Version Control in MDE

Adrian Rutle[1], Alessandro Rossini[2], Yngve Lamo[1], Uwe Wolter[2]

[1]Faculty of Engineering, Bergen University College, Norway

[2]Department of Informatics, University of Bergen, Norway

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HØGSKOLEN I BERGEN

Outline

Model-Driven Engineering

- Model-Driven Engineering (MDE)
  - models as primary artefacts of the software development process
- Models undergo a complex evolution during their life cycles
  - need for techniques and tools to support model evolution activities
- Version control enables concurrent and distributed software development

Version Control Paradigms

- *Lock-Modify-Unlock*
  - lock an artefact
  - modify it
  - release the lock
- *Copy-Modify-Merge*
  - create a local copy of the repository
  - modify the local copy independently
  - detect conflicting changes
  - merge the modifications into the repository

Motivation

- Lock-modify-unlock is workable if the developers always know who is planning to do what
- Traditional copy-modify-merge systems are focused on the management of text-based files
  - techniques based on per-line comparison
  - not suitable for graph-based structures
- Adoption of the copy-modify-merge paradigm enables effective version control in MDE

Motivation

- Solutions proposed by research are not sufficient to enable version control in MDE
  - lack of mature techniques targeting graph-based structures
  - same operations are given different semantics in different works/tools
  - concepts are described only semiformally
  - terminology is not precise and unique

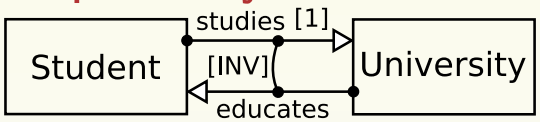
Our contribution

- Formalisation of the copy-modify-merge paradigm in MDE
- Definition of common models and merge models by means of pullback and pushout constructions respectively
- Representation of model differences and detection of syntactic conflicts by using Diagram Predicate Framework (DPF)

Outline

Example

Repository



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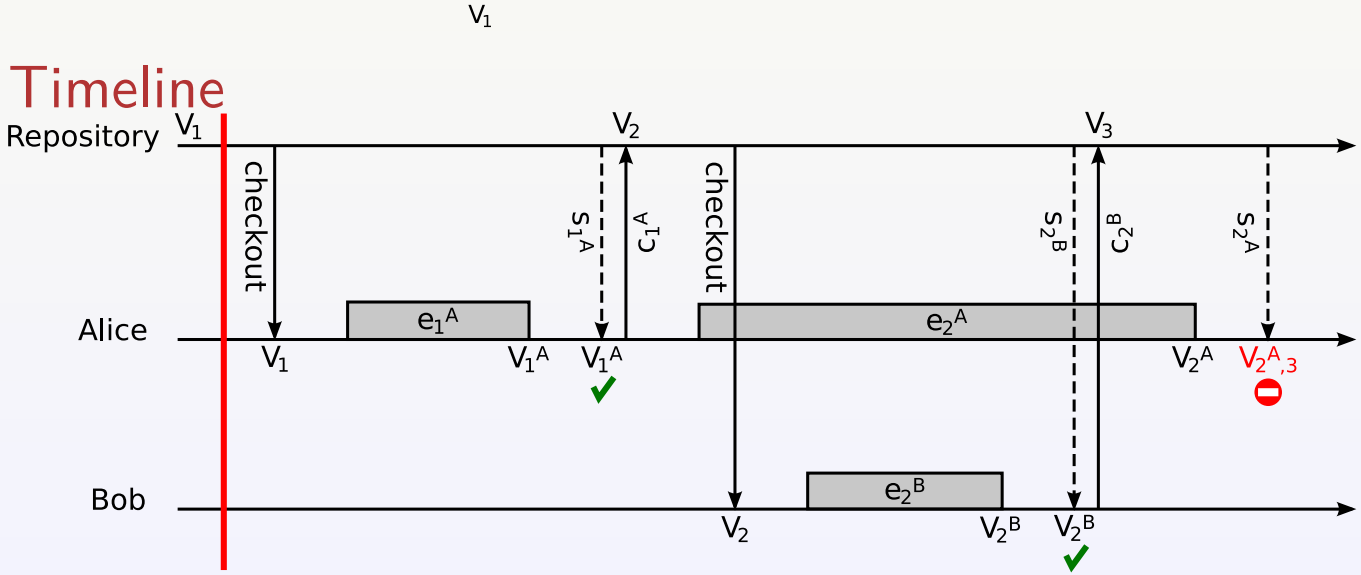
Timeline



