Introduction to the Logic of Definitions

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What follows is a summary of basic principles pertaining to the definitions used in constructing an ontology. A definition is a statement of necessary and sufficient conditions. What this means in the simplest case can be understood as follows. To say that ϕ-ing is a *necessary condition* for being an A is just another way of saying that every A ϕ's; to say that ϕ-ing is a *sufficient condition* for being an A is just another way of saying that everything that ϕ's is an A. The goal in writing a definition is to specify a set of conditions of this sort which are all necessary, and which are jointly sufficient.

The following is a set of necessary conditions for being a triangle which are also jointly sufficient, and which thus form a definition:

> *X* is a triangle =def. *X* is a closed figure; *X* has exactly three sides; each of *X*'s sides is straight; *X* lies in a plane.

Everything which satisfies all of the conditions on the right hand side is also a triangle. And everything which is a triangle satisfies all of these conditions.

Not every statement of necessary and jointly sufficient conditions is a definition. 1. The statement of necessary and sufficient conditions used to define the term A should itself use terms which are easier to understand than (and are logically simpler than) the term A itself. 2. The necessary and sufficient conditions must be satisfiable; that is, there must be actual examples of entities which satisfy the definition. Thus we cannot, for example, define a perpetual motion machine as a prime number that is divisible by 4, even though everything which is a perpetual motion machine is also a prime number that is divisible by 4.

A useful template for creating definitions along the lines described above is provided by what are called Aristotelian definitions, which is to say definitions of the form

> S =def. a G which Ds

where 'G' (for: genus) is the parent term of 'S' (for: species) in some ontology. Here 'D' stands for 'differentia', which is to say that 'D' tells us what it is about certain Gs in virtue of which they are Ss. An example Aristotelian definition (from the Foundational Model of Anatomy Ontology):

> cell =def. an anatomical structure which consists of cytoplasm surrounded by a plasma membrane

> plasma membrane =def. a cell part that surrounds the cytoplasm

The benefits of using Aristotelian definitions are 1. That each definition reflects the position in the ontology hierarchy to which the defined term belongs. Every definition, when unpacked, takes us back to the root node of the ontology to which it belongs. 2. Circularity is prevented automatically. 3. The definition author always knows where to start when formulating a definition. 4. It is easier to coordinate the work of multiple definition authors.

Aristotelian definitions work well for common nouns (and thus for the names of types or universals by which ontologies are principally populated). They do not work at all for those common nouns which are in the root position in an ontology, for here there is no parent term (no genus) to serve as starting point for definition. Root nodes in an ontology must therefore either be defined using as genus some more general term taken from a higher-level ontology such as BFO, or they must be declared as primitive. Primitive terms cannot be defined, but they can be elucidated (by means of illustrative examples, statements of recommended usage, and axioms).

Note that the Aristotelian rule will bring the benefits mentioned above only if the ontology in question satisfies the principle of single inheritance, which is to say, only if each term in the ontology has at most one parent. For only thus is the choice of 'G' for each given 'S' unique. Single inheritance itself however brings multiple benefits to ontology authoring: 1. It prevents a number of common errors which derive from the tendency once dominant among ontology authors of what has been called "is_a overloading". 2. It promotes integration of an ontology with its neighboring ontologies. 3. It prevents forking of ontologies. 4. The benefits of multiple inheritance, for example in terms of surveyability of an ontology (so that it is easier for human beings to find the terms they need) can be gained in any case by formulating the official (or 'asserted') version of an ontology as an asserted monohierarchy and allowing the development of inferred polyhierarchies for specific groups of users.

References

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