A requirements analysis of a method for harmonizing the conceptual modeling language, the ontology and the model setting

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Position Paper

1 Introduction

Since the late 1960s, the importance of conceptual modeling grew substantially due to the many project failures that were the consequence of faulty requirement analysis. *Conceptual modeling* was introduced as a means to enable early detection and correction of errors. Over the years, conceptual modeling has become a fundamental discipline in several communities in computer science. Its main objective is concerned with identifying, analyzing and describing the essential concepts and constraints of a universe with the help of a modeling language that is based on a set of basic modeling concepts [1]. Because of the importance attributed to conceptual modeling, a wide range of conceptual modeling models and methods were developed and introduced, in such a way, that this abundance even led to notions such as the YAMA syndrome (yet another modeling approach) [2] and the NAMA hysteria (not another modeling approach) [3]. The main criticism that followed from these new approaches tackled their lack of theoretical foundations [4, 5], stating that most modeling languages were based on common sense and the intuition of their developers [6]. Another often heard criticism is the lack of empirical testing of these approaches [7].

As a response to this criticism, different disciplines were explored for providing a theoretical foundation for conceptual modeling [8] e.g. cognitive psychology and cognitive science [3, 9], linguistics [10], semiotics [11] and ontologies [12]. As the title of this paper already may presume, we tend to focus on ontologies. In information systems, *ontologies* were introduced to provide a foundational theory that articulates and formalizes the conceptual modeling grammars needed to describe the structure and behavior of the modeled domain [13]. Ontologies were used to analyze the constructs used in conceptual models and to compare them against the constructs of a specific ontology. This kind of analysis could then reveal different types of grammatical deficiencies such as constructs overload, construct deficit, construct redundancy or construct excess [14].

However, the role of ontologies did not stop at merely evaluating conceptual grammars for their ontological expressiveness. The role of ontological theories evolved towards improving and extending conceptual modeling languages. This new development of enriching existing conceptual modeling languages with methodological guidelines that have their origin in a formalized ontology, can be called *ontology-driven conceptual modeling*. As mentioned by [1], many of these ontological theories such as those of Heller & Herre (2004), Chisholm (1996) and Bunge (1977) have been successfully applied. Both towards the evaluation of conceptual modeling languages or frameworks (e.g., UML, ORM, ER, REA, OWL) and towards the development of structuring rules [15], modeling profiles (e.g. OntoUML) [16] and design patterns and anti-patterns [17].

Nonetheless the successful application of ontologies as theoretical foundations for conceptual models, we can again observe a similar evolution, where numerous ontological analyses are performed and a plethora of ontological methods and ontology-driven conceptual models are developed. In fact, the extension and improvement of conceptual modeling languages through ontologies have even contributed to the YAMA syndrome and the NAMA hysteria, instead of resolving these issues. This development leads to similar warnings concerning the lack of empirical testing of these ontology driven models [18, 19]. The few empirical studies that have been conducted to examine the effect of applying ontology-based modeling rules, gathered mixed results. In [20], Bera et al. found that ontological rules can alleviate cognitive difficulties when developing conceptual models. Modelers would also commit fewer modeling errors when applying these ontological rules. However, Soffer and Hadar [21, 22] obtained less promising results. Their results agreed with those of Bera that, using ontology-based modeling rules can indeed provide guidance in developing a conceptual model and can reduce modeling variations, although the overall effect of these rules was not convincingly significant and did not always seem sufficient enough. It thus seem that ontology-driven conceptual modeling has not yet achieved the desired effects researchers were hoping for. Neither did we obtain a significantly better quality of conceptual models nor have these models become easier to understand and interpret. This brings us to a particularly interesting observation of the research by Soffer and Hadar, were they observed that the desired effect of applying easier to understand ontological rules was far larger than applying more complicated ontological modeling rules.

This ill-favored effect of complexity is also noticed by Guizzardi [1], where he states that ontology-driven conceptual modeling on the one hand needs to provide theoretically sound conceptual tools with precisely defined semantics but on the other hand must hide as much as possible the complexity that arise of these ontological theories. Perhaps this growing complexity of ontology-driven conceptual modeling is related to an increasingly problematic bottleneck in IS and system development, i.e. a growing demand for constant creation of formal models in specific and dynamic operational contexts, combined with a lack of people who are capable and willing to perform the modeling required [23].

