Standardisation connecting the initiative ‘Industry 4.0’ and Service Life Cycle

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Abstract

In the manufacturing domain there are two major challenges in the future, innovation via integration enabling improved decision making and servitization, the design and use of innovative services. The German Industry 4.0 initiative is aiming to support the integration and virtualisation of manufacturing design and production processes using the internet in infrastructure to create smart products. These smart products are the basis for creating smart services. This transition from product to service is the second challenge for manufacturing firms but this servitization allows the companies to extend their business. In this paper a conceptual proposal is presented to integrate the two challenges and to identify standards for interoparation via the main interfaces.

1 Introduction

Today traditional product-centric sectors evolve step by step to more service-centric companies, but not only for a company but also for their products, services and employees. This evolutionary process is often referred to as the servitization process for non-tertiary sectors (Baines et al. 2007, Spohrer/Maglio 2010, Freitag/Ganz 2011, acatech 2014). The Industry 4.0 initiative is aiming to integrate research, development and production of innovative manufacturing technologies and the management of complex industrial processes in a holistic approach to strengthen industrial enterprises to survive in the global competition (Spath et al. 2010, acatech 2013). In the future, both the infrastructure of the Internet of Things and servitization will play an increasing role for the manufacturing industry. One way to better connect these two systems in the manufacturing world is to standardize the interfaces between the manufacturing and the service process. The paper is addressing this challenge, it is structured in the following main sections:

- the German initiative “Industry 4.0” ,
- Service Lifecycle Management,
- challenges for Standardisations in Product-Service-Systems
- concluding remarks

2 German initiative “Industry 4.0”

The German initiative “Industry 4.0” started by the German Federal Government intends to enhance manufacturing technology and the ICT in order to become prepared for the challenges in the next decade in the manufacturing domain. The Federal Ministries of Education and Research (BMBF) and Economic Affairs and Energy (BMWi) are coordinating funding activities in this regard. These are supported and monitored by the Industry 4.0 platform established by the associations ZVEI, VDMA and BITKOM, and the Scientific Advisory Board (acatech 2013).

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In: M. Zelm (eds.): Proceedings of the 6th Workshop on Enterprise Interoperability, Nîmes, France, 27-05-2015, published at http://ceur-ws.org

The aim of the Initiative Industry 4.0 is to exploit the potentials resulting from the extensive use of the internet, the integration of technical processes and business processes, the digital mapping and virtualization of the real world and the opportunity to create 'smart' products.

Industry 4.0 describes a new, emerging structure in which manufacturing and logistics systems are interacting together. The network uses the globally available information for an extensively automated exchange of information and in which production and business processes are matched. It can be regarded as an additional level of integration on the basis of the existing structures, which, however, is itself the basis of the newly emerging structure and thus creates the new quality and improved performance. A conceptual overview of the extended manufacturing network with four axes and production located in the centre is given Figure 1.

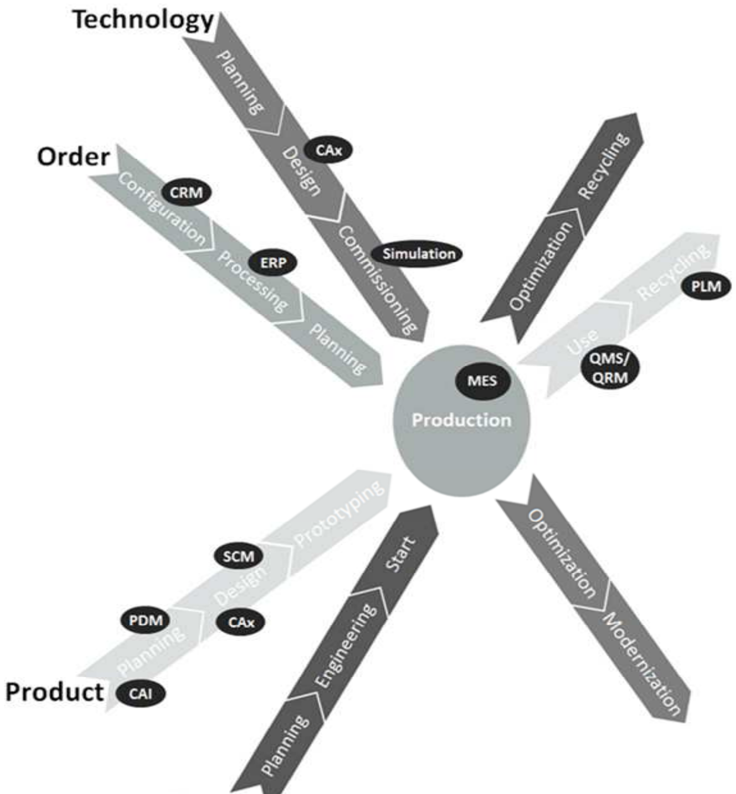

Figure 1: Industry 4.0 manufacturing network (VDE 2014)

Figure 1 shows the four lifecycles of the product, the factory, the technology and the business processes. All four lifecycles are interlinked by the concrete time at which the product is manufactured. Different software products support the lifecycle phases . A large number of standards exists which can be employed in the lifecycle phases. Details are provided in the German Standardisation Roadmap (VDE 2014)

Industry 4.0, aiming to create a System of Systems (SoS) to enhance the networking between the present autonomous systems, for instance via integration of product design, factory production and the logistics. The SoS requires an increased amount of interoperation between the components a well as requirements for common terminology and standardization.

