Service Modelling Language Applied for Hyper Connected Ecosystem

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Abstract: The paper elaborates the application of service modelling language for hyper-connected ecosystems. A specific target is to demonstrate the use of ISO 19440 standard together with a set of specialized service modelling constructs developed in the scope of CEN TC310/WG1. It presents a conceptual use case to model a 'Matching Service' and the service system required to provide the Matching Service in a service ecosystem. The purpose of this study is to test and demonstrate the use of a service modelling language related to ISO19440:2020 to describe in a formal and systematic way a service and its needed service system at business level for communication and validation. The paper first presents the motivation of the study and recalls related works. The service modelling language and the background of this work are discussed. The Matching service use case will be presented in detail and the concluding summary as well as some outlooks are given at the end of the paper.

1 INTRODUCTION AND MOTIVATION

Cloud service approaches for companies and company networks increase within the last years. The development of related standards for the virtualisation of company assets such as the administration shell of the reference model for industry 4.0 (RAMI4.0) and OPC-UA are ongoing. It supports the use of company assets in terms of Internet of Things (IoT) objects. Examples of related activities are BASYS4.0 (BASYS4.0, 2021) with BASYSx (BASYSx, 2021) but also other initiatives such as the international data space (IDS). These technologies provide the basis to realise the asset administration shell to define the exchange of information in the context of Industry 4.0 (Idtwin, 2021).

The technological evaluation opens a wide field of service provision opportunities especially to the further development of industrial ecosystems. Services for communication became an essential prerequisite in terms of increasing home office and company cooperation e.g. to manage the current pandemic situation. Services for tracking information between different partners in a value net or immediate reorganisation of suppliers support the resilience of companies. Examples for related research activities are, RESYST (RESYST 2021) (Holtmann 2021), GAIAX (GAIAX 2020), WvSC and I4Q (I4Q, 2021).

The service modelling and interface design are still a challenge for business and IT engineers. How to design the structures, the processes, the constrains and the dynamics between different classes of service providers, e.g. cloud service providers and service providers within the cloud infrastructure, which includes both the product as a service and the services around the products.

It needs tthe design of the business but at the same time the design of implementation requirements. Different methods and notations are available such as BPMN and UML but its application to the services modelling still needs to be guided in terms of specific properties and relationships.

Enterprise modelling is a proven tool for the integrated development and implementation of structures and processes of enterprises and enterprise networks including technologies and services. Methods like IEM/MO²GO, ARIS, GRAI and CIMOSA exist since a long time. Enterprise frameworks have also been developed in the past, such as the Zachman Framework for Enterprise Architecture Management and the Generalized

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Enterprise Reference Architecture and Methodology (GERAM) which have existed since a long time.

Of course, in a specific case, service engineers will create their own guidelines, terminologies and modelling support for expressing and designing services. This becomes complicated if different services need to work together and have to be handled together. An example is the integration of several enterprise applications into a service ecosystem providing a seamless IT support between supply chain services, enterprise resource planning and manufacturing execution services coming from different vendors or providers. Comparing and understanding of the design in terms of completeness and understandability is required. This calls for interoperability of service descriptions.

Enterprise modelling methods and frameworks are summarized in an international standard: ISO 19440 "Constructs for enterprise modelling" (ISO 19440:2020). This standard provides a reference for enterprise modelling constructs in relation to its definition and internal structure. A further detail of the service modelling constructs is currently in discussion to provide details of the use of ISO 19440 related to service modelling demands. This will provide a reference for terminology and guidelines for service modelling constructs.

The goal of the paper is to demonstrate the usage of a standard based modelling and implementation of service modelling language in a hyper connected ecosystem via an example. The presented use case focuses on the business service modelling to provide a formal specification of the service and service system for stakeholders, service design and implementation engineers for discussion, assessment and validation before to actually build the service system.

In other words, the main benefits for the user result from a coordinated use of a common modelling language in the representation, design and operation of service system. This leads to considerable quality improvement in the design process and cost reduction in the system operation.

