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The Double Role of Ontologies in Information Science Research

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ABSTRACT

In philosophy, Ontology is the basic description of things in the world. In information science, an ontology refers to an engineering artifact, constituted by a specific vocabulary used to describe a certain reality. Ontologies have been proposed for validating both conceptual models and conceptual schemas. However, these roles are quite dissimilar. In this paper, we will show that ontologies can be better understood if we classify the different uses of the term as it appears in the literature. First we explain *Ontology* (with a capital O) as used in Philosophy. Then, we propose a differentiation between ontologies *of* information systems from ontologies *for* information systems. All three concepts have an important role in information science. We clarify the different meanings and uses of Ontology and ontologies through a comparison of the research by Wand & Weber and by Guarino in ontology-driven information systems. The contributions of this paper are twofold. First, it provides a better understanding of what ontologies are. Second, it explains the double role of ontologies in information science research.

Keywords: Ontologies, Modeling, Theory of Ontology

1. INTRODUCTION

Ontology is a basic description of things in the world. For philosophy, ontology is the "branch of metaphysics that concerns itself with what exists" (Blackburn, 1996 p.269). For computer and information sciences, an often cited definition of ontologies is that "an ontology refers to an engineering artifact, constituted by a specific vocabulary used to describe a certain reality, plus a set of explicit assumptions regarding the intended meaning of the vocabulary words" (Guarino, 1998).

Examining the recent work on ontologies published in a major information science journal, we can find on the one hand studies of the use of ontologies ***for*** information systems (Hyun Hee, 2005; Kabel, Hoog, Wielinga, & Anjewierden, 2004; Leroy & Chen, 2005) and research on ontologies ***of*** information systems (Holsapple & Joshi, 2004) on the other. In order to lay a strong foundation for research on ontologies in information science, it is necessary to clarify the two ways the term *ontology* is being used. We offer two points of distinction for information scientists. The first distinction deals with the creation of ontologies. What are the best methods to create representations of reality? How can we be sure that our ontologies are good? Among all the ontologies that may be created to describe the different aspects of reality, information scientists are particularly interested in ontologies that describe information systems, i.e., they are interested in what we call *ontologies **of** information systems*. These are ontologies that will support the validation of tools which are used to create conceptual models. The second distinction concerns the use of ontologies. From the set of all ontologies, we select those that have been captured in computational form and that may be used to generate or validate information system components. We call these *ontologies **for** information systems* (Figure 1). The different uses of the term by information science communities, having different connotations, may lead to confusion in the study and use of ontologies. In this paper, we will focus on these two distinctive meanings for ontologies.

