D4.3: Data Interoperability Enablers

WP4 – Data-driven Technological Innovation

PLOUTOS

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Executive summary

The objective of this document is primarily to briefly describe the implementation of the Ploutos Interoperability Enabler and a scenario for deployment and testing of the PIE. Interoperability in Ploutos is realized using the common terms in the Ploutos Common Semantic Model (PCSM), which is also briefly introduced.

The PIE's main role within the Ploutos architecture is allowing existing information systems (named knowledge bases) to exchange data in an interoperable manner with other participants of the Ploutos data sharing network in terms of the PCSM. A Knowledge Base (KB) can be any service, application or platform that: 1) needs certain knowledge to function, 2) provides certain knowledge that others might need, or 3) both. To bridge the gap between the PCSM and a specific API of a knowledge base, the PIE contains a generic "Knowledge Mapper" (KM) component that needs to be fine-tuned for the specific API.

The testing scenario makes use of an existing Knowledge Base, namely the Gaiasense system. The PIE and the Gaiasense KM are available as Docker images and can be started using a docker-compose.yml file that instantiates the Docker containers for the PIE and the KM with the correct configuration parameters and ports. Once this is done, the Gaiasense KB and a Knowledge Interaction (KI) in terms of the PCSM can be registered at the PIE. Finally, an ASK can be fired onto the PIE to request data that complies to this KI upon which the PIE will instruct the KM to fetch the correct data from the Gaiasense API and return it as result bindings.

All the code and documentation are available on a Ploutos GitLab server at TNO:

https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler.

Request for access to this GitLab server can be done at info@ploutos-h2020.eu.

Future development steps include:

1. Simplifying the deployment process of the required components (PIE and KM). The integration of a python package-management system like PIP is foreseen.
2. Integrate fine-tuned access control mechanisms based on the role of data requestor and the type of requested information. An initial, straightforward implementation of this mechanism in the KM will be available first soon. A more extensive implementation in the reasoning engine of the PIE is scheduled afterwards. A complete implementation in the reasoning engine using an Ontology-Based Access Control mechanism is the ultimate goal.
3. Deploy and test the PIEs within the context of the various SIPs. This will allow the development team to get users feedback and extract additional technology requirements. Based on these additional features and code refinements will be implemented.

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1 Introduction

1.1 Project summary

The Ploutos project focuses on rebalancing the value chain for the agri-food system, transforming it into one that works for the benefit of society and the environment. The project will develop a Sustainable Innovation Framework (SIF) that follows a systems-based approach to the agri-food sector, building on the three Ploutos innovation streams: Behavioural Innovation; Sustainable Collaborative Business Model Innovation; and Data-driven Technology Innovation. Exploiting a history of significant agri-food projects and the respective ecosystems around these, the project deploys 11 innovative systemic Sustainable Innovation Pilots (SIPs), where, using a multi-actor approach, new innovative solutions and methodologies will be implemented, tested and assessed, and practical lessons learned will be extracted. The SIPs cover a large range of agri-food ecosystems, across 13 countries, covering arable, horticulture (both open fields and greenhouses), perennials and dairy production amongst others. In each case, behaviour change, collaborative business modelling and data-driven technological innovation will be integrated to deliver the most environmentally, socially, and economically sustainable solutions. A Ploutos Innovation Academy (PIA) is established as a vehicle for integrating the know-how, best practices and assessments developed across the project, principally derived from the SIPs. Ploutos includes 33 partners, 23 of them being end-users, representing all relevant actors in the food system, including farmers, food industry companies, scientists, advisors, ICT specialists and policy makers.

1.2 Document scope

This report escorts the first code release of the core data interoperability mechanism of the Ploutos project. The implementation of the data models and the data sharing functional components is based on the specifications provided by “D4.2 Data interoperability for the agri-food sector” and “D4.4 Initial agri-food data-sharing reference architecture”. The code and the respective documentation is available at:

https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler.[1]

1.3 Document structure

- **Chapter 1** summarises the project, places this deliverable in the overall structure of the project and presents the structure of this report.
- **Chapter 2** provides descriptions of the implemented components.
- **Chapter 3** presents future steps.

