Towards an Operational REA Ontology Using Web Ontology Languages

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POSITION PAPER

Research Goal, Background and Motivation

Ontology engineering is a promising direction for information systems research and practice. The use of ontologies can improve communication between people and organizations, can create interoperability between systems, and can improve the reusability and reliability of the systems engineering process[1]. Many researchers have recognized these opportunities, but the adoption of ontology applications in practice is still low. This lack of use in practice can be partly attributed to the scarcity of well-formalized ontologies. The last five years the World Wide Web Consortium (W3C) has published a series of recommendations about XML technologies that offer support for using ontology in practice. Nowadays stable ontology languages like RDF and OWL can be used for the formalization of ontologies. More recently languages were proposed that make it also possible to query ontologies (SPARQL and OWL-QL), which is a requirement for realizing Semantic Web applications.

Despite the availability of supporting languages and technologies, business domain ontologies are generally underspecified and insufficiently formalized for practical application purposes. Analogous to traditional software development, quality problems with proposed ontologies are often the result of a poor development process. Our research project aims to improve the development process of business domain ontologies, which should result in ontologies that can be applied in practice for a variety of business applications. Our target business domain ontology is the Resource Event Agent ontology. The REA ontology is based on the REA accounting model developed by McCarthy [2] and was further extended into a comprehensive enterprise information architecture by

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Geerts and McCarthy [3]. Other business domain ontologies that could be used as case-studies in our research are the Toronto Virtual Enterprise Ontology (TOVE) [4], the ENTERPRISE ontology [5], and the Business Model Ontology [6].

Geerts [7] has explored how XML technologies can be used for the operationalization of the REA ontology. According to Geerts a business domain ontology becomes operational when its specification is recorded and actively used by applications. Geerts [7] defines an enterprise system architecture based on XML technologies for supporting an operational REA ontology. The components of the conceptual enterprise system architecture are the enterprise data, the enterprise schema that contains enterprise-specific information structures and business rules, and the enterprise ontology which imposes the 'enterprise domain' –specific REA structure on the enterprise schema. The implementation part of the architecture separates these three components by codifying them in different XML or XML Schema documents. Separately describing the three components allows XML validation and transformation technologies to be used to verify compliance of the enterprise data against the enterprise schema and the enterprise schema against the REA ontology. We consider the XML-based REA enterprise system architecture of Geerts (2004) a useful framework and starting point for our research. We extend and adapt this framework in two directions.

First, the enterprise system architecture proposed by Geerts corresponds to a large extent to the single ontology approach that can be used for ontology-based data integration [8]. The single ontology approach (see figure 1-i) means that different source schemas are directly related to a global ontology that provides a vocabulary of business concepts and an axiomatic structure of relationships between these concepts. The major drawback of this approach is that all source schemas have nearly the same view on a domain, with the same level of granularity. In order to realize this approach a certain degree of standardization is needed and its our opinion that this will be very hard to realize in business practice. Another possible approach for realizing ontology-based data integration is the multiple ontology approach (see figure 1-ii), where each data source is described by its own local ontology and instead of using a common ontology, local ontologies are mapped to each other. The third and probably most feasible approach is the combination of the two preceding approaches. The hybrid ontology approach (see figure 1-iii) builds a local ontology for each data source schema which is mapped to a global shared ontology. The REA ontology could now be a local ontology (or one of many local ontologies) for (part of) an enterprise, and data integration can be achieved by reference to the shared ontology.

