Towards a Well-Founded Legal Domain Reference Ontology by Combining Conceptual Ontology Patterns

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Abstract. Building well-founded domain ontologies is a great challenge in the ontology engineering field. This concept has raised recently and it refers to ontologies that are grounded in foundational ontologies. This paper addresses the building of well-founded legal domain reference ontology by combining different levels of conceptual ontology patterns. The ontology patterns are derived from the foundational ontology UFO and the legal core ontology UFO-L. The use of the legal domain ontology is demonstrated in the domain of carriage of goods by sea for traceability purposes.

Keywords. Well-founded ontology, legal domain ontology, pattern-based ontology, conceptual ontology patterns, UFO, UFO-L

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1. Introduction

Building "well-founded" domain ontologies is a prominent challenge in the ontology engineering field. This concept has been used mainly in Guizzardi's works [1, 2] and it refers to ontologies that are "grounded" in validated foundational ontologies. In other words, concepts and relations in a well-founded domain ontology must be previously analyzed in the light of a foundational ontology.

Generally, ontologies are classified according to their abstraction level into three main categories [3]: *foundational*, *core* and *domain*. Foundational ontologies such as UFO [1, 4, 5], that are located at the most abstract level, define a range of top-level domain-independent ontological categories which form a general foundation for more elaborated domain-specific ontologies. Underneath of foundational, core ontologies, such as UFO-L [6] in the legal domain, are situated. They provide a precise definition of structural knowledge in a specific field that spans across different domain applications. At the lowest level, the domain ontologies, that describe the conceptualization related to a specific domain (e.g. penal law, maritime law), are located. In addition, a relevant classification of ontologies is proposed by Guizzardi [2] who differentiates between *reference* and *operational* ontologies. Reference ontologies are particular kind of conceptual models that are developed with the goal of making the best possible description of the domain in reality [2]. Namely, when developing a reference ontology,

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the focus is on the expressivity of the representation and truthfulness to the domain being represented [7]. Meanwhile, operational ontologies are machine readable implementation version of reference ontologies [8]. Unlike reference ontologies, operational ontologies are not focused on representation adequacy, but are designed with the focus on guaranteeing desirable computational properties [9].

In the legal domain, building domain reference ontologies is a difficult task due to the complexity of the domain and the difficulty of extracting semantic knowledge from textual resources such as regulations and codes. It is important to notify that legal domain ontologies differ from ontologies in other fields of practice, like medicine or engineering in that they have to cover a wide range of common-sense concepts that are part of physical, abstract, mental, and social worlds [10]. Legal domains share complex and varied notions of norm and responsibility, but besides this, a legal domain refers to some world of social activities [10].

The *Unified Foundational Ontology* (UFO) [5] is an example of a descriptive foundational ontology that employ results from formal ontology, cognitive psychology, linguistics and philosophical logics. In this context, reusing foundational and/or core ontologies to support the development of domain ontologies is recognized as a promising approach in the ontology engineering domain since it enables a speeding up of the ontology development process [11]. Meanwhile, it is considered as a hard research issue and one of the most challenging and neglected areas of ontology engineering [12]. The problems of selecting the right ontologies to reuse, extending them and composing several fragments have not been properly addressed yet [13].

Ontology patterns (OPs) are recognized as a promising approach to solve recurrent ontology development problems [14]. OPs are modeling solutions that favor reuse of encoded experiences and good practices [15]. In the ontology engineering community, OPs have been addressed mainly in the works of [12,13,15, 16]. Recently, this approach has gained more attention specially in [11,14,7] where its main goal is to support the building of more consistent ontologies in a reuse-centered process. There are many different types of OPs that can be used in different phases of the ontology engineering process [11]. In this work, we are interested in Conceptual Ontology Patterns (COPs), since the focus is on building a domain reference ontology in the legal domain.

The main goal of this paper is to build a well-founded legal domain reference ontology by combining different levels of ontology patterns. The ontology patterns are derived from the foundational ontology UFO [5] and the legal core ontology UFO-L [6]. After derivation, they will be combined to build the domain ontology. The targeted ontology will be used for traceability in logistic networks in the domain of carriage of goods by sea. The remainder of this paper is organized as follows: section 2 outlines the unified foundational ontology UFO and the legal core ontology UFO-L. Section 3 describes the derivation of conceptual ontology patterns from UFO and UFO-L. In section 4, the application of the ontology patterns is demonstrated in the domain of carriage of goods for building a well-founded legal domain reference ontology. Finally, section 5 outlines the related works and section 6 concludes the paper.

