Onto-DESIDE GA number: 101058682

ONTO-DESIDE

DELIVERABLE

Software and protocol releases - v.2

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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 several 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, analyze and assess new circular value chain configurations opened 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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Abbreviations

Abbreviation	Explanation
MfM	Multi-Flow Metabolism
CEON	Circular Economy Ontology Network
RDF	Resource Description Framework
RML	RDF Mapping language
UI	User Interface
URI	Uniform Resource Identifier
WP	Work Package

1 Introduction

This deliverable is the second version of a compiled set of instructions on how to work with the delivered methodology from WP5, the ontologies delivered by WP3, and the open circularity platform delivered by WP4. Together these artefacts form the Onto-DESIDE prototype, which will be released in a new version in each of the three project iterations. In addition to this, the use-case descriptions produced by WP6 will be used as input to generalize instructions relevant to modeling circular value networks in the setting of the project infrastructure.

This deliverable is intended to be used as a source of documentation for setting up the technical infrastructure used by the Onto-DESIDE project, so that it is reproducible for someone that aims at setting up a similar environment. The ambition is to provide easy to use instructions that will enable further uptake of the technologies used.

1.1 Objectives of the deliverable

The main objectives of this deliverable are to:

- Provide an integrated framework and documentation that describes how the different components of what is delivered in Onto-DESIDE fits together.
- Document software, data, as well as sharing protocols used in the project.

In this first version of the deliverable, the main focus is on how WP4 and WP3 results can be used together, while WP5 results and specifics for the WP6 evaluations are still under development, and will be covered more in detail in the next version of the deliverable. In addition, the deliverable will not attempt to reproduce already existing documentation from the work packages themselves, but merely point to such material.

2 Integration and validation

Integrating the components of the software platform of Onto-DESIDE is visualized at a high level in Figure 1. Starting with the user interaction layer, this is the point of interaction for all users of the platform. There is the possibility of querying the CEON ontology directly but that use case is not seen as part of the integrated setup from an end-user perspective. The possibility of querying the CEON ontology directly will be used in the project to validate and verify the ontology itself, as well as to validate and verify data-mappings that are used to fulfill the requirements of the respective industry use-cases.

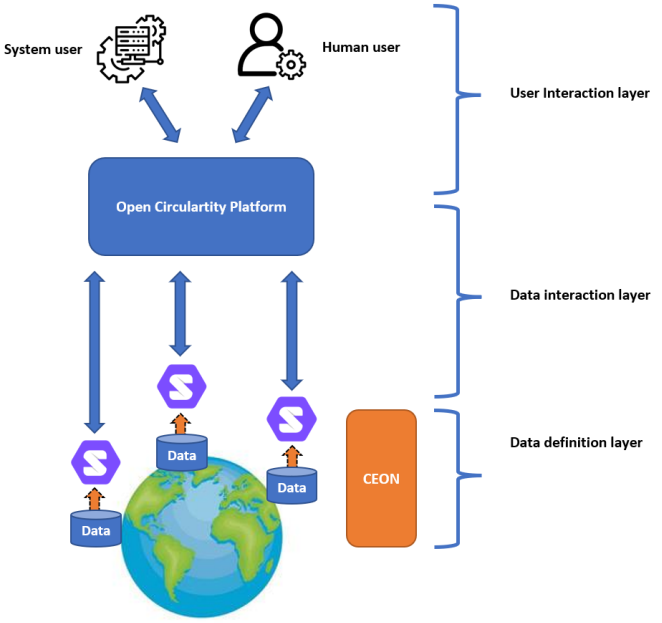

Figure 1: High-level overview of the integrated flow of the software platform for Onto-DESIDE

The data definition layer is represented by the CEON ontology which acts as the common data model across the distributed heterogeneous data sources. The data interaction layer is to be seen as a distributed network of existing data sources which are annotated with the CEON ontology, so that they can be interpreted as linked data sources. These data sources and the data therein should conceptually be seen as residing with the organization or individual that owns the data. Using the Solid protocols allows to interact with these resources in a secure way. The Open Circularity Platform in turn uses the Solid protocols, interacting with this data in a secure way.

