Epistemological Perspectives on Ontology-based Theories for Conceptual Modeling

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Abstract. Conceptual modeling is a core activity in Information Systems analysis and design. In response to continuous criticism lamenting a lacking theoretical foundation of conceptual modeling, the notion of ontology as a theoretical reference gained immense popularity over recent decades. At the forefront of these ontology-based theories is the Bunge-Wand-Weber representation model, which has become widely applied in conceptual modeling research, most notably for the task of evaluating conceptual Information Systems analysis and design models and modeling grammars. Recently, however, ontology-based theories have also been subjected to criticism, in particular in respect to their epistemological presuppositions. In our paper we address the question of epistemology in conceptual modeling research based on ontological theories, and argue that there is an immanent need for publishing the epistemological assumptions of these theories in order to be able to critically evaluate boundaries, scope and limits of these theories for conceptual modeling. We present a discussion framework that facilitates the analysis of epistemological viewpoints and their implications. We apply this framework to the commonly known Bunge-Wand-Weber model and discuss the implications of our findings towards the feasibility of ontology as a reference theory for conceptual modeling.

Keywords: Conceptual Modeling, Epistemology, Representation Theory, Ontology

1. Introduction

A major task undertaken by information systems (IS) analysts and designers is to develop graphical representations of selected phenomena in a real-world domain with the aim of enhancing understanding and communication amongst stakeholders (Siau, 2004). These so-called conceptual models have been found to be a very conducive way of articulating knowledge and perceptions about real-world domains and are widely believed to be crucial to IS analysis and design (Karimi, 1988; Kottemann and Konsynski, 1984). Conceptual modeling comprises four elements, a grammar (i.e. a set of constructs and rules to combine those constructs), a method (i.e. procedures by which the grammar can be used), a script (i.e. the product of the modeling process), and a context (i.e. the setting in which the modeling occurs) (Wand and Weber, 2002).

The quality of conceptual modeling is believed to have an enormous impact on information systems analysis and design. Conceptual models used in the requirements engineering phase of a system development process determine the acceptability and usability of the product to be built (Lauesen and Vinter, 2001). As the cost of fixing errors grows exponentially as an elapsed time to discovery (Moody and Shanks, 2003), the importance of an adequate problem and domain representation through conceptual models is recognized, as they may reveal errors such as faulty requirements specification in an early stage of systems development.

The growing relevance of conceptual modeling for information systems analysis and design is quite evident, on the one hand in the growing number of available modeling approaches - think of entityrelationship modeling, object-process modeling or UML, and on the other hand in the number of scholarly articles that has focused the theoretical foundation of conceptual modeling. Numerous attempts have been crafted to theorize conceptual modeling and associated phenomena. Amongst others, the fundamental principles underlying conceptual modeling have been discussed from the perspectives of meta-modelling (Kühne, 2006), action theory (Agerfalk

and Eriksson, 2004), semiotics (Lindland et al., 1994) and cognitive psychology (Veres and Mansson, 2005).

One of the more recent responses to the quest for theoretical foundations of conceptual modeling in information systems analysis and design, which has gained immense popularity over the last decades, is the reference to the notion of *ontology*. However, the concept of ontology, as used in contemporary IS research, draws on two different notions: While some approaches refer to an understanding of ontology in a philosophical sense, i.e. as a theory to describe reality in categorical terms, e.g. (Guizzardi, 2005; Milton and Kazmierczak, 2004), other approaches refer to a "specification of some conceptualization" (Gruber, 1993) and use domain ontologies to devise semantic interoperability in computer science, e.g. (Staab et al., 2001). In this paper we elaborate on the philosophical understanding of ontology. In particular we focus on the Bunge-Wand-Weber (BWW) model of representation (Wand and Weber, 1990a, 1993, 1995), that denotes the most prominent representative of ontology-based theories used in the IS field in association with conceptual modeling research. Over recent decades the BWW model has gained considerable popularity, proven by a large number of academic applications - Green and Rosemann (2004) provide an overview. Most of the scholarly papers in this context apply the BWW model to evaluate conceptual modeling artifacts, such as grammars, methods or scripts, and their implications for IS analysis and design. Hence, we will focus our elaborations on this application area.

In general, the aim of evaluation theory and practice is to produce appropriate answers to the questions of usefulness, effect, and impact of an IS artifact through the application of systematic studies (Wynekoop and Russo, 1997). Like any other research, evaluation research is determined through certain epistemological commitments. This argument rests on the observation that IS research in general can be seen as a rich tapestry of diverse research methods, paradigms and approaches (Benbasat and Weber, 1996; Wade and Hulland, 2004). Several research methodologies and approaches have been found to be adopted in IS research practice (Chen and Hirschheim, 2004; Orlikowski and Baroudi, 1991). Given this state of paradigmatic and methodological pluralism in IS, i.e. several epistemological viewpoints determining certain research actions co-exist in the field, one has to pay special attention to the implications and interrelationships of these viewpoints upon science and research and, concordantly, to the evaluation of such research process and progress.

Against the background of distinct and often inexplicit epistemological assumptions, working on the same research topic or evaluating a certain IT artifact (conceptual models, for instance) does not necessarily ensure mutual understanding. The potential lack of understanding in this context is a result of differing epistemological assumptions. In particular, the understanding of such concepts as validity, reliability, or quality of research, depends substantially on epistemological presuppositions. This is evident, for instance, in the controversy over positivist and interpretivist research within the information systems field, see for instance (Chen and Hirschheim, 2004; Hirschheim and Klein, 1989; Weber, 2004). More recently, this controversy has also entered the field of conceptual modeling. In a recent issue of the Scandinavian Journal of Information Systems (Kautz et al., 2006), a number of IS scholars debated the epistemological implications of ontology-based theories for conceptual modeling. These and similar endeavors, e.g. (Mingers and Stowell, 1997; Nissen et al., 1991), indicate that the discussion of epistemological assumptions of IS research is almost mandatory if not essential. The recent debate by Kautz et al. (2006) further indicates that what applies to IS research methods in general also holds for conceptual modeling in particular, especially for those attempts that rely at their core upon exquisite paradigms, such as an ontology-based approach like the BWW model.

