Model Consistency ensured by Metamodel Integration MoConseMI

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Motivation

- various Artifacts in Software Development:
  - Diagrams, DSLs, Tools, ...
  - Artifacts are technically separated
  - Artifacts are interrelated regarding content
- Ensure Consistency between Artifacts automatically

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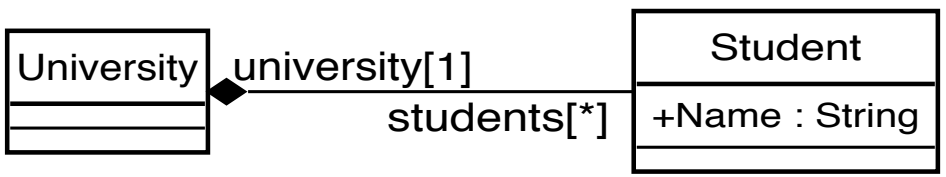

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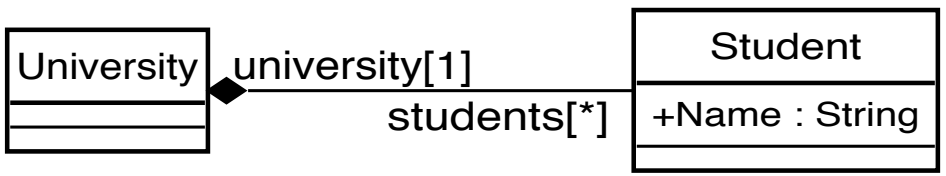

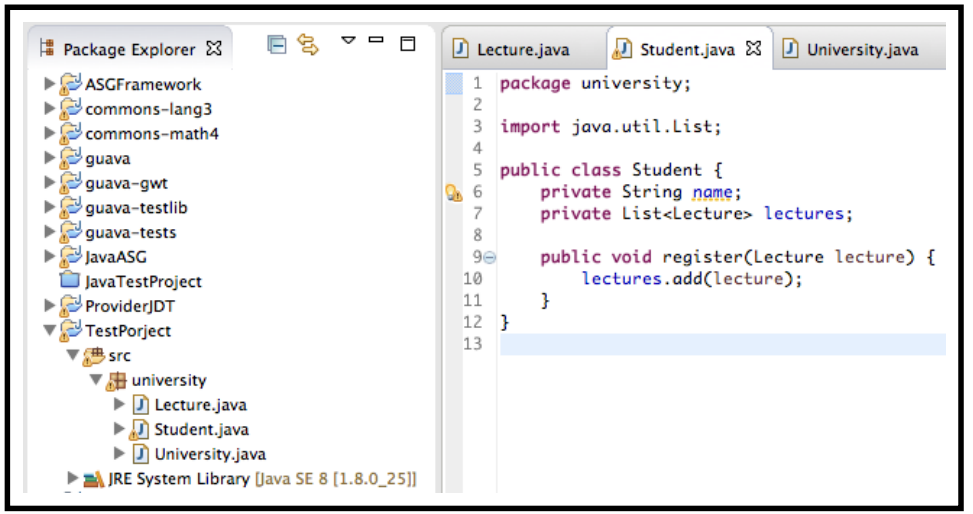

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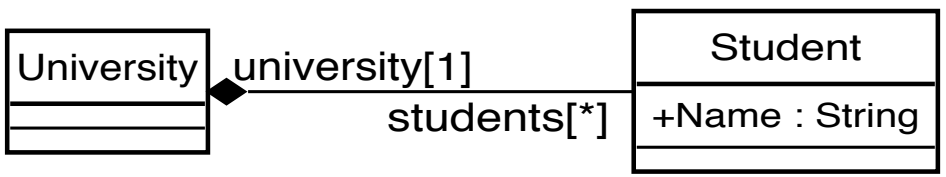

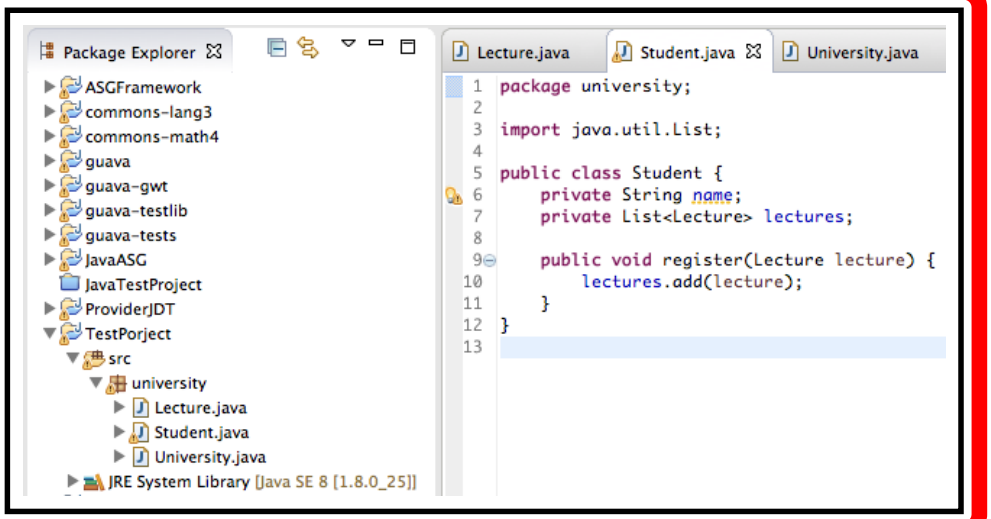

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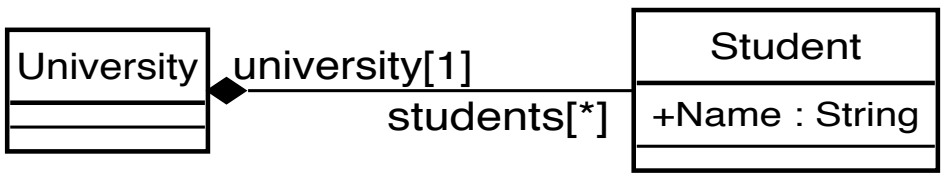

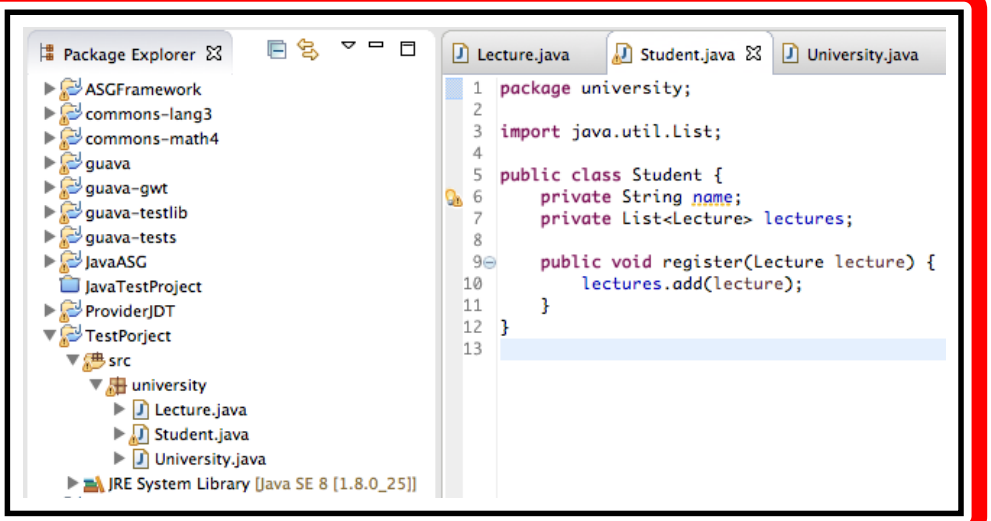

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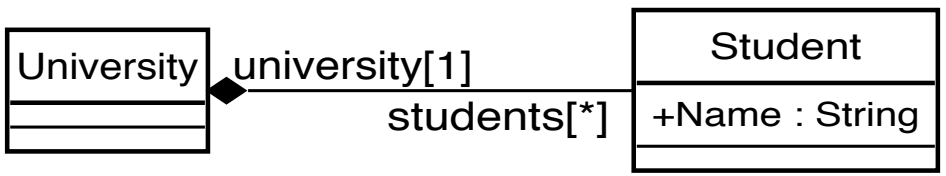

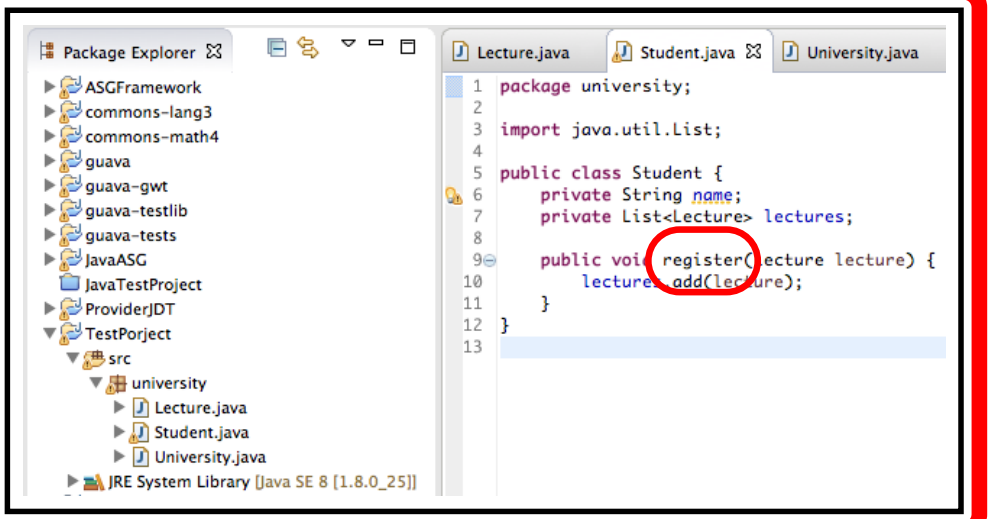

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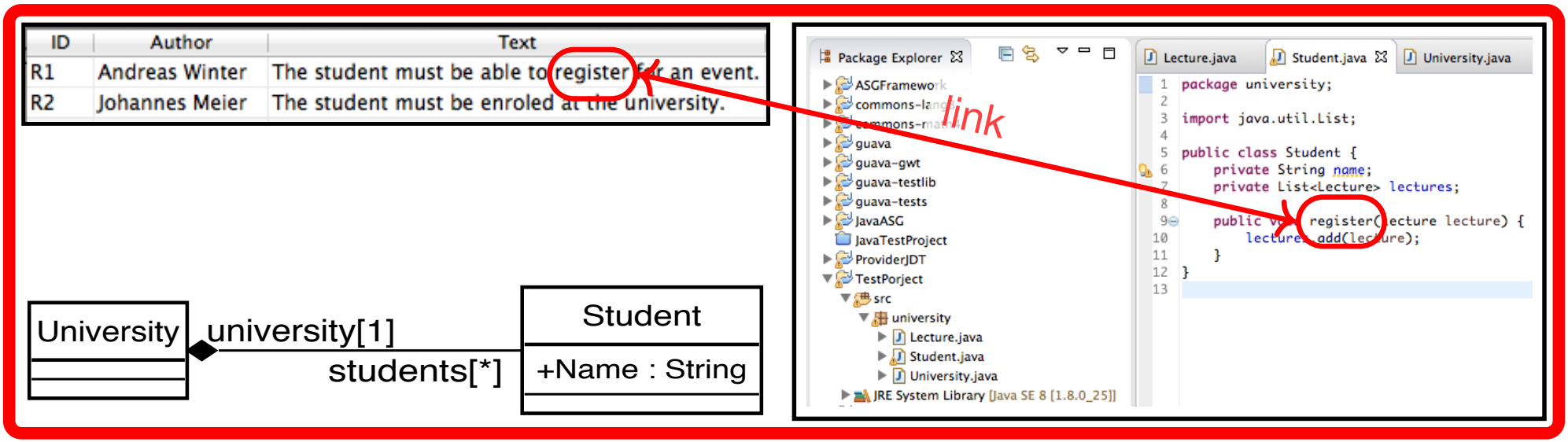

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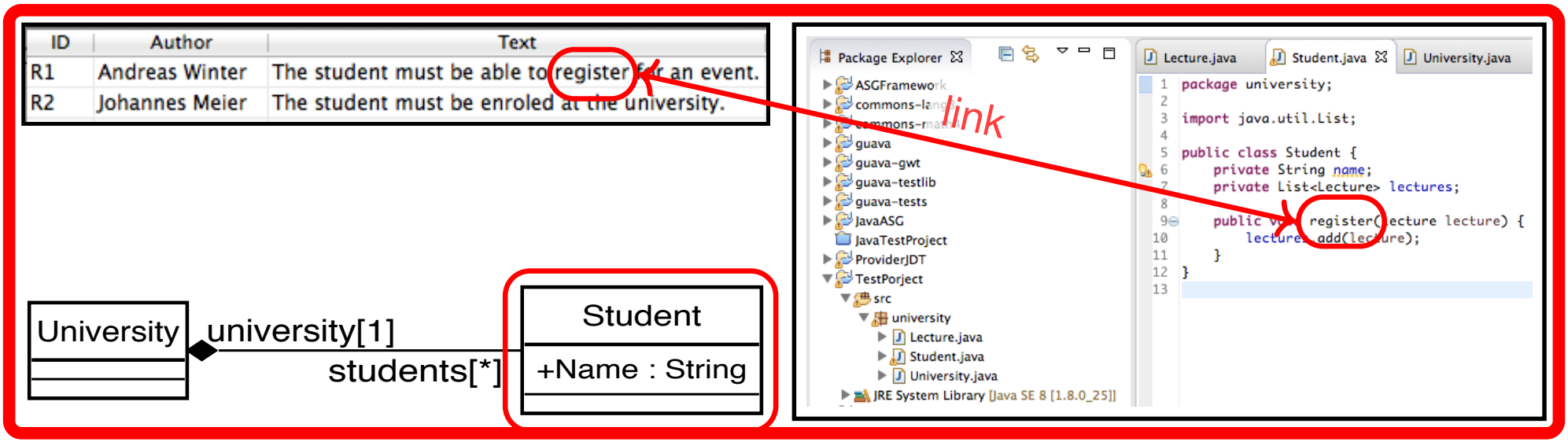

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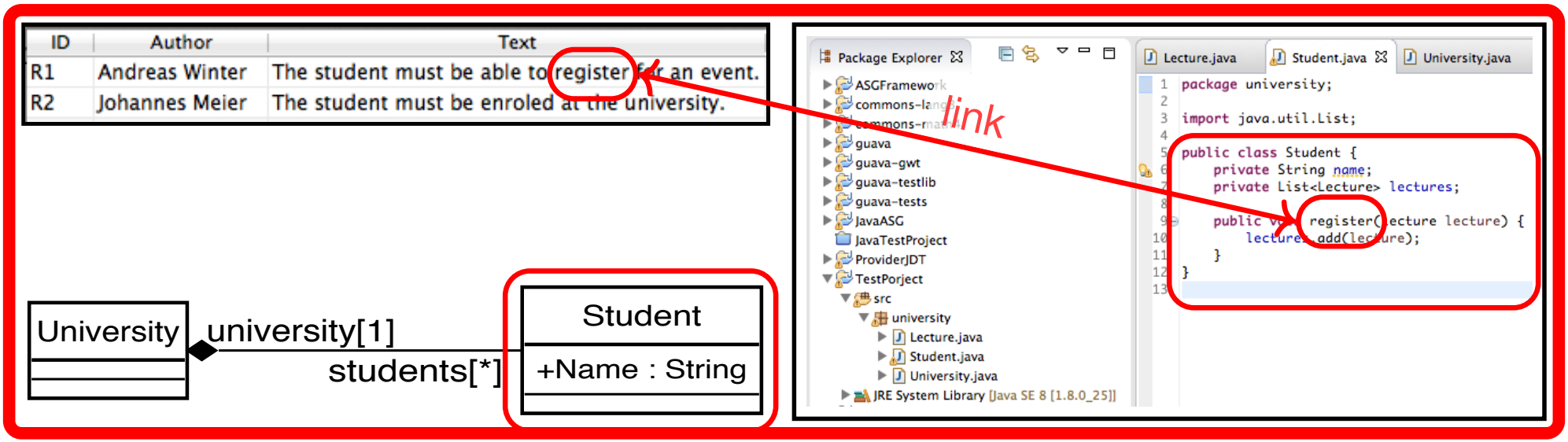

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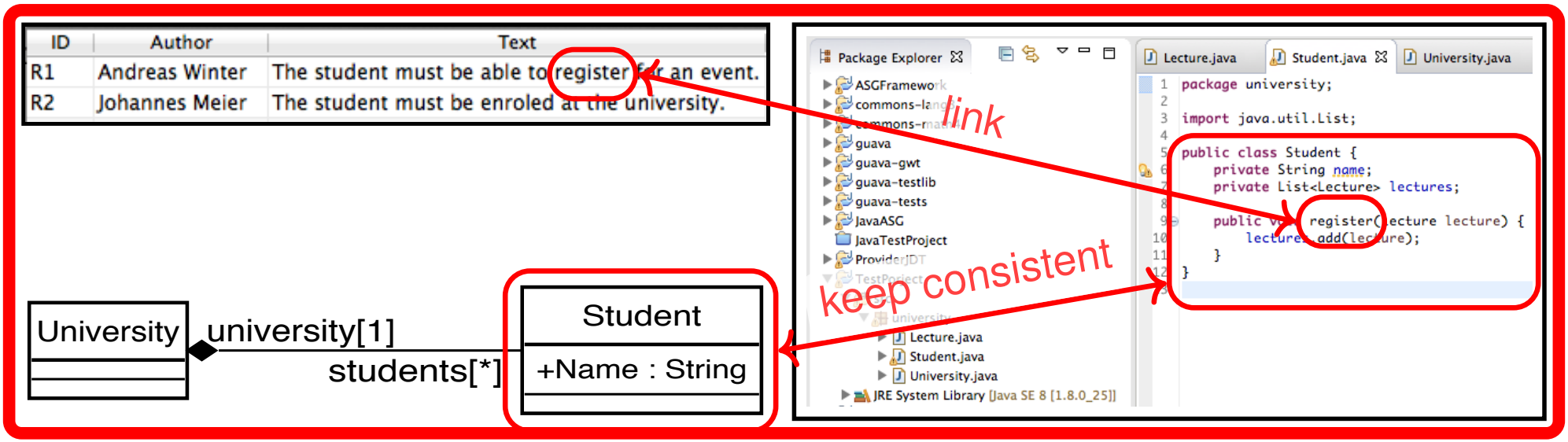

Problem

There are further Software Development Projects:

- e.g. with formal Specifications, C++, Test Cases, Documentation, Project Management, Build Tools
- Traceability
- $\rightarrow$ further Consistency issues

General Problem:

- Artifacts are technically separated, but interrelated contentwise
- specific Consistency Rules have to be fulfilled automatically

Goal

Ensure Consistency between Artifacts automatically!

- Artifact == Model + Metamodel (structural formalization [CNS12])
- $\rightarrow$ Model Integration

Challenges

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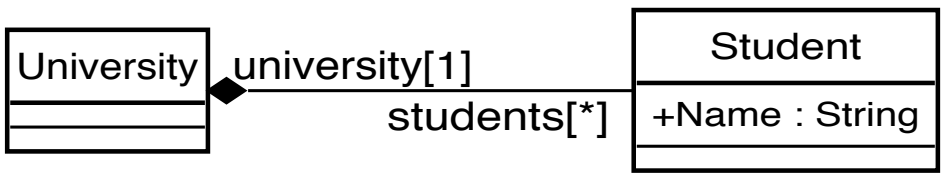

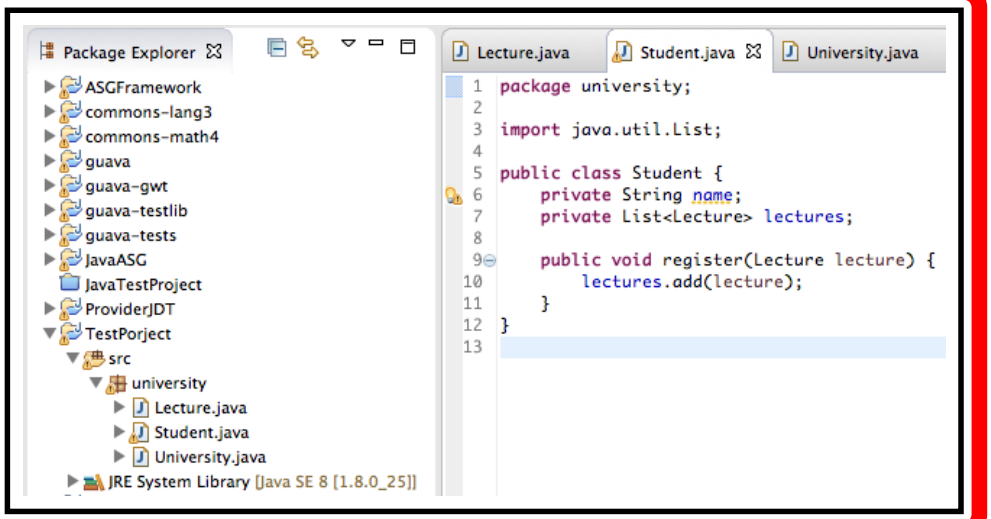

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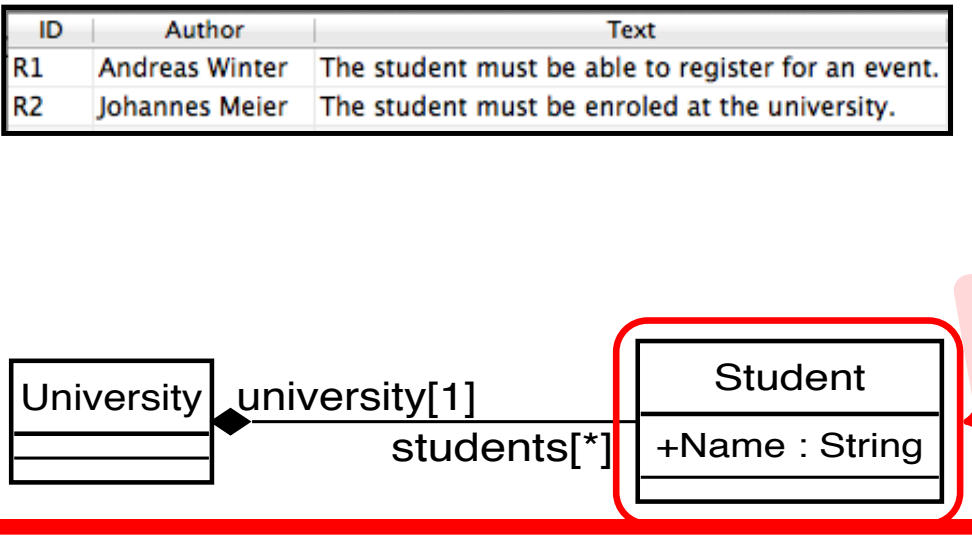

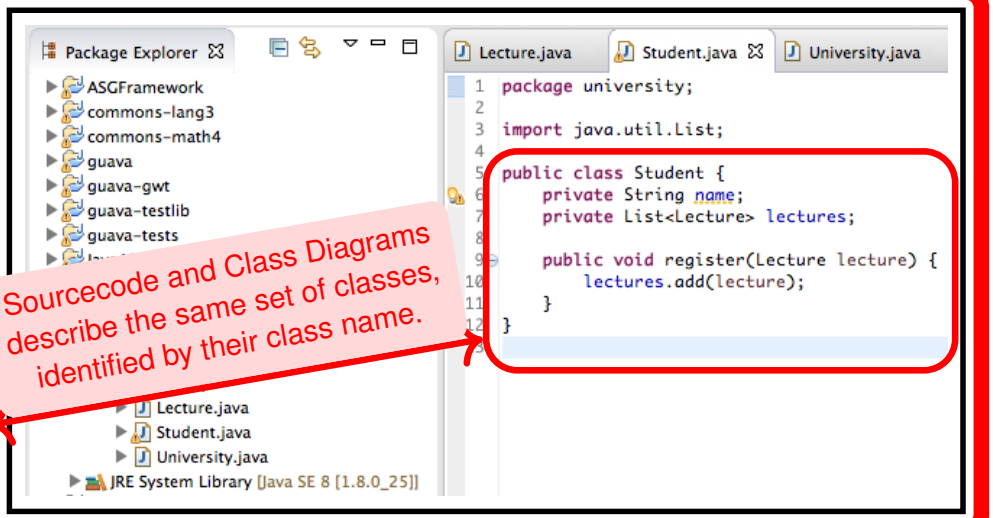

Sourcecode and Class Diagrams describe the same set of classes, identified by their class name.

