AI REDGIO 5.0

Industry 5.0 Data Spaces and semantic WP4 Interoperability - M12

D4.3

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Abbreviations and Acronyms:	
API	Application Programming Interface
CA	Certificate Authority
DID	Decentralised Identifier
DF	Didactic Factory
DSSC	Data Spaces Support Centre
Dx.y	Deliverable x.y
EDC	Eclipse Dataspace Components
FAIR	Findability Accessibility Interoperability Reusability
ICT	Information and Communications Technology
IDS	International Data Space
IDSA	International Data Spaces Association
MVDS	Minimum Viable Data Space
OC	Open Call
SME	Small- and Medium-sized Enterprise
Tx.y	Task x.y
UI	User Interface
UX	User Experience
v.x	Version x
WPx	Workpackage x

1. Executive Summary

This deliverable (D4.3 - "Industry 5.0 Data Spaces and semantic Interoperability") accompanies the first release of the AI REDGIO 5.0 Data Space Marketplace [M12] and reports on the research, design and development activities in the context of task T4.5 – "Industry 5.0 Data Spaces and semantic Interoperability". The AI REDGIO 5.0 Data Space delivers the functionalities that will facilitate manufacturing stakeholders address data exchange and interoperability challenges in their journey towards Industry 5.0.

D4.3 documents the design and implementation of the AI REDGIO 5.0 Data Space and provides an illustrative walkthrough of the solution. An initial analysis on the foundations of Data Spaces is performed, highlighting the design principles, architecture requirements, building blocks suggested by key players in the field (e.g. the International Data Spaces Association, GAIA-X and OpenDEI). This analysis combined with the user requirements extracted in the context of D2.3 – "User Requirements Specification for edge-AI Industry 5.0" set the ground for the specification of the AI REDGIO 5.0 Data Space, comprising of functional and non-functional system requirements. Additionally, the envisioned users have been identified (i.e. manufacturing SMEs and Didactic Factories that need data to perform their AI and analytics operations), that will act as Data Providers and Data Consumers within the AI REDGIO 5.0 Data Space.

The implementation of the AI REDGIO 5.0 Data Space v1 was based on the open-source implementation of a Minimum Viable Data Space (MVDS) provided by the Eclipse Foundation, under the Eclipse Dataspace Components (EDC) project. The AI REDGIO 5.0 Data Space v1 is available in the respective GitHub repositories (Frontend: https://github.com/Suite5/ai-redgio-5-front , Connector: https://github.com/Suite5/ai-redgio-5-connector , Backend: https://github.com/Suite5/ai-redgio-5-dataspace), and encompasses various enhancements and adaptations performed in the context of AI REDGIO 5.0. The walkthrough of the AI REDGIO 5.0 Data Space v1, that concludes the main body of the deliverable, illustrates the available functionalities and end-user interactions in two paths: making data available through the AI REDGIO 5.0 Data Space (i.e. provide data) and consuming data that have been made available (i.e. consume data).

This deliverable constitutes the first version of the AI REDGIO 5.0 Data Space and contains the features planned for the first release of the solution. The AI REDGIO 5.0 Data Space v1 will be integrated with the rest of the WP4 components in the context of T4.6 – "Data4AI Integration, Testing, Technical Validation, OC support", wherein also technical verification and validation will be performed. User validation and feedback will be acquired in the context of the first cycle of demonstration activities under WP6. The upcoming deliverable D4.7 [M30] will constitute the second and final release of the AI REDGIO 5.0 Data Space and will deliver the complete set of envisioned functionalities, along with enhancements and bug fixing performed after the validation and verification activities.

2. Introduction

2.1. Scope of the Deliverable

The AI REDGIO 5.0 Data Space aims to facilitate stakeholders from the manufacturing domain take the leap towards the edge-cloud continuum and AI-enabled collaborative intelligence, by addressing data exchange and interoperability aspects through their own edge or/and cloud data space instantiations. It is designed and developed in the context of task T4.5 - "Industry 5.0 Data Spaces and semantic Interoperability", planned to be delivered in two iterations (at M12 and M30 respectively). Deliverable D4.3 - "Industry 5.0 Data Spaces and semantic Interoperability" constitutes the first version of the implementation of the AI REDGIO 5.0 Data Space. The report at hand accompanies the AI REDGIO 5.0 Data Space v1 and provides an overview of the activities towards the delivery of the relevant software, including design and implementation insights, while also encompassing a high-level usage walkthrough.

In particular, D4.3 describes the specification and implementation of the AI REDGIO 5.0 Data Space as a result of the process guided by the following four axes: (a) compliance with the design principles, guidelines and protocols by well-established data space initiatives; (b) alignment with the AI REDGIO 5.0 reference architecture; (c) facilitation of the user requirements extracted from the business needs of the 7 SME driven experiments and the 14 Didactic Factories (DFs), with a focus on secure and sovereign data exchange for manufacturing stakeholders; and (d) utilisation of compliant state-of-the-art open-source implementations.

After a brief landscape analysis on adjacent research areas – i.e. principles and architectural aspects od Data Spaces– (Section 3), the user roles, system requirements and underlying data models and access policies devised to realise the four design axes are presented (Section 4), while the technical aspects of the current implementation, that was driven by the reference architecture of D4.1 - "Reference Architecture for AI REDGIO 5.0" and was based on state-of-the-art technologies for data spaces, follow (Section 5). Finally, the usage walkthrough (Section 6) serves as a comprehensive guide for the utilisation of the AI REDGIO 5.0 Data Space instance by an end-user for the registration and exchange of assets with the other users.

The present deliverable captures the progress towards the first release of the AI REGIO 5.0 Data Space and the relevant outcomes. The upcoming deliverable D4.7 [M30] will constitute the second and final release of the AI REDGIO 5.0 Data Space and will deliver the complete set of envisioned functionalities to the end-user.

2.2. Relations to other WPs and Deliverables

As part of WP4, that represents the data viewpoint of the AI REDGIO 5.0 reference architecture (T4.1), the AI REDGIO 5.0 Data Space is in close interplay with the other WP4 components for data security (T4.2 – "Secure edge-to-cloud data and computation continuum for Industry 5.0") and data quality (T4.3 – "Industry 5.0 Data Pipelines and Data Quality Assurance"). Integration of the AI REDGIO 5.0 Data Space of T4.3 with the rest of the WP4 components, as well as the technical verification and validation of the integrated solution will be part of T4.6 – "Data4AI Integration, Testing, Technical Validation, OC support". The integration and testing will follow the iterative approach of the development of the individual components. Thus, it will happen in two cycles, reported in D4.4 / D4.8 – "Data4AI Platform Technical Validation" (due in M18 and M33 respectively).

The AI REDGIO 5.0 Data Space design and specification is based on the user needs, scenarios and requirements extracted in the context of WP2. Additionally, the AI REDGIO 5.0 Data Space should facilitate the AI operations (WP5), by making the required data for the execution of AI pipelines and analytics operations, while it will also be at the disposal of the AI REDGIO 5.0 SME- and DF – driven experiments (T6.2-T6.3 and T6.4) and Open Call SMEs (T6.5) to serve their data exchange needs in the context of WP6.

3. Data Spaces Foundations

This section briefly presents the core underlying notions that guided the design and implementation of the AI REDGIO 5.0 Data Space.

3.1. Design Principles

Data Spaces, constituting a core aspect of the European Data Governance Act [1] and the European strategy for data [2], are envisioned as infrastructures governed by the appropriate frameworks to enable data pooling and exchange, while addressing legal and technical obstacles in data sharing [3]. Under this prism, data previously underused in siloed environments will reach their full potential trough cross-organisational and cross-sectorial sharing, while at the same time the rights of individuals and businesses owning the data will be fully respected and protected.

The International Data Spaces Association (IDSA)[1], the GAIA-X initiative[2] and the OPEN DEI[3] project are among the most eminent initiatives in the field, establishing and promoting rules and principles that should govern Data Spaces, as standards (e.g. the IDSA standard), frameworks (e.g. the GAIA-X Framework) or design principles (e.g. the OpenDEI design principles), that aim to bridge the gap between data and infrastructure ecosystems and guarantee the trust of data owners.

