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ONTO-DESIDE

DELIVERABLE

D4.4: Open Circularity Platform

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Project information

Project summary

Circular economy aims at reducing value loss and avoiding waste, by circulating materials or product parts before they become waste. Today, lack of support for sharing data in a secure, quality assured, and automated way is one of the main obstacles that industry actors point to when creating new circular value networks. Together with using different terminologies and not having explicit definitions of the concepts that appear in data, this makes it very difficult to create new ecosystems of actors in Europe today. This project will address the core challenges of making decentralized data and information understandable and usable for humans as well as machines. The project will leverage open standards for semantic data interoperability in establishing a shared vocabulary (ontology network) for data documentation, as well as a decentralized digital platform that enables collaboration in a secure and privacy-preserving manner.

The project addresses a number of open research problems, including the development of ontologies that need to model a wide range of different materials and products, not only providing vertical interoperability but also horizontal interoperability, for cross-industry value networks. As well as transdisciplinary research on methods to find, analyse and assess new circular value chain configurations opened up by considering resource, information, value and energy flows as an integral part of the same complex system. Three industry use cases, from radically different industry domains, act as drivers for the research and development activities, as well as test beds and demonstrators for the cross-industry applicability of the results. The developed solutions will allow for automation of planning, management, and execution of circular value networks, at a European scale, and beyond. The project thereby supports acceleration of the digital and green transitions, automating the discovery and formation of new collaborations in the circular economy.

Project start date and duration

1st of June 2022, 36 months

Project consortium

No	Partner	Abbreviation	Country
1	Linköping University	LiU	Sweden
2	Interuniversitair Micro-Electronica Centrum	IMEC	Belgium
3	Concular Ug Haftungsbeschrankt	CON	Germany
4	+Impakt Luxembourg Sarl	POS	Luxembourg
5	Circularise Bv	CIRC	The Netherlands
6	Universitaet Hamburg	UHAM	Germany
7	Circular.Fashion Ug (Haftungsbeschrankt)	FAS	Germany
8	Lindner Group Kg	LIN	Germany
9	Ragn-Sells Recycling Ab	RS	Sweden
10	Texon Italia Srl	TEXON	Italy
11	Rare Earths Industry Association	REIA	Belgium

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1.0	30.03.2023	Incorporating feedback	Gertjan De Mulder, Ben De Meester	

Document approval

Version	Date	Name	Role in the project	Beneficiary
0.1	29.03.2023	Mikael Lindecrantz	WP2 Leader	RS
0.1	30.03.2023	Svjetlana Stekovic	Project Manager	LIU

Table of Content

1 Summary

At https://github.com/KNowledgeOnWebScale/open-circularity-platform, we finalized the first documented implementation of the Open Circularity Platform. We demonstrate our platform based on an example user story within the Construction domain.

2 Introduction

Semantic interoperability of data is one of the biggest barriers towards data sharing in the Circular Economy. Onto-DESIDE aims to provide the technical foundations for information flows that will transform European Industry towards a Circular Economy, by means of digitalisation and data sharing. The project leverages a decentralised digital platform that enables collaboration in a secure manner. This allows for automation of discovery, planning, management, and execution of cross-industry circular value networks, at a European scale and beyond. Combined with access control policies for data privacy and confidentiality, automation is enabled whilst protecting company-internal data, and allows data sharing to happen at the right level of granularity.

