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ONTOLOGICAL ANALYSIS OF VALUE MODELS

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Abstract

The current lack of consistency between business processes and their underlying business models lead to a lack of understanding about business process contribution to the value chain. In order to enhance understanding of business models and their impacts to business processes, consistency of value model representations is one important aspect. Examining representations - i.e. e³value, Resource Event Agent model, and the Business Object Model -concerns both grammar and method. Therefore, the paper presents in a first step an ontologic grammar evaluation of value models, which bases on the Bunge Wand Weber Representation Model. By examining conceptual representations using e³value, UML class diagram and ER modelling in context of value models, their impact to business processes is analysed evaluating the expressiveness in terms of ontologic coverage and overlap. Impact refers to the ability to transform the concepts of value models to the process level. The paper's contribution is not the overall evaluation, but the proof of appropriateness of value modelling grammars to their potential of an enhanced user understanding.

Keywords: Value Models, Enterprise Modelling, Business Process Modelling,

1 INTRODUCTION

According to an empirical study of the Technical University of Vienna (2008), only 10 percent of the companies have a consistent integration of business processes to their business model behind. In fact, consistency reveals the contribution of business processes to the value chain. The consequences of a missing consistency are a missing understanding of business models and an unoriented strategic alignment (ibid, Delen 2005; Fox et al 1993). Due to these drawbacks, business models as conceptual representations are used to reduce misunderstanding of value creation, distribution, and consumption (Gordijn et al. 2000). In this context, business models are used as value models. They are defined as a blueprint of how companies doing business in order to create value (Osterwalder 2004). However, fostering understanding of business models and processes is driven by modelling (Rode 2000). Even vom Brocke et al. (2010) emphasize the meaning of value considerations in process modelling by giving contextual value information to functions and processes within *event-driven-process chains* (EPC). However, the contextualisation does not show users the meaning of activities to their contribution to the business model and value creation. The correspondence of value models and business process models is necessary providing an overall assessment of business processes and their influence to the value considerations in terms of revenues and benefits (Weigand et al. 2006). In this context, the research goal is the design of a value model framework, which provides an assessment of strategic value- and corresponding process models using both models as well as semantic based approaches (Buder and Felden 2010). However, the contribution of value model representations to an enhanced understanding remains unclear. Even if enterprise architectures and models address the correspondence and integration of different organisational views including strategy and processes, they do not consider the integration and correspondence of value in terms of financial and stimuli aspects. Due to this drawback, the integration of current used value models, i.e. *Business Model Ontology* (BMO) (Osterwalder 2004), *e³value* (Gordijn 2004), and the *Resource Event Agent* (REA) (McCarthy 1982), in enterprise model is not analysed (Andersson et al. 2006). Therefore, the correspondence and consistency to the process level is not clear. One important aspect to enhance a consistent understanding of value activities is the modelling language grammar and its expressiveness to real world phenomena (Wand and Weber 2002). By providing modelling constructs, grammatical deficiencies impede the understanding of the underlying discourse of universe (ibid). The grammatical analysis bases on an ontology as a pervasive feature of reality (Weber 1997). The expressiveness of a grammar affects the effectiveness in use and understanding (Wand and Weber 1995). Therefore, it is the paper's goal to evaluate three value models to their potential of a consistent modeling to enhance understanding by using the *Bunge Wand Weber* (BWW) *representation model* (Wand and Weber1989; 1995; Weber1997).

The need of a correspondence and even integration of value models is emphasised by various approaches. First, vom Brocke et al. (2010) enrich EPCs with contextual value information. However, they refer only to financial aspects of business processes ignoring the meaning of the value chain and Porters' five forces. Moreover, this approach is not empirical validated and ignore semantic overlaps of models (see Weber 1997). Second, enterprise architectures address the integration of different organisational views, including value models (Johannesson et al. 2008). However, frameworks like *The Open Group Architecture Framework (TOGAF)* (TOV2009*)* or the *Zachman Framework for Enterprise Architecture* (Zachman 1987) do not obtain to specific modelling languages and give no advice to enhance understanding of value models and their correspondence to the process level. Third, enterprise models are concerned with specific methods and languages to integrate different enterprise perspectives (Uschold et al. 1997). We have examined five different enterprise models, i.e. the *Architecture of Integrated Information Systems* (ARIS) (Scheer 1991), the Enterprise Ontology (Uschold et al. 1997), REA (McCarthy 1982), the *Semantic Object Model* (SOM) (Ferstl and Sinz 1997), and the *Toronto Virtual Enterprise Ontologies* (ToVE) (Fox et al. 1993). Although they all emphasize the meaning of value models, they all renounce the formalisation of value processes and their correspondence and feedback to the process level. Especially ARIS with its high practical relevance ignores the value creation as a process, even when using the *value-added chain diagram*.

