TRANSFORMING SBVR BUSINESS SEMANTICS INTO WEB ONTOLOGY LANGUAGE OWL2: MAIN CONCEPTS

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Abstract. The future vision of business information systems rely on semantic technologies as the Web Ontology Language OWL (currently, OWL2) that defines a meaning of business concepts and make them unambiguously understandable by human experts and software systems. Nevertheless, the spread of these technologies is observed mainly in the scientific papers and in some special domains, but not in everyday business operations. The reason for this is the fact that OWL is a language for information technology experts but not for business people – the actual managers of business policies and rules. From the other side, the Semantics of Business Vocabulary and Business Rules (SBVR), one of the recent OMG specifications, provides a means for describing semantic formulations of business concepts and business rules in a language that business people use. Currently some researchers ground their works on assumptions that formal logic-based SBVR formulations are transformable into OWL. However, an exhaustive study how these transformations could be built still is lacking. OWL2 presents new capabilities for linking two worlds. The goal of the paper is to introduce main concepts and problems in transforming SBVR into OWL2 by extending the relevant information from original SBVR specification and related works.

Keywords: Semantics of Business Vocabulary and Business Rules, Web Ontology Language, transformation, semantic technologies, SBVR, OWL2.

1 Introduction

Semantic technologies give a possibility for computer systems and human experts to understand and share semantics in a real time, thus presenting new capabilities for information processing. Unfortunately, these technologies are not mature yet to the certain level that we could notice significant benefits of them in everyday business operations. One of the problems for spreading these technologies is that they are based on sophisticated tools and languages as Web Ontology Language OWL, currently, OWL2 [10], [18] that are too difficult for business users. Therefore, ontology development is the main responsibility of information technology staff.

Object Management Group (OMG) has created the Semantics of Business Vocabulary and Business Rules (SBVR) metamodel [12] that provides opportunity to describe business concepts and business rules using so called Controlled Natural Language (CNL), which is understandable for business users. With the SBVR, domain experts are able to construct business vocabularies and business rules, or at least understand them for validation purposes. SBVR is based on formal logics and can be applied for computer processing, but it cannot be directly used in semantic technologies because these have their own languages as OWL2 or RDFS. Therefore, we are investigating a possibility of transforming SBVR into OWL2 for allowing business users to describe ontologies using the language similar to their everyday business language. That allows to prove consistency of company’s business vocabulary and rules by using OWL2 reasoners, and to gain other benefits.

Currently, some researchers ground their works on assumptions that formal logic-based SBVR formulations are transformable into OWL. However, an exhaustive study how these transformations could be built still is lacking. As we will see, some mere SBVR constructions are not easy comparable with OWL. Besides, existing works concern OWL, while OWL2 provides more capabilities for linking the both worlds. Therefore, the goal of the paper is to introduce main concepts in transforming SBVR into OWL2 by extending the relevant information from SBVR specification and related works. This task will gain the particularly importance when application of business vocabularies will become available for the wide range of business users.

The rest of the paper is structured as follows. In section 2, we analyze related works. Sections 3 and 4 shortly present main concepts of SBVR and OWL2. Section 5 is devoted to considering transformations from main SBVR concepts into OWL2. Section 5 presents conclusions and future works.

2 Related works

The vision of filling the gap between semantic technologies and business experts is to use CNL for authoring ontologies and then transforming them to Web Ontology Language. For developing such CNL, there are two slightly conflicting requirements: the need to see OWL in the form of natural language, and the need to make a straightforward mapping to and from OWL. Different scientific groups are developing their own CNLs,
but none of them is widely accepted. E.g. we can mention First-Version Controlled English Rule Language [19], Attempto Controlled English (ACE) [7], Rabbit and Sydney OWL Syntax (SOS) whose comparison in [13] ends with conclusion that none of these languages is suitable for semantic representations equally acceptable to business users and computing.

