Automatability of Coupled Evolution of Metamodels and Models in Practice

Markus Herrmannsdoerfer[1], Sebastian Benz[2], and Elmar Juergens[1]
(Technische Universität München[1], BMW Car IT GmbH[2])

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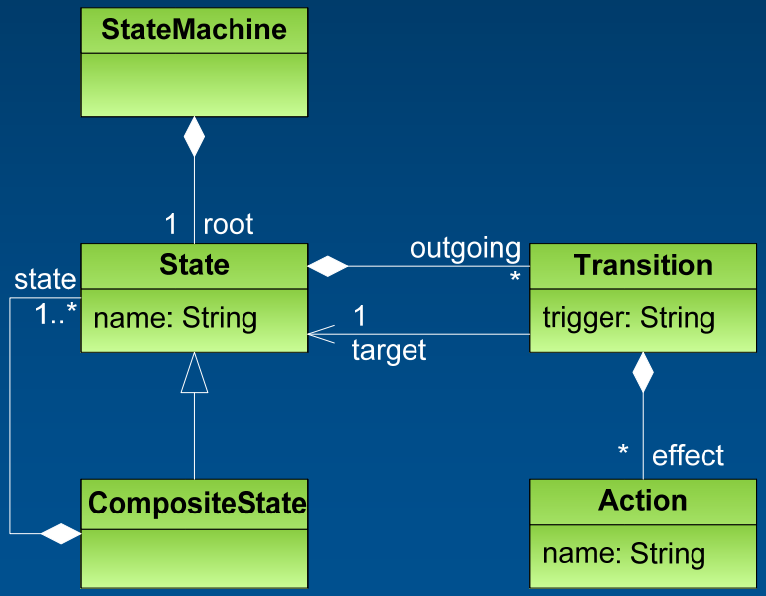
(Domain-Specific) Modeling Language

Metamodel



(Domain-Specific) Modeling Language

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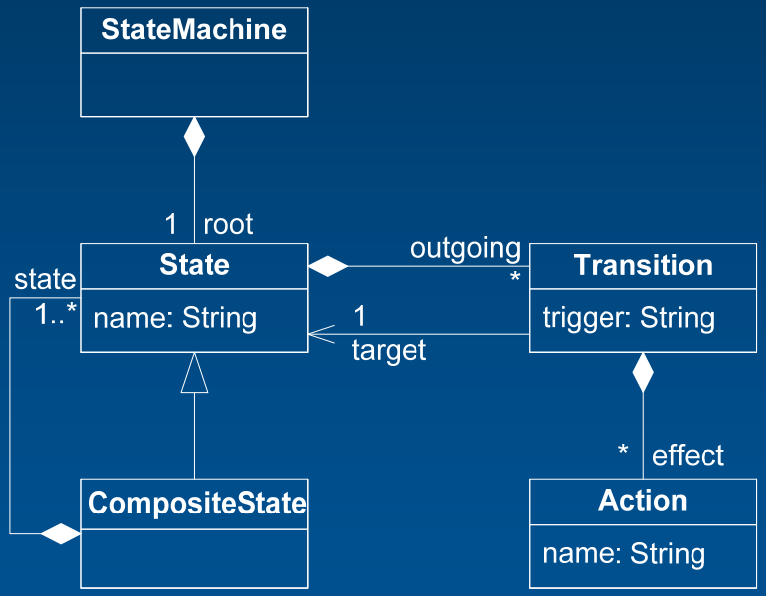
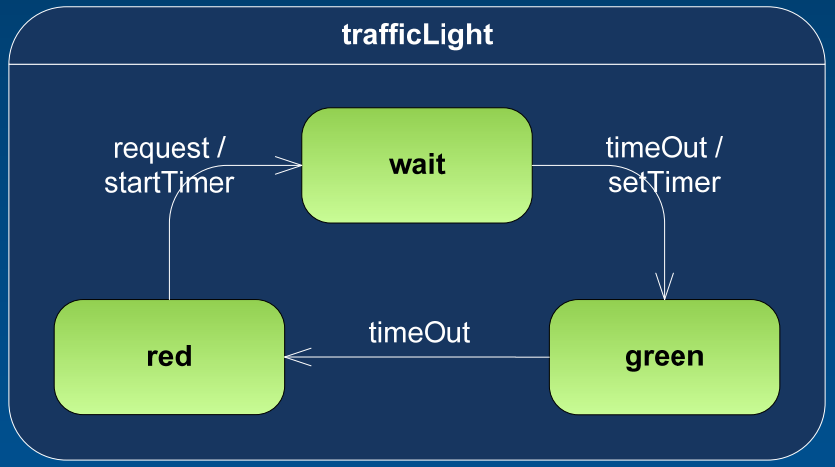


Model

Concrete syntax



(Domain-Specific) Modeling Language

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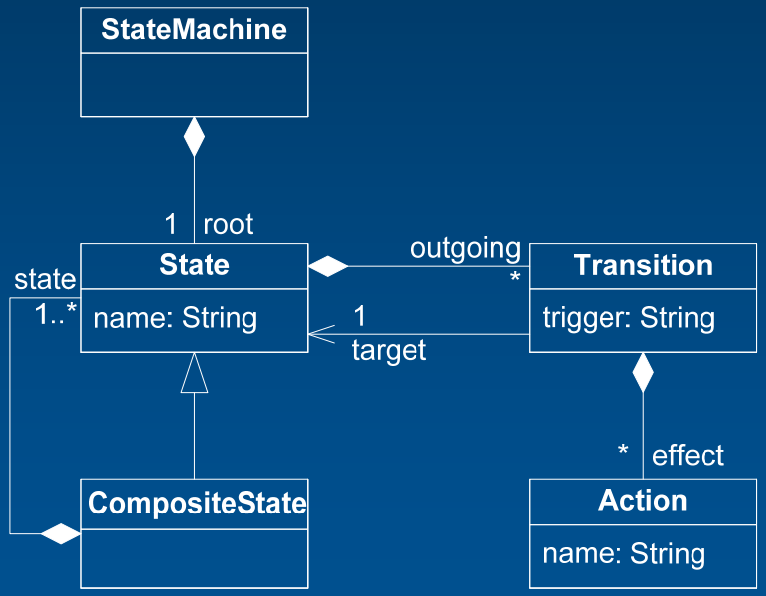
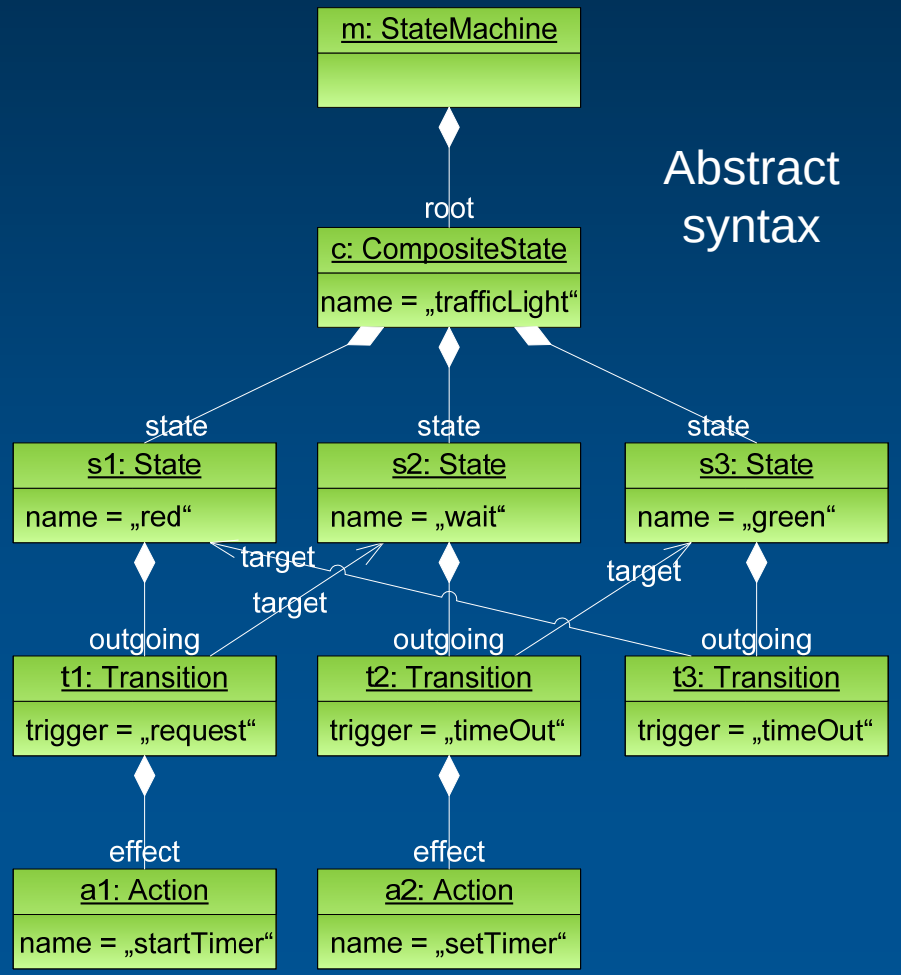
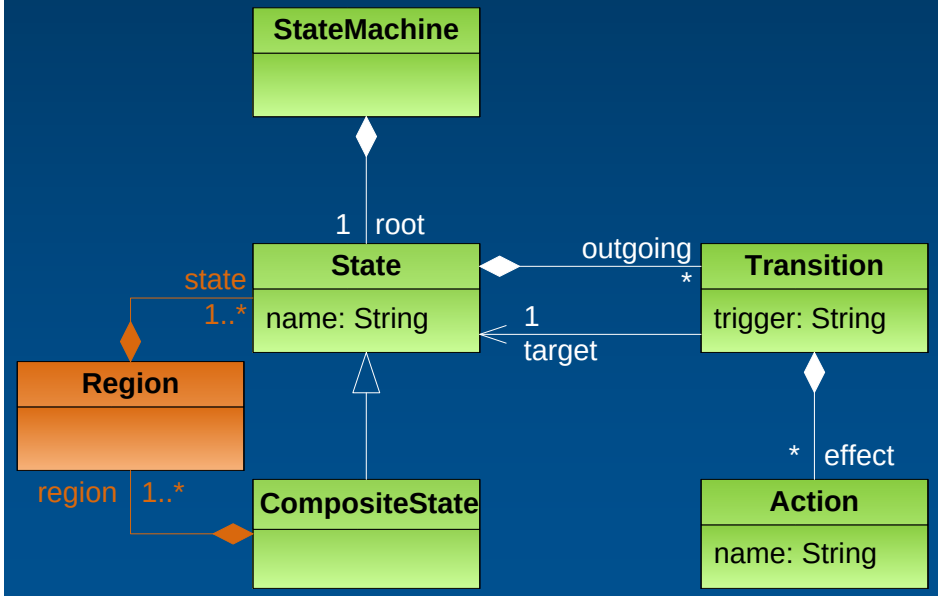


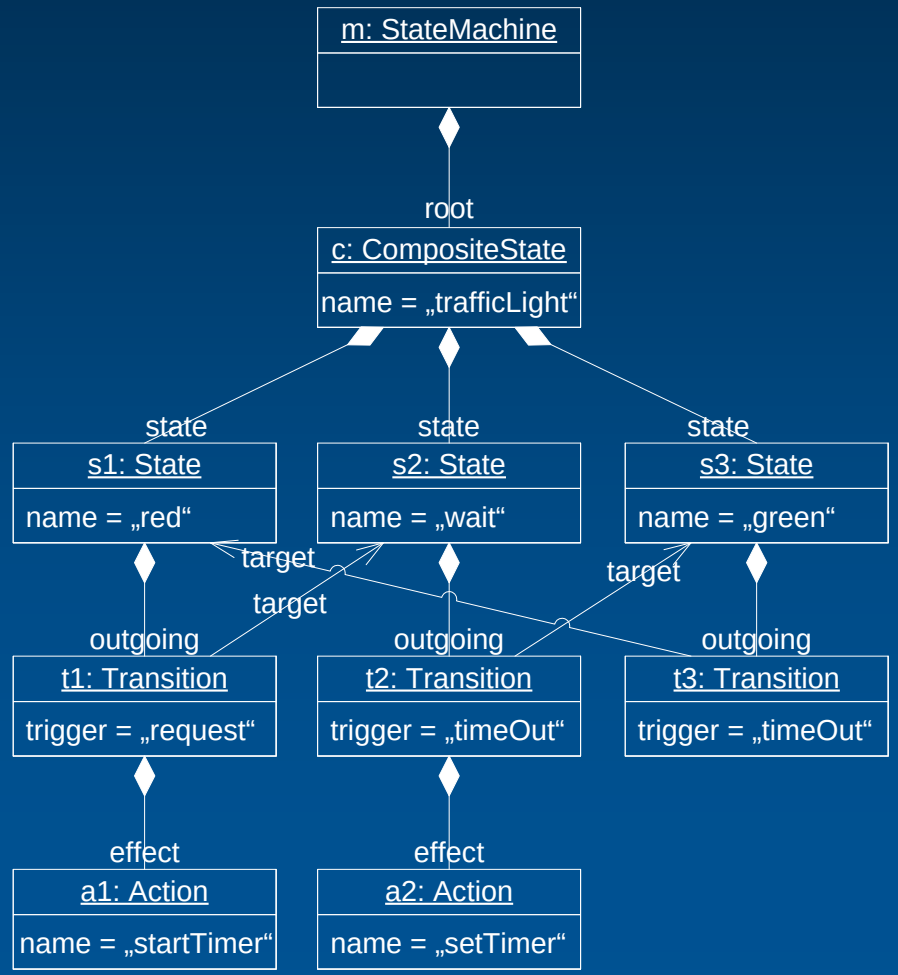
Model



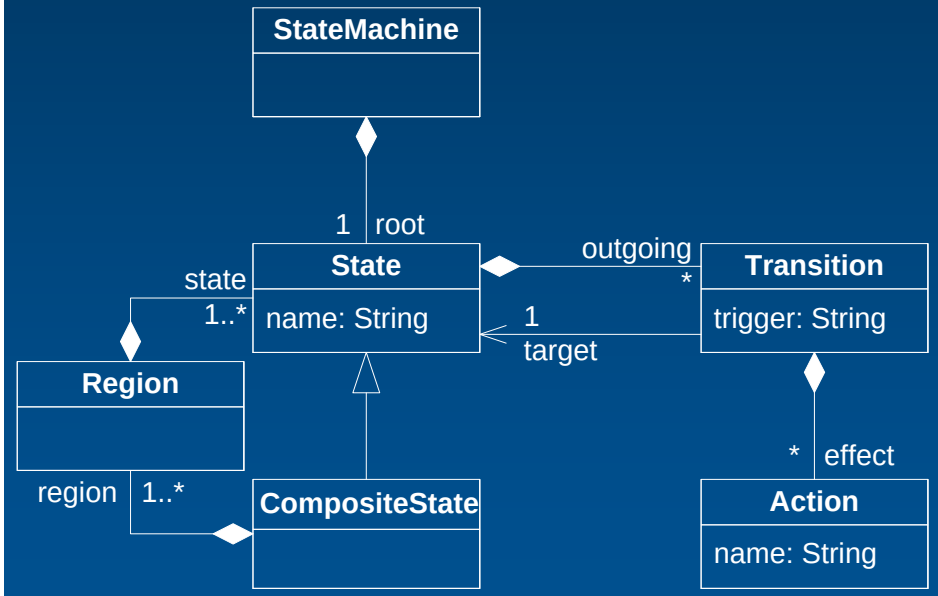
Coupled Evolution of Metamodels and Models

