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ONTO-DESIDE

DELIVERABLE

D4.5: OPEN CIRCULARITY PLATFORM

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Contributing partners	LIU, CIRC, FAS
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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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2.1	29.03.2024	Final version	Els de Vleeschauwer, Gertjan De Mulder, Ben De Meester	

Document approval

Version	Date	Name	Role in the project	Beneficiary
2.0	22.03.2024	Caroline Braus	Internal reviewer	CON
2.1	29.03.2024	Eva Blomqvist	PC	LIU

Table of Content

1 Summary

In this deliverable, we released
i) a second version of the Open Circularity Platform's implementation and documentation, available at https://github.com/KNowledgeOnWebScale/open-circularity-platform; and
ii) a first version of the generic data viewer, available at https://github.com/SolidLabResearch/generic-data-viewer-react-admin .

Updates to the Open Circularity Platform include:

- The deployment of a live demonstrator, available at https://viewer.onto-deside.ilabt.imec.be/, showcasing the practical viability of the platform in a cross-domain (incl. construction, electronics, and textile) setting.
- The addition of example data, for the Textile user story, to better reflect real-world scenarios.
- The integration of Verifiable Credentials, to enable verifying the authenticity and integrity of data and data sources.

The generic data viewer updates include the addition of a verifiability check mark (indicating verified data sources), and bug fixes.

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.

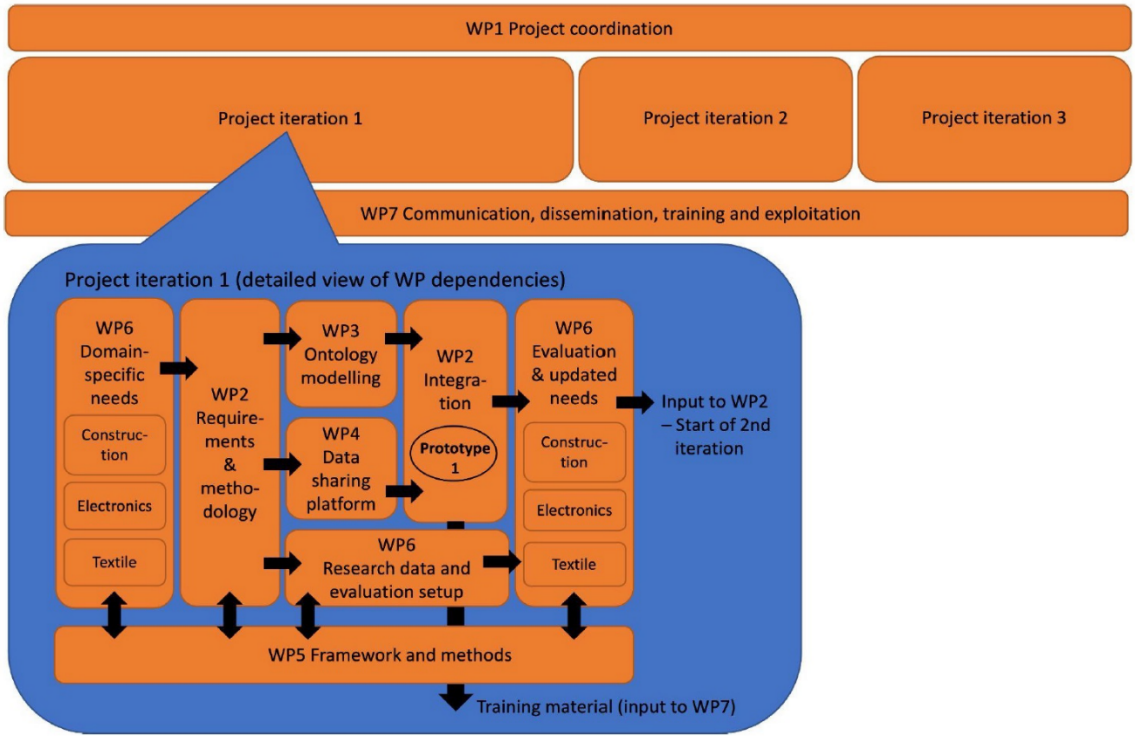
This project will develop at its basis a technology for allowing data sharing about materials and products at a global scale. Since access to verifiable information is central, the project will use well-established open standards for secure data and information sharing. As ownership and storage of data 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.