Several shared concepts and principles lie in the convergence of these works, including data sovereignty, interoperability, federation and decentralisation, security and more. Indicatively, the following points from the OpenDEI Design Principles for Data Spaces [4] encapsulate the core of the four proposed axes towards sovereign data sharing of data for the future of the data economy:

- Data sovereignty: “the capability of a natural person or corporate entity for exclusive self-determination with regards to its economic data goods”
- Data level playing field: “new entrants face no insurmountable barriers to entry because of monopolistic situation”
- Decentralised soft infrastructure: “the data sharing infrastructure is the de facto collection of interoperable implementations of data spaces that comply to a unified set of agreements in all disciplines – functional, technical, operational, legal and economic”
- Public-private governance: “for the design, creation and maintenance of the data level playing field a sound governance is essential”

Architecture requirements for Data Spaces according to the GAIA-X Architecture Document [5] entail:

- Interoperability of data and services: “the ability of several systems or services to exchange information and to use the exchanged information in mutually beneficial ways”
- Portability of data and services: “data is described in a standardised protocol that enables transfer and processing to increase its usefulness as a strategic resource. Services can be migrated without significant changes and adaptations and have a similar quality of service (QoS) as well as the same compliance level”

[1] https://internationaldataspaces.org/

[2] https://gaia-x.eu/

[3] https://www.opendei.eu/

- Sovereignty over data: "participants can retain absolute control and transparency over what happens to their data, emphasizing on a general 'compliance-by-design' and 'continuous-auditability' approach"
- Security and trust: "security technology at its core to protect every Participant and system of the Gaia-X Ecosystem (security-by-design). An Identity management system with mutual authentication, selective disclosure, and revocation of trust is needed to foster a secure digital ecosystem without building upon the authority of a single corporation or government"

Additionally, the IDSA rulebook [6] highlights the following points as foundational for a data space: (a) Establishing trust; (b) Data discoverability; (c) Data contract negotiation; (d) Data sharing & usage; (e) Observability; (f) Vocabularies and semantic models

Interoperability

As noted in the GAIA-X Architecture Document [5], Interoperability is one of the four architecture requirements for Data Spaces. According to [7], interoperability is "the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organisations, through the business processes they support, by means of the exchange of data between their ICT systems". Interoperability consists of four main layers: legal, organisational, semantic and technical [8].

- Legal interoperability ensures that organisations are able to work together despite differences in the legal frameworks, policies and strategies that govern and drive their operations.
- Organisational interoperability refers to the way public organisations align their business processes, responsibilities and expectations to achieve commonly agreed and mutually beneficial goals.
- Semantic interoperability ensures that the exchanged data are meaningful among all parties. It is heavily based on the use of metadata and standardised data modelling (also noted in the IDSA rulebook [6] as a foundational point for Data Spaces) that links data elements to a controlled, shared vocabulary, constituting the common language between the systems, and facilitating machine interpretation, inference and logic.
- Technical interoperability is related to the technical side of data exchange between infrastructures and ICT systems, addressing aspects of communication protocols, APIs, security and more.

3.2. Architectural Aspects

As proposed by OpenDEI [4], from an architectural point of view, a Data Space can be created through the synthesis of a collection of building blocks, which are integrated in line with the technical architecture, the business structure, and the policy requirements of the data space. In essence, the proposed building blocks bring into life the design principles discussed in the previous section.

The Data Spaces Support Centre (DSSC) propose the following taxonomy of building blocks for Data Spaces [9]. It is built based on the Design Principles for Data Spaces by OpenDEI, and is continuously improved based on the latest insights on Data Spaces. An important addition introduced was the elaboration on the business, governance, and legal building blocks as crucial parts of a Data Space.

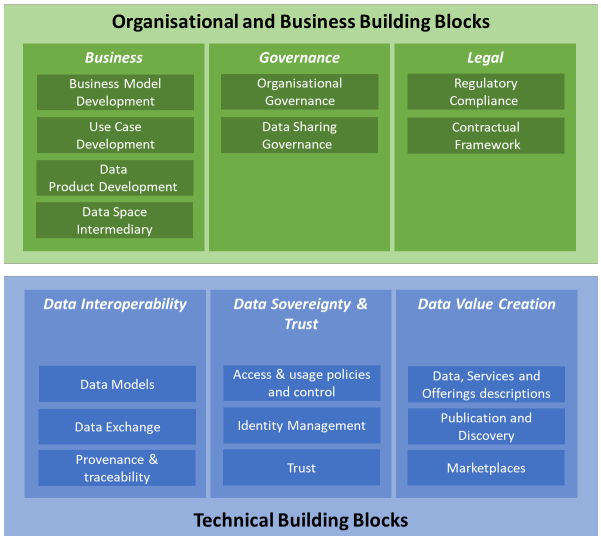

Figure 1 - Building Blocks for Data Spaces by DSSC [4]

As illustrated in (Figure 1), the Data Space building blocks can be classified in two main categories:

- Organisational and Business Building Blocks: encompassing Business, Governance and Legal aspects
- Technical Building Blocks: including modules for Data Interoperability, Data Sovereignty & Trust and Data Value Creation

Each block can be specified and implemented in an independent manner and come together under the same Data Space in a plug-and-play manner. Although a Data Space can be designed to only support a subset of these building blocks, some guiding principles need to be respected for all implementations. Those are the following:

- decentralisation
- scalability
- collaboration support
- federation
- interoperability
- compatibility
- trust management
- auditability

4. Specification of the AI REDGIO 5.0 Data Space

The AI REDGIO 5.0 Data Space delivers cloud-to-edge instances of Industry 5.0 Data Spaces for the collection, management, persistence and sharing of data, with the necessary mechanisms to ensure interoperability.

Towards the development of a sustainable and resilient solution, the AI REDGIO 5.0 Data Space design relies on the standards, design principles and reference architectures introduced by established entities in the domain (OpenDEI, IDSA and GAIA-X). Thus, the following principles drive the design and implementation of the AI REDGIO 5.0 Data Space, with some of them being closely related or even intertwined, but each one contributing to the bigger picture of the AI REDGIO 5.0 Data Space vision:

1. FAIR Data: Making data findable, accessible, interoperable and reusable (FAIR), through the implementation of the appropriate mechanisms. The use of standardised, well—described metadata plays a significant role towards this direction. In the context of AI REDGIO 5.0, metadata should also serve domain-specific needs, apart from domain-agnostic purposes.
2. Interoperability: Facilitating the interplay among systems and actors with the appropriate technical and semantic mechanisms, while respecting legal and organisational restrictions and frameworks. Interoperability is a multi-faceted challenge that can be approached through flexible access policies that incorporate organisational views on data usage, connectors that facilitate the exchange of data, data models for the semantic representation and description of data, etc.
3. Security: Security is a core requirement for Data Spaces. It can be approached through an authentication and authorisation paradigm, as the one proposed by Eclipse Arrowhead[4], or through the setup of secure (encrypted) communication channels between systems, other systems, and users.
4. Data Sovereignty: Referring to the binding of usage policies and restrictions to data. Closely related to interoperability and FAIRness, it can be addressed through the attachment and enforcement of usage rules on exchanged data.

Apart from the general principles guiding the design of Data Spaces (Section 3), the AI REDGIO 5.0 Data Space should be aligned with the requirements of the SME and DF-driven experiments as well as with the AI REDGIO 5.0 reference architecture.

The following User Requirements extracted in the context of D2.3 – "User Requirements Specification for edge-AI Industry 5.0" [10] for AI REDGIO 5.0 based on the analysis of the experiment scenarios and on targeted inputs, are relevant to the AI REDGIO Data Space:

Table 1 – AI REDGIO 5.0 Data Space User Requirements [10]

Identifier	User Requirement	Description
R.Data.01	Data security	The platform must provide a secure and reliable communication channel between edge to local or external cloud
R.Data.02	Data storage	The platform must provide secure data storage
R.Data.03	Data validity	Support in identification of valid data. Data must be relevant and representative for intended use

[4] https://projects.eclipse.org/projects/iot.arrowhead

R.Data.04	Data privacy	Data must be only accessible by the intended users
R.Data.05	Data interoperability	The platform must be able to ensure data interoperability for data exchange
R.Data.06	Data interpretation	Provision of data interpretation support to collect information and draw conclusion using different analytical approaches

4.1.1. Users and Actors

According to the user scenarios and requirements of D2.3, the envisioned users of the AI REDGIO 5.0 Data Space are the SMEs and the Didactic Factories that drive experiments utilising AI and analytics for the optimisation of their operations. The AI REDGIO 5.0 Data Space will enable data exchanges required for the execution of the experiments and the optimisation of the results through the availability of data.