2. UFO and UFO-L

In this section, the unified foundational ontology (UFO) [1] and the legal core ontology (UFO-L) [6] are introduced.

2.1. UFO

UFO [1] is a well-founded foundational ontology that employ results from formal ontology, cognitive psychology, linguistics and philosophical logics. It makes a fundamental distinction between *Individuals* and *Universals*. Individuals are entities that exist in reality and obey a unique and determinate principle of identity, while Universals are abstract patterns of features that can be realized in a number of different individuals [7]. In UFO, two main kinds of individuals are distinguished: *endurants* and *perdurants* [1]. Endurants are entities that are wholly present whenever they are present i.e. they don't have temporal parts [18]. They can be further specialized into *Substantials* (Objects) and *Moments* (Tropes [17]). Substantials are existentially-independent Endurants (e.g., a house, a person, the moon). Moments, or Tropes, in contrast, are individuals that can only exist by inhering in other individuals [17]. Two main types of moments are distinguished in UFO: Intrinsic moments and relators. Intrinsic moments are moments that inhere in one single individual (e.g. the redness of a T-shirt). An example of an intrinsic moment is a Mode (e.g. belief, intention, skill). Relators are moments that depend on two or more endurants (e.g. marriage, enrollment).

Perdurants (events) are individuals composed of temporal parts and are existentially dependent on endurants. They *happen in time* in the sense that they extend in time accumulating temporal parts [19]. Examples of perdurants are a football game, a birthday party or a business process. Therefore, two main layers of UFO are distinguished: the layer A that consists of the ontology of substance and tropes individuals (UFO-A), the layer B that consists of the ontology of events (UFO-B). In this paper, we are interested in UFO-A, namely endurants and moments.

Concerning the Universals, mainly Endurant Universals (Figure 1), they are composed of Substantial Universals and Moment Universals [1]. For the Substantials Universals, UFO distinguishes between *Sortal* and *Non-Sortal* (*Mixin*) Universals [7]. Sortal universals are sortal types that either provide or carry a uniform *principle of identity* for their instances [11,7]. Meanwhile, the Mixin universals, or Non-Sortals, are universals that aggregate properties of distinct Sortals, i.e., it can have as instances individuals obeying different principles of identity [7]. Within the category of Sortal Universals, UFO differentiates between *Rigid* and *Anti-Rigid* sortals [11]. *Kinds* are sortal rigid universals that provide a uniform principle of identity for their instances (e.g., Person). *Subkinds* are sortal rigid universals that carry the principle of identity supplied by a unique Kind (e.g., a Kind *Person* can have the Subkinds *Man* and *Woman* that carry the principle of identity provided by *Person*) [7]. Regarding Anti-Rigid, two main types are identified: *Role* (e.g. *Student*) and *Phase* (e.g. *Child*). The meta-properties of rigidity and anti-rigidity can be applied to Mixins where *Rigid Mixins* and *Anti-Rigid Mixins* are distinguished. A *Category* (e.g. *Physical Object* aggregates essential properties of *Table*, *Car*, *Glass*, etc.) represents a rigid mixin and a *RoleMixin* (e.g. *Customer* that aggregates properties of *Individual Customer* and *Corporate Customer*) represents anti-rigid mixin.

In order to capture all these distinctions between endurants types, UFO-A has been employed in the design of an ontologically well-founded conceptual modeling language named OntoUML [5]. The modeling constructs in OntoUML are illustrated in the leave categories in the hierarchy represented in Figure 1 [7]. Moreover, its metamodel contains a number of formal constraints derived from the axiomatization of UFO that prescribe the rules that govern the allowed combination of these constructs [7].

