Ontological evaluation of the specification framework proposed by the "Standardized Specification of Business Components" memorandum – some preliminary results

Peter Fettke, Peter Loos

Johannes Gutenberg-Universität Mainz
Information Systems & Management
Lehrstuhl Wirtschaftsinformatik und Betriebswirtschaftslehre
D-55099 Mainz, Germany
E-Mail: {fettke|loos}@isym.bwl.uni-mainz.de

Abstract: The specification framework for business components proposed by the research group "Component Oriented Business Application System" defines seven specification levels of business components. According to this framework several notations are used to describe a business component, e. g. the OMG Interface Definition Language (OMG IDL) and the Object Constraint Language (OCL). The specification framework implicitly claims to allow a complete specification of a business component. However, this proposition is not justified by the authors of the specification framework. In this paper, we use the Bunge-Wand-Weber-model (BWW-model) to evaluate the specification framework's completeness. The BWW-model has already been used for the evaluation of several other modeling grammars. This study demonstrates that the proposed approach is feasible. Based on the preliminary findings, we suggest some directions for further developments of the specification framework.

1 Introduction

Component-based software development is a potential reuse paradigm for the future (D'SOUZA, WILLS 1998; SZYPERSKI 2002). While the required technologies for component-style system development are widely available, e.g. Sun's Enterprise Java Beans, a problem inhibits the breakthrough of the component paradigm in business application domains: In practice, there is a lack of a standardized, well-known approach to describe the business component's functionality and its quality characteristics. To overcome this situation, the research group "Component Oriented Business Application System" – a subgroup of the "Gesellschaft für Informatik" (German Informatics Society) – proposed a specification framework for business components (ACKERMANN et al. 2002) (see section 2.1, in the following, the term "specification framework" always refers to this proposal).

The specification framework implicitly claims to allow a *complete* specification of business components (ACKERMANN et al. 2002, 3-5). However, this proposition is not justified by the authors. The objective of this paper is to analyze the specification framework's completeness. We define the completeness of the specification framework in terms of ontology – a well-known branch of philosophy. Our analysis is based on the Bunge-Wand-Weber-model (BWW-model, section 2.2). The BWW-model has already been used for the evaluation of several other modeling grammars (see section 2.4).

The main contributions of this work is to show some ontological deficiencies of the specification framework. In doing so, we will demonstrate the usefulness of the BWW-model for the evaluation of business component specifications too. However, a critical discussion of limitations of an ontological evaluation is out of the scope of this paper.

The paper is structured as follows: The theoretical background of this study is described in the next section. In section three some preliminary results of the ontological evaluation of the specification framework are presented. Section four concludes our findings and gives directions for further research.

2 Theoretical background

In this section we describe the theoretical background of this study. We present:

- an outline of the specification framework (section 2.1),
- an outline of the BWW-model (section 2.2),
- the method for the ontological evaluation of modeling grammars (section 2.3), and
- an overview of prior work on ontological evaluations (section 2.4).

2.1 Standardized Specification of Business Components

The specification framework uses seven specification levels (cf. figure 1) (ACKERMANN et al. 2002). Each level focuses on a specific aspect of a business component specification and addresses the needs of different development roles. Various notations are used on all specification layers. For an in-depth discussion of the various specification aspects and notations used on each specification level see the work cited above. An exemplar specification of a business component based on this specification framework is given in (FETTKE, LOOS 2003b; FETTKE, LOOS 2003c).

