Enershare

The Energy Data Space for Europe

European Common Energy Data Space Framework Enabling Data Sharing - Driven Across – and Beyond – Energy Services

enershare.eu

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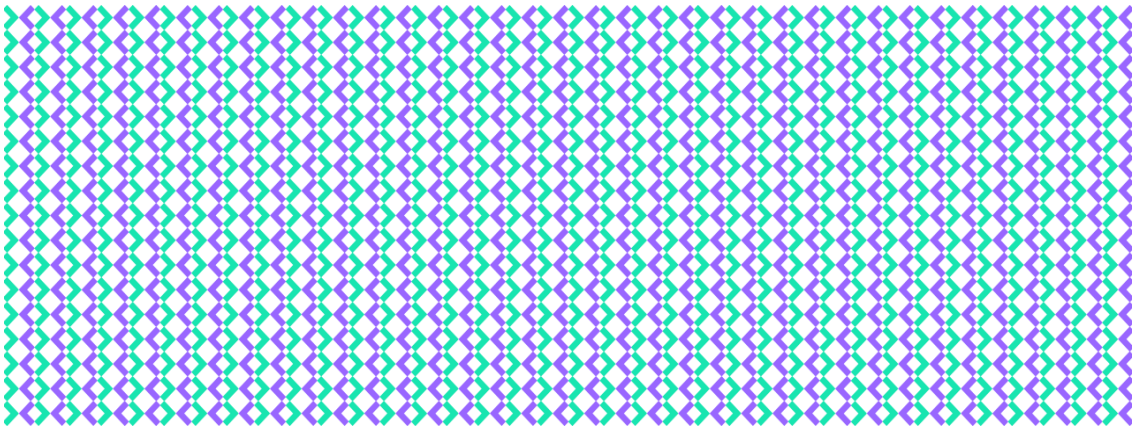
D5.2 ENERSHARE Data Value Stack

Beta version



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Publication details

Grant Agreement Number	101069831
Acronym	ENERSHARE

Full Title	European Common Energy Data Space Framework Enabling Data Sharing-Driven Across — and Beyond — Energy Services
Topic	HORIZON-CL5-2021-D3-01-01 'Establish the grounds for a common European energy data space'
Funding scheme	HORIZON-IA: Innovation Action
Start Date	Jul 1, 2022
Duration	36 months
Project URL	enershare.eu
Project Coordinator	Engineering
Deliverable	D5.2 – ENERSHARE Data Value Stack (Beta version)
Work Package	WP5 – Data and Services Marketplaces for data sharing value creation and energy compensation
Delivery Month (DoA)	M19
Version	1.0
Actual Delivery Date	January 31, 2024
Nature	Report
Dissemination Level	PU
Lead Beneficiary	ENG

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Keywords	Marketplace, data value stack, data service, trading

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Document History

Ver.	Date	Description	Author	Partner
0.1	Nov 22, 2023	ToC	Diego Arnone, Marzia Mammina	ENG
0.2	Nov 24, 2023	Final Toc	Diego Arnone, Marzia Mammina	ENG
0.3	Dec 5, 2023	Draft	Lorenzo Cristofori Marzia Mammina, Alessandro Rossi, Silvia Clementina Santoro	ENG
0.4	Dec 15, 2023	Draft	Fábio Coelho, José Andrade, André Garcia, Ricardo Bessa Apostolos Kapetanios, Konstantinos Kotsalos, Adelaida Lejarazu, Sonia Bilbao	INESC TEC, ED, TECNALIA
0.5	Dec 18, 2023	Draft	Marzia Mammina	ENG
0.6	Jan 4, 2024	Draft	Arjan Stoter, Fábio Coelho, José Andrade, André Garcia, Ricardo Bessa Marzia Mammina	TNO, INESC TEC, ENG
0.6.1	Jan 15, 2024	Draft	Lorenzo Cristofori Marzia Mammina, Alessandro Rossi, Silvia Clementina Santoro, Piero Di Liberto, Arjan Stoter	ENG, TNO
0.6.2	Jan 17, 2024	Draft	Kostantinos Kotsalos, Ricardo Bessa, Marzia Mammina, Alessandro Rossi	ED, INESC TEC, ENG
0.7	Jan 17, 2024	Consolidated	Marzia Mammina	ENG
0.8	Jan 29, 2024	Reviewed	Vassilis Sakas, Haris	ED, NTUA

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			Doukas	
0.9	Jan 30, 2024	Release Candidate	Marzia Mammina	ENG
0.99	Jan 31, 2024	Quality Checked	Massimo Bertoncini	ENG
1.0	Jan 31, 2024	Final version	Massimo Bertoncini	ENG

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List of Acronyms

API	Application Programming Interface
App	Application
CH	Clearing House
DAPS	Dynamic Attribute Provisioning Service
DLT	Distributed Ledger Technology
EC	European Commission
ERC20	Ethereum Request for Comments 20
GUI	Graphical User Interface
HTTP	HyperText Transfer Protocol
HTTPS	HyperText Transfer Protocol over Secure Socket Layer
IDS	International Data Spaces
JSON	JavaScript Object Notation
LD	Linked Data
MVDS	Minimum Viable Data Space
PoE	Proof of Existence
RAM	Reference Architecture Model
TSG	TNO Security Gateway
UC	Use Case
UML	Unified Modeling Language
WP	Work Package

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Executive summary

The ENERSHARE Data Space includes features and services for enabling access and sharing of data assets (datasets, data services) among a variety of data infrastructures and for facilitating their trading through the ENERSHARE Data Value Stack.

This Deliverable 5.2 “ENERSHARE Data Value Stack (Beta version)” is the intermediate result of the joint activities of Work Package (WP) 5, namely Task 5.1 “Publication and data marketplace services”, Task 5.2 “Data usage accounting (Clearing House)”, and Task 5.3 “Tokenised Appstore marketplace and smart contracts for heterogeneous data vs energy services compensation”. First result has been documented in Deliverable 5.1 “ENERSHARE Data Value Stack (Alpha version)” and final result will be provided in Deliverable 5.3 “ENERSHARE Data Value Stack (Final version)”, which is due in M28.

In order to deliver an energy-adapted stack of common data value services within the ENERSHARE Data Space, WP5 evolves and adapts the implementations of the following International Data Spaces (IDS) Building Blocks:

- The IDS Metadata Broker, which acts as a mediator between data providers offering data/data service and data users requesting data.
- The IDS Clearing House, which provides clearing and settlement services for all financial and data exchange transactions. The Clearing House logs all activities performed during data exchanges.
- The IDS App Store, which consists of a registry for available IDS Apps, which are independent, functional, and re-usable software assets that are deployable, executable, and manageable on an IDS Connector.

Moreover, WP5 provides for the ENERSHARE Marketplace structured as below reported:

- A shop window: a shelf on top of which asset providers may publish the assets they want to sell (such as dataset, data service, Apps, charging station availability) and interested consumers may buy them.
- A barter of data: valuable data for a specific service (e.g., load and renewable energy time series forecasting) are distributed across multiple owners/devices and monetary and non-monetary (barter) incentive mechanisms foster data sharing and enable collaborative data analytics.
- The cross-domain services/assets auction: a user can propose data/data service to obtain cross-domain services (data or no data) by opening an auction of a specific duration. During the auction timeframe, other participants can propose any asset in exchange. As soon as the auction is closed, the user who started the auction can decide

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to accept a counterproposal (by choosing what they prefer) or to reject all the counterproposals.

The ENERSHARE Marketplace also allows energy consumers to ask energy trader for new contract conditions. Finally, through the Marketplace, members of an Energy Community may propose a modification of the distribution coefficients in an energy community for providing flexibility.

Following the 4+1 architectural view model, ENERSHARE Data Value Stack is being described by:

- The Logical View, that represents the ENERSHARE Data Value Stack architecture via a block diagram.
- The Use Cases view, which represents the functionality and behaviour of the system as it is perceived by external users. It is presented as a number of use cases and actors in use case diagrams.
- The Consolidated functional and non-functional requirements.
- The Process View, which describes the dynamic behaviour of the ENERSHARE Data Value Stack architecture through sequence diagrams.
- The Development View, which illustrates the ENERSHARE Data Value Stack system from a programmer's perspective and is concerned with software management.

This document also includes the description of ENERSHARE Data Value Stack Beta Version software release..

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1 Introduction

1.1 About the project

The overall purpose of ENERSHARE is to develop and establish a European Common Energy Data Space that will deploy an intra-energy and cross-sector interoperable and trusted Energy Data Ecosystem. Private consumers, business (energy and non-energy) stakeholders and regulated operators will be able to access, share, and reuse, based upon voluntary agreements or legal obligations, large sources of currently fragmented and disseminated data and data-driven cross-value chain (energy and non-energy) services.

1.2 About this document

This Deliverable 5.2 ENERSHARE Data Value Stack (Beta version) is the intermediate result of the joint activities of WP5, namely Task 5.1 “Publication and data Marketplace services”, Task 5.2 “Data usage accounting (Clearing House)”, and Task 5.3 “Tokenised Appstore Marketplace and smart contracts for heterogeneous data vs energy services compensation”.

The purpose of this document is to present the design of the Data Value Stack architecture through the “4+1” architectural view model. Four views are provided, namely the Logical View, the Use Case View, the Process View, and the Development View. The Deployment View will be provided in D5.3 “ENERSHARE Data Value Stack (Final version)”. Moreover, the document provides details on the ENERSHARE Data Value Stack software components.

1.3 Intended audience

This document effectively communicates the ENERSHARE Data Value Stack framework specifications and design to the members of the development team. The document is marked as "Public"; thus, beyond being consulted by the consortium partners and the European Commission (EC) representatives tasked with reviewing the project, it will be published on the project website and made available for a wider access. Making project deliverables and reports publicly available can also help to foster collaboration, promote transparency, and facilitate the adoption of new technologies and practices. Furthermore, project stakeholders may use the document to evaluate the adequacy of the ENERSHARE Data Value Stack framework from the perspective of their individual areas of expertise.

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1.4 Reading recommendations

The remainder of this deliverable is structured as follows:

- In Chapter 2, the Logical View of ENERSHARE Data Value Stack architecture is presented as a block diagram.
- Chapter 3 provides the Use Cases view. It represents the functionality and behaviour of the system as it is perceived by external users. It is presented as a number of use cases and actors in use case diagrams.
- Chapter 4 provides the consolidated functional and non-functional requirements.
- Chapter 5 provides the Process View. The dynamic behaviour of the ENERSHARE Data Value Stack architecture is described through sequence diagrams.
- Chapter 6 provides the Development View. It illustrates the ENERSHARE Data Value Stack system from a programmer's perspective and is concerned with software management.
- Chapter 7 provides details on ENERSHARE Data Value Stack Beta Version software release. For each component, the source code repository, the status of the component, and what to expect for the final version is specified.
- In Chapter 8, conclusions are given.

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2 Logical View

The following Figure 1 represents the Logical View of the ENERSHARE Data Value Stack architecture. A block diagram has been used to describe the static behaviour of the system.

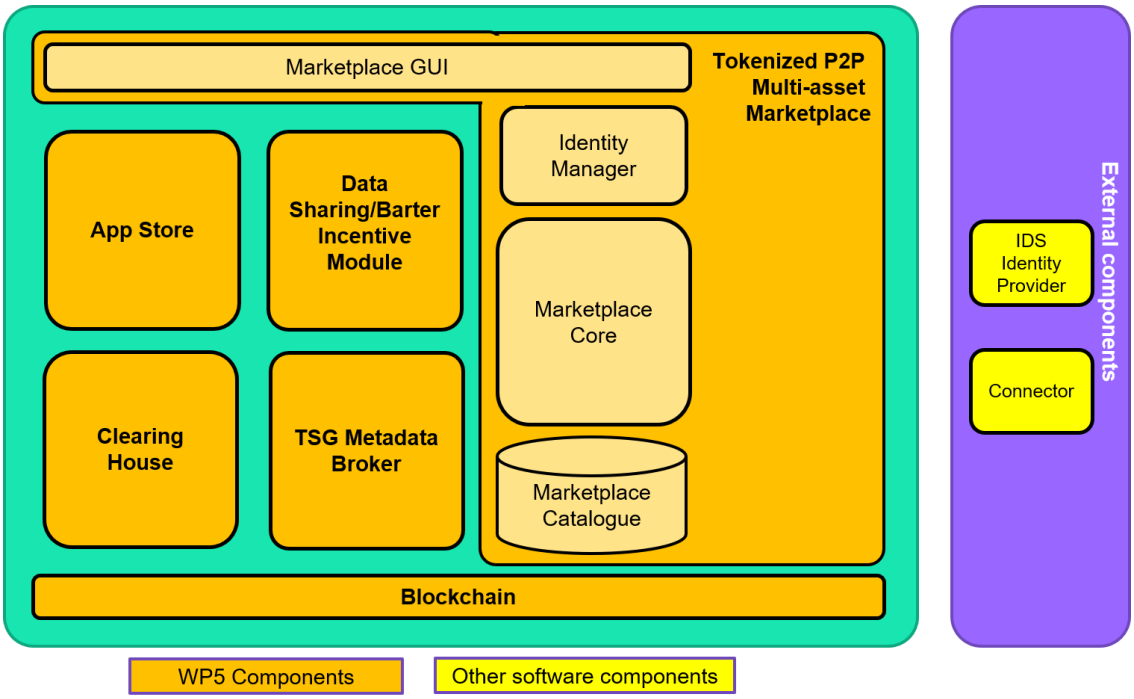

Figure 1: ENERSHARE Data Value Stack Architecture

The ENERSHARE Marketplace is accessed via a graphical user interface, represented by the Marketplace Graphical User Interface (GUI) module. Through the GUI, it is possible to register to the Marketplace and take advantage of the functions it offers through the Marketplace Core module. The ENERSHARE Marketplace is structured as a shop window: a shelf on top of which asset providers may publish the assets they want to sell (such as dataset, data service, Apps, charging station availability). Interested consumers may buy them.

The ENERSHARE Marketplace gives access to:

- Auction mechanism: a user who wants to provide any data/data service asset open an auction characterized by a specific duration. Participants to the Marketplace can propose any cross-sector asset in exchange. As soon as the auction is closed, the user

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who started the auction can decide to accept an offer (by choosing what her/he prefers) or to reject all the offers received.

- Barter of data, which is implemented via the Data Monetization and Barter Sharing Incentive Module: valuable data for a specific service (e.g., load and renewable energy time series forecasting) are distributed across multiple owners/devices and monetary and non-monetary (barter) incentive mechanisms foster data sharing and enable collaborative data analytics.

Moreover, the ENERSHARE Marketplace allows energy consumers to ask an energy trader for new contract conditions. Finally, through the Marketplace, the members of an Energy Community may propose a modification of the distribution coefficients in an energy community (flexibility).

The Blockchain module manages a custom token and uses smart contracts to customise the functionality offered by the blockchain. The use of smart contracts in conjunction with a custom token would allow token crediting policies to be defined for Marketplace Participants (e.g., after an asset is published the Participant could receive some tokens) so as to incentivise asset sharing in the Marketplace. Smart contracts also generate receipts containing the main information attached to a transaction that took place in the Marketplace; in this way, all transactions and their main information would always be available in the blockchain for periodic or time-to-time checks.

The Data Monetization and Barter Sharing Incentive Module provide precise forecasting of energy production from renewable sources for an efficient energy management and for ensuring grid stability. Collaborative forecasting capabilities based on data Marketplace promote cooperation among various data owners and improve the overall quality of energy forecasting. By leveraging advanced machine learning algorithms, this module facilitates the buying and selling of energy production data indirectly through the application and computation of collaborative forecasting services.

Moreover, the ENERSHARE Data Value Stack architecture includes the following International Data Space (IDS) components:

- Metadata Broker: it acts as a mediator between providers offering data/data service and users requesting data/data service. It also acts as a data/data service source registry.
- AppStore: it consists of a registry for available IDS Apps in this AppStore. IDS Apps are independent, functional, and re-usable software assets that are deployable, executable, and manageable on an IDS Connector, which is the core of the data space, the gateway to connect existing systems and their data to an IDS ecosystem. The

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AppStore also features the capability to search for IDS Apps using different search options.

- Clearing House: it bases all its functions on a logging service that records information relevant for clearing and billing as well as usage control.

Data or data service results bought in the ENERSHARE Marketplace are exchanged by seller (producer) and buyer (consumer) through their IDS Connectors.

ENERSHARE Data Value Stack block diagram illustrated in Figure 2 shows the connections between blocks.

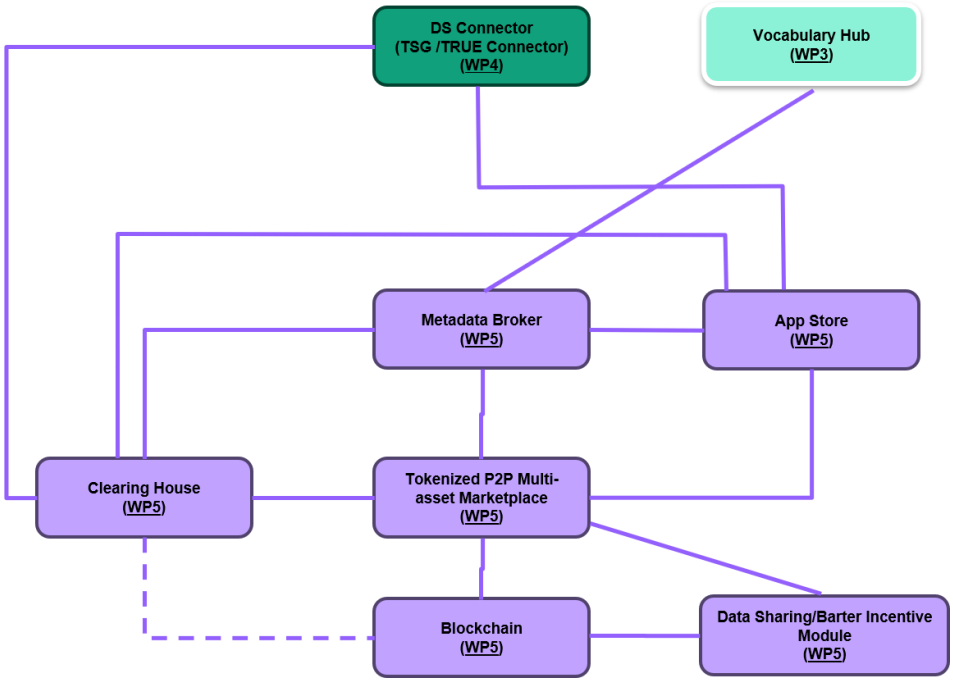

Figure 2: ENERSHARE Data Value Stack system block diagram

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3 Use Case View

The Use Case view describes how the behaviour and functionalities of a system are perceived by external actors or users. It can be presented as a number of use cases and actors in use case diagrams. The use case diagram is one of the Unified Modeling Language (UML) Behavioral Diagrams that can be used to describe the goals of the users and other systems that interact with the system that is being modeled.

The Use Case View is central because the contents drive the development of the other views.

Figure 3 represents the *Marketplace Participant account management use case* diagram and describe the actions that a Market Participant and the Marketplace Administrator can done for managing participant's account.

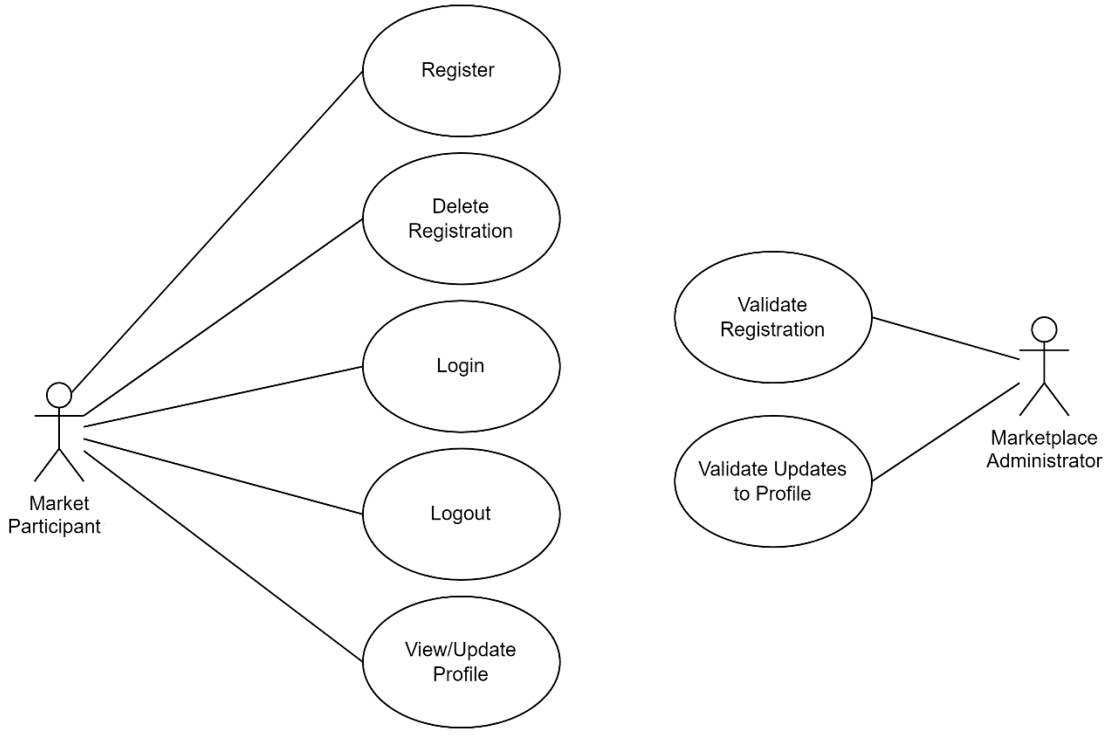

Figure 3: Marketplace Participant account management

Figure 4 represents the *Publishing/purchasing assets* use case diagram, which describes all the operations done by a Seller (asset Provider) and a Buyer (asset Consumer) to put an asset up for sale and to purchase it. After a purchase, a Buyer can rate the purchased asset or the its

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Seller; a Seller can see their ratings or the ratings of their assets in any moment. Both Seller and Buyer can see the history of the transactions at any time.

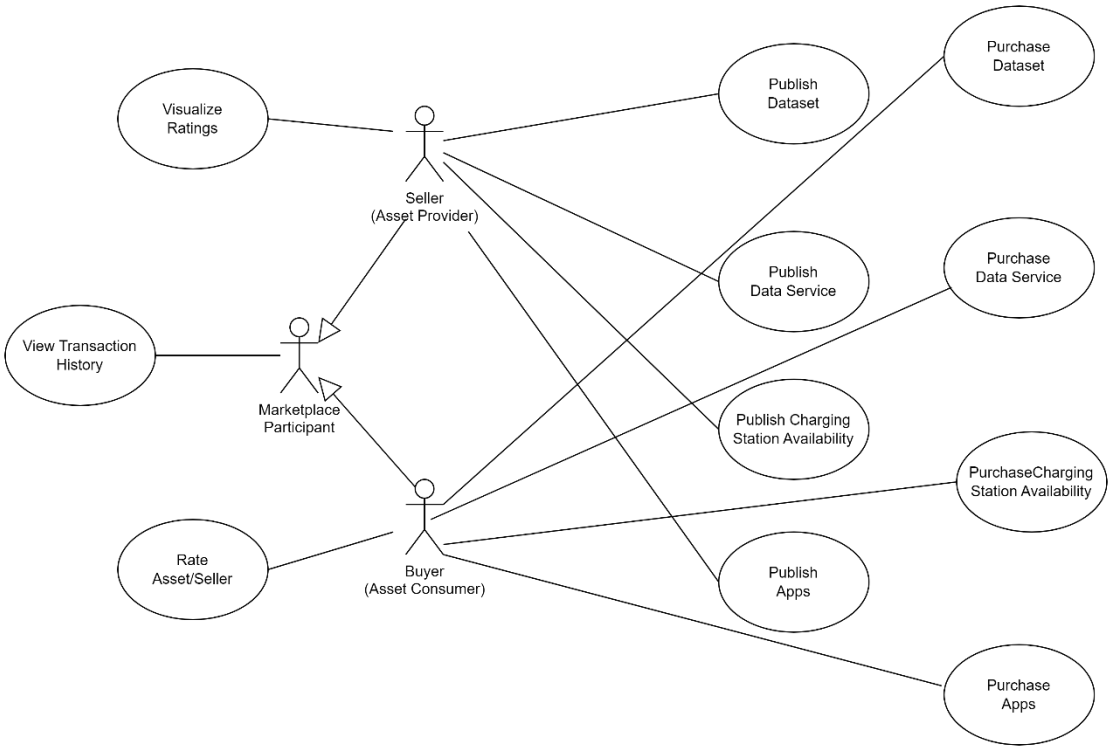

Figure 4: Publishing/purchasing assets

The ENERSHARE Marketplace gives the opportunity to energy consumers to request proposal of new contracts, as represented in the *New energy contract proposal* use case, which is depicted in Figure 5.

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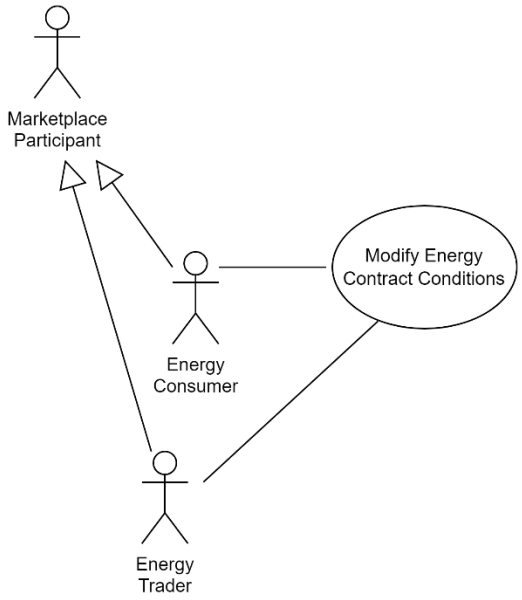

Figure 5: New energy contract proposal

Through the ENERSHARE Marketplace, a member of an energy community can propose the modification of the coefficient distribution. The proposal must be approved by the other member of the community. These functionalities are represented in *New coefficient distribution proposal in an Energy Community* use case diagram in Figure 6.

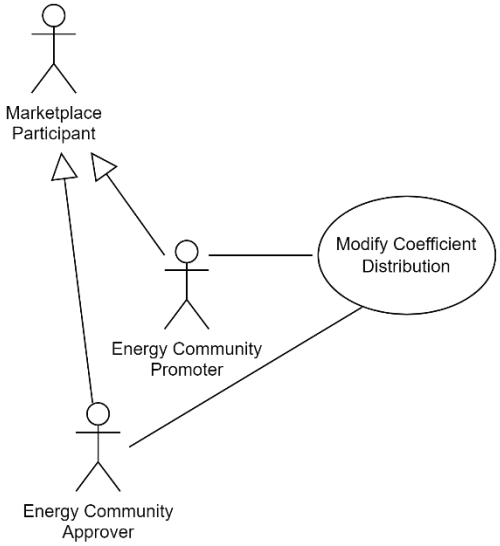

Figure 6: New coefficient distribution proposal in an Energy Community

In the ENERSHARE Marketplace, a Data/Data Service Provider (Auction Promoter) may arrange auctions to exchange one of their assets with data/data service or even with no data service

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offered by another Market Participant (Action Bidder), as represented in *Auction management* use case diagram in Figure 7.

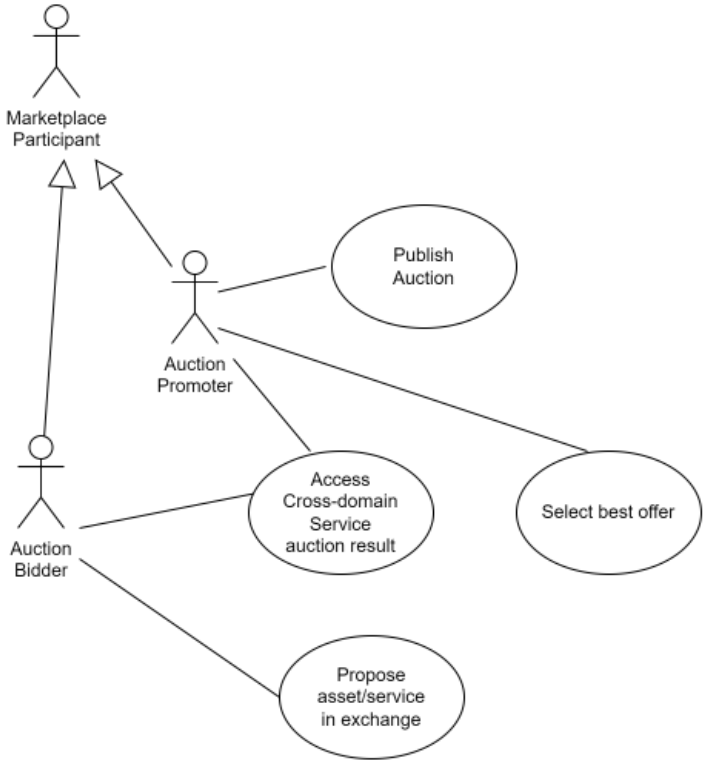

Figure 7: Auction management

The ENERSHARE Marketplace offers the opportunity to its participants to participate to a barter of data: valuable data for a specific energy service are distributed across multiple owners/devices and monetary and non-monetary (barter) incentive mechanisms foster data sharing and enable collaborative data analytics. The participation to the barter is described in *Exchange Data/Collaborative Data Analytics Services* use case diagram in Figure 8.

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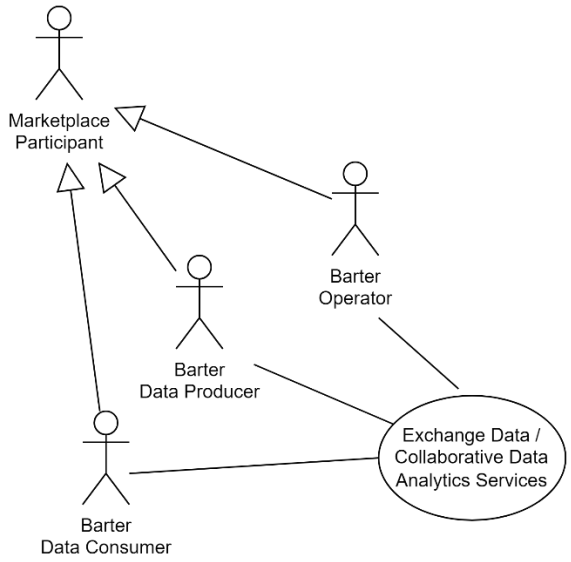

Figure 8: Exchange Data/Collaborative Data Analytics Services

The complete description of the Use Cases (UC) can be found in the deliverable D5.1 "ENERSHARE Data Value Stack Alpha version". The list below in Table 1 presents a brief description of the various use cases.