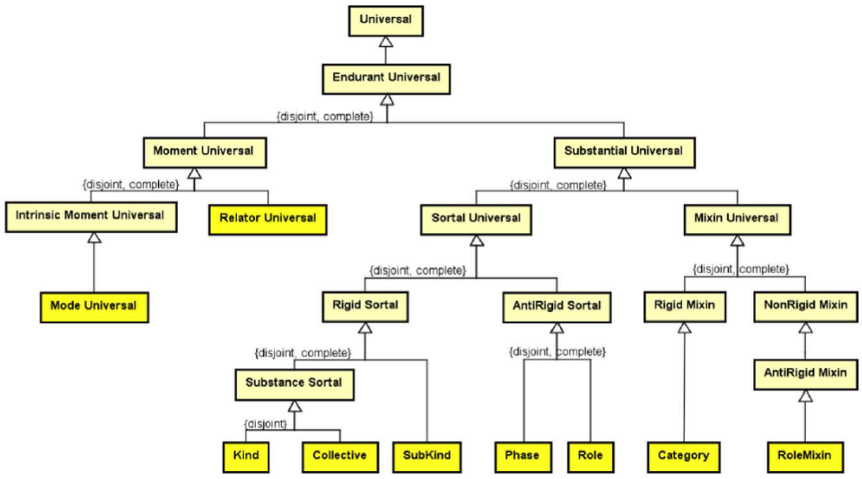

Figure 1. Fragment of UFO-A (Endurant Universals), adapted from [7].

2.2. UFO-L

UFO-L is a 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 [6]. UFO-L defines list of legal core concepts, such as *Legal_Agent*, *Legal_Object*, *Legal_Normative_Description*, *Legal_Moment*, *Legal_Norm*, *Legal_Role*, *Legally_Defined_Event*, *Legal_Relator*. By extending these concepts, a conceptualization of the legal domain can be built. Moreover, UFO-L defines a reusable modeling pattern (Legal_Relator pattern), illustrated in Figure 2. In this pattern, two *Legal_Agent* play roles (*Legal_Role*) that are grouped into two different categories (*Legal_Role_Mixin*). These categories are related through a *Legal_Relator*. The *Legal_Relator* is grounded on an event relevant to the legal field called *Legal_Event*. *Legal_Relator mediates* between legal categories of roles (*Legal_Role*) and consists of legal moments (Legal_Moment) that are inherent in legal roles and externally dependent on them. Legal moments are interlinked by correlation.

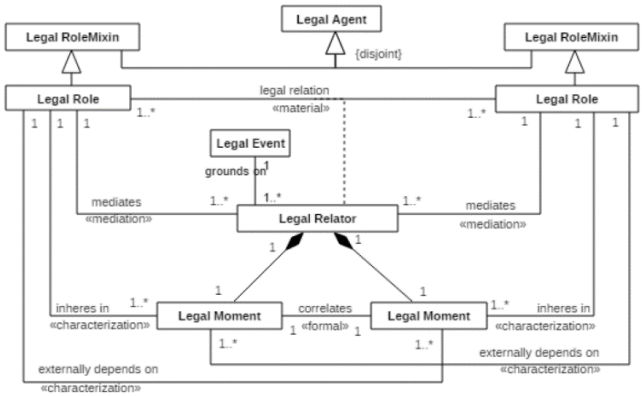

Figure 2. Legal_Relator pattern, adapted from [6].

3. Derivation of COPs from UFO and UFO-L

COPs are small fragments of ontology conceptual models that address a specific modeling issue and can be directly reused by importing them in ontology under development [12]. Thus, they are to be used during the ontology conceptual modeling phase and focus only on conceptual aspects without any concern with the computational part of the ontology [14]. COPs can be derived from either foundational ontologies (Foundational Ontology Patterns - FOPs) or core/domain ontologies (Domain-Related Ontology Patterns - DROPs) [11]. A COP extracted from a higher-level ontology can be used to support the development of lower-level ontologies [7]. COPs should be encoded in higher-order representation language [12] such as OntoUML [5]. This language has been designed to reflect the ontological distinctions and axiomatization put forth by the Unified Foundational Ontology (UFO) [4,5]. In the following, the conceptual ontology patterns, FOPs extracted from UFO and DROPs extracted from UFO-L, are introduced and illustrated in diagrams encoded in OntoUML [5].

3.1. Derivation of FOPs from UFO

Foundational ontology patterns (FOPs) are extracted from the foundations and rules of a foundational ontology. A FOP is not a foundational ontology fragment; instead, it is a self-contained set of related foundational rules and constraints that is applied to solve a common modeling problem independently of domain [11]. Since FOPs are extracted from foundational ontologies, they tend to be more generally applied and can be utilized in isolation with weak dependencies with other patterns [8]. FOPs are reused by analogy between the pattern and the problem in hand [14]. The result is an ontology fragment with the FOP structure shaping the structures at the level of domain concepts [11]. FOPs can be applied for building both core and domain ontologies. In this work, FOPs are derived from the Unified Foundational Ontology (UFO). Three main FOPs patterns are derived from UFO: *Category*, *Role-Relator* and *Subkind*.

