Data Sovereignty in Inter-organizational Information Systems

Findings from Demand and Capacity Management in the Automotive Industry

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Appendix A: Project Communications

The following tables provide an overview of the communication between the research team and practitioners. A total of 240 meetings were held over 305 business days. Workshops and steering committees were conducted both in person and virtually.

Table 1. Overview of workshops in the design of the data-sovereign IOIS (Opriel 2021 p. 117).

Date Range	Duration [h]	Location	Content	Participants
Mid 2019	7:00	City A	Identifying relevant sensitive data not being shared	9
	7:00	City B	Selection of identified but not exchanged information to be exchanged with the prototype; definition of the to be exchanged with the prototype; definition of the data granularity and the terms of use for the data exchange	10
	2:10	Online	Presentation of the concept and discussion	7
	5:00	City B	Detailed analysis of the actual process, tools used, and currently recorded KPIs (Key Performance Indicators)	5
	8:00	City B	Rework of the concept	5
	5:30	City B	Identifying data sources and their APIs, formulation of software requirements	7
	8:30	City B	Evaluation of the mock-up for the front end; Discussion about technologies (e.g., blockchain).	4
Early 2020	6:00	City A	Detailed discussion about usage control policies; identification of remaining white spots.	8

Table 2. Overview of steering committees (Opriel 2021 p. 117).

Date Range	Duration [h]	Location	Content	Participants
Mid 2019	6:00	City D	Kick-Off	13
	1:30	Online	Feedback for detailed concept	12
	2:30	City B	Agreement on detailed concept	13
	5:30	City B	Intermediary report	13
	1:15	Online	Data Sovereignty in downstream systems	11
	2:30	Online	Intermediary report	14
	2:45	Online	Agreement on case study	18
	0:30	Online	First intermediary report on the pilot	6
Mid 2020	0:45	Online	Second intermediary report on the pilot	6

Appendix B: Problem Statement

Based on the outlined single-case study and nine expert interviews, we were able to pinpoint (in prior work) a set of issues that arise in the context of data sharing in the supply chain.

Table 3. Problems in supply chain data sharing

ID	Problem	Explanation
P01	Lack of information	Data is required but not available. Reasons for this are data silos in large companies or legacy systems. For example, shipping documents in the Automotive industry are not transmitted digitally because that process is deemed too slow.
P02	Rigid Structures	Long-established organizational structure, conservative culture, and legacy systems (e.g., MS-DOS applications) prevent digitization and data exchange.
P03	Manual data exchange	Still, supply chain participants are migrating to EDI standards and using fax machines. To a significant extent, information exchange occurs via video calls or e-mails with various attachments (tables, pictures, PDFs, or presentations).
P04	Hard to process data formats	Using unstructured data results in hard-to-process data. For example, tables are usually not restricted, making manipulation easy. Typical examples of problems are newly added or deleted content shifted around columns or rows and unknown terminology. Other data, such as pictures, pose a significant effort for automated processing.
P05	Human error	Naturally, human handling of data potentially leads to problems. For example, the manual exchange of data about suppliers in bottleneck situations must be entered manually into the Planning and Production Systems (PPS). Manual errors include incorrect entries or using inaccurate formulas.
P06	Low data quality	Poor data quality leads to all other information derived from that data being inaccurate, insufficient or not useable.
P07	Malicious actions	Some errors can occur by intent, through actions such as phantom orders.
P08	Misuse of power position	Supply chains are characterized by power struggles between OEMs, suppliers, and customers.
P09	The unknown value of data	The value of the exchanged data is unclear. No one wants to give away something valuable 'for free.'
P10	The unknown benefits of data for others	The specific value added through receiving data from others is also not clear. It seems obvious that in some situations, data should help (e.g., in bottleneck situations), but details (e.g., about context, processes, or algorithms) are still missing.
P11	Missing foresight to use data	Partners often lack the foresight of their value and usage potential even if data is made available. Explanations for this include that data have not been available and that there are no obvious use cases in the organization.
P12	Efforts to make data available	A large number and variety of data silos in large organizations (e.g., local data on employees' workstations), shadow systems (parallel systems to the 'official' systems), or separate databases result in a high effort in cost to make data available.
P13	Lack of digital capabilities	Especially in lower-tier suppliers, digital capabilities are not native. Subsequently, one can only assume minimal equipment of computers and an internet connection.
P14	Investment cost	Missing digital capabilities result in a variety of (high) investment cost.
P15	Data misuse	Data can be used against the interests of the data provider. For example, the production capabilities of an OEM depend on its suppliers. If the

		dependencies on these (specific) suppliers become common knowledge, this could influence price negotiations.
P16	Data breaches	Data breaches resulting from attacks or human errors.

