Development of a formal REA-ontology Representation

Frederik Gailly[1], Geert Poels

Ghent University
Hoveniersberg 24, 9000 Gent
Frederik.Gailly@Ugent.Be, Geert.Poels@Ugent.Be

Abstract. Business domain ontologies offer great opportunities for facilitating communication between people in business, for improving the enterprise system engineering processes and for creating interoperability between enterprise systems. However despite these opportunities, their use in practice is still limited. This can be partly attributed to the lack of formal representation of these ontologies. This paper proposes a structured approach which uses conceptual models as intermediary representation for formalizing business domain ontologies. The proposed methodology is used for the process level specification of the Resource Event Agent Ontology.

Introduction

The use of business domain ontologies offers very promising opportunities for businesses. However successful application of business domain ontologies requires properly engineered ontologies with a strong theoretical basis. Nowadays one of the most compelling problems with existing business domain ontologies is the lack of a proper formalization. A lot of papers show possible benefits of the use of business domain ontologies, but these benefits are hard to demonstrate because most business domain ontologies are only represented in a semi-formal way.

One of the most promising business domain ontologies is the Resource Event Agent ontology (REA-ontology). This application ontology is based on McCarthy's Resource Event Agent model [1] which has strong roots in accounting and economics. [2] also recognized the possibilities of the REA-ontology and evaluated the REA-ontology from an operational perspective. Like other business domain ontologies[2] the REA-ontology lacks a formal representation that is useful for its application in practice.

[7] extended the original REA-model and provide informal, graphical representations of the REA-ontology. These representations are used for analyzing the ontology from the ontological perspective of John Sowa [14]. One of the problems of this ontological analysis according to [11] is the inconsistent and confusing terminology of the constructs of the REA-ontology. [9] also criticize the REA-

[1] Corresponding author
[2] Tove [5], Enterprise Ontology [16] and Business Model Ontology [13]

ontology because it lacks ontological clarity. In our opinion this is partly caused by the intuitive representation of the REA-ontology. The use of a well known ontology representation language can avoid such semantic problems. Recently, [3] and [8] gave a more formal representation of the REA-ontology. However, in these works only parts of the REA-ontology were addressed and the representations were not developed using a structured approach. It is common knowledge in the ontology engineering field that the quality of the ontology is better when a good methodology is used for the development of the ontology. Unfortunately existing methodologies are very general and only provide basic guidance.

It is our opinion the lessons learned in the ontology engineering field can support the development of a better REA-ontology specification. A better specification based on a structured approach will contribute to a successful operationalization of the REA-ontology in practice. A formal representation of the REA-ontology offers great opportunities for validation of enterprise schemata, model-driven development of systems [3] and multi-company supply-chain [10].

In the next section a description of the proposed methodology is given. Moreover we justify it. In the third section we use this approach for the preliminary development of a formal representation of the REA-ontology. Finally, the last section outlines future research avenues.

Methodology for developing formal business domain ontologies

In the ontology engineering field many different approaches are used for the formalization of an ontology. However, many authors have recently recognised the opportunities that the conceptual modelling and database field can offer for ontology engineering. Conceptual modelling approaches have been designed to give a semantically rich description of the universe of discourse and "could, at least to some extent, handle the description of the conceptualisation that is the subject of some ontology" ([15], p. 25).

In our approach we want to use a graphical representation of the application ontology as an intermediate for the formal representation of the ontology (see figure 1). This means that in a first stage a graphical representation must be developed for the business domain ontology. For the graphical representation different languages can be used. Nevertheless, our choice for UML is obvious because of the wide acceptance of this modelling language and the wide range of possibilities UML offers. For example UML can also model dynamic aspects which make it more useful than data modelling languages like (E)ER and ORM. In case UML is not sufficient for modelling the ontology we can always use the Object Constraint Language (OCL) for specifying additional semantics.

In a second stage the UML representation and perhaps the OCL statements can be converted into a formal representation in an ontology representation language like RDF(S) or OWL. Different authors have researched the differences between conceptual modelling languages and ontology representation languages like DAML, RDF(S) and OWL, as well as how conceptual diagrams can be mapped into one of these languages. Specific for UML, [4] developed a framework to convert class diagrams in RDF Schemas. This approach also shows that this mapping can be easily automated by using XMI specification for serialising an UML document as an XML document. An XSLT stylesheet will transform the document to the target ontology representation language.

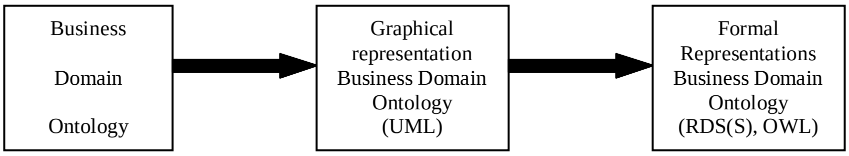


Fig. 1.: Methodology for the development of a formal representation of a domain ontology

Despite the many common features of UML and ontology representation languages like RDF(S) and OWL, there are some specific characteristics that make the transformation not straightforward. One of the issues identified in literature is the concept of property in DAML or OWL which can be split into the notions of object property and datatype property. An object property appears to be the same as an association in UML and a datatype property appears to be the same as an attribute. Nonetheless there is a difference in DAML+OIL and OWL, an objectproperty can exist independently of any class.