SOM and ToVE use value models as informal, descriptive model, called *enterprise plan* (SOM) or *goal* (ToVE). Even the REA model can be also used for value modelling (Johannesson et al. 2008, Osterwalder et al. 2005). But REA does not refer explicitly to the concepts of value activities and is difficult to model in this context (ibid; Geerts and McCarthy 1997). Therefore, neither correspondence nor an integration of business models and contextual value information to the business process level in enterprise models exist. In addition to the overall research goal, correspondence addresses not only the semantic level, but also the representational one. A key factor of an enhanced understanding is the quality of representations (Rode 2000). Quality refers both to the analysis of grammar as well as user perceptions (Wand and Weber 2002). The first step of the quality analysis of value models concentrate therefore on the evaluation of modelling grammar. By analysing the grammar, the implications of a consistent modelling of value models and their impact to the process level becomes obvious. The grammar of a modelling language requires a set of rules, constructs, and construct relationships to represent a domain (Wand and Weber 2002). The appropriateness to a domain is measured by using ontologies as real world phenomena like the BWW representation model. Although various authors have recognised the need for a value model evaluation (Andersson 2006; Gordijn et al. 2000, 2005), they ignore the use of accepted ontologies. Grammar evaluation addresses adopters of value models to take appropriate modelling languages improving the user understanding and system integration of value models and their implications to business processes (Wand and Weber 2002). For this reason, the contribution of this paper is the ontologic evaluation of three conceptual modelling languages, i.e. *e³value*, *ER modelling* (ERM), and *UML class diagram*, in context of the value models *e³value, BMO*, and *REA*. Evaluation refers to the appropriateness of conceptual representations concentrating on the assessment of congruence and consistency between modelling grammar and reality in a systematic way.

To achieve our research goal, the remainder of the paper is as follows: Section 2 examines the problem in-depth by analysing the drawbacks of current enterprise models to value modelling. Furthermore, the need for value modelling and its integration in BPMS to reduce the lack of understanding is explained. Section 3 describes the concept of model quality to get access to the meaning of ontologic analysis. Section 4 introduces the BWW representation model in respect to the conceptual business and value modelling and introduces into the research design of the ontologic analysis. The results are presented in Section 5. In conclusion, the meaning of model quality in business modelling is discussed.

2 PROBLEM FORMULATION

The ontologic analysis of value models is driven by the need of an enhanced understanding of value activities (see Gordijn 2004) in BPM. According to empirical findings of Palmer (2010), 75 percent of all BPM projects are reengineering projects with the goal of process improvement. Nevertheless, only 46 percent see process improvements after a BPM project (IDG Research 2008). In this context, the definition and redesign of business processes and their analysis need a higher level of abstraction (Dietz 2005). Business process modelling does not provide capabilities to present contextual value information to users (vom Brocke et al. 2010). But even the contextual enrichment of individual process activities (ibid) does not explain the meaning of activities to the value chain. Moreover, the problem of a reduced value understanding is aggravated by multiple modelling languages (Ko et al. 2008). For these reasons, the goal of value models is to explain business models with their value objects and activities to foster the understanding of business models and to facilitate the decision making. Identifying recourses, actors, and transactions in context of value creation is emphasized as a crucial factor to increase understanding of business processes (Andersson et al. 2005; Jayaweera 2004; Osterwalder 2004; Sheth 2003). The current gap between conceptual models and process models in general is addressed by enterprise models. They build conceptual artefacts that represent structure, activities, processes, information, resources, people, behaviour, and constraints of business and the enterprise environment (Fox and Gruninger 1998).

Whereas architecture frameworks like *Zachman Framework* (1987) or the more recent *TOGAF* (TOV 2009) give advice to consider value aspects, they do not give instruction to certain modelling languages. In TOGAF, the aspect of value refers only to the framework, not the enterprise and business model behind. We have analysed the following enterprise models to their potential of value modelling. They are chosen because they contain a strategic or business perspective. We have categorised the enterprise models if they contain explicit or implicit value modelling. Explicit means that the enterprise model provides both method and language to design value models. The goal of the review is to identify the current drawbacks of enterprise models in respect to value modelling and its conjunction with the process level.

