Placeholder Name of the conference

Placeholder Session title

https://doi.org/10.52825/xxxx..... DOI placeholder (WILL BE FILLED IN BY TIB Open Publishing)

Published: (WILL BE FILLED IN BY TIB Open Publishing)

Operations As a Service

Implementation of FDO Operations for a Commercial Use-Case in a Data Space

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Abstract. This work describes a commercial use-case where an innovative data service is offered as a service in an industrial Data Space and the implementation of a novel pattern of using FDO Operations: A single service endpoint of Remote Procedure Call API is being described as a machine-actionable FDO Operation such that clients can interact with the endpoint without implementing any other specialized logic than creating input forms and submitting the data to a DOIP Extended Operation for executing the FDO Operation. As such the approach can be extended to other functions which can be described as an FDO Operation with a defined set of input and output parameters.

Keywords: FDO, Operations, Data Space, Service, Architecture, Demonstration

1. Introduction

As part of the "FDO Connect" project, the use-case "Industrial Manufacturing" demonstrated the implementation of FDOs to support the sharing of data and services in the BatCAT[4] Data Space. The Data Space[3] connects partners from the BatCAT consortium using the Eclipse Dataspace Connectors (EDC) to enable trustworthy sharing of data and data services in order to develop a digital twin for the industrial manufacturing of battery cells from the design to the production phases. A part of the digital twin is the decision support system which can guide the design of batteries and battery components using physics-based and surrogate modeling, multi-criteria optimization, answer set programming, and other machine learning techniques. However, the data which is necessary to facilitate these techniques sometimes needs to extracted from unstructured PDF documents, such as the data sheets of electronic components of the battery management system. It was the goal to replace the tedious and error-prone manual extraction of the electrical and physical properties of operational amplifiers from PDF data sheets published by the distributors of the operational amplifiers with an automatable procedure using artificial intelligence. The AI-driven extraction of structured data is a non-trivial and expensive process which therefore needs a sustainable business model. Data Spaces are a place where such a service can be offered under a commercial model. The use-case demonstrated how the extraction can be offered as a service using FDOs to define and describe the service provider's API, the operation's signature and to execute the operation asynchronously. For a high-level overview of the business use-case, a Use-Case Diagram is shown in figure 1.

