What is a Formal Ontology?
Some Meta-Ontological Remarks

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1. The Elements of Formal Ontologies

In information science, an ontology is a graph-like structure consisting of entity types and formal ontological relations between these entity types. Typical formal ontological relations are the subsumption relation *is*_a and mereological relations like *part_of*. Thus an ontology consists of

– at least one entity type (but probably many more)

– at least one formal ontological relation type (but probably some more).

For short, I will speak of "formal relations", as opposed to "material relations"; the latter term I will use for the relational entity types of an ontology. Though some of the entity types can be relation types, the set of the entity types and the set of formal relations of an ontology must always be disjoint. In contemporary ontologies, formal relations are normally dyadic relations because of the formal restrictions imposed on them through the description logic used in these systems. In principle, also relations of higher adicity could be formal relations. (This would, of course, diminish the graph-likeness of such ontologies.) Formal relations may or may have instances among tupels of entity types, though from an engineering perspective there seems to be no point in introducing formal relations that will not be used in the end. But if we allow for non-instantiated formal relations, then the smallest possible ontology consists of exactly one entity and exactly one formal relation type with an empty extension.

Given this framework, we can introduce some formal vocabulary. Let O_1, O_2, …, O_n be formal ontologies. O_1 and O_2 are *identical* (i.e. they are *the same ontology*), if and only if they share the same entities and the same formal relations with exactly the same extensions. O_1 and O_2 are *co-elemental*, if and only if they have the same entities. O_1 and O_2 are *co-structured*, if and only if they use the same types of formal relations. O_1 is a *conservative extension* of O_2, if O_1 contains all entity types and all types of formal relations of O_2, but O_2 not all those of O_1; O_2 can then be called a *sub-ontology* of O_1. And trivially, if O_1 is either a conservative extension or a sub-ontology of O_2, then O_1 and O_2 are either not co-elemental or not co-structural or both. If O_1 is an *elemental extension* of O_2, if O_1 contains all contains all entity types of O_2, but O_2 not all entity types of O_1. O_1 is a *relational extension* of O_2, if O_1 contains all types of formal relations of O_2, but O_2 not all types of formal relations of O_1. Finally, O_1 is a *relational modification* of O_2, if O_1 contains the same entity types and the same types of formal relations of O_2, but at least one formal relation has different extensions in the two ontologies.

2. What is a formal ontological relation?

This formal framework gives rise to two material questions: First, which entity types should be chosen to be represented in an ontology? And second, which relations should be considered as formal ontological relations (and not themselves as entity types of the ontology)? These questions seem to open wide the doors for pragmatic deliberations, and they do so indeed: Many times it might be possible to turn a relation that is a formal relation in one ontology into a material relation in another ontology – a strategy that is often called "reification" (e.g. by Severi, Fiadeiro & Ekserdijan, 2010). (It should be noted that in the case of the reification it is underdetermined to which top-level category the new entity type belongs. Apart from the category *Relation*, categories like *Process*, *Action*, or *Disposition* would be possible candidates, in general any category that can directly or indirectly link to two or more distinct entity types via formal relations such as *participates_in* or *has_realization*.)

There are, however, principled reasons that restrict the options for reifications. These reasons are motivated by the suggestion to define a formal relation as a relation that can apply to its relata without an additional truthmaker (Ceusters, Elkin & Smith, 2006; Schwarz & Smith, 2008, p. 155). A truthmaker is an entity by virtue of whose existence a truth-bearer (a proposition) becomes true: "Socrates died" is true in virtue of the event of Socrates' death, "Peter is clever" is true in virtue of Peter's cleverness and "Tigers are carnivorous" is true in virtue of the universal tiger being characterized by the property universal carnivority. One truth-maker can often make several truth-bearers true (e.g., both "Socrates died" and "Xanthippe's husband died"); and one truth-bearer can sometimes be made true by several different truth-makers (e.g., "There is at least one number dividable by three" is made true by each such number).

Sometimes there are indeed good reasons not to treat some ontological vocabulary (like "existence" and "identity") as matching to distinct entities: It is absurd to suppose that an entity exists because it is combined with another entity, its existence (Tegtmeier, 1997). Rather, existence is part and parcel of any entity whatsoever. (It might be objected that fictional entities like Hamlet are cases of non-existing entities. However, the the fictional character Hamlet does in fact exist, though not as a real person.)

Similar reasoning applies to the concept of identity: syntactically a relation, it is not reasonable to suppose that an entity has to be combined with a token of the reflexive, symmetrical and transitive identity relation in order to be self-identical: Again, identity comes "for free" with the entities themselves. (In logic, we speak of reflexivity, symmetry and transitivity as "properties" of the identity relation. This, however, should not mislead us into thinking of these "properties" as dependent continuants inhering in the identity relation. They rather are general laws that are fulfiled by the identity relation.)

Similar conclusions can be reached by regress arguments, as can be demonstrated for, e.g., the relation of inherence. There is a token of the color white that inheres in my office wall. If inherence was a material relation, i.e. a type of relational entity, there would be three entities involved in this example: The color token, the wall, and a token relation of relation type inherence. But a relation token needs bearers, and this token's relata are the wall and the color token. Does it *inhere* in the wall or the color or both? If there is anything it inheres in, then we have already entered an infinite regress. This can be avoided if we do not align the inherence relation to distinct relational entities, but regard it as a formal ontological relation. Thus there are some concepts for which there are principled reasons not to represent them as entities but as formal ontological predicates. For other relations, however, there is such a choice, as I have shown by means of the pathway example.

4. Conclusion

In this paper I have suggested a formal characterization of formal ontologies and discussed some of their properties using this formal characterization. At first sight, this formal characterization leaves plenty of room for pragmatic and even arbitrary modeling decisions. There are, however, principled reasons for modeling some ontological vocabulary as representing formal relations only. It would be worthwhile to check the hitherto defined formal ontological relations whether these are necessarily formal or whether they could optionally be modeled as relational entities. If such a choice exist, it would be helpful to have design patterns that allow to switch more or less automatically between the two alternative ways of modeling or to map the alternative ontologies onto each other. To develop such patterns is, however, already beyond the scope of the present paper.

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