Category	Framework	Construct
Explicit value modelling	ARIS (Scheer 1991)	• *Value-adding chain diagram as formal modelling language*
	Semantic Object Model (SOM) (Ferstl and Sinz 1997)	• Interaction schema that defines *goals*, *objects*, and *transactions*. • Focus on Information System (IS) development
Implicit value modelling	*Resource Event Agent Model* (McCarthy 1982, Geerts and McCarthy 2006)	• Implicit value modelling using the entities of *RESOURCE* and *COMMITMENT* and the relationships of *DUALITY* and *FULLFILMENT*
	(AIAI) Enterprise Ontology (Uschold et al. 1997)	• Implicit value modelling using the entities of NEED and MARKET NEED within the SALE process.
	Toronto Virtual Enterprise Project (ToVE) (Fox et al. 1993)	• Implicit value modelling expressing *business goals*.

Table 1. Categorisation of enterprise models threw value models

Enterprise models of the first category contain value models. But they have certain drawbacks of integration and task. The *ARIS* framework uses various visual representations with the goal of an integrated view in EPCs. The strategic level of *ARIS* enables consistency by using meta-models. *Value adding chain diagrams* are also used, but they ignore the exchange of value and are not part of the integrated *ARIS*-views (Scheer 1991). Moreover, Hepp and Roman (2007) have criticised *ARIS* due to its limitations in model expressiveness and consistency. *SOM* consists of three layers. In the first layer, an *enterprise plan* with *enterprise goals* is formulated. But formulation is informal. Even in the second layer, the *interaction-schema* presents as an object oriented model the goals and transactions of the enterprise plan. However, the schema concentrates only on an internal view. In contrast to value models *ARIS* and *SOM* are more related to the development of information systems as to perform business models (Ferstl and Sinz 1997). The second category show enterprise models that do not provide modelling language rules, but give methodological support. All of the examined enterprise models are formalised as an explicit specification of a shared conceptualisation which is also known as ontologies (Gruber 1993). In contrast to the first category, they do contain strategic levels to formulate and explain business models, e.g. the integration of value aspects in process activities is not specified in *ToVe* (*Activity Ontology*). Moreover, *The Enterprise Ontology* (Uschold et al. 1997) and *REA* (McCarthy 1982) do not refer to value models. But they can be used for it with methodological guidance of formalised value models (Osterwalder et al. 2005).

Formalised value models are designed to present strategic positioning and goals into a model that explicitly states how business works (Osterwalder et al. 2005). Reviewing the literature, *REA*, *e³value* model, and *BMO* are used to represent value propositions. The ability to facilitate the understanding of business models by using value models is shown in practice (see various works of Gordijn and Weigand). But the analysis of the different value models to their appropriateness of an enhanced value model understanding remains not clear. Due to the current drawbacks of business process modelling, the examination of the potential of value models to give contextual value information in business process modelling constitutes also an important topic. As conceptual models, the grammar of the representation influences the expressiveness in terms of model effectiveness and efficiency (Moody 2001). By mapping model constructs to a well defined and accepted ontology[1], the potential of value modelling languages to their impact to business process modelling is examined. Impact can be understood as a transformation of conceptual model objects to enrich process models as done in ARIS. The examination refers to *REA*, *e³value,* and *BMO,* because they are common used value models in

[1] The meaning of ontology is used as a pervasive feature of reality (Weber 1997).

practice. Although Andersson et al. (2006) have examined these three value models, they do not consider the meaning of value models to guide business processes and there integration in enterprise modelling frameworks and therefore, its meaning for BPM. Also Gordijn (2004) and Gordijn et al. (2005) provide a comparison by creating an ontology. But the goal of this comparison is the integration of different value models and the understanding of differences and similarities – therefore, model consistency is not a defined goal. For these reasons, we examine and evaluate the representation of value models to their consistency with BPM. This is done by using the *Bunge Wand Weber* (BWW) ontology (Wand and Weber 1989; ibid 1995; Weber 1997). We have modified the ontology considering the goodness of representation for communication between model users and conceptual modelling requirements. Representation aspects are expressiveness in terms of construct deficit and overload in order to understand strengths and weaknesses of a value modelling language. For this reason, the paper follows the research question, which of the conceptual modelling languages for value modelling are appropriate to enhance understanding of business models and improve understanding of value adding activities in business process models.