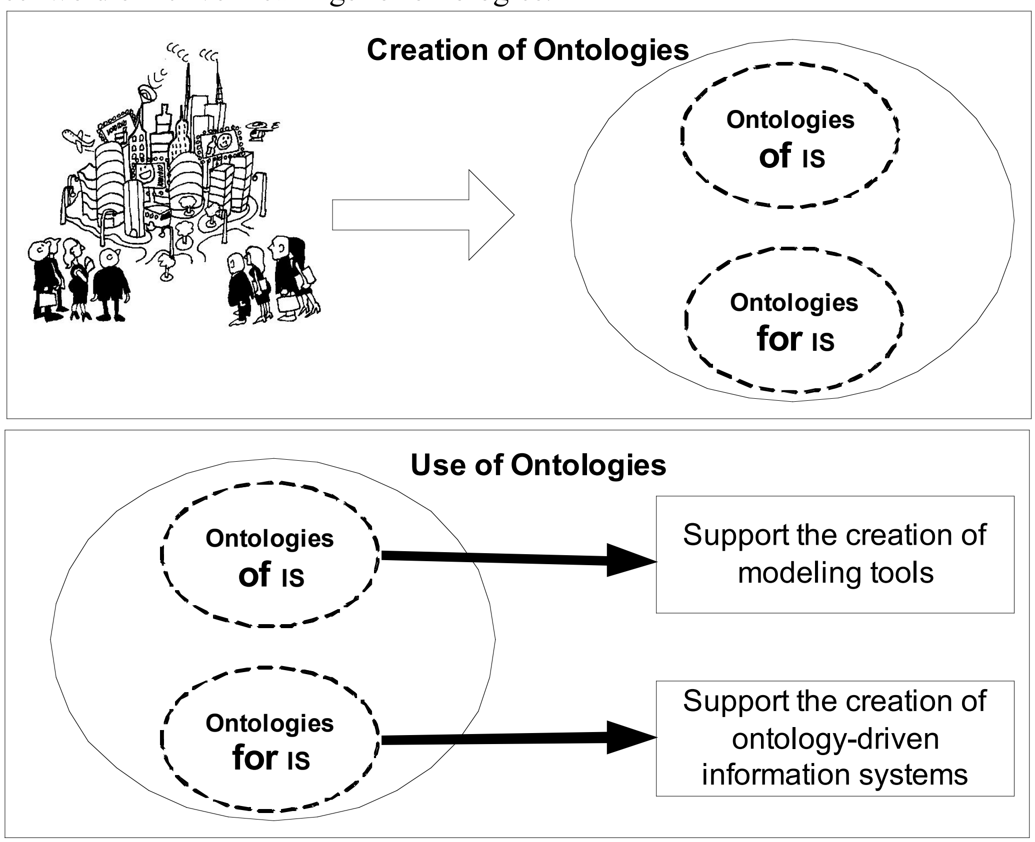

Figure 1 – Creation and use of ontologies

In order to understand the research on ontologies ***of*** information systems we reviewed the work of Wand and Weber (Wand & Weber, 1989; Wand & Weber, 1995; Wand & Weber, 2002, 2004; Wand & Weber, 1990; Weber, 1997) and Milton & Kazmierczak (Milton, 1998; Milton & Kazmierczak, 1999, 2004). Their work uses *Ontology* (with a capital O) applied to the understanding of the basic constructs of information systems. Ontology is used to model and reason about information systems at the conceptual level (as opposed to a specific information system at implementation time). This type of use concerns information systems in general and its purpose is to support the creation of conceptual modeling tools. To discuss the research on ontologies ***for*** information systems, we use the work of Guarino (1998). According to Guarino, an ontology is one of the components of the IS. This kind of ontology describes "the vocabulary related to a generic domain (like medicine, or automobiles) or a generic task or activity (like diagnosing or selling)"(Guarino, 1998). This type of use concerns a specific information system in particular and its purpose is to support the creation of conceptual schemas.

This paper is organized as follows. Sections 2 and 3 focus on the creation of ontologies, while sections 4, 5, and 6 discuss the use of ontologies. Specifically, section 2 discusses philosophic assumptions used in the creation of ontologies and models. Section 3 presents basic concepts about ontologies, as the term is used in information science, and about Ontology (singular, capital O) as a philosophical discipline. We also review the use of Ontology in conceptual frameworks for understanding modeling in IS. Section 4 explores the role that Ontology has for the development of information systems. Section 5 shows how we can think about our ontologies for IS as being theories, and how these ontologies will help us to build better information systems. In section 6, we draw a parallel between the process of creating ontologies (ontology engineering) and the activity of creating conceptual schemas (conceptual modeling). The comparison highlights the role of Ontology and ontologies in both processes. In the final section we offer our conclusions regarding the roles that Ontology and ontologies have in advancing research on information science.

The contributions of this paper are twofold. First, it provides a better understanding of what ontologies are. Second, it explains the difference between *ontologies* ***of*** *IS* and *ontologies* ***for*** *IS*, as well as the importance of each in the use and development of information systems. The clear distinction that we intend to make in this paper will help the advancement of the research on ontologies in information science. This is important for a field in which "we [have] barely begun to explore the implication of ontological theories for how we undertake conceptual modeling work" (Wand & Weber, 2004). We will explain (1) how ontologies *of* IS can support the creation of better modeling tools, and (2) how ontologies *for* IS can facilitate the design of better information systems.

2. HOW GOOD ARE OUR ONTOLOGIES?

A good starting point in discovering the different meanings of the term *ontologies* is the contrast between what Ontology means to philosophy and the way in which ontologies are used in information sciences. Prior to discussing what ontologies are, one must consider the epistemological question of how can we know the world and record our knowledge. If we are going to use ontologies as a way to build better information systems then we have to make sure that the ontologies we rely upon are trustworthy.