Therefore, in this paper, we will address the following research questions: What are the epistemological aspects relevant in the discussion of ontology-based approaches to conceptual modeling? What implications derive from certain epistemological presuppositions towards an ontological foundation of conceptual modeling? Where are limits of ontology-based theories as to the field of conceptual modeling? Addressing these research objectives, we seek to answer the following sub-questions progressively in the course of this paper:

1. Why is it necessary to have an epistemological discussion of IS research methods and what are the epistemological aspects relevant to our discussion (Section 2.1)?

2. What are particularities of the conceptual modeling domain and ontology-based theories, respectively, in the IS discipline that demand special consideration in our discussion (Section 2.2)?

3. What are the general characteristics of the Bunge-Wand-Weber (BWW) representation model (Section 2.3)?

4. What other research has addressed our field of investigation (Section 2.4)?

5. What particular aspects of consideration need to be addressed when discussing the epistemological stance of theories for conceptual modeling (Section 3.1)?

6. What are the epistemological characteristics of conceptual modeling foundations based on the notion of ontology, such as the BWW program (Section 3.2)?

7. What kind of epistemological consequences and implications with regard to conceptual modelling activities must be considered that may restrain the application of the BWW model (Section 3.3)?

8. What are the conclusions from our research (Section 4)?

Addressing our research objective, the research method chosen is that of conceptual/philosophical research. This type of research is dedicated to identifying, scrutinizing and questioning the presuppositions of research approaches in order to determine their scope, applicability, possibilities, and limits towards a given research objective. We will hence provide philosophical-logical arguments rather than empirical ones. However, our arguments will (where applicable) also refer to empirical research results, for instance (Chen and Hirschheim, 2004) and others. Furthermore, we will present additional evidence by giving examples from IS research practice.

2. Background & Related Research

2.1. An Epistemological Framework for IS Research

The Information Systems (IS) discipline is relatively new. It evolved at the intersection of historically well-established research fields such as Management Science, Technology Science, Social Science etc. (Vessey et al., 2002). Moreover, researchers studying in the IS area are originally coming from disparate research disciplines, bringing with them not only a range of methods and methodologies but also a diversity of underlying philosophical assumptions towards research, and, going deeper, towards understanding and cognition of reality, language, and truth. However, as we understand our discipline as concerned with “the effective design, delivery, use and impact of information technology in organizations and society”

(Avison and Fitzgerald, 1995, p. xi), we feel that it is - opposed to some of its so-called "foundational research disciplines" - quite uniquely placed at the interface of technology and organization, i.e. it addresses the interaction in human-machine systems (Lee, 2001, p. iii):

Research in the information systems field examines more than just the technological system, or just the social system, or even the two side by side; in addition, it investigates the phenomena that emerges when the two interact.

This tapestry of diversity in IS research leads to an urge for publishing underlying paradigmatic assumptions of research work so that fellow researchers and other readers fully comprehend the research approach and the perspective taken by the researcher. Furthermore, an evaluative criticism of research work is not possible without understanding the perception of science underlying the research to be evaluated. The debate on philosophy in IS research may or may not be seen as essential, however, an engagement in philosophy cannot be avoided, since (Collier, 1994, p. 17):

[...] a good part of the answer to the question "why philosophy?" is that the alternative to philosophy is not no philosophy but bad philosophy. The 'unphilosophical' person has an unconscious philosophy, which they apply in their practice - whether of science or politics or daily life.

While it is not the purpose of this research to fully investigate all parts of philosophy, it is nevertheless essential to delineate specific terms of interest, especially those that form research paradigms common to the IS discipline. Generally, a paradigm is understood as a specific way of thinking about problems based on a set of achievements that are acknowledged as a foundation of further research practice. It therefore denotes a constellation of fundamental metaphysical beliefs that make up a theoretical framework within which scientific theories can be tested, evaluated and if necessary revised (Kuhn, 1962). In IS research, several endeavors have been undertaken researchers to systematically analyze different research paradigms while taking into account their different epistemological assumptions (for a selection of such efforts, see Table 1).

Table 1
Previous work on the analysis of epistemological assumptions of IS research

Author	Criteria	IS research paradigm
Burrell and Morgan (1979)	a. Ontology b. Epistemology c. Methodology	Functionalism, interpretivism, radical humanism and radical structuralism
Lee (1991); Chen and Hirschheim (2004)	a. Ontology b. Epistemology	Positivism, interpretivism
Fitzgerald and Howcroft (1998)	a. Ontology b. Epistemology c. Truth	Positivism, interpretivism
Monod (2003)	a. Epistemology I: object of knowledge b. Epistemology II: origin of knowledge	Diverse IS research paradigms and philosophical trends, e.g. functionalism, constructivism, critical realism
Weber (2004)	Multiple. Amongst others, ontology, epistemology, research object, method and theory of truth.	Positivism, interpretivism

Epistemology (in a broader sense) refers to the branch of philosophy that addresses knowledge, its nature and sources, and particularly the acquisition of knowledge (Hirschheim, 1985). It may be understood as the science of analyzing the way human beings (IS researchers in this case)

comprehend knowledge about what is (perceived to) exist (Burrell and Morgan, 1979). As such, this broad definition of epistemology embodies certain distinct epistemological aspects in a narrower sense on which we will elaborate on in the subsequent section. Some of these distinct epistemological aspects in a narrower sense (especially the question of ontology and epistemology) have been discussed in the IS literature in order to differentiate between IS research paradigms, as shown in Table 1. As we feel that these frameworks do not sufficiently explain all epistemological notions in a narrower sense that together make up epistemology in a broader sense we will draw on an epistemological framework that takes into account multiple aspects relevant to, and discussed within, the IS discipline. We have developed the framework in (Becker and Niehaves, 2007). The framework addresses a set of relevant questions that is to our belief more differentiated than previous approaches. Our framework has previously been applied in diverse research contexts including an epistemological discussion of multi-method research (Niehaves, 2005), eGovernment initiatives (Becker et al., 2005a), design science (Niehaves, 2007) and simulation (Becker et al., 2005b). This in turn presents justification and first evidence that our epistemological framework is both feasible and applicable to the IS context in general and our research question in particular.