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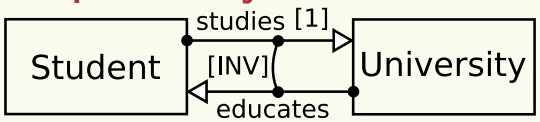

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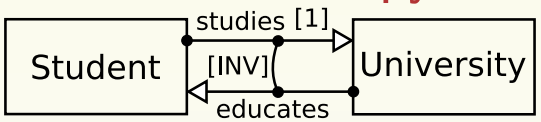

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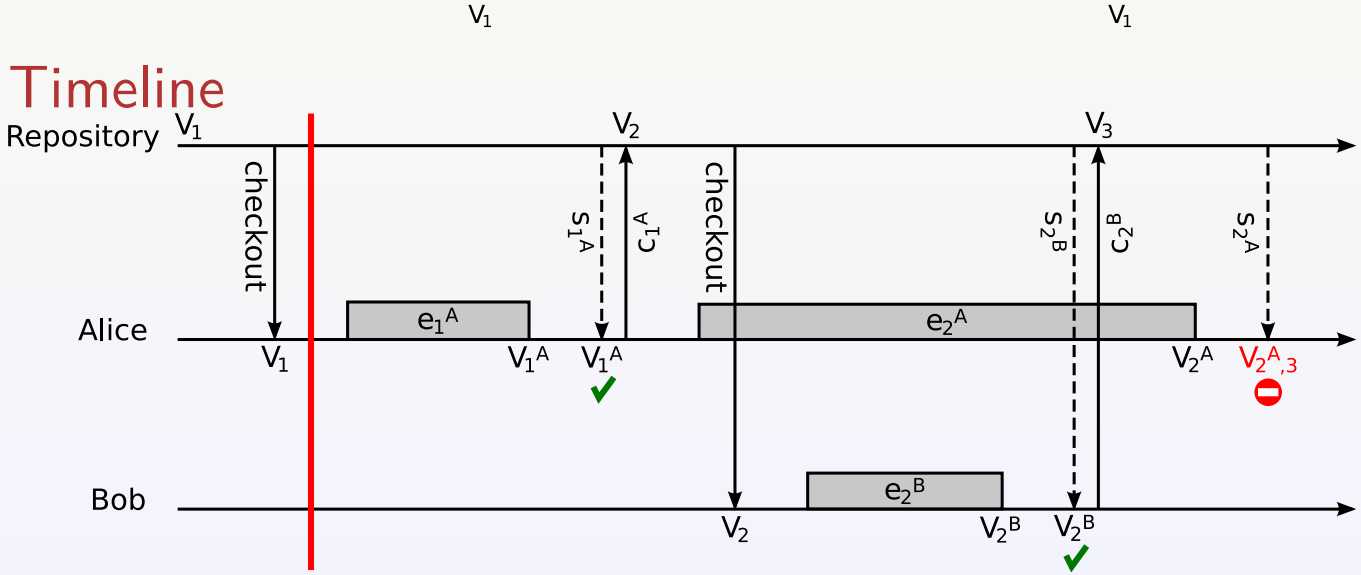

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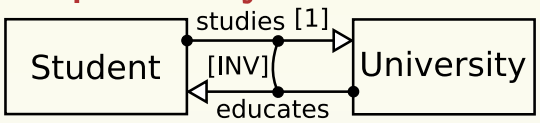

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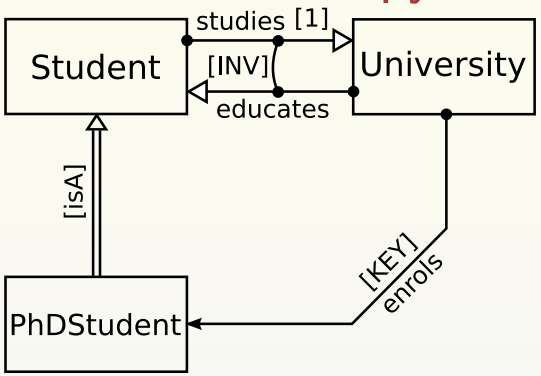