[1] A guest account is available to view the code and can be requested at info@ploutos-h2020.eu.

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2 Ploutos Interoperability Enablers software

The implementation and working of the Ploutos Interoperability Enabler is based on the Ploutos Common Semantic Model (PCSM). This model is first briefly described before introducing the Ploutos Interoperability Enabler and the deployment and testing activities needed to execute and use the PIE.

2.1 Ploutos Common Semantic Model

The implementation of the PCSM is based on the specifications that are described in [D4.2]. In [D4.2] the requirements on data capturing, storage and sharing for a subset of the Ploutos SIPs were formulated and a selection of common concepts and relations were derived. These common concepts and relations were modelled in a first version of the PCSM. The PCSM defines its own Ploutos namespace for the common concepts but reuses existing ontologies as much as possible and only defines new concepts and relations where needed. The PCSM has been defined to be used as the basis for semantic interoperability in data exchange via the Ploutos Data Sharing Platform within the Ploutos SIPs. As such, the PCSM will be used in that platform as the means to bridge semantic differences between the data models of the various organization in the agrifood supply chain. A short summary of the core design principles follows:

1. The PCSM is based on semantic technologies, like RDF and OWL, because it is currently the best way of intuitively defining formal semantics (OWL) and provides the flexibility for modular reuse of existing data models or extend them.
2. The PCSM should be a small, core model that covers the main common concepts in the agrifood domain ranging from the farm via the supply chain to the consumer.
3. The concepts and relations for the PCSM are selected from the requirements of the SIPs. When most of the SIPs require a certain concept, it is part of the PCSM, e.g., the concepts farm, farmer, parcel, and soil that are required by most of the SIPs.
4. Existing ontologies that already define the required concepts are reused by the PCSM as much as possible. Nonetheless, we define a specific Ploutos namespace for the PCSM, namely https://www.tno.nl/agrifood/ontology/ploutos/common# prefixed as *ploutos*, that is used to inherit the concepts of these existing ontologies.
5. Existing ontologies are only reused when they have a clear formal OWL structure that is publicly available and accessible or downloadable in a .owl, .ttl or .rdf format, for instance at the W3C website or the AgroPortal (http://agroportal.lirmm.fr). Consequently, no reuse of proprietary ontologies of different projects will be done.
6. Vocabularies and thesauri/taxonomies that simply define and list a large set of hierarchical terms will not be reused in the PCSM other than using the *rdf:isDefinedBy* property to point to the definition of the concept in a vocabulary.
7. Reuse of existing concepts and properties in the PCSM is done using the *rdfs:subClassOf* or *owl:equivalentClass* construct for concepts and the *rdfs:subPropertyOf* construct for properties.
8. Concepts and properties that are required by the PCSM but are not yet part of existing ontologies will be added as concepts and properties to the *ploutos* namespace.
9. The well-known ontology design pattern called Part-Observation-Property pattern is used in which as much as possible concepts are expressed in a *ploutos:partOf* relation with another concept and measurements are defined as observations of observable properties of features of interest. More details on this pattern can be found in the following subsection.

The PCSM reuses the ontologies that are listed in Table 1.

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Table 1. Existing ontologies reused in the PCSM.

