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SBVR to OWL 2 Mapping in the Domain of Legal Rules

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Abstract. The Semantics of Business Vocabulary and Business Rules (SBVR) is a specification created by the Object Management Group (OMG) to provide a way to semantically describe business concepts and specify business rules. However, reasoning with SBVR is still an open subject, and current efforts to provide reasoning are done through the Web Ontology Language (OWL), by providing a mapping between SBVR and OWL. In this paper we focus on the problem of mapping SBVR vocabulary and rulebook to OWL 2, but unlike previous mappings described in the literature, we provide a novel and unorthodox mapping that allows to describe *legal rules* which have their own intricate anatomy.

Keywords: SBVR, OWL, Rule, Legal

1 Introduction

Following the global financial crisis of 2008, more interest has been geared towards information systems of the financial industry as they were key contributors to the failures that occurred across the industry.

The Governance, Risk, and Compliance Technology Center (GRCTC) was established in 2012 to conduct R&D on the use of semantic technologies for GRC in the financial industry. One of its objectives is to design and build semantic technologies based on regulatory ontologies to enable sense-making by GRC actors around complex regulations in order to facilitate regulatory change management in financial organizations and to help address the aforementioned problems. The main technologies used are Semantics of Business Vocabulary and Business Rules [1] (SBVR) to capture rules from legislative text, and the Web Ontology Language [16] (OWL 2) to perform advanced reasoning tasks which are not supported in SBVR.

To this end, we have developed at GRCTC a Regulatory Compliance Interpretation Methodology [3] (RIM), which indicates how to extract rules from regulations and represent them in a machine-readable knowledge base. Simply speaking, the RIM is a collaborative methodology requiring 2 agents: 1) the Subject-Matter Expert (**SME**), a lawyer knowledgeable of the legislative text

and responsible of capturing the rules and transmitting them to the *STE*, and 2) the Semantic Technology Expert (**STE**), a knowledge engineer whose role is to translate the rules captured by the SME into an OWL ontology.

The *lingua franca* of the SME and the STE is SBVR Structured English (SBVR SE): the SME produces a regulatory vocabulary and rulebook in SBVR and transmits them to the STE [2]. The STE can ask for clarification, so the process is repeated until all ambiguities are eliminated and the STE is satisfied with the vocabulary and the rulebook.

Once the SME - STE interaction is done, the STE becomes responsible of the translation of the developed vocabulary and rulebook from SBVR to OWL 2, and this is the subject of this paper. Current mappings [5, 6, 10–12] are generic and do not take into account the unique nature of a legal rule. In our approach, a legal rule defines conditions that in turn qualify events as relevant or not, and if an event is relevant to the rule, it is considered as compliant to the rule if, and only if, it complies to a *complicance condition* (it is actually called a *deontic condition*, but more on that in Section 5), otherwise the event breaches the rule.

In order to support this kind of reasoning, we developed the Financial Industry Regulatory Ontology [7] (FIRO). The FIRO-H module of FIRO provides all the necessary scaffolding needed to map SBVR to OWL, while its details and its reasoning capabilities are out of the scope of this paper. We will introduce FIRO-H concepts as we require them to understand the mapping. To the best of our knowledge, this is the first mapping from SBVR to OWL that is tailored for a practical application in a specific domain.

The rest of the paper is organized as follows: Section 2 introduces SBVR; Section 3 discusses the different components of FIRO; Sections 4 and 5 show how to map SBVR vocabulary and rulebook, respectively, to OWL using FIRO; Section 6 reviews the state of the art on SBVR to OWL mapping; and finally we conclude in Section 7.

2 SBVR

The Object Management Group (OMG) created the Semantics of Business Vocabularies and Business Rules (SBVR) specification [1] to define business concepts and rules using a *controlled natural language*, SBVR Structured English (SBVR SE). It is meant to be used by business people to describe their business activities, hence its adoption in the RIM of GRCTC: it allows non-technical experts (SMEs) to define rules using a controlled language (as opposed to legalese).

The elements of SBVR vocabulary (that are of relevance to our discussion) are:

1. General Noun Concepts. They are nouns that describe classes of objects; they classify things based on their common properties (e.g. Bank, Share, ...).
2. Individual Noun Concepts. They designate individual occurrences of things (e.g. Cork is a city in Ireland, however Cork is an individual instance, a single and unique concept).