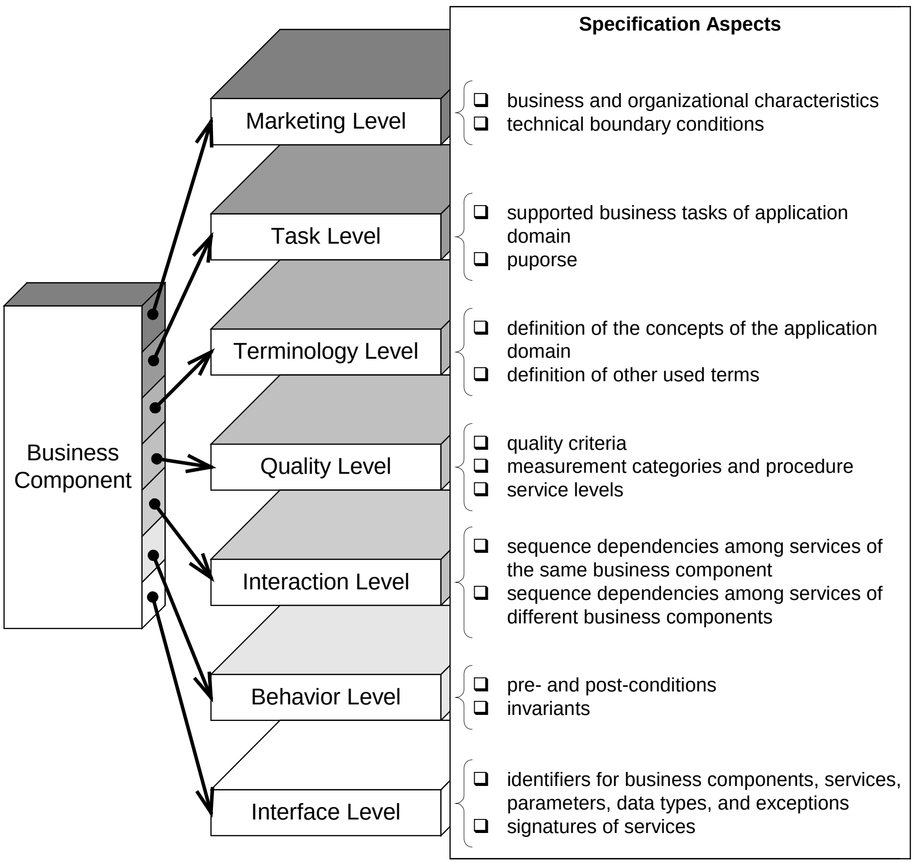

Figure 1: Specification levels and specification aspects (ACKERMANN et al. 2002)

2.2 Bunge-Wand-Weber-model

The philosophical discipline of ontology studies "the most pervasive features of reality, such as real existence, change, time, causation, chance, life, mind, and society"(BUNGE 2003, p. 201). This discipline provides a foundation for conceptual modeling, if the assumption is followed that conceptual models represent reality (WAND et al. 1995). Note, that our definition of the term "ontology" may not be confused with the common interpretation of this term as a more or less formalized "concept directory" (FENSEL 2001; GRUBER 1995).

Up to the present, there does not exist a generally accepted set of ontological principles and assumptions. Our analysis is based on the ontology initially introduced by Bunge (BUNGE 1977; BUNGE 1979) and adapted by Wand & Weber for the information systems field (WAND, WEBER 1989b; WAND, WEBER 1995; WEBER 1997). In the following, the term "ontology" refers to the Bunge-Wand-Weber-model (BWW-model). To improve the BWW-model's clarity, Rosemann and Green developed a meta-model of the BWW-model (ROSEMANN, GREEN 2002). For brevity, we do not introduce the BWW-model in detail. Instead, table 1 summarizes it's main constructs.

Ontological Construct	**Explanation**
Thing	"The elementary unit in our ontological model. The real world is made up of things. A composite thing may be made up of other things (composite or primitive)"
Property	"Things possess properties. A property is modeled via a function that maps the thing into some value. A property of a composite thing that belongs to a component thing is called a *hereditary* property. Otherwise it is called an *emergent* property. A property that is inherently a property of an individual thing is called an *intrinsic* property. A property that is meaningful only in the context of two or more things is called a *mutual* or *relational* property"
State	"The vector of values for all property functions of a thing"
Conceivable state space	"The set of all states that the thing might ever assume"
State law	"Restricts the values of the property functions of a thing to a subset that is deemed lawful because of natural laws or human laws"
Lawful state space	"The set of states of a thing that comply with the state laws of the thing. It is usually a proper subset of the conceivable state space"
Event	"A change of state of a thing. It is effected via a transformation (see below)"
Event space	"The set of all possible events that con occur in the thing"
Transformation	"A mapping from a domain comprising states to a codomain comprising states"
Lawful transformation	"Defines which events in a thing are lawful"
Lawful event space	"The set of all events in a thing that are lawful"
History	"The chronologically ordered states that a thing traverses"

