Categories for Highly Abstract Ontologies: Limitations & Recommendations

Robert Rovetto[1]

Abstract. What's in a name? This paper highlights some limitations of existing category terms for highly abstract ontologies (and similar types of abstraction models), and proposes recommendations. It thereby contributes to research into terminology, conceptual analysis, conceptual modeling, ontology, foundational ontology development, and knowledge representation and reasoning.

1. Introduction

Ontologies can be developed to varying degrees of abstraction, generality and specificity. Along with other types of knowledge organization systems such as taxonomies (here collectively called 'abstraction models') their constructs can be broad or particular. This paper[2] highlights limitations of existing category terms used to signify highly abstract ontologies (and other abstraction models), in particular, and proposes recommendations. This paper thereby contributes to research into terminology, conceptual modeling, foundational ontology development, and knowledge representation.

The abstraction models in question are ontologies, and similar systems which go by various names—to the extent they are distinct—such as conceptual (data) models, semantic (data) models, knowledge models, knowledge graphs, meta-models, classifications, taxonomies, and so on. Disciplines that sometimes pursue the creation of these models include information science, library science, computer science, data science, artificial intelligence, knowledge management, computational linguistics, philosophy, etc.

The most abstract of such modeling activities may use highly broad categories, concepts, or terms such as 'event', 'thing', 'system', 'association', 'relation'. They may also include bespoke constructs and jargon not found or typically used in common speech and natural language, such as 'perdurant'. Thus, an abstraction model can be developed to exclusively contain some of the broadest of words or phrases, and/or to assert/declare the most generic of terms.

[1] Robert Rovetto. Email: rrovetto@terpalum.umd.edu. ORCID: https://orcid.org/0000-0003-3835-7817.
[2] Previously expressed in a presentation [10] to (and as a member of) the International Association for Ontology and its Applications.

From the mental and conceptual standpoint, these terms may be intended to express the broadest of concepts and ideas. From the more ambitious philosophical standpoint (metaphysics/ontology), some developers may intend these terms/constructs to reflect or posit the most basic or generic of ontological categories. That is, they may be making metaphysical claims about the world, and are thereby adding philosophical or ideological assumptions [13] to what is assumed to be a data-centric use-case of the ontology development process.

By contrast, less abstract (more specific) models—sometimes called domain- or enterprise-specific models—whose constructs may be intended to focus on a given topic, set of concepts, the data of a given enterprise, a given business context, or a discipline—may also include some highly broad categories. The intent for including such abstract categories may also vary.

When intended to be widely applicable, i.e., applicable to various topics, concepts, domains of interest, disciplines, or universes of discourse, they are sometimes described as *domain-neutral* or *domain-independent*. These are sometimes called 'upper ontologies' [1].

It's worth noting that whether they actually are domain-neutral is a distinct and open question [13]. One reason it is questionable is that in each modeling activity, particularly these of a highly abstract character, philosophical assumptions and biases can be reflected in the model which may deviate from supposed neutrality or domain independence. Moreover, each discipline (or individual practitioner) may have a unique understanding and targeted purpose for the activities and their products.

2. Limitations of existing names for highly abstract ontologies

The most abstract, broad or general type of ontologies have gone by a few category name: foundational ontology [2], upper ontology [1][11], top ontology, top-level ontology [3][4], core ontology [12], generic/general ontology [6,7,8,9], etc. In computational disciplines, and according to some methodologies, these highly abstract ontologies may subsume, or otherwise link, more specific (less abstract) ontologies. This section notes some limitations of these category terms, followed by recommendations.

Two starting assumptions are:

(i) the type of ontology being named are those that are most or maximally abstract/generic. That is, this is the intended meaning of the would-be term signifying this sort of ontology.

(ii) the name or term, assuming it is human-readable, should match the intended meaning as closely as possible.

Assumption (ii) is partially motivated by ontology engineering practices (which themselves vary), and partially motivated by intuitions on comprehension (e.g. readability), user-friendliness, etc. For both, a common intuition is that it is reasonable to have semantically transparent (i.e. understandable) and consistent names or labels for the constructs (e.g. classes) in an ontology.

3. The foundation in 'foundation(al) ontology' is not so foundational

The category terms 'foundation ontology' and 'foundational ontology' imply directionality to the degree of abstractness/generality. This direction is arbitrary, but analogical. Here, the foundation, as it were, is the high degree of generality. The use of the word 'foundation(al)' is presumably reflective of colloquialisms or ideas such as "the foundation upon which something is built". With this analogy applied to ontologies, the idea is that of the foundation (the ontology) being the base upon which other things (e.g., other ontologies) are constructed. Then, from the analogy, building on that foundation one moves in directions of higher specificity, i.e., less generality.