Table 1: List of Use Cases

Use Case ID	Name	Description
UC_MANAGEMENT_1	Register (to the Marketplace)	The transacting parties must be registered users to participate in the Marketplace. Marketplace Participant can register as Seller, Buyer or both and the Marketplace Administrator will later validate the registration.
UC_MANAGEMENT_2	Login (to the Marketplace)	The user (Marketplace Administrator, Marketplace Participant) will be prompted to login with their Marketplace account information before they can use the system.
UC_MANAGEMENT_3	Logout (of the Marketplace)	The user (Marketplace Administrator, Marketplace Participant) clicks on "Logout" and their session is terminated.
UC_MANAGEMENT_4	Validate registration (to the Marketplace)	The Marketplace Administrator validates the registration of the

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		Marketplace Participant to the Marketplace, after verifying if eligibility requirements are met.
UC_MANAGEMENT_5	View/Update Profile	The Marketplace Participants may like to view and/or update their personal profile.
UC_MANAGEMENT_6	Validate updates to Profiles	The Marketplace Administrator validates updates on Marketplace Participant profile, after verifying if eligibility requirements are still met.
UC_MANAGEMENT_7	Delete registration (to the Marketplace)	The Marketplace Participants may like to delete their personal profile.
UC_TRANSACTION_1	View transactions history (on the Marketplace)	The Marketplace Participants may like to view their transaction history.
UC_DATASET_1	Publish Dataset	The Marketplace Participant as Seller inserts descriptive and technical information, including licence, price, and pricing scheme, about the offered dataset to make it available on the Marketplace catalogue for selling.
UC_DATASET_2	Purchase Dataset	The Marketplace Participant as Buyer wants to purchase datasets.
UC_DATASERVICE_1	Publish Data Services	The Marketplace Participant as Seller inserts descriptive and technical information, including price and pricing scheme, about the offered Data Service to make it available on the Marketplace catalogue for selling.
UC_DATASERVICE_2	Purchase Data Services	The Marketplace Participant as Buyer may like to purchase a Data Service. The Marketplace Participant as Buyer accesses the Marketplace catalogue and selects the Data Service for buying it. A notification is then sent to the Marketplace Participant as Seller, informing her/him of the sale.

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UC_CHARGINGSTATION_1	Publish Charging Station Availability	The Marketplace Participant as Seller inserts descriptive information, including location, price and pricing scheme, about her/his charging station on the Marketplace catalogue for selling time slot availability.
UC_CHARGINGSTATION_2	Purchase Charging Station Availability	The Marketplace Participant as Buyer may like to purchase availability of a charging station. The Marketplace Participant as Buyer accesses the Marketplace catalogue (or a map) and selects a charging station among the available ones. The Marketplace Participant as Buyer selects an available time slot for buying it. A notification is then sent to the Marketplace Participant as Seller, informing her/him of the sale.
UC_APP_1	Publish Apps	The Marketplace Participant as Seller publishes a new data app in the App Store.
UC_APP_2	Purchase Apps	Acquire Apps access usage rights.
UC_ENERGYCONTRACT_1	Modify Energy Contract Conditions	The Marketplace Participant as Energy Consumer wants to modify the energy contract conditions with the Energy Trader.
UC_COEFFICIENTSENERGYCOMMUNITY_1	Modify Distribution Coefficients (in an Energy Community)	The Marketplace Participant as Energy Community Promoter wants to propose a modification of the distribution coefficients in an energy community (flexibility).
UC_CROSSDOMAINSERVICE_1	Publish Auction (renamed: old name in D5.1 was Publish Cross-domain Services)	The Marketplace Participant as Auction Promoter accesses the auction area and inserts metadata about the service so that it becomes available in a catalogue of active auctions. The metadata contains descriptive/technical information about the service. The Marketplace Participant as

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		Auction Promoter sets up start and stop of auction. The system starts the auction.
UC_CROSSDOMAINSERVICE_2:	Propose asset/service in exchange (renamed: old name in D5.1 was Propose exchange to obtain a Cross-domain Service)	While the auction is active, the Marketplace Participant as Auction Bidder selects the cross-domain service from the active auctions list. The Marketplace Participant as Auction Bidder proposes something to be provided in exchange, providing descriptive- /technical information.
UC_CROSSDOMAINSERVICE_3	Selects best offer (renamed: old name in D5.1 was Selects best offer as exchange for a Cross-domain Service)	After the closure of the auction, the Marketplace Participant as Auction Promoter accesses the auction area and selects the best offer received. The Marketplace Participant as Auction Bidder is notified that the exchange is accepted.
UC_CROSSDOMAINSERVICE_4	Access Cross-domain Service auction result	Marketplace Participant as Auction Bidder accesses her/his offer result.
UC_EXCHANGE_1	Exchange Data/Collaborative Data Analytics Services	Data Exchange flows are established between data or data analytics services between data producers and data consumers. This use case covers scenarios where valuable data for a specific service (e.g., load and renewable energy time series forecasting) is distributed across multiple owners/devices and monetary and non-monetary (barter) incentive mechanisms are needed to foster data sharing and enable collaborative data analytics.
UC_REPUTATION_1	Rate Asset/Seller	Marketplace Participant as Buyer wants to rate an asset or a Seller.
UC_REPUTATION_2	Visualize Ratings	Marketplace Participant as Seller wants to know a rating for herself/himself, or for the asset sold.

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4 Consolidated Requirements

The following Table 2 and Table 3 contain respectively the consolidated list of functional requirements and non-functional requirements of the ENERSHARE Data Value Stack.

Table 2: Functional Requirements

ReqID	Name	Derived from	Description	Priority
FR_1	Registration	UC_MANAGEMENT_1	The system shall allow Marketplace Participants to register to the Marketplace as Sellers, Consumers or both.	High
FR_2	Profile update	UC_MANAGEMENT_5	The system should allow Marketplace Participants to update their personal profiles.	Medium
FR_3	Delete registration	UC_MANAGEMENT_7	The system should allow Marketplace Participants to delete their personal profiles from the Marketplace.	Medium
FR_4	Login	UC_MANAGEMENT_2	The system shall allow Marketplace Participants to log into the Marketplace.	High
FR_5	Logout	UC_MANAGEMENT_3	The system shall allow Marketplace Participants to logout from the Marketplace.	High
FR_6	Profile information storage	UC_MANAGEMENT_1, UC_MANAGEMENT_2, UC_MANAGEMENT_3, UC_MANAGEMENT_4, UC_MANAGEMENT_5, UC_MANAGEMENT_6, UC_MANAGEMENT_7	The system shall store Marketplace Participants' profiles and logon details.	High
FR_7	View profile	UC_MANAGEMENT_4,	The system shall be able to display stored data related	High

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		UC_MANAGEMENT_5, UC_MANAGEMENT_6, UC_MANAGEMENT_7	to Marketplace Participants.	
FR_8	Validate registrations	UC_MANAGEMENT_4	The system shall allow the Marketplace Administrator as Operator to validate the Participant's registration.	High
FR_9	Validate profile updates	UC_MANAGEMENT_6	The system should allow the Marketplace Administrator as Operator to validate updates in the Marketplace Participants' profiles.	Medium
FR_10	Validation notifications	UC_MANAGEMENT_4, UC_MANAGEMENT_6	The system should notify Marketplace Participants of the validation process result.	Medium
FR_11	Delete registration	UC_MANAGEMENT_7	The system should allow Marketplace Participants to delete their registration.	Medium
FR_12	Catalogue availability	UC_DATASET_1, UC_DATASET_2, UC_DATASERVICE_1, UC_DATASERVICE_2, UC_CHARGINGSTATION_1, UC_ CHARGINGSTATION_2, UC_APP_1, UC_APP_2, UC_EXCHANGE_1	The Marketplace shall provide a catalogue with information about available datasets, services and apps, charging station, including descriptions, attributes, usage rights, and associated metadata.	High
FR_13	Search and filtering in the catalogue	UC_DATASET_2, UC_DATASERVICE_2, UC_ CHARGINGSTATION_2, UC_EXCHANGE_1	The Marketplace shall offer intuitive search capabilities and filters to facilitate exploration and retrieval of metadata.	High

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FR_14	Publish Data Services	UC_DATASERVICE_1, UC_EXCHANGE_1, UC_APP_1	The system shall allow the Marketplace Participants as Seller to publish Data Services for selling.	High
FR_15	Purchase Data Services	UC_DATASERVICE_2, UC_EXCHANGE_1, UC_APP_2	The system shall allow the Marketplace Participants as Consumer to purchase Data Services.	High
FR_16	Publish Dataset	UC_DATASET_1, UC_EXCHANGE_1, UC_APP_1	The system shall allow the Marketplace Participants as Seller to publish Data for selling.	High
FR_17	Purchase Dataset	UC_DATASET_2, UC_EXCHANGE_1, UC_APP_2	The system shall allow the Marketplace Participants as Consumer to purchase Data.	High
FR_18	Publish Charging Station Availability	UC_CHARGINGSTATION_1	The system may allow the Marketplace Participants as Seller to publish charging station availability data for selling.	Low
FR_19	Purchase Charging Station Availability	UC_CHARGINGSTATION_2	The system may allow the Marketplace Participants as Buyer to purchase charging station availability time slots.	Low
FR_20	Select Charging Stations from map	UC_CHARGINGSTATION_2	The system may allow the Marketplace Participants as Buyer to view charging station locations on a map and select the available ones.	Low
FR_21	Select Charging Stations from catalogue	UC_CHARGINGSTATION_2	The system may allow the Marketplace Participants as Buyer to view charging station locations in a catalogue and select the available ones.	Low
FR_22	Schedule cross-domain	UC_CROSSDOMAINSERVICE_1	The system should allow Marketplace Participants as	Medium

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	service auction		Auction Promoters to publish a service and schedule an auction for cross-domain exchange.	
FR_23	Store cross-domain service auction information	UC_CROSSDOMAINSERVICE_1, UC_CROSSDOMAINSERVICE_2, UC_CROSSDOMAINSERVICE_3, UC_CROSSDOMAINSERVICE_4	The system should record information related to cross-domain auctions.	Medium
FR_24	Propose cross-domain service auction	UC_CROSSDOMAINSERVICE_2	When the auction is running, the system should allow Marketplace Participants as Auction Bidders to propose an exchange (dataset, data service, etc.).	Medium
FR_25	Select best proposal for cross-domain service auction	UC_CROSSDOMAINSERVICE_3	When the auction is stopped, the system should allow Marketplace Participants as Auction Promoters to select the best proposal for exchange (dataset, data service, etc.).	Medium
FR_26	Auction result notification	UC_CROSSDOMAINSERVICE_3	The system should notify by email Marketplace Participants as Auction Bidders about auction results.	Medium
FR_27	Access auction result notification	UC_CROSSDOMAINSERVICE_4	The system should allow Marketplace Participants as Auction Bidders to visualise auction results.	Medium
FR_28	Transaction storage	UC_TRANSACTION_1	The system shall store Marketplace Participants' transaction details.	High
FR_29	Transaction history	UC_TRANSACTION_1	The system shall be able to display transaction history to Marketplace Participants.	High
FR_30	Log transactions	UC_TRANSACTION_1	The Marketplace shall provide a secure mechanism to log transactions.	High
FR_31	Trust and reputation management	UC_REPUTATION_1, UC_REPUTATION_2	The Marketplace may implement trust and reputation mechanisms to	Low

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			rate apps, services, datasets, and participants.	
FR_32	Payment support	UC_DATASET_2, UC_DATASERVICE_2, UC_CHARGINGSTATION_2, UC_APP_2	The Marketplace should support payment of apps, services or datasets.	Medium
FR_33	Sale notifications	UC_DATASET_2, UC_DATASERVICE_2, UC_CHARGINGSTATION_2, UC_APP_2	The system shall notify Marketplace Participants as Seller of the sale of their Data Services, Datasets, Apps and Charging Station Availabilities.	High
FR_34	Notification of data operation call to the clearing House	UC_TRANSACTION_1	Upon data consumer request for data, a notification shall be sent to the Clearing House for logging the data operation request.	High
FR_35	Notification of data operation call reception to the Clearing House	UC_DATASET_1, UC_DATASERVICE_1, UC_CHARGINGSTATION_1, UC_APP_2, UC_CROSSDOMAINSERVICE_3	Upon Data Provider reception of data consumer's request, a notification shall be sent to the Clearing House for logging reception.	High
FR_36	Clearing house logs all transactions in a persistent data storage	UC_TRANSACTION_1	The Clearing House shall log all transactions in a persistent data storage, ensuring data provenance and traceability.	High
FR_37	Notification of data operation result sent to the Clearing House	UC_DATASET_1, UC_DATASERVICE_1, UC_CHARGINGSTATION_1, UC_APP_2, UC_CROSSDOMAINSERVICE_3	Notification of data operation result shall be sent to clearing House by the Data Provider.	High
FR_38	Notification of data operation result received at the Clearing House	UC_DATASET_2, UC_DATASERVICE_2, UC_CHARGINGSTATION_2, UC_APP_2, UC_CROSSDOMAINSERVICE_3	Notification of data operation shall result received at Clearing House.	High
FR_39	Auditing and tracking	UC_TRANSACTION_1	The system may allow auditing and tracking of data transactions for determining accountability and resolving possible conflicts.	Low
FR_40	Monetization of all exchanged data with fairness	UC_EXCHANGE_1	Data Producers and Data Consumers shall give a settlement price for the data or service they provided to the Data	High

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			Monetization and Barter Sharing Incentive Module. Payment division among Data Producers should be fair (e.g., according to data value).	
FR_41	Possibility to exchange data-by-data (non-economic data exchange)	UC_EXCHANGE_1	Data Producers and Data Consumers shall be able to exchange data without financial compensations and solely based in data properties (e.g., information content).	High
FR_42	Two-Factor Authentication	UC_EXCHANGE_1	The system should provide the option for users to enable two-factor authentication for enhanced security during login.	Medium
FR_43	Market Analytics and Insights	UC_EXCHANGE_1	The system should provide analytics and insights on market trends, transaction history, and user behaviour to assist Participants in decision-making	Medium
FR_44	Forgot Password Recovery	UC_EXCHANGE_1	The system shall allow users to recover their password through a secure process that includes sending a password reset link to their registered email.	High
FR_45	Integrated Support System	UC_EXCHANGE_1	The system should include an integrated support system, allowing users to submit queries, report issues, access FAQ´s and receive assistance from administrators.	Medium
FR_46	Vote for different coefficients distribution proposals	UC_COEFFICIENTSENERGYCOMMUNITY_1	The system should provide the means to carry out a voting procedure for a coefficient distribution proposal in an Energy Community.	Medium
FR_47	Manage several Energy Communities	UC_COEFFICIENTSENERGYCOMMUNITY_1	The system shall support data privacy and filter data	High

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			according to each Energy Community.	
FR_48	Publish data with a specific profile/user	UC_ENERGYCONTRACT_1	The system shall support publishing data with specific profiles/users.	High
FR_49	Access AppStore	UC_APP_1, UC_APP_2	The system shall provide access to the App Store.	High
FR_50	Access Barter	UC_EXCHANGE_1	The system shall provide access to the Barter.	High

Table 3: Non-functional Requirements

ReqID	Name	Type	Description	Priority
NFR_1	App Store identity	Identity Management	The App store requires an identity certificate provided by the DS.	High
NFR_2	Identity certificate	Identity Management	Identity certificates may be provided through X.509 certificate.	High
NFR_3	Data App metadata is available	Data management	A Data App metadata information is available	High
NFR_4	Data App container is available	Data management	A Data App container information is available	High
NFR-5	Data App is certified	Data management	A Data App successfully terminated the certification process and is awarded a certificate.	Low
NFR_6	Embedded IDS connector available	Data management	The IDS connector embedded in the App Store backend is available and connected to a Data Apps service (optionally as part of a test bed)	High
NFR_7	A Minimum Viable Data Space (MVDS) is available	Data management	A MVDS provides the identity services and metadata services for which the App Store is integrated.	High
NFR_8	Expose data and services to authorized users	Security	Only authorised users should have access to the resources being targeted.	High
NFR_9	Support access control mechanisms	Security	Access control mechanisms are in place to provide role-based control on resources.	High
NFR_10	Have security mechanisms to protect data transmission	Security	Transmission channels require TLS encryption.	High
NFR_11	Provide trusted and secure communication and information management	Trust	Validation of authentication mechanism are in place, shapped as logs.	Medium
NFR_12	The marketplace platform infrastructure	Trust	Verifiable certificates should be put in place secure the connections.	Medium

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	and services shall be trustable			
NFR_13	Provide privacy protection for users interacting with the platform	Privacy	GDPR and usage and data policies should be available and explicitly granted.	Medium

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5 Process View

This section provides details on the dynamic behaviour of the ENERSHARE Data Value Stack architecture through sequence diagrams.

5.1 (Market Participant) Register to the Marketplace

The sequence diagram in Figure 9 describes the (Marketplace Participant) registration to the Marketplace.

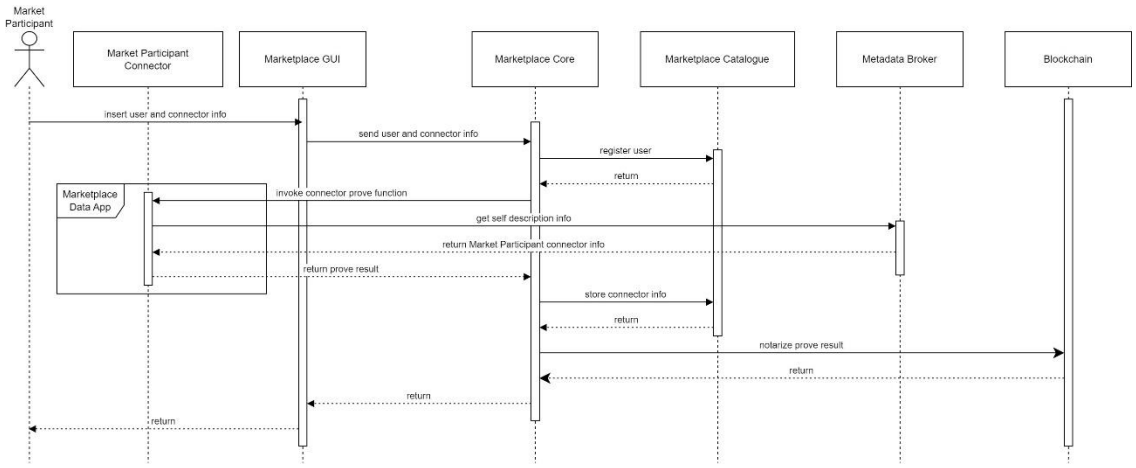

Figure 9: *Register* sequence diagram

5.2 (Marketplace Administrator, Marketplace Participant) Login to the Marketplace

The sequence diagram in Figure 10 describes logging in to the Marketplace.

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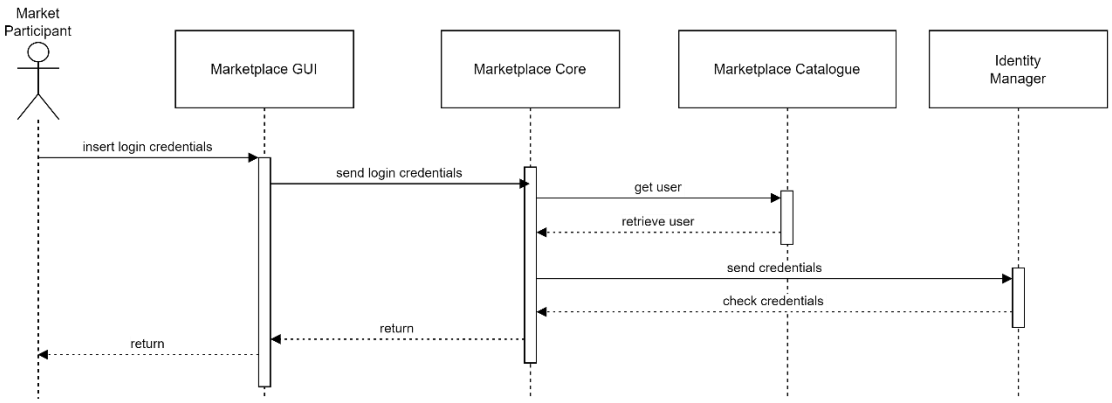

Figure 10: *Login* sequence diagram

5.3 (Marketplace Administrator, Marketplace Participant) Logout of the Marketplace

The sequence diagram in Figure 11 describes logging out of the Marketplace.

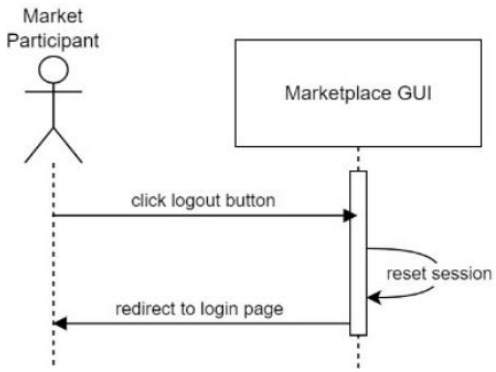

Figure 11: *Logout* sequence diagram

5.4 (Marketplace Administrator) Validate registration to the Marketplace

The sequence diagram in Figure 12 describes the process of validating the registration to the Marketplace.

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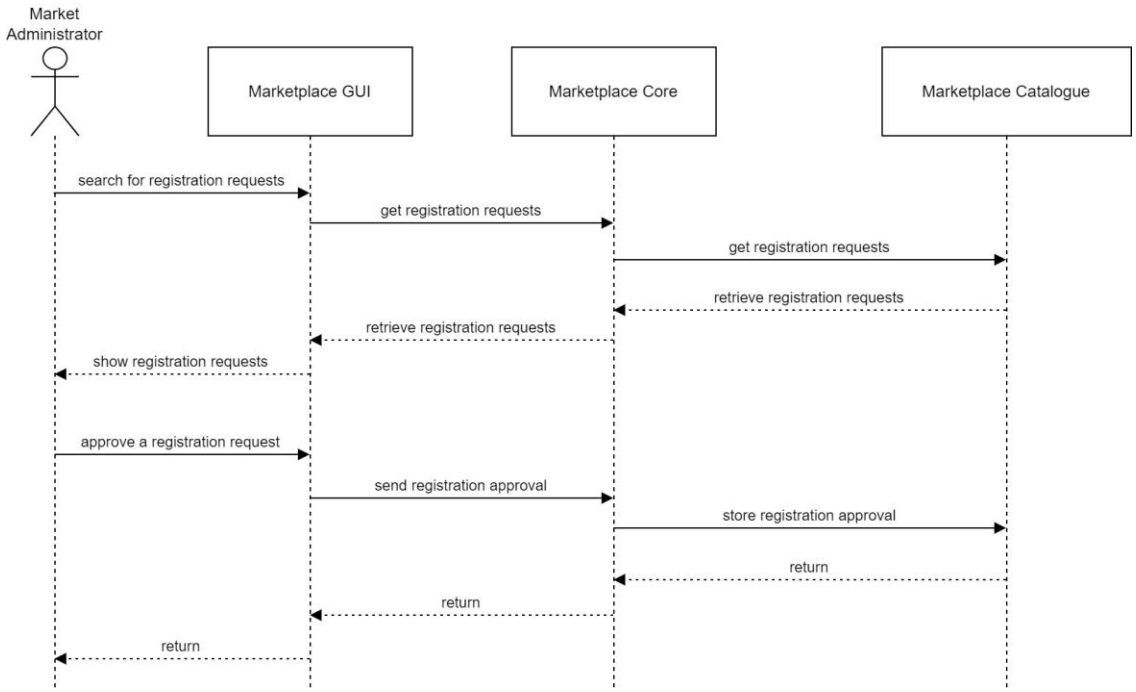

Figure 12: *Validate registration* sequence diagram

5.5 (Marketplace Participant) View/Update Profile

The sequence diagram in Figure 13 describes the process of updating a updating Profile.

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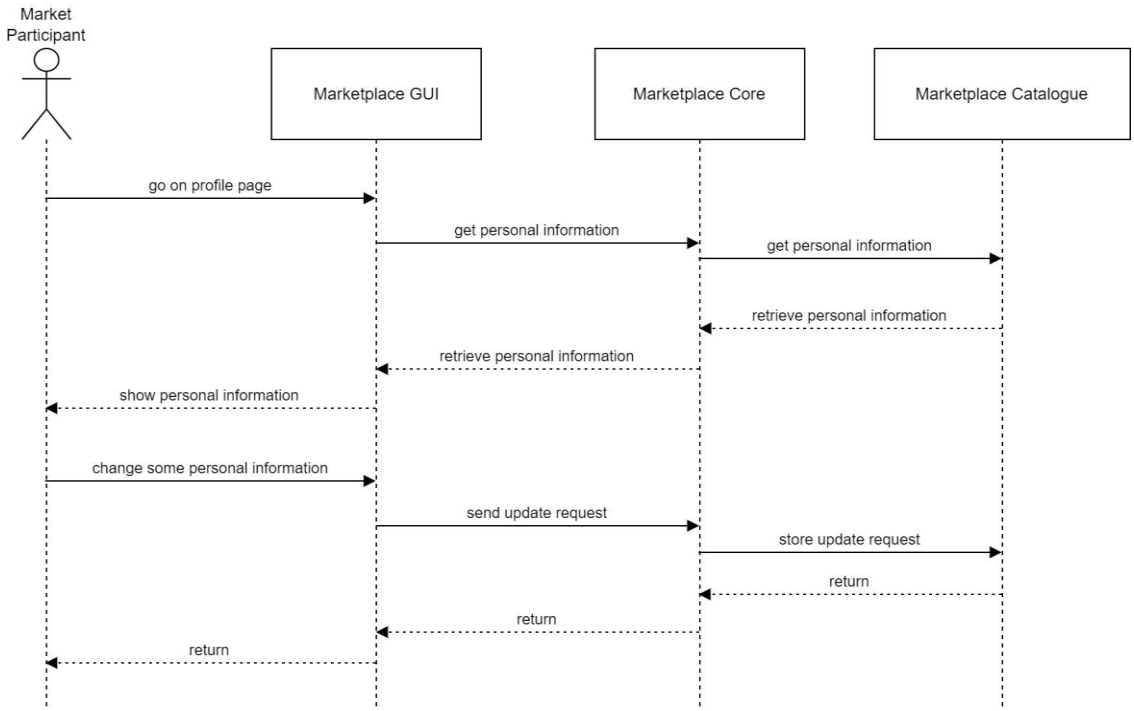

Figure 13: *View/Update Profile* sequence diagram

5.6 (Marketplace Administrator) Validate updates to profiles

The sequence diagram in Figure 14 describes the process of validating updates to Marketplace participants' profiles.

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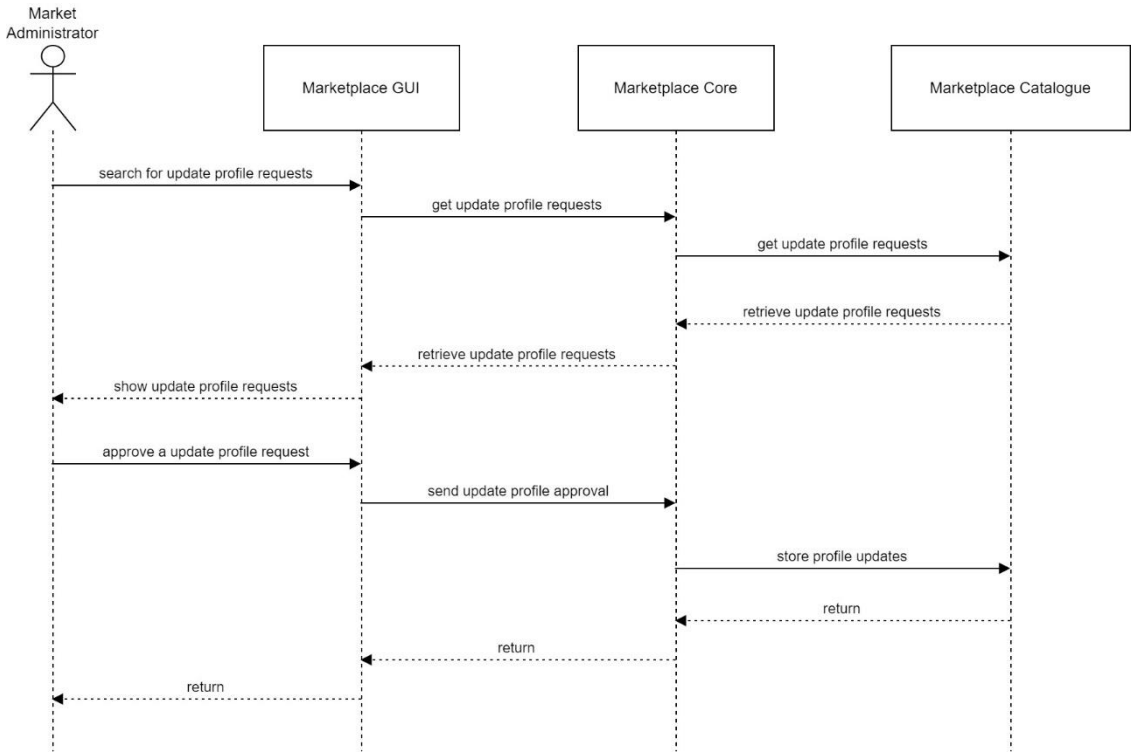

Figure 14: *Validate updates to profiles* sequence diagram

5.7 (Marketplace Participant) Delete registration to the Marketplace

The sequence diagram in Figure 15 describes the process of deleting a registration to the Marketplace.