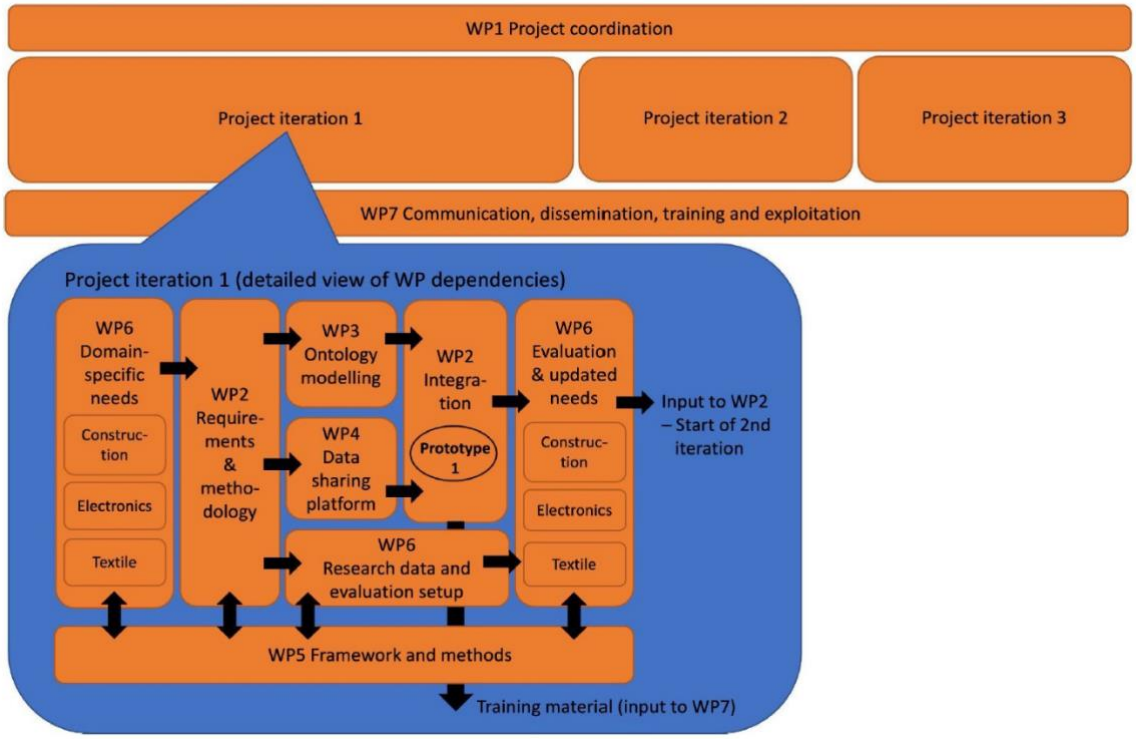
This project will develop at its basis a technology for allowing data sharing about materials and products at a global scale. Since access to verifiable information is central, the project will use well-established open standards for secure data and information sharing. As ownership and storage of data should remain with the actor that produces the data, a decentralised approach is necessary. Metadata and structures for transforming data into information (semantic descriptions and vocabularies) will be open, and comply with FAIR principles, to enable the highest possible degree of semantic interoperability and automation in data sharing. For sensitive data, methods allowing for proof of the existence of the data will be used, where these proofs can be shared while the actual data is kept private.

Further, this interdisciplinary project will also develop integrated tools and methods for further enhancing a Circular Economy. Although the importance of various 'flows' – resource flows (the various forms resources can take along their journey, e.g. material, component, product), information flows, energy flows, and value flows – has been widely acknowledged within the transformation to a Circular Economy, they have not been integrated or linked into a single framework or approach. Without such integration or linking it is not possible to make robust designs of circular value networks and to implement and operate value network coordination within industry.

The Onto-DESIDE project applies an iterative methodology, where research and innovation are driven by industry needs identified in a set of industry use cases, and solutions become more mature with each iteration. Three project use cases representing three distinct industry sectors – construction, electronics and appliances, and textile – will contribute to identify the needs and technical requirements of the Open Circularity Platform, but also act as test beds and evaluation scenarios for the novel solutions produced. This way, the project aims to show that the Open Circularity Platform is concrete enough to solve specific problems (i.e., the three specific use cases) but also has potential to be widely applied.

