TOWARDS A MORE RELATIONSHIP-FRIENDLY ONTOLOGY FOUNDATION FOR CONCEPTUAL MODELLING

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Abstract: Researchers have for some years been looking to the field of Ontology to provide a foundation structure of meaning which would provide a yardstick against which different modelling systems and methodologies can be evaluated. The Bunge-Wand-Weber ontology (BWW) has led the field in this endeavour, but since 2000 has undergone some criticism. A notable feature of BWW is that it does not treat relationships as first-class objects. Several recent proposals have proposed ontologies that do emphasize relationships, although to a somewhat limited extent. Based on previous work on a relationship-oriented ontology, this paper suggests directions in which a Mark 2 BWW could be evolved.

1 INTRODUCTION

There have been a number of attempts to find a common structure of meaning for the field of Information Systems, to try and reduce confusion when IT analysts, who might have been brought up in different methodologies, have to work together, especially on large projects. A standard ontology would, researchers argue, be preferable to a Tower of Babel of different meta-models and methodologies.

The practice of Information Systems Development seems inevitably dominated by rival fashions, each with their own conceptual modelling approaches. Examples are Database Orientation (e.g. Entity-Relationship, Relational); Process Orientation (e.g. BPR, ARIS, SAP, Workflow), Object Orientation (e.g. UML); Web Services; Agile Methods and so on. At the same time, a number of good ideas that better address the wider socio-technical scope of Information Systems have never become widespread in IT practice, e.g. LAP (Language Action Perspective), Organizational Semiotics and Activity Theory.

One attempt to address the Tower of Babel problem has been the idea of Model Driven Architecture (MDA). This depends on having a Platform Independent Architecture (PIA) based on an extended form of UML (UML-Profile), together with a series of transformations (ideally able to be generated automatically) from the PIA to different modelling architectures and ultimately to systems built with specific software tools.

Other academics have argued the need to go back to a more formal, philosophical and rigorously defined ontology that shows a semantic structure of all the things one needs to talk about when developing information systems. As well as being formal and rigorous, such a basis should not have more concepts than are absolutely necessary.

Section 2 of this paper summarises some of the recent attempts to build such a foundation, the major example being the ontology known as Bunge-Wand-Weber (BWW for short). Section 3 puts forwards a brief justification for treating relationships as a more central aspect of any architecture. Section 4 discusses how the specific relationship oriented ontology FROLIO might contribute to an improved foundation ontology. Finally, Section 5 offers some concluding thoughts and ideas for future work.

2 RELATED WORK

2.1 The Bunge-Wand-Weber Ontology

(Wand and Weber 1990) developed the BWW ontology on the basis of a more philosophical ontology developed around 1977 by Mario Bunge. BWW follows some of Bunge's original ideas, but not all.

Tagg R. (2010).
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The idea of BWW is to be used as a basis to evaluate the "grammars" of the various conceptual IS modelling methods such as those mentioned in the introduction. It can, for example, be used to assess if a methodology is missing certain essential concepts, or if some of their concepts are redundant.

The main concepts (objects) included in BWW are listed in Table 1.

Table 1: Main objects in the BWW ontology.

Thing Property - In General *(alias attribute)* - In Particular *(attribute value for an individual)* - Hereditary - Emergent - Intrinsic *(of a single thing only, i.e. not "Mutual")* Class *(things that have one property the same)* Kind *(things that have 2 or more properties same)* Acts On Coupling - Binding Mutual Property - Non-Binding Mutual Property	
State - Stable State - Unstable State Conceivable State Space State Law - Stability Condition - Corrective Action Lawful State Space	**Transformation** Lawful Transformation - Stability Condition - Corrective Action Conceivable Event Space Lawful Event Space External Event Internal Event - Well-defined Event - Poorly-Defined Event History
System - Subsystem - System Decomposition - Level Structure System Composition System Structure System Environment	

Relationships, such as they exist in BWW, are represented either by *Functions* or by *Mutual Properties*. The basic "relationship" functions are:

- A Thing *possesses* a Property
- A Property *precedes* another Property (in the sense that possessing the first is a pre-condition for possessing the second)
- An Event *marks the change between* State 1 and State 2
- A Composite Property *is a conjunction* of Property 1, Property 2 etc (e.g. Date is a conjunction of Day, Month and Year)
- A Composite Thing *is an association of* Thing 1, Thing 2 etc
- A Composite Event *is a composition of* Event 1, Event 2 etc

There are a number of "supplementary functions" which test if, for example, one of the individual objects is part of a given Composite object, or a member of a given Class or Kind.

