Using the Unified Foundational Ontology (UFO) for Grounding Legal Domain Ontologies

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Abstract: In this paper, the concept of ontology-driven conceptual modelling is outlined where grounding a modular legal domain ontology in the unified foundational ontology UFO is overviewed. The domain ontology is modularized in four independent modules. The top ontology modules are discussed in this work: *upper* and *core*. The ontology modelling language OntoUML is used for the conceptual modelling process.

1 INTRODUCTION

In this paper, the concept of grounding domain ontologies in foundational ontologies is discussed specifically in the legal domain. Generally, the grounding concept is defined by *placing a foundation*. The ontology grounding is introduced by Harnad who claimed that existing approaches to ontology design pose the classical symbol grounding problem (Harnad, 1990). Harnad wondered how a logical theory of a concept, that can be explicit, easier to communicate and axiomatized, is feasibly related to a human understanding of that same concept and avoiding constructing an abstract theory or model for another model. Moreover, how are its primitives grounded outside the formal system? In other words, how the semantic interpretation of a formal symbol system can be made intrinsic to the system, rather than just parasitic on the meanings in human head (Harnad, 1990). Furthermore, some studies such as (Kohn, 2003) illustrated the ontology grounding by avoiding resorting endlessly from one formal system to another in explaining the meaning of symbols. They claim that if ontologies are not grounded in something that their users share, they will be of very limited practical use. Therefore, ontology engineering methods have to supply a list of concepts (or at least of the kinds of concepts) considered meaningful outside the formal theories (Kohn, 2003).

In other words, ontology grounding is expressed by the application of foundational ontologies in conceptual modelling for building domain ontologies. In this context, grounding domain ontologies using existent foundational ontologies refers to the (partial) reuse process of the basic categories of a foundational ontology.

Foundational ontologies are the most general and formal ontologies (Borgo and Leitão, 2004). Theoretically, they are well-founded domain independent systems of categories that have been successfully used to improve the quality of conceptual models and semantic interoperability (Guizzardi et al., 2010). Moreover, reuse of foundational ontologies can facilitate and speeding up the ontology development process by preventing to reinvent known modelling solutions (Keet, 2011).

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the ontology development process by preventing to reinvent known modelling solutions (Keet, 2011).

Actually, we motivate to build a legal domain ontology for modelling the legal norms of the criminal domain serving as a basis for legal reasoning purposes. More specifically, the legal domain ontology will be used as a knowledge base for a legal decision support system. In this context, a foundational and legal core ontologies are reused for grounding this ontology. Therefore, the conceptual architecture of the legal domain ontology is modularized in different modules including the upper and core modules that serve for the grounding aspect. The modularization technique is inspired from the literature that suggests that legal ontologies may be distinguished by the levels of abstraction of the discipline they represent (Guizzardi et al., 2010) - (Borgo, 2011), with the key distinction being between different levels such as upper, core and domain.

From these perspectives, a modular middle-out approach is introduced to support the grounding process of the legal domain ontology (El Ghosh et al., 2016). The approach is based on ontology modularization process where the legal domain ontology is modularized into four independent modules stated on different levels: *upper*, *core*, *domain* and *domain-specific*. The *upper* and *core* modules are constructed for the grounding using a *top-down* strategy that performs ontology-driven conceptual modelling process guided by reusing foundational and legal core ontologies such as the unified foundational ontology (UFO) (Guizzardi and Wagner, 2005a) and the LKIF-Core (Hoekstra et al., 2007) respectively. The *upper* module represents the most general concepts and relations that cover all the domains (such as *Agent*, *Act* and *Action*). The *core* module provides a definition of structural knowledge in the legal domain. For instance, concepts, such as *Legal_Source*, *Legal_Act* and *Legal_Document*, are common for all the legal fields (criminal, civil, etc.). Meanwhile, the *domain* and *domain-specific* modules are extracted from the available sources of the domain, such as legislation and codes, by applying a *bottom-up* strategy as an ontology learning process with the support of NLP techniques. For more details about this strategy, refer to (El Ghosh et al., 2017).

At the end, the modules will be integrated together to compose the global ontology (see Figure 1).

In this work, the *top-down* is discussed and the *upper* and *core* modules are overviewed.

The remainder of this paper is organized as follows: In section 2, the ontology-driven conceptual modelling is overviewed. Section 3 presents the unified foundational ontology UFO. The ontology-grounding process is discussed in section 4. Finally, section 5 concludes the paper.