Prefix	Name	Base URI
ENVO	Environment Ontology	http://purl.obolibrary.org/obo/envo.owl#
s4agri	SAREF4AGRI	https://saref.etsi.org/saref4agri/
SSN	Semantic Sensor Network	http://www.w3.org/ns/ssn/
SOSA	Sensor Observation Sample Actuator	http://www.w3.org/ns/saso/
OM	Ontology of units of Measure	http://www.ontology-of-units-of-measure.org/resource/om-2/
Weather	BIMERR Weather Ontology	https://bimerr.oit.linkeddata.es/def/weather#

Besides the common concepts of the PCSM there is a need for SIP-specific concepts and relations that only are of interest for data sharing within the SIP. These concepts can be modelled using a SIP-specific ontology that imports and reuses the PCSM. Future extensions of the PCSM are guided by new requirements from the various SIPs or new requirements that pop up from the innovative activities in Ploutos WP2 and WP3 work packages. With respect to the latter, concepts related to behaviour change to support better sustainability or concepts related to business model aspects could be added. In that sense, sustainability can be expressed in terms of social, environmental, and economic parameters. Each of these can be expressed in terms of concepts related to all the stakeholders in the agrifood supply chain, such as water usage, pesticides, poorly paid labor, etc.

Software verification: In order to support this continuous development process, the PCSM is maintained in a collaborative workspace on a gitlab server. For each SIP, an extended version of the PSCM is maintained allowing the necessary definitions and extensions of the required information concepts. The first release of the PCSM is formulated in .ttl format and it is available at:

https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler/-/tree/master/ploutos-common-semantic-model

The code repository is not yet publicly available and access credentials are provided on demand. For more details and request for access please contact: info@ploutos-h2020.eu

2.2 Ploutos Interoperability Enabler

The core component that aims to enrich existing systems with data sharing functionalities is the Ploutos Interoperability Enabler (PIE). The PIE is a stand-alone service and from a deployment perspective is hosted within the underlying system's administrative cyber premises (e.g. FMIS, DSS, data collection service). It is a trusted service while the overall functionality and data sharing can feasibly be controlled by the administrators of the system. The PIE consists of a set of functional components which aim to extend the functionality of existing systems with specific features. The PIE's main role within the Ploutos architecture is allowing existing information systems (knowledge bases) to exchange data in an interoperable manner with other participants of the Ploutos data sharing network in terms of the PCSM. A "Knowledge Mapper" KM can be any service, application or platform that: 1) needs certain knowledge to function, 2) provides certain knowledge that others might need, or 3) both. Examples of Knowledge Bases are a service that provides a forecast of local temperatures when given a GPS location, an app that gives insight into the supply chain of tomatoes, a platform that manages different sensors on a farm or a database that stores a farmer's planning.

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A functional component diagram of the PIE along with the potential interactions with external systems is presented in Figure 1. Detailed specifications of PIEs design principles and functional components are available in [D4.4]. The PIE uses the PCSM as the “common language” to facilitate interaction and data sharing among the various heterogeneous systems.

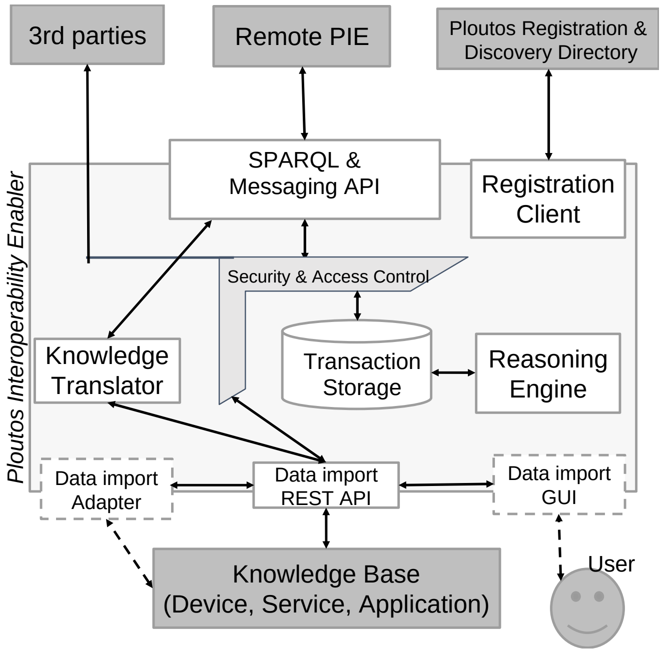

Figure 1. Functional component diagram of the Ploutos Interoperability Enabler

An important component towards the data sharing realization is the KM. This component enables interoperability at semantic level through a data translation service that realizes the conversion of data streams provided by the hosting system to the PCSM and vice-versa. The translation functionality of the KM must be adapted according to the custom data model and API of the hosting system. The KM acts as a translator and API mediator customized to the information system’s specifications that it is deployed at.

