

# Evaluation of the Ontological Completeness and Clarity of Object-Oriented Conceptual Modelling Grammars

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## ABSTRACT

Several research studies have concluded that modelling grammars that support the Object-Oriented (OO) methodology focus more on modelling system design and implementation phenomena than real-world phenomena in IS users' domains. Thus, the purpose of this research study was to evaluate the suitability of OO modelling grammars for conceptual modelling. Although the research work focused on one widely used OO modelling grammar—namely, the Unified Modelling Language (UML)—the approach developed can be applied to any OO modelling grammar. The first phase of this research study focused on evaluating all UML constructs and identifying a subset of UML constructs that are capable of representing real-world phenomena in user domains. The second phase was an empirical evaluation of the identified subset of UML constructs. The results of this empirical evaluation suggest that instead of using all UML constructs the subset of UML constructs is better suited for conceptual modelling.

## KEYWORDS

Bunge-Wand-Weber (BWW) Ontology, Canonical Action Research (CAR), Conceptual Modelling, Ontological Completeness and Clarity, OO Modelling Grammars, UML

## INTRODUCTION

Modelling is the essence of the Information System (IS) development process. It can be divided into two main genres: conceptual modelling and system modelling. Conceptual modelling represents phenomena that occur in a selected real-world scenario by transforming human perceptions of that real-world scenario into a model of perceived reality (Weber, 2003; Whitten, Bentley, and Dittman, 2001). A conceptual model is later used as the basis for building a system model during the design phase of IS development.

Conceptual modelling is important because IS development often commences with conceptual modelling. Hence, errors in a conceptual model are likely to propagate to subsequent phases of the IS development process (Wand and Weber, 2002). Such errors become more costly to fix if they are discovered in later IS development phases.

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Conceptual and system modelling primarily emphasize the data and process characteristics of a real-world scenario and the IS being developed. In the early history of both conceptual and system modelling, the data and process characteristics were captured and modelled separately (Milton, Rajapakse, and Weber, 2010). The IS community found that real-world phenomena and the IS domain cannot be represented precisely when this distinction is made. As such, in the 1980s, a new methodology for IS development was introduced—the Object-Oriented (OO) methodology (Eliens, 2000).

Nevertheless, researchers have found that OO modelling grammars do not have all the constructs needed to completely and clearly represent the types of phenomena that occur in the real world (Evermann and Wand, 2005a, 2005b, 2009; Opdahl and Henderson-Sellers, 2002a; Opdahl, Henderson-Sellers, and Barbier, 2000, 2001). The reason is that the fundamental notion of object in the OO methodology was introduced for the development of system models rather than conceptual models (Tilakaratna and Rajapakse, 2012). In contrast, the primary objective of conceptual modelling is the representation of real-world scenarios. In this regard, use of OO modelling grammars for conceptual modelling is problematic. Accordingly, our research study is motivated by the desire to evaluate the completeness and clarity of OO modelling grammars for conceptual modelling.

Evermann (2003, 2005) and Evermann and Wand (2001, 2005a, 2009) have already evaluated an OO modelling grammar, the Unified Modelling Language (UML), in terms of its suitability for conceptual modelling purposes. They chose UML because it is evolving into the most prominent and widely accepted OO modelling grammar (Evermann and Wand, 2005a). UML has 14 diagrammatic notations that are capable of modelling different views (e.g., static structure, interactions, internal and external phenomena) of an IS. Nevertheless, Evermann (2003, 2005) and Evermann and Wand (2001, 2005a, 2009) evaluated only a few of the constructs that exist in three UML diagrammatic notations—namely, class diagrams, state-machine diagrams, and activity diagram.

Therefore, in this research study, we extend Evermann and Wand's research work in three ways. First, we analyse all constructs in the 14 UML diagrammatic notations to identify the subset that are suitable for conceptual modelling purposes. Second, using an ontological approach, we evaluate whether this subset can represent any type of real-world phenomena completely and clearly. Third, we assess empirically whether practicing system analysts find the subset to be useful for conceptual modelling purposes.

The remainder of the paper is structured as follows. We begin by discussing relevant literature. We then outline our methodology. Next, we present our evaluation of constructs in the existing UML grammar. We conduct this assessment to identify which constructs in the 14 UML diagrammatic notations are suitable for conceptual modelling. We then evaluate the ontological completeness and clarity of the existing UML grammar based only on the chosen set of UML constructs. Subsequently, we present an evaluation of these constructs in a practical context. Finally, we evaluate the outcomes of our research and present some brief conclusions.

## **BACKGROUND AND RELATED WORK**

### **Ontological Approach**

Ontology is a philosophical discipline that deals with the nature of reality (Angeles, 1981). Potentially it provides a methodical basis for creating a shared understanding about the domain and the grammar among conceptual modelling users (Gruninger and Lee, 2001).

A number of ontologies have been used in IS-related research studies (Fensel, Van Harmelen, Horrocks, McGuinness, and Patel-Schneider, 2001; Uschold, King, Moralee, and Zorgios, 1998). The most widely used, however, is Bunge's (1977, 1979) ontology (Evermann, 2003, 2005; Evermann and Wand, 2001, 2005a, 2009; Wand and Weber, 1988). It is concerned with characterizing the nature of real-world phenomena in general. Weber (1997, p. 33) states that Bunge's ontology is the "best formulated and most complete theory of ontology" that he was able to find for the creation of a theory to evaluate IS analysis and design approaches.

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