The discussion of epistemological issues must, at least for the time being, be considered an open issue. No theory based on a certain philosophy of science can be considered as binding for IS researchers. The individual or social-collective selection of an epistemological position, however, necessitates an extensive publication of the epistemological assumptions made. We will present some relevant epistemological aspects in the IS field, and we will show how different research schools approach these aspects. Our epistemological framework comprises five questions, each addressing one core epistemological aspect. As for these aspects, for clarification and illustration purposes we present dichotomous obtainable positions while bearing in mind that the paradigms formed by these positions are as such permeable at the edges - their so-called “transition zones”. Ergo, the paradigm distinctions drawn here must not be used uncritically but rather as an illustrative guide.

The concept underlying our framework is the explicit breakdown of epistemological questions that are highly relevant to IS research. Again, note that the following dichotomous distinctions are for clarification and illustration purposes, we are well aware that

1. there are more possible positions obtainable as to each epistemological question,

2. there are more combinations possible for research paradigms as to these epistemological questions, and

3. not all of the positions necessarily and unquestionably refer to the paradigm distinctions drawn here.

Question [*I*] about ontology, see for example (Falconer and Mackay, 2000; Walsham, 1995; Weber, 2004), refers to the question whether an object of cognition exists beyond subjective imagination and perception (Bunge, 1977). Ergo, a researcher has to position himself in terms of the assumption “existence of an objective reality”. We differentiate three obtainable positions that were identified by Chen and Hirschheim (2004) to be of use in IS research (see Table 2).

Question [*II*] about epistemology refers to the question whether objective (re-) cognition of concepts is possible beyond subjective perception. Again, in referral to the literature surveys conducted on paradigms in published IS research (Chen and Hirschheim, 2004; Orlikowski and Baroudi, 1991; Vessey et al., 2002), we differentiate three main positions that have been found to

be of relevance and use in IS research (see Table 2). Both question [*I*] and [*II*] are fundamental to the discussion of positivism and interpretivism, see for instance (Weber, 2004).

Question [*III*] about the concept of truth has not yet been widely considered in the IS research literature. A brief mention can be found in the works of Weber (2004) as well as Fitzgerald and Howcroft (1998). Nevertheless, this aspect becomes highly important in analyzing, for instance, the influence of language on research (Klein and Lyytinen, 1985), conceptual modeling and modeling in general, especially the semantic theory of truth (Tarski, 1944), and inter-personal validity/truth of research results. The concept of truth refers to the question as to how true knowledge can be obtained and how the truth of knowledge can be verified. Again, we differentiate three approaches that provide possible answers to this aspect (see Table 2).

Question [*IV*] about the origin of knowledge, see for instance (Monod, 2003), as well as question [*V*] about the means of achieving knowledge (methodology) have also been discussed in recent IS literature, see for instance (Butler, 1998; Hirschheim and Klein, 1989). The question as to the origins of cognition relates to the fundamental capability to perceive and to create knowledge. The methodological aspect of epistemology deals with the question of how humans perceive. This question addresses the modes of acquiring knowledge.We present the three main approaches identified from literature to each of these two questions (see Table 2).

Presenting these questions and reporting on distinct approaches towards these questions by different IS research schools, we construct our epistemological framework based on which we can analyze contemporary IS research methods and approaches, i.e. here specifically, ontology-based theories for conceptual modeling (see Table 2).

As shown in Table 2, the framework facilitates the identification and differentiation of certain epistemological positions. As an example, the two popular research paradigms in the field of Information Systems research, namely positivism and interpretivism, have particular epistemological assumptions. Positivism is known to often take the position of an ontological [*I ¡ A*] and epistemological realism [*II ¡ A*] as well as to follow the correspondence theory of truth [*III ¡ A*]. On the other hand, interpretivism is often associated with an ontological idealism [*I ¡B*], an epistemological constructivism [*II ¡B*], and the con- sensus theory of truth [*III ¡ B*]. However, researchers branding their position with either positivism or interpretivism may opt for different combinations of epistemological standpoints.

As indicated by Chen and Hirschheim (2004) as well as Orlikowski and Baroudi (1991), positivism (still) dominates IS research with interpretivism being the main alternative so far. Consequently, our paper mainly focuses on these two (epistemological) paradigms. However, it should be noted that the discussion on IS research paradigms is at current considered an open issue as several researchers argue for post-approaches, e.g. (Iivari, 1991; Orlikowski and Baroudi, 1991). Especially the so-called “critical research paradigm” provides a new perspective on IS research (Dobson, 2002; McGrath, 2005; Mingers, 2004). However, the term “critical” knows many interpretations (McGrath, 2005) that also allows it to be understood as “value-critical”. Hence, one may also argue that it is logically possible to associate critical research with existing epistemological research paradigms including positivism and interpretivism, i.e. to follow an example of methodological or epistemological pluralism (Landry and Banville, 1992; Monod, 2002).

