Product Passport through Twinning of Circular Value Chains

Deliverable 2.1

RM-recovery and Waste Data Space v1

WP2: Supply Chain DT modelling and Operation

Editor:	Dimitris Verlekis
Lead beneficiary:	MAG
Version:	1.1
Status:	Final
Delivery date:	30/06/2024
Dissemination level:	PU

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101092008

Document Factsheet

Grant Agreement No.	101092008
Project Acronym	Plooto
Project Title	Product Passport through Twinning of Circular Value Chains
Start date	01/01/2023
Duration	36 months

Deliverable Name	RM-recovery and waste Data Space v1
Related WP	WP2: Supply Chain DT modelling and Operation
Due Date	30/06/2024

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Document History

Version	Date	Author(s)	Organisation	Description
0.1	14/05/2024	Dimitris Verlekis	MAG	Table of Contents
0.2	03/06/2024	Dimitris Verlekis	MAG	Intro & Sections Summaries
0.3	06/06/2024	Dimitris Verlekis	MAG	Completion of Sections 2 & 3
0.4	12/06/2024	Dimitris Verlekis	MAG	Completion of Section 4
0.5	18/06/2024	George Arampatzis, Jose Gonzalez Castro, Ilias Kritikopoulos, Costas Christidis, George Koustas, Olga Serifi	TUC, EUT, BIT, FRONT, ACCELI, KPAD	Integration of Partner Input
0.6	19/06/2024	Dimitris Verlekis	MAG	Ready for Internal Review
0.7	21/06/2024	Aris Zompras	ACCELI	Peer review
0.8	24/06/2024	Linda Leonardi	CETMA	Peer review
0.9	25/06/2024	Dimitris Verlekis	MAG	Integration of comments from internal review
0.10	28/06/2024	Armend Duzha	MAG	Quality check
1.0	30/06/2024	Dimitris Verlekis	MAG	Final version ready for submission
1.1	29/11/2024	Dimitris Verlekis	MAG	Addressing the comments from the EC

Executive Summary

This document is the first version of the deliverable "RM-recovery and waste Data Space", which presents the intermediate output of Task 2.2 on the design of a Raw Material recovery and waste Data Space (RMDS) within the project's ecosystem, in accordance with the International Data Spaces Association principles (IDSA).

First of all, three different collaboration models between two organisations of a value chain are defined, depending on the relationship each negotiating party has with the Plooto ecosystem. An abstract design for a Minimum Viable Data Space (MVDS) is provided for all three pilots. An adaptation of the IDS Reference Architecture Model (IDS-RAM) Information Layer follows, along with the reasoning that led to it, in order to achieve a proper form for data integration within the core platform. Then, the document describes main IDS functionalities that are, or will be implemented, including authentication, discoverability, negotiations, and secure data sharing, while explaining how they fit into the Plooto platform.

Since all IDS protocols are completely agnostic with respect to the exchanged data, the whole document focuses on the modelling and the technical aspects of the project's Data Space, omitting any data related presentations, which are thoroughly studied in other deliverables.

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Table of Contents

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List of Figures

Acronyms and Abbreviations

Acronym	Description
DBMS	Database Management Systems
DCAT	Data Catalogue Vocabulary
IDS(A)	International Data Spaces (Association)
IDS-RAM	International Data Spaces Reference Architecture Model
IoT	Internet of Things
JWT	JSON Web Token
MVDS	Minimum Viable Data Space
ODRL	Open Digital Rights Language
RBAC	Role Based Access Control
RMDS	Raw Material recovery and waste Data Space

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1 Introduction

The last decade has proven that the term “Climate Change" has evolved into “Climate Crisis” much faster than expected. Extreme weather phenomena, which seldom occurred are becoming more and more frequent, foreshadowing an ominous, dystopian future, unless imminent action is taken.

The model of linear economy, resulting in massive volumes of waste that could be utilised in a much more efficient way, plays an integral role in this outcome, and is greatly responsible for the current state of the planet. Most of the damage is irreversible for periods much longer than a human lifetime, however, the transition to a much more resilient, circular economy in major sectors of industrial activities can help in mitigating the damage in future years.

Circular economy though, demands a great deal of effort to effectively organise the processes and systems that can accommodate the necessary flows of reusable materials, without causing an equivalent or ever higher environmental footprint due to the byproducts wasted in the process. Accurate measurements on energy consumption and level of recyclability on materials that are currently turned into waste are important factors in calculating the most efficient strategies. Similarly, listing as many byproducts and secondary raw materials as possible on the one hand, and input necessities for industrial processes on the other hand, is of paramount importance to match supply and demand.

Today’s technology offers the infrastructure to create systems which can efficiently handle great amounts of data and provide recommendations for such cases. The greatest challenge is not the efficiency of technical means, but the teamwork and coordination among interested parties. In order to achieve a common understanding of processes and define mutually acceptable solutions, initiatives had to be carried out. Gaia-X[1] and International Data Spaces are such initiatives, aiming to create common infrastructure, with well-defined ontologies to provide users with the ecosystems to handle modern problems, requiring data driven solutions.

For the purpose of Plooto, a Data Space will be built to accommodate the exchange of information among members of value chains on available secondary raw materials, waste, and byproducts. The aim of this ecosystem is the efficient utilization of such materials by reusing, upcycling, and recycling to reduce the environmental footprint of said value chains as much as possible. The three pilots of the project will use this Data Space to record such data and leverage technology to analyse, reform and optimise their processes.

The potential success of this venture may spark an increasing interest for industrial partners to join this or other similar Data Spaces, resulting in a minor, yet not detrimental reduction of the environmental footprint caused by major industries in Europe.

[1] https://gaia-x.eu/what-is-gaia-x/about-gaia-x/

1.1 Purpose and Scope

This document is the first version of iteration on the deliverable "RM-recovery and waste Data Space" and provides an insight into the interim results in design and development of a Data Space for the exchange of data related to cyclical processes and the monitoring of waste in the scope of Plooto. Along the document, all important facets of the developed ecosystem are described, and crucial models for various aspects of the Data Space are defined, ranging from data representation to collaboration cases.

1.2 Relation with other deliverables

Since D2.1 contains interim results of the tasks related to the project's Data Space, the final results of these tasks will be presented in the next version, D2.2 "RM-recovery and waste Data Space v2", due in April 2025. Some of the described entities and software components are described in deliverable D1.5 "CRIS requirements and specifications v1.0", while some Plooto services that implement optional IDS functionalities are presented thoroughly in deliverable D2.3 "Plooto complete suite of services v1".

1.3 Structure of the document

The document is structured as follows:

- **Section 2** introduces the three basic collaboration models that can occur in a Plooto Data Space ecosystem
- **Section 3** presents the Information Layer of the Data Space Reference Architecture Model (IDS-RAM), adapted to the needs of the project.
- **Section 4** describes the core Plooto platform features, which implements IDS related functionalities and compares them to the functional, process, and system layers of IDS-RAM.

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2 Collaboration Models Using Plooto

In the case of circular value chains, the utilisation of a Data Space infrastructure implies that each node of the chain, a digital twin (DT) representing an actual organisation, can establish collaborations for the exchange of information on production related data. In order to successfully model all the collaborations throughout a value chain, the cases for a minimal collaboration between two organisations must be defined.

It is expected that not all entities in a circular value chain outside the scope of the project will be Plooto users. To make the platform viable in these real-life conditions, the collaborations cases where one or both organisations don't use Plooto inside a larger value chain which utilises the platform, should be considered.

Thus, three collaboration models are defined, depending on the number of organisations with access to Plooto:

1) Collaboration between Plooto users.
2) Collaboration between a Plooto user and an external party.
3) Collaboration between two external parties.

In all of these cases Plooto should be able to provide the minimal infrastructure needed for the whole value chain to be considered IDS compliant. To achieve this the concept of a Minimum Viable Data Space (MVDS) is considered.

2.1 Minimum Viable Data Space Infrastructure

The IDSA specifies a minimal set of requirements, that an ecosystem has to meet in order to be regarded as a Data Space.[2] Such an ecosystem is called an MVDS, and consists of three components:

1) **Data Provider IDS Connector**: A software component which serves as representative agent for an entity providing data to the ecosystem. Its role is to emit and receive the necessary messages for the successful authentication, negotiation and data exchange processes with other entities in the Data Space.
2) **Data Consumer IDS Connector**: A software component which serves as representative agent for an entity consuming data from the ecosystem. Its role is to emit and receive the necessary messages for the successful authentication, negotiation and data exchange processes with other entities in the Data Space.
3) **Identity Provider**: A neutral software component responsible for registering, authenticating, and managing IDS Connectors in the Data Space. Its two main purposes are issuing

[2] https://docs.internationaldataspaces.org/ids-knowledgebase/v/ids-reference-testbed/minimum-viable-data-space/mvds

certificates to verify the identity of Connectors, and dynamic management of Connector attributes to determine their access rights.