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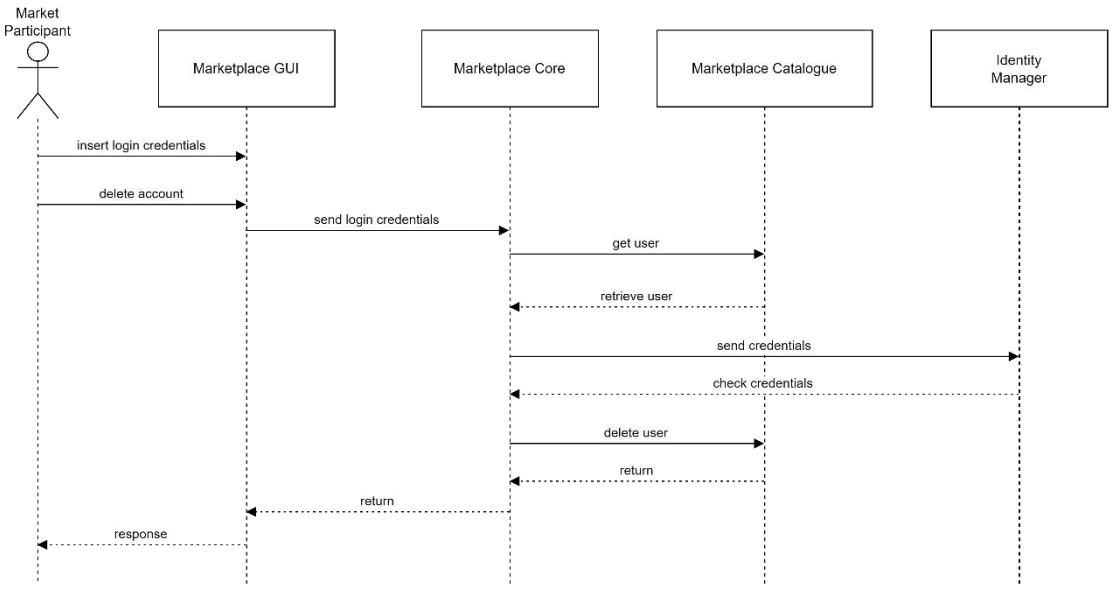

Figure 15: *Delete registration* sequence diagram

5.8 (Marketplace Participant) View transaction history on the Marketplace

The sequence diagram in Figure 16 describes the process of viewing the transaction history on the Marketplace.

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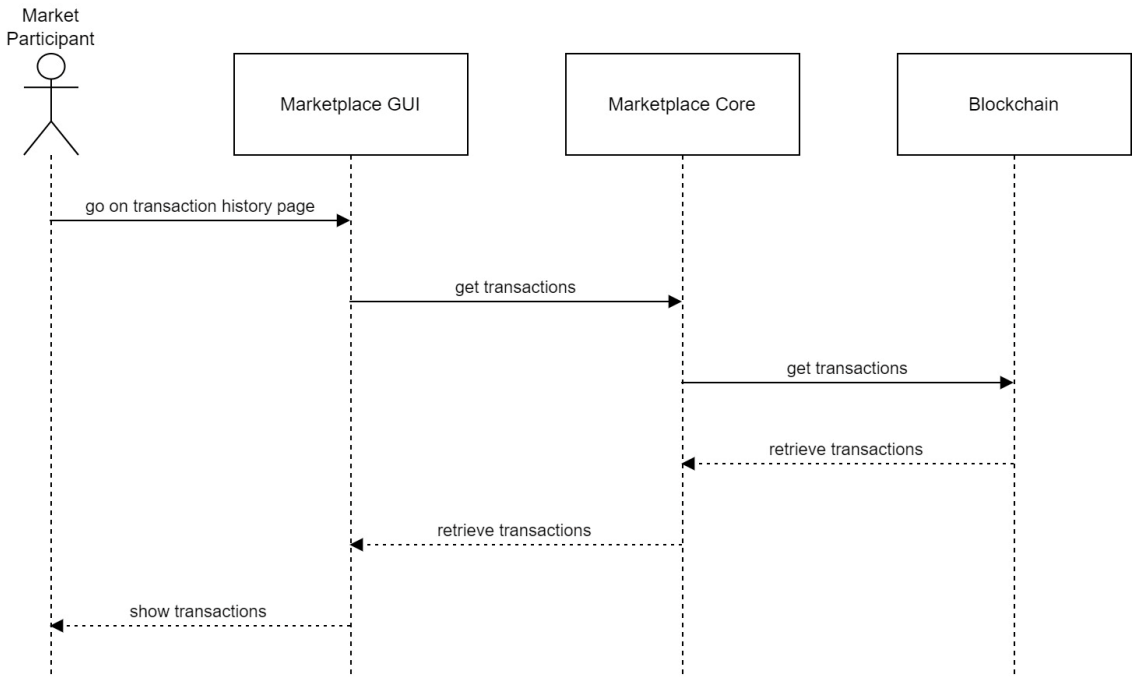

Figure 16: *View transaction history* sequence diagram

5.9 The Marketplace updates its internal Catalogue based on information retrieved from the Metadata Broker

The sequence diagram in Figure 17 describes Marketplace updating its internal Catalogue based on information retrieved from the Metadata Broker.

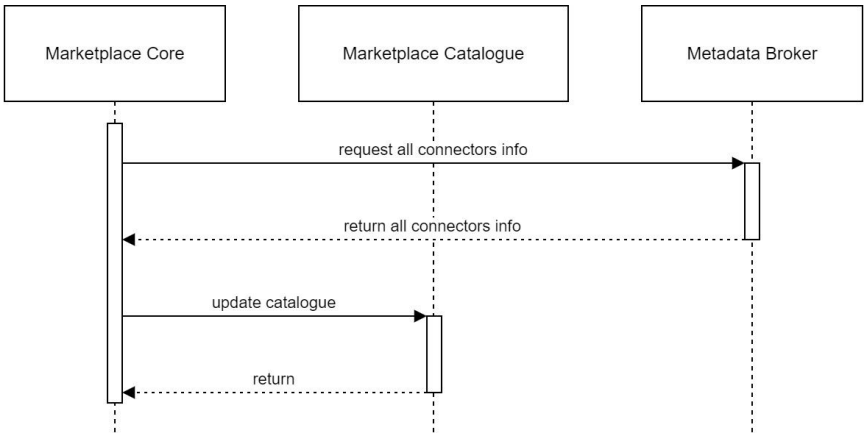

Figure 17: *Marketplace Catalogue update* sequence diagram

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5.10 (Marketplace Participant as Seller) Publish Dataset

The sequence diagram in Figure 18 describes dataset publishing.

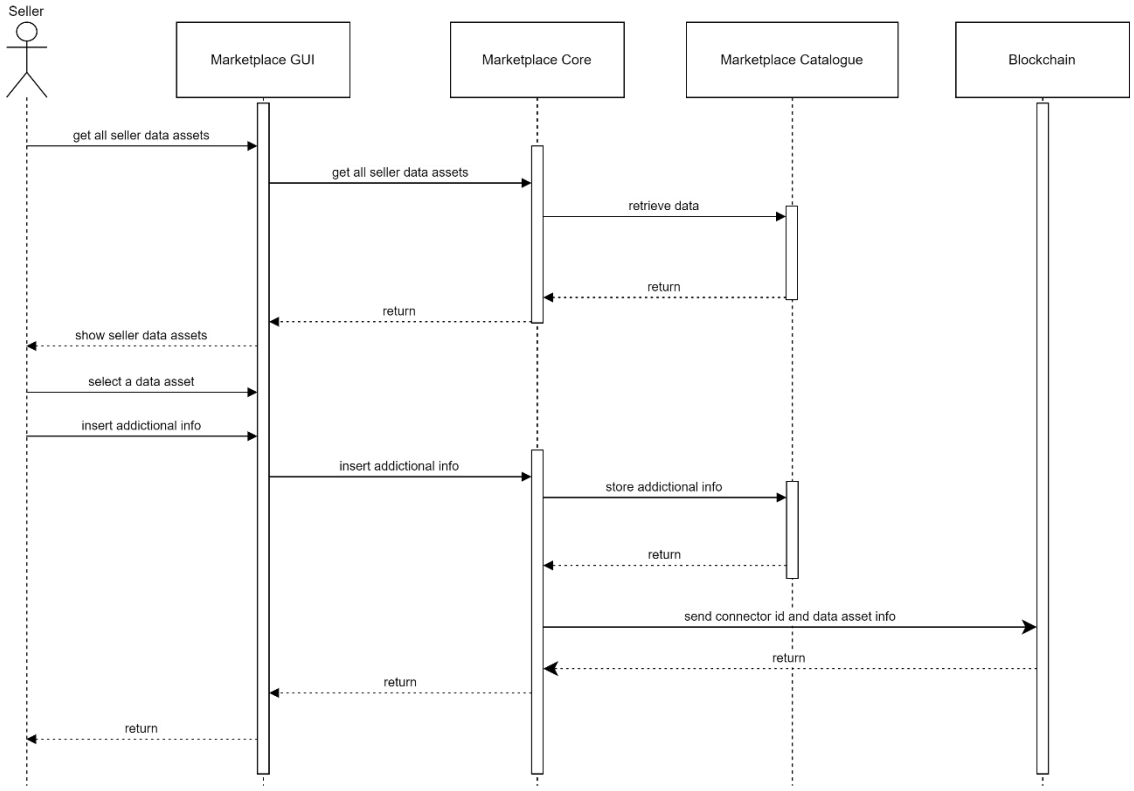

Figure 18: *Publish Dataset* sequence diagram

5.11 (Marketplace Participant as Buyer) Purchase Dataset

The sequence diagram in Figure 19 describes dataset purchasing.

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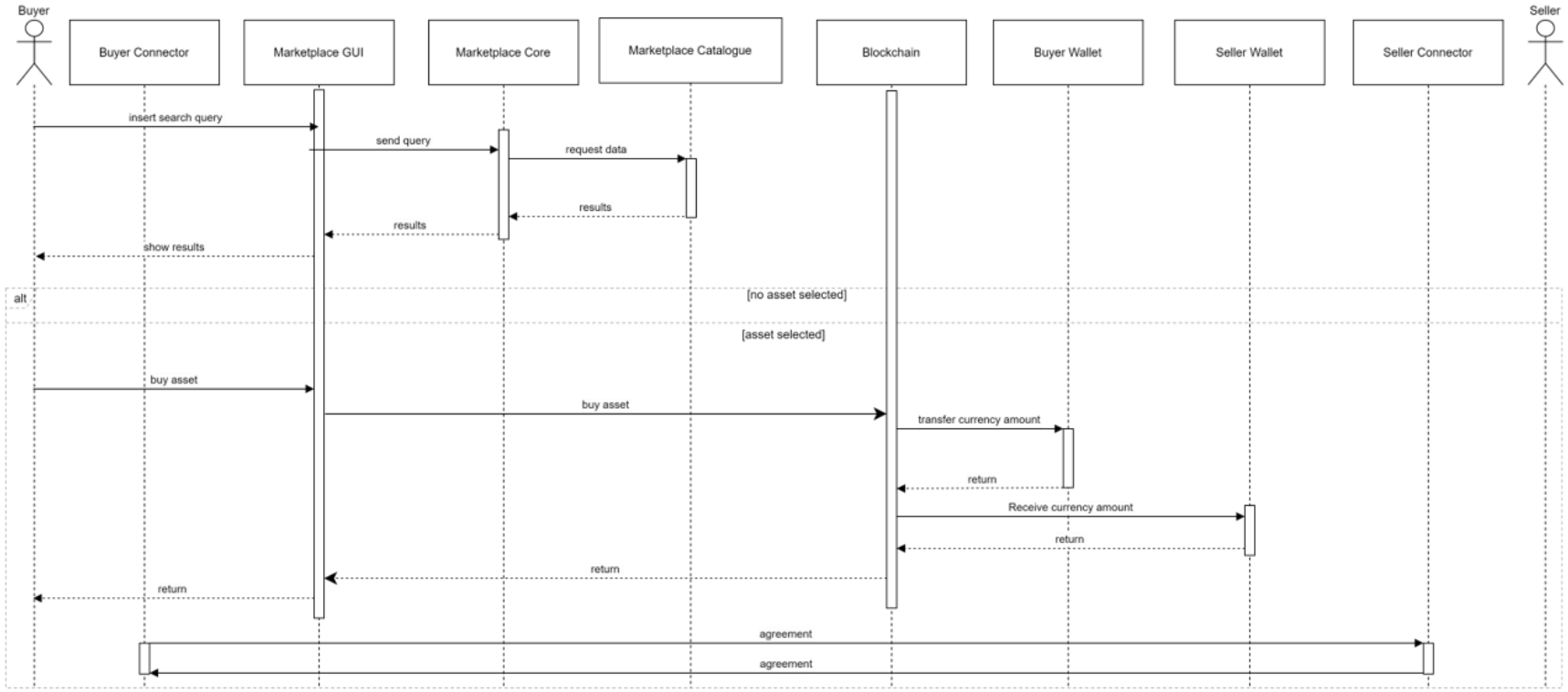

Figure 19: *Purchase Dataset* sequence diagram

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5.12 (Marketplace Participant as Seller) Publish Data Services

The sequence diagram in Figure 20 describes data services publishing.

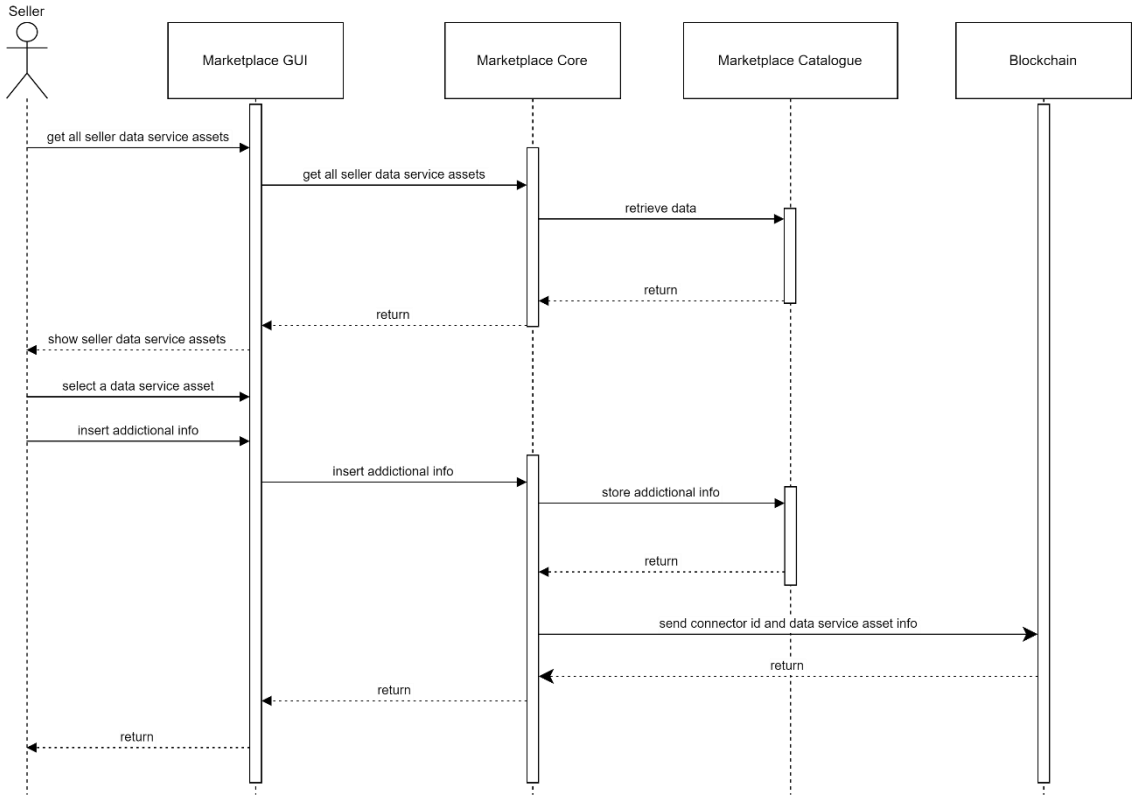

Figure 20: *Publish Data Services* sequence diagram

5.13 (Marketplace Participant as Buyer) Purchase Data Services

The sequence diagram in Figure 21 describes the process of data services purchasing.

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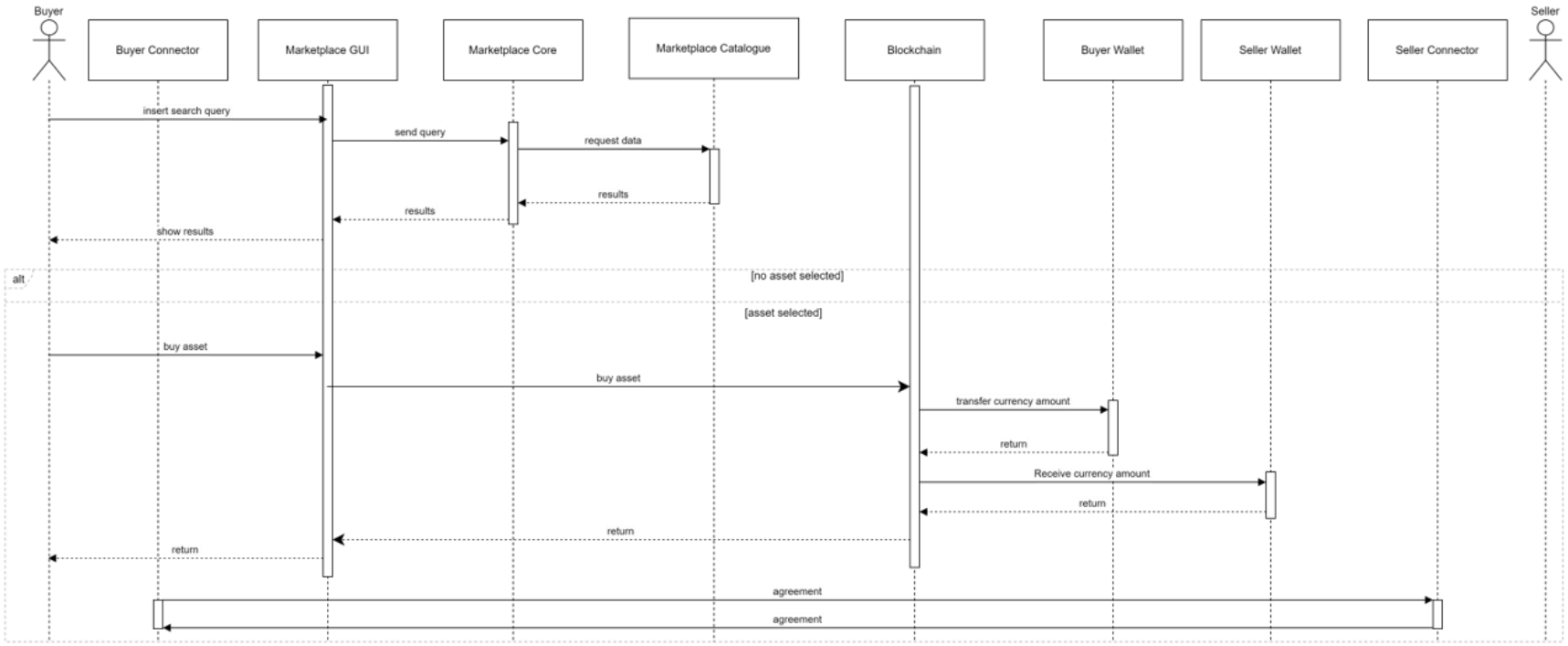

Figure 21: *Purchase Data Services* sequence diagram

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5.14 (Marketplace Participant as Seller) Publish Charging Station Availability

The sequence diagram in Figure 22 describes the process of charging station availability publishing.

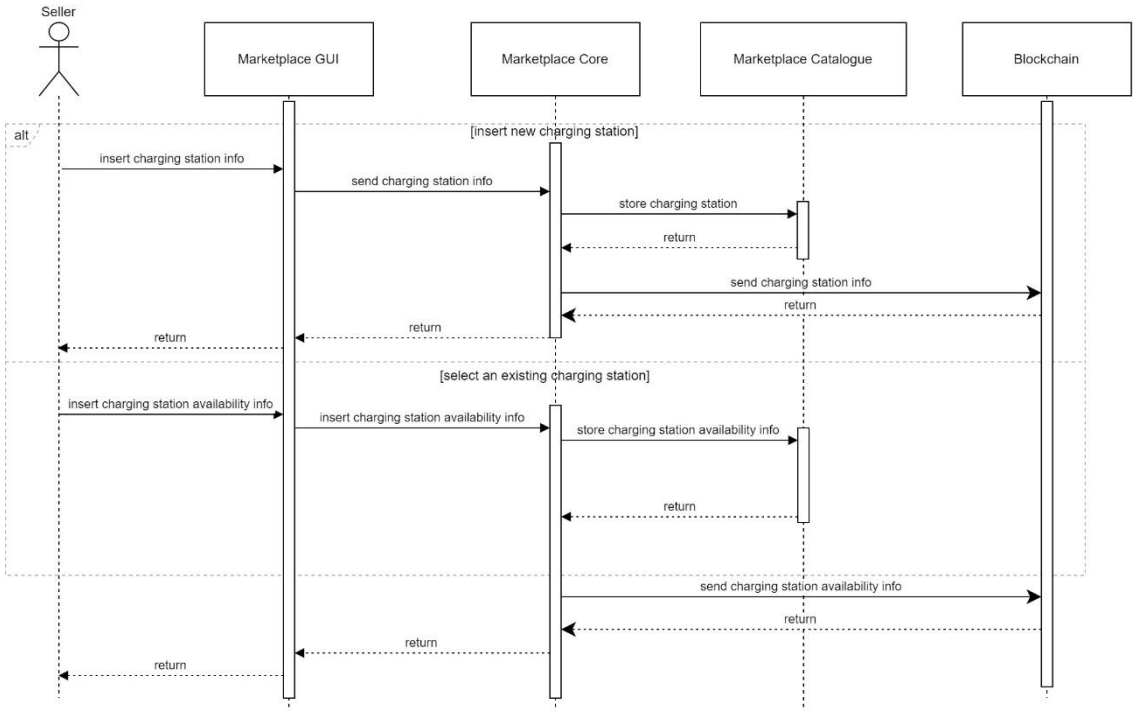

Figure 22: *Publish Charging Station Availability* sequence diagram

5.15 (Marketplace Participant as Buyer) Purchase Charging Station Availability

The sequence diagram in Figure 23 describes the process of charging station availability purchasing.

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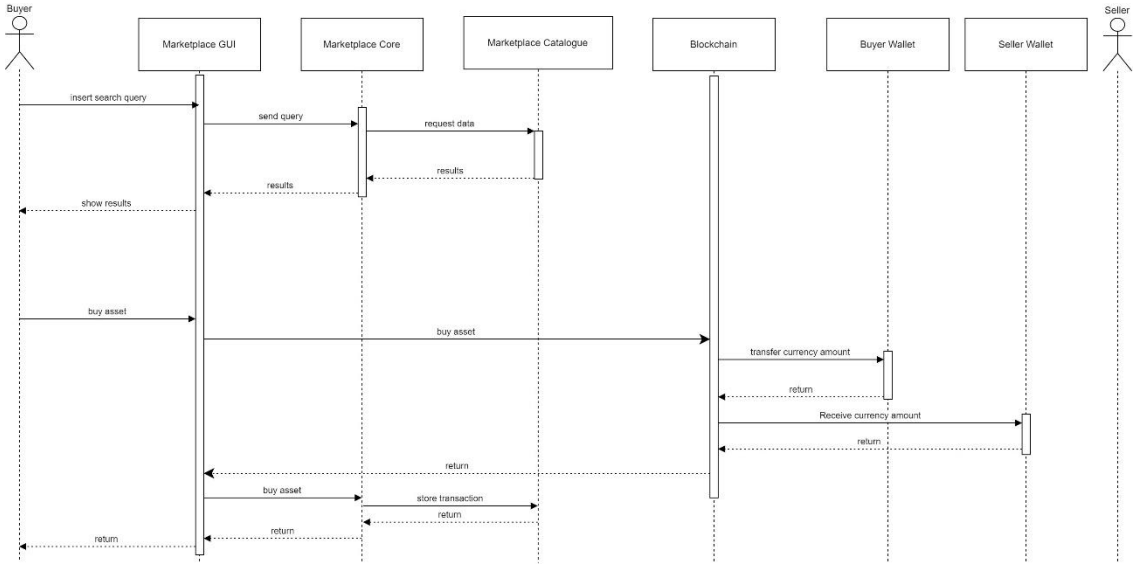

Figure 23: ***Purchase Charging Station Availability*** **sequence diagram**

5.16 (Marketplace Participant as Seller) Publish Apps

The sequence diagram in Figure 24 describes the process of Apps publishing.

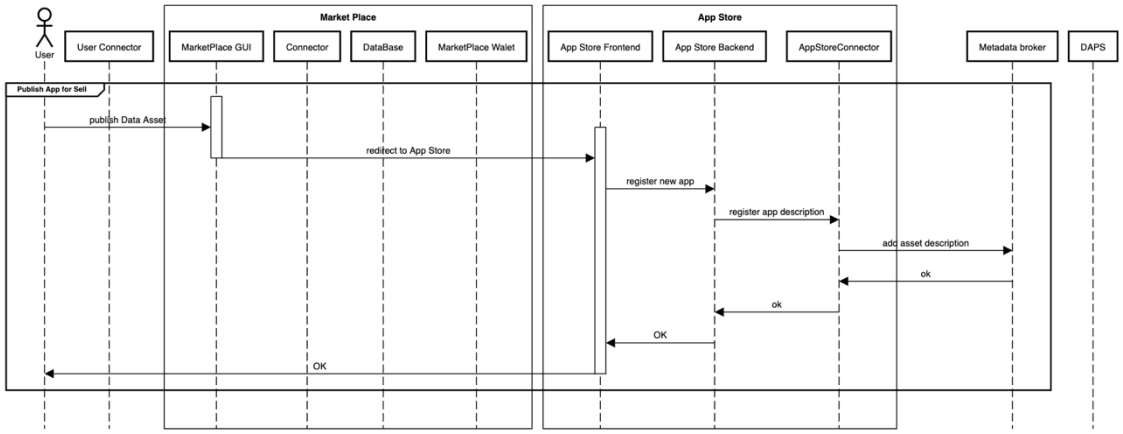

Figure 24: ***Publish App*** **sequence diagram**

5.17 (Marketplace Participant as Seller/Buyer) Purchase Apps

The sequence diagram in Figure 25 describes Apps purchasing.

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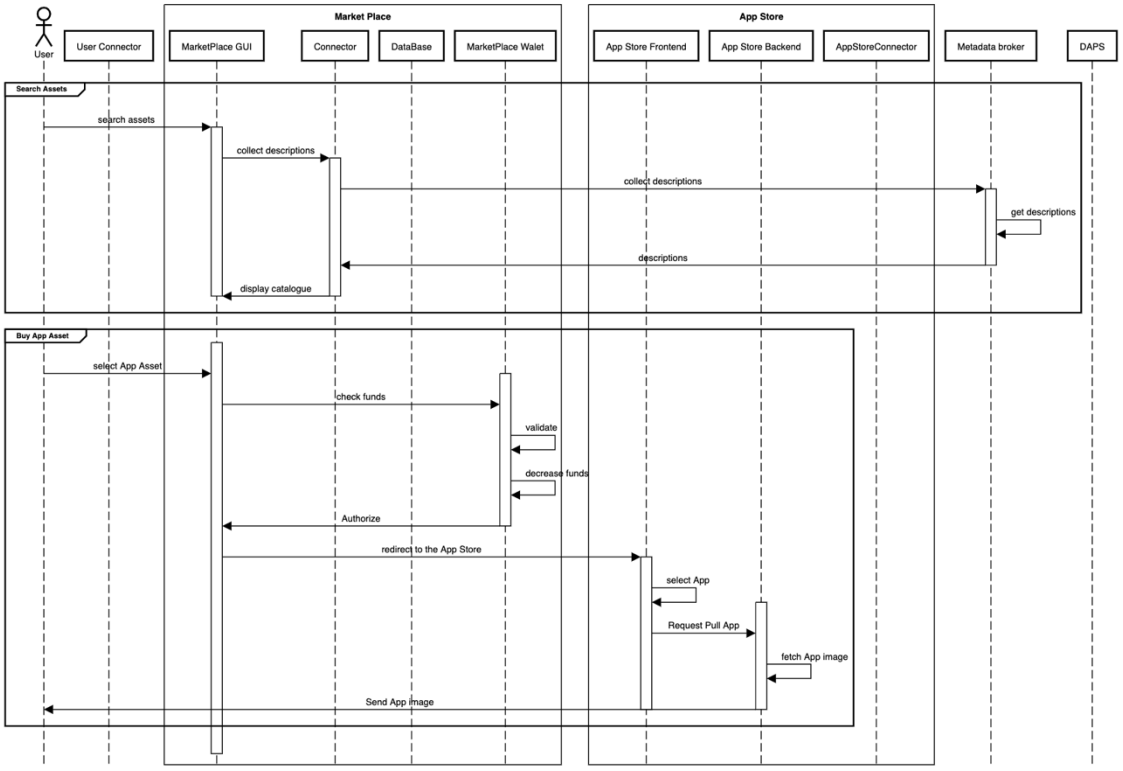

Figure 25: *Purchase App* sequence diagram

5.18 (Marketplace Participant as Energy Consumer) Modify Energy Contract Conditions

The sequence diagram in Figure 26 describes energy contract conditions publishing.