Table 2

Epistemological framework. Based on, and extends, the framework developed by Becker and Niehaves (2007)

Epistemological aspect	Selected positions		
[*I*]	*Realism*	*Idealism*	*Kantianism*
What is the object of cognition? (ontology)	An objective reality exists independently from human cognition, i.e. independent from thought and speech processes (Bunge, 1977).	'Reality' is a construct depending on human consciousness, i.e. subjective perception, cognition and language (Berger and Luckmann, 1966).	There are entities that exist independent from (*noumena*) as well as dependent on human mind (*phenomena*) (Kant, 1929).
[*II*]	*Realism*	*Social constructionism*	*Radical constructivism*
What is the relationship between cognition and the object of cognition? (epistemology *in a narrower sense*)	Objective cognition of a real object is possible without subjective distortion by a cognitive subject (Losee, 2001).	Reality is constructed trough social discourse. The relationship between cognition and the object of cognition is determined by the social historicity of an individual (Neimeyer, 1998).	Reality perception is always "private", i.e. the solipsistic construction of the cognition of reality by an individual (von Glasersfeld, 2001).
[*III*]	*Correspondence theory*	*Consensus theory*	*Semantic theory*
What is true cognition? (concept of truth)	True statements are those which correspond with 'real world facts' (Kirkham, 1992).	A statement is true if, and only if, it is rationally acceptable for everyone under ideal and optimal conditions (Kirkham, 1992).	A condition for truth is the differentiation of an object and a meta language (Tarski, 1944).
[*IV*]	*Rationalism*	*Empiricism*	*Kantianism*
Where does cognition originate?	Cognition originates from the intellect. Such non-experience-based knowledge is referred to as *a priori* knowledge (Popper, 1959).	Cognition originates from the senses. Such experience-based knowledge is called *a posteriori* or *empirical* knowledge (Aristotle, 1991).	Both experience and intellect are sources of cognition. Thoughts are meaningless without content, cognitions are blind without being linked to terms (Kant, 1929).
[*V*]	*Deductivism*	*Inductivism*	*Hermeneutic*
By what means can cognition be achieved? (methodology)	Deduction is the derivation of the individual from the universal (Greer, 1969).	Induction is the inference of universal propositions from specific cases, e.g. generalization (Merton, 1957).	The understanding of a certain phenomenon is influenced by the pre-understanding of the entire context (Gadamer, 1976).

But since pluralism is not the main thrust of this paper we will focus on traditional epistemologies of IS research in the remainder of this paper.

2.2. Conceptual Modeling and Ontology

In the process of describing, explaining or designing information systems several circumstances of the considered subject matter are to be neglected so that only relevant aspects are examined. This eliding process is called *abstraction* and serves the purpose of complexity reduction (Olivé, 1983). Abstraction by means of conceptually modeling information systems denotes a core concept within IS research and practice. It is used for the analysis, design, implementation, deployment, and assessment of information systems.

In the process of requirements engineering for IS analysis and design, conceptual modeling is used to represent an information processing problem independently from the implementation of an eventual solution, i.e. to describe domain requirements in a conceptual form, e.g. (Young and Kent, 1958). Since information systems are essentially built to solve user problems and to meet

user expectations, a description of an information processing problem that is to be solved by the information system should be prepared in terms of the users' conceptualizations of the relevant domain. Conceptual modeling provides the means to develop models that are abstract enough to be independent from their technical implementation, semantically rich enough to be comprehensible for involved stakeholders and detailed enough to sufficiently specify structure or behavior of the resulting system (Hull and King, 1987; Loucopoulos and Zicari, 1992).

Criticisms of conceptual modeling, e.g. (Siau and Rossi, 1998;Weber, 2003) have targeted the deficit of underlying theoretical foundations. Modelers are confronted with the situation that they seek to represent the requirements in a conceptual form, yet, there is no theory available to guide the development of models of real-world domains. Such theory, if available, would allow for the analysis of whether a conceptual model is a good reflection of a real-world domain, and which modeling language would be better in facilitating the design of good models.

In an attempt to remedy this situation, IS researchers have turned to the philosophical branch of ontology. Ontology dates back to Aristotle (1991), whose treatise on metaphysics is widely accepted as the foundation of the theory of ontology. The philosophical discipline of ontology studies the most pervasive features of reality, such as real existence, change, time, causation, chance, life, mind, and society (Bunge, 2003). Being a theory that attempts to describe reality in categorical terms, ontology would appear suitable for presenting guidance to modelers in 'what' to model. As Guarino and Guizzardi (2006) correctly point out, ontology is not concerned with how individuals categorize their perceptions of real-world domains, but instead seeks to develop abstract categorical terms to describe reality, independent from any concrete domain. Accordingly, in the context of IS research, several researchers have turned to this philosophical branch to devise theories for conceptual modeling. Most notable are the approaches by Guizzardi (2005), Milton and Kazmierczak (2004) andWand andWeber (1990a, 1993, 1995). In the remainder of our paper, we refer to Wand and Weber's model of representation as a popular candidate of ontology-based theories. This selection is solely made in referral to the widespread adoption of this model in well over hundred applications to conceptual modeling (Green and Rosemann, 2004) and is by no means intended to discredit the intellectual merit, usefulness, validity or applicability of other ontology-based reference theories such as the ones by Guizzardi (2005) or Milton and Kazmierczak (2004).

2.3. The BWW Representation Model

Concerned that the lack of theoretical foundations for conceptual modeling would result in the development of information systems that were unable to completely capture important aspects of the real world, Wand and Weber (1990a, 1993, 1995) developed and refined a set of models for the foundation of modelling grammars and the scripts prepared using these grammars. Based on the premise that computerized information systems are, in their essence, representations of real world systems, Wand and Weber (1990a, 1993, 1995) suggest that ontology can be used to help define and build information systems that contain the necessary representations of real world constructs and their interactions. They adopted a scientific ontology developed by Bunge (1977, 1979) into a theory of representation that is widely known as the *Bunge-Wand-Weber (BWW) representation model.*

The application of the BWW representation model as a foundational theory for the conceptual modelling of information systems has been referred to by a vast number of researchers (Green and Rosemann, 2004) and so the representation model is now often referred to as simply "the" BWW model. It consists of an inter-related set of categories, which can be grouped into the following clusters: things including properties and types of things; states assumed by things;

events and transformations occurring on things; and systems structured around things. Due to space limitations we do not discuss the set of categories further but instead refer to its complete description by Weber (1997b).