3. *Verb Concepts*. Composed of a *verb* (technically *verb symbol*) and one or more Verb Concept Roles. A Verb Concept Role is a noun concept, either general or individual. Examples of a basic verb concepts:
   (a) Bank *transfers* Asset. *transfers* is a verb that has 2 Verb Concept Roles, namely Bank and Asset.
   (b) Bank of Ireland *issues* Share. *issues* is a verb that has 2 verb concept roles, namely the individual noun concept Bank of Ireland and the general noun concept Share.
   (c) Bank *defaults*. defaults is a verb with 1 verb concept role, namely the general noun concept Bank.

The rulebook contains *Definitional* (or *Structural*) rules and *Behavioural* (or *Operative*) rules. In the legal context, definitional rules correspond to *Constitutive Norms* that are characterized by their alethic modality (i.e. necessity, possibility, impossibility); behavioral rules correspond to *Regulative Norms* that are characterized by their deontic modality (i.e. obligation, permission, and prohibition). Every rule is a combination of: 1) a modality, and 2) one or multiple verb concepts connected with keywords. In this paper we will restrict ourselves to behavioural rules only, therefore, we will be considering deontic modalities only. Example of a rule:

It is obligatory that each Price *reflects* the Prevailing Market Condition for each Share.

The modality of the rule is expressed in "It is obligatory that" which indicates an obligation. We have 3 noun concepts: 1) Price, 2) Prevailing Market Condition, and 3) Share, and 2 Verb Concepts: 1) Price *reflects* Prevailing Market Condition, and 2) Share *has* Prevailing Market Condition.

The vocabulary only contains Noun Concepts and Verb Concepts. The universal quantifier each is not present in the Verb Concept, but it is present in the rule. The modality is also in the rule only. This distinction is crucial for the modeling of rules in FIRO, which we will introduce in Section 3.

3 FIRO

GRCTC is currently developing a set of ontologies called FIRO (Financial Industry Regulatory Ontology) to enable semantic applications such as classification, querying, and reasoning. FIRO is composed of different modules, from which we are only interested in:

FIRO-H. This ontology is a *high-level* ontology focused on the concept of regulatory compliance. It defines all the concepts and relationships necessary to represent legal and business rules, and their compliance.

FIRO-D. This ontology specializes FIRO-H by describing the concepts and the relationships expressed by a specific regulation (e.g. UK AML Regulation, MiFID, US Bank Secrecy Act). In other words, in FIRO-D we find *domain*-specific rules.

FIRO-Op. This ontology uses FIRO-H as a framework and one or multiple FIRO-Ds to support a specific GRC-related process or task. In FIRO-Op we taylor an ontology for a specific GRC *operation*.

Please note that a full discussion of FIRO, classes and relations in every module, and its reasoning capabilities are out of the scope of this paper. We will only introduce concepts of FIRO (FIRO-H more specifically) as we need them.

4 The Vocabulary

4.1 Definitions

Definition 1 (Factor). *A generic or specific entity that plays a role in an action. It is the result of the interpretation of the entities involved in the rule.*

Definition 2 (Action). *An abstract category of events that is defined arbitrarily. It is the result of the interpretation on the behaviour required by the rule.*

Definition 3 (Event). *A concrete manifestation of an abstract action.*

Action and Factor roughly correspond to *Verb Concept* and *Verb Concept Role*, respectively, in SBVR. They are defined during *rule interpretation* (intended as statutory interpretation, see [4]) which means that the same rule found in the legislative text can have multiple interpretations (that is, can be "defined arbitrarily"). An example of an action would be:

Bank *transfers* Asset

This action describes in an abstract manner all the events that consist in a bank transferring an asset. It does not designate a specific Bank or a particular Asset. It describes the category of actions that are qualified as Bank *transfers* Asset.

Events are actions described in data, not the rule. Examples of events relating to the *Action* Bank *transfers* Asset:

Bank of Ireland *transfers* Share N. 0001234
Central Bank of Ireland *transfers* Parcel N. 0004321

4.2 Mappings

We find in the literature different papers (e.g. [5, 6, 10–12]) talking about the transformation of SBVR vocabulary to OWL 2, and they are all based on the same basic notion also described in the official documentation of SBVR [1, Section 10.3]. Table 1 summarizes this translation.

In FIRO, we take a different approach. Indeed, FIRO-H describes 3 main classes:

Factor. The equivalent of a *Verb Concept Role* in SBVR.

