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Applied Ontology 3 (2008) 1–12
DOI 10.3233/AO-2008-0049
IOS Press

Guest-editorial

Ontological foundations for conceptual modelling

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1. Introduction

Etymologically, the term "ontology" means the study of existence. In philosophy, ontology is the branch of metaphysics concerned with the fundamental nature of being, addressing deep questions such as "Do nonphysical things exist?", "Does an object remain identical to itself when it undergoes change?", and so on. Ontology in this sense is a mature discipline, with a history of systematic development in western philosophy at least since Aristotle. The business of ontology "... is to study the most general features of reality" (Peirce, 1935), as opposed to the several specific scientific disciplines (e.g., physics, chemistry, biology), which deal only with entities that fall within their respective domain. However, there are many ontological principles that are utilized in scientific research, for instance, in the selection of concepts and hypotheses, in the axiomatic reconstruction of scientific theories, in the design of techniques, and in the evaluation of scientific results (Bunge, 1977, p. 19). Thus, to quote the physicist and philosopher of science Mario Bunge, "*every science presupposes some metaphysics*".

In the beginning of the 20th century, the philosopher Edmund Husserl coined the term "formal ontology" as analogous to formal logic. Whilst formal logic deals with formal logical structures (e.g., truth, validity, consistency) independently of their veracity, formal ontology deals with formal ontological structures (e.g., theory of parthood, types and instantiation, identity, dependence, unity), i.e., with formal aspects of entities irrespective of their particular nature. The unfolding of formal ontology as a philosophical discipline aims at developing a system of general categories that can be used in the development of scientific theories and domain-specific common sense theories of reality.

According to Smith (2004), the term "*ontology*" in the computer and information science literature appeared for the first time in 1967, in a work on the foundations of data modeling by S.H. Mealy, in a passage where he distinguishes three distinct realms in the field of data processing, namely: (i) "*the real world itself*"; (ii) "*ideas about it existing in the minds of men*"; (iii) "*symbols on paper or some other storage medium*". This view bears obvious resemblance to the famous semiotic triangle of Ogden & Richards (1923). Mealy concludes the passage arguing about the existence of things in the world

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regardless of their (possibly) multiple representations and claiming that "*This is an issue of ontology, or the question of what exists*" (Mealy, 1967, p. 525). In the end of this passage, Mealy includes a reference to Quine's essay "*On What There Is*" (Quine, 1953).

In recent years, there has been a growing interest in the role played by formal ontology, as well as areas such as philosophical logics, cognitive sciences and linguistics, in the development of theoretical foundations for conceptual modeling. Conceptual modeling (including information or data modeling) is a fundamental discipline to several communities in computer science. Its main objective is concerned with identifying, analyzing and describing the essential concepts and constraints of a universe of discourse with the help of a (diagrammatic) modeling language that is based on a set of basic modeling concepts. In particular, what is termed *Domain Ontology* in the realms of artificial intelligence (including the Semantic Web) is a special type of conceptual model. As it has been shown in a large number of recent publications (e.g., Guizzardi, 2007; Soffer & Hadar, 2007; Guizzardi & Guarino, 2006; Guizzardi et al., 2006; Purao & Storey, 2005; Rosemann & Green, 2005; Evermann, 2005; Evermann & Wand, 2005; Guizzardi, 2005; Milton, 2004; Milton & Kamierczak, 2004; Guizzardi et al., 2004; Bera & Wand, 2004; Shanks et al., 2003; Geert & McCarthy, 2002), ontological theories such as those of Heller & Herre (2004), Chisholm (1996) and Bunge (1977) have been successfully applied to the evaluation of conceptual modeling languages and frameworks (e.g., UML, ORM, ER, REA, TROPOS, OWL) and to the development of engineering tools (e.g., methodological guidelines, modeling profiles, design patterns) that contribute to the theory and practice of this discipline.

The objective of this issue entitled "*Ontological Foundations for Conceptual Modeling*" is to collect innovative and high-quality research contributions regarding the role played by the aforementioned theoretical disciplines to the foundations of conceptual modeling. The issue should be of interest to several academic communities, including primarily the communities of applied ontology and conceptual modeling, but also the ones of database and information systems design, knowledge engineering, semantic interoperability and information integration, enterprise modeling, agent and object orientation, software engineering (in particular domain and requirements engineering), natural-language processing, business rules and model-driven engineering.