Wand and Weber (2004) point to the quality of our knowledge of IS as a potential problem saying that some ontologies created by information systems scholars "are not always rooted in a sound foundation of more fundamental constructs like things and properties". Smith speaks of good and bad ontologies and how Science can help us build the former (2003). He says that "our best candidates for good conceptualizations will, however, remain those of the natural sciences – so that we are, in a sense, brought back to Quine, for whom the job of the ontologist coincides with the task of establishing the ontological commitments of scientists, and of scientists alone"(p.163). The fact that philosophers have been studying Ontology since Aristotle may help us find an answer for how we can build good ontologies. Philosophy, however, has different branches that have different assumptions about the world and how we understand it. Although the basic philosophical assumptions behind the theories used in the creation of ontologies of IS are an important subject of study, it is not our main concern here. A brief review can help illuminate the differences between other approaches and ours. We will show that in some cases our approach is complementary to previous work and in other cases, orthogonal.

Milton's (1998) main question concerns top-level ontologies, which "are used to provide theoretical underpinning for representation and modeling in information systems" (Milton, 1998). The idea is that if we follow the rigid methods of philosophy we will come up with good top-level ontologies. All other ontologies would then be derived from the top-level ontologies. Milton distinguishes between ontologies that are theory-focused and those that are pragmatically-oriented (1998). For Milton, theory-focused ontologies are the ones created using philosophical theory. Pragmatically-oriented ontologies, which we call *ontologies* ***for*** *IS*, are very common in the practice of information sciences and are targeted to specific domains such as banking or taxation. Ontologies *for* IS often combine a philosophical approach with pragmatic purposes. This odd combination may result in incompatible philosophical underpinnings being used in the same pragmatically-oriented ontology. Although we agree with Milton's distinction between theory-focused and pragmatically-oriented ontologies, and our distinction is similar to his, our final goal here is different. Milton seeks to prescribe which kind of philosophical work should be the foundation for the ontologies of IS. He argues that "effective assessment and development of tools for information systems analysis and design must use an appropriate top-level ontology" (Milton, 1998). Our objective is to clarify what ontologies are in information science research independent of which philosophical work is supporting their creation. As Milton says, theory-focused research and pragmatically-oriented research on ontologies are clearly related. One of our objectives in this essay is to clearly describe how they are related.

Wyssusek (2004), like Zuniga (2001) and Smith (2003), is interested in how the term, *ontologies*, is employed in philosophy and in the information sciences. Wyssusek focuses on information systems analysis and design (ISAD) and claims that a philosophical theoretical foundation will help advance the field of information systems. Wyssusek echoes Milton's interest in the philosophical theories behind the tools and methods used in ISAD. Wyssusek and Milton agree with Wand & Weber's criticism of Bunge's (Bunge, 1977, 1979) use of ontological theory as a foundation for ISAD, although they disagree on the possible alternative solutions. Milton (1998) argues for the creation and use of ontologies based on Aristotelian common-sense realism in line with Chisholm's work (Chisholm, 1996). Wyssusek argues that information scientists should question the notion that "the analytical approach toward the development of the axiomatic reference system exemplified by the BUNGE-WAND-WEBER ontology is superior to, e.g., a phenomenological or a hermeneutical approach".

This discussion is similar in spirit to other work. Smith (2003) makes a plea for ontologies that reflect the categories of current scientific theories because they represent our best knowledge of the world. Fonseca & Martin (2005) develop an argument for a hermeneutic approach to ontologies, arguing that the literature in the history and philosophy of science supports a hermeneutic interpretation of the nature and growth of science. They argue that the problems associated with understanding and creating ontologies for IS can be addressed fruitfully only if one begins by acknowledging that databases are mechanisms for communication, involving judgments and interpretations by intelligent and knowledgeable users. They conclude that ontologies for IS should take into consideration perspectives from the history and philosophy of science.

We will not carry this line of inquiry—into where ontologies should originate or how they should be created—any further at present. We are interested in distinguishing the types of ontologies currently used in information science, to which we will now turn our attention.

3. ONTOLOGY AND ONTOLOGIES

The work on Ontology is related to philosophy while ontologies for IS have a much more pragmatic character. Therefore it is necessary to discuss the philosophical origins of the term *Ontology* (singular, capital O) and contrast it to the way the term *ontologies* (plural, small o) is used in information science research.

3.1. Ontology vs. ontologies

In philosophy, Ontology is the basic description of things in the world, the description of what is said to truly exist. Philosophers use the term with an upper-case O, as it is the *Philosophia Prima* concerned with metaphysics. Guarino (1998) considers the philosophical meaning of Ontology to be a particular system of categories that reflects a particular view of the world. Smith (1998) notes that since Ontology for a philosopher is the science of being, it is inappropriate to talk of a plurality of ontologies as software engineers do. To solve this problem, Smith suggests a terminological distinction that reminds us of Milton's theory-focused and pragmatically-oriented ontologies (1998). Smith distinguishes between referent or reality-based ontology (R-ontology) and elicited or epistemological ontology (E-ontology). R-ontology is a theory about how the whole universe is organized and corresponds to the philosopher's framework. An E-ontology fits the purposes of software engineers and information scientists and is defined as a theory about how a given individual, group, language, or science conceptualizes a given domain.

