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Reasoning with Deontic Notions in a Decidable Framework

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Abstract. The development of legal reasoning using decidable fragments of knowledge modeling languages is essential in the Semantic Web for the huge amount of triples available nowadays as Linked Open Data. This Chapter introduces a framework for legal knowledge representation and reasoning based on the distinction between the concepts of provision and norm, suited for different kinds of legal reasoning: legal provisions accessibility and norm compliance, respectively. The proposed framework allows the addressed types of reasoning to be implemented using OWL 2 decidable profiles and reasoners. Examples of decidable reasoning within the proposed framework are presented and tested.

Keywords. legal reasoning, legal provisions retrieval, norm compliance, semantic web, description logic

1. Introduction

The transformation of legal regulations in machine readable, actionable rules represents a precondition for developing systems endowed with automatic reasoning facilities for advanced information services in the legal domain.

In literature several approaches have been proposed aiming to formalize legal rules able to support automatic reasoning, as reasoning on deontic notions [1], reasoning for norm compliance [2] or for legal argumentation [3]. When implemented in the Semantic Web, legal reasoning approaches usually utilize languages like OWL/RDF(S) for modeling real world scenarios, as well as mainly SWRL, RIF or LegalRuleML for representing legal rules for such scenarios. Approaches for modeling real world scenarios and rules often, even not always [4], result in non-decidable profiles, so that the available reasoners are not guaranteed to be tractable from a computational point of view in large scale.

The current successful trend of Semantic Web implementation according to a Linked Open Data approach has produced, and is supposed to produce in the next few years, a huge and growing amount of RDF triples, representing concepts, legal rules and facts. The availability of decidable reasoners is therefore essential for dealing with the huge amount of Linked Open Data (LOD), so to guarantee the computational tractability of reasoning. Hence the need to represent the semantics of LOD triples by decidable fragments of knowledge modeling languages.

Also for these reasons in [5] a study has been carried out about how the Linked Open Data framework (including RDF(S)/OWL, LegalRuleML and SPARQL) can be

applied to the formalization, publication and processing of legal knowledge, in particular normative requirements and rules.

In terms of knowledge modeling languages for the Semantic Web, OWL DL represents a decidable profile (subset) of OWL, and OWL 2 extends the OWL expressiveness introducing three additional decidable sub-profiles:

- OWL 2 DL: direct extension of OWL DL within the OWL 2 semantics, thus representing a decidable profile of the First Order Logic for OWL 2;
- OWL 2 EL: particularly useful in applications employing ontologies that contain very large numbers of properties and/or classes. It introduces specific restrictions allowing for example existential quantifications, while universal quantification or cardinality restrictions are not allowed;
- OWL 2 QL: particularly useful in applications dealing with a large amount of data. In this profile for example existential quantification to a class expression or a data range are not allowed;
- OWL 2 RL: particularly useful in scalable reasoning without sacrificing too much expressive power. It supports all axioms of OWL 2 apart from disjoint unions of classes (DisjointUnion) and reflexive object property axioms (ReflexiveObjectProperty).

In this Chapter we introduce a legal reasoning framework based on the distinction between the concepts of *Provision* and *Norm*, suited for different kinds of legal reasoning: legal provisions accessibility and norm compliance, respectively. Moreover, an approach based on decidable OWL 2 profiles is presented and tested. The claim of this study is not to address the whole complexity of legal reasoning, including for example non-monotonic reasoning, resolution of norm conflicts [6] or reasoning with incomplete and contradictory information, for which reasoners exist [7]; [8]. This study rather aims to present an approach which can be effectively implemented in a decidable framework for the type of reasoning mentioned (provisions retrieval and norms compliance). On the other hand this study may create the ground for investigating how more complex legal reasoning types actually affects the computational burden of the present approach.

This Chapter is organized as follows: in Section 2 a review of related work about legal reasoning is given, including examples within a description logic computational complexity; in Section 3 the distinction between the concepts of *Provision* and *Norm* from the legal theory point of view is discussed [9]; in Section 4 an approach for modeling deontic notions and implementing Hohfeldian reasoning for legal provisions retrieval within a decidable computational framework is recalled [10]; [11] and tested on examples; in Section 5 an approach for modeling norms using ontologies, able to implement norm compliance checking within a decidable computational framework is described and tested on examples; in Section 6 some conclusions are reported.

2. Related Works

OWL is the state-of-the-art standard for knowledge modeling in the Semantic Web, effectively used for creating ontologies able to represent concepts and relations of real world scenarios [12]: examples in the legal informatics literature are LRI-Core [13], LKIF [14], CLO [15], DALOS [16], PrOnto [17]. On the other hand legal rules in the Semantic Web have been represented in literature using a variety of languages. [18] proposed to

use SWRL or RIF in combination with an ontological representation of norms and facts; [19] introduced rules description using specific XML schemas in combination with ontologies. More recently LegalRuleML [20] as specialization of the RuleML standard has been proposed as language for representing legal rules.