The project consists of three iterations, where each technical Work Package (WP) contributes to all the iterations. The WP dependencies are illustrated in Figure 1 where the details of the first project iteration are shown. The duration of the first project iteration is Month (M) 1-18, while the second and third iterations are shorter (M19-27 and M28-36 respectively). Each iteration ends with a collection of feedback from the industry use cases, analysed and reported in a WP6 evaluation report.

FIGURE 1- PROJECT OUTLINE AND DETAILED DEPENDENCIES BETWEEN WORK PACKAGES EXEMPLIFIED BY THE FIRST ITERATION



2.1 Objectives and Research Methodology

2.1.1 Objectives

Today, lack of support for sharing data in a secure, quality-assured, and automated way is one of the main obstacles that industry actors point to when attempting to create new circular value chains.

Work package 4 (WP4) will contribute to an open decentralised digital platform that enables secure collaboration. This includes supporting the correct enforcement of access control policies, as well as using verifiable credentials to prove the existence of sensitive data instead of publishing or sharing this sensitive data. The outcome of the WP will be an Open Circularity Platform, i.e., an open framework for secure and privacy-preserving digital and automated data sharing, which enables verifiable, traceable, and decentralised sharing of data expressed and documented using the ontologies from WP3, within and across industry domains.

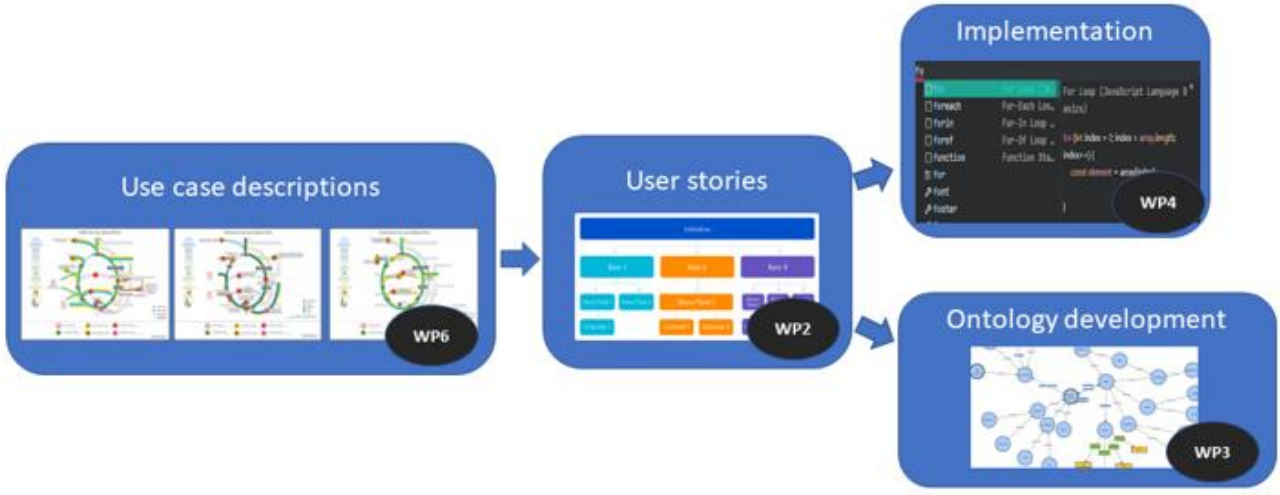
2.1.2 Research Methodology

The concrete research process of the Onto-DESIDE project has been divided into three iterations, each divided in 3 steps (cf. Figure 2):

- Step 1: analysis of needs and elicitation of requirements
- Step 2: research and technical development, including solution integration into a coherent prototype
- Step 3: use case-based observation and evaluation, providing feedback as well as revised and extended needs and requirements to start off the next iteration.

Specifically, for WP4, the focus is the technical development of the Open Circularity Platform, adhering to the technical requirements as put forward in WP2. For this, a new method will be devised to set-up decentralised networks of data vaults and actors.

