

# Semantic Model Differencing Based on Execution Traces

Tanja Mayerhofer, Philip Langer, Gerti Kappel

Vienna University of Technology, Austria  
{mayerhofer, langer, gerti}@big.tuwien.ac.at

**Abstract:** Managing the evolution of software artifacts is a crucial issue in software engineering. As in the software engineering paradigm model-driven engineering (MDE), the main software artifacts are models, managing the evolution of models constitutes a key concern in MDE. One important technique in this realm is model differencing, which is concerned with identifying differences among different versions of models. While the majority of existing model differencing approaches use a purely syntactic approach, we propose an approach that takes the semantics of models into account. In particular, our approach utilizes the behavioral semantics of the used modeling language to execute the models to be compared and obtain execution traces constituting the models' semantic interpretation. By comparing the obtained execution traces, semantic differences among the models are identified.

Model differencing is concerned with the identification of differences among independently developed or consecutive versions of models. Therewith, it constitutes the basis for performing important change management tasks, such as model merging, model versioning, conflict detection among concurrent changes, and incremental testing.

The majority of existing model differencing approaches use a syntactic approach, which applies a fine-grained comparison of two models based on their abstract syntax representation. The result of this comparison is a set of *syntactic differences* among the considered models, such as model elements existing in only one of the models. Although syntactic differences constitute valuable and efficiently processable information sufficient for several application domains, they are only approximations of the *semantic differences* among models. As pointed out by Maoz *et al.* [MRR11], a few syntactic differences among models may induce very different semantics and syntactically different models may still induce the same semantics.

Until now, only a few model differencing approaches have been proposed that take the semantics of models into account. Maoz *et al.* [MRR11] and Fahrenberg *et al.* [FLW11] propose general procedures for realizing semantic differencing operators requiring the definition of the used modeling language's semantics as a translation into an adequate semantic domain and the implementation of the semantic model comparison in this semantic domain. However, developing semantic differencing operators in this way constitutes a major challenge, as one has to develop translations of models into a semantic domain, comparison algorithms in this semantic domain, and translations of comparison results back into the originally used modeling languages.

To mitigate this challenge, we have developed a *generic semantic model differencing framework* [LMK14] that can be instantiated to realize semantic differencing operators for

modeling languages. This framework utilizes the specification of the behavioral semantics of a modeling language to support the semantic differencing of models. In particular, the behavioral semantics is used for executing the models to be compared and obtaining execution traces. The obtained execution traces constitute semantic interpretations of the models and are compared for identifying semantic differences among them. This comparison is performed by applying match rules indicating which syntactic differences among the execution traces constitute semantic differences among the models. The match rules are specific to the used modeling language as well as the semantic equivalence criterion to be applied in the semantic model differencing. They constitute the only artifact specific to a semantic model differencing operator realized with our framework.

We provide an implementation<sup>1</sup> of our semantic model differencing framework that employs the executable metamodeling language xMOF [MLWK13] for defining the behavioral semantics of modeling languages and the model comparison language ECL [Kol09] for defining match rules comparing execution trace. Using this implementation, we evaluated our framework regarding expressiveness and performance [LMK14]. Concerning expressiveness, the evaluation result indicates that our framework provides sufficient expressive power for defining non-trivial semantic differencing operators. Regarding performance, the main finding is that the model execution is the most expensive step in the semantic model differencing requiring a high performance of the employed model execution environment and a reasonable number of performed model executions.

**Acknowledgments.** This work is partly funded by the European Commission (grant no. 317859) and by the Austrian Federal Ministry of Transport, Innovation and Technology (grant no. 832160).

## References

- [FLW11] Uli Fahrenberg, Axel Legay, and Andrzej Wasowski. Vision Paper: Make a Difference! (Semantically). In *Proc. of 14th Int. Conf. on Model Driven Engineering Languages and Systems (MODELS'11)*, volume 6981 of *LNCS*, pages 490–500. Springer, 2011.
- [Kol09] Dimitrios Kolovos. Establishing Correspondences between Models with the Epsilon Comparison Language. In *Proc. of 5th Europ. Conf. on Model Driven Architecture - Foundations and Applications (ECMDA-FA'09)*, volume 5562 of *LNCS*, pages 146–157. Springer, 2009.
- [LMK14] Philip Langer, Tanja Mayerhofer, and Gerti Kappel. Semantic Model Differencing Utilizing Behavioral Semantics Specifications. In *Proc. of 17th Int. Conf. on Model Driven Engineering Languages and Systems (MODELS'14)*, volume 8767 of *LNCS*, pages 116–132. Springer, 2014.
- [MLWK13] Tanja Mayerhofer, Philip Langer, Manuel Wimmer, and Gerti Kappel. xMOF: Executable DSMLs Based on fUML. In *Proc. of 6th Int. Conf. on Software Language Engineering (SLE'13)*, volume 8225 of *LNCS*, pages 56–75. Springer, 2013.
- [MRR11] Shahar Maoz, Jan Oliver Ringert, and Bernhard Rumpe. A Manifesto for Semantic Model Differencing. In *Models in Software Engineering: Workshops and Symposia at MODELS 2010, Reports and Revised Selected Papers*, volume 6627 of *LNCS*, pages 194–203. Springer, 2011.

---

<sup>1</sup>Details about the implementation may be found at our project website: <http://www.modelexecution.org>.