Another anemic aspect of ontology-driven conceptual modeling, and perhaps a contributor to the cause of this observed complexity of some ontological modeling rules, is the random approach of how ontologies are selected. Often, a sound motivation lacks for why a certain ontology is chosen to provide a theoretical foundation for a specific conceptual modeling language. In the case a motivation for the choice of an ontology is actually given, it is most often limited to suggesting that similar work has been done with this specific ontology or that the ontology has a high degree of formality. Thus it seems that the current way of performing ontology-driven conceptual modeling is done by somewhat forcing an ontology to a conceptual modeling language.

This rather paradoxical situation of not having any sound criteria for providing a theoretical foundation for a conceptual model is also referred to by [14]. Here Weber states the need for sound ontological principles when one is about to design new conceptual modeling grammars and that otherwise we risk continuing to perpetrate unsound conceptual modeling practices. He concludes that we need to be especially cautious with our choice of the ontological theories we use in conceptual modeling. After all, the IS research domain is developing ontologies while most IS researchers never actually had any philosophical education. Therefore we ought not to expect that either our colleagues or ourselves can develop new, high-quality ontological theories. Also Wyssuek [24] calls for critical reflection when adopting any ontological theory as a foundation for information analysis and design. These issues tend to confirm that ontologies have not yet reached their destined goal of aiding conceptual models as they should do.

2 Requirements Analysis

Hence, in order to provide a sound motivation for selecting an ontology as a foundation for constructing a conceptual model, we must ask ourselves *why do I choose this ontology* and perhaps even more difficult to answer that why is *how do I choose an ontology*? With our research, we would like to provide an answer for these questions.

But before we can answer these questions, we have to look to a more fundamental level and to the more elemental question of *why do we model*? Hoppenbrouwers et al. [23] asks themselves a similar question. As a reply they arrive at a view on conceptual modeling that is deeply rooted in communication. They advocate a point of view that conceptual modeling should be understood in context of what models are for and taking into account the capacities and goals of the individuals who create or use them. Their research emphasizes to understand the process of conceptual modeling and more specific to better understand what courses of action lead to good models in line with the demands and goals posed by their contexts. Similarly, Wand and Weber [18] highlight the importance of the context or setting in which conceptual modeling occurs and where they are used. The task or purpose of the model was identified as one of the critical contextual factors to consider when constructing a model. From here on, we refer to setting as the context and purpose of which the conceptual modeling process takes place in.

It seems only logical that the reason why we develop a conceptual model is intrinsically related to the setting of this very model. Davies et al. [25] asked themselves the same question in their (empirical) research: *'How do practitioners actually use conceptual modeling in practice?'* where additionally one of their sub-questions was: *'What are the purposes of modeling?'*. Their research conducted a web-based survey in Australia, achieving a total of 312 responses where 87% of the participants were professionals who performed conceptual modeling on a regular basis. The remaining participants were academics and students. Also 85% of the participants characterized themselves as an IT service person while only 15% referred to themselves as a business user or end user. With regard to the overall purpose, the terms with the highest average score were: design and management, documentation, improvement and development. Fettke [26] performed a similar research, investigating how practitioners use conceptual modeling through a web survey targeted at German professionals who were familiar with conceptual modeling. Again, he also formulated a sub-question relating to the purpose of conceptual modeling. When ranking these purposes by average score, we notice rather similar results as those of Davies et al: design and management, development, improvement and documentation. An interesting observation made was that the purpose of the conceptual models could be linked to the results of the most frequently used modeling techniques, indicating that a conceptual modeling language was chosen according to the purpose of the model. It makes sense to choose an ontology in a similar way i.e. depending on the context and the purpose of the conceptual model, we choose an ontology that aids to fulfill this purpose. This approach is also advocated by Davies et al. in [27], arguing that, given the important and potential use of ontologies, the principal question becomes: which ontologies do we use for which purpose and how do we compare and evaluate the strengths and weaknesses of these ontologies for the purpose required? In their research they propose meta-models to analyze, compare and evaluate different ontologies for determining their strengths and weaknesses according to the purpose.

It is our believe that a conceptual model should be constructed in such a way that it takes into account three determining aspects: (1) the relationship between conceptual modeling language and its setting, (2) the relationship between an ontology and the model setting and (3) the relationship between the ontology and the conceptual modeling language. These relationships are represented in figure one.