FIGURE 2 DIAGRAM VISUALISING THE WORKFLOW OF WP4 AND THE RELATED ARTEFACTS



2.2 Tasks and Deliverables

WP4 is led by IMEC and is divided into five tasks, each related to the objectives of the work package. These tasks are outlined below:

- T4.1 - Data transformation - lead: IMEC, participants: CIRC
- T4.2 - Retrieving public and private data - lead: IMEC, participants: LIU
- T4.3 - Verifiable statements and credentials - lead: IMEC, participants: LIU, CIRC
- T4.4 - Blockchain-based implementation - lead: CIRC, participants: IMEC
- T4.5 - Querying data - lead: IMEC, participants: LIU, FAS

Two deliverables are to be produced for WP4 during the project:

- D4.1, D4.2, D4.3 Digital twin concept design, including ontology-based data sharing platform architecture and methodology (v1 M9, v2 M24, v3 M33) - report
- D4.4, D4.5, D4.6, D4.7 Open circularity platform (v1 M10, v2 M22, v3 M31, v4 M33) - software

This document constitutes the report for deliverable D4.4 and aims to describe the Open Circularity Platform featuring the digital twin concept design, including ontology-based data sharing platform architecture and methodology as discussed in deliverable D4.1. In this deliverable, we implemented T4.1, T4.2, and T4.5 (discussed in greater detail in deliverable D4.1). The remaining tasks, T4.3 and T4.4 are only recently started and will be part of v2 of deliverables D4.1 and D4.4.

2.3 Introduction to deliverable

This deliverable reports on the associated repository, containing source code and instructions to set up and run the first version of the Open Circularity Platform as part of the Onto-DESIDE Horizon Europe project.

3 Open Circularity Platform

The repository at https://github.com/KNowledgeOnWebScale/open-circularity-platform contains the implementation of an Open Circularity Platform as part of the Onto-DESIDE Horizon Europe project. We demonstrate the Open Circularity Platform through an example use case within the Construction domain. The setup of the Open Circularity Platform is made reproducible by relying on Docker

containers[1] and Docker Compose[2] for setting up the network locally that represents the Solid-based decentralized data sharing platform.

Within the network, we have set up:

- multiple data providers each publishing their data behind a secure access layer using Solid pods,
- a webclient providing a Web UI to execute queries on these Solid pods, and
- a Firefox container providing a means to browse the Solid-based data-sharing platform.

During the setup-flow, an administrative user generates and loads all data structured using the Resource Description Framework (RDF) into a Solid pod.
During the usage-flow, an end user browses to the emulated Firefox browser (http://localhost:5800/) which provides access to the Solid-based decentralised data-sharing platform. Within the emulated browser, the user navigates to the Comunica Webclient (https://webclient) which provides a set of predefined queries the user can execute over the Solid pods.

All set-up instructions are available at https://github.com/KNowledgeOnWebScale/open-circularity-platform.

4 Use case: Construction

The use case is as follows, of which a simplified version is visualized in Figure 3:

A building owner owns some buildings. Floors in a building are covered with floor tiles, delivered by a manufacturer (Lindner Group), who uses materials to construct the tiles. At some time in a building's lifetime, the building owner refurbishes a building and wants to decide on what to do with the floor tiles, based on economic and environmental costs.

From Lindner Group's perspective, all product data and quality metrics are known. On the other hand, Lindner does not have information on dismantled raised floor elements: where to find them, how many can be found, when we these elements be available? Therefore, procuring secondary raw materials in a secure way is hard due to lack of data on those materials. Access to more data, and at increased granularity, would increase the usage of those materials.

Information on product level are not registered throughout the lifecycle of the product which makes it hard to securely assess the quality and secure the correct handling of the product, either for reuse or to transform it into secondary raw materials.

