Managing Inter-Model Inconsistencies in Model-based Systems Engineering: Application in Automated Production Systems Engineering

Stefan Feldmann[1], Konstantin Kernschmidt[1], Manuel Wimmer[2], Birgit Vogel-Heuser[1]

Abstract: This work summarizes our paper [Fe19] originally published in the Journal of Systems and Software in 2019 about a model-based inconsistency management approach.

Keywords: Automated production systems, Model-based systems engineering, Inconsistency management

The use of model-based approaches [BCW17] is a crucial and competitive factor for successful engineering processes in the automated production systems domain, and hence an emerging practice in industry. To represent the specific views of the system under design, e.g., requirements engineering, system specifications, software design or system analyses, as well as to deal with the multitude of involved disciplines, e.g., mechanical, electrical, and software engineering, a variety of different models is created within a project. In addition, to address their specific viewpoints, stakeholders make use of various, heterogeneous modelling languages and tools [Br10].

Although all models represent different aspects of the same system under investigation, dependencies between these models are inevitable [Vo15]. As a consequence, inconsistencies between models are likely to occur and have to be carefully considered to guarantee a high quality of the final system design. In particular, the necessity to continuously diagnose and handle inconsistencies between models arises.

To tackle this challenge, we propose a comprehensive approach to specify, diagnose, and handle inconsistencies in model-based systems engineering. To explicitly capture the dependencies and consistency rules that must hold between the different engineering models, a dedicated graphical modelling language is proposed. By means of this language, stakeholders can specify, diagnose, and handle inconsistencies in the accompanying inconsistency management framework.

[1] Chair of Automation and Information Systems, Technical University of Munich, Boltzmannstr. 15, 85748 Garching near Munich, Germany {feldmann,kernschmidt,vogel-heuser}@ais.mw.tum.de
[2] Institute of Business Informatics - Software Engineering, JKU Linz, Altenbergerstr. 69, 4040 Linz, Austria manuel.wimmer@jku.at

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With the help of the proposed approach we enable stakeholders to:

- explicitly specify and elaborate n-to-m links between the different, but overlapping engineering models,
- graphically specify consistency rules between models including different mathematical mapping properties and function types,
- continuously diagnose potentially occurring inconsistencies, and
- systematically handle the life-cycle of these inconsistencies through either ignoring, tolerating or resolving them.

The approach is implemented based on the Eclipse Modeling Framework (EMF). The resulting prototypical tool support allows for automatically generating executable consistency rules from the graphically expressed consistency patterns and for automatically creating inconsistency management repositories. The prototypical tool support has been evaluated based on a case study about a production system demonstrator project [Vo14] as well as a user experiment. Our findings indicate that the approach is expressive enough to capture typical dependencies and consistency rules in the automated production system domain and that it requires less effort compared to manually developing and maintaining inter-model inconsistency management solutions. The findings gained from the case study based evaluation are underpinned through the user experiment.

Literatur

[BCW17] Brambilla, M.; Cabot, J.; Wimmer, M.: Model-Driven Software Engineering in Practice. Morgan & Claypool, 2017.

[Br10] Broy, M.; Feilkas, M.; Herrmannsdoerfer, M.; Merenda, S.; Ratiu, D.: Seamless Model-Based Development: From Isolated Tools to Integrated Model Engineering Environments. Proceedings of the IEEE 98/4, S. 526–545, 2010.

[Fe19] Feldmann, S.; Kernschmidt, K.; Wimmer, M.; Vogel-Heuser, B.: Managing inter-model inconsistencies in model-based systems engineering: Application in automated production systems engineering. Journal of Systems and Software 153/, S. 105–134, 2019.

[Vo14] Vogel-Heuser, B.; Legat, C.; Folmer, J.; Feldmann, S.: Researching Evolution in Industrial Plant Automation: Scenarios and Documentation of the Pick and Place Unit, Techn. Ber. TUM-AIS-TR-01-14-02, TU Munich, 2014, URL: https://mediatum.ub.tum.de/node?id=1208973.

[Vo15] Vogel-Heuser, B.; Fay, A.; Schaefer, I.; Tichy, M.: Evolution of Software in Automated Production Systems: Challenges and Research Directions. Journal of Systems and Software 110/, S. 54–84, 2015.