Exercises for Aggregation, Composition, and Generalization in UML

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Abstract: This paper is loosely connected to the paper 'Teaching Touchy Transformations' presented at the Educator's Symposium during the MODELS conference in 2008 by the same author. That paper reports on a teaching unit on model transformations within a course on UML and OCL. The current paper puts forward course exercises dealing with the UML concepts aggregation, composition, and generalization.

Context

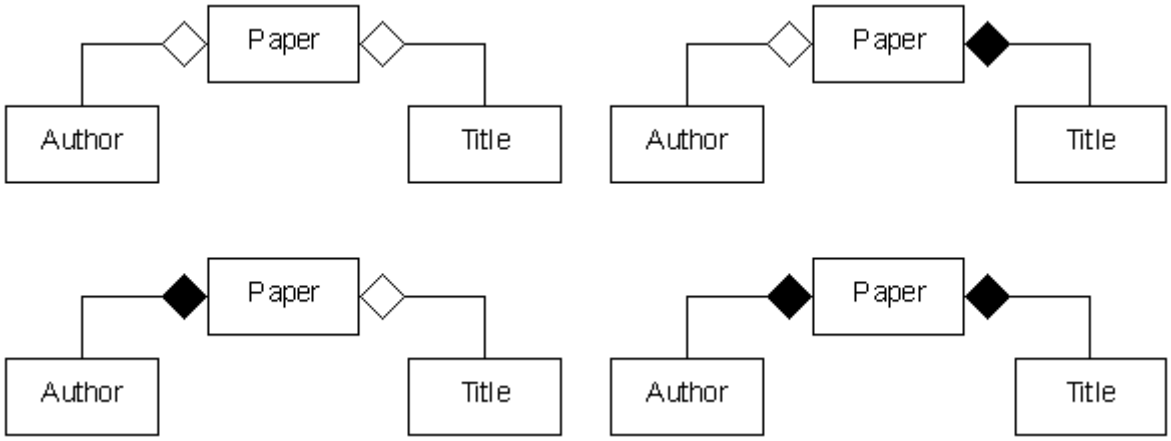
The teaching unit from the paper at the Educator's Symposium during the MODELS conference in 2008 is part of a course on UML and OCL. The course formally explains the UML concepts aggregation, composition, and generalization in terms of the OCL, see [Gogolla and Richters, 2001]. This paper describes exercises which delve into the details by discussing the similarities and differences between these UML concepts in terms of various small example models and by demanding to point out the differences in terms of object diagrams.

Exercises

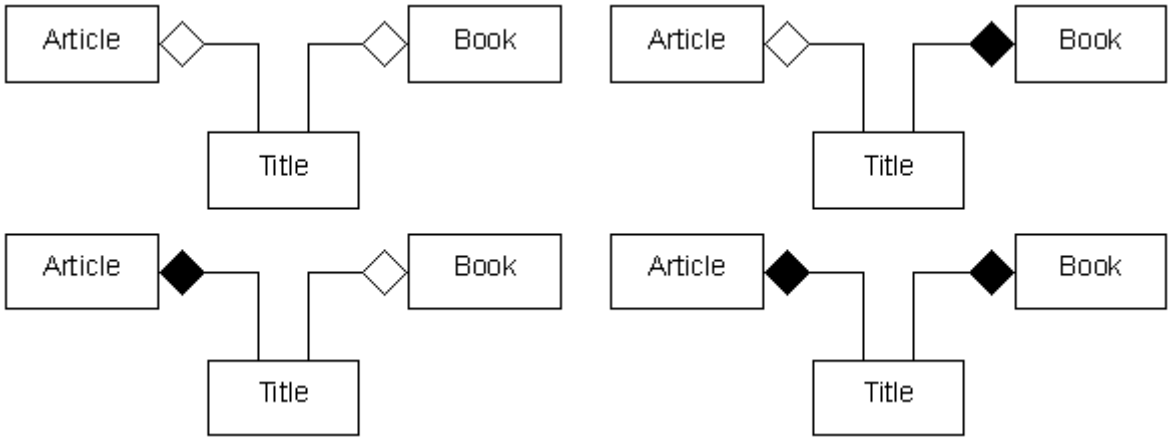
Below we show different modeling alternatives A1, A2, A3, and A4 for different universes of discourse. Each modeling alternative consists of a collection of class diagrams with slightly different features. For each modeling alternative carry out the following.

