On Ontological Foundations of Conceptual Modelling

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Abstract. Failures in information systems development have frequently been attributed to the application of insufficient or faulty information systems development methods. Some of these methods are concerned with the creation of conceptual models, which are used for multiple purposes throughout the information systems development process. Criticism of conceptual modelling methods usually targets their lacking of theoretical foundations. In response to such criticism, various approaches towards theoretical foundations of conceptual modelling have been proposed. They can be differentiated by the reference disciplines they are drawing on. Though the relevance of the philosophical discipline ontology for data modelling had already been recognised in the late 1950s, approaches that have been built on ontology are a rather recent phenomenon. It was not before 1986 that Wand and Weber commenced working on an ontological foundation of conceptual modelling—drawing on the scientific ontology by Mario Bunge, thus later named Bunge-Wand-Weber (BWW) ontology. Twenty years after its inception, claims regarding the validity of theoretical foundations of conceptual modelling based on the BWW ontology have not been scrutinised yet. In an attempt to open up a debate, a critical review of the BWW ontology and its application in the context of theoretical foundations of conceptual modelling is being offered.

Key words: conceptual modelling, ontology, Bunge-Wand-Weber ontology.

1 Introduction

In developing information systems, conceptual modelling and conceptual models are among the most fundamental means. Both the task of “conceptual modelling” and its outcome, “conceptual models”, fulfill multiple purposes throughout the entire information system development process (e.g., Kung and Sølvberg 1986; Ashenhurst 1996). The importance attributed to conceptual modelling and conceptual models has not only given rise to a wide range of conceptual modelling methods, but also to the “yet another modelling approach (YAMA)” syndrome (Oei et al. 1982) and the “not another modelling approach” (NAMA) hysteria (Siau 2003, p. 107). What drives both the YAMA syndrome and the NAMA hysteria is the often observed impossibility to prove the advantages claimed for yet another modelling approach, since it may—like the approaches it aims to replace—be solely based on idiosyncratic intuitions and experiences of its developers (e.g., Siau 2003, p. 108). Consequently, such approaches have been criticised for their lack of theoretical foundations. Complementarily, the need for theoretical foundations of conceptual modelling methods in particular—and information systems development methods in general—has been claimed (e.g., Wand and Weber 1990a; Weber 2003; Siau 2003).

One of the more recent responses to the quest for theoretical foundations of conceptual modelling in information systems development is the reference to the philosophical discipline *ontology* (or, metaphysics). Traditionally, ontology holds the promise of the most general knowledge—an insight that motivated McCarthy and Hayes (1969, p. 469) to call for “metaphysically adequate modeling” of the world. Judged by the relative number of publications, the currently most prominent of diverse approaches towards ontological foundations of conceptual modelling in information systems development appears to be the so-called Bunge-Wand-Weber (BWW) ontology (e.g., Wand and Weber 1988). So far, claims made for the validity of the BWW ontology have not been subjected to critical evaluation. The 20th anniversary of the BWW ontology motivates a careful reconsideration whether ontological approaches to foundations of conceptual modelling are feasible and defensible. The following essay is an attempt to open up this debate. It is structured as follows: First, we follow up the development of conceptual modelling and trace the quest for its theoretical foundation. The currently strongest theoretical impact is being attributed to ontological approaches, with the BWW ontology singled out. Second, to investigate the transposition from a scientific ontology to an ontology for conceptual modelling, we present the salient assumptions underlying Bunge’s ontology, which is the philosophical source of the Bunge-Wand-

Weber ontology. Third, we recount the adaptation of Bunge's ontology by Wand and Weber, and conclude by questioning the overall project of ontological foundations of conceptual modelling.

2 The Roots of Conceptual Modelling and the Quest for Its Theoretical Foundation

Methodical information systems development is a process consisting of successive phases, and a variety of conceptual modelling methods may be used throughout the process. Even if nowadays conceptual modelling is generally considered to be a most fundamental means in information systems development, the development of conceptual modelling only began around the year 1960 in a number of computing-related domains (e.g., Brodie et al. 1984; Hull and King 1987; Mylopoulos 1998)

In *artificial intelligence* it was the need for knowledge representations that eventually led to the development of conceptual modelling. Based on findings from cognitive science, it has been assumed that the mind stores abstract knowledge in so-called "concepts" and "conceptual structures" (e.g., Schank 1975). Conceptual modelling, understood as the modelling of concepts and conceptual structures, would thus be the most natural way to represent conceptual knowledge. Yet the representation of the postulated concepts and conceptual structures requires its own abstract concepts. "Scripts" (Schank and Abelson 1977), "frames" (Minsky 1975), and "semantic networks" (Quillian 1968) are such abstract concepts employed by conceptual modelling methods for the purpose of knowledge representation.

