

# The Application of ODCM for Building Well-Founded Legal Domain Ontologies: A Case Study in the Domain of Carriage of Goods by Sea

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## ABSTRACT

The ontology engineering community is facing several key challenges about the development of domain ontologies. One major challenge is the building of well-founded domain ontologies. This concept has raised recently and it refers to ontologies that are grounded in validated foundational ontologies. This paper addresses the effective contribution of ontology-driven conceptual modeling process (ODCM) for developing such ontologies in the legal domain. A case study in the domain of carriage of goods by sea is presented.

## CCS CONCEPTS

• Computing methodologies~Ontology engineering • Applied computing~Law

## KEYWORDS

Ontology-Driven Conceptual Modeling, well-founded ontologies, UFO, OntoUML, legal ontologies.

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## 1 Introduction

The ontology engineering community is facing several key challenges about the development of ontologies. The building of “well-founded” domain ontologies is considered as a major challenge. This concept has introduced mainly in Guizzardi’s works [1,2] where authors admit that “*ideally domain ontologies*

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*should be developed grounded in foundational ontologies*” [3]. Thus, concepts and relations in a well-founded domain ontology must be previously analyzed in the light of a foundational ontology. Foundational ontologies define a range of top-level domain-independent ontological categories which form a general foundation for more elaborated domain-specific ontologies [4, 5]. In this context, we consider that ontology-driven conceptual modeling (ODCM) could have an effective contribution for developing well-founded domain ontologies. ODCM is firstly introduced by Guarino [6] who considered that introducing ontologies will provide a foundation for conceptual modeling by expressing the fundamental elements of a domain [7]. Recently, Guizzardi [8] has described ODCM as the utilization of ontological theories, coming from areas such as formal ontology, cognitive science and philosophical logics, to develop engineering artifacts (e.g. modeling languages, methodologies, design patterns and simulators) for improving the theory and practice of conceptual modeling. In fact, ODCM is still a relatively a new research domain in the field of information systems, there is still much discussion on how the research in ODCM should be performed and what the focus of this research should be [9,10].

The main goal of this paper is to present the role of ODCM, by the application of ontological analysis based on foundational ontologies [11], in supporting the development of well-founded domain ontologies in the legal domain. The domain application of this work is the carriage of goods by sea conventions.

The remainder of this paper is structured as follows: Section 2 briefly presents ODCM. Section 3 demonstrates the application of ODCM in the legal domain for building well-founded domain ontology named Cargo. Section 4 outlines the related works and finally section 5 presents our final considerations.

## 2 Ontology-Driven Conceptual Modeling Process

As aforementioned, ODCM is described as the application of ontological analysis based on foundational ontologies in order to improve the theory and practice of conceptual modeling [12]. Therefore, the application of ODCM is motivated by two main essentials [13]: a foundational ontology and an ontology-driven conceptual modeling language. In this context, the unified foundational ontology UFO [1] is the most convenient as a foundational ontology for three main reasons:

1. Its successful application in a large number of domains ranging from natural science domains such as Petroleum and

Gas to social domains such as organizations, services and software [14].

2. The fact that UFO comprises a rich theory of relations and complex relational properties that is absent in other foundational ontologies [15, 16].
3. The availability of conceptual modeling language founded on this ontology (OntoUML) [1, 16].

## 2.1 The Unified Foundational Ontology (UFO)

The Unified Foundational Ontology (UFO) is developed by Guizzardi [1, 16, 17] to support the activities of both conceptual and organizational modeling. UFO addresses issues such as [1, 18, 19]: (i) the general notions of types and their instances; (ii) objects, their intrinsic properties and property-value spaces; (iii) the relation between identity and classification; (iii) distinctions among sorts of types (e.g., kinds, roles, phases, mixins) and their admissible relations; (iv) distinctions among sorts of relational properties; (v) Part-whole relations. The foundational ontology UFO is divided into three layers: UFO-A (ontology of objects), UFO-B (ontology of events) and UFO-C (ontology of social entities). Therefore, UFO permits the building of ontologies by reusing some generic concepts as modeling primitives such as among others, *category*, *kind*, *subkind*, *role*, *relator* and *phase*, where the ontologists does not need to rebuilt these concepts.