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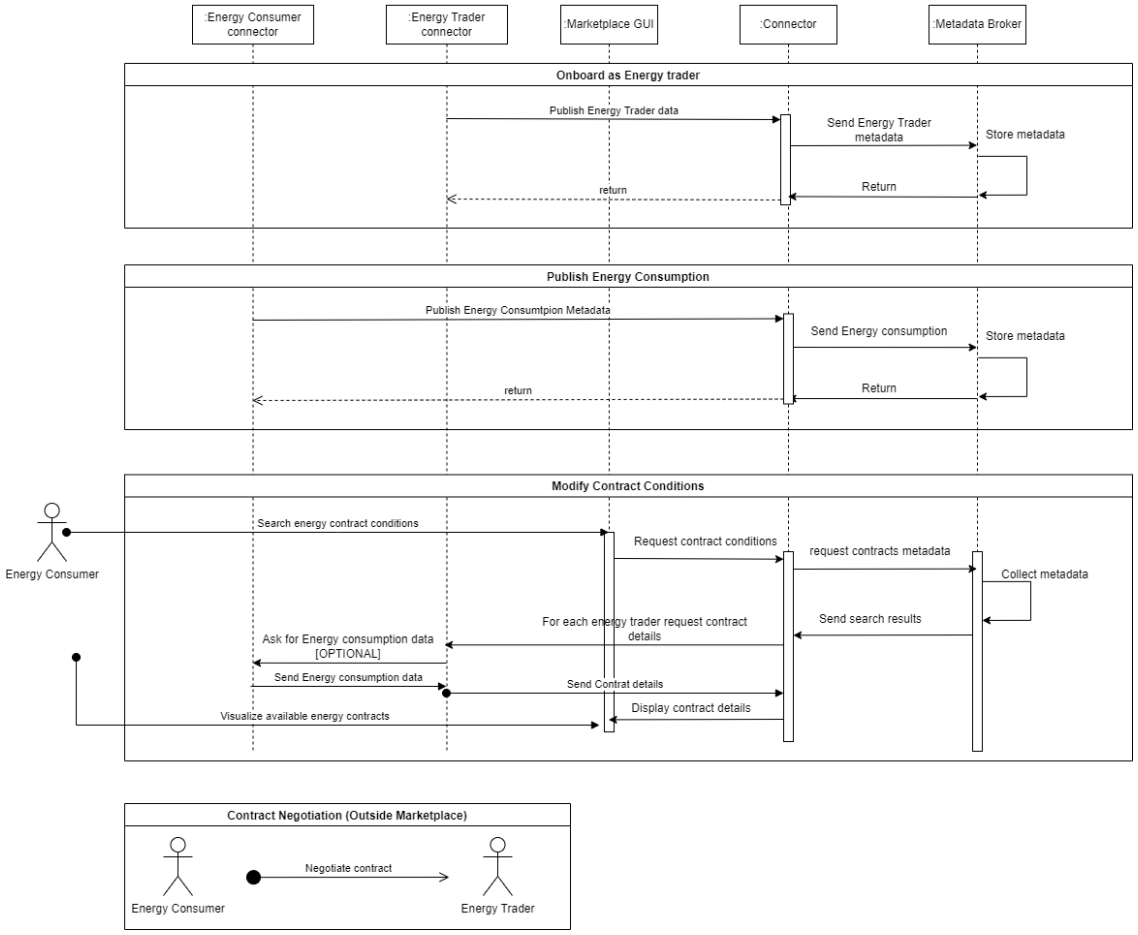

Figure 26: *Modify Energy Contract Conditions* sequence diagram

5.19 (Marketplace Participant as Energy Community Promoter) Modify Coefficient Distribution in an Energy Community

This sequence diagram in Figure 27 describes the process of new coefficient distribution proposing in an Energy Community.

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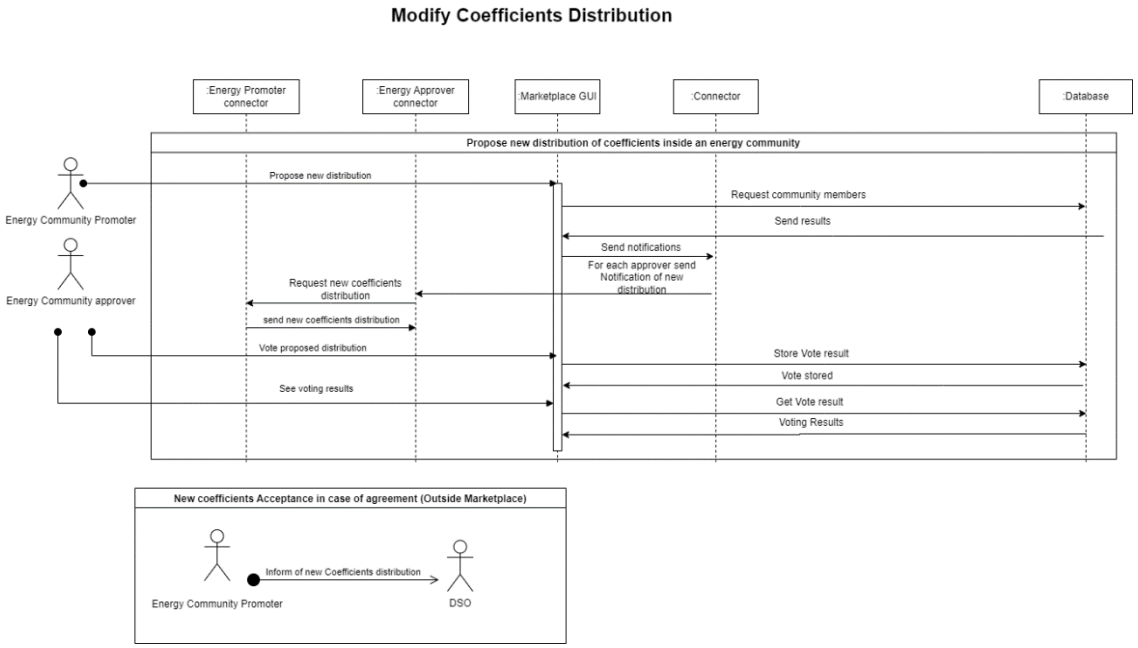

Figure 27: *Modify Coefficient Distribution* sequence diagram

5.20 (Marketplace Participant as Auction Promoter) Publish Auction

The sequence diagram in Figure 28 describes the process of data or data service publishing to obtain cross-domain (data or no data) services.

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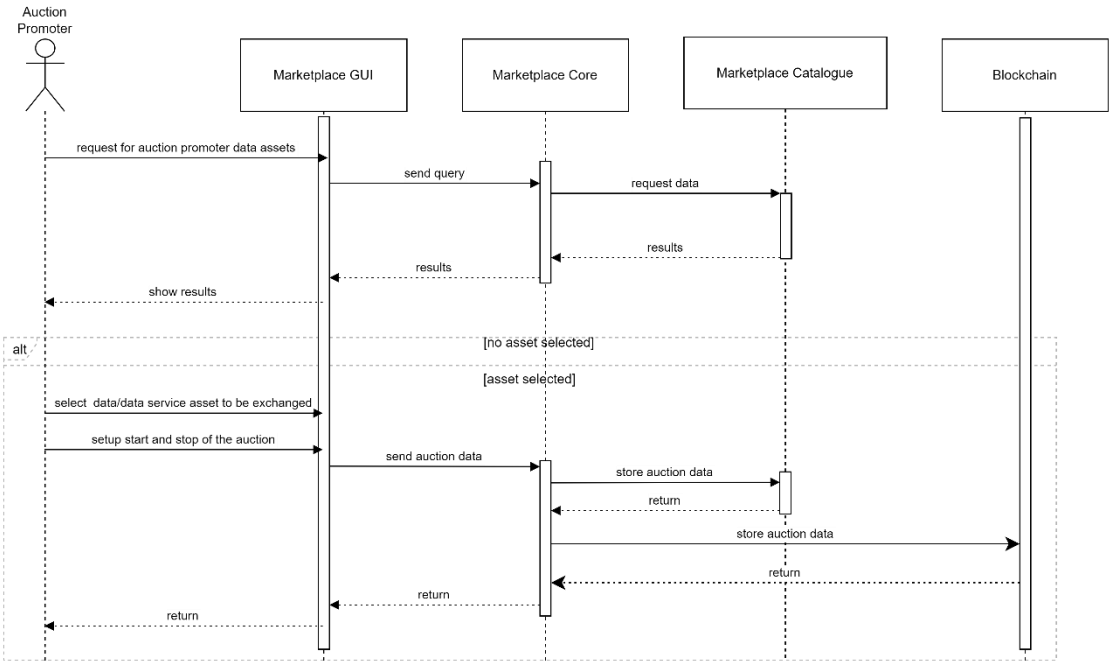

Figure 28: *Publish auction* sequence diagram

5.21 (Marketplace Participant as Auction Bidder) Propose something in exchange to obtain a Data/Data Service asset

The sequence diagram in Figure 29 describes the proposal of a no-data cross-domain service, while the auction is active, in order to obtain a data/data service asset.

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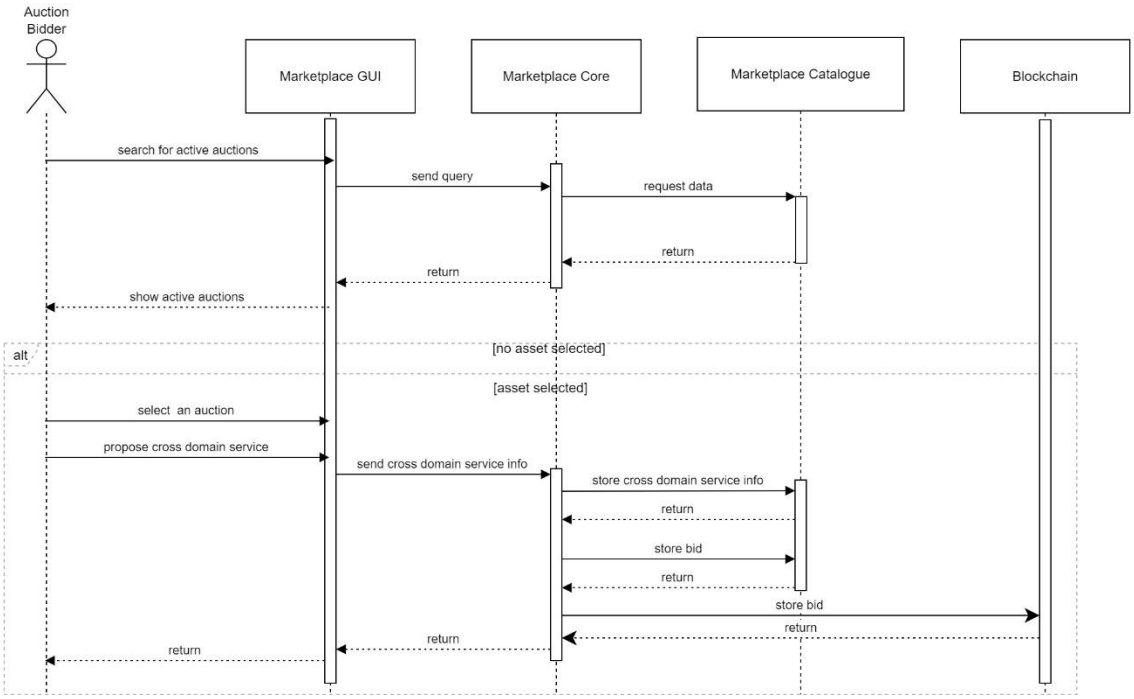

Figure 29: *Propose no Data Cross Domain Service in exchange* sequence diagram

The sequence diagram in Figure 30 describes the proposal of data/data service asset, while the auction is active, in order to obtain a data/data service asset.

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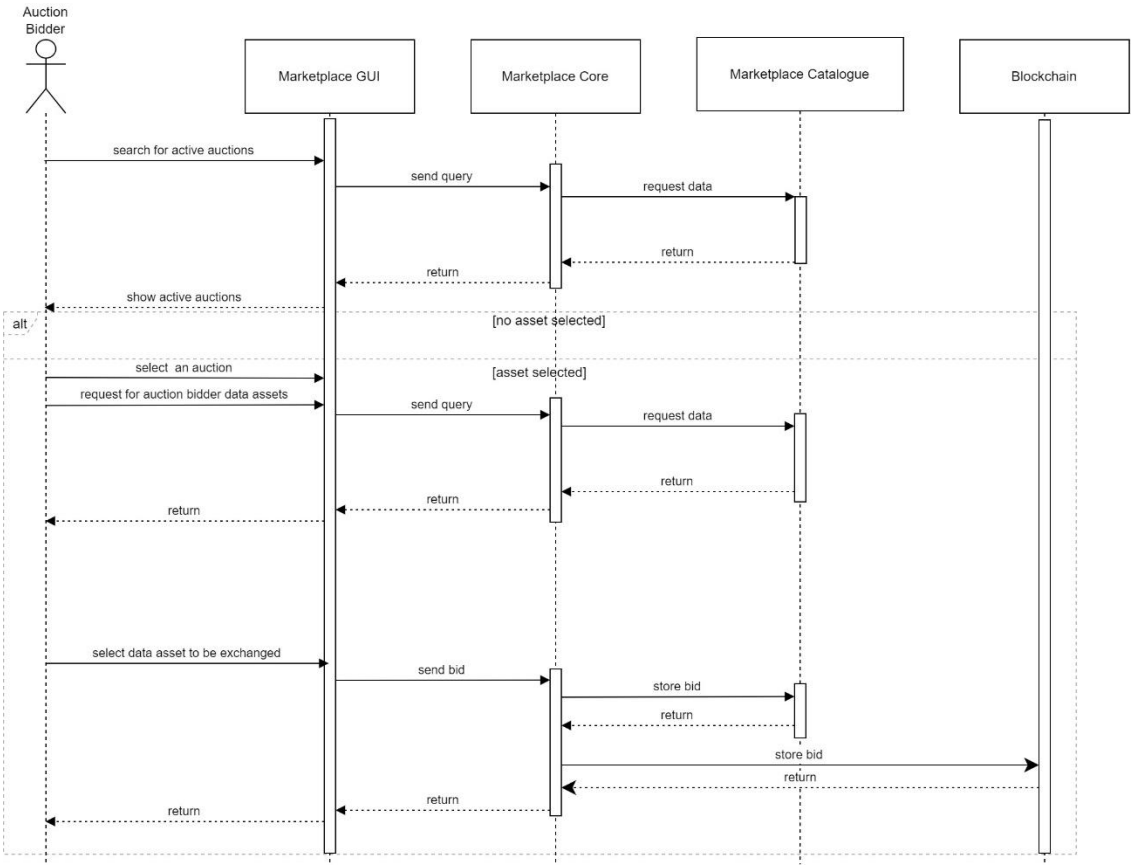

Figure 30: ***Propose Data/Data Service in exchange*** **sequence diagram**

5.22 (Marketplace Participant as Auction Promoter) Selects best offer as exchange for a Data/Data Service asset

The sequence diagram in Figure 31 describes (Marketplace Participant as Auction Promoter) selecting best offer as exchange for the Data/Data Service asset published.

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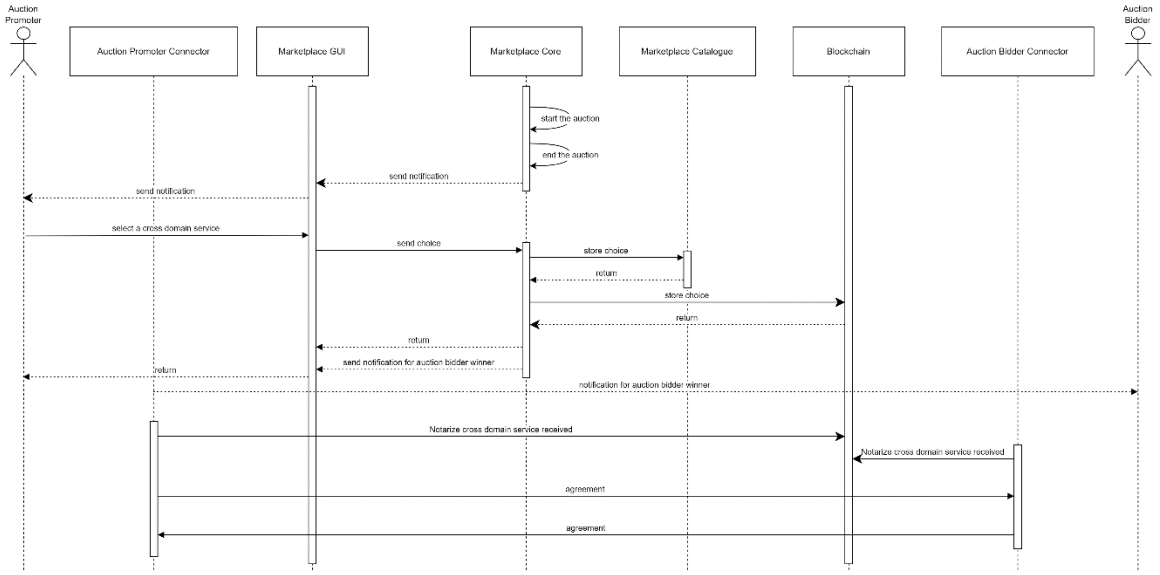

Figure 31: ***Select auction best offer*** **sequence diagram**

5.23 (Marketplace Participant as Barter Data Producer/Consumer) Exchange Data/Collaborative Data Analytics Services

The sequence diagrams depicted in the following Figure 32, Figure 33, Figure 34, Figure 35, and Figure 36 describe the main processes for the interaction with the Barter.

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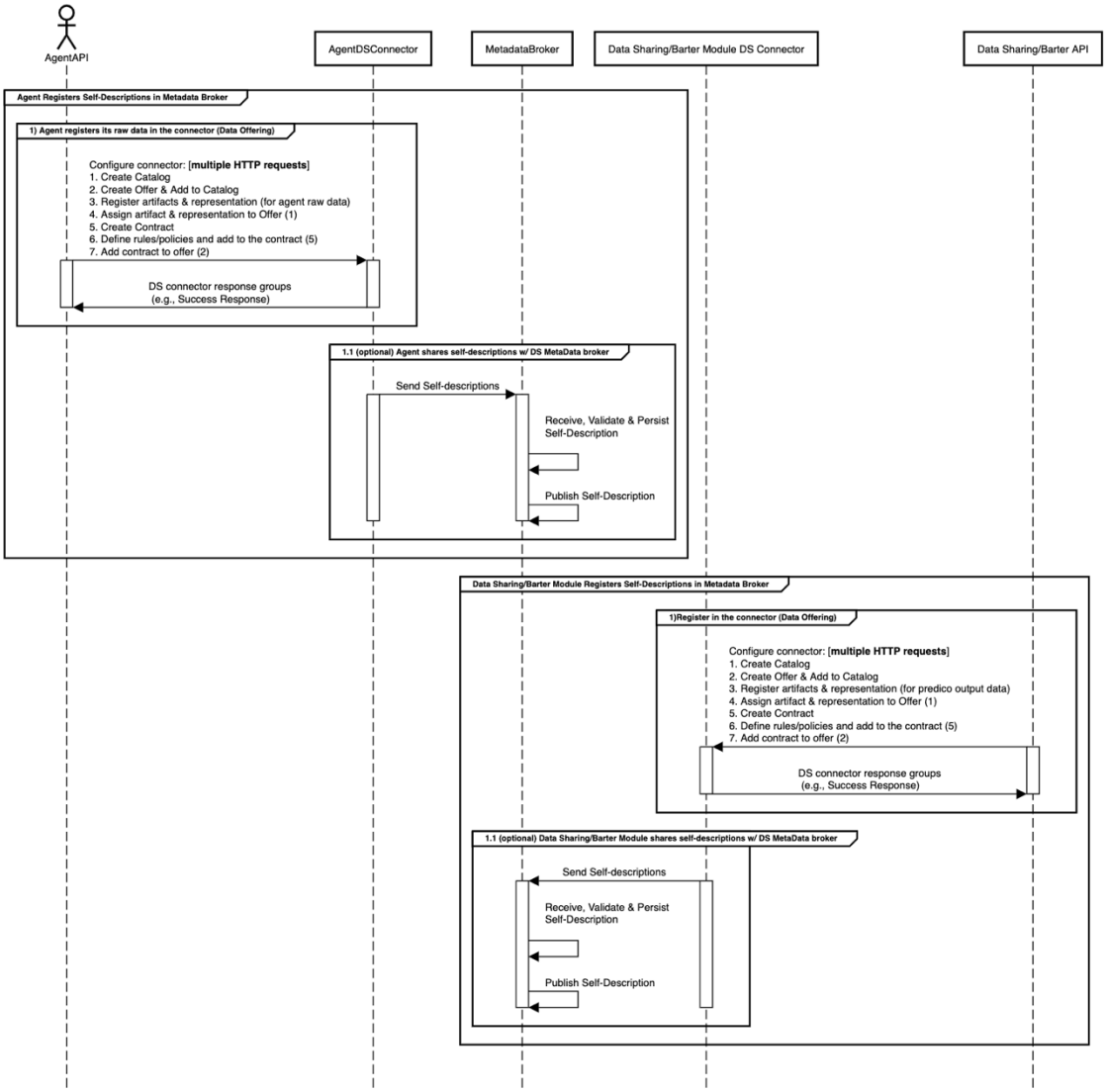

Figure 32: *Self-description registration* sequence diagram

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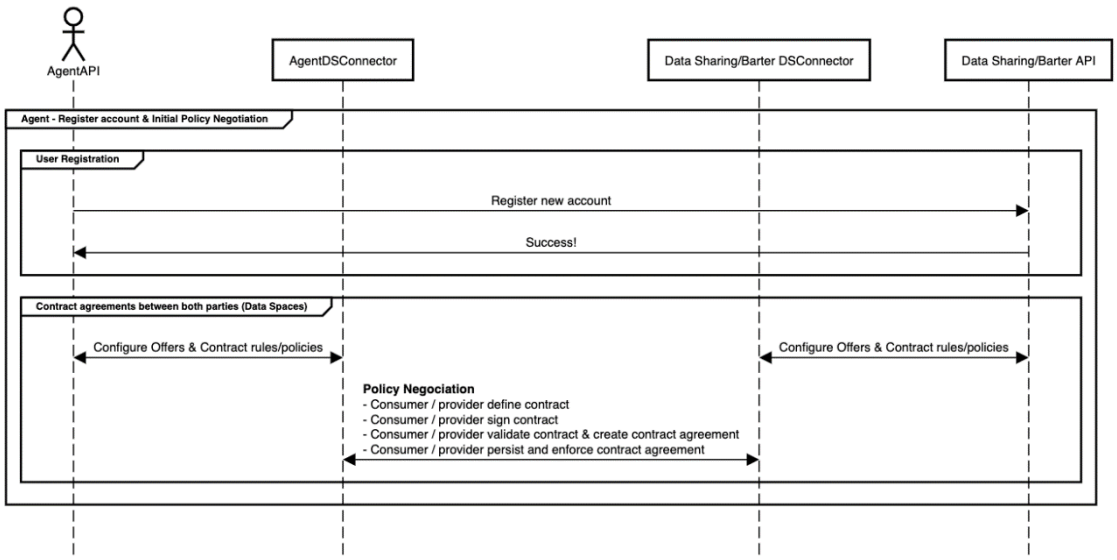

Figure 33: *Agent account registration* sequence diagram

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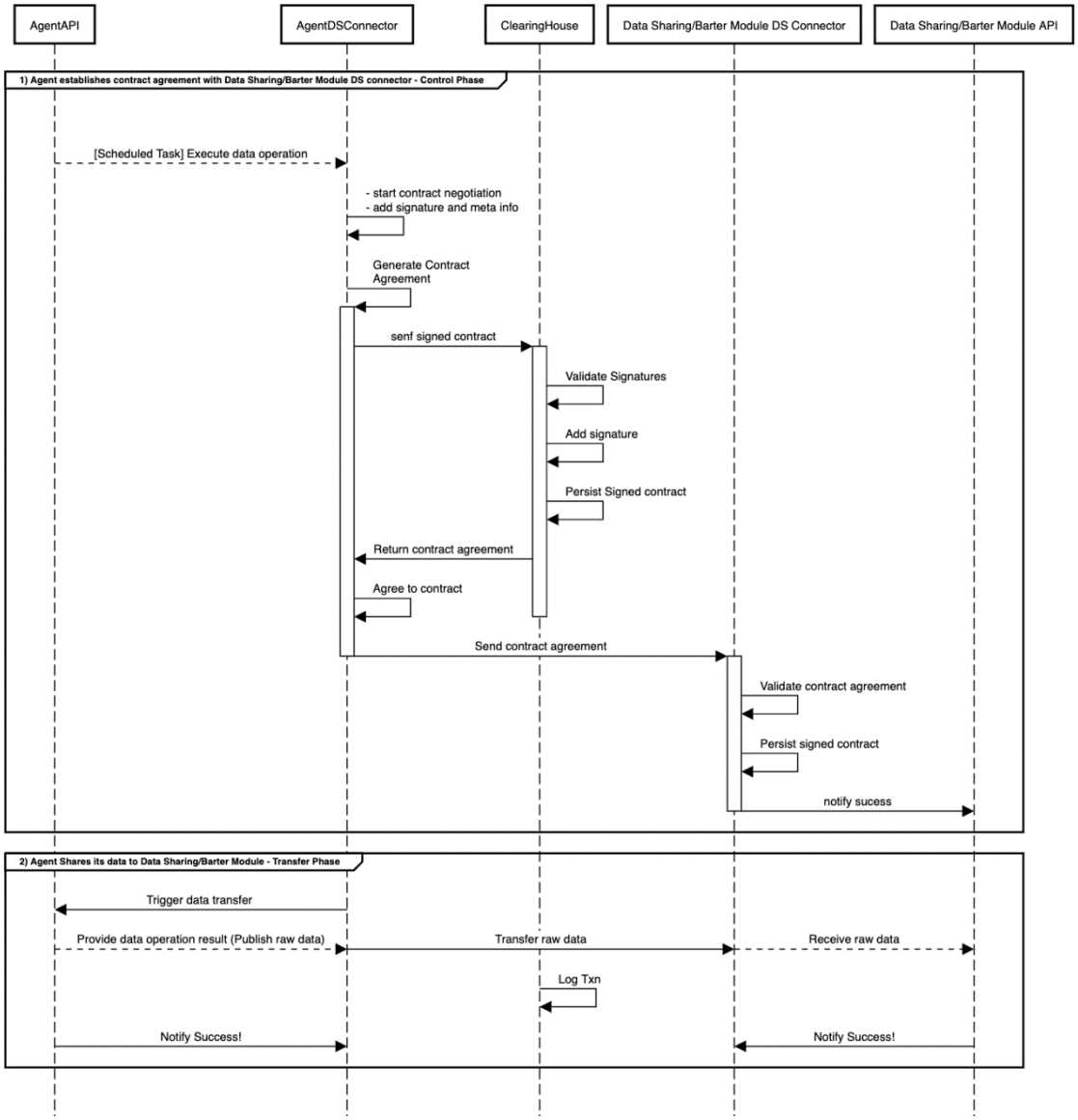

Figure 34: *Agent publishes raw data* sequence diagram

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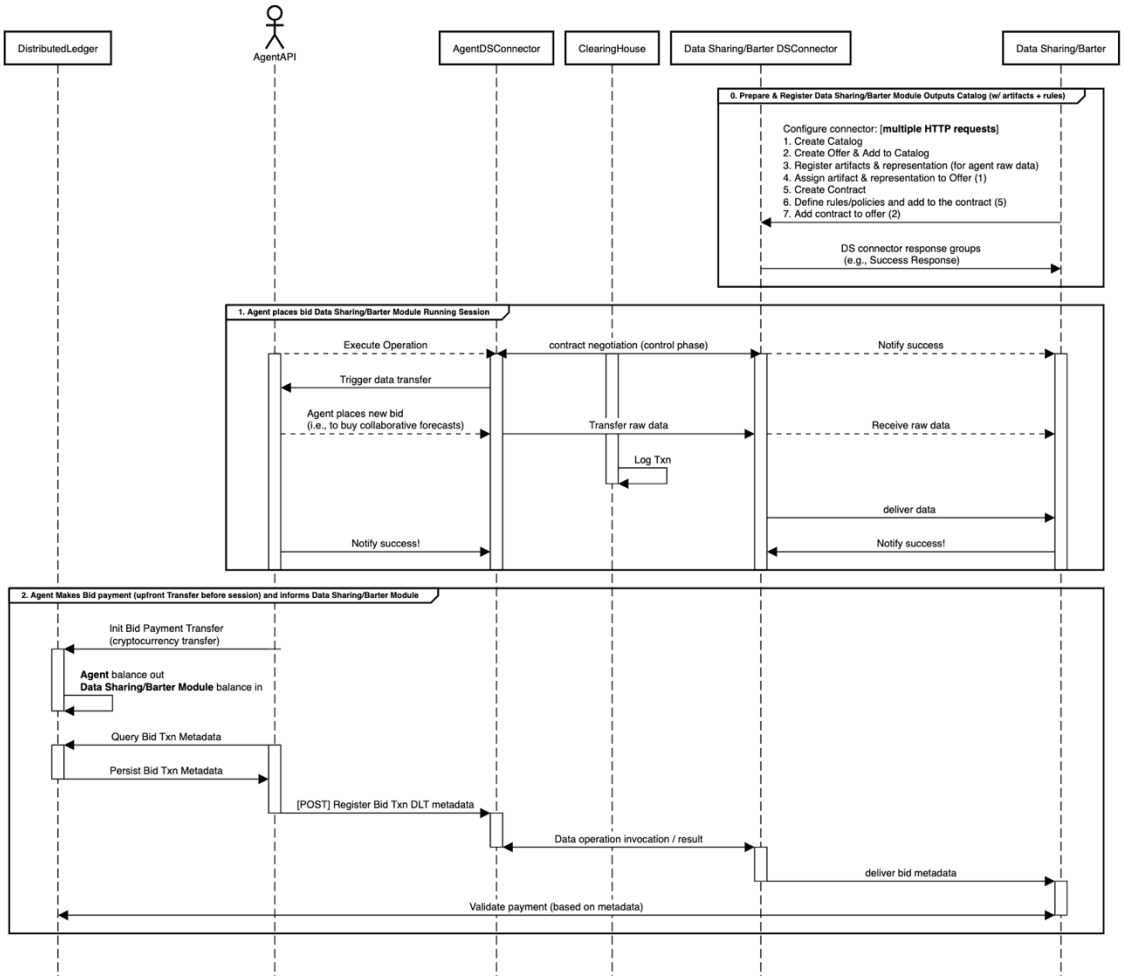

Figure 35: *Data space interactions* sequence diagram

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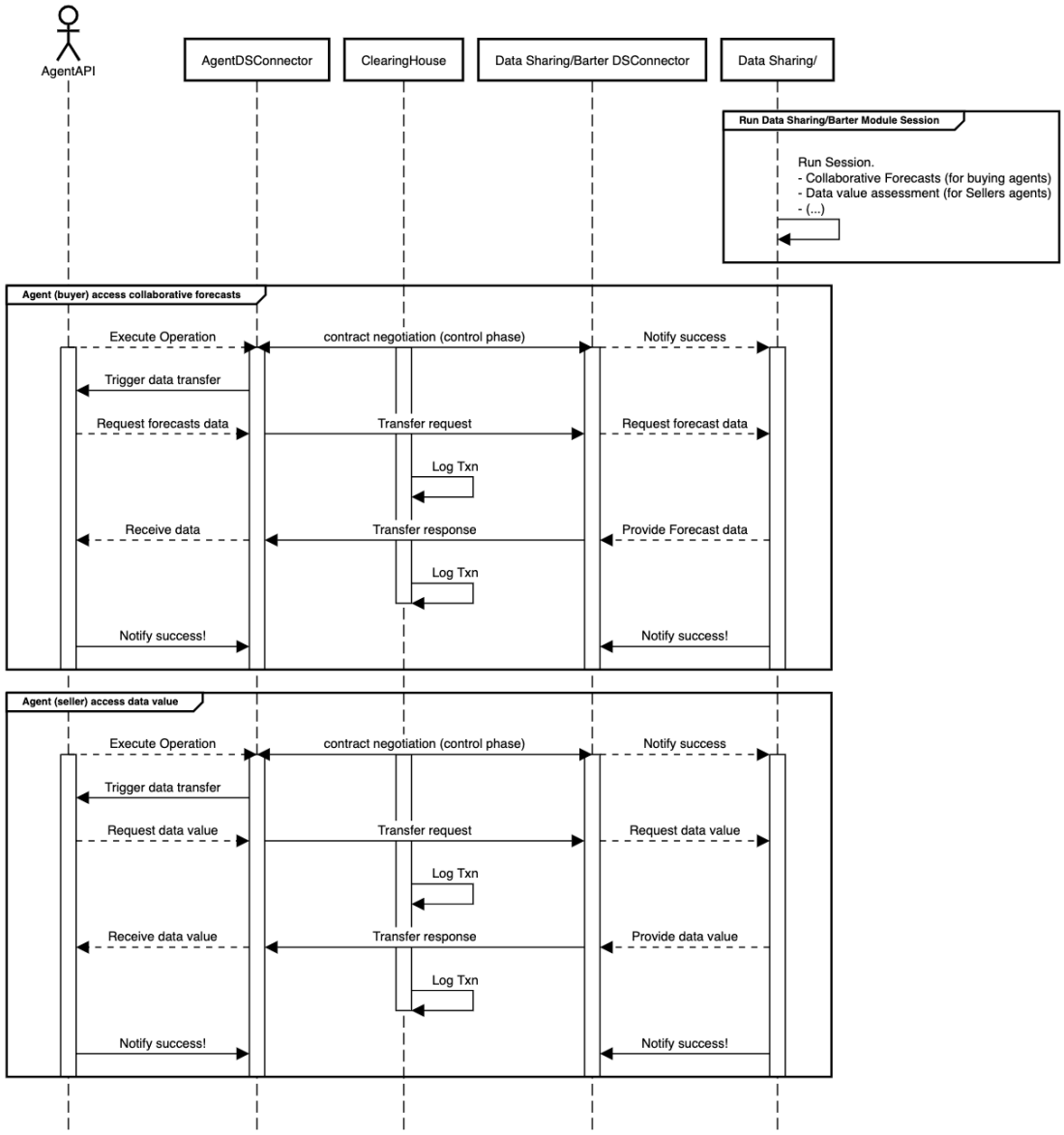

Figure 36: ***Agents retrieve DataSharing/Barter outputs*** **sequence diagram**

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5.24 (Marketplace Participant as Buyer) Rate Asset/Seller

The sequence diagram in Figure 37 describes the process of rating an asset/seller.

