Development and Outlook of the Circular Economy Track at the Ontology Alignment Evaluation Initiative

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Abstract

In recent years, a growing number of ontologies have been developed for the circular economy (CE) domain, reflecting its increasing importance in sustainability and industry. Although these ontologies are designed for varied application scenarios, they often share overlapping concepts and relationships. This overlap makes ontology alignment essential to ensure semantic interoperability and facilitate knowledge integration across systems. However, aligning CE-related ontologies remains a challenging task due to heterogeneity in modeling approaches and cross-industry domain nature of CE. To address this, we introduced a new schema matching track for the CE domain within the Ontology Alignment Evaluation Initiative (OAEI), starting in 2024. This track is grounded in the alignment work of the Onto-DESIDE project, which developed the Circular Economy Ontology Network (CEON). In this poster, we present the development and current status of the CE track, as well as an outlook on its future evolution, including plans to incorporate additional sub-tasks.

Keywords

Circular Economy Ontology Network, Ontology Alignment, OAEI

1. Introduction and Background

The Circular Economy (CE) track was introduced in 2024 of which the alignment task was within the context of the Onto-DESIDE project.[1] One of the main objectives of Onto-DESIDE is to develop a network of ontologies for knowledge representation in the CE domain, aiming to support semantics-aware data documentation and sharing across circular value networks (CVNs) in which diverse actors and processes are included. To this end, we developed the Circular Economy Ontology Network (CEON)[2] [1], which comprises core ontology design patterns covering topics such as actors, processes, circular value networks, and resources, with specialized modules for value, materials, and products. CEON aims to represent essential domain knowledge for CVN modeling, and to reuse or connect to existing ontologies wherever possible [2]. A survey of CE-related ontologies was conducted, encompassing not only CE-specific ontologies but also those related to cross-industry domains such as sustainability, materials, product and manufacturing [3]. Examples include the Sustainable Bioeconomy and Bioproducts Ontology (BiOnto) [4] for the CE domain, Material Ontology (MATONTO) [5] for the materials domain. Given the diversity among these ontologies, it is crucial to systematically analyze and align them. To address this, we defined three key tasks [2] within Onto-DESIDE: (1) **Task A**, aligning CE-specific ontologies; (2) **Task B**, aligning CEON with industry domain-specific ontologies and (3) **Task C**, aligning CEON with top-level ontologies. Moreover, a pipeline for generating and

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[1]https://ontodeside.eu
[2]CEON: http://w3id.org/CEON

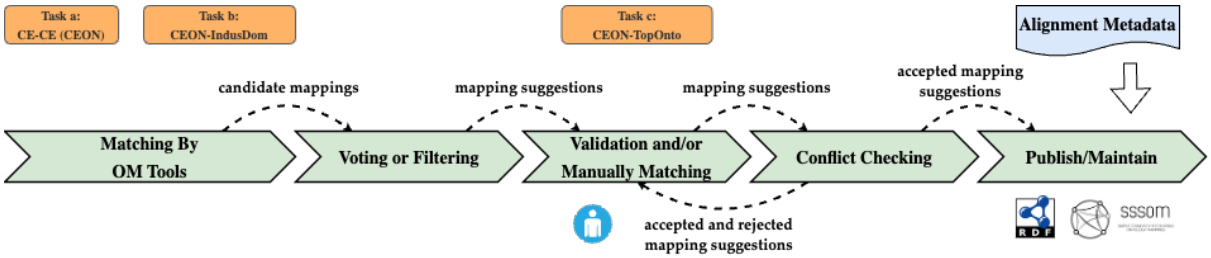

Figure 1: A pipeline of producing alignments in Onto-DESIDE.

validating alignments was established as shown in Figure 1 [6]. Based on alignment results[3] from the first and second tasks from the Onto-DESIDE project, we initiated the circular economy track focusing on schema matching at the Ontology Alignment Evaluation Initiative (OAEI) since 2024. The first task involved identifying four relevant ontologies and producing alignments between them and CEON, which contributed to the CE track at OAEI 2024 [7]. The second task focused on aligning CEON with materials-related ontologies, further contributing to a sub-task in the 2025 edition of the CE track.

Unlike other TBox/Schema matching tracks organized in OAEI over the years, such as the Anatomy track, which has already benefited from substantial human validation efforts on mappings, the Circular Economy domain only recently witnesses a growing trend of ontology development for knowledge representation. Furthermore, CE-related ontologies span a wide range of domains, including materials, products, and specific sectors such as construction. Therefore, our ontology alignment work serves distinct task-specific purposes. In the next section, we outline this pipeline and the ongoing development of the CE track.