The concept of a MVDS is used in the following sections, to ensure that each of the three collaboration models described in the beginning of the section can be part of a larger Data Space compliant ecosystem. The terms data provider and data consumer, correspond to the respective roles of two consecutive collaborating nodes in a value chain, where the previous node provides the next with some input, such as materials, energy etc.

2.2 Collaboration between Plooto users

The most prevalent collaboration model is the one between two Plooto users. In this case, both organisations have access to the platform and utilise its services. In this model, the IDS Connector is embedded in the platform. Users can synchronise an external data lake with Plooto or assemble a data lake for their organisation in the platform. Regardless of the case, all actions relevant to negotiations and data exchange are managed on a Plooto interface, and all IDS Connector functionalities are implemented within the system, on both ends of a collaboration.

In this model, Plooto also acts as an identity provider. An organisation is registered into the system, allowing related users to authenticate and access its data, depending on dynamically assigned roles by the system, with three clearance levels: user, admin, and owner. Authentication and role management is handled by Keycloak[3], and is explained thoroughly in Section 4.1.

This model is already implemented in Plooto.

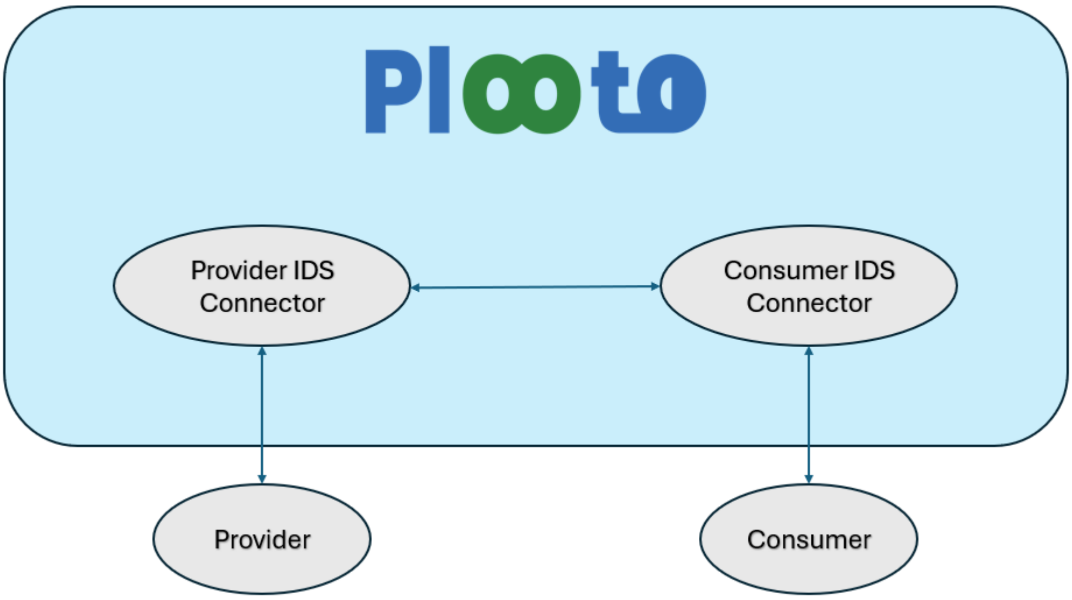

Figure 1: Collaboration between Plooto users

[3] https://www.keycloak.org/documentation

2.3 Collaboration between a Plooto user and an external party

This case includes two variations. An external data provider, or an external data consumer collaborating with a Plooto user on the other end. The designed IDS Connector for external parties will provide functionalities for both roles. Thus, the example of this section with the case of a provider using Plooto would apply equivalently in the case of a Plooto user in the role of the consumer.

The differentiation from the previous model affects only the organisation which is not a Plooto user. The provider will still be authenticated by the platform and will use the integrated IDS Connector for all purposes. On the other side, the consumer will have to register as an external party. Authentication will also be handled by the same service of Plooto, but the process will most likely happen through an API, rather than a graphical interface. As for the IDS Connector, the consumers may implement their own software components, but will have an available Connector API to send and receive the appropriate messages.

This model is not implemented in the current versions of Plooto, and its architecture details are still in development.

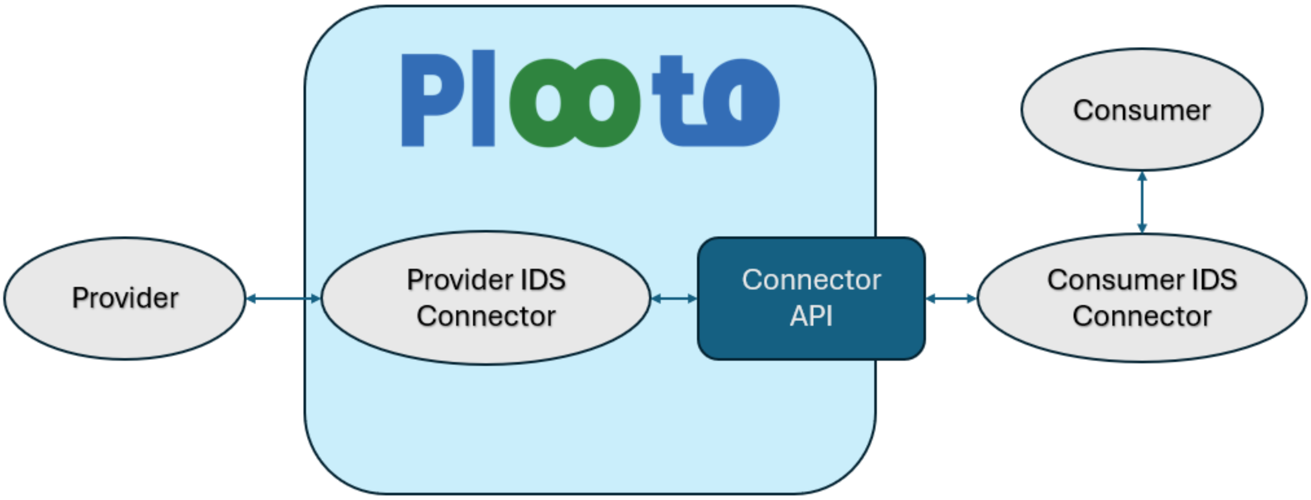

Figure 2: Collaboration between a Plooto user and an external party

2.4 Collaboration between two External Parties

This model refers to the case where both collaborating parties have no access to Plooto but wish to leverage its Data Space Connector API.

This model will be similar to the consumer side of the previous section. IDS Connector messages will have to be created by the external party, but the API provided by Plooto will be used to forward them appropriately to the other collaborating end. The core differences with the previous model are two.

Since there is no collaborating party in Plooto, the messages between the IDS Connectors will not be stored internally. A messaging queue may be implemented to forward these them, adding a software component compared to the previous model. Furthermore, Plooto will act as an identity

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provider once again, but since the only interaction between the platform and the collaborating parties is limited to message exchanges, the service responsible for authentication may be handled by the messaging queue service, instead of Keycloak.

This model is also not implemented in the current versions of Plooto, and is highly subject to changes, depending on the final form of the other models, since it will be implemented last.