In the last few years several studies have been made to approach the problem of legal reasoning in a decidable computational complexity profile. [21] proposed HARNESS, a knowledge-based system developed within the ESTRELLA project, able to implement reasoning on norms for legal assessment, basically the evaluation whether a case is allowed or disallowed given an appropriate body of legal norms. HARNESS includes two knowledge bases: a domain ontology and a set of norms representing the normative articles. Both are developed within the OWL 2 DL profile. Assessment consists of classifying the individuals and properties making up a case description in terms of both ontology and norms simultaneously. The result tells whether norms are violated or not.

As anticipated in Section 1, recently in [5] an approach to represent legal rules as Linked Open Data has been proposed. It aims to respond to the requirements of representing and reasoning on the deontic aspects of normative rules with standard Semantic Web languages, as RDFS and OWL for knowledge representation and SPARQL for inquiries. The rationale of the proposed approach is the coupling of OWL reasoning with SPARQL rules to formalize and implement reasoning (as for example deontic reasoning). In particular normative requirements are represented using LegalRuleML and the the deontic conclusions of the legal rules are added to each named graph of the concerned state of affairs.

In [22] an OWL 2 judicial ontology library (JudO) representing the interpretations performed by a judge when conducting legal reasoning towards the adjudication of a case is illustrated. On the other hand [23] combines the features of description logic-based ontologies with non-monotonic logics such as defeasible logics.

In this Chapter we present an approach based on the distinction between *Provisions* and *Norms* represented by decidable fragments of OWL 2/RDFS for knowledge modeling and rules representation. This allows us to rely on available decidable reasoners able to derive implicit knowledge and conclusions on the model and related individuals, while leaving to SPARQL the sole task to query the dataset of inferred triples in order to verify deontic conclusions or norm compliance.

3. Provisions and Norms

According to the legal theory point of view, the legal order can be seen as a legal discourse composed by linguistic entities or *speech acts* [24] with descriptive or prescriptive functions. Every linguistic entity can be seen in a twofold perspective: as a set of signs organized in words and sentences, as well as the meaning of such signs. Following the same twofold view for the legal domain, we can distinguish two levels of interpretation of a linguistic entity expressing a legal rule: in terms of a set of signs organized in words and sentences for creating a normative statement, typically called *Provision* [25]; [26], and in terms of the meaning of such normative statement, typically called *Norm* [27]; [9].

Provisions have been classified in [26] in terms of provision types, organised into two main groups (Figure 1): *Rules* and *Rules on Rules*. *Rules* can be *Constitutive Rules*

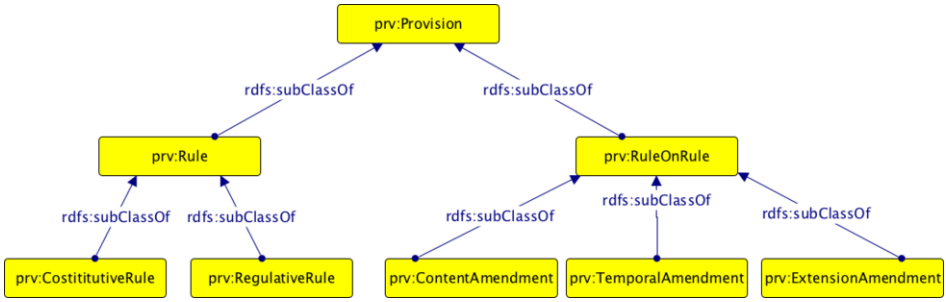

Figure 1. The *Provision Model* top classes ('prv:' is the namespace for provisions)

as *Definition* introducing entities, or *Regulative Rules* as the deontic concepts *Duty*, *Right*, *Power*, etc., regulating subject roles and activities. *Rules on Rules* are different kinds of amendments: *Temporal*, *Extension* or *Content amendments* as *Insertion*, *Substitution*, *Repeal*. Each provision type is characterized by specific *attributes* (for example the *Bearer* or the *Counterpart* of a *Right*), reflecting the lawmaker directions. Provision types and attributes can be considered as a sort of metadata model able to analytically describe fragments of legislative texts, hence the name of *Provision Model* [28]. In Figure 2 the *Provision Model* classes prv:Right and prv:Duty, and the related properties (as prv:hasRightBearer, prv:hasDutyCounterpart, etc.), under the namespace prv: for provisions in the Semantic Web, are sketched.