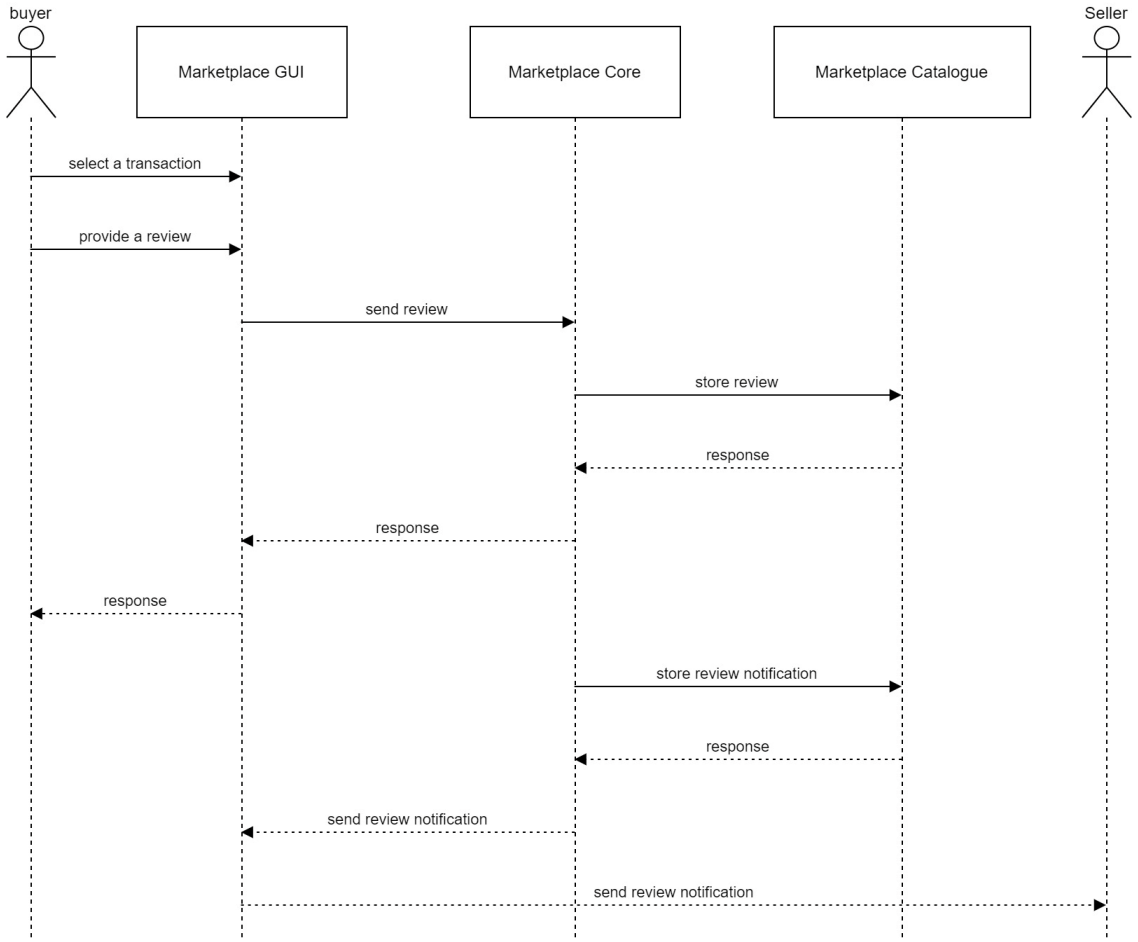

Figure 37: *Rate asset/seller* sequence diagram

5.25 (Marketplace Participant as Seller) Visualize Ratings

The sequence diagram in Figure 38 describes the process of visualizing ratings received.

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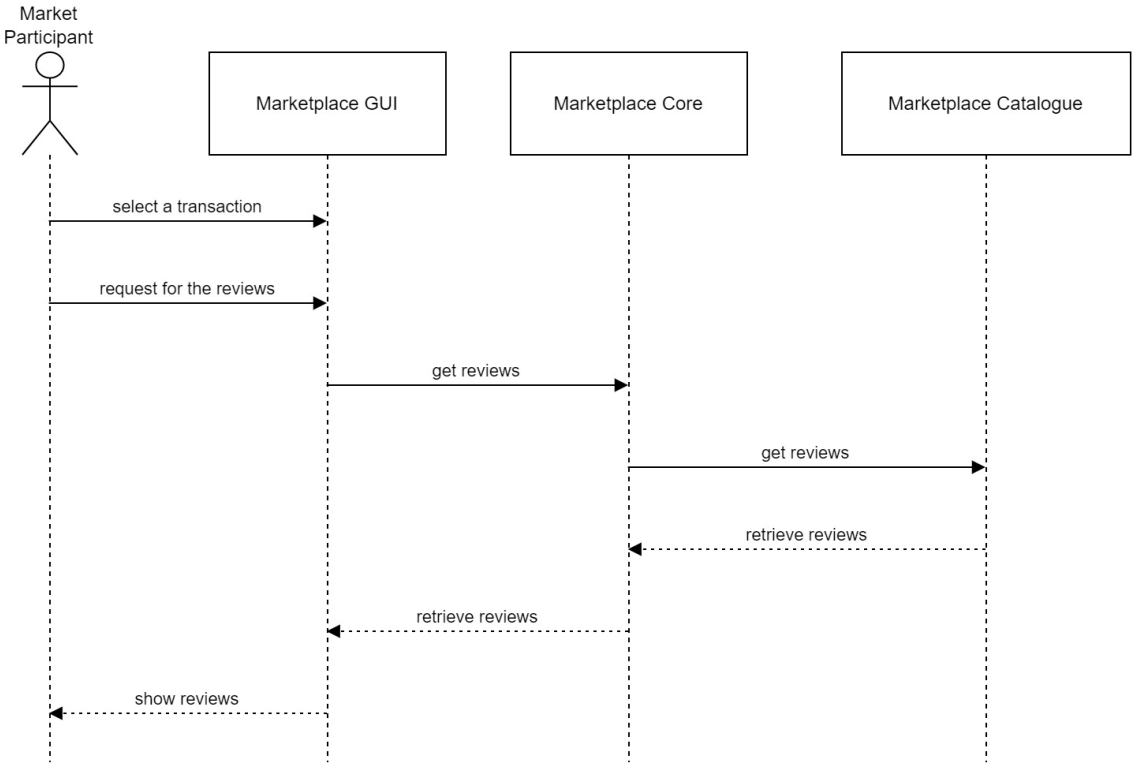

Figure 38: *Visualise ratings* sequence diagram

5.26 Clearing House

The sequence diagram in Figure 39 shows the process of logging at the Clearing House of an incoming message received by a Connector to another Connector.

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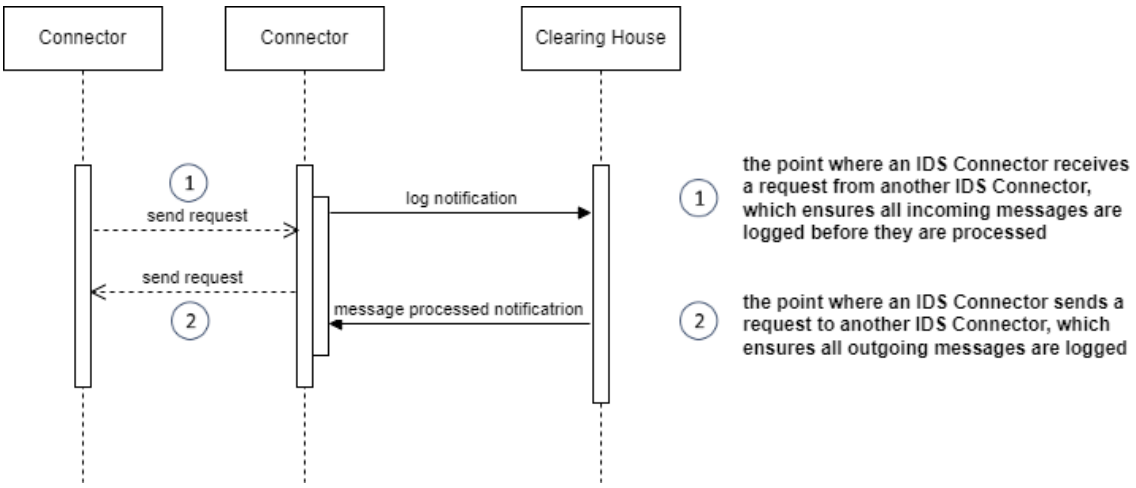

Figure 39: *Logging notification* sequence diagram

The sequence diagram in Figure 40 shows how is inquired the Clearing House by a Connector.

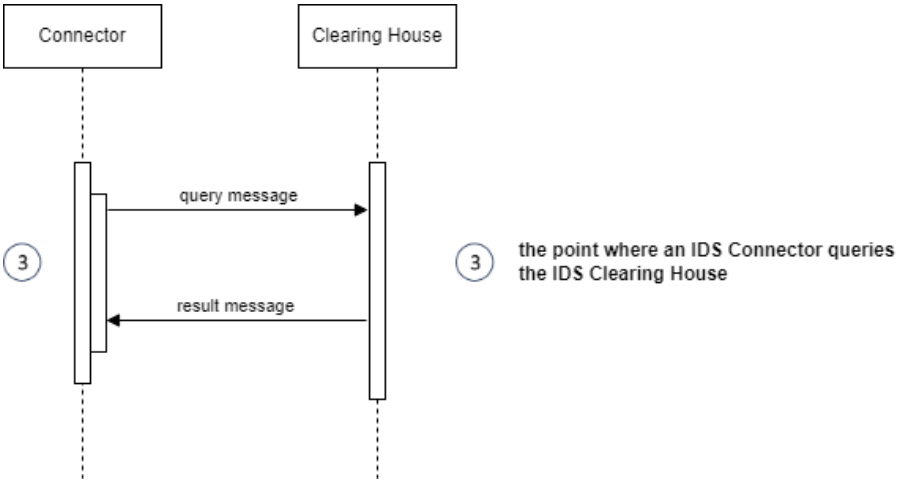

Figure 40: *Query Clearing House* sequence diagram

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6 Development View

This section illustrates the ENERSHARE Data Value Stack system from a programmer's perspective and is concerned with software management. UML diagrams used to represent the development view are the component diagrams, where system and subsystem are represented. Each component is described using the template in Table 4.

Table 4: Component Identity Card

<<COMPONENT NAME>>		
Framework Sub-System		
Responsibility		
Provided Interface	**<<INTERFACE NAME>>**	
	Description	
	Provided to	
	End-point	
	Protocol used	
	Allowed Methods	
	<<INTERFACE NAME>>	
	Description	
	Provided to	
	End-point	
	Protocol used	
	Allowed Methods	
Required Interface	**<<INTERFACE NAME>>**	
	Provided by	
	Description	
	<<INTERFACE NAME>>	
	Provided by	
	Description	

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6.1 Marketplace

6.1.1 Marketplace GUI

The Marketplace GUI is responsible for displaying the entry point for the marketplace participant to sell/buy data, data services, charging station availability, create or participate in cross-domain service exchange auctions. She/he can search for new energy contracts or if she/he is an energy trader proposes new ones. If part of an energy community, she/he can propose new distribution coefficients or vote on those proposed by other members of the community. All this can be done directly from the Marketplace GUI, alternatively the Market participant can buy/sell Apps or use the incentive barter module by accessing the appropriate external sections directly from the Marketplace GUI.

Table 5: Marketplace GUI Identity Card

Marketplace GUI		
Framework Sub-System	Marketplace	
Responsibility	Entry point for the Marketplace participant.	
Provided Interface	**Login**	
	Description	Provides the page with the login form to login to the marketplace.
	Provided to	Market Participant
	End-point	/login
	Protocol used	HTTPS
	Allowed Methods	GET
	Register	
	Description	Provides the page with the register form to send the register request to the marketplace.
	Provided to	User
	End-point	/register
	Protocol used	HTTPS
	Allowed Methods	GET
	AssetsForSale	
	Description	Shows the list of a type of asset available for purchase. The supported types are: “data” – “data services” – “charging-station-availabilities”. Provides search and filter functionality as well as the possibility of buying a chosen asset.
	Provided to	Market Participant as a Buyer
	End-point	/{type}
	Protocol used	HTTPS
	Allowed Methods	GET

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	PublishNewAsset	
	Description	Shows a form to fill out to put a new asset up for sale. The supported types are: “data” – “data services” – “charging station availabilities”.
	Provided to	Market Participant as a Seller
	End-point	/new-{type}
	Protocol used	HTTPS
	Allowed Methods	GET
	Auctions	
	Description	Shows the list of active auctions provides the possibility to insert a bid to an active auction.
	Provided to	Market Participant as Auction bidder
	End-point	/auctions
	Protocol used	HTTPS
	Allowed Methods	GET
	NewAuction	
	Description	Shows a form to fill out to create a new auction selecting a data or data service asset.
	Provided to	Market Participant as Auction Promoter
	End-point	/new-auction
	Protocol used	HTTPS
	Allowed Methods	GET
	EnergyContracts	
	Description	Shows the list of all energy contracts.
	Provided to	Market Participant
	End-point	/energy-contracts
	Protocol used	HTTPS
	Allowed Methods	GET
	NewEnergyContract	
	Description	Shows a form to fill out to create a new energy contract.
	Provided to	Market Participant as Energy trader
	End-point	/new-energy-contract
	Protocol used	HTTPS
	Allowed Methods	GET
	EnergyCoefficients	
	Description	Shows the list of the energy community coefficients and provide the possibility to send a request for modification or to vote for the modifications requested by other energy community member.
	Provided to	Market Participant as Energy community member

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	End-point	/energy-community
	Protocol used	HTTPS
	Allowed Methods	GET
	Profile	
	Description	Shows the profile details. Provides the possibility to change some information.
	Provided to	Market Participant
	End-point	/profile
	Protocol used	HTTPS
	Allowed Methods	GET
	ENERSHARETokens	
	Description	Shows the balance of tokens and the balance of blockchain currency for the connected crypto wallet. Provides the possibility to buy or sell enershare tokens.
	Provided to	Market Participant
	End-point	/enershare-tokens
	Protocol used	HTTPS
	Allowed Methods	GET
	TransactionsHistory	
	Description	Shows all the transactions made through the connected crypto wallet. Permits to view reviews received or to provide new reviews for acquired assets.
	Provided to	Market Participant
	End-point	/transactions-history
	Protocol used	HTTPS
	Allowed Methods	GET
Required Interface	**Login**	
	Provided by	Marketplace Core
	Description	Login the Marketplace Participant using username and password.
	LoginIDM	
	Provided by	Marketplace Core
	Description	Login the Marketplace Participant using IDM Token.
	Register	
	Provided by	Marketplace Core
	Description	Register the Marketplace Participant using username password.
	Delete	
	Provided by	Marketplace Core
	Description	Delete the Marketplace Participant account.

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	UpdateProfile	
	Provided by	Marketplace Core
	Description	Save updates for the Marketplace Participant account.
	ValidateProfileUpdates	
	Provided by	Marketplace Core
	Description	Update the Marketplace Participant account.
	PublishData	
	Provided by	Marketplace Core
	Description	Publish new Data or Data service for selling.
	PublishChargingStationAvailability	
	Provided by	Marketplace Core
	Description	Publish new Charging Station Availability for selling.
	CreateAuction	
	Provided by	Marketplace Core
	Description	Create new Auction.
	GetData	
	Provided by	Marketplace Core
	Description	Retrieve the data based on the end-points.
	SearchData	
	Provided by	Marketplace Core
	Description	Retrieve the data based on the end-points and on the search query provided.
	BuyTokens	
	Provided By	ENERSHARE Token Smart Contract
	Description	Buy ENERSHARE Tokens
	SellTokens	
	Provided By	ENERSHARE Token Smart Contract
	Description	Sell ENERSHARE Tokens
	BuyAsset	
	Provided By	ENERSHARE Transaction Processor Smart Contract
	Description	Buy an asset and notarize the relative information.
	GetTransactions	
	Provided by	Marketplace Core
	Description	Retrieve the transactions for a specified user/wallet.

6.1.2 Marketplace Core

The Marketplace Core is a backend application responsible for the provision and execution of processes and services for data management and storage, database searches, and user management. It is in support of the Marketplace GUI.

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Table 6: Marketplace Core Identity Card

Marketplace Core		
Framework Sub-System	Marketplace	
Responsibility	Processes, services, and data management	
Provided Interface	**Login**	
	Provided to	Marketplace GUI
	Description	Login of a Marketplace Participant using username and password.
	End-point	/login
	Protocol used	HTTP
	Allowed Methods	POST
	Register	
	Provided to	Marketplace GUI
	Description	Registration of a Marketplace Participant.
	End-point	/accounts
	Protocol used	HTTP
	Allowed Methods	POST
	RemoveProfile	
	Provided to	Marketplace GUI
	Description	Delete a Marketplace Participant's account.
	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	DELETE
	GetProfile	
	Provided to	Marketplace GUI
	Description	Retrieve a Marketplace Participant's account.
	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	UpdateProfile	
	Provided to	Marketplace GUI
	Description	Save updates for a Marketplace Participant's account.
	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	ValidateProfile	
	Provided to	Marketplace GUI
	Description	Validate a Marketplace Participant's account.

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	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	PATCH
	GetProfiles	
	Provided to	Marketplace GUI
	Description	Retrieve all Marketplace Participant's accounts.
	End-point	/accounts/
	Protocol used	HTTP
	Allowed Methods	GET
	UpdateMarketplaceParticipant	
	Provided to	Marketplace GUI
	Description	Save updates for a Marketplace Participant.
	End-point	/marketplaceParticipant/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	GetMarketplaceParticipants	
	Provided to	Marketplace GUI
	Description	Retrieve all the Marketplace Participants.
	End-point	/marketplaceParticipants
	Protocol used	HTTP
	Allowed Methods	GET
	GetMarketplaceParticipant	
	Provided to	Marketplace GUI
	Description	Retrieve a Marketplace Participant.
	End-point	/marketplaceParticipants/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	AddChargingStation	
	Provided to	Marketplace GUI
	Description	Add a charging station to the Marketplace catalogue.
	End-point	/chargingStations
	Protocol used	HTTP
	Allowed Methods	POST
	RemoveChargingStation	
	Provided to	Marketplace GUI
	Description	Delete a charging station.
	End-point	/chargingStations /{id}
	Protocol used	HTTP
	Allowed Methods	DELETE

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	GetChargingStation	
	Provided to	Marketplace GUI
	Description	Retrieve a charging station.
	End-point	/chargingStations/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	UpdateChargingStation	
	Provided to	Marketplace GUI
	Description	Save updates to a charging station.
	End-point	/chargingStations/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	GetChargingStations	
	Provided to	Marketplace GUI
	Description	Retrieve all the charging stations.
	End-point	/chargingStations/
	Protocol used	HTTP
	Allowed Methods	GET
	AddChargingStationAvailability	
	Provided to	Marketplace GUI
	Description	Add a new charging station availability to the Martketplace catalogue.
	End-point	/chargingStationAvailabilities
	Protocol used	HTTP
	Allowed Methods	POST
	RemoveChargingStationAvailability	
	Provided to	Marketplace GUI
	Description	Delete a charging station availability
	End-point	/chargingStationAvailabilities/{id}
	Protocol used	HTTP
	Allowed Methods	DELETE
	GetCharginStationAvailability	
	Provided to	Marketplace GUI
	Description	Retrieve a charging station availability.
	End-point	/chargingStationAvailabilities/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	UpdateChargingStationAvailability	
	Provided to	Marketplace GUI
	Description	Save updates to a charging station availability.
	End-point	/chargingStationAvailabilities/{id}

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	Protocol used	HTTP
	Allowed Methods	PUT
	GetChargingStationAvailabilities	
	Provided to	Marketplace GUI
	Description	Retrieve all the charging station availabilities.
	End-point	/chargingStationAvailabilities/
	Protocol used	HTTP
	Allowed Methods	GET
	PublishChargingStationAvailability	
	Provided to	Marketplace GUI
	Description	Publish a charging station availability for selling.
	End-point	/chargingStationAvailabilities/{id}
	Protocol used	HTTP
	Allowed Methods	PATCH
	PublishData	
	Provided to	Marketplace GUI
	Description	Publish new Data or Data service for selling.
	End-point	/resources/{id}
	Protocol used	HTTP
	Allowed Methods	POST
	CreateAuction	
	Provided to	Marketplace GUI
	Description	Create new auction.
	End-point	/auctions
	Protocol used	HTTP
	Allowed Methods	POST
	DeleteAuction	
	Provided to	Marketplace GUI
	Description	Save updates to an auction.
	End-point	/auctions/{id}
	Protocol used	HTTP
	Allowed Methods	DELETE
	UpdateAuction	
	Provided to	Marketplace GUI
	Description	Save updates to an auction.
	End-point	/auctions/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	GetAuction	
	Provided to	Marketplace GUI

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	Description	Retrieve an auction.
	End-point	/auctions/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	GetAuctions	
	Provided to	Marketplace GUI
	Description	Retrieve all the auctions.
	End-point	/auctions
	Protocol used	HTTP
	Allowed Methods	GET
	ProposeAuctionBid	
	Provided to	Marketplace GUI
	Description	Propose a bid for an active auction.
	End-point	/bids
	Protocol used	HTTP
	Allowed Methods	POST
	GetBids	
	Provided to	Marketplace GUI
	Description	Retrieve all the bids.
	End-point	/bids
	Protocol used	HTTP
	Allowed Methods	GET
	GetAuctionBids	
	Provided to	Marketplace GUI
	Description	Retrieve all the bids of an active auction.
	End-point	/bids/search/findAuctionBids
	Protocol used	HTTP
	Allowed Methods	GET
	SelectBestOffer	
	Provided to	Marketplace GUI
	Description	Select the best offer.
	End-point	/bids/{id}
	Protocol used	HTTP
	Allowed Methods	PATCH
	PublishEnergyContract	
	Provided to	Marketplace GUI
	Description	Publish a new energy contract.
	End-point	/contracts
	Protocol used	HTTP
	Allowed Methods	POST

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	GetEnergyContracts	
	Provided to	Marketplace GUI
	Description	Retrieve all the energy contracts.
	End-point	/contracts
	Protocol used	HTTP
	Allowed Methods	GET
	GetEnergyContract	
	Provided to	Marketplace GUI
	Description	Retrieve an energy contract.
	End-point	/contracts/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	UpdateEnergyContract	
	Provided to	Marketplace GUI
	Description	Save update to an energy contract.
	End-point	/contracts/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	DeleteEnergyContract	
	Provided to	Marketplace GUI
	Description	Save update to an energy contract.
	End-point	/contracts/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	AddCommunity	
	Provided to	Marketplace GUI
	Description	Add a new community.
	End-point	/communities
	Protocol used	HTTP
	Allowed Methods	POST
	UpdateCommunity	
	Provided to	Marketplace GUI
	Description	Save updates to a community.
	End-point	/communities/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	RemoveCommunity	
	Provided to	Marketplace GUI
	Description	Remove a community.
	End-point	/communities/{id}

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	Protocol used	HTTP
	Allowed Methods	DELETE
	GetCommunity	
	Provided to	Marketplace GUI
	Description	Retrieve a community.
	End-point	/communities/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	GetCommunities	
	Provided to	Marketplace GUI
	Description	Retrieve all the communities.
	End-point	/communities
	Protocol used	HTTP
	Allowed Methods	GET
	ProposeDistribution	
	Provided to	Marketplace GUI
	Description	Propose new coefficient distribution.
	End-point	/distributions
	Protocol used	HTTP
	Allowed Methods	POST
	GetDistribution	
	Provided to	Marketplace GUI
	Description	Retrieve a coefficient distribution.
	End-point	/distributions/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	GetDistributions	
	Provided to	Marketplace GUI
	Description	Retrieve coefficient distributions.
	End-point	/distributions
	Protocol used	HTTP
	Allowed Methods	GET
	VoteForDistribution	
	Provided to	Marketplace GUI
	Description	Vote for a coefficient distribution.
	End-point	/preferences
	Protocol used	HTTP
	Allowed Methods	POST
	GetResources	
	Provided to	Marketplace GUI

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	Description	Retrieve all the resources.
	End-point	/resources
	Protocol used	HTTP
	Allowed Methods	GET
	GetFilteredResources	
	Provided to	Marketplace GUI
	Description	Retrieve all the resources or selected ones on the basis of filters and/or by user id.
	End-point	/resources/search/filterResources
	Protocol used	HTTP
	Allowed Methods	GET
	RateResource	
	Provided to	Marketplace GUI
	Description	Rate a purchased resource.
	End-point	/ratings
	Protocol used	HTTP
	Allowed Methods	POST
	PurchaseAsset	
	Provided to	Marketplace GUI
	Description	Purchase an asset and save the related transaction information.
	End-point	/transactions
	Protocol used	HTTP
	Allowed Methods	POST
	GetTransactions	
	Provided to	Marketplace GUI
	Description	Retrieve all the transactions made by a Marketplace Participant.
	End-point	/transactions
	Protocol used	HTTP
	Allowed Methods	GET
Required Interface	**GetConnectors**	
	Provided by	Metadata Broker
	Description	Retrieve the list of the registered connectors and their provided resource catalogues.
	Login	
	Provided by	Marketplace Identity Manager
	Description	Login of a Marketplace Participant using username and password.
	Register	
	Provided by	Marketplace Identity Manager
	Description	Registration of a Marketplace Participant.

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	RemoveProfile	
	Provided by	Marketplace Identity Manager
	Description	Delete a Marketplace Participant's profile.
	UpdateProfile	
	Provided by	Marketplace Identity Manager
	Description	Update a Marketplace Participant's profile.

6.1.3 Identity Manager

The Identity Manager is a crucial component responsible for identity management and access control within the system. Its primary role is to guarantee that only authorized users can access resources and that they possess the necessary privileges. In the context of the Marketplace, it provides support for both the Marketplace GUI and the Marketplace Core.

Table 7: Identity Manger Identity Card

Identity Manager		
Framework Sub-System	Marketplace	
Responsibility	Identity and access management	
Provided Interface	**Login**	
	Description	Login to the Marketplace using username and password
	Provided to	Marketplace GUI, Marketplace Core
	End-point	/login
	Protocol used	HTTP
	Allowed Methods	POST
	Register	
	Description	Registration of a Marketplace Participant
	Provided to	Marketplace GUI
	End-point	/accounts
	Protocol used	HTTP
	Allowed Methods	POST
	Reset password	
	Description	Password recovery for a Marketplace Participant
	Provided to	Marketplace GUI, Marketplace Core
	End-point	/reset-password
	Protocol used	HTTP
	Allowed Methods	PUT
	Logout	
	Description	Logout to the Marketplace

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	Provided to	Marketplace GUI, Marketplace Core
	End-point	/logout
	Protocol used	HTTP
	Allowed Methods	POST
	GetProfile	
	Description	Retrieve a Marketplace Participant's account.
	Provided to	Marketplace GUI, Marketplace Core
	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	GET
	UpdateProfile	
	Description	Save updates for a Marketplace Participant's account.
	Provided to	Marketplace GUI, Marketplace Core
	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	PUT
	RemoveProfile	
	Description	Delete a Marketplace Participant's account.
	Provided to	Marketplace GUI, Marketplace Core
	End-point	/accounts/{id}
	Protocol used	HTTP
	Allowed Methods	DELETE

6.1.4 Marketplace Catalogue

Figure 41 provides an overview of the Marketplace Catalogue Entity-Relationship diagram.