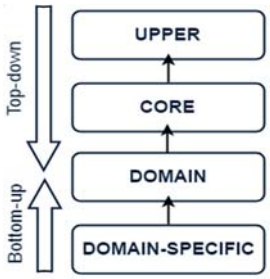

Figure 1: Modular middle-out approach.

2 ONTOLOGY-DRIVEN CONCEPTUAL MODELLING

As aforementioned, the *top-down* strategy of the middle-out approach represents an ontology-driven conceptual modelling process (ODCM) guided by reusing foundational and legal core ontologies for grounding the legal domain ontology. ODCM is firstly introduced by Guarino et al. (Guarino and Schneider, 2002).

Generally, conceptual modelling is defined as "*the activity of representing aspects of the physical and social world for the purpose of communication, learning and problem solving among human users*" (Mylopoulos, 1992). In other words, conceptual modelling is concerned with identifying, analyzing and describing the relevant concepts and constraints of a domain with the help of a modelling language that is based on a small set of basic meta-concepts (Guizzardi et al., 2004).

In order to make conceptual modelling languages more suitable for representing the real world and less oriented by systems, the attention of researchers have turned to philosophy where ontologies, dealing with the modelling reality, represent a branch of it (Verdonck, 2014).

Therefore, the ontologies were introduced in order to provide a foundation for conceptual modelling by expressing the fundamental elements of a domain (Guarino, 1998). Moreover, ontologies are used to analyze and improve existing conceptual modelling languages (Wand, 1996). Thus, ontological or ontology-driven modelling is concerned with capturing the relevant entities of a domain in an ontology of that domain using an ontology specification language that is based on a

small set of basic, domain-independent ontological categories (forming an upper level ontology) (Guizzardi et al., 2004).

Recently, ontology-driven conceptual modelling is defined by Guizzardi as the utilization of ontological theories, coming from areas such as formal ontology, cognitive science and philosophical logics, to develop engineering artifacts (e.g. modelling languages, methodologies, design patterns and simulators) for improving the theory and practice of conceptual modelling (Guizzardi, 2012). In other words, ODCM aims at formalizing conceptual modelling languages for reducing different kind of interpretations of concepts (Kohn, 2003).

3 THE UNIFIED FOUNDATIONAL ONTOLOGY

Generally, foundational ontologies define a range of top-level domain-independent ontological categories, which form a general foundation for more elaborated domain-specific ontologies (Guizzardi and Wagner, 2005a), (Borgo, 2004). Various foundational ontologies exist in the literature such as DOLCE (Masolo, 2003) and UFO (Guizzardi and Wagner, 2005a). Four our work, UFO is the most convenient for two main reasons: (1) its successful application in a large number of domains ranging from natural science domains such as Petroleum and Gas and Electrophysiology of the heart to social domais such as organizations, services and software (Griffo, 2015); (2) the fact that UFO comprises a rich theory of relations and complex relational properties that is absent in other foundational ontologies (Guizzardi, 2005c).

The unified foundational ontology UFO is an example of a descriptive foundational ontology that has been constructed for more than a decade employing results from formal ontology, cognitive psychology, linguistics, philosophical logics, but also significant accumulated empirical and theoretical results from the area of conceptual modelling in computer science (Griffo, 2015). UFO is initially proposed by Guizzardi and Wagner (Guizzardi and Wagner, 2005a) and developed to support the activities of both conceptual and organizational modelling. Therefore, UFO permits the building of an ontology by reusing some generic concepts such as *category*, *kind*, *subkind*, *relator*, *role* and *role mixin* where the ontologist does not need to rebuild these concepts.

The concept *kind*, for instance, provides a principle of application and a principle of identity for its instances (Guizzardi, 2005b). It represents a rigid concept, i.e., a class that applies necessarily to its instances. In other words, instances of these types will continue to be so as long as they exist in the model (Guizzardi, 2005b). A *kind* can be described in a taxonomic structure where its subtypes are also rigid types known as *subkinds* (e.g., Man and Woman) (Guerson et al., 2014).

The concept *role*, in turn, is an anti-rigid concept, applying contingently to its instances (e.g., Offender, Instigator).

A *phase* is an anti-rigid concept that it is defined by a partition of a kind and whose contingent instantiation condition is related to intrinsic changes of an instance of that kind.