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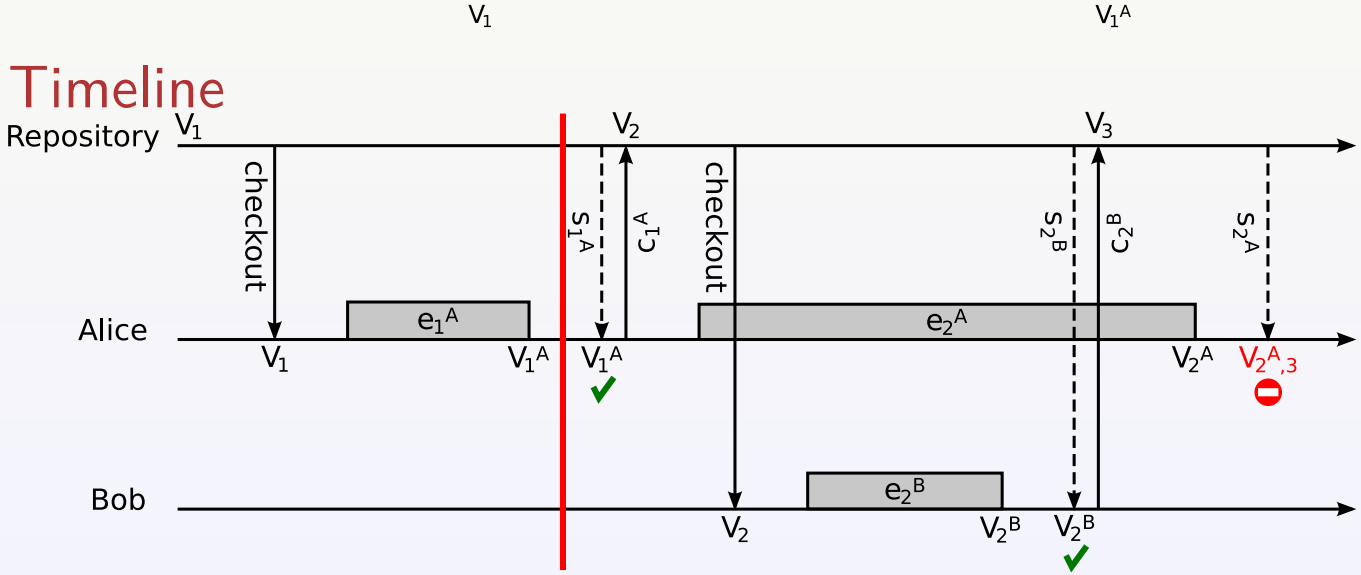

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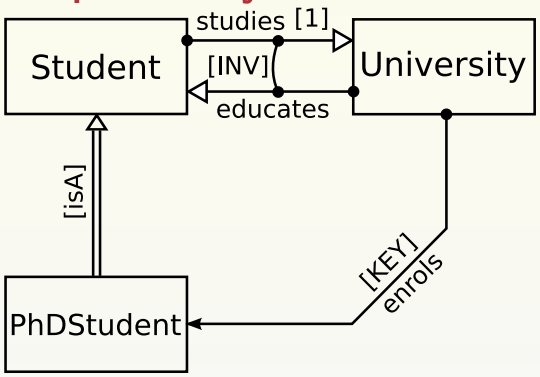

V_2

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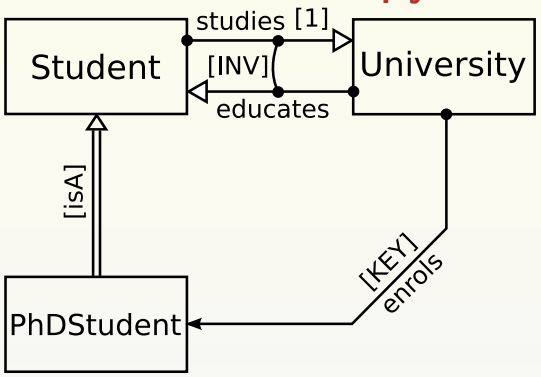