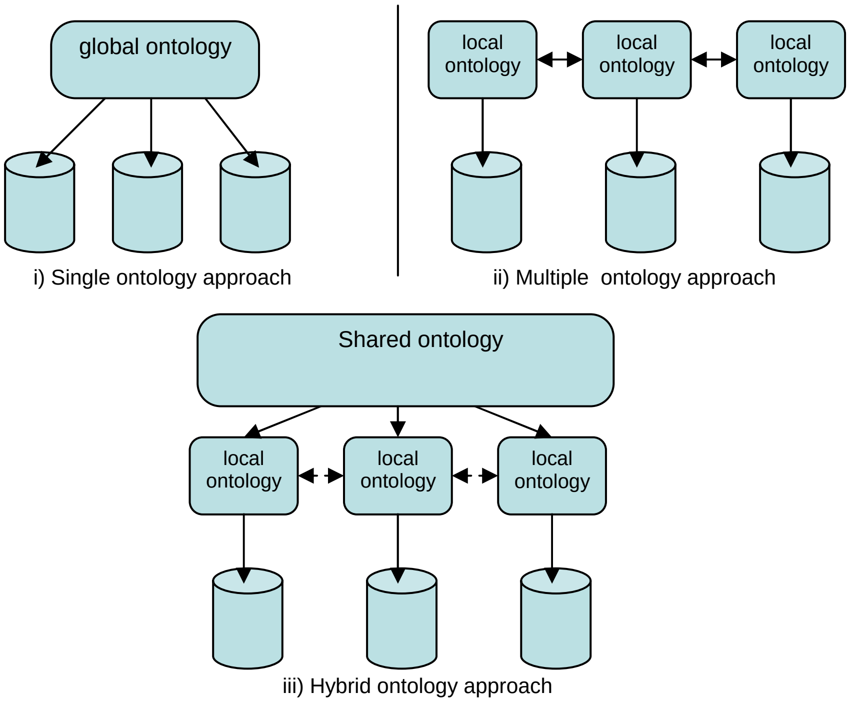

Figure 1: Ontology-based Information Integration Approaches

Second, we argue that the implementation part of the REA enterprise system architecture should include ontology languages for the formalization of the ontologies. It is true that the difference between XML Schema and web ontology languages is small, but we follow the view of Klein et al. [9] which see XML schemata as a means to provide integrity constraints for information sources and ontology languages as a means to specify domain theories. Domain theories consist of domain rules which must be able to express integrity of data but also the domain conceptualization and therefore must have a greater expressive power [10]. Using ontology languages also means that the ontology can be more easily mapped onto another ontology which is for instance necessary when the ontology is used in a hybrid ontology approach for data engineering (e.g. mapping a local ontology to the global, shared ontology). As a result we adapted Geerts' architecture and stipulated that for the implementation (formalization) of the ontological primitives, enterprise concepts and ontological logic of the REA ontology we intend to use ontology languages like RDFS and OWL. For the implementation of the enterprise schema XML Schema, RDF or even the instantiation constructs of OWL could be used. Important at this level is that the proposed schema corresponds to the formalized ontology. Figure 2 represents an overview of our adjusted enterprise system architecture based on the work of Geerts.