In *systems analysis* the development of conceptual modelling was motivated by the need to represent an information processing problem independently from the implementation of an eventual solution (e.g., Young and Kent 1958). What does this mean? Obviously, before the development of conceptual modelling in (business-oriented) systems analysis, the description of an information processing problem would have been a specification of an implementation of a solution to the problem. Even if such a specification is an important intermediate goal within the information systems development process, it should not be created during problem analysis, since a problem analysis in terms of an implementation of a solution to the problem has some severe disadvantages: First, only the currently technically feasible will be considered during analysis. Second, the focus on the determination of *how* functions should be implemented distracts from the determination of *what* functions should be implemented. Third, already during problem analysis detailed knowledge of the implementation technology is required. Fourth, the focus on implementation details hinders the communication with non-technical stakeholders such as users. Fifth, the evaluation of alternative implementations may be impossible due to the idiosyncratic character of their descriptions. Since information systems are built to solve the users' problems, a description of an information processing problem should be prepared in terms of the users' domain. With other words, the information processing problem of the users should be described with words (referring to concepts) that are commonly used by the users when they conceptualise and talk about the problem. Conceptual modelling methods eventually provided the means to do so (e.g., Ross 1977).

Similarly, in *database development* the traditional focus on aspects of the implementation of data models led not only to problems with respect to the portability of data models, but also with respect to the communication between users and developers. On the one hand, developers of databases had to design databases in terms of some given database management system. Without any layer of abstraction, the database description was highly specific and bound to the respective database management system. The logic of the database was merged with the logic of database management system, and sometimes even with the physical structure of the data storage hardware. On the other hand, data(base) descriptions in terms of database management systems rendered these descriptions meaningless to everyone not familiar with the technical details of those systems. Thus, the development of conceptual modelling in database development served at least two goals: (1) Enabling the description of data and data structures at a level of abstraction that renders them meaningful to system analysts and users. (2) Enabling database developers to specify databases independent from the technical details of a specific database management system. This independency not only allows the portability of databases between different database management systems, but also relieves the database developer from the need to know and understand the technical details of database management systems, making the development process more efficient. Conceptual modelling methods eventually provided the means to develop models that would be abstract enough to be independent from their technical implementation, and semantically rich enough to be comprehensible for the relevant parties involved (e.g., Chen 1976; Hull and King 1987).

The evolution of *programming languages* in particular and *human-computer interaction* in general seems to have followed a common path: moving away from techno-centrism of machine languages (also in a transitive sense covering user interfaces) towards anthropo-centrism of higher-level languages (e.g., Feigenbaum 1996). In the early days of computing, information processing problems had to be stated in a language the vocabulary of which referred to rather technical concepts belonging to the realm of the machine. With every new generation of programming languages, the concepts referred to were closer to the problem domains of the users. Domain-specific programming languages are already very close to natural language, allowing the users to state their problems in terms of the respective problem domain. Similarly, the improvement of the graphical capabilities of computers made dramatic changes in human-computer interaction possible. Powerful metaphors such as "desktop", "folder", and "spreadsheet" allow users to interact with computers by means of familiar concepts—without the traditionally required translation from the language of the problem domain to the machine language 'understood' by the computer. Hence, "conceptual" and "concept" refer to the concepts that have to be used by users and developers when interacting with computers. Nowadays, high-level programming languages and the design of human-computer interaction refer to and make use of concepts that are rooted in the domain of application, and not in the technical domain of computers.

Summing up, the development of conceptual modelling was driven by the need to represent conceptual knowledge in a form that is (1) adequate to the task at hand, (2) comprehensible for all parties involved in the development *and* use of these representations, and (3) independent from the eventual technical realisation of the representation.

Criticism of conceptual modelling methods usually targets their lacking of theoretical foundations (e.g., Siau and Rossi 1998; Weber 2003). Even if critics rarely explain why they believe a theoretical foundation would improve the practice of conceptual modelling, or, what they mean by "theoretical foundations of conceptual modelling", it appears that most critics implicitly or explicitly question the justification for the semantics of the elements of the respective conceptual modelling language (a.k.a. "modelling grammar"). For example, Siau (2003, p. 108) laments: "Despite the importance of modeling constructs, not much research has been done in this area. Most modeling constructs are introduced based on common sense, superficial observation, and the intuition of researchers and practitioners." Thus, the quest for theoretical foundations of conceptual modelling is bound to a certain outlook on knowledge. It is driven by the belief that non-theoretical knowledge, i.e., knowledge that does not meet the standard set by the scientific worldview (scientism) (e.g., Bunge 1983b, pp. 258–271), is insufficient for good practice, or, for the improvement of practice.