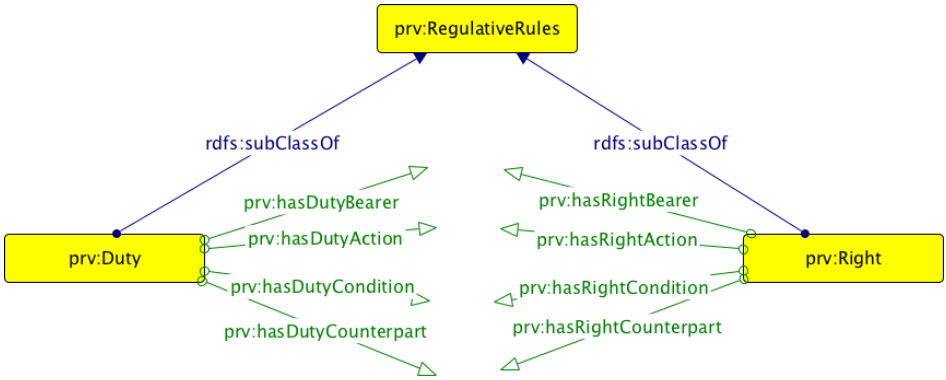

Figure 2. Examples of provisions attributes, represented as ontology classes and properties

Norms represent the application of provisions; as such they represent the product of an interpretative process [29].

Provisions and related norms have different roles and properties pertaining to the different abstraction levels they operate at. The need of distinguishing between provisions and norms becomes essential when we observe that there may be not a bijective relationship between them: a norm can be expressed by different provisions, as well as it can be valid the opposite, namely one provision can include more norms [30].

Moreover, they have different relationships with time. Provisions, as pure textual objects, are the product of lawmaking (legal drafting activity and promulgation) and they have a specific relation with time represented by the *in-force* date, namely the starting

date of its existence in the legal order. On the other hand norms are the meaning of provisions, namely their interpretation; as such they have a specific relation with time represented by the *efficacy* date, namely the starting date in which a norm can be concretely applied. Therefore, while it is obvious that we can have cases of provisions not in-force and related norms not effective, as well as provisions in-force and related norms effective, we can also have provisions in-force and related norms not effective, as well as the symmetric case (this last one is usually referred as *ultra-activity* of a norm).

Having different nature, such concepts operate in different domains. A provision, as pure textual object, represents the building block of the legal order (new provisions can enter or leave the legal order). On the other hand norms, can either modify the text of other provisions (in case of different type of amendments) or can introduce restrictions on the real world (in case of obligations, for example).

We have underlined the different nature of such objects as a background for introducing an approach for legal reasoning using such different concepts in different types of legal reasoning. Advanced legal document retrieval systems able, for example, to implement Hohfeldian reasoning on deontic notions, is a type of reasoning managing textual information, thus pertaining to provisions. Legal compliance checking is a process aiming to verify if a fact, occurring in the real world, complies with a legal norm. Real world scenarios and facts can be effectively represented in terms of ontologies and related individuals, respectively. Norms, which facts have to be compliant with, provide constraints on the reality, therefore they can be modeled, in particular as far as obligations are concerned, as restrictions on ontology properties, used for legal compliance checking.

Let's consider two examples of rules, R1 and R2, to illustrate our approach:

R1 : *The supplier shall communicate to the consumer all the contractual terms and conditions*

R2 : *According to a [country] law one cannot drive over 90 km/h*

Both rules are speech acts, namely *Provisions* in specific regulations. In this sense R1 can be classified as a *Duty* of a *Supplier* towards *Consumer*, while R2 can be classified as an *Obligation* for any *Vehicle* in the related specific country. Such classification can be used for implementing an advanced retrieval system able to select provisions by provision types and attributes. Moreover, R1 is an example in which Hohfeldian reasoning can be applied, since that provision can be seen as a *Right* of the *Consumer* to receive communications by *Supplier*. Such provision has to be retrieved either if we search for the supplier's duties or if we search for the consumer's rights. In all these cases an advanced legal retrieval system endowed with legal reasoning facilities pertains to provisions.

When we consider the application of R1 and R2 on specific facts, we actually talk about *Norms*. As previously discussed, norms which facts have to be compliant with, can be viewed as constraints on the real world to be regulated.

In the case of R1, the scenario can be modeled in terms of an ontology including a class *Supplier*, having a boolean property *hasCommunicatedConditions*, while the norm R1 can be modeled in terms of restriction on that property, so that the compliant supplier must have set to 'true' the value of such property when he has complied with his communication duties.

Similarly, in case of R2, the vehicles circulation scenario of a specific country can be modeled in terms of an ontology including a class *Vehicle*, having a property *hasSpeed*, while the norm R2 can be modeled in terms of restriction on that property, so that the

compliant individual vehicles must have set the value of such property in the interval [0.0, 90.0 Km/h] (detected for example by the police through a speed checker station). In both cases legal reasoning in terms of legal compliance checking can be obtained by managing norms modeled as restrictions on property values of ontology classes.

In Section 4 we recall the modeling approach, described in [10]; [11], about how legal reasoning on deontic notions (as reasoning over Hohfeldian relations) for an advanced legal provisions retrieval system can be modeled within a description logic implemented in OWL 2 DL. Similarly, in Section 5 we show how legal reasoning for norm compliance can be implemented by modeling norms as ontology properties restriction using decidable fragments of OWL 2. In both cases inferences and related legal reasoning can be effectively calculated using decidable reasoners.

