Representation of n-ary relations on the Semantic Web by reducing the arity through aggregation

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Introduction

- This work is part of a joint project between the Departments of Computer Science and History of Art and Film at the University of Leicester.
- Ontology of Altarpieces is a good example of a domain in which n-ary relations arise quite naturally and frequently (for $n \geq 3$).
- Relations of arity greater than 2 have to be represented in OWL in an indirect way by coding them as classes (also called reification).

Problems with Reification

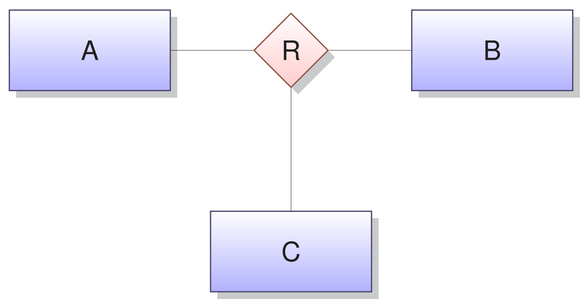
- As any codification, reification requires hard work: extra classes, roles, individuals and axioms.
- Ontologies can become very difficult to read and understand.
- Information (which is encoded) is not directly visible.
- Mismatch between the layer of abstraction at which domain modellers work and that of the representation where information is encoded, which is particularly harmful when we want to extend and reuse ontologies.

OUR SOLUTION

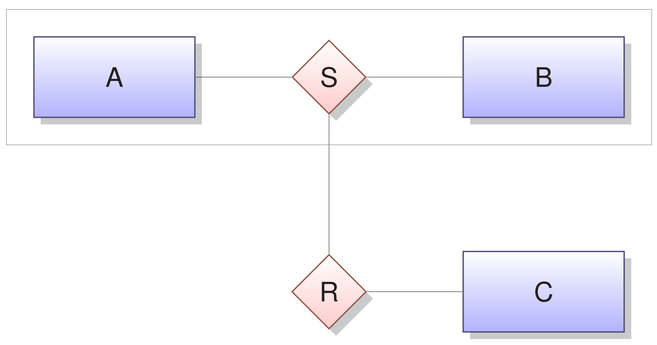
1. We propose a method explained in a paper published in the Journal of Semantic Web:
   Paula Severi, José Luiz Fiadeiro, David Ekserdjian: *Guiding the representation of n-ary relations in ontologies through aggregation, generalisation and participation.* J. Web Sem. 9(2): 83-98 (2011)
2. We developed a Protege 4.1 plugin that assists in the representation of relations of arity n.

REDUCING THE ARITY OF A RELATION

TERNARY RELATION $R \subseteq A \times B \times C$ represented by the Entity-Relation diagram:



CAN BE TRASFORMED INTO A BINARY RELATION between S and C as follows:



THE TRANSFORMED RELATION IS NOW A BINARY RELATION AND CAN BE DIRECTLY REPRESENTED IN OWL USING AN OBJECT OR A DATA TYPE PROPERTY.
The aggregation of a relationship is indicated by the box that surrounds the relationship diagram.

Participation Constraint

- We say that S participates in R if the following condition is satisfied:
  - For all $x \in A, y \in B, z \in C$,

$$(x, y, z) \in R \Rightarrow (x, y) \in S$$

- If S participates in R then R "can be seen" as a binary relation between the aggregation of S and C.

Method for representing n-ary relations

- Our method for guiding reifications consists in analysing which relations participate in other relations.
- If S participates in R then, instead of reifying the whole relation R, we should consider reifying the participating relation S and represent R as a property whose domain is the reification of S.

ADVANTAGES OF OUR METHOD

- Elimination of redundancy and fewer codifications per individual.

Relation R

attributeA	*attributeB*	*attributeC*	ReificationR
a_1	b_1	c_1	r_1
a_1	b_1	c_2	r_2
a_1	b_1	c_3	r_3
a_1	b_2	c_1	r_4
a_1	b_2	c_1	r_5
a_1	b_2	c_2	r_6
a_1	b_2	c_2	r_7

Relation S

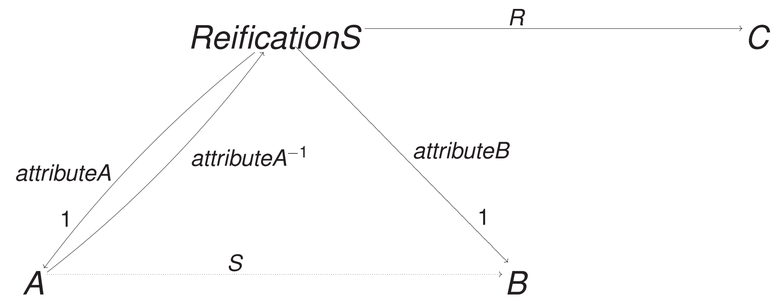
attributeA	*attributeB*	ReificationS
a_1	b_1	s_1
a_1	b_2	s_2

Relation R transformed into a relation of arity 2

reificationS	*attributeC*
s_1	c_1
s_1	c_2
s_1	c_3
s_2	c_1
s_2	c_1
s_2	c_2
s_2	c_2

The reification of R would contain 7 individuals (one for each row). While the reification of S has only 2 individuals.

- A way of expressing and forcing the participation constraint in OWL.



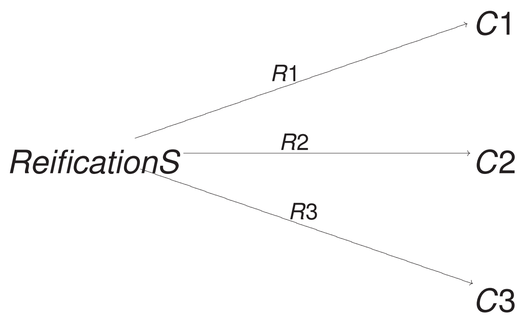
The reasoner will infer the assertions in S.

- It is always possible to apply (take $S = A \times B$) and there are several choices (at least three: $S = A \times B$, $S = B \times C$ and $S = A \times C$).
- It generalizes to arbitrary relations:

Proposition (Arity Reduction)

Let R be a relation of arity n and S of arity m.
If S participates in R then R can be reduced to a relation of arity n-m.

- Reusability. The reification of S can be reused to represent any relation in which S participates.



- Fewer number of reifications. For representing the relations R1, R2 and R3, we have to reify only one relation which is S.

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