This extended editorial article contains the following complementary sections. Section 2 discusses the five scientific contributions that compose this special issue. Section 3 elaborates on topics that permeate these contributions and are particularly salient in the current discussion of this community as a whole.

2. The contributions collected in this issue

During the submission process for this special issue, we received seventeen papers from a number of different countries (with a particular concentration of European submissions): Australia, Austria, Belgium (2), Germany (6), Israel, Italy (2), Spain, Switzerland, United Kingdom and the USA. After a phase of rigorous reviewing, five quality contributions were selected for appearing in the journal. These articles are now discussed.

2.1. An ontology engineering methodology for DOGMA

This article by Peter Spyns, Yan Tang and Robert Meersman proposes a comprehensive methodology based on 10 years of research and practice in the topic of ontology engineering. The construction of this methodology has been carried out by an interdisciplinary team of researchers at the STARLabs laboratory in the context of the DOGMA Ontology Engineering Framework. As a cumulative effort, the proposed methodology builds on several inspiration sources. Firstly, from a theoretical point of view, it is based on theories coming from disciplines such as database semantics, natural language processing and literary analysis (e.g., the use of narratological schemes), but also from research in areas such as meaning negotiation, pragmatics and interaction patterns, mostly originating from research on collaboration in social sciences. Secondly, from a methodological stance, it builds on a number of classical methodologies such as TOVE, Enterprise Ontology, Methontology, OnToKnowledge, CommonKADS and, besides the typical ontology construction phases, it also congregates umbrella activities such as *vision statement*, *feasibility study* and *project management*. Finally, from a technical aspect, it contemplates a number of computational supporting techniques for the realization of some aspects prescribed by the methodology (e.g., text mining and ontology learning tools, machine learning techniques, social-tagging tools).

The proposed ontology engineering methodology is founded on a number of principles (the so-called *Seven Dogmas*) regarding the nature of ontologies (e.g., independence of language and of state of affairs), about the suitability of a general language for representing domain ontologies (a strong focus in natural language semantics and the choice of Object-Role Modeling (ORM) in particular (Halpin, 2007; Halpin & Morgan, 2008)), and about how semantics are defined and the nature of truth (e.g., "absolute meaning does not exist"). Furthermore, the authors subscribe to a view that defends the need of differentiating the characteristics of the artifacts that are (or need to be) produced by distinct phases of an ontology engineering process. In their approach this is highlighted by their *meaning independence* principle (a transposition of the *data independence* principle in databases), which advocates for an analogous three-tier structure in ontology engineering: a conceptual level to model the subject domain (universe of discourse), a logical level in which a specific modeling paradigm is chosen (e.g., frame-based system, flat predicate logics), and an implementation level that is concerned in producing an actual implementation in an actual language and environment abiding to the chosen modeling paradigm.

2.2. AEON: An approach to the automatic evaluation of ontologies

The second article of this issue by Johanna Völker, Denny Vrandečić, York Sure and Andreas Hotho addresses the need for proper tool support in ontology engineering – a subject also superficially tackled in the previous article. In particular, it proposes a tool named AEON which aims at supporting the use of the OntoClean methodology.

OntoClean is a methodology for construction and evaluation of taxonomic relationships based on the consistent use of a number of philosophical meta-properties, namely, *rigidity*, *unity*, *identity* and (notional) *dependence* as well as on constraints delimiting the possible relations that can be established between concepts (types, properties) tagged with these different meta-properties. For instance, on the one hand, a meta-property such as rigidity allows for the explicit intentional differentiation between the type Person (a rigid type) and the type Student (an anti-rigid type) – the difference being that while the former is necessarily (in the modal sense) instantiated by its instances, the latter is instantiated by its instances only contingently (again, in the modal sense). To put it bluntly, a student can stop being a student and still maintain its identity whilst, in contrast, a person cannot cease to be a person without ceasing to exist. Moreover, according to the constraints proposed by this methodology, an anti-rigid type cannot generalize (subsume) a rigid type. Consequently, by tagging Person as rigid and Student as anti-rigid, we cannot have in a conceptual model the latter as a (direct or indirect) supertype of the former without rendering this model ontologically inconsistent.