Semantics of Business Rules and Business Vocabulary (SBVR), adopted in 2008, was the first OMG specification created with intention to incorporate natural languages in modeling. SBVR is an integral part of the OMG’s Model Driven Architecture (MDA) [5] and uses SBVR structured English (SSE) as one of possible CNLs. SBVR is the most matured specification of semantics, but it also has limitations [15]: facts may be inferred, but SBVR does not standardize inference; no references to discourse (rules are stated in one sentence); no free variables in a logical formulas; necessity to introduce concepts before referencing to them; impossibility to express directives, no meaning for past tense or future tense etc. The lack of advanced SBVR editors capable parsing SBVR SSE style texts also is a problem. These circumstances prevent the wider usage of SBVR.

The possibility and necessity to fill the gap between SBVR and semantic technologies was noticed by many authors [2], [3], [8], [16]. For example, Demuth and Liebau [3] suggested a translation from SBVR to OWL and REWERSE Rule Markup Language (R2ML), however, no further research in this direction was made. Ceravolo et al. [2] analyzed possibility to translate SBVR specification into the OWL+SWRL knowledge base with intention to check business rules consistency. These researches have shown that SBVR2OWL transformations are desirable and would gain wide applicability, however, currently they are under construction.

SBVR can serve many purposes: ensuring semantic interoperability between distributed information systems [8]; engineering information systems [11], [14] or verbalizing software models [1]; often it is related with service oriented systems [9]. The largest advantages in implementing SBVR seem achieved in commercial Collibra tool suite for Business Semantics Management*. Collibra presents capabilities for authoring SBVR vocabularies and rules, generate ontologies and various models of information systems. It has inherited experience from several EU projects, e.g. OPAALS [9]. Related research has started in ONTORULE project**, which purpose is extraction of SBVR business rules from different sources including texts in natural language, to manage them and implement in software applications. The research group of Kaunas University of Technology needs SBVRToOWL2 transformation for the further development of the VeTIS tool [11] (also, you can see the paper by Sukys et al. in current IT'2011 proceedings). Here we faced with real problems; a part of them are under discussion in the literature, the another part is not mentioned at all. So we are trying to find concrete solutions that would allow widening the usage of SBVR for authoring OWL2 ontologies and making the bridge between user friendly structured languages and applications of semantic technologies.

3 Main concepts of SBVR

The peculiarity of SBVR metamodel is the explicit separation of meaning, representation and symbolization: the same meaning can have many representations and the same expression can represent different meanings (Figure 1).

![Figure 1. Subtypes of meaning in SBVR metamodel](http://www.collibra.com/)

SBVR meaning is defined as “what is meant by a word, sign, statement, or description; what someone intends to express or what someone understands”. Subtypes of meaning are concepts (object types, roles, fact types, fact type roles, individual concepts), questions and propositions. Meaning corresponds to thing that is understood as “anything perceivable or conceivable” [12], and every other concept implicitly specializes the concept „thing“ similarly to OWL2 where “Thing” is a supertype of all OWL2 classes. SBVR specification [12]

* http://www.collibra.com/
** http://ontorule-project.eu/
suggests matching of some main SBVR concepts to OWL concepts, but this list is incomplete. OWL directly covers only part of the SBVR as the ability to represent rules in the Web Ontology Language is very limited. The Semantic Web Rule Language (SWRL), combining OWL and RuleML, and Rule Interchange Format (RIF) are frequently mentioned as a solution for adding some rules to the Web Ontology Language.

4 Main concepts of OWL2

The Web Ontology Language OWL2 is a family of languages for authoring ontologies. The previous OWL specification included the definition of three sublanguages with different levels of expressiveness: OWL Lite, OWL DL and OWL Full. In the rest of the paper, when mentioning OWL2, we will assume mainly OWL2 DL, because OWL2 DL reasoning supports the maximum expressiveness, computational completeness and decidability. OWL DL has some restrictions, e.g. a class cannot also be an individual or a property what OWL Full allows. Main OWL2 concepts corresponding to the part of SBVR are presented in Figure 2 and Figure 3. OWL2 ontology consists of axioms. The main concept of the OWL2 ontology metamodel is OWL2 Class, which is a subclass of the ClassExpression (Figure 2).