Most of the work done on ontologies *of* IS is rooted in the philosophical meaning of Ontology (i.e., R-ontology). That is, researchers in this area typically use the theory, tools, and methods developed within the philosophical discipline of Ontology to find the basic constructs of information systems. They are investigating the abstract, cognitive conceptualization of information systems. Their findings define the primitives that conceptual models should use so that better information systems are built. On the other hand, when Guarino is talking about ontology-driven information systems, what he is referring to are ontologies *for* IS, (the E-ontologies Smith mentions above). These ontologies are engineering artifacts that explain a specific domain. This is the most common use of the term ontologies in information science. However, even the more specific term *ontology* has been used with more than one meaning in the literature, as we discuss below.

3.2. Ontologies are theories

In this section, we review some of these different meanings and show that the most common meaning of ontology is a *theory that explains a domain*. Chandrasekaran et al. (1999) consider that "ontologies are content theories about the sorts of objects, properties of objects, and relations between objects that are possible in a specified domain of knowledge" (p.20). Guarino and Giaretta (1995) describe ontology as theory instead of a simple specification of particular epistemic states. They say that "an ontological theory differs from an arbitrary logical theory (or knowledge base) by its semantics, since all its axioms must be true in every possible world of the underlying conceptualization" (p. 31). Smith (2003) says that an IS ontology is "a formal theory within which not only definitions but also a supporting framework of axioms is included (perhaps the axioms themselves provide implicit definitions of the terms involved)" (p. 158). Wand & Weber (2004) say that although many ontologies are more a taxonomy than a theory, they still have predictive and explanatory capabilities. They say "if phenomena are classified correctly according to the theory, humans will be better able to understand and predict the phenomena and thus work more effectively and efficiently with the phenomena" (p. iv).

Gruber's much used definition of an ontology–*a specification of a conceptualization*–contradicts the notion that an ontology is a theory (1995). One of the interpretations of Gruber's definition, which Guarino wants to avoid, is that a conceptualization would define a state of affairs. Guarino (1998) gives an example of the relations among a set of blocks on a table. In Gruber's definition, an ontology would specify, for instance, that block *A* is over block *B* and that block *C* is on the side of block *A*. Guarino says that the problem with this notion of conceptualization is that it refers to common relations on the blocks world, i.e., extensional relations. These relations depict a particular state of affairs. In this case, they are reflecting a specific arrangement of blocks on the table. Guarino thinks we need to address the meaning of these relations instead of the current situation on the table. He says that an ontology should describe intensional relations such as the meaning of *above*, for instance. Guarino summarizes with the definition 'C = <D,W,R>' in which C is a conceptualization, D is a domain, W is a set of relevant state-of-affairs or possible worlds, and R is a set of conceptual relations on the domain space <D, W>. After clarifying what a conceptualization is, Guarino (1998) gives a new definition of ontology:

> "*an ontology is a logical theory accounting for the intended meaning of a formal vocabulary, i.e. its ontological commitment to a particular conceptualization of the world. The intended models of a logical language using such a vocabulary are constrained by its ontological commitment. An ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models*." (p. 7).

In the next two sections we discuss how Ontology (in the philosophical sense) and ontologies (as engineering artifacts) may be used in the development of information systems. Considering the centrality of models for IS, it is important to understand the relation of ontologies with data models and with the conceptual schemas.

4. ONTOLOGY IN THE SUPPORT OF BETTER MODELS

Creating a solid conceptual model is at the foundation of systems design. Research in the area of conceptual modeling remains a "vibrant, central element of information systems development and implementation work" (Wand & Weber, 2004). Lately, ontologies have been brought into the discussion on modeling. Since Ontology is a tool that helps us describing a specific world (the target of an IS), "our information systems will only be as good as our ontologies" (Wand & Weber, 2004).

