On the Definition of ‘Ontology’

Fabian NEUHAUS [a]
[a] *Otto-von-Guericke University Magdeburg, Germany*

Abstract. In ‘What Is an Ontology?’ Guarino, Oberle and Staab offer a widely cited analysis of the term ‘ontology’ [5]. According to them an ontology is, roughly speaking, a logical theory, which models approximate, as best as possible, the intended models according to a given ontological commitment (which is based on a conceptualization).

In this paper we offer six arguments against their proposed analysis of ‘ontology’. It has technical flaws that lead to absurd consequences. Further, the analysis is based on implausible assumptions about the nature of conceptualizations.

Keywords. ontology, definition

1. Introduction

In 2009 Nicola Guarino, Daniel Oberle and Steffen Staab published the paper ‘What Is an Ontology?’ where the authors analyze the term ‘ontology’ [5]. It builds on previous work in [4,3]. In the tradition of Gruber [2], Borst[1], and Studer [8] they start their analysis with the following definition: ‘an ontology is a formal, explicit specification of a shared conceptualization’. What distinguishes [5] from the related work is that it contains a formal analysis of terms like *conceptualization*, *ontological commitment*, *formal and explicit specification*, *intended models* and, of course, *ontology*.

The author of this paper has long considered [5] to offer the best available answer to the question: “What is an ontology?” Given the number of its citations (according to Google Scholar more than 440 as of July 2017) many in our community seem to share this high regard for [5].

Nevertheless, the purpose of this paper is simple: to convince the reader that the answer to “What is an ontology?” that [5] offers just does not work. The proposed definitions have unintended consequences and its contains philosophically implausible claims about the ontological nature of conceptualizations.

Since [5] offers a conceptualist’s perspective on ontology, a realist would reject the proposed definitions outright, starting with its terminology [7]. However, in this paper we intend to argue that the analysis of “ontology” in [5] is not convincing even from a conceptualist’s point of view, because of its intrinsic difficulties. Therefore, for the purpose of this paper (and in spite of the author’s philosophical sympathies) we will abstain from any critique that could be leveled at [5] from a realist’s perspective.

For this purpose we will first motivate why the question “What is an ontology?” needs answering (section 2) and then summarize the analysis of “ontology” in [5] (section 3). In section 4 we will offer three technical arguments against the proposed definitions. This is followed in section 5 by three arguments against philosophical assumptions in [5] about the nature of conceptualizations.

2. The need for a definition of 'ontology'

Since most of this paper is going to be critical of [5], let's start with an appreciation of its contributions. As mentioned in the introduction the starting point of [5] is Definition 1 based on [8]:

Definition 1 ('Ontology' – an initial definition) *"An ontology is a formal, explicit specification of a shared conceptualisation." [8], p. 25.*

Definition 1 is a variant from other definitions in the literature [1,2]. Given these succinct definitions, one may ask why would one need a seventeen page long answer to the question: "What is ontology?"

The answer is that all of these definitions are not helpful. Any definition is only useful if the meaning of its definiendum is less clear than the meaning of its definiens. It is quite easy to introduce the term "ontology" to a novice to the field by illustrating it with examples and use cases. Such an introduction leads to an operational understanding of the term 'ontology', which allows the novice to recognize typical examples of ontologies and to recognize typical situations where ontologies may be used to solve a problem. Thus, any definition of "ontology" is only helpful if our understanding of the definiens exceeds this kind of operational level of understanding.

However, the definiens of Definition 1 is at least as unclear as the term "ontology", in particular the term "conceptualization" is not well understood. Of course, the literature contains attempts to clarify the terms in the definiens. For example, according to [8] "[a] conceptualisation refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon". But this explanation just pushes the problem from "conceptualization" to "abstract model" and "relevant concept". Both expressions are more murky than 'ontology'. What is a model and what distinguishes an abstract model from a (non-abstract) model? Is, for example, Picasso's "Guernica" a specification of an abstract model of war? What makes a concept relevant? The answers to these questions are unclear. And, thus, Definition 1 does little to illuminate the meaning of "ontology".

The major contribution of [5] is to push the analysis of "ontology" to a new level by providing a formal definition of ontology. This kind of definition allows us a clearer understanding of the subject of Applied Ontology and it provides a foundation for further research, e.g., ontology evaluation, ontology alignment etc. In the following section we will present the analysis of "ontology" in [5] in detail.

