# The MULTI 2018 Bicycle Challenge

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**Abstract**

The MULTI Bicycle Challenge 2018 is intended as a basis for demonstrating the benefits of multi-level modelling. Our aim is to allow researchers to present their solutions to the challenge at the MULTI workshop at MODELS 2018 in Copenhagen. The challenge is intended to be open to different multi-level modeling styles and approaches.

The challenge consists of a case description and a set of comparison criteria; following these should make it easy to compare and relate different solutions. Contributions clearly addressing the review criteria described in this document will be included in the workshop proceedings. The workshop organizers plan to invite selected contributions to a special journal issue.

## 1 Introduction

The MULTI Bicycle Challenge is intended as a basis for demonstrating the benefits of multi-level modeling (MLM). A previous version of the challenge has been presented and discussed at the MULTI workshop 2017 in Austin. The discussion resulted in a number of suggestions to extend the challenge. The participants of MULTI 2017 decided to offer the challenge as a community initiative to promote MLM. For this purpose, the challenge serves as a joint effort to compare and consolidate existing approaches, to identify topics for future research and to demonstrate the benefits of MLM.

### 1.1 Review Criteria

Each submission will be reviewed against the following criteria:

- Does it address the case study domain as given in Section 2 and demonstrate the use of multi-level features?
- Does it evaluate/discuss the proposed solution against the criteria presented in Section 4?
- Does it discuss the benefits and challenges of multi-level features in the context of the case study?

Additionally, authors are invited to suggest furter requirements that clearly demonstrate the utility of multi-level modeling.

### 1.2 Proceedings, Demo, and Journal Special Issue

Papers that clearly address the review criteria listed above will be accepted for presentation at the workshop and for inclusion in the workshop proceedings. Additional tool demonstrations that are suited to show the strengths of the proposed solution are appreciated.

In addition to being included in the workshop proceedings, the MULTI organizers plan to invite selected contributions to the challenge as articles for a special issue of a journal that is intended to showcase the benefits of multi-level modelling using the challenge as a common basis.

### 1.3 Paper Submission and Structure

Papers are submitted like regular papers. Each paper should have the subtitle: A contribution to the MULTI 2018 challenge. The proposed solution should be presented in a paper that reflects the following structure (as detailled in this document).

1. Introduction (Presentation of the approach that is used)
2. Case Analysis (Analysis, interpretation, completion of case description, additional requirements)
3. Model Design (step by step development of model, including comprehensive justifications for non-trivial design decisions)
4. Discussion along Common Criteria
5. Conclusions

## 2 Case Description and Analysis

The challenge is focused on the configuration and sale of physical products with special emphasis on the configuration of bicycles from the perspective of a bicycle retail company. The case description consists of a mandatory part and an optional part. The challenge participants may extend the case description.

### 2.1 Mandatory Parts

The following bullet points are mandatory for participants of the challenge.

- A configuration is a physical artefact that is composed of components. A component may be composed of other components or of basic parts.

- A component has properties, for example weight, size, colour, unique serial number.
- A bicycle is built of components like a frame, a fork, two wheels, and so forth, each of which being a component. Front wheel and rear wheel must have the same size.
- There are different categories of bicycles, such as mountain bike, city bike, or racing bike, for different purposes such as mountain, city, or race. A racing bike is not suited for tough terrain. A racing bike is suited for races. It can be used in cities, too.
- Each category is further associated with some constraints, for example:
  - Every category of bicycle except for racing bikes may be equipped with an electric motor. Electric bikes need enforced brakes and a battery.
  - A mountain bike or a city bike may have a suspension.
  - A mountain bike may have a rear suspension. That is not the case for city bikes.
  - A racing bike has a racing fork and racing frame.
  - A racing fork does not have a suspension. It does not have a mud mount either.
  - A racing frame is specified by top tube length, down tube length, and seat tube length.
  - A racing frame is made of steel, aluminum, or carbon.
  - A racing bike can be certified by the Union Cycliste Internationale (UCI).
  - A professional racing bike is a racing bike and certified by the UCI. A professional racing bike has a professional race frame which is made of aluminum or carbon and has a minimum weight of 5200 gr.
  - A carbon frame allows for carbon wheels or aluminum wheels only.
- Each category of bicycle is associated with a person acting as category manager. Peter Parker is category manager for the racing bike category.
- Challenger A2-XL is a professional racing bike model for tall cyclists. A Challenger A2-XL bike is equipped with a Rocket-A1-XL which is a professional race frame. The Rocket-A1-XL has a weight of 920.0 gr.
- Bike#134123, a physical instance of Challenger A2-XL, has Frame#134123, a physical instance of Rocket-A1-XL with serial number s134123, as component.
- Bicycles are sold to customers. A customer is a natural person or an organization. The act of selling a bicycle requires the creation of an invoice. An invoice is a read-only business document.