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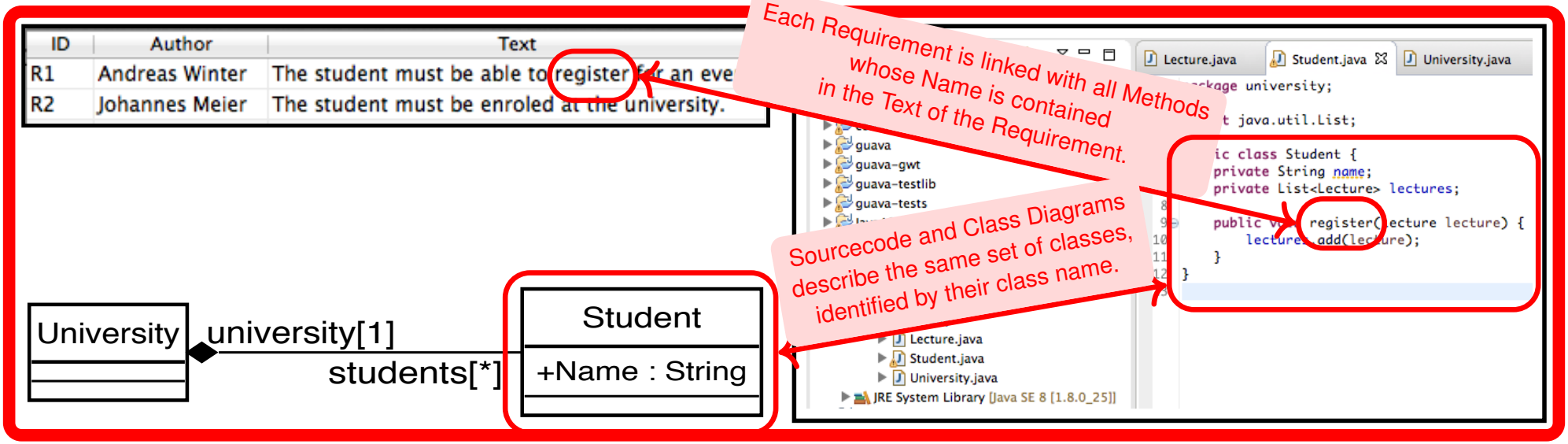

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- used as single Point of Truth
- Single Underlying Model [ASB09]
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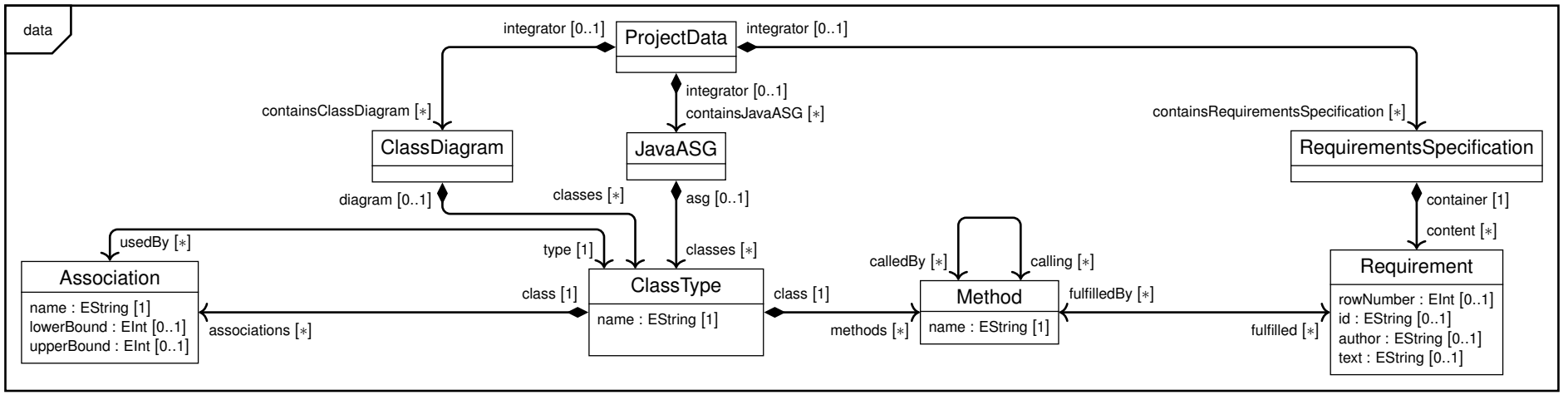

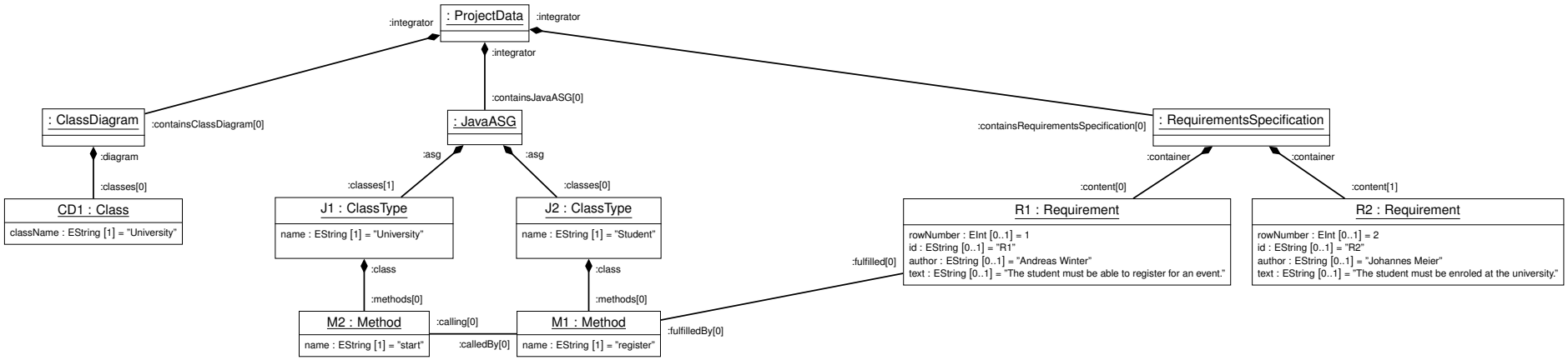

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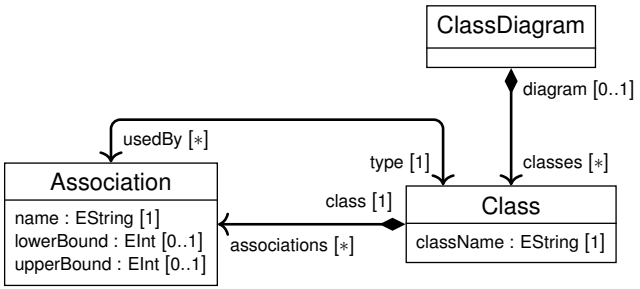

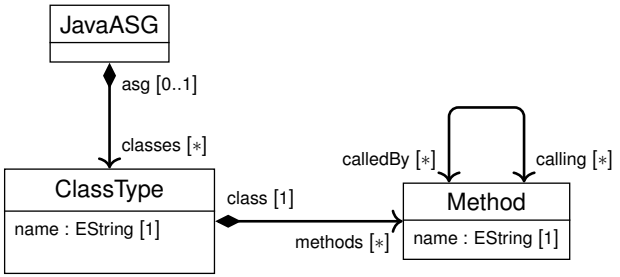

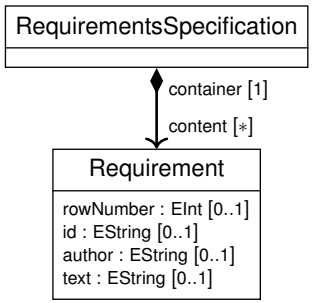

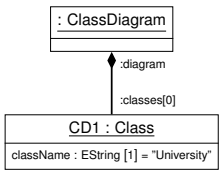

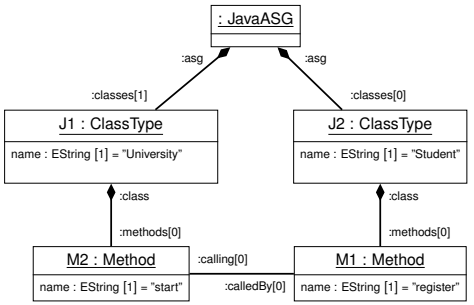

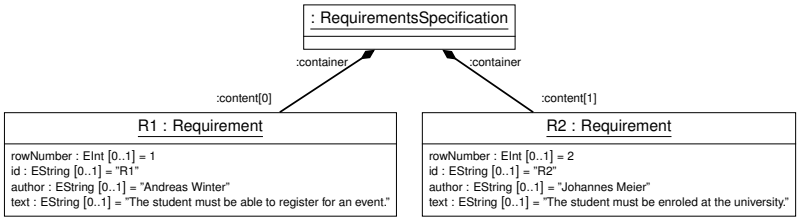

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Related Work

	synthetic	projectional		
		OSM	Vitruvius	GEMOC
1. Formalize Consistency Rules	✓	✓	✓	✓
2. Create explicit SUM(M)	✗	✓	✗	✗
3a. Reuse initial Models	✓	✗	✓	✓
3b. Fix initial Inconsistencies	✓	–	✗	?
3c. Consistent initial Models	✓	–	✓	✓
4. Ensure Model Consistency	✓	✓	✓	✓

- ISO Standard 42010:2011 [IEE11]: synthetic vs. projectional
- synthetic: TGGs [SK08], QVT-R [RJV09], explicit correspondences [EEC+14]
- OSM: Single Underlying (Meta)Model (SUM(M)) [ASB09]
- Vitruvius [KBL13, BHK+14]
- GEMOC Approach [LDC18]

Metamodel Integration

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Activities

1. Configuration of Operators

SUMM

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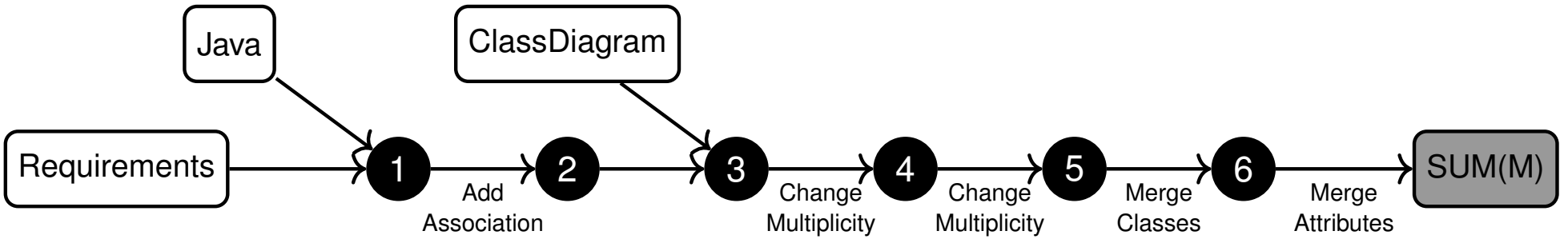

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2. Initialization of SUM

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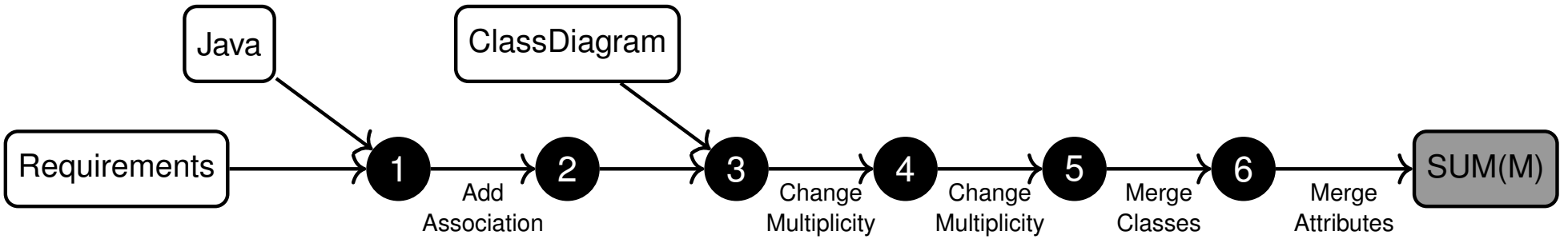

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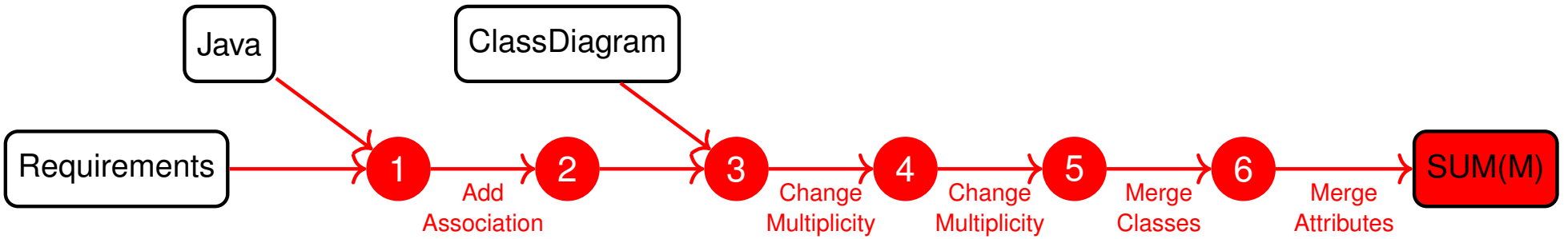

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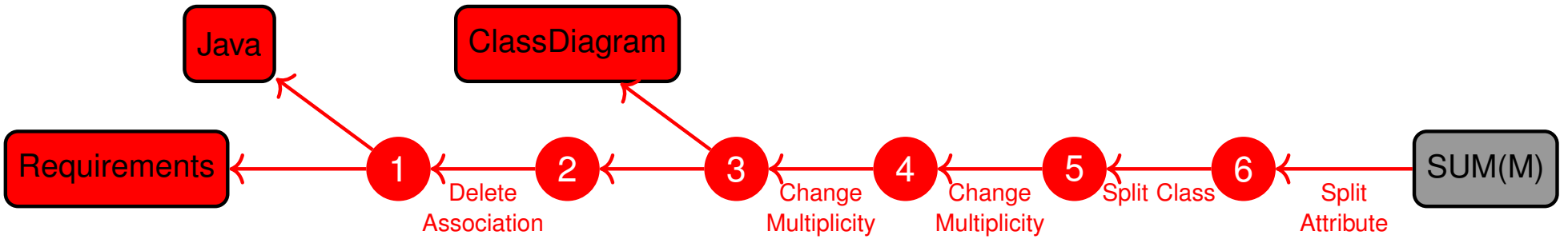

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3. Consistency Assurance

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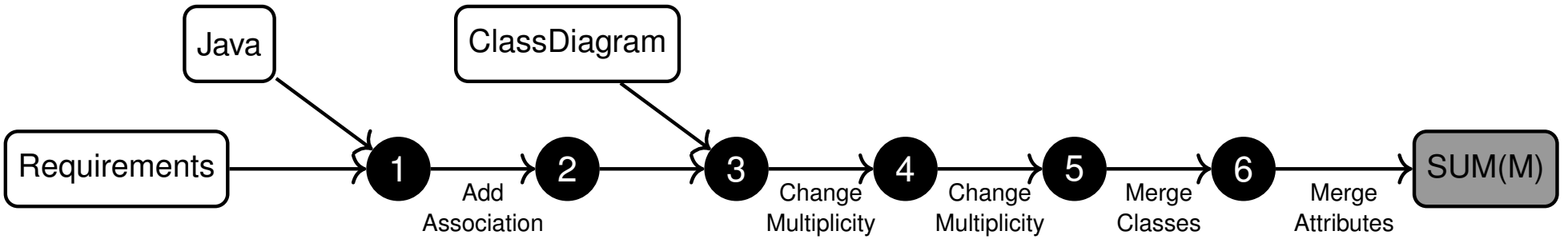

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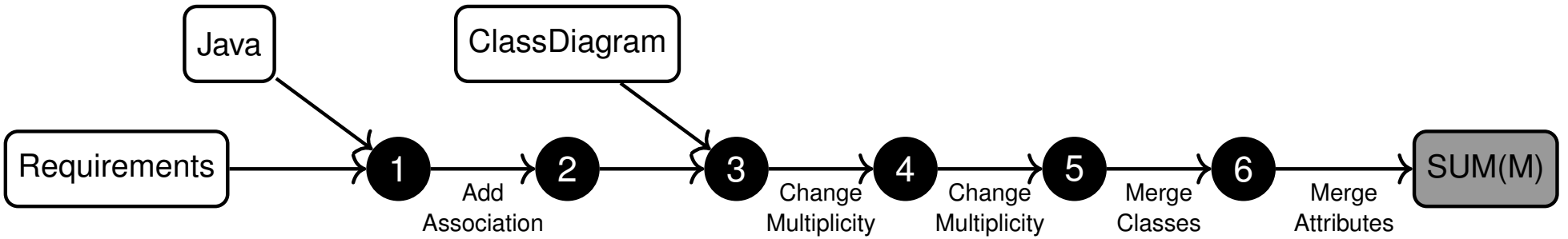
1x Methodologist



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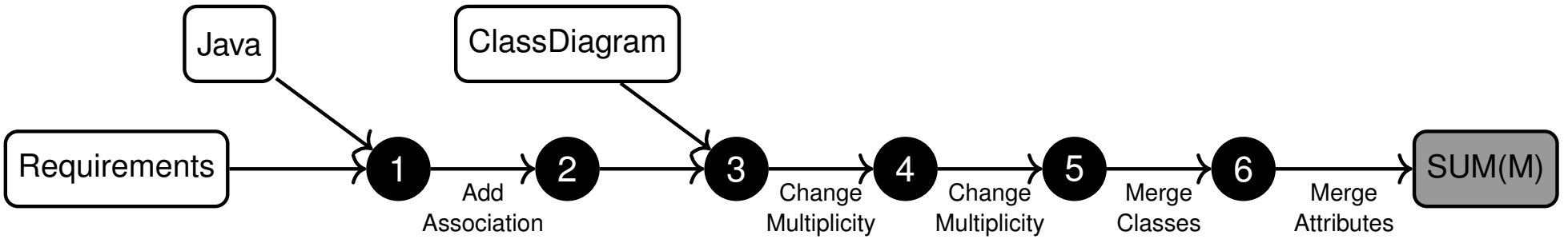
n x User



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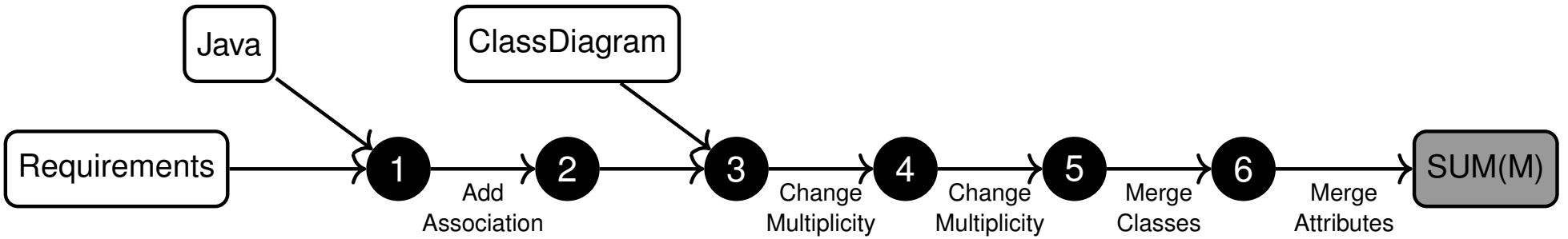