4. Modeling Provisions for Advanced Legal Provisions Accessibility

In [11] and [10] it is shown how Hohfeldian relations on deontic and potestative notions can be managed within a description logic computational framework. We recall here the main aspects of the approach to show, for the examples R1 and R2, how *Provisions* can be used to implement an advanced legal provisions retrieval system, endowed with legal reasoning facilities, using a decidable fragment of OWL 2 (in particular OWL 2 DL), therefore exploiting existing decidable reasoners.

In this recall, we show the approach for deontic notions and their relations, sketched in the schema of Figure 3[1].

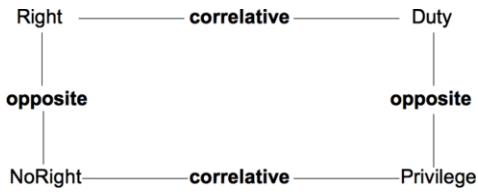

Figure 3. Hohfeldian relations on deontic concepts

In order to implement an advanced legal provisions retrieval system, it is necessary to describe the relations between provisions at the level of the Provision Model. For example the Hohfeldian relation between *Duty* and *Right* can be effectively represented by observing that a *Right*, in correlative correspondence with a *Duty*, is actually not explicitly expressed in the text, but represents an implicit provision, basically a different view of the *Duty* itself, where the values of the related bearer and counterpart attributes are swapped. Therefore, the Provision Model can be extended in terms of Duty and Right[2] implicit and explicit disjoint subclasses, able to represent a complete covering of the related superclass (ex: ExplicitRight and ImplicitRight disjoint subclasses represent a complete covering of the Right superclass).

Attributes can also be specified as regards both implicit and explicit provisions, so that hasImplicitDutyBearer and hasExplicitDutyBearer are sub-properties of hasDuty-

[1] More details on this modeling approach and its application to potestative notions (*Power, Liability, Disability Immunity*), can be found in [11] and [10].

[2] Where 'prv:', namespace for provisions, is hereinafter implied.

Bearer, as well as hasImplicitRightBearer and hasExplicitRightBearer are sub-properties of hasRightBearer.

To represent the hohfeldian fundamental relations between Duty and Right, firstly an equivalence relation between their explicit and implicit views is established: ImplicitRight ≡ ExplicitDuty and ImplicitDuty ≡ ExplicitRight. In Figure 4 the established sub-class and equivalence relations between Duty and Right in their explicit and implicit views are summed up.

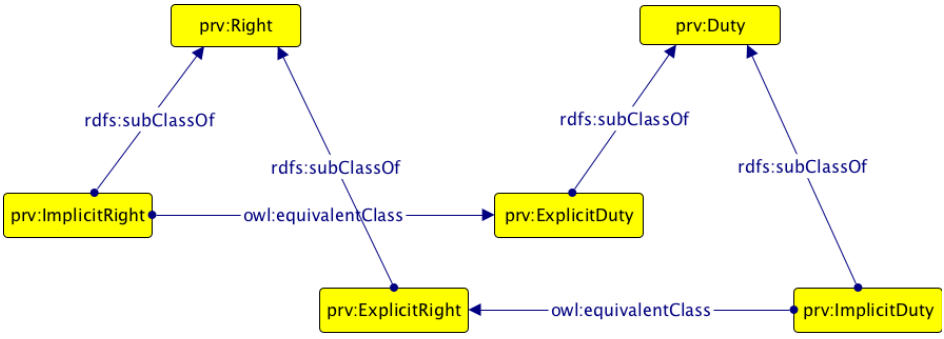

Figure 4. Sub-class and asserted equivalence relations between Duty/Right deontic correlative provisions

Moreover, equivalence relations between implicit/explicit Duty and Right attributes can be established. In Figure 5 the asserted properties of ExplicitDuty and ImplicitRight and their mutual equivalence relations are shown (hasImplicitRightBearer ≡ hasExplicitDutyCounterpart and hasImplicitRightCounterpart ≡ hasExplicitDutyBearer).

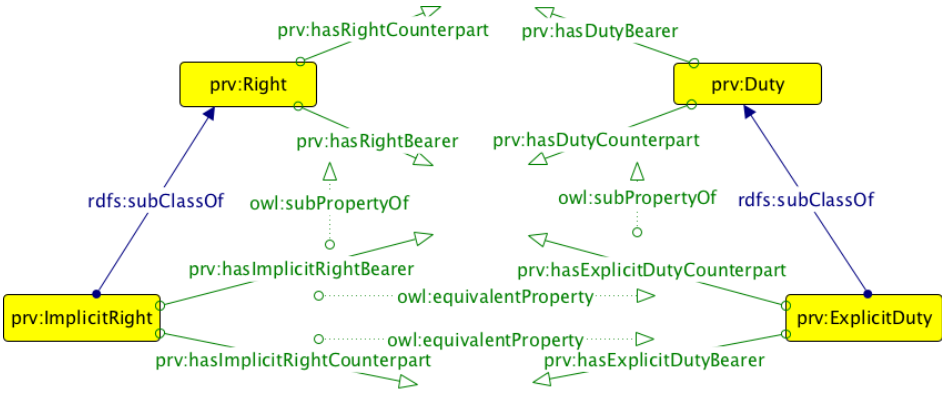

Figure 5. Asserted properties of ExplicitDuty and ImplicitRight and their mutual equivalence relations