3 DISCOURSE OF UNIVERSE

The meaning of model quality is not unambiguous, but it has become an important aspect in conceptual and process modelling (Lindland et al. 1994, Moody 2001, Recker et al. 2007). In order to evaluate the grammar of value models, quality of representation is the key factor of the system development effort (Frank 1998; Nelson and Monarchi 2007). We use the quality definition of Lindland et al. (1994), which is deduced from the *semiotic theory* (Morris 1970) and also used by model quality evaluations (Frank 1998; Moody 2001; Recker et al. 2007). According to Lindland, a model consists of four components of a representation, which are called *sets*. A model *M* is a set of statements that has been represented. The language *L* is the set of statements that can be made according to the syntax. The domain *D* is the set of statements that would be correct and relevant for a problem of the discourse of universe. The interpretation *I* is the set of statements that the audience thinks the model contains. The components are linked with three quality aspects expressing linguistic concepts (Lindland et al. 1994; Morris 1970).

Quality aspect	Description
Syntactic quality	• the relationship between model and language with the goal of correctness • $M \setminus L = \emptyset$ means that morphologic errors and syntactic incompleteness lead to syntax errors
Semantic quality	• the relationship between model and the domain. • Validity, described as $M \setminus D = \emptyset$, means that all statements made by the model are correct and relevant to the problem. • Completeness, described as $D \setminus M = \emptyset$, means that all statements about the domain that are correct and relevant.
Pragmatic quality	• describes the relationship between model and audience interpretation • as $M \setminus I_i = \emptyset$ & $I_i \setminus M = \emptyset$, i.e. there are no statements in the model that are not in the stakeholder's model interpretation, and vice versa

Table 2: Quality dimensions of the Lindland Framework

Considering the research question, the evaluation of value models addresses both the *modelling method* and the *modelling grammar* (Wand and Weber 2002). Whereas the grammar provides a set of constructs and rules to model real-world domains, the method implies a procedure by which a grammar can be used to identify instances of all phenomena that can be modelled via a grammar (ibid 2002). For this reason, a twofold research approach is necessary. On the one hand, conceptual value modelling grammar has to be examined according to the expressiveness of the representation of aspects concerning the real-world domains (i.e. *actual semantic quality* (see Moody 2001)). Expressiveness relates to the technical actor interpretation (Recker et al. 2007). On the other hand, users' acceptance and understanding depends on their perception and cognitive style (Frank 1998). Therefore, the method has to be analysed according to performance, adoption, and behaviour as well (see Frank 1998; Lindland et al. 1994; Moody 2001). We focus on the goodness of conceptual modelling grammar in context of value models as its build the first step in our model evaluation. According to Wand and Weber (2002), the context is the setting, where models are used. Context is influenced by technical task factors like grammar and the real-world constructs, whereas individual and social factors reflect the users' modelling experience, knowledge and the organizational environment. According to the framework, the expressiveness of the modelling grammar influences the modelling method. Therefore, the perceived effectiveness and efficiency (see Moody 2001) of a value modelling method based on users` perception and the grammar expressiveness. The more constructs a value modelling language provide, the more the language will fit with the users modelling purpose and preferences (Frank 1998; Weber 1997). The evaluation is arranged by using an ontology, which is based on prior ontological work, generalised, and well-formalised. A high expressiveness and therefore semantic quality is reached, if there is a high degree of correspondence between ontologic constructs and modelling grammar constructs.

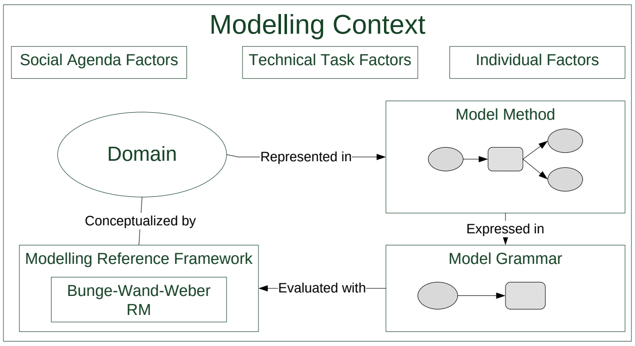

Figure 1. Research Framework of Conceptual Modelling (adapted from Wand and Weber 2002 and Recker et al. 2007)