SBVR	OWL Only	OWL + FIRO
General Noun Concept	*Class*	*Class* subclass of *Factor*
Individual Noun Concept	*Individual*	*Individual* of a (*Class* subclass of *Factor*)
verb	*Object* or *Data Property*	*Individual* of *Verb*

Table 1. SBVR to OWL: The Classical Approach *vs* FIRO

Verb. Corresponds to the class of Verbs in SBVR. A verb (symbol) found in a verb concept is an individual of the class *Verb* and not an *Object* or *Data Property* as described in the literature.

Action. Corresponds to a verb concept in SBVR. It is composed of one or multiple Factors. The class *Action* is used in conjunction with two object properties:

hasFactor. Has a domain *Action* and ranges over *Factor*. (FIRO further specifies hasFactor into *hasSubject*, *hasObject*, etc. for more meaningful querying and reasonning).

hasVerb. Has a domain *Action* and ranges over *Verb*.

Let us take the example Bank *transfers* Asset. This verb concept would be created in FIRO-D using FIRO-H as follows: 1) Bank and Asset become OWL classes, each of them *subclassOf Factor*, 2) *transfers* becomes an individual of the class *Verb*, and 3) the whole verb concept will be defined (using the Manchester syntax [9]) as a class `Bank_Transfers_Asset`:

```
Class Bank_Transfers_Asset: Action and (hasSubject some Bank)
and (hasObject some Asset) and (hasVerb value transfers)
```

5 The Rulebook

5.1 Definitions

Definition 4 (Condition). *An Action used in a rule. A condition has the same properties as actions and may restrict factors by specifying 1) their scope or value, or 2) the role they play in another condition.*

Definition 5 (Rule). *A rule is made of 1 deontic modal operator, 1 deontic condition, and any number of applicability conditions.*

Definition 6 (Applicability Condition). *It is a condition that determines if a given event is relevant to a given rule or not. It corresponds to the "condition of application" of prescriptions in [8].*

Definition 7 (Deontic Condition). *It is a condition that determines if a relevant event complies/breaches a rule. It corresponds to the "legal effect" of prescriptions in [8]. A deontic condition has 1 deontic factor.*

Definition 8 (Deontic Factor). *A deontic factor of a deontic condition is a* Factor *that is the direct object/main target of the deontic modal operator. If a relevant event meets the deontic factor, it is compliant with the rule, if it does not meet it, it breaches the rule.*

Let us take the example *Action* Bank *transfers* Asset to demonstrate the types of specifications mentioned in Definition 4:

1. Bank *transfers* at least 2 Assets is a specification of scope.
2. Central Bank of Ireland *transfers* Asset is a specification of value.
3. Bank *transfers* Asset *of* Enterprise. Here Asset plays a role also in a second action Enterprise *has* Asset.

Let us take an example rule to explain Definitions 4 to 8:

It is obligatory that each Bank *transfers* less than $10'000

The *deontic modal operator* of this rule is expressed in "It is obligatory that". This rule has 1 *deontic condition*: Bank *transfers* less than $10'000. The *deontic condition* is based on the *action* Bank *transfers* Asset. An event is relevant to the rule if it is describing a bank transferring an amount of money. An event describing *a company* (other than a bank) transferring an amount of money is not relevant to this rule. If the event is relevant, and if the amount of money is less than $10'000, then the event is compliant with the rule, otherwise it breaches it. Therefore, the factor of $10'000 is the critical point that determines if an event is compliant or not; it is the *deontic factor*, the direct object of the obligation.

5.2 Mappings

FIRO-H provides the following:

Condition. Is a *subclassOf Action* used to define both *deontic* and *applicability* conditions.

hasDeonticFactor. An object property to specify the deontic factor.

RegulatoryStatement. The class of regulatory statements. Every rule is represented as an individual of this class.

DeonticModality. A class containing 3 individuals: *obligation, prohibition,* and *permission.*

hasDeonticModality. An object property with a domain *RegulatoryStatement* and a range *DeonticModality.*

To illustrate the mapping of a rule described in SBVR to OWL using FIRO-H, let us take the following example: we have a vocabulary made of the noun concepts Quote, Bid Price, Share, and Trading Venue and verb concepts Quote *include* Bid Price, Share *traded on* Trading Venue, and Share *has* Quote. The rule we are considering is:

It is obligatory that each quote (for each share *traded on* a trading venue) *include* at least two bid price

First of all, noun concepts and individual noun concepts should be created, then, 3 verb concepts should be translated into 3 Actions as described at the end of Section 4.2 (namely `Share_Has_Quote`, `Share_Traded_TradingVenue`, and

`Quote_Include_BidPrice`). Finally, we should create *rule2* as an individual of the class *RegulatoryStatement* as follows: `rule2 hasModality obligation`.