3.1.1. Category Pattern

The *Category* pattern, depicted in Figure 3 as example, represents two main variants. In the first variant (a), a *kind* generalization set collecting a disjoint set of *kinds* that specialize the same *Category*. In the second variant (b), a simple *Mixin* specializing a *Category* is illustrated.

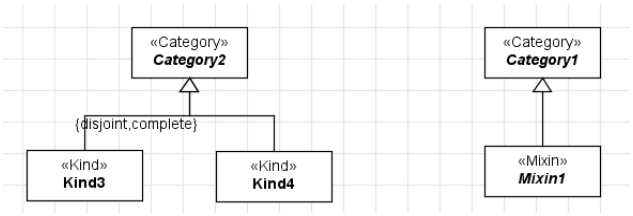

Figure 3. Category FOP.

3.1.2. Role-Relator Pattern

The *Role-Relator* pattern, depicted in Figure 4, represents a *Relator* connected via mediation relation to two different *Roles* that inherit the identity principle of exactly one

kind [11]. For instance, the relator *marriage* that connects two main roles *Wife* and *Husband* that are inherited from *Woman* and *Man* respectively. This pattern is composed of Role FOP where *Role* inherits *Kind*.

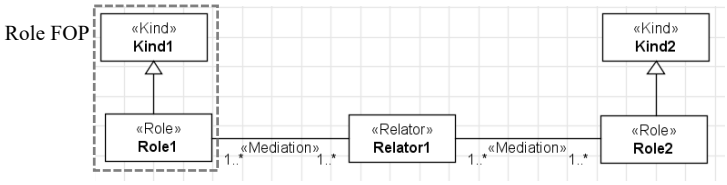

Figure 4. Role-Relator FOP.

3.1.3. Kind-Subkind Pattern

The *Kind-Subkind* pattern, depicted in Figure 5 as example, presents in two variants. In the first variant (a), a simple *subkind* (or *Kind*) specializing a *kind* is illustrated. In the second variant (b), a *subkind* (or *Kind*) generalization set collecting a disjoint set of *subkinds* (or *Kind*) that specialize the same *kind*.

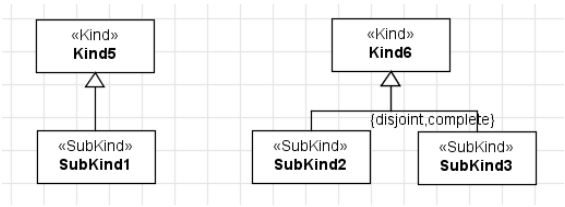

Figure 5. Subkind FOP.

3.2. Derivation of DROPs from UFO-L

Domain-related ontology patterns (DROPs) are reusable fragments extracted from core or domain ontologies. They capture the core knowledge related to a given domain [14]. Therefore, DROPs are very inter-related and it is very difficult to apply them in isolation [8]. DROPs, extracted from a core/domain ontology modeled already reusing FOPs, are richer, carrying both structural and domain knowledge, characterizing a chained COP application at the domain level [11]. DROPs are reused by extension, i.e. concepts and relations of the pattern are specialized when the pattern is reused and also by including new properties and relationships with the extended concepts [14]. Core ontologies are important sources of DROPs, since they describe the core knowledge of a wide domain that spans across different subdomains. Their models contain fragments of knowledge that can be reused when modeling more specific domain ontologies [7]. For the derivation of DROPs, the approach presented in [7] is applied. This approach is based mainly on a fragmentation process that tends to extract sub-ontologies from UFO-L [6] and splitting them into smaller pieces still meaningful to the domain. Therefore, two main DROPs are extracted from UFO-L: *Legal_Substance* and *Legal_Relator*. This process is guided by a list of Competency Questions (CQs) that can reveal modeling needs in small pieces.

3.2.1. Legal_Substance Pattern

Legal_Substance pattern, depicted in Figure 6, represents the hierarchical structure of *Legal_Objects* and *Legal_Agents* and their relationships. Two main CQs are addressed for this pattern: (CQ1) How are *Legal_Objects* and *Legal_Agents* structured? (CQ2) What categories are defined by *Legal_Normative_Description*?