Software verification:

- The first release of the PIE source code is available at Ploutos code repository: **https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler/-/tree/master/smartconnector-master**

The PIE’s source code is useful only to technical experts that are willing to get more insights on how the overall implementation is realised. System administrators that want to enable data interoperability of their systems can use the dockerised version of the PIE. More instructions on this are provided at the following section “2.3 Deployment and Testing”.

- The implementation code of a knowledge-mapper tailored to the Gaiasense smart farming system specifications is available here: **https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler/-/tree/master/Gaiasense-km**

It should be noted that the Gaiasense implementation of the KM stands as an example. For information systems that want to enable data sharing, a KM tailored to the underlying system’s API must be implemented. Instructions on how to configure a Knowledge Mapper (KM) are provided in the

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respective README.md file:
https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler/-/blob/master/Gaiasense-km/README.md

The code repository is not yet publicly available and access credentials are provided on demand. For more details and request for access please contact: info@ploutos-h2020.eu.

2.3 Deployment and testing

In general, a system that aims to utilise the PIE needs to perform the following steps:

1. Implement and configure a customised KM
2. Download and execute a PIE that is bound with the KM of step 1

To make the deployment process easier both the PIE and Knowledge Mapper are available as docker images. The implemented, customised functionality of the knowledge mapper is appended to the core functionality through the proper configuration parameters.

Detailed descriptions on how to download and deploy a single PIE along with utilisation examples are available at the following link:

https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler/-/blob/master/testing/README.md

The current testing scenario includes the following:

1. Instantiate a PIE and the Gaiasense KM.
2. Register the Gaiasense Knowledge Base to the PIE.
3. Register knowledge interactions at the PIE for data retrievable from the Gaiasense API.
4. Ask the PIE for data, the PIE will query the Gaiasense API and will provide the response back.

From a technical perspective the following steps are realised:

- A Docker engine v20.10.8 or higher is required.
- Docker images will be used for the execution of the scenario, one for the PIE and one for the KM.
- A docker-compose.yml is used to start both images with the correct environment variables and port mappings.
- The credentials for accessing the Gaiasense API will be configured through the "env." file found inside the git clone.
- The “docker-compose up” command will start the images and will result in the instantiation of 1 PIE and 1 KM.
- Upon instantiation, the PIE will start listening for requests on port 8280.
- The test scenario can then start with the registration KB, registration of a Knowledge Interaction and execution of an ASK request as described in the readme.

Given that the testing process is subject to updates the presented steps are only indicative. Please follow the directions provided in README.md:

https://ci.tno.nl/gitlab/ploutos/data-interoperability-enabler/-/blob/master/testing/README.md

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3 Future steps

Future implementation steps include:

1. Simplifying the deployment process of the required components (PIE and KM). The integration of a python package-management system like PIP is foreseen.
2. Integrate fine-tuned access control mechanisms based on the role of data requestor and the type of requested information. An initial, straightforward implementation of this mechanism in the KM will be available first soon. A more extensive implementation in the reasoning engine of the PIE is scheduled afterwards. A complete implementation in the reasoning engine using an Ontology-Based Access Control mechanism is the ultimate goal.
3. Deploy and test the PIEs within the context of the various SIPs. This will allow the development team to get users feedback and extract additional technology requirements. Based on these additional features and code refinements will be implemented.

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4 References

[D4.2] Ploutos Deliverable "D4.2 Data interoperability for the agri-food sector", 2021

[D4.4] Ploutos Deliverable "D4.4 Initial agri-food data-sharing reference architecture", 2021

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