Wand, Storey and Weber (1999) describes how the BWW ontology addresses the concept of relationships. It does not regard them as "first class concepts", on the grounds that they are too imprecise and vague in their semantics, and "reflect a design and implementation view".

Some researchers, e.g. (Rosemann and Green 2002, Kiwelekar and Joshi 2007) have proposed "meta models" of the BWW ontology.

Criticisms of Bunge-Wand-Weber. Various authors have commented that BWW - as presented - is not intuitive for many of the people that might use it. Others say that, while well oriented to information systems, it does not appear to address the more "soft" (i.e. less formal, more human-oriented) areas of information systems. Critics point out that Bunge's original ontology (or at least that part of it which Wand and Weber built on) is very restricted to the world of matter, being based on dialectical materialism. It therefore tends to be light on some important aspects in IS development, e.g. Intention, Goal etc. It is also claimed that Wand and Weber didn't use enough aspects of Bunge's ontology, or they didn't use it as he intended.

(Allen and March 2006) say that Bunge's ontology "has no place for human intentions, interpretations or meaning", or what (Searle 1995) calls "institutional reality", which includes "corporations, government agencies, money, educational institutions, contracts and transactions". They claim that BWW has no support for "rules, policies and procedures".

(Herrera et al 2005) point out that Bunge did publish – admittedly in 1993 and after BWW appeared - a *Social* ontology. They have proposed extensions to BWW to take this on board, under the name IOMIS.

(Rosemann and Green 2002) suggested that BWW should be extended to cater for multiple perspectives in IS conceptual modelling, particularly the Process-centric perspective. They tested their extensions on the Activity Based Costing component of SAP, where concepts such as direct and indirect costs, cost pools, cost allocation base and activity were involved.

(Rosemann and Wyssusek 2005) suggested revisiting Bunge's original ideas and adding back in

Bunge's concept of "hierarchies of systems", at the bottom of which lies the Physical system, the top level being the Socio-Technical system. Since BWW already includes a hierarchy of System Composition (see Table 1) this use of the word "hierarchy" seems confusing – it might be better to talk about an interconnected network of different spheres.

In 2006, a set of papers was published in the Scandinavian Journal of Information Systems. To begin with, (Wyssusek 2006) summarized a number of criticisms of the BWW Ontology. Responses to these criticisms, from Guarino & Guizzardi, Krogstie, Lyytinen, Miller & Kazmierczak, Opdahl - and Wand & Weber themselves – then follow, together with an afterword from Wyssusek. In Krogstie's response, he points out that Organizational Semiotics approaches, such as his group's SEQUAL, have also been used for assessing the quality of modelling approaches, and that these naturally incorporate a multi-level view, following Stamper's "semiotic ladder".

2.2 Some other Active Ontology Foundation Projects

A number of recent projects have taken a less dismissive view of relationships, and have given them more attention in their proposals.

GFO. Herre, Heller and colleagues in the Onto-Med group in Leipzig, Germany have been developing an ontology system for application in medical informatics (Herre et al 2006). They started with a proposal GOL intended for informatics and data dictionaries, which has evolved into GFO - General Foundational Ontology and GFO-Bio. It recognizes a whole range of relationships types, some of them with 3 rather than the usual 2 roles. In some cases the third role is Context. GOL included 12 main relationship categories.

UFO. Guizzardi, who was a former collaborator with the Onto-Med group above, proposed with colleagues a family of ontologies (with relationships) named UFO - Unified Foundational Ontology (Guizzardi et al 2008, Guizzardi and Wagner 2008). UFO-A covers similar ground to BWW; while UFO-B addresses temporal relationships and UFO-C social relationships.

Sheth's Relationship Web. Amit Sheth, formerly of the LSDIS research group at the Univ of Georgia, now leads a group named kno.e.sis at Wright State University in Dayton, Ohio. (Sheth 2007) is a keynote slide presentation describing his new group's research directions, which recognize the so-called "Relationship Web". The primary application at kno.e.sis seems to be the automatic extraction of relationships from material on the web.

Storey's Relationship Ontology. Veda Storey (a former colleague of Wand at UBC and contributor to the 1999 BWW paper on relationships), together with colleagues at Georgia State University, has published papers about an Ontology for Relationships, e.g. (Ullrich et al 2000, Storey 2005). They have proposed 24 categories of relationships, drawn from sources such as WordNet, including common verb phrases (e.g. is, has, gets), data abstractions and business processes.