An interesting approach to understanding how Ontology can support modeling is the framework introduced by Wand & Weber (2002). They proposed a structure in which the modeling activity is always inserted into the environment in which IS users and designers live. They call this environment *conceptual-modeling context*. In order to create a conceptual schema, which they call a *conceptual-modeling script*, we need to use a basic set of constructs and rules. This basic set consists of a *conceptual-modeling grammar*. They call the procedures that guide the use of conceptual-modeling grammar in the process of creating conceptual-modeling scripts, *conceptual-modeling methods*.

Ontology is a powerful tool to ensure that the conceptual-modeling grammar is correct. On the other hand, ontologies *for* IS are useful in ensuring that the conceptual-modeling scripts we build using the conceptual-modeling grammar are also correct (Figure 2). In this section we focus our discussion on Ontology and grammar while in the next section we will focus on ontologies *for* IS and scripts.

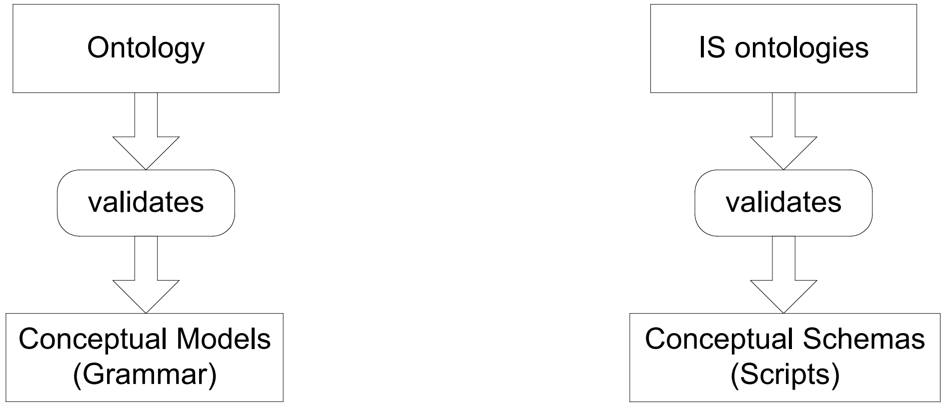

Figure 2 – Ontologies validate models

A primary purpose behind much of the research on the use of Ontology in modeling is the need to know what an information system is, i.e., our need to investigate its basic constructs. It is presumed that once we understand the foundations of models we will be able to create better modeling tools. One of the criticisms of the current research on modeling is that there is a proliferation of new models. A reason for this proliferation is the lack of a sound theoretical basis in modeling. In order to provide such a theoretical foundation we need to resort to Ontology (Wand & Weber, 2004). Some authors propose developing qualitative methods *"for conceptually evaluating individual data modeling languages through ontologies"* and *"for comparing a range of data modeling languages with an ontology based on a number of individual evaluations*" (Milton & Kazmierczak, 2004).

We can say that in most of their work on ontology with regard to modeling, Wand & Weber address how Ontology can help the creation of better conceptual-modeling grammar. One exception is the paper "*An Ontological Evaluation of Systems Analysis and Design Methods*" (Wand & Weber, 1989). In this paper, instead of using Ontology as a tool to check for grammar correction, they are really using Ontology to find the basic set of constructs that would be present at the same time in system analysis methodologies and in reality (the object of Ontology in the philosophical sense). Their research proposes for the first time an evaluation of data modeling languages (the term *conceptual-modeling grammar* appears only in their later work). They adapt the ontology formalisms developed by Bunge (Bunge, 1977, 1979) with the purpose of fitting them for use in information systems analysis and design. Wand & Weber's premise is that "for the information system to be a good representation of the real system, it must contain a representation of the meaning of reality. In other words, some characteristics of reality are invariants of the information systems development transformations." They claim that "the identification and preservation of these invariants is the basis for formalizing systems analysis and design" (1989).

Milton & Kazmierczak (2004) offer another example of the use of Ontology related to information systems. They carry out a comparison of some modeling languages using a philosophical ontology as an external reference. They use a theory based on Ontology to understand better the fundamental nature of data modeling languages (conceptual modeling grammar). They apply their own methods to analyze the grammar and use Chisholm's ontology (Chisholm, 1996) as a foundation. Smith (2003) describes the work of Chisholm as seeking "a taxonomy of the entities in reality at all levels of aggregation, from the microphysical to the cosmological, and including also the middle world (the mesocosmos) of human-scale entities in between" (p.155).