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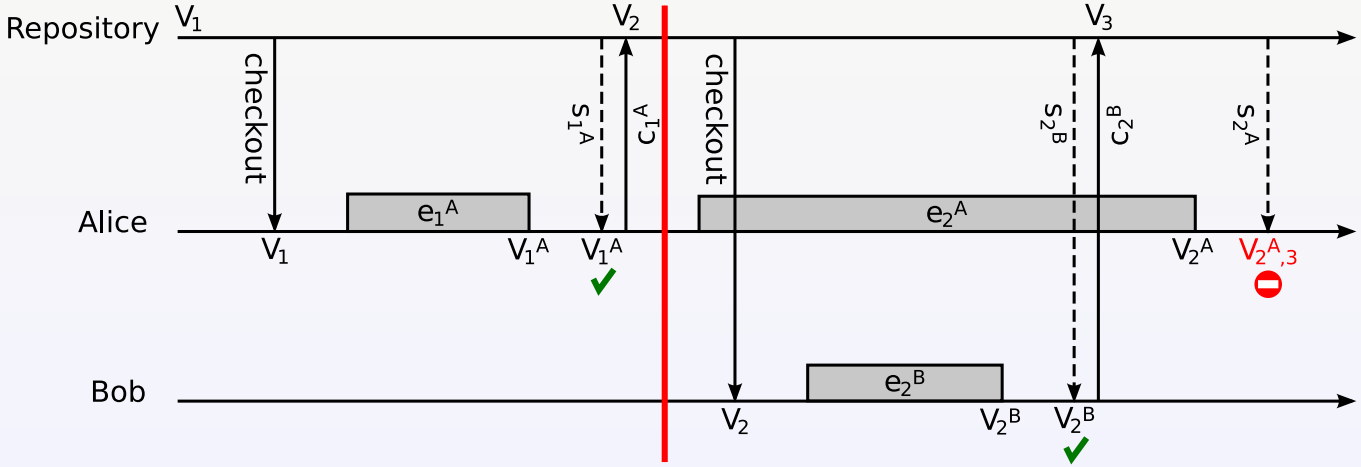

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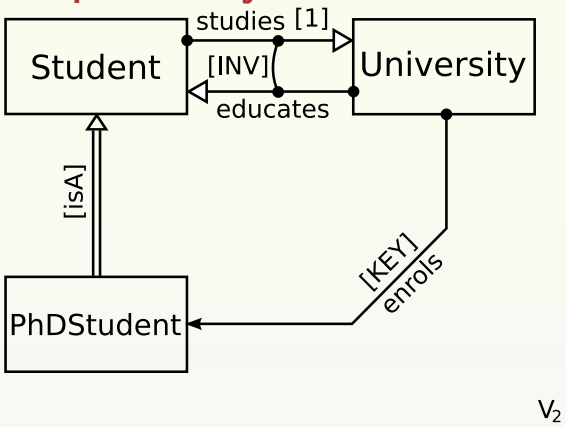

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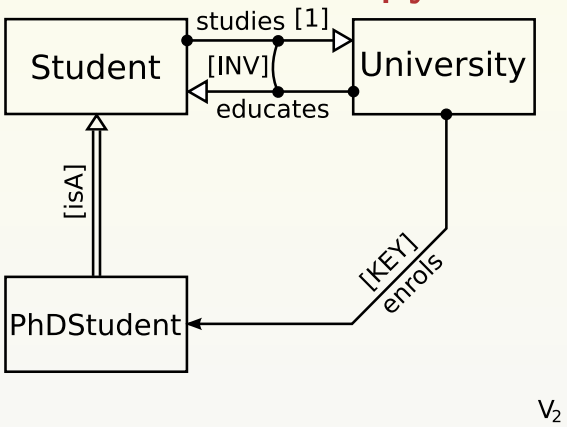

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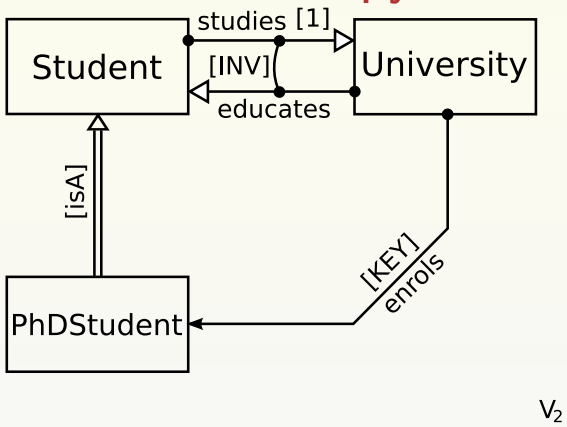