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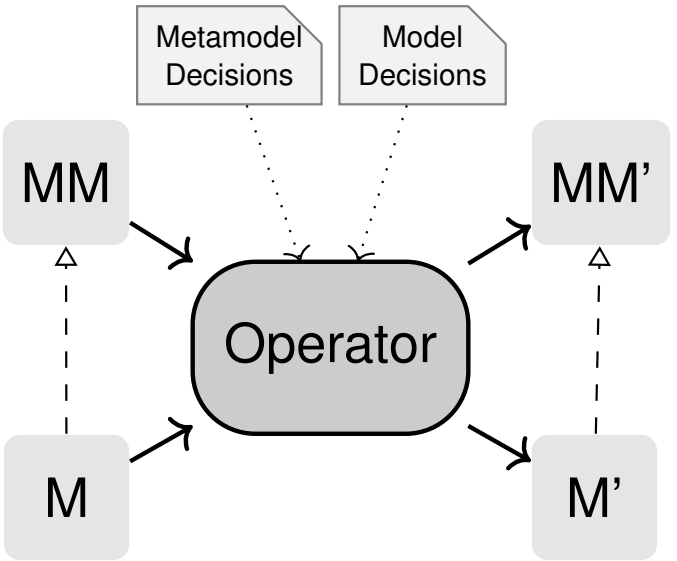

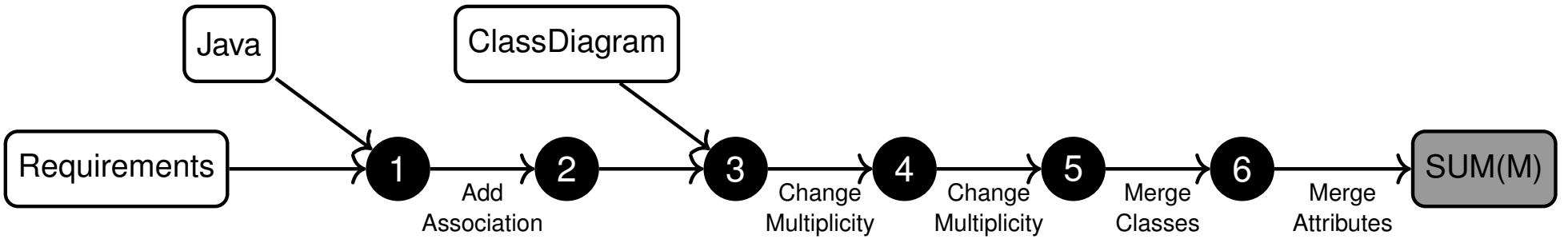

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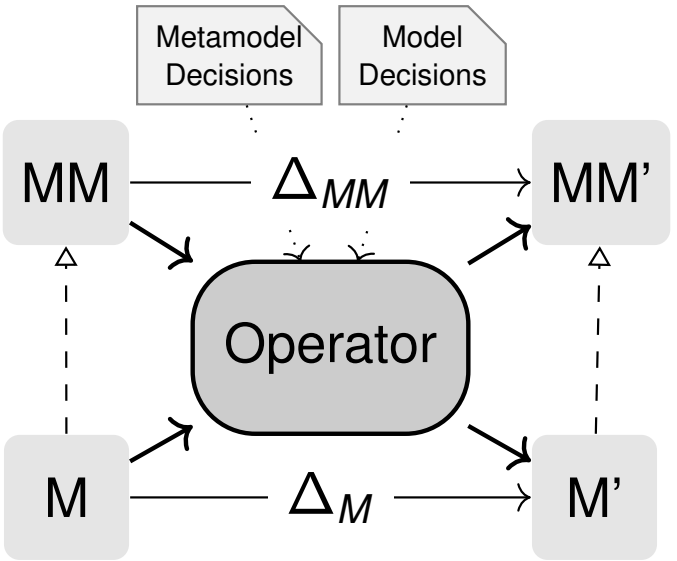

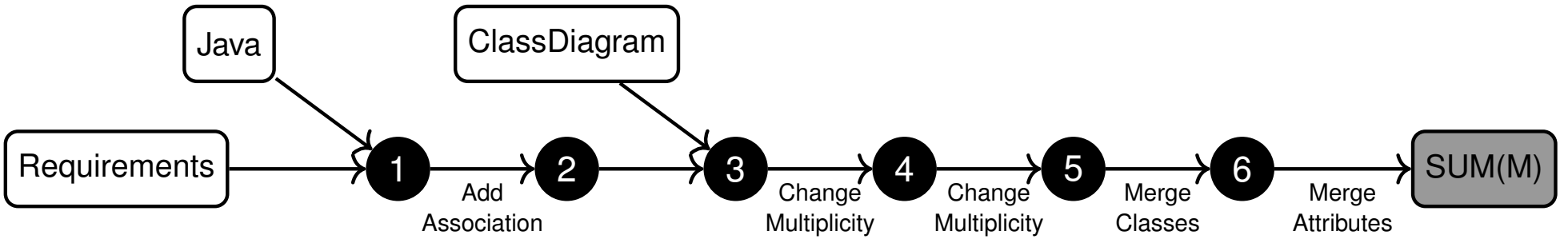

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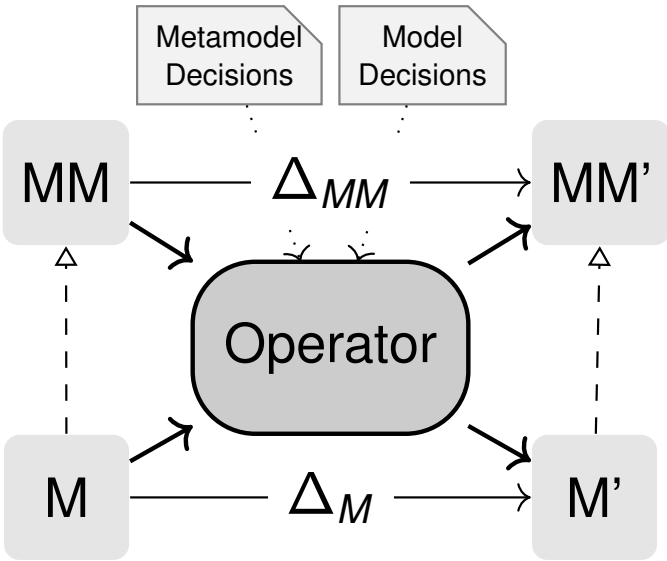
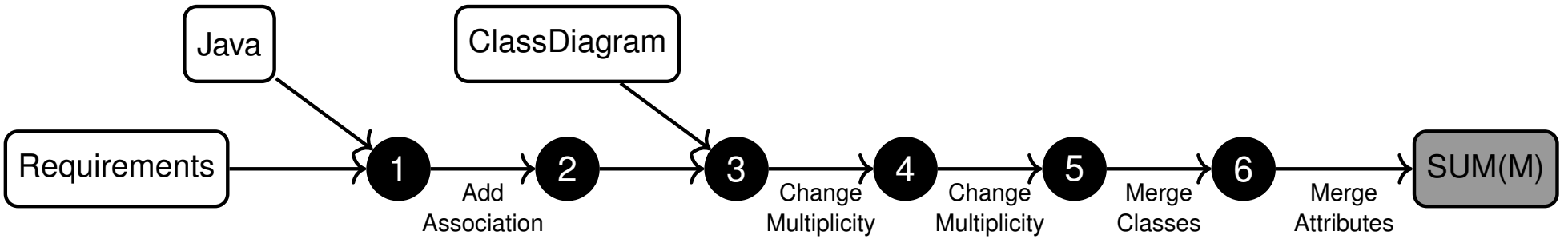


Chechik, Nejati, Sabetzadeh:
A Relationship-Based Approach to Model Integration (2012)

→ merge, composition, weaving

Herrmannsdoerfer et al.:
An Extensive Catalog of Operators for the Coupled Evolution of Metamodels and Models (2011)

→ extended Coupled Operators



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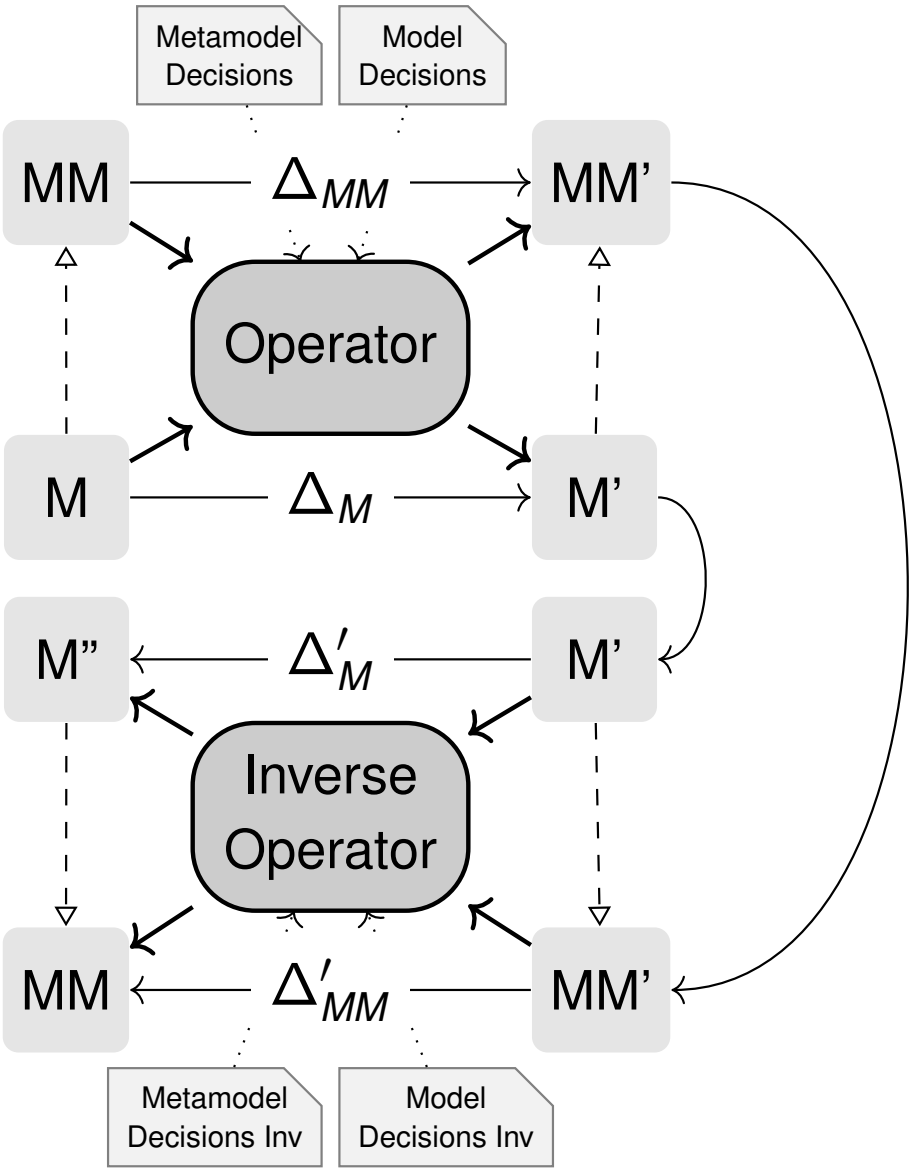

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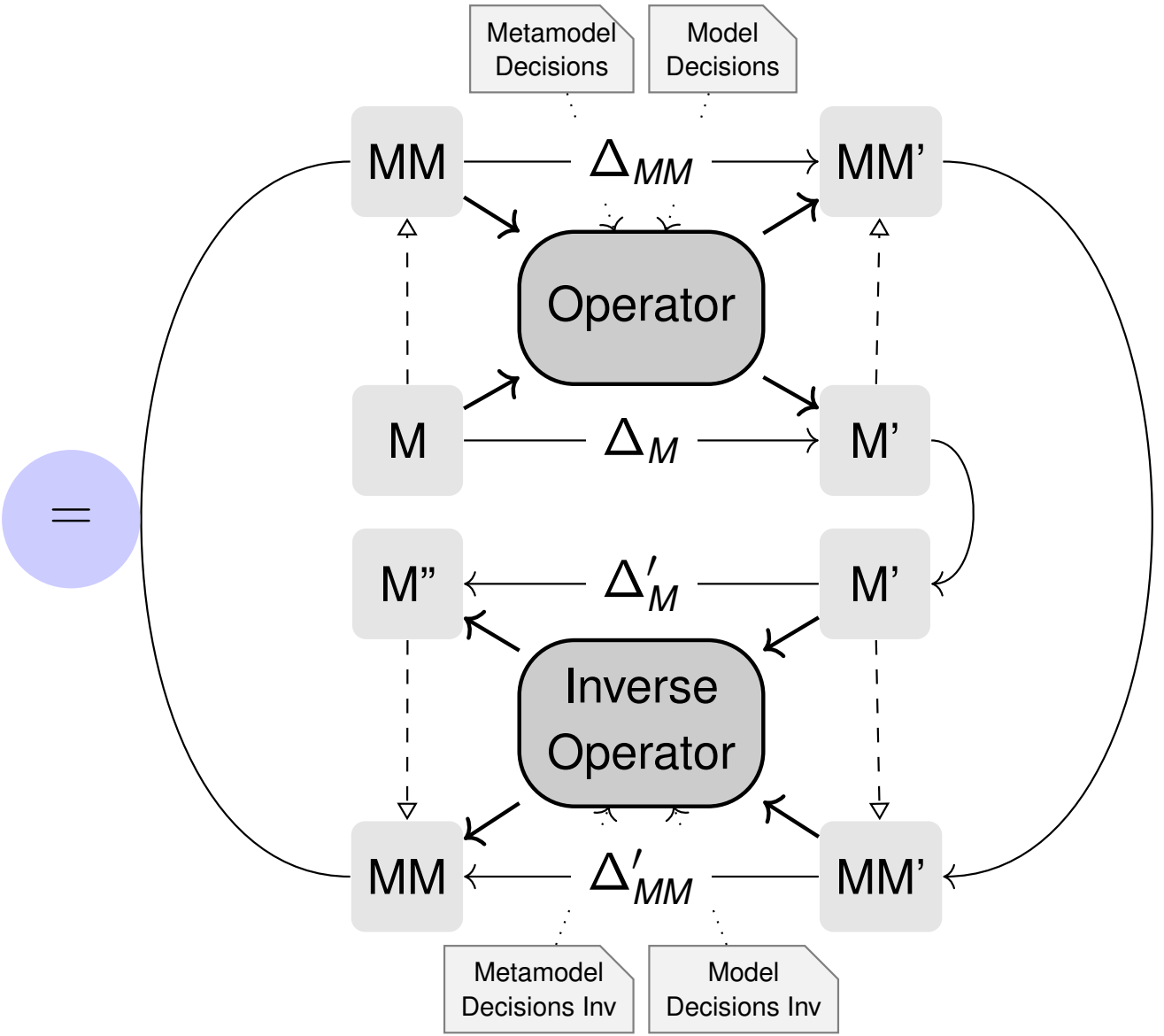

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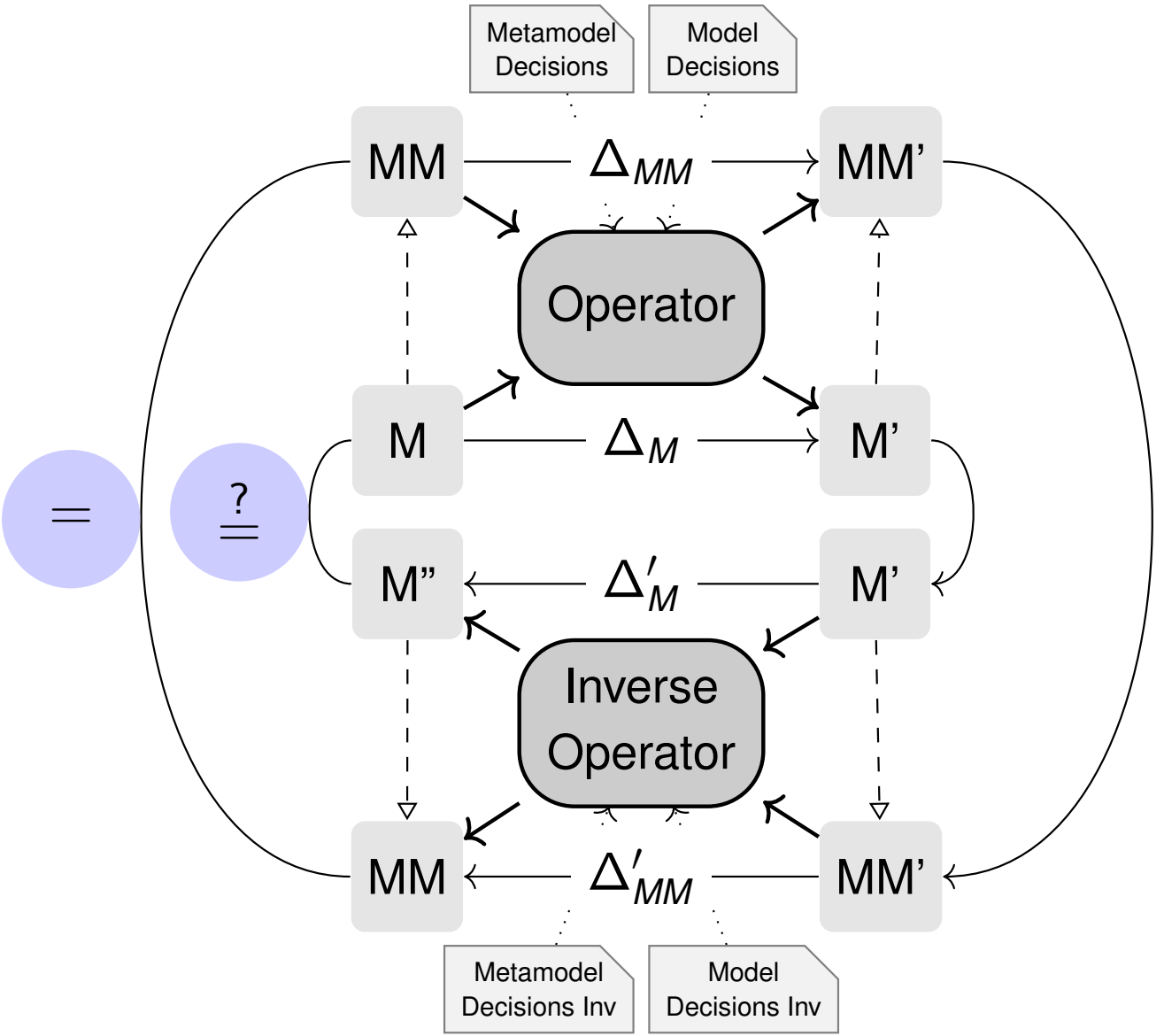

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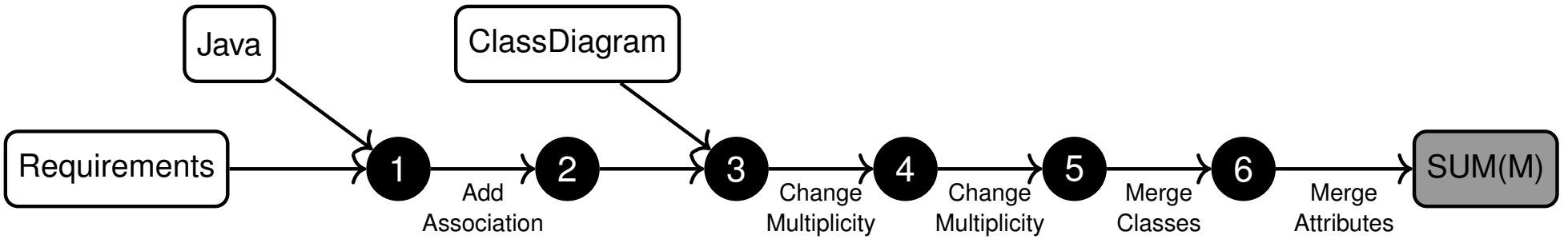

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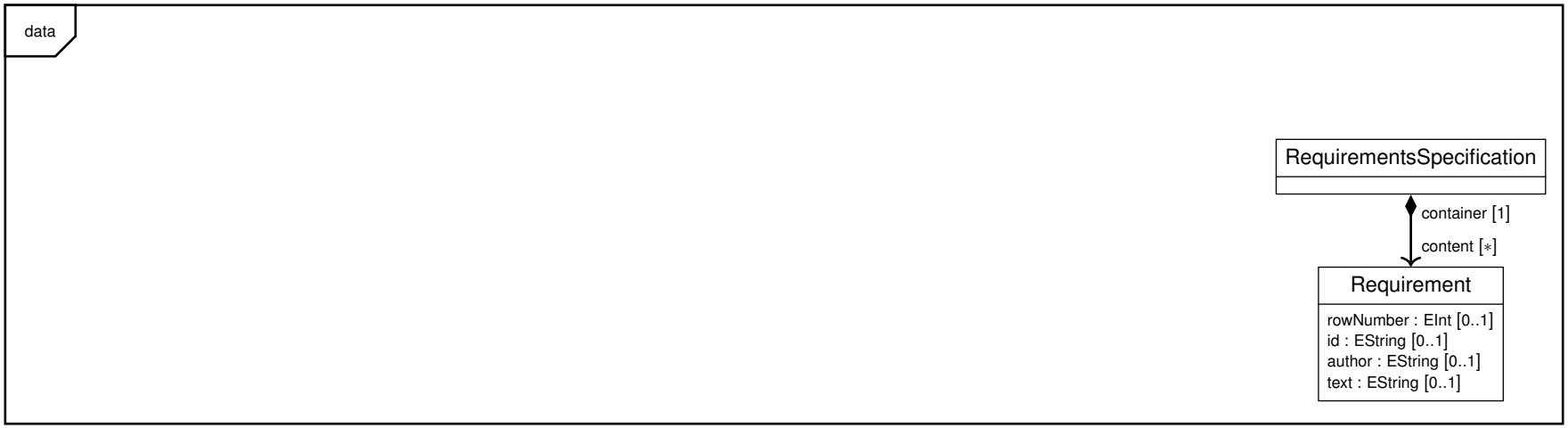