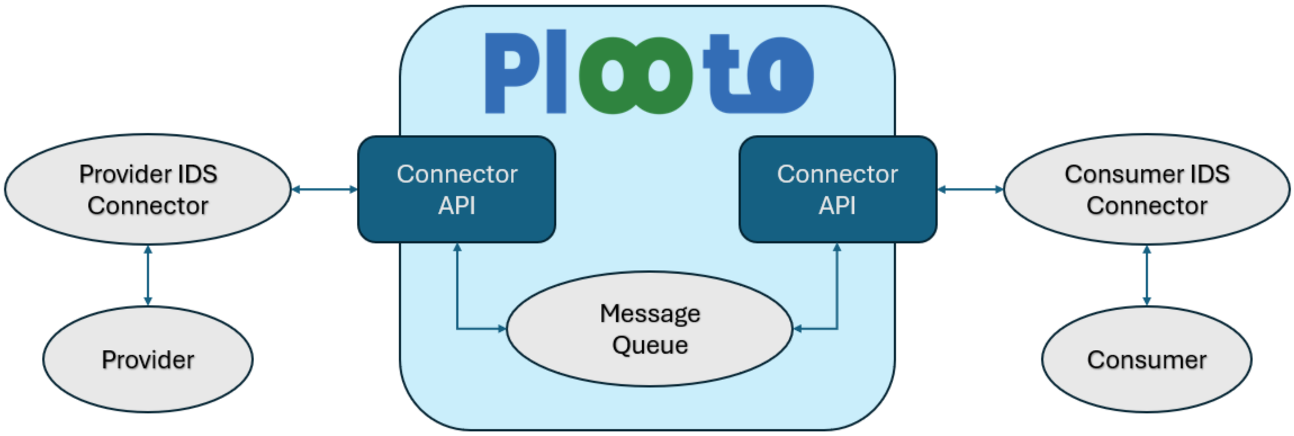

Figure 3: Collaboration between two external parties

2.5 Overall Value Chain MVDS

A value chain exchanging information on production data gathered on organisations' digital twins can be a MVDS if all sets of collaborations in its scope meet the requirements of an MVDS. Along value chains that utilise Plooto infrastructure, all collaborations will fall in one of the three models described in the previous sections. All models feature at least one identity provider, one provider IDS Connector, and one consumer IDS Connector. Thus, value chains using Plooto will meet the criteria to be viable Data Spaces.

Value chains that fully integrate with Plooto, will have many additional applications that surpass the limited services of MVDS. However, the guarantee of compliance that this concept ensures remains an important threshold that is easy to achieve throughout a production cycle, without depending on the loyalty of other involved organisations to a specific platform.

3 IDS-RAM Information Layer Adaptation

This section is dedicated to the data model used for IDS related purposes in the scope of Plooto. It includes the way datasets are represented in transactions with external parties, and the ontologies related to negotiations, and usage policies on exchanged data.

This model can be regarded as part of a greater, five-layer architecture model proposed by the IDSA and used as a reference when building a Data Space. The next section gives an overview of this reference architecture and its layers, and the following sections present the model and its adaptation to the needs of Plooto.

3.1 IDS Reference Architecture Model

IDS Reference Architecture Model[4] provides an abstract approach to the components, functions and interactions in a Data Space, and defines five layers depicting different viewpoints of the overall structure.

1) **Business Layer**: Specifies the various roles of participating entities, defining their activities, goals and interactions with each other.
2) **Functional Layer**: Defines the functional requirements for each Data Space component, and the ecosystem as a whole.
3) **Information Layer**: Defines the models of information architecture, including representation of data entities and rules on related actions.
4) **Process Layer**: Provides a dynamic view of the architecture, by specifying the interactions between components and their characteristics.
5) **System Layer**: Specifies the details of the logical software components, considering aspects of configuration, integration, deployment and extensibility.

The data model described in the next section is part of the Information Layer.

3.2 Information Layer Data Model

In a Plooto Data Space, the flow of exchanged data is mainly expected to follow paths along the flow of value chains, with some upstream exceptions, where reusing, upcycling or recycling transactions take place. To provide an IDS compliant information system, the entities describing the exchanged data along a value chain and the rules governing the corresponding transactions must be in line with the proposed IDS Data Models available on the IDSA website[5] and GitHub page[6].

[4] https://docs.internationaldataspaces.org/ids-knowledgebase/v/ids-ram-4
[5] https://docs.internationaldataspaces.org/ids-knowledgebase/v/dataspace-protocol/catalog/catalog.protocol#id-1.1-dcat-vocabulary-mapping
[6] https://international-data-spaces-association.github.io/DataspaceConnector/Documentation/v6/DataModel

Both models, even though expressed with slightly different terms, present the same structure based on the idea that an exchangeable collection of data can be represented in various formats and may be stored in multiple locations, either partially or as a whole.

This approach implies a hierarchy of three layers, presented below. The different terms from both IDSA sources are mentioned, as well as the proposed classes for representing the corresponding entities. These classes are members of existing namespaces for Data Catalog Vocabulary (DCAT)[7], while the classes concerning negotiations and access rights are defined with Open Digital Rights Language (ODRL)[8].

The model for data representation contains:

1) Dataset/Resource: It refers to the description of contents and the generic metadata of a data collection, independently of media types, file formats, or physical storage information. It describes what the data collection is about, how it was collected, and what qualities it has, without paying attention to any technical details. The proposed class to implement this entity is the ***dcat:Dataset***.
2) Distribution/Representation: This layer refers to the form of data, such as the media type, file format, character encoding, and other related formatting information, specifying its expected structure. It also specifies the granularity in which information is presented, and the inclusion or not of all data aspects. One resource can have multiple representations corresponding to the different ways it is structured or to the extend in which the included data are shared. However, it must certainly have at least one representation defining at least one format in which it is expressed. This layer is very useful in cases where different views of the same data are provided to more than one consumer with different access rights. The proposed class to implement this entity is the ***dcat:Distribution***.
3) Data Service/Instance: This layer is the most ambiguously defined in the model. The IDS Connector Data Model in GitHub refers to it as "Artifact", but the equivalent term "Instance" is used in IDS RAM documentation. It refers to the physical information of a file or directory that contains the data, including the location where it can be fetched from, and the access method. This is the reason it also matches the term Data Service used in the Dataspace Protocol Specification on the IDSA website. All terms refer to the layer which defines where the actual files containing the data are, and how they can be retrieved. Different instances refer to different files or endpoints, available for multiple consumers of the same data collection. Naturally, one instance is the incarnation of a specific representation, while one representation has at least one instance, with no upper limit. The designated class for this layer is ***dcat:DataService***.

[7] https://www.w3.org/TR/vocab-dcat-3/
[8] https://www.w3.org/TR/odrl-model/

For the rest of the document the terms **Resource**, **Distribution** and **Instance** will be used to refer to the above entities, in order to avoid ambiguity, since the terms dataset, representation and service are also used in this deliverable to describe other concepts or entities.

In practice, a data collection is described as a resource, which may have multiple distributions, for different file formats, or various views of the dataset containing subsets of fields, in respect to the recipient's access rights. A distribution may have multiple instances depending on the connection point they are available on per consumer, the various access methods to fetch them, or other related details, such as different number of files or compression format.

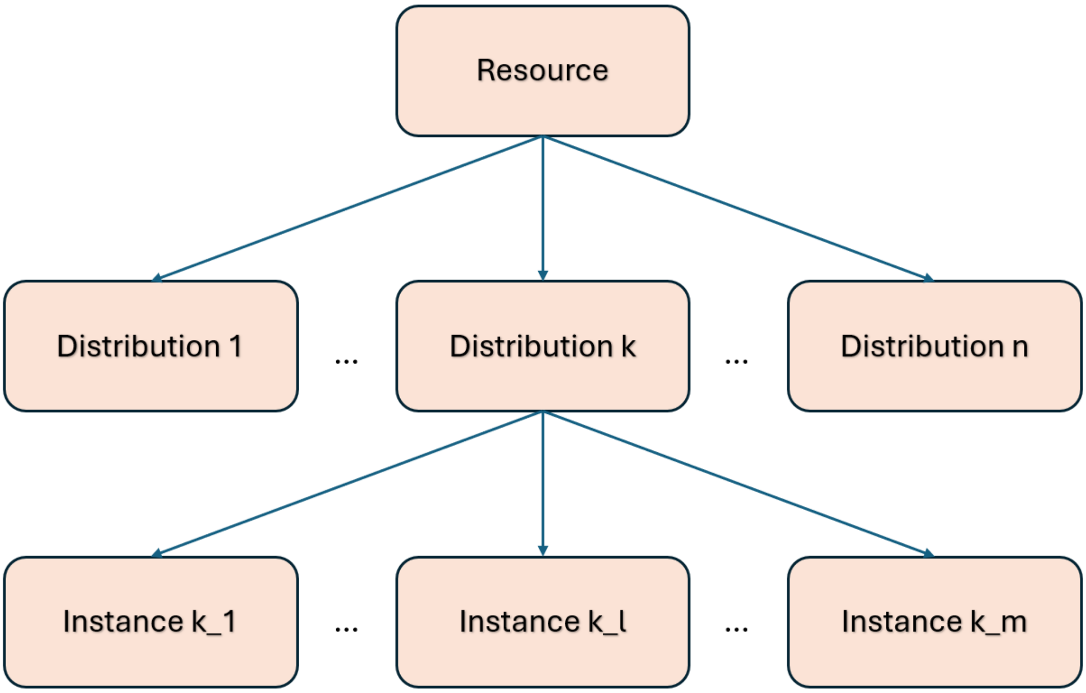

Figure 4: Hierarchy of Data Model Layers.

