An Ontology-Based Framework to Provide Legal Interoperability Within International Data Spaces

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Abstract

The phenomenon of providing value to data, especially for sensitive data among companies has remarkably increased in the past years. As a treatment for exchanging sensitive data without losing control or competitive advantage, the International Data Spaces (IDS) initiative provides the complete lifecycle architecture for deploying a safe and data sovereign data ecosystem. The IDS architecture is influenced by the European Interoperability Framework (EIF), which further divides interoperability into four complementary layers, i.e., legal, organizational, semantic, and technical. This research focuses on the lack of endorsement regarding the prior layer of interoperability, i.e., legal interoperability. The EIF defines legal interoperability as the capability of companies from different countries (grounded by different legislations) to exchange data, and further enhanced by a provided systematic literature review, as the capability of representing contractual clauses in an unambiguous representation. Based on the cited assumptions, this paper provides the triangulation of problem and solution sets based on Design Science Research, guaranteeing a set of methodologies for tackling such gaps.

Keywords

Domain Ontology, Design Science Research, Ontology Engineering, International Data Spaces, Machine Learning, Natural Language Processing

1. Introduction

Since the rise of Industry 4.0, companies have perceived and exploited the benefits of sharing data in the industrial environment [1]. Sharing data may lead to value creation in a holistic approach, however, sharing sensitive data relies on a systematic and secure approach, to avoid losing control over data, and competitive advantage. Based on those assumptions, the Fraunhofer Institute has developed the Industrial Data Spaces initiative [2], which provides a framework for sharing sensitive data in a secure data space, that relies on trust and *data sovereignty*. Data sovereignty stands for the capability of a data owner to maintain control over their data, determine who can access it, for what duration, and for what specific purposes it may be used. One year later, in 2015, the Industrial Data Spaces initiative was enhanced into the International Data Spaces (IDS) initiative. Grounded by the same pillars, the IDS initiative differs from its precursor, because of its capability to exchange data internationally.

The International Data Spaces Association (IDSA) manages the IDS initiative by providing ar-

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chitecture models, policies, and maintenance capability. The IDSA has developed the Reference Architecture Model (RAM) [3], which describes the IDS architecture and instantiates patterns for development and deployment. The RAM leans on the European Interoperability Framework (EIF) regarding its interoperability capabilities [4], which divides the concept of interoperability into four layers, i.e., legal, organizational, semantic, and technical, hierarchically. Even though recently, in 2024, the EIF has been updated, and now counts with the four layers of interoperability, a cross-cutting layer (integrated public service governance), and a background layer (interoperability governance), the RAM only reflects the four fundamental layers, hence, we have defined our scope towards those layers. Legal Interoperability is defined as the capability of companies under different legislations to exchange data. To provide a licit service contract of IDS, there must be compliance between the data provider and the data consumer. This compliance is achieved by the commitment to the data usage policy - a set of usage policies defined by the data owner regarding its data. The data usage policy may be negotiated in the contract negotiation phase, but only the data owner has the power to update it.

The IDSA also provides the Information Model [5], an OWL ontology that defines the domain of IDS. This ontology was developed to provide a framework for further development, providing an incipient description of IDS, and proposing its branches expansion. This present work was fostered by such an assumption to provide a better description of the legal domains of IDS. Although the legal interoperability layer carries the role of a fundamental one, it is seldom undervalued by researchers and enthusiasts. We performed a Systematic Literature Review (SLR) to validate and retrieve knowledge regarding such an assumption. To represent the legal interoperability domain in IDS, we propose the development of an ontology called Legal Interoperability Ontology for International Data Spaces - *LegIOn-IDS*, which is available in the supplementary material[1]. Moreover, we propose the reuse of the Service Contract Ontology [6], which provides a framework for contractual relationships, and its description in a machine-readable way, given the high-level concepts of legal entitlements and legal lacks.

With this work, we propose a protocol for legal interoperability in IDS, by offering an ontological representation of the legal aspects domain regarding the IDS infrastructure, a clear concept of legal interoperability in IDS, and finally, providing an unambiguous machine-readable language that can feasibly describe a service contract in IDS, leading to human resources and financial savings. Furthermore, we advocate implementing Natural Language Processing machine learning models, which based on the instantiation of the ontology (with contractual clauses), can provide a service contract based on the IDS architecture. Figure 1 provides a bottom-up application for our framework.

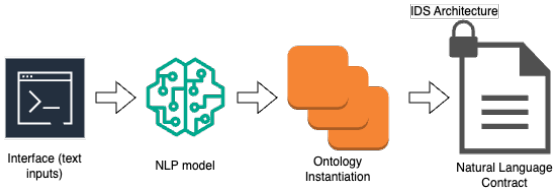

Figure 1: Bottom-up architecture for the proposed framework - Original Authorship

[1]https://github.com/VictorBenoiston/legal_interoperability_IDS_ontology

2. Methodology

For developing such research, we propose the usage of Design Science Research (DSR). DSR is stated as a practical research development methodology that is based on a problem set, and relies on several methods, Research Questions (RQ), and goals to provide a concise set of solutions (treatment) [7]. The research questions of this present work are presented as follows: **General Research Question:** How to Achieve Legal Interoperability in IDS? **General Conceptual Question:** What is legal interoperability in Dataspaces? **General Technical Question:** How to effectively enforce Legal Interoperability in IDS?**General Practical Question:** How does Proper Legal Interoperability affect IDS-based ecosystems?

Furthermore, we may summarize our goals as **Knowledge goal:** Provide a conceptual foundation for legal interoperability in IDS-based data ecosystems, identify gaps, challenges, and opportunities. **Artifact Goal:** Develop a legal interoperability protocol that encompasses the IDS architecture, especially the contractual phases (offer, request, and negotiation), and data exchange between countries under different legislations. The artifact must provide a natural language contract for easier negotiation of clauses, and screening of interoperability barriers [4]. Finally, the **Instrument Design:** Develop a FAIR ontology [8], which works as a foundation for further applications. The ontology ought to unambiguously represent the legal interoperability domain in IDS.

To answer those RQs, and guided by the knowledge, artifact design, and instrument design goals, we performed an SLR, grounded by the guidelines proposed by [9]. Furthermore, an ontology for describing legal interoperability within IDS is being developed, fostered by the SABiO [10] and SABiOx [11] systematic methodologies for building ontologies. Finally, the functional and non-functional requirements, the referential and operational versions of LegIOn-IDS, and documentation are available in the supplementary material.

3. Conclusion and Prior Results

As an ongoing work, the proposed ontology is incipient, lacking real-world validation, and real user evaluation [12]. For that purpose, we propose the implementation of such ontology into real-world use cases, such as the alignment with the recently launched Brazilian IDS hub, or even providing a scenario of data sharing between different countries with local oil companies, or Dutch logistics companies using digital twins. However, we can already retrieve knowledge through SPARQL queries, answering its competency questions (functional requirements). Finally, as future steps, we aim to implement machine learning NLP models able to classify the contractual clauses and their further implementation in the service contract template, leveraging easier validation for lawyers, enthusiasts, and IDS potential participants.

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