## 2.2 OntoUML

OntoUML (Ontological Unified Modeling Language) is a ODCM language that extends UML by defining a set of stereotypes in order to reflect UFO ontological distinctions into language constructs [13]. OntoUML was proposed by Guizzardi [1, 17] based on the need of a conceptual modeling language that would provide the necessary semantics to construct conceptual models using concepts faithful to realities. OntoUML can be used to produce conceptually cleaner and semantically unambiguous models in concrete application scenarios [18] by the application of the ontological constraints of UFO as modeling primitives. This language has been successfully employed in a number of industrial projects in several domains such as Petroleum and Gas, News Information Management, E-Government and Telecommunication [20]. In order to build, evaluate and implement OntoUML models, a model-based environment is needed such as the tool Menthor Editor<sup>1</sup> [11].

## 3 Application of ODCM in the Legal Domain

This section presents the main contribution of this paper which is the application of ODCM in the legal domain for building a well-founded domain ontology, called *Cargo*. This ontology is intended to represent the domain of carriage of goods by sea. In this context, in order to represent the basic concepts in the legal domain, there is a need for a legal core ontology as an additional motivation for the application of ODCM. Core ontologies provide a precise definition of structural knowledge in a specific field that spans across different domain applications (such as criminal domain, carriage of goods, etc.) [21]. Two legal core ontologies are founded in the literature: LKIF-Core<sup>2</sup> [22] and UFO-L [23]. LKIF-Core contains “basic concepts” of law and composed of 15

modules which are located into three main layers: top-level, basic-level and legal-level. UFO-L is a recent legal core ontology that uses domain-independent concepts provided by UFO to represent essential concepts of law based on Alexy’s theory of fundamental rights ontology [24]. In this work, UFO-L is selected since it is founded on UFO which will simplify its representation in OntoUML. Therefore, in the legal domain, the application of ODCM is motivated by: the foundational ontology UFO, the legal core ontology UFO-L and the ODCM language OntoUML. Based on this perspective, a layered architecture of Cargo, composed of three main layers, is proposed: Upper ontology layer (UOL), Core ontology layer (COL) and Domain ontology layer (DOL).

### 3.1 Upper Ontology Layer (UOL)

UOL contains the most abstract concepts imported from UFO. Actually, the domain of carriage of goods, as any other legal domain, is concerned by categories such as, among others: **Agent**, **Object**, **Event**, **Normative\_Description**, etc. In this regard, for simplifying the building of UOL and not reinventing the wheel, it is feasible to import the abstract categories (concepts, relations and axioms) from a developed legal domain ontology, called CriMonto [25]. CriMonto is a modular legal ontology developed for the criminal domain for building a legal rule-based reasoning system. It is composed of four ontology modules located at different abstraction levels: upper, core, domain and domain-specific. The upper module is concerned with the most abstract categories which are imported from UFO-A, UFO-B and UFO-C. This module contains 74 concepts and 54 relations and is designed to be reusable for building well-founded legal domain ontologies. Due to the limitation of space, readers may refer to [26] for more details about CriMonto. In the following, some basic concepts of UOL, that are reused from the upper module of CriMonto, are defined [27].

1. **Agent** (Figure 1) is a **Substance** in UFO. **Agent** can be physical (**Physical\_Agent**) or social (**Social\_Agent**). **Natural\_Person** is an example of **Physical\_Agent**. **Organization** is an example of **Social\_Agent**.
2. **Object** (Figure 1) is a **Substance** and can be social (**Social\_Object**) or physical (**Physical\_Object**).
3. **Normative\_Description** (Figure 1) is a **Social\_Object** and is recognized by at least one **Social\_Agent**.

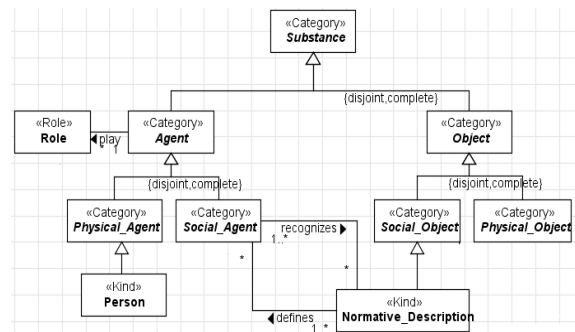
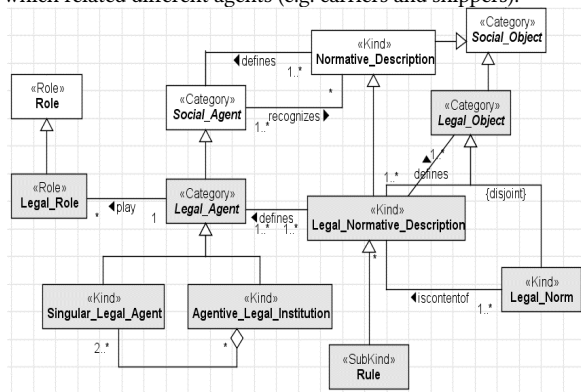


Figure 1: Excerpt from UOL of Cargo in OntoUML.