Table 4. Examples of data sources to explore the problem space.

Code	**Requirement**	**Source Type**	**Location**
System Performance	Data should be exchanged more often and be transferred with more details to allow better planning.	Kick-Off Meeting	Germany
User Requirements	Existing shortage case tools should be integrated into the prototype.	Expert interview	Germany
System Policy and Regulation	Access and usage control are central aspects and the main benefit of the prototype.	Conference	France
System Interface	Data should be available in internal systems for analysis purposes.	Workshop	Germany

Appendix C: Design Features

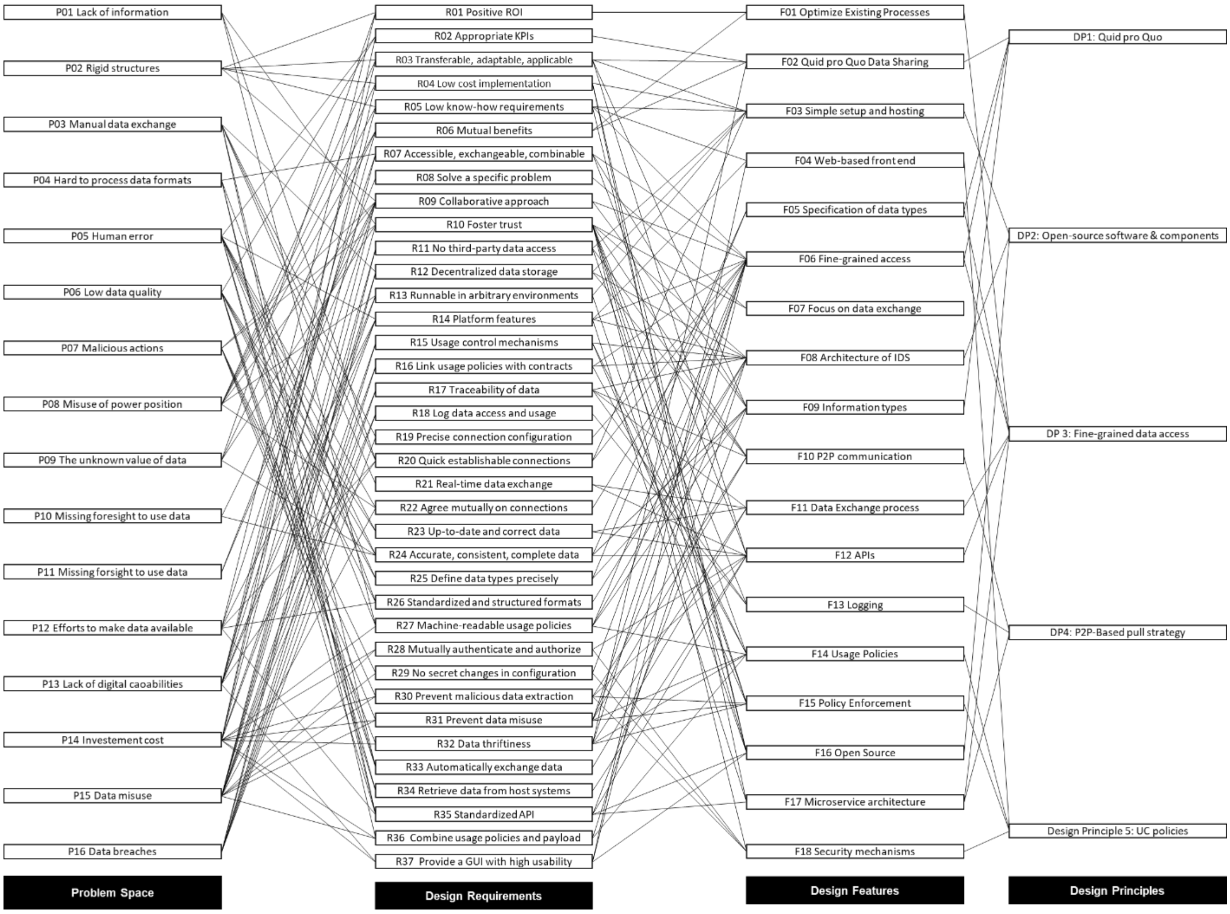
We derived the following design features for IOIS for sovereign data exchange from exploring the problem space (Appendix B) and a structured analysis of the design requirements.

Table 6. Design Features for an IOIS in Supply Chain Data Exchange (Opriel 2021 p. 145).

Category	ID	Design Feature	Design Requirements
Business Model	F01	Optimize Existing Processes	R01, R06
	F02	Quid pro Quo Data Sharing	R02, R03, R06, R32
Functionalities	F03	Simple setup and hosting	R03, R04, R05, R11, R12, R13, R20
	F04	Web-based front end	R05, R14, R37
	F05	Specification of data types	R24, R25
	F06	Fine-grained access	R05, R07, R09, R14, R16, R19, R20, R22, R29, R31, R32, R37
	F07	Focus on data exchange	R08, R10
	F08	Architecture of IDS	R10, R12, R14, R15, R17, R26, R27, R31, R36
Data Access and Data Exchange	F09	Information types	R03, R07, R09, R24, R25, R27, R35
	F10	P2P communication	R10, R11, R12, R17, R30, R31
	F11	Data Exchange process	R17, R21, R23, R32, R33
	F12	APIs	R03, R07, R21, R23, R24, R28, R30, R34, R35
	F13	Logging	R10, R17, R18
Usage Control	F14	Usage Policies	R10, R15, R16, R27, R31, R32, R36
	F15	Policy Enforcement	R10, R11, R15, R30, R31, R32
Source Code	F16	Open Source	R04, R05, R10, R13, R35, R37
	F17	Microservice architecture	R04, R14, R35
	F18	Security mechanisms	R10, R28, R29, R30

Appendix D: Mapping Diagram

Figure 1. Mapping Diagram.



Appendix E: Information Model

A central path within the information model for implementing UC mechanisms and ensuring data sovereignty is the going path from the BMKConnector to the TimeDataWrapper. First, the data connection is defined and stored in a set of connections in the BMKConnector class. The Connection class has two ConnectionDetails references, allowing swapping the object on the specific side of a connection (supplier or OEM) to build a hash over a Connection easily. The ConnectionDetails itself holds a DomainQueue, which holds a PlantDataWrapper list to implement the data retention and data history policy. In case the queue size is exceeded, the wrapper's oldest element is deleted, and a new one is added. Likewise, the duration is used to delete all expired data from the wrapperQueue field. The PlantDataWrapper itself maps data for different plants (production sites), which may be received with one data transmission. The DataWrapper maps the exchanged part information on time horizons to allow, e.g., the transmission of demands for the next day separately at the TimeDataWrapper class.

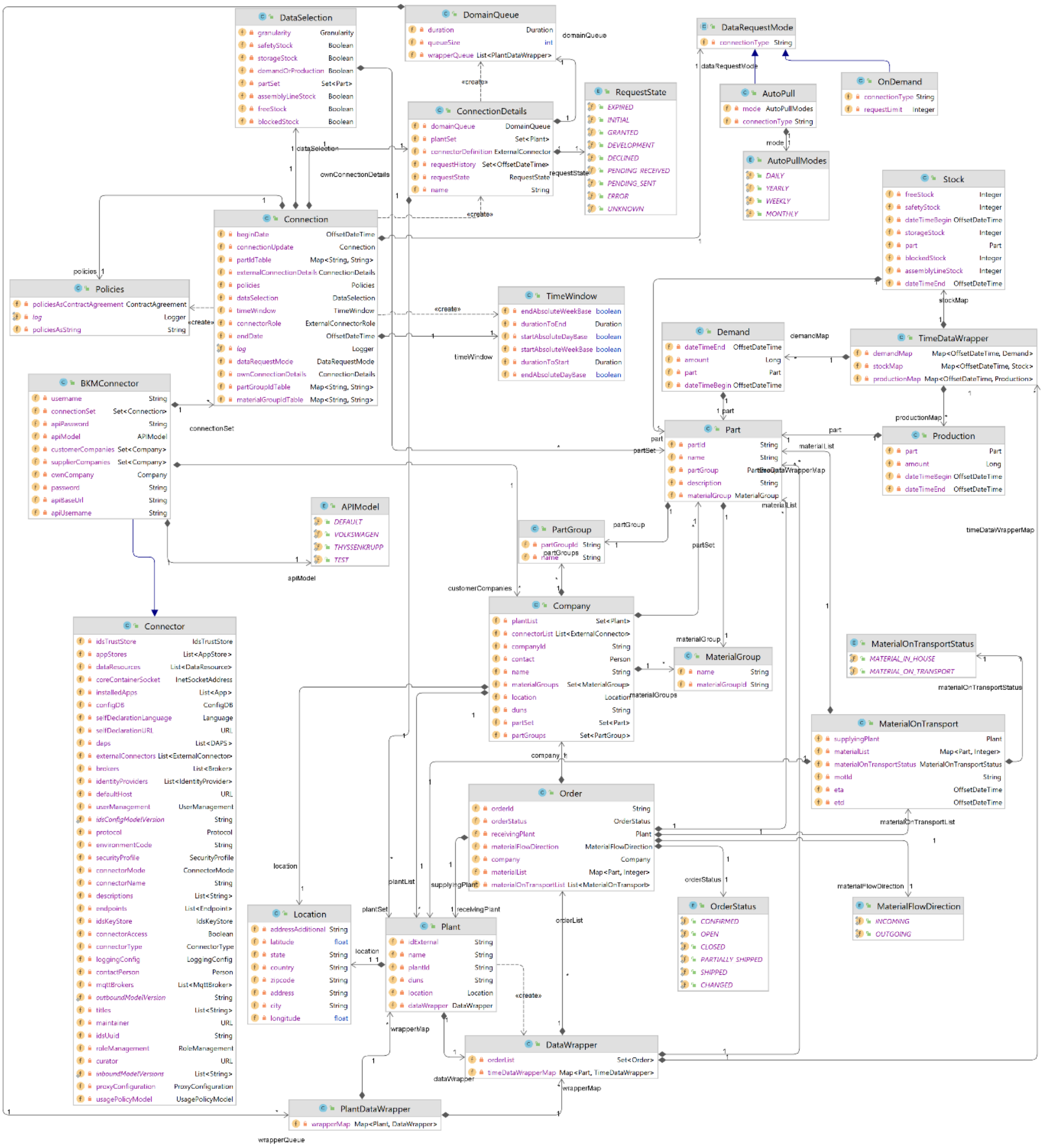


Figure 2. Information model.

Appendix F: XACML Architecture

In our research, we draw from XACML (eXtensible Access Control Markup Language) as a markup language to implement UC policies (OASIS 2013). The front end defines connections, and the respective business logic is the Policy Administration Point (PAP). On data receipt, on data access, and as a scheduled event, the policy enforcement point (PEP) triggers the policy decision point (PDP) to check policies attached to data and connections. Information like the connection settings (e.g., valid time range), defined policies, or other needed information for the check is provided by the policy information point (PIP). If action like deleting data is necessary, the PDP delegates the task to the policy execution point (PXP). Enforcing policies before data access and receipt ensures that no unauthorized access is given to data. Nevertheless, the software runs a scheduler every five minutes at its PEP to check if data are expired (PDP). These notions of UC policies are mandatory components of the architectural design of data sovereign data exchange based on the International Data Spaces (IDS) that we also use in the paper (Jarke 2020).

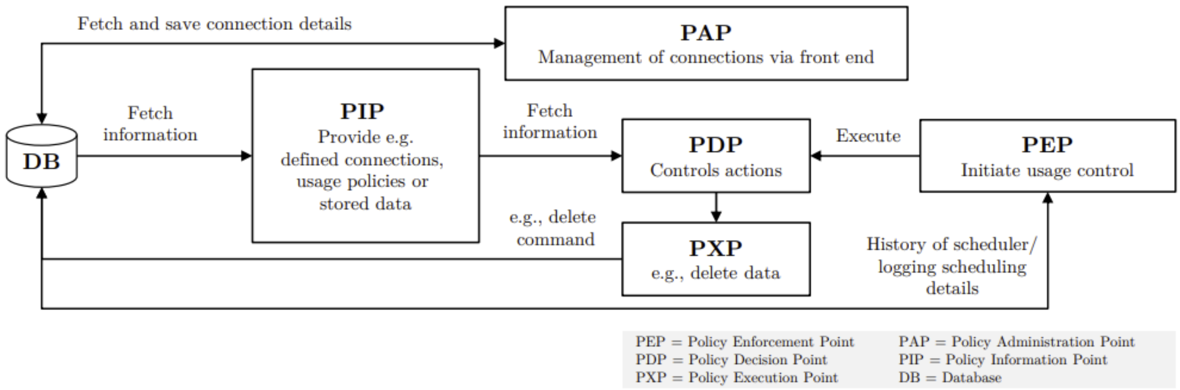


Figure 3. Policy points and their tasks are based on Eitel et al. (2021) used in the software prototype (Opriel 2021 p. 167).