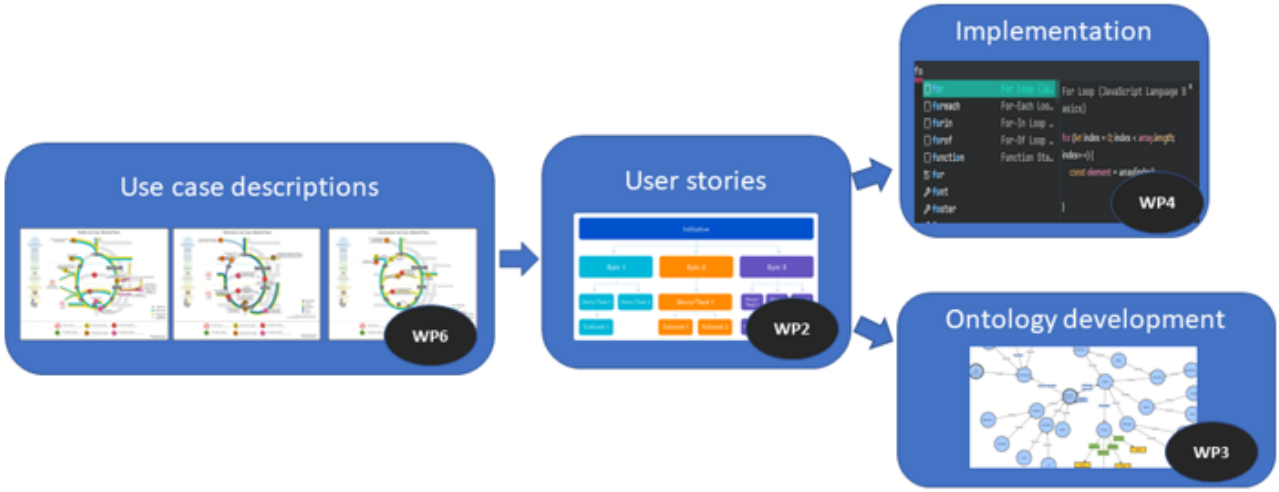
2.1.2 Research Methodology

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, and
- 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 D4.5 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, T4.3, and T4.5 (the details of T4.1, T4.2, and T4.5 are discussed in greater detail in deliverable D4.1). The remaining task, T4.4, is only at a design phase. An updated and elaborated description of the work done in Tasks 4.1 to 4.5 will be provided in D4.2.

2.3 Introduction to deliverable

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

3 Open Circularity Platform

The repositories at https://github.com/KNowledgeOnWebScale/open-circularity-platform and https://github.com/SolidLabResearch/generic-data-viewer-react-admin contain the implementation of an Open Circularity Platform and demonstration User Interface as part of the Onto-DESIDE Horizon Europe project. We demonstrate the Open Circularity Platform through an example user story within the Textile domain, via the User Interface. 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.

We set up the network with:

- multiple data providers each publishing their data behind a secure access layer using Solid pods,
- a Web UI to execute and visualized queries on these Solid pods.

The online demonstration is available at https://viewer.onto-deside.ilabt.imec.be/.

During setup, an administrative user generates and loads all data structured using the Resource Description Framework (RDF) into a Solid pod.
During usage, an end user browses to the Web UI which provides access to the Solid-based decentralised data-sharing platform. The Web UI provides – in a user-friendly way -- 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 User Story: Textile

The user story is as follows, of which a simplified version is visualized in Figure 3:

A material supplier provides components to a shoe manufacturer that combines different components that make up the shoe, sold by a brand.

As a brand, I want to show my sustainability efforts via a visible and transparent score on my product circularity performance.