Weber (1997b) suggests that the BWW model can be used to analyze artifacts and phenomena associated with conceptual modeling (such as grammars, methods or scripts). He clarifies two main evaluation criteria that may be studied according to the BWW model: *Ontological Completeness* and *Ontological Clarity*. The underlying premise is that the results of a conceptual modeling exercise, i.e. the conceptual model (or script) should be complete in that it covers all phenomena the user sought to have represented. Furthermore, it should be clear in that the conveyed real-world semantics should unambiguously and effortless be understandable.

At the time of writing, the BWW model has been applied, both analytically and empirically, in a large number of IS research studies concerned with conceptual modeling phenomena. Gemino and Wand (2005), for instance, showed how the non-conformance to certain principles of ontological clarity negatively affected the development of domain comprehension by means of a conceptual model. Similarly, Bodart et al. (2001) showed that ontological clarity was a significant factor in conceptual model understanding and problem solving. Bowen et al. (2006) found that ontologically clearer conceptual models increased database query performance. TheBWWmodel has furthermore been applied to research involving modeling grammar evaluation, e.g., (Green and Rosemann, 2000; Opdahl and Henderson-Sellers, 2002; Recker and Indulska, 2007), reference modeling (Fettke and Loos, 2007), modeling method engineering (Wand, 1996) or model quality measurement (Wand and Wang, 1996).

2.4. Related Work

Related work in this area of research can be differentiated into 1. research on ontology-based foundations of conceptual modeling, 2. the critical examination of such, and 3. other approaches towards a foundation for conceptual modeling.

1. Research in conceptual modeling has increasingly referred to ontology in its original philosophical sense, i.e. referring to the theory of being, respectively the theory of researching ‘what is’ and ‘how it is’ (Angeles, 1981). We exclude research work that applies a different understanding to ontology, e.g. research in artificial intelligence (Guarino and Welty, 2002) or knowledge engineering (Holsapple and Joshi, 2002), that refers to ontology as a taxonomy or dictionary without implying a firm commitment to a certainWeltanschauung (Uschold and Grüninger, 1996). Among the theories based on philosophical ontology that have been proposed as a theoretical basis for the conceptual modelling of information systems, the work of Milton and Kazmierczak (2004), who use an ontology developed by Chisholm (1996), and Guizzardi (2005) are to be regarded as closest to the ideas of Wand and Weber (1990a, 1993, 1995). These upper-level ontologies proposed have been built for similar purposes and seem to be equally expressive, as shown, for instance, in the meta model comparison by Davies et al. (2005). However, we would like to stress that we do not consider the BWW model to be superior to its contenders in any form. Wand and Weber (2006) concede that “the question of ‘which’ ontology to use is an open one. Unless it is pre-determined by agreement within a relevant community, we need to ‘guess’ the appropriate ontology. In the absence of compelling evidence in favor of a specific ontology, the final verdict about the validity of any ontology-based conclusions must be based on empirical methods and outcomes” (p. 135). Every ontology, for instance the one by Bunge (1977, 1979) that builds the foundation for the BWW model, the one by Chisholm (1996), upon which Milton and Kazmierczak (2004) based their work, or the ontology devised by Guizzardi

(2005), captures a certain viewpoint from its philosophical commitments and so gives a different perspective on conceptual modeling (Milton and Kazmierczak, 2006). In our work we consider the BWW model - with the mere justification that there has been ample scholarly work based on this model presenting empirical evidence that supports the 'validity' of this model, e.g. (Bodart et al., 2001; Bowen et al., 2006; Gemino and Wand, 2005; Green and Rosemann, 2001).

2. Regarding the second area of related work, in recent years, criticisms have been leveled that target ontology-based theories for conceptual modeling, such as limited empirical testing (Wyssusek, 2006) or problems in the procedure of applying ontology-based theories for the analysis of conceptual modeling phenomena (Rosemann et al., 2004). Certainly, the work to date has attempted to mitigate each of these criticisms. There is ample empirical support a number of authors have undertaken empirical tests of the "validity" of predictions stemming from representation theory, e.g. (Bodart et al., 2001; Green and Rosemann, 2001; Parsons and Cole, 2004; Gemino andWand, 2005; Bowen et al., 2006; Burton-Jones and Meso, 2006), while others have undertaken efforts to provide procedural guidelines for the application of the theory, e.g., (Rosemann et al., 2004). However, the most consistent criticism lies in the referral to ontology as a meta theory for conceptual modelling (Hirschheim et al., 1996; Lyytinen, 2006; Wyssusek, 2006) and the resulting epistemological implications towards conceptual modeling. As noted above, a whole special issue has been devoted to this debate (Kautz et al., 2006). This and other, similar debates primarily target the question of the epistemological assumptions of ontological theory as such and the implications of these for conceptual modeling, without reaching a coherent conclusion yet. Our paper attempts to rectify this situation by using an epistemological framework to explicate a wide range of these assumptions, including ontological, epistemological, methodological aspects as well as the concept of truth and the origin of cognition. As such, we respond to Lyytinen (2006) who states that "we should scrutinize more carefully both the theoretical assumptions and practical implications of the modeling program suggested by Wand and Weber" (p. 82).