The same holds for the asserted properties of ImplicitDuty and ExplicitRight and their mutual equivalence relations (hasImplicitDutyBearer ≡ hasExplicitRightCounterpart and hasImplicitDutyCounterpart ≡ hasExplicitRightBearer) (Figure 6) .

Note that the proposed patterns do not interfere with the relations between Right and Duty, which still hold. In fact, for the couple Right/Duty, an individual of ExplicitDuty is also an individual of Duty, given the axiom rdfs:subClassOf(ExplicitDuty,

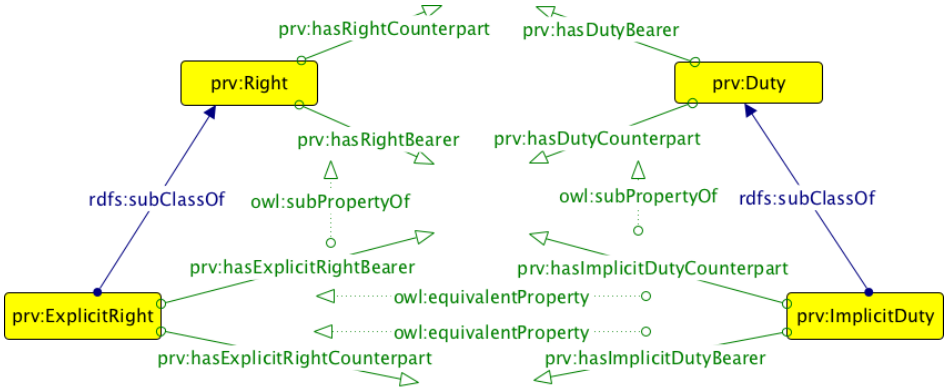

Figure 6. Asserted properties of ImplicitDuty and ExplicitRight and their mutual equivalence relations

Duty). Moreover the axiom owl:equivalentClass(ImplicitRight, ExplicitDuty) tells us that such individual is also an ImplicitRight, which is also a Right, given the axiom rdfs:subClassOf(ImplicitRight, Right). Since this is done symmetrically for explicit and implicit duties and rights, we can deduce that Right is equivalent to Duty, namely is another reading of the Duty itself, given that the union of the disjoint explicit and implicit subclasses covers completely the related superclass.

4.1. Provisions R1 and R2 representation and reasoning

Such modeling approach can be used to represent the provisions R1 and R2 in a way that a provision retrieval system can be implemented using a decidable reasoner. For example R1 can represented as follows:

```
<rdf:Description rdf:about="[URI]#R1">
 <rdf:type rdf:resource="prv:ExplicitDuty"/>
 <prv:hasExplicitDutyBearer rdf:resource="myo:Supplier"/>
 <prv:hasExplicitDutyAction
         rdf:datatype="http://www.w3.org/2000/01/rdf-schema#Literal">
         has communicated</prv:hasExplicitDutyAction>
 <prv:hasExplicitDutyObject rdf:resource="myo:Conditions"/>
 <prv:hasExplicitDutyCounterpart
         rdf:resource="myo:Consumer"/>
</rdf:Description>
```

where myo: is a fictitious namespace for a fictitious 'MyOntology', while the values of the provisions attributes can be either ontology concepts (as in the example for duty bearer and counterpart) or literals (as for the duty action). Note that only explicit provision classes (and consequently explicit properties) are used to annotate textual provisions, as they are the only provisions actually (explicitly) expressed in the text, while implicit provisions act as a sort of 'abstract' classes, which are used for reasoning.

As both the Provision Model (and related instances) result in OWL 2 DL profile, inferences can be calculated through an OWL 2 DL reasoner. In this example the Pellet[3] Java based OWL 2 DL reasoner is used to derive the inferred model.

[3]https://www.w3.org/2001/sw/wiki/Pellet.

Let's assume to query the system as follows in order to retrieve the suppliers' duties:

```
SELECT ?x WHERE  {?x  prv:hasDutyBearer myo:Supplier}
```

where x is the variable that will contain the identifiers of the retrieved provisions instances. In case the *non-inferred* model is queried, no provisions are retrieved since only ExplicitDuty and related attributes are used for provision annotation. In case the *inferred* model is queried, the inferred provisions are retrieved, either annotated as ExplicitDuty of Supplier, if any, or implicitly deduced by provision relations. By exploiting the established rdfs:subClass relations between provisions type and attributes, the system will act as virtually expanding the query in terms of hasExplicitDutyBearer and hasImplicitDutyBearer, thus being able to retrieve R1, which is the provision having Supplier as value of the property hasExplicitDutyBearer.