In order to negotiate data collections apart from the definition of the above entities, a set of terms has to be defined to properly express the permissions, obligations, and constraints a consumer has during an agreement for data sharing.

IDSA protocols use the term Offer to describe the set of conditions a negotiation is discussed upon. An Offer is set on an asset, which is the Offer's target. Entities of all three layers can be assigned as targets of an Offer. Modelling offers should be based on the ***odrl:Offer*** class.

The contents of an Offer are:

1) A reference to its target asset.
2) An assigner, which in the scope of Data Spaces is the data provider.
3) A set of Policies defining access and usage policies on the target asset.

Policies defined in an Offer are pairs of actions and rules, each one determining if and how an action can be performed by a consumer, in case of agreement on the offer. Actions may be predefined ODRL action instances[9] or domain specific actions defined for the purpose of each data space. There are three main rules that can be paired with actions:

1) Permission: Allows the performance of the underlying action.
2) Prohibition: Bans the performance of the underlying action.
3) Duty: Obliges the consumer to perform the underlying action.

To initiate a negotiation process, there must be an offer assigned to the requested data entity, serving as a starting point. During the process, counteroffers from both parties may be proposed, making changes to the pairs of actions and rules until a consensus is reached, or either party quits the process. When a negotiation process ends successfully, the Offer containing the policies accepted by both ends, turns into an Agreement, with the addition of an extra assignee field, referring to the consumer. Additional information about the deal, such as a natural language part, with legal details may be included.

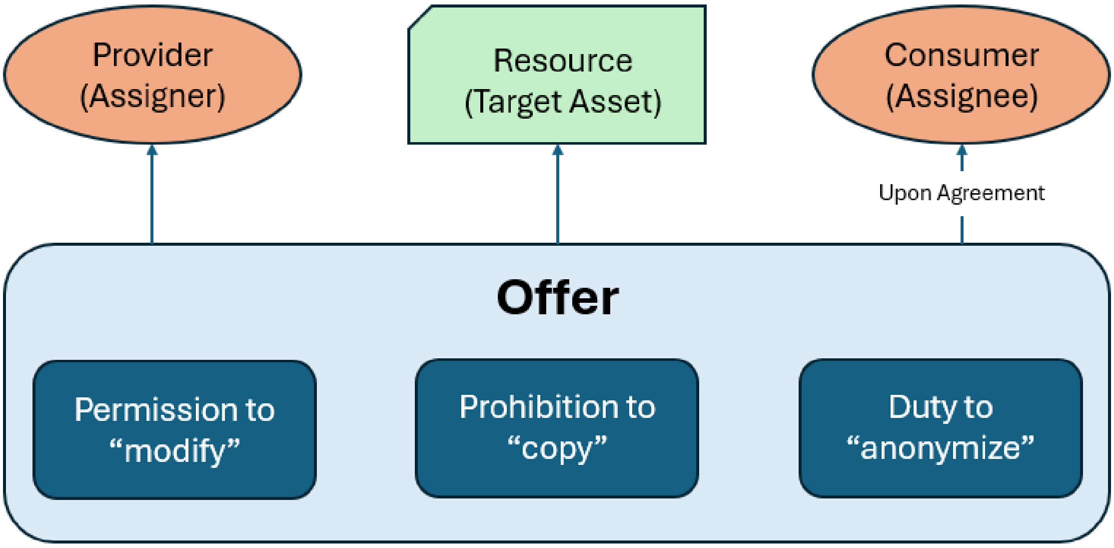

Figure 5: Structure of an Offer.

3.3 Adaptation to Plooto

In versions of Plooto developed until month 18, only the first collaboration model described in Section 2.2 is implemented, where two Plooto users exchange data among them. The descriptions of internal entities corresponding to Resources, Distributions and Instances are not modelled using DCAT classes, since the integrated IDS Connectors of both negotiating parties are implemented on the platform and use the same backend ontology. Future versions will feature relevant adaptations to communicate with IDS compliant external parties.

[9] https://www.w3.org/TR/odrl-vocab/#actionConcepts

The current version of Plooto uses the term **Asset** to depict a Resource for its users. Each asset has one or more **Telemetries**, which contain rows of data fed to them through **Data Sources**. A data source can be populated with three different ways. Readings can be transmitted to Plooto in real time by sensors and other IoT devices, or data collected in external data lakes can be pushed periodically into the platform. In cases of historical, offline data, there is also the option of manual bulk insertion.

Fields from a data source can be assigned to telemetries, thus feeding an asset with data. Practically, each telemetry is equivalent with a table in a relational model [1]. Each row of this table has two fields, the actual value and an associated timestamp. As a result, an asset is a structured dataset with multiple tables, one per telemetry.

During negotiation process, according to the IDS protocols, an offer must be defined for the requested items. The subject of a negotiation in Plooto is an asset, which is set as the target of the offer. The assigner here is the organisation which owns the asset. The set of policies is not explicitly discussed in a formal fashion on current versions of Plooto by pairing actions and rules. However, part of the process dictates which telemetries will be shared with the consumer, implying the request for permission to access a telemetry. To formalise this process in case it proves necessary in future versions, request for permission on a predefined action such as "copy", or a domain specific action called "access" could be used, by leveraging the additional property "target" of the **odrl:Rule** class. This way access requests could be depicted separately for each telemetry of an asset.

The outcome of a successful negotiation is a shared asset. This asset accompanied with the agreed telemetries should be provided to the consumer. The concept of distribution is considered here. An asset with N telemetries can produce 2^N different distributions depending on the subset of shared telemetries. Apart from this aspect, in future cases of consumers with no access to Plooto, the shared data could be formatted in various file types, to match the needs of the different recipients.

Lastly, in most cases there will be a one-to-one relation between distributions and instances, but in rare occasions, the need for multiple instances might rise. As an example, a recipient might be enforced by local laws to restrict the retrieval data coming from servers located in specified geographical areas. In such cases, multiple access points with instances of the same distribution could prove useful.

4 Plooto Ecosystem IDS Functionalities

This section presents some key IDS functionalities that are already part of the Plooto ecosystem in the current stage of the project, and discusses both the addition of new important features and the extension of current ones for collaboration models with external parties or enhanced adherence to the IDS protocols.

Since the IDS-RAM was listed in a previous section, it is used as a reference in some of the following sections to highlight the alignment of Plooto features with the desired results. While some features concerning the model of two Plooto collaborators are almost finalised, many others are in early stages of design and development. As a result, every topic covered in this section is subject to significant changes until the final version of this deliverable in April 2025.

4.1 Authentication & Authorisation

IDS-RAM identifies trust and security as two of the six core functional aspects in a Data Space. The basis of trust is identity management and user certification. Security on the other hand is based on robust methods to verify the identity and attributes of each user. Registering, authenticating and authorising users with access to the proper assets in Plooto are the three main actions which satisfy the above needs.

As it was first mentioned in Section 2.2, the service responsible for identity management and authentication is based on Keycloak, an open-source identity and access management tool. Plooto is using a two-level approach for user management, by creating organisations in Keycloak.

Assets and their respective telemetries belong to organisations, which are the negotiating parties in Plooto. Each organisation is registered to Keycloak and receives a unique identifier. However, in order for negotiations to take place, there must be at least one user related to the organisation. Users are registered in Keycloak independently but have no access whatsoever on their own. The crucial point is the connection between the two entities. Through Keycloak, a user is assigned to one or more organisations and during the login process, once a user's password is verified, Keycloak fetches the organisations related to the user and incorporates their identifiers in a JSON Web Token (JWT) which is sent to the user and gives him access to the organisation's content on Plooto.

User management in Keycloak also incorporates a hierarchy. When assigned to organisation, a user receives one or more roles in it. The default roles in Plooto are:

1) **Owner**: These users have full visibility over an organisation and complete access to its assets and settings.
2) **Admin**: These users also have full visibility over an organisation, complete access to its assets, but cannot perform changes in crucial settings.
3) **User**: This is the basic role assigned in an organisation. It limits visibility over settings and assets and allows minor editing privileges throughout the organisation.

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Apart from these roles, Keycloak is capable of providing custom roles per organisation with a slight modification, but there seems to be no benefit in this prospect.