3. Regarding the third area of related work, there is some research that draws upon action theory (Agerfalk and Eriksson, 2004), semiotics (Lindland et al., 1994; Krogstie et al., 2006) or cognitive theory (Evermann, 2005; Veres and Mansson, 2005) as a theoretical foundation for conceptual modeling. In particular, work based on cognitive psychology, e.g. (Evermann, 2005; Veres and Mansson, 2005; Siau and Wang, 2007) attempts to provide a perspective on conceptual modeling different from, and challenging, ontology-based theories. Instead of targeting a reference theory for modeling real-world domains, where ontology as a description of the nature and structure of the world can be used as a benchmark, they argue that evaluation of conceptual modeling should be conducted on the basis of the underlying psychological representations of the stakeholders involved in conceptual modelling (Veres and Mansson, 2005). Psychological theory attempts to explain how individuals perceive reality and thus, how descriptions of real-world domains are being formed and understood by modelling individuals. This attempt essentially tackles the challenge of conceptual modeling from an angle that we deem highly fruitful as well as complementary to ontological theory. While the latter provides one (not necessarily the) conceptualization of real-world domains, the former provides a potential conceptualization of the cognitive model of reality that is formed by individuals when engaging in conceptual modeling. It would be most interesting to see where these two conceptualizations overlap, align or even clash.

3. An Epistemological Perspective on Ontology-based Conceptual Modeling

3.1. Constructing a Discussion Framework

As different epistemological viewpoints determine and impact an artifact construction process, the same can be said about the choice of underlying theories that come into play, for instance, in evaluation design and conduct. Different world views of researchers designing evaluation approaches and theoretical foundations serve the basis for evaluation, e.g. by coining the understanding of what it means to engage in conceptual modeling, and how the quality of such endeavors might be judged.. A discussion of these assumptions would leverage understanding of what kind of statements can be derived by applying the theoretical foundation in question to a given modeling context. Consequently, possibilities as well as scope and limits of selected theories can be better understood. This in turn would allow research and practitioners alike to carefully reflect upon their work and be aware of the strengths and weaknesses associated with theories and methods. Only this way can deep understanding of different sorts of knowledge be attained by reflexive researchers (Weber, 2004).

With our work we seek to contribute to this goal. We will utilize the framework presented in Table 2 to aid the discussion of the ontology-based foundation of conceptual modeling. Looking at the particularities of this research domain, i.e. conceptual modeling and related phenomena, we deem it adequate to put emphasis on three aspects of relevance to conceptual modeling that theoretical foundations have attempted to tackle. Accordingly, we will focus on the three following questions when discussing the epistemological presuppositions of ontology-based theories for conceptual modeling and their implications.

What does it mean to engage in conceptual modeling? This aspect of consideration refers to epistemological implications towards the perception of the concepts “model” and “modeling”. For instance, interpretive research may favor a construction-oriented understanding of the notion “modeling” that incorporates modeling subject and modeling purpose as important term defining factors while positivists may argue for a pure representation-oriented understanding.

What does it mean to judge the outcome of conceptual modeling? This aspect of consideration refers to epistemological implications towards the evaluation methodology, i.e. as to how evaluation can be conducted. Positivists, for instance, may judge conceptual modeling quality by comparing a model or a modeling grammar against taxonomy of ‘real-world’ constructs in an ontology. Interpretive research rather argues for consensus-oriented approaches towards conceptual modeling, seeking an agreement on a model amongst a group of “experts”.

What does it mean to achieve quality in conceptual modeling? This aspect of consideration refers to epistemological implications towards the perception of quality. For positivist researchers, for instance, the quality of a modeling artefact may be determined through its compliance to reality, whereas in interpretive research, the perception of quality is subject- and purpose-oriented and needs to be agreed on in an accordant social community. Thus, a model is deemed of high quality, if a group of experts (or users) agrees on this statement.

Integrating these aspects of consideration with our epistemological framework, we can structure our forthcoming discussion as follows: Investigating the chosen approach of a particular epistemological school with respect to a particular epistemological question, we can identify a certain perspective unto our consideration aspects. We can thereby classify the BWW model in terms of its epistemological presuppositions and also identify epistemological implications, in particular towards our aspects of consideration.

3.2. Applying the Discussion Framework to the BWW Model

In identifying the epistemological presuppositions of the BWW model as the predominant representative of ontology-based theories for conceptual models, we reviewed and critically assessed the works and arguments of Wand and Weber and their colleagues in the past, see (Wand and Weber, 1988, 1989a,b, 1990a,b,c, 1993; Weber and Zhang, 1996; Wand and Weber, 1995; Weber, 1997b,a; Wand et al., 1999; Weber, 2003; Wand and Weber, 2004, 2006). As Wand and Weber were at times rather vague about their epistemological presuppositions, we feel the need to reason some of our discussion results, which are summarized in Table 3, and will do so in the following.

Ad 1 Wand and Weber take a both ontological and epistemological realistic position, believing that the world is made up of things that "really exist in the world" (Weber, 1997b, p. 34). This position is reasoned as follows: presuming a world of matters that exists independently of observers (Wand and Weber, 2006), conceptual models should faithfully describe domains of the real world. Conceptual

Table 3
Epistemological discussion of the BWW representation model and its premises

