DiTTO: Diagrams Transformation inTo OWL

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Abstract. In this paper we introduce DiTTO, an online service that allows one to convert an E/R diagram created through the yEd diagram editor into a proper OWL ontology according to three different conversion strategies.

1 Introduction

Ontology design is an activity that involves the use of many different languages, resources, and technologies. When dealing with formal or semi-formal languages used by different people such as domain experts, knowledge engineers or final users, a correct transformation strategy can be crucial to guarantee an effective design. For instance, it seems preferable to adopt intuitive languages when the ontology should be introduced to and/or discussed with an heterogeneous audience, which may not be expert of formal languages and knowledge representation. In these cases, graphical languages seem to support well both ontology understanding and the discussion between knowledge engineers and final users.

The recent project ran by the Italian National Research Council (CNR)[4] and SOGEI[5], the Information and Communication Technology company owned by the Italian Ministry of Economy and Finance, presents the aforementioned scenario. The aim of the CNR-SOGEI project is twofold. One goal is the re-engineering of the E/R (Entity-Relationship) models SOGEI use to describe fiscal entities (such as taxpayers, laws, deposits, etc.) into standard Semantic Web languages, such as OWL 2. Another goal is to propose tools that facilitate future interactions (changes, re-use in different application contexts, etc.) with these semantic models.

In this paper we present one of the aforementioned tools called *DiTTO*, which stands for *Diagrams Transformations inTo OWL*. As its name suggest, DiTTO is able to translate E/R diagrams expressed in crow's foot notation and created with *yEd*[6], an open source application to quickly and effectively generate high-quality diagrams, into OWL ontologies.

[4] CNR homepage: http://www.cnr.it.

[5] SOGEI homepage: http://www.sogei.it.

[6] yEd homepage: http://www.yworks.com/en/products_yed_about.html.

In Section 2 we present some relevant diagram models originally developed for particular purposes (e.g. software engineering, databases, AI), and progressively adapted to also model OWL ontologies. In Section 3 we introduce DiTTO, describing its implementation and showing how to use it for diagram transformation. We also discuss a set of transformation rules to convert E/R diagrams into OWL. Finally, in Section 4, we present our plans for future developments of the tool, in terms of both new transforming features and diagrams support.

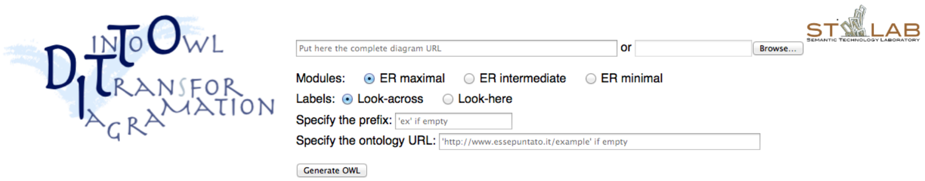
2 Related work

One of the most common graphical notations for logical languages is a *semantic network*, which can be defined as a "graphic notation for representing knowledge in patterns of interconnected nodes and arcs" [5]. Ontology classes and individuals are defined as nodes of a graph; at the same time, direct and labelled arcs can interlink nodes in order to represent predicates between them.

Gasevic *et al.* [3] and Brockmans *et al.* [2] propose another UML profile that enables one to define OWL entities using an extended set of UML-based graphic notations. The industry consortium responsible of UML, the Object Management Group, released an official UML profile [4] for defining OWL ontologies, called *Ontology Definition Metamodel* (*ODM*). TopBraid Composer[7] is a commercial tool featuring a diagramming component that adopts a proprietary UML profile to represent a substantial part (focusing on subclasses and associations, including restrictions and class constructions) of OWL semantics.

3 From E/R to OWL

DiTTO has been implemented as a Web service[8], as shown in Fig. 1.


DiTTO
Diagram Transformation into OWL
ST LAB
Semantic Technology Laboratory
Browse...
Generate OWL

Put here the complete diagram URL or

Modules: ● ER maximal ○ ER intermediate ○ ER minimal

Labels: ● Look-across ○ Look-here

Specify the prefix: 'ex' if empty

Specify the ontology URL: 'http://www.essepuntato.it/example' if empty

Fig. 1. The home page of DiTTO.

The core of DiTTO is a set of XSLT 2.0 documents included in a Java Web Application Archive (i.e. a WAR file) served as a Tomcat application. These XSLT documents apply several rewriting templates to the source file of the E/R diagram created by means of yEd, which is stored in GraphML format[9].

[7] http://www.topbraidcomposer.com

[8] http://www.essepuntato.it/ditto

[9] GraphML specification: http://graphml.graphdrawing.org/specification.html.