A *relator* (e.g. entities with the power of connecting other entities) is a rigid concept and existentially depends on the instances it connects through mediation relations.

UFO is divided into three layered sets:

- UFO-A: ontology of objects, defines terms related to endurants such as *universal*, *relator*, *role*, *intrinsic moment*;
- UFO-B: ontology of events, defines terms related to perdurants such as *event*, *state*, *atomic event*, *complex event*;
- UFO-C: defines terms related to intentional and social entities including linguistic aspects such as *social agent*, *social object*, *social role* and *normative description.*

The current work covers two fragments from UFO, UFO-B and UFO-C, for grounding the legal domain ontology in order to build the *upper* and *core* modules since they define some basic concepts for the criminal domain such as *Agent*, *Intentional Moment*, *Action*, *Event*, and *Normative Description*. In order to make possible the activity of conceptual modelling via UFO, a conceptual modelling language, named OntoUML (Benevides et al., 2009a) is used. OntoUML is a well-founded modelling language that allows modellers to formalize world-views in a technologically neutral way, aiding in the solution of such interoperability challenges (Benevides and Guizzardi, 2009b). According to (Guerson et al., 2014), 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 Telecom. OntoUML uses the ontological constraints of UFO as modelling primitives and is specified above the UML

2.0 meta-model (Guizzardi, 2005b). To build, evaluate and implement OntoUML models, a model-based environment is needed such as the standalone tool OLED (OntoUML Lightweight Editor) (Benevides and Guizzardi, 2009b).

4 TOP-DOWN STRATEGY

As aforementioned, the top-down strategy represents an ontology-driven conceptual modelling process since it will be based on reusing UFO for grounding the legal domain ontology. In this section, the strategy and the resulted ontology modules, *upper* and *core*, are overviewed.

4.1 Upper Module

The upper module consists of abstract concepts and relations which are effectively independent of any specific domain for grounding the legal domain ontology. Concerning the conceptual modelling process of the upper module, the ontology modelling language OntoUML is used for representing the upper concepts reused from UFO in order to compose the upper ontology module (see Figure 2) (Guizzardi, 2005b).

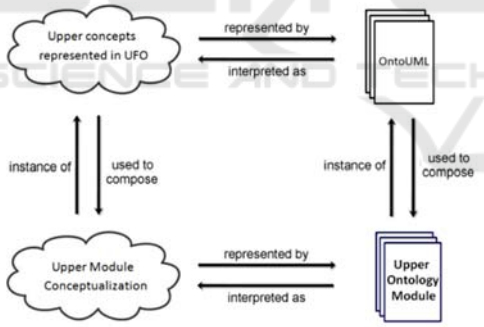

Figure 2: Conceptualization process of *upper* module.

For a well-founded building of this module, a partial reuse of existent validated foundational, or top-level, ontologies can help. In the literature, several works seek for reusing concepts from foundational ontologies in order to support in maintaining a well-structured construction of domain ontologies that could serve as a future reusable artifact (Torres et al., 2011). Thus, the upper module is built by reusing the concepts and relations of the unified foundational ontology UFO represented using OntoUML as an ontology modelling language, in order to form the conceptualization of the upper module. Two main layers are partially reused from UFO: UFO-C and UFO-B.

4.1.1 UFO-C

There are list of essential concepts in UFO-C to reuse for building the upper module, mainly those related to social entities such as *Agents* and *Objects* (see Figure 3).

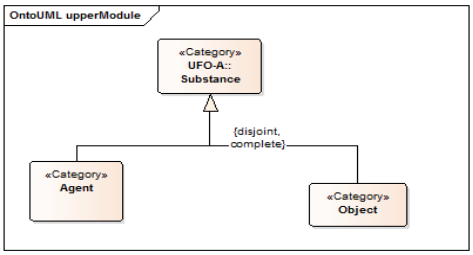

Figure 3: Fragment of upper module in OntoUML.

Agents can be physical (e.g. *Person*) or social (e.g. *Organization*) (see figure 4).

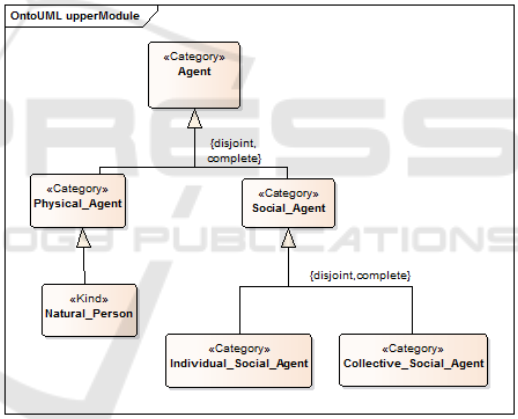

Figure 4: The concept *Agent* in *upper* module.