This rule has 2 conditions expressed in 2 separate actions: 1) a share should have a quote and be traded on a trading venue, and 2) the quote of the aforementioned share should include at least two bid prices.

If there is an event that does not satisfy the first condition, it is not relevant to the rule; the event does not constitute a breach of *rule2*. Therefore, the first condition is an *applicability condition*. However, the second condition is necessary for the rule: if an event satisfies the first condition, but does not satisfy the second one, it may constitute a breach; otherwise, the event complies to the rule. Therefore, the second condition is a *deontic condition*.

```
Class Rule2_Condition1: Condition
equivalentClass (Share_Has_Quote and hasSubject some
  (Share and (subjectOf some Share_Traded_TradingVenue)))
Class Rule2_Deontic: Condition
equivalentClass (compliesTo rule2)
equivalentClass (Quote_Include_BidPrice
  and hasSubject some (Quote and (objectOf Rule2_Condition1)
  and hasObject min 2 BidPrice)
```

6 State of the Art

The work described in the literature dealing with the transformation of SBVR to OWL follow the same pattern. All of them take their inspiration from the SBVR specification [1] which gives a rather basic mapping. One of the earliest mappings was described by Demuth and Libeau [6] who decided to translate SBVR vocabulary to OWL and SBVR rules to R2ML [17] of the REWERSE project. They created their own SBVR MOF representation to express SBVR hierarchy; they also restricted the expressiveness to unary and binary facts (verb concepts).

Cearvolo, Fugazza, and Leida [5] proposed a mapping between SBVR vocabulary and rules to OWL. However, SBVR facts that could not be translated into OWL were expressed in SWRL; e.g. round-trip car movements cannot be expressed with OWL DL: defining CarMovements whose fillers of properties hasReceivingBranch and hasSendingBranch are the same individual would involve dynamically defined enumerated classes (with the property filler as the only member) and this is not even possible with OWL Full.

Karpovic and Nemuraite [11] talked about the transformation from SBVR to OWL exclusively. They presented a mapping of different concepts and fact types (partitive, associative, property of, etc.). In a subsequent work, Kaprovic et al. [10] presented a (detailed) reverse mapping: from OWL 2 to SBVR; the aim of this goal was to show that SBVR can be used to describe OWL 2 concepts.

Reynares, Caliusco, and Galli [13–15] presented also a detailed mapping of SBVR to OWL 2, however they attack the vocabulary, facts and logical operators. Rules are not described. Moreover, they conclude by sharing the same concern of Cearvolo, Fugazza, and Leida [5], that OWL is not expressive enough to describe all kinds of SBVR semantics.

The most comprehensive mapping between SBVR and OWL 2 was described by Kendall and Linehan [12]. The goal of their work was to provide a reversible mapping between both specification without any loss of semantics. However, they restrict themselves to SBVR vocabularies only; i.e. behavioral rules are excluded.

7 Conclusion

In this paper we presented a mapping of SBVR vocabulary and rulebook to OWL 2 using the Financial Industry Regulatory Ontology (FIRO) as a framework that governs our mapping. We showed the parallels between FIRO-H and SBVR vocabulary, more precisely, we showed that in SBVR a *Verb Concept* and a *Verb Concept Role* correspond to *Action* and *Factor*, respectively, in FIRO-H. An *Action* used in a rule is a *Condition*.

We then showed how to model a rule using *Actions* as building blocks: a rule is defined by a *Deontic Modal Operator*, a *Deontic Condition* (the direct object of the modal operator), and any number of *Applicability Conditions*. Applicability conditions will qualify an event as relevant to a rule or not. The deontic condition will decide, via its *Deontic Factor*, if a relevant event is compliant to or breaching a rule.

The mapping we presented is significantly different from what has been described in the literature. The value of this approach as compared to the state of the art lies in the reasoning capabilities it enhances in terms of rules comparison and data classification. An interesting research direction would be attempting to automatically transform an SBVR logical formulation to OWL using FIRO-H as a host framework.

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