This study of the semantics of the Whole-Part relationship in OO modeling is based upon, extends and, specifically, formalizes earlier analyses of the semantics of UML’s Aggregation and Composition (white and black diamonds, also called shared aggregation and composite aggregation). Although UML is nowadays regarded as a standard and is widely used as an OO modeling language, the way the Whole-Part relationship is formalized is unsatisfactory. Here, we provide a rigorous specification of various forms of the Whole-Part relationship using OCL (Object Constraint Language). The first part of the specification is based on the differentiation between primary characteristics (applicable to all Whole-Part relationships) assigned to a new Whole-Part metatype in the UML and secondary features, which are possessed by subtypes of this metatype and permit the representation of several “flavors” of the Whole-Part relationship. This UML-compliant style of specification, based on the use of OCL as well as metamodeling, allows us to directly incorporate our results into the UML metamodel, in particular revising UML’s definition of Composition.
INTRODUCTION

The Whole-Part (WP for short) relationship in OO modeling has been a subject of keen interest since, among others, its appearance in OMT (Rumbaugh, Blaha, Premerlani, Eddy & Lorensen, 1991). Named “aggregation” in OMT, this relationship is considered to be important for object modeling, although neither OMT nor its successor UML (OMG, 1997, 1999) provide well-grounded semantics. As it happens, UML supports two inconsistent kinds of WP relationship despite the fact that, both inside and outside the world of OO software engineering, numerous high-quality contributions exist on this very old research theme. This chapter is aimed at rectifying the current ambiguities and confusion in UML’s white and black diamonds (shared aggregation and composite aggregation, respectively) and thus hopes to influence the next versions of the UML standard. We purposefully use a UML-compliant style of specification, i.e., the use of OCL (Warmer & Kleppe, 1998) which is part of UML, complementing the metamodel, which is the primary way in which the UML’s semantics are currently described.

The second section of this chapter, named “Background,” is a concise overview of the WP relationship in OO modeling. In the third section called “Foundation,” we present and formalize a minimal set of characteristics for the WP relationship. In particular, we analyze this set according to three viewpoints: ontological, mathematical and software engineering-based considerations. In the fourth section named “Properties of the WP Relationship in OO Modeling,” we specify in OCL the key features (e.g. separability, existence dependency) for possible subtypes of the WP relationship. We finally conclude in the fifth and last section (“Conclusion and Future Trends”) by showing how this work can be used to modify the next version of the UML.

BACKGROUND

A WP relationship is a binary relationship from a set called **Whole** to a set called **Part**. A tuple is then \((w, p)\) with \(w\) being an instance of **Whole** and \(p\) an instance of **Part**. These two sets are not necessarily disjoint. For instance, the Programming statement object type can be linked to itself by using a WP relationship. In OO modeling, a given object type \(T\) in a given object model \(M\) corresponds to a set of potential instances that, by definition, conform to \(T\). \(T\) plays the role of either **Whole** or **Part** or both depending upon which \(T\) is involved in one or more WP relationships. Throughout this chapter, we deal with the generic terms **Whole** and **Part** in order to talk about “the” WP relationship as a metatype (called **Whole-Part** on the left side of Figure 1) from which “a” WP relationship in a specification model \(M\) is known to be its instance (“model level” on the right side of Figure 1). One major challenge of this chapter is then to supply robust criteria for distinguishing without ambiguity a WP relationship from an ordinary binary relationship (also called binary association in UML [OMG, 1999] or referential relationship in OML [Firesmith, Henderson-Sellers & Graham, 1997]) or, more accurately, to distinguish it from a non-WP relationship. In the UML 1.3 documents, it is written that: “An association may represent an aggregation, i.e., a whole/part relationship.” and “Only binary associations may be aggregations.” (OMG, 1999, pp.2-57). Therefore, in Figure 1, depicted using the UML’s style of notation (white diamond or Aggregation for convenience to mean simply WP relationship), we show a WP relationship between \(X\) and \(Y\) as an instance of the **Whole-Part** metatype. As a result, a WP linkage (tuple) between \(x\) (an instance of \(X\)) and \(y\) (an instance of \(Y\)) is also an instance of the WP relationship between \(X\) and \(Y\).
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