OntoClean is based on a number of theories from analytical philosophy, formal ontology and philosophy of language and, more particularly, in the tradition of philosophers such as Quine (1953, 1969), Kripke (1982), Strawson (1959) and Wiggins (2001). Additionally, the meta-properties that constitute the core of this methodology have been completely formally characterized in the framework of modal logics. However, despite its philosophical and formal rigor (or maybe because of that), the methodology has been reported as difficult for non-technical practitioners to learn and apply. In fact, in order for ontology-driven conceptual modeling and ontology engineering to be established as engineering disciplines we need, on the one hand, theoretically sound conceptual tools with precisely defined semantics, but, on the other hand, engineering tools (e.g., computational environments, design patterns, modeling languages, methodologies) that hide as much as possible the complexity of these theories from the general users. The contribution of this article takes a step in this direction.

AEON is a computational tool that uses linguistic (lexico-syntactic) domain-independent patterns to automatically tag concepts in a given ontology with appropriate OntoClean meta-properties. Furthermore, once this phase of automatic tagging is finished, the tool performs automatic checking in the ontology at hand regarding the constraints prescribed by the methodology. The first step of automatic tagging relies on the assumption that statistics about the occurrences of lexico-syntactic patterns in the largest repository of common sense knowledge (i.e., the web) provide a feasible means to infer the ontological meta-properties of concepts in a given conceptual model. In other words, the tool uses the web as an embodiment of world knowledge and performs text-mining in the search for patterns that present positive or negative evidentiary support for a particular tagging of a concept. In order to accomplish automatic checking of OntoClean constraints in the conceptual models produced in the previous step, the tool relies on: (i) an OWL DL codification of the OntoClean ontology of universals; (ii) a reification of tagged conceptual model elements such that its concepts and subsumption relations are instantiated as instances of concepts and roles in the OntoClean OWL ontology; (iii) a tool for checking inconsistency in a DL model (RaDON is the one used in the experiments reported in the article).

In experiments conducted by the authors, the conceptual models which underwent automatic tagging and constraint checking by AEON were compared with (what the authors name) *Golden Standards*, i.e., conceptual models in the same domains manually produced by a group of OntoClean experts. The results of these comparisons are presented and discussed in the paper.

2.3. Observations, measurements and semantic reference spaces

In line with the OntoClean methodology discussed in the previous paper, this article by Florian Probst builds on a theoretical foundation that employs a cognitive descriptive ontology. In particular, it builds on top of *DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering)*, which can be considered a complement of the upper-level theory underlying OntoClean, i.e., whilst OntoClean embodies an ontology of substantial universals, DOLCE is a formal ontology of particulars. Furthermore, the approach presented in this article takes an explicit inspiration in the conceptualist approach sponsored by Gardenförs (2000), both in the geometric treatment of *Quality Spaces* as well as in its orientation towards cognitive semantics. In contrast with the previous articles, however, the focus here is neither on methodological issues nor computational tool support but on how an ontologically well-founded theory can elucidate the nature of conceptual modeling concepts and provide unambiguous real-world semantics for conceptual modeling constructs.

Quality Spaces and related notions (Quality Domains, Quality Dimensions, Quality Regions) have been successfully used to provide a foundation for what is (from an ontological point of view) one of the most neglected areas in conceptual modeling, namely, the concepts of attribute value spaces, or simply, *datatypes* (Guizzardi, 2005; Guizzardi et al., 2006). Traditionally, datatypes have been taken for granted as “sets of pure values” (OMG, 2003). However, if a conceptual model is supposed to represent a certain conceptualization of reality, a question begging issue is what are the ontological counterparts of these entities or, to put it simply, where do these values come from?

In pace with the existing literature in this area, the article recognizes the distinction among a number of entities of different nature involved in the process of recognizing (or ascribing) the "*value of a property of a thing*". For instance, suppose that we have *an apple of color red*. In this case, we have the existence of a property which applies to a certain thing (the color property), and the bearer of this property (the apple). However, these theories also countenance the existence of at least two additional kinds of entities: (i) the observation of this property through a given apparatus (e.g., through the human cognitive system), with this observation result termed a *quale*; (ii) *quality spaces* – for each property (type) there is an associated quality space that (topologically, mereologically, geometrically) structures the possible qualia that can be an observation result of that property. In this particular case, the quality space that structures the possible color qualia is the so-called *Color Splinter* (Gardenförs, 2000) composed by the three dimensions of hue, saturation and brightness.