- Each bicycle model has a regular sales price. The regular sales price of Challenger A2-XL is EUR 4999.00. The actual sales price of physical instances of the bicycle model, i.e., the price given in an invoice, may be lower.
- Bike#134123 was sold on September 19th, 2017 for EUR 4299.00 to customer Susan Storm.

### 2.2 Optional Parts

- A sales manager may be interested in derived properties such as:
  - The average actual sales price for a bike model. For example: In 2017, physical instances of Challenger A2-XL are sold, on average, for 4532.00
  - The average actual sales price for a bike category. For example: In 2017, the average actual sales price of racing bikes was 2321.00
  - The average regular sales price of bike models for a bike category. For example: In 2017, the average regular sales price of bike models of category race bikes was 2834.00
  - The revenue, i.e., sum of actual sales price, per bicycle model. For example: In 2017, the Challenger A2-XL generated a revenue of 78,232.00
  - The top-seller, i.e., the bike model with the highest revenue, per bicycle category. For example: Challenger A2-XL is the top-seller of the racing bike category.

### 2.3 Extensions of the Case Description

Participants are invited to extend the case description with additional points necessary to exemplify features of their modeling approach.

## 3 Multi-level Model Design

In this section, papers provide a step by step development of a multi-level model representing the case description, including comprehensive justifications for non-trivial design decisions. The model should be sufficiently specified to demonstrate how it could be implemented.

The case is described in a way that allows different MLM approaches and styles. In order to foster comparability between challenge papers, participants are asked to make sure that underlined concepts in the mandatory part of the case description are represented explicitly by one or more model elements. Depending on the modeling style or method, there may not be a one-to-one correspondence between concepts in the description and model elements in the multilevel model (for example, Bicycle could be represented by a model element BicycleClass, by a model element Bicycle together with a model element BicycleClass, or by model elements BicyclePhysicalInstance, BicycleModel, BicycleCategory, and so forth, or by something different).

# 4 Discussion along Common Criteria

In this section, participants should discuss their multilevel model solution with regard to the following comparison critera. For each criterion, participants should relate their solution with related work.

## 4.1 Mandatory Comparison Criteria

1. **Basic modeling constructs:** Discuss the basic modeling constructs of the presented approach.

2. **Levels and Layers:** Discuss the nature of levels or layers in the model and how model elements are arranged on this levels and are connected across levels (such as instance-of and specialization-of)

3. **Abstraction:** To avoid redundancy between models and/or model elements, knowledge about the domain, which may include particular aspects, should be represented at the highest level possible.

4. **Reuse**: It should be possible to use the model (or parts of it) as a foundation for a software system that is suited for a wide range of bicycle stores and adapt (customize) it to the peculiarities of each shop.

5. **Cross-level relationships:** Discuss if and how associations and links can connect model elements at different levels.

6. **Cross-level constraints:** Discuss if and how constraints can span multiple levels, especially with regard to cross-level relationships.

7. **Integrity mechanisms**: Discuss how the integrity of lower levels of the model is protected from changes that occur on higher levels and/or how changes at higher levels are propagated to lower levels.

8. **Code Generation and Consistency:** There should be a mapping to implementation languages that preserves the semantics of the model. Also discuss mechanisms to foster the synchronization of MLM-based models with code.

## 4.2 Additional Comparison Criteria

Challenge participants are invited to introduce additional criteria, for example regarding:

- Multi-level modelling used as a basis for configuration, for example: Every bicycle type except for racing bikes may be equipped with an electric motor. Electric bikes need enforced brakes and a battery.
- Multi-level modelling as a basis for advanced business analytics, for example: Find every bicycle type that has an electric motor and that has the least number of sales in 2017.
- Representing business processes in multi-level models, for example: Order management, such as Customer, Order, etc.
- Addressing behaviour abstraction within multi-level models, for example: Most dealerships favour their own type of order management process. A multi-level model of an order management process should support the reuse of common aspects of order management and extend/refine them to satisfy particular requirements.
- Adding constraints to multi-level models. The additional abstraction enabled by multi-level models can substantially increase the adaptability of systems. At the same time, it creates additional dependencies, which create a threat to maintainability. The model should be supplemented with constraints that protect integrity as much as possible in case of changes.
- Software or tool generation from multi-level models, for example: generating a bicycle product management system from a multi-level model that uses models@run-time to support the addition of new types of bicycle.
- Furthermore, the challenge could be extended with requirements that relate to accompanying model editors and runtime environments.

# 5 Conclusions

In the conclusion, participants should summarize their paper and highlight:

- Limitations of the paper
- Key advantages and drawbacks of the presented solution with regard to the challenge.
- Key advantages and drawbacks of the presented MLM approach that do not become evident with regard to the challenge but are worth mentioning
- Key extensions of the case description and the set of comparison criteria.