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Abstract

The objective of this paper is to demonstrate the usefulness of Meta models in supporting research opportunities in information systems and conceptual modelling that are influenced by ontologies. In particular, our aim is to show the importance of Meta models for comparing and evaluating ontologies. We propose a mechanism for analysing and evaluating the Meta models of two well-known ontologies that had been used previously in information systems grammar research – the BWW representation model and Chisholm's ontology. The mechanism provides guidance for evaluating the Meta models of the two ontologies according to ontological equivalence, depth of structure, and comprehensiveness of scope of the models. In the portions of the models analysed, we found that the two models were not completely ontologically equivalent; that Chisholm's model may have a deeper structure than the BWW model; and, that the BWW model is more comprehensive in scope. These findings must be viewed mindful of the limitation that only portions of the Meta model of the full BWW representation model and Chisholm's ontology were used in this analysis.

Keywords

Information Systems; Conceptual modelling; Meta model; Ontology; Ontological Constructs; Bunge-Wand-Weber; Chisholm

INTRODUCTION

Wand and Weber (2002) have speculated on a research agenda for information systems and conceptual modelling. Their objective is to motivate research that addresses the fundamental question, "How can we model the world better to facilitate our developing, implementing, using, and maintaining more valuable information systems?" Using a theoretical foundation based on ontology could facilitate many of the potential research areas that they identify. Ontology has influenced research in many application areas over the past decade: knowledge representation, natural language processing, knowledge management, and Web services.

Given the important use and potential use of ontologies over the past ten years, the principal question then becomes: which ontologies do we use for which purposes? How do we compare and evaluate different ontologies for determining their strengths and weaknesses for the purpose required? The objective of this paper is to demonstrate the usefulness of Meta models in supporting research opportunities in information systems and conceptual modelling that are influenced by ontologies. In particular, our aim is to show the importance of Meta models for comparing and evaluating ontologies. In this way, researchers may gain some guidance on which ontology might be useful for their area of interest.

We are motivated to perform this work for three reasons. First, we can provide practical guidance to researchers and practitioners alike on how to compare and evaluate ontologies. In this way, they will be better able to determine the ontology most applicable for their purposes. Second, we are extending the usefulness of Meta models from understanding individual modelling techniques like process modelling and workflows, to understanding and comparing the theoretical bases (ontologies) on which those techniques can be compared and evaluated. In this way, we are extending the work of Rosemann and Green (2002) where they demonstrated how through comparing the Meta model of an ontology to that for a modelling technique like ARIS, and using a pattern-matching process, they could evaluated the strengths and weaknesses of the process modelling technique. Finally, we are explaining, and demonstrating using a limited example, how ontologies and Meta models can be very useful in conducting research in many of the areas of information systems and conceptual modelling identified by Wand and Weber (2002).

Accordingly, the paper unfolds in the following manner. The next section explains what ontology is and it exemplifies it in the form of the BWW representation model. Moreover, this section introduces the research framework for work in the information systems and conceptual modelling discipline presented by Wand and Weber (2002), and it provides an assessment of the usefulness of ontologies to each of those areas. The third section explains what Meta models are, where they have been applied previously, and in relation to the Wand and Weber (2002) research areas, it assesses their usefulness. The next section presents a section of the Meta model for two popular ontologies – the BWW representation model and Chisholm's (1976) ontology. It provides guidelines for comparing and evaluating Meta models generally, and then it demonstrates the application of these analytical processes to the two small example Meta models. Differences are highlighted under the categories of *ontological equivalence*, *depth of structure*, and *comprehensiveness of scope*. The paper concludes with a summary of results and an indication of further work planned.

WHERE ONTOLOGIES ARE USEFUL FOR INFORMATION SYSTEMS

What is Ontology?