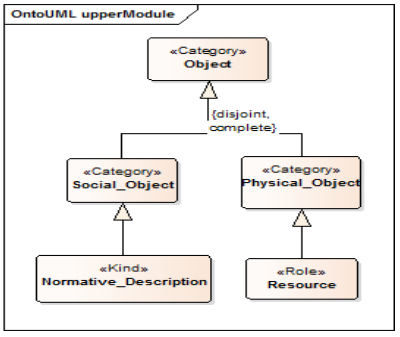

Figure 5: Object in *upper* module in OntoUML.

Objects are also categorized in physical (e.g.

book) and social objects (e.g. normative description) (see Figure 5). *Normative_Description* defines one or more rules/norms recognized by at least one *Social_Agent*. Regulations and constitutions are examples of normative description.

4.1.2 UFO-B

The ontology of perdurants, UFO-B, defines *Event*, which is a basic concept in the criminal domain (e.g. crime is an event), as a main category. In UFO-B, events can be atomic or complex depending on their mereological structure (Guizzardi et al., 2013). Complex events are aggregations of at least two events that can themselves be atomic or complex (see Figure 6).

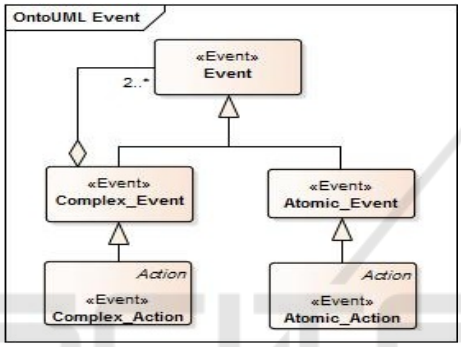

Figure 6: *Event* of *upper* module in OntoUML.

In UFO-B, an event can be an *Action* or *Participation* (see Figure 7).

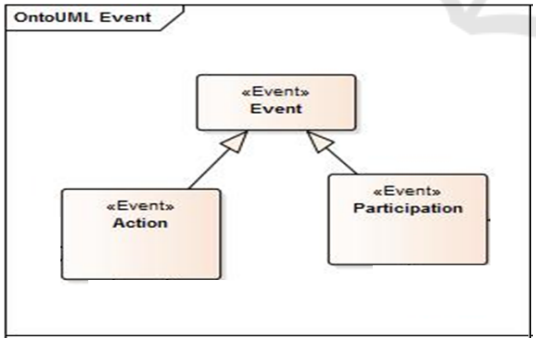

Figure 7: *Event* in *upper* module in OntoUML.

Actions are performed by agents and considered as intentional events caused by intentions (see Figure 8).

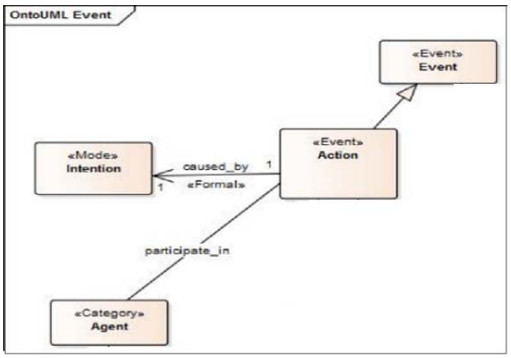

Figure 8: *Action* in *upper* module in OntoUML.

Participation can be for agents and objects (see Figure 9).

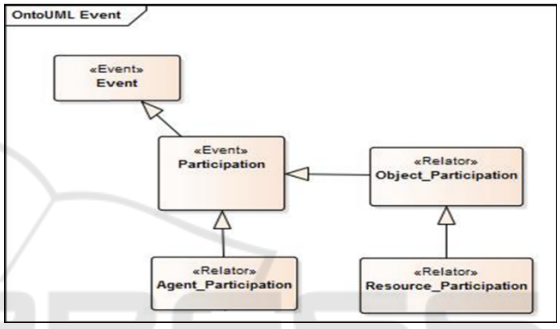

Figure 9: *Participation* in *upper* module in OntoUML.