The use case presented in the paper discusses the use of ISO 19440 to model a hyper connected service ecosystem. The use case is derived from the work in a project of the Werner-von-Siemens Centre for Industry and Science in Berlin (WvSC, 2021a) about electric drives (WvSC, (2021b) call hyper connected ecosystem for industry. It is used because of different types of services, infrastructures and actors.

The ISO 19440 standard provides detailed structured semantic knowledge represented by the templates of the constructs. A specific target of the paper is to demonstrate the use of this ISO 19440 standard together with a set of specialized service modelling constructs currently in discussion under CEN TC310/WG1. It is also focusing on the test of service modelling constructs concerning the feasibility of its usage in terms of consistency and completeness.

2 ROOTS OF THE ADDRESSED SERVICE MODELLING LANGUAGE

The service modelling language has been developed in European research projects like the Integrated Project about Manufacturing Service Ecosystem (MSEE) (MSEE, 2011) and the H2020 project PYMBIOSYS (PYMBIOSYS, 2018). Related modelling standards have influenced the original constructs of the service modelling language such as

- ISO 19439:2006 Enterprise integration— Framework for enterprise modelling
- ISO 19440:2007 Enterprise integration — Constructs for enterprise modelling

The standards also refer to the ISO 15704:2000 "Industrial automation systems - Requirements for enterprise-reference architecture and methodologies". This illustrates the wide range of considered services from shopfloor to business activities. This leads to the service implementation of new technologies not only for enterprise applications and business but also for industrial automation. The implementation of requirements designed in enterprise models is a useful technology to improve the realisation of new processes, organisations, services and technologies. The two standards ISO 19439 and ISO 19440 provide a holistic knowledge about information concerning the design of enterprise models. They are briefly introduced below.

"ISO 19439:2006 specifies a framework conforming to requirements of ISO 15704, which serves as a common basis to identify and coordinate standards development for modelling of enterprises, emphasising, but not restricted to, computer integrated manufacturing. ISO 19439:2006 also serves as the basis for further standards for the development of models that will be computer-enactable and enable business process model-based decision support leading to model-based operation, monitoring and control. In ISO 19439:2006, four enterprise model views are defined in this framework. Additional views for particular user concerns can be generated but these additional views are not part of this International Standard. Possible additional views are identified in ISO 15704." (ISO 15704:2019).

The ISO 19440 "identifies and specifies constructs necessary for users that model enterprises in conformance with ISO 19439. This standard focuses on, but is not restricted to, engineering and the integration of manufacturing and related services in the enterprise. The constructs enable the description of structure and function of an enterprise for use in configuring or implementing in different application domains." (ISO 19440:2020).

Other languages addressing the modelling of services have been developed and implemented as standards. Examples are Service-oriented architecture Modeling Language (SoaML) using UML and focusing on model integration. Web Services Description Language (WSDL) for application integration within and across organizations. The constructs for service modelling (CEN, 2020) are currently in an updating process related to their conformity to the ISO 19440 (2020).

The definitions of constructs related to the service modelling language from ISO 19440 and used within the use case are public available (ISO 19440:2020). However, these definitions are just in terms of a glossary. The standard includes detailed templates describing the scope and properties of each construct as well as an UML class diagram with the specific relationships. Constructs derived from ISO 19440 are as follows: Organizational Unit, Order, Product, Resource, Process, Functionality, Service, User, and Decision. In ISO 19440, a service is described as "functionality resulting from interaction between a supplier (provider) and a user, often in the context of a supplied product in use by the user" (ISO 19440:2020).

3 SERVICE MODELLING LANGUAGE

The service modelling language addresses service designers, service engineers, process engineers and designers to achieve common understanding in the service usage, needed service system, related challenges and benefits. It supports interoperability of a service design across organisation and business demands by providing a common metamodel for terminology and structuring the service modelling constructs with associated templates. One of the goals of using such a language is a pluggable service design for service architectures together with other enterprise model views. However, it requires the common use of the constructs and templates as well as in a later step the implementation of these standard constructs into enterprise modelling systems. The ISO 19440 provides detailed structured semantic knowledge described in the templates of the constructs.