2. The Development of CE Track

The pipeline for producing alignment as shown in Figure 1 including five steps. In the first step, we selected several state-of-the-art ontology matching tools, based on their performance in previous OAEI editions, to generate candidate mappings. After generating candidate mappings, we intended to apply voting or filtering strategies to include only the most relevant ones. In the third step, domain experts and ontology engineers validated the filtered mappings. This was followed by a conflict-checking step to ensure coherence and prevent modeling defects in the resulting ontology network.

In 2024, we applied this pipeline using one ontology pair from **Task A** to organize the first edition of the CE track. This pair included CEON (version v0.2.0) and BiOnto where both ontologies have quite number of class and object property definitions as shown in Table 1. In this initial run, only three tools were used to generate candidate mappings. They were AgreementMakerLight (AML) [8], AgreementMakerDeep (AMD) [9] and LogMap [10]. In 2025, the matching tool set is expanded to include additional tools: ATBox (ATM) [11], MATCHA [12], and LogMapLite [10]. Specifically, in the second step of the pipeline, mappings supported by fewer than three tools were excluded. Table 2 summarizes the selected tools and their performance on **Task A**. Some tools, such as AML, LogMap, and LogMapLite, have participated in OAEI long-term and employ conventional matching strategies like various forms of string similarity (e.g., Jaccard, Levenshtein distances). These tools achieved relatively higher F-measures. Metrics such as precision, recall, and F1-score were computed based on a reference alignment created via the pipeline. Three domain experts and ontology engineers then validated the selected mappings, and we used RepOSE [13] to check for logical coherence in the resulting ontology networks. In 2025, we introduced a new sub-task to the CE track: aligning CEON with MATONTO. This addition is significant, as materials are a central concept in circular value networks. Understanding how CE-related ontologies align with material-domain ontologies provides valuable insights for semantic interoperability.

[3]The results are presented in more detail in [2] and [6].

Table 1
CE track for OAEI 2024 and 2025.

		Task A: CE-CE		Task B: CE-Material	
	CEON	BiOnto	Reference	MATONTO	Reference
2024	214 classes, 154 object properties, 214 subsumption axioms	780 classes, 64 object properties, 804 subsumption axioms	18 mappings	–	–
2025	235 classes, 129 object properties, 305 subsumption axioms	780 classes, 64 object properties, 804 subsumption axioms	31 mappings	848 classes, 83 object properties, 1190 subsumption axioms	16 mappings

Table 2
Characteristics of selected tools and their performance for Task A [6].

Tool	Matching Strategies	# of mappings for Task A	TPs	FPs	FNs	Prec.	Reca.	F1
AMD	Sentence-BERT model (textual aspect), TransL (structural aspect)	31	21	10	19	0.677	0.525	0.591
AML	string equivalence, Jaccard, WordNet, structural similarity propagation, logical repair	57	32	25	16	0.561	0.667	0.609
ATM	string equivalence, Levenshtein, English Wiktionary synonyms, reliance on instance	57	29	28	17	0.509	0.630	0.563
LogMap	lexical and structural indexation, unsatisfiability detection and repair, ISUB	58	36	22	13	0.621	0.735	0.673
LogMapLite	string matching techniques only	69	36	33	13	0.522	0.735	0.610
MATCHA	AML's strategies and Sentence-BERT model (textual aspect)	153	39	114	13	0.255	0.750	0.381

3. Summary and Outlook

In this poster paper, we present the development of the Circular Economy (CE) track at OAEI, initiated in 2024 and developed further in 2025. The track is built on ontology alignment work carried out in the Onto-DESIDE project. Based on the latest results, we introduced updates to the track this year. Although currently limited in scale—both in terms of the number of reference alignments and participating ontologies—we foresee continued growth in CE-related ontologies. Improving semantic interoperability among them will become increasingly important. Thus, we aim to continue evolving this track. In the future, we plan to introduce additional sub-tasks, such as aligning CE ontologies with those from related domains like sustainability and energy.

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Declaration on Generative AI

During the preparation of this work, the authors used GPT-4-turbo in order to grammar and spell check, and improve the text readability. After using the tool, the authors reviewed and edited the content as needed to take full responsibility for the publication's content.

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