Table 1: Constructs of the BWW-model (source: (WAND, WEBER 1993; WEBER, ZHANG 1996), part 1/2)

Coupling	"A thing acts on another thing if its existence affects the history of the other thing. The two things are said to be coupled or interact"
System	"A set of things is a system if, for any bi-partitioning of the set, couplings exist among things in the two subsets"
System composition	"The things in the system"
System environment	"Things that are not in the system but interact with things in the system"
System structure	"The set of couplings that exist among things in the system and things in the environment of the system"
Subsystem	"A system whose composition and structure are subsets of the composition and structure of another system"
System decomposition	"A set of subsystems such that every component in the system is either one of the subsystems in the decomposition or is included in the composition of one of the subsystems in the decomposition"
Level structure	"Defines a partial order over the subsystems in a decomposition to show which subsystems are components of other subsystems or the system itself"
Stable state	"A state in which a thing, subsystem or system will remain unless forced to change by virtue of the action of a thing in the environment (an external event)"
Unstable state	"A state that will be changed into another state by virtue of the action of transformation in the system."
External event	"An event that arises in a thing, subsystem or system by virtue of the action of some thing in the environment on the thing, subsystem or system. The before-state of an external event is always stable. The after-state may be stable or unstable."
Internal event	"An event that arises in a thing, subsystem, or system by virtue of lawful transformations in the thing, subsystem, or system. The before-state of an internal event is always unstable. The after-state may be stable or unstable."
Well-defined event	"An event in which the subsequent state can always be predicted given the prior state is known"
Poorly defined event	"An event in which the subsequent state cannot be predicted given the prior state is known"
Class	"A set of things that possess a common property"
Kind	"A set of things that possess two or more common properties"

Table 1: Constructs of the BWW-model (source: (WAND, WEBER 1993; WEBER, ZHANG 1996), part 2/2)

The BWW-model has been successfully used for several application areas: for instance, definition of an object model (WAND 1989), formalization of audit-procedures (WAND, WEBER 1989a), foundation of model quality (WAND, WANG 1996), proposal for modeling rules (WAND, STOREY, WEBER 1999) and evaluation of modeling grammars.

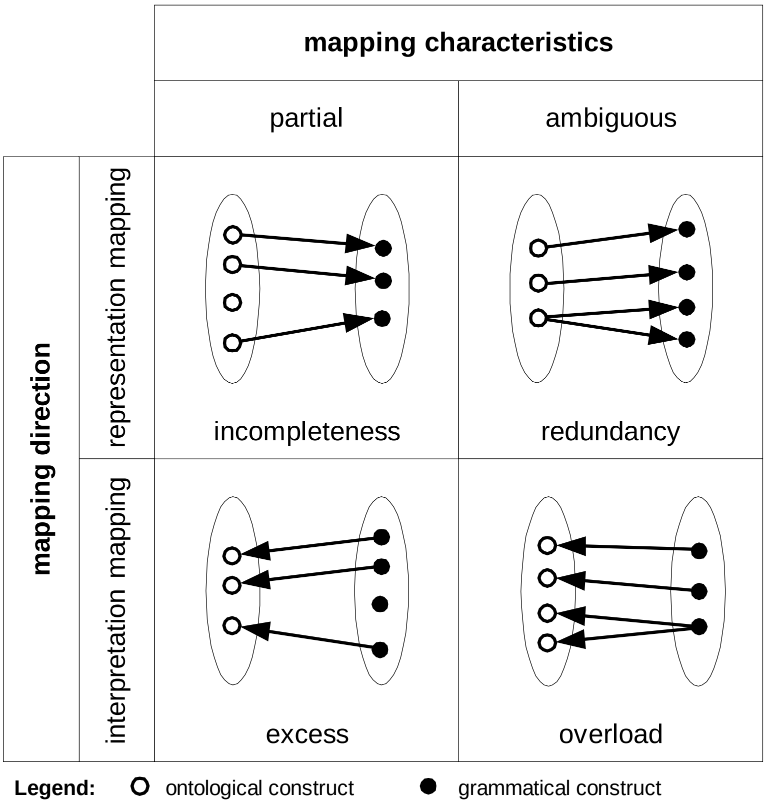

Figure 2. Ontological deficiencies of a grammar

2.3 Ontological evaluation of modeling grammars

The objective of an ontological evaluation is to develop a transformation mapping between the constructs of the BWW-model and the constructs of the modeling grammar being assessed (WAND, WEBER 1993; WAND, WEBER 1995; WAND, WEBER 2002; WEBER 2002; WAND et al. 1995). The transformation mapping consists of two mathematical mappings: First, a representation mapping describes how the constructs of the BWW-model are mapped onto the grammatical constructs. Second, the interpretation mapping describes how the grammatical constructs are mapped onto the constructs of the BWW-model.