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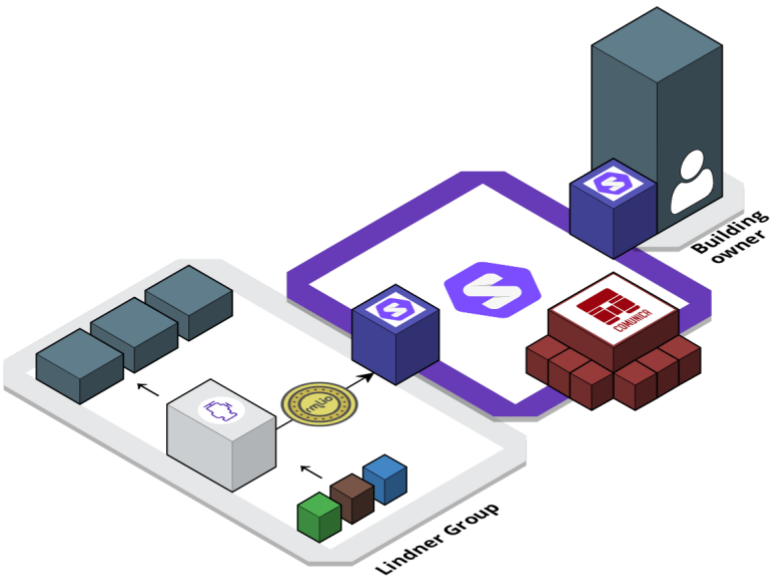
[1] https://www.docker.com/resources/what-container/
[2] https://docs.docker.com/compose/

FIGURE 3 - VISUALIZATION OF SIMPLIFIED SCENARIO



4.1 Implementation

We map the source data to Linked Data using the YARRRML parser and the RMLMapper. As a result, every actor's source data will be transformed to RDF, serialized as Turtle.

Every actor has their pod, hosted by their own Community Solid server. Each pod contains the Turtle files of the actor owning the pod. To operate on the Solid pods (e.g. specifying access control), we leverage Bashlib: a Command-Line Interface to interact with actors in a Solid. To query the distributed data, we use the Comunica Webclient: a jQuery widget to query heterogeneous interfaces using Comunica SPARQL.

4.2 Features

4.2.1 Flexible support for heterogeneous systems

There are 4 actors, each storing their data using a different data model and different serialization:

- Building Owner (User)
  - Buildings (CSV)
- Building Owner 2 (User)
  - Buildings (JSON)
- Lindner Group (Manufacturer)
  - Bill of Materials (CSV)
  - Materials (CSV)
  - Products (CSV)
- Ragn-Sells (Sorter, Recycler)
  - Services (XML)

4.2.1.1 Related user stories

ID	Name	AS A	I WANT TO
CUS1	End of life scenarios	Building owner	I want to know which are the different EOL scenarios for building materials
CUS2	Material business case	Building owner	I want to obtain economic and environmental costs of different end-of-life scenarios for building material
CUS3	Inventory	Manufacturer	I want to obtain information on quantities and locations of my products that will be dismantled.
CUS4	Rest material from production	Manufacturer	I want to find out if the rest material from my production could be used in other production processes
CUS5	Cost	Manufacturer	I want to know the costs of dismantling and refurbishing my products.
CUS8	Tender	Tenderer	I want to retrieve product information from the manufacturer.
CUS10	Deconstruction	Deconstruction company	I want to be informed on buildings where the deconstruction is planned and for what
CUS13	Planning	Manufacturer, Dismantler, Tenderer, Recycler, Deconstruction company, Planner, Marketplace	I want to retrieve product information such as measurements, composition, qualities, quantities, and location. I also need to be able to access the process and handling information that are related to these products.