By assigning roles, a RBAC (Role Based Access Control) methodology is followed, which allows organisations to be run by multiple users, with rights corresponding to their actual job role. Incoming shared assets work similarly, which means that a consumer organisation will provide access to it according to its own roles.

Future versions will feature an identity provider service for external organisations that communicate either with Plooto users or with other external parties through the Data Space of Plooto. The first case will be probably handled with Keycloak. The second case, where no collaborating end is signed to Plooto may alternatively handle authentication with the user credentials of the message queue service, that will be used for the message flows between the external parties.

4.2 Data Discoverability

In an IDS ecosystem, it is important to provide consumers with a mechanism to discover data collections which can accommodate their needs. An integral feature of IDS Connectors is the ability to create and publish catalogues, in order to advertise their resources. In fact, catalogues can be considered as an extra layer in the data model presented in Section 3.2, on top of Resources.

In the current version of Plooto, even though collaborators can explicitly describe and request an asset according to their needs, they have no mechanism to browse a list, or descriptions of the available assets, or an overview of the telemetries which may satisfy their demands. This functionality is in design phase for all collaboration models and will be presented in the final version of this deliverable.

4.3 Negotiation Process

The most vital process in an IDS ecosystem is the negotiation between data providers and data consumers. Since the current implemented collaboration model includes only Plooto users, this section describes the negotiation steps in detail and provides some screenshots of the related interface. As mentioned in the previous section, even though the process of selecting which telemetries to share is semantically similar to the negotiation of policies proposed by IDSA, Plooto has no formative reference to rules and action for the time being.

For a negotiation process to take place between two organisations, they must be registered in each other's collaborator list. If this is not the case, the first step to initialise a negotiation is the collaborator registration. One of the parties has to access the section "Collaborators" under "External Partners". This section lists all available collaborators, either active or not. To add a new collaborator, the user has to click the "Invite" button, on the upper right corner.

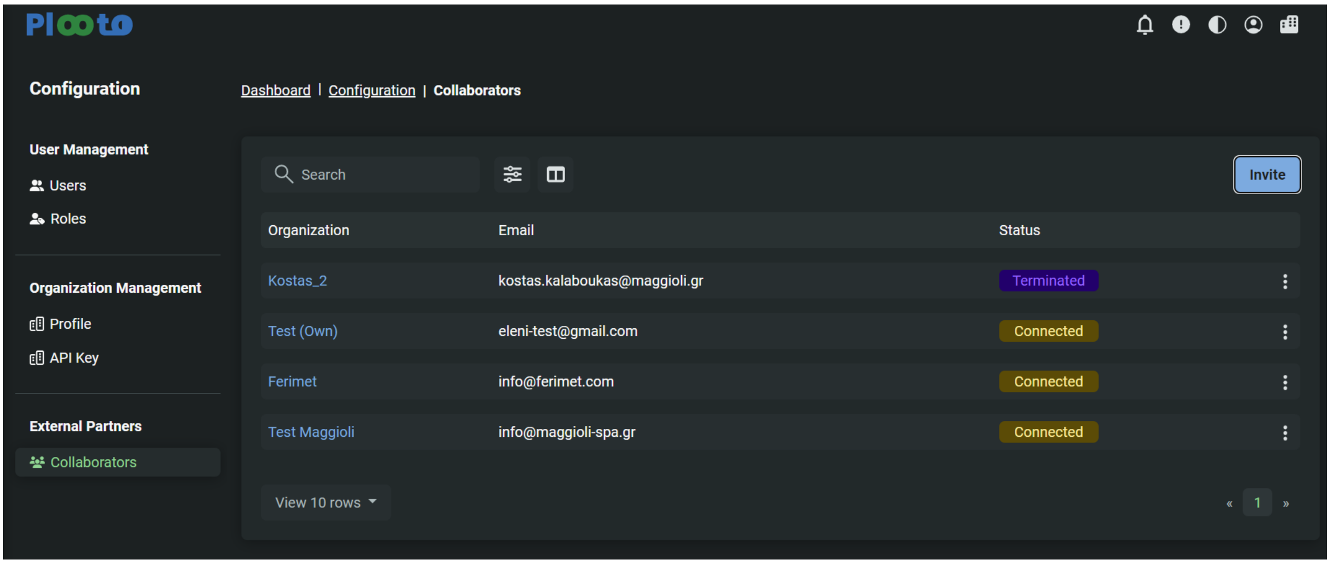

Figure 6: Collaborators Section

By clicking on "Invite", a form is provided on the right side of the screen to enter the account mail of the potential collaborator, a locally assigned organization name, a free text description field and the option to upload a document with collaboration details, ideal for specifying legal aspects of the collaboration, which cannot be globally mapped for all collaboration cases.

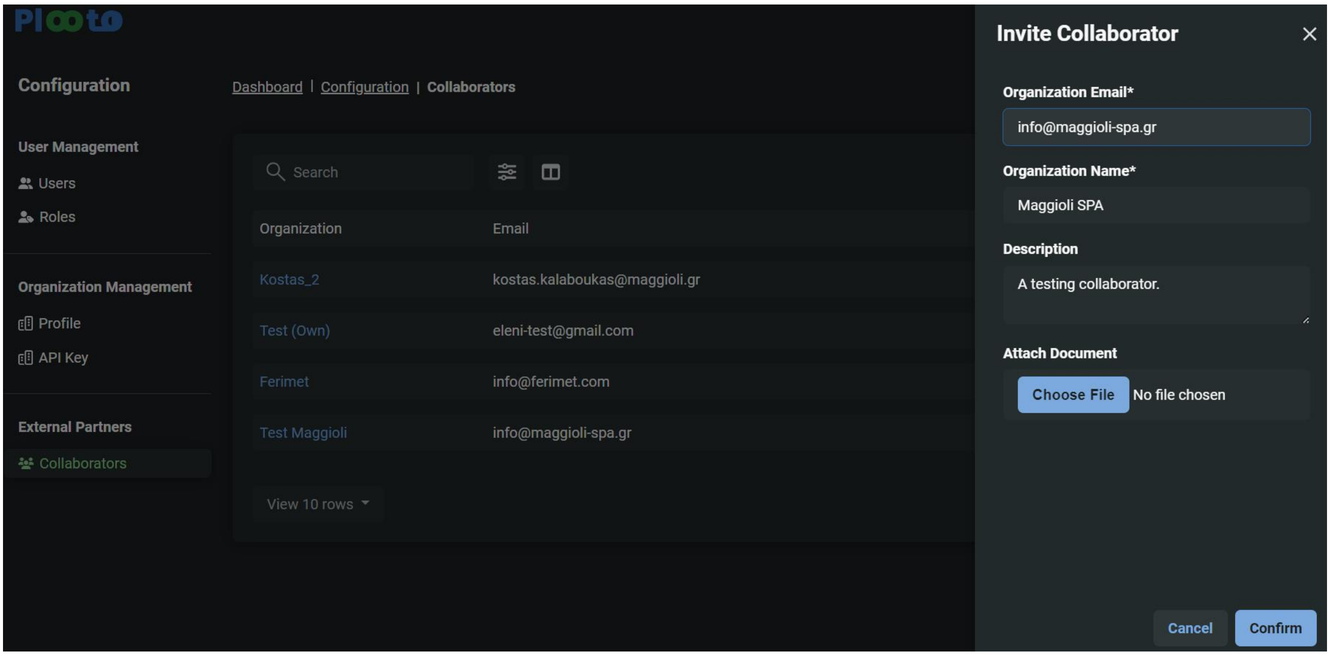

Figure 7: Collaborator Invitation – Sender View

Confirming the invitation request sends a notification to the potential collaborator via email. In next versions of Plooto, a notification system will be integrated into the platform, alerting the invited organization users of the pending invitation through the interface. Upon reacting with the notification, the recipient will see a pop-up window with the collaboration request, including contact information, description and an option to download the attached document if there is one.