2.1 Validation data

For the purpose of validating the use case scenarios within Onto-DESIDE we will make use of real industry data provided by the industry partners of the project. This data come in various formats and schemas and are not harmonized, rather it should represent the raw real-life view of the data that would be available when collaborating in the way described by the use-cases. To operationalize the data it will be mapped to the CEON ontologies using RML and made available through the Open Circularity Platform.

The industry data used for validation are part of the 6.4 deliverable of the Onto-DESIDE project, this is a **non-public** deliverable and is thus not readily available for download. For any inquiry's regarding this data, please

reach out to the project coordinator at Linköping University[1].

2.2 Test cases and demonstrations

Validation and verification of functionality of the integrated platform have been done using the data provided by industry partners in the three use cases in the project. Figure 2 illustrates the complete overview of how technologies, methodology and data are used for validating the platform.

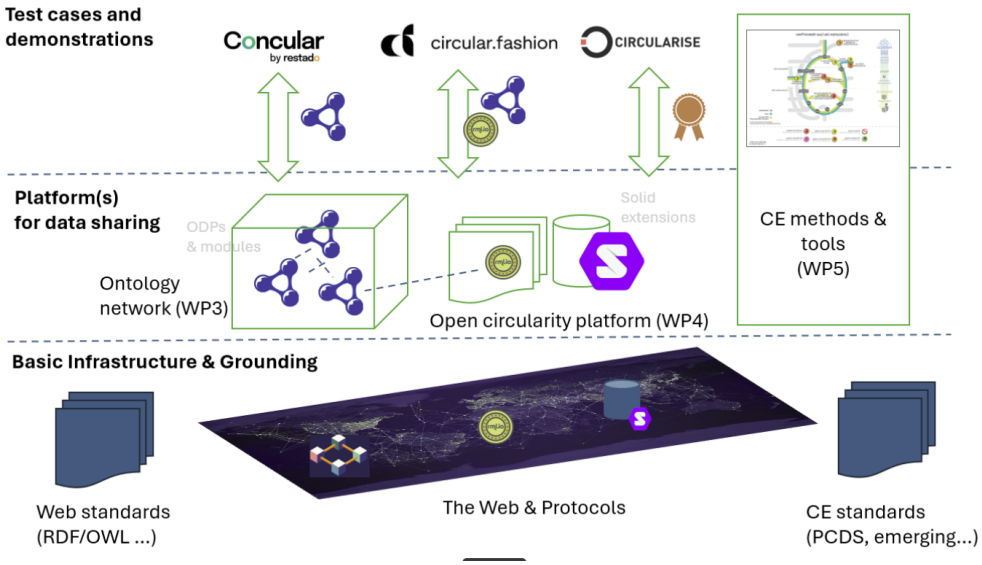

Figure 2: High-level overview of the integrated stack for demonstrating the platform functionalities through test cases.

2.2.1 Requirements produced by the industry use cases

For the design and implementation of the software stack of the Onto-DESIDE project, each of the three industry use cases have provided requirements that aim at fulfilling their needs in terms of functionality. These requirements were firstly documented as user stories and given a unique identifier, these stories were then detailed in WP3 for the ontology development, and in WP4 for the platform development. To conclude the work, all the validations done on the platform were connected back to the specific requirements. This provides traceability and a good overview of what requirements have been implemented.

The most current version of the requirements can be found on the Onto-DESIDE website at:
https://ontodeside.eu/wp-content/uploads/2022/12/Onto-DESIDE_Deliverable_D2.1_v1.1_final.pdf

2.3 Versioning of releases

Releases are iterations of the Onto-DESIDE repositories that can be packaged and made available for download and use. The project uses semantic version numbering for releases following the pattern:
MAJOR.MINOR.*PATCH*