The name appears to assume and/or connote a particular architecture for the ontological system, network, or framework: it assumes a preferred direction for generality/specificity; where the most generic model is the foundation, i.e., bottom of an architecture in which more specific ontologies are on top of it. Figure 1 expresses this idea: viewed as a set of linked ontologies, the foundational ontology is the lower-most rectangle.

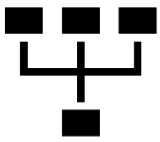

Figure 1: Visualization of a foundational ontology, signified by the bottom box.

This, then, raises the question:

- Is there—truly—a foundation to (in/using) foundational ontologies?

4. The top in 'top / top-level ontology' is not high

The category term 'top ontology' or 'top-level ontology' also implies a directionality to the degree of abstractness/generality. It assumes and/or connotes an architecture for the conceptual or ontological framework: again, it assumes a preferred direction for generality/specificity; where the most generic ontology is the top of the system, i.e., top of an architecture in which more specific ontologies are below of it. Figure 2 visualizes this idea: it can be viewed as a set of linked ontologies where the top ontology is the

top-most rectangle. The name using ‘level’ further assumes an architecture that involves so-called levels, where presumably each level is an ontology or ontological demarcation. However, not all developers will subscribe to a levels viewpoint.

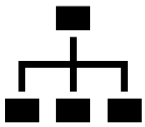

Figure 2: Visualization of a top-level ontology, signified by the top-most box.

5. The upper & lower limits of ‘upper ontologies’ and ‘lower-level ontologies’

The distinction upper vs. lower, or the spectrum from upper to lower, is often applied to signify degrees of abstraction, generality, or broadness. That which is upper, as in an upper ontology or upper-level ontology, is more abstract or broader. That which is lower, as in lower-level ontology, is more specific (e.g. as in domain ontologies). However, as with the terms ‘top(-level) ontology’ and ‘foundational ontology’, there is no inherent reason for this semantic ascription.

The category name ‘upper ontology’ is particularly limited with respect to the starting assumptions (i and ii). First, use of the word ‘upper’ implies gradation, not a maximal or a terminal point as intended for the most abstract ontologies. It therefore is not as closely-matching to the intended meaning as other category names. It also implies directionality to the degree of generality/specificity, where ‘upper’ or ‘higher’ signifies more abstract or general. This directionality is also arbitrary, if only arguably. One may appeal to the natural language senses of phrases like ‘high-level’ or ‘top-level’, arguing that they sometimes signify broadness. I do not believe this would be a sufficient rebuttal, however.

Ontology developers can create a system of ontologies varying by generality. Consider if we ignore considerations of maximal abstractness (to the degree reaching it is feasible). With exception of the bottom-most and top-most, that which is an upper ontology is relative to other ontologies in the system. That is, ignoring maximal abstractness, the phrase ‘upper ontology’ suggests a directionality and architecture. An ontology can be an upper ontology to a domain-specific ontology while not being the maximally (i.e., the most) abstract. In short, all foundational/top ontologies are upper ontologies, but not all upper ontologies are foundational/top ontologies.

Thus, if the intended meaning is the most generic/abstract ontology, then the name ‘upper(-level) ontology’ less precisely matches the intended meaning. The concept and associated term of *levels* also suggests an architecture: an architecture supposedly consisting of distinct levels, each varying by degrees of abstractness.

6. The core in ‘core ontology’ is not so central

The name ‘core ontology’ also appears to assume and/or connote a particular architecture of the ontological system. Here, the most generic/abstract ontology is at the center of an architecture in which more specific ontologies may link to it—by analogy as (a) extending from it, (b) layering around it, etc. There is no preferred direction of generality/specificity except that of outward from a central position.

Figure 3: Visualizations of the category of a core ontology (the center black disc).

7. Recommendations

In summary, category names such as ‘foundational ontology’, ‘upper ontology’, ‘core ontology’ or their variants that include the word ‘level’ have a degree of arbitrariness, where differing (or lack of) directionality analogically expresses degrees of generality/specificity. And in these names, the degree of generality is expressed through a potential but implied architecture. The degree of abstraction is indirectly expressed in the name.

By contrast, it is directly expressed in the category name 'generic ontology‘ or ‘general ontology’, by virtue of the relevant natural language meanings of ‘generic’ and ‘general’. Moreover, [9] describes foundational and top level ontologies as generic ontologies. Thus, given the starting points (i) and (ii), ‘generic/general ontology’ is more accurate as a name for highly abstract, if not the most abstract, ontologies and conceptual models.

Based on this analysis, some recommendations are as follows.

1. If using a category to signify the (supposedly) broadest or most abstract ontologies, use the ‘generic ontology’ or ‘general ontology’.
2. Do not use ‘upper ontology’ to exclusively signify the most generic/abstract/broad ontologies.