Ontology is a well-established theoretical domain within philosophy dealing with models of reality. Unfortunately, as with most areas of scientific endeavour, over the years, many different models of reality – ontologies – have emerged (*c.f.*, Bunge, 1977; Chisholm, 1976; Husserl, 1934). Mylopoulos (1998) suggests that ontologies can be classified into four categories: static, dynamic, intentional, and social. Each of these categories focuses on different concepts in the real world. Ontologies that fall into the static category focus on things and their properties. Dynamic ontologies extend static ontologies to focus on such concepts as events and processes – that is, how concepts in the real world change over time. Intentional ontologies attempt to explain abstract concepts like goals and objectives while social ontologies emphasise the concepts of values and beliefs.

Today however interest in, and applicability of ontologies, extends to areas far beyond metaphysics. As Gruninger and Lee (2002:39) point out, "…a Web search engine will return over 64,000 pages given "ontology" as a keyword…the first few pages are phrases such as "enabling virtual business", "gene ontology consortium, and "enterprise ontology"." The usefulness of ontology as a theoretical foundation for knowledge representation and natural language processing is a fervently debated topic at the present time in the artificial intelligence research community (Guarino and Welty, 2002). Holsapple and Joshi (2002), for example, argue the importance of ontologies in the emergent era of knowledge-based organisations and the conduct of knowledge management in those organisations. Kim (2002) shows how ontologies can be engineered to support the first phase of the evolution of the "semantic Web".

Our work to date has focused on a set of ontological models known as the BWW (Bunge-Wand-Weber) models. Wand and Weber (1990) and Weber (1997) have taken, and extended, an ontology presented by Bunge (1977) and applied it to the modelling of information systems. Their fundamental premise is that any information systems analysis and design modelling grammar (set of modelling symbols and their construction rules) must be able to represent all things in the real world that might be of interest to users of information systems; otherwise, the resultant model is incomplete. If the model is incomplete, the analyst/ designer will somehow have to augment the model(s) to ensure that the final computerised information system adequately reflects that portion of the real world it is intended to simulate. The BWW models consist of the representation model, the state-tracking model, and the good decomposition model. The work reported in this paper uses the representation model and its constructs. The representation model defines a set of constructs that, at this time, are thought to be necessary and sufficient to describe the structure and behaviour of the real world[1].

Ontologies and Research Directions

Wand and Weber (2002) have speculated on a research agenda for information systems and conceptual modelling. In particular, with regard to research on conceptual modelling, they suggest that four elements can be used to structure a framework for the research: conceptual modelling *grammar* – a set of constructs and their construction rules, conceptual modelling *method* – a procedure by which the grammar can be used, conceptual modelling *script* – the product of the conceptual modelling method, and *context* – the setting in which the modelling occurs.

Table 1 summarises the research opportunities under each of those four elements according to Wand and Weber (2002). Moreover, for each proposed research opportunity, column 2 of the table presents a ranking of the usefulness of ontologies in conducting research in that area.

Future Research Opportunities	Usefulness of Ontologies*	Usefulness of Meta Models*
Conceptual Modelling Grammars		
1. Evaluation of ontologies	++	++
2. Evaluation of grammars	++	++
3. Assigning real-world semantics to grammars	++	++
4. Better use of grammars	++	++
5. Study of ontological issues	++	++
6. Empirical testing of theoretical predictions and rules	++	0
7. Use of multiple grammars	++	++
8. Implications of grammar deficiencies	++	++
Conceptual Modelling Methods		
1. Performance of alternative methods	0	0
2. Methods to identify types of phenomena	+	+
3. Methods to classify phenomena	++	++
4. The effects of values and beliefs	+	0
Conceptual Modelling Scripts		
1. Intra-grammar evaluation of scripts	+	+
2. Inter-grammar evaluation of scripts	+	+
3. Evaluation of multi-grammar scripts	+	+
4. Theoretical analyses of how humans understand and use scripts	+	0
Conceptual Modelling in Context		
Individual Contextual Factors		
1. Improving individuals' performance	+	+
2. Studying the effects of cognitive characteristics	0	0

1 For a detailed description of all the constructs in the representation model, see Green and Rosemann (2000) or Weber (1997).