As users of the AI REDGIO 5.0 Data Space managing their own Data Space instance, the users are able to act at the same time as:

- **Data Providers:** collect and manage data and make them available to other users of the AI REDGIO 5.0 Data Space through their own data space instance
- **Data Consumers:** use their data space instance to access data made available through the AI REDGIO 5.0 Data space by other users

4.1.2. System Requirements

The following Table 2 enlists the functional and non-functional requirements of the AI REDGIO 5.0 Data Space as the result of analysis on the user requirements and the design principles for Data Spaces. The requirements will be gradually supported in two development cycles following the iterative development of the AI REDGIO 5.0 Data Space, with the first version delivered in the context of the current deliverable at [M12] and the second version anticipated in the context of D4.7 at [M30].

Table 2 – AI REDGIO 5.0 Data Space System Requirements

Identifier	Type	Description The AI REDGIO 5.0 Data Space should …	Planned for Version
FR-001	Functional	Allow users to have their own AI REDGIO 5.0 Data Space instance	v1
FR-002	Functional	Allow users to register their data assets to the Data Space	v1
FR-003	Functional	Allow users to define access policies for their data assets	v1
FR-004	Functional	Allow users to attach usage policies to their data assets	v1
FR-005	Functional	Allow users to discover data assets in a federated catalogue based on defined access policies	v1
FR-006	Functional	Allow users to acquire data assets, based on usage policies	v1
FR-007	Functional	Allow users to find a log of past data exchanges, where they were involved either as providers or as consumers	v1

FR-008	Functional	Allow exchange of data with the AI REDGIO 5.0 AI Pipeline Designer	v2
FR-009	Functional	Allow exchange of data with the AI REDGIO 5.0 Industry 5.0 Data Pipelines	v2
FR-010	Functional	Allow exchange of data with other applications and tools of the users	v2
NFR-001	Non-Functional	Be compatible with technologies used in the AI REDGIO 5.0 reference architecture	v1
NFR-002	Non-Functional	Comply to the IDSA standard	v1
NFR-003	Non-Functional	Support various storage infrastructures	v2
NFR-004	Non-Functional	Be compatible with edge and cloud infrastructures	v2
NFR-005	Non-Functional	Be scalable	v1
NFR-006	Non-Functional	Ensure secure data exchange	v1

The conceptual architecture of the envisioned AI REDGIO 5.0 Data Space is presented below (Figure 2), as a schematic illustration of the features and the high-level interactions that take place.

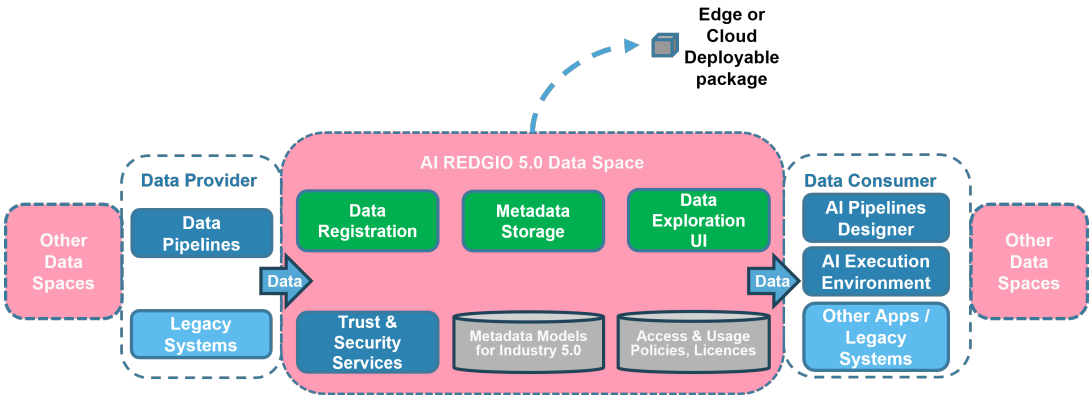

Figure 2 - AI REDGIO 5.0 Data Space Conceptual Architecture

The AI REDGIO 5.0 Data Space instance should be deployable either on the edge or on cloud infrastructures. Data are registered in the Data Space from the data sources of the Data Providers (e.g. their legacy systems and databases or from their data pipelines constructed with the relevant tools of T4.3). The accompanying metadata are attached to facilitate the findability and exploration of the registered assets. Additionally, each registered asset is bound to the access and usage policies defined by the corresponding Data Provider.

Data Consumers can explore the available data through the Data Exploration user interface (UI). They can only view data they are allowed to access based on the applicable access policies. Once they find data of their interest, they can retrieve them to feed them in their own systems (e.g. in the AI Pipeline Designer of WP5). Again, the retrieval action is available only if the specific Data Consumers are eligible to acquire the data based on usage policies.

5. The AI REDGIO 5.0 Data Space Implementation

This section provides the technical insights on the implementation of the AI REDGIO 5.0 Data Space v.1 available in M12. Starting from an overview of the development decisions, continuing with details on the architecture of the component, the selected technologies and finally describing some of the envisioned enhancements for the second version of the AI REDGIO 5.0 Data Space.

5.1. Overview

The AI REDGIO 5.0 Data Space needs to provide a robust solution, developed fast and with high quality and readiness to use, that is in alignment with the data space design principles. In this context, the decision was made to develop the AI REDGIO 5.0 Data Space based on existing, open-source implementations that have already been tested, and further extending them, instead of re-inventing the wheel and building from scratch the respective components.

The approach of focusing on a Minimum Viable Data Space (MVDS), speeds up the development and experimentation process, through the release of a working version of a Data Space that allows data exchange without compromising data security, privacy and sovereignty, thus it has been selected for the implementation of the AI REDGIO 5.0 Data Space.

In particular, a MVDS is defined as the combination of building blocks that provide the required features to facilitate secure and sovereign data exchange [11].

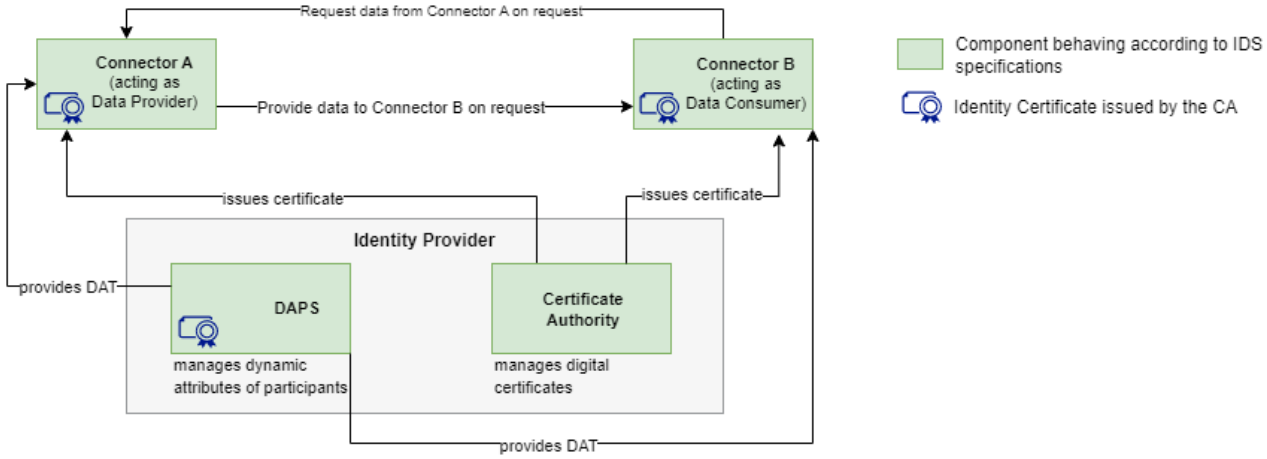

Figure 3 - Components of a Minimum Viable Data Space [11]

As depicted in Figure 3 an MVDS consists of the following components:

- Two or more IDS connectors for the facilitation of data exchange, providing the capability for data discovery, transfer, contract negotiation, policy enforcement, auditing.
- Identity Provider, comprised of:
    - A Certificate Authority (CA) granting X.509 certificates, to ensure secure and trustworthy communications
    - The Dynamic Attributes Provisioning Service (DAPS) handling dynamic attributes and managing dynamic access tokens that allow connectors access the data and services of other connectors

5.2. Development Details

In the spirit of re-usability, standardisation, compliance with the leaders in the domain and continuous interplay and contribution to the open-source community, the AI REDGIO 5.0 Data Space has been implemented based on the open-source implementation of the MVDS provided by Eclipse as a comprehensive framework, i.e. the Eclipse Dataspace Components (EDC)[5]. The EDC provides the complete set of customisable components (available in GitHub[6]), that are considered mandatory for the implementation of a MVDS, built based on standards and compliant with GAIA-X AISBL Trust Framework and the IDSA Dataspace protocol[7].