With respect to both mappings, four ontological deficiencies can be distinguished (figure 2):

- Incompleteness: Can each ontological construct be mapped onto a construct of the grammar? A grammar is incomplete if the representation mapping is not defined in total. Otherwise a grammar is complete.
- Redundancy: Can each ontological construct be mapped onto exactly one or more than one grammatical constructs? A grammar is redundant if the representation mapping is ambiguous.
- Excess: Can each grammatical construct be mapped onto an ontological construct? A grammatical construct is excessive if it can not be mapped onto an ontological construct. A grammar is excessive if at least one of its constructs is excessive.
- Overload: Can each grammatical construct be mapped onto exactly one or on more than one ontological constructs? A grammatical construct is overloaded if it can be

mapped onto more than one ontological construct. A grammar is overloaded if at least one of its constructs is overloaded.

We refer to the term “grammar” as “ontologically clear” if it is neither incomplete nor redundant. A grammatical construct is adequate if it is neither excessive nor overloaded, so that it is defined unambiguously with respect to the interpretation mapping. A grammar is adequate if each of its grammatical constructs is adequate.

2.4 Prior research

We conclude the theoretical background of our study with an overview of the prior research. Table 2 depicts prior research, modeling grammars evaluated by the studies and used empirical research methods – if applicable. The primary intention of this overview is to demonstrate that an ontological evaluation is already used for several other applications areas. However, we are not aware of an ontological evaluation approach in the area of business component specifications.

Authors	**NIAM**	**DFD**	**ERM**	**UML**	**ARIS**	**OML**	**SOM**	**Jackson**	**Others**	**Empirical Inquiry**
(Wand, Weber 1989b)		●	●							-
(Wand, Weber 1990)			●							-
(Weber, Zhang 1991)	●									-
(Wand, Weber 1993)	●	●							●	-
(Wand, Weber 1995)			●							-
(Rohde 1995)								●		-
(Weber, Zhang 1996)	●									-
(Weber 1996)			●							laboratory experiment
(Green 1996)		●	●						●	survey
(Wand, Storey, Weber 1999)			●							-
(Green, Rosemann 2000)					●					-
(Opdahl, Henderson-Sellers 2001)						●				-
(Evermann, Wand 2001a)				●						-
(Evermann, Wand 2001b)				●						-
(Green, Rosemann 2001)					●					survey
(Bodart et al. 2001)			●							laboratory experiment
(Opdahl, Henderson-Sellers 2002)				●						-
(Fettke, Loos 2003a)							●			-

Table 2: Overview of prior work on the ontological evaluation of modeling grammars

3 Results

We evaluate the specification framework with respect to its ontological characteristics. For reasons of brevity, we focus our analysis on the representation mapping. See table 3 for an overview of the representation mapping introduced. We see this mapping as a first idea how to ontologically interpret the specification framework.

A BWW-thing can be represented by a whole business component (e.g. a business component “article”), indirectly by a data type on the interface level (e. g. data type “article”), and by a concept definition on the terminology level (e.g. concept “article”). So, these constructs are ontological partially redundant and may lead to confusions. The BWW-class and BWW-kind constructs are not represented by the specification framework.

There are several ways to represent properties of a BWW-thing. First of all, attributes of data types on the interface level may represent a property, e.g. article’s names may be represented by strings. Furthermore, BWW-properties can be described by quality criteria, concept definitions on the terminology level, and characteristics on the marketing level. The BWW-state of a BWW-thing is represented by concrete values of the properties described before. Restrictions of states can be formulated by expressions on the behavior level. For example, the warehouse stock of an article may not be less than 100 units. State values represented by quality criteria or characteristics on the marketing level cannot be restricted. BWW-state laws can be represented by expressions on the behavior and interaction level. However, the BWW-lawful state space is not represented explicitly.