3 JUSTIFICATION FOR MORE DIRECT TREATMENT OF RELATIONSHIPS

According to (Osborne 2006), Dogen, the Japanese Zen master said, around 1250 AD, "Things do not have a meaning in themselves, but only in relation to other things". Osborne comments: "For Westerners obsessed with the classification of material things, this is a truly radical idea". This, in a nutshell, is the basic justification for giving relationships higher importance in foundation onto-logies that are to be used as a basis or yardstick for deciding if conceptual models, languages or methods are complete or contain redundancy. Wand and Weber's argument that relationships are a design-implementation construct relies on seeing relationships only in the Chen Entity-Relationship sense. In this paper, relationships are seen, in the Zen sense, as more fundamental to the universe of discourse – possibly more fundamental than entities.

Further, if an ontology oriented to conceptual modelling is to be applicable to systems beyond those that deal with strictly material "bean-counting", then it needs to be able to capture more of the meaning inherent in the wider socio-technical environment. This implies the need to include relationships covering intention, desire, interpretation, representation and so on.

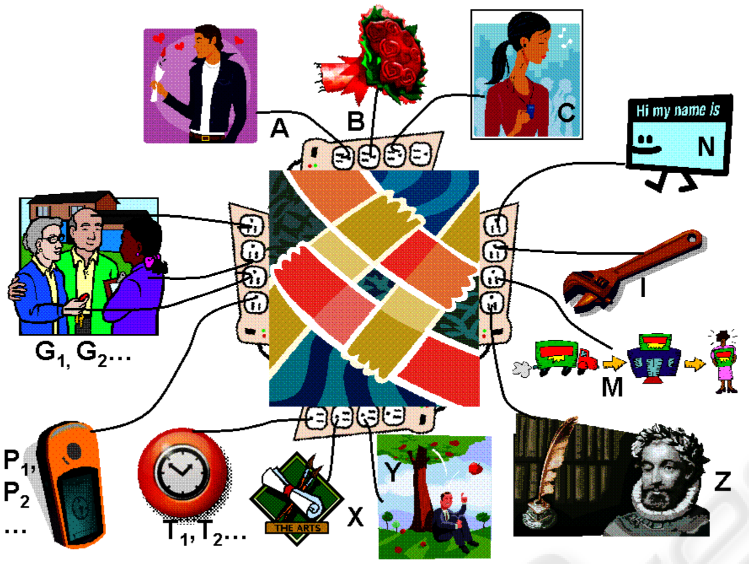

Figure 1: Default roles in a FROLIO relationship.

4 A MORE RELATIONSHIP-FRIENDLY APPROACH

FROLIO (Formalizable Relationship-Oriented Language Insensitive Ontology) was introduced in (Tagg 2008). It was built up initially from a trawl through Roget's Thesaurus (Roget 1852 etc).

It treats relationships as N-ary by default, and recognizes a number of common roles that appear in many relationship types. This contrasts with most of the ontologies mentioned in 2.2 above, where relationships are usually binary - although compound relationships are included in (Ullrich et al 2000).

In Figure 1 above, the four clasped hands represent the relationship, and the sockets the various roles. The **A**, **B** and **C** roles represent the entities that are being primarily related, with **G1**, **G2** etc representing further active roles if needed. In simple binary relationships only **A** and **B** may appear. The **I** role (Instrument) and **M** role (Method) represent any tools or processes involved in creating and maintaining the relationship. The **N** role is used as a name for the relationship when it itself plays the role of one of the entities in a further relationship.

The remaining "secondary" roles are **P** (Place) and **T** (Time), each either with a single value or a "From … To" pair; **X** (Context), i.e. the scope of what we are talking about; **Y** (Theory), i.e. the model of reality we are working with; and **Z** (Authorship) i.e. the person or authority who is asserting the relationship.

FROLIO currently encompasses 12 major relationship categories, with 47 subcategories and 280 named relationship types. These show some similarity with those in (Storey 2005).

Arrangement (56 relationship types) has 4 main subcategories, dealing with Space, Time, Physical Connection and Interpersonal, Organisational, or Abstract Structures. Some relationship types are Static by nature, others Dynamic.

Classification has just 3 relationship types, *instance-of*, *sub-class-of* and *shares some instances with*.