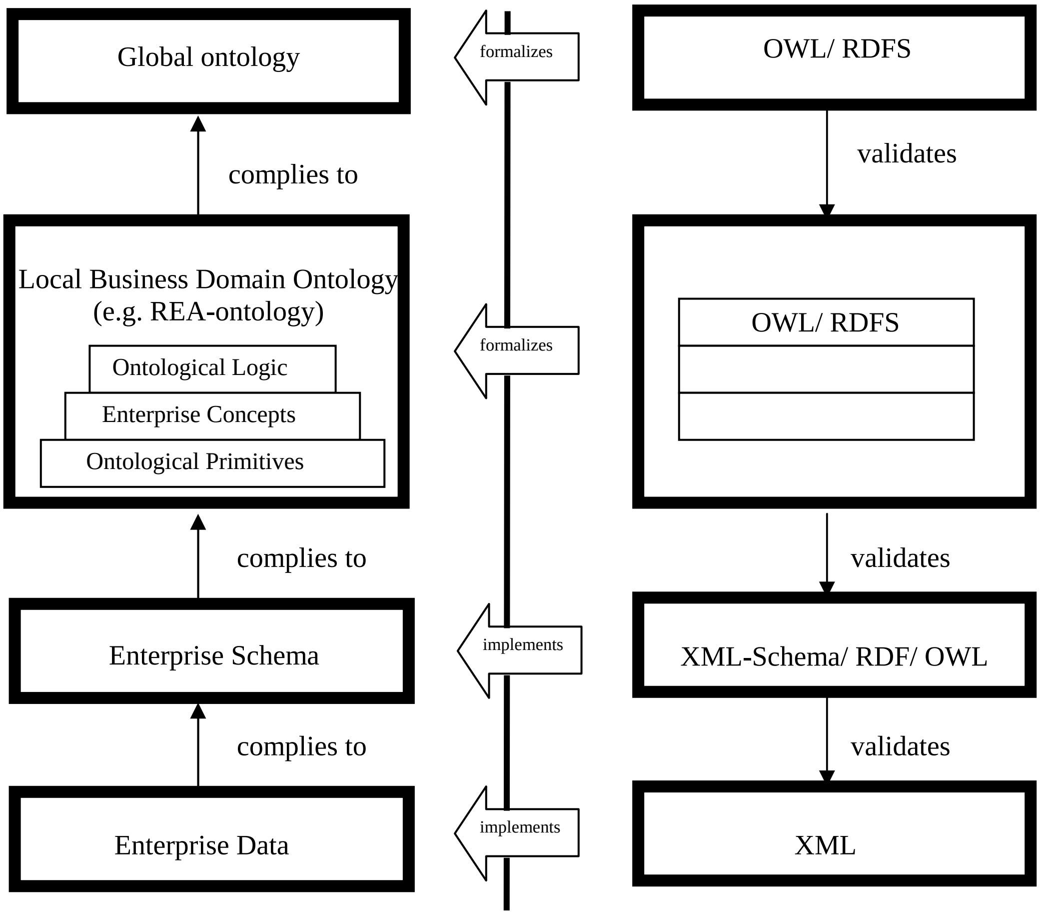

Figure 2: Operationalisation of the REA-ontology (based on [7] p81)

APPLICATIONS

Today the REA ontology is mainly used as a guide during the software engineering process and in this sense it can be used as a quality assurance tool when developing enterprise systems. The REA ontology provides the basis for various business process reference models and thus assists the identification of requirements and helps assuring the correctness, relevance and completeness of the requirements specifications.

One of the challenges of today is to use business domain ontologies to give semantic meaning to enterprise data and as a result make it easier to create interoperability within and between enterprise applications. Web ontology languages make it possible to implement the REA ontology as a local ontology for a business or business application and as a result give semantic meaning to enterprise data. Additionally the local REA ontology can be mapped to a global ontology which provides a common framework that allows data to be shared and reused across application and enterprise boundaries.

The use of the REA ontology in real applications is still very limited. Borch et al. [11] explored how their REA ontology formalization in XML could be used as a platform independent model in the Model Driven Architecture (MDA) approach to the development of accounting systems. Other proposed applications of the REA ontology are only theorized but are to our knowledge not illustrated with real applications. Haughen and McCarthy [12] state that the REA ontology is perfect for multi-company supply chain collaboration and REA can offer a standardized semantic model that can actually support all supply chain activities. During the first International REA Technology Workshop different authors have also proposed possible applications for the REA ontology: automated reasoning about business processes, and valuation and optimization of processes , automating processes across supply-chains, but they all agree that a formal representation is necessary [13].

DESIGN APPROACH AND CURRENT STATE OF THE PROJECT

One of the first problems that must be solved to achieve a successful operationalization of the REA ontology is the development of a good formal representation of the ontology. A series of methodologies for ontology engineering have been proposed by the Artificial Intelligence community. One of the most complete ontology engineering methodologies is METHONTOLOGY, which in accordance to the IEEE standard for software engineering distinguishes four different activities in the ontology development process: specification, conceptualization, formalization and application [14]. The METHONTOLOGY development process has also been extended for the reengineering of ontologies [15] and identifies three main activities: reverse engineering, restructuring and forward engineering (see figure 3).