Metamodel Adaptation

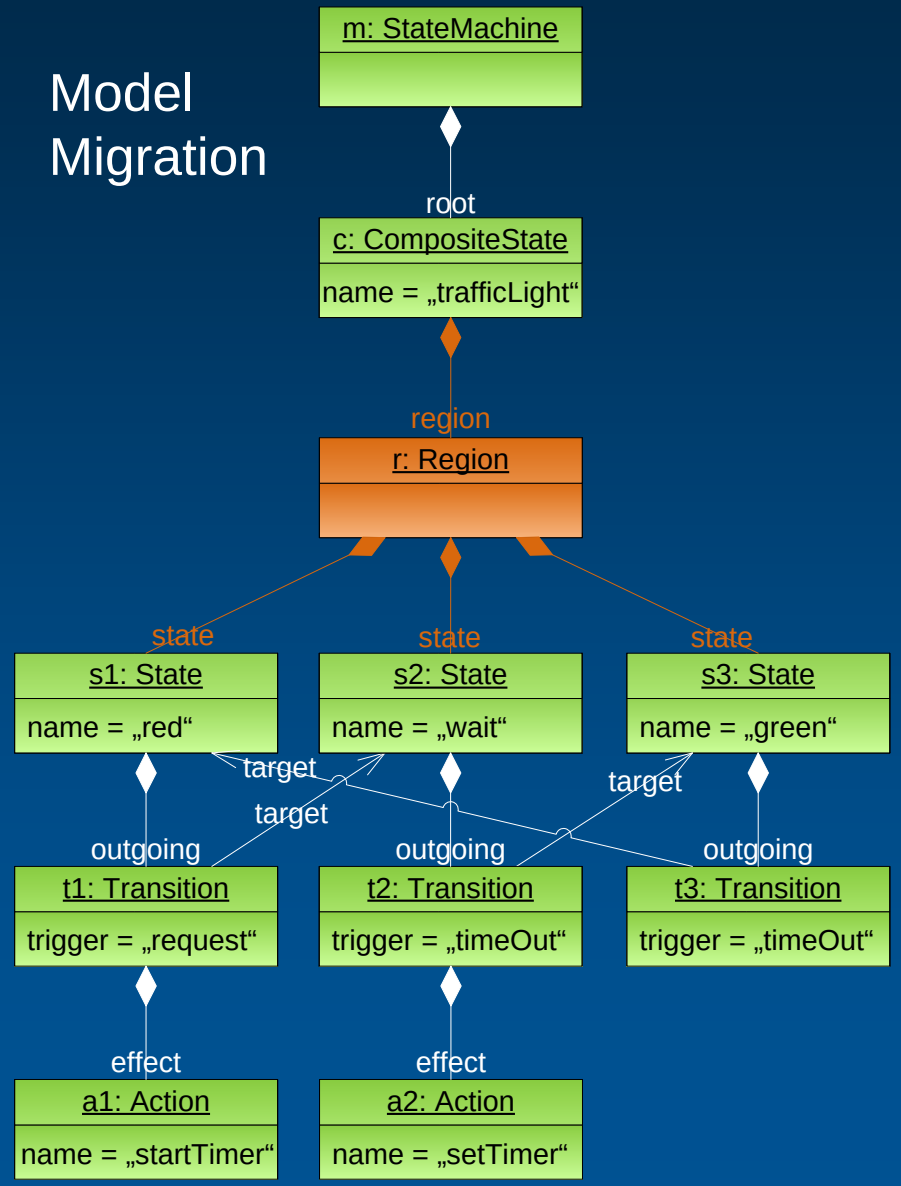




Coupled Evolution of Metamodels and Models



Model Migration



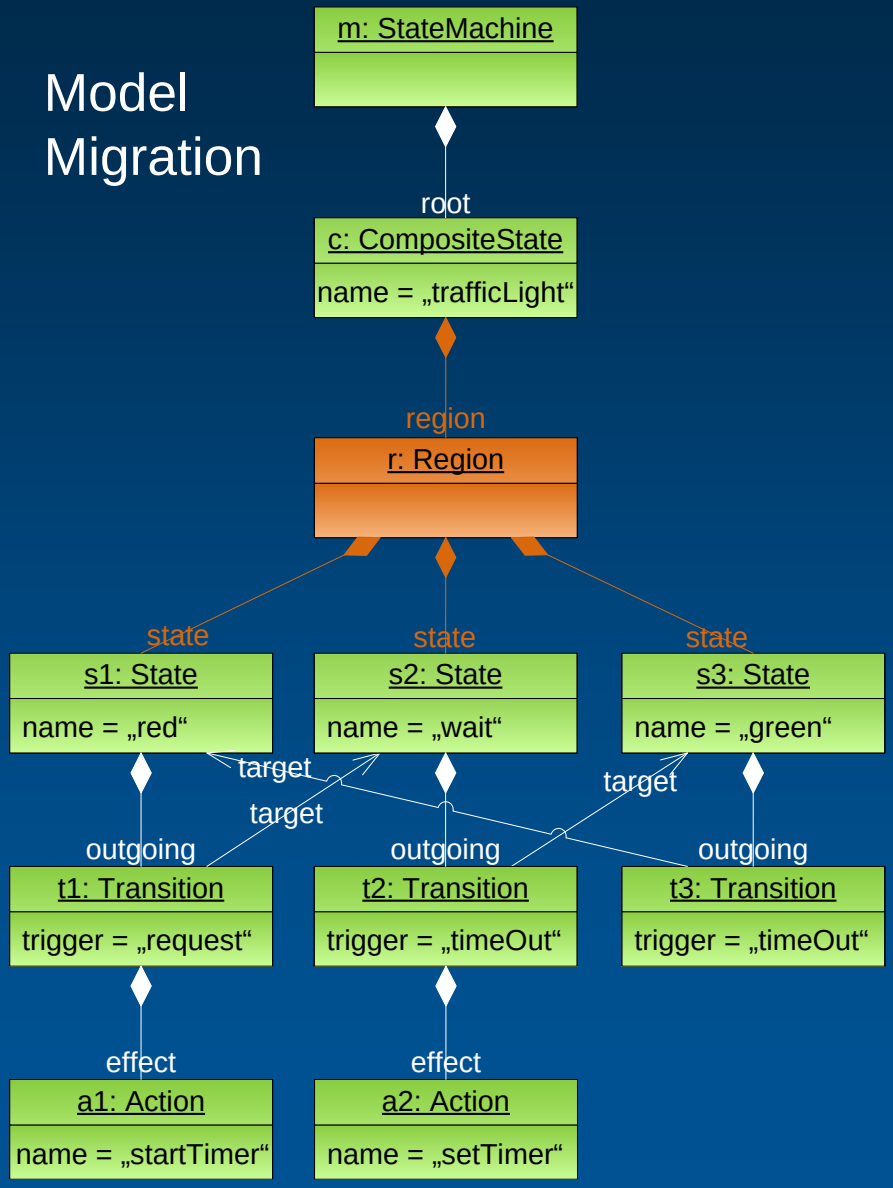
Coupled Evolution of Metamodels and Models

Manual migration

- expensive
- error-prone

⇒ Tool support required

Model Migration



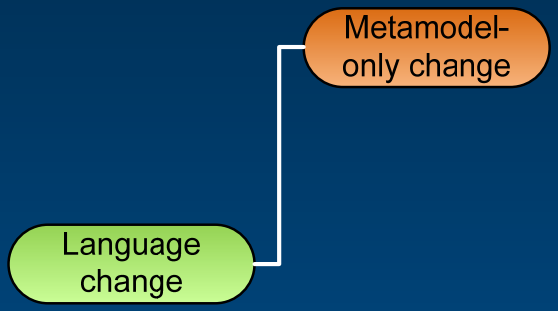
Research Question

To which degree
coupled evolution of metamodels and models
can be automated in practice?

Approach

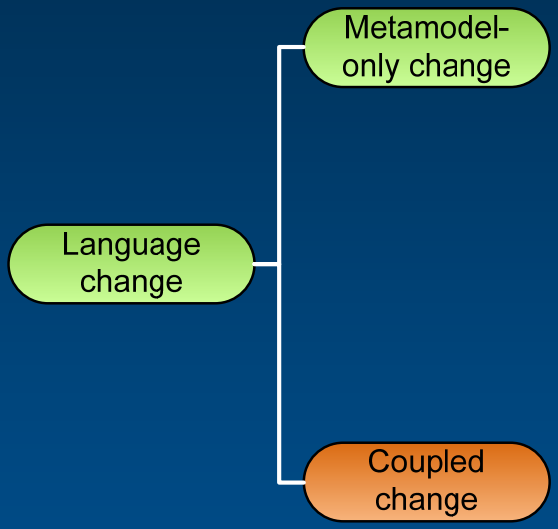
- Classification of coupled evolution operations w.r.t. potential of automation
- Application of the classification to two industrial metamodel histories

Classification – Automatability of Coupled Changes



No need for model migration

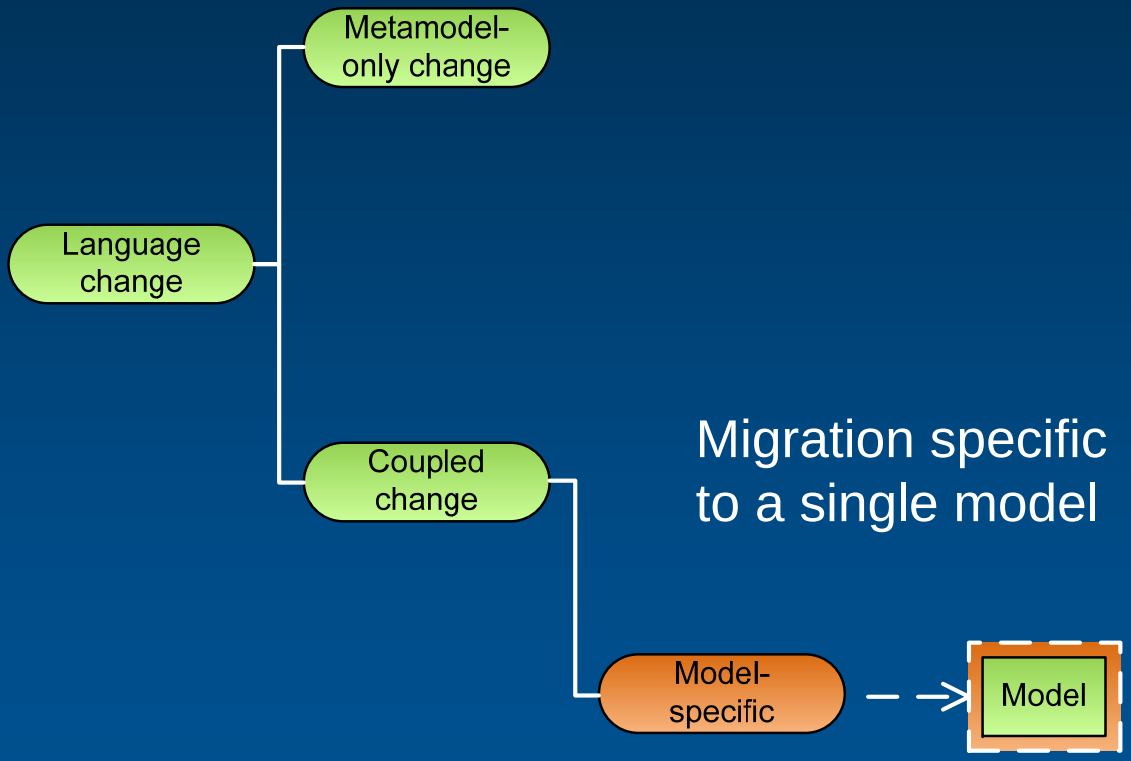
Classification – Automatability of Coupled Changes



No need for model migration

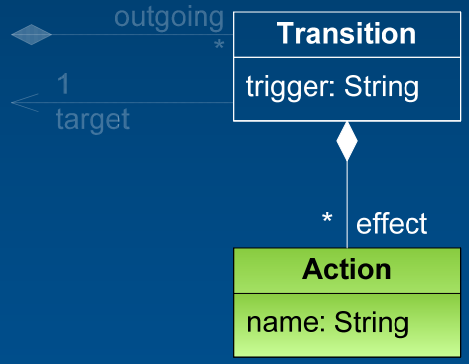
Combination of metamodel adaptation and model migration

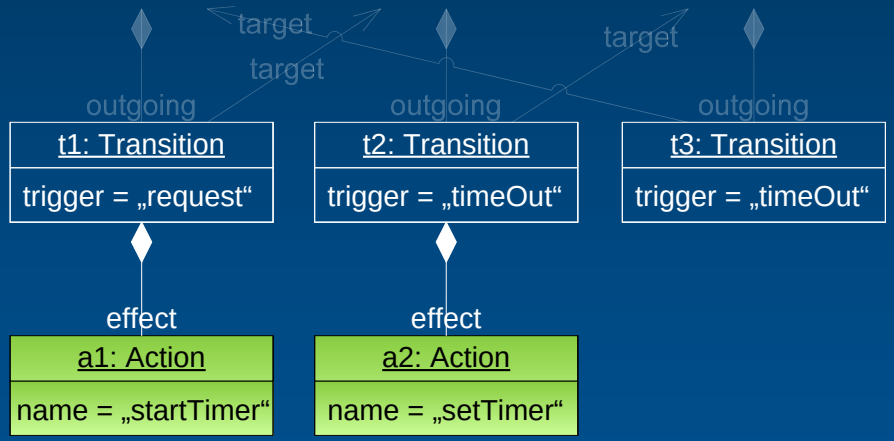
Classification – Automatability of Coupled Changes