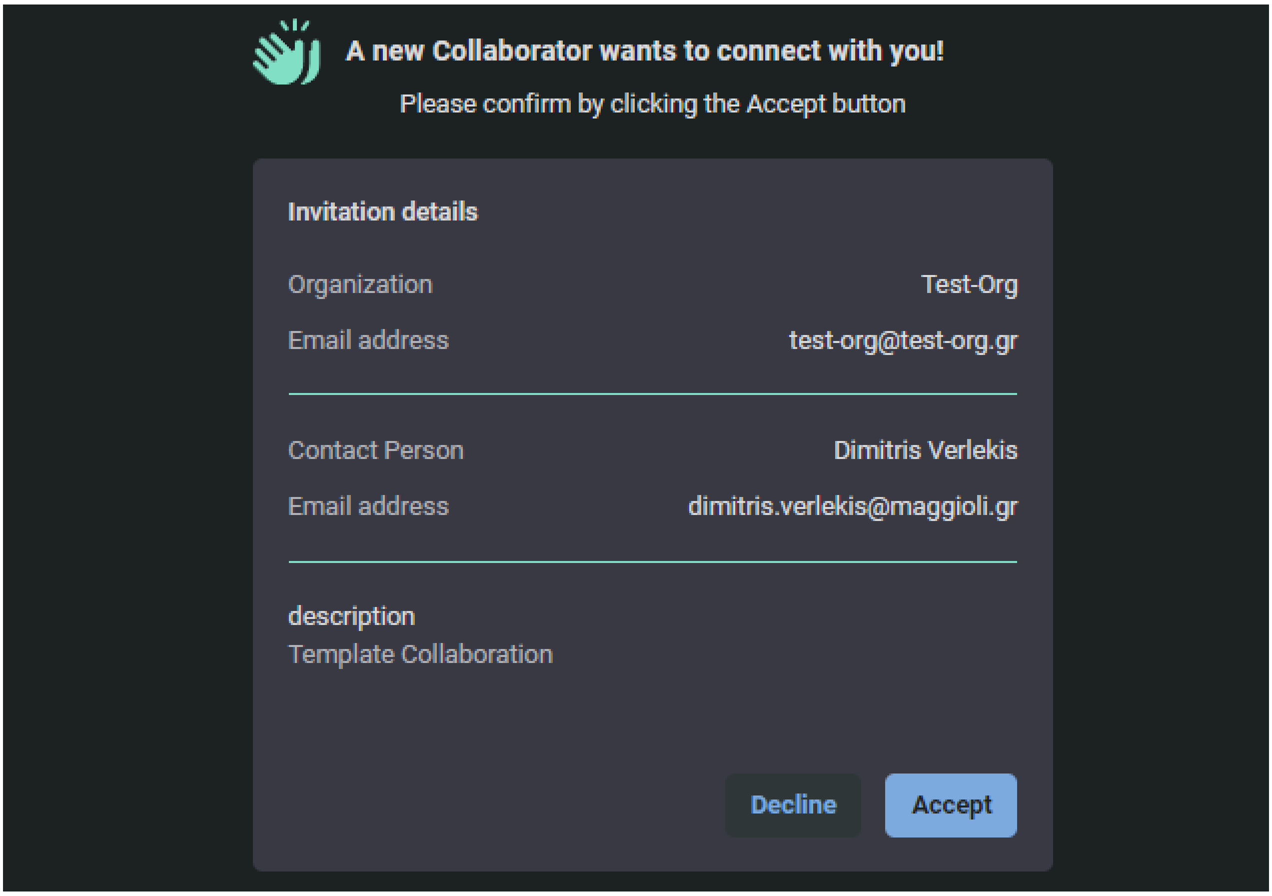

Figure 8: Collaboration Invitation – Recipient View

Upon accepting an invitation, users of both organisations will see the new entry on top of the list, with a green label indicating this is a new collaborator.

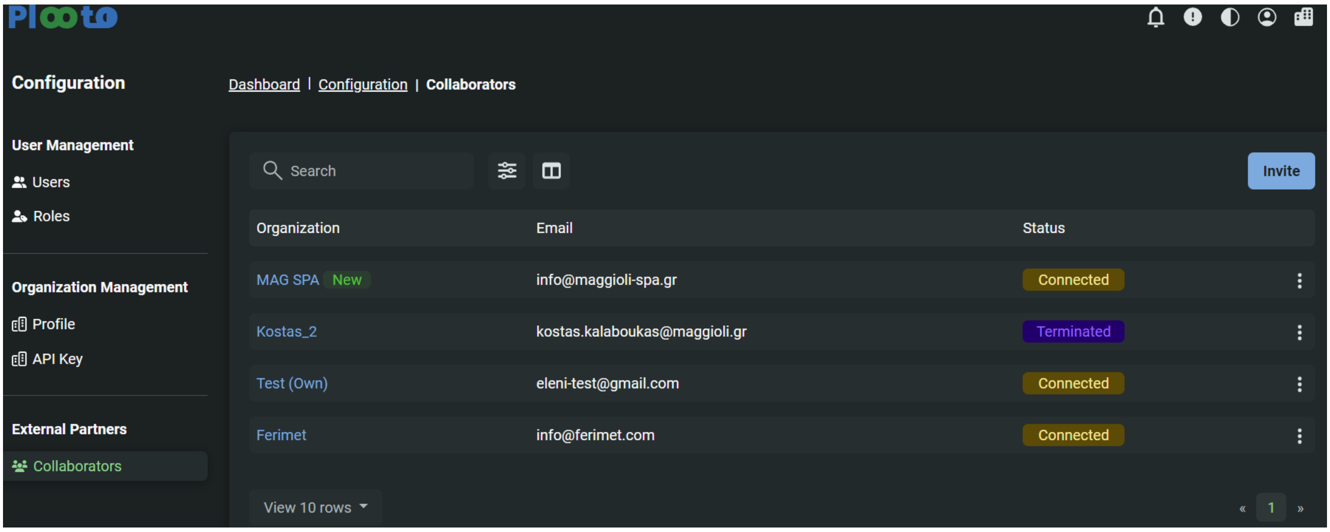

Figure 9: Collaborators Section with New Entry

This step finalises the establishment of collaboration between two organisations. In this state, negotiations for asset sharing are available for both parties.

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In order to request access to an asset, one has to visit the “Shared Assets” section. There, a listing of current shared assets is available with fields about their ownership and whether they are incoming or outgoing. In a process similar to collaborators invitation, there is a “Request” button on the top right side of the screen. Pressing it initiates the negotiation process.

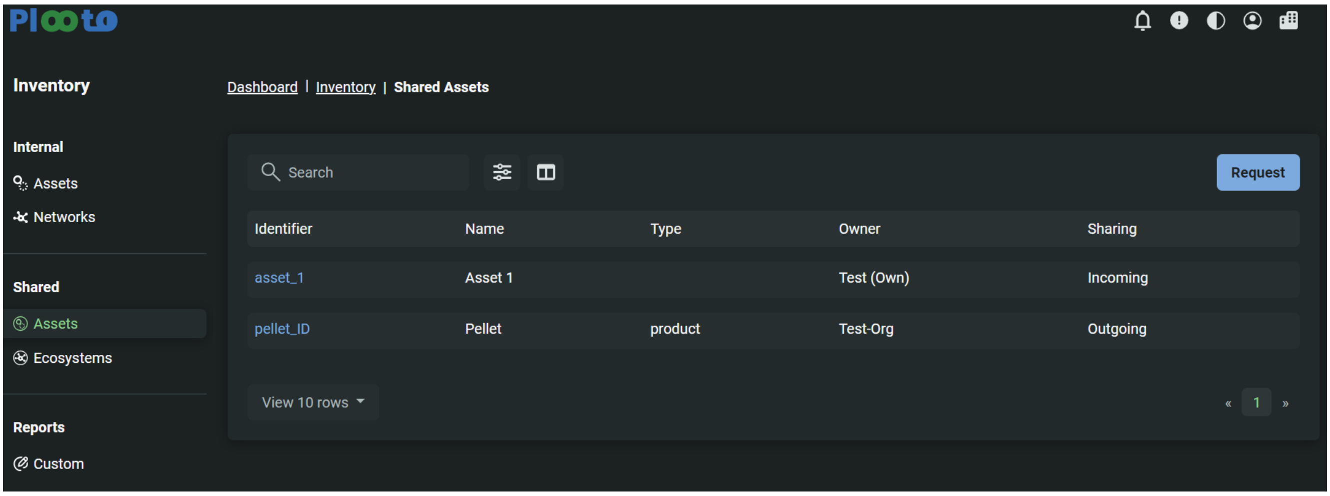

Figure 10: Shared Assets Section

Due to the current lack of a cataloguing feature, consumers have no access to specific details of the assets available per provider. An asset request begins by specifying the collaborator to whom the request will be sent. Then, the consumer must specify an indicative asset name, type and description for the provider to decide which asset and telemetries to share. Optionally, a contractual document can be sent to clarify details about the intended use of asset data and further specify user needs. This document could also contain legal details to establish the rules of collaboration.