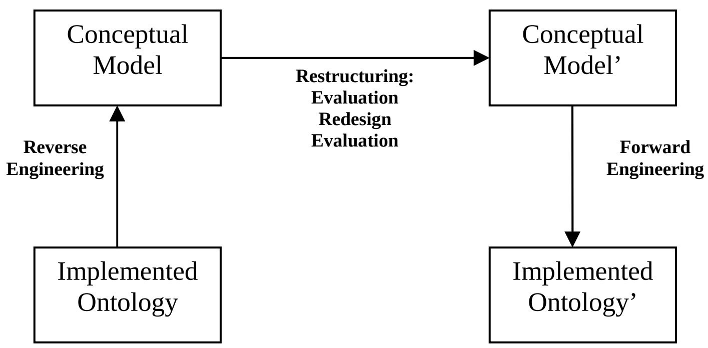

Figure 3: Ontology reengineering process

This reengineering methodology can use techniques described in the METHONTOLOGY development process (see [16] for an overview), but specific for the reengineering of business domain ontologies we think it is important to include a top-level ontological analysis. It is our believe that a further integration of existing top-level ontologies like SUMO [17], BWW [18] and

SOWA [19] into the development process could further improve the business domain ontologies and will make it easier to create interoperability between different systems because it makes it easier to compare and map the different local ontologies or define a global ontology.

Furthermore it is also important to use existing data modeling languages during the conceptualization of a business domain ontology. Data modeling languages like ER and UML are generally known by business people and this will make it easier to communicate and discuss the business domain ontology. However some issues need to be taken into account when using data models as conceptualizations for ontologies. Unlike data models which are developed for a specific application, ontologies need to be as generic and task-independent as possible [10]. Ontology engineers must also follow an Open World Reasoning approach during the development of the domain ontology. As opposed to data modeling, in ontology engineering something is false only if it can be proved to contradict other information in the ontology. In most cases data modeling languages like ER and UML will not be able to express all domain rules and constraints. For UML this can be partly solved by the incorporation of OCL but for more sophisticated ontologies even the expressive power of OCL will be too limited. Including a top-level analysis and using data modeling languages for the conceptualization will also facilitate the forward engineering process because it makes it easier to select the appropriate formalization rules and could also in the long run automate the formalization process. For instance, UML-to-OWL mapping rules could be used. For the moment no uniform approach exists but the Ontology Definition Metamodel (ODM) proposal of the Object Management Group (OMG) intends to offer such an approach [20].

In the first faze of our research project we adopted this reengineering methodology for the development of a formal representation of the basic transaction pattern of the REA-ontology. The REA ontology does not contain a widespread accepted formalization and as a result the original conceptualization was used as a starting point. Geerts and McCarthy[3] have used mainly text for describing the REA-ontology and have added some graphical representations in some traditional data modeling languages like ER and UML class diagrams.

The restructuring of the existent conceptualization resulted in natural language definitions of the basic concepts and their relations. An ontological analysis of the concepts based on Sowa’s ontology was already performed by Geerts and McCarthy [3] and was used as a starting point. In the future we will extend this analysis with other more commonly used high-level ontologies.

Based on the obtained definitions and the original graphical representations, a new reengineered conceptual model of the basic REA pattern in UML was developed (see figure 4). A distinctive characteristic of the REA-ontology which is not represented in the original conceptualization is the specialization of the relations between the different concepts. For instance the stock-flow relation is specialized in inflow and outflow relations which can be further specialized in use, consumption, give (for outflow) and take and production (for inflow). It is our opinion that the relations should be represented with association classes which can be further specialized. Specializing the different relations opens up the possibility of using OCL for the representation of ontological axioms, e.g. the basic REA axiom stipulating that all (types of) events effecting an outflow of economic resources must be paired in duality relationships with (types of) events effecting an inflow and vice-versa [3].