5.2.1. AI REDGIO 5.0 Data Space Components

In the context of AI REDGIO 5.0, the EDC components have been adapted to fit the needs of the project, without however tampering the underlying original design principles and implementation specifics, to guarantee the core features of the Eclipse approach towards data security, privacy and sovereignty are maintained.

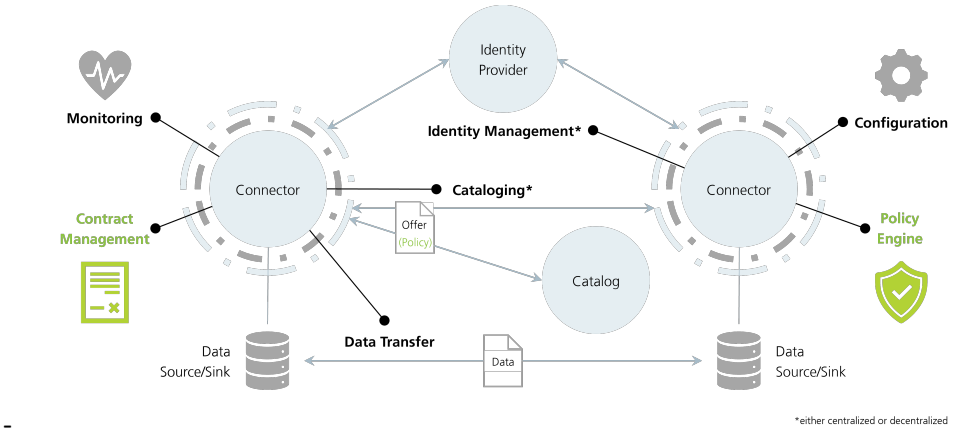

Figure 4 - EDC Connectors in the MVDS (applicable also in AI REDGIO 5.0 Data Space)[8]

The AI REDGIO 5.0 Data Space is available in GitHub[9,10,11]. It is comprised of the following components:

- **Connector:** the main features of this component entail (a) the registration of data in the Data Space, (b) the definition and enforcement of access and retrieval policies, (c) the negotiation,

[5] https://projects.eclipse.org/projects/technology.edc

[6] https://github.com/eclipse-edc

[7] https://internationaldataspaces.org/eclipse-dataspace-components-and-idsa-lets-build-our-data-driven-future-together/

[8] https://eclipse-edc.github.io/docs/#/README

[9] https://github.com/Suite5/ai-redgio-5-front

[10] https://github.com/Suite5/ai-redgio-5-connector

[11] https://github.com/Suite5/ai-redgio-5-dataspace

execution and logging of contracts, (d) the auditing of data-related actions, (e) the transfer of data

- **Federated Catalogue**: catalogue of registered assets, facilitating access to the available data ensuring data sovereignty, availability and scalability
- **Identity Hub**: a Decentralised Web Node (DWN) as defined by the Decentralised Identity Foundation[12], for the allocation and management of unique Decentralised Identifiers (DID) enabling federated data security, management and transaction
- **Registration Service:** the component is responsible for the management of the participants in the Data Space (i.e. adding and listing participants)
- **Data Dashboard** (Management UI): making the AI REDGIO 5.0 Data Space functionalities available to the end-users through a frontend application built on top of the EDC DataManagementAPI

5.2.2. Adaptation of EDC in AI REDGIO 5.0

For the first version of the AI REDGIO 5.0 Data Space, the interventions on the functional side of the original EDC were minimal, since the already provided functionalities are in alignment with the planned features of v.1. From the side of User Interface (UI) and User Experience (UX), various enhancements have been performed in the context of the customisation for the AI REDGIO5.0 project, including:

- **UI customisation:** Alignment with the AI REDGIO 5.0 visual identity (project palette and logo).
- **Simplification and enhancement of user input forms**: Renaming of fields to make easily comprehensible, the addition of indications for required fields, removal of options that are not applicable in the context of AI REDGIO 5.0 (and were not obligatory from a functional side), enforcement of user input validation checks prior to input submission, simplification of policy definition format (initially requested in JSON format, but now structured as a simple combination of dropdown fields).
- **Enhancement of presented information**: The displayed information about the assets, policies and contracts has been adapted (e.g. fields renaming, omission of non-required information and addition of UI fields of interest to the user) to make them easily comprehensible to the user and to enhance the discovery of the entities of interest.

5.3. Technologies

The following technologies have been utilised for the implementation of the AI REDGIO 5.0 Data Space:

- **Frontend:** The development of the Data Dashboard UI is based on the combination of Angular[13], Typescript[14] and the Angular Material[15] design components.

[12] https://identity.foundation/decentralized-web-node/spec/

[13] https://angular.io/

[14] https://www.typescriptlang.org/

[15] https://material.angular.io/

- **Backend**: The backend development is heavily based on Java (v.17+)[16], and on Gradle (v8.0+)[17] build system. The Azure Key Vault[18] is used for the secure storage of credentials and other keys and secrets. Communications happen through REST APIs.

5.4. Future Enhancements

The following assumptions of the first version and foreseen enhancements for the second version of the AI REDGIO 5.0 Data Space (due in M30) are noted:

- Cloud deployment: The first version supports only local deployment of the AIREDGIO 5.0 Data Space. This comes in line with the requirements of the project for local and edge data management and AI execution. Cloud deployment will be an enhancement of the second version.
- Support various storages: Connection with the storages of the experiments will be investigated in the upcoming version, according to the requirements of the experiments and to the advancements made in the core MVDS project's functionalities by its developers.
- Go beyond region-, permission-based policies: The extension of the participant entities model to include also other attributes (e.g. country, type etc.) will be investigated based on the experiments feedback and needs after the first cycle of demonstration and the exact access control schemes to be defined. The addition of restriction-based policies is planned for the second iteration of the AI REDGIO 5.0 Data Space.
- DevOps and deployment enhancements: For the setup of the first version of the AI REDGIO 5.0 Data Space the original steps defined by EDC should be followed. For the second version, the containerisation of the service will allow easy deployment even by non-technical people.
- Data/Contracts/Policies Exploration: The asset metadata model will be extended to allow data exploration based on various attributes. Filter and sorting options will be added in all pages to facilitate exploration.
- Adaptation to the Manufacturing domain: The current underlying asset metadata model is domain-agnostic. The extension of the asset metadata model in the second version will encompass manufacturing-related attributes, based on analysis of feedback to be collected from the SMEs and DFs driving the relevant experiments.

[16] https://www.oracle.com/java/technologies/downloads/#java17

[17] https://gradle.org/

[18] https://azure.microsoft.com/en-us/products/key-vault

6. The AI REDGIO 5.0 Data Space Walkthrough

This section guides the user through the features available in the AI REDGIO 5.0 Data Space v1.

6.1. Terminology

The following Table 3 presents the terminology used in the context of the AI REDGIO 5.0 Data Space.

Table 3 – AI REDGIO 5.0 Data Space Terminology

Term	Description
Asset	• the entities to be shared through the AI REDGIO 5.0 Data Space • point to one or more (physical) asset elements (*Blob*(s))
Blob	• the asset element residing in the connected *Blob Storage* of the *Participant*
Blob Storage	• the object storage account of the *Participant*
Contract Agreement	• points to a *Contract Offer* • results from a successful *Contract Negotiation* process
Contract Negotiation	• process initiated by a Participant acting as *Data Consumer* • action only available to eligible *Data Consumers* based on *Contract Offers*
Contract Offer	• generated by the *Participant* acting as Data Provider • set of permissions/restrictions/obligations bound to an *Asset* • available to AI REDGIO 5.0 Data Space *Participants* through the Catalogue
Participant	• the user of a Data Space instance • can represent an organisation, physical person, company or any other entity that wants to participate in the AI REDGIO 5.0 Data Space • can act as Data Provider and Data Consumer
Policy	• define the usage terms of *Assets* in the AI REDGIO 5.0 Data Space • exist independently from *Assets*
Transfer Process	• based on a *Contract Agreement* • download an asset to *Participant*'s (Data Consumer's) *Blob Storage*

6.2. Provide Data

This section guides the user through the pages relevant to the provision of assets through the AI REDGIO 5.0 Data Space. The Participant here acts as a Data Provider.