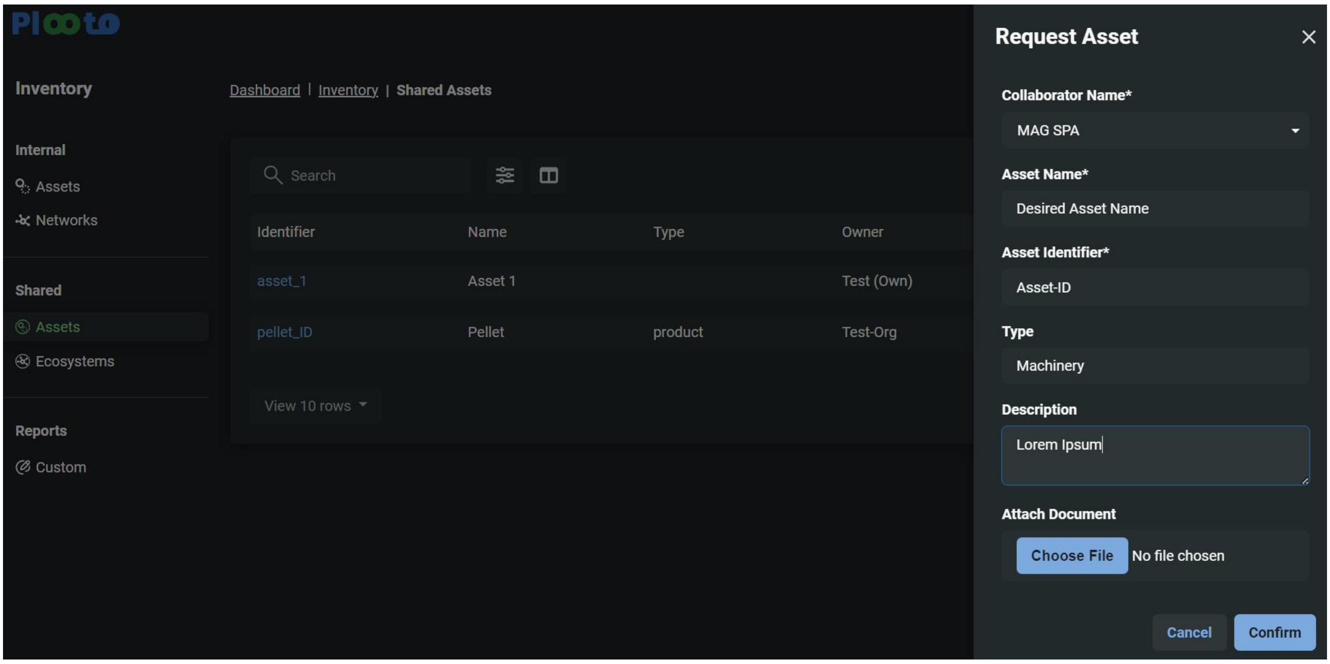

Figure 11: Shared Asset Request – Sender View

Upon confirmation, providers are notified of the incoming request. A pop-up window provides them with requested data, in order to decide whether to accept or decline the request. In case of acceptance, a form appears on the right side of the screen, allowing them to pick an asset for sharing and select a subject of its telemetries to be included in the exchange.

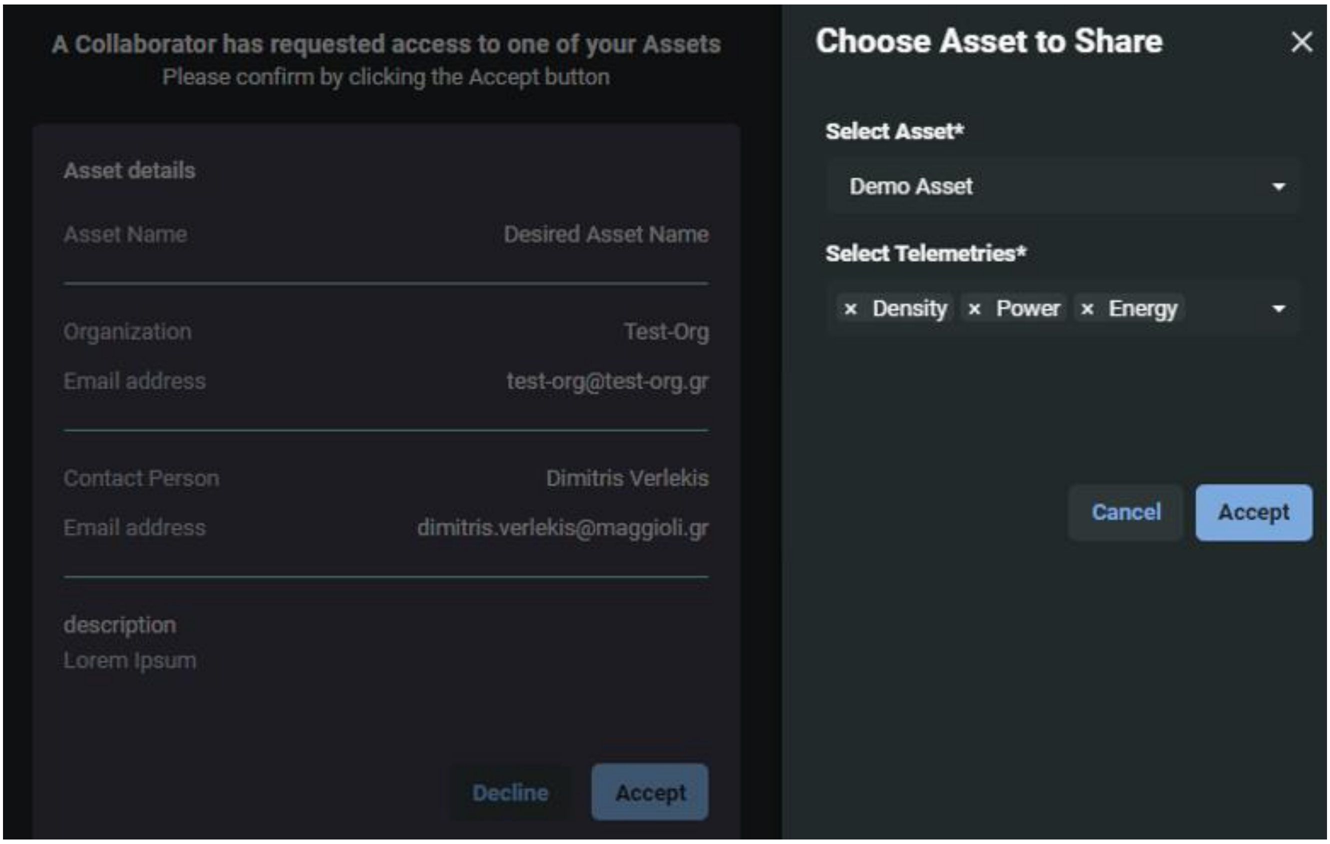

Figure 12: Shared Asset Request – Recipient View

Finally, when providers pick an asset and a subset of its telemetries and accept the request, both parties can see the shared asset appearing on their "Shared Assets" sections.

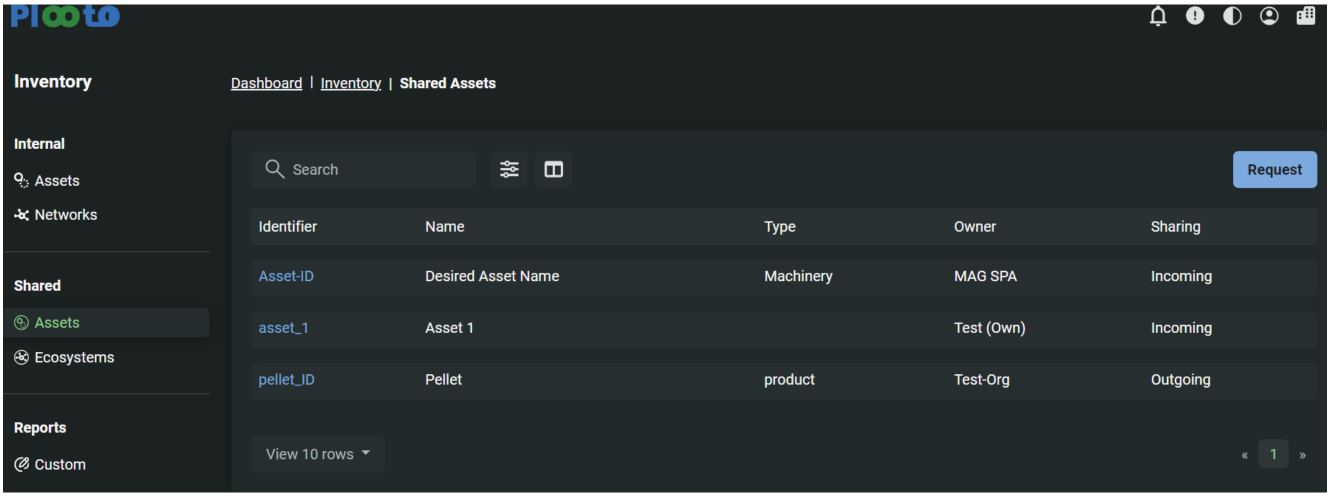

Figure 13: Shared Assets Section with New Shared Asset

An obvious aim for future versions is the extension of the negotiation step shown in figure 12, and its transformation into an iterative process, by giving both parties the ability to renegotiate on the number of telemetries and the contents of the optional contract document, which is expected to play an integral role in industrial collaborations.