- Extend the class diagrams by specifying the most appropriate multiplicities for all present association ends. Choose only from the following, most common multiplicities: 0..1, 0..*, 1, 1..*.
- Show the OCL constraints underlying the class diagrams, i.e., present which restrictions are stated by the white diamond or the black diamond.
- Explain the differences between the models by showing object diagrams. For this, follow the method given below.
- Choose your favourite class diagram and explain in verbal form why you think your choice is the best choice.

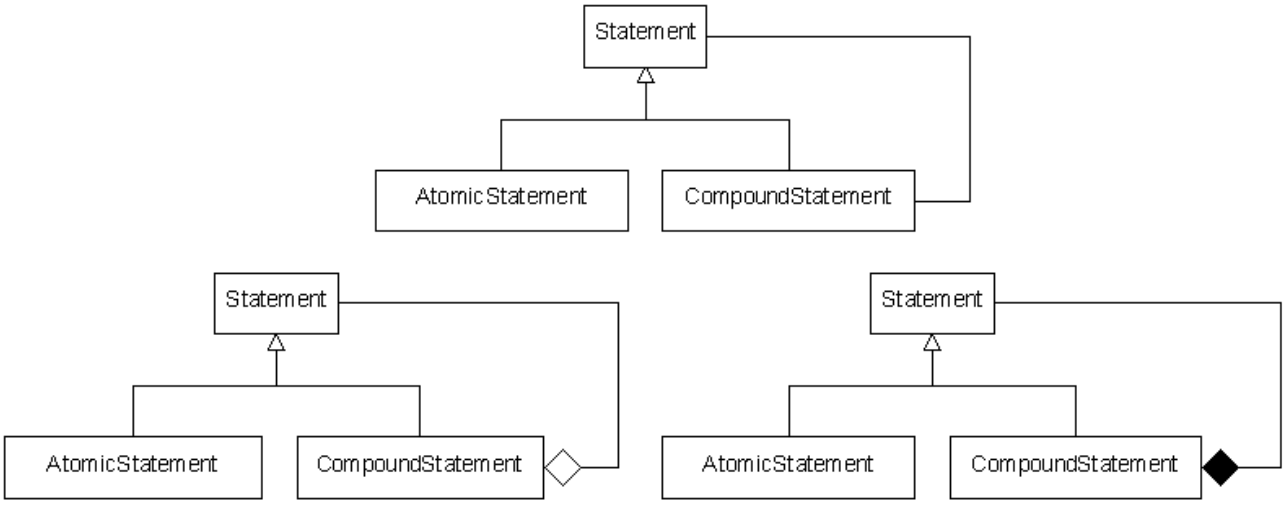
Alternative A1



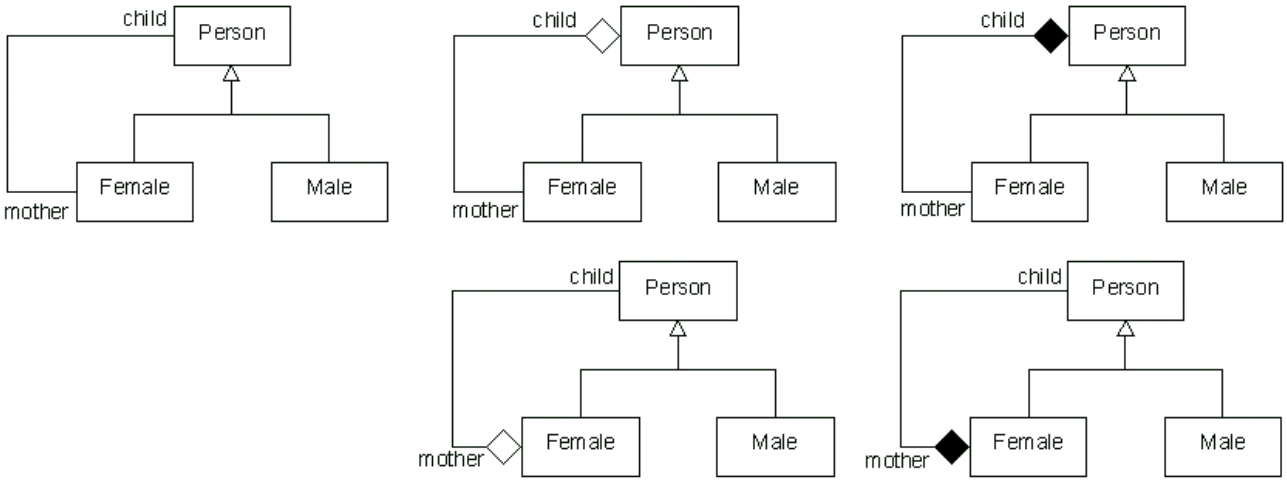
Alternative A2



Alternative A3



Alternative A4



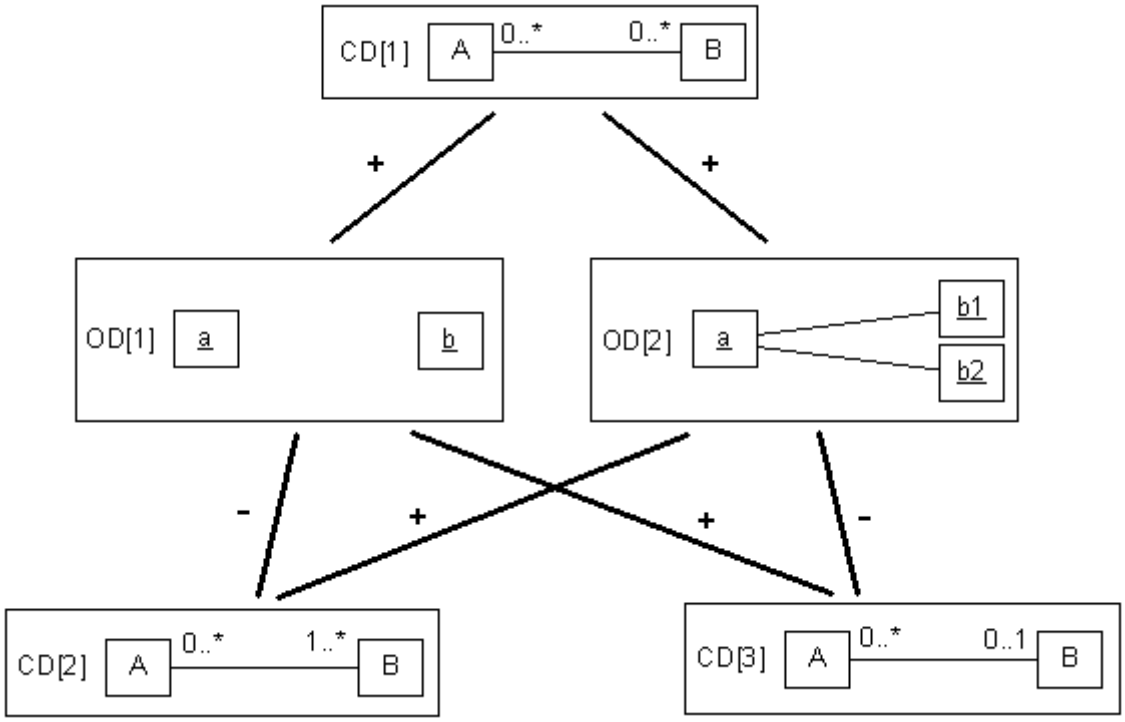
Method for Showing Differences between Models by Using Object Diagrams