3. 'Ontology' according Guarino et al.

In [5] 'ontology' is defined as follows (see Definition 2). In the rest of this section we will unpack this definition. For the sake of brevity we present the concepts in a different way than Guarino et al. present them in [5], but the content of the definitions is unaltered.

Definition 2 (Ontology as defined in [5], p.11) *"Let **C** be a conceptualization, and **L** a logical language with the vocabulary **V** and an ontological commitment **K**. An ontology O_K for **C** with vocabulary **V** and ontological commitment **K** is a logical theory consisting of a set of formulas, designed so that the set of its models approximates as well as possible the set of intended models of **L** according to **K**."*

The authors assume that $\mathbf{L}$ is a given (variant of) first-order logic; the signature of $\mathbf{L}$ consists of constants and predicate symbols. (There are no function symbols.) The vocabulary $\mathbf{V}$ that is referred to in Definition 2 is defined as the signature of $\mathbf{L}$, hence the vocabulary is not an independent parameter. Thus, in the rest of the paper we just use $\mathbf{V_L}$ to denote the vocabulary of $\mathbf{L}$ and $\mathbf{V^c_L}$ and $\mathbf{V^p_L}$ to refer to the constants of $\mathbf{L}$ and predicate symbols of $\mathbf{L}$, respectively. Further, we use $\mathrm{WFF}_{\mathbf{L}}$ to denote the set of all well-formed formulas of $\mathbf{L}$.

A model of $\mathbf{L}$ is defined as a tuple $\langle D, \mathbf{R}, I\rangle$, where the universe of discourse D is a set[1], $\mathbf{R}$ is a set of relations on D, and the interpretation function I maps $\mathbf{V^c_L}$ to elements of D and $\mathbf{V^p_L}$ to elements of $\mathbf{R}$. Let $\mathbf{Mod_L}$ be the set of all models of $\mathbf{L}$. Further, [5] assumes that there is a satisfaction relationship $\models$ between models and sets of well-formed formulas. The satisfaction relationship is not defined in [5] but for the sake of this paper we assume that it is defined as usual: for any model M and any set $\Gamma \subseteq \mathrm{WFF}_{\mathbf{L}}$, $M \models \Gamma$ iff $M \models \phi$, for any $\phi \in \Gamma$; and that $M \models \phi$ is defined compositionally based on M, for any sentence $\phi \in \mathrm{WFF}_{\mathbf{L}}$.

Note that there is no reference to the conceptualization $\mathbf{C}$ in the body of Definition 2. Let's further represent the 'approximates as well as possible'-relationship with the symbol $\approx$ and 'intended models of $\mathbf{L}$ according to $\mathbf{K}$' as $\mathit{Intended}(L,K)$. This allows us to rewrite Definition 2 as follows:

Definition 3 (Ontology definition, partially rewritten)
Let $\mathbf{L}$ *be a logical language and* $\mathbf{K}$ *be an ontological commitment for* $\mathbf{L}$. $\mathbf{O}$ *is an ontology for* $\mathbf{K}$ *in* $\mathbf{L}$ *iff*

- $\mathbf{O} \subseteq \mathit{WFF}_{\mathbf{L}}$*; and*
- $\{M \in \mathbf{Mod_L} \mid M \models \boldsymbol{O}\} \approx \mathit{Intended}(\mathbf{L},\mathbf{K})$.

Definition 3 contains three elements that require clarification: (i) What is an ontological commitment $\mathbf{K}$? (ii) What is the meaning of the intended-models-function *Intended*? (iii) What does the 'approximates as well as possible'-relation $\approx$ mean? Unfortunately, we cannot answer question (iii), since the nature of $\approx$ remains unclear in [5]. We will come back to it in section 4.2. In the remainder of this section we will answer questions (i) and (ii).