Once the user is logged into their Data Space instance using their credentials, they can make their data available through the following steps:

1. Add and manage assets in the AI REDGIO 5.0 Data Space (through the Assets page)
2. Create policies that specify the terms of usage with the AI REDGIO 5.0 Data Space (through the Policies page)
3. Create Contract Definitions that bind asset(s) to specific policies (through the Contract Definitions page)

6.2.1. Assets Page

In the Assets page the Participant can view and manage the assets they have added to the AI REDGIO 5.0 Data Space (if any) and add new assets. Each asset in the AI REDGIO 5.0 actually points to an already existing asset (blob) in their connected object storage (blob container).

In the Assets page (Figure 5), the Participant can view the details of the assets they have added to the AI REDGIO 5.0 Data Space and use the free-text search field to identify specific assets based on their name.

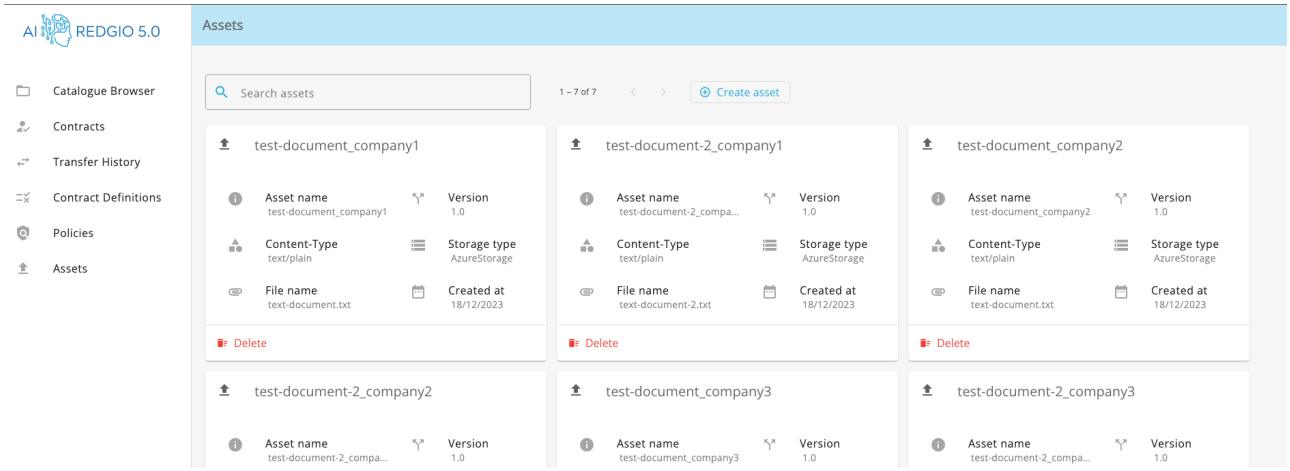

Figure 5 - Assets Page

The Participant can click on the 'Create asset' button to add a new asset to the AI REDGIO 5.0 Data Space. A pop-up input form appears (Figure 6) where the Participant should fill in the information about the new asset, including:

- asset name (free text): to be used within the AI REDGIO 5.0 Data Space
- blob name (free text): to establish the link to the existing asset in their storage
- account (free text): the Participant's name in the AI REDGIO 5.0 Data Space
- other metadata (free text with format validation check): version (must follow the convention integer.integer) and content-type (e.g. text/json), as additional asset information

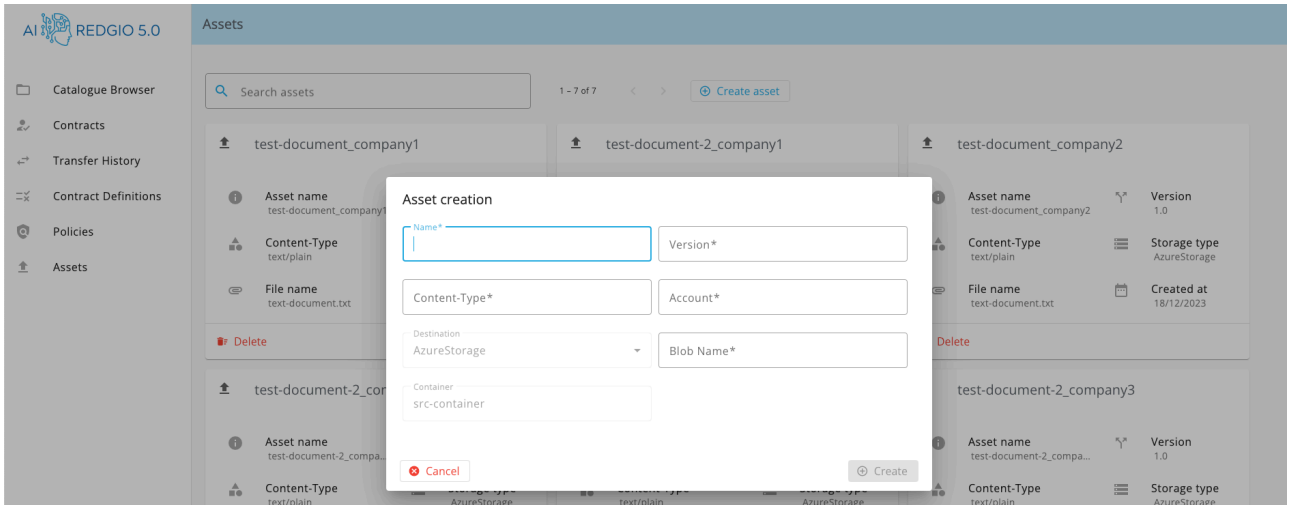

Figure 6 - Create Asset

Once the Participant has filled in all the input fields they can click on the 'Create' button. The Asset page is refreshed and contains the newly registered asset.

The Participant can remove from the AI REDGIO 5.0 Data Space any added asset, by clicking on the 'Delete' button (Figure 7).

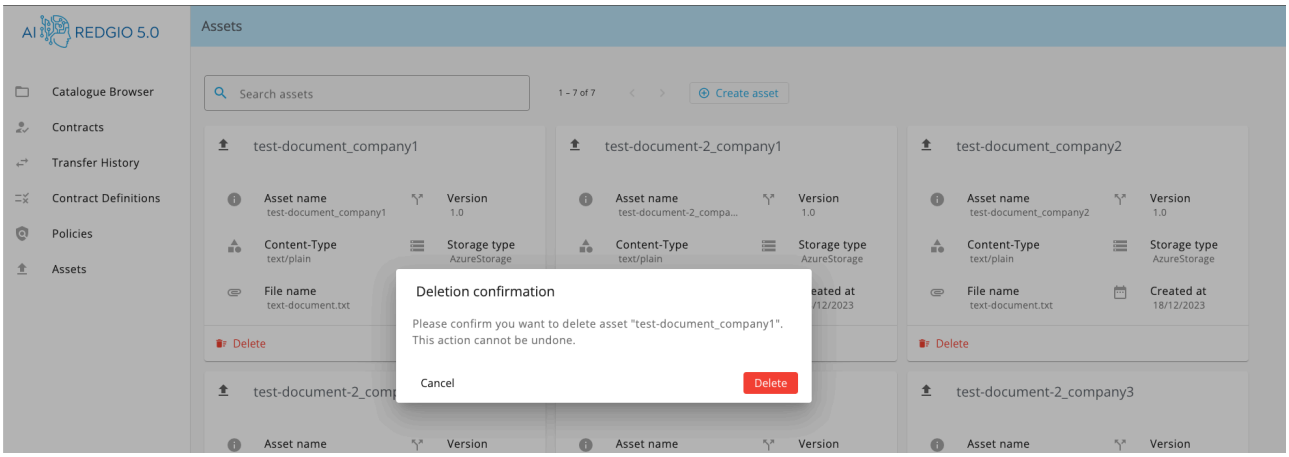

Figure 7 - Delete Asset

More details about the Assets page and the add-asset process are available at:

https://github.com/eclipse-edc/MinimumViableDataspace/blob/main/docs/developer/edc-data-dashboard/add-asset.md

6.2.2. Policies Page

In the Policies page the Participant can create and view their already created usage policies that define the terms of treatment of their outbound assets by the other Participants of the AI REDGIO Data Space 5.0. The Policies are created in an independent manner from the assets.

The Participant can view the details of existing policies and perform free-text search based on the policy name (Figure 8).