Future Research Opportunities	Usefulness of Ontologies*	Usefulness of Meta Models*
3. Studying the effects of personality characteristics	+	0
Task Contextual Factors	0	0
Social Agenda Factors		
1. Studying underlying values and beliefs	+	0
2. Effects of adopting alternative perspectives	0	0
3. Developing methods to support perspectives	0	0
4. Fit between perspectives and grammars and methods	0	0

*** '0' indicates little/ no use; '+' indicates some use; '++' indicates highly useful.**

Table 1: Usefulness of Ontologies to Research Opportunities in Information Systems and Conceptual Modelling.

In performing the ranking, ontology is used in its broadest sense (Mylopoulos, 1998). The ranking was performed by reviewing Wand and Weber's (2002) description of each potential research opportunity and the activities and examples provided with it. From this information, an assessment of the amount of work that had already been done in the area using ontologies and the potential future work claimed was made. Moreover, where no previous work using ontologies had been done (to the best of our knowledge), we assessed the potential usefulness of ontologies to the area. On the basis of this assessment procedure, a ranking of "0" (little/ no use), "+" (some use), or "++" (highly useful) was assigned to each area of research opportunity.

Reviewing Table 1, we can see that ontologies appear to be highly useful when researching issues around conceptual modelling grammars and methods. They appear to be of some actual and potential use in the research areas specified for conceptual modelling scripts and individual contextual factors. However, it would appear that ontologies have limited actual (and potential) use for research in social agenda factors.

Given the above areas of use and potential use of ontologies, which ontologies do we use in which research opportunity? How do we compare and evaluate different ontologies for determining their strengths and weaknesses for the purpose required in the particular research area? The next section of the paper proposes the use of Meta models of various ontologies for this comparison and evaluation task.

THE POTENTIAL OF META MODELS

Meta modelling is an attempt to adequately model all aspects of any given modelling technique (Steele and Zaslavsky, 1994). A model (M) is a representation of a relevant part of the real world (W) and is created for the purpose(s) of a subject. On a higher level such a model (M) can also be described in models (MM). These models (MM) are called Meta models. Because of this degree of abstraction a *Meta model* can be seen as "a design framework that describes the basic model elements and the relationships between the model elements as well as their semantics. This framework also defines rules for the use and specialization of model elements and relationships" (Ferstl and Sinz, 2001:86). "Meta models ... might be expressed using one or more modelling techniques, that in combination are able to adequately model all relevant aspects…" (Steele and Zavlavsky, 1994:317).

Meta models using a meta language have proved popular in explaining and communicating the constructs of some modern modelling techniques, for example, workflow models (Rosemann and Zur Muehlen, 1998), object-oriented schemas (Saeki, 1995), and ontology (Rosemann and Green, 2002). In relation to ontologies in particular, Rosemann and Green (2002) point out that the production of a Meta model can help to further structure and analyse any ontology. This process will allow clarification of inconsistencies and anomalies in the targeted ontology. Moreover, Meta models for ontologies streamline the ontological analysis of modelling grammars as they facilitate a direct mapping of elements and relationships between the ontological model and the modelling grammar (as long as there is a pre-existing Meta model for the modelling grammar). Finally, the Meta model can be used to derive new modelling techniques (that is, ontology-based method engineering).

Using a ranking procedure similar to that used for ontologies, column 3 in Table 1 shows an assessment of the usefulness of Meta modelling for the various research opportunities proposed by Wand and Weber (2002). Again, reviewing Table 1, we can see that Meta models appear to be highly useful when researching issues around conceptual modelling grammars. They appear to be of some actual and potential use in the research areas specified for conceptual modelling methods and scripts. However, it would appear that Meta models have limited actual (and potential) use for research in contextual factors.

The next section of the paper shows, as an example, how Meta models can facilitate research into the comparison and evaluation of ontologies, which is research opportunity 1 in the category of conceptual modelling grammars.