The Industry 4.0 Standards Roadmap defines requirements for standards and identifies seven categories of standardization in industry recommending the categories general requirements, strategy, system architecture, use cases, fundamentals, non-functional properties and reference models. We take a look at four standardization categories, which appear specific to addressing product and services in the manufacturing domain, namely system architecture, use cases, reference models and development and engineering.
- System architecture: A large number of architectural models have been documented mostly in IEC standards of the 61/62 series. The models are of key importance for interoperability and need to be further harmonized.
- Use cases serve to improve comprehension, comparability and uniform usability. They should be defined on the base of standardized templates. Export to UML is being defined in IEC TC8 WG5.
- Reference models – for technical systems, organisational processes, life cycle processes , instrumentation and control functions – must have a standardized description structure. Numerous standards exist in ISO TC 184 Industrial automation systems, SC1 to SC5 as well as in the IEC 62 series. Some harmonization activities are going on.
- Development and engineering need clear common semantics of key terms and functions such as digital factory, model based development or reverse engineering

From the above examples it becomes clear that the full harmonization of the numerous specifications is a long term ultimate gaol. Nevertheless, selected harmonization activities to solve practical issues from industry have to be addressed immediately

3 Service Lifecyle Management

The Service Lifecycle consists of the four phase ideation, engineering, delivery and decommission (Freitag *et. al.* 2013, Freitag 2014).

Service ideation is the first phase of the Service Lifecycle. It consists mainly of two pillars collecting ideas and evaluation of ideas. The different source of ideas can come from changing customer needs, new emerging technologies, transformations of the company environment and other causes or drivers of change. After collecting ideas they have to be structured and evaluated in order to find the most successful, innovative solutions.

In the engineering phase the requirements analysis is taking part at first. After this, service development is started, in which the new service is defined and described. After development the new service should be tested by customers or by using a simulation tool or at least by a checklist. This makes the following implementation of the service much more simply and easier to handle. Furthermore, the involved employees need to be trained as planned.

In the delivery phase the sales function have to acquire orders from customers respectively service projects. After the acquisitions phase the service needs to be delivered to the customers. This happens within “service delivery”. The support activities for Service Operations Management are also important, here for instances to manage the service portfolio and to control the service operations.

In the decommission phase the company has to decide the point when the service has be updated or determine the date until the service will be not delivered any more. This information has to be communicated to the customer.

Several different standards support the management of the service lifecycle. The service engineering phase was standardized at the DIN Technical Report 95. It summarizes the phases and the different methods. The DIN PAS 1076 is standardised document about establishing, expanding, and improving international services. PAS 1076 is based on the methodology of Service Engineering written in the DIN Technical Report 95. The DIN SPEC 77224 is a specification, which is dedicated to the highly relevant and complex issue of creating and promoting service excellence. Standards to support Service Lifecycle Management are shown in the table below (Freitag, Hirsch and Neuhüttler 2015).

Table 1: Semantic standards in the service domain

Notion	Standards and/or standardisation proposals
Service Catalogues and Offers	Well established open standard 'Unified Service Description Language' (USDL) for automation in service offer retrieval and bundling
	„Standards zu Servicekatalogen in der Leistungsbeziehung zwischen Service Provider und Dienstleistungsempfänger" Catalogues of exchange between Service Provider and Service Consumer. Initiative of DIN NADL, NA 159
Services	Attempt for standardization of Management Consultancy Services (NADL, NA 159 BR-01 SO) as well as the already established standard for management-related information services (ISO/IEC 10165)
	IT-Service Definition in ISO/IEC 20000 about Service Quality and Processes. Web-Service Description Language (WSDL) of "Norm 225 BiPRO" for web-service orchestration and communication. Human-machine-interaction DIN EN ISO 9241-210:2011-01.
	Collaborative production and manufacturing related standards not yet applicable.
Process	Well established ISO 18629, 'Process Specification Language' (PSL) allows for representing arbitrary (business) processes and workflows
	Service Modelling Language, CEN TC310 WG1 Working Draft 2015, Constructs for a Service Modelling Language (SML) for Virtual Manufacturing Enterprises (VMEs)
	Process management standard DIN/ISO 9001-2000 and project management standard DIN 69901 are also applicable for the service design and operation phases.
Manufacturing	DIN ISO 37500 Outsourcing and DIN ISO 9000 ff. on quality related aspects in production and manufacturing industry, both also covering semantic glossaries
	Formal Manufacturing Reference Ontology in (Usman et al , 2013)[1] ISO 20543 NWI (2015)
Collaboration & Innovation	Very early attempt to provide comprehensive collaboration support by means of the Collaborative Innovation Ontology (CIO) in (Hirsch, 2012)
	Standardisation attempts for innovation management, IPR and service/product design (CEN/TC 389, 00389001-7 of NADL, NA 159)