Model-Specific Coupled Change

Example: Refinement of Action





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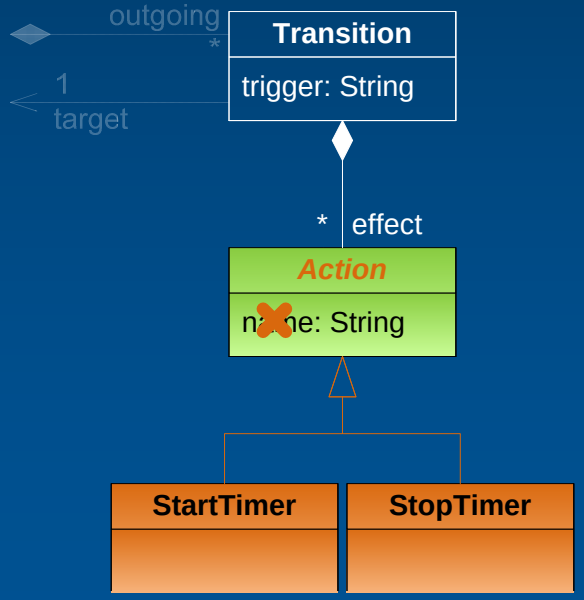
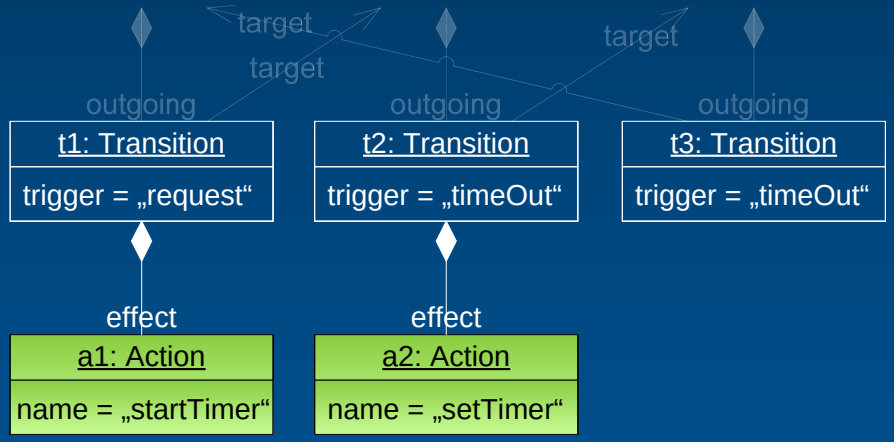
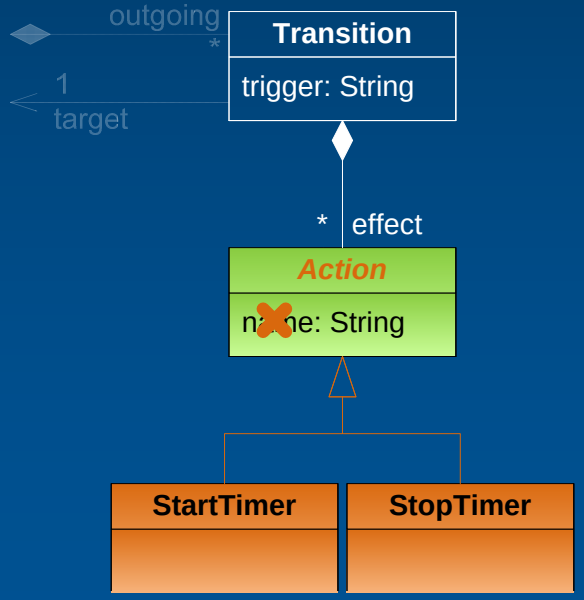


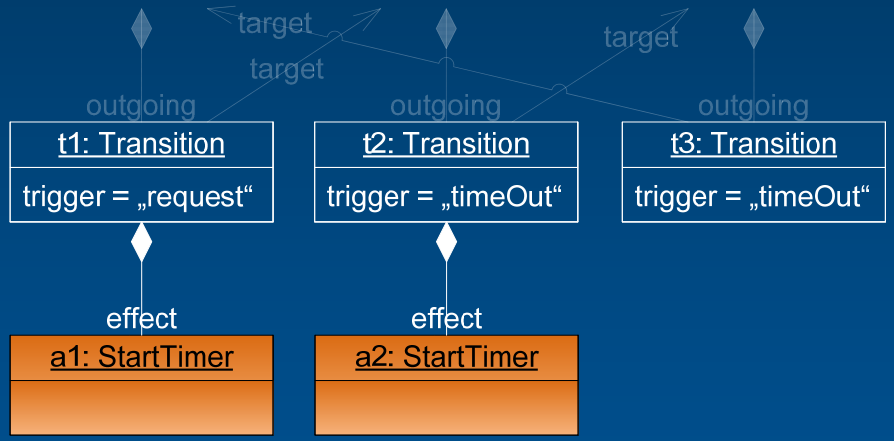


Model-Specific Coupled Change

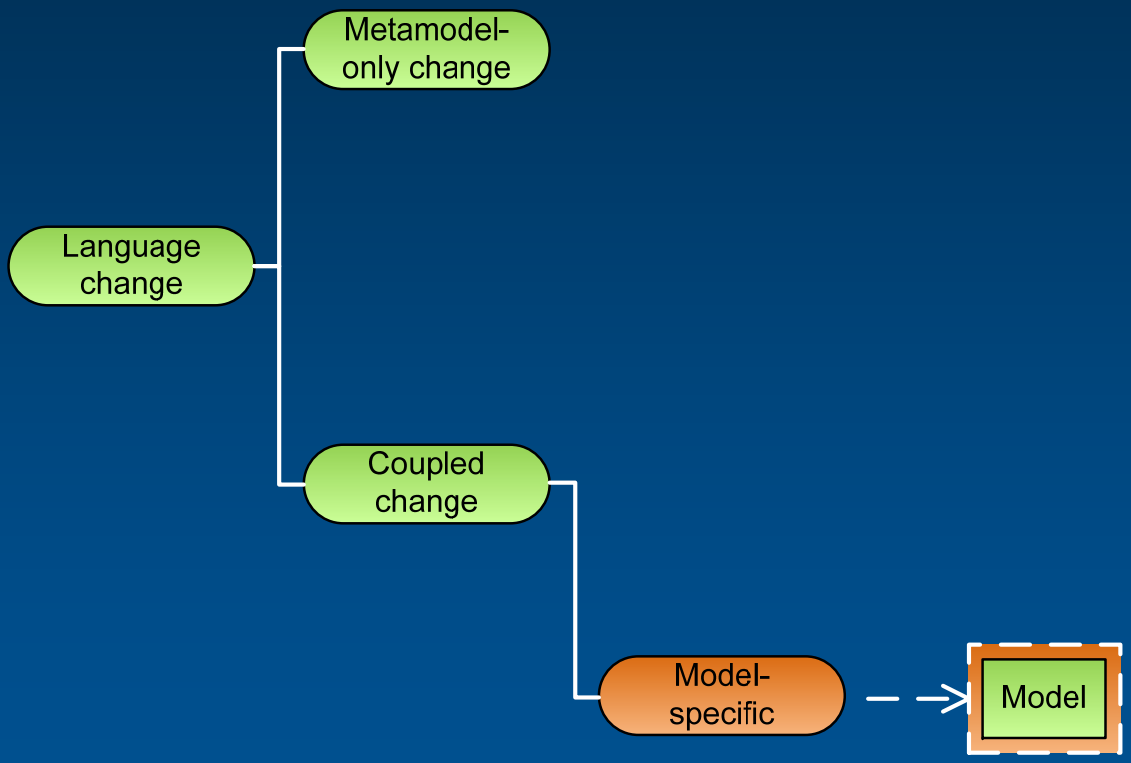
Example: Refinement of Action

Different names might denote
the same kind of action
in different models





Classification – Automatability of Coupled Changes



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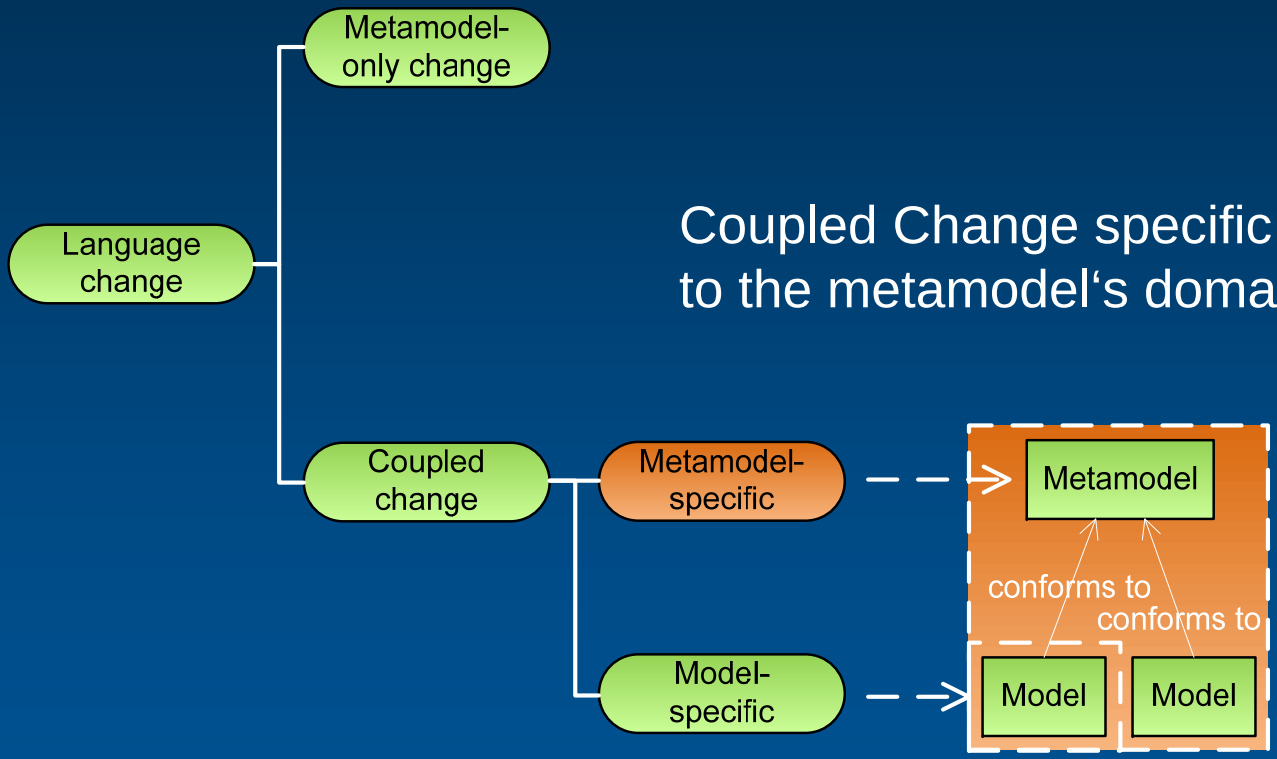
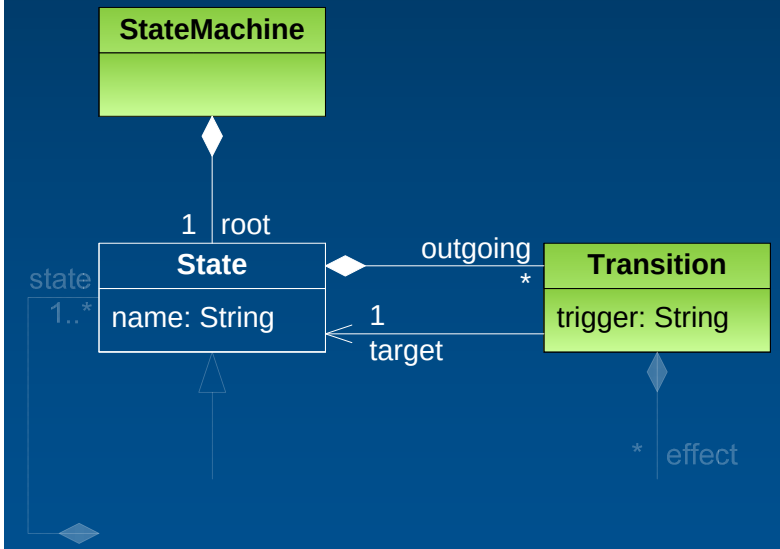
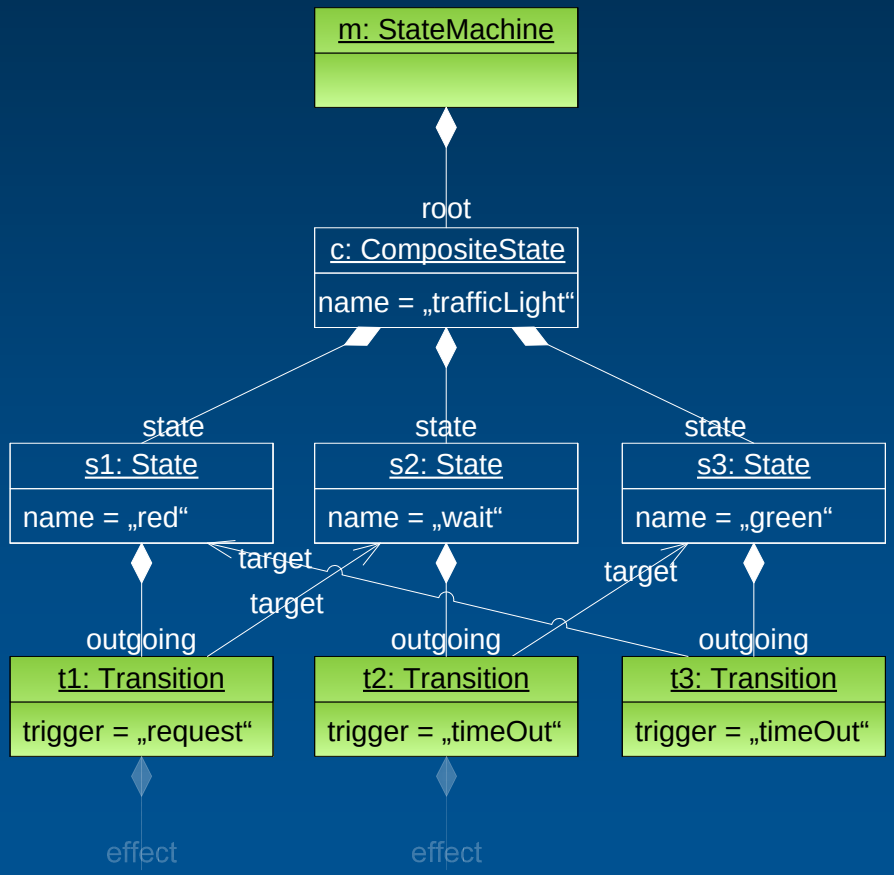