The following modelling constructs of ISO 19440:2020 and derived extensions for service modelling have been selected for the use case.

The construct "Organisation" can be derived from the "Organisational unit" defined in ISO 19440:2020 and might be extended by this way to company or enterprise.

The **abstract class "Actor"** can be derived from the "Role" construct of the ISO 19440 and might be extended to Persons and Organisation.

The **abstract class "Actor"** covers subclasses, which represents specific roles in the service infrastructure such as "Vendor", "Customer", "Provider", "Stakeholder" but also "User" derived from ISO 19440:2020. A specific construct is the construct "Service Level Agreement" which represents contractual regulations and becomes more important with additional regulations for service delivery such as data ownership and security.

The service constructs are currently further analysed and detailed in the working group "Systems architecture" CEN/TC 310/WG1. One task in this activity is the design of a use case example using and testing the described service modelling constructs together with the ISO 19440 (2020). This has different perspectives:

- The use of the constructs to design the services and its interrelations in terms of the applicability and completeness of the constructs.
- The use case should also provide a reference about who should use the constructs and why they are useful.
- A minor point but helpful in terms of the use of the constructs is their implementation in existing enterprise modelling systems.

The next section outlines the current work on this use case, particularly with regard to the verification of the constructs.

4 USE CASE DERIVED FROM HYPER CONNECTED ECOSYTEM

The previous development of the SML focuses on business aspects for one service delivered to the market with a viewpoint form the service provider. It leads to the definition of constructs to externalize the specific elements and its interrelation for the service modelling. An example of the constructs is described in the paper “Service Modelling Language and potentials for a new standard” (Chen, 2013).

In today’s service development, it is usual to have combination of services provided by different provides working together. Some of these services just come into the business during the service deployment such as infrastructure services in terms of apps stores or clouds. This creates specific challenges such as interoperability of the technical interfaces but also interoperability on business aspects such as regulations defined in service level agreements and data ownership regulations.

The view across several services extended the SML constructs with the element of “service provider” as a specific partner in the service model. Now the service can be defined in a standardized way and then combined with other services by interrelation of the constructs. This leads for example to a blueprint of a service ecosystem like the “Hyper-connected Ecosystem for industrial networks” used in the use case. It is a work package within the framework of the Werner von Siemens Centre for Business and Science (WvSC) in Berlin (Wvsc, (2021a) in the project on electric drives (Wvsc, (2021b).

The use case covers different kinds of services such as approaches and solutions in the context of Industry 4.0, IoT, Cyber Physical Systems, Cloud Computing and integration/federation of services of enterprise applications such as SCM, ERP, MES. Also, enterprise application services such as supply chain network and manufacturing execution services integrating modular shopfloor IT services (Jaekel, 2017) (Jaekel, 2020) are reflected in the use case with interfaces like OPC-UA.

The idea behind the Hyper-connected Ecosystem for industrial networks is to make necessary information available at any time and any place across infrastructures and platforms. It should create the required communication channels semi-automatic via a protocol between the partners such as asking for communication and agreeing to communicate similar to social network technologies. For example, a partner can find other partners via certain characteristics and then address them specifically.

A central component is a matching service, which provides opportunities to create partnerships like value or supply chains but also purchasing pools and other networks within the hyper connected ecosystem. The matching service running in a cloud infrastructure and using other services has been selected as one focus for the use case.

The use case scenario considers cloud infrastructures, a matching service, a service to provide partner information to different service providers, a pump producer and a product service provider for water supply as well as a list of part suppliers (see Figure 1).

In terms of a supply chain information can be directly discovered from the devices via IoT (OPC-UA) interfaces. This will also require to ensure data ownership and security aspects. The IoT interfaces can also be used to provide information to the customer of the water supply service.