Epistemological aspect	Note	Position taken in the BWW approach
[*I*]		*Realism*
What is the object of cognition? (ontology)		Wand and Weber take an ontological realistic position, believing that the world is made up of things that "really exist in the world". See (Weber, 1997b, p. 34).
[*II*]	Ad 1	*Realism*
What is the relationship between cognition and the object of cognition? (epistemology *in a narrower sense*)		Wand and Weber take an epistemological realistic position as they seek to establish a relationship between conceptual modeling artifacts and reality, thereby defining formal schemes as suitable measures for eliminating subjective distortions. See (Wand and Weber, 1988, p. 214).
[*III*]		*Correspondence theory*
What is true cognition? (concept of truth)		The model notion utilized by Wand and Weber is that of a representation. In their program, a modeling artifact is valued as to its correspondence to a model of reality, which complies with the premises of the correspondence theory of truth. See (Klaus and Wyssusek, 2005, p. 336).
[*IV*]		*Rationalism*
Where does cognition originate?	Ad 2	Wand and Weber refer to the school of rationalism, presupposing that an object of cognition can be identified as such through the use of a differentiation system (i.e. the BWW model). Thereby, knowledge about conceptual models can be achieved by identifying their correspondence to the categories in the BWW model.
[*V*]		*Inductivism*
By what means can cognition be achieved? (methodology)	Ad 3	We conclude that the BWW program inherently deploys an inductive methodology by deriving statements about the general representation fidelity of a conceptual modeling artifact by mapping individual facets of it against a certain reference theory, i.e. the BWW model.

modeling provides the modeler with concepts to do so, which in its essence is an ontological question that is answered by the belief of realism. The means provided, however, need to be assessed as to whether they are sufficient for representing concepts in the real world. The BWW representation model defines the formal scheme with which such a comparison can be facilitated. Note that Weber (1997a) argued that the question of objective or subjective perception of reality (the epistemological aspect) does not really matter for the development of an ontology-based foundation for conceptual modeling but instead it is the question of whether or not someone

beliefs in the usefulness of a model of representation for setting the foundation for conceptual modeling activities. The demonstrated usefulness (Green and Rosemann, 2004) and the amounts of empirical evidence, e.g. (Bodart et al., 2001; Parsons and Cole, 2004; Gemino andWand, 2005; Bowen et al., 2006), which has been gathered on account of the BWW model appears to make a conclusive statement in favor of Wand and Weber's argument.

Ad 2 As Wand and Weber do not thoroughly explicate their epistemological stance we must try to derive their presuppositions based on their elaborations related to the BWW model. Here, we conclude that the idea of ontology-based foundations for conceptual modeling is based on synthetic, a prior knowledge about things in the world for the following reason. As Bunge, a philosopher dedicated to (dialectic) materialism, engineered his ontology in the tradition of rationalist philosophers like Aristotle, Leibniz, Descartes etc. he presupposes a given structure of ontological concepts in reality and thus in his model. In short, matter precedes thought. Following the schools of realism and rationalism, his ontological categories are derived independently from experience. In fact, Bunge (1979) stresses the incompatibility of his concept of science with other theories of cognition including empiricism. The BWW theory, being based upon Bunge's work, adheres to this view and uses a differentiation reference system, viz., the representation model as an articulation of concepts that scientists may refer to for conceiving real world domains.

Ad 3 We find that the epistemological question $[V]$ must, at the time of writing, better be left open to discussion. Nevertheless, we justify our favor for inductivism as follows. As Bunge himself was committed to (dialectic) materialism, a sibling to logical positivism, this scientific worldview holds that objective human knowledge is possible by means of scientific methods, viz. by means of using logic expressions it is possible to derive general truth from logical instances of truth. Furthermore, our investigation revealed that the BWW model relies at its core on a realistic paradigm, which, by itself, is traditionally associated with the method of inductive inquiry (Popper, 1959).

3.3. Discussing the Results

Having identified the epistemological presuppositions of the BWW model, we are able to discuss the implications of its epistemological stance with respect to the field of conceptual modeling, so we can provide some conclusive arguments on its scope and limits as a theoretical foundation for conceptual modeling. In the following, some implications of the identified epistemological stance are discussed with respect to the consideration aspects previously introduced, namely the implied perceptions of conceptual modeling, the understanding of how the goodness of a modeling phenomena can be judged and the perception of what constitutes quality in conceptual modeling.

In terms of the question what conceptual modeling actually is, following the paradigm of realism (Wand and Weber, 2006, p. 129), the universe of discourse (the modeled domain) comprises immutable objects and object structures that exist as empirical entities. Consequently, models of the universe of discourse exist in their essence independently from any observer's perception. Therefore, a conceptual model is a descriptive representation of the universe of discourse, i.e., the modeled real world domain. The model perception is more that of a reproduction or representation rather than that of a (re-) construction. A conceptual model can, following this perception, be seen as a perspective upon reality through which observers can perceive reality (relatively unbiased), independent from whether the conceptual model describes an existing or a future reality (for instance, in the form of an information system to be built).

With respect to the question of how the goodness of conceptual modeling and associated artifacts can be measured, according to the chosen epistemological presuppositions, the theoretical

foundation of conceptual models in its essence refers to an investigation of how well a modeling artifacts faithfully and accurately describes objects in real-world domains. The BWW representation model hereby serves as a reference differentiation system for evaluation. Following the correspondence theory of truth (Tarski, 1944), the BWW model can be seen as a fact statement that is assumed to be an appropriate set of beliefs about real world domains. The theoretical foundation of models in the sense of using the BWW model for evaluating the goodness of a representation is then a structural analysis of analogies and dissimilarities between constructs of the conceptual modeling artifact in question (such as, for instance, the elements contained in a grammar or script) and ontology constructs as defined in the BWW model, thereby determining statements in the model under observation which do or do not correspond to the statements of the BWW model. These, themselves are founded on the assumption that Bunge's original set of categories is an appropriate set of beliefs about real-world domains. Whether or not the set of categories contained in the BWW model is in fact appropriate, must be considered an unanswered question. Milton (2007), for instance, notes that Bunge's ontology has difficulty in representing purposeful human action. Future work may investigate whether sets of categories different from the ones used in the BWW program may be more suitable to contemporary conceptual modeling. At the time being, however, Wand and Weber (2006) rightfully concede (p. 130) that the extensive amount of empirical work on basis of the BWW set of models provides convincing evidence to support the assumption that their set of categories would appear adequate to judge conceptual modeling.