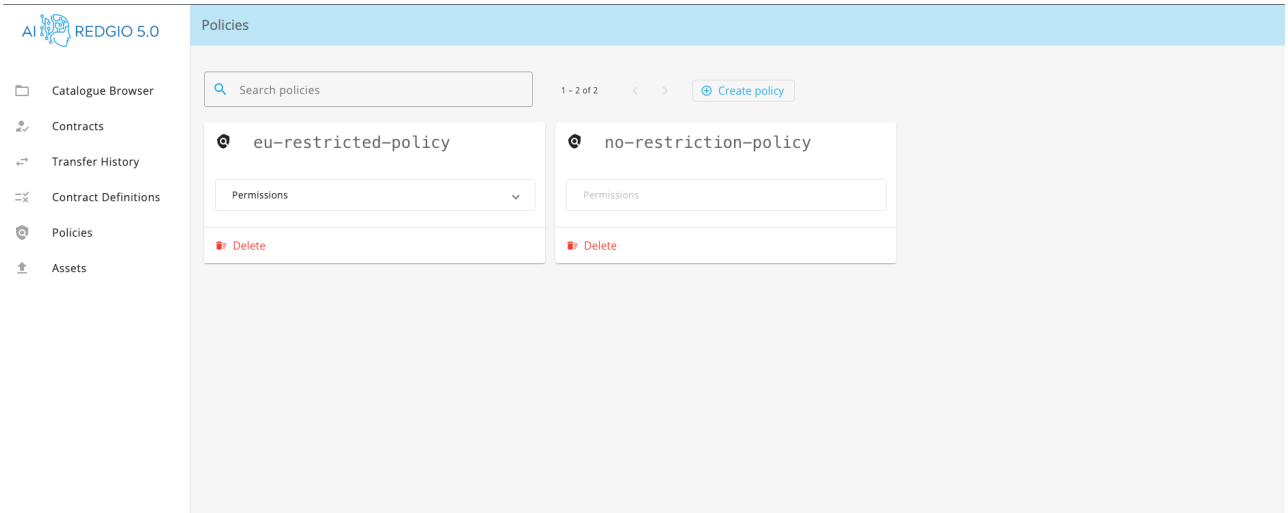

Figure 8 - Policies Page

The Participant can expand the policy to view the complete description of the permissions (Figure 9).

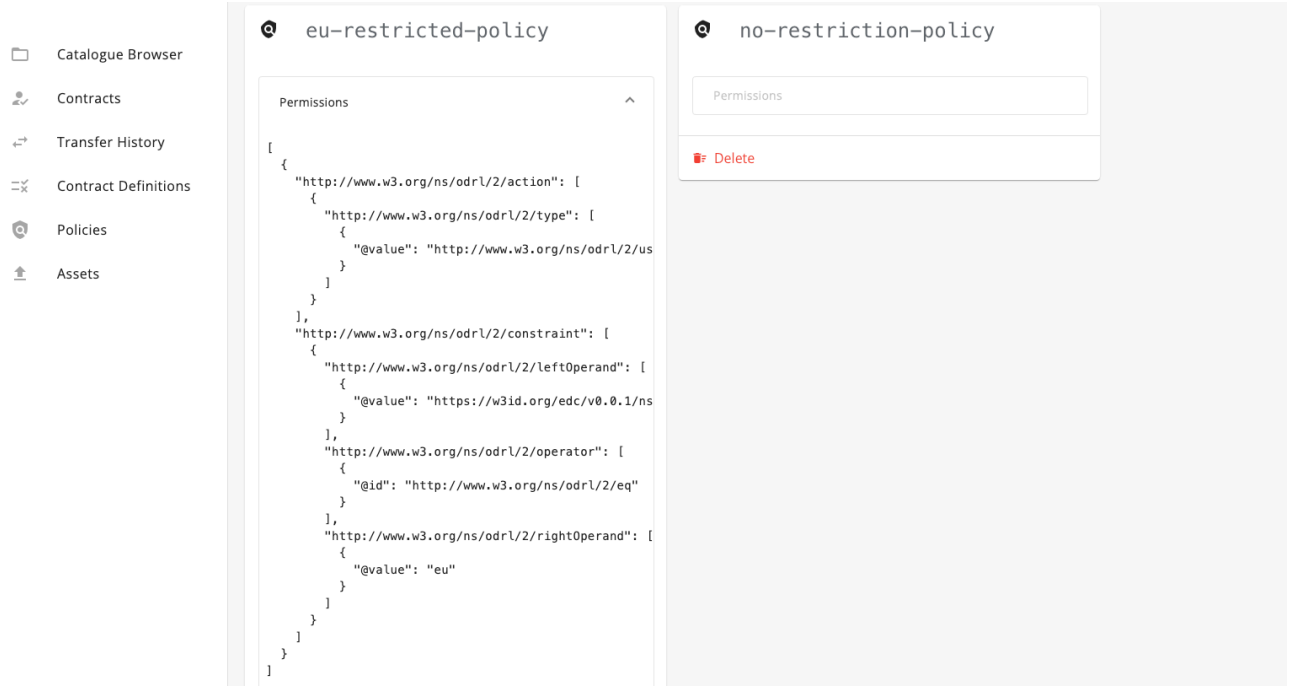

Figure 9 – Expanded Policy Details

To create a new policy, the Participant can click on the 'Create policy' button. A pop-up form appears (Figure 10), requesting the required information about a new policy, including:

- Policy Id (free text): the identifier of the policy
- Type (dropdown): the policy type. 'Permission' type is available
- Operator(dropdown): equal or not-equal
- Region (dropdown): contains the options Europe, Asia, United States

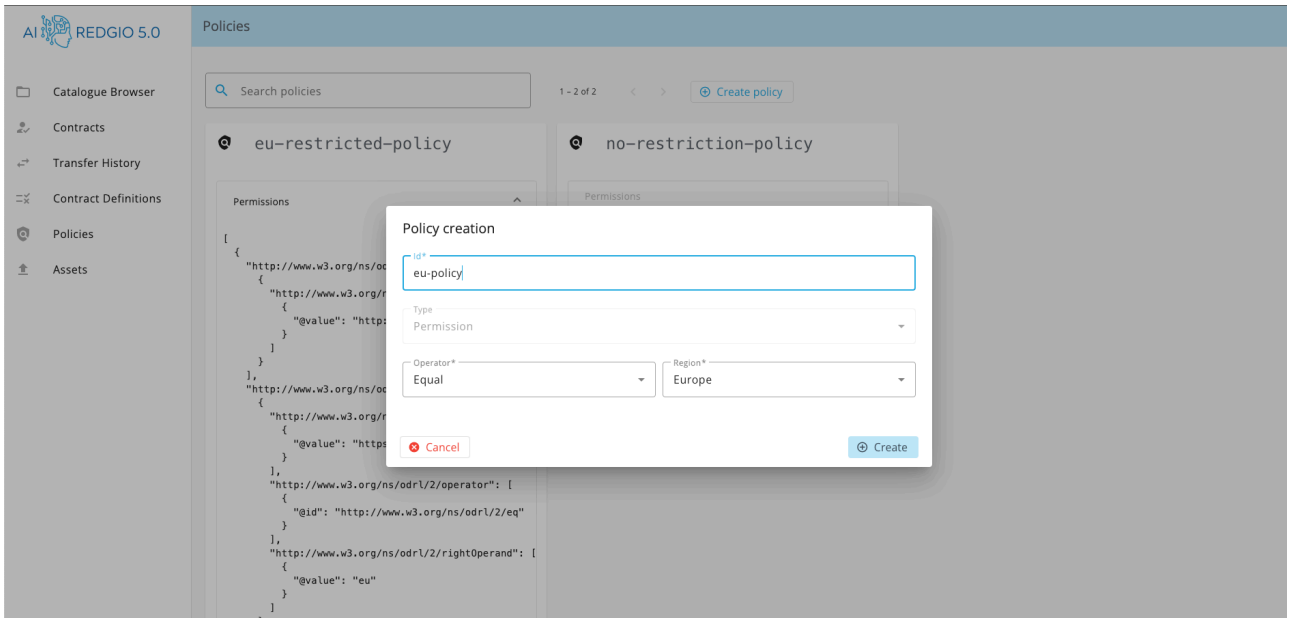

Figure 10 - Create Policy

Once the Participant has filled in all the required fields, they can click the 'Create' button and the new policy becomes available in the Policies page.

More details about the Policies page and the add-policy process are available at:

https://github.com/eclipse-edc/MinimumViableDataspace/blob/main/docs/developer/edc-data-dashboard/add-policy.md

6.2.3. Contract Definitions Page

The Contract Definitions bind one or more assets added to the AI REDGIO 5.0 Data Space with existing policies. Before binding an asset to a contract, it is only available to its owner (Data Provider) and only through the Data Provider's Assets page. After a contract definition has been completed, the specific asset(s) are published on the Federated Catalogue and become available to other participants of the AI REDGIO 5.0 Data Space according to the rules defined in the selected policies.