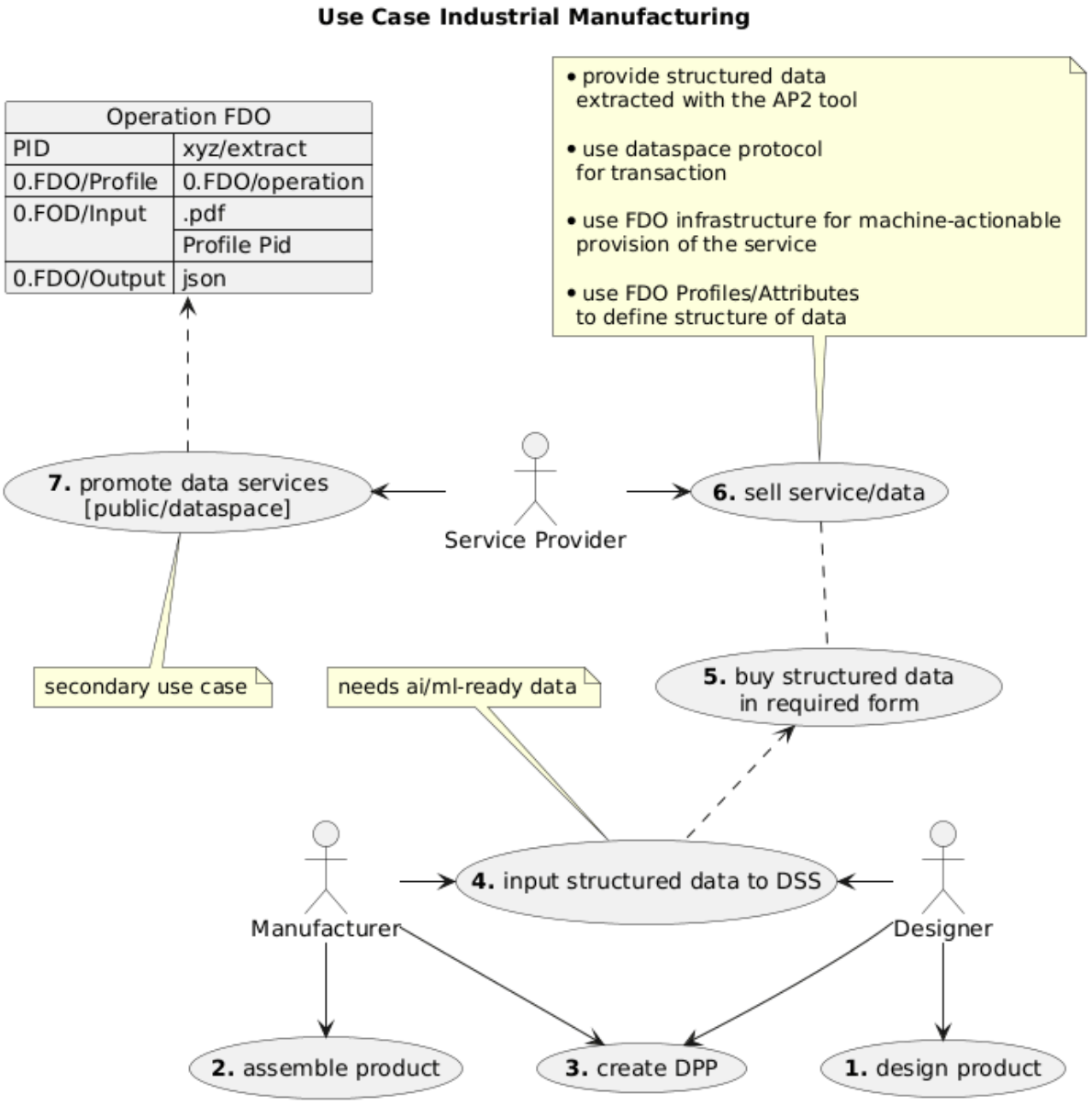

Figure 1. *Use-Case Diagram of the use-case "Industrial Manufacturing": A Service Provider offers a data service in a data space which can extract structured data from a PDF document. The structured data is needed by consumers ("Manufacturer", "Designer") to design and assemble products using a Decision Support System (DSS) and create a Digital Product Passport (DPP).*

2. FDO Operations

FDO Operations are a topic of on-going research. The FDO Specifications[5] mention FDO Operations and give examples for applications of this concept, e.g., the calculation of mean values of columns in a tabular dataset (also [2]). [1] discuss the concept of FDO Type in connection to FDO Operations and evaluate several approaches to bind operations to FDOs similar to class/member functions of object-oriented programming languages. This contribution has a complementary approach. It does not study operations on the conceptual level, systematically and comparative. Instead it presents a use-case and a practical solution which involves FDO Operations as interfaces to a service architecture.