All the negotiation steps discussed in this section, even though applicable to other models, refer to the collaboration model between Plooto users. The process of negotiating between one or more external parties will be implemented according to the IDS negotiation protocol, after finalising the related collaboration models. When negotiating between a Plooto user and an external party, a matching between sharing telemetries and defining usage policies will be featured, in a manner similar to the one described in Section 3.3.

4.4 Contract Validation

The document part of an agreement, shared during the final step of the negotiation process, will contain the sharing details agreed between the negotiating parties. This document may also include terms and conditions, custom to each deal, that cannot be structured in a well-defined ontology. Including such details is desired as a part of Legal Aspects mentioned in the Functional Layer of IDS-RAM.

Plooto keeps internal track of such documents and can provide them in cases of audit or conflict between collaborators, due to different interpretations of an agreement. As an additional measure of contract validation, an integration with a blockchain service is actively in development.

The contractual document will be given as an input in a hash function and the output will be stored on the blockchain service. When a doubt for the validity of a contract document rises, the file under question shall be given to the service, parsed through the same hash function and cross checked with the stored hash of the initial document. In this way the immutability of contracts can be guaranteed.

This service is easily expansible to accommodate contractual documents from external parties. The only prerequisite is that identifiers of said parties, should be stored and treated in a way similar to those of Plooto users.

4.5 Safe Data Exchange

The current version of Plooto supports data exchange between registered organisations. This process, called asset sharing has already been mentioned in previous chapters. This section explains the internal process run in the system, including how data are joined among organisations, assets and telemetries and the process flow to retrieve them when a user tries to access them.

First of all, two Database Management Systems (DBMS) are used in the backend of Plooto:

1) Neo4j[10] to depict the business layer connecting, among others, organisations with assets, and assets with telemetries.
2) PostgreSQL[11] to keep a robust relational schema including all data collected in data sources.

To see an asset, users have to be member of an organisation with access to it. The JWT provided to authenticate the user by Keycloak contains this information. If a user successfully earns access to an organisation, the connections between Neo4j nodes, ensure that the user's organisation has access to an asset with a specific set of telemetries. One field of each telemetry node stores the identifier of the data source that is associated with it. Using this key, a query to PostgreSQL returns all the rows related to this telemetry. This way, all asset and telemetry data can be constructed on the fly for the user.

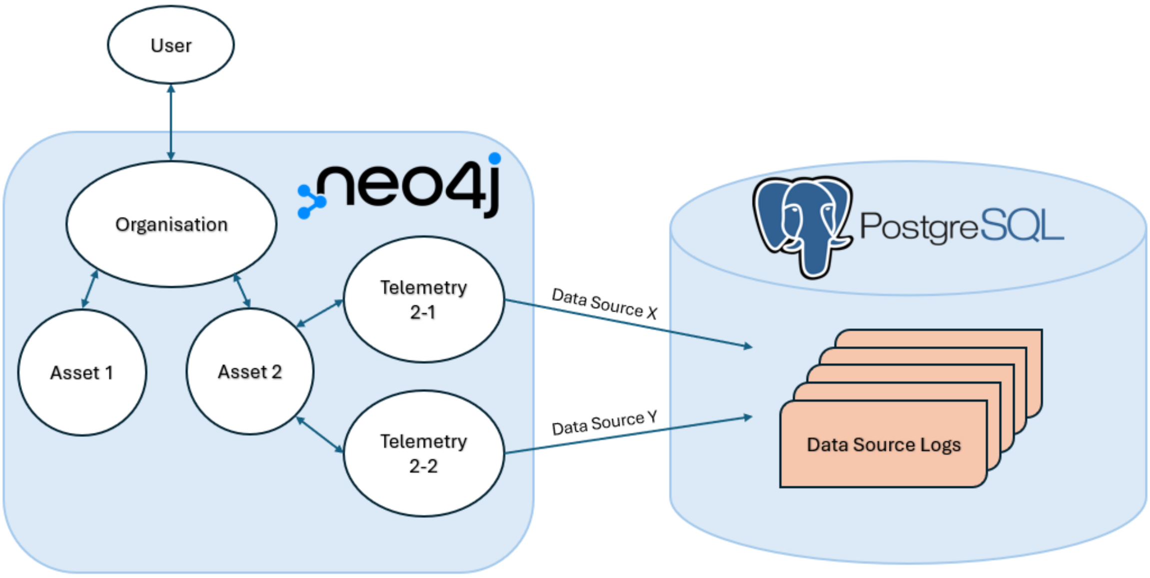

Figure 14: Asset data retrieval process.

When an asset is shared, some of its telemetries are shared too. The representation of these new entities in Plooto occurs in Neo4j. A new shared asset node is created and connected to the original asset. The same procedure occurs for the shared telemetries. In order for a consumer to retrieve the actual data, the shared telemetries match with a subset of the original telemetries, fetching the key to the appropriate data source. A query is run in PostgreSQL and the appropriate content is retrieved. Since the data never leave Plooto, the security of this transaction is already guaranteed by the security specifications of both DBMS.

As a next step, the process requirements for the safe and secure transfer of data from and to external parties will be designed. The implementation of this feature will follow after finalising both

[10] https://neo4j.com/
[11] https://www.postgresql.org/

collaboration models including external parties. The next version of this deliverable will include a thorough presentation of the data exchange between parties outside the Plooto ecosystem.

4.6 Value Adding Apps

Apart from all the above integral features, a Data Space should also promote the utilisation of data with additional applications, which can process data and create knowledge. The IDS-RAM Functional Layer proposes Value Adding Apps as one of the six core aspects of a Data Space. The Process Layer mentions usage of Data Apps as an important feature and the System Layer includes an App Ecosystem.

In Plooto Data space, additional services implemented by the consortium are such Apps. Specifically, in the scope of pilot needs, there are four main types of services:

1) **Analytics**: Implemented separately for each pilot, such apps can forecast future data, detect anomalies, or estimate "what-if?" scenarios.
2) **Process Simulation**: These apps can visualise the components of a process and provide users with a comprehensive interface to manage their network of assets.
3) **Optimisation**: These apps use custom models to calculate the best possible inputs to meet production demands, given a set of available resources.
4) **Digital Product Passport**: These apps use the Data Space infrastructure to assemble data related to a final product and assign a digital passport to it, with information about materials, processes, and carbon emissions related to its production, as well as additional, useful information about it.

All above services are presented and explained in full detail in deliverables D2.3 and D3.1. They are and will remain available only for users of Plooto, so there is no plan of integrating them in data exchanges related to the third collaboration model between two external parties.

Conclusions

Based on the work accomplished so far, an Information Model has been developed in accordance with the standards of IDSA, already matching the existent implementation of Assets and Telemetries in the core platform. Also, the main functionalities required within a Data Space are already in place when it comes to collaborations between Plooto users.

The upcoming related tasks will focus on the two collaboration models including at least one non-Plooto user. The specifics of these models will be defined explicitly, followed by the implementation of appropriate IDS Connectors for each model.

Finally, the addition of new features and the enhancement of those already in place, will strengthen the adherence of future Plooto versions to IDS specifications, for all collaboration models. Such developments will be formally presented in the final version of the deliverable, due in Month 28.

References

[1] E. F. Codd, A Relational Model of Data for Large Shared Data Banks, Communications of the ACM, Vol. 13, No. 6, June 1970, pp. 377-38. https://doi.org/10.1145/362384.362685

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