SELECTING, EVALUATING AND ENGINEERING ONTOLOGIES WITH META MODELS

The Meta models in this paper are designed using extended Entity-Relationship Models (Chen, 1976). Generalisations are established for reasons of clarity. For every generalisation a description of the disjointness constraint (d (disjoint) or n (not disjoint)) and the completeness constraint (p (partial) or t (total)) is given (Elmasri and Navathe, 1995).

Prior to the evaluation of Meta models it must be ensured that all possible conflicts between the models have been resolved. Three major kinds of conflicts can be identified (Rosemann and zur Muehlen, 1998).

First, *naming conflicts* occur, if the naming conventions of the models to be compared show synonyms or homonyms. These are the most common conflicts during the evaluation of Meta models. A synonym can be found if two or more linguistic expressions share the same meaning. A homonym results in the ambiguity of a linguistic element. In its context the meaning of a homonym is unique, but not because of its notion alone.

The determination of *synonyms* requires an analysis of different terms with identical meaning and associations. Hints about potential synonyms can be found by tracing similar structures embedding information objects with different names (concept likeness) (Batini and Lenzerini, 1984; Batini *et al*., 1992). *Homonyms* contradict the clarity of a model, because the notion of the term can be determined depending on the user and the context, but not in general. A potential indicator for the identification of homonyms in Meta models is an information object with the same name that is embedded in different structures (concept unlikeness).

Second, a *type conflict* can be located if the same fact is represented semantically correct in two models through different methodical concepts. Third, *structural conflicts* arise if the Meta models to be integrated depict the same facts using different semantics. This is a violation of the semantic correctness. Structural conflicts often arise if different people are involved in the modelling process. Type and structural conflicts are not relevant at this point, because the Meta data models to be compared and to be evaluated were created by the same group of people.

These conflicts have to be resolved before two or more Meta models of ontologies can be compared. At the same time, they highlight the need for sound modelling guidelines covering, for example, naming and layout conventions. A separate repository has to capture all transformations that are made to one model in order to resolve these conflicts e.g. re-naming of an entity type in order to avoid synonyms. Corresponding Meta models are called conflict-free when these conflicts have been resolved.

When two conflict-free Meta models are compared, the following information objects can provide useful information:

Entity types

The comparison of the number and kind of entity types provides the most essential information for the comparison of Meta models. Within a given degree of abstraction, the width of an ontology increases with the number of entity types in the Meta model.

Relationship types

Another metric concerning the integration within an ontology is the number of relationship types. The structural density of an ontology increases with the number of relationship types if the number and kind of entity types stay the same. An example can be found in the relationships between thing (individual) and property (attribute) shown in Figures 2 and 3 below.

Beyond entity and relationship types, the comparison of cardinalities and attributes provides typically further information. However, in the context of Meta models for ontologies, attributes are rather the exception. Thus, they are not further analysed here.

Independent from entity types and relationship types, three different situations can be distinguished when comparing conflict-free Meta models for ontologies (see Figure 1).

a) Between two corresponding elements in two ontologies might be a 1-1 relationship. This case describes ontological e*quivalence*.
b) It might also be the case that one element in an ontology is further specified by two or more elements in the other ontology. For the case depicted in Figure 1, that situation would suggest that ontology B has the *deeper structure*.
c) Finally, it might be the case that one element in one ontology does not have any correspondence in the other ontology at all. Figure 1 shows an example in which it can be assumed that ontology A has a *more comprehensive scope*.

All three cases are depicted in Figure 1. The following section elaborates on these differences using the Bunge-Wand-Weber model (Weber, 1997) and Chisholm's ontology (as described in Milton and Kazmierczak, 1999).

