OntoSustain: Towards an Ontology for Corporate Sustainability Reporting

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Abstract

The sustainability reporting of small and medium-sized enterprises is gaining significance, as their business partners often rely on them to ensure compliance and promote sustainability along the supply chain. However, the implementation of reporting remains challenging, as companies may lack the appropriate human resources to comprehend the informal textual descriptions from various reporting standards. In order to support the sustainability reporting of the companies, we present our ongoing work on the OntoSustain ontology. OntoSustain models sustainability domain knowledge, and offers good comprehensibility, transparency, and reusability for companies' sustainability officers in data collection and indicator value derivation.

Keywords

Corporate Sustainability Reporting, Ontology, Sustainability Indicator, SMEs

1. Introduction

The significance of sustainability reporting for small and medium-sized enterprises (SMEs) should not be overlooked, as buying firms may rely on them to enforce sustainability standards [1]. As an example, 90% of greenhouse gas (GHG) emissions come from the supply chain [2]. Nevertheless, the implementation of sustainability reporting remains challenging. Sustainability data collection relies on informal textual descriptions in reporting standards, which can give rise to ambiguity, making it challenging to precisely comprehend and consistently meet the requirements of the sustainability indicators [3]. Besides, as SMEs serve global customers, they must navigate through the complexities of preparing reports based on multiple standards with varying jurisdictional scope. Due to the lack of appropriate human resources, these tasks become even more intricate.

Ontologies can serve as an approach to model complex application domains, addressing ambiguity in natural language [4]. For sustainability reporting, existing research presents several ontologies. [5] and [6] developed an ontological model grounded in the Global Reporting Initiative (GRI). The primary contribution of [5] lies in the translation of the GRI content from XBRL to OWL, but minimal attention was directed toward the taxonomy of sustainability aspects. In contrast, [6] provided a comprehensive ontological model, emphasizing the representation of

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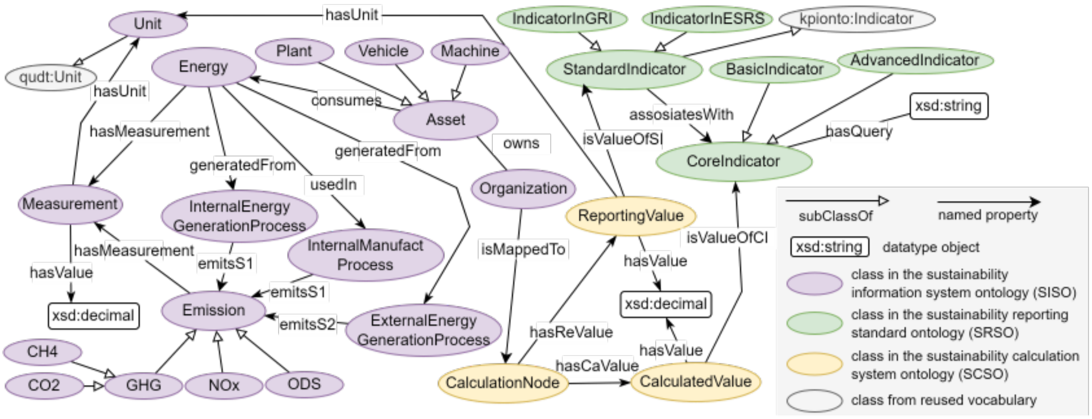

Figure 1: Main classes and properties of the OntoSustain ontology

association and composition relationships among sustainability aspects and indicators. Both [3] and [7] collaborated on the integration of indicators sourced from GRI and other sustainability indicator collections. [7] primarily focused on representing the structural relationships among indicators. However, this approach fell short of providing the essential details required for indicator value conversion. Contrarily, [3] modeled mathematical relationships among indicators with an explicit representation of the position of each argument within the calculation formulas. To date, there have been limited endeavors to depict the connection between sustainability indicators and the corresponding business activities. Additionally, few contributions involve the indicator value conversion among multiple standards.

We present our ongoing work on OntoSustain, an ontology that helps SMEs prepare compliant sustainability reporting. This paper provides an overview of the ontology, encompassing the ontology engineering process, the ontology schema, as well as the use cases of the ontology.

2. The OntoSustain ontology

The aim of OntoSustain is to represent knowledge about the underlying business activities, the calculation, and the derivation method of sustainability indicators in the context of the corporate sustainability reporting application. Following the METHONTOLOGY [8] method, the ontology engineering process consists of four phases: specification, conceptualization, implementation, and evaluation.

Ontology specification The identified ontology scope covers sustainability indicators from reporting standards. We chose GRI[1], the most widely used sustainability reporting framework around the world, and the European Sustainability Reporting Standards (ESRS)[2], a core component of the sustainability reporting landscape within the European Union. Both frameworks categorize the indicators under sustainability aspects, such as emissions, workforce, and corrup-

[1]https://www.globalreporting.org/
[2]https://www.efrag.org/lab6

tion, in accordance with the environmental, social, and governance dimensions. To delimit the scope of OntoSustain and to represent the ontology requirements, we formulated competency questions (CQs). Presented below are two examples:

CQ 1. Which business activities could have impacts on a specific sustainability indicator?

CQ 2. Can the value of a specific ESRS indicator be mathematically derived from any GRI indicator(s)? If not, which other data is needed for the conversion?

Ontology design OntoSustain consists of three modules: 1) sustainability information system ontology (SISO), 2) sustainability reporting standards ontology (SRSO), and 3) sustainability calculation system ontology (SCSO). In Figure 1, we present the modules along with their respective main classes and properties, as well as the utilized existing ontologies, such as the QUDT Ontologies[3], and the KPIOnto ontology[9]. We provide an introduction as follows.