As with most, if not all, categorizations, there will be various ways to do so. Distinctions between so-called foundational, core, top-level, and generic ontologies can be made. The former three, for instance, may be defined as specializations of the fourth: depending on their content and how they were developed, they may be sub-types of

generic ontologies from a certain viewpoint, philosophical theory, worldview, etc., or sub-types for a given domain or enterprise.

Not all who use existing generic ontologies that make philosophical assumptions do so for those assumptions, and they may not agree with them. Rather, that may use such models assuming they may bring some practical utility. Moreover, some may use on some constructs (classes) in the model. In these ways, users may not be truly using them as a conceptual or ontological foundation or top-level. Others may find no use or utility in top-level ontologies at all. And lastly, some may develop their own to suit their goals, use-cases, applications, and requirements.

10. Closing

This paper highlighted limitations of some categories terms for the supposedly most abstract of ontologies (and other types of abstraction models, i.e., conceptual models, semantic models, etc.). It proposed recommendations based on the analysis. Future work can include a comparative examination of various definitions [14] of the mentioned terms and cognates; as well as analysis of the concepts and distinction of generality and specificity; the relationship between the mentioned terms and concepts with others that may categorize ontologies; how the previous two may impact the ideas expressed here; and so on. What more, multi-language and culture-specific aspects would benefit this inquiry, providing further perspectives and insights. Ending with some food for thought: the category names for highly abstract ontologies suggests at times a hierarchical structure that may be too brittle and starved for the supposed relational richness that ontology development often held to afford.

References

[1] ‘Upper ontology’, Wikipedia.com, URL: https://en.wikipedia.org/wiki/Upper_ontology

[2] "Foundational Ontologies & Their Library Motivations and Examples" Lecture 4 of the Laboratory of Applied Ontology, Doctorate course - Formal Ontology for Knowledge Representation and Natural Language Processing 2004-2005.

[3] Asunción Gómez-Pérez, Mariano Fernández-López, and Oscar Corcho (2004). Ontological Engineering. London, GB: Springer-Verlag.

[4] Nicola Guarino. "Formal ontology and information systems." In Proceedings of Formal Ontology in Information Systems (FOIS’98), Frontiers in Artificial intelligence and Applications, Amsterdam, Netherlands, pp.3-15, June 6-8, 1998.

[5] Roberto Poli. "Descriptive, Formal and Formalized Ontologies", URL: https://www.ontology.co/essays/descriptive-ontologies.pdf

[6] Riichiro Mizoguchi, J. Vanwelkenhuysen, and M. Ikeda. “Task Ontology for Reuse of Problem Solving Knowledge” In Towards Very Large Knowledge Bases: Knowledge Building & Knowledge Sharing. IOS Press. 1995. 46-59.

[7] Asunción Gómez-Pérez, Mariano Fernández-López, Oscar Corcho. "The Role of Ontologies in the Semantic Web" (PPT presentation on "Ontology Engineering"), URL: https://pdfs.semanticscholar.org/e697/68f52f6525b336da3c9fb8d3e8007693e840.pdf

[8] Debajyoti Mukhopadhyay, and Sajeeda Shikalgar. "A Model Approach to Build Basic Ontology" (2013) URL: https://www.researchgate.net/publication/258849608_A_Model_Approach_to_Build_Basic_Ontology

[9] Catherine Roussey, Francois Pinet, Myoung Ah Kang, and Oscar Corcho “Chapter 2: An Introduction to Ontologies and Ontology Engineering” In G. Falquet et al., Ontologies in Urban Development Projects, Advanced Information and Knowledge Processing 1, DOI 10.1007/978-0-85729-724-2_2 URL: https://oa.upm.es/10381/1/An_Introduction.pdf

[10] Robert J. Rovetto. “A generic name for the most generic ontologies”. PowerPoint presentation at Semantic Web and Applied Ontology Special Interest Group conference call 14 January 2022.

[11] Adam Pease, and Peter Yim. “Explicit Semantics for Business Ontology, an interim work report from the Ontolog Forum”, URL: http://ontolog.cim3.net

[12] Nicola Guarino, Daniel Oberle, and Steffen Staab. "What Is an Ontology?" (2009). In Handbook on Ontologies, International Handbooks on Information Systems

[13] Robert J. Rovetto, “The Ethics of Conceptual, Semantic, Ontological and Knowledge Modeling”, AI and Society, 39, 1547–1568 (2024). https://doi.org/10.1007/s00146-022-01563-3

[14] Robert Rovetto, ”Catalog of Definitions of Ontology” https://purl.org//rrovetto/CatalogOntologyDefinitions

Acknowledgements

Thanks to anonymous reviewers of conferences and journals since at least 2021.