Preliminary formal representation of the REA-ontology

[6] give a general overview of the whole REA ontology. In this paper we illustrate our formal representation process using the business process level specification of the operational infrastructure of the REA-ontology. Later on, we will also add the other parts of the operational infrastructure (e.g. value chain and task level specifications) and the policy infrastructure. The policy infrastructure contains "what could be or what should be" happening in business reality, the operational infrastructure contains the events that actually occurred or that have been committed to.

Following the proposed methodology the first step is the development of a UML representation of the REA-process specification (see figure 2). The developed class diagram is based on [6][3]. At this stage this preliminary class diagram is basically a classification of the different concepts in the business process level specification of REA's operational infrastructure. The diagram will be extended with more constraints (e.g. stock-flows are of the use, consume or produce types if duality is a transformation), but first a thorough analysis of existing REA literature is needed to identify all these constraints. As mentioned before there are some problems with the terminology of the different REA constructs and this must be clarified first. The main objective here is illustrating the methodology, not to present a complete and final UML representation.

[3] Currently, the most complete description of the REA-ontology is found in [6]

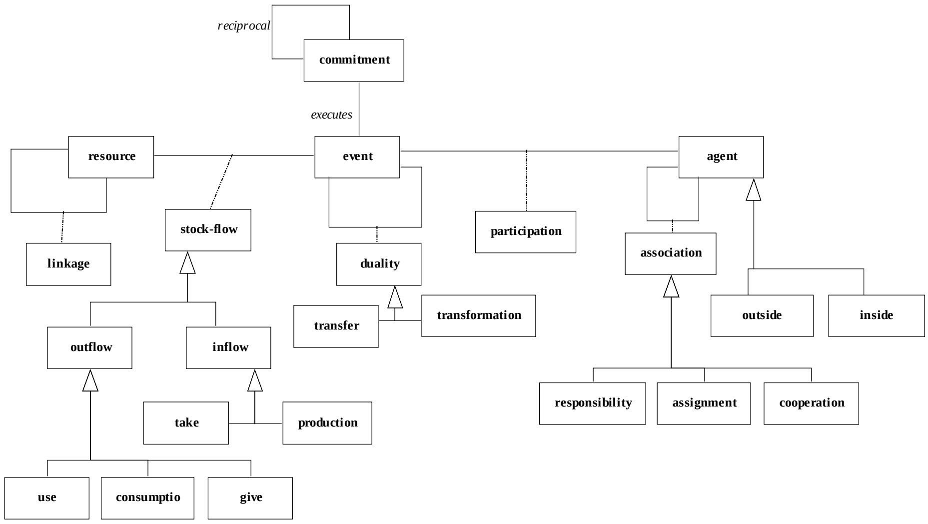
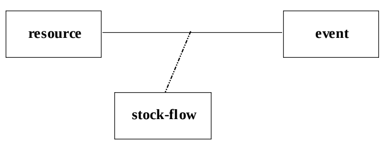


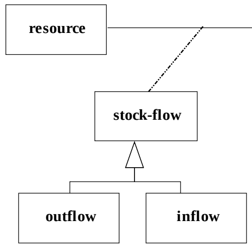
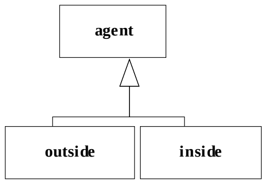
Fig. 2. UML class diagram of the REA-ontology

Based on this UML class diagram a formal representation of the operational infrastructure of the REA-ontology is developed. This mapping is based on the work of [1] which compare UML with DAML and give some rules for the mapping between UML and DAML. In our transformation we will use these rules as guidelines for the mapping between the UML class diagram of the operational infrastructure of the REA-ontology and OWL. At this stage other ontology representation languages could also be used, but we expect that in a later stage when additional constraints will incorporated, OWL will offer the best solution.

Table 1 gives some examples of the applied transformations. The UML classes were transformed in OWL classes, associations were represented in OWL as 'objectproperties'. The generalizations in the UML class were transformed in two ways depending on either if it were generalisations of classes or association classes. In the case of generalization of a normal class the OWL 'subTypeOf' construct was used, in the other case the 'subPropertyOf' construct was used. Another approach could have been reifying the association classes and using the 'subTypeOf' in every case.