4 RESEARCH DESIGN

We have chosen the BWW representation model as reference framework in order to evaluate the expressiveness of modelling grammars in respect to their appropriateness to enterprise models and business process coupling. The BWW representation model builds an ontology in terms of representing elements of the real world (Wand and Weber 2007) and is taken, because

- it is designed to evaluate modelling languages by providing a multiple set of criteria of constructs of the real world;
- the criteria provide theoretical guidance by grouping the representation constructs into different clusters (Wand and Weber 1995; Weber 1997);
- it has been used in more than 20 modelling evaluation projects (Rosemann et al. 2006). By using the BWW, the ontologic analysis of combining modelling grammars and translating conceptual models between different grammars is facilitated (Gehlert and Esswein 2007; Weber 1997);
- other ontology evaluations like the one from Moody and Shanks (2003) focus on data modelling, on the whole modelling process, and ignore the differentiation between modelling grammar and method.

For these reasons, the BWW is an appropriate ontology to evaluate the grammar of value models threw their consistency within enterprise architectures.

The BWW representation model bases on a set of ontological constructs $O = \{o_1,...,o_n\}$ which are mapped pairwise with a set of grammar constructs $G = \{g_1,...,g_n\} (n \in \mathbb{N}, n > 0)$ of the modelling language. The Ontology O builds a reference to analyse different types of relationships to analyse the ontologic expressiveness. Let MAP^r represent a set of mappings map^r that relate one ontological construct o to a set of grammatical constructs $\widehat{G}$ ($map^r: o \rightarrow \widehat{G}$ with $o \in O$ and $\widehat{G} \subset G \times G$).

- *Equivalence*: A one to one between ontologic and grammatical construct. (1.)
- *Deficiency*: An ontological construct is not present in the modelling grammar. (2.)
- *Redundancy*: There is more than one grammatical construct for at least one ontological construct. (3.)

Let MAP^i represent a set of mappings map^i that compare one grammatical construct g to a set of ontological constructs $\widehat{O}$ ($map^i: g \rightarrow \widehat{O}$ with $g \in G$ and $\widehat{O} \subset O \times O$).

- *Overload*: There is more than one ontologic correspondent of the grammatical construct. (4.)

- *Overplus*: The ontologic correspondent of the grammatical construct is missing. (5.)

Figure 2 presents the concept of an ontologic mapping with the five different relationships.

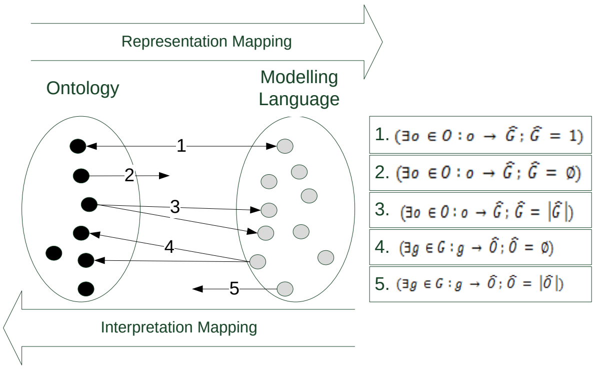

Figure 2. Representation Model for Language Evaluation with types of relationships

Based on the considerations, pragmatic quality of different modelling languages is evaluated by using two criteria: The *Minimum Ontological Overlap* (MOO) and the *Maximum Ontological Coverage* (MOC). Whereas MOO is achieved, if the same ontological construct cannot represent via alternative grammars, MOC refers to a minimum of construct deficits in both grammars.

The research design considers the relationship between different *tasks*, evaluating *participants* and the different *value model representations* (see Shanks 1997). *Tasks* are a case study representation in three different value modelling languages. The case study describes the value encounter in a hospital between the patient, his/her insurance company, and the medical treatment. The *value model representations* are three value models. One of them is presented with the e³value modelling language, the other models, REA and BMO, are presented both in ER-modelling and UML-class diagrams. Although ER-diagrams and UML (Opdahl and Henderson 2002) are mapped against BWW, e³value is not. The constructs of the representations are mapped threw the BWW constructs. The ontologic analysis is done in three steps (see Green et al. 2007):

Step 1: Three researchers evaluate separately the different value model representations (e³value, UML, and ER) by using existing UML and ER BWW-analyses. The result is a first draft of the evaluation. The evaluating participants are three practising information professionals, whereas two of them work at the university and the one as BPM expert in a company.