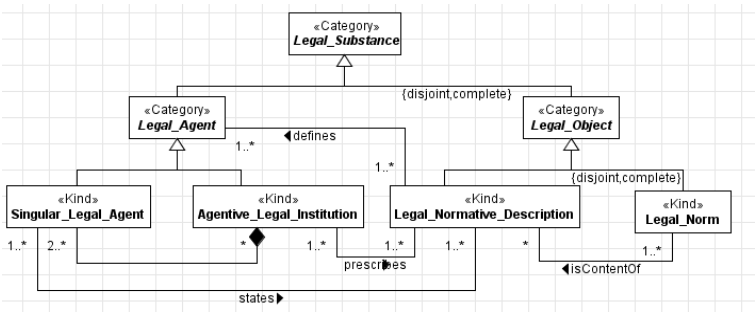

Figure 6. Legal_Substance DROP.

3.2.2. Legal_Relator Pattern

UFO-L distinguishes two main types of *Legal_Relator*: *Simple_Legal_Relator* and *Complex_Legal_Relator*. *Right-Duty*, *NoRight-Permission*, *Power-Subjection* and *Disability-Immunity* are legal relators instantiating *Simple_Legal_Relator*. *Liberty_Relator* instantiates *Complex_Legal_Relator*. In this section, *Right-Duty_Relator* pattern, depicted in Figure 7, is extracted as DROP. Different CQs can be addressed for this pattern such as [6]: (CQ1) Which agents are involved in the legal relationship? (CQ2) What categories of legal roles are involved? (CQ3) What legal moments compose the legal relationship? (CQ4) Who are the holders of each legal moment? (CQ5) Whose legal moment is externally dependent? (CQ6) What event is the basis of the legal relationship? (CQ7) is there a legal rule that defines the legal relationship?

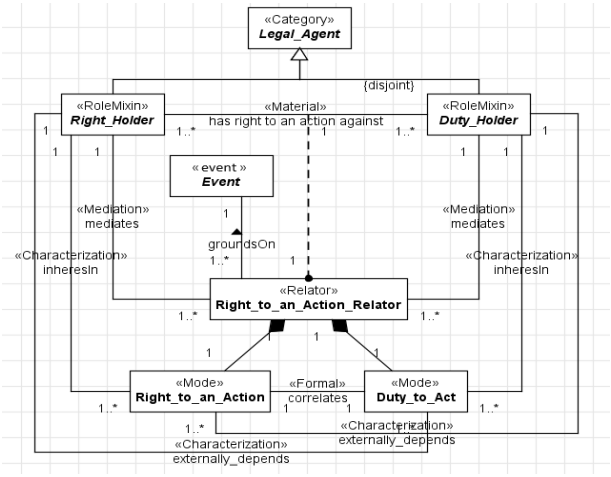

Figure 7. Right-Duty_Relator DROP.

4. Application of COPs for Building a Well-Founded Legal Domain Reference Ontology

According to [11], modeling domain ontologies is not limited to the direct application of patterns. Domain ontology fragments created from COPs are interrelated and need to be put together. To do that, the ontology engineer can look for related DROPs, and also use FOPs for combining the structure inherent to the different fragments [11]. Therefore, when FOPs and DROPs are systematically applied in combination, the reuse is maximized, the ontology building process become more productive, and the quality of the resulting domain ontologies are improved [11]. In this section, reusing FOPs, extracted from UFO, in combination with DROPs, extracted from UFO-L, is applied for building a portion of a well-founded legal domain reference ontology in the domain of carriage of goods by sea[2] illustrated in Figure 8.