Metamodel-Specific Coupled Change

Example: Introduction of Event





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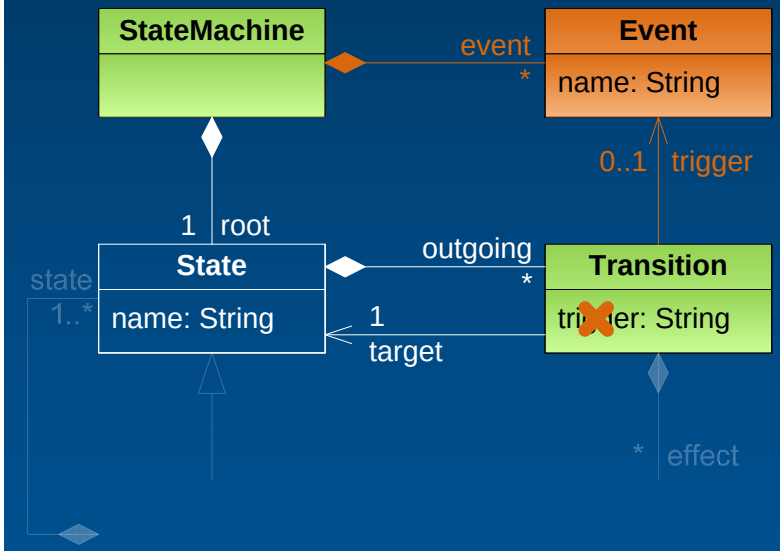

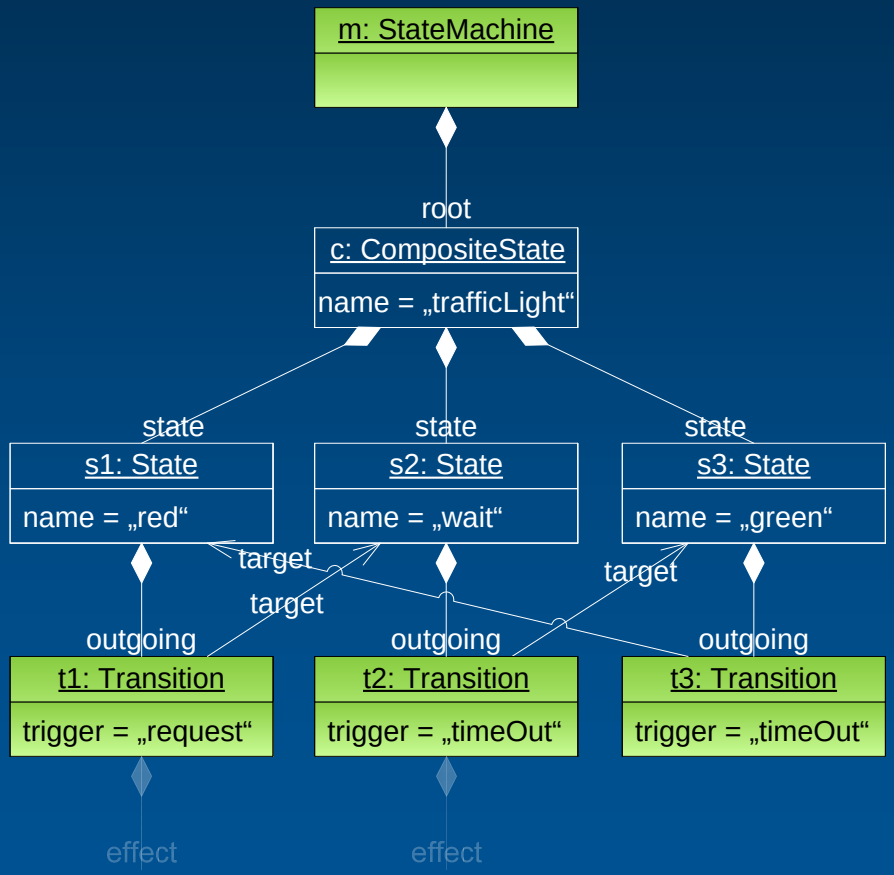

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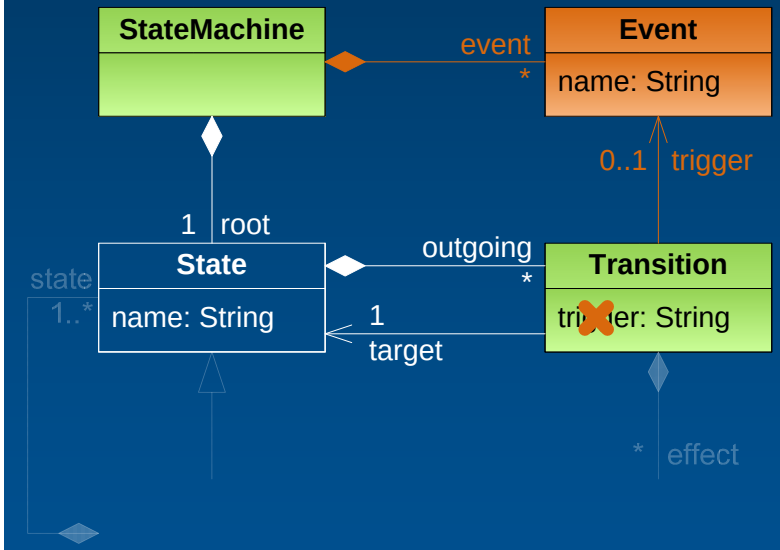
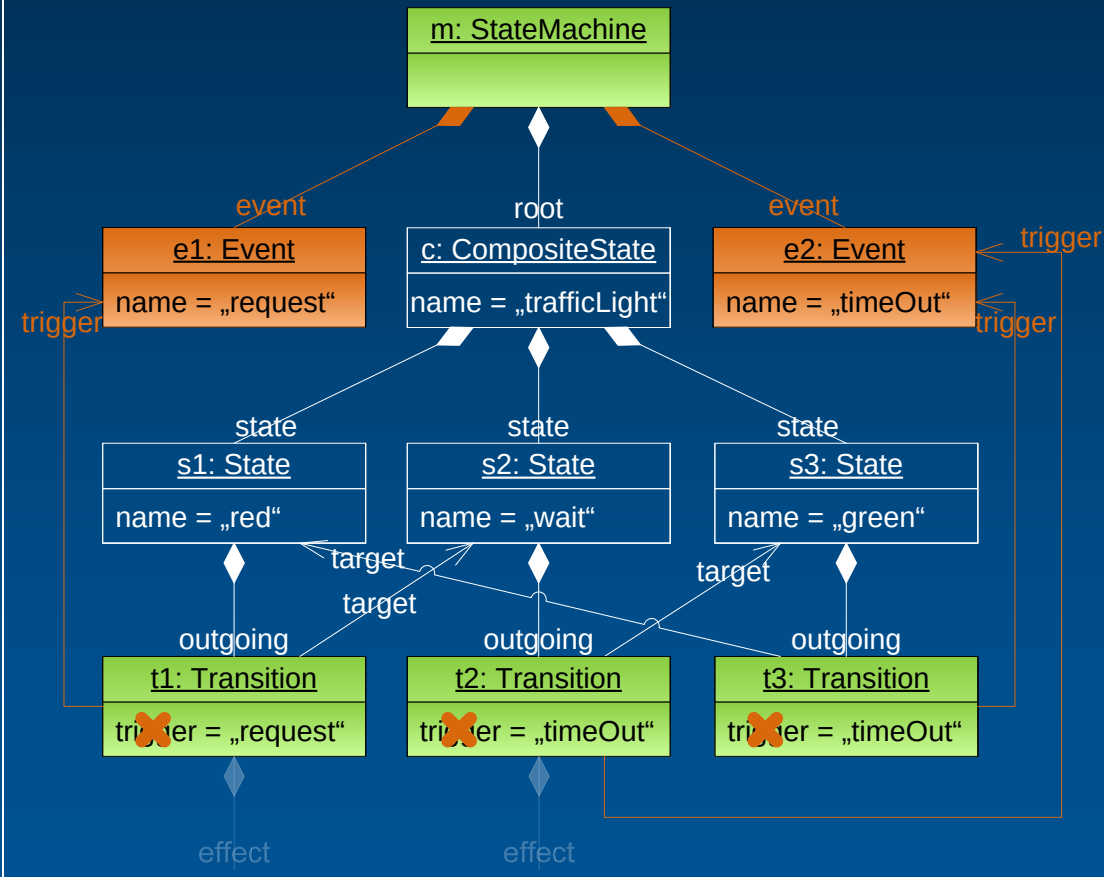
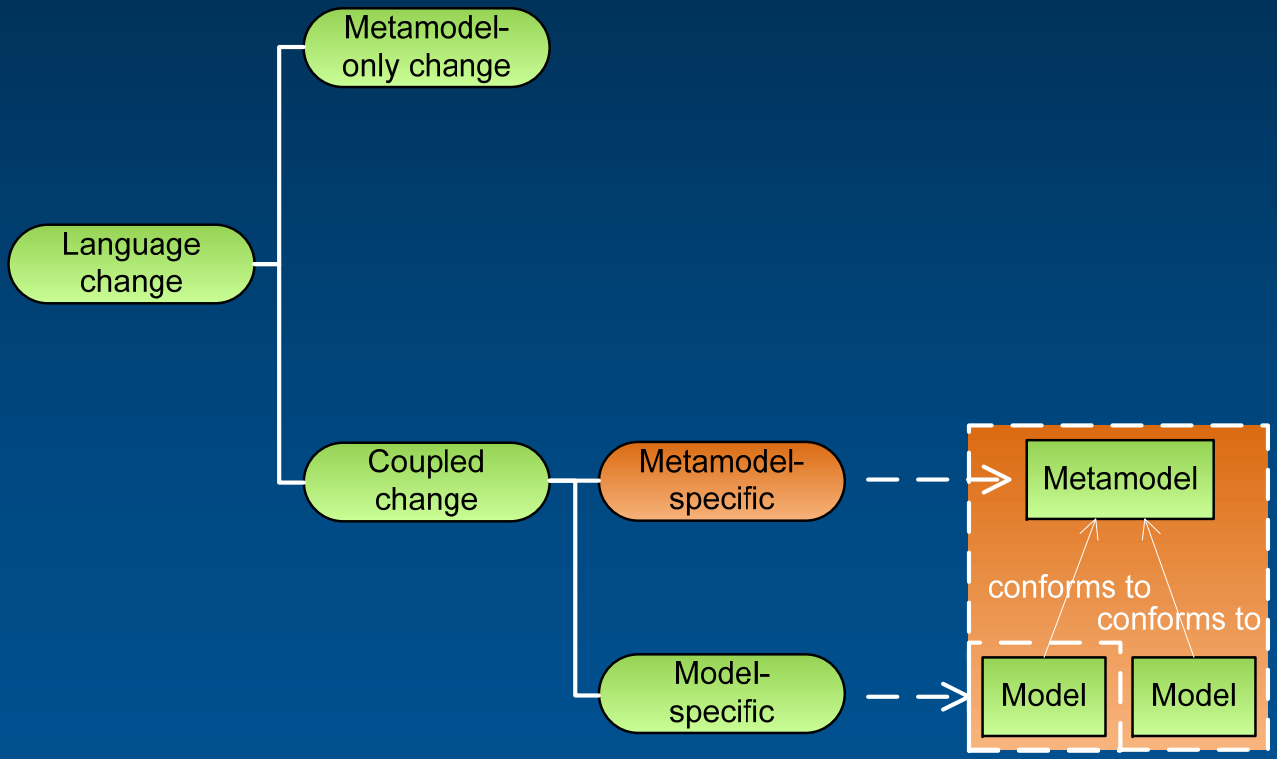