The intuition behind the formalization of 'ontological commitment' in [5] is that an ontological commitment is the result of linking the terms of a language to concepts of a conceptualization of a given domain. Conceptualizations are in the mind of people and enable them to classify entities as instances of concepts in different situations. This is intuition is analyzed in [5] as follows: an ontological commitment $\mathbf{K}$ is an *intensional first-order structure*, which consists of a conceptualization $\mathbf{C}$ and an intensional interpretation function $\mathcal{I}$. A conceptualization is an *intensional relational structure* that consists of (i) a universe of discourse; (ii) a set of possible worlds that represent possible states of the domain that the ontology is about; and (iii) intensional relations on this domain, that is a set of functions that assign to each world the extension of the relation in this world. The intensional interpretation function $\mathcal{I}$ maps constants to elements of the universe of discourse and predicate symbols to intensional relations in $\mathcal{R}$. We summarize this in Definition 4, which corresponds to Definitions 2.4 and 3.2 in [5].

[1] In contrast to usual classical first-order models the domain of discourse D is not required to be non-empty. This is likely just an oversight in [5].

Definition 4 (Conceptualization and ontological commitment) *Let L be a logical language.*

$\mathbf{C} = \langle D, W, \mathcal{R} \rangle$ *is a conceptualization iff*

1. *the universe of discourse D and the set of possible worlds W are sets;*
2. $\mathcal{R}$ *is a set of intensional relations; i.e. any* $r \in \mathcal{R}$ *is a function* $r : W \to \wp(D^n)$*, for some arity* $n \in \mathbb{N}$.

$\mathbf{K} = \langle D, W, \mathcal{R}, \mathcal{I} \rangle$ *is an ontological commitment for* $\mathbf{L}$ *iff*

1. $\langle D, W, \mathcal{R} \rangle$ *is a conceptualization;*
2. $\mathcal{I}$ *is a total function* $\mathcal{I} : \mathbf{V_L} \to D \cup \mathcal{R}$ *such that* $I(v) \in D$ *if* $v \in \mathbf{V_L^c}$ *and* $I(v) \in \mathcal{R}$ *if* $v \in \mathbf{V_L^p}$.

Since an ontological commitment **K** is an intensional first-order structure for a language **L**, it provides for any possible situation (a possible world) the extensions of the relations in this situation. Guarino et al. assume a rigid interpretation of the constants and a constant domain. (We will revisit this assumption in section 4.3.) Under these assumptions **K** determines what models of **L** are possible. These are the intended models of the **L** according to **K** (see Definition 5), which corresponds to Definition 3.3 in [5].

Definition 5 (Intended models) *Let* $\boldsymbol{L}$ *be a logical language and* $\mathbf{K} = \langle D, W, \mathcal{R}, \mathcal{I} \rangle$ *be an ontological commitment for* $\boldsymbol{L}$.

A model $M = \langle D, \mathbf{R}, I \rangle$ *of* $\boldsymbol{L}$ *is an intended model of* $\boldsymbol{L}$ *according to* $\boldsymbol{K}$ *iff*

- *for any* $c \in \mathbf{V_L^c}$, $I(c) = \mathcal{I}(c)$;
- *there exists some* $w \in W$ *such that, for all* $p \in \mathbf{V_L^p}$, $I(p) = (\mathcal{I}(p))(w)$.

$\mathit{Intended}(\mathbf{L}, \mathbf{K}) = \{M \in \mathbf{Mod_L} \mid M \textit{ is an intended model of } \boldsymbol{L} \textit{ according to } \boldsymbol{K}\}$

Definition 5 allows us to finish our rewrite of Definition 2 by substituting $\mathrm{Intended}(\mathbf{L}, \mathbf{K})$ in Definition 3. This results in Definition 6.

Definition 6 (Ontology definition, fully rewritten)
Let $\boldsymbol{L}$ *be a logical language and* $\mathbf{K} = \langle D, W, \mathcal{R}, \mathcal{I} \rangle$ *be an ontological commitment for* $\boldsymbol{L}$. $\mathbf{O}$ *is an ontology for* $\mathbf{K}$ *in* $\mathbf{L}$ *iff*

- $\mathbf{O} \subseteq \mathit{WFF}_\mathbf{L}$; *and*
- $\{M \in \mathbf{Mod_L} \mid M \models \boldsymbol{O}\} \approx \{\langle D, \mathbf{R}, I \rangle \in \mathbf{Mod_L} \mid$
$\forall c \in \mathbf{V_L^c} : I(c) = \mathcal{I}(c) \textit{ and } \exists w \in W\ \forall p \in \mathbf{V_L^p} : I(p) = (\mathcal{I}(p))(w)\}$

If we compare Definition 6 with Definition 1, it turns out that the 'shared' aspect was lost, but the other components of Definition 1 are represented. The ontology is 'formal' and 'explicit', since it is a set of sentences of a first-order language **L**. The conceptualization $\langle D, W, \mathcal{R} \rangle$ is part of the ontological commitment **K**. And the specification relation is represented as the approximation relation $\approx$ that holds between the models of **O** and the intended models of **K**.