[1] https://liu.se/medarbetare/evabl45

- **Major** releases (e.g. going from version v1.1.0 to version v2.0.0) indicate changes that significantly alter functionality or might break backward compatibility
- Minor releases (e.g. going from version v1.0.2 to v1.1.0) indicate a change of functionality. This can be any functionality change or new functionality but should not break backward compatibility
- *Patch* releases (e.g., going from version v1.0.1 to version v1.0.2) indicate bug fixes or trivial updates

Semantic versions are released by creating the corresponding Git tag in the GitHub web interface, which adds a marker to a Git commit that signifies that it is meaningful in some way, and then this is marked as a release. Each new release should be accompanied by release notes:

- A **major** release should contain a list of removals, a list of additions, and instructions on how to upgrade from the previous version (if needed)
- A minor release should contain a list of changes and usage details
- A *patch* release should contain a list of bugfixes

All releases of the integrated platform of Onto-DESIDE can be found in appendice A.

2.3.1 Beta releases

It is sometimes useful to be able to publish a release before all the features are developed and tested. In these cases, the use of semantic versioning still applies; however, the release should be tagged with the ‘beta‘ suffix. In the GitHub web interface, the new tag name (e.g., ‘v.1.0.0-beta‘) is defined and then the radio button ‘Set as a pre-release‘ is set prior to publishing the release. When the release has been tested, a new release without the beta suffix is created.

3 Methodology

Firstly we reintruduce the reader of the overall project research methodology, in terms of the three project iterations, and their steps. This in order to position the work reported in this deliverable to these steps. The overall process can be illustrated as in Figure 3, where each project iteration consists of a needs & requirements analysis steps, followed by research & development, and concluded through evaluation & validation, e.g. in our use cases.

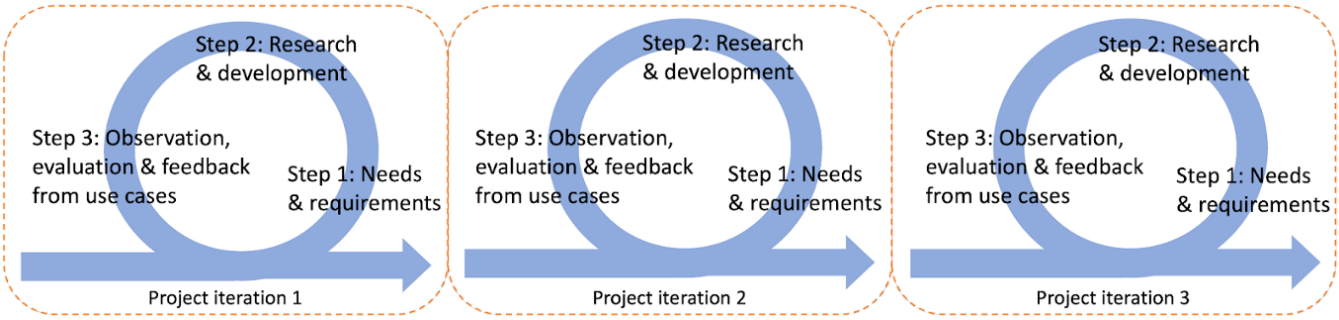

Figure 3: The overall research process of the project, conducted in three iterations.

Specifically for D2.4 through top D2.6 we rely on deliverables from WP2, WP3, WP4, WP5 and WP6 in synthesising a coherent outline of how the results interlink, and could be applied for usage both in our evaluation phase (step 3 above), as well as outside the project and after the project has concluded. The outline presented in this deliverable will be further developed and detailed throughout the three iterations of the project, ending up in a complete description of our resources at the end of the last iteration. Therefore the contents of this document is to be seen as preliminary.

In terms of methods and infrastructure, the Onto-DESIDE project consists of four parts;

- Circular value network analysis and design
- Functional and non-functional requirement engineering
- Ontology design and development
- Open circularity platform

All these parts fit together in creating both the methodological setting as well as the technical infrastructure for developing, extending, and using an ontology network for the circular economy domain. Following are a short description of each part, together with references to detailed documentation.