Complex,
non-recurring migration



Classification – Automatability of Coupled Changes



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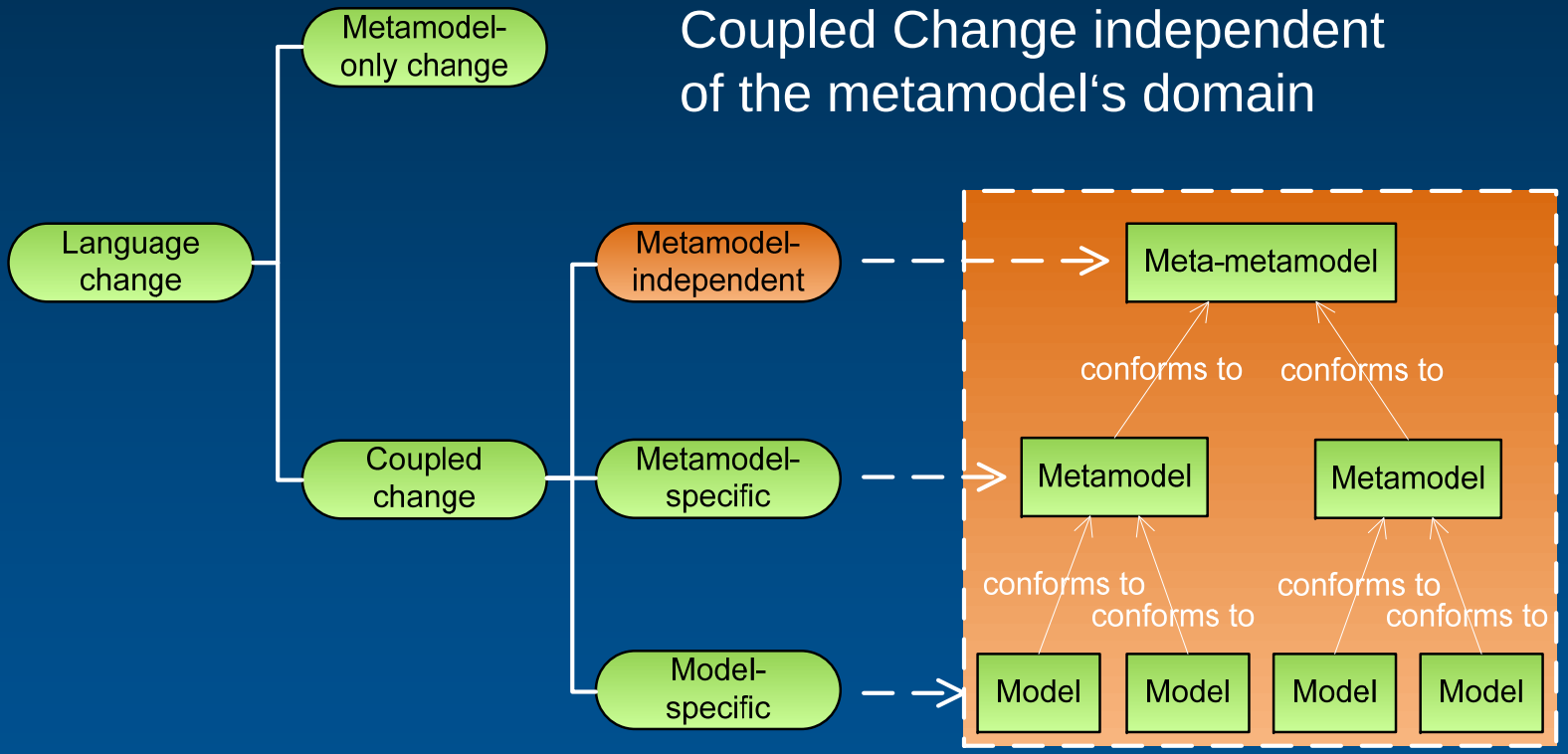
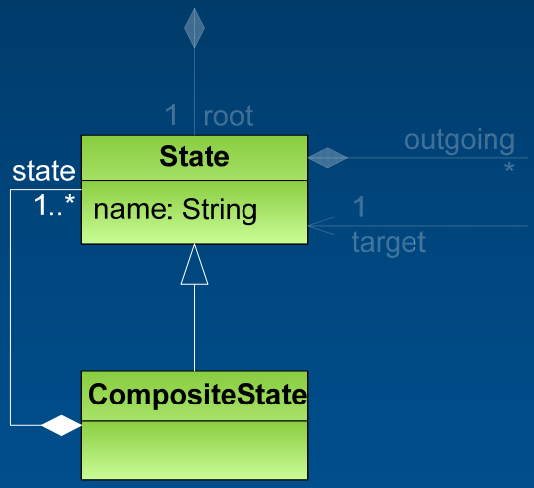
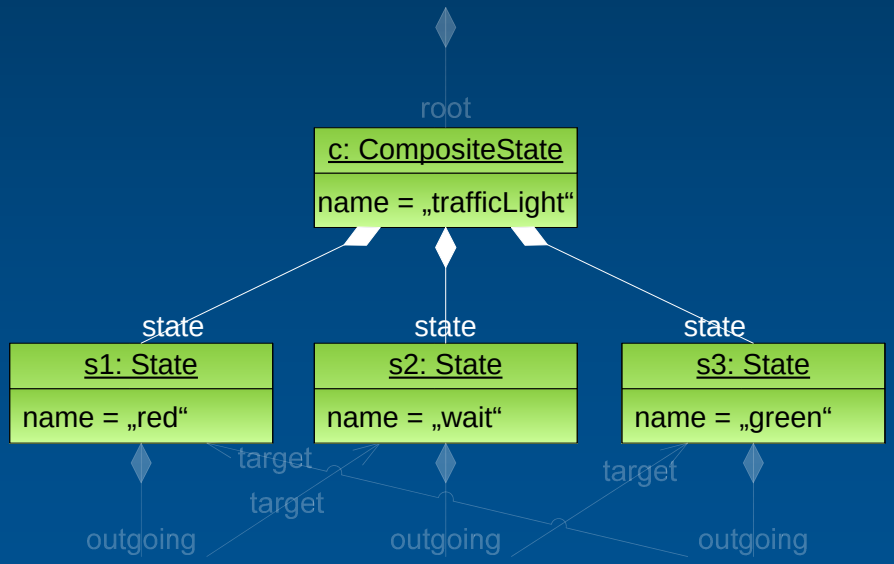