4. Issues in standard adoption

A manufacturing network combined with a service lifecycle creates a Product-Service-System. The four lifecycles of the product, the factory, the technology and the business processes must be complemented with a fifth lifecycle, the service lifecycle, presented in Figure 2. It is important to add not only the service lifecycle but also to consider the interconnections between the different lifecycles, so for instance the interconnections between the product and the service lifecycle. One important task from the developer's perspective is to combine PLM and SLM approaches to support the lifecycle of an integrated Product-Service System. (Wiesner et al. 2015).

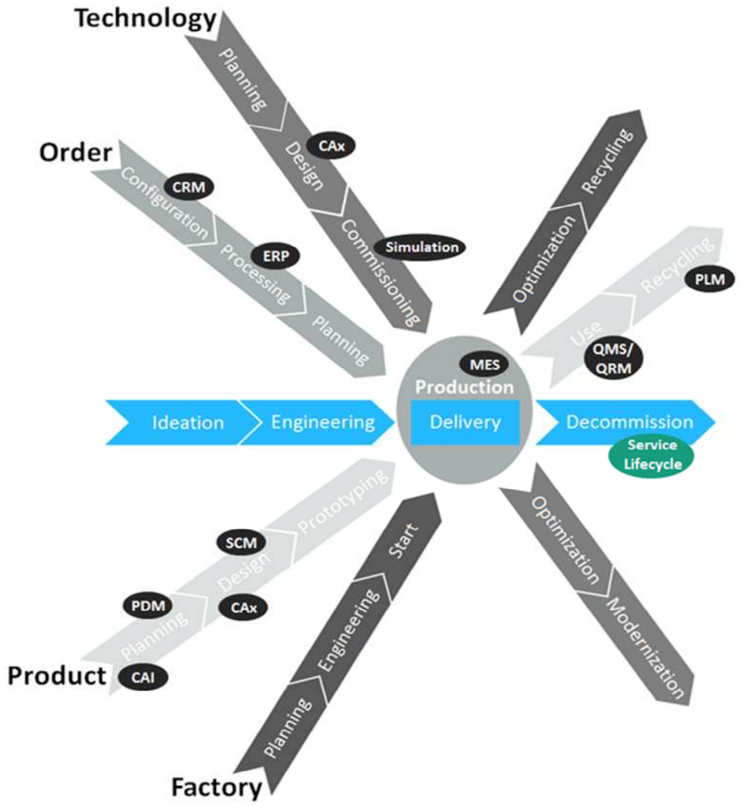

Figure 2: Product-Service System (adopted from VDE 2014)

Integration can be improved by using standards which enable seamless interoperation. One challenge is that numerous standards exist side by side in PLM and SLM which need to be harmonized. It is recommended to proceed with selected harmonization activities following the above Standardisation Roadmap (VDE 2014) to solve existing issues.

5. Concluding remarks

There are two new challenges in the manufacturing world. First is the integration of Internet of Things, second the integration of service. In order to manage the different lifecycles in a Product-Service-System the paper recommends to standardise the interactions between different phases of this lifecycles to enhance interoperation. At present standards address single manufacturing domains but not the interactions between these domains or between lifecycle phases.

Standards based interoperation between the two concepts offer several benefits: First, a standardized interface can work as a foundation, enabling a volume market for innovation while avoiding the compatibility issues that arise from multiple, proprietary interfaces. Second, the above identified standards can act together as a framework of standards for improved overall information exchange.

The proposal for standards based interoperation in Industry 4.0 and SLM is meant to present a first step in a high level framework. More work on new interoperation standards and harmonization of existing standards is required. For instance, the ISO/IEC Joint Technical Committee, JTC1 is involved in interfaces, protocols, architectures, and associated interconnecting media for information exchange in various industry sectors.

One opportunity to improve the interoperation between Industry 4.0 and SLM, could be the elaboration of common information models in the SLM cycles as well as in the Industry 4.0 product life cycles indicated in Figure 2. These models would then become the base for the development of standardized interfaces.

Acknowledgement

This work has been partly funded by the European Commission through the FoF-ICT Project MSEE: Manufacturing Service Ecosystem (project No. 284860) and PSYMBIOSYS: Product Service sYMBIOtic SYStems, (project No. 636804). The authors wish to acknowledge the Commission and all the project partners for their contribution.

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