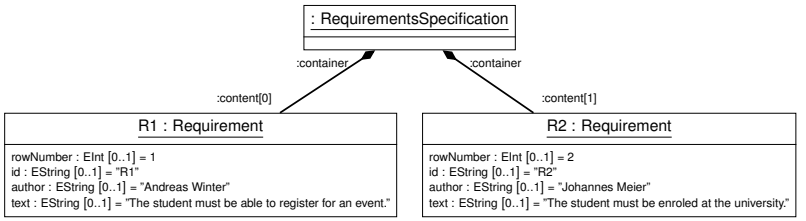

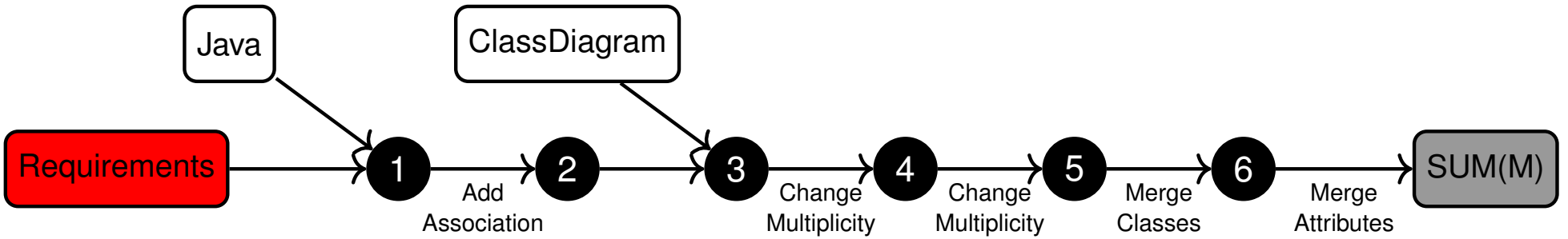

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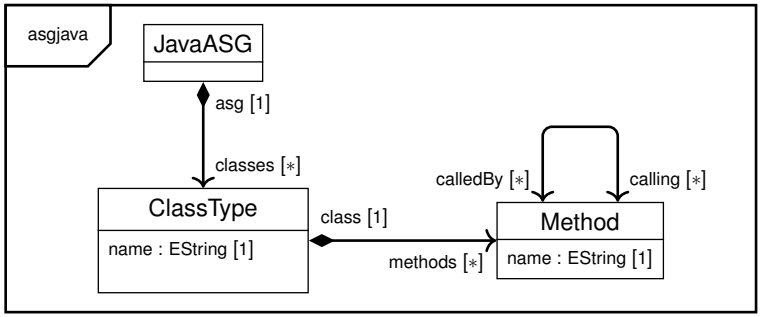

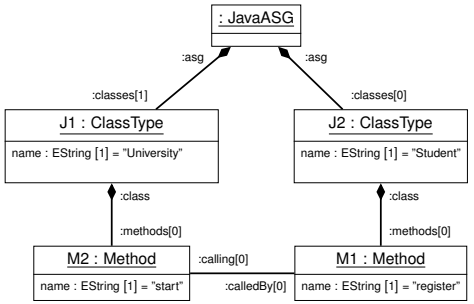

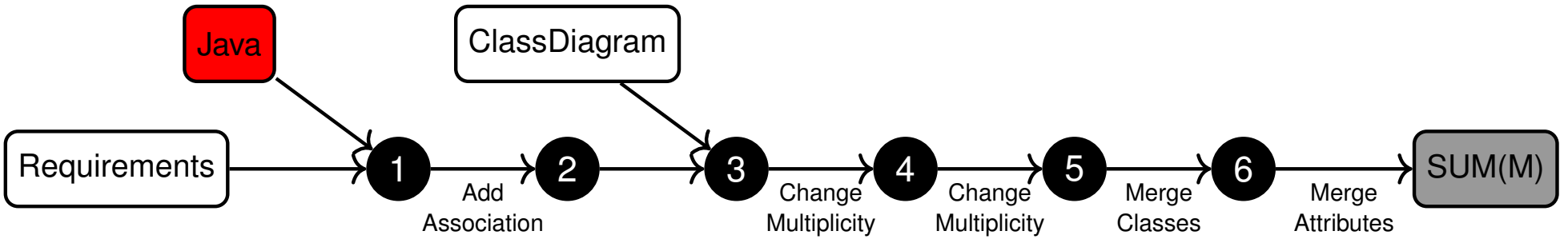

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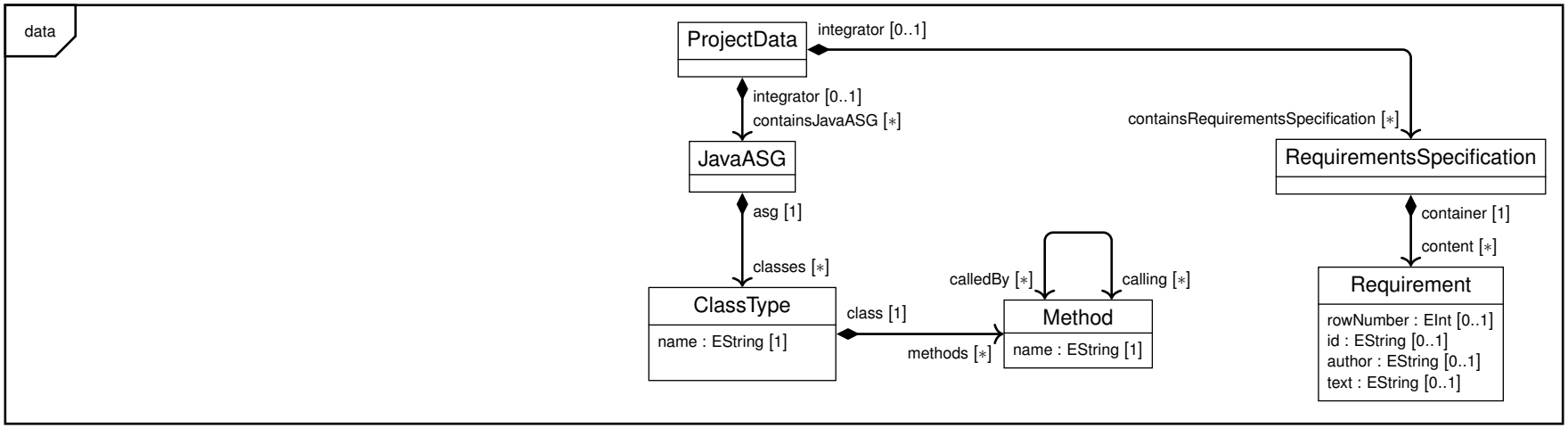

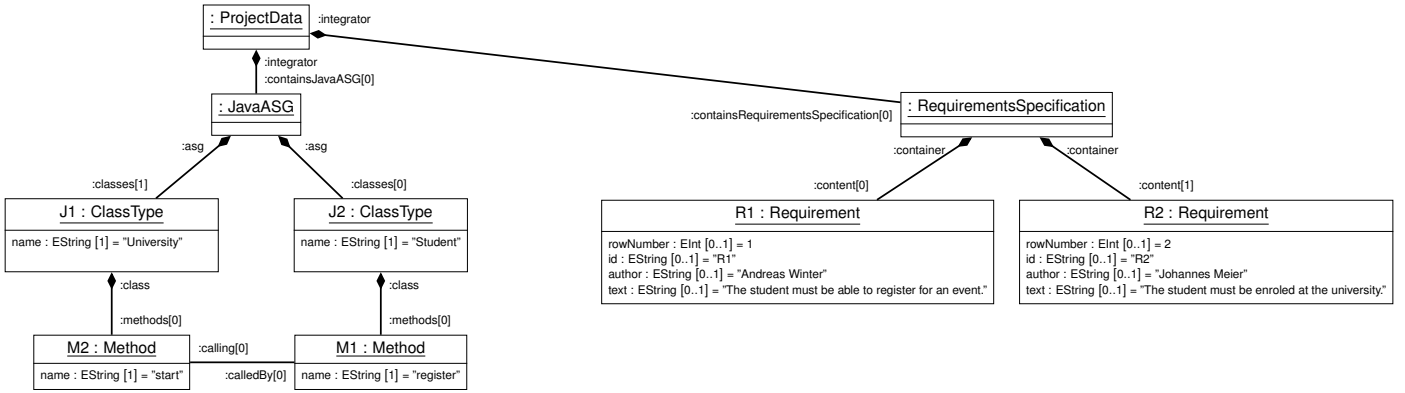

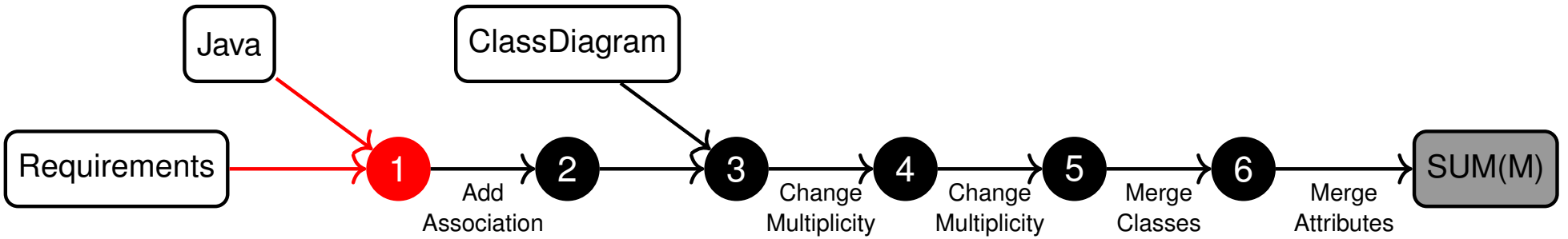

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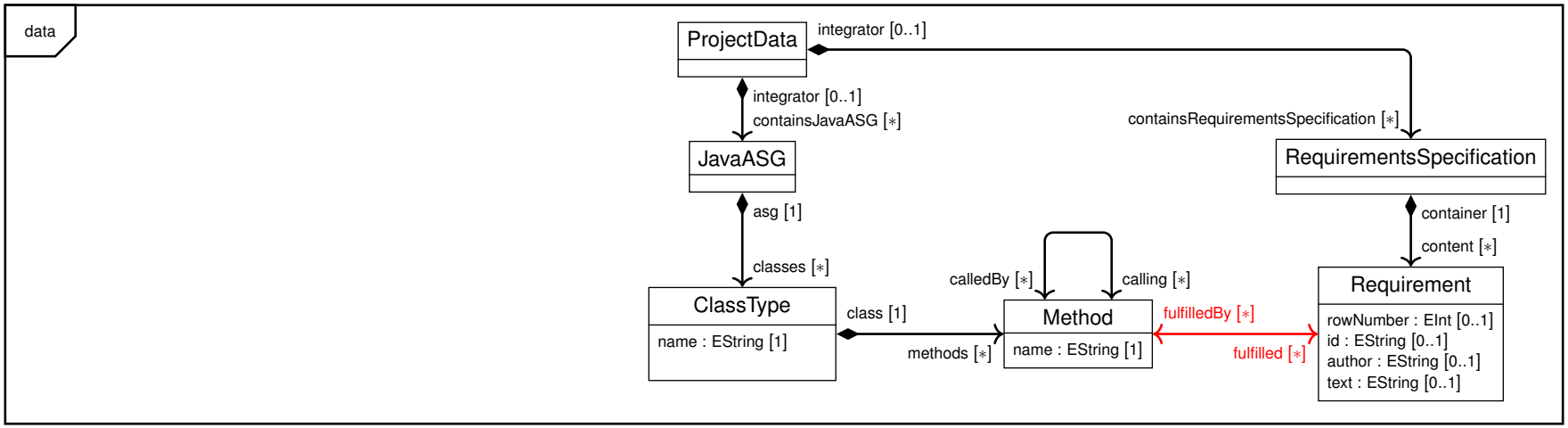

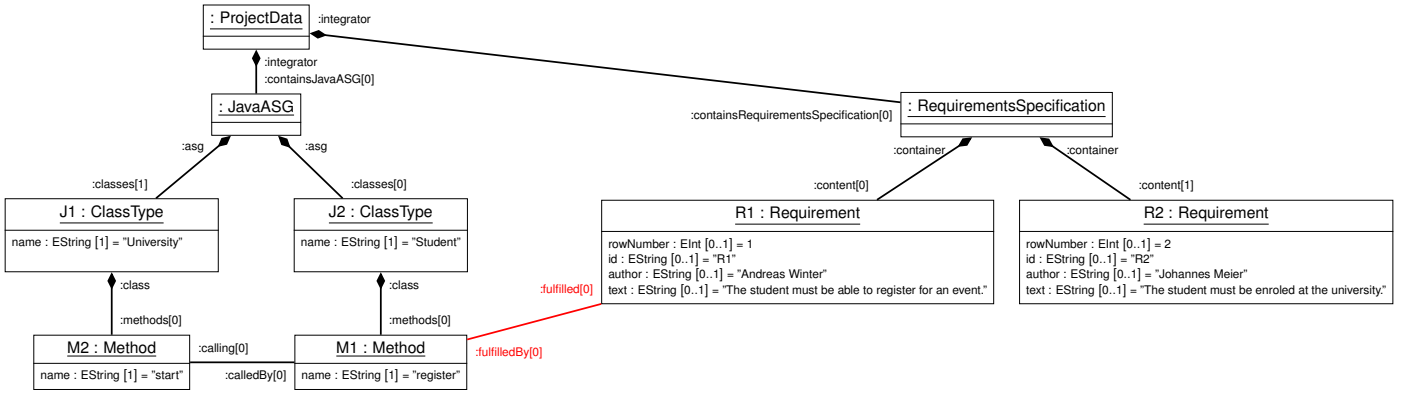

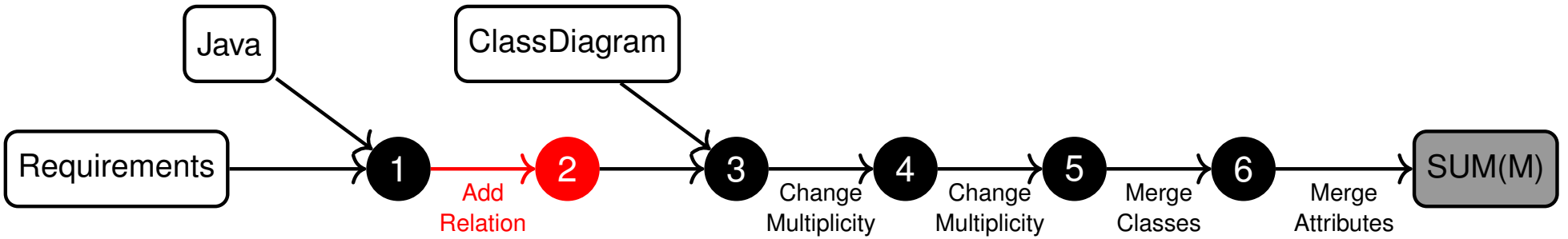

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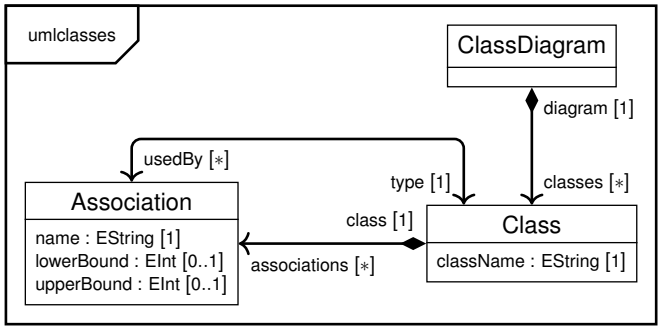

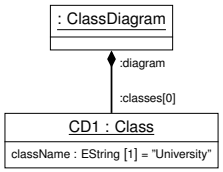

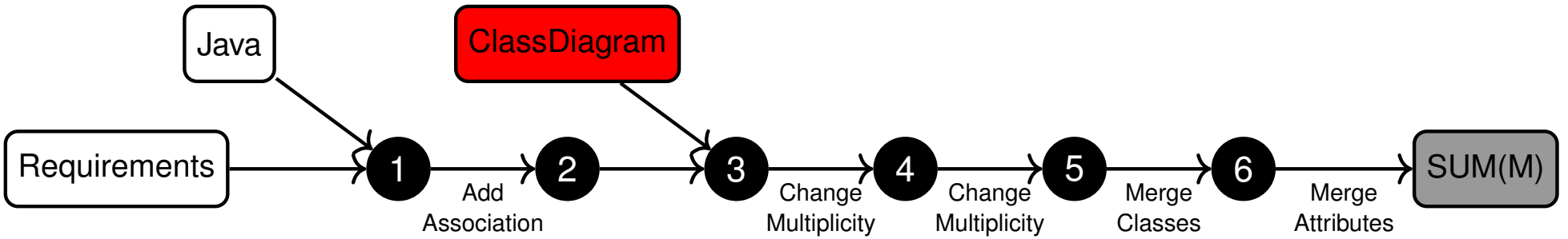

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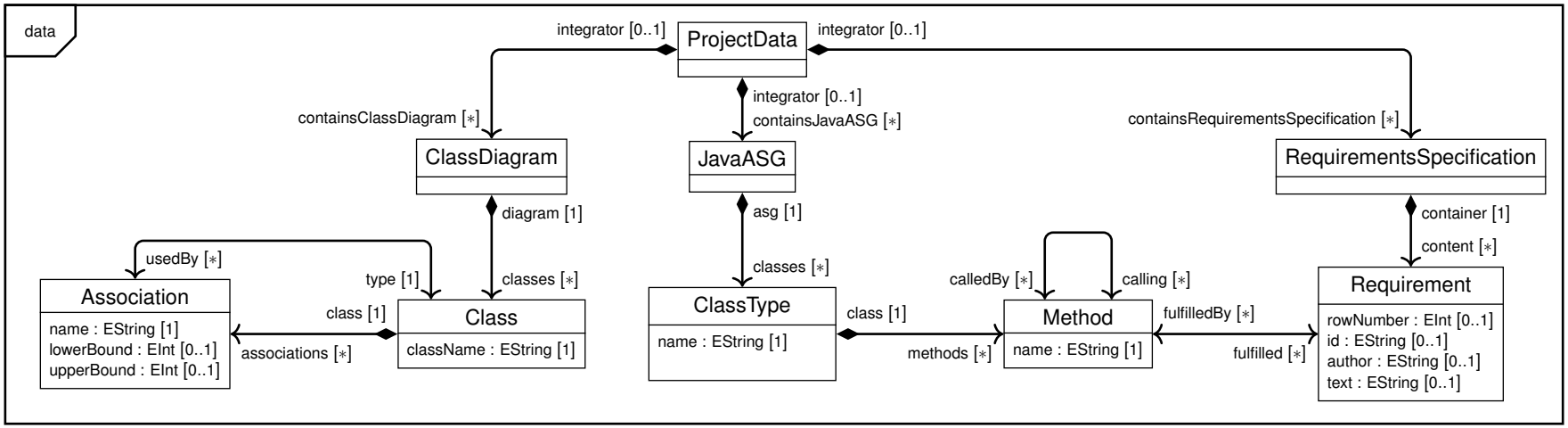

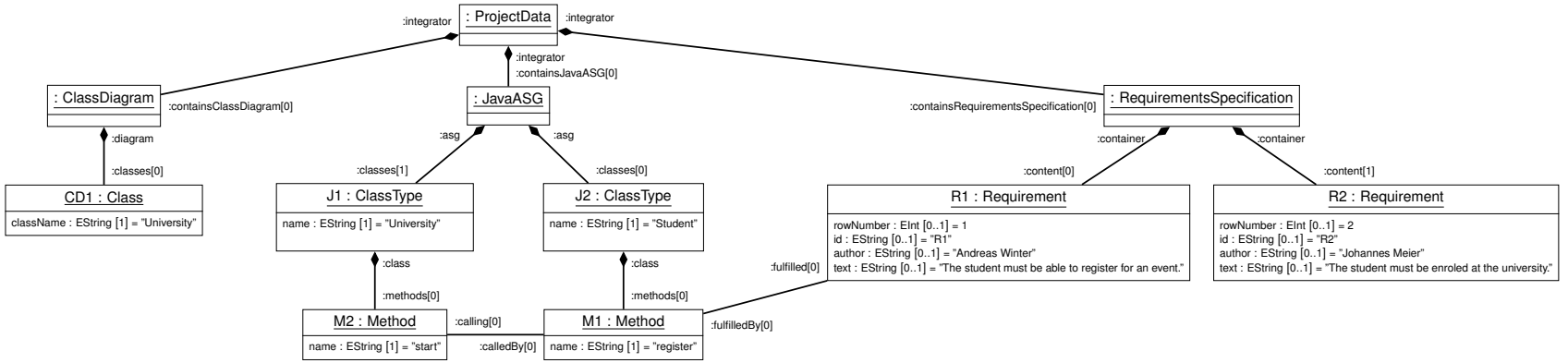

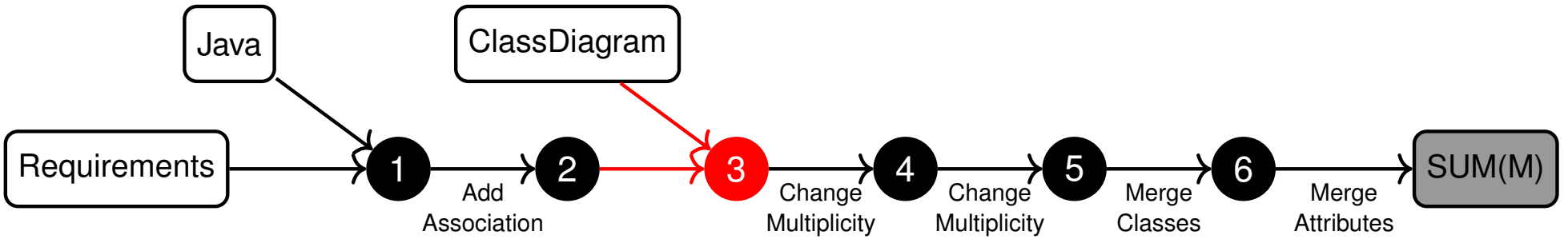

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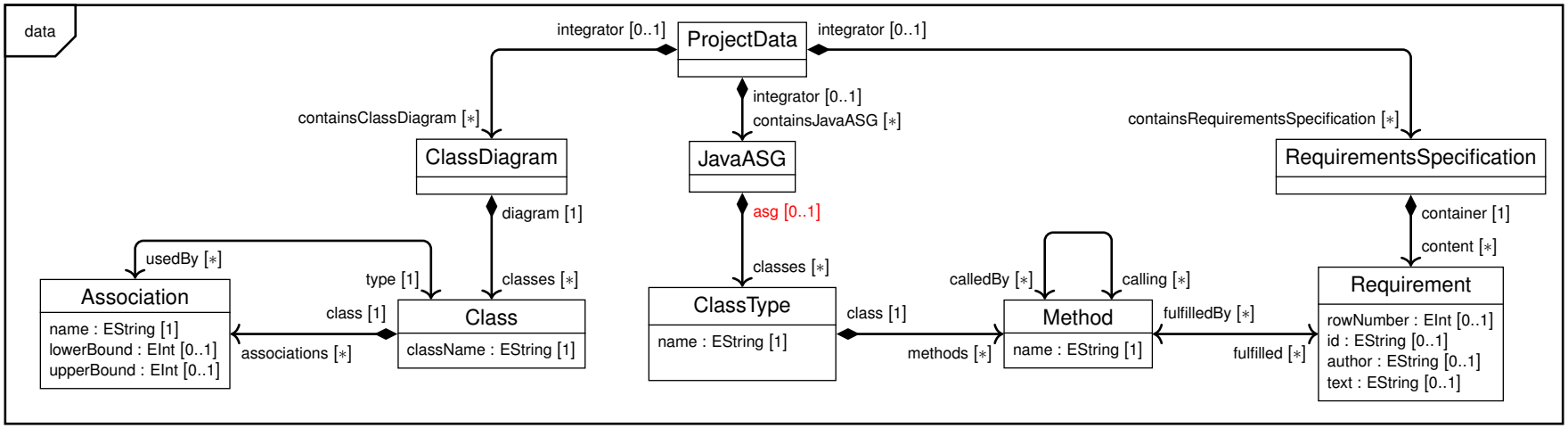