SISO models two aspects: a company's daily business activities and sustainability domain knowledge. We adopted the class- and property hierarchy, and the domain and range descriptions to semantically differentiate sustainability indicators, e.g., properties *emitsS1* and *emitsS2* are both sub-properties of *emits*, but we define distinct domains for them to distinguish between the scope 1 and scope 2 GHG emissions[4].

Listing 1: Excerpt of a core indicator individual with an associated SPARQL query that is parametrized and used for indicator value derivation (prefix definitions are omitted)

```
srso:CI0014 a srso:CoreIndicator ; srso:hasQueryText
       ”SELECT (SUM(?value) AS ?PurchasedElectricityConsumption) ?unit
       WHERE { VALUES (?organization) {
                  (siso:Org1) # PARAMETER
              }
              ?organization siso:owns ?asset .
              ?asset a siso:Asset ; siso:consumesPurchasedElectricity ?electricity .
              ?electricity siso:hasMeasurement ?measurement .
              ?measurement siso:hasNumericalValue ?value ; siso:hasUnit ?unit .
       } GROUP BY ?unit” .
```

SRSO models sustainability indicators and provides the value conversion based on the indicator requirements. The indicator metadata such as name, ID, and description is also modeled (*StandardIndicator (SI)*). We acknowledge that a simple ”same-as” relation is insufficient to achieve complete interoperability among diverse standards, as indicators from different standards may differ in their required measurement unit or disaggregation level. As an example, GRI mandates reporting the consumption of purchased energy in units of ”joules, watt-hours, or multiples” while ESRS specifies reporting in megawatt-hours and requires an additional breakdown of the quantity between renewable and non-renewable sources. Therefore, the atomic indicators are derived and modeled using *CoreIndicator (CI)*. Distinct *CIs* specific to each standard only associate with their respective SIs, whereas shared *CIs* associate with multiple *SIs*, facilitating interoperability among diverse standards.

SCSO is designed to derive indicator values by linking SISO and SRSO. The values of *CIs*

[3]https://www.qudt.org/

[4]https://www.globalreporting.org/standards/media/1012/gri-305-emissions-2016.pdf

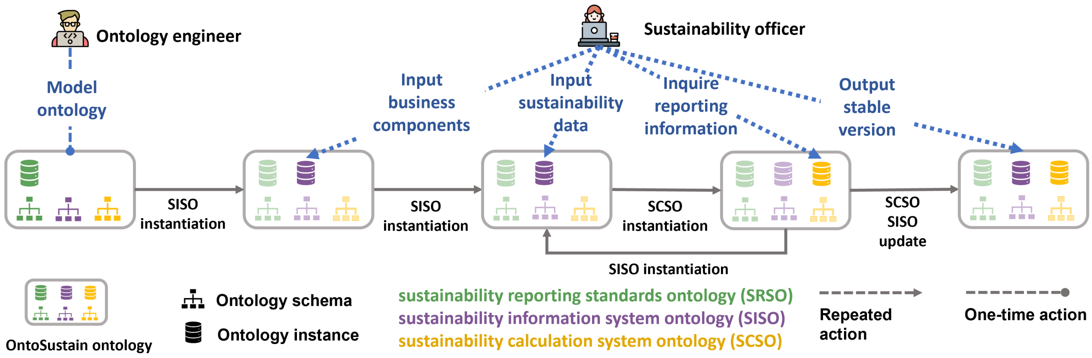

Figure 2: The interaction pipeline between the stakeholders and the OntoSustain ontology

are calculated using pre-stored SPARQL query templates, from which the reporting values (*ReportingValue*) of associated *SIs* are then evaluated. The core indicator specification in Listing 1 shows how the SISO model can be used to calculate SRSO reporting values. Thereby, the assessment of individual indicator values can be achieved independently for different timeframes and without impacting the metadata of SISO and SRSO.

Ontology implementation We use the Protégé ontology editor[5] for the OWL-based formalization of terminological knowledge. GraphDB[6] serves as a database for persistently storing and visualizing terminological and related assertional organizational data.

3. OntoSustain in Use

Figure 2 illustrates the interaction pipeline between OntoSustain and its stakeholders. OntoSustain is developed by the ontology engineer and used by sustainability officers for three use cases: 1) managing sustainability data, 2) inquiring indicator values, and 3) converting the values across multiple standards. Sustainability officers will use a graphical user interface in their daily work: they input and update their organization's business activities, as well as enter sustainability data within specific time periods. When there's a need to generate sustainability reports, they inquire about reporting information. Additionally, they can translate the reporting information between multiple standards, if needed. Using the ontology offers the advantage of ensuring consistent indicator calculation procedures for the same organization across different time periods and even enables comparability among multiple organizations.

4. Conclusion and Future Work

This paper presents ongoing work on OntoSustain, which aims to offer good comprehensibility, transparency, and reusability in sustainability data collection and indicator value calculation, derivation, and conversion. OntoSustain will facilitate organizations in achieving cost-efficient

[5]https://protege.stanford.edu/
[6]https://graphdb.ontotext.com/

sustainability reporting practices. In the future, we plan to conduct an ontology evaluation using data from a manufacturing SME to assess the problem of the three Cs[10]: Consistency, Completeness, and Conciseness. Thereafter, the validated knowledge graph will be stored in a knowledge base with appropriate interfaces to be used flexibly. The entities of the sustainability ontology are intended to be linked with other knowledge entities from the manufacturing company regarding manufacturing processes, associated products, and involved manufacturing resources to enable dynamic per-product sustainability score calculations.

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