4.2.1.1.1 Data - Building

The (dummy) data describes a *Building* owned by *Building Owner 2*. The data is loosely based based on the BIM model.

```
{
  "id": "fsml88",
  "address": "88 Fairview Street Mount Laurel, NJ 08054",

  "building-storey": [
    {
      "type": "floor",
      "name": "l0",
      "tiles": [ "0x03", "0x04", "0x05" ]
    },
    {
      "type": "floor",
      "name": "l1",
      "tiles": [ "0x06", "0x07", "0x08" ]
    }
  ]
}

```

4.2.1.1.2 Data - Service

The (dummy) data describes the *Sorting* service provided by Ragn-Sells. The *Sorting* service accepts different *Waste Streams*.

```
<root>
    <services>
        <service name="Sorting">
            <waste-streams>

                <waste-stream name="LDPE">
                    <description>
                        Low-density polyethylene (LDPE) is a thermoplastic made from the monomer ethylene. It was the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high pressure process via free radical polymerization.
                    </description>
                </waste-stream>

                <waste-stream name="HDPE">
                    <description>
                        High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a thermoplastic polymer produced from the monomer ethylene. It is sometimes called "alkathene" or "polythene" when used for HDPE pipes.[1] With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code.
                    </description>
                </waste-stream>

                <waste-stream name="Ferrous">
                    <description>
                        ...
                    </description>
                </waste-stream>

                <waste-stream name="ConstructionAndDemolition">
                    <description>
                        The EPA defines this type of waste as “Construction and Demolition (CD) debris is a type of waste that is not included in municipal solid waste (MSW).”[11] Items typically found in CD include but are not limited to steel, wood products, drywall and plaster, brick and clay tile, asphalt shingles, concrete, and asphalt. Generally speaking, construction and demolition waste can be categorized as any components needed to build infrastructures. In 2018, the EPA estimated that the US generated approximately 600 million tons of CD waste. [11]  The waste generated by construction and demolition is often intended to be reused or is sent to the landfill. Examples of reused waste is milled asphalt can be used again for the asphalt mixture or fill dirt can be used to level grade.
                    </description>
                </waste-stream>
            </waste-streams>

        </service>
    </services>
</root>

```

These different *data models* and different *serializations* are mapped onto a common (draft) data model, showcasing that this Open Circularity Platform can cope with multiple existing systems.

4.2.2 Access Control

Generally, the following ACL rules are applied

- a Manufacturer can *READ* User/Customer data
- a User can *READ* the *Products* of a *Manufacturer*
- every authenticated actor can *READ* the available services of a Recycler or Sorter
- the platform Administrator can *READ* all data generated by the actors

Applied to the construction example use case, this comes down to

- “Lindner Group” can *READ* buildings data from “Building Owner” & “Building Owner 2”
- “Building Owner” & “Building Owner 2” can *READ* product data from “Lindner Group”
- All actors can *READ* service descriptions from Ragn-Sells
- The “admin” actor can *READ* every actor’s generated data (i.e. data within <actor>/data/dt/out)

5 Demonstration

We demonstrate how this Open Circularity Platform copes with multiple existing data sources in different serializations, and with different actors that have different authorization levels.

Demo

When an actor is not yet authenticated, only access to publicly shared data can be read. For example, the actors within the Solid network. [Not authenticated] Query actors within the Solid network

A Manufacturer can *READ* User/Customer data.
When authenticating as a Manufacturer, like Lindner Group, one can query the where its tiles are located.

- Authenticating as Lindner Group
- [Authenticated as Lindner Group] Query: What are the tiles of Building B0?
- [Authenticated as Lindner Group] Query: What are the tiles of the building at a specific address?
- [Authenticated as Lindner Group] Query 1: What are Linder Group's Products? Query 2: What are the product details?

A User can *READ* the *Products* of a *Manufacturer*.
From the perspective of a Building Owner, only product data is readable. However, it is not possible for a *User* to read *Product Details*.
More specifically, the *Building Owner* is not able to query the product details.

- Authenticating as Building Owner
- [Authenticated as Building Owner] Query Lindner Group's products
- [Authenticated as Building Owner] Query Lindner Group's product details: Not Authorized!

The *Admin* actor can *READ* every actor’s generated data.

- [Authenticated as Admin] Count & Query all triples!