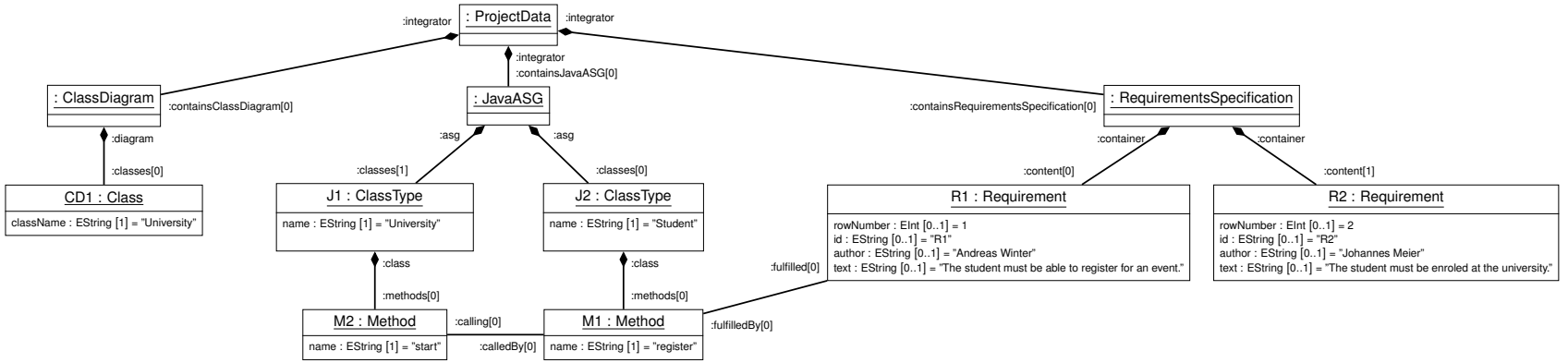

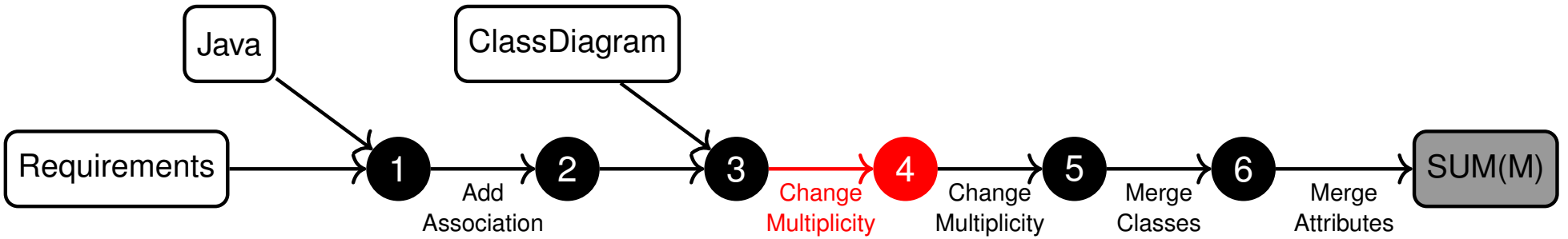

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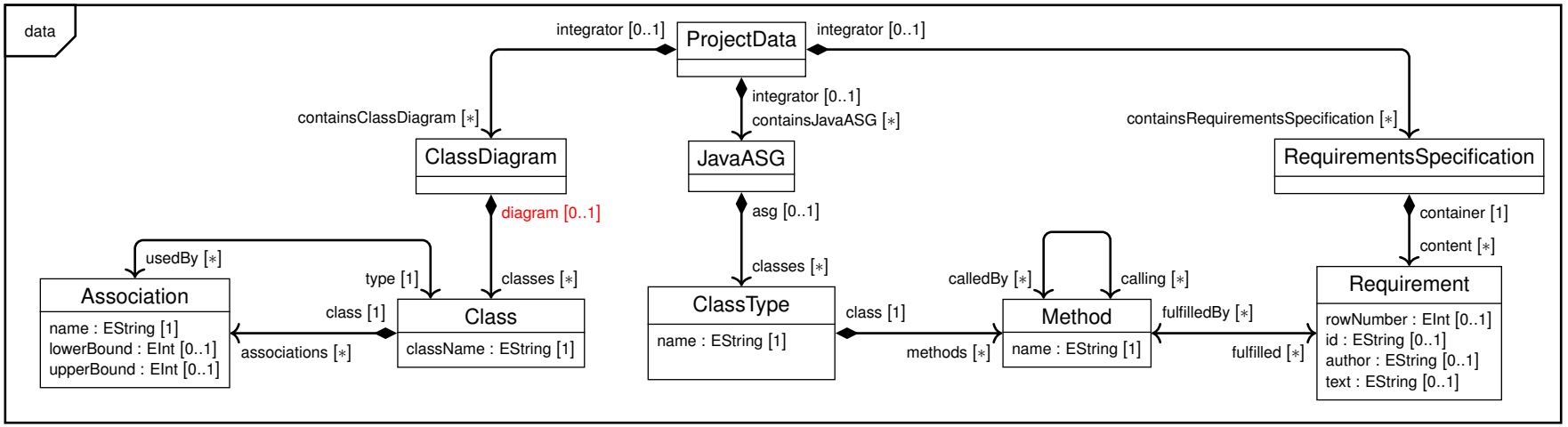

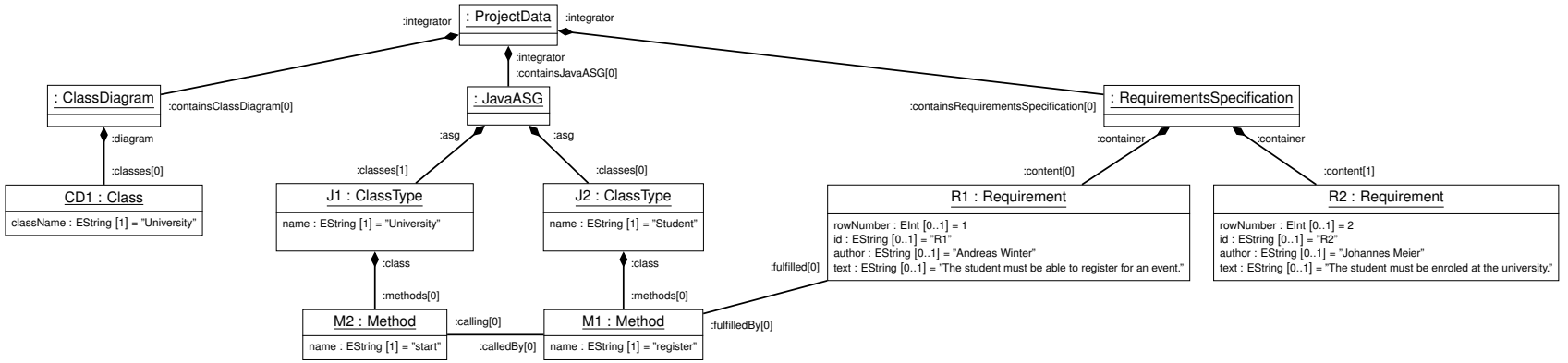

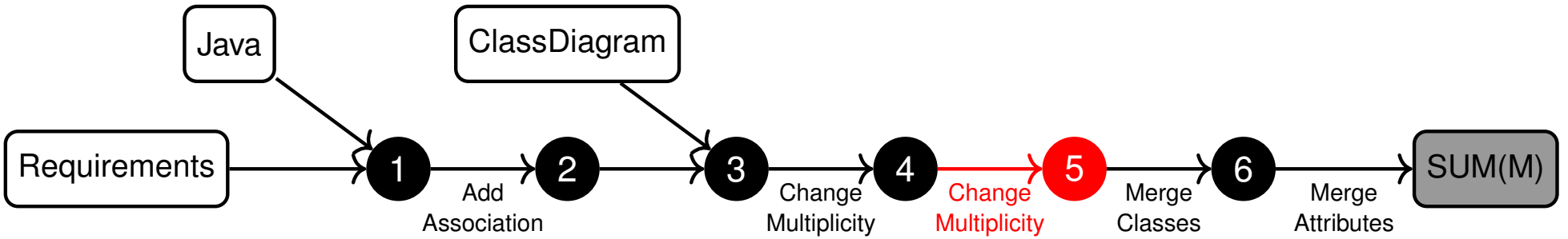

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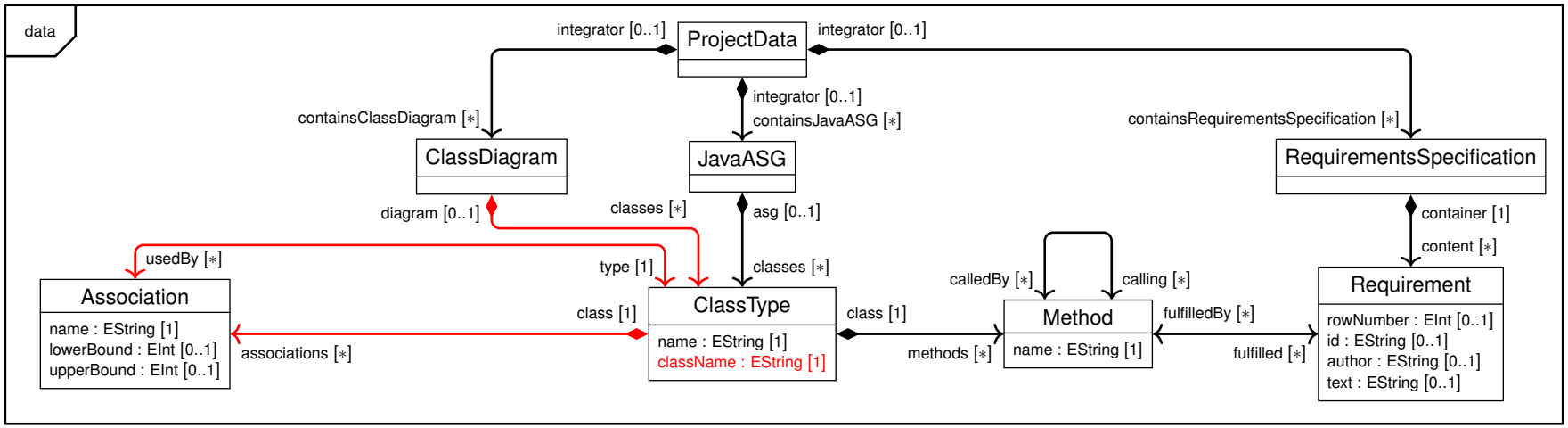

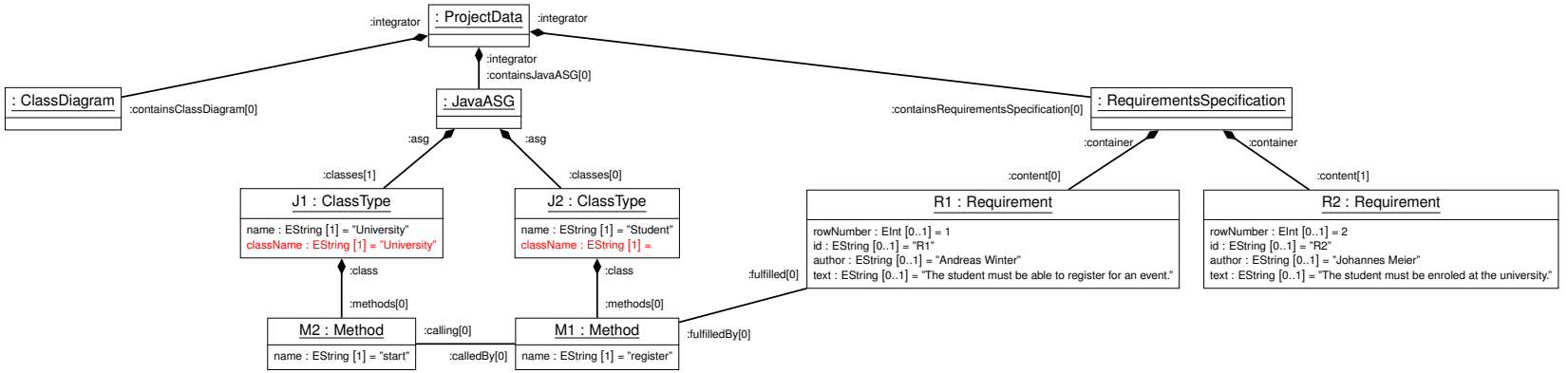

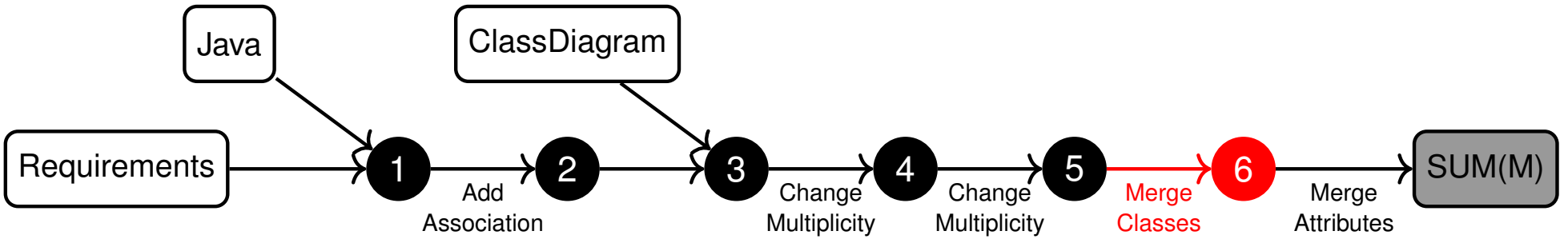

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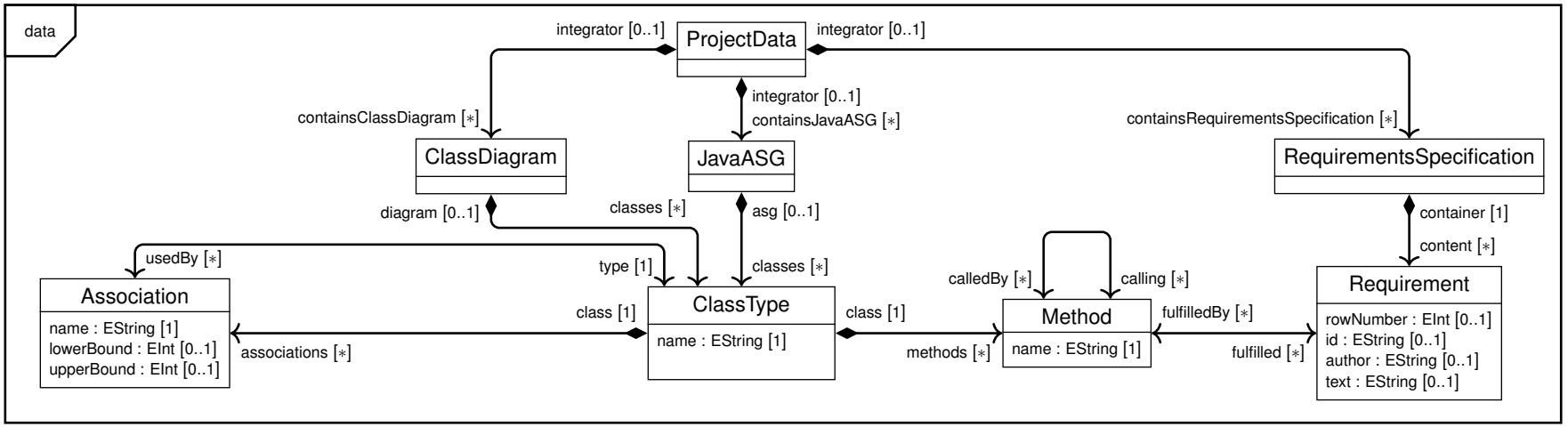

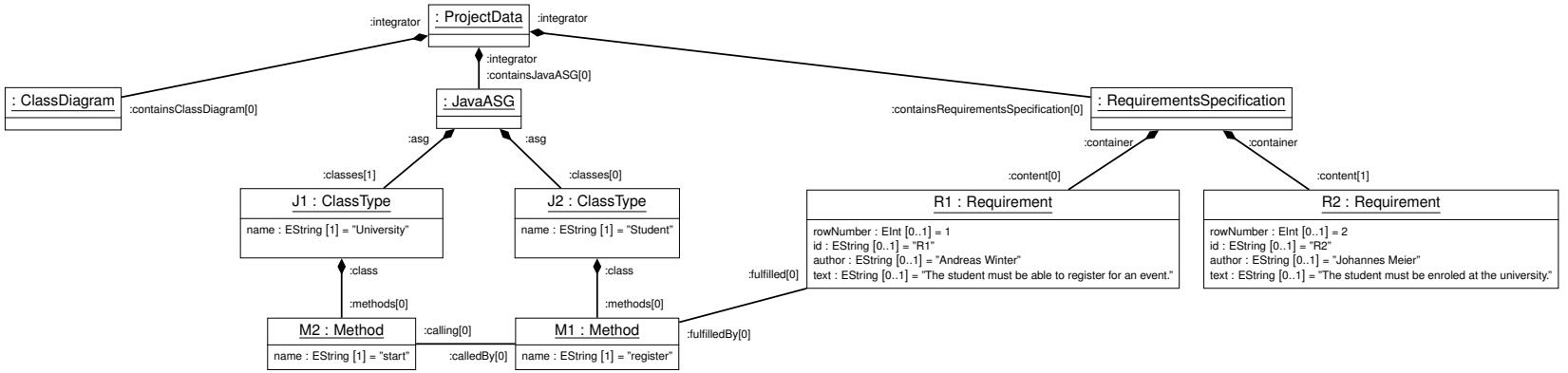

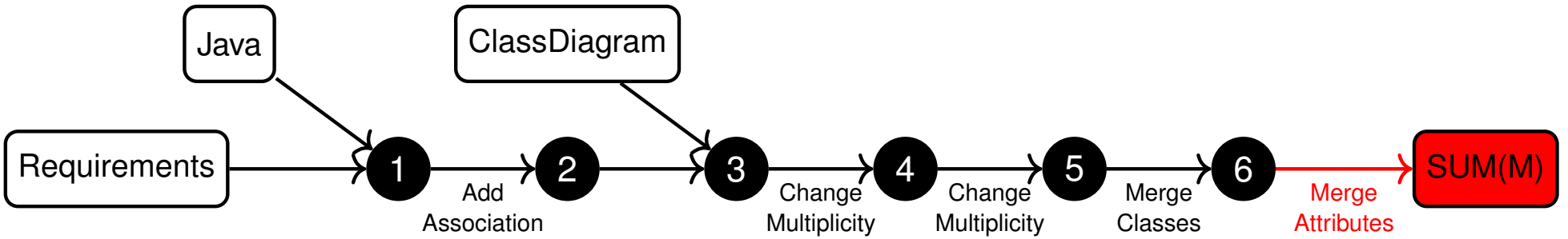

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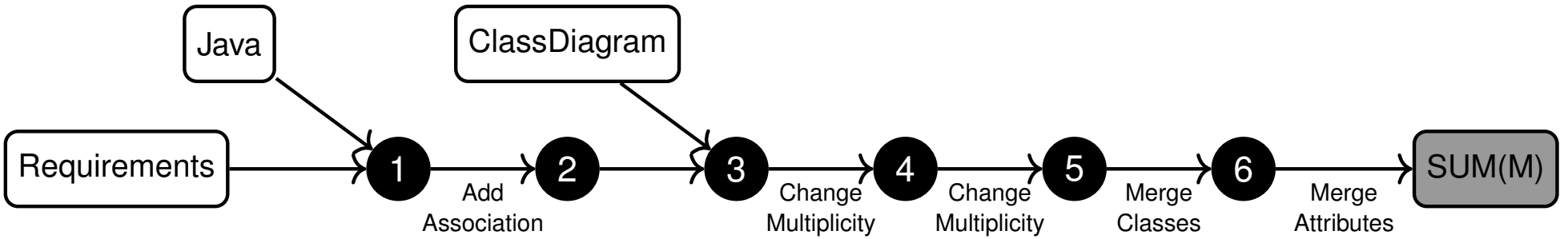

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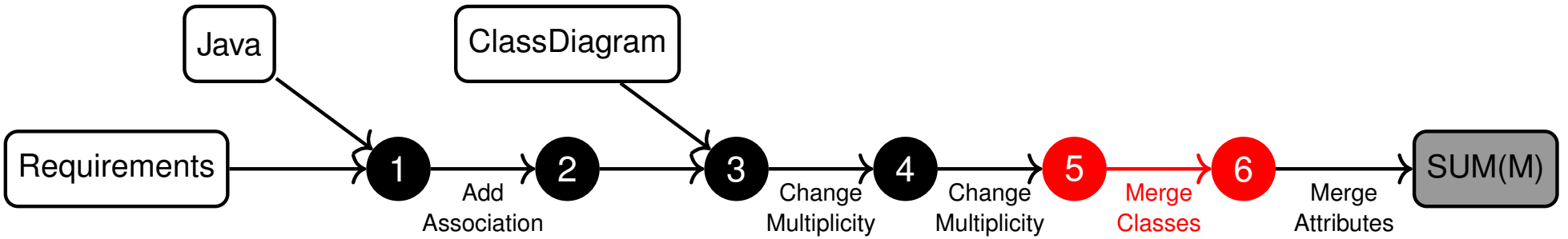