Pre- and post-conditions of expressions on the behavior and interaction level partially represent BWW-events. The pre-condition can define the pre-state of an event (e.g. delivery received) and the after-state of the event is represented by the post-condition (e.g. warehouse stock is incremented). The BWW-event space is not represented explicitly. Furthermore, the specification framework does not allow to explicitly represent external, internal, well-defined and poorly defined events. BWW-transformations are represented by services and the corresponding specifications on the behavior and interaction level. All BWW-transformations are deemed to be lawful. As the BWW-event space, the BWW-lawful event space is not represented explicitly. The BWW-history cannot be represented at all.

A BWW-coupling between BWW-things can be partially represented by the “interface extern” specification on the interface level. A BWW-system is defined by a whole business component. Furthermore, the BWW-system environment is partially represented by the “interface extern” specification on the interface level. However, it is not possible to represent system composition, system structure, subsystem, system decomposition, and level structure within the specification framework.

Ontological constructs	**Constructs of the specification framework**
Thing	Whole business component, data types, concept
Property	Data types, concept, quality criteria, characteristics on the marketing level
State	Values of data types are not directly represented, values of quality criteria, values of the characteristics on the marketing level
Conceivable state space	Restrictions of values of data types can be represented by specifications on the behavior level; quality criteria and characteristics on the marketing level cannot be restricted
State law	Can be represented by invariants specifications on the behavior and interaction level
Lawful state space	Is not represented directly
Event	Events are represented by pre- and post-conditions of expression on the behavior and interaction level.
Event space	Is not represented explicitly
Transformation	Transformations are represented by services and the specifications on the behavior and interaction level.
Lawful transformation	See transformations
Lawful event space	Is not represented explicitly
History	-
Coupling	Some couplings between components are represented by the "interface extern" on the interface level.
System	Whole component
System composition	-
System environment	Partially represented by the "interface extern" on the interface level.
System structure	-
Subsystem	-
System decomposition	-
Level structure	-
Stable state	-
Unstable state	-
External event	-
Internal event	-
Well-defined event	-
Poorly defined event	-
Class	-
Kind	-

Table 3: Ontological analysis of specification framework

4 Conclusions, limitations and further work

The preliminary findings of our ontological analysis allows to draw the following conclusions:

- First, the main constructs of the BWW-model (thing, property, transformation, state) can be represented by the specification framework. So, the specification framework can be called ontological complete with respect to these main constructs.
- Second, the BWW-constructs representing the structure of a system (BWW-system structure, BWW-subsystem etc.) cannot be represented by the specification framework. So we conclude, that the specification framework should be enhanced by constructs which allow to represent the system's composition. On the one hand, it may be argued that such constructs will violate the black-box-principle of a component specification. On the other hand, the composition of simple business components to larger assemblies or modules is a well-known engineering principle. Furthermore, the developer of a business component assembly will have the need to specify a business component structure. In summary, we believe that the advantage of an explicit specification of the business component's structure will outperform its flaws.
- Third, BWW-events may be represented by the specification framework. However, it is not possible to explicitly define external and internal events. We argue that this ontological deficiency may cause problems when using the business component in different application environments. For example, it cannot straightforward be assessed if a business component fulfils the state requirements of given business environment. Such information is always attached to a specific service of a business component and not to a business component as a whole.
- Fourth, the ontological evaluation shows that some constructs of the specification framework are ontological redundant. For example, BWW-things, BWW-properties and BWW-states can be represented by several constructs. These deficiencies may lead to problems when using the specification framework. For example, should the characteristic "real-time accounting" be described on the quality level or on the task-level? On the one hand, it can be argued that this characteristic is a business task, so it should be described on the task level. On the other hand, "real time accounting" can be clearly viewed as a quality characteristic of book keeping components.