4. Technical Challenges

In this section we discuss three different technical objections against Definition 6.

4.1. FOL centricity

According to Definition 6 an ontology is a set of axioms in a first-order logic $\mathbf{L}$ whose models approximate the set of models that are possible according to a given intensional first-order logic structure (a.k.a. ontological commitment). This intensional first-order logic structure consist of a conceptualization and an intensional interpretation function. Conceptualizations are represented as intensional relational structures (see Definition 4).

One obvious challenge against Definition 6 is its first-oder logic centricity. Most ontologies are not written in first-order logic, but in the Web Ontology Language OWL. However, we assumed explicitly in section 3 that $\mathbf{L}$ is a first-order logic language.

What happens if we ignore that $\mathbf{L}$ is supposed to be first-oder logic? For the sake of the argument, let's assume $\mathbf{L}$ in section 3 is OWL 2 DL with Direct Semantics[2] that uses a particular OWL vocabulary $\mathbf{V}$, and let $\mathbf{K} = \langle D, W, \mathcal{R}, \mathcal{I} \rangle$ be any ontological commitment, where $\mathcal{I}$ is a suitable mapping that maps $\mathbf{V}$ to the conceptualization $\langle D, W, \mathcal{R} \rangle$.

An OWL 2 DL model is a 10-tuple that involves two different universes of discourse and seven different interpretation functions and a distinguished set of named individuals [6]. The details of OWL 2 models do not really matter, the important fact is that their structure differs significantly from first-order models of the form $\langle D, \mathbf{R}, I \rangle$ as defined in Section 3. These structural differences are significant, because according to Definition 5 intended models are first-order models that match a given intensional first-order relational structure (a.k.a. ontological commitment). Hence, it follows trivially from Definition 5 that intended models are first-order models of the form $\langle D, \mathbf{R}, I \rangle$. Thus, given Definition 5 there are no intended models of OWL 2 according to the ontological commitment $\mathbf{K}$. In other words, for any given ontological commitment $\mathbf{K}$, $\mathit{Intended}(\text{OWL 2 DL}, \mathbf{K}) = \emptyset$. Therefore, the best ontology of $\mathbf{K}$ in OWL 2 DL is an inconsistent logical theory $\mathbf{O}$, because in that case $\{M \in \mathbf{Mod}_{\text{OWL 2 DL}} \mid M \models \mathbf{O}\} = \mathit{Intended}(\text{OWL 2 DL}, \mathbf{K})$. This absurd result shows that the definition of 'ontology' in [5] excludes OWL ontologies.

One obvious strategy to fix the problem would be to introduce an OWL-analog for all definitions in section 3, in particular by introducing an OWL-conceptualization, which consists of mappings of possible worlds to OWL models, and an OWL-ontological commitment. This would be a rather straightforward task, but it would be philosophically incongruent with the whole approach of [5].

According to [5], conceptualizations are in the mind of people, and concepts that are part of a conceptualization are providing the meaning for the signs of languages. One advantage of this theory of meaning is that it explains the possibility of translations between languages: different languages use different signs to invoke the same concept; e.g., the fact that "feles" in Latin may be correctly translated as "Katze" in German is explained by the fact that both invoke the concept *Cat*, and, thus, both signs share the same meaning. Hence, it is essential for the approach of [5] that concepts and conceptualizations, whatever their nature may be, are language independent. The introduction of FOL-conceptualization, OWL-conceptualization, Frame-Logic-conceptualizaton etc. would contradict this language independence.

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[2] A similar argument can be made for the RDF-based semantics for OWL 2.