![Subclasses of Axioms, Entities and Individuals in OWL2 metamodel](image)

Figure 2. Subclasses of Axioms, Entities and Individuals in OWL2 metamodel [10]

![Subclasses of OWL2 ClassExpressions in OWL2 metamodel](image)

Figure 3. Subclasses of OWL2 ClassExpressions in OWL2 metamodel [10]

Ontology and OWL2 entities (Classes, ObjectProperties, DataProperties, Datatypes and NamedIndividuals) are identified by IRI. The SubClassOf axiom states that each instance of one class expression is also an instance of another class. The EquivalentClasses axiom states that all class expressions $CE_i, 1 \leq i \leq n$ in EquivalentClasses ($CE1 ... CEn$) are semantically equivalent to each other. This axiom allows one to use each $CE_i$ as a synonym for each $CE_j$ — that is, $CE_i$ can be replaced with $CE_j$ without affecting the meaning of the
ontology. The DisjointClasses axiom states that several class expressions are pair wise disjoint (have no common instances). The DisjointUnion class expression defines a class as a disjoint union of several class expressions and thus allows expressing covering constraints. ClassExpression subclasses are presented in Figure 3. They define various restrictions on ObjectPropertyExpressions and propositional connections that are allowed between ClassExpressions or Individuals. These expressions mainly have their counterparts in SBVR.

5 Transformation of main SBVR concepts into OWL2

5.1 SBVR object type

SBVR object type is defined as a noun concept that classifies things on the basis of their common properties. It corresponds to OWL2 class where classes can be understood as sets of individuals. SBVR meaning can have many representations (Figure 4) that are treated as synonyms for noun concepts and synonymous forms for fact types. This contrasts with OWL2 where meaning and representation are not separated. SBVR metamodel has no explicit elements for synonyms and synonymous forms: both are implied by multiple representations of the same meaning. Unusually, SBVR business vocabulary entry introduces the primary representation of meaning, and this primary representation also is the preferred designation of that meaning [12]. Additionally, a meaning can have prohibited or not-preferred designations that are included in the vocabulary entry as synonyms or synonymous forms. If a vocabulary entry is not a preferred designation, then the preferred designation is referenced under the caption “See:” All synonyms (or synonymous forms) of the same meaning share the same definition.

![Figure 4. SBVR representation of meaning][1]

SBVR object type having exactly one (preferred) designation, should be transformed into OWL2 Class and the expression value of that designation should be transformed into Class IRI. Otherwise, SBVR object type is transformed into several classes – synonyms that are defined by OWL EquivalentClasses axiom [10]. We create OWL2 Class for each synonymous noun concept and constrain these class expressions with EquivalentClasses axiom, where Class CE1 corresponding to the preferred designation is supplemented with Annotation (Comment) “Preferred_designation” (Figure 5).

![Figure 5. Example of transforming synonyms from SBVR into OWL2][2]

OWL2 does not distinguish preferred designation between synonyms – this possibility is essential going from ontology or SBVR vocabularies and rules towards software applications used in everyday enterprise activities. We propose supplementing Classes CEi, corresponding to prohibited or not preferred designations, with comments “Prohibited_designation” or “Not_preferred_designation”. SBVR definition, general concept, concept type and other items of SBVR Vocabulary entry are transformed into OWL2 concepts related with class commented as Preferred_designation. Fact types and formulations of business rules can be transformed into OWL2 concepts related with prohibited or not-preferred equivalent classes representing synonyms. The presented way of distinguishing preferred, prohibited and not preferred designations is also suitable for object and data properties.
5.2 SBVR fact type

SBVR fact type denotes some type of relationship between noun concepts (object types) or is a characteristic of the noun concept. We will consider associative fact type, "is_property_of" fact type, partitive fact type, categorization fact type, assortment fact type and characteristic.

The associative fact type is a fact type having one or more roles and representing a relation between noun concepts is the most common fact type. The associative fact type having two fact type roles is transformed into OWL2 ObjectProperty (Figure 6) where the first fact type role is transformed into the domain Class, and the second fact type role – into the range Class of the corresponding ObjectProperty. The fact symbol of the preferred designation of the fact type form is transformed into the IRI of OWL2 ObjectProperty.