Using the service is quite simple. One needs to specify a URL referring to a yEd diagram, or, alternatively, to choose such a diagram from the file system. Then, after choosing among the available options and after specifying the prefix for naming ontological entities and the full URI of the ontology itself, the "Generate OWL" button can be used to produce an RDF/XML file containing the OWL ontology result of the conversion.

The transformation rules DiTTO implements are as follows. E/R *entities*, *attributes* and *relations* are converted into OWL *classes*, *data properties* and *object properties* respectively. All the subtype relations between E/R entities -▷ are converted into rdfs:subClassOf axioms. In addition, DiTTO adds appropriate restrictions to classes according to the edges that link E/R entities. In particular:

- a link between an E/R entity and an attribute results in restricting the related OWL class with a qualified cardinality;
- a symbol -○< (i.e. zero-to-many) of a relation results in restricting the domain class with a universal quantifier. This restriction is also added if any of the symbols in the following point is specified;
- the symbols |< (i.e. one-to-many), ++ (i.e. one-to-one) and |○- (i.e. zero-to-one) result in restricting the domain class with an existential quantifier, a qualified cardinality and a qualified maximum cardinality respectively.

In addition to these rules, DiTTO allows one to chochooose what E/R semantics to apply for the transformation. We have identified three alternative conversion strategies, which depends on the application of two assumptions:

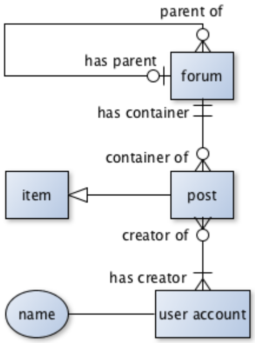
- *global semantics* (*GS*) is a characteristic of OWL ontologies (but not typically of E/R), and has the effect of unifying the formal interpretation of domain and range axioms, property characteristics, and all the restrictions that act at a global level. When GS does not hold, one is not allowed to assume such unification, even when the axioms regard two constants with the same name;
- *unique name assumption* (*UNA*), which is a characteristic in E/R semantics (but not of OWL), and whose consequence is that two objects named differently always refer to different entities in the world.

In particular, the *minimal strategy* interprets the semantics of E/R in its purest form (cf. [1]) by not using GS, while using UNA, the *intermediate strategy* does not use either GS or UNA, and finally the *maximal strategy*, which is the closest to OWL semantics, use GS, but UNA does not hold.

Different strategies proved useful in the aforementioned project because they address different requirements. The minimal strategy is of course conservative with the possible conceptualisations admitted by the original specification, while the maximal one allows us to simulate the consequences of E/R into OWL semantics, with its pros and cons, e.g. suggesting domains and ranges, or unification of properties, as well as spotting potential issues when applying the simulation.

In Fig. 2 we illustrate a small E/R diagram based on SIOC[10], and an excerpt of the OWL ontology returned by DiTTO by using the maximal strategy for the conversion.

[10] SIOC Ontology: http://sioc-project.org/ontology.



```
Class: UserAccount
    Annotations:
        rdfs:label "user account"
    SubClassOf:
        name exactly 1 rdfs:Literal,
        creatorOf only Post

Class: Forum
    Annotations: rdfs:label "forum"
    SubClassOf:
        containerOf only Post,
        parentOf only Forum,
        hasParent max 1 Forum

Class: Post
    Annotations: rdfs:label "post"
    SubClassOf: Item,
        hasContainer exactly 1 Forum,
        hasCreator only UserAccount,
        hasContainer only Forum,
        hasCreator some UserAccount
```

```
Class: Item
    Annotations: rdfs:label "item"

ObjectProperty: parentOf
    Annotations:
        rdfs:label "parent of"
    Domain: Forum
    Range: Forum
    InverseOf: hasParent

ObjectProperty: containerOf
    Annotations:
        rdfs:label "container of"
    Domain: Post
    Range: Forum
    InverseOf: hasContainer

DataProperty: name
    Annotations:
        rdfs:label "name"
    Domain: UserAccount   ...
```

Fig. 2. The exemplar E/R diagram developed through yEd and the conversion (shown in Manchester Syntax) produced by DiTTO using the maximal strategy.

4 Conclusions

In this paper we presented DiTTO, an online service that converts E/R diagrams created with the yEd editor into proper OWL ontologies according to three different conversion strategies: minimal, intermediate and maximal. Future extensions of the tool will address the management of additional E/R features (such as primary and foreign keys, and multiple and optional attributes), as well as different kinds of diagrams (e.g. UML and Graffoo[11]) as input.

References

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[11] Graffoo: http://www.essepuntato.it/graffoo.