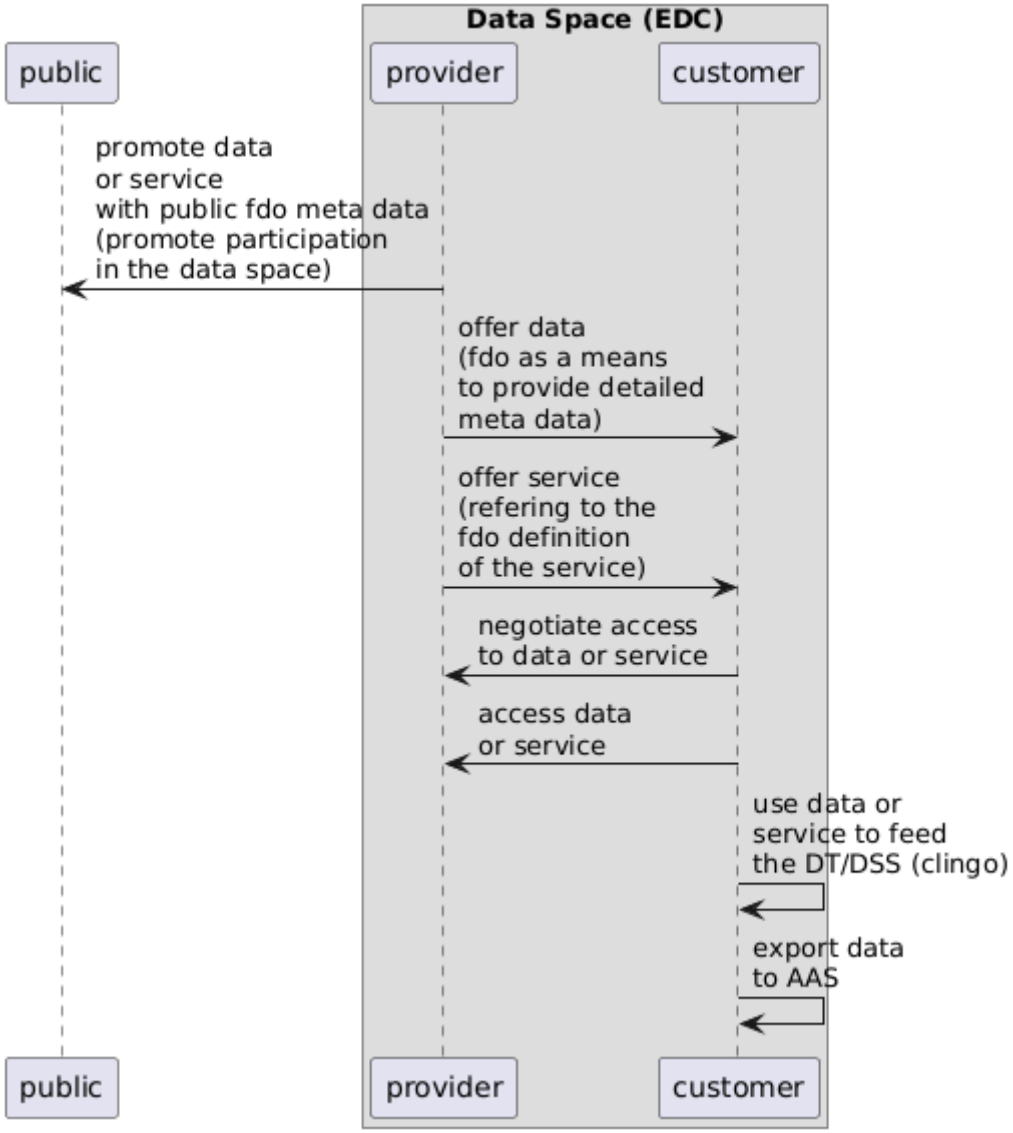

Figure 2. *Flow Diagram of the use-case "Industrial Manufacturing". This is a very simplified view on the Data Space Protocols flow for negotiating access to a service or data.*

The service architecture exposed a bespoke Remote Procedure Call (RPC) Application Programming Interface (API) using HTTP as transport protocol. The API allows to upload PDF files and extract data into a JSON-based serialization. The structure of the extracted data is defined by an FDO Profile which is passed as a parameter to the extraction function which then tries to find the values in the PDF, one for each attribute that is referenced by the profile. However, the bespoke RPC-API should be regarded as a private API which is access proteced and accessible only for the service provider. Service clients would instead use the Data Space Protocol (DSP) as implemented by EDC to discover the service offer of the "provider" in the Data Space through a DCAT catalog which references the service via the PID of an FDO Operation. The FDO Operation is an FDO which defines the signature of a function by referencing an FDO Profile for the input parameters and another FDO Profile for the output parameters. Upon discovery of the service in the Data Space, the "consumer's" client can use the FDO Profiles to create a web form for uploading the PDF data sheet and submitting any additional attributed required by the FDO Operation as input parameters. The DSP is used to request and negotiate access to the service and send an access token to the con-

sumer. The consumer can then access a DOIP-based service endpoint of the provider, upload the PDF file, start the extraction and request the results after the process has finished. See figure 2 for an overview of the process.

This is a completely novel pattern of using FDO Operations: A single service endpoint is being described as a machine-actionable FDO Operation such that clients can interact with the endpoint without implementing any other specialized logic than creating input forms and submitting the data to a DOIP Extended Operation for executing the FDO Operation. As such the approach can be extended to other functions which can be described as an FDO Operation with a defined set of input and output parameters.

Data availability statement

No data was collected.

Underlying and related material

The demonstrator code will be publicly available under an open-source license on gitlab.com: https://gitlab.com/fdo-connect

Author contributions

TF: Conceptualization, funding acquisition, methodology, software, writing, visualization. HtW: Conceptualization, funding acquisition, methodology, project administration, software, validation. IN: software, validation. FS: software, validation.

Competing interests

The authors declare that they have no competing interests.

Funding

This work is funded by the National Academy of Science and Engineering, MISSION KI Bundesministerium für Digitales und Staatsmodernisierung.

Acknowledgement

We thank the partners of BatCAT consortium for their input and valuable feedback.

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