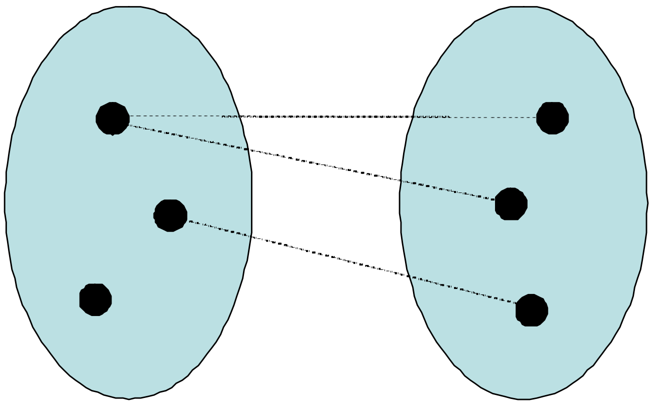

Figure 1: Situations determined when comparing conflict-free Meta models for ontologies

We have translated a portion of both the Bunge-Wand-Weber model and Chisholm's ontology into eERM Meta models in order to clearly depict the key elements and constructs of each. Furthermore, by using a common Meta language, we are able to easily compare the elements and constructs of each model. The names given to the entity and relationship types within each model closely follow the wording used by the original sources.

Description of the BWW Meta model

The BWW (Bunge-Wand-Weber) model, see Figure 2, is based on the fundamental elements of *Things*, which exist in the real world, and their *Properties*. Every thing in the real world *possesses* at least one property. Conversely, every property belongs to at least one thing. The generalisation symbol depicts things as being either *Composite* or *Simple,* the "d" symbolises a disjoint constraint (one or the other) and the "t" symbolises a total constraint (all subtypes which exist are depicted). A composite thing is associated with two or more other component things (simple or composite), which together comprise the composite thing. A simple thing, on the other hand, is comprised of only itself.

Properties can be further divided into sub-properties or types of properties. A “d” disjoint, “t” total constraint shows that a property can be either a *Property in general* or a *Property in particular*. Furthermore, a Property in particular is an instance of a Property in general. Other sub-types may be used to describe the characteristics of a property. An *Instrinsic Property* is inherent in an individual thing. A *Mutual Property* is a property that is shared by two or more things. Mutual Properties can be either *Binding*, affecting the things involved or *Non-binding*, do not affect the things involved, for example, order relations or equivalence relations. A *Hereditary Property* is a property of a composite thing that belongs to (i.e. is inherited from) a component thing. An *Emergent Property* is a property of a composite thing that does not belong to a component thing; rather it emerges as a result of the relationship between the component things involved. The generalisation constraint “n,p” used to categorise these sub-types describes them as being non-disjoint (a property may be characterised by more than one of these subtypes) and partial (there may be further subtypes not depicted in the model) (Green and Rosemann, 2000; Weber, 1997).