The work of Wand & Weber, Milton & Kazmierczak, and others described above are examples of the work on Ontology. This kind of research uses the ontology methods, tools and theories developed within the philosophical discipline of Ontology to find the basic constructs of information systems. It is an investigation of the fundamental nature of information systems. The products of this kind of work are ontologies of IS, i.e., the primitives that conceptual models should use if we are to build better information systems.

Next we examine the other type of ontologies, ontologies for IS, which are theories that describe a given domain. They are tools that will help us build better conceptual-modeling scripts and other IS components as suggested by Guarino (1998) in his concept of ontology-driven information systems.

5. *ONTOLOGIES FOR IS*: CONTENT FOR MODELS

The term ontology applied to computer systems was introduced in the Artificial Intelligence (AI) literature to describe the categorical framework required for the processing of common-sense reasoning (McCarthy, 1980). The concept of ontologies was adopted in the IS field as part of the search for an answer to the difficulties that appear in the process of conceptual modeling. Adopting ontologies advanced the research on conceptual modeling by enabling system designers to develop better conceptual modeling scripts.

In analyzing the difficulties of capturing, in an information system, the complete context in which the system will be used, Naur (1992) says "the dependence of a theory on a grasp of certain kinds of similarity between situations and events of the real world gives the reason why the knowledge held by someone who has the theory could not, in principle, be expressed in terms of rules. In fact, the similarities in question are not, and cannot be, expressed in terms of criteria, no more than the similarities of many other kinds of objects, such as human faces, tunes, or tastes of wine, can be thus expressed" (p. 40). We argue that one reason why ontologies appeared in IS research was an attempt to address this kind of problem.

Where are the ontologies in ontology-driven information systems? Guarino sees a temporal and a structural dimension in the use of ontologies in information systems. In the temporal dimension, an ontology can be used at development time or at run time. Using an ontology during the development stage enables designers to practice a higher level of knowledge reuse than is usually the case in software engineering. The use of a common vocabulary across heterogeneous software platforms provides for the reuse and sharing of the application domain knowledge. This way, designers can focus on the structure on the domain itself, avoiding the consequences of being overly concerned with implementation details. At run time, an ontology may enable, for instance, the communication between software agents or be used to support information integration.

Naur's ideas regarding problems with system maintenance preceded most of the research in ontology-driven information systems. He says "the point is that building a theory to fit and support an existing program text is a difficult, frustrating, and time consuming activity." (p.44). Guarino (1998) makes this idea more explicit when he argues that "*application programs are still an important part of many ISs. They usually contain a lot of domain knowledge, which, for various reasons, is not explicitly stored in the database. Some parts of this knowledge are encoded in the static part of the program in the form of type or class declarations, other parts (like for example business rules) are implicitly stored in the (sometimes obscure) procedural part* *of the program*." (p.13). Sowa (2000) claims that a programmer trying to solve a problem has the knowledge to implement a solution, but the way of encoding this knowledge can vary from one individual to another. Both the programmer and the modeler have their own ontologies, which can be either implicit or explicit. This variation is one of the reasons for creating ontology-driven information systems, i.e., to build the theories of programs before the system is created (Guarino, 1998). The difference between ontology-driven and other types of information systems is that the ontology is made explicit before the IS is even designed.

If we adhere to Guarino's concept of an ontology-driven IS, we can see that the path of system development begins with personally held horizons (i.e., personal interpretations based on one's experiential knowledge), and progresses to the data stored in the databases before being accessed by the applications (Figure 3). We contend that in order to build a model to be used in an information system, we have to start with theoretically informed interpretations of the world as well as objectives for application, so that we may properly select, assess, and organize the facts that make up the system. These horizons have to be described in some kind of language, formal or informal. Then, in accord with Guarino's proposal, instead of starting with the creation of the conceptual schemas that are concerned with how we collect and store the facts, we should first build the ontologies *for* IS. These ontologies are by definition broader than conceptual schemas. They also may include the interest and points of view of larger communities. As Smith (2003) says, IS ontology "came to be used by information scientists to describe the construction of a canonical description" which represents "a shared taxonomy of entities" (p.158). Thus, ontologies *for* IS allow us to create better conceptual schemas and applications.

