the technical possibilities brought by the applications of IoTs in the acquisition of lifecycle data, the calculation and communication of sustainability data is still perceived by companies as a critical domain. Because industrial processes are typically undertaken in a competitive economic context, preventing potential competitors from learning sensitive information about their activities remains of paramount importance. At the same time, many different kinds of organizations are motivated to make public disclosures about their environmental performance. These motivations

inspired by regulatory requirements, marketing initiatives, or as part of a broader project of corporate sustainability

Moving towards a digital economy, where industrial services are accessed by means of digital platforms and cloud based solutions, it becomes of paramount importance to create sound methodologies and tools able to manage data transactions through trust based mechanisms. This is expected to improve propension of industrial firms to make use of sensible data generated internally and elaborated by means of external platforms.

In this paper we propose a methodology to support the calculation and exploitation of LCA data by guaranteeing the maintenance of data sovereignty by integrating the IDS approach. The calculated LCA data are used as indicators supporting ranking of suppliers while assessing requests for quotations on a MaaS platform (MANU- SQUARE platform). Hereinafter a brief introduction of the platform is described together with its basic architecture. Two evolutions of the architecture are thus provided, both integrating the IDS approach, the first exploiting the platform for sustainability data calculation, the latter demanding LCA calculation to a self-standing LCA tool deployed in the factory environment, thus enabling to store all the sensible data, locally in the factory.

Implementation of IDS Policies in a MAAS Digital Platform

Introduction to the MANU-SQUARE Platform

The purpose of the MANU-SQUARE platform is to allow any company to increase its level of machinery employment by sharing its production capacity within a network of companies. Resource finding & sharing is the platform service which allows users to share underexploited manufacturing capacities, capabilities, know-how, technology and by-products. To address this service, the platform enables customers to define request for quotations (RFQ) for the production of components matching the mentioned underused production capacity. The input data defining the RFQ are processed by a matchmaking tool that carries out the selection of a set of suppliers who can carry out the project, according with parameters defined by the customer (price, quality, sustainability). Subsequently, the platform enriches the supplier's data with a company sustainability calculation to make the customer more aware of the impact of his choice. The platform shares a Request for Quotation with a set of suppliers providing all the information needed to calculate the cost of production. The customer will receive offers from all suppliers that comply with the specific requests and can start with each of them a series of communications to clarify all possible outstanding points before a decision can be made.

In order to select qualified candidates for the implementation of the customer's project, several customers' and suppliers' information is required, some of it sensitive. Focussing on the sustainability aspect alone, there is a risk that this information will not be recorded by the supplier for two main reasons:

- The supplier does not want to share information about its environmental impact with an external platform.
- The probability of being selected for an assignment could not be perceived as a sufficient incentive to cover the costs of entering the necessary data into the platform. The technological costs related with the integration of the used system in order to share data is perceived as a barrier.

In order to mitigate the negative impacts of the two points described above, in the following chapter the current architecture of the platform is described, two evolutions to make the platform complainant with the IDS approach are then designed.

Manu-Square Platform Reference Architecture

The MANU-SQUARE platform architecture is composed by four architectural layers respectively covering (Figure 1):

- web portal;
- business processes execution;
- tools orchestration
- data storage and management

Figure 1: High level schema of MANU-SQUARE operation

The web portal is the access point for customers and suppliers to all the available functionalities provided by the platform. The web portal will be in communication with the business layer, represented by the Gateway Orchestrator, component that has the task of implementing the processes made available to the platform's stakeholders, behaving like a Mediator to a) reduce the close coupling between a series of services that interact with each other b) change the interaction between a set of services independently.

The gateway orchestrator interfaces directly with the tool layer, composed by independent tools, each responsible for covering one of the functionalities provided by the MANU-SQUARE platform e.g. the sustainability assessment layer, with regard to the sustainability calculation. This tool aims to provide indications of the sustainability of the process, or of the set of processes necessary for the realization of the customer's project. The final result that the sustainability layer elaborates is an environmental impact value that will be used in the ranking of the various suppliers.

Evolving the MANU-SQUARE Architecture Towards Data Sovereignty in Sustainability Assessment

The MANUSQUARE foundation forms the basis on which the ideas presented here capitalize. A safe migration of data

from businesses to cloud systems is a critical problem for most business applications, and thus for the MANUSQUARE platform too. In this way, Industrial Data Space is: it reflects a virtual data environment leveraging current standards and technology, as well as agreed data economy governance frameworks, to promote stable and consistent data sharing and connectivity within a trustworthy business ecosystem. It thus provides a basis for smart service scenarios and innovative cross-company business processes, while ensuring data sovereignty for the participating data owners is guaranteed.

The Reference Architecture, depicted in the left, was formalized adapting the model of the IDS reference architecture to the context proposed here. This architecture is structured to identify the core components involved, and their interactions. In reality, the Industrial Network Room consists of a series of accredited modules, here known as connectors, which enforce service endpoints at network providers' and service consumers' sites.

Companies represent data owners who hold all the legal rights to their data and have complete control. As per the IDS method, a person acting as a data owner often typically takes on the role of the data provider. The data provider makes data accessible for direct sharing with the data customer, as illustrated here by the MANUSQUARE Platform, which may request data from the data provider directly. Related to the Data Owner as the person that has the moral rights of the data, the IDS reference model formalizes the Data User definition as the individual that has the moral right to access the data shared as set out in the Use Agreement. This is also the case in other cases, Data User corresponds with Data User except in this instance. The MANUSQUARE platform also assumes the role of Identity Provider which is the entity intended to create, maintain, manage and validate Identity Information of and for Industrial Data Space participants in order to avoid unauthorized access to data.

A connector represents a key component required for the interface between companies and the MANUSQUARE platform according to the reference architecture shown above. The key function of a connector is to control the handling of data transfers from and/or to a peer connector according to the following potential configurations: (i) the client connector uploads data from the local site, passes the data to the receiving connector on the side of the MANUSQUARE network that copies data to the local site. In this case the firms serve the service suppliers and the service consumer's MANUSQUARE network. (ii) After the MANU-SQUARE platform collects data from customers, the MANU-SQUARE platform can use the data to execute LCA and reports can in turn be transmitted back to the organization that downloads data on its local location.

CONCLUSIONS

In this paper we discussed the architecture behind a MaaS platform and its development in the acquisition and elaboration of LCA indicators towards an IDS-based data management. The two approaches proposed are intended to provide an acceptable degree of versatility for companies interested in entering the MANU-SQUARE ecosystem while remaining able to retain control and autonomy over the data used to measure their environmental index. As a reference implementation in the LCA domain, the architecture can be easily applied to third-party applications that companies can access either on or within the MANU-SQUARE network. Next steps should call the implementation by FIWARE Generic Enablers of the built evolutionary architecture and thorough testing of its functionalities.

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