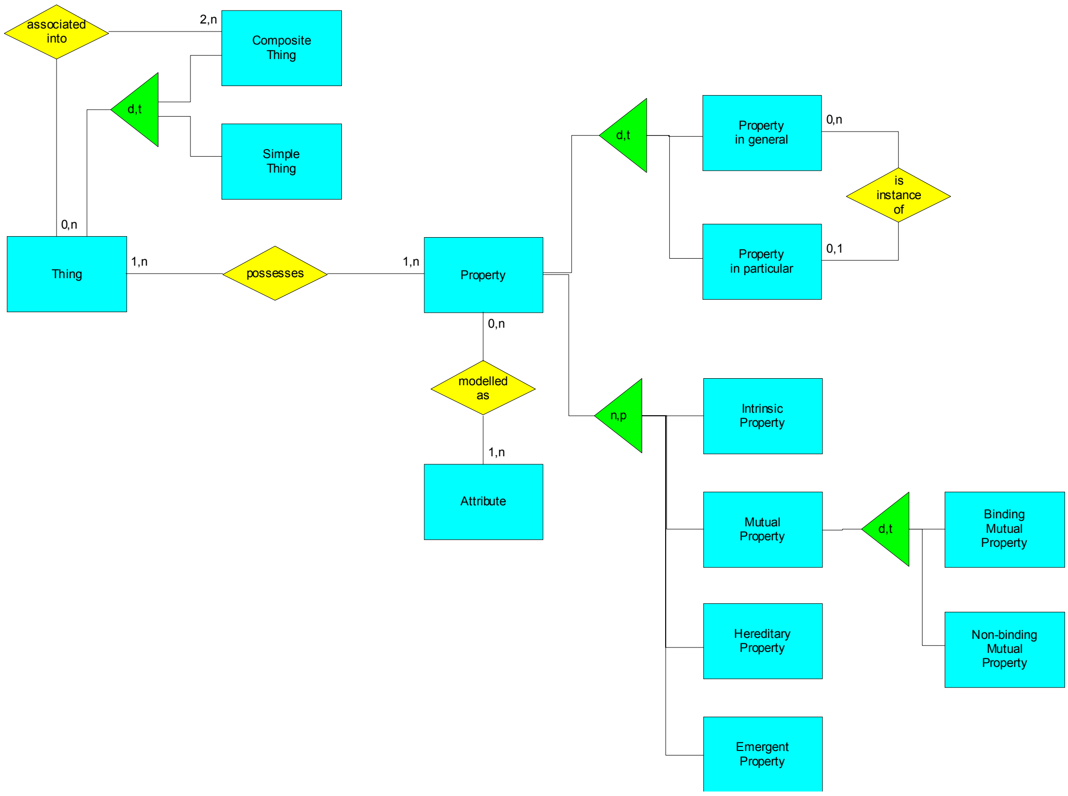

Figure 2: Meta model of selected BWW ontological constructs

We use *Attributes* to name and represent the properties we wish to model. Often we can assign a single attribute to a particular property directly, however at times it is not so easy to determine or fully understand some properties. In this case we can model a combination of properties, of which we are aware but do not fully understand, via a single attribute (Weber, 1997).

Description of the Chisholm Meta model

Chisholm’s ontology has at its core the elements of *Individuals*, which are contingent entities, and the *Attributes* they *exemplify* (exhibit), (see Figure 3). Individuals are described as being transient objects that come into being and pass away. In other words they are created and destroyed, giving them a lifespan. Furthermore, they need not be material or physical in nature. Individuals may also be structured into *Constituents* or parts. A constituent is, in itself, an individual.

Each individual is *identified by* one or more attributes that it also exemplifies. Individuals may also exemplify (or exhibit) several more attributes. Some attributes, on the other hand, might never be exemplified. In contrast to the transient nature of individuals, attributes are enduring. In other words they do not come into being or pass away. Rather they continually exist. For many of the reasons above, attributes are loosely coupled with individuals. Attributes are also described as being either *Compound* or *Simple*. The Meta model shows the constraints of this attribute generalisation as being disjoint (one or the other) and total (all subtypes which exist are depicted). A compound attribute results from the conjunction or disjunction of several other compound or simple attributes.