4. Contributions & Conclusions

Our research demonstrated the usefulness of a structured discussion of epistemological presuppositions of research approaches. In order to be able to fully comprehend any given research context, assumptions underlying any research method, approach or theory should be thoroughly explicated. This paper presented an epistemological framework that can be used to provide more epistemological rigor in IS research by explicating several presuppositions that pose, in our case, several implications towards the scope, limits and boundaries of approaches for the foundation of conceptual modeling. Our investigation focused the domain of philosophical ontology for the task of providing a theoretical foundation for conceptual modeling, using the example of the well-known BWW representation model. The application of our framework to this ontology-based theory revealed the epistemological stance underlying the BWW approach and identified some implications towards how the authors of this theory understand phenomena nominally ascribed to conceptual modeling, such as the act of modeling, the quality of modeling or its results.

Resulting from this research, we want to raise awareness for more epistemological rigor in IS research. IS research in general demands more care as to epistemological presuppositions of research context, theory and method. We want to stress the guideline for IS researchers to thoroughly explicate their epistemological stance clearly during all research process and progress, not only during the creation of research artifacts but also during the evaluation of those. IS researchers should maneuver more carefully through available theories and methods both for artifact development and validation to select appropriate, i.e. epistemologically compliant approaches within their research context. The framework presented in this paper can be used as a guideline towards answering this question. It provides a set of aspects that can guide researchers in becoming aware, understanding and making explicit the set of beliefs underlying their research work, i.e. to become more reflexive and critical of the scope and limits of their own and others' work.

Further conclusions can be drawn as to the scope and limits of ontology-based theories for conceptual modeling. Ontology-based theories rely at their core on the premise of a real world, immutable and incontrovertible, which is to some extent represented by information systems and in conceptual models of these systems. Following this belief models should provide "good" (i.e. faithful and accurate) representations, with this goodness being evaluated through a modeling artifact's correspondence to a description of the real-world domain that is sought to be represented.

Does this mean that arbiters of the BWW program necessarily share its very same epistemological commitment? We think not. We believe that the use of the BWW model does not inevitably prescribe an ontological commitment to those who use it. In fact, what is of importance is merely the fact that there is an ontological system that may be of use for defining and manifesting a set of concepts that is of pertinence to conceptual modeling of information systems and ultimately real-world domains. The BWW model serves as a reference description of real-world domains. Whether we perceive the world accordingly, is a question of cognitive psychology and should be answered before the background of this research discipline. Existing work, e.g. (Evermann, 2005; Siau and Tan, 2005; Veres and Mansson, 2005; Siau and Wang, 2007), has ventured in this direction and has certainly provided initial compelling and stimulating insights into this area.

Consequently, the validity, usability, appropriateness or effectiveness of a chosen set of ontological concepts is not affected by an underlying epistemological commitment but is rather subject to the verdict of empirical methods on basis of the theory. Only empirical research can establish whether the set of categorical beliefs about real-world domains, as captured, for instance, in the BWW model, does in fact align or comply with modelers' perceptions of reality. The choice of empirical methods should be in accordance with such a research target. While we have not yet encountered a great deal of interpretive or qualitative empirical work on the basis of the BWW representation model, we certainly deem this an interesting endeavor to pursue. In fact, in earlier work (Recker, 2005) we provided a first description of how qualitative research could be used in combination with ontology-based theories for conceptual modeling.

A second fruitful stream of research could investigate whether one set of categories would be more adequate to describe real-world domains than others. Some work has been carried out in comparing the BWW model with the Chisholm ontology (Davies et al., 2005). Similar work could be carried out to compare these ontologies with the one suggested by Guizzardi (2005). Since Milton (2007) as well as Guarino and Guizzardi (2006) note that the epistemological positions underlying their programs are different fromWand andWeber's, our framework can be used to explicate and compare these positions and to tease out the implications of the differences. As such, our discussion aids in explicating implicit assumptions underlying different conceptual modeling programs. As such, it provides a useful starting point for these endeavors and we would like to invite our colleagues to join us in this challenge. Yet, we would like to stress that our framework does not strive (nor is it intended to do so) to judge a theory in terms of its appropriateness or validity. Such judgment should, as Wand and Weber (2006) themselves concede (p.136), rather depend on the merits that a theory has for understanding, predicting, analyzing or designing its relevant domain. The insights that ontology-based theories have provided to the domain of conceptual modeling can hardly be neglected - even amongst critics, see, for instance, (Lyytinen, 2006, p. 82), is this undisputed. The BWW program, similar to other ontology-based programs, has provided ample empirical support for its usefulness. Maybe it would be wise to simply acknowledge this and to move on towards gaining insights into phenomena ascribed to conceptual modeling that ontology-based theories cannot provide - for

instance, how social action based on modeling is enabled, how cognitive factors affect the act of modeling, or how contextual influences shape conceptual modeling outcomes, to name just a few.

As a concluding remark we would like to point to the theory of methodological pragmatism (Rescher, 1973), which suggests that theories and methods that are more effective in achieving their objectives will be adopted in favor of others. Rescher's concept of "rational selection" predicts that more effective theories are more likely to "survive". Maybe it is of benefit to adopt this relaxed, pragmatic viewpoint. The main claim of pragmatism is that the worth of a proposition, theory or model is to be judged by the consequences of accepting it (Wicks and Freeman, 1998). Basically, the tenet of pragmatism is that any picture, theory or model is good or true or valuable if and only if it is useful - in the sense of helping people to fulfill a given need. Hence, the final judgment on ontology-based theories for conceptual modeling should be based on whether it is in fact helpful for IS researchers (which can only mean that it would be fruitful in generating testable propositions and hypotheses about conceptual modeling phenomena), while the ultimate test will be whether colleagues and students still be talking about these ideas the future.

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