In response to the criticism, various approaches towards theoretical foundations of conceptual modelling have been proposed. The approaches can be distinguished by the disciplines from which they received their inspiration and borrowed their fundamental concepts and theories. Popular source disciplines are cognitive psychology and cognitive science (e.g., Siau 2003; Evermann 2005), semiotics (e.g., Stamper 1997), ontology (e.g., Wand and Weber 1988; Guizzardi, Herre and Wagner 2002), and linguistics (e.g., Goldkuhl and Lyytinen 1982).

3 The Ontology of Mario Bunge

Bunge's main work on ontology is part of his eight volume "Treatise on Basic Philosophy", in which he sought to cover comprehensively and rigorously traditional fields of philosophical investigation, such as semantics (Bunge 1974b; 1974c), ontology (Bunge 1977; 1979), epistemology and methodology (Bunge 1983a; 1983b; 1983c; 1985), and ethics (Bunge 1989). Covering two volumes of the treatise, it is impossible to give a detailed account of his ontology. Rather, the following expands the principal assumptions of Bunge's ontology with a view on its epistemological implications, and its explicit concept of science and philosophy at large. This will help to demonstrate that these assumptions are not lofty speculations that can be safely cast aside in both theory and practice of conceptual modelling. They determine the claims that are being made for the validity and significance of ontological foundations of conceptual modelling. Consequently, these assumptions eventually also determine how conceptual modelling is methodically organised and how it is performed.

Bunge is committed to dialectical materialism (Bunge 1977, p. 5), which is an offspring of the materialism of the 19th century and a philosophical doctrine developed by Engels (1940), and later by Lenin (1927) (for an overview see, e.g., Lichtheim 1973). Materialism explains the world as being constituted ultimately by matter. In our era, its ontological correlate is realism and its epistemological is objectivism (or, scientific realism) (Bunge 1983b, pp. 264–267). Dialectics refers to the overall dynamics of matter, which is conceived of as akin to a debate in ancient Greece: antagonistic forces (thesis and antithesis) are in contention, out of which emerges a higher force (synthesis) that overcomes the contradictory state of the former. According to that, Bunge claims that the real world, i.e., the material world, exists independent from our knowledge (Bunge 1993, p. 229). His scientific worldview, i.e., scientism (e.g., Bunge 1983b, pp. 258–271), also holds that objective human knowledge is possible, since—as far as it is based on scientific methods—it represents the real world (Bunge 1993, p. 233). Hence, truth is possible, but only by means of science, as the scientific method is the only way to obtain truth (Bunge 1993, p. 231). From that follows that truth must find its expression in the languages of science, which are logic and mathematics (Bunge 1977, p. 7). Statements, to be valid, need to be transformed into symbols ruled by logic. Thus he claims: "Unless a construct is assigned a definite mathematical status […] it is not exact and may be a fake, i.e. a *flatus vocis* rather than a genuine concept" (Bunge 1977, pp. 8–9). Bunge stresses the incompatibility of his concept of science with other theories of cognition, such as empiricism and phenomenalism. He holds that science is non-phenomenological, i.e., science "attempts to account for reality behind appearance" (Bunge 1979, p. 147), and that although "phenomena […] are experientially immediate, […] they are neither ontologically or scientifically primary" (Bunge 1979, p. 147).

The position of the human being within this worldview implies that there is only one way left to come to fundamental statements about world. Materialism means that "*res cogitans is a res extensa*" (Bunge 1979, p. 146). In other words, since matter is all that is, and this is accessible to science directed towards that matter, including the human being, all other attempts at knowledge are void, including so-called non-scientific philosophical knowledge. From that follows the determination of ontology as "general science" and that its task is to "stake out the main traits of the real world as known through science" (Bunge 1977, p. 5). Bunge thus emphasises: "[I]t is not true that ontology has become impossible after the birth of modern science. What has become impossible *de jure*—though unfortunately not *de facto*—is nonscientific ontology" (Bunge 1977, p. 7). The historically primal domain of philosophy in this way becomes a secondary domain of scientific activity. In Bunge's terms, ontology is an *a posteriori science* (Bunge 1977, p. 8), and thus nothing external to science. It draws together the diverse disciplines and their projections of world into a coherent whole: "A complete ontology should include both universal and regional ontological theories. The former serve as frameworks for the latter, which will in turn illustrate and in a way test the former" (Bunge 1977, p. 11).

The coherent whole is being constituted by means of formal logic. "Formal science, or at least some of it, constitutes both the language and the formal skeleton of scientific ontology. In particular, scientific ontology presupposes abstract mathematics, including deductive logic" (Bunge 1977, p. 13). This unifying view is ontological theory that "is a theory that contains and interrelates ontological categories, or generic concepts representing components or features of the world" and that "is a [hypothetical deductive] system, not just a set, of interrelated ontological categories" (Bunge 1977, p. 11). Bunge's largely formalised ontology, imbued with abstractions and formal logic, suggests its proximity to formal and semi-formal symbolic or conceptual modelling: "Theoretical science and ontology handle not concrete things but concepts of such, in particular conceptual schemata sometimes called *model things*" (Bunge 1977, p. 119).