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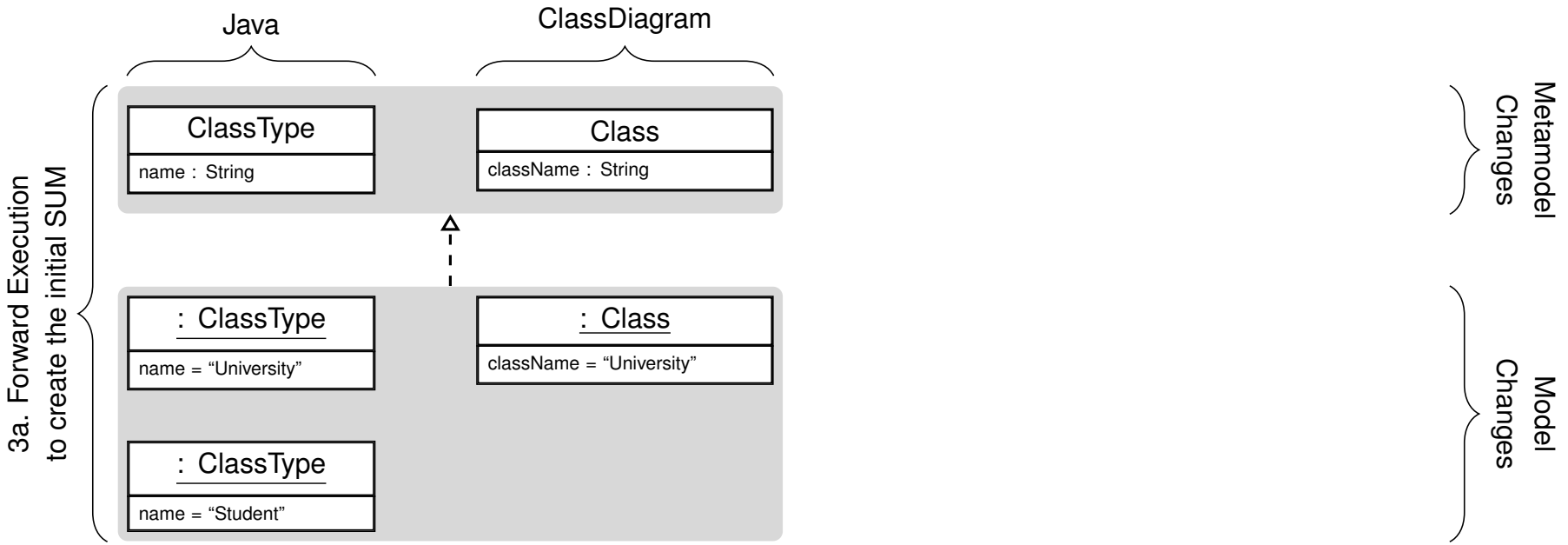

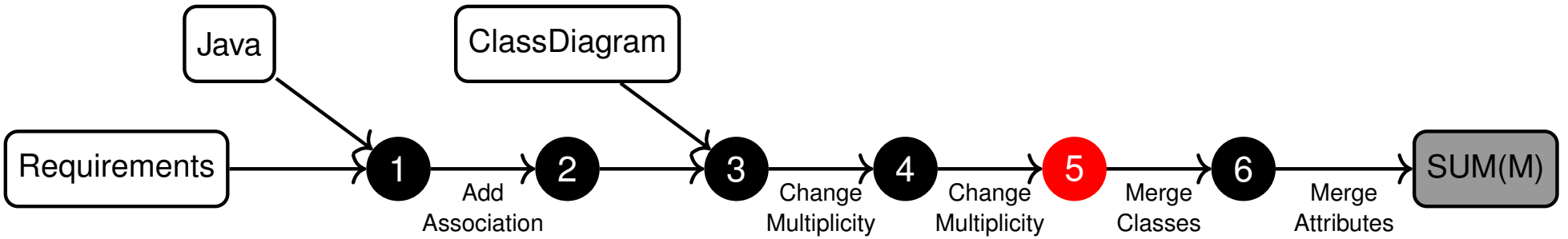

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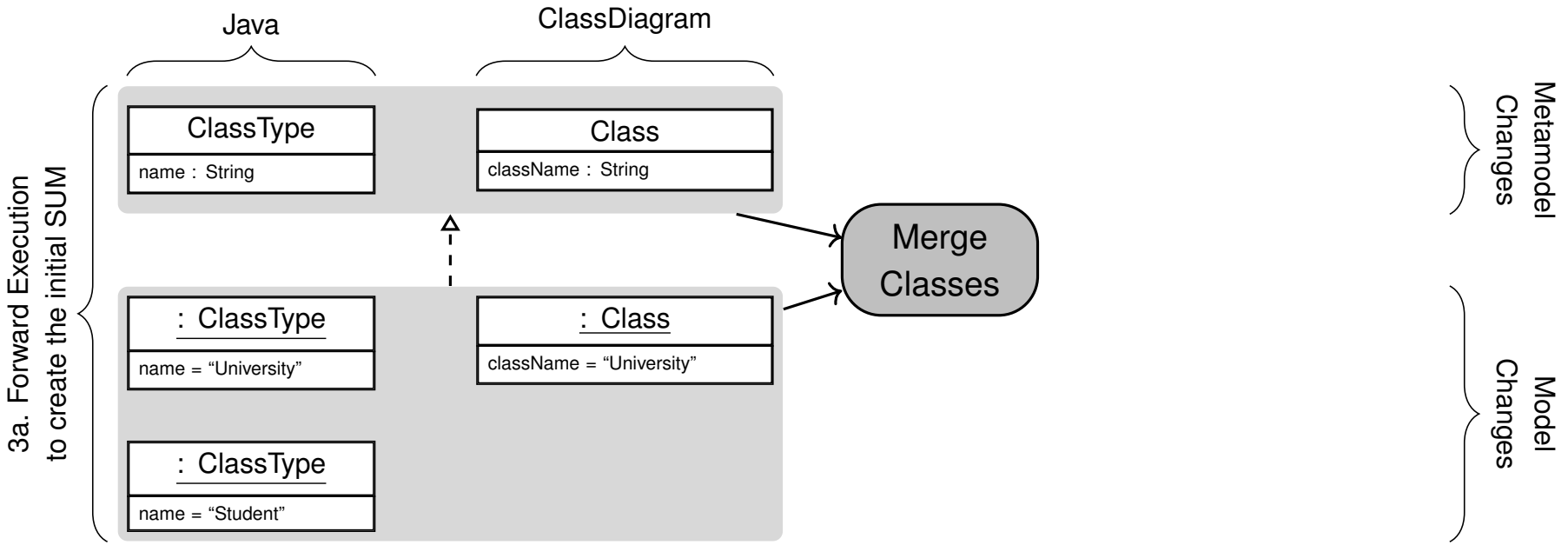

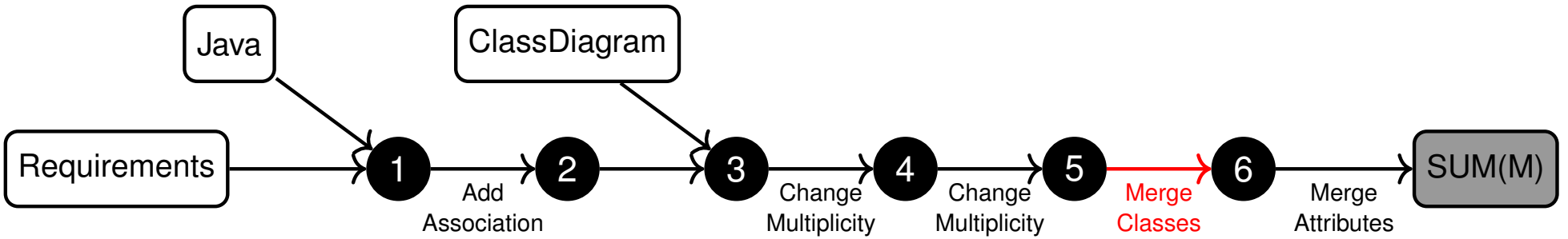

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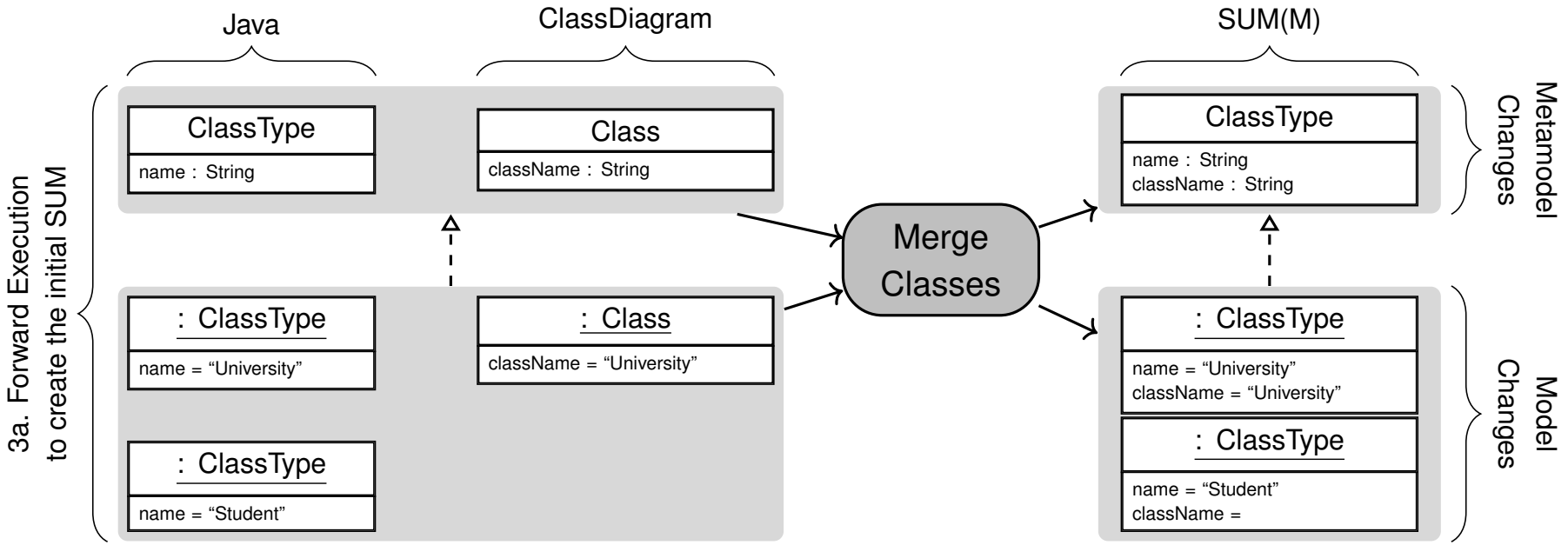

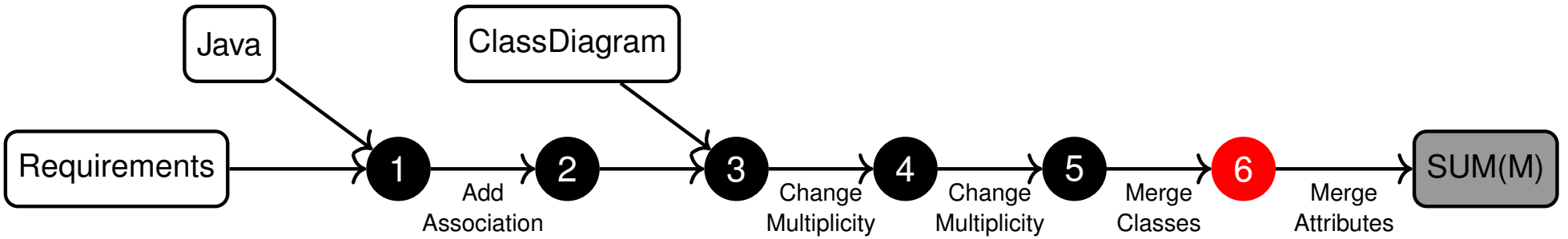

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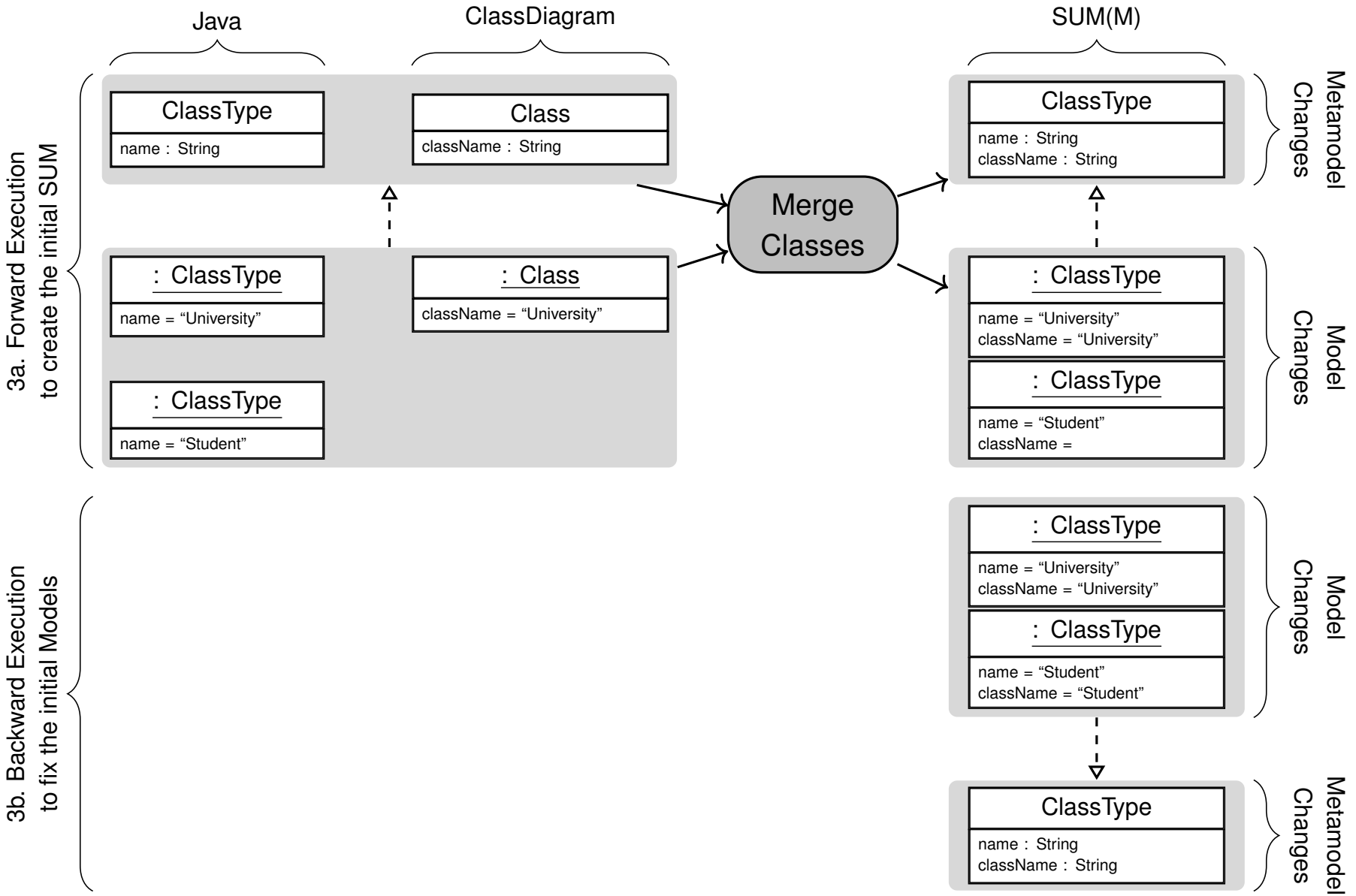

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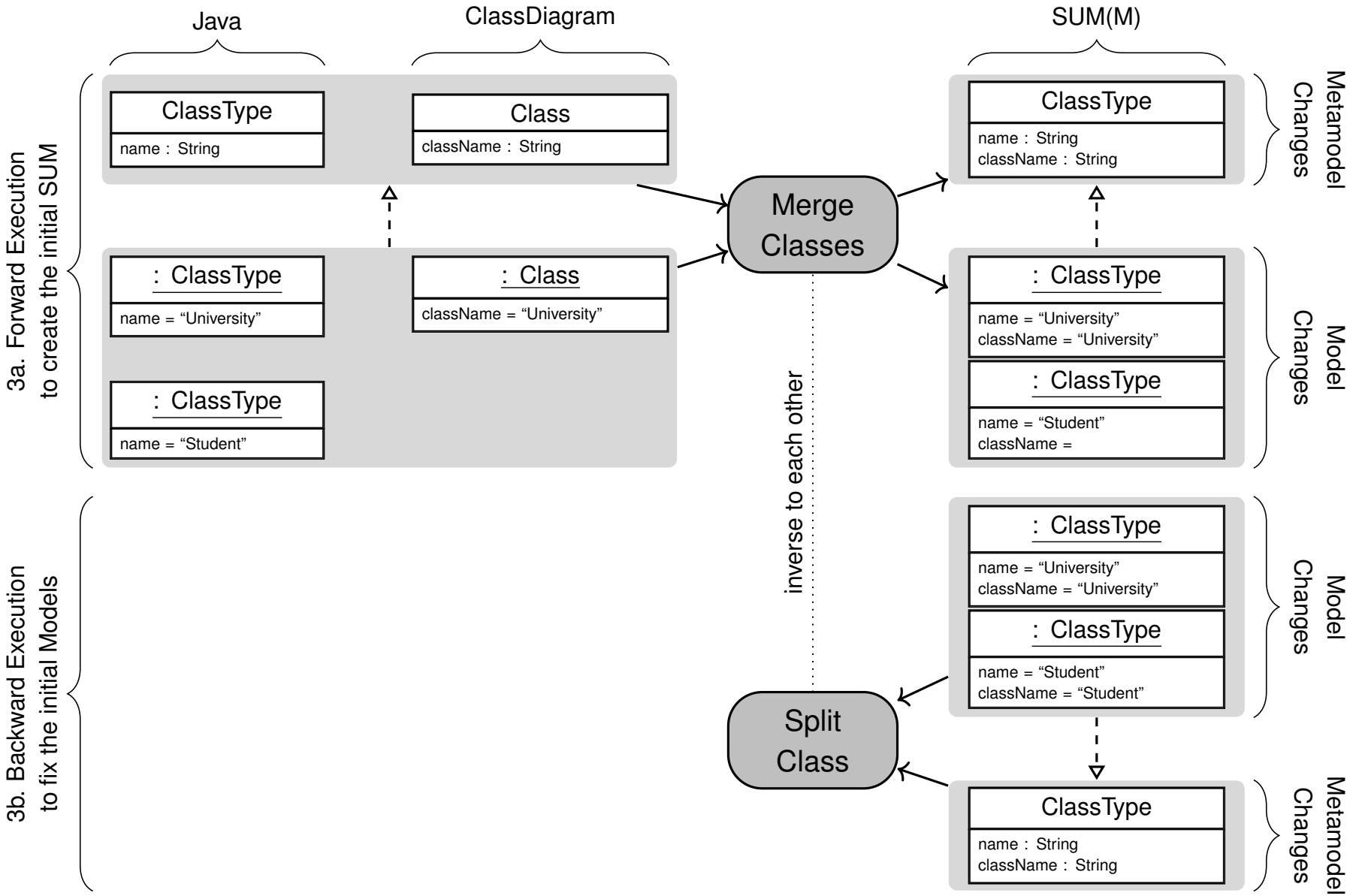

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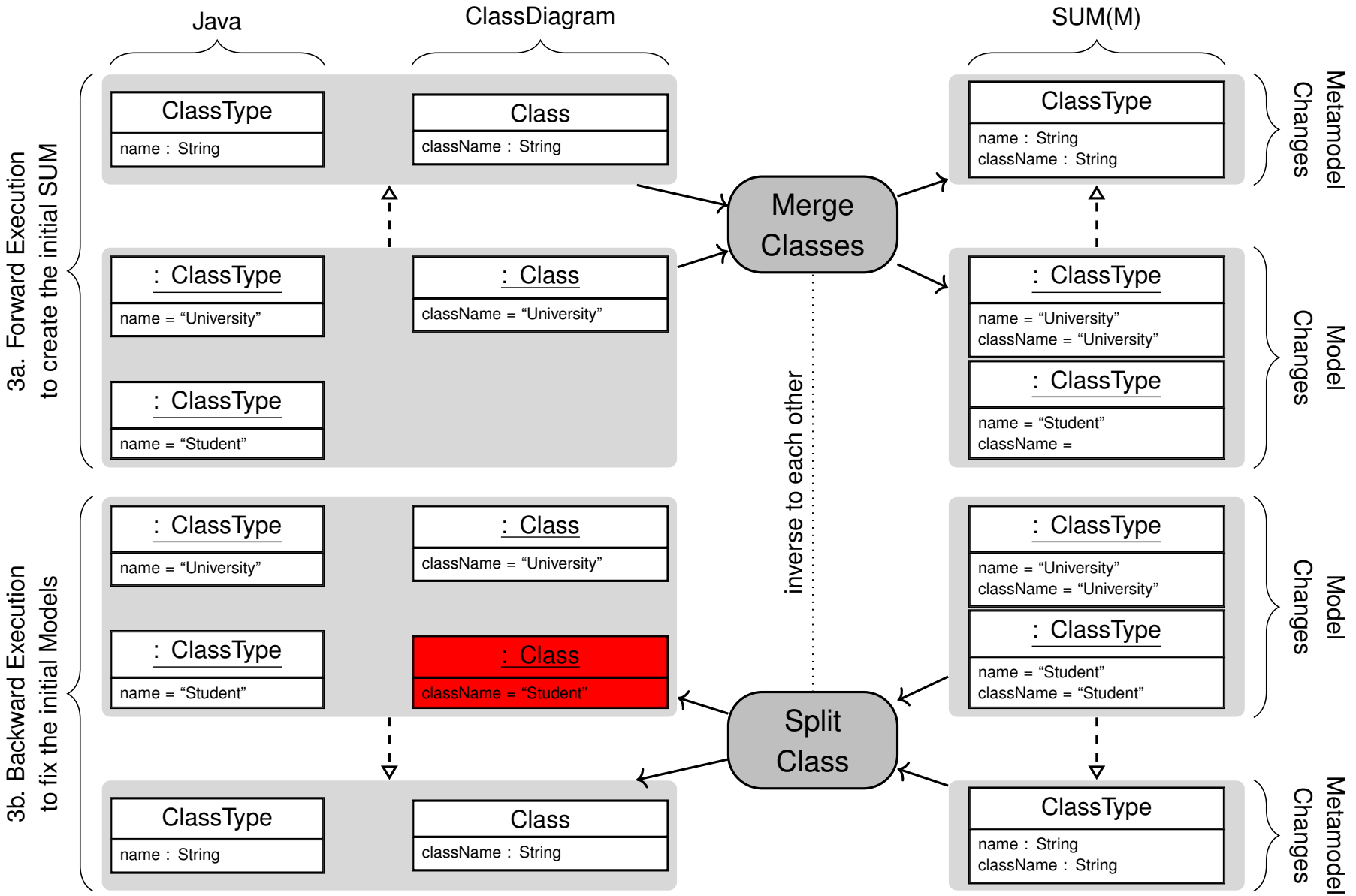
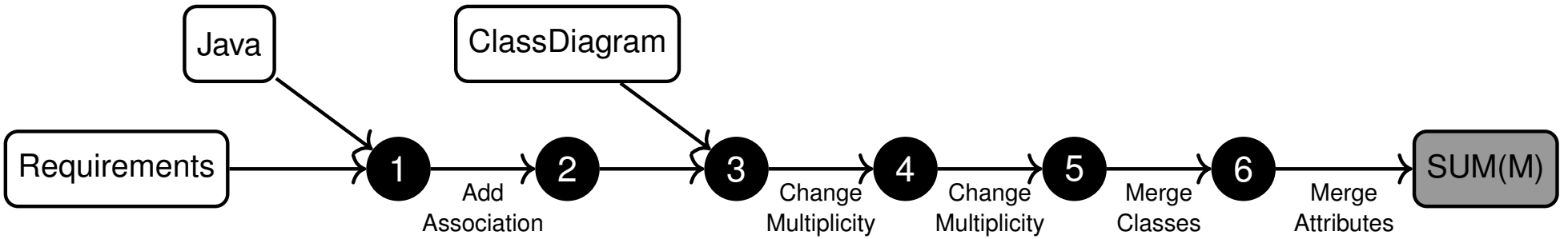