This article makes a further important contribution to these theories by making explicit an additional distinction, namely, the distinction between *Observation* and *Measurement*. The article extends the DOLCE ontology by introducing the concept of a *Semantic Reference Space* (along with a number of related notions). A Reference Space is a structure homomorphic to a quality space, which partitions the latter in such a way that *communicable signs* can be assigned to its individual partitions. For instance, a Reference Space associated with the color quality space can partition its Hue circle in a number of regions, and associate with each of these regions a set of lexical symbols such as "red", "green", "blue", "orange", and so on. Now, take that x is the observation result of the color of an apple, and let y be a partition created by a reference space such that x is located inside that partition. Finally, let z be the communicable sign associated to y by that semantic reference space. We now have that z (e.g., "red") is the measurement result of the color property of that apple. In summary, an observation process is turned into a measurement process if the observation result is associated with a communicable sign. Reasoning in the converse direction we can state that the result of any measurement process is the identification of a named partition of a semantic reference space associated with a quality space and, ultimately, associated with a property.

Finally, in the article, different Reference Spaces (and different sets of communicable signs) can be associated with the same Quality Spaces. This feature of the theory enables it to deal (among other things) with the issue of granularity in measurement results. Thus, if two observation results are located in the same partition then they will have the same measurement result (e.g., two distinct shades of color can receive the same lexical label in this reference system). Nonetheless, in a different Reference Space with finer-grained partitions, these two observation results can give rise to different measurement results.

By explicitly differentiating Quality Spaces from their associated Semantic Reference Spaces, the article brings a number of contributions to the foundations of conceptual modeling. Firstly, it separates ontological aspects of observation results from semantic and naming aspects of measurement results. It decouples, for instance, aspects such as the nature of the quality spaces associated to a property, from issues such as defining the semantics of a given property value (e.g., red). Secondly, it allows for the explicit representation in conceptual models of alternative Reference Spaces associated with the same Quality Space and, consequently, with the same property. Additionally, by explicitly representing these entities, it allows for the definition of rules that govern the translation of measurement results between these different Reference Systems. These results offer conceptual tools for addressing concrete semantic interoperability problems. More directly, they make even more explicit that a Semantic Reference

Space and its associated set of communicable signs are the ontological counterparts of a datatype and its associated set of member values.

2.4. Representing and reasoning over a taxonomy of part–whole relations

The fourth article of this special issue by C. Maria Keet and Alessandro Artale is akin in spirit to the previous one in at least two aspects. Firstly, it shares with that article one of its general objectives, namely, the use of a principled ontological theory to improve the expressivity and clarify the real-world semantics of conceptual modeling languages. Secondly, the ontological theory of reference selected here is again the foundational ontology DOLCE. Still in that respect, it takes a stance that explicitly recognizes that formal ontology alone is insufficient to provide the theoretical support needed for the foundations of conceptual modeling, and that cognition and language should play a similarly fundamental role. In particular, the paper deals with a very important and much discussed topic in conceptual modeling, knowledge representation and object-orientation (without mentioning linguistics, formal ontology and cognitive science), that is, the conceptualization, formal characterization and modeling of part–whole relations.

The paper presents a taxonomy of ontological distinctions in the category of part–whole relations. This taxonomy is based on an interdisciplinary body of work that, on one hand, takes into account the theoretical distinctions recognized by the existing formal theories of parts in formal ontology, the so-called *mereologies*. On the other hand, it considers the treatment of the notion of parthood received in linguistics and cognitive science, the so-called meronymic relations. In particular, it builds on a vast body of work in the conceptual modeling literature, part of which has been constructed by taking a similarly interdisciplinary path. Thus, from a theoretical point of view, a novel contribution of the paper is to formally align their proposed taxonomy of types of individuals that can take the roles of parts and wholes to the ones recognized by the DOLCE ontology (e.g., processes, physical objects, social objects, amounts of matter, spatial regions). In addressing this range of individuals pertaining to different ontological categories, the paper deals not only with part–whole relations between endurants (the standard treatment in the conceptual modeling literature), but it also addresses relations between processes, between regions, as well as a cross-categorical relation between objects and processes.