In the Contract Definitions page (Figure 11), the Participant can view the existing contract definitions (if any) and perform name-based search.

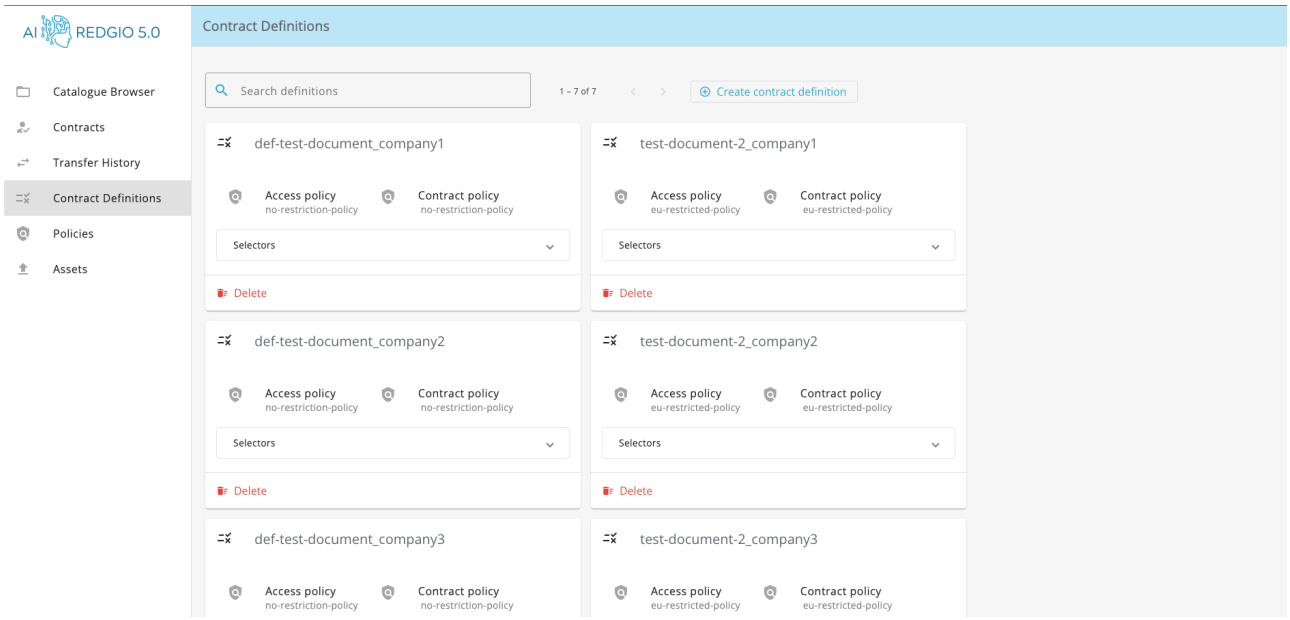

Figure 11 - Contract Definitions Page

If the Participant wants to create a new Contract Definition, they can click the 'Create contract definition' button. A pop-up input form appears (Figure 12), where they are requested to fill in the required information:

- Contract Definition Id (free-text): the identifier of the Contract Definition
- Access policy (dropdown): defines the visibility of the asset(s) by other Participants through the Catalogue. All defined policies are available as options
- Contract policy (dropdown): defines the ability of other Participants to acquire the asset(s). All defined Policies are available as options
- Assets (dropdown): asset(s) that will be published to the Catalogue based on the specific Contract Definition. All assets added by the Participant are available as options

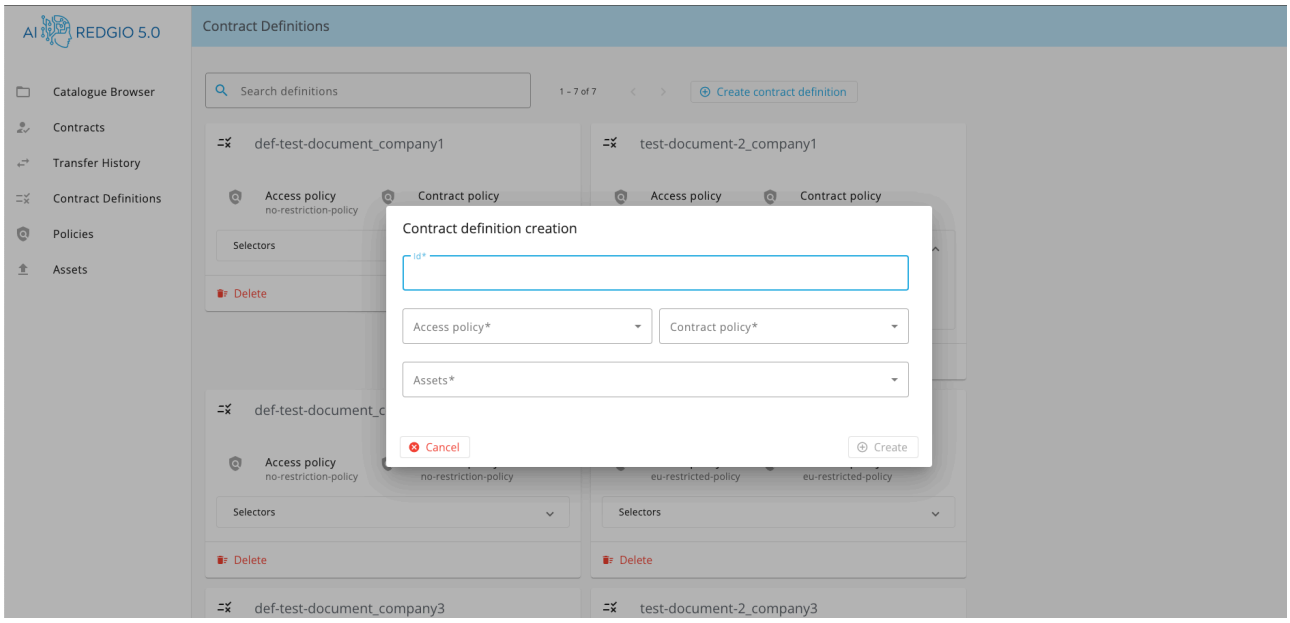

Figure 12 - Create Contract Definition

Once the Participant has completed the Contract Definition form, they can click the 'Create' button. Afterwards the new Contract Definition becomes available in the Contract Definitions page, and the respective assets are published in the Catalogue (see Section 6.3.1) and become available as Contract Offers to the rest of the AI REDGIO 5.0 Data Space Participants according to the binding access and contract policies.

More details about the process of publishing an asset available at:

https://github.com/eclipse-edc/MinimumViableDataspace/blob/main/docs/developer/edc-data-dashboard/publish-asset.md

6.3. Consume Data

This section guides the user through the pages relevant to the consumption of assets through the AI REDGIO 5.0 Data Space and the logging of any data transaction that takes place. The main actor here is the Participant acting as a Data Consumer; however, the process of data exchange and inspection of the relevant transaction logs also implies the direct or indirect (through the Connector) involvement of the respective Data Provider.

Once the user is logged into their Data Space instance using their credentials, they can perform the following actions that are relevant to the consumption of data and the traceability of data exchanges:

1. Identify Contract Offers of interest and make a negotiation (through the Catalogue Browser page)
2. Acquire the asset in the object storage (through the Contracts page)
3. Check the completed data transactions (through the Transfer History page)

6.3.1. Catalogue Browser Page

The Catalogue Browser enlists all the assets that have been published as Contract Offers to the AI REDGIO 5.0 Data Space, based on Contract Definitions. Each Participant of the Data Space can only view and acquire assets they are eligible to, based on the access policies in the respective Contract Definition.

The Participant can view the details of each asset, including name, metadata (creation date, version, content type, etc.), and perform name-based search to find assets of their interest (Figure 13).