Figure 6. Transformation of the SBVR associative fact type with two fact type roles into OWL2 ObjectProperty

Fact type role. In Figure 6 we assume that SBVR fact type role coincides with the object type which is playing that role (a journal plays the role of the journal in the fact type “journal is referred_in database”). However, fact type roles often are separate concept types, e.g. “journal is published by publisher” where fact type role “publisher” ranges over the object type “organization”. Representing SBVR fact type roles is cumbersome in OWL2 because ontology roles rather mean SBVR associative fact types than SBVR fact type roles (or roles in UML). For example, we can simply formulate fact “A journal ITC is_published_by publisher KTU” having facts “ITC is journal”, “KTU is organization” in SBVR vocabulary or in UML (Figure 7) but it is not so easy in OWL2.

Figure 7. Example of representing role „publisher“ in SBVR and UML

Representing fact type role as OWL Class CE1 being subclass of OWL2 Class CE2 that represents the corresponding object type is not a good solution [4]. We solve this problem by using OWL2 SubObjectPropertyOf and ObjectPropertyChain. SubObjectPropertyOf(ObjectPropertyChain (OPE1 ... OPEn) OPE) axiom states that, if an individual x is connected by a sequence of object property expressions OPE1, ..., OPEn with an individual y, then x is also connected with y by the object property expression OPE. In our case, for representing role “publisher” we should transform SBVR vocabulary on Figure 7 into OWL ontology (Figure 8) having the following axioms:

SubObjectPropertyOf (ObjectPropertyChain (is_published_by o is_role_of ) publisher ),
SubObjectPropertyOf (is_published_by publisher )

Figure 8. Example of representing role “publisher” in OWL2

When we specify instances „KTU“ of type „Organization“, „ITC“ of type „Journal“ and object property „ITC is published by KTU“, ontology reasoner derives object property “publisher” between ITC and KTU. However, ITC property assertion “publisher KTU” not fits well with OWL2 style. Hoekstra [6] proposes more sophisticated solution for representing roles in OWL, but he uses OWL Punning that is restricted in OWL DL.

Is_property_of fact type defines an essential quality or a characteristic of a given noun concept and is identified by the verb phrase “has” (the passive form “is_property_of”). In the “is_property_of” fact type, the first fact type role ranges over an object type that is an elementary concept (number, integer or text). The “is_property_of” fact type is transformed into OWL DataProperty where the first fact type role is transformed
into the domain (OWL2 Class) and the second fact type role – into the range (OWL2 Datatype) of the corresponding DataProperty. The value of designation’s expression of the first fact type role is transformed into the value of DataProperty’s IRI.

![Diagram](image)

Figure 9. SBVR is_property_of fact type transformation into OWL2 DataProperty

Specialization (categorization) fact type is a fact type that represents relationship between two object types (noun concepts): the more general one and more specific another. The more specific noun concept is a category of the first (more general) one. In consequence, SBVR categorization fact type could be transformed to the SubClassOf/OWL2 concept (Figure 10).

![Diagram](image)

Figure 10. Categorization fact type transformation into OWL SubClassOf hierarchy

N-ary associative fact types having more than two fact type roles (require additional consideration, because they cannot be directly represented in OWL2. There are some proposals for possible representations of n-ary associations in OWL2 on the base of reification when a new class is introduced for representing the relation instead of a property [17]. However, such a way seems unnatural in many cases. Hoekstra in [6] states that the disadvantage of n-ary associations is rather an advantage than the drawback of the OWL2. He claims that n-ary associations always can be expressed by binary associations, and formulations of n-ary associations only demonstrate that the meaning of the corresponding associations is not well-understood. Similarly, in [11] it was assumed that SBVR associative fact types have at most two fact type roles. W3 Consortium suggests several solutions to solve or pass-thru this problem [17]: introducing a new class for a relation or using lists for arguments in a relation. These proposals are applicable to OWL2, UML or ER languages but they do not solve the problem when queries or business rules must be constructed using controlled natural language because such constructions sometimes will appear unnatural. Another possible solution is to represent some fact type roles of SBVR n-ary fact types as properties of OWL2 properties. OWL2 lets us declare properties and classes with the same name (it is called Punning in OWL2 specification). We will consider these possibilities more deeply in the future.