Metamodel-Independent Coupled Change

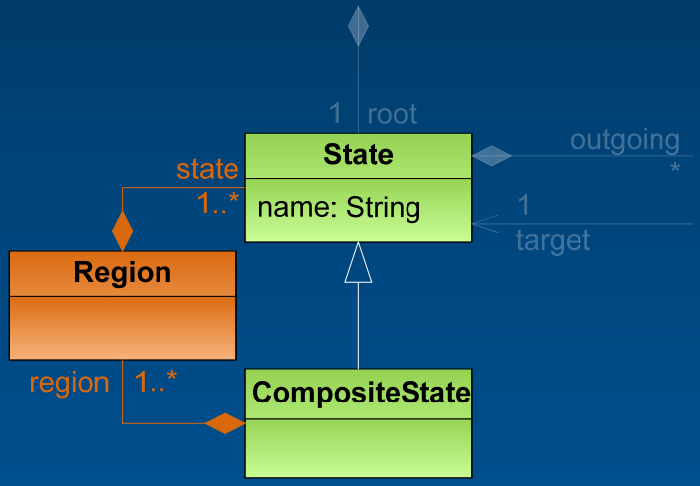
Example: Introduction of Region

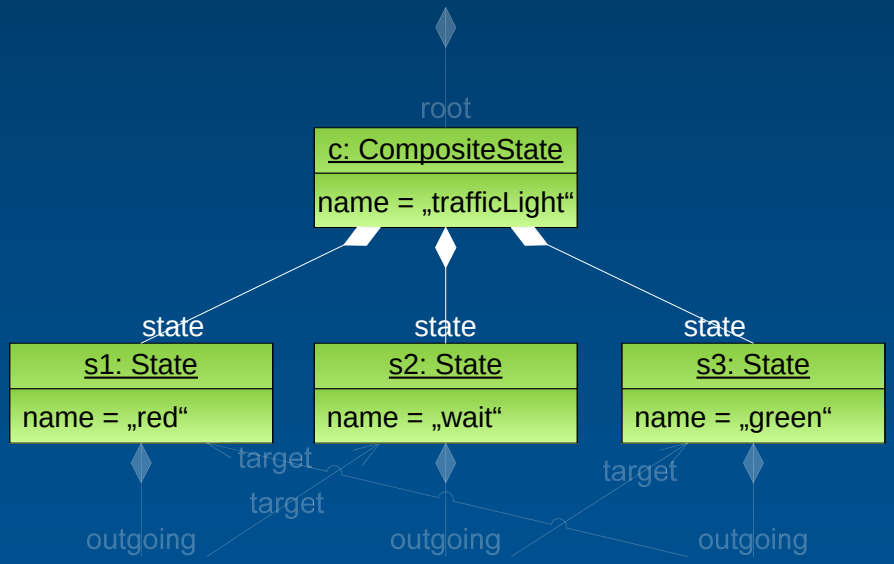




Metamodel-Independent Coupled Change

Example: Introduction of Region

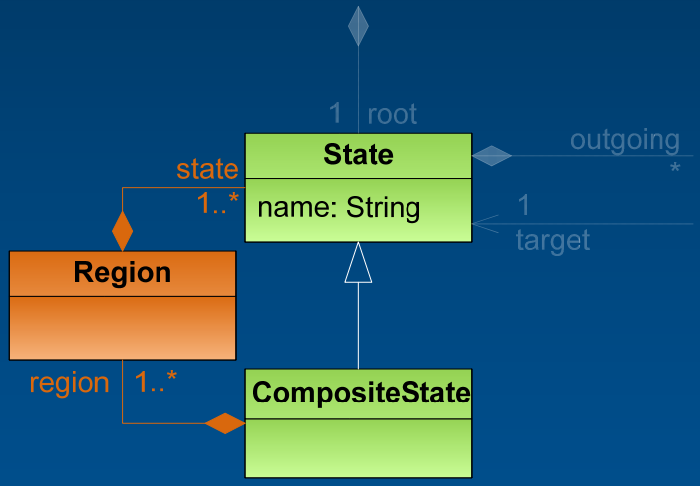


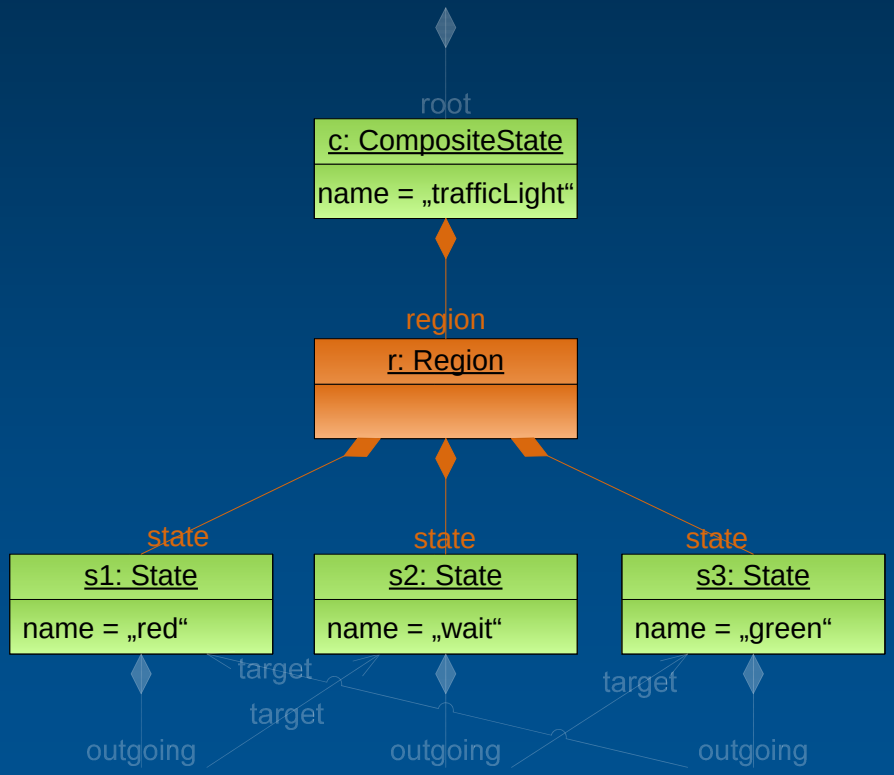


Metamodel-Independent Coupled Change

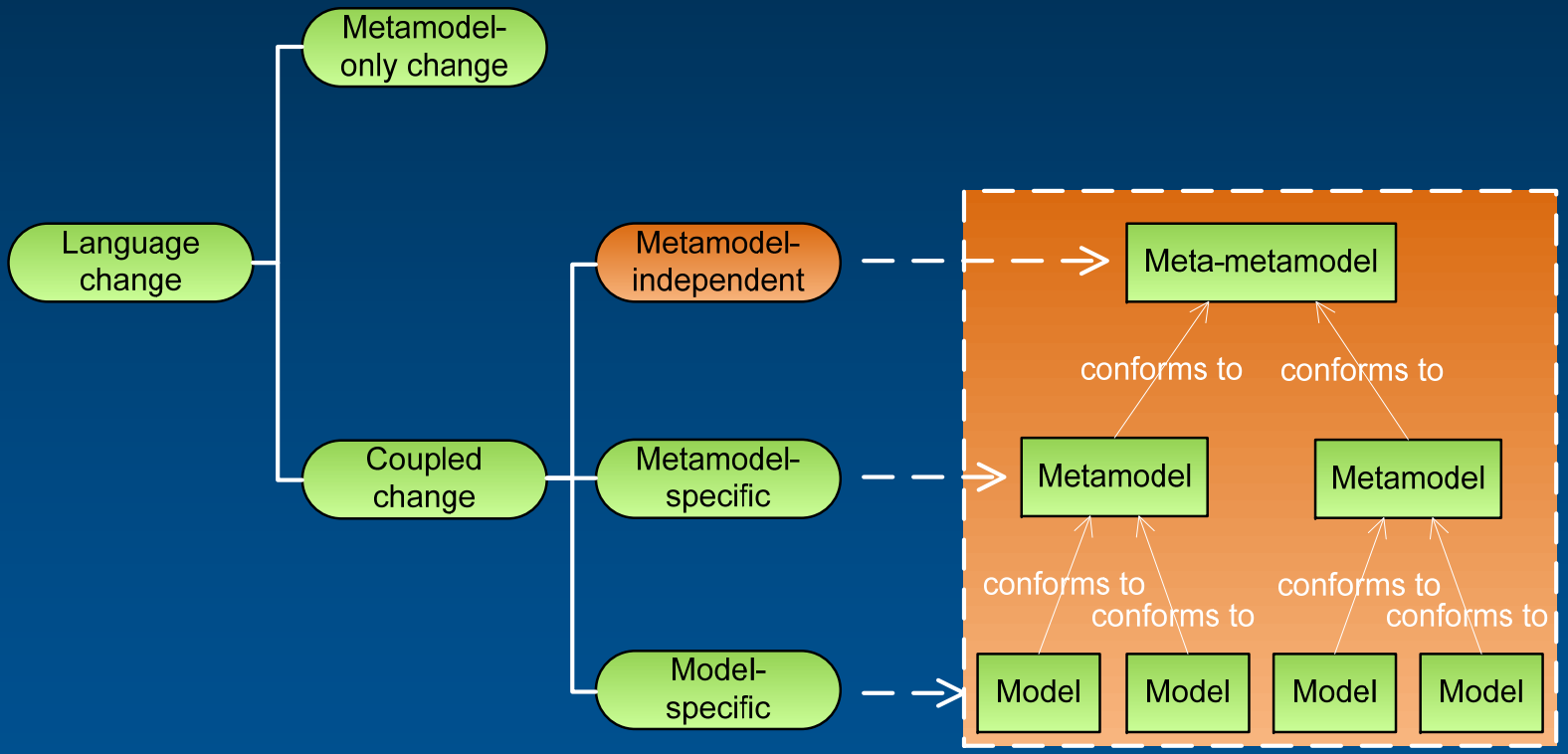
Example: Introduction of Region

Generalizable into an operation to extract a class





Classification – Automatability of Coupled Changes



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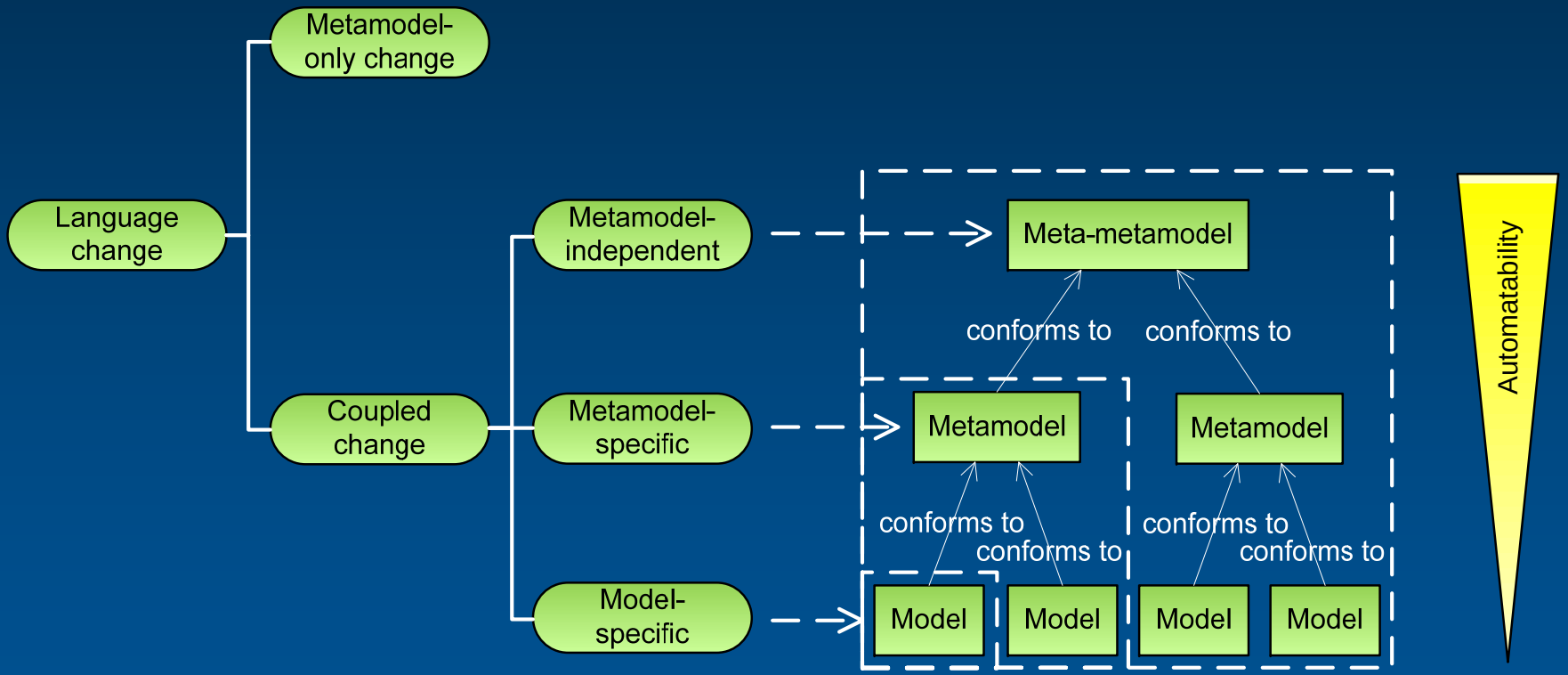


Study – Input

Industrial metamodels from BMW Car IT

- *FLUID* (FLexible User Interface Development):
  specification of Human Machine Interfaces

- *TAF-Gen* (Test Automation Framework - Generator):
  specification of test models and test cases for Electronic Control Units

Study – Execution

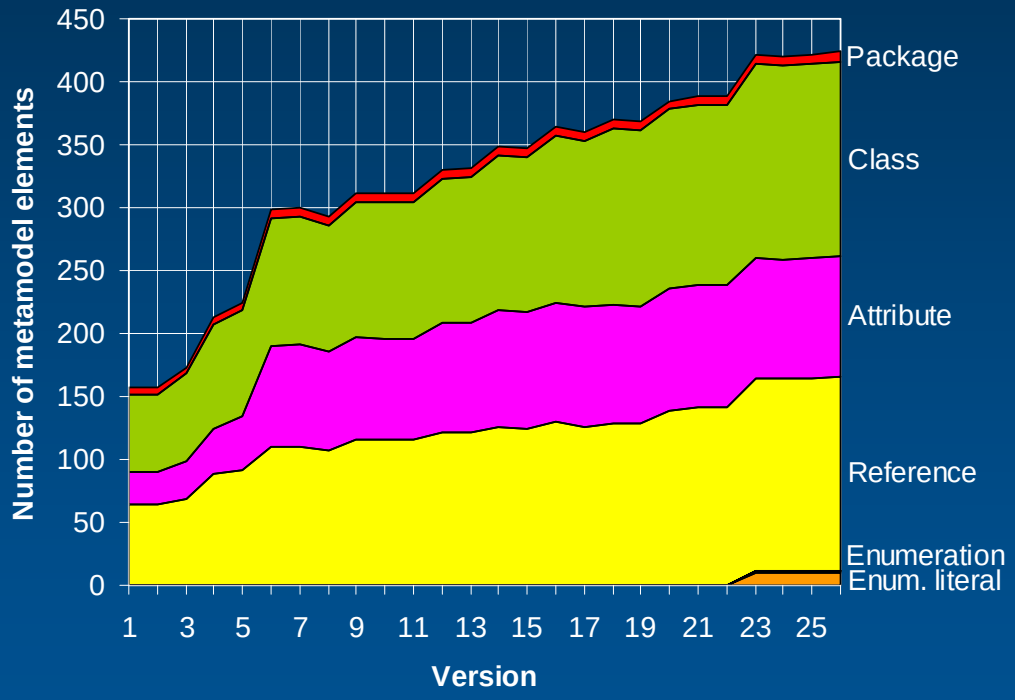
1. *Extraction* of metamodel versions:
   from the revision control system

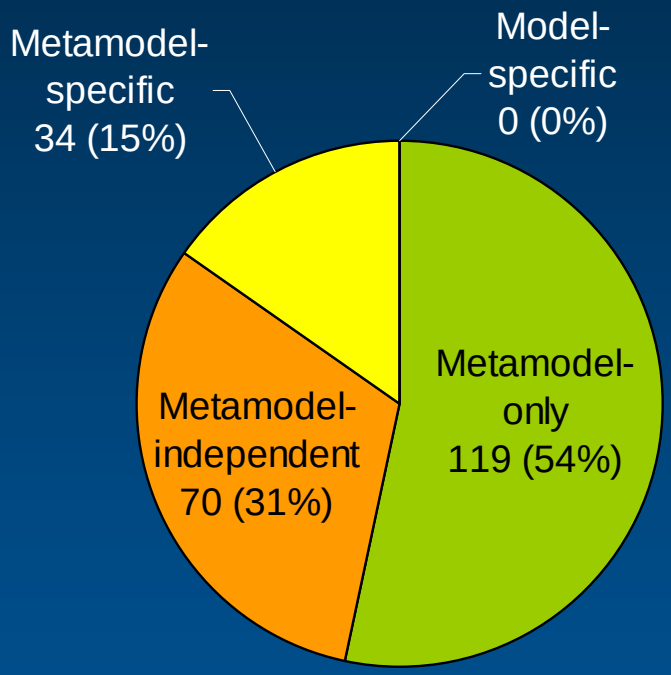
2. *Comparison* of subsequent metamodel versions:
   difference model consisting of primitive changes

3. *Detection* of coupled changes:
   combination of primitive changes based on model migration