3.1 Value network design

To explore circular potential using a formalized method the Onto-DESIDE project is making use of the Multi-Flow Metabolism model developed by Fenna B. et al [1] in guiding stakeholder discussion's and documenting the outcome, taking into account the material-, energy-, information- and value-flows that are seen as dimensions of a circular economy ecosystem. The MfM model have been used to visualise and formalize the three use-cases in the project. The result of using this model and the underlying theory are documented and described in detail in deliverable 6.1[2] from WP6 and 5.1 from WP5[2]. However, the method development in WP5 is still in an early stage, and further descriptions of the extensions and modifications to the MfM resulting from the project will be reported in future versions of this deliverable.

[2] https://ontodeside.eu/results/

3.2 Functional and non-functional requirement engineering

As an intermediate step towards designing an ontology network and building the open circularity platform, the concept of user stories is used to move from user stories described using the Multi-Flow Metabolism design, towards more verbose textual descriptions of requirements from the perspective of different actors. The concept of user stories and how they are applied in the context of Onto-DESIDE is described in detail in the 2.1 deliverable[2].

Non-functional requirements describe operational capabilities of a system and constraints and attempt to improve its functionality. These are basically the requirements that outline how well it will operate including things like speed, security, reliability, data integrity, etc. Non-functional requirements applicable to the Open Circularity Platform are detailed as part of the 2.1 deliverable from WP2[2]. In addition, a specific focus is put on ethical requirements, which has been outlined in D8.1, and will be followed up in the yearly ethical reviews of the project.

3.3 Ontologies

Ontologies are used in several fields, both in philosophy and humanities, as well as a technology to achieve semantic interoperability of data in computer science. For the purpose of the Onto-DESIDE project, the notion belonging to computer science is used, where an ontology is defined as an "explicit specification of a conceptualization" [3]. An ontology in computer science is an artefact that consists of a formal structure that explicitly defines the concepts and relations between concepts existing within some domain, or related to a specific application. To design an ontology, requirements needs to be developed, turning the user stories in D2.1 and the use case descriptions in D6.1 into ontological requirements. The requirements process and methodology used are described in detail in the 3.1 deliverable[2] of WP3. Further results, i.e. the first version of the ontology network itself was delivered in D3.3.

3.4 Open circularity platform

Semantic interoperability and ontology-based data documentation are essential enablers for large scale digital Circular Economy but not enough in itself. Semantically described data also needs to be put into use, in automated processes. To facilitate the open collaboration needed to automate processes, Onto-DESIDE introduces the concept of digital twins in the context of circular economy. Digital twins, built upon a shared vocabulary – i.e. defined in an ontology network – are reusable as templates for a certain type of circular value network, and could at minimal effort be shared with a different set of actors or used within a different industry domain to instantiate new value networks.

Technically, the digital twin concept will be implemented as an open circularity platform using existing and emerging Web technologies, such as RML[2] for semantically annotating and mapping heterogeneous data sources, Solid[3] for building decentralised applications based on Linked Data principles, and incorporating validation and verification methods[4] that provide proofs of data authenticity. The technologies and methods used are described in detail in deliverable 4.1[2] of WP4, and software was released in its first version in D4.4.

RML is used to annotate existing data sources with the ontologies designed within Onto-DESIDE. This translation layer decouples the partner's existing IT systems from the open circularity platform and thus lowers the barrier of adoption. Existing resources describing how to use and apply RML (and it's human-friendly syntax YARRRML) will be used, and further enriched to provide the necessary knowledge to the project partners and others beyond the project[5]. The Solid protocols allow for interoperable secure interaction between (human and

[3] https://solidproject.org/TR/
[4] https://www.w3.org/TR/vc-data-model/
[5] https://rml.io/yarrrml/tutorial/getting-started/

machine) client applications on the one hand and data sharing services on the other hand. The open circularity platform can thus be seen as the combination of client applications, data sharing services, and the interactions between them. Existing resources describing how to use Solid will be used and further enriched to provide the necessary knowledge to the project partners and others beyond the project[6].