3. Consistency Assurance: Details



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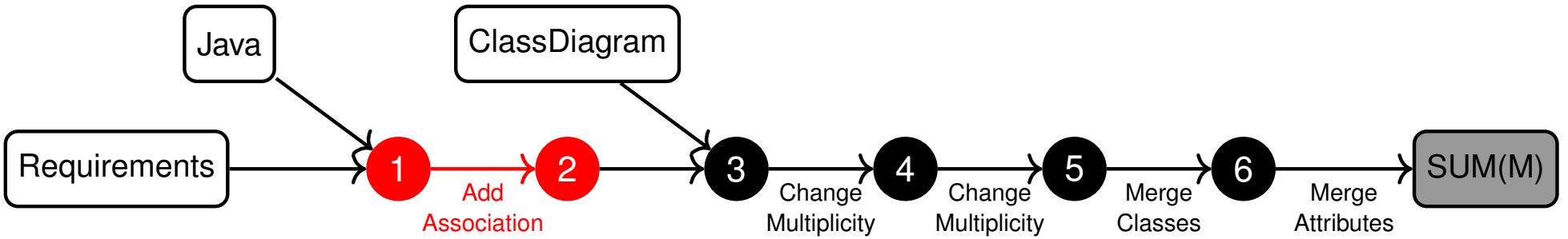
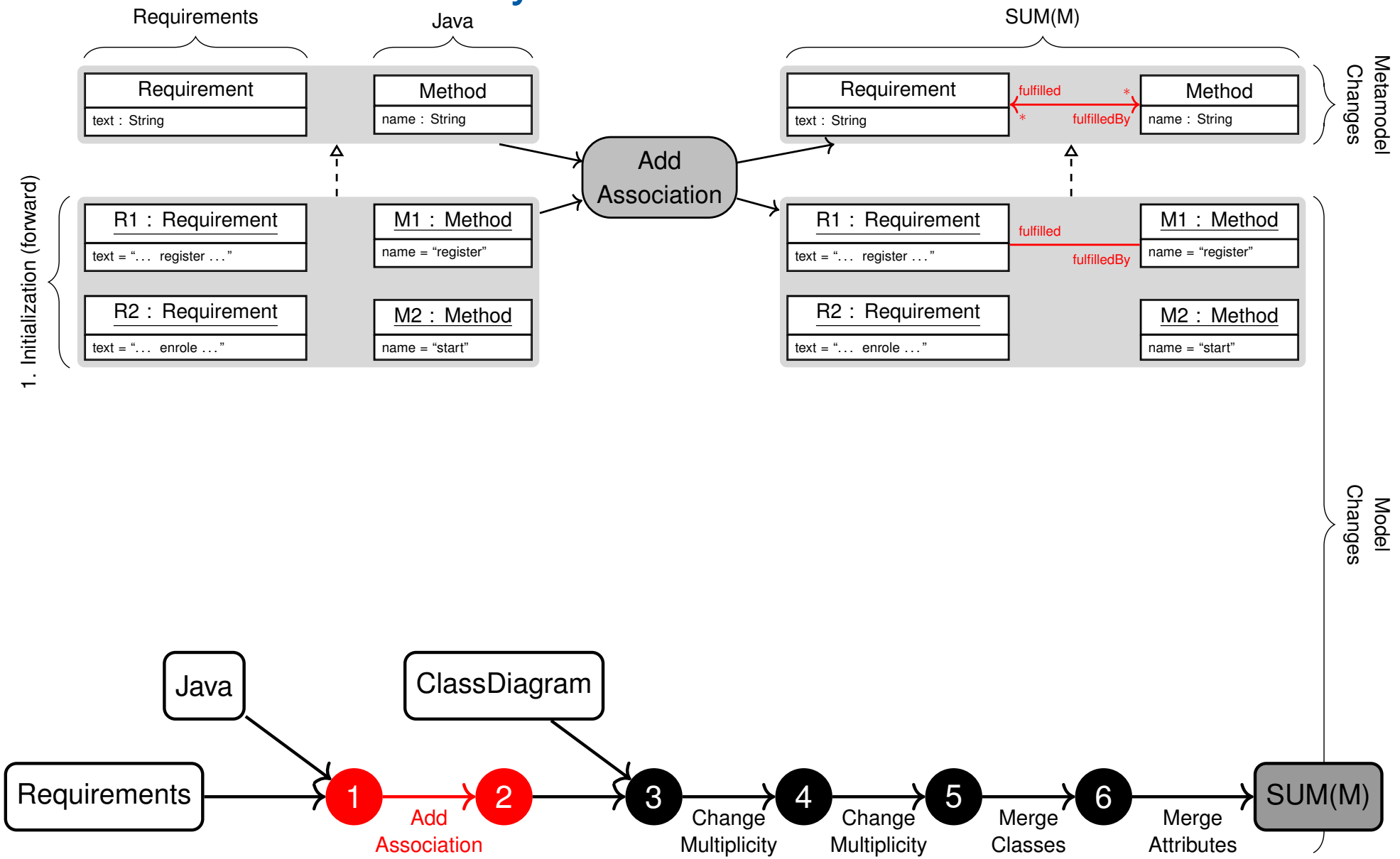


3. Consistency Assurance: Details



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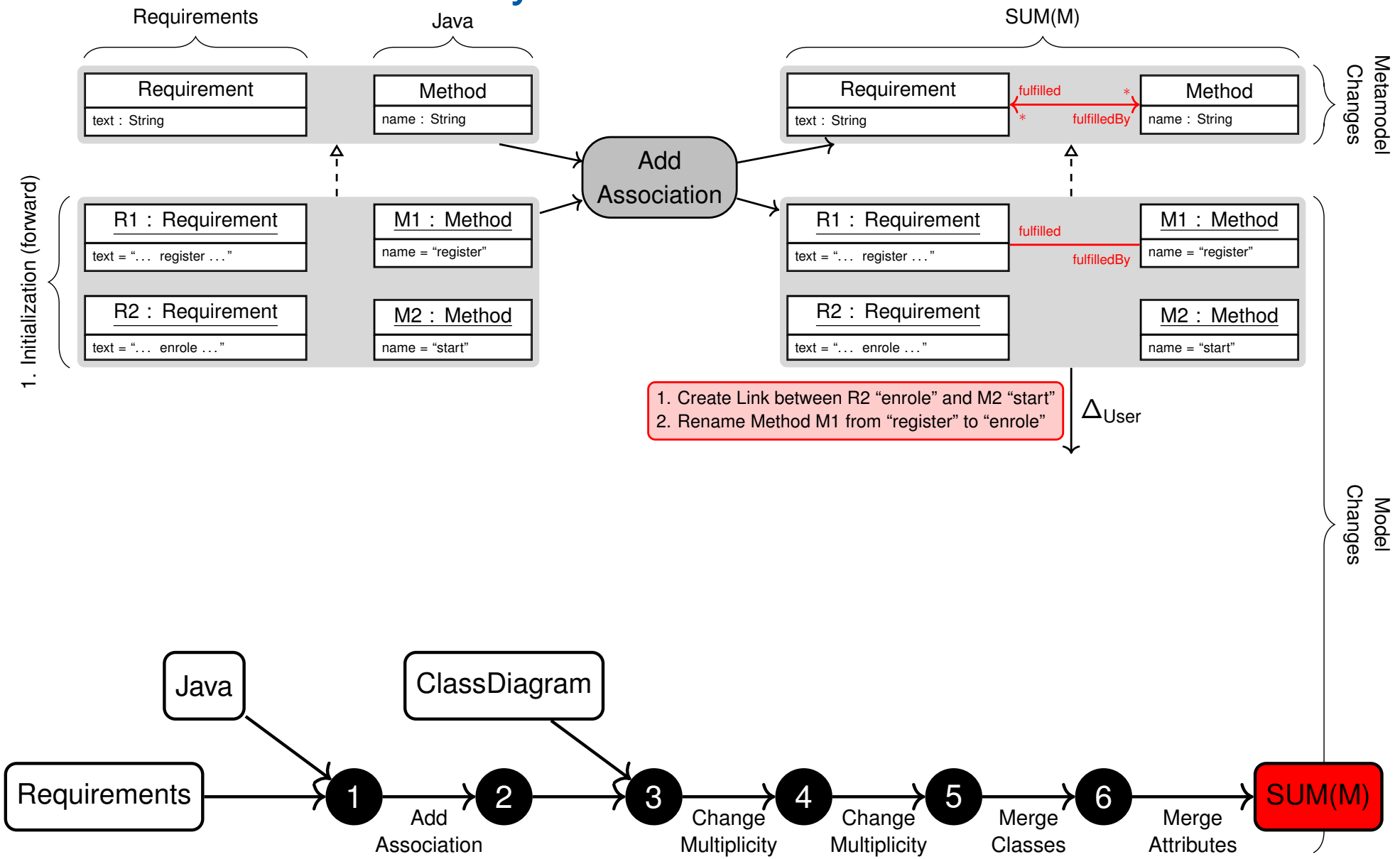

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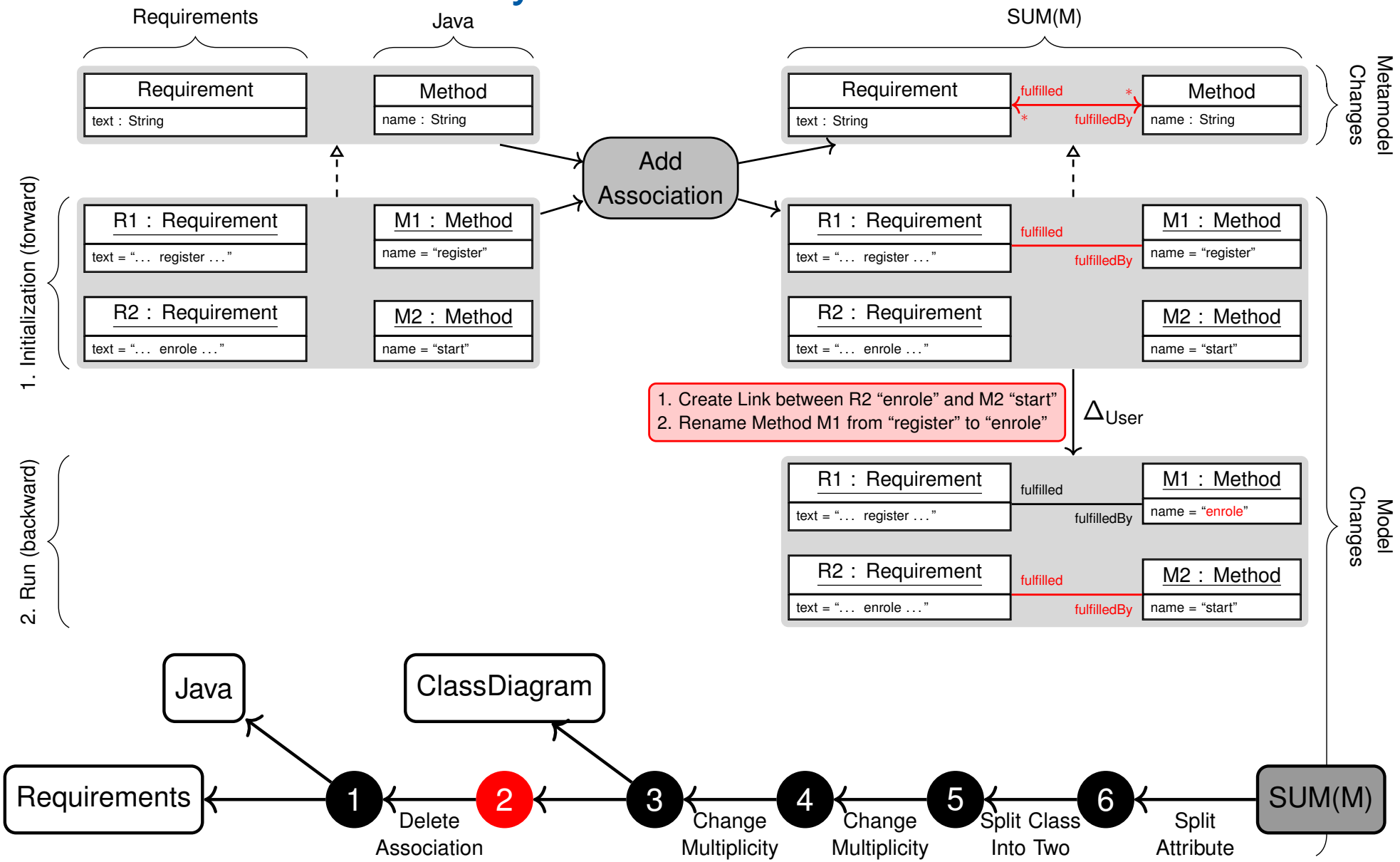

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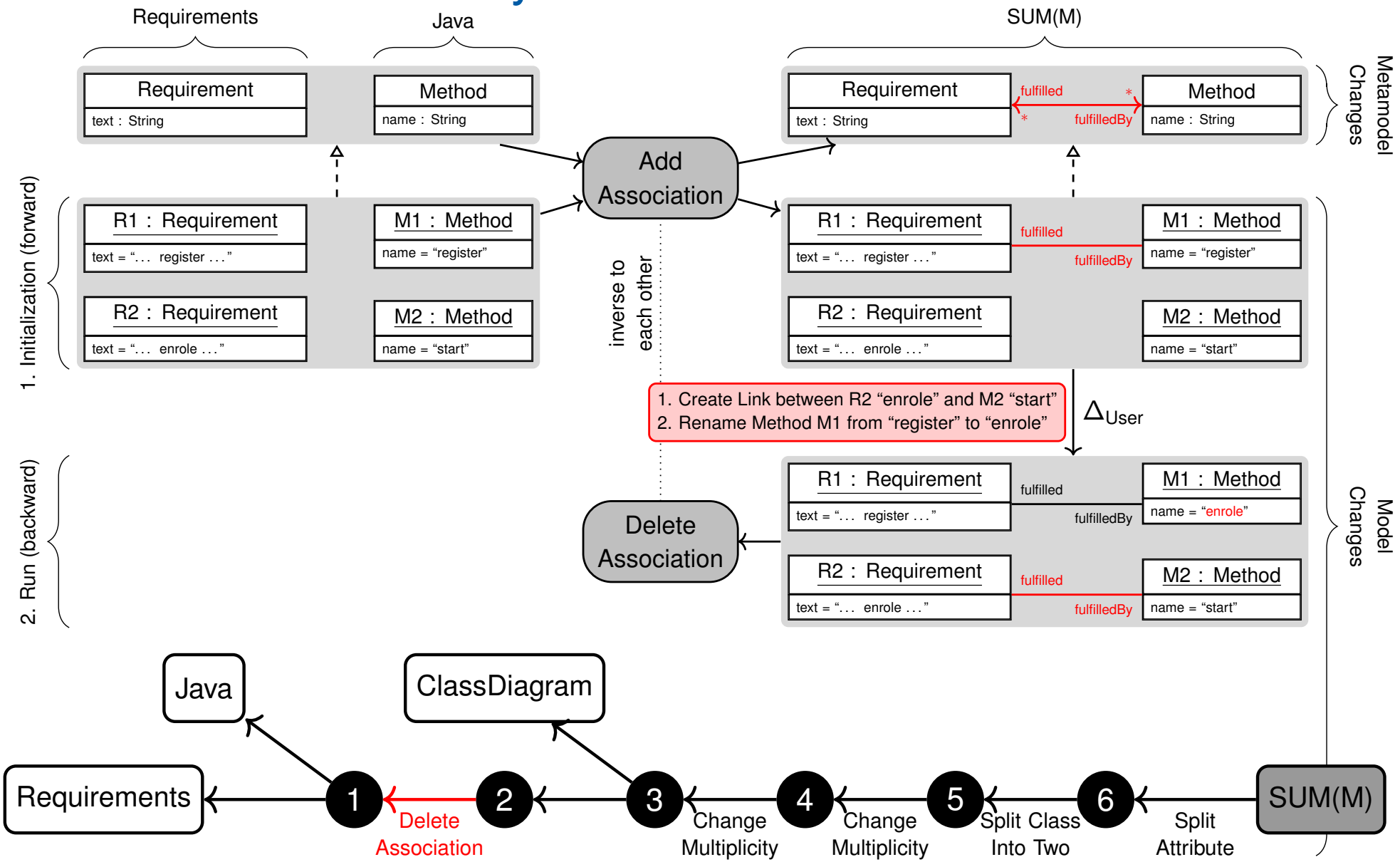

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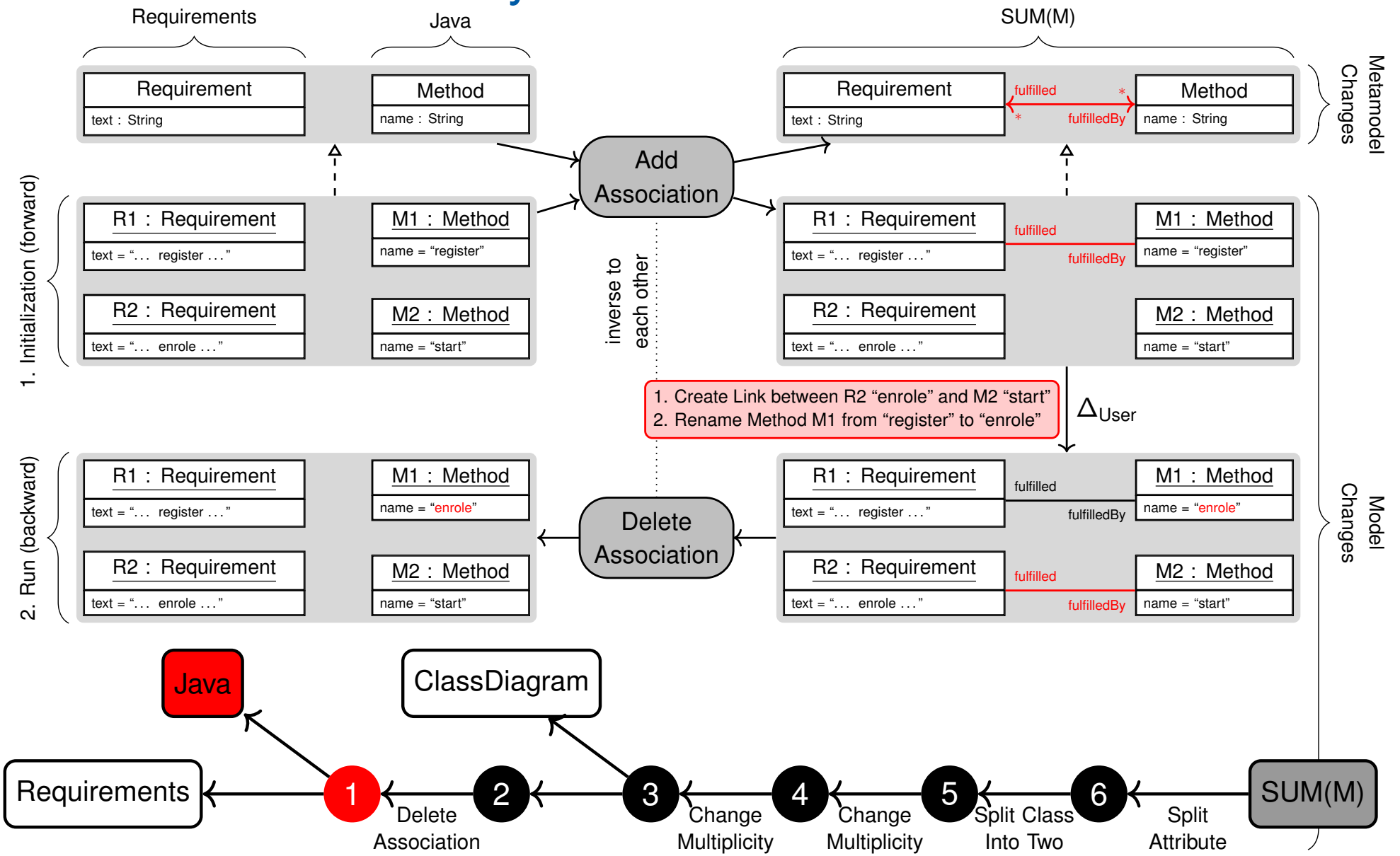