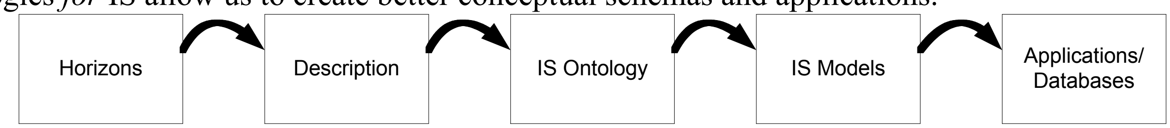

Figure 3 – The path from personally held horizons to facts in a database

In summary, if we are able to build the theories (ontologies *for* IS) before starting the activity of conceptual modeling, we will build better models. Of course we also need to be careful as to use Ontology to ensure that we have an IS ontology that is faithful to the domain being modeled. These are the first steps towards building ontology-driven information systems. Ontologies *for* IS in the context of ontology-driven information systems are theories that describe and explain a domain, which is the same domain the information system is trying to model. Building better information systems depends, at least in part, on the construction of better models of reality. Ontology *of* IS provides us with the tools (conceptual modeling grammar) to validate the models we use against reality, while ontologies *for* IS give us the framework to validate the models themselves (conceptual modeling scripts) within the domain context of the particular IS being built.

6. ONTOLOGY ENGINEERING AND CONCEPTUAL MODELING

In order to understand better the difference between Ontology *of* and ontologies *for* IS we can make a parallel between the process of creating ontologies for IS (ontology engineering) and the activity of creating conceptual schemas (conceptual modeling).

In the process of creating ontologies for IS, we use a known universe of discourse (UoD) and then use methods such as MethOntology, WebODE, or On-To-Knowledge in conjunction with ontology languages such as DAML+OIL, OWL, or RDF (Dieter Fensel, 2001, 2002; D Fensel, van Harmelen, Horrocks, McGuinness, & Patel-Schneider, 2001; Gomez-Perez &

Benjamins, 2002; Gomez-Perez, Fernandez-Lopez, & Corcho, 2004; Noy & Hafner, 1997). In a similar fashion, we need modeling grammar and methods to create conceptual schemas. Entity-Relationship (ER) (Chen, 1976), Object Modeling Technique (OMT) (Rumbaugh, Blaha, Premerlani, Eddy, & Lorensen, 1991), and Unified Modeling Language (UML) (Rational Software Corporation, 1997) are examples of grammar that are used with methods such as the Soft Systems Methodology (Checkland, 1999) or Structured Analysis (Yourdon, 1989) (Figure 4).

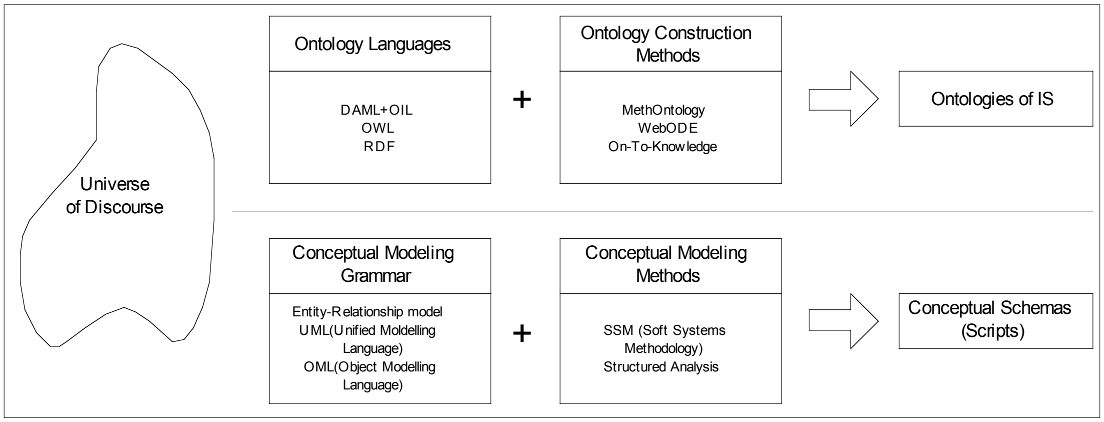

Figure 4 - A comparison between ontology engineering and conceptual modeling

It is important to note that most work on methodologies to develop ontologies *for* IS ignores work done in philosophy. We discussed in Section 2 the role that philosophy has for the creation of ontologies. We pointed out the importance of using philosophical methods from Ontology to validate the grammar that we use to create our schemas. Philosophy can serve as a foundation for creating better ontologies *for* IS. Smith (2003) says that information scientists can learn from philosophers. Ontology, as a philosophical discipline that looks for the truth, for what is, has a tradition going back for more than 2000 years. Smith also mentions the work of Guarino & Welty (2000) that uses "standard philosophical analyses of notions such as identity, part, set-membership, and the like in order to expose inconsistencies in standard upper-level ontologies, such as CYC (a commercially available ontology), and they go on from there to derive metalevel constraints which all ontologies must satisfy if they are to avoid inconsistencies" (Smith, 2003). This view is consistent with many of the other views discussed in this paper.