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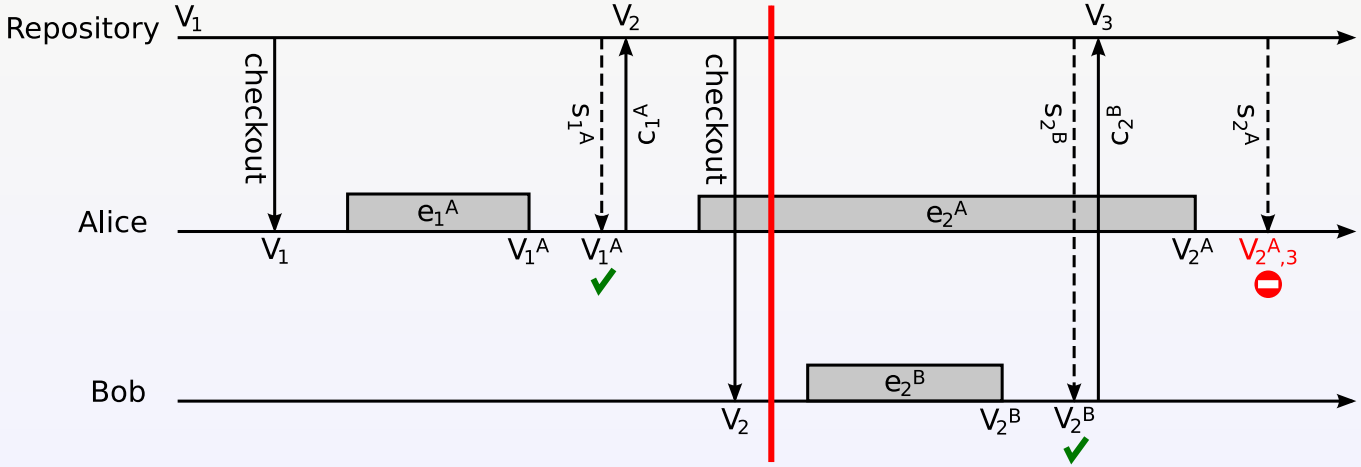

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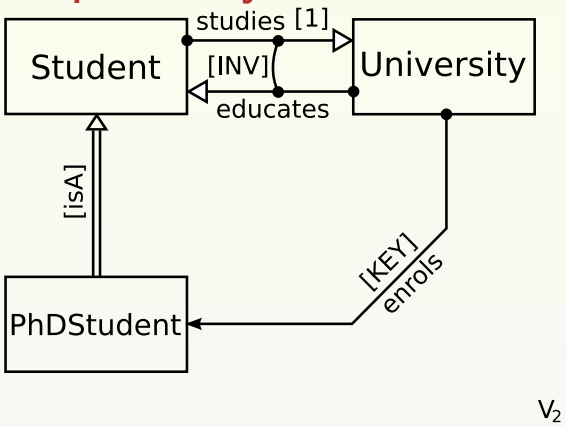

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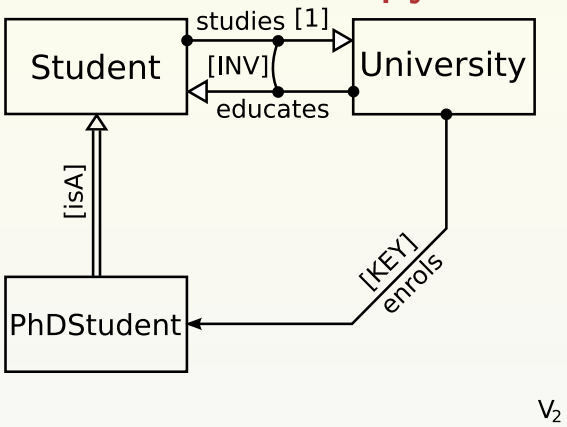

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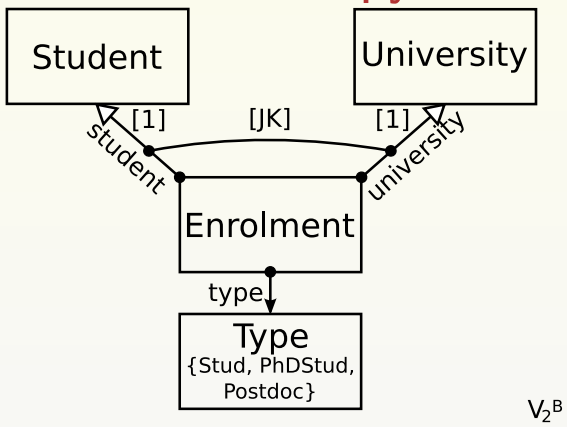