More specifically, as a brand, I want to show how much material of my product comes from recyclable material.

This requires integration of data of the material supplier, the manufacturer, and the brand.

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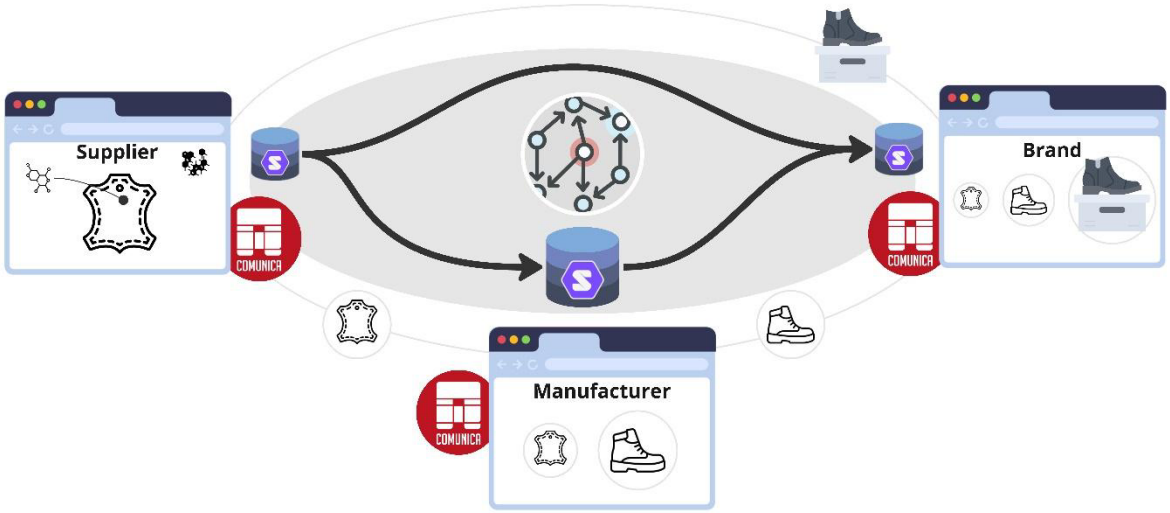
[1] https://www.docker.com/resources/what-container/
[2] https://docs.docker.com/compose/

FIGURE 3 - VISUALIZATION OF SIMPLIFIED SCENARIO



4.1 Implementation

We map each actor's source data to RDF according to the CEON ontology, developed by WP3, using the RMLMapper. The resulting RDF data can subsequently be stored on the actor's self-controlled Solid Pod.

Every actor has their pod, hosted by their own Community Solid server. To operate on the Solid pods (e.g. specifying access control), we extended RML to declaratively describe how to structure the data and specify their access control within a Solid pod. To query the distributed data, we use Comunica to query heterogeneous interfaces using SPARQL. The technical interaction with Comunica is facilitated by our newly implemented generic data viewer: a user can just click through a demonstrator application, which under the hood executes individual SPARQL queries.

4.2 Features

4.2.1 Flexible support for heterogeneous systems

By using RML, we support heterogeneous data sources. We apply our proof-of-concept on top of tabular (CSV) data, however, we currently support:

- Local data sources:
  - Excel (.xlsx)
  - LibreOffice (.ods)
  - CSV files (including CSVW)
  - JSON files (JSONPath)
  - XML files (XPath)
- Remote data sources:
  - Relational databases (MySQL, PostgreSQL, Oracle, and SQLServer)
  - Web APIs with W3C Web of Things
  - SPARQL endpoints
  - Files resolved over HTTP
    - CSV files
    - JSON files (JSONPath)
    - XML files (XPath)

Figure 4 shows an excerpt of source data, with product information about shoes, that will be mapped to RDF according to the CEON ontology.