3.5 Digital twins of circular value networks

To facilitate open collaboration in a data driven circular economy the Onto-DESIDE project suggest a new entity to conceptually think of a circular collaboration in terms of a digital twin of circularity. The concept of digital twins has been put to use for many use cases and in many industries and the fundamental theory behind the concept is not a new thing. But, the idea of constructing digital twins of circular value networks, with the value network defined by an ontology, in this case the CEON ontology, expand on the idea of what a traditional digital twin is.

In the context of the Onto-DESIDE project we frame the digital twin concept as being the digital representation supporting the physical flows in the real world. Think of it as the digital plumbing that is needed to be put in place for materials to be able to move and transform.

If digital twins are built upon shared ontologies, i.e. the ontology network, once defined, their blueprints are also reusable as templates for a certain type of circular value network, and could be shared with a different set of actors or used within a different industry domain to instantiate new value networks.

A central part of Onto-DESIDE are three industry use cases, these use cases are to be seen as prototypes of digital twins of circular value networks in that they are a combination of physical objects and real world actions, supported by a digital infrastructure built up by the CEON ontology and the Open Circularity Platform.

[6] https://github.com/CommunitySolidServer/tutorials/blob/main/getting-started.md

4 Technical Infrastructure

To setup and extend frameworks and technical architecture used in the Onto-DESIDE project there are a number of components that underpin the development pipeline. For both the Open Circularity Platform and the ontology development, all development is done in public repositories on GitHub. Further instructions detailing how to contribute and use different releases of the deliverables are published in the read-me of the respective repository.

4.1 Open circularity platform

The setup of the Open Circularity Platform is made reproducible by relying on Docker containers[7] and Docker Compose[8] for setting up the network that represents the Solid-based decentralized data sharing platform locally. This setup is not to be seen as a complete setup of the platform as that will vary based on what data sources and systems are integrated. The setup presented here is based on the needs of the use cases and the corresponding validations of project requirements that need to be performed.

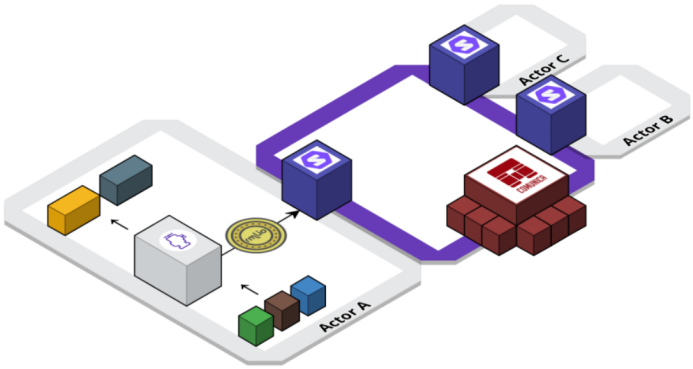

Figure 4: Diagram visualizing the complete open circularity platform (c.f. D4.1 and 4.4).

Within that network the following components are spun up:

- Multiple data providers each publishing their data behind a secure access layer using Solid pods
- A Web client providing a Web UI to execute queries on these Solid pods
- A Firefox container providing a means to browse the Solid-based data-sharing platform

During setup, an administrative user generates and loads RDF[9] structured data into a Solid pod. Then an end user accesses the platform using a browser on localhost using port 5800, which provides access to the data-sharing platform. Within the emulated browser, the user navigates to the Comunica webclient[10] (http://webclient) which provides a set of predefined queries to run on the Solid pods.

[7] https://www.docker.com/resources/what-container/
[8] https://docs.docker.com/compose/
[9] https://www.w3.org/TR/rdf11-primer/
[10] https://comunica.dev/docs/query/getting_started/setup_web_client/

The Open Circularity Platform is meant to be a plaform that will enable data sharing and as a consequence, end-user facing interfaces or graphical design are not top priority. These are important and critial for services based on the platform to be adopted but the focus of the project are to establish the fundamental infrastructure to build upon. For the validation of the use-cases, an end user facing intreface to query distributed RDF data has been developed.