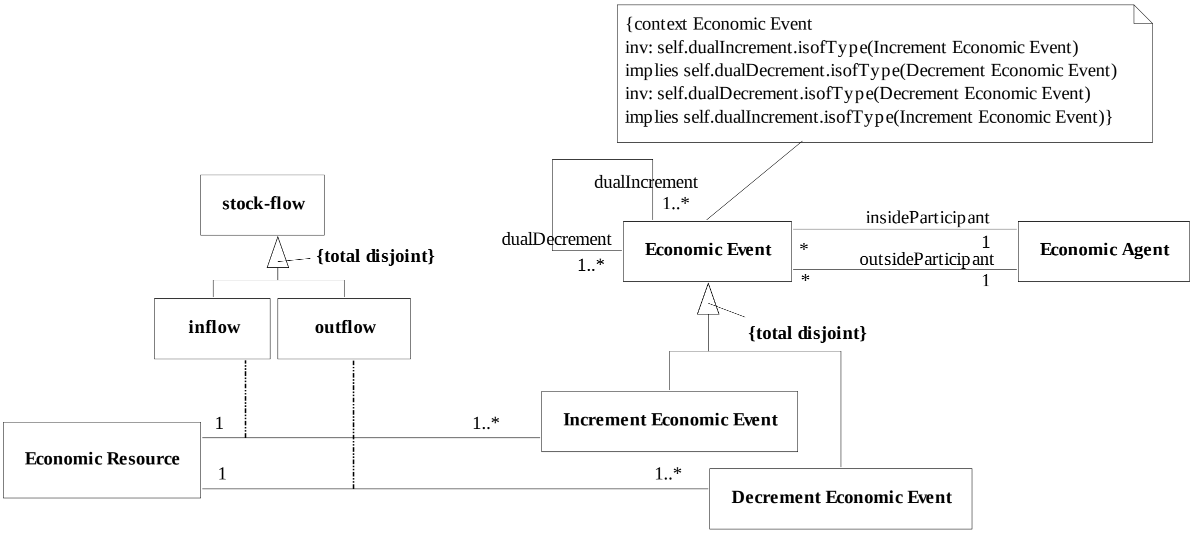

Figure 4: Reengineered conceptual model basic REA pattern

The tentative ODM proposal is used for the formalization of the basic REA pattern. Some of the transformations from UML to OWL are very straightforward, but even in this small part of the REA-ontology it is sometimes hard to determine the most appropriate mapping. According to the guidelines, UML associations can be mapped into OWL object properties, but during the formalization of the REA UML class diagram we came across some problems. The mapping rule is stipulated for associations that are directed and where the associations are labeled by properties. This is not the case in the REA UML class diagram where we have two sorts of associations: association classes and labeled bidirectional associations. We hope that future ODM developments will solve this issue. A full overview of the formalization of the basic REA pattern will not be presented in this paper, but can be consulted at http://users.ugent.be/~fgailly/phd.

NEXT STEPS

The final objective of this research project is the operationalization of existing business domain ontologies. The first thing that needs to be done is improving the quality of the existing ontologies. This can be partly achieved by using recent ontology engineering methods and tools and should eventually result in better formalized ontologies which can be used in practice.

At this stage we have developed an ontology reengineering methodology specific for business domain ontologies which we plan to extend in a number of ways. Primarily the proposed methodology needs to be further elaborated and described. More specifically the ontological analysis of the concepts needs to be further investigated for some existent high-level ontologies and the use of data modeling languages for the conceptualization of ontologies should be further explored. Afterwards the proposed methodology will be applied for the reengineering of the complete REA-ontology and for other existing business domain ontologies.

At a later stage the obtained and improved conceptualizations and formalizations are going to be compared and evaluated. During this analysis emphasis will be evaluating the feasibility of already proposed applications and identifying possible new applications of the domain ontologies. Eventually this should lead to the development of some small scale applications which must illustrate the usefulness of business domain ontologies for practical businesses applications.

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