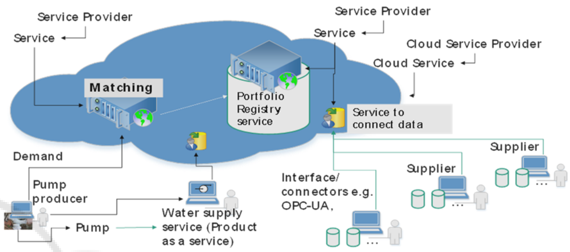

Figure 1: Use case scenario for service modelling.

The "pump manufacturer" produces a pump and offers this pump to the customer as part of a water supply service. An example of a possible customer could be a state water supply authority. This implies several services to produce the pump and to deliver the service with several contracts with suppliers of parts and services.

A matching service helps to find the suppliers but also customer networks. The matching service uses a profile service that provides information about potential business partners. However, these two services run on cloud service infrastructures. The cloud service provides also the infrastructure to deliver the IT components of the water supply service such as monitoring the amount of water, potential maintenance, breakdowns, replacements as well as the payment. The maintenance also invokes the matching service concerning potential material and local maintenance service providers. This creates a far-reaching network of services and dependencies on a legal, business and technical level.

The use case illustrates the challenges and dynamic arising in the design of a service infrastructure. The current model is in development to review the SML constructs. It includes the following main elements in terms of instantiated SML constructs. “Actor” is an abstract class related to persons or organisation and incorporates service providers, vendors, stakeholders and other roles:

- Actors
  - Pump producer and water supply provider
  - Matching service provider
  - Cloud infrastructure provider
  - Provider of partner profile services
  - Suppliers (parts and maintenance services)

The service construct covers all kinds of services in the use case such as IT services and product as a service and services around a product:

- Services
  - Water supply service
  - Cloud infrastructure service
  - Matching service
  - Portfolio service
  - Maintenance service

In the current work, UML is used to express the elements of the use case via instances of SML constructs. Each SML construct as well as each ISO 19440 construct has a related template. Therefore, for each use case element a related template is available in text form. Table 1 illustrates an example of such template about the matching service construct. UML also supports the modelling of the relation between the SML constructs in a flexible way which helps to follow the current evaluation of the SML in CEN/TC 310/WG 1. The services modelling language are used in a native way by UML models and template descriptions for the use case.

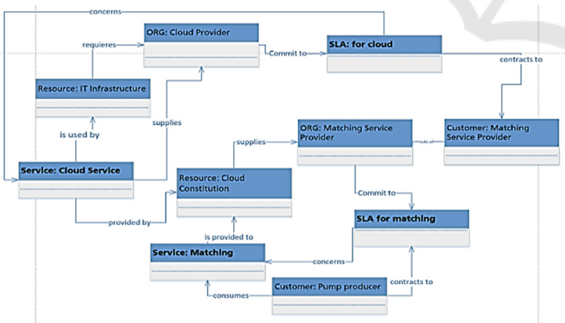

Figure 2: Use Case UML model clipping.

Related to the size of the model the structure just covers the cloud service and the matching service. The example provides an indication of how to interrelate the service level agreements like the information technology infrastructure library (ITIL) between providers, sellers, users, services and products in the context of cloud infrastructures.

The matching service requires the cloud service to provide its functionality. Therefore, the matching service provider is at the same time a customer of the cloud service provider. This implies a service level agreement (SLA) between the cloud service provider and the matching service provider. The model express clearly a further SLA between the matching service provider and the pump producer using the matching service. Both SLAs are decoupled in terms of contracting and concerning one service but the integrated view illustrates that they finally related because if the cloud service disappears also the SLA of the matching service is affected. The construct of SLAs in the SML is a placeholder for various regulations such as data ownership, data security and data privacy.

Table 1: Example of Service construct template.