Similar considerations can be given if we want to retrieve the consumers' rights, as follows

```
SELECT ?x WHERE  {?x  prv:hasRightBearer myo:Consumer}
```

In this case hohfeldian reasoning is produced. In fact by exploiting the established rdfs:subClass and owl:equivalentClass relations between provisions type and attributes, the system will act as virtually expanding the query in terms of hasExplicitRightBearer and hasImplicitRightBearer. For the last one the following relation holds hasImplicitRightBearer $\equiv$ hasExplicitDutyCounterpart): this allows the system to retrieve R1, which is the provision having Consumer as value of the property prv:hasExplicitDutyCounterpart. Since this is the result of axioms established in the Provision Model for implementing hohfeldian relations, the result is an hohfeldian reasoning over provisions (namely searching for consumers' rights and retrieving the related suppliers' duties).

Very similar considerations can be given for the annotation of R2 and a query able to retrieve it. The provision R2 can be represented as follows:

```
<rdf:Description rdf:about="[URI]#R2">
 <rdf:type rdf:resource="prv:Obligation"/>
 <prv:hasObligationBearer rdf:resource="myo:Vehicle"/>
 <prv:hasObligationAction
         rdf:datatype="http://www.w3.org/2000/01/rdf-schema#Literal">
            cannot overcome 90Km/h</prv:hasObligationAction >
</rdf:Description>
```

where again, myo: is a fictitious namespace for a fictitious ontology "MyOntology", while the values of the provisions attributes can be either ontology concepts (as for the obligation bearer) or literals (as for the obligation action). The following SPARQL query is able to retrieve the provision R2:

```
SELECT ?x WHERE {?x  prv:hasObligationBearer myo:Vehicle}
```

Both the previous cases represent retrieval examples including legal reasoning on deontic notions which can be managed within the OWL 2 DL decidable computational profile.

5. Modeling Norms for Legal Compliance Checking

As discussed in Section 3, norms can be viewed as the application, subject to interpretation, of legal provisions, providing constraints on a real world scenario to be regulated. In the Semantic Web a real world scenario is usually represented by a domain ontology. In this context a norm, providing constraints to such scenario, can be modeled in terms of constraints on the domain ontology: for example, in case of obligations, as ontology property restrictions. In the following of this Section we show how the norms expressed in R1 and R2, can be represented as restrictions on the addressed scenarios, and how such a representation can be used for norm compliance checking, within a computational complexity decidable profile. Note that in the examples, the relations between text, provisions and corresponding norms have not been reported for the sake of simplicity, but can obviously be expressed by relations between the related URIs.

5.1. Norm R1 Representation and Compliance Checking

In the case of R1, the scenario can be modeled in terms of an ontology including a class Supplier, having a boolean property hasCommunicatedConditions. In OWL 2 terms the scenario concerning R1 can be expressed as follows:

```
<owl:Class rdf:about="myo:Supplier">
 <rdfs:comment
   xml:lang="en">The class of the Suppliers</rdfs:comment>
 <rdfs:label xml:lang="en">Supplier</rdfs:label>
</owl:Class>

<owl:DatatypeProperty rdf:about="myo:hasCommunicatedConditions">
  <rdfs:domain rdf:resource="myo:Supplier"/>
  <rdfs:range rdf:resource="xsd:boolean"/>
  <rdfs:comment
       xml:lang="en">The property describing purchasing
       conditions communicated or not</rdfs:comment>
  <rdfs:label xml:lang="en">has communicated the conditions
  </rdfs:label>
</owl:DatatypeProperty>
```

Norm R1, expressing a duty for the suppliers states that suppliers must communicate purchasing conditions to the consumers: the individuals of the class Supplier complying with this norm are all those ones belonging to the subclass SupplierR1Compliant identified by a restriction on the boolean property hasCommunicatedConditions to have value 'true' (Figure 7).