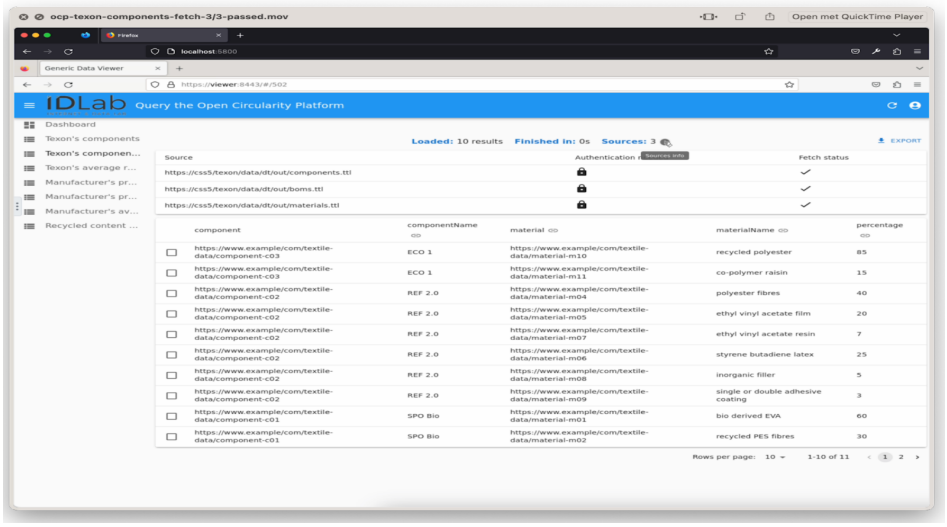

Figure 5: Screenshot showing the data viewer component of the Open Circularity Platform.

This viewer is packaged and released as part of the OCP releases. The sources and attached instructions for the OCP platform are published in the GitHub repostory located at:
https://github.com/KNowledgeOnWebScale/open-circularity-platform

4.2 CEON - The Circular Economy Ontology Network

The Circular Economy Ontology Network (CEON) provides a shared vocabulary in the form of a network of ontologies to support efficient decentralized sharing of industry data in circular economies.

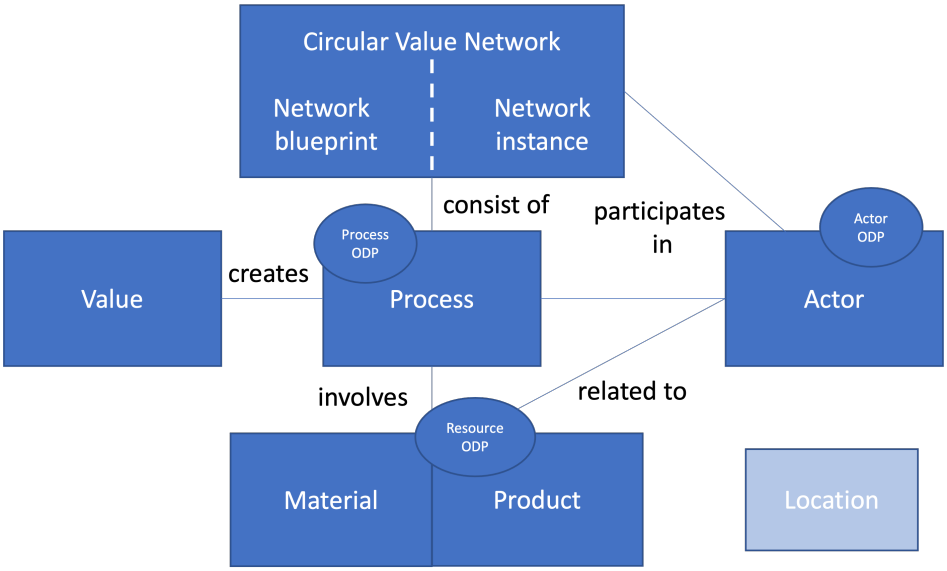

Figure 6: Topics covered by the Circular Economy Ontology Network (CEON - c.f. D3.2 and D3.4).

The CEON repository uses GitHub Actions to automate the generation of ontology documentation and to publish content to https://liusemweb.github.io/CEON/. The action is configured to trigger whenever a pull request is merged into the main branch. The code on the main branch is stable, properly tested and should be viewed as the latest release of the code (i.e. ontology network).