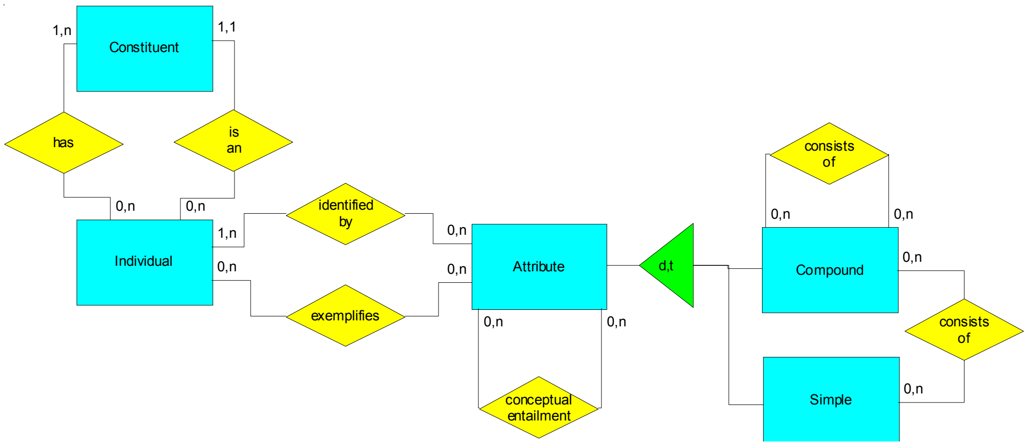

Figure 3: Meta model of portion of Chisholm's ontology

Lastly, two or more attributes may share the relationship of *conceptual entailment*. This is a construct that infers when an individual exhibits one attribute it necessarily exhibits the other, making two or more attributes equivalent.

Comparison of the BWW and Chisholm Meta models

Resolving conflicts

Before comparing the two Meta models we need to resolve any naming, type or structural conflicts between them, as discussed earlier. When developing each Meta model it was decided to name each element with the wording used by the source of the models as closely as possible. As a result, we need to identify some synonyms and homonyms between the models. Firstly, we can establish that *Thing* and *Property* in the BWW model are essentially the same concepts as *Individual* and *Attribute* in Chisholm's model. The names expressing the relationship between these two entities, *possesses* and *exemplifies,* are also considered synonyms. Further synonyms identified are the names *Constituent* and *Compound Thing* expressed in the BWW model and the Chisholm model respectively. One homonym that can be identified is A*ttribute*. Attribute is described in both models but has a slightly different meaning in each. In the BWW model, attribute is described as being the name we use to model one or more properties. In Chisholm's model, on the other hand, attributes directly identify what the BWW model calls properties. The same group of people developed the two Meta models, therefore there are no type or structural conflicts to resolve.

Different situations determined

Comparisons can be made by focusing on the difference between: the number and nature of the entities described in each of the models; the number and nature of the relationships between comparable entities; and the cardinality of the comparable entity relationships. Comparing the two models using the three situations of Figure 1 results in the following analysis:

a) Ontological equivalence

Ontological equivalence can be established between a number of constructs in the BWW and Chisholm models. Comparing in the direction from the BWW model to the Chisholm model, we assert that *Thing* is essentially equivalent to *Individual*; *Property* is equivalent to *Attribute*; *possess* is equivalent to *exemplifies*; *Compound Thing* is equivalent to *Constituent*;

and *associated into* is equivalent to *has*. However, when taking cardinality into account a difference between Property in the BWW model and Attribute in the Chisholm model can be seen. The BWW model stresses that Properties can only exist with Things. Chisholm's ontology, on the other hand, asserts that Attributes (Properties in the BWW model) are enduring and can exist even if not exemplified by any particular Individual (Milton and Kazmierczak, 1999). Therefore, while some ontological equivalence is apparent, the two models are not completely ontologically equivalent.

b) Deeper structure

Both models refer to a Composite Thing (BWW) or Constituent (Chisholm) as being a thing in itself and part of a greater thing. The BWW model takes the concept of Thing further by breaking it down by way of generalisation to being either a composite thing or a simple thing. This situation might suggest a deeper structure to the BWW model. Furthermore, Property in the BWW model is generalised into numerous subtypes, each categorising a property in a particular way. In a slightly different way Attribute in the Chisholm model is also broken down showing structure. Chisholm structures Attributes into compound and simple classifications to enable different levels of expressiveness. This situation may imply that Chisholm's ontology also has a deep structure. Another way in which the Chisholm model could be viewed as having a deep structure is the further clarification of the relationship between Individual and Attribute, one relationship being *identified by* and the other being *exemplified*. The BWW model relates Thing and Properties via only one relationship – *possesses*. Milton and Kazmierczak (1999) suggest that Chisholm views attributes as being fundamental to his ontology, second only to individuals, which may explain his efforts in further structuring the Attribute element and distinguishing further relationships. The number of relationships associated with attribute and the level of effort to describe the construct illustrate this view. Although it is beyond the scope of the models depicted, attributes are further used in Chisholm's ontology to describe sets, classes, and relations. However, many other elements in Chisholm's ontology do not appear to be broken down to the same extent as the Attribute element. Therefore, for the sake of illustrating the concept of deeper structure and its analysis, we can say only for the limited scope of the model portions described in this paper that Chisholm's ontology has a deeper structure.