As previously mentioned, one of the important trends in the development of ontology-driven conceptual modeling and ontology engineering as sound engineering disciplines is to recognize the different sets of requirements which are posed on different artifacts produced in the conceptual modeling, design and implementation (codification) phases of these engineering processes (see the principle of *meaning independence* in Section 2.1). This paper also makes a contribution in this direction. Besides proposing a number of ontological distinctions that should be reflected in conceptual modeling languages, the paper also investigates how existing reasoning services would support automatic reasoning with conceptual models produced using these distinctions. The paper particularly examines the existing support in languages and computational tools pertaining to a popular paradigm in domain ontology engineering, knowledge representation and conceptual modeling, namely, *Description Logic (DL)*. This investigation points out that important features for supporting automatic reasoning with partonomies (e.g., role hierarchies and transitivity) are already supported by more recent expressive DLs. However, it also demonstrates that current DL reasoners are insensitive to a required compatibility between the hierarchies or roles, on one hand, and the hierarchies of role-fillers, on the other. In other words, if a role (in this case, a specific type of part–whole relation) is a specialization of another one, then the role-fillers of the latter (in this case, the whole and part types) cannot be more general than those of the former.

In order to address this issue, the article proposes a new reasoning service termed *RBox compatibility*, which extends existing tools by offering (what the authors name) an "ontological correctness" test (in addition to logical correctness tests). The objective, in the specific case of this article, is to verify whether the parthood role hierarchy in the DL RBox strictly conforms to the type hierarchy comprising the kinds of concrete individuals defined by DOLCE.

2.5. Epistemological perspectives on ontology-based theories for conceptual modeling

The fifth contribution in this special issue by Jan Recker and Björn Niehaves concludes this collection by elaborating on a subject that permeates the topics discussed in the previous papers. Over the years many works have been carried out that employ ontological theories as benchmarks for evaluating and (re)designing conceptual modeling languages and methods, as well as the specific models produced with them. Nevertheless, an area that has been neglected by this enterprise is the explicit definition of the epistemological foundations underlying these approaches.

This article discusses some epistemological questions that are of substantial importance for conceptual modeling research. As the authors indicate, these questions deal with epistemology in a broader picture. This means that they address not only epistemological questions in the strict sense (e.g., the relation between cognition and the object of cognition), but also deal with aspects on ontology (e.g., "is there any objective reality?") and methodology (e.g., how true knowledge can be acquired) as well as the concept of truth (e.g., the validity of knowledge) and the origin of cognition. Besides discussing the alternatives of paradigmatic choices underlying each of these aspects, the paper proposes a framework that can be used as a theoretical tool to help conceptual modeling researchers explicate their particular choices.

In the specific matter of ontological foundations for conceptual modeling, the authors elaborate on three relevant questions. These questions are then used to elaborate on the implications derived from particular sets of epistemological presuppositions regarding the scope, limits and boundaries of ontology-based theories for conceptual modeling. These additional questions are: (i) *What does it mean to engage in conceptual modeling?* (e.g., is it about collectively constructing an artifact that reflects subjectivity and purpose, or is it about producing a direct representation of an external reality?); (ii) *What does it mean to evaluate the outcome of conceptual modeling?* (e.g., by comparing to a reference model of reality, or by testing it against the consensus of experts?), and, finally, (iii) *What does it mean to achieve quality in conceptual modeling?* (e.g., is a model considered of high-quality if it preserves the properties of a portion of reality being represented, or if it is perceived as such by a social community?).

In order to exemplify the application of the proposed framework and relevance of the theme, the authors focus on the BWW representation model, selected due to its high number of citations in the conceptual modeling community. The framework is employed to classify the BWW in terms of its epistemological assumptions and consequent implications. However, as a concluding remark for this session, we can perhaps offer an additional illustration of this relevance. We do that by pointing to few passages in the articles that make up this special issue which refer to aspects of epistemology in the broader sense: "meaning is negotiated between the relevant stakeholders" (paper 1); the assumption that the correctness of model depends on how close it is to a "golden standard" produced by experts (paper 2); the assumption that a quality has an absolute magnitude independently of being observed or measured, and that the measurement of such absolute magnitude is impossible (paper 3).

3. Discussion

A subject that repeatedly appeared in the discussion of our previous section concerns the need to recognize the different sets of models that need to be produced by different phases of a development process (conceptual modeling, design and implementation) and which should fulfill different sets of requirements. The position defended here is that domain ontology engineering, in the sense practiced by the artificial intelligence, knowledge and software engineering and semantic web communities, is a special sort of conceptual model engineering activity. A domain ontology is, thus, a special kind of conceptual model, an engineering artifact with the additional requirement to represent a model of consensus within a community, where the model is designed to facilitate sharing information about that domain by conforming to some standard set of constructs. For this reason, this activity should be structured in process paths that are analogous to the ones practiced in other disciplines that also support the transition from a representation of a conceptualization to some coding artifact. In this transition path, the process must take into account that the produced coding artifact should preserve not only the real-world semantics of the original representation but it should also typically comply with a number of non-functional requirements that must be realized in a specific computational environment.