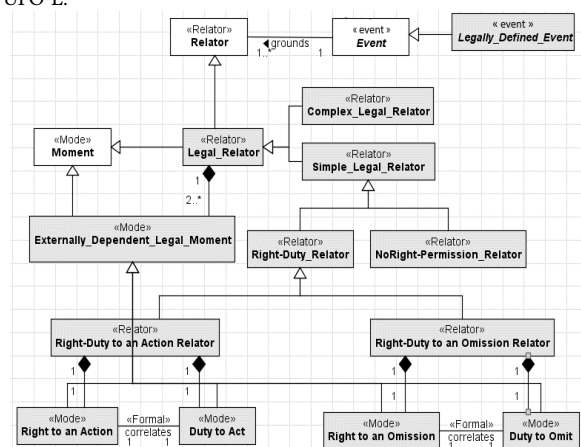
<sup>1</sup> Ontology-driven conceptual modeling platform

<sup>2</sup> <https://github.com/RinkeHoekstra/lkif-core>

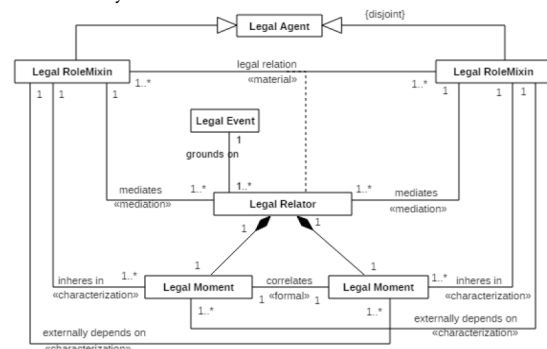
COL consists of legal concepts and relations that are reused from UFO-L such as, among others, **Legal\_Agent**, **Legal\_Role**, **Legal\_Object** and **Legal\_Event** (Figure 2). These concepts describe the fundamentals of any legal domain. For instance, carriers and shippers are examples of **Legal\_Role** in the domain of carriage of goods. An example of **Legal\_Normative\_Description** is a contract of carriage of goods which related different agents (e.g. carriers and shippers).



In Figure 3, the concepts that support legal relations (**Legal\_Relator**) are indicated. In UFO-L, any **Legal\_Relator** is grounded by a legal event (**Legally\_Defined\_Event**) and is composed of two or more pairs of **Externally\_Dependent\_Legal\_Moment**. Regarding structural complexity, **Legal\_Relator** is composed of **Simple\_Legal\_Relator** and **Complex\_Legal\_Relator**. **Right-Duty\_Relator** and **NoRight-Permission\_Relator** are, among others, types of **Legal\_Relator** in UFO-L.



Moreover, UFO-L define a modeling pattern (Figure 4) based on **Legal\_Relator** [24] in order to simplify its reusability. The **Legal\_Relator** pattern will be applied by extension for building the domain layer.



1. Which agents are involved in the legal relationship?
2. What categories of legal roles are involved?
3. What legal moments make up the legal relationship?
4. Who are the holders of each legal moment existing in the legal relationship?
5. Whose legal moment is externally dependent?
6. What event is the basis for the legal relationship?
7. Is there a legal rule that defines the legal relationship?

DOL consists of categories that represent the domain of carriage of goods by sea conventions, such as Hague<sup>3</sup> and Hamburg<sup>4</sup> rules, where the main concepts of this domain are, among others: Carrier, Contract of carriage, Bill of lading, Goods, Ship, etc.

In DOL, the main categories are extended from COL. In Figure 5, the main legal roles (**Carrier**, **Shipper** and **Consignee**) are identified as subclasses of **Legal\_Role**. **Contract\_of\_Carriage** and **Bill\_of\_Lading** are examples of legal documents that considered as subclasses of **Legal\_Normative\_Description**. In the domain of carriage of goods, the **Contract\_of\_Carriage** is covered by a **Bill\_of\_Lading**.