Step 2: The first drafts are discussed together to examine the results of step 1. A mapping of the first drafts builds the input to analyse the representations according to MOO and MOC. The result is one second draft of the ontologic analysis.

Step 3: The researchers defend and discussed their results to two remaining researchers. The outcome is the final result of the ontologic analysis and evaluation.

MOO and MOC can be evaluated in the purpose of value modelling. Whereas MOC is reached by the *degree of correspondence* (DoC) ($DoC = |O \cap O| \,/\, |O \cup O|$), MOO has to be evaluated by analysing the number of *construct overload*. A high level of overlap between the grammar means that grammar constructs have the same meaning. Therefore, overlaps lead to ambiguity and confusion. Green et al. (2007) suggest that developers would use the least grammars with the highest expressiveness. But in regard to our research question, a high MOO is not interpreted negatively concerning the aspect of integrating value models and BPM. A value modelling language is appropriate, if the DoC will be high and overlaps and overplus in accordance will be minimal.

5 EVALUATION & DISCUSSION

After presenting the ontologic evaluation of the different conceptual value model languages based on a modified case study, the results of the analysis are discussed through the research question.

5.1 Ontologic Analysis

The analysis and grammar evaluation of value models is done by using the *value encounters* case (Weigand 2009). The following figure represents the use case using the e^3value modelling language and the corresponding REA model presented in the UML class diagram. In order to reach a high accuracy, all representations are modelled in UML and ERM.

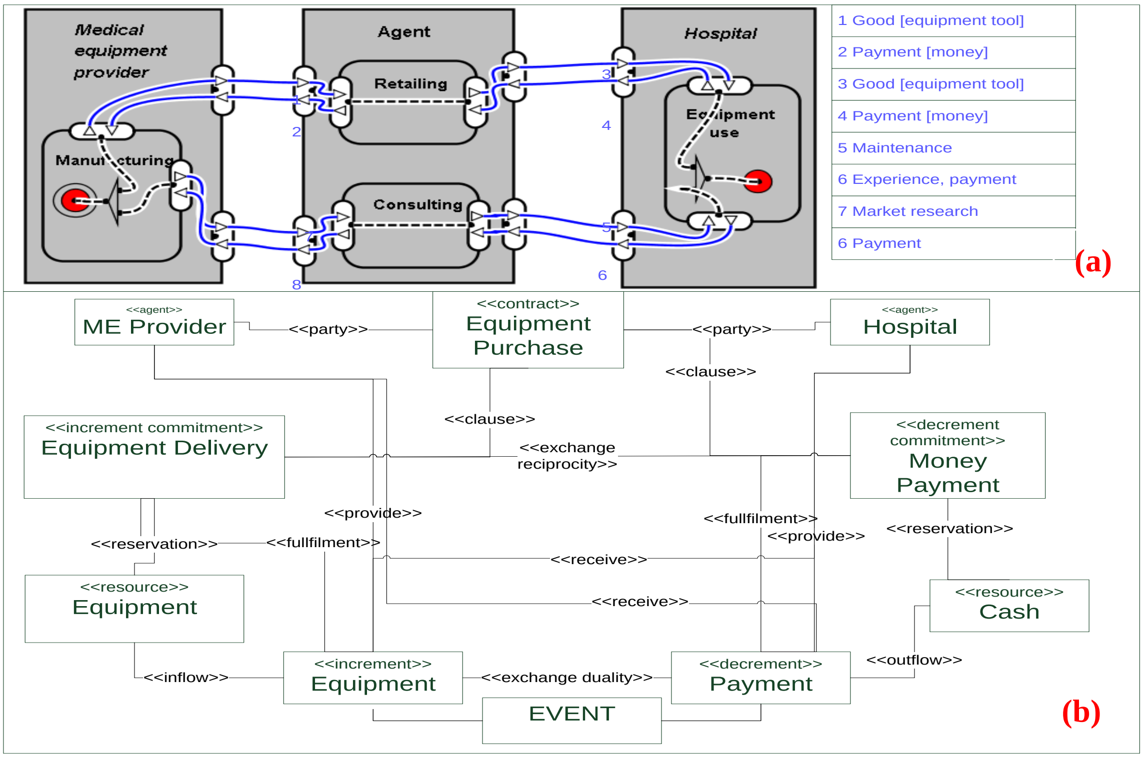

Figure 3. Representation of the Value Encounters Case in e^3value (a) and REA (b)