In sharp contrast to Bunge's claims to a scientific ontology only obliged to reason and logic is his rather disquieting polemic against any other conceptions of philosophy and science. For example, for Bunge, opposing philosophical schools must be based on irrational motives: Subjectivists are not able to differentiate between a model and what the model is about, hence subjectivists suffer from "a form of mental derangement" (Bunge 1977, p. 121). This implies that any deviation from Bunge's doctrine, especially from realism and objectivism, is unworthy of any serious consideration; even more, anything else cannot be simply erroneous, it can only be explained out of a person's mental insanity.

4 The Adaptation of Bunge's Ontology by Wand and Weber

In the year 1986 Weber spent a sabbatical at University of British Columbia, where Wand held a position at the same time. Wand and Weber shared a common interest in some fundamental issues of information systems development. Understanding an information system as "a human-created representation of a real-world system as perceived by somebody", and understanding the process of information system development as "a transformation from human perceptions to an artifact representing these perceptions" (Wand and Weber 1990c, p. 125), they came up with the following fundamental question that would guide their joint work for many years: "Given a user's or a group's conception of the real world, under what conditions would an information system provide a good or a poor representation of this conception?" (Weber 1997a, pp. xi, 73). Weber explains further: "In short, the phenomena we concluded we might seek to explain were (a) the conditions under which users of information systems would deem them to be 'good' representations of their conception of the real world, and (b) the conditions under which users of information systems would deem them to be 'poor' representations of their conception of the real world" (Weber 1997a, p. 72). "Wand and I are simply trying to provide a way of representing humans' perceptions of their worlds. Whether these perceptions map to an independent reality or whether they manifest a social construction is neither here nor there" (Weber 1997a, p. 176). With other words, Wand and Weber have been interested in the quality of the mapping between information system users' conceptualisations of the real world and the representations of these conceptualisations in the information system. They have not been interested in the quality of the mapping between the "real world" and the users' conceptualisations of the "real world" (see also Wand and Wang 1996, p. 88).

On the occasion of his sabbatical, it happened that Weber had an office next to Mattessich, a renowned accounting researcher and philosopher of science (e.g., Mattessich 1978). Once, Weber asked Mattessich the following question: "[W]hat were the set of generic constructs that people employ to structure their conceptions of the world?" Mattessich handed Weber the Treatise by Bunge (Weber 1997a, p. 73)[1]. Subsequently Weber "discovered theoretical foundations that excited [Weber] in terms of their implications for information systems. When [Weber] showed the contents of Volume 3 [i.e., Bunge 1977] to [Wand], [Wand] too concluded they had important implications for theory in the information systems discipline" (Weber 1997a, p. xi). In various accounts Wand and Weber describe the appeal and their motivation for their use of Bunge's ontology as follows:

- "We turned […] to Mario Bunge's *Ontology* in order to obtain the formal foundation for modelling information systems" (Wand and Weber 1990c, p. 124).
- Bunge's "*Ontology* was used for three purposes: first, as a point of view, and as a source of some fundamental propositions; second, as a source for basic constructs to be applied to modelling information systems; and third, as a source of notation for the model" (Wand and Weber 1990c, p. 146).
- Bunge's "Ontology was chosen because its objective is to describe the structure of the real world" (Wand and Weber 1988, p. 214).
- "Bunge's ontology attracted us because many concepts he examines are directly applicable to the information-systems and computer-science domains" (Wand and Weber 1990b, p. 63).
- "We chose to employ, adapt and extend Bunge's ontology for several reasons. First, in our view his ontology is better developed and better formalized than any we have encountered so far. […] Second, Bunge models the world as a world of systems. Thus, he is concerned with concepts that are fundamental to the computer science and information system domains. […] Third, we believe we have been able to use Bunge's ontology to obtain useful theoretical and practical results" (Wand and Weber 1993, pp. 220–221).
- "We have chosen to work with Bunge's ontology because it deals directly with concepts relevant to the information systems and computer science domains (e.g. systems, subsystems and couplings). Moreover, Bunge's ontology is better developed and better formalized than any others we have encountered" (Wand and Weber 1995, p. 209).