In Figure 6, the concept **Carriage\_of\_Goods\_Relator** is a specialization of **Right\_Duty\_Relator** and is composed of two **Externally\_Dependent\_Legal\_Moment** concepts: **Right\_to\_Carriage** and **Duty\_to\_Carriage**. **Right\_to\_Carriage** is composed of several externally dependent legal moments such as: **Right\_to\_load**, **Right\_to\_handle**, **Right\_to\_carry** and **Right\_to\_discharge**. Meanwhile, **Duty\_to\_Carriage** is composed of **Duty\_to\_load**, **Duty\_to\_handle**, **Duty\_to\_carry** and **Duty\_to\_discharge**.

<sup>4</sup> The United Nations Convention on the Carriage of Goods by Sea 1978

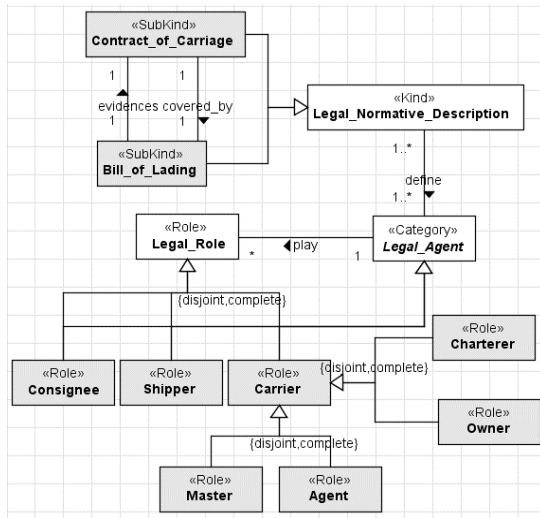


Figure 5: Excerpt from DOL of Cargo in OntoUML.

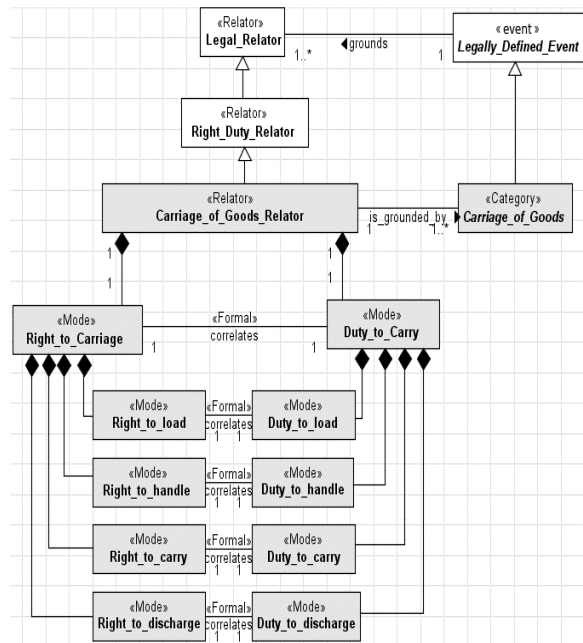


Figure 6: Excerpt from DOL of Cargo in OntoUML.

In figure 7, the proposed **Legal\_Relator** pattern is applied in the domain of carriage of goods where an example of the **Carriage\_of\_Goods\_Relator** is presented. This relator is grounded on an event (**Carriage\_of\_Goods**) and defined by a **Legal\_Normative\_Description**. Thereby, the application of this pattern has simplified the representation of relations between agents (**Shipper** and **Carrier**) during carriage of goods as well as the legal moments (**Right\_to\_Carriage** and **Duty\_to\_Carriage**) inherited in them.