The ontologic evaluation of the ERM- and UML- representations considers former works of Opdahl and Henderson (2002) as well as Wand et al. (1999). Only those ontologic constructs are considered, which are relevant to conceptual modelling and complemented. The examined BWW constructs are modified from Wand and Weber (1995) and Wand et al. (1999). Ontologic constructs that do not refer to conceptual modelling like *event*, *transformation*, and *history* are not considered.

Ontologic Construct	***e^3value***	***UML***	***ERM***
Thing	Actor, market segment	Class, Object	Entity, Object
Property (of a thing)	Refined as follows	Refined as follows	Refined as follows
Intrinsic property (of a thing)	Property of a thing	Property of a class, object	(Intrinsic) attribute of an entity
Mutual property (of two or more things)	No direct representation	Association	(Mutual) attribute
Binding Mutual Property	No direct representation (only defined in *market segment*)	Association	(Binding, mutual) attribute
Class	Actor, market segment, value object	Class	Entity type
Kind	No specific counterpart	Class	Entity type
Natural kind	No specific counterpart	Class type	Entity type
Simple thing	Actor, market segment, value object	Class	Instance (type:simple)
Composite thing	Value transfer	Association, Aggregation	Instance (type: composite)

System	The composition of actors and value objects represents a system	Implicit, composition of classes, associations	Implicit, composition of relationships
System composition	Set of all objects and exchanges (implicit)	Set of all classes (implicit)	Set of all entities and relations (implicit).
System environment	Set of all objects and exchanges (implicit)	Set of all classes (implicit)	Set of all entities and relations (implicit)
System structure	Set of all objects and exchanges (implicit)	Set of all classes (implicit)	Set of all entities and relations (implicit)
System decomposition	No specific counterpart (implicit)	Aggregation	Attribute (type: mutual)
Level Structure	No specific counterpart	Inheritance and specialisation	Attribute (type: is part)
DoC:	11/15=0,733[2]	15/15=1	15/15=1

Table 3. BWW Evaluation on conceptual value models

The analysis shows that the *DoC* of e³value is less than of ERM and UML modelling. e³value reveals drawbacks in presenting properties of things and level structure. We did not find any ontologic overload and overplus of e³value according to the chosen constructs. Regarding to the research question of expressiveness, e³value reaches a high level of *MOC*. The drawbacks of *system decomposition* and *level structure* will have an impact, if large and complex tasks are modelled using many models. In this case, usage of UML class diagrams is appropriate. Whereas UML provides full ontologic coverage, it contains an ontologic overload concerning class and object (e.g. an UML object can represent a BWW thing or BWW class). Additionally, UML facilitate a reuse of conceptual model constructs in terms of model refinement, transformation, and purpose (Opdahl and Henderson 2002). Therefore, the transformation of conceptual value models to process models (as shown in Weigand et al. 2006) is facilitated by using UML. The ER-diagram provides also a maximum ontologic coverage. However, Wand et al. (1999) argue that the use of mutual properties can lead to model overloads. Moreover, the model redundancy will occur, if relationships are modelled ambiguously and differ modelling grammar is used.

In conclusion, the evaluation of the three different conceptual modelling languages shows that e³value has drawbacks concerning *MOC*, but does not include ontologic overplus. Concerning the question of value contextualisation in BPM, the e³value grammar is limited. Instead, the use of UML facilitates consistency. The fact that UML contains ontologic overload does not mean that the grammar has drawbacks in expressiveness. Considering a contextual integration of value models in process models, ontologic overload can be helpful.