- "I have chosen Bunge's work to explicate the notion of a system for two reasons. First, while I am not a philosopher, in my view it is the best formulated and most complete theory of ontology that I have been able to find […]. Bunge has strived to make his theory clear and exact by articulating his constructs via mathematics. Second, Bunge (1977, p. 24) [claims]: 'Metaphysics can render service by analyzing fashionable but obscure notions such as those of system, hierarchy, structure, event, information,....'" (Weber 1997a, p. 33).
- "We chose [Bunge's] work for several reasons. First, it is oriented towards systems. Second, it is intended to deal with a wide range of systems, from physical to social. Third, it is well formalized, both in defining the concepts and outlining the premises and in providing a consistent notation. Finally, it draws upon an extensive body of prior work related to ontology" (Wand et al. 1995, p. 287).
- "I have used Bunge's theory because it articulates constructs and relationships that appear useful in the information systems and computer science disciplines. For instance, Bunge's theory is framed in terms of constructs like thing, property of a thing, law, state, event, coupling, system, and level structure. Moreover, I have yet to find an ontological theory that matches Bunge's in terms of clarity, precision, and formality" (Weber 2003, p. 3).

Summarising the above statements, it can be said that—after Mattessich pointed them to Bunge's work—Wand and Weber have been using Bunge's ontology because: (a) it uses a familiar terminology and deals with notions such as "system," "subsystem," and "event," which are most relevant to conceptual modelling in information systems; (b) it is to a large extent formalised; (c) it comes with formalisms and notations that can be re-used; (d) it appears to be a highly developed work in ontology; (e) its application has provided Wand and Weber with valuable insights. Comparing the preceding section on Bunge's ontology with the paragraphs above, it becomes obvious that Wand and Weber proceeded in a reductionistic fashion when they adapted Bunge's ontology.

First, Wand and Weber's justification of their adaptation of Bunge's ontology lacks the ontological commitment that makes Bunge's ontology what it is: a dialectical materialist, hence a realist ontology. The only reasonable justification for choosing such an ontology should read: "We have chosen Bunge's ontology because we believe in dialectical materialism". Without such an ontological commitment any reference to Bunge's ontology is void. Wand and Weber's adaptation of Bunge's ontology as an essentially formal theory, i.e., a theory relating concepts that do not have a "factual reference", (e.g., Bunge

1974b, pp. 37–42)), hence not as a formalised ontological theory in the sense of Bunge, contributed substantially to their ability to use Bunge's ontology for the ontological foundation of conceptual modelling. Having freed the ontological theory from its ontological commitment, Wand and Weber adapted, among others, the following ontological constructs: "system", "subsystem", "thing", "property", "law", and "state" (e.g., Weber 1997a, pp. 33–54). Yet without ontological commitment, those constructs are no longer ontological.

Second, focusing on familiar terminology and formalisation, Wand and Weber transferred the *formalisms*, i.e., mostly logic and set theory, as well as the respective *terminology* from the domain of scientific ontology to the domain of conceptual modelling. However, terminology and formalisms are only accidental to ontology, meaning that a particular ontology can be expressed using different terminologies and formalisms: "[A] mathematical formalism is by itself neutral with respect to matters of fact. So, unless the formalism is 'read' in factual terms, it will 'say' nothing about reality. […] [T]he mathematical formalism becomes a factual theory, or rather one of a number of possible factual theories with the same underlying formalism, if the suitable factual interpretation is supplied" (Bunge 1974b, pp. 104–105). Thus, without ontological commitment, the borrowing of constructs, formalisms, and terminology boils down to using Bunge's ontology as a language (Bunge 1974b, pp. 18–19).

Third, Wand and Weber apparently understood (Bunge's) ontology in terms of conceptual modelling: "As Wand and I read Bunge's work, however, we realized that a number of researchers within the information systems and computer science fields unknowingly had been working on ontological questions. These researchers had been working in the area that is usually called 'conceptual modeling' or 'semantic data modeling' (see, e.g., Hull and King 1987). Like the ontological researchers in philosophy, they, too, were concerned with how humans structure their conceptions of the world" (Weber 1997a, p. 73)[2]. The latter claim is obviously at variance with (not only) Bunge's understanding of ontology, since ontology *is not* "concerned with how humans structure their conceptions of the world". Rather, ontology is concerned with "concrete objects" (Bunge 1977, p. 6). Concepts, however, are not concrete objects. They "are fictions […]. Hence they are not part of the real world even when they take part in our representations of the latter" (Bunge 1977, p. 118). "The investigation of the patterns of representation […] belongs to psychology, epistemology and methodology" (Bunge 1974b, p. 104) – but, for obvious reasons, *not* to ontology.

Fourth, on the one hand, Wand and Weber were obviously very impressed by Bunge's work. On the other hand, they not only ignored the larger part of it, but also the, for conceptual modelling, most relevant parts. For example, Bunge devoted an entire chapter to conceptual representation and issues of conceptual modelling (Bunge 1974b, pp. 83–114). Bunge (1983a, pp. 129–198) also addressed comprehensively matters of "perceiving" and "conceiving".