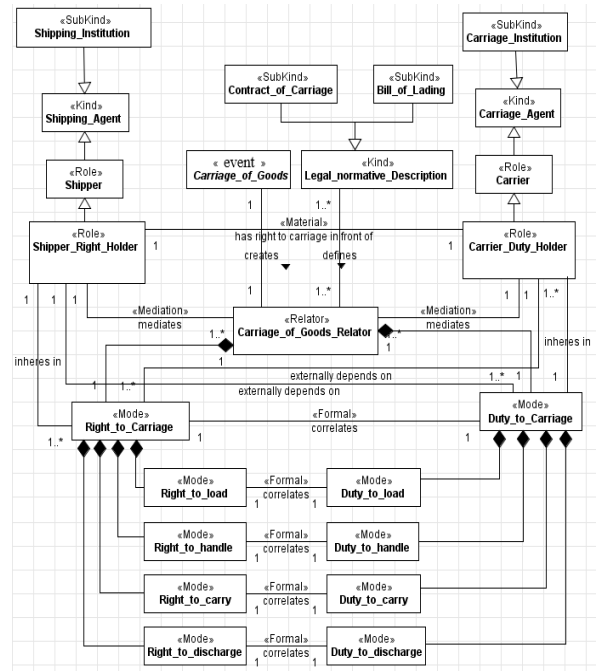


Figure 7: Carriage\_of\_Goods\_Relator in OntoUML.

## 4 Related Work

This paper discusses the application of ontology-driven conceptual modeling process (ODCM) for building well-founded ontologies in the legal domain. In the literature, there are few works addressing this modeling problem such as [25, 26] where the authors discussed the development of a well-founded ontology for the criminal domain called CriMonto. Thereby, an ODCM is applied, as a top-down strategy, starting from reusing the most abstract categories of UFO. Concerning the legal level of CriMonto, a reuse process of the legal core ontology LKIF-Core [22] is applied. The modular architecture of LKIF-Core has simplified its reusability. Meanwhile, it was mandatory to define the reused concepts and relations of LKIF-Core in the light of the foundational ontology UFO for the best application of the ODCM language OntoUML. For instance, in CriMonto, concepts such as, among many others, **Medium**, **Legal\_Document**, **Legal\_Source**, **Code** and **Regulation** have been reused from LKIF-Core. Each concept should be redefined in OntoUML according to the modeling primitives of UFO (*category*, *kind*, *subkind*, *role*, *relator*, etc.). for instance, **Medium**, **Legal\_Document** and **Legal\_Source** are defined in UFO as *kind* and **Code** and **Regulation** as *subkind*. Actually, this task is considered as hard and time consuming and requires the intervention of legal experts to verify its correctness.

In the current work, we have applied UFO-L as a legal core ontology for building the legal layer of Cargo. The main reason of this decision was the possibility of representing the reused concepts of UFO-L in OntoUML without redefining them which will simplify its reusability. Meanwhile the intervention of the legal experts remains necessary for the evaluation of the targeted developed ontology. An additional reason is the feasibility of the

application of the **Legal\_Relator** pattern (Figure 4) defined in UFO-L. This pattern has clarified essential modeling problems such as the relationships between the different agents of the domain of discourse. Moreover, by extending the **Legal\_Relator** pattern, the domain layer of the legal domain ontology is constructed.

## 5 Final Considerations

In this study, ontology-driven conceptual modeling (ODCM) process is applied to support the building of a well-founded legal domain ontology called Cargo for the domain of carriage of goods. In this regard, the application of ODCM in the legal domain is motivated by: a well-known foundational ontology (UFO), a legal core ontology (UFO-L) and an ODCM language (OntoUML). Therefore, a layered architecture of Cargo, composed of three main layers: UOL, COL and DOL, is proposed. In order to simplify the building of UOL and COL, a reuse process is applied. For UOL, it was feasible to reuse the upper module from an existent developed legal domain ontology called CriMonto [25, 26]. For COL, the basic legal categories of the legal core ontology UFO-L [24] have been reused. Finally, DOL is developed by extending COL, including the **Legal\_Relator** pattern, in the domain of carriage of goods. In this context, the application of the **Legal\_Relator** pattern is considered as a modeling solution for representing the relationships among different agents in the domain of carriage of goods. Therefore, grounding Cargo in the unified foundational ontology (UFO), by the application of ontological constraints of UFO as modeling primitives, has helped to overcome the challenge of building well-founded domain ontologies. In addition, the layered architecture of Cargo encourages its reusability.

As future work, Cargo is intended to be used for building a knowledge based system to support the traceability of goods during transportation by sea. For this reason, we are studying the possibility of combining Cargo with other ontologies, such as ontology of events (this model is under construction). The main purpose of this combination is the modeling of legal events in the domain of carriage of goods such as loading containers, discharging containers, route deviation, damage of goods, delay of delivery, etc.

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