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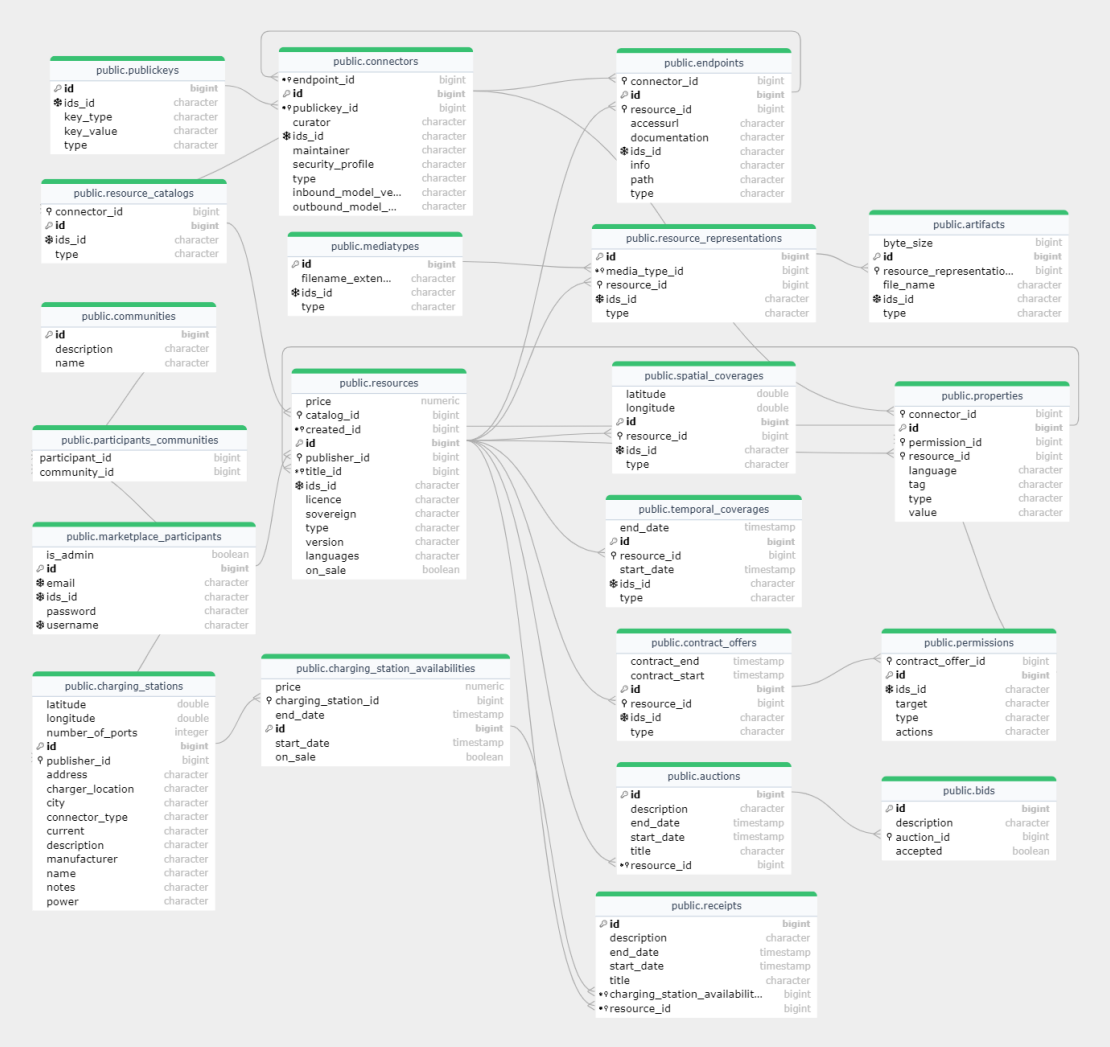

Figure 41: Marketplace Catalogue Entity-Relationship Diagram

6.2 IDS App Store

The App Store integrates into the IDS ecosystem as one of the building blocks. It interfaces with the IDS Connector and enables Data Apps to be distributed within the data space. Data Apps are reusable applications that are used to process or transform data before or after the data is exchanged. Users consider the App Store to browse the available Apps, verifying their requirements/ functionalities before downloading them. When users download Data Apps, they are instantiated in the user's IDS Connector instance. Users also consider the App Store to publish their own Data Apps so they can be used by other users. Moreover, users consider the App Store to fast prototype new Data Apps, focusing on the business-related data acquisition

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or data transformations, while ensuring key data acquisition and integration with the IDS connector environment is taken care of. Table 8 introduces the component identity card.

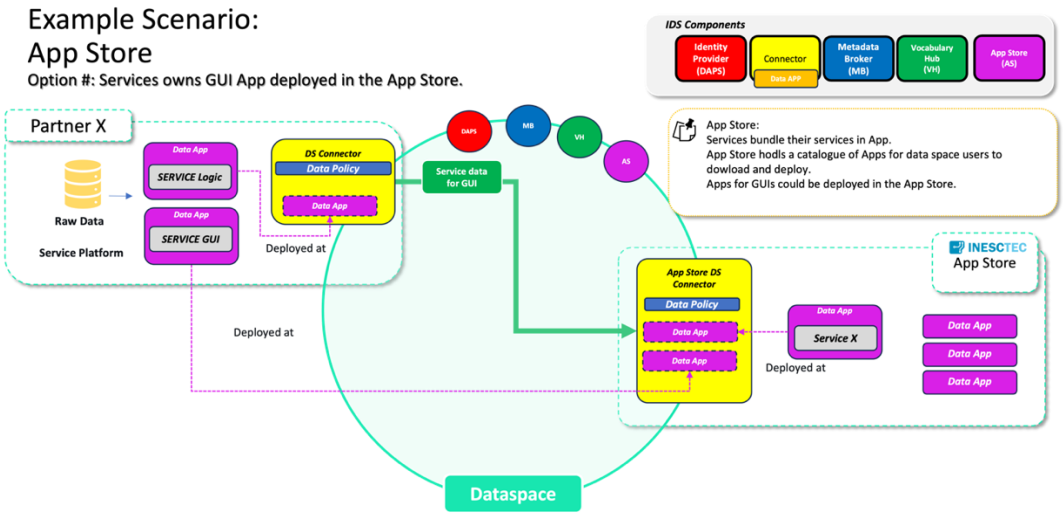

Figure 42: IDS App Store positioning towards the Data Space Components

Table 8: IDS App Store Identity Card

IDS App Store		
Framework Sub-System	Marketplace	
Responsibility	Distribute IDS Apps (Push and Pull), App Catalogue, Manage APP KPIs	
Required Interface	**Docker Registry Controller**	
	Pull App Docker Image	
	Description	Pulls one image from the docker registry
	Provided to	IDS App Store Frontend, Connector Controller
	End-point	/api/{vX}/app/images
	Protocol used	HTTP
	Allowed Methods	GET
	Push App Docker Image	
	Description	Pushes one image to the docker registry
	Provided to	IDS App Store Frontend, Connector Controller
	End-point	/api/{vX}/app/images
	Protocol used	HTTP
	Allowed Methods	PUT
	App Container Controller	

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	Download App	
	Description	Donwloads one app from the App Store container registry
	Provided to	App store frontend, IDS Connector
	End-point	/api/{vX}/app/image/{imageId}
	Protocol used	HTTP
	Allowed Methods	GET
	Get Apps	
	Description	Returns all apps available.
	Provided to	App store frontend
	End-point	/api/{vX}/app/all
	Protocol used	HTTP
	Allowed Methods	GET
	Get App Metadata	
	Description	Returns metadata for one specific app
	Provided to	App store frontend
	End-point	/api/{vX}/app/{appId}/metadata
	Protocol used	HTTP
	Allowed Methods	GET
	Toggle App Visibility	
	Description	Toggles the current visibility for this app.
	Provided to	App store frontend
	End-point	/api/{vX}/app/{appId}/toggleVisibility
	Protocol used	HTTP
	Allowed Methods	POST
	Edit app metadata	
	Description	Edit details for this app
	Provided to	App store frontend
	End-point	/api/{vX}/app/{appId}/edit
	Protocol used	HTTP
	Allowed Methods	POST
	Create App	
	Description	Create a record for a new App
	Provided to	App store frontend
	End-point	/api/{vX}/app/
	Protocol used	HTTP
	Allowed Methods	PUT
	Get My Apps	
	Description	Get Apps for the active user.
	Provided to	App store frontend

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	End-point	/api/{vX}/app/
	Protocol used	HTTP
	Allowed Methods	GET
	Delete App	
	Description	Remove one App and all its images
	Provided to	App store frontend
	End-point	/api/{vX}/app/{appId}
	Protocol used	HTTP
	Allowed Methods	DELETE
	Delete App Image	
	Description	Delete one specific Image from an App
	Provided to	App store frontend
	End-point	/api/{vX}/app/{appId}/image/{imageId}
	Protocol used	HTTP
	Allowed Methods	DELETE
	Authentication Controller	
	User Login	
	Description	Allows a user to enter the service
	Provided to	App store frontend
	End-point	/api/{vX}/users/login
	Protocol used	HTTP
	Allowed Methods	POST
	User Verification	
	Description	Verifies recently created accounts.
	Provided to	App store frontend
	End-point	/api/{vX}/users/verification
	Protocol used	HTTP
	Allowed Methods	POST
	Forgot Password	
	Description	Allows the user the claim a new password
	Provided to	App store frontend
	End-point	/api/{vX}/users/forgot-password
	Protocol used	HTTP
	Allowed Methods	POST
	Reset Password	
	Description	Allows a user to enter a new password after claiming it as forgotten
	Provided to	App store frontend
	End-point	/api/{vX}/users/reset-password

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	Protocol used	HTTP
	Allowed Methods	POST
	Change Password	
	Description	Allows the use to change its current password
	Provided to	App store frontend
	End-point	/api/{vX}/users/change-password
	Protocol used	HTTP
	Allowed Methods	POST
	Get User	
	Description	Retrieves the user profile details from one user.
	Provided to	App store frontend
	End-point	/api/{vX}/users/{userId}
	Protocol used	HTTP
	Allowed Methods	POST
	SignUp	
	Description	Creates one account for one user.
	Provided to	App store frontend
	End-point	/api/{vX}/users/signup
	Protocol used	HTTP
	Allowed Methods	POST
	Notification Controller	
	Create Notification	
	Description	Create a new notification
	Provided to	App store frontend
	End-point	/api/{vX}/notification
	Protocol used	HTTP
	Allowed Methods	PUT
	Get Notifications	
	Description	Retrieves all notifications
	Provided to	App store frontend
	End-point	/api/{vX}/notification/all
	Protocol used	HTTP
	Allowed Methods	GET
	Get Notification	
	Description	Retrieves one notification
	Provided to	App store frontend
	End-point	/api/{vX}/notification/{notificationId}
	Protocol used	HTTP
	Allowed Methods	GET

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	Delete Notification	
	Description	Removes one notification
	Provided to	App store frontend
	End-point	/api/{vX}/notification/{notificationId}
	Protocol used	HTTP
	Allowed Methods	DELETE
	Mark Notification as Read	
	Description	Toggle status of notification from read/unread
	Provided to	App store frontend
	End-point	/api/{vX}/notification/{notificationId}/toggleRead
	Protocol used	HTTP
	Allowed Methods	POST
	GetConnectors	
	Provided by	Metadata broker
	Description	Transfers information about all available connectors.
	Pull Docker Image	
	Provided by	Docker-Registry
	Description	Pulls an OCI image on an App
	Endpoint	/v2/{imageName}/blobs/{digest}
	Allowed Methods	GET
	Push Docker Image	
	Provided by	Provided by Docker-Registry
	Description	Pushes an OCI docker image for an App
	Endpoint	/v2/{imageName}/blobs/uploads
	Allowed Methods	POST
	Delete Docker Image	
	Provided by	Provided by Docker-Registry
	Description	Removes an OCI docker image from one App.
	Endpoint	/v2/{imageName}/blobs/{digest}
	Allowed Methods	DELETE
	Get Catalogues	
	Provided by	TNO Security Gateway (TSG connector
	Description	Retrieve the catalogue of a given connector
	Endpoint	/ui/api/description
	Allowed Methods	GET
	Get contract for asset	
	Provided by	TSG connector
	Description	Negotiate a contract with a connector for an asset
	Endpoint	/ui/api/artifacts/consumer/contractRequest

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	Allowed Methods	POST
	Get Self-description	
	Provided by	TSG connector
	Description	Retrieve the self-description of a given connector
	Endpoint	/selfdescription
	Allowed Methods	GET
	Upload Artifact	
	Provided by	TSG connector
	Description	Upload an artifact to one connector
	Endpoint	/ui/api/artifacts/provider
	Allowed Methods	POST
	Get Artifact after negotiation	
	Provided by	TSG connector
	Description	Retrieve artifact from a given connector after negotiation
	Endpoint	/ui/api/artifacts/consumer/artifact
	Allowed Methods	GET
	Auth user	
	Provided by	TSG connector
	Description	Authenticate User In connector
	Endpoint	/ui/api/auth/signin
	Allowed Methods	POST
	KPI Controller	
	Get all App KPIs (download metrics, upload metrics and releases)	
	Description	Retrieves the list with all KPIs
	Provided to	App Store Frontend
	End-point	/api/{vX}/kpi/all
	Protocol used	HTTP
	Allowed Methods	GET
	Get KPI by ID	
	Description	Retrieve one specific KPI
	Provided to	App Store Frontend
	End-point	/api/{vX}/kpi/get
	Protocol used	HTTP
	Allowed Methods	GET
	Post KPI	
	Description	Insert one KPI
	Provided to	App Store Frontend
	End-point	/api/{vX}/kpi
	Protocol used	HTTP

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	Allowed Methods	POST
	Post KPI Historic	
	Description	Insert readings for one specific KPI
	Provided to	App Store Frontend
	End-point	/api/{vX}/kpi/{kpi_Id}/historic
	Protocol used	HTTP
	Allowed Methods	POST
	Remove KPI	
	Description	Removes one specific KPI
	Provided to	App Store Frontend
	End-point	/api/{vX}/kpi/{kpi_Id}
	Protocol used	HTTP
	Allowed Methods	DELETE
	Get KPI History	
	Description	Retrieves all the history reading for one KPI
	Provided to	App Store Frontend
	End-point	/api/{vX}/kpi/{kpi_Id}/historic
	Protocol used	HTTP
	Allowed Methods	GET

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6.2.1 App Store Component diagram

The App Store component view is composed of several modules as depicts in Figure 43. A summary for each module is provided in Table 9.

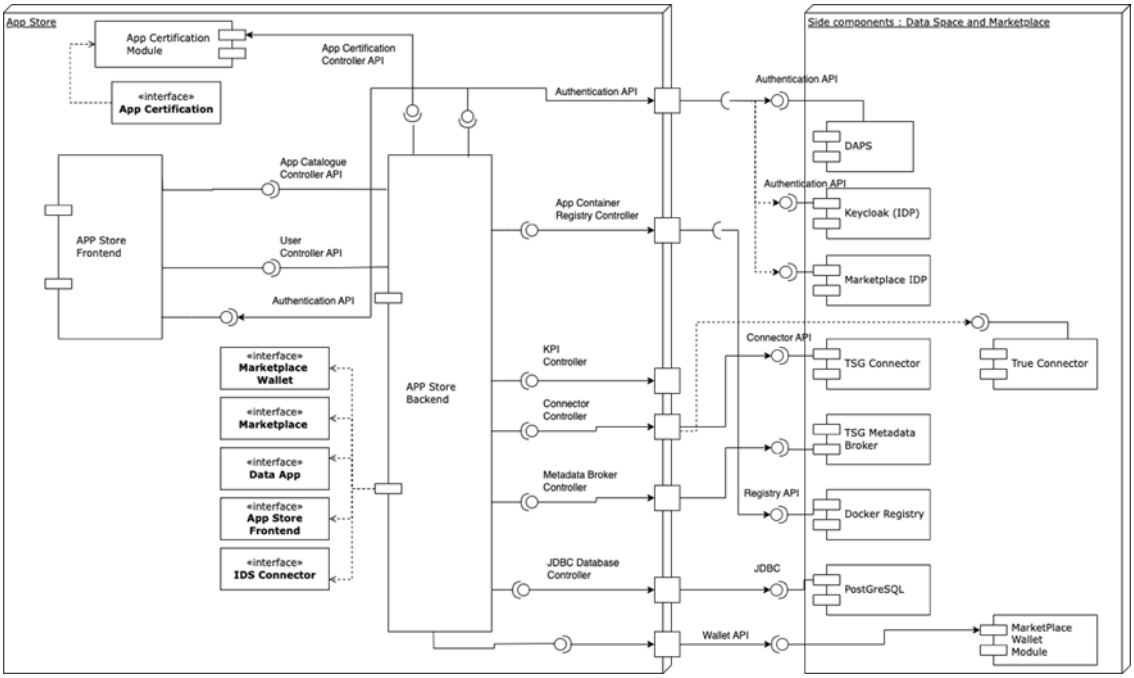

Figure 43: IDS App Store component view

Table 9: App Store Component detail

Component Detail	
Module Name	**Detail**
App Store Backend	Includes all the sub-modules that expose the identified interfaces and embody the business logic for managing data apps.
App Store Frontend	Includes a single page application all the view needed to export the information exported by the App Store Backend.
App Certification	Includes all the functionalities and exports a certification API to be adopted by an entity that certifies data apps.
Dynamic Attribute Provisioning Service (DAPS)	External module that handles identities in the IDS Dataspace (for connectors and organisations)
Keycloak	Standard, open-source Identity provider system
MarketPlace IDP	Identity provider system used in the Marketplace
TSG Connector	Dataspace compliant connector from TSG distribution.
True Connector	Dataspace compliant connector from ENG1 distribution.

[1] Together with possibly other participants.

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TSG Metadata Broker	Dataspace Metadata Broker needed to instantiate a Dataspace.
Docker Registry	External Registry for the App Images, rendered a OCI container Images.
PostGreSQL	Relational Database Management System for operational purposes.
MarketPlace Wallet	Cryptographic wallet used for token transactions in the MarketPlace.

6.3 Data Sharing and Barter Incentives Service

6.3.1 General description

The Data Sharing and Barter Incentives service enables data owners to engage in a dynamic data-sharing environment. Within this framework, they can share data and assess its value across various use cases. For ENERSHARE, two primary R&D lines are actively pursued to augment this service with new functionalities, namely:

Improve the existing collaborative forecasting engine with new algorithms.

In this use case, various agents can share historical (or future) time-series data such as power generation, weather measurements data or other features and/or acquire time-series forecasts improved by the collective pool of data available on the central platform (i.e., the Data Sharing and Barter Incentives Service). The economic value of data shared by one agent is inherently tied to its utility for other participants that also buy collaborative forecasts from this service.

New barter sharing functionalities.

In this use case (currently being developed within the scope of WP7), agents are interested in collaborating with their competitors but only if they provide and receive information with the same value (non-monetary incentive). The algorithms being developed for ENERSHARE aim to maximize the multilateral data exchange while ensuring each data owner provides and receives data with approximately the same value. Currently, these data-by-data exchange algorithms are in the process of integration with the central engine of the Data Sharing and Barter Incentives service and will be accessible in the forthcoming version of this service.

In addition to the ongoing research efforts mentioned earlier, we are also exploring the integration of an additional payment option into the Data Sharing and Barter Incentives service. The current version of the service relies on the robust IOTA Distributed Ledger Technology (DLT) infrastructure, which can be further explored at IOTA Official Website[2]. To expand our service's compatibility and reach, we are in the process of testing new software modules for integration with Ethereum. Specifically, we are utilizing the Sepolia network[3] (a testnet network in the

[2] https://www.iota.org/
[3] https://sepolia.etherscan.io/

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Ethereum environment) to explore the potential of making our service compliant with the ENERSHARE blockchain, which operates using an ERC20 token standard[4].

6.3.2 Component Diagram

The current version of the Data Sharing and Barter Incentives service is organised in a client-to-server architecture, which is compliant and greatly enhanced by Data Spaces architecture and available infrastructure. Figure 44 illustrates a general overview of the service integration with ENERSHARE Data Space.

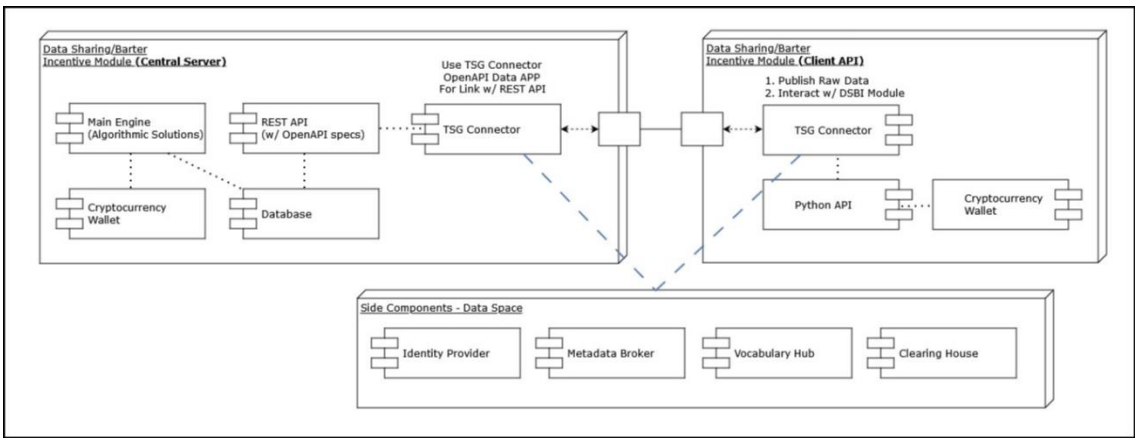

Figure 44: Data Sharing and Barter Incentives Module component view

As depicted by the figure, both central server and client API are composed by multiple software components. These systems interface with ENERSHARE Data Space via the TSG Connector, leveraging on existing Data APPs such as the TSG Openapi Data APP (https://tno-tsg.gitlab.io/docs/data-apps/existing/#openapi-data-app) which will expose the Data Sharing and Barter Incentives service RESTful API endpoints to the Data Space environment.

Table 10 provides a description of each component of the central server illustrated in Data Sharing and Barter Incentives Module component view.

Table 10: Data Sharing and Barter Incentives Module Component Detail

Component Detail	
Module Name	**Detail**
Main Engine	Data Sharing and Barter Incentives internal algorithms (e.g., collaborative forecasting and data-by-data exchange)
REST API	Data Sharing and Barter Incentives RESTful API to be used by external agents for client-to-server interface (mediated by the TSG Connector)

[4] https://docs.openzeppelin.com/contracts/4.x/erc20

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Cryptocurrency Wallet	Data Sharing and Barter Incentives cryptocurrency wallet, for secure store of value and token transactions.
Database	Data Sharing and Barter Incentives database, to accommodate user data and user assets (e.g., timeseries) data.
TSG Connector	Dataspace compliant connector from TSG distribution.

Table 11 provides descriptions for each component of the client API.

Table 11: Data Sharing and Barter Incentives Module Component Detail - Client API

Component Detail	
Module Name	**Detail**
Python API	Python API enabling users to easily communicate with the Data Sharing Barter Incentives central server REST API and perform cryptocurrency transactions via the available DLT options.
Cryptocurrency Wallet	Client cryptocurrency wallet, for secure store of value and token transactions.
TSG Connector	Dataspace compliant connector from TSG distribution.

6.3.3 Service central REST API

As previously described, the Data Sharing and Barter Incentives external interface consists of a RESTful API, crafted to enable secure data exchange and incentivized collaboration among multiple agents and a central server, where the execution of the collaborative forecasting and data-by-data exchange algorithms takes place. An overview of the service main endpoints (to be used by external clients) is provided below.

Table 12: Data Sharing and Barter Incentives Module - REST API detail

Data Sharing Barter Incentives SERVER – REST API	
Endpoint	**Detail**
/api/user/register	Method for new agent registration. An email is issued with validation link upon registration.
/api/token	Method for agents to get bearer token for REST API authentication
/api/market/wallet-address/	Method for agents to register the address for their cryptocurrency wallet
/api/market/session/	Method for agents to preview market sessions history
/api/market/bid/	Method for agents to register and preview their bids in the market.
/api/market/balance/	Method for agents to preview their current balance in the Data Sharing Barter Incentives Service platform
/api/data/raw-data/	Method for agents to post their raw timeseries data
/api/data/market-forecasts/	Method for agents to get collaborative forecasts data

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A detailed description of all available endpoints is overviewed in Table 12 and (and respective data models) is provided in the project Github, in the form of OpenApi Specifications, rendered as Swagger Docs that can be found in Section 7.5.

Note: This RESTful API is exposed to the ENERSHARE Data Space via the TSG Connector Open API Data APP. The TSG connector Data APP and the REST API are linked via the available OpenAI specification, provided above.

6.3.4 Client Python API

The Client Python API, provided by the Vendor, is engineered to run client interactions with the Central REST API. It serves as a user-centric interface that simplifies the complexities involved in managing cryptocurrency transactions and data exchanges. Designed for the ENERSHARE ecosystem, the Client Python API ensures that users can securely conduct data sharing and financial transactions within their own network infrastructure. It also abstracts the intricacies of blockchain/DLT transactions and data exchange protocols, specifically within the IDS Dataspaces framework, facilitating a more accessible development experience for users and developers alike.

Table 13: Data Sharing and Barter Incentives Module Client API

Data Sharing Barter Incentives CLIENT – REST API		
Method	**Endpoint**	**Detail**
POST	*/api/user/register*	Method to register the user in the Server and create a local cryptocurrency wallet.
POST	*/api/resource*	Method for creating a new resource in the Server.
GET	*/api/resource*	Method to list available resources in the server
GET	*/api/wallet/balance*	Method to retrieve the current wallet balance
POST	*/api/wallet/register/*	Method to associate the user wallet address with the user registered in the Server
GET	*/api/wallet/fund*	Method to top up wallet with funds from faucet
POST	*/api/session/bid*	Method for bid in open sessions
GET	*/api/session/bid*	Method to list bids in sessions
POST	*/api/data/measurements*	Method to send measurements

6.3.4.1 Functionality

REST API Communication: The Python API is specifically designed to communicate effectively with the Data Sharing and Barter Incentives Service's REST API. It simplifies the process of sending and receiving data, managing market sessions, handling bids, and accessing collaborative forecasts.

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Cryptocurrency Transactions: The Python API integrates a cryptocurrency wallet module, enabling secure and efficient transactions using the DLT infrastructure. Users can manage their wallets, perform transactions, and check balances directly through the provided REST client API without any required extensive knowledge in DLT/Blockchain technology.

Data Handling: The API offers functionalities for managing time-series data within the Data Sharing and Barter Incentives Ecosystem. It enables users to efficiently upload raw time-series data and access enhanced collaborative forecasts. This capability is pivotal for effective data management and utilisation in various applications.

IDS Dataspace Compliance: The Data handler component of the Client API is fully compliant with the IDS Dataspace protocol. The client API's design aligns with the TSG Connector's specifications compatible within the ENERSHARE Data Space. This compatibility is relevant for the smooth transfer, management, and usage of data across the ecosystem.

Integration with TSG Connector: The Python API interfaces directly with the TSG Connector included within the Client package through Docker, leveraging the capabilities of existing Data Apps. This integration enhances the user/developer experience by providing a comprehensive and cohesive interface for interacting with the Data Sharing and Barter Incentives Service. Importantly, the API's connection with the TSG Connector not only ensures compliance with the dataspace protocols but also abstracts the developer from the in-depth technical knowledge of the IDS Dataspace standard. This enriches the API's functionality by linking it with a wide range of data-related services and tools available within the ENERSHARE ecosystem.

The Client Package deployment will automatically include the connector infrastructure, while the "*Vendor REST API*" will be pre-configured with readily available sharing policies and dataspace contracts that can be used or customized to suit any specific requirements clients may have.

Note: While it is recommended to use the provided "*Client Package*", users have the flexibility to interface directly with the public Server REST API available. However, in doing so, users are responsible for incorporating the necessary logic associated with the Decentralized Ledger Technology (DLT) and adhering to the IDS Dataspaces protocol standards for data exchange.

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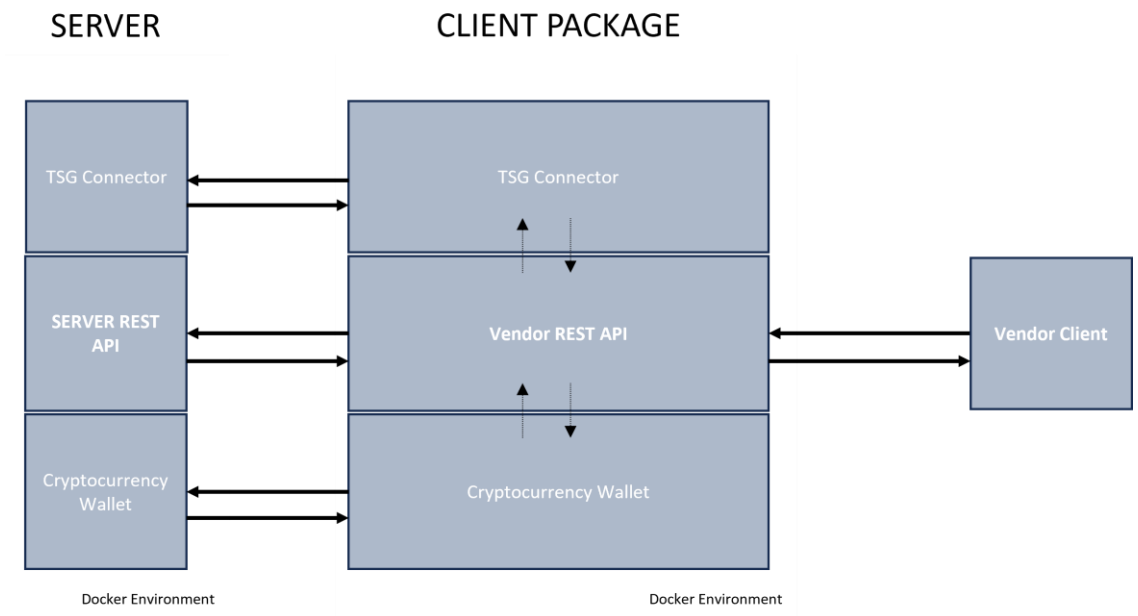

Figure 45: Integration diagram between internal components of the Data Sharing / Barter Module.