In order to show with the use of object diagrams the differences betweeen some alternative class diagrams CD[1], ..., CD[n] one proceeds as follows: Find object diagrams OD[1], ..., OD[k] and determine for each i from 1..n and for each j from 1..k whether OD[j] is valid or invalid for CD[i]; the object diagrams must be choosen in such a way that for distinct pair (i1,i2) (from 1..n with i1<>i2) the validity vectors for class diagram CD[i1] and CD[i2]

[valid(CD[i1],OD[1]), ..., valid(CD[i1],OD[k])]
[valid(CD[i2],OD[1]), ..., valid(CD[i2],OD[k])]

are different.

Example

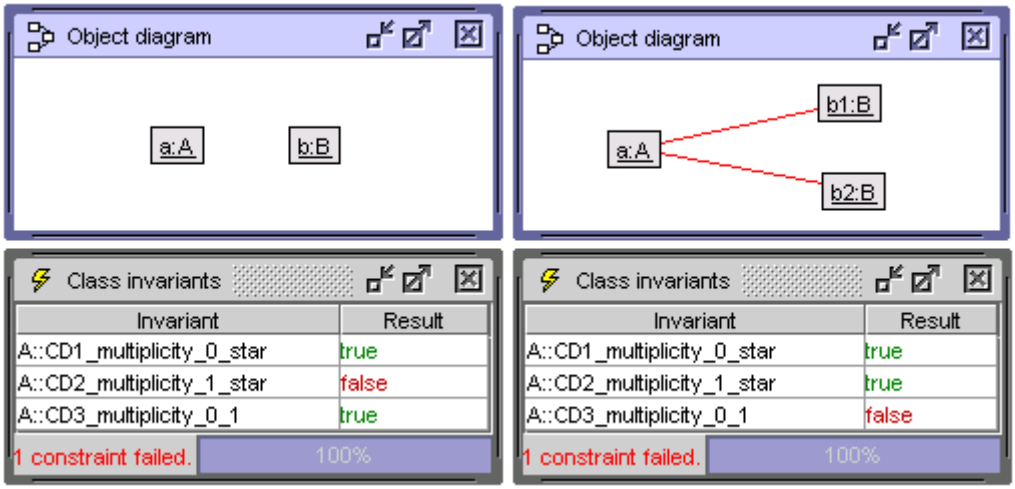


The above figure shows three simple class diagrams with different multiplicities and two object diagrams explaining the differences between the class diagrams. The three validity vectors for each class diagram look as follows.

[valid(CD[1],OD[1])=true , valid(CD[1],OD[2])=true]
[valid(CD[2],OD[1])=false, valid(CD[2],OD[2])=true]
[valid(CD[3],OD[1])=true , valid(CD[3],OD[2])=false]

Difference shown by	**CD[1]**	**CD[2]**	**CD[3]**
CD[1]	./.	OD[1]	OD[2]
CD[2]	see 1/2	./.	OD[1], OD[2]
CD[3]	see 1/3	see 2/3	./.

The above table captures the differences in form of a symmetric matrix. As shown in the figure below, the validity of an object diagram with respect to a class diagram may be checked with the USE tool, see [Gogolla et al., 2007].



Validating Objects Diagrams in USE

References

[Gogolla and Richters, 2001] Martin Gogolla and Mark Richters. Expressing UML Class Diagrams Properties with OCL. In Tony Clark and Jos Warmer, editors, *Advances in Object Modelling with the OCL*, pages 86-115. Springer, Berlin, LNCS 2263, 2001.

[Gogolla et al., 2007] Martin Gogolla, Fabian Büttner, and Mark Richters. USE: A UML-Based Specification Environment for Validating UML and OCL. *Science of Computer Programming*, 69:27-34, 2007.