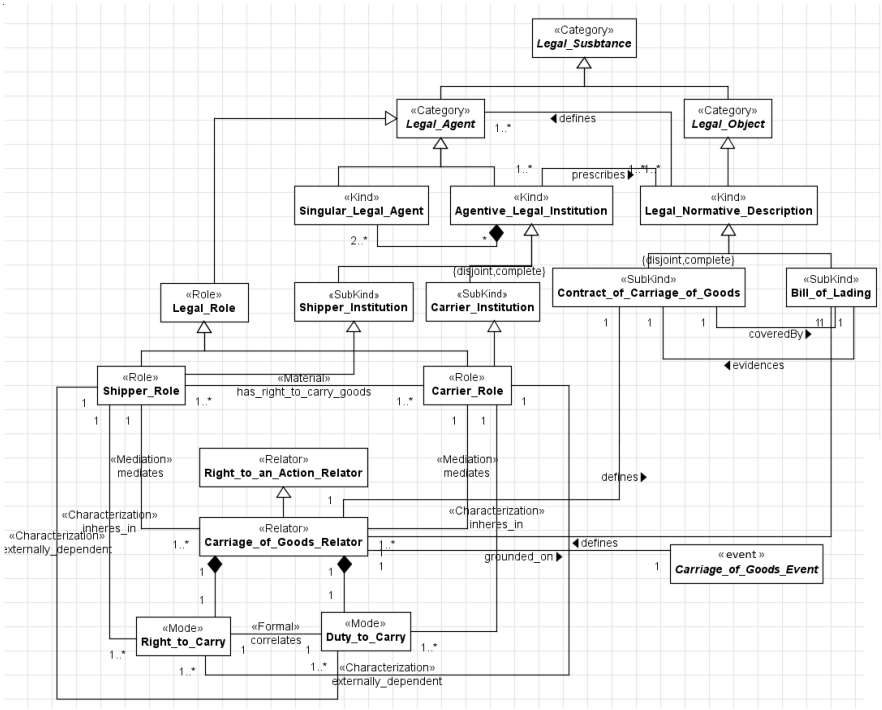

Figure 8. Building a Legal Domain Reference Ontology with different types of COPs.

For this portion of the legal domain reference ontology, that represents how carriage of goods relationship is performed between carrier and shipper agents, seven competency questions are defined: (CQ1) Which legal agents are involved in the carriage of goods relator? (CQ2) What categories of legal roles are involved? (CQ3) What legal moments compose the carriage of goods relationship? (CQ4) Who are the holders of each legal moment? (CQ5) Whose legal moment is externally dependent? (CQ6) What legal event

[2] Hague (The International Convention for the Unification of Certain Rules of Law relating to Bills of Lading of August 1924) and Hamburg (The United Nations Convention on the Carriage of Goods by Sea 1978) Conventions

is the basis of the carriage of goods relationship? (CQ7) is there a legal rule that defines the carriage of goods relationship?

As noticed, the list of competency questions are specializations of the competency questions of the legal core ontology UFO-L. Two main DROPs (Figures 6 and 7) are applied to answer the list of the competency questions of the portion of the domain ontology. In this context, the *Right-Duty Relator* DROP (Figure 7) inherits the structure of the *Role-Relator* FOP (Figure 4) and the *Legal_Substance* DROP (Figure 6) inherits the structure of the *Category* FOP (Figure 3). In addition, the *Kind-Subkind* FOP is reused and applied by analogy in the domain ontology for representing two main structures: (1) *Shipper_Institution* and *Carrier_Institution* are subkinds of *Agentive_Legal_Institution* and (2) *Contract_of_Carriage_of_Goods* and *Bill_of_Lading* are subkinds of *Legal_Normative_Description*. Therefore, FOPs and DROPs are reused in combination for building a portion of the legal domain reference ontology. Moreover, the combined reused has supported the axiomatization of the targeted ontology by reusing and adapting the axioms defined for the COPs (FOPs and DROPs) such as the disjointness axiom defined for *Category* (Figure 3) and *Kind-Subkind* (Figure 5) patterns.

5. Related Works

The work presented in this paper is inspired mainly by the studies presented in [7,11]. In previous works, such as [20], we have applied a reuse process of foundational and legal core ontologies for building a well-founded legal domain ontology in the criminal domain. The targeted ontology has been grounded in the foundational ontology UFO by the application of the ontology-driven conceptual modeling language OntoUML. The legal core ontology LKIF-Core [21] has been reused for representing the legal core concepts and relations. We faced some difficulties during the ontology reuse process, specifically on how to define the ontology parts to be reused and how the reuse process will be applied. However, in this work, the application of ontology patterns is recognized as a beneficial approach for building a well-founded legal domain ontology. Specifically, by reusing patterns from the legal core ontology UFO-L which is modeled by reusing the foundational ontology patterns of UFO. This strategy has led to a legal domain ontology richer with the structural and domain knowledge.

6. Conclusion

This paper discussed the building of a well-founded legal domain reference ontology, in the domain of carriage of goods by sea, by combining different levels of conceptual ontology patterns (FOPs and DROPs). FOPs are derived from the foundational ontology UFO and the DROPs are extracted from the legal core ontology UFO-L. The combined reuse has enriched the domain ontology with structural and domain knowledge as well as has contributed for reusing competency questions and axioms from foundational and core ontologies [11]. Therefore, we can conclude that for building well-founded domain ontologies it is essential and mandatory to reuse foundational and domain aspects in combination by applying foundational and domain-related ontology patterns. Fore future works, the targeted well-founded legal domain ontology will be used for building a decision support system for the traceability in logistic networks.

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