Distinguishing is concerned with difference sameness and similarity, and has 17 relationship types in 4 categories, Identity, Observable Attributes, Space-Time and Instinct-Feeling- Logic.

Interaction (47 relationship types) has the 4 sub-categories of Cooperation, Contention, Influence and Speech Acts.

Logic (24 types) has the 6 sub-categories Deduction, Explanation, Forethought, Insight/Induction, Justification and Summarization.

Motivation has just 7 types in 3 sub-categories, Direct Motivation, Goal Orientation and Indirect Commitment; in the last case a Contract or other commitment is intermediate between the human or animal and a potential action.

Partitioning has just 2 sub-categories; the main one is Composition, whereas the other covers Membership (implying a collection of similar things in a group). Part-hood in this sense covers abstract things (e.g. sub-issues, factors, organization units) as well as physical parts as in an assembly or a machine.

Representation (14 types) is split into 5 sub-categories, Identification, Delegation, Expression (e.g. articulation in language, translation, paraphrase, spin), Notation (e.g. measurement, recording) and Modelling (*is-a-model-of*).

Sensation (44 types) comes in 3 sub-categories, Emotional, Observational (i.e. through one of the 5 senses) and Robotic Detection.

Transformation (26 types) covers the relationship between things in a "before" state and an "after" state. The 5 sub-categories in FROLIO are Creation and Manufacture, Reproduction, Modification-Metamorphosis, Destruction-Consu-mption and Transfer.

Utility has one main sub-category, Usefulness, and 3 others, Substitute-Alternative, Opportunity and Habit. There are currently 10 types in all.

Volition has 21 relationship types. One of the main entities (A or B role) is always a state of affairs, situation or scenario. The 4 sub-categories are Desire, Intention, Constraint and Risk.

As currently documented, the roles appropriate for each main category and sub-category are identified, and examples of real-world relationships offered.

However, as it exists today, FROLIO is only a partial ontology, concentrating on relationships. It is not complete on the four aspects of ontology (Things, States, Transformations and Systems) addressed by BWW (see Table 1). The intention has up to now been that FROLIO would complement practical ontologies that already exist, like SUMO (Pease 2010) or OpenCyc (Cycorp 2010). In the context of the conceptual "platform independent" modelling of information systems, it would seem possible for FROLIO to complement most of BWW, or to enrich the already-proposed relationship-friendly ontologies such as GFO, UFO or Storey's. It could possibly also complement the Ontology Charts used with Stamper's Semantic Analysis Method (SAM), with their concepts of *Affordances* and *Norms* (Cordeiro and Filipe 2005).

5 CONCLUSIONS AND FUTURE WORK

5.1 Where Have we got to?

The BWW ontology has been available now for 20 years, and, according to several comments in (Wyssusek 2006), has been put to some good use. However some disquiet seems to be being expressed from a variety of researchers, and more recent projects (including that of Storey who was part of some of the early BWW work) have moved to a stance that treats relationships with more importance.

However it is possible that some of these projects have not yet taken on board some of the important semantics of relationships, and of the underlying philosophical nature of human activity, coloured as it is by desire, purpose and emotion. It is in this respect that consideration of the structure of FROLIO might add value to current proposals.

A symptom of the current importance of the issues addressed by this paper is the forthcoming publication by Springer (scheduled for April 2010) of a collection titled "Theory and Applications of Ontology" (Poli et al 2010). There are two volumes: "Philosophical Perspectives" and "Computer Applications". The latter includes contributions by Herre, Guizzardi and Wagner, and the developers of Cyc.

5.2 Future Work

The present author having recently retired, it is not easy to predict how this work can continue. FROLIO itself is continuing to be developed, but as a platform for guiding individuals to examine the models behind mass media, social and political pronouncements, rather than the models of Information Systems development.

A BWW Mark 2 might be a good direction in which to go. The quality of the discussions on Wyssusek's criticisms in the 2006 ScanJIS issue seems very high. The issue of whether or not the current downplaying of relationships in BWW should continue needs revisiting. More certainly, the need to better recognize institutional and social realities seems unquestionable.

This paper therefore suggests that a new foundation ontology should be built on the efforts of Guizzardi and his team. The relationship-specific parts could usefully be enhanced by consideration of FROLIO, Organizational Semiotics and the work of Storey and her colleagues. The new ontology should also take on board both Bunge's social ontology and domain-specific applications such as GFO-Bio.

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