5 Conclusion

The preceding discussion, even when limited in scope, has demonstrated that the project of developing theoretical foundations of conceptual modelling on the basis of philosophical ontology is neither feasible nor defensible. Yet, this conclusion does not mean that Wand and Weber's work has been erroneous. Rather the project of ontology-based conceptual modelling appears to be impossible in principle. As Bunge made clear, ontology is a response to ontological questions. However, questions regarding our conceptualisations are not ontological question. Conclusively, Wand and Weber, being concerned with theoretical foundations of conceptual modelling, asked the right question. But they failed to recognise that ontology is not and cannot be the answer. This has not only gone apparently unnoticed up until now, but rather ontology-based modelling is an expanding area of theoretical research and publication within the domain of systems analysis and design. Following Klein and Lyytinen (1985), this may be attributed to one of the traits of scientism, namely its inability to reflect on its own presuppositions and limitations – as exhibited most clearly by the following quote: "[W]e can clearly debate [the] relative merits [of alternative ontologies] at a philosophical level, but I suspect it will be more productive if we focus instead on how well they inform conceptual modelling practice and the design of conceptual modelling grammars" (Weber 2003, p. 15). With the lack of critical reflection combined with the institutional bias and dominance of scientism, dysfunctional discourses are bound to prosper. The empirical analysis of how Wand and Weber's foundational work became adopted and diffused—despite its fundamental misconceptions—remains a task to be addressed in a separate publication.

Notes

1. Accounts of this event vary. According to one account, Mattessich handed the entire Treatise: "During a discussion with [Mattessich] one day about my research interests, he suggested I read Mario Bunge's work. I gulped when he handed me the [then] seven volumes of Bunge's *Treatise on Basic Philosophy*.

I made a start, however, and in Volume 3 of the Treatise I discovered theoretical foundations that excited me in terms of their implications for information systems" (Weber 1997a, p. xi). According to another account, Mattessich provided Weber with just the two volumes on ontology (i.e., Bunge 1977; 1979) (Weber 1997a, p. 73). Nevertheless, whenever Wand and / or Weber explain why they have "selected" or "chosen" Bunge's ontology one has to be careful with the interpretation of these terms: First, according to the accounts provided by Wand and Weber, they did not actively look for an ontological theory, since they had no idea that such a theory might be relevant for their work. Second, they never published a comparison of different ontologies. References to other ontologies are made only superficially, i.e., Wand and Weber do not refer to a particular alternative ontological theory. Given this evidence one might conclude that a *selection* – in the literal meaning of the word – did not take place.

2. Wand and Weber do not provide convincing examples of these "ontological questions". Especially when we look at the following sample of ontological questions provided by Bunge (1977, p. 1), it is difficult to imagine what ontological questions the conceptual modelers are concerned with: "Ontological (or metaphysical) views are answers to ontological questions. And ontological (or metaphysical) questions are questions with an extremely wide scope, such as 'Is the world material or ideal – or perhaps neutral?', 'Is there radical novelty, and if so how does it come about?', 'Is there objective chance or just an appearance of such due to human ignorance?', 'How is the mental related to the physical?', 'Is a community anything but the set of its members?', and 'Are there laws of history?'"

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References

Ashenhurst, R. L., "Ontological aspects of information modeling," *Minds and Machines*, (6:3), 1996, pp. 287–394.

Brodie, M. L., Mylopoulos, J. and Schmidt, J. W. (eds.), *On Conceptual Modelling: Perspectives from Artificial Intelligence, Databases, and Programming Languages*, Springer, New York, 1984.

Bunge, M., *Method, Model and Matter*, Reidel, Dordrecht, 1973.

Bunge, M., "The relations of logic and semantics to ontology," *Journal of Philosophical Logic*, (3:3), 1974a, pp. 195–209.

Bunge, M., *Treatise On Basic Philosophy: Volume 1: Semantics I: Sense and Reference*, Reidel, Dordrecht, 1974b.

Bunge, M., *Treatise On Basic Philosophy: Volume 2: Semantics II: Interpretation and Truth*, Reidel, Dordrecht, 1974c.

Bunge, M., *Treatise On Basic Philosophy: Volume 3: Ontology I: The Furniture of the World*, Reidel, Dordrecht, 1977.

Bunge, M., *Treatise On Basic Philosophy: Volume 4: Ontology II: A World of Systems*, Reidel, Dordrecht, 1979.

Bunge, M., *Treatise on Basic Philosophy: Volume 5: Epistemology & Methodology I: Exploring the World*, Reidel, Dordrecht, 1983a.

Bunge, M., *Treatise on Basic Philosophy: Volume 6: Epistemology & Methodology II*. Reidel, Dordrecht, 1983b.

Bunge, M., *Treatise on Basic Philosophy: Volume 7: Epistemology & Methodology III. Part I*, Reidel, Dordrecht, 1983c.

Bunge, M., "Philosophical problems in linguistics," *Erkenntnis*, (21:2), 1984, pp. 107–173.