4.2. The $\approx$-relationship

Definition 6 contains a glaring 'then a miracle occurs'-element: the "approximates as well as possible"-relationship $\approx$. While the rest of the definition of 'ontology' is explained in detail, [5] leaves it to the imagination of the reader to interpret this relationship.

In spite of the vague nature of this relationship, one can still easily see that its current formulation is highly problematic. Assume you have a logical theory $\mathbf{O}_1$ that axiomatizes a conceptualization $\mathbf{K}$ in some $\mathbf{L}$[3]. Further assume that during debugging it turns out that $\mathbf{O}_1$ lacks an axiom ϕ, thus ϕ is added to the theory, yielding theory $\mathbf{O}_2 = \mathbf{O}_1 \cup \{\phi\}$. The interesting question is now: Is $\mathbf{O}_1$ an ontology for $\mathbf{K}$? Since $\mathbf{O}_2$ is a better axiomatization of $\mathbf{K}$ than $\mathbf{O}_1$, it follows that the models of $\mathbf{O}_2$ approximate the intended models of $\mathbf{K}$ better than the models of $\mathbf{O}_1$. Hence, the models of $\mathbf{O}_1$ do not approximate the intended models of $\mathbf{K}$ *as well as possible*. Thus, according to Definition 6 (and given the reading of $\approx$ as "approximates as well as possible"), $\mathbf{O}_1$ is not an ontology for $\mathbf{K}$.

If we would take this seriously, it would mean that very few of the artifacts we call 'ontologies' are ontologies. Because any existing ontology that models a complex domain (e.g., regardless of whether it is an upper level ontology like DOLCE or a domain ontology like the Gene Ontology) has areas where it would be possible to fill out the details by adding additional axioms and, thus, achieve a closer approximation of the intended models. Obviously, the conclusion is not that these logical theories are not ontologies, but that the "as well as possible"-requirement is too strong.[4]

4.3. Fixed universe of discourse

Assume $\mathbf{O}$ is an ontology in some first-order logic with equality $\mathbf{L}$ about subway systems, which contains the term "passenger". Given Definition 6, since $\mathbf{O}$ is an ontology, it is an ontology of an ontological commitment $\mathbf{K} = \langle D, W, \mathcal{R}, \mathcal{I} \rangle$ and the models of $\mathbf{O}$ approximate the intended models according to $\mathbf{K}$. The ontological commitment $\mathbf{K}$ determines the meaning of "passenger" by providing its extensions in all possible worlds; more technically, the interpretation of "passenger" is a function from possible worlds in W to subsets of the universe of discourse D. Thus, the set D includes all possible passengers. This includes about 7.5 billion people that are currently living on Earth, all past people, all people who will live in the future, and all people who might have lived and used a subway. Further, since we talk about all possible situations we also may want to include aliens, robots and other entities that could, possibly, be passengers of a subway.

Since the same consideration is true of any other class in $\mathbf{O}$ (e.g., train, station, platform), it is save to assume that the cardinality of D is going to be large. However, regardless of size, according to Definition 4 there exists a specific set D that is the domain

[3] In the following we often omit references to $\mathbf{L}$ for the sake of readability.

[4] As mentioned in the introduction, [5] is a refinement of previous work [4,3]. Note that in both of these papers the "as well as possible" requirement is missing. E.g., in [3] ontology is defined as follows:

> "An ontology is a logical theory accounting for the intended meaning of a formal vocabulary, i.e. its ontological commitment to a particular conceptualization of the world. The intended models of a logical language using such a vocabulary are constrained by its ontological commitment. An ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models."

of the ontological commitment and, thus, of the underlying conceptualization of the train system, which includes all the possible passengers, trains, stations, platforms etc., but nothing else. Let's assume the cardinality of D happens to be 314159265359 and let ϕ be the formalization of "there are exactly 314159265359 entities" in $\mathbf{L}$.

Why is the universe of discourse D of the ontological commitment of our subway ontology so interesting? Because according to Definition 5 the same set D is also the universe of discourse of *every* intended model of $\mathbf{K}$ in $\mathbf{L}$. Therefore, $\mathit{Intended}(\mathbf{L},\mathbf{K}) \models \phi$.