Header	
Construct label	SRV (Service)
Identifier	Identifier
Name	Matching service
Body	
Attributes	
Description	The service provides a search of potential matches between potential suppliers and demands.
Objective	The service supports the tendering between customers and suppliers to create a partner network or supply chain.
Constraint	A profile service provides the partner information in a formal way. The same for the product description of the supply parts.
Nature	Information
Relationships to other model elements	
Product	Water pump
Functionality	Partner search and matching
Resource	- Cloud infrastructure
Process	- identify supplier / matching
Customer	- Pump producer
Decision	- Not apply
Performance Indicator	- Number of alternative providers, correspondence between demand and identified providers – correct match
Value	- Fast correlation between demand and supplier, evolution support by information of the suppliers about additional demands of potential customers
Stakeholder	- Pump producer
Decomposition	- a set of parameter related correlation services - a service for logical connecting of the single results of parameter matching - a priority service of managing the resulting sets of suppliers, …

In terms of modelling, the matching services and the cloud service are modelled separately and then orchestrated in one model thanks to the common SML modelling. The example related to the SLAs is just one usage for the model. The SML provides a structured method for modelling a service that provides a better understanding of the service components. It also helps to include the required elements into the service blueprint.

An important element is the template related to each service model construct and of course to each instance of the constructs. It provides a deeper semantic to the constructs and especially to instances like the matching service. Table 1 provides an example to each of the properties of this template. The whole set of templates is part of the current work and provides a comprehensive guideline of the use of construct templates in the service design.

In the template the service is described with its objectives and constrains but also with related aspects like the water pump because the product covers parameter values which are needed to select the right part suppliers.

Initial work has started to map the constructs into the enterprise modelling system IEM/MO²GO to provide interconnection with other enterprise aspects such as the manufacturing or the enterprise management. This task is performed to show the possibility of using the SML in terms of different enterprise modelling systems by extending their information model.

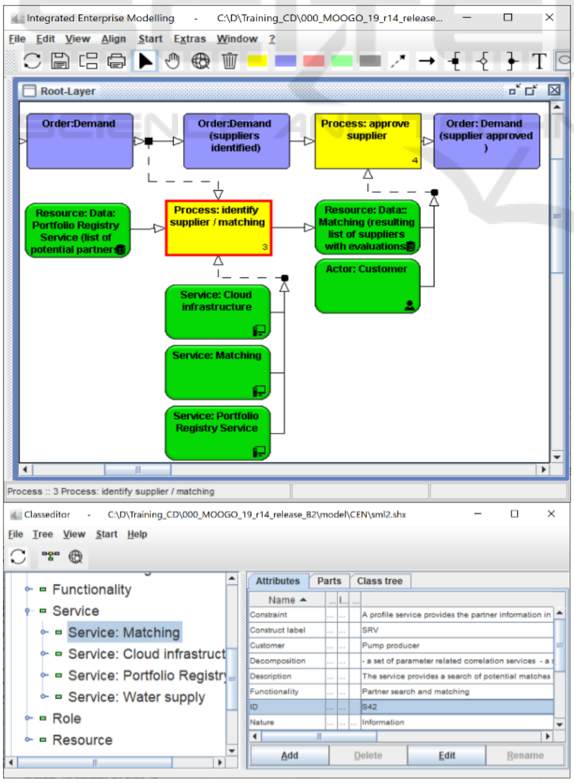

Figure 3: IEM/MO²GO Example for SML.

The constructs are added to the MO²GO class structure and the template properties are attributes for each construct (Figure 3). This is afterwards used to provide the related process diagram. However, the SML process construct could also be part of the previous UML diagram to provide a modelling system independent view which might be used to exchange SML models between different modelling systems. Also, this is a benefit which would be provided by a standardise service modelling language. In difference to just exchanging notations also a significant part of the semantic is provided.

5 CONCLUSION

The paper provides a brief inside of current work related to service modelling language. It presents some findings in terms of a use case applied in the work such as modular combination of service models to a service ecosystem. The benefits are in structured service development, modular combination of service designs and the externalisation of specific challenges of the design. In addition, the interoperability for service models is supported not only by notation but also by semantics.