In the image presented above, the "*Client Package*" architecture is designed to operate within a secure and isolated environment within the client own controlled network, which is suitable for protecting sensitive operations like those involving automated cryptocurrency transactions and data exchanges – a middleware. The "Vendor Client" represents any custom-developed application by the user that interfaces with the Vendor-provided REST API client package.

The TSG Connector included in the "*Client Package*" ensures that interactions between the "*Vendor REST API*" and custom developments made in the "*Vendor Client*" adhere to the rules, security and trustworthiness requirements that can be initialized within the Client Package Docker deployment and configured through requests made to the "*Vendor REST API*" with

With the "*Client Package*" deployment the objective is to offer instant interoperability between the DLT/Blockchain and IDS Dataspace infrastructure and the underline policies required to participate within the scope of those technologies between the Data Sharing Barter Incentives Server and the end user.

A detailed description of all available endpoints is overviewed in Table 13 (and respective data models) and is provided in the project Github, in the form of OpenApi Specifications, rendered as Swagger Docs that can be found in Section 7.5.

Note: This RESTful API is exposed to the ENERSHARE Data Space via the TSG Connector Open API Data APP. The TSG connector Data APP and the REST API are linked via the available OpenAI specification, provided above.

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6.4 IDS Metadata Broker

As previously described in ENERSHARE deliverable D5.1 “Data Value Stack Alpha Version”, the Metadata Broker is a component that acts as a centralized catalogue of Connector Self-Descriptions in a Data Space, in accordance with the IDS-RAM 4[5]. It allows Providers to publish their resources so that they become discoverable by Consumers.

The Metadata Broker is a combination of a Broker Data App[6] and a TSG Core Container[7]. The Broker Data App implements the business logic to manage Self-Descriptions, while the Core Container represents the core component of the IDS ecosystem and supports message routing, IDS messaging, artifact handling, policy enforcement, container orchestration and embedded workflow management. The Metadata Broker stores the Connector Self-Descriptions in a Fuseki triple store[8], which can be queried using SPARQL queries.

Table 14 describes the interfaces of the Metadata Broker.

Table 14: Metadata Broker identity card

Metadata Broker		
Framework Sub-System	Marketplace	
Responsibility	Publication and discovery of resource Self-Descriptions.	
Provided Interface	**Publish Self-Description**	
	Description	Publication of a Self-Description
	Provided to	Data Space Connectors
	End-point	/infrastructure
	Protocol used	HTTP
	Allowed Methods	POST
	Query Self-Descriptions	
	Description	Query of Self-Descriptions
	Provided to	Data Space Connectors
	End-point	/infrastructure
	Protocol used	HTTP
	Allowed Methods	POST

[5] https://docs.internationaldataspaces.org/ids-knowledgebase/v/ids-ram-4/layers-of-the-reference-architecture-model/3-layers-of-the-reference-architecture-model/3_5_0_system_layer/3_5_4_metadata_broker
[6] https://gitlab.com/tno-tsg/broker/data-app/-/tree/master
[7] https://gitlab.com/tno-tsg/core-container
[8] https://jena.apache.org/documentation/fuseki2/index.html

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Required Interface	**N.A.**	
	Provided by	N.A.
	Description	N.A.

6.4.1 Metadata Broker message flows

As can be seen in Table 14, both the interfaces for publication and querying of Self-Descriptions use the same end-point with an HTTP POST method. However, they each consist of a different IDS message.

Please note that the exact message flows for the interface interactions are described in detail in the TNO Security Gateway Architecture & Documentation, which is also the source for Figure 46 and Figure 47[9].

The first interface interaction, the publication of a Self-Description at the Broker, contains a ConnectorUpdateMessage (sent to the Metadata Broker by the Connector) with its Self-Description as payload of the message. Publication is triggered by the Connector's Core at either a fixed time interval or a change event of the Connector's Metadata (Figure 46).

The second interface interaction, query of Self-Descriptions, is depicted in Figure 47. It consists of a QueryMessage with a SPARQL query as its payload. The response has a JavaScript Object Notation (JSON) – Linked Data (LD) format, since the intended result of a query is an Information Model object, in most cases

[9] https://tno-tsg.gitlab.io/docs/communication/message-flows/

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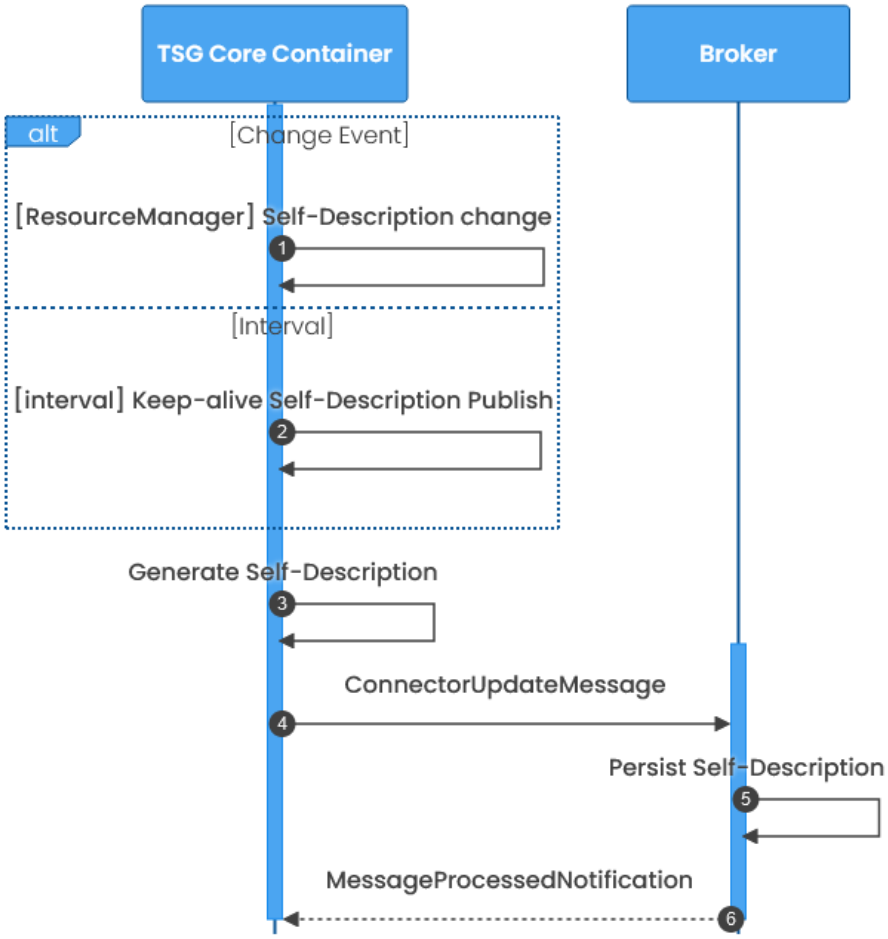

Figure 46: IDS Metadata Broker Self-Description publication[9]

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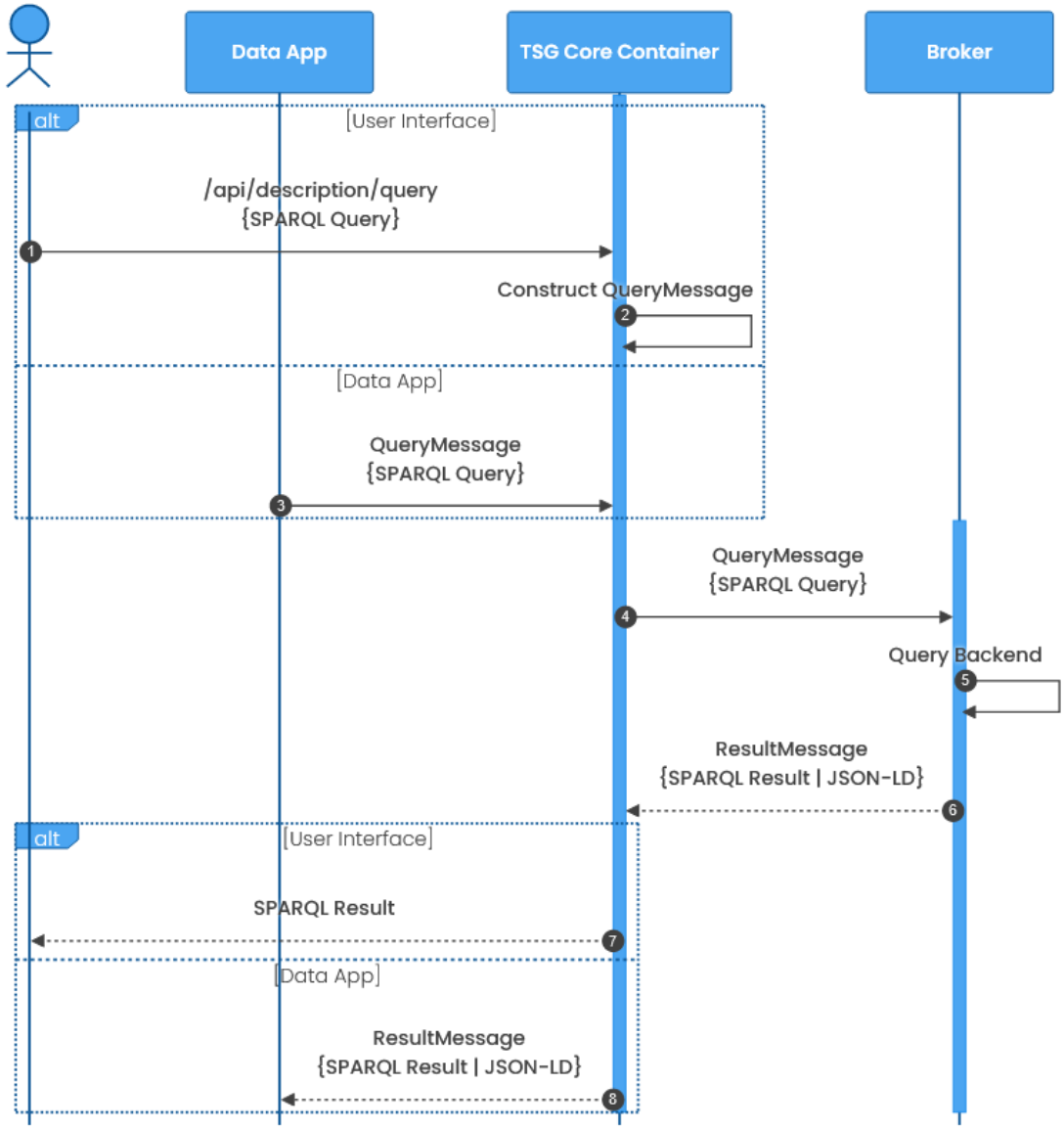

Figure 47: IDS Metadata Broker Self-Description query[9]

6.5 Clearing House

6.5.1 Clearing House overview

The IDS Clearing House consists of an IDS Connector and bases all its functions on a logging service that records information relevant for clearing and billing as well as usage control. The

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information sent to the Clearing House is defined in the Process Layer of IDS Reference Architecture Model (RAM).

The Clearing House is a central component that provides access to a trustworthy persistence store. Connectors may log messages in the Clearing House and read messages from it. Using the Clearing House is optional for all connectors, fact which necessitates proper configuration at connector's level. A valid DAPS token is required in all requests to the Clearing House.

Data in the Clearing House (CH) are stored encrypted and are practically immutable (CH Core Processor). There are multiple ways in which the Clearing House enforces Data Immutability:

- Using the Logging Service there is no way to update an already existing log entry in the database
- Log entries in the database include a hash value of the previous log entry, chaining together all log entries. Any change to a previous log entry would require rehashing all following log entries.
- The connector logging information in the Clearing House receives a signed receipt from the Clearing House that includes among other things a timestamp and the current chain hash. A single valid receipt in possession of any connector is enough to detect any change to data up to the time indicated in the receipt.

The figure below visualizes the Clearing House components focusing on the CH Core Processor and the service dependencies:

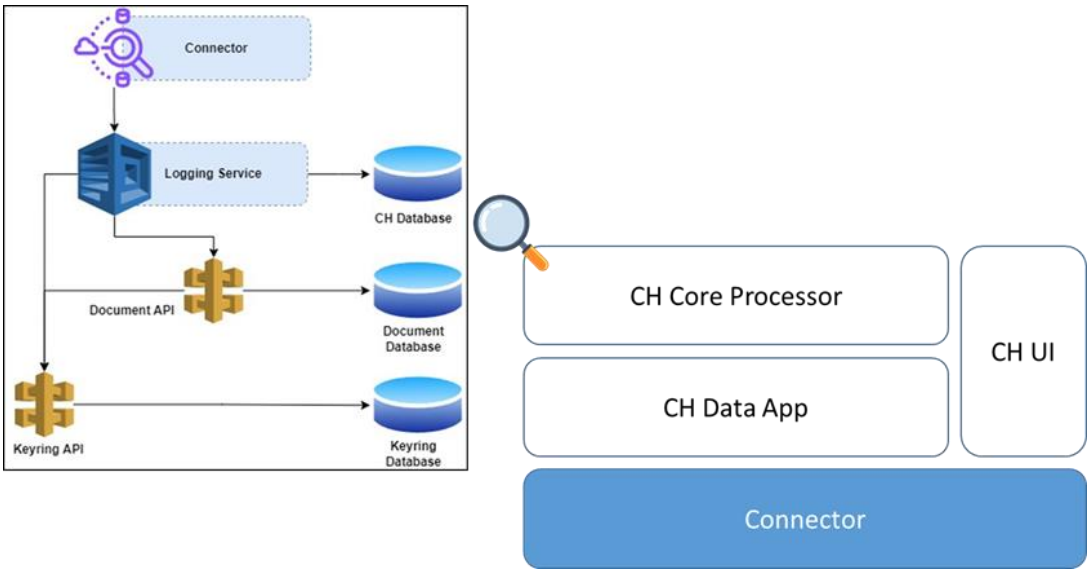

Figure 48: Clearing House Logging Dependencies Architecture

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6.5.2 Clearing House endpoints

The Clearing House endpoints and their documentation can be found available as a postman collection[10]. The endpoints are formulated adopting the ids information model addressing messages ProcessedNotificationMessage, LogMessage, RejectionMessage. Those can be summarized by the following table.

Table 15: CH Core Processor endpoint

Endpoint	Description
localhost:port/ch-processor/version	Optional: the IDS Clearing House, as any IDS Connector, should publish a self-description at its root
localhost:port/ch-processor/process	The endpoint for creating process in the Clearing House
localhost:port/ch-processor/messages/log	The endpoint for logging messages in the Clearing House
localhost:port/ch-processor/messages/query	The endpoint for querying messages from the Clearing House

6.6 Blockchain

6.6.1 ENERSHARE Token

The ENERSHARE Token Smart Contract is a ERC20[11] Token and is the official token for the ENERSHARE Marketplace. This smart contract allows the tokens of the system's users to be managed and enables them to buy or sell tokens. A percentage of the tokens exchanged is retained by the owner account of the smart contract.

Table 16: ENERSHARE Token Identity Card

ENERSHARE Token		
Framework Sub-System	Blockchain	
Responsibility	The ENERSHARE Token Smart Contract is a ERC20 Token and is the official token for the ENERSHARE Marketplace	
Provided Interface	**BuyTokens**	
	Description	Permit to add ENERSHARE tokens to the sender crypto wallet.

[10] https://www.postman.com/crimson-escape-67103/workspace/clearing-house/request/13905546-c4ba3b82-36f1-4131-bd08-4c1ba72a5cb6

[11] https://docs.openzeppelin.com/contracts/4.x/erc20

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	Provided to	Marketplace GUI
	End-point	buyTokens
	Protocol used	JSON-RPC
	Allowed Methods	buyTokens
	SellTokens	
	Description	Permit to remove ENERSHARE Tokens from the sender crypto wallet.
	Provided to	Marketplace GUI
	End-point	sellTokens
	Protocol used	JSON-RPC
	Allowed Methods	sellTokens
	TransferTokens	
	Description	Permit to move tokens from an account to another one, only for admin accounts.
	Provided to	ENERSHARE Transaction Processor
	End-point	transferTokens
	Protocol used	JSON-RPC
	Allowed Methods	transferTokens

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6.6.2 ENERSHARE Transaction Processor

The ENERSHARE Transaction Processor is a smart contract that handles transactions for the purchase and sale of marketplace assets. for each purchase/sale, it produces a receipt and notarize the information on the blockchain, thus maintaining a history of all transactions that have taken place.

Table 17: ENERSHARE Transaction Processor Identity Card

ENERSHARE Transaction Processor		
Framework Sub-System	Blockchain	
Responsibility	handles transactions for the purchase and sale of marketplace assets.	
Provided Interface	**BuyAsset**	
	Description	Permit to acquire an asset and create the receipe.
	Provided to	Marketplace GUI
	End-point	buyAsset
	Protocol used	JSON-RPC
	Allowed Methods	buyAsset
	RegisterAsset	
	Description	Permit to notarize an asset for sale.
	Provided to	Marketplace GUI
	End-point	registerAsset
	Protocol used	JSON-RPC
	Allowed Methods	registerAsset
	VerifyTransaction	
	Description	Verify the validity of a transaction notarized inside the blockchain.
	Provided to	Clearing House
	End-point	verifyTransaction
	Protocol used	JSON-RPC
	Allowed Methods	verifyTransaction
Required Interface	**TransferTokens**	
	Provided by	ENERSHARE Token
	Description	Move token from an account to another one.

6.7 ENERSHARE Data Value Chain Component diagram

Figure 49 provides an overview of the relationship through the ENERSHARE Data Value Chain components.

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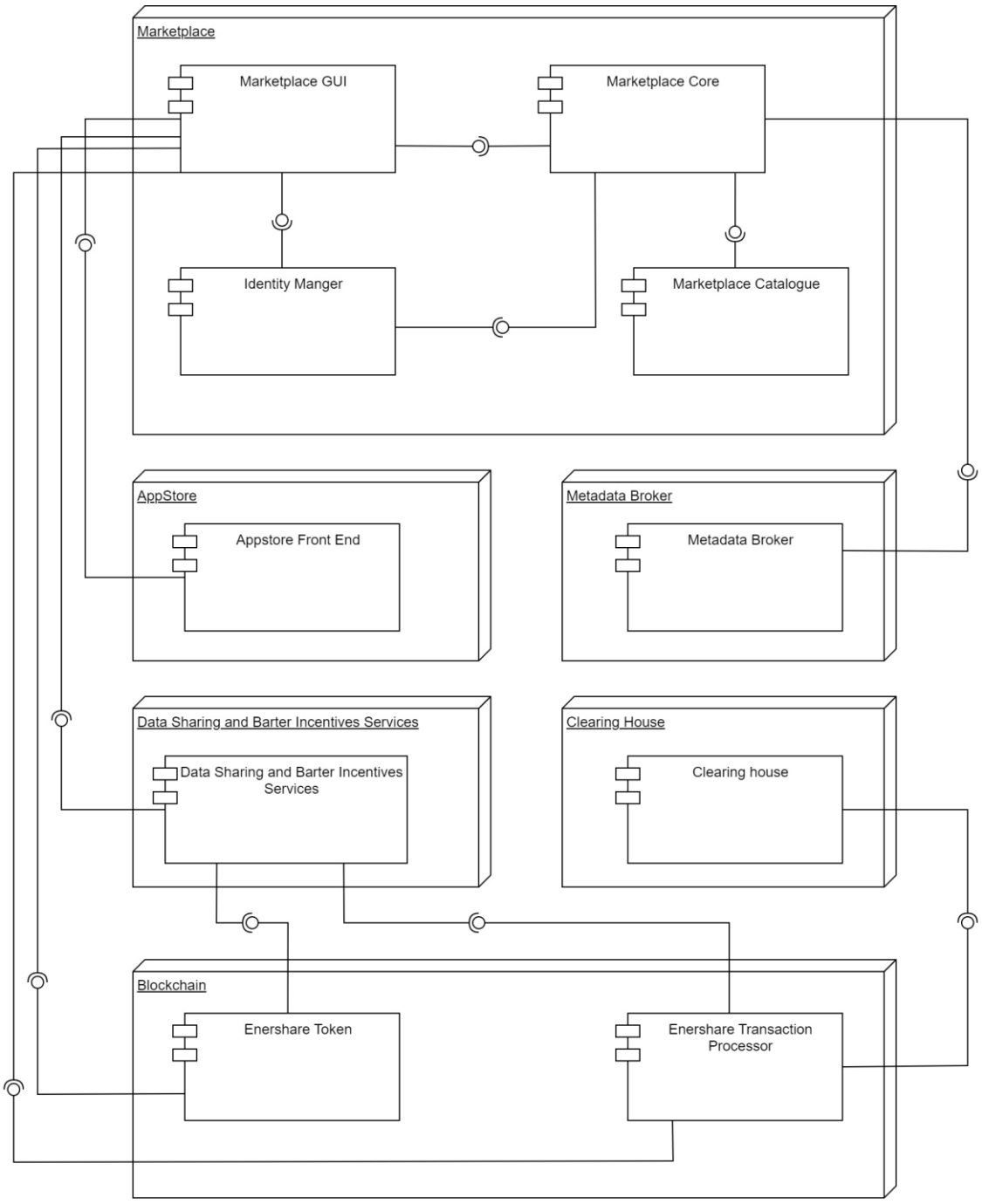

Figure 49: ENERSHARE Data Value Chain Component Diagram

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7 ENERSHARE Data Value Stack Beta Version

This section provides details on ENERSHARE Data Value Stack Beta Version software release. For each component, the source code repository, the status of the component, and what to expect for the final version is specified.

7.1 Identity Manager

This module utilizes an external identity and access management component, Keycloak[12], an open-source platform that provides a secure and flexible approach to handling authentication, authorisation, and user information.

The module takes advantage of Keycloak robust authentication functionality, which adheres to standards like OAuth 2.0, ensuring a secure environment and compliance with established security standards. Furthermore, the module harnesses Keycloak advanced authorisation management system to implement granular access controls, guaranteeing that users only receive the necessary access to resources.

In summary, the Identity Manager module, integrated with Keycloak, stands as a reliable and flexible solution that significantly enhances system security.

7.2 Marketplace GUI

At the time of writing this deliverable, the source code of the Marketplace GUI is available on the following GitLab repository: https://gitlab.com/dt-iot/enershare/marketplace-gui.

This module is a single page application build using React[13] Typescript[14]. The Marketplace GUI uses web3 libraries to interact with the blockchain using a wallet provider like MetaMask[15]. All the Marketplace components are built through Docker compose and so can be easily installed.

[12] https://www.keycloak.org/
[13] https://react.dev/
[14] https://www.typescriptlang.org/
[15] https://metamask.io/

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Table 18: Marketplace GUI development status

Component	Marketplace GUI
Alpha/ Beta Version Functionalities	Log in page Sign in page Data list page Data service list page Charging Station availabilities list page Publish new charging station availability asset Tokens management Page Buy and Sell tokens functionality Purchase Asset functionality Profile page
Final Version Functionalities	Publish new data asset Publish new data service asset Transactions history page Rating functionality Auction list page Create new auction Propose auction bid Energy community page Propose new energy coefficients functionality Energy contracts page

7.2.1 Marketplace Graphical User Interface

7.2.1.1 Marketplace GUI entry points

The entry points of the Marketplace GUI are two, the sign in page to create a new account (Figure 50) and the log in page (Figure 51).

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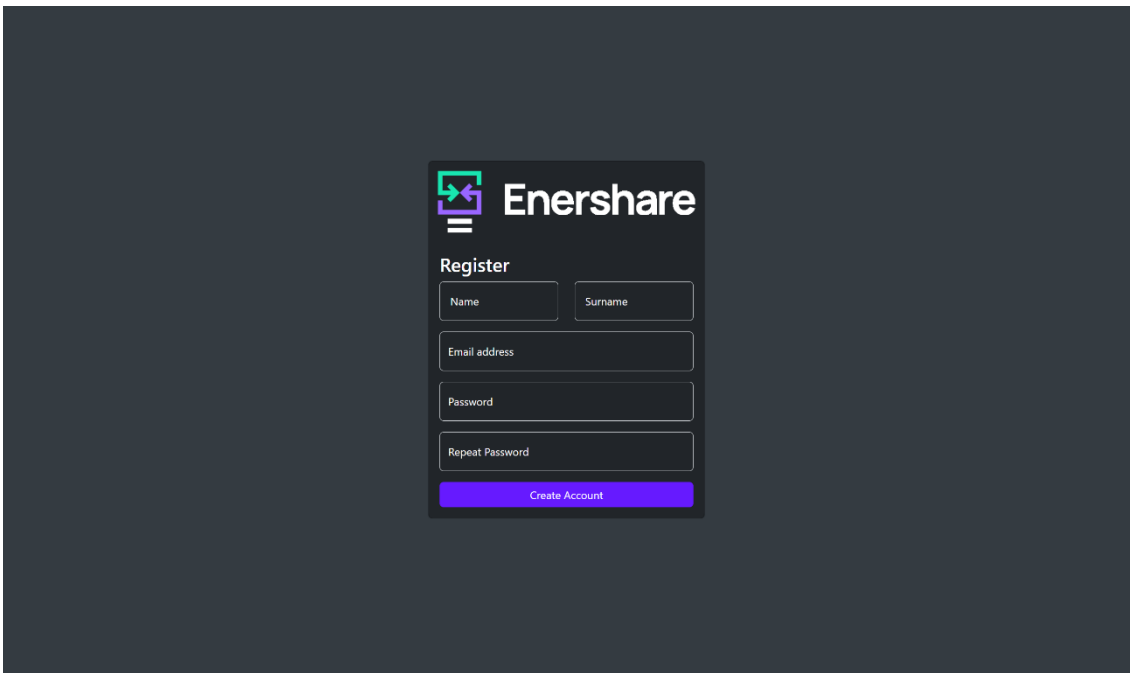

Figure 50: Registration Form

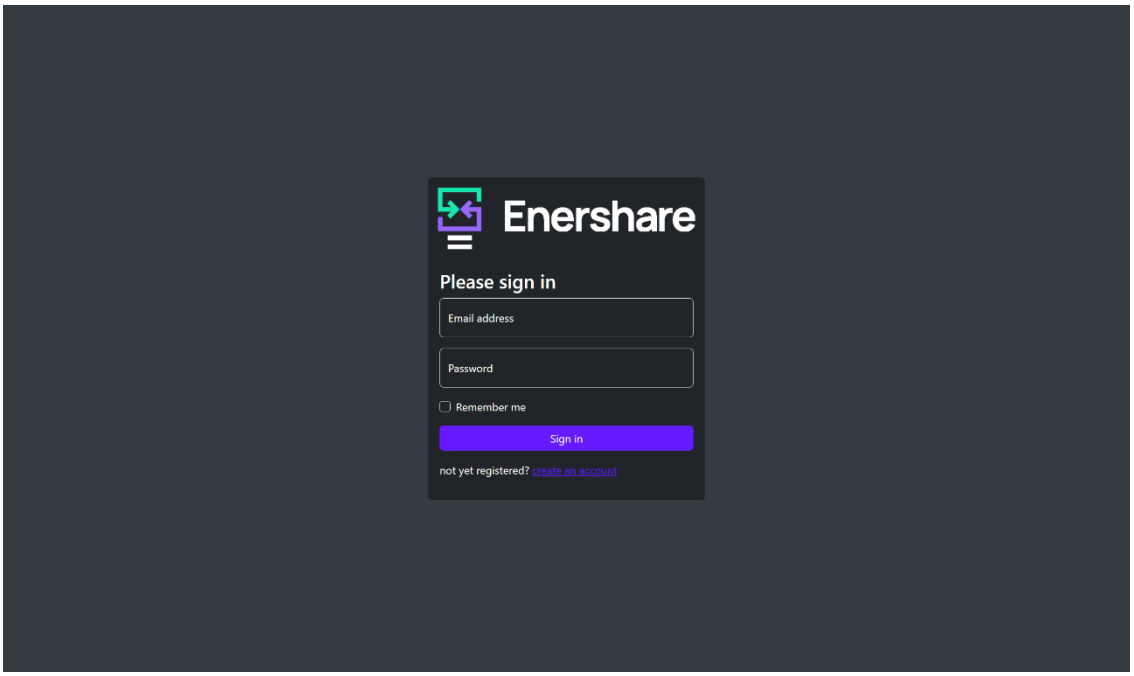

Figure 51: Login Form

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7.2.1.2 Data asset page

The Marketplace GUI is a single page application with a left sidebar menu that can be used to navigate through the application.

In the Data section (Figure 52) there are all the data assets, one for row, with some preliminary information like the title, the description, the publisher, the keywords, and the price. In each row there are two buttons, the left button opens a modal window (Figure 53) with more details regarding the asset selected, the right button allows to buy the asset.