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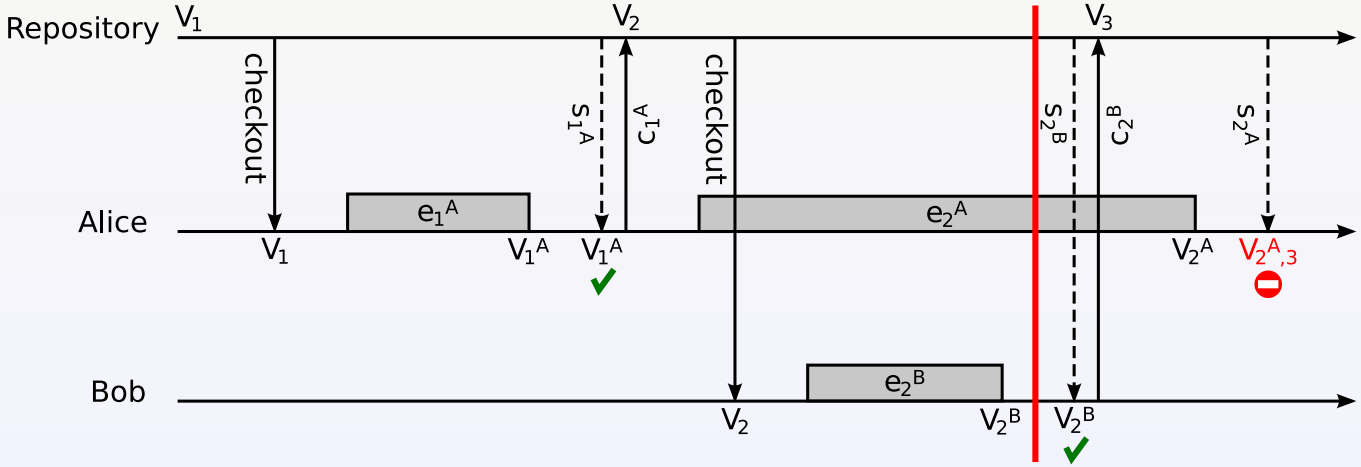

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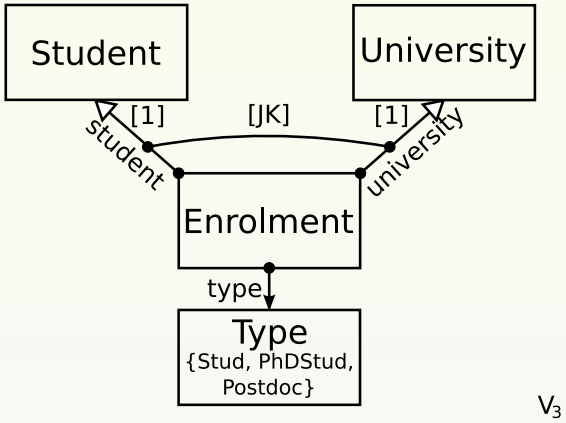

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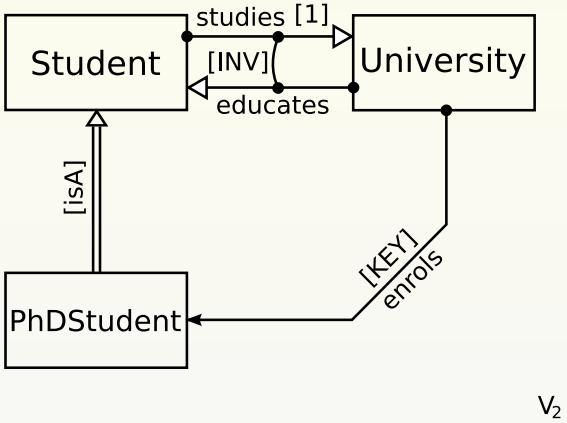

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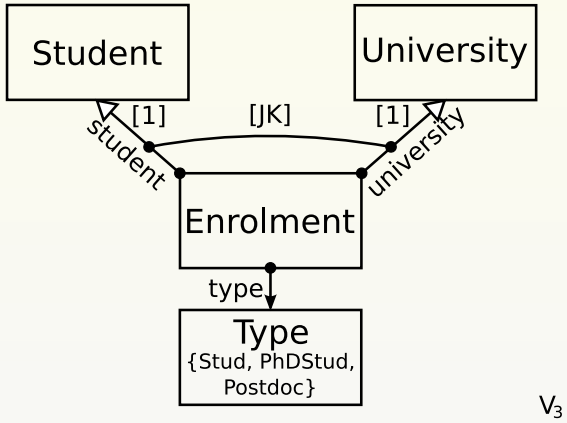