Table 1. Transformation examples between REA-ontology UML class and OWL

REA UML class diagram elements	OWL representation
	<owl:Class rdf:ID="resource" />
	<owl:ObjectProperty rdf:ID="stock-flow"> <rdfs:domain rdf:resource="#event" /> <rdfs:range rdf:resource="#resource" /> </owl:ObjectProperty>

REA UML class diagram elements	OWL representation
	<owl:ObjectProperty rdf:ID="outflow"> <rdfs:subPropertyOf rdf:resource="#stock-flow" /> </owl:ObjectProperty> <owl:ObjectProperty rdf:ID="inflow"> <rdfs:subPropertyOf rdf:resource="#stock-flow" /> </owl:ObjectProperty>
	<owl:Class rdf:ID="outside"> <rdfs:subClassOf rdf:resource="#agent" /> </owl:Class> <owl:Class rdf:ID="inside"> <rdfs:subClassOf rdf:resource="#agent" /> </owl:Class>

Conclusions and Future Research

A correct formal representation of the REA-ontology offers great opportunities and will facilitate the operationalization of the REA-ontology. In this paper a formal representation process is proposed with as key characteristic the use of conceptual modelling as an intermediate step for this formalization. The methodology is also illustrated for the formalization of the business process level specification of the operational infrastructure of the REA-ontology without additional constraints.

In future research the existing REA-literature will be used for the development of a conceptual model of the REA ontology that captures the business domain. The class diagram will be elaborated with additional constructs and constraints. For the constraints that cannot be modelled with UML, OCL can be used.

The second step of our methodology also needs further investigation. The mapping rules used at this stage were very straightforward and logical. However, the graphical representation will become more complex when more constructs and constraints are added and more complex mapping rules will be needed. In future research we will evaluate existing mapping rules and how they can be used for the development of a formal representation of the REA-ontology. Finally, the mapping rules can be translated into an XSLT stylesheet which can be used for transforming the XMI representation of the UML diagrams into a representation in the target ontology representation language.

References

[1] Baclawski K., M. K. Kokar, P. A. Kogut, L. Hart, J. Smith, W. S. Holmes, J. Letkowski, M. L. Aronson (2001): Extending UML to Support Ontology Engineering for the

Semantic Web, In: Proceedings of the Fourth International Conference on the Unified Modeling Language (UML 2001), Lecture Notes in Computer Science 2185 , 342-360
[2] Borch, S.E. and C. Stefansen (2004): Evaluating the REA Enterprise Ontology from an Operational Perspective. In: Proceedings of the Enterprise Modelling and Ontologies for Interoperability workshop 2004 (EMOI-INTEROP 2004)
[3] Borch, S.E., J.W. Jespersen, J. Linvald and K. Østerbye (2003) A Model Driven Achitecture for REA based systems. Proceedings of the Workshop on Model Driven Architecture: Foundations and Applications June 26-27, 2003 University of Twente, Enschede, The Netherlands
[4] Cranefield. S. (2001) Networked knowledge representation and exchange using UML and RFD. Journal of Digital Information, 1(8), February
[5] Fox, M.S. (1992) The TOVE Project: Towards A Common-sense Model of the Enterprise, Enterprise Integration Laboratory Technical Report.
[6] Geerts, G.L. and W. E. McCarthy (2000) An Ontological Analysis of the Primitives of the Extended REA Enterprise Information Architecture, Working paper.
[7] Geerts, G.L. and W.E. McCarthy (2002) An ontological analysis of the economic primitives of the extended-REA enterprise information architecture. International Journal of Accounting Information Systems, 3, 1 (March), 1-16.
[8] Geerts, G.L. (2004) An XML Architecture for Operational Enterprise Ontologies. Journal of Emerging Technologies in Accounting, 1, 73-90.
[9] Guizzardi, G. and G. Wagner (2004) A Unified Foundational Ontology and Some Applications of it in Business Modeling. In: Proceedings of the Enterprise Modelling and Ontologies for Interoperability workshop 2004 (EMOI-INTEROP 2004).
[10] Haugen, R. and W. E. McCarthy (2000) REA: A Semantic Model for Internet Supply Chain Collaboration. In: Proceedings of the Business Objects and Component Design and Implementation Workshop VI: Enterprise Application Integration.
[11] Lampe, J.C. (2002) Discussion of an ontological analysis of the economic primitives of the extended-REA enterprise information architecture. International Journal of Accounting Information Systems, 3, 1 (March), 17-34.
[12] McCarthy, W.E. (1982) The REA Accounting Model: A Generalized Framework for Accounting Systems in A Shared Data Environment. The Accounting Review (July), 554-578.
[13] Osterwalder, A. and Y. Pigneur (2003) Towards Strategy and Information Systems Alignment through a Business Model Ontology. Proceedings of the 23rd Annual International Conference of the Strategic Management Society (SMS), 2003, Baltimore.
[14] Sowa, J. (1999) Knowledge Representation: Logical, Philosophical, and Computational Foundations. Pacific Grove, CA: Brooks/Cole.
[15] Spaccapientra, S., C. Parent, C. Vangenot and N. Cullot (2004) On Using Conceptual Modeling for Ontologies. In: Proceedings of the Web Information Systems Workshops (WISE 2004 Workshops), Lecture Notes in Computer Science 3307, 22-33
[16] Ushold, M., M. King, S. Moralee and Y. Zorgio (1998) The Enterprise Ontology. The Knowledge Engineering Review, 13(1), 31-89.