5.2 Discussion

The result of the ontologic analysis does not show a clear answer to the research question. First, the evaluation of the three modelling grammar through value modelling is not seen as a challenge between them. One reason is that an evaluation does not exclude subjective influences because different analyses lead to different results (Gehlert and Esswein 2007). Another reason refers to the evaluation of the ontology constructs. *Ontologic completeness*, and therefore *DoC*, as quality factor depends on the ontologic constructs considering that an ontology never comprise all real world constructs (Frank 1998). Reviewing the literature also shows that the evaluation of the ERM differs (ibid 1997; Weber 1997). It depends on the mapping types and users' interpretation. Frank (1998) has criticised the ontologic evaluation because of the limited use and poor meaning. However, the evaluation bases on a theoretical framework. The BWW builds on the set theory and have been used in various evaluations. The shown evaluation explicates only a first step to analyse value models and their consistent transformation to business process models. The fact that e³value is limited to consistency has no impact to its appropriateness of its modelling purpose. The BWW ontology does not provide any constructs to analyse the grammars' appropriateness. Furthermore, the users' perception and cognitive

[2] The DoC does not consider constructs that are not represented and have no specific counterpart in the ontology.

style has to be considered. Moreover, e³value does not only provide a modelling grammar, but also a modelling method, which can also represented in other grammars as well. Due to this fact, the result of the ontologic analysis to the research question show only a limited grammar of e³value to consistency in terms of *level structure* and *model decomposition*. Concerning the expressiveness, all modelling grammars provide similar results with advantages of ERM and UML concerning consistency.

According to the research question, all examined modelling languages are appropriate in terms of MOC to enable and to improve the understanding of value models. The evaluation of e³value grammar shows that it is limited in two ways. In comparison with the other conceptual models, it has a lower MOC and has reduced capacities to correspondent with process models. According to the research question, all conceptual modelling grammars have a high degree of MOC so that the underlying domain can be represented appropriate. In respect of an enhanced understanding of business processes, the analysis shows a restrictive use of e³value in terms of level structure and system decomposition. Whereas ERM could be integrated in process models, as the ARIS framework shows, UML consists of a set of modelling languages that can be conducted. Therefore, it is easier to enrich value concepts in process models. Therefore, ontologic overlaps as found in UML are quite helpful to enhance the understanding of value in process models, as Weigand et al (2006) also show. The analysis reveals a further research on e³value in context of an integration of value objects and activities in process levels. In conclusion, the ontologic analysis shows that the considered languages are appropriate to represent value models. But there are differences concerning the aspect of business process enrichment. Whereas ERM and UML provide modelling capabilities to combine value modelling concepts to business process models, e³value has to be examined in respect to business process modelling. Moreover, the ontologic analysis does not consider the perceived understanding. For this reason, analysing the grammar has to be complemented with the perceived effectiveness and efficiency (see Moody 2001) of value models in order to evaluate value models to their ability of user understanding, process modelling integration, as well as overall process understanding.

6 CONCLUSION

The paper's goal was the evaluation of the three value modelling grammars to their expressiveness to improve understanding of value and business process models by providing value context. Although there have been enterprise models like *ARIS* or *ToVE*, the examined models renounce the meaning of value modelling to describe the companies' business. Moreover, the information and knowledge of value processes is ignored within the process level. On the other hand, existent value models are exclusively conceptual models. Moreover, common used business process modelling languages do not provide adequate semantics to express the contribution of process activities to the value chain. Therefore, the research question refers to the appropriateness of value models' grammar to enhance understanding of business models and improve understanding of value adding activities in business process models. Besides the use of a specific value modelling method, the choice of grammar builds a first important step to evaluate the expressiveness and appropriateness. Whereas REA and BMO do not have their own modelling grammar, e³value can be modelled with its own one.

Therefore, we have compared the UML class diagram, ERM, and e³value through the expressiveness of the modelling grammar by using the BWW ontology. Expressiveness is measured by MOO and MOC. We have seen that all three modelling languages have a high MOC concerning conceptual modelling language. Even when using complex cases, e³value has drawbacks to express different modelling levels and system decompositions, e.g. enterprise or holding company structures. Moreover, many constructs like system are not explicit. According to the research question, ERM and UML provide capabilities to enrich process models with contextual value information. Whereas UML consists of a set of various conjunct models, ERM can be integrated in current enterprise models. In this context, the capabilities of e³value to en enhanced understanding have to be analysed. But in fact, an ontologic analysis is a subjective task, although the BWW ontology is a highly formalised and accepted method to evaluate modelling languages. In respect to the research question, all examined modelling grammars are appropriate, whereas ERM and UML provide the best capabilities to combine value models. The analysis reveals a further research on e³value in context of an integration of value objects and activities in process levels.

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