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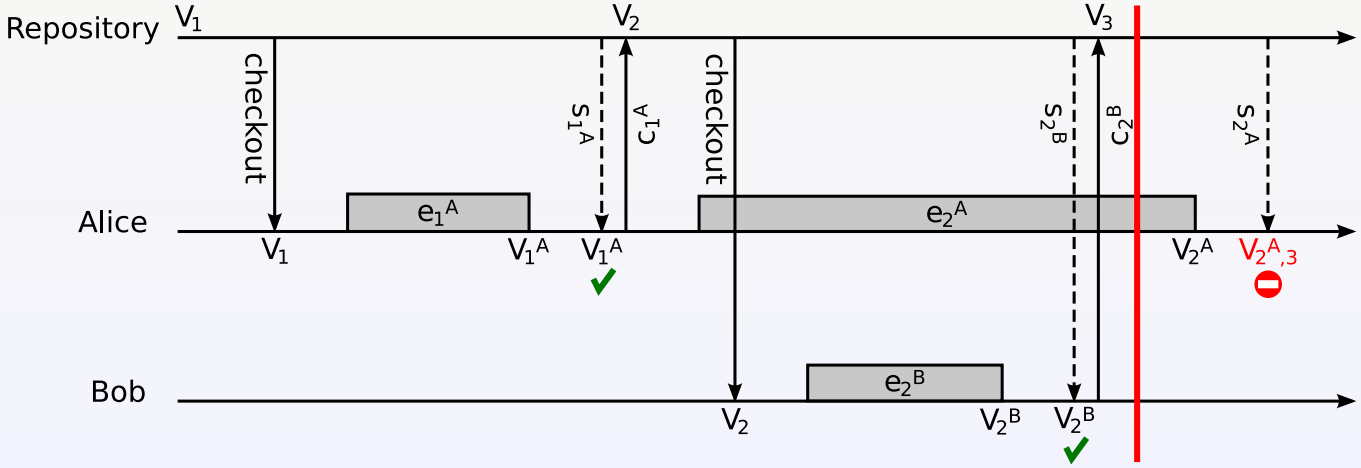

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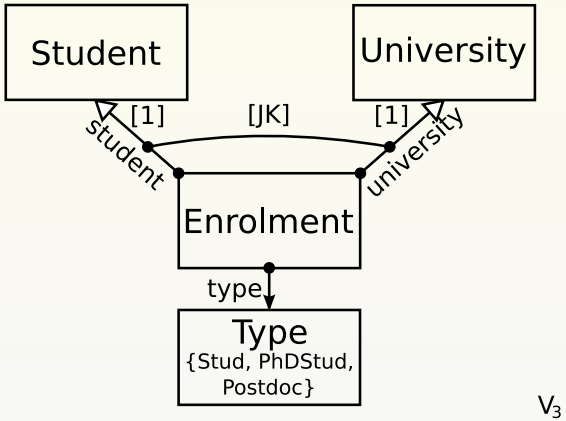

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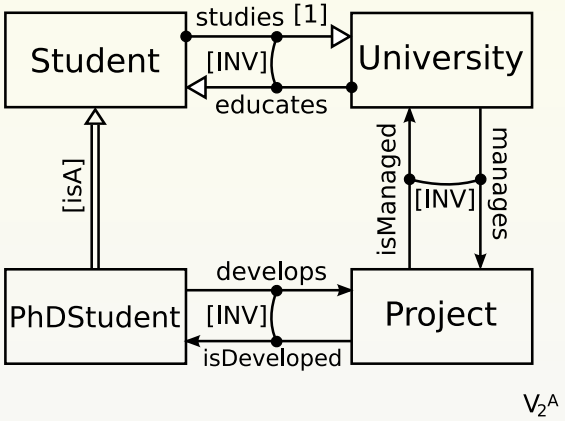