Bunge, M., *Treatise on Basic Philosophy: Volume 7: Epistemology & Methodology III. Part II*, Reidel, Dordrecht, 1985.

Bunge, M., *Treatise on Basic Philosophy: Volume 8: Ethics*, Reidel, Dordrecht, 1989.

Bunge, M., "Realism and antirealism in social science," *Theory and Decision*, (35:3), 1993, pp. 207–235.

Bunge, M., "Semiotic systems," in *Systems. New Paradigms for the Social Sciences*, G. Altmann and W. A. Koch (eds.), de Gruyter, Berlin, 1998, pp. 337–349.

Carnap, R., *Philosophical Foundations of Physics*, Basic Books, New York, 1966, chapters 23–26.

Chen, P. P., "The entity-relationship model – toward a unified view of data," *ACM Transactions on Database Systems*, (1:1), 1976, pp. 9–36

Engels, F., *Dialectics of Nature*, Lawrence and Wishart, London, 1940.

Evermann, J., "Towards a cognitive foundation for knowledge representation," *Information Systems Journal*, (15:2), 2005, pp. 147–178.

Feigenbaum, E. A., "How the 'what' becomes the 'how'," *Communications of the ACM*, (39:5), 1996, pp. 97–104.

Fettke, P., and Loos, P., "Ontological evaluation of reference models using the Bunge-Wand-Weber model," in *Proceedings of the Americas Conference on Information Systems*, Tampa, 2003, pp. 2944–2955.

Goldkuhl, G., and Lyytinen, K., "A language action view of information systems," in *Proceedings of the International Conference on Information Systems*, M. J. Ginzberg and C. A. Ross (eds.), Ann Arbor, 1982, pp. 13–29.

Green, P., Rosemann, M., and Indulska, M., "Ontological evaluation of enterprise systems interoperability using ebXML," *IEEE Transactions on Knowledge and Data Engineering*, (17:5), 2005, pp. 713–725.

Guizzardi, G., Herre, H., and Wagner, G., "On the general ontological foundations of conceptual modeling," in *Conceptual Modeling – ER 2002, 21st International Conference on Conceptual Modeling*, S. Spaccapietra, S. T. March and Y. Kambayashi (eds.), Springer, Berlin, 2002, pp. 65–78.

Hull, R., and King, R., "Semantic database modelling: survey, applications, and research issues," *ACM Computing Surveys*, (19:3), 1987, pp. 201–260.

Klein, H. K., and Lyytinen, K., "The poverty of scientism in information systems," in *Research Methods In Information Systems*, E. Mumford, R. A. Hirschheim, G. Fitzgerald, and T. Wood-Harper (eds.), Elsevier, Amsterdam, 1985, pp. 131–161.

Kung, C. H., and Sølvberg, A., "Activity modelling and behaviour modelling," in *Information Systems Design Methodologies: Improving the Practice*, T. W. Olle, H. G. Sol and A. A. Verrijn-Stuart (eds.), North-Holland, Amsterdam, 1986, pp. 145–171.

Lee, R. M., and Stamper, R. K., "Ontological aspects of logical databases," *Information Systems*, (10:3), 1985, pp. 331–338.

Lenin, V. I., *Materialism and Empirio-Criticism: Critical Notes Concerning a Reactionary Philosophy*, Lawrence and Wishart, London, 1927.

Lichtheim, G., "Historical and dialectical materialism," in *Dictionary of the History of Ideas, Volume 2*, P. P. Wiener (ed.), Charles Scribner's Sons, New York, 1973, pp. 450–456.

Mahner, M., and Bunge, M., *Foundations of Biophilosophy*, Springer, Berlin, 1997.

Mattessich, R., *Instrumental Reasoning and Systems Methodology: An Epistemology of the Applied and Social Sciences*, Reidel, Boston, 1978.

McCarthy, J., and Hayes, P., "Some philosophical problems from the standpoint of AI," in *Machine Intelligence 4*, B. Meltzer and D. Michie (eds.), Edinburgh University Press, Edinburgh, 1969, pp. 463–502.

Minsky, M., "A framework for representing knowledge," in *The Psychology of Computer Vision*, P. J. Winston (ed.), McGraw-Hill, New York, 1975, pp. 211–277.

Mylopoulos, J., "Information modeling in the time of the revolution," *Information Systems*, (23:3/4), 1998, pp. 127–155.

Mylopoulos, J., and Levesque, H. J., "An overview of knowledge representation," in *On Conceptual Modelling: Perspectives from Artificial Intelligence, Databases, and Programming Languages*, M. L. Brodie, J. Mylopoulos and J. W. Schmidt (eds.), Springer, New York, 1984, pp. 3–17.

Navathe, S., "Evolution of data modeling for databases," *Communications of the ACM*, (35:9), 1992, pp. 112–123.