This consequence is absurd. If somebody builds an ontology of subway systems, the ontologist intends to represent the relationships between the classes and relations in this domain. The ontologist who is axiomatizing $\mathbf{O}$ has no specific intent concerning the exact number of entities in the universe of discourse and, probably, does not really care about individual entities in the universe of discourse unless they are particularly relevant to his task. Thus, Definition 5 should not require all intended models of $\mathbf{O}$ to share exactly one universe of discourse D. Rather, to accurately reflect the the intentions of the ontologist, the intended models of $\mathbf{O}$ should vary with respect to their universes of discourse.

The fact that $\mathit{Intended}(\mathbf{L},\mathbf{K}) \models \phi$ has additional unintended consequences. Since by Definition 3 the ontology $\mathbf{O}$ is supposed to be a logical theory whose models approximate $\mathit{Intended}(\mathbf{L},\mathbf{K})$ *as well as possible*, it follows that the ontologist who develops our train system ontology $\mathbf{O}$ is supposed to include axioms in $\mathbf{O}$ to reflect that $\mathit{Intended}(\mathbf{L},\mathbf{K}) \models \phi$. Now, given the fact that our D includes all possible entities in all possible worlds (including entities that actually never existed) it is probably hard to for our ontologist to pinpoint whether there are exactly 314159265359 entities in D or only 314159265358. However, it is save to say that every currently living person is a passenger in some possible world. Thus, if we take Definitions 3 and 5 literally, our ontologist is supposed to include the formalization of "There are at least 7.5 billion entities" as axiom in $\mathbf{O}$.

Of course, no ontologist would include such an axiom in a subway system ontology. This example just illustrates that Definition 5 leads to absurd consequences, because it implies that all intended models use as their domain the universe of discourse of the ontological commitment D.

5. The Nature and Role of Conceptualizations

In the previous section we argued against the definition of ontology in [5] on technical grounds. In this section we consider philosophical arguments that do not address technical details of the definition, but rather its philosophical assumptions about the nature of conceptualizations and their relationships to ontologies. [5] offers us two important pieces of information: conceptualizations are (i) intensional relational structures (as defined in Definition 5) and (ii)"[c]onceptualisations are typically in the mind of people", and they are based on the perception of invariants across patterns of phenomena of reality.

5.1. Conceptualizations Are Not Intensional Relational Structures

In section 4.1 we argued that the identification of a conceptualization with an intensional relational structure $\langle D, W, \mathcal{R} \rangle$ is problematic: the definition is tuned to first-order logic, but since it is possible to write ontologies in many logics, a conceptualization cannot be something that is specific to a particular logic.

However, the problem runs deeper. For a given intensional relational structure $\langle D, W, \mathcal{R} \rangle$, the set W is the set of all possible situations, D contains all entities that occur in these situations, and $\mathcal{R}$ determines, for any relevant relation, the extension of the relation in any given situation. If conceptualizations were intensional relational structures, all of this information would be in the mind of an agent A who develops an ontology. Thus, if [5] was correct, in the example from section 4.3 the mind of the ontologist who develops an ontology for subway systems would contain (1) all possible situations that a subway could be in, and (2) all the possible passengers, trains, stations, etc., and (3) all the relations that could hold between these entities in all situations. It is doubtful that anybodies brain could store that amount of information; let alone learn it based on the available perceptions of reality.[5]

Possible world semantics and intensional relational structures are useful tools in logic and linguistics for studying semantics. The utilization of these tools in the definitions in Section 3 provide us with a formal model for the capability of people to classify objects and relationships in new circumstances based on recurring patterns of reality that they observed in the past. (One could call this capability “conceptualization”.) However, this does not mean that we can *identify* the capability to classify objects and relationships with intensional relational structures. There are no possible worlds in people’s minds.

5.2. Shallow Conceptualizations and Incomplete Knowledge

There is a second reason why conceptualizations cannot be intensional relational structures. If our conceptualizations were intensional relational structures, then each of our concepts would be a function from situations (possible worlds) to the extension of this concept in these situations. Thus, in any given situation (world), we would be cognizant of the extensions of the concepts in that situation. However, that is not necessarily the case. For example, the author of this paper knows that there are aspens and birches, but if confronted with a bunch of trees in a forest, he would not be able to tell them apart. The reason is that the conceptualization of trees in the mind of the author is too shallow: he knows that *Aspen tree* and *Birch tree* are two disjoint classes and that both are deciduous trees with white bark. This conceptualization is sufficient to distinguish these trees from pines and palm trees, but too shallow to determine the extension of these classes in a given situation. This observation contradicts any analysis of a concept as a function from possible situations (worlds) to its extension in the situation.