In other terms the norm R1 is represented as restriction on the property hasCommunicatedConditions able to identify the class SupplierR1Compliant which is equivalent (see owl:equivalentClass relation here below) to the class of all individuals for which the value of the property under consideration is 'true', as follows:

```
<owl:Class rdf:about="myo:SupplierR1Compliant">
  <owl:equivalentClass>
  <owl:Restriction>
   <owl:onProperty
          rdf:resource="myo:hasCommunicatedConditions"/>
```

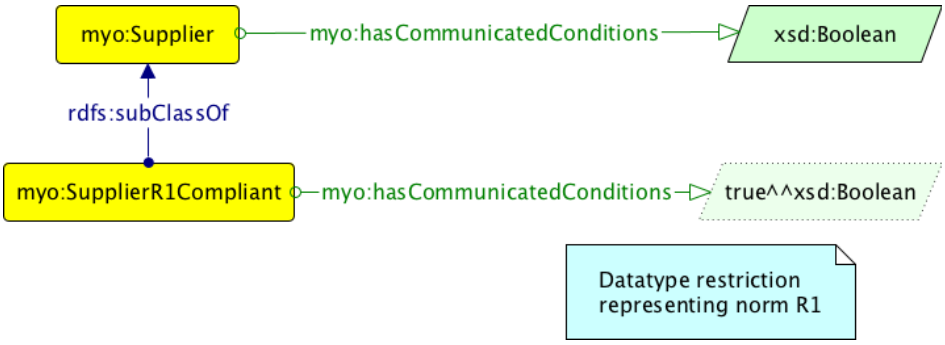

Figure 7. Norm R1 represented as restriction on the Supplier's property hasCommunicatedConditions (note that the subclass relation between SupplierR1Compliant and Supplier is inferred)

```
    <owl:hasValue
          rdf:datatype="xsd:boolean">true</owl:hasValue>
  </owl:Restriction>
  </owl:equivalentClass>
</owl:Class>
```

Such a representation for the real world scenario and related norm expressed by R1 results in the OWL 2 DL, as well as OWL 2 RL, decidable profiles.[4] This allows us to use a OWL 2 DL decidable reasoner, as for example Pellet, in order to implement reasoning facilities, preparing the ground for compliance checking with respect to R1. The inferred model produced by Pellet establishes a rdfs:subClassOf relationship between SupplierR1Compliant and Supplier (as shown in Figure 7), where SupplierR1Compliant is the class of all the individuals of type Supplier having 'true' as value of the property hasCommunicatedConditions. Therefore, compliance checking according to the norm R1 is a problem of checking if an individual of type Supplier belongs to the class SupplierR1Compliant.

As an example let's consider the following two individuals myo:s1 and myo:s2 of the class Supplier:

```
<myo:Supplier rdf:about="myo:s1">
 <myo:hasCommunicatedConditions rdf:datatype="xsd:boolean">
    false</myo:hasCommunicatedConditions>
</myo:Supplier>

<myo:Supplier rdf:about="myo:s2">
 <myo:hasCommunicatedConditions rdf:datatype="xsd:boolean">
    true</myo:hasCommunicatedConditions>
</myo:Supplier>
```

myo:s1 is an individual not compliant with R1, while myo:s2 is complaint with R1. The following SPARQL query

```
SELECT ?x WHERE { ?x rdf:type myo:SupplierR1Compliant }
```

[4]This can be verified using the Manchester validator at http://mowl-power.cs.man.ac.uk:8080/validator/.

is able to select the individuals which are complaint with R1 (in our case s2). Legal reasoning in terms of norm compliance checking is therefore performed within a decidable computational complexity profile.

5.2. Norm R2 Representation and Compliance Checking

In the case of R2, the vehicles circulation scenario can be modeled in terms of an ontology including a class Vehicle, having a datatype property hasSpeed with range in the xsd:float datatype. In OWL 2 terms, the vehicles circulation scenario concerning R2 can be expressed as follows:

```
<owl:Class rdf:about="myo:Vehicle">
  <rdfs:comment xml:lang="en">The class Vehicles
                                          </rdfs:comment>
  <rdfs:label xml:lang="en">Vehicle</rdfs:label>
</owl:Class>

<owl:DatatypeProperty rdf:about="myo:hasSpeed">
  <rdfs:domain rdf:resource="myo:Vehicle"/>
  <rdfs:range rdf:resource="xsd:float"/>
  <rdfs:comment xml:lang="en">Speed of a Vehicle
                                          </rdfs:comment>
  <rdfs:label xml:lang="en">has speed</rdfs:label>
</owl:DatatypeProperty>
```

Norm R2, expressing an obligation on the vehicles circulation scenario, states that, according to the related country law, one cannot drive over 90 km/h: the individuals of the class Vehicle complying with this norm are those ones belonging to the subclass VehicleR2Compliant having value $\in$ [0.0, 90.0 Km/h] on the datatype property hasSpeed (Figure 8).