In disciplines such as software and information systems engineering, there is a clear distinction between conceptual modeling, design and implementation. In conceptual modeling, a solution-independent specification is produced with the aim to make a clear and precise description of the domain elements for the purposes of communication, learning and problem-solving. In the design phase, this conceptual specification is transformed into a logical design specification (e.g., a relational database schema or an object class model) by taking into consideration a number of issues ranging from architectural styles, non-functional quality criteria to be maximized (e.g., performance, adaptability), target implementation environment, etc. The same conceptual specification can potentially be used to produce a number of (even radically) different logical designs. Finally, in the implementation phase, a physical design is coded in one or more target languages to be then deployed in a computational environment. Again, from the same logical design, a number of different implementations can be produced (e.g., a relational schema might be mapped to a physical database schema in Oracle or IBM DB2 or Microsoft SQL Server etc.). Design, thus, bridges conceptual modeling and implementation. This three-tiered structure is recognized in the methodology proposed by Spyns et al., but also (implicitly) in the concerns of the contribution by Keet and Artale.

Again, the aforementioned reasoning should be applied to domain ontology engineering. In a conceptual modeling phase in ontology engineering, the main requirements for the resultant models (and, hence, for the modeling languages) is *domain appropriateness* and *comprehensibility appropriateness*. On the one hand, the models should be truthful to the phenomena being represented. On the other hand, it should be clear for users of the language what elements of the universe of discourse are represented by elements of the model, as well as what problem-solving operations are to be performed on these elements.

As a consequence, from a formal semantics point of view, in a conceptual modeling phase highly-expressive languages should be used to create strongly axiomatized models that characterize as well as possible an underlying conceptualization being represented. The commitment should be to preciseness and communication (pragmatic) efficiency. As a consequence, the features of a modeling language that maximize these quality attributes should not be sacrificed in favor of issues such as decidability and computational efficiency for automatic reasoning (which are non-functional design concerns, not conceptual ones). As nicely put by Mylopoulos (1992): "... *the descriptions that arise from conceptual modelling* *activities are intended to be used* ***by humans, not machines*** *. . . [and] The adequacy of a conceptual modelling notation rests on its contribution to the construction of models of reality that promote a common understanding of that reality among their human users*". In addition to expressivity and clarity, other features such as simplicity, orthogonality, semantic stability, semantic relevance, validation mechanisms, abstraction mechanisms and a formal foundation are desirable criteria for conceptual modeling languages (Halpin & Morgan, 2008, pp. 60–62).

However, engineering is also about using tools for building practical things. The theoretical notions which are required for suitable characterizations of domain conceptualizations are of a complex nature. This puts emphasis on the need for appropriate computational support for hiding as much as possible this inherent complexity from conceptual modeling practitioners. A step in this direction is taken here by Völker et al.

As it is the case in software and information systems engineering, the quality of the codified ontology strongly depends on the quality of the underlying conceptual model and errors made in the conceptual modeling phase are the most costly ones and the ones with a higher potential of shortening the lifetime of the ontology itself. This certainly does not diminish the importance of paying attention to design and implementation (codification) issues in ontology engineering. In fact, it is paramount to explicitly map the characteristics of the solution spaces such as to understand the different expressivity and tractability tradeoffs involved in different sorts of codification languages. Furthermore, it is of great importance to develop implementation infrastructures (e.g., languages and reasoning services) that preserve as well as possible the real-world semantics of the conceptual modeling primitives while still complying to design requirements. The paper by Keet and Artale in this special issue (as well as other works of the authors) makes a clear contribution in this direction.

Once more, design is about bridging the problem and solution spaces. Therefore, a sufficient understanding of both spaces is fundamental for developing adequate design tools (e.g., design patterns, transformation models, and methodological guidelines) that provide an engineering support for reasoning with (possibly) contrasting design concerns, for choosing the correct elements in the solution space, as well as to systematically transforming conceptual modeling structures to the elements in the chosen target environment.