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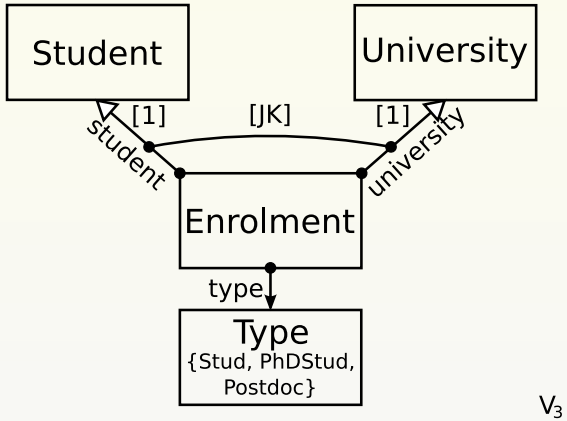

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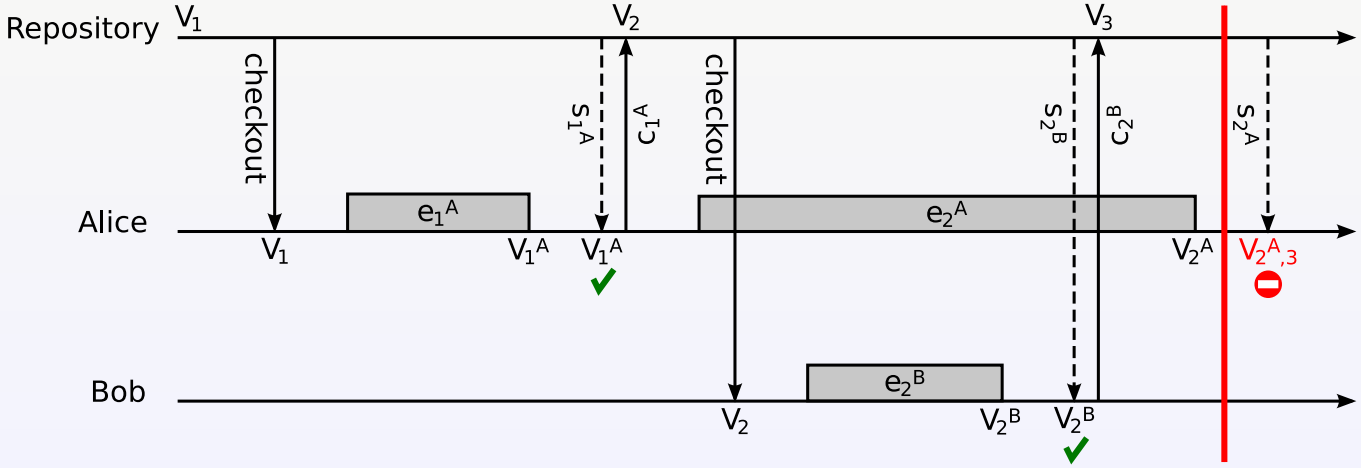

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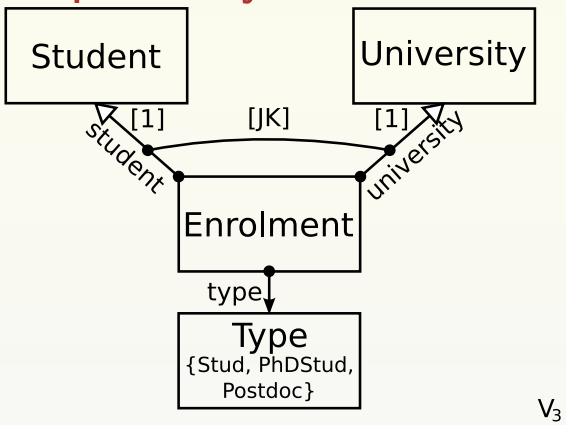

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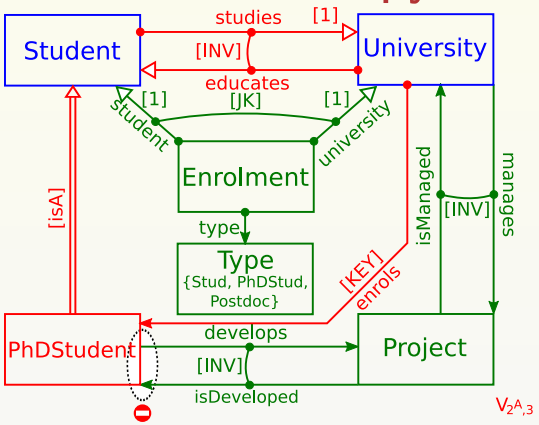

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