c) More comprehensive scope

It is difficult to illustrate comparisons between the scope of each model, considering the limited portion of each model chosen and depicted in this paper. Within the restricted boundaries of the models represented, however, there is a relationship *conceptual entailment* described in the Chisholm model, which is not apparent in the BWW model. This additional element could be grounds to argue that the Chisholm model is more comprehensive in scope. However, when we look at both models in their entirety we can see that the BWW model appears to describe more constructs than Chisholm's ontology as a whole. Green and Rosemann (2000) identify 28 main constructs in the BWW model whereas Milton and Kazmierczak (1999) identify only 12 categories described in Chisholm's ontology. This finding suggests that the BWW model is in fact more comprehensive in scope.

Issues to consider with this method of comparison

Having employed the above method to compare two ontological Meta models, some issues that may carry implications for further comparison activities involving Meta models for ontologies are apparent.

1. To ascertain a comparison of ontological equivalence, it would be more beneficial to establish one set of naming conventions for each comparable element in the two ontological models. Although we considered naming conflicts and resolved them through descriptive comparison, it would be easier to refer to the same concept in each model in subsequent sections of a paper using one common term for each concept. For example, we could decide at the outset to label the equivalent construct of Thing (in BWW model) and Individual (in Chisholm model) as Thing, when referring to this concept in further comparison discussions.
2. Deeper structure is difficult to ascertain when each model has a different focus. For example, in model A, a particular element may be described in more detail

than in model B, while in model B a different but still comparable element may be described in more detail than in model A. A comparison of the deeper structure of models, therefore, needs to be performed on the models as a whole, following a more comprehensive form of analysis.

3. For a similar reason as point 2 the entire models, rather than a chosen portion, need to be compared in order to establish an accurate comparison of the comprehensiveness of scope of the models.

CONCLUSION AND FURTHER WORK

This paper has explained what ontology is. It has explained that, over the years, many different ontologies have evolved. These different ontologies can be categorised according to the elements on which they focus: static, dynamic, intentional, and social. Moreover, the paper has shown that much interest has occurred in the use of ontologies in application areas such as knowledge representation, natural language processing, knowledge management, and the first phase of the provision of web services.

We then explained, using the Wand and Weber (2002) framework for research into information systems and conceptual modelling, how useful ontologies could be in supporting research in various of those areas. The paper then went on to explain what Meta models were, how they had been applied to date, and their relevance to ontologies. In this way, the usefulness of Meta models in the Wand and Weber (2002) research framework could also be assessed. We then showed as an example how Meta modelling could assist to do research in the first opportunity area of conceptual modelling grammars in the Wand and Weber (2002) framework – evaluation of different ontologies. We proposed a mechanism for analysing and evaluating the Meta models of (a portion of) two well-known ontologies that had been used previously in information systems grammar research – the BWW representation model and Chisholm's ontology. The mechanism provided guidance for evaluating the Meta models of the two ontologies according to *ontological equivalence*, *deep structure*, and *comprehensiveness of scope* of the models. In the portions of the models analysed, we found that the two models were not completely ontologically equivalent; that Chisholm's model may have a deeper structure than the BWW model; and, that the BWW model is more comprehensive in scope.

These findings must be viewed mindful of the limitation that only portions of the Meta model of the full BWW representation model and Chisholm's ontology were used in this example. Further work will entail completing a Meta model for the full Chisholm ontology (as it is relevant to Information Systems research) and then using the comparison mechanism described, performing a full evaluation of the two ontological models. Moreover, we will pursue our work investigating the usefulness of Meta models of ontologies in the other relevant areas of research opportunity described by Wand and Weber (2002).

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