Next, we discuss some limitations of our work. An ontological evaluation is not an objective procedure or an algorithm which can be codified in some program language and processed automatically. Instead, it relies on the evaluator's interpretation of modeling constructs. This interpretation is to a certain degree subjective. So, it is necessary that the interpretation's rationale is made explicit and justified by specific reasons. We have to admit that our analysis is not based on an in-detail discussion of possible representation and interpretation mappings. This is a clear limitation of our study. However, the intention of our work is to point out that the implicitly stated claim of the specification framework to allow a *complete* specification of business components is not justified yet. Hence, we propose the BWW-model as a mean to analyze the completeness of the specification framework. The obtained results of our preliminary study are promising and demonstrate that this approach is feasible. On the other hand, we believe that other criteria can be developed to describe and to measure the quality of business component specification frameworks. For example, from a user oriented point of view, proposed specification techniques should be easily to use .

We see several directions for further work: First, our study focuses the representation mapping. It is possible to investigate ontological interpretations of the constructs of the specification framework. Furthermore, our study examined the correspondence between the BWW-model and the constructs of the specification framework on a rather rough level. Such an ontological evaluation should be conducted in a deeper way to exactly identify partial correspondences. Second, the ontological deficiencies identified in this study give some insights to improve and to develop the specification framework. Third, the specification framework should not only evaluated analytical, but also empirical. The BWW-model provides for such investigations a sound theoretical foundation.

References

ACKERMANN, J.; BRINKOP, F.; CONRAD, S.; FETTKE, P.; FRICK, A.; GLISTAU, E.; JAEKEL, H.; KOTLAR, O.; LOOS, P.; MRECH, H.; RAAPE, U.; ORTNER, E.; OVERHAGE, S.; SAHM, S.; SCHMIETENDORF, A.; TESCHKE, T.; TUROWSKI, K.: Standardized Specification of Business Components. http://wi2.wiwi.uni-augsburg.de/gi-memorandum.php.htm, accessed: 2003-03-01.

BODART, F.; PATEL, A.; SIM, M.; WEBER, R.: Should Optional Properties Be Used in Conceptual Modelling? A Theory and Three Empirical Tests. In: Information Systems Research 12 (2001) 4, pp. 384-405.

BUNGE, M.: Ontology I: The Furniture of the World. Dordrecht, Holland 1977.

BUNGE, M.: Ontology II: A World of Systems. Dordrecht, Holland 1979.

BUNGE, M.: Philosophical Dictionary. 2. ed., Amherst, New York 2003.

D'SOUZA, D. F.; WILLS, A. C.: Objects, Components, and Frameworks with UML - The Catalysis Approach. Reading, MA, et al. 1998.

EVERMANN, J.; WAND, Y.: An Ontological Examination of Object Interaction in Conceptual Modeling. Proceedings of the 11th Workshop on Information Technologies and Systems (WITS 2001). New Orleans, Louisiana 2001a

EVERMANN, J.; WAND, Y.: Towards Ontologically Based Semantics for UML Constructs. In: H. S. Kunii; S. Jajodia; A. Sølvberg (Ed.): Conceptual Modeling - ER 2001 - 20th International Conference on Conceptual Modeling, Yokohama, Japan, November 27-30, 2001, Proceedings. Berlin, Heidelberg 2001b, pp. 354-367.

FENSEL, D.: Ontologies - A Silver Bullet for Knowledge Management and Electronic Commerce. Berlin et al. 2001.

FETTKE, P.; LOOS, P.: Ontologische Analyse des Semantischen Objektmodells. 11. Fachtagung Modellierung betrieblicher Informationssysteme (forthcoming). Bamberg 2003a

FETTKE, P.; LOOS, P.: Specification of Business Components. In: M. Aksit; M. Mezini; R. Unland (Ed.): Objects, Components, Architectures, Services, and Applications for a Networked World - International Conference NetObjectDays, NODe 2002, Erfurt, Germany, October 7-10, 2002, Revised Papers. Berlin et al. 2003b, pp. 62-75.

FETTKE, P.; LOOS, P.: Specifying Business Components in Virtual Engineering Communities. Ninth Americas Conference on Information Systems 2003. Tampa, FL, USA 2003c, pp. 1937-1947.

GREEN, P.: An Ontological Analysis of Information Systems Analysis and Design (ISAD) Grammars in Upper Case Tools. PhD Thesis, 1996.