FIGURE 4 - SCREENSHOT OF THE CSV FILE CONTAINING DATA FROM 4 PRODUCT DATA SHEETS OWNED BY ONE ACTOR. THIS DATA IS CONVERTED TO LINKED DATA USING THE RMLMAPPER AND ADDED TO THE POD OF THE ACTOR.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	1100	1101	1102	1103	1104	CF100	CF101	1200	1201	1202	1203	1204	1205	1206	1300	1301	1302	1303	1304	1400	1401
2	REF 2.0	TEXON	NA	product1	NA	Counter - 1	NA	TEXON INT	Building 5,	Saltburn B	TS12 2LH	UNITED KI	05329617	NA	company1	NA	NA	NA	China	1	45235
3	ECO 1	TEXON	NA	product2	NA	Shoe insol	NA	TEXON INT	Unit 1-4, 1	Wanchai, I	999077	CHINA	0596572	NA	company2	NA	NA	NA	NA	1	45235
4	SPO Bio	TEXON	NA	product3	NA	toe puff - a	NA	TEXON INT	Building 5,	Saltburn B	TS12 2LH	UNITED KI	05329617	NA	company3	NA	NA	NA	NA	1	45235
5	Verde	TEXON	NA	product4	NA	Cellulose t	multicolou	Texon Inter	Contrade N	Ripatransc	63038	ITALY	MI 182830	NA	company4	NA	NA	NA	NA	1	45235
6																					

By using RML, we can showcase that the Open Circularity Platform can cope with multiple existing systems.

4.2.2 Access Control

We applied access control rules conforming to feedback from the textile use case, i.e., in a realistic setting. This way, we can make sure that, e.g. a brand can only read the data it is allowed to see, as validated by the use case partners.

In Figure 5, you can find how access rules are configured for the Open Circularity Platform.

FIGURE 5 - SCREENSHOT OF CSV FILE DESCRIBING THE ACCESS RULES TO 3 FILES ON THE POD OF ONE ACTOR. THE LINKED DATA GENERATED FROM THE SOURCE DATA (FIGURE 4) IS SPLIT OVER 3 TURTLE FILES. THE OWNER OF THE DATA GETS CONTROL, WRITE AND READ ACCESS TO THE 3 FILES. OTHER ACTORS GET READ ACCESS TO SELECTED FILES.

	A	B	C	D	E
1	target_id	access_to	agent	mode	agent_webid
2	manuf1_1	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_1	manufacturer	Control	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
3	manuf1_1	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_1	manufacturer	Write	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
4	manuf1_1	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_1	manufacturer	Read	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
5	manuf1_2	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_2	brand	Read	https://css7.onto-deside.ilabt.imec.be/brand/profile/card#me
6	manuf1_2	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_2	manufacturer	Control	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
7	manuf1_2	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_2	manufacturer	Write	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
8	manuf1_2	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_2	manufacturer	Read	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
9	manuf1_3	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_3	brand	Read	https://css7.onto-deside.ilabt.imec.be/brand/profile/card#me
10	manuf1_3	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_3	manufacturer	Control	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
11	manuf1_3	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_3	manufacturer	Write	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
12	manuf1_3	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_3	manufacturer	Read	https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me
13	manuf1_3	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_3	recycler	Read	https://css8.onto-deside.ilabt.imec.be/recycler/profile/card#me
14	manuf1_3	https://css5.onto-deside.ilabt.imec.be/texon/ceon/manuf1_3	sorter	Read	https://css10.onto-deside.ilabt.imec.be/sorter/profile/card#me

4.2.3 Verifiability

We created Verifiable Credentials for each published data set so that the user of the data can verify that the data is genuine and unaltered. This results in a Verifiable Credential envelope over the existing CEON-annotated data, that allows verification using standard Verifiable Credential.

4.2.4 Demonstrator pods

We provided a set of demonstrator pods that are accessible via the Web, behind Solid's authorization layer.

The following pod is set up:

- https://css5.onto-deside.ilabt.imec.be/texon/: contains data about 4 product datasheets owned by a manufacturer. For this scenario, we use Texon as an example manufacturer. Texon shares its data with selected actors.