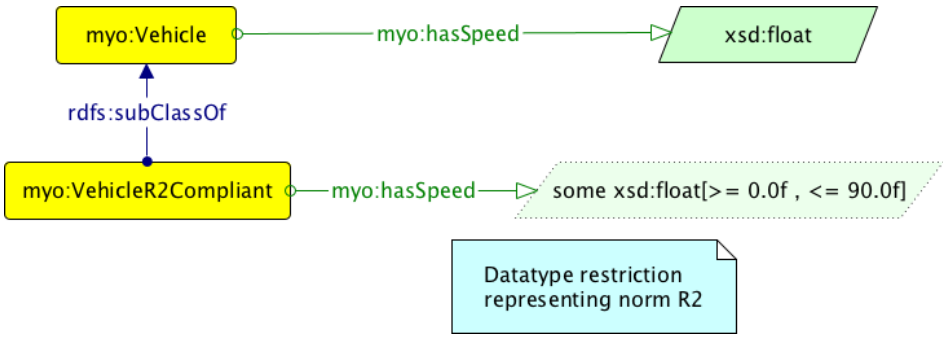

Figure 8. Norm R2 represented as restriction on the Vehicle's property hasSpeed (note that the subclass relation between VehicleR2Compliant and Vehicle is inferred)

In other terms the norm R2 is represented as restriction on the property hasSpeed able to identify the class VehicleR2Compliant which is equivalent to the class of the individuals for which the values of the property under consideration are in the range [0.0, 90.0 km/h]. In order to represent such constraints the following restriction on the datatype property myo:hasSpeed to values (inclusively) between 0.0 and 90.0 can be

expressed by the xsd:minInclusive and xsd:maxInclusive datatype bound properties. In OWL 2 this results as follows:

```
<owl:Class rdf:about="myo:VehicleR2Compliant">
 <owl:equivalentClass>
 <owl:Restriction>
   <owl:onProperty rdf:resource="myo:hasSpeed" />
   <owl:someValuesFrom>
      <rdfs:Datatype>
      <owl:onDatatype rdf:resource="xsd:float"/>
      <owl:withRestrictions rdf:parseType="Collection">
      <rdf:Description>
        <xsd:minInclusive
           rdf:datatype="xsd:float">0.0</xsd:minInclusive>
      </rdf:Description>
      <rdf:Description>
        <xsd:maxInclusive
          rdf:datatype="xsd:float">90.0</xsd:maxInclusive>
        </rdf:Description>
      </owl:withRestrictions>
      </rdfs:Datatype>
   </owl:someValuesFrom>
 </owl:Restriction>
 </owl:equivalentClass>
</owl:Class>
```

Such a representation results in the OWL 2 DL decidable profile[5]. As in the previous example, the inferred model, produced by Pellet, establishes a rdfs:subClassOf relationship between VehicleR2Compliant and Vehicle (as shown in Figure 8), where VehicleR2Compliant is the class of all the individuals of type Vehicle having values of the property hasSpeed in the interval [0.0, 90.0 km/h]. Therefore, compliance checking according to the norm R2 is a problem of checking if an individual of type Vehicle belongs to the class VehicleR2Compliant.

As a concrete example, let's consider the following four individuals of the class Vehicle:

```
<myo:Vehicle rdf:about="myo:v1">
    <myo:hasSpeed
             rdf:datatype="xsd:float">50.0</myo:hasSpeed>
</myo:Vehicle>
<myo:Vehicle rdf:about="myo:v2">
    <myo:hasSpeed
             rdf:datatype="xsd:float">60.0</myo:hasSpeed>
</myo:Vehicle>
<myo:Vehicle rdf:about="myo:v3">
    <myo:hasSpeed
             rdf:datatype="xsd:float">70.0</myo:hasSpeed>
</myo:Vehicle>
<myo:Vehicle rdf:about="myo:v4">
    <myo:hasSpeed
             rdf:datatype="xsd:float">95.0</myo:hasSpeed>
</myo:Vehicle>
```

[5]This can be verified using the Manchester validator at http://mowl-power.cs.man.ac.uk:8080/validator/.

In this list, the individual myo:v4 is not compliant with R2 (having speed 95.0 Km/h $\geq$ 90.0 Km/h). The following query:

```
SELECT ?x WHERE { ?x rdf:type myo:VehicleR2Compliant }
```

is able to select the individuals which are complaint with R2 (in our case myo:v1, myo:v2, myo:v3). Also in this case the norm compliance checking is performed within a decidable computational complexity profile.

6. Conclusions and Future Developments

In this Chapter we have presented a legal reasoning approach based on the distinction between the concepts of provisions and norms, able to deal with different types of legal reasoning, in particular advanced legal provisions retrieval, as well as norms compliance checking. The method is based on the use of decidable fragments of OWL 2, able to guarantee the computational tractability of the approach. This represents an essential property of a legal reasoning system in the Semantic Web, characterized by a huge amount of Linked Open Data in the form of triples.

Actually, legal reasoning is characterized by a more complex logic, the typical case being the defeasible one. On the other hand, the aim of this approach is to identify a framework, which seems promising in terms of computational tractability, under whose umbrella investigating the sufficient conditions according to which some types of legal reasoning can be managed by decidable reasoners, so to guarantee not only a computational tractability, but also the possibility to reuse existing reasoners developed for decidable profiles of OWL 2.

In the next future we aim to explore the semantics and use of DL-safe Rules [31], which are a specific decidable fragment of SWRL, able to describe a type of rules where variables appears in the rule premise in both unary and binary predicates.

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