It is worth noting that the added value of the service modelling language allows to model both service and service system providing the service. The resulting service model studied in this paper provides a formal specification with templates for all actors involved in the project to achievement a common understanding and agreement before to start the technical development of the targeted service and service system.

6 OUTLOOK

The upcoming Technical Report of the European Committee for Standardization (CEN) will document the relation between the ISO 19440 and the service modelling language and report on further use cases. It is foreseen to provide applications of ISO 19440 to the service domain. The technical report will describe the approach between the service modelling language and application development aspects such as the use cases to describe the application of the service modelling constructs related to cloud services, apps and product as a service.

The target of the use cases is to elaborate the benefits, the usage as well as potential improvements of the service modelling language.

The corresponding work is currently being prepared and further discussed in CEN/TC 310/WG1. A first draft should be available in 2022 for balloting.

The work related to the hyper-connected ecosystem is under development in the Werner-von-Siemens Centre for Industry and Science at Berlin with initial feasibility tests currently under preparation.

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REFERENCES

OPC-UA, https://opcfoundation.org/, viewed on August 30th 2021. viewed on August 1st 2021.

BASYS4.0, https://www.basys40.de/, viewed on July 30th 2021.

BASYSx, https://www.eclipse.org/basyx/?target=blank, viewed on July 30th 2021.

I4Q (2021), https://www.i4q-project.eu/, viewed on July 30th 2021.

Idtwin (2021), Details of the Asset Administration Shell: https://idtwin.org/wp-content/uploads/2021/02/Details_of_the_Asset_Administration_Shell_Part1_V3.pdf

WvSC, (2021a), https://wvsc.berlin/en/, viewed on July 30th 2021.

WvSC, (2021b), https://wvsc.berlin/en/research-project-electrical-drives/

ISO 19440 (2020), https://www.iso.org/standard/74491.html

CEN (2020), Service Modelling Language (SML), prCEN TR, CEN TC310/WG1 working document, 2020.

Chen, David, (2013), Service Modelling Language and potentials for a new standard, International conference IWEI’13.

MSEE (2011), Deliverable 11.1, Service concepts, models and method: Model Driven Service Engineering, MSEE Integrated Project, 2011.

PYMBIOSYS (2018), https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5acf71f40&appId=PPGMS.

ISO 15704 (2019), https://www.iso.org/fr/standard/71890.html

IDS (2019) International data space association - Reference Architecture Model, Version 3.0, April 2019. Boris Otto, Fraunhofer ISST, Sebastian Steinbuß, International Data Spaces Association, Andreas Teuscher, SICK, Steffen Lohmann, Fraunhofer IAIS.

RESYST (2021), Resilient Value Creation Systems,

https://www.produktion.fraunhofer.de/en/research/futuretopics/resyst.html, viewed on August 1st 2021.

Holtmann(2021), Jörg; Jäkel, Frank-Walter; Schlegel, Andreas. https://www.produktion.fraunhofer.de/de/forschung-im-verbund/zukunftsthemen/RESYST/Blog/12_ModelleundPlattformenWertschoepfungsresilienz2.html. viewed on July 30th 2021.

GAIAX (2021), https://www.gaia-x.eu/what-is-gaia-x, viewed on August 1st 2021.

Jaekel, F.-W. (2017); Torka, J.; Eppelein, M.; Schliephack, W.; Knothe, T. Model based, modular configuration of cyber physical systems for the information management on shop-floor. International Workshop on Enterprise Integration, Interoperability and Networking (EI2N) 12, 2017, Rhodes. OTM Workshops 2017: 16-25.

Jaekel, Frank-Walter (2020), Wolff, Tobias; Happersberger, Vincent; Knothe, Thomas. Ensure OPC-UA Interfaces for Digital Plug-and-Produce. International Workshop on Enterprise Integration, Interoperability and Networking (EI2N). in On the Move to Meaningful Internet Systems: OTM 2019 Workshops. Springer 2020. DOI: https://doi.org/10.1007/978-3-030-40907-4_5