Smith (2003) also criticizes the poor use of Ontology, as a philosophical discipline, by information scientists. He says that modelers are resorting to ontological methods in order to impose constraints on data so that data derived from different sources can be made compatible from the beginning. Here, Smith is arguing against what he calls 'instrumental ontologies'. Such ontologies may be interpreted in terms of the 'closed world assumption'. In such cases, what Gruber (1995) asserts for AI, will be true of ontologies: "what 'exists' is that which can be represented" (p. 907). Consequently, ontologies may have no relevance to the actual situations in which it has been hoped that computers would be helpful. Communication about different actual realms involves taking into account a variety of ambiguities that can only be deciphered by considering the complex (and often confusing and imperfectly understood) world that is the object of the communication. We agree with Smith (2003) when he says that ontologies for IS should follow the Ontologist's Credo. For philosophers constructing or discovering ontologies, the Credo involves a commitment to the assumption that "to create effective representations it is an advantage if one knows something about the things and processes one is trying to represent," (Smith, 2003). Smith mentions Ontek and the work of Guarino as examples of ontologists that follow the Credo.

To summarize, ontologies *for* IS are different from Ontology. Ontologies *for* IS are created to explain a domain. Ontology refers to methods and tools borrowed from philosophy to help the identification of the basic things in the world, or as we are interested here, the basic constructs of information systems, as well as the invariants that are present in the world and in an information system. Ontologies *for* IS will enable us to evaluate, according to Guarino, the ontological adequacy of an IS. Ontology will help us, according to Wand & Weber and Milton & Kazmierczak, to evaluate the ontological adequacy of conceptual modeling grammar, the tools we use to create information systems.

7. CONCLUSIONS

Although ontologies are becoming an important topic in information science research, meaningful use of the term still requires careful explanation. Some researchers warn us that we have to be careful with our references to ontologies. Green and Rosemann (2004) say that not only "the type of research work that is conducted under the umbrella term, 'ontologies', varies significantly" but also the "understanding of an ontology in terms of its scope, details and purpose varies significantly" (p. i).

Our objective in this paper was to clarify the use of the term ontologies in order to facilitate and advance research in the field. We made a distinction between research on the creation of ontologies and research on the use of ontologies. We focused on the use of the term as it relates to the use and development of information systems. We showed that the term *ontologies* can be better understood if we classify the research into two major areas. First, there is research on *Ontology*, a powerful tool to ensure that data modeling languages (conceptual-modeling grammar) are correct. A part of this effort is the creation of ontologies that study the information system as an object per se with the objective of creating better modeling tools. These ontologies are called *ontologies **of** IS*. Second, there is research on *ontologies* ***for*** *IS*, which are useful to ensure that the conceptual schemas (conceptual-modeling scripts) we create using the grammar are correct.

We discussed the work of Wand & Weber, Milton & Kazmierczak, and others as the exemplars of the work on Ontology. This kind of research uses methods, tools, and theories developed within the philosophical discipline of Ontology to find the basic constructs of information systems. It is an investigation of what information systems ***are***. The products are the primitives that conceptual models should use if we are to build better information systems.

The field of ontologies *for* IS is well represented by the work of Guarino on ontology-driven information systems. Guarino (1998) says that ontologies are 'engineering artifacts'. Ontologies drive all aspects of an ontology-driven information system. They are created and formalized as the first step in the system development process. After that, ontologies influence and drive the construction of the conceptual schemas and the construction of the applications.

The concept of ontologies was brought to the IS field as part of the search for an answer to some problems in conceptual modeling. Ontologies *of* IS and ontologies *for* IS are the result of a long-term research effort on conceptual modeling. Ontologies are one step forward in our endeavor to create better models. It is also very important to understand the philosophical origins of the term. Ontology as a *Philosophia Prima* is at the root of the term *ontologies* and has a lot to offer to information science. Ontologies *for* IS – the engineering artifacts that are one of the results of our modeling activities – will improve the way we develop and use information systems. The clear understanding of what ontologies are and of the ways in which we can use them is a fundamental step in our journey to build better models and, consequently, better information systems, as the initial work on ontology-driven information systems is beginning to show.

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