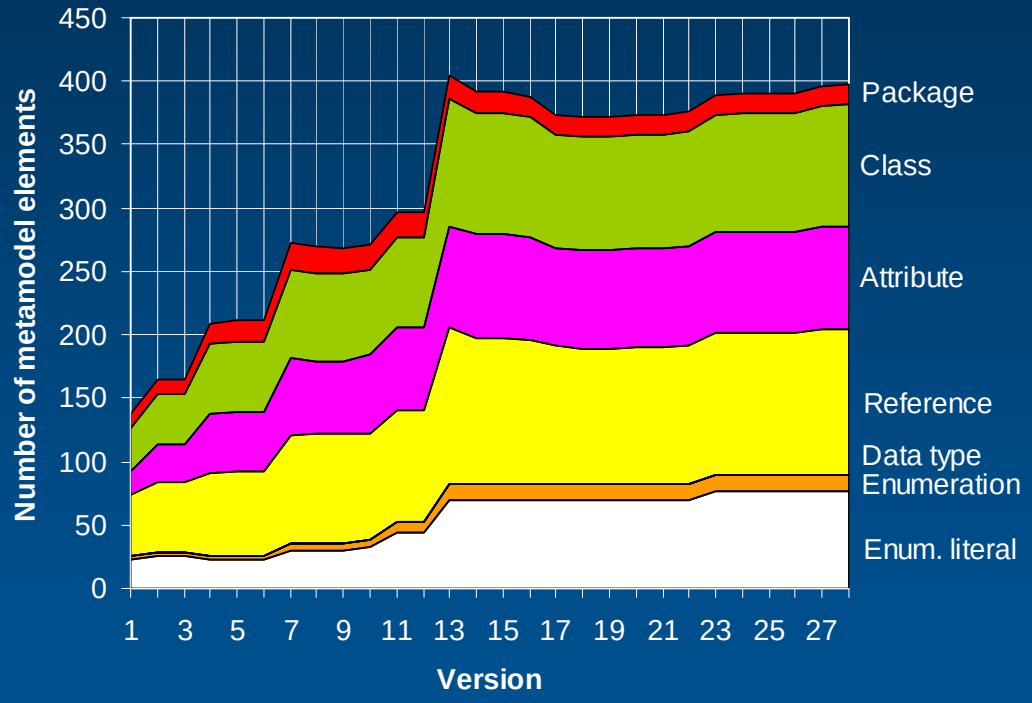
4. *Classification* of coupled changes

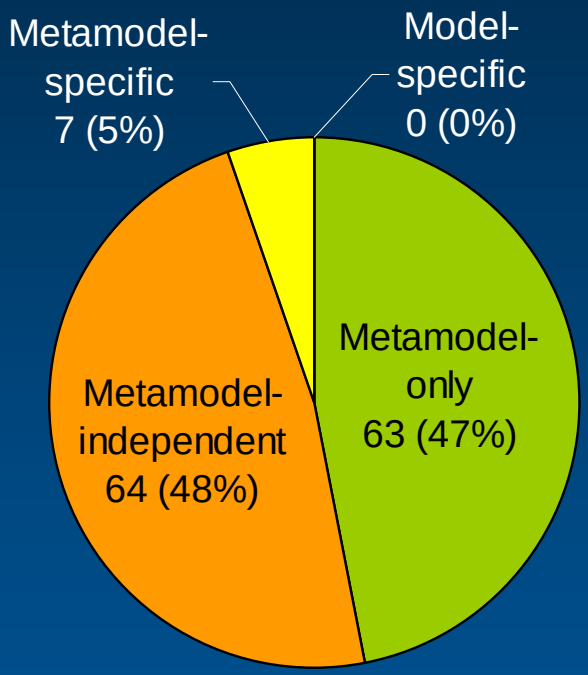
Study – Result for FLUID



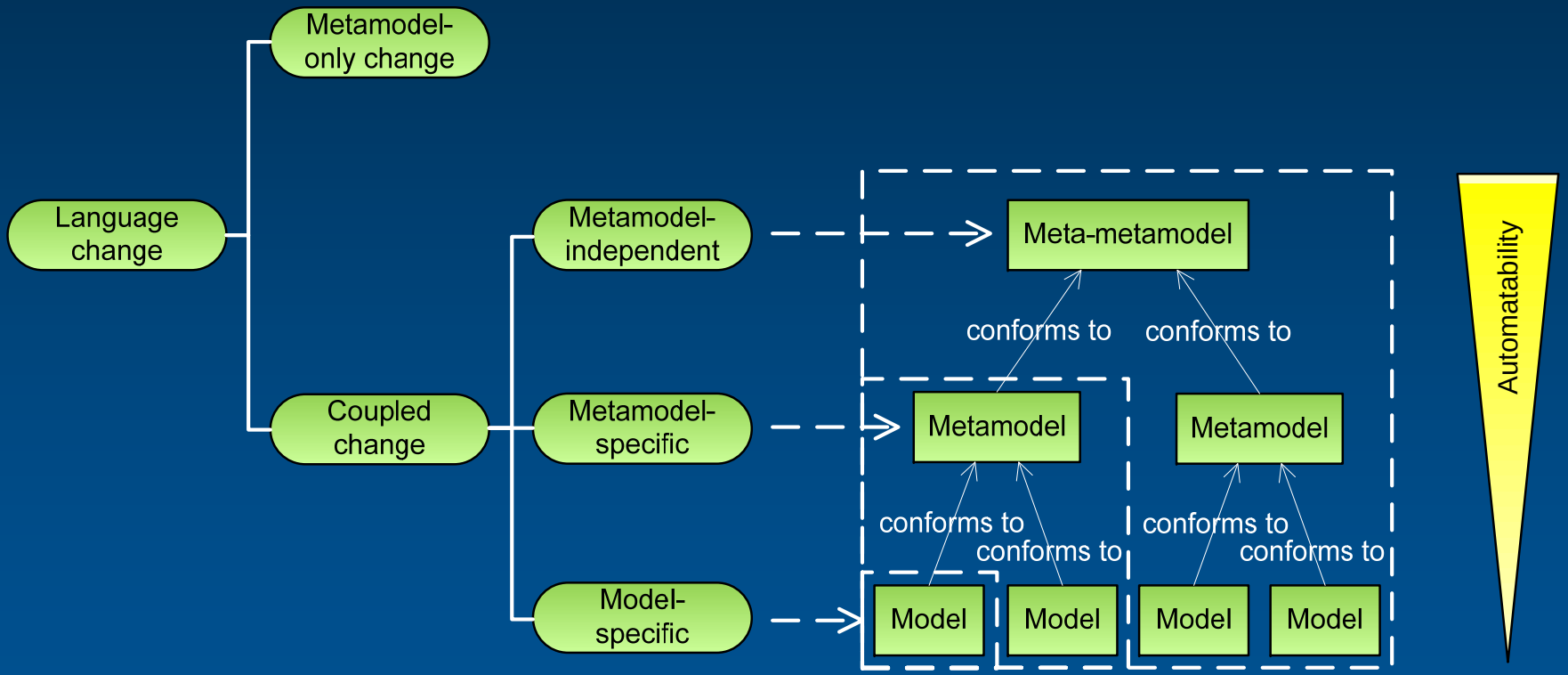


Study – Result for Taf-Gen





Study – Result



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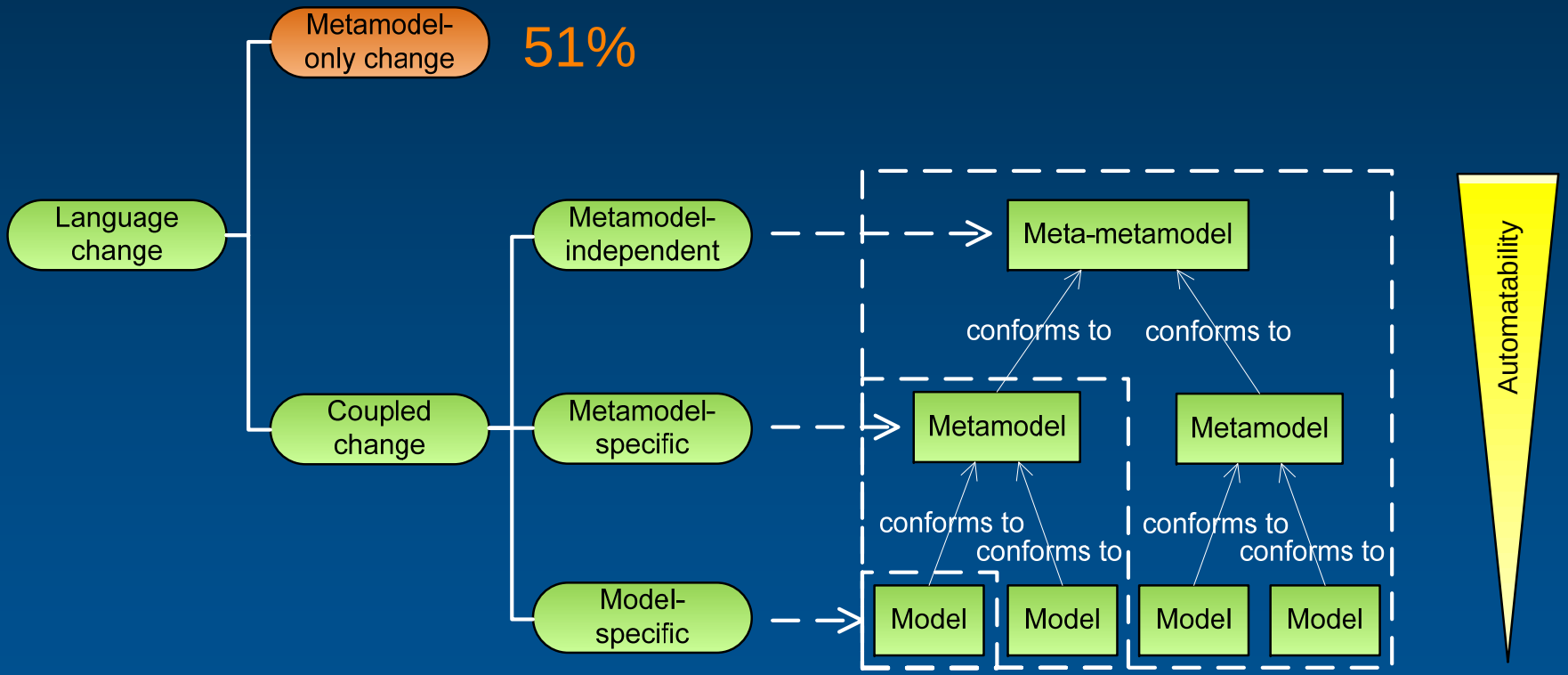

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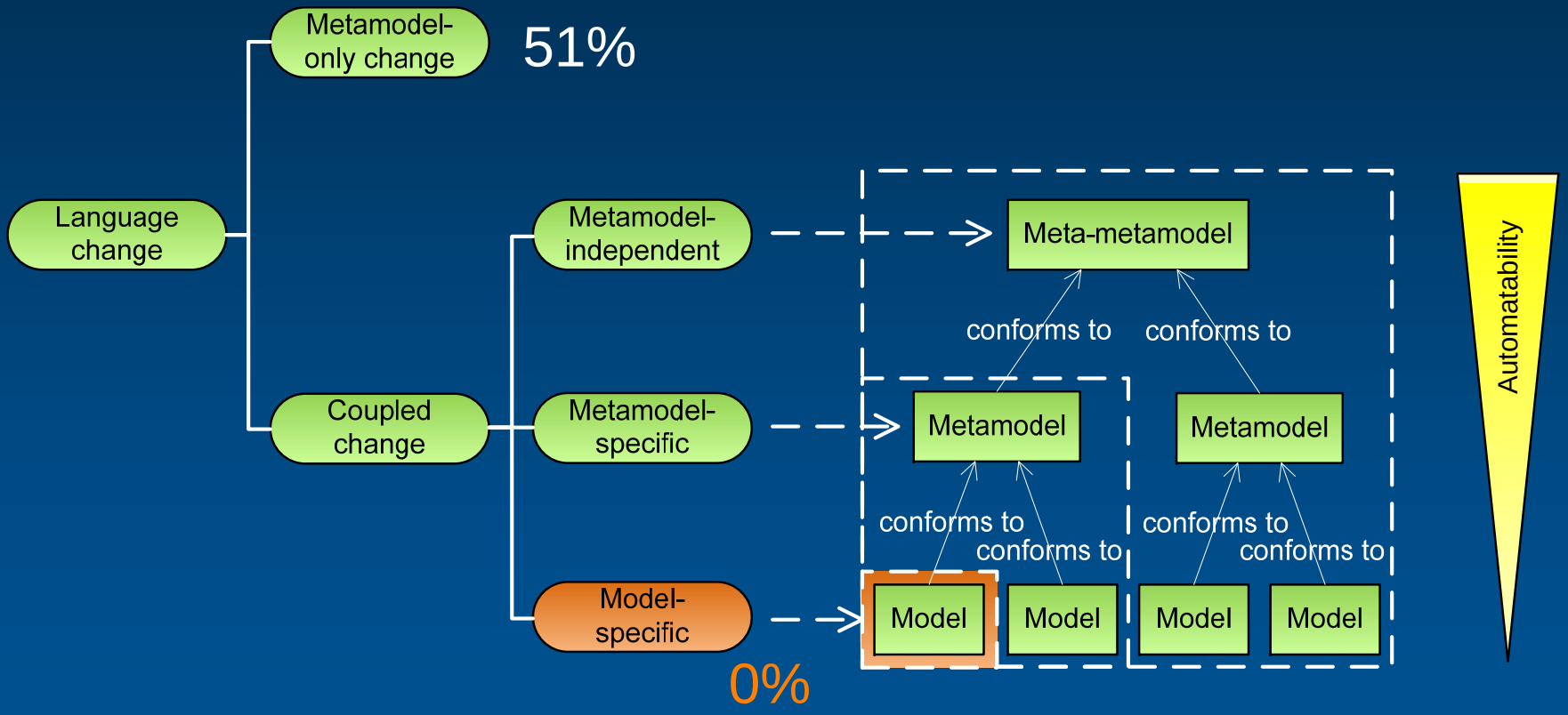

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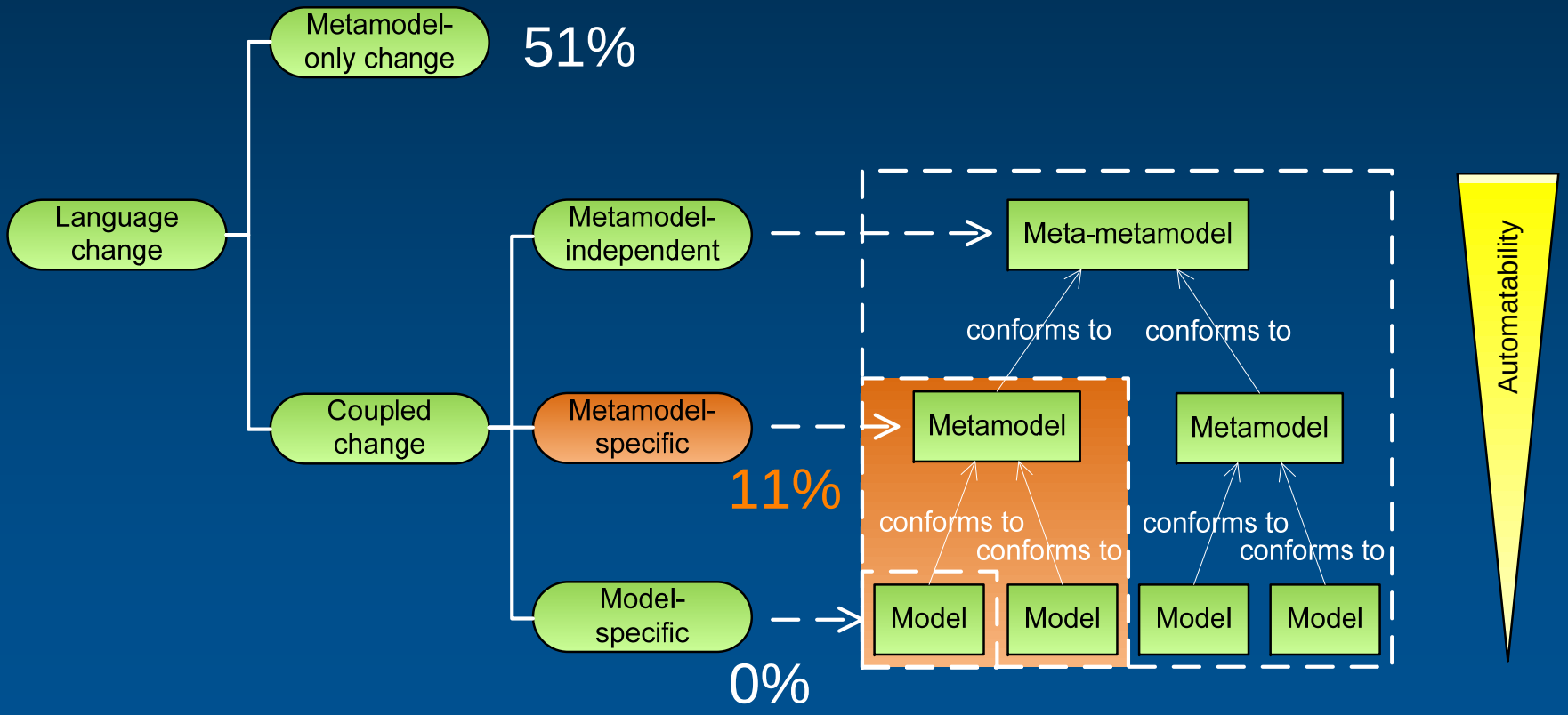