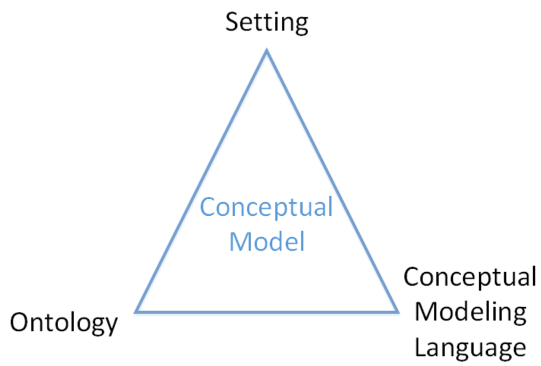

Figure 1: The composition of a conceptual model

If a conceptual model would be developed through the use of a method that encompasses the above-mentioned relationships, we believe the effects of ontology-driven conceptual modeling method would prove more desirable than they have been thus far. The requirements of this method can be distinguished according to the relationships defined above:

1. *Provide pre-defined user guidance based on the relation between the setting and the conceptual modeling language.*

During this phase, user guidance should aim at supporting the user in understanding the purpose(s) of his conceptual model and the potential use(s). The method should therefore already have a pre-defined set of the different kind of purposes and uses that a conceptual model can be applied for. For example, Wand and Weber [18] identified a minimum set of four modeling purposes: (1) supporting the communication between developers and users; (2) assisting the understanding of a domain; (3) aiding the design process and (4) documenting requirements for future reference. A similar set could be constructed in the method or such a set could be based on an existing classification as the one of Wand and Weber. Further, the method would have to provide certain guiding rules enabling the user or modeler to select a conceptual modeling language that fits most appropriately to the setting of the conceptual model. Ergo, the method would need a way of classifying conceptual modeling languages in such a way that they match certain purposes and uses. This classification could be based on the characteristics, strengths and weaknesses of the conceptual modeling languages and then match these strengths and weaknesses according to the requirements certain settings pose.

2. Provide pre-defined user guidance based on the relation between the setting and the ontology.

This aspect of the method is rather similar compared to the relationship between setting and conceptual modeling language. Since the user or modeler has already identified the purpose of his model, the focus here is on connecting the setting of the model with an ontology. The method should again have a pre-defined classification of ontologies in which a user can select the best fitting ontology. This classification could be made identifying ontologies according to a specific criterion. For example, Mylopoulos [28] classified ontologies into four categories: static, dynamic, intentional and social. Each of these categories targets different concepts in the real world. The classification should again identify the strengths and weaknesses of an ontology and match these with the requirements a specific setting holds.

3. Integrate the user-requested conceptual modeling language with the user-requested ontology.

The real difficulty of this method lies in connecting the conceptual modeling language with the ontology. Both have been selected individually according to their characteristics, strengths and weaknesses and are then matched with a specific setting. However, as mentioned by Evermann et al. [29], the validity of any ontology-based model rests on the assumption that the chosen ontology is a good description of the domain. Hence, the last aspect of the method should focus on harmonizing a conceptual modeling language with an ontology according to how well the each respectively represent and describe a certain domain.

In short, the method should select the conceptual modeling languages and ontologies that fit best with the requirements of a specific setting. This should lead to a selection of a few modeling languages and ontologies. These remaining modeling languages and ontologies should then be matched towards each other and their ability of representing and describing a domain. Finally, the setting, the conceptual modeling language and the ontology should be harmonized and integrated with one another to develop a complete conceptual model.

3 Conclusion

In this position paper we gave a short overview the development of conceptual modeling, the introduction of ontologies to provide a theoretical foundation for these models and the eventual upcoming of ontology-driven conceptual modeling. Ontology-driven conceptual modeling however does still hold some shortcomings. The main shortcomings arrive from the lack of empirical testing, a certain degree of complexity and an absence of motivation for why a certain ontology is chosen as theoretical foundation for a conceptual model.

Based on these shortcomings, we argue for the development of a method that questions the choice of an ontology. This method would focus on the three-fold relationships between the setting of a conceptual modeling language, the conceptual modeling language and the ontology. As a preparation for developing this method, we identified certain requirements this method should account for. Departing from these requirements, we intend to develop this method in our future research. But before starting to develop this method, we will first further analyze the requirements of this method, and acquire feedback from both the academic as of the professional community and practitioners.

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