Therefore, participation of an agent can be intentional or unintentional (see Figure 10).

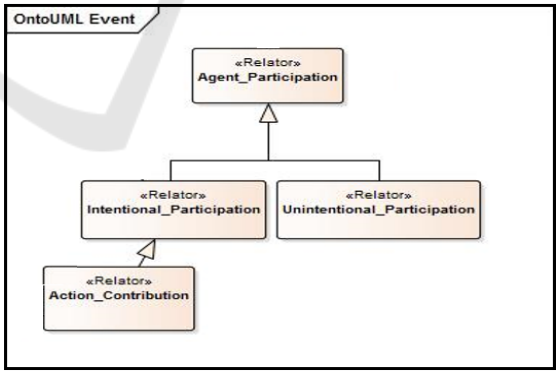

Figure 10: *Agent_Participation* in *upper* module in OntoUML.

The intentional participations are actions and termed here *Action_Contribution*.

4.2 Core Module

The core module is built by reusing the concepts and relations of an existent validated legal core ontology such as LKIF-Core (Hoekstra et al., 2007). Actually the core concepts are represented in the unified foundational ontology UFO, using OntoUML as an ontology modelling language, in order to compose the conceptualization of the core module which is represented by the core ontology module (see Figure 11).

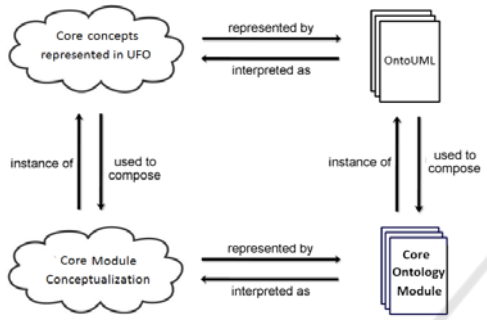

Figure 11: Conceptualization process of the core module.

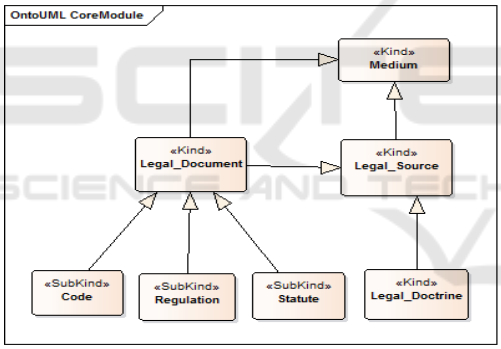

Figure 12: Fragment of the core module.

Generally, core ontologies provide a broad view of a given domain, such as the legal domain in this study, suitable for different target domains such as criminal and civil law (Guarino and Oberle, 2009). In the domain of conceptual modelling, core ontologies are used for providing real-world semantics for conceptual modelling languages (Guizzardi and Wagner, 2011). Concerning the *core* module, it consists of concepts and relations that are common across the domains of law and can provide the basis for specialization into domain and domain-specific concepts. In order to build this module, the legal core ontology LKIF-Core (Hoekstra et al., 2007) have been reused since it contains essential legal concepts such as *Medium*, *Document*, *Legal_Source*, *Legal_Document*, and *Code*. In this study, list of basic concepts of LKIF-Core are represented using the generic concepts of UFO (see Figure 12).

5 CONCLUSION

This paper discussed the application of foundational and core ontologies in conceptual modelling for grounding a well-founded legal domain ontology. A case-study that describes the partial reuse of existent validated ontologies such as the unified foundational ontology UFO and the legal core ontology LKIF-Core is presented. Throughout this study, we have illustrated the importance of these ontologies in the conceptual modelling process for building consistent legal domain ontologies. In this paper, a modular legal domain ontology is presented. The upper and core modules are developed as a grounding modules for the ontology. The modelling process of these modules is discussed. The ontology modelling language OntoUML has been used for this purpose since the grounding process is based mainly on the unified foundational ontology UFO. For the upper module, concepts and relations from UFO-C and UFO-B have been reused. For the core module, concepts and relations from the legal core ontology LKIF-Core has been reused by defining them in the context of UFO using OntoUML.

After building the upper and core modules, they will be integrated using semantic mappings such as parent-child, or hierarchical relationships since they are located on vertical conceptual levels. The integration process will be applied as well for the domain and domain-specific modules. At the end, the global modular ontology will be used as a knowledge base for a legal decision support system that performs legal reasoning purposes.

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