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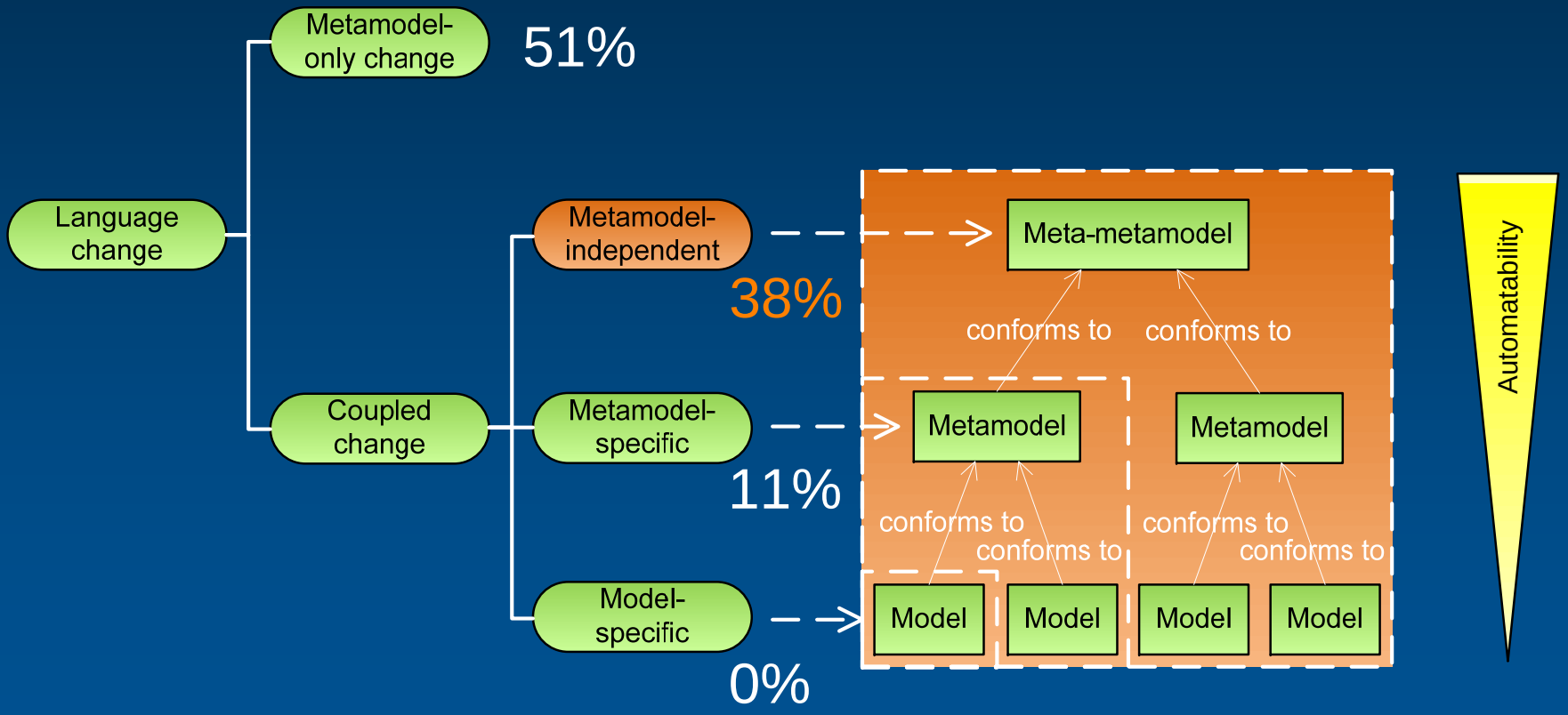
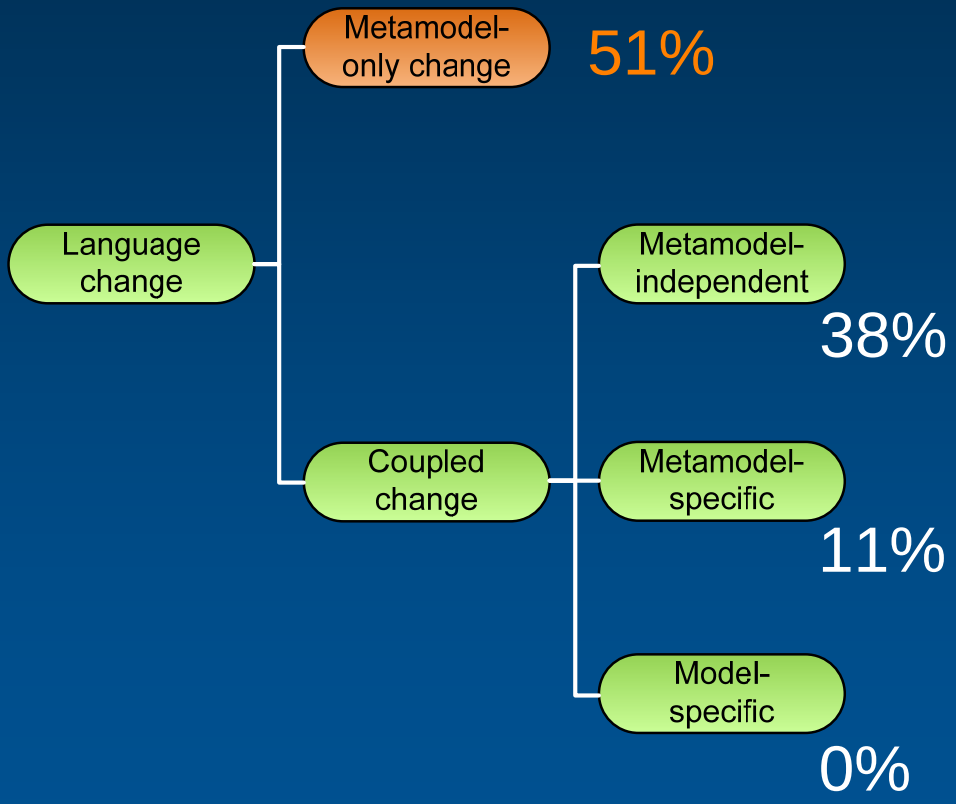
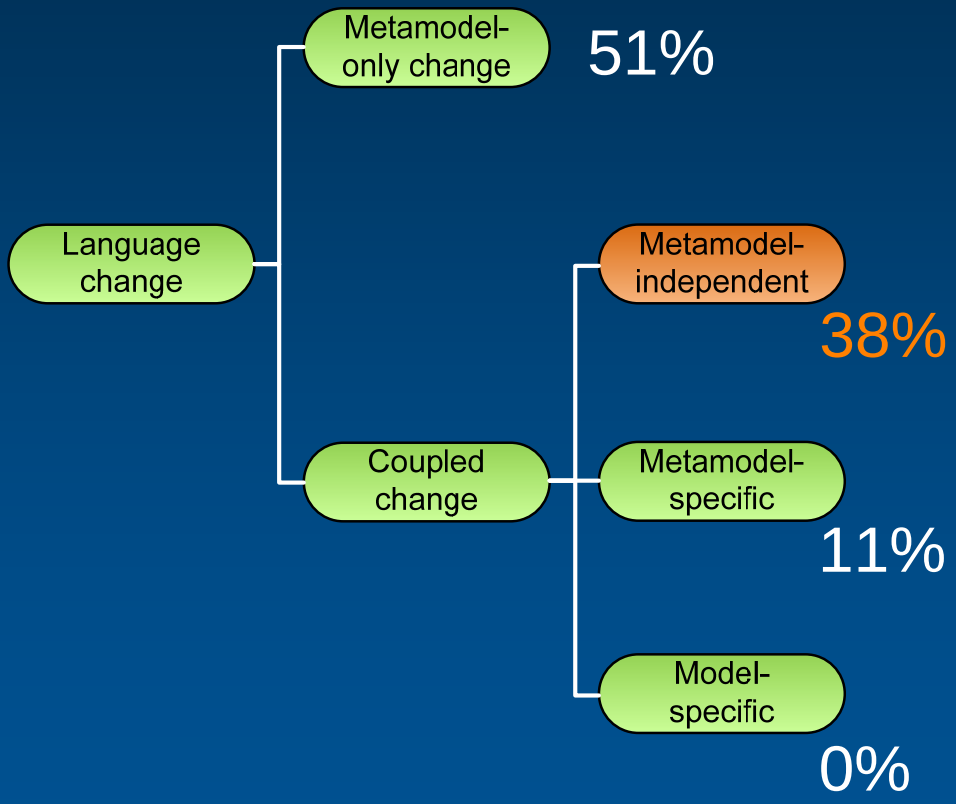


Study – Discussion



Tool support required

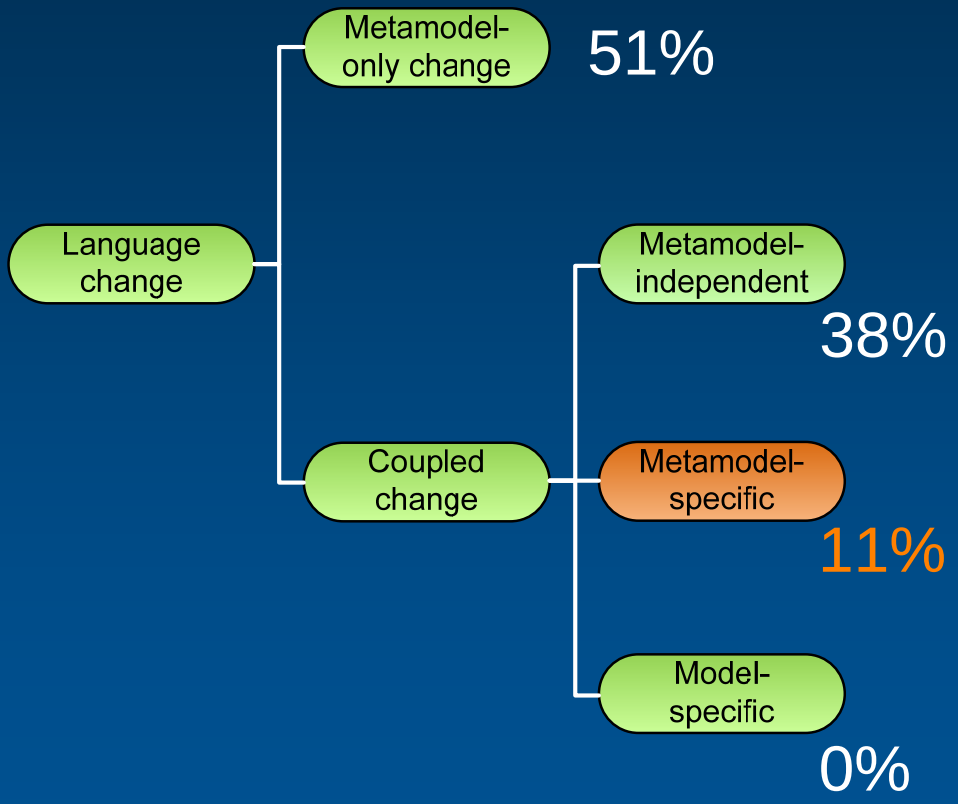
Study – Discussion



Tool support required

Reuse of migration knowledge

Study – Discussion

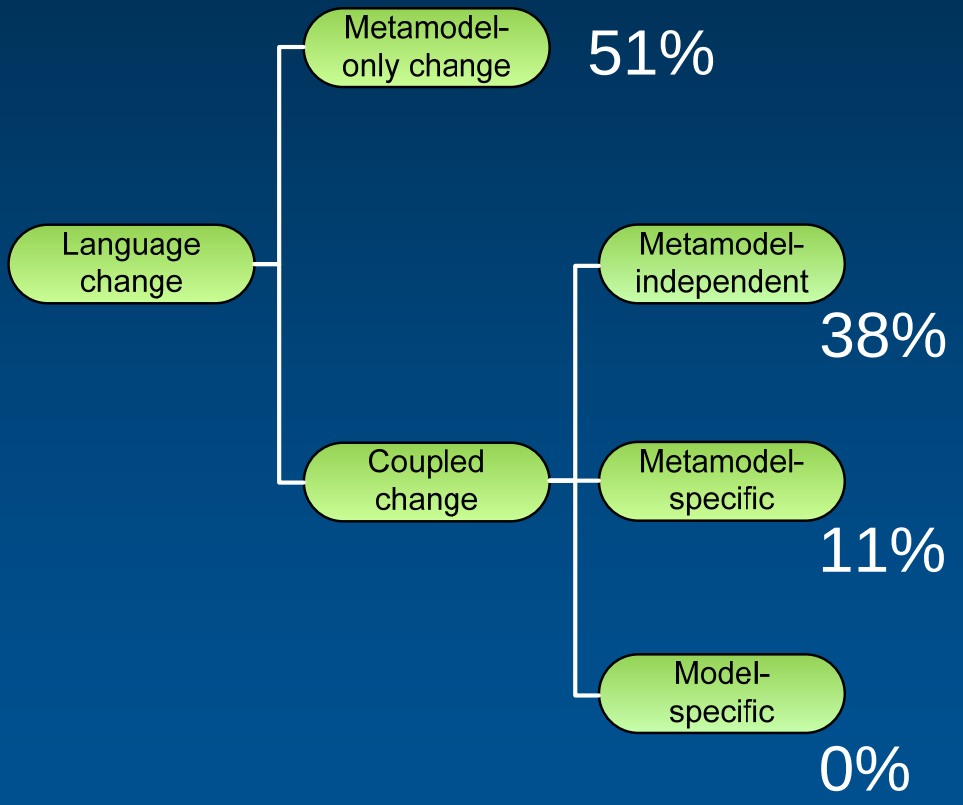


Tool support required

Reuse of migration knowledge

Expressive, custom migrations

Study – Discussion



Tool support required

Reuse of migration knowledge

+

Expressive, custom migrations

Composeability

Study – Threats to Validity

Threat	Mitigation
1. *Extraction*: Commit as indication for new metamodel version ⇒ Primitives combined only from one commit to the next	1. Primitive changes of other metamodel versions taken into account in case of missing information
2. *Comparison*: Comparison of metamodel versions ambiguous ⇐ Absence of unique identifiers, changes overwritten by others	2. Validation of primitive changes in close cooperation with the metamodel developers
3. *Detection*: Models not available for all metamodel versions	3. Exhaustive questioning of the metamodel developers about the correctness of the derived migration
4. *Classification*: Differentiation between metamodel-specific and -independent coupled changes not 100% sharp	4. Conservative strategy: Classification rather metamodel-specific than metamodel-independent in case of uncertainty

Conclusion

Contributions

- Classification of coupled changes w.r.t. potential for automation
- Empirical study of two industrial metamodel histories

Result

- Metamodels change!
- Model migration necessary for many metamodel changes
- Huge potential for automation

Requirements for tool support

- **Expressiveness**: to cater for complex model migrations
- **Reuse**: to significantly reduce maintenance effort

Future Work

Further studies of metamodel histories

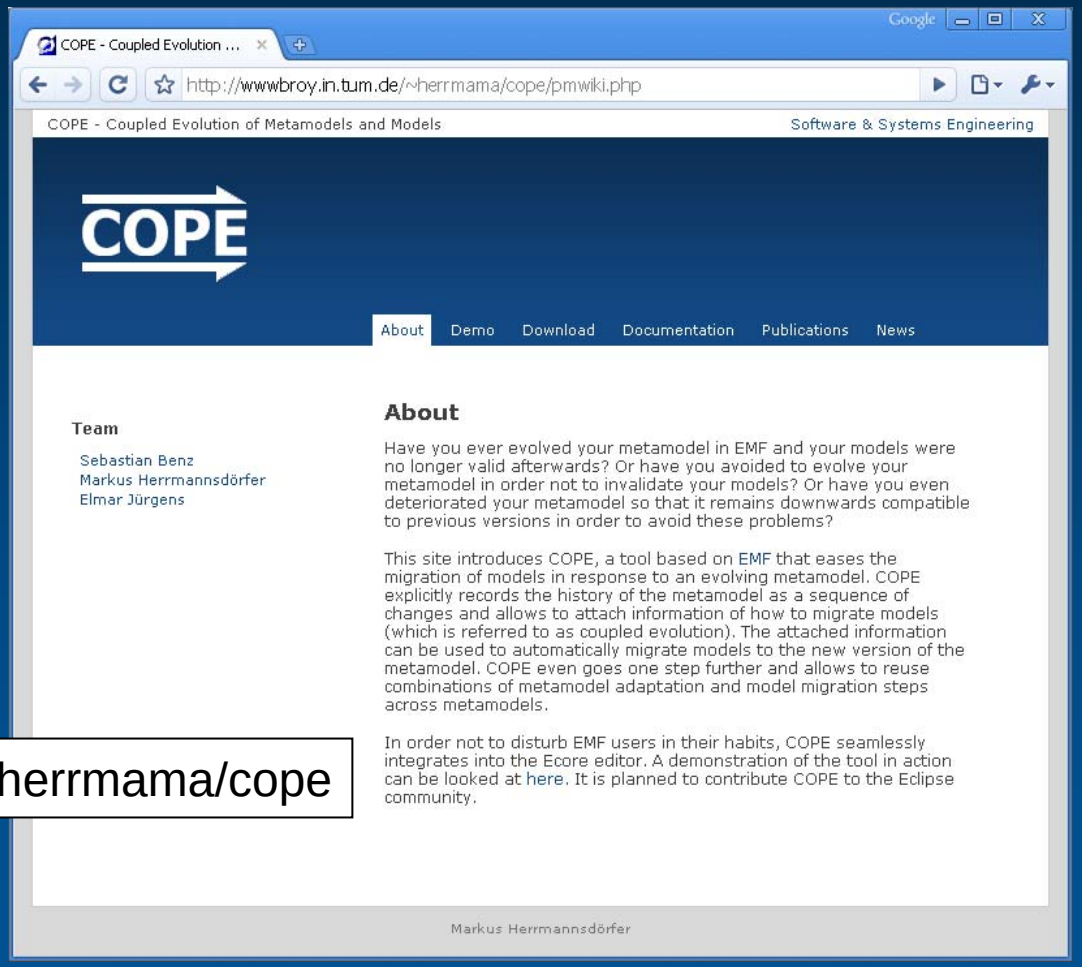
- Refinement of classification
- Different aspects of language evolution
- Open source metamodels ($\Leftarrow$ Confidentiality of the presented metamodels)

Tool Support for Automated Coupled Evolution

- Classification of existing approaches according to requirements
- Approach fulfilling the requirements
- Performance of a case study to validate against requirements

Thank you very much for your attention!

- Questions?
- Criticism?
- Suggestions?



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