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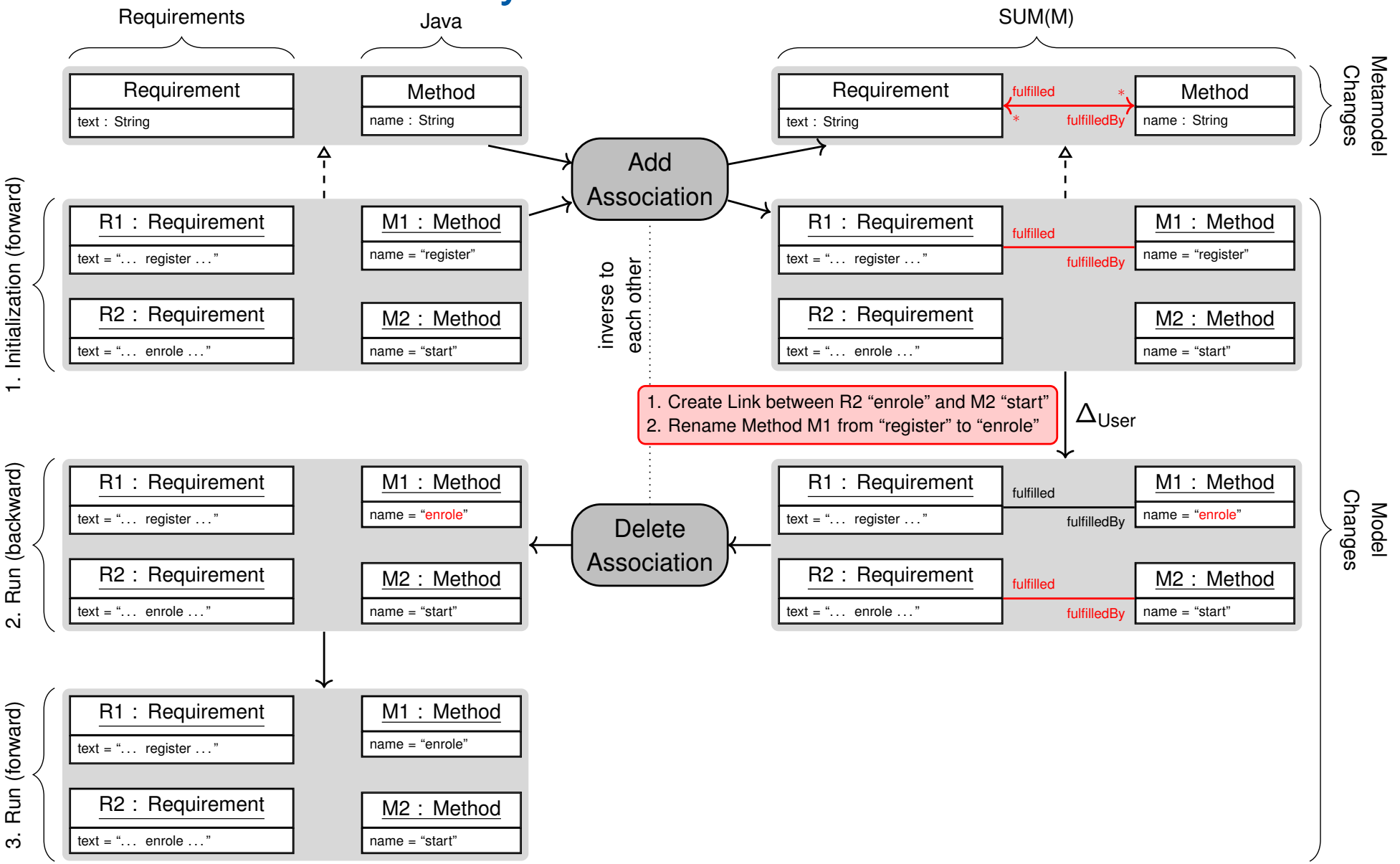

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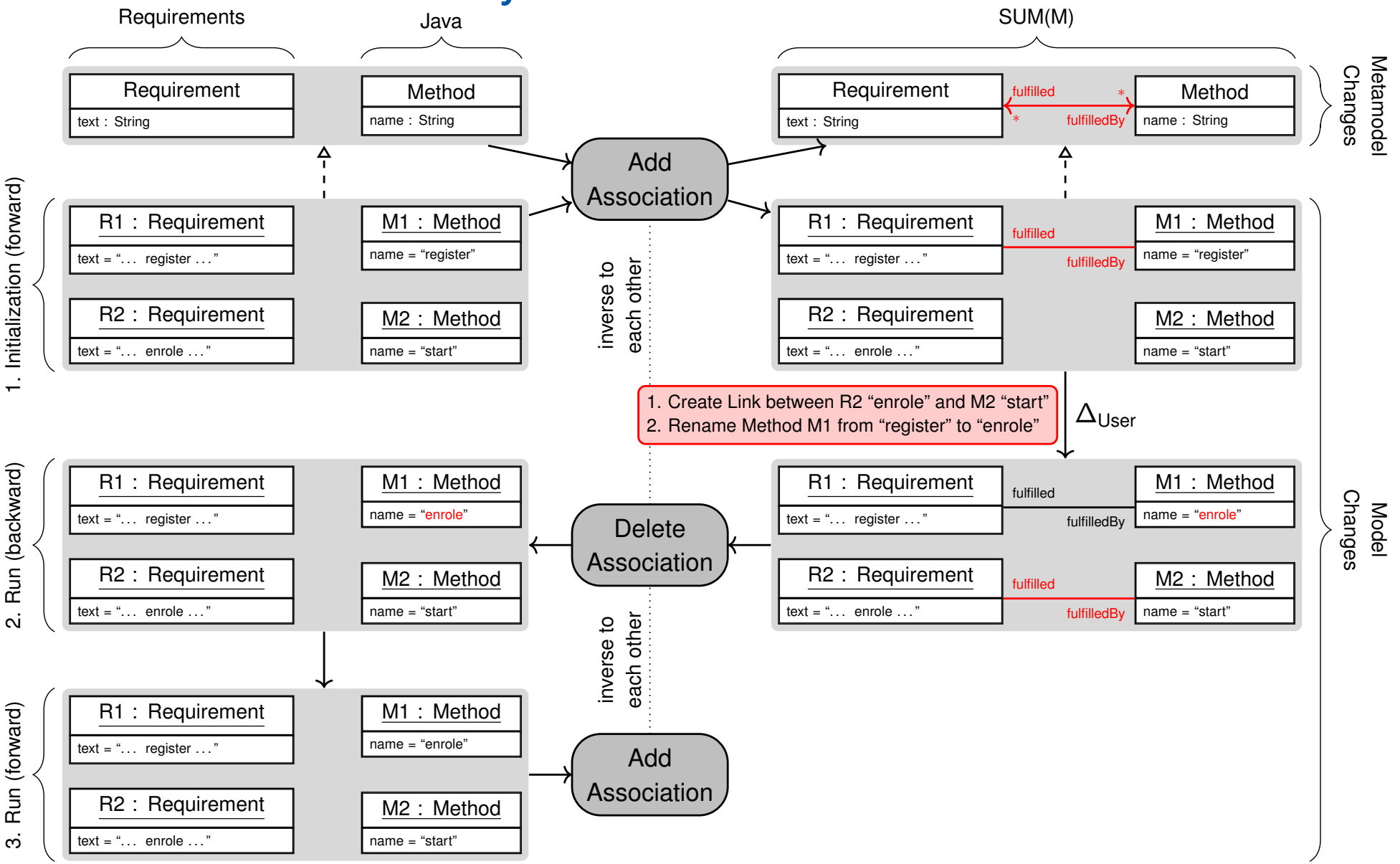

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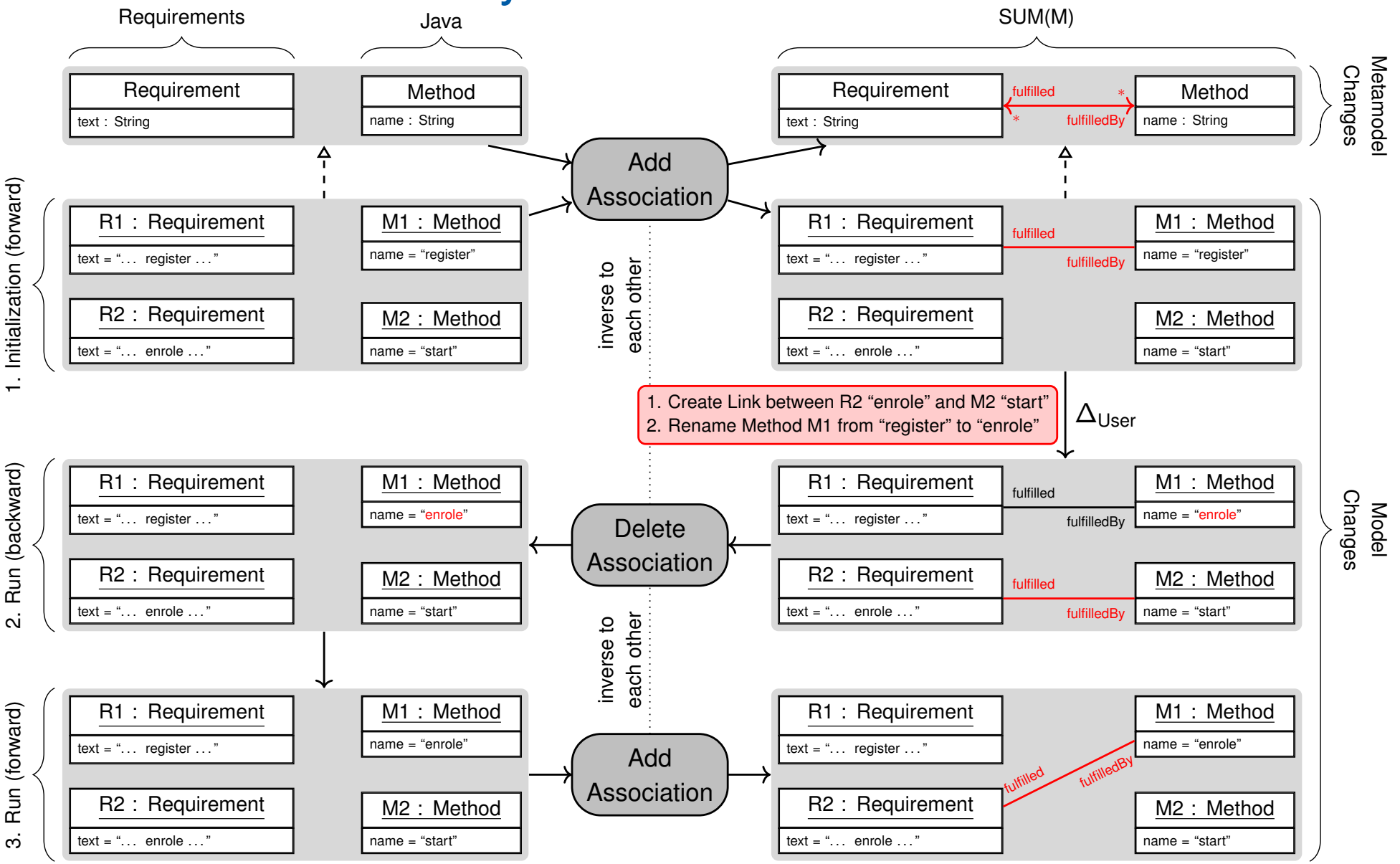

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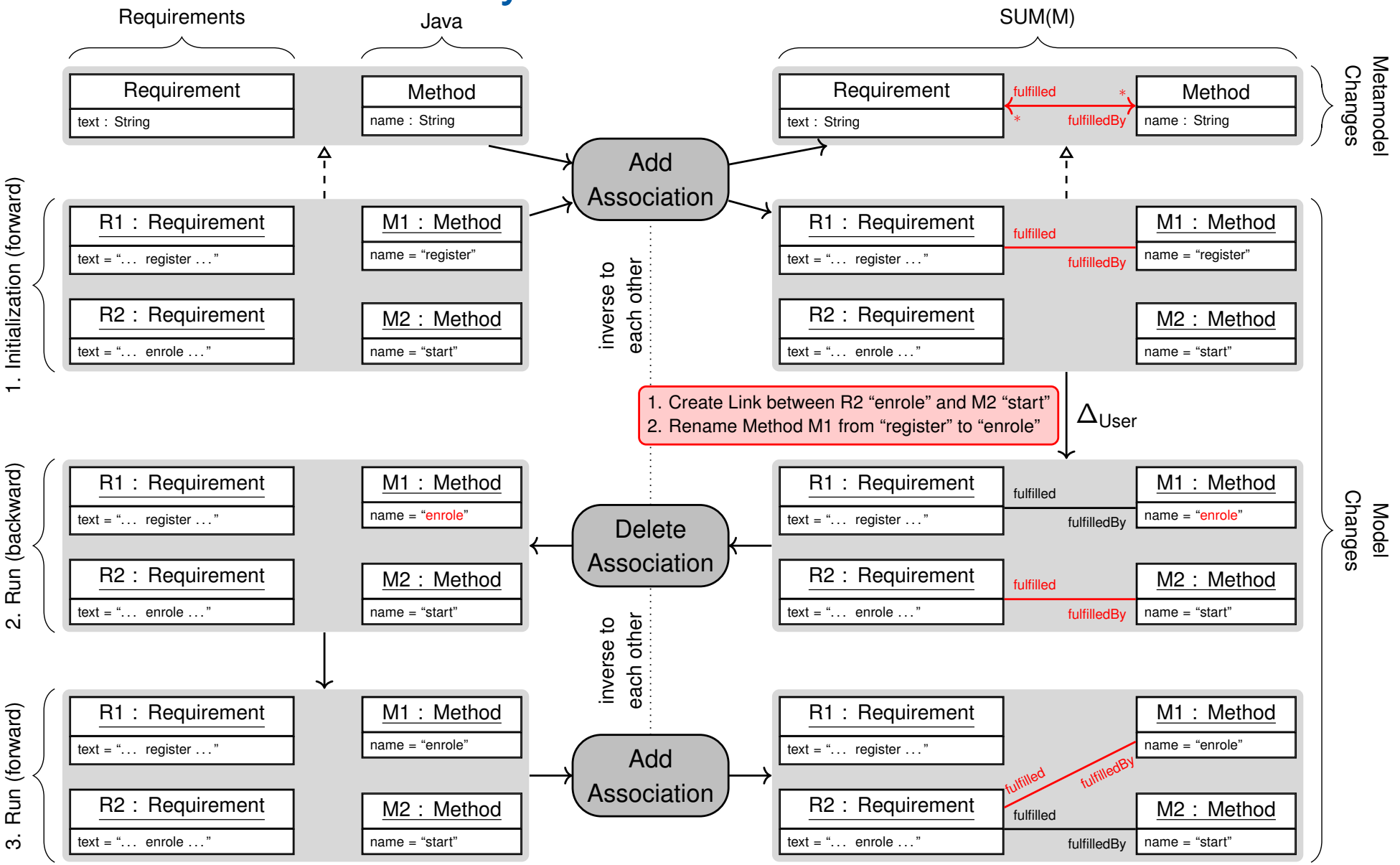

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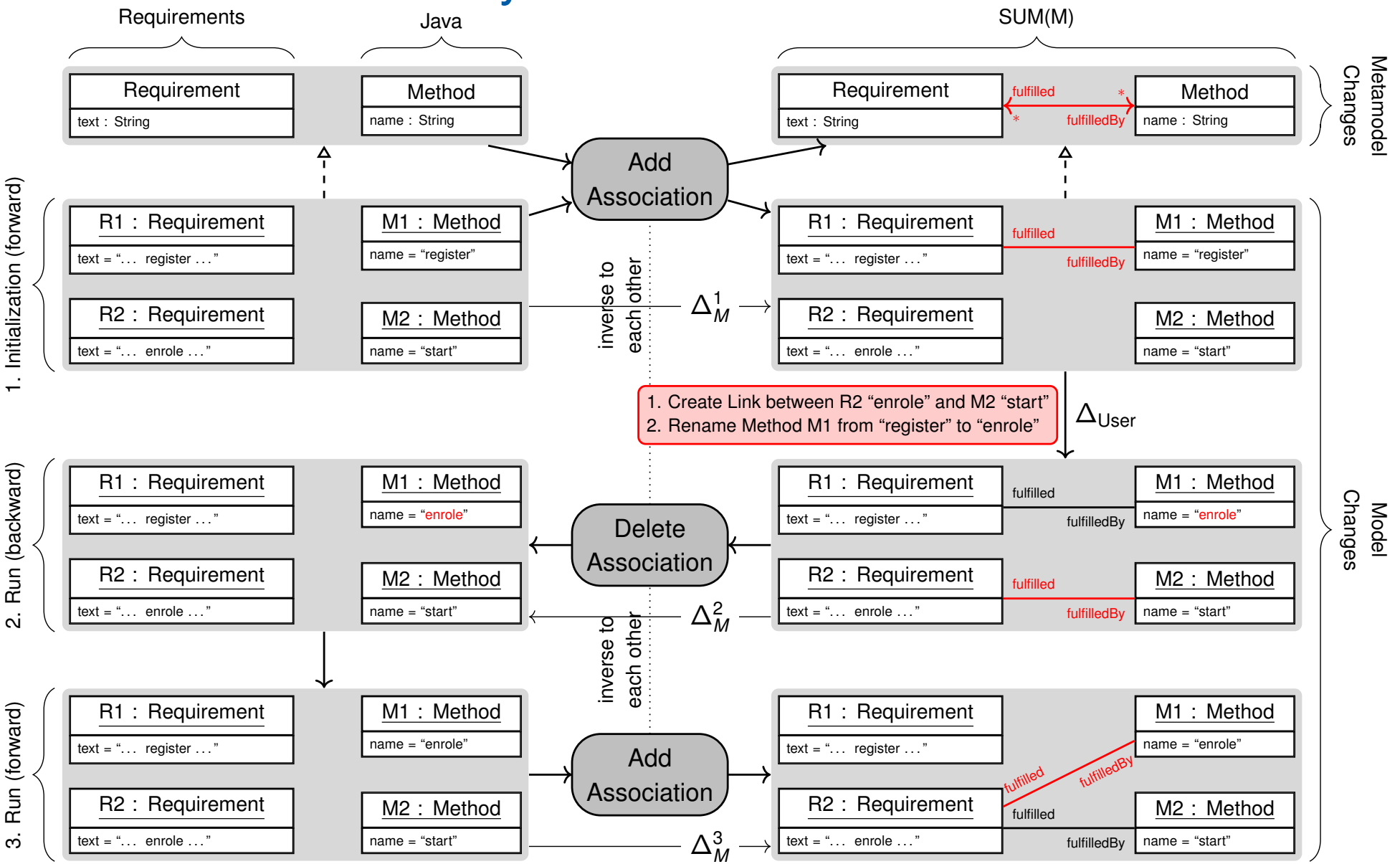
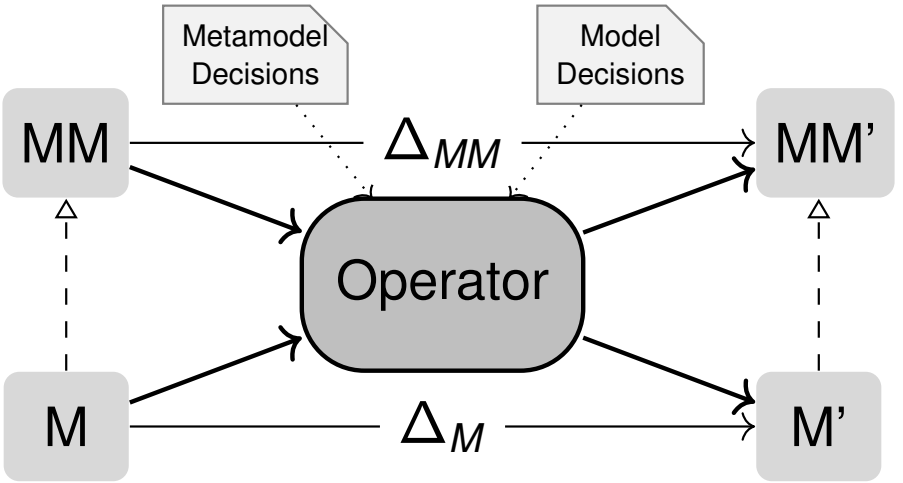


Operators: Summary

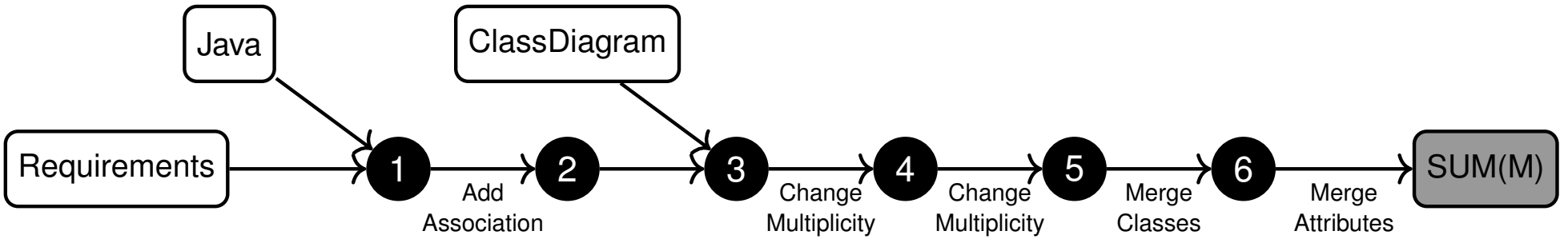


- **Metamodel Change** Δ_{MM}:
  small Change in the Metamodel
- **Model Change** Δ_M:
  handle Model-Co-Evolution (Coupled Operators [HVW11])
- Configurations by the Methodologist:
  - **Metamodel Decisions**: set Properties for wanted Metamodel Changes
  - **Model Decisions**: describe Model Changes for Consistency Rules
- **Bi-Directionality only for MM**: combine with inverse Operator
- currently 20 Operators implemented

Summary

Operator-based bottom-up SUM-Approach for Model Consistency:

- Methodologist configures arbitrary, but stable Chain of configured Operators (once)
- User applies Changes and Model Consistency is ensured automatically by executing the Operator Chain
- $\rightarrow$ separated Models are migrated to projectional Views on the SUM



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