

Preface to the 5th international workshop on multi-level modelling (MULTI 2018)*

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A growing community of researchers are excited about the prospects offered by multi-level modelling. However, there is still no clear consensus on what this new paradigm actually entails and how it should be applied. For example, there are different views on whether it is sound to combine instance facets and type facets into so-called *clabjects*, whether *strict metamodeling* is too restrictive, and what tool architectures provide the best framework for modeling with multiple classification levels. This lack of a foundational consensus is mirrored by the lack of a common focus in current multi-level tools.

MULTI 2018 aims to address these challenges and continue to develop the community established by the previous workshops. The workshop goals encourage the community to delineate different approaches to multi-level modeling and define objective ways to evaluate their respective strengths and weaknesses. A key way to address this goal is to identify standard/canonical examples specially designed to exercise the abilities of multilevel modelling approaches.

The workshop encouraged submissions on new concepts, implementation approaches and formalisms as well as submissions on controversial positions, requirements for evaluation criteria or case-study scenarios. Contributions in the area of tool building, multilevel modelling applications, canonical examples and educational material were equally welcome.

The first MULTI workshop (www.miso.es/multi/2014/) was held at MODELS 2014 in Valencia and spawned a special theme issue of SoSyM. Since then, three MULTI workshops have been organized in 2015, 2016, and 2017 as satellite events of the MODELS conference. This MULTI workshop continues the same tradition as a satellite event of MODELS 2018. The MULTI series of workshops has succeeded in providing a forum for presenting and discussing advances in the field.

The workshop received 13 submissions of high quality, of which 10 were accepted for publication in the CEUR workshop proceedings. This year, authors of all the 13 submissions got the opportunity to present their work at the workshop. Three of the submissions were responses to a specific challenge—the Bicycle challenge—which was designed to promote the exchange between different schools of multilevel modelling and to contribute to a consolidation of the field. Challenge participants were asked to develop a multilevel model, or multilevel DSMLs respectively, to represent a domain that is provided in a natural language description. The solutions were required to account for certain requirements and were expected to be submitted in a given structure.

The workshop started with a keynote given by Manuel Wimmer from TU Wien, Austria, with the title *Multi-Level Modeling in the Wild with AutomationML*. We finalized the workshop with a plenary session where the position papers were used as the basis for discussions on the present and future of multi-level modeling.

The contributions to the workshop were organized into the following main sessions:

Position/Discussion:

- *A story of levels* describes the options for defining levels in multi-level modeling and the impact of respective choices on modelers.
- *Multilevel modeling: What's in a level?* A *position paper* argues that a theory of multi-level modeling must have a distinguished notion of level, which should have both a syntactic and a semantic status.
- *Toward a unified conception of multi-level modelling: Advanced requirements* identifies differences with respect to specific features and terminology as obstacles for the further development of the field, and suggests a selection of possible requirements for advanced multi-level modeling.

* <https://www.wi-inf.uni-duisburg-essen.de/MULTI2018/>

Dynamic Aspects of Processes:

- *Multilevel modelling of coloured Petri nets* describes a proposal to facilitate the development of domain-specific versions Coloured Petri nets, with separation of concerns, through multi-level modeling.
- *Practical experiences with multi-level modeling using FMMLx: A hierarchy of domain-specific modeling languages in support of life-cycle assessment* reports on practical challenges the authors have faced while designing a hierarchy of Domain-Specific Modeling Languages (DSMLs) spanning through a reference DSML, an industry-specific DSML and finally, an enterprise-specific DSML (ESML) supporting a life-cycle analysis of products.

Fundamental Advances:

- *A tool for the convergence of multilevel modelling approaches* presents a tool that may provide empirical data and practical instrumentation to aid in the discussion of the foundational concepts of the multi-level modeling paradigm.
- *Context-aware factors in rearchitecting two-level models into multilevel models* analyzes context-aware factors of accidental complexity in multi-level modeling, suggest quantitative measures for these factors, and show how they can be used for evaluating alternative transformations of two-level models into multilevel models.
- *Multi-level modeling with XML* proposes design principles of an XML format for representing multi-level models as XML documents. The approach is realized as a lightweight extension to the XML Schema Definition (XSD) standard, using built-in XML language extension mechanisms.

Bicycle Challenge:

- *The bicycle challenge in DMLA, where validation means correct modeling* describes a solution to the challenge using the Dynamic Multi-Layer Algebra (DMLA). The solution specifies all mandatory and several of the optional requirements; moreover, all of them have been automatically validated for correctness as well.
- *Multi-level modeling with MELANEE A contribution to the MULTI 2018 Challenge* presents a solution to the challenge using the MELANEE deep modeling tool. The paper presents a detailed description of the developed deep model, followed by a discussion of the strengths and weaknesses of the approach and a discussion of its benefits over traditional two-level modeling. The presented model covers all mandatory and optional aspects of the case study.