One possible counterargument against the argument above is the following: *The concepts* Aspen tree *and* Birch tree *are functions from possible worlds to sets of entities. You do not know the extensions of* Aspen tree *and* Birch tree *because you are uncertain about the situation (possible world) that you are in.* Thus, according to this argument the uncertainty of how to classify a tree is not caused by shallow conceptualizations of *Aspen tree* and *Birch tree*, but by the inability to distinguish the various possible worlds one may be in. However, this argument fails to explain our ability to change our conceptualization without a change of extensions. E.g., if the author would study aspens and birches and learn about the shapes of their leaves, he would presumably gain the ability

[5] A variant of the same argument could be made by considering ontologies that are only satisfiable by models with an infinite universe of discourse (e.g., the Peano axioms). In these cases the universe of discourse of any corresponding intensional relational structure would need to be infinite, and, thus, not fit into the memory of a finite being.

to determine the extensions of *Aspen tree* and *Birch tree* in any given situation. Thus, the conceptualization of these classes in the mind of the author would have changed. However, the extension of these classes in any given situation would have not.

Therefore, intensional relational structures are not only different from conceptualizations, they even provide flawed models for the capability of people to classify objects and relationships in different situations.

5.3. Conceptual Division of Labor and 'Shared' Conceptualization

In the last argument we argued that the conceptualization of a domain (e.g., trees) may vary in depth and that one may deepen one's conceptualization by acquiring additional knowledge. For example, one may know that birches and aspens are different trees without knowing how to distinguish them. Note that such a shallow conceptualization is derivative, because it relies on the fact that somebody else possesses a conceptualization of the domain that is deep enough to identify birches and aspens. This conceptual division of labor is not an exception, but the norm. Since the acquisition of a conceptualization of a given domain requires effort, we tend to develop rich conceptualizations only on subjects that are important to us; for other subjects we rely on the expertise of others.

A conceptual division of labor raises difficulties for the assumption in [5] that an ontology corresponds to *one* conceptualization. In [5] it is assumed that an ontologist – based on her perceptions of phenomena – is able to develop a conceptualization in her mind, and that this conceptualization is axiomatized in the ontology. However, if we consider large ontologies, e.g., the Gene Ontology, this is not a realistic model. There is no *single* person who, based on the observation of phenomena, has a conceptualization that is reflected by the axioms of the *whole* Gene Ontology.

Large ontologies are the result of a collaborative effort of many people. Each of these collaborators has, typically, a rich conceptualization of the subdomain that is covered by the part of the ontology that they are responsible for, but a limited conceptualization (or even no conceptualization) of other areas that are covered by the ontology. Therefore, there is no single, shared conceptualization that is represented by the ontology. In contrast, the ontology is a reflection of many conceptualizations, which may differ significantly from each other.[6]

6. Conclusion

In [5] Nicola Guarino, Daniel Oberle and Steffen Staab proposed a definition of 'ontology'. In this paper we offered six arguments why this definition does not work. These arguments do not rely on any philosophical commitment in the ongoing debate between conceptualists and realists, but on the intrinsic problems of the proposed definition. In short, it is too reliant on intentional first-order logic structures and has technical prob-

[6]An anonymous reviewer pointed out that [5] does not require an ontology to corresponds to a conceptualization in the mind of *single* person and that a complex ontology (like the Gene Ontology) could correspond to a conceptualization that is developed by the interaction among many people. It seems that this kind of 'collective conceptualization' would not be realized in the mind of any single person, but would exist in some distributed form in the minds of many people. While this idea is philosophically interesting, it raises the question how such a 'collective conceptualization' is supposed to relate to the conceptualizations that are in the mind of individual people.

lems that lead to absurd consequences. Further, its definition of ‘conceptualization’ as intensional relational structure lead to various philosophical problems.

While this paper argues that the definition of “ontology” in [5] does not work, we do not want to detract from the fact that a definition like the one offered in [5] is needed. Just a different one.

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