The ontologies produced as part of Onto-DESIDE is published on GitHub are made available through the permanent identifier CEON using the w3id.org[11] URI, resulting in the full identifier of:
http://w3id.org/CEON

The ontology modules included in CEON are not to be seen as static, they will evolve and expand during the project. Given adoption after the project, they will continue to be added to. At some point, what is to be seen as the core parts of CEON will become somewhat stable and changes will be more of the nature of alignments from and to CEON. The most current state, complete with documentation and a graphical visualization using WebVOWL[12] will be maintained at the CEON github.

The sources and detailed instructions are published in the GitHub repository located at:
https://github.com/LiUSemWeb/CEON/

[11] https://w3id.org/
[12] https://github.com/VisualDataWeb/WebVOWL

Conclusions

This deliverable documents the technical components released by the Onto-DESIDE project and how those fit together to form an integrated platform that supports validating the goals of the respective use cases. The ambition is also to provide instructions that will enable organizations external to the project to gain an understanding of how to set up a similar platform. Making it easy to reproduce the infrastructure used in the project we hope to support further uptake of the technology and methods used.

This document will be updated throughout the iterations of the project, but it will never contain all the complete instructions or the most up-to-date sources for any of the components. As the parts of what make up the technical infrastructure develop at different speeds, the most up-to-date versions will be kept in the respective repository connected to that deliverable or WP. Also, in many cases there are software components that are not directly developed by the project but used as part of the technology stack, these components will also be referenced through the respective repositories as to best keep up with current versions.

This document focused on providing the overview of major components of the infrastructure and the documentation that is needed to understand how they fit together. For the final version of this deliverable, there will also be a section added on data sources and formats. This will be done to provide an overview of the types of formats and protocols used in validating the user stories. No actual data will be part of this deliverable, data as part of the validation of use cases are non-public and not made available for public use.

Finally, there are a balance needed to be struck between repetition and addition. In this revision of the deliverable we have continued the path of providing the glue that connects all the technical components and methodology into something coherent for someone that wants to start setting up the same infrastructure. In the last phase of the project we will develop training materials, the ambition for the final version of this deliverable is to also adapt to that by connecting to that material. Also, we expect to add to the training material from the perspective of the integrated platform.

References

[1] Fenna Blomsma, Mike Tennant, and Ritsuko Ozaki. Making sense of circular economy: Understanding the progression from idea to action. *Business Strategy and the Environment*, 32, 05 2022. doi:10.1002/bse.3107.

[2] Anastasia Dimou, Miel Vander Sande, Pieter Colpaert, Ruben Verborgh, Erik Mannens, and Rik Van de Walle. Rml: A generic language for integrated rdf mappings of heterogeneous data. volume 1184, 04 2014.

[3] Thomas R. Gruber. A translation approach to portable ontology specifications. *Knowledge Acquisition*, 5(2):199–220, 1993. URL: https://www.sciencedirect.com/science/article/pii/S1042814383710083, doi:10.1006/knac.1993.1008.

Appendices

A Integrated releases of the Onto-DESIDE platform

#	Ontology	Software platform
V1	This represents the initial release of the Circular Economy Ontology Network (CEON) as part of the integrated release and its corresponding documentation. Release notes and download at: https://github.com/LiUSemWeb/CEON/releases/tag/v0.1.0	This represents the initial release of the Open Circularity Platform as part of the integrated release and its corresponding documentation. Release notes and download at: https://github.com/KNowledgeOnWebScale/open-circularity-platform/releases/tag/v0.1.0
V2	This represents the second release of the Circular Economy Ontology Network (CEON) as part of the integrated release and its corresponding documentation. Release notes and download at: https://github.com/LiUSemWeb/CEON/releases/tag/v0.2.0	This represents the second release of the Open Circularity Platform as part of the integrated release and its corresponding documentation. Release notes and download at: https://github.com/KNowledgeOnWebScale/open-circularity-platform/releases/tag/v0.2.4