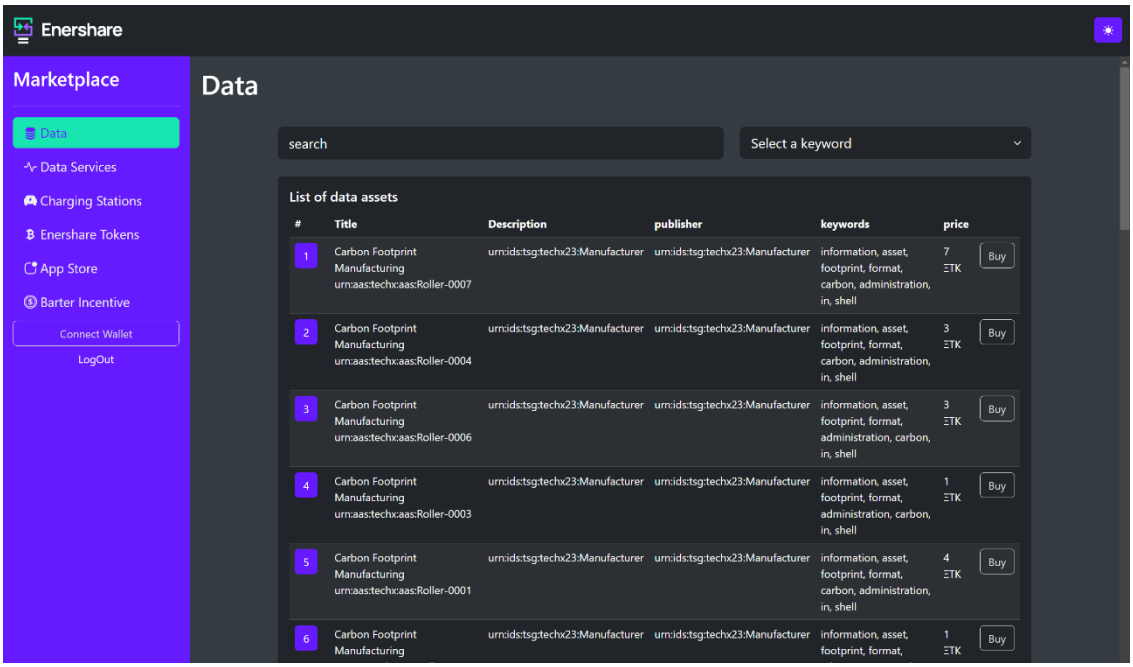

Figure 52: Data Asset Page

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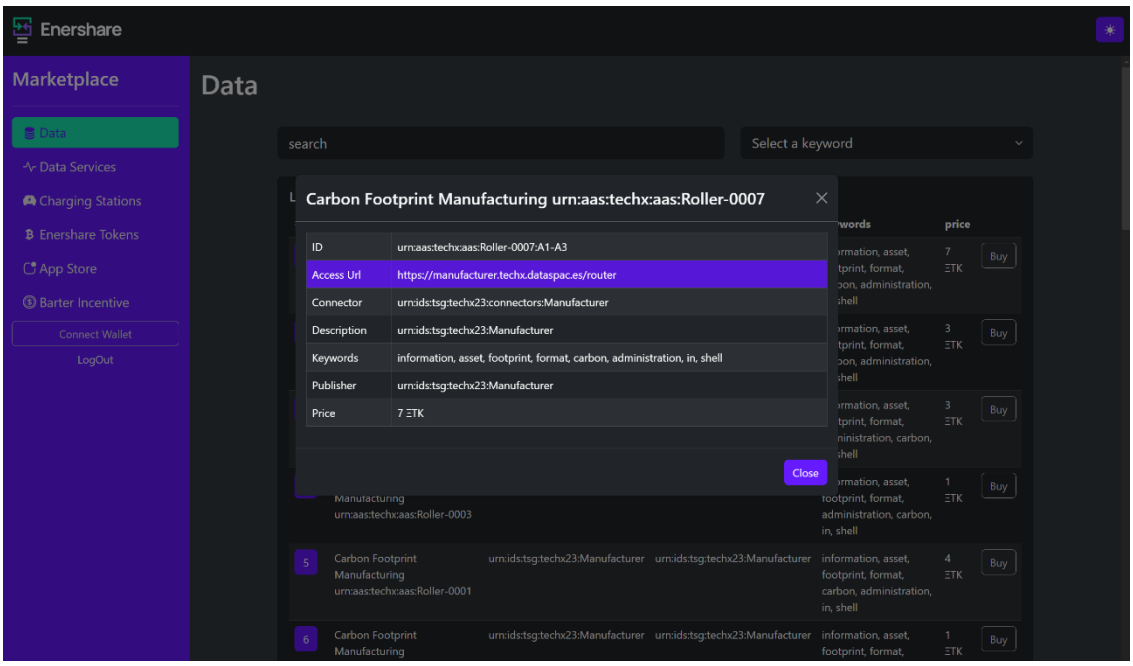

Figure 53: Data Asset Details Modal

7.2.1.3 Charging Station Availability Page

In the charging station availability section, there are all the charging station availability assets (Figure 54). Each row contains some preliminary information like the title, the description, the address, the keywords, and the price. In each row there are two buttons, the left button open a modal window (Figure 55) with more details regarding the asset selected, the right button allow to buy the asset.

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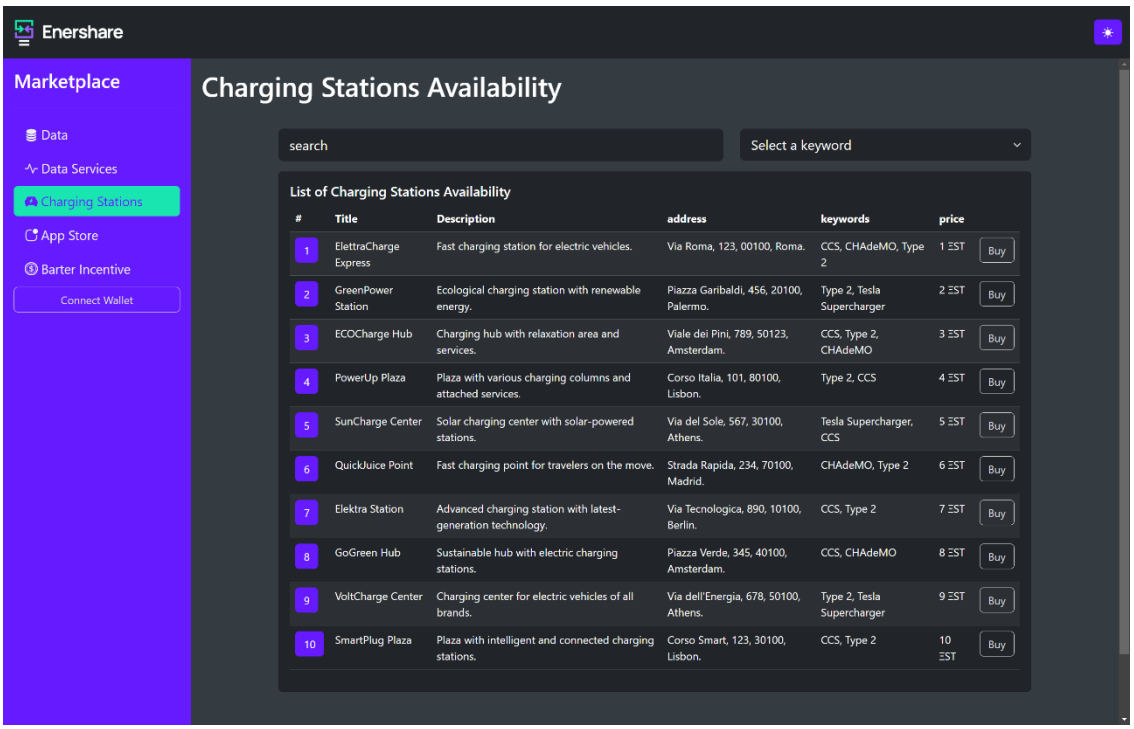

Figure 54: Charging Stations Availability Page

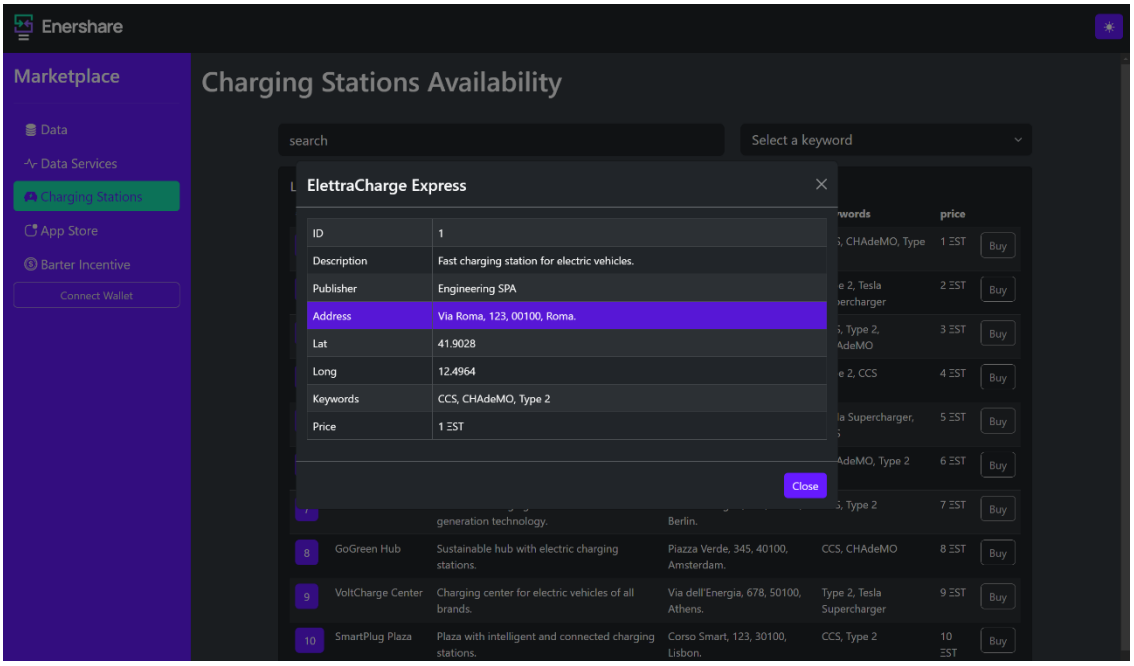

Figure 55: Charging Stations Availability Details Modal

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7.2.1.4 ENERSHARE Tokens page

The ENERSHARE Tokens (Figure 56) section allow the user to buy or sell ENERSHARE Tokens. The page shows the balance in ENERSHARE Tokens and in Ethers of the connected cryptocurrency wallet. Clicking on “buy tokens” button, the application opens a MetaMask dialog (Figure 57) with the amount of tokens to buy entered by the user. The user can decide to approve or deny the transaction. Subsequently, if the user has approved the transaction, MetaMask returns a success message and the corresponding amount of tokens (Figure 58) and ethers owned by the user is changed on the ENERSHARE Tokens page (Figure 59).

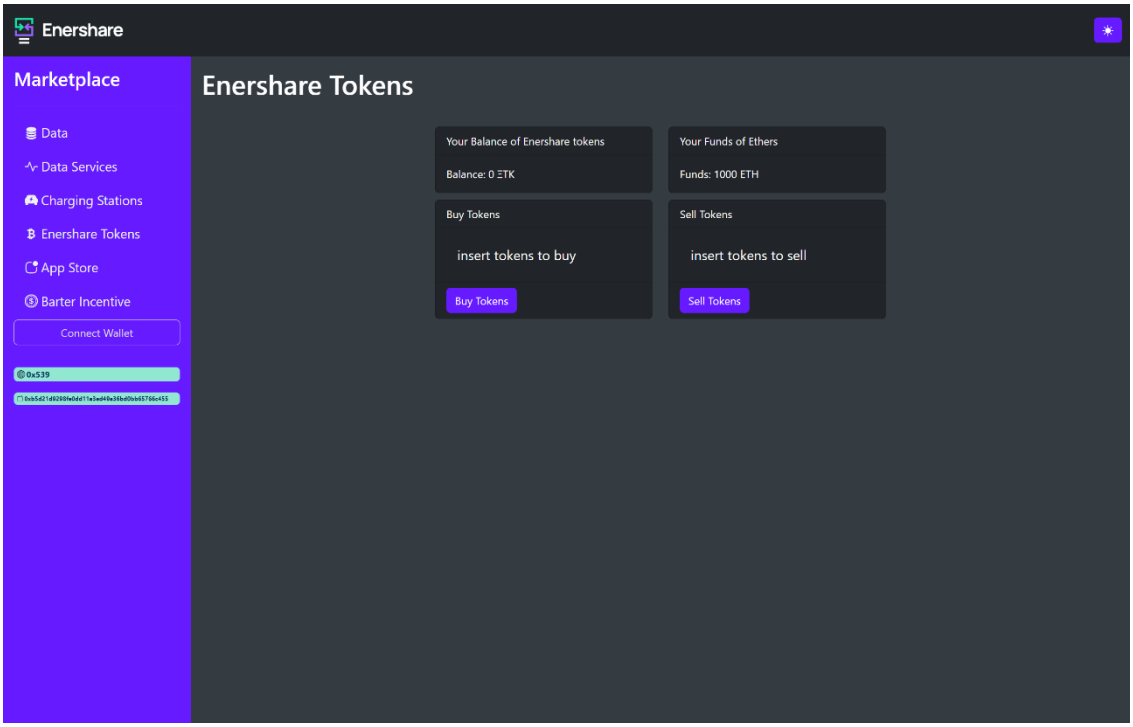

Figure 56: ENERSHARE Tokens Page

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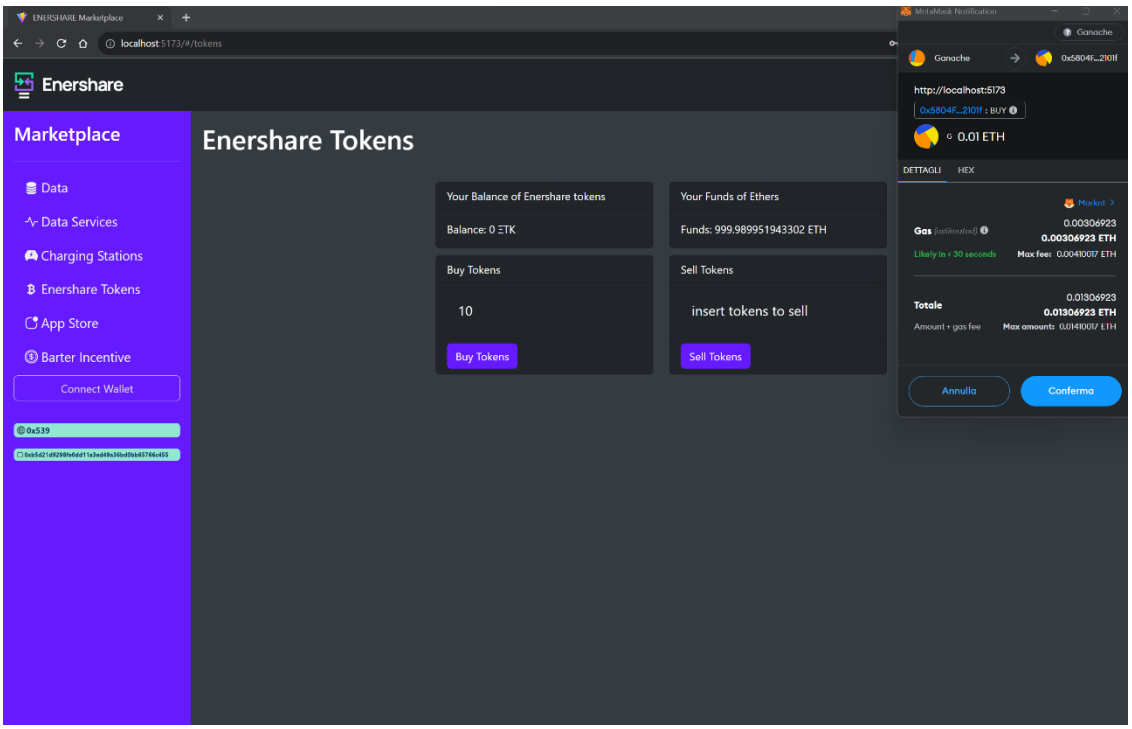

Figure 57: MetaMask Dialog

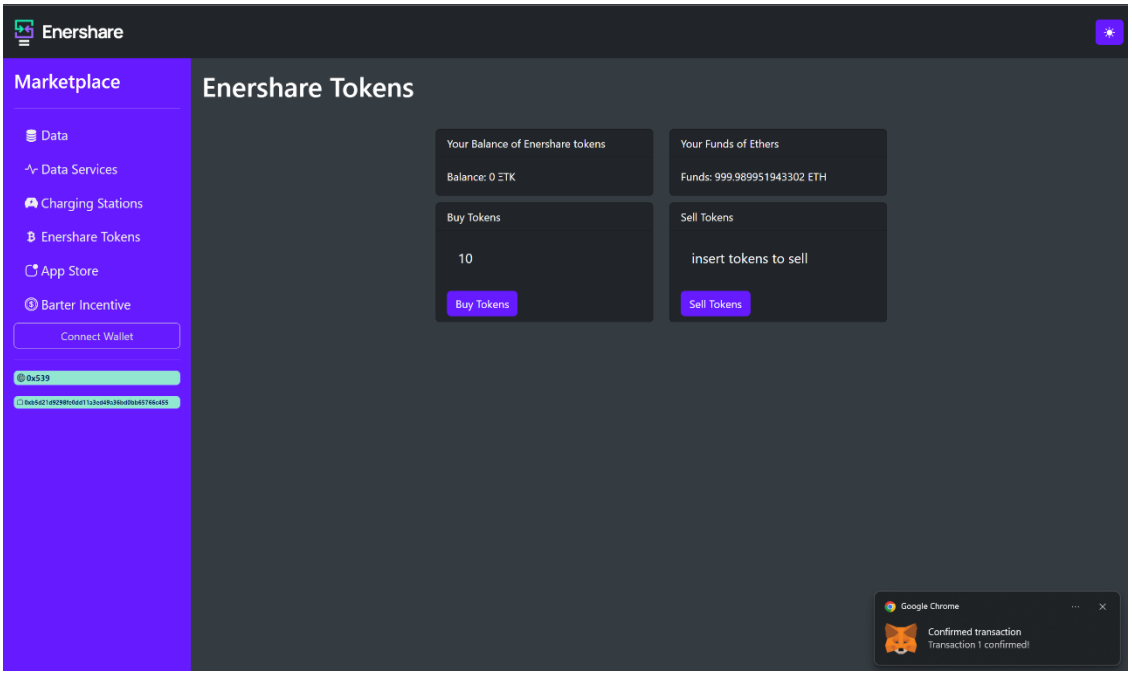

Figure 58: MetaMask Success Notification

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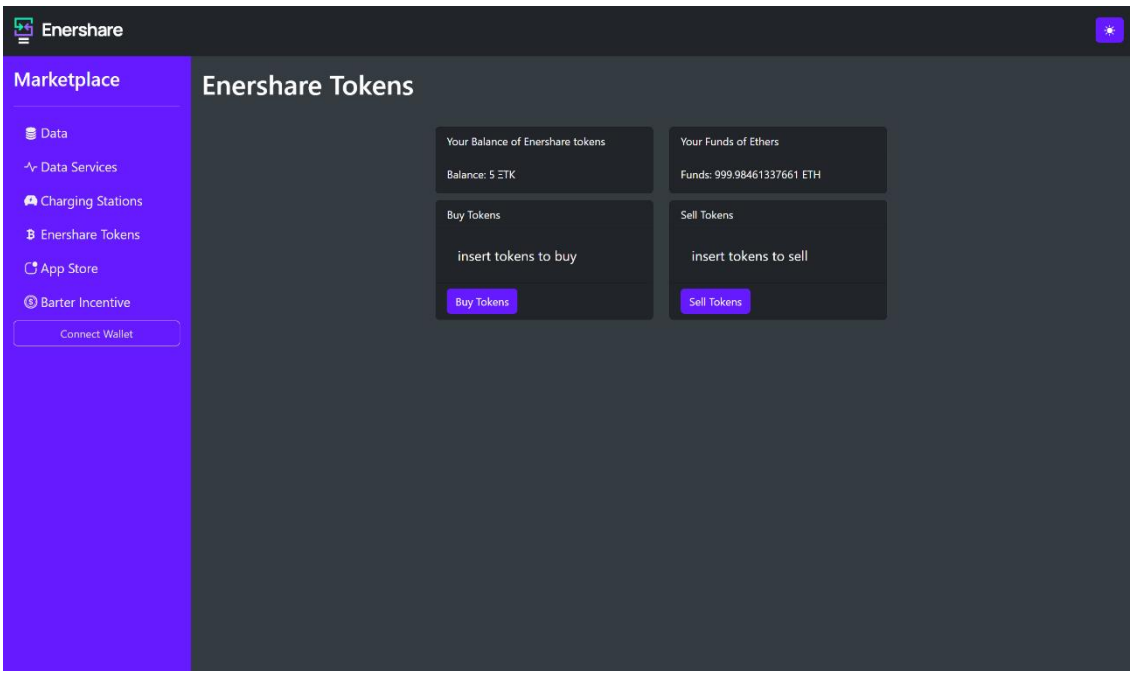

Figure 59: Balance updates

7.3 Marketplace Core

At the time of writing this deliverable, the source code of the Marketplace Core is available on the following GitLab repository: https://gitlab.com/dt-iot/enershare/marketplace-core.

For the installation and proper functioning of this module, two auxiliary components are required, namely the Identity Provider (Keycloak)[16] and an operational database (PostgreSQL)[17]. All the components are built using Docker compose and can therefore be easily started and managed.

All functionalities that are being implemented are listed in Table 19.

Table 19: Marketplace Core development status

Component	Marketplace Core
Beta Version Functionalities	Metadata Broker resource catalogue synchronisation Data/Data Service Resource management Data/Data Service Resource catalogue Market Participant management

[16] https://www.keycloak.org/
[17] https://www.postgresql.org/

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	Charging Station management Charging Station catalogue Integration with Identity Manager
Final Version Functionalities	Full integration with Metadata Broker Authorisation and authentication modules Market Participant's registration management Market Participant's profile management and validation Publish/Purchase Data/Data Service Resources Publish/Purchase Charging Station Availabilities Publish Energy Contracts Asset/Seller rating Transaction history Auctions Energy communities and distribution coefficients management

7.4 IDS App Store

The IDS App Store through its modules is available on the INESC-TEC Gitlab instance. This component is built from two main modules, namely the IDS App Store Backend and the IDS App Store Frontend. Other modules are required to sponsor the instantiation but configure satellite or *off-the-shelf* software modules such as: the Identity Providers, Operational database (PostGreSQL) and Docker-Registry. These are provided as part of the documentation for this component through its dependencies. Others build the cornerstone of ENERSHARE through its data space instantiation, namely: the DAPS, the connectors, and Metadata Broker, and the components described in this document.

Table 20: IDS App Store Component Repository

Component Repository Details	
Module Name	**Detail**
App Store Backend	Includes all the sub-modules that expose the identified interfaces and embody the business logic for managing data apps. https://gitlab.inesctec.pt/dataspaces/ids-app-store-backend
App Store Frontend	Includes a single page application all the view needed to export the information exported by the App Store Backend. https://gitlab.inesctec.pt/dataspaces/ids-app-store-frontend

At the time of writing this deliverable, the basic functionalities and part of the advanced features are completed. Details are provided in Table 21.

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Table 21: IDS App Store development status

Component	App Store
Alpha/ Beta Version Functionalities	Register Data Apps Remove Data Apps Integration with TSG Connector Publish Data App Publish Data App Metadata Search Data Apps
Final Version Functionalities	Build Data App Wizzard Integration in the MarketPlace Integration with the MarketPlace Wallet App Certification Decentralized Identity mechanisms from WP4

7.5 Data Sharing and Barter Incentives Module

The Data Sharing and Barter Incentives Module, including all its internal components and materials can be found in Table 22.

Table 22: Data Sharing and Barter Incentives Module Repository Details

Component Repository Details	
Module Name	**Detail**
Data Sharing and Barter Incentives Module – Central Server	Enables the secure exchange of data and incentivizes collaboration among multiple agents. https://cpes-power-and-energy-systems.github.io/data-sharing-barter-incentives-rest-api/
Data Sharing and Barter Incentives Module – Client API	Enables the market client to interface with the service, simplifying market interactions i.e., cryptocurrency and data exchange. https://cpes-power-and-energy-systems.github.io/data-sharing-barter-incentives-client/

Table 23: Data Sharing and Barter Incentives Module development status

Component	Data Sharing and Barter Incentives Module
Alpha/ Beta Version Functionalities	- Communications between Agents (client) and Central server (bids, data sharing) via HTTP requests; - Initial integration with TSG Connector for agents measurements data sharing via dataspace environment
Final Version Functionalities	- Update Central Server collaborative forecasting algorithms according to developments of WP7 - Central Server integration with Enershare Data Space Environment - Python API (client) integration with Enershare Data Space Environment - Integration with Enershare Marketplace

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7.6 IDS Metadata Broker

The IDS Metadata Broker is available on the TNO Gitlab as an open-source IDS connector implementation: the TNO Security Gateway (TSG). It consists of three modules: the (TSG) Core Container, the Broker App and a user interface (UI). The key functionality and repository of each module are described in Table 24.

Table 24: IDS Metadata Broker Component Repository

Component Repository Details	
Module Name	**Detail**
(TSG) Core Container	The central component of the Connector that enables secure and sovereign data sharing. It serves as a gateway for exchanging data with other components in a data space. Its primary objective is to ensure that mechanisms for identification, authentication, and authorisation are in place. https://gitlab.com/tno-tsg/core-container
Broker App	A Data App that is combined with the TSG Core Container to create the TSG Metadata Broker, where the Broker Data App provides the business logic. https://gitlab.com/tno-tsg/broker/data-app
Generic UI	A generic UI for the Metadata Broker, with configuration options to adjust look and feel. https://gitlab.com/tno-tsg/broker/generic-ui

Table 25 contains the functionalities of the Metadata Broker at the time of writing. The final version will involve alignment with WP4, regarding the Dataspace Protocol and decentralized identity mechanisms.

Table 25: IDS Metadata Broker development status

Component	**Metadata Broker**
Alpha/ Beta Version Functionalities	Register Self-Descriptions Remove Self-Descriptions Query Self-Descriptions
Final Version Functionalities	Alignment with Dataspace Protocol updates from WP4 Decentralized identity mechanisms from WP4

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7.7 Clearing House

The Clearing House (CH) will be made available via the European Dynamics' GitHub channel, it is maintained with public access. The source code and the documentation at the current stage of reporting is in progress.

Table 26: Clearing House Repository Details

Component Repository Details	
Module Name	**Detail**
CH Data App	The central component of the Clearing House integrated with the Clearing House database. This component is solely responsible for the integration of CH with the connector. It will be made available via the European Dynamics' GitHub channel https://github.com/european-dynamics-rnd/Clearing-House/
CH Core Processor	This component develops all the CH. It will be made available via the European Dynamics' GitHub channel https://github.com/european-dynamics-rnd/Clearing-House/

Table 27: Clearing House development status

Component	Clearing House
Alpha/Beta Version Functionalities	Basic (without encryption) logging mechanism Every logged processed is issued with a unique pid Connector validity through DAT Implementation of create process/log message/ query Integrated version with IDS (trusted) connector
Final Version Functionalities	Full integration with TSG connector Usage Contract validation Optional settlement features Hash implementation chaining together all log entries Single valid receipt to the involved participants for rehashing logs and data Integration of Keyring with document database

7.8 Blockchain

The Blockchain technology is at the basis of the implementation of the Marketplace. As architectural component, it consists of the Ethereum[18] based infrastructure and the smart contracts developed and deployed. Specifically, it will make a virtual currency available to all

[18] https://ethereum.org/it

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the other components for all the economical transactions. Another smart contract will allow the purchase of assets and the creation of receipts, persistently notarized into the Blockchain to ensure its immutability, non-repudiability and integrity. The two smart contracts are available in the following GitLab repositories:

- ENERSHARE token https://gitlab.com/dt-iot/enershare/enershare-token.
- Transaction Processor https://gitlab.com/dt-iot/enershare/transaction-processor

The two smart contracts are written in Solidity[19] and tested in the Ethereum based private chain Ganache[20] and in the public testnet Sepolia[21].

Table 28: Blockchain smart contracts Repository Details

Component Repository Details	
Module Name	**Detail**
ENERSHARE token	A standard ERC20 token provided with a customizable automatic mechanism for market operator remuneration. https://gitlab.com/dt-iot/enershare/enershare-token
Transaction Processor	A smart contract designed to be used for asset purchase, notarisation of the receipt and verification. https://gitlab.com/dt-iot/enershare/transaction-processor

Table 29: Blockchain smart contracts development status

Component	**Blockchain smart contracts**
Alpha/ Beta Version Functionalities	ENERSHARE Token smart contract v1 Buy ENERSHARE Token functionality Sell ENERSHARE Token functionality Transaction Processor smart contract v1 Proof of Existence (PoE) functionality
Final Version Functionalities	ENERSHARE Token smart contract v2 Transaction Processor smart contract v2

[19] https://soliditylang.org/
[20] https://trufflesuite.com/ganache/
[21] https://sepolia.dev/

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8 Conclusions

The ENERSHARE project aims to extend the concept of a Data Space, including shared capabilities and services aimed to facilitate and enable the access, sharing, and trading of energy related data assets (datasets, data services) among a variety of data infrastructures and actors.

This Deliverable 5.2 ENERSHARE Data Value Stack (Beta version) constitutes the intermediate results of the joint activities of WP5, namely Task 5.1 “Publication and data marketplace services”, Task 5.2 “Data usage accounting (Clearing House)”, and Task 5.3 “Tokenised Appstore marketplace and smart contracts for heterogeneous data vs energy services compensation”.

A static representation of ENERSHARE Data Value Stack architecture has been given in Chapter 2.

The functionality and behaviour of the ENERSHARE Data Value Stack as it is perceived by external users has been described in the Use Cases View in Chapter 3. Possible interactions of different type of users in the different use cases have been represented by using use case diagrams.

Consolidated functional and non-functional requirements have been provided in Chapter 4.

The dynamic aspects of the ENERSHARE Data Value Stack have been captured in the Process View in Chapter 5. Processes have been described in sequence diagrams.

The Development View, which is concerned with software management and illustrates the ENERSHARE Data Value Stack system from a programmer's perspective, have been provided in Chapter 6.

In Chapter 7, details on ENERSHARE Data Value Stack Beta Version software release have been given.

The Deployment View, which describes the technical infrastructure used to execute ENERSHARE Data Value Stack and the mapping of software building blocks to that infrastructure elements, and updates on software components of the ENERSHARE Data Value Stack will be provided in D5.3 “Data Value Stack (Final version)”.

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