5.3 Transformation of SBVR quantifications

Almost all SBVR quantifications can be directly transformed into OWL restrictions. “universal quantification” \( \forall x \) means that the meaning, formulated by the logical formulation of \( x \), for each instance of \( x \) is true. It could be transformed into OWL restriction, owl:allValuesFrom (ObjectAllValuesFrom or DataAllValuesFrom). “existential quantification” \( \exists x \) means, that there is at least one \( x \), so this is a special case of the “at-least-n quantification, where \( n=1 \). This quantification could be transformed into the OWL2 owl:minCardinality 1. Another possibility is to render existential quantification as owl:someValuesFrom restriction. Both cases are correct from the logical point of view.

![Diagram](image)

Figure 11. Example of SBVR “exactly-n quantification“ transformation into OWL2

“exactly-n quantification” \( \exists^* x \) could be transformed into the OWL2 restriction owl:cardinality \( n \) (ObjectExactCardinality or DataExactCardinality elements of OWL2 metamodel). “exactly-one quantification” \( \exists^1 x \) is a special case of the exactly-n quantification, where \( n=1 \) (Figure 11). Alternatively, it can be represented by FunctionalObjectProperty or FunctionalDataProperty axioms. At-least-n quantification \( \exists^* x \), where \( n=1, 2, 3, \ldots (n \geq 1) \) means that there is at least \( n \) objects or properties marked as \( x \). It could be expressed as OWL cardinality restriction: owl:minCardinality \( n \) (ObjectMinCardinality or DataMinCardinality) (Figure 12).
It is necessary that the organization employs at least one employee.

Figure 12. Example of SBVR “at-least-n quantification” transformation into OWL2

“at-most-n quantification” $\exists^{0..n} x$, where $n=1, 2, 3, \ldots (n \geq 1)$ restricts the maximum number of instances or properties. It can be transformed to $\text{owl:maxCardinality } n$ (ObjectMaxCardinality or DataMaxCardinality from OWL metamodel). “at-most-one quantification” $\exists^{0..1} x$ is a special case (subclass) of at-most-n quantification, where $n=1$, so it is rendered as $\text{owl:maxCardinality 1}$.

5.4 Transformation of SBVR categorization schemas and segmentations into OWL2

In practice, object types often have several generalization hierarchies (generalization sets in UML) on the basis of different criteria (power types in UML). In SBVR, these generalization sets are represented by categorization schemas (corresponding to {disjoint, incomplete} generalizations) and segmentations in SBVR (corresponding to {disjoint, complete} ones) (Figure 13). Unaccountably, multiple generalizations are insufficiently addressed in ontology related literature. SBVR categorization schema corresponds to OWL2 $\text{ObjectUnionOf}$. OWL2 $\text{DisjointUnion}$ can cover SBVR segmentation (Figure 14). Several categorization schemas (segmentations) of the same OWL2 $\text{Class}$ are defined by the $\text{EquivalentClasses}$ axiom.

Figure 13. SBVR segmentation

Figure 14. Representing SBVR segmentations in OWL2
6 Conclusions and future works

SBVR is the most matured semantic representation that can use SBVR Structured English or other CNL for ontology development. Although OMG specification declares that SBVR is compatible with OWL, an exhaustive study how transformations from SBVR into OWL could be built still is lacking. Currently, OWL is superseded by OWL2 that provides more capabilities for expressing semantics of business domain.

The analysis of the related research has shown that while SBVR2OWL transformation is considered as straightforward elsewhere, it is true only for main concepts of SBVR but even there are some primary questions unanswered yet. Solutions to some of these primary questions – how to represent SBVR synonyms and synonymous forms, preferred designations, categorization schemas and segmentations, some (but incomplete) approximation to fact type roles, – were presented in the current paper. The further work will be directed towards including a more comprehensive subset of SBVR concepts that are worth to represent in OWL2, and implementing the corresponding transformations for accelerating employment of SBVR and OWL2 in practise.

References