The following actors have been defined:

- Texon, a manufacturer (WebID: https://css5.onto-deside.ilabt.imec.be/texon/profile/card#me): shares selected part of his data with the actor Brand, Recycler and Sorter
- Brand (WebID: https://css7.onto-deside.ilabt.imec.be/brand/profile/card#me): can read part of the data of Texon
- Recycler (WebID: https://css8.onto-deside.ilabt.imec.be/recycler/profile/card#me): can read part of the data of Texon
- Retailer (WebID: https://css9.onto-deside.ilabt.imec.be/retailer/profile/card#me): has no read access to data of Texon
- Sorter (WebID: https://css10.onto-deside.ilabt.imec.be/sorter/profile/card#me): can read part of the data of Texon

Table 1: Construction Use Case Actors

actor	webId	email	password
admin	https://css0.onto-deside.ilabt.imec.be/admin/profile/card#me	admin@ocp.com	admin123
lindner-group	https://css1.onto-deside.ilabt.imec.be/lindner-group/profile/card#me	info@lindner-group.com	lindner123
building-owner	https://css2.onto-deside.ilabt.imec.be/building-owner/profile/card#me	info@building-owner.com	building123
building-owner2	https://css3.onto-deside.ilabt.imec.be/building-owner2/profile/card#me	bob@realestate.com	bob123
ragn-sells	https://css4.onto-deside.ilabt.imec.be/ragn-sells/profile/card#me	mikael@ragn-sells.se	mikael123

Table 2: Textile Use Case Actors

actor	webId	email	password
texon	ıttps://css5.onto-deside.ilabt.imec.be/texon/profile/card#me	info@texon.com	texon123
brand	https://css7.onto-deside.ilabt.imec.be/brand/profile/card#me	info@brand.com	brand123

Table 3: Extra Actors

actor	webId	email	password
recycler	https://css8.onto-deside.ilabt.imec.be/recycler/profile/card#me	info@recycler.com	recycler123
retailer	https://css9.onto-deside.ilabt.imec.be/retailer/profile/card#me	info@retailer.com	retailer123
sorter	https://css10.onto-deside.ilabt.imec.be/sorter/profile/card#me	info@sorter.com	sorter123

5 Demonstration

We demonstrate how this Open Circularity Platform copes with multiple existing data sources, mapped to the CEON ontology, using a user-friendly User Interface, with different actors that have different authorization levels, and being able to verify that data is genuine and unaltered.

Demo

The demo scenario is as follows:

- Login as manufacturer actor (e.g. Texon):
  - Select identity provider (https://css5.onto-deside.ilabt.imec.be/)
  - Enter email (info@texon.com, texon123)
  - Read CSS dialogue and Authorize
- Select a query (“Product Datasheets”)
  - Select product <http…product1>
- View results
  - Focus on the number of results in the list
- Click the “i” next to “Sources”
  - Have a look at the list of the sources
  - Highlight that the results come from a combination of sources, with different levels of authorization
  - Click the “?” in the column “Verified” to verify the data
  - Click on a specific property and be redirected to the CEON ontology documentation
- Logout
- Login as brand actor
- Select the same query (“Product Datasheets”)
  - Select the same product <http…product1>
- View results
  - Notice that you see a different set of results
- Logout

6 Changes with respect to D4.4

Since the last deliverable, we updated the software in following ways:

- We updated the RML support to directly interact with the Solid pod (T4.1,2)
- We updated the Open Circularity Platform, including:
  - The deployment of a live demonstrator, available at https://viewer.onto-deside.ilabt.imec.be/, showcasing the practical viability of the platform in a cross-domain (incl. construction, electronics, and textile) setting.
  - The addition of example data, for the Textile user story, to better reflect real-world scenarios.
  - The integration of Verifiable Credentials (T4.3), to enable verifying the authenticity and integrity of data and data sources.
- We built a more user-friendly demonstrator to showcase the different functionalities of the Open Circularity Platform, including the addition of a verifiability check mark (indicating verified data sources).