GREEN, P.; ROSEMANN, M.: Integrated Process Modeling: An Ontological Evaluation. In: Information Systems 25 (2000) 2, pp. 73-87.

GREEN, P.; ROSEMANN, M.: Ontological Analysis of Integrated Process Models: Testing Hypotheses. In: Australian Journal on Information Systems 9 (2001) 1, pp. 30-38.

GRUBER, T. R.: Toward principles for the design of ontologies used for knowledge sharing. In: International Journal of Human-Computer Studies 43 (1995), pp. 907-928.

OPDAHL, A. L.; HENDERSON-SELLERS, B.: Grounding the OML metamodel in ontology. In: The Journal of Systems and Software 57 (2001) 2, pp. 119-143.

OPDAHL, A. L.; HENDERSON-SELLERS, B.: Ontological Evaluation of the UML Using the Bunge-Wand-Weber Model. In: Software and Systems Modeling 1 (2002) 1, pp. 43-67.

ROHDE, F.: An Ontological Evaluation of Jackson's System Development Model. In: Australian Journal of Information Systems 2 (1995) 2, pp. 77-87.

ROSEMANN, M.; GREEN, P.: Developing a meta model for the Bunge-Wand-Weber ontological constructs. In: Information Systems 27 (2002) 2, pp. 75-91.

SZYPERSKI, C.: Component Software - Beyond Object-Oriented Programming. 2. ed., London et al. 2002.

WAND, Y.: A Proposal for a Formal Model ob Objects. In: W. Kim; F. Lochovsky (Ed.): Object-Oriented Concepts, Applications, and Databases. Reading, MA 1989, pp. 537-559.

WAND, Y.; MONARCHI, D. E.; PARSONS, J.; WOO, C. C.: Theoretical foundations for conceptual modelling in information systems development. In: Decision Support Systems 15 (1995), pp. 285-304.

WAND, Y.; STOREY, V. C.; WEBER, R.: An Ontological Analysis of the Relationship Construct in Conceptual Modeling. In: ACM Transactions on Database Systems 24 (1999) 4, pp. 494-528.

WAND, Y.; WANG, R. Y.: Anchoring Data Quality Dimensions in Ontological Foundations. In: Communications of the ACM 39 (1996) 11, pp. 86-95.

WAND, Y.; WEBER, R.: A Model of Control and Audit Procedure Change in Evolving Data Processing Systems. In: The Accounting Review 64 (1989a) 1, pp. 87-107.

WAND, Y.; WEBER, R.: An Ontological Evaluation of Systems Analysis and Design Methods. In: E. D. Falkenberg; P. Lindgreen (Ed.): Information Systems Concepts: An In-Depth Analysis. North-Holland 1989b, pp. 79-107.

WAND, Y.; WEBER, R.: Toward a Theory of the Deep Structure of Information Systems. In: J. I. DeGross; M. Alavi; H. Oppelland (Ed.): International Conference on Information Systems. Copenhagen, Denmark 1990

WAND, Y.; WEBER, R.: On the ontological expressiveness of information systems analysis and design grammars. In: Journal of Information Systems 3 (1993) 4, pp. 217-237.

WAND, Y.; WEBER, R.: On the deep structure of information systems. In: Information Systems Journal 5 (1995), pp. 203-223.

WAND, Y.; WEBER, R.: Research Commentary: Information Systems and Conceptual Modelling - A Research Agenda. In: Information Systems Research 13 (2002), pp. 363-377.

WEBER, R.: Are Attributes Entities? A Study of Database Designer's Memory Structures. In: Information Systems Research 7 (1996) 2, pp. 137-162.

WEBER, R.: Ontological Foundations of Information Systems. Melbourne 1997.

WEBER, R.: Conceptual Modelling and Ontology: Possibilities and Pitfalls. http://er2002.cs.uta.fi/info/weberspeech.rtf, accessed: 2003-01-27.

WEBER, R.; ZHANG, Y.: An Ontological Evaluation of NIAM's Grammar for Conceptual Schema Diagrams. International Conference on Information Systems. New York, New York 1991

WEBER, R.; ZHANG, Y.: An analytical evaluation of NIAM's grammar for conceptual schema diagrams. In: Information Systems Journal 6 (1996), pp. 147-170.