Oei, J. L. H., Van Hemmen, L. J. G. T., Falkenberg, E., and Brinkkemper, S., *The Meta Model Hierarchy: A Framework for Information Systems Concepts and Techniques*, Technical Report No. 92-17, Department of Information Systems, University of Nijmegen, 1982.

Quillian, R. M., "Semantic memory," in *Semantic Information Processing*, M. Minsky (ed.), MIT Press, Cambridge, 1968, pp. 227–270.

Rohde, F., "An ontological evaluation of Jackson's system development model," *Australian Journal of Information Systems*, (2:2), 1995, pp. 77–87.

Ross, D., "Structured analysis: a language for communicating ideas," *IEEE Transactions on Software Engineering*, (3:1), 1977, pp. 16–34.

Schank, R. C., *Conceptual Information Processing*, Elsevier, New York, 1975.

Schank, R. C., and Abelson, R., *Scripts, Plans, Goals, and Understanding*, Erlbaum, Hillsdale, 1977.

Siau, K., "The psychology of information modeling," in *Advanced Topics in Database Research, Volume 1*, K. Siau, K. (ed.), Idea Group Publishing, Hershey, 2003, pp. 106–118.

Siau, K., and Rossi, M., "Evaluation of information modeling methods – a review," in *Proceedings of the Hawaii International Conference on System Sciences, Volume 5*, 1998, pp. 314–321.

Soffer, P., Golany, B., Dori, D., and Wand, Y., "Modelling off-the-shelf information systems requirements: an ontological approach," *Requirements Engineering*, (6:3), 2001, pp. 183–199.

Sølvberg, A., "A contribution to the definition of concepts for expressing users' information systems requirements," in *Entity-Relationship Approach to Systems Analysis and Design*, P. P. Chen (ed.), North-Holland, Amsterdam, 1980, pp. 381–402.

Stamper, R. K., "Organizational semiotics," in *Information Systems: An Emerging Discipline?*, J. Mingers and F. Stowell (eds.), McGraw-Hill, London, 1997, pp. 267–284.

Wand, Y., "Ontology as a foundation for meta-modelling and method engineering," *Information and Software Technology*, (38:4), 1996, 281–287.

Wand, Y., Monarchi, D. E., Parsons, J., and Woo, C. C., "Theoretical foundations for conceptual modeling in information systems development," *Decision Support Systems*, (15:4), 1995, pp. 285–304.

Wand, Y., and Wang, R. Y., "Anchoring data quality dimensions in ontological foundations," *Communications of the ACM*, (39:11), 1996, pp. 86–95.

Wand, Y., and Weber, R., "An ontological analysis of some fundamental information system concepts," in *Proceedings of the International Conference on Information Systems*, J. I. DeGross and M. H. Olson (eds.), Minneapolis, 1988, pp. 213–225.

Wand, Y., and Weber, R., "An ontological model of an information system," *IEEE Transactions on Software Engineering*, (16:11), 1990, pp. 1282–1292.

Wand, Y., and Weber, R., "Toward a theory of the deep structure of information systems," in *Proceedings of the International Conference on Information Systems*, J. I. DeGross, M. Alavi, and H. Oppelland (eds.), Copenhagen, 1990, pp. 61–71.

Wand, Y., and Weber, R., "Mario Bunge's ontology as a formal foundation for information systems concepts," in *Studies on* Mario Bunge's *Treatise*, P. Weingartner and G. J. W. Dorn (eds.), Rodopi, Amsterdam, 1990, pp. 123–149.

Wand, Y., and Weber, R., "On the ontological expressiveness of information systems analysis and design grammars," *Journal of Information Systems*, (3:4), 1993, pp. 217–237.

Wand, Y., and Weber, R., "On the deep structure of information systems," *Information Systems Journal*, (5:3), 1995, pp. 203–223.

Weber, R., *Ontological Foundations of Information Systems*, Coopers & Lybrand Research Methodology Monograph No. 4, Coopers & Lybrand, Melbourne, 1997a.

Weber, R., “The link between data modeling approaches and philosophical assumptions: a critique,” in *Proceedings of Americas Conference on Information Systems*, Indianapolis, 1997b.

Weber, R., “Conceptual modelling and ontology: possibilities and pitfalls,” *Journal of Database Management*, (14:3), 2003, pp. 1–20.

Wyssusek, B., and Klaus, H., “On the foundation of the ontological foundation of conceptual modeling grammars: the construction of the Bunge-Wand-Weber ontology,” in *Proceedings of the CAiSE ’05 Workshops, Vol. 2, First International Workshop on Philosophical Foundations of Information Systems Engineering*, J. Castro and E. Teniente (eds.), FEUP Edições, Porto, 2005, pp. 583–593.

Young, J. W., and Kent, H. K., “Abstract formulation of data processing problems,” *The Journal of Industrial Engineering*, (9:6), 1958, pp. 471–479.