A fundamental tenet of this special issue is the need for appropriate theoretical foundations for conceptual modeling languages methods and tools so that the quality requirements of *domain* and *comprehensibility appropriateness* can be fulfilled by the produced conceptual models. In particular, the contributions collected here sustain the principle that formal ontology (in the strong philosophical sense) plays a fundamental role in this enterprise. The practice of conceptual modeling is permeated by ontological questions (again in the strong sense). We exemplify here just a few. Is there one unique identity criterion for all objects? Can a type be subsumed by multiple supertypes? Is there such a thing as a property of properties? What kind of relation holds the parts of a whole together? Are there objects that exist only by being part of a specific whole (or of a whole of a certain kind)? Are there objects that exist only by having a specific object as part (or a part of a specific kind)? There are also dozens of recurrent conceptual modeling problems whose solution relies on answering ontological questions. Examples include the following problems (discussed in depth in Guizzardi, 2005): (i) *role modeling with multiple admissible types*; (ii) *harmonizing different notions of roles and the counting problem*; (iii) *transitivity of parthood relations*. Finally, although typical conceptual modeling languages provide facilities for structuring domain elements (e.g., taxonomic, partonomic, data value structures), the justification of the validity of many structuring choices (as much as the justification for the grammar of many natural language sentences) can only be made on ontological grounds (Guarino & Guizzardi, 2006). The articles by Probst, Keet and Artale address ontological issues in that spirit.

Ontology, however, is not a one-branch discipline. In (Strawson, 1959), the author draws a distinction between two kinds of ontological investigation, namely, *descriptive* and *revisionary methaphysics*. Descriptive metaphysics aims to lay bare the most general features of the conceptual scheme that are in fact employed in human activities. The goal is to make explicit the ontological categories underlying natural language and human cognition. Nonetheless, the very existence of these categories can often be empirically uncovered by research in cognitive psychology (McNamara, 1986, 1994; Xu, 2004; Xu & Carey, 1996; Xu & Baker, 2003; Xu, Carey & Quint, 2004) in a manner that is analogous to the way philosophers of science have attempted to elicit the ontological commitments of the natural sciences. Needless to say, the development of a cognitive descriptive ontology requires theoretical contributions coming not only from philosophical ontology and logics but also from linguistics and cognitive science.

Revisionary metaphysics, conversely, is prepared to make departures from common sense in light of developments in science, and considers linguistic and cognitive issues of secondary importance (if considered at all). To put it differently, a revisionary ontology is committed to capture the intrinsic nature of the world in a way that is independent of conceptualizing agents. Now, if conceptual modeling is about creating representations of domain conceptualizations for the purpose of understanding and communication, it should commit to a foundational theory that, albeit ontological, takes human language and cognition seriously. This position is sustained here by Spyns et al., Keet and Artale, Probst and (indirectly) Völker et al. Nevertheless, as important as sponsoring a well-founded philosophical position is to be explicit about which commitments are implied by this position. The contribution of Recker and Niehaves in this issue gives researchers in this field a practical tool for doing exactly that.

The final message of this editorial is to openly advocate that developing philosophical foundations is a necessary step to be taken if conceptual modeling, in general, and domain ontology engineering, in particular, are to become mature disciplines with sound principles and practices. "*Every science presupposes some metaphysics*", hence, a scientific field can either choose to develop and make explicit its philosophical foundations or to remain oblivious to its inevitable and often ad hoc ontological and epistemological commitments. Or, as nicely put by Recker and Niehaves citing (Collier, 1994), "*the alternative to philosophy is not no philosophy, but bad philosophy*". The articles of this special issue are a welcome support to this idea.

Acknowledgements

We would like to thank the following people for their professional reviews: Alan Rector, Andreas Opdahl, Barry Smith, Boris Wyssusek, Chris Menzel, Chris Welty, Claudio Masolo, Csaba Veres, Dragan Gažević, Edward Haeusler, Elisa Kendall, Enrico Franconi, Frederico Fonseca, Frederico Freitas, Guido Boella, Jeff Pan, João Paulo Almeida, Jörg Evermann, John Mylopoulos, Luís Ferreira Pires, Marten van Sinderen, Martin Doerr, Mattew West, Mustafa Jarrar, Natalya Noy, Patrick Lambrix, Paul Johannesson, Peter Gärdenfors, Peter Rittgen, Remco Dijkman, Renata Guizzardi, Ricardo Falbo, Riichiro Mizuguchi, Veda Storey and Wolfgang Hesse. We also would like to express our immense gratitude to Nicola Guarino, Mark Musen, Roberta Ferrario and Sira Greco in their continuous support in the organization of this issue.

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