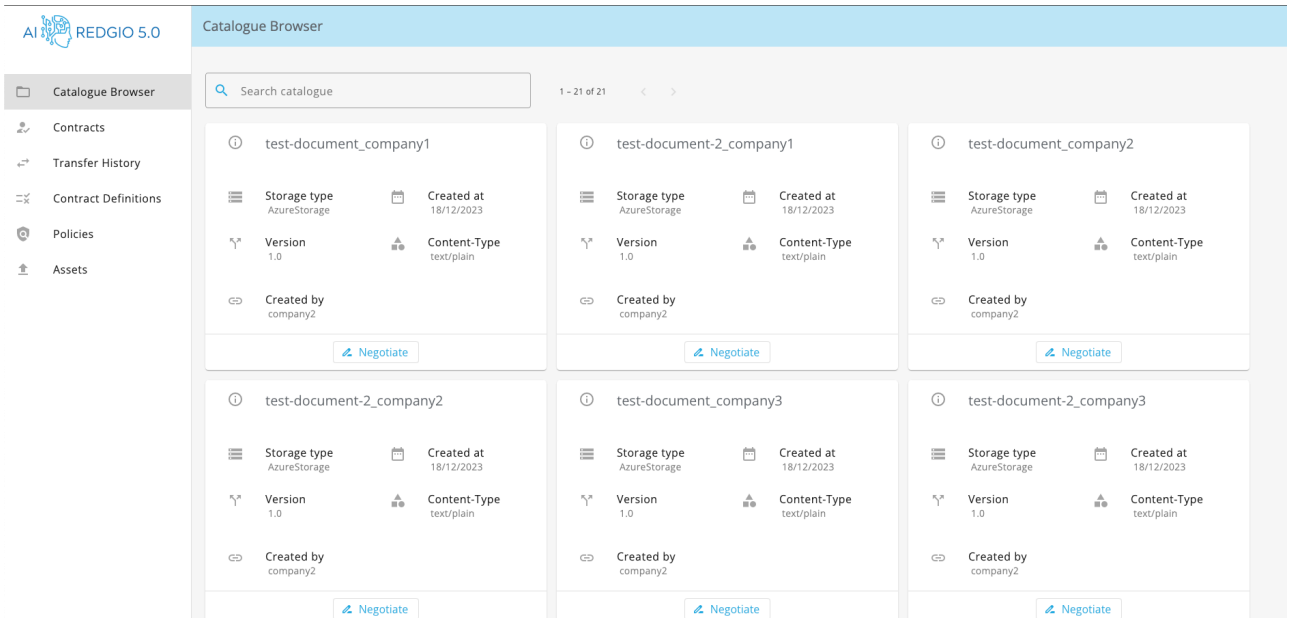

Figure 13 - Catalogue Browser Page

By clicking on the 'Negotiate' button (available to Participants according to applicable usage policies defined by Contract Definition), the Participant acting as the Data Consumer initiates the data acquisition process. After it is successfully completed, the relevant Contract is automatically created (see Section 6.3.2).

More details about the process are available at:

https://github.com/eclipse-edc/MinimumViableDataspace/blob/main/docs/developer/edc-data-dashboard/negotiate-contract.md

6.3.2. Contracts Page

In the Contracts page, the Participant can find all the Contract Agreements created after a successfully completed Negotiation.

Each Contract card contains the automatically generated Contract id, the name of the relevant asset, the Data Provider DID and the date of the contract signing (Figure 14).

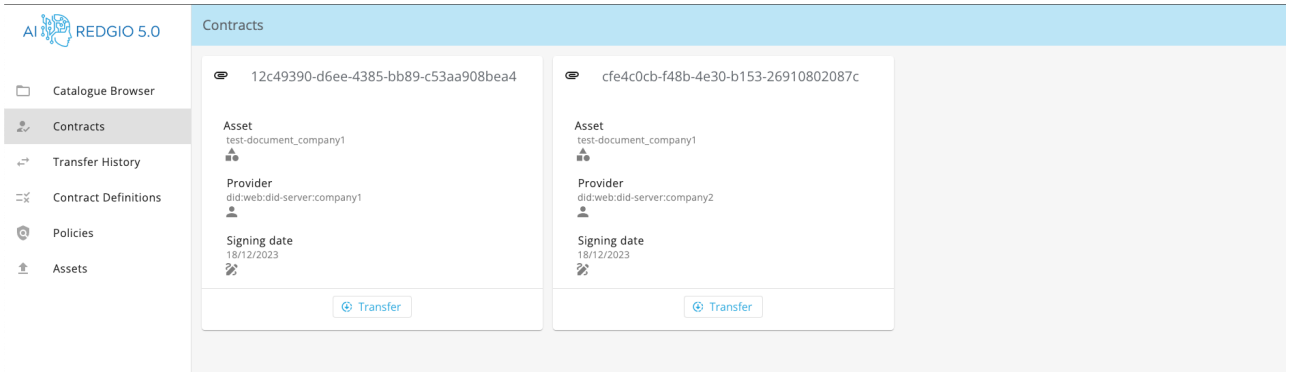

Figure 14 - Contracts Page

The Participant can acquire the relevant asset by clicking on the 'Transfer' button. Once the data transfer process is completed, the Participant can find the asset in their Blob Storage.

More information about the data transfer process available at:

https://github.com/eclipse-edc/MinimumViableDataspace/blob/main/docs/developer/edc-data-dashboard/initiate-transfer.md

6.3.3. Transfer History Page

In the Transfer History page (Figure 15), the Participant views the logs of data transfers they have participated in (either as Data Providers or as Data Consumers), including information about the Transfer id, the state of the transfer (e.g. Completed, In progress), the date the log was last updated, the role of the Participant in the transfer (consumer or provider), the relevant asset name and the Contract id.

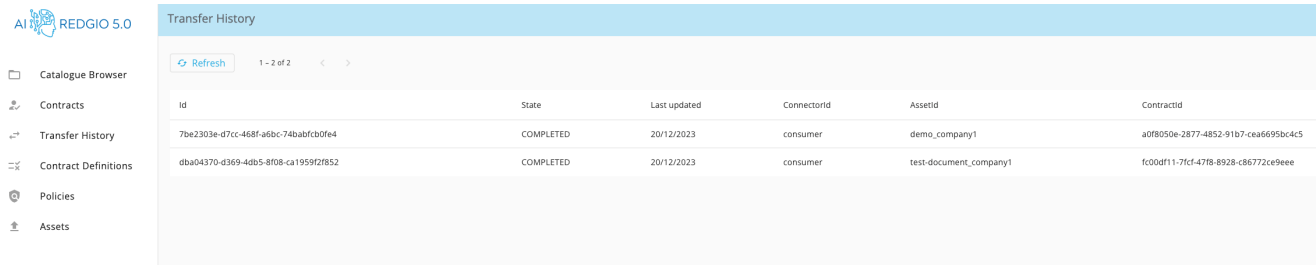

Figure 15 – Transfer History Page

More details about the transfer history logs are available at:

https://github.com/eclipse-edc/MinimumViableDataspace/blob/main/docs/developer/edc-data-dashboard/transfer-history.md

7. Conclusions and Next Steps

Deliverable D4.3 presents the activities performed in the context of task T4.5 towards the first release of the AI REDGIO 5.0 Data Space [M12]. Starting with a brief presentation of the core concepts and principles guiding the development of Data Spaces, the deliverable proceeds with the specification of the AI REDGIO 5.0 Data Space, including the envisioned users and actors in the context of AI REDGIO 5.0, and the definition of the system requirements, in accordance with the user requirements of D2.3 and the design principles promoted by eminent initiatives in the domain. Finally, the report concludes with a walkthrough of the AI REDGIO 5.0 v.1, illustrating the steps required to perform the two main flows of interaction (i.e. provision and consumption of data).

The first version of the AI REDGIO 5.0 Data Space provides various features that aim to enable a manufacturing stakeholder participating in the Data Space exchange data with other participants in a secure and sovereign manner, in order to enhance their analytics and AI-related operations. It has been developed as an extension of the reference implementation of a Minimum Viable data Space based on the Eclipse Dataspace Components (EDC) Framework. The currently available version of the AI REDGIO 5.0 will be integrated with the other data-related solutions developed under WP4, in the context of T4.6, and the results of the first integration, testing and validation will be reported in D4.4 – "Data4AI Platform Technical Validation" [M18]. Additionally, the AI REDGIO 5.0 Data Space v.1 will be available to serve the data exchange needs of WP6 experiments, that will perform the first cycle of demonstrations and report the results in M18, in the respective deliverables. Various enhancements are foreseen for the second release of the AI REDGIO 5.0 Data Space, that along with further additions based on user feedback and bug-fixing, will lead to the delivery of the second and final release of the AI REDGIO 5.0 in the context of D4.7 [M30].

8. References

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[2] European Commission, European Strategy for Data, COM(2020, 66). Available at: https://digital-strategy.ec.europa.eu/en/policies/strategy-data (last accessed: 10/01/2024)

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[11] International Data Spaces Association, Minimum Viable data Space (MVDS). Available at: https://docs.internationaldataspaces.org/ids-knowledgebase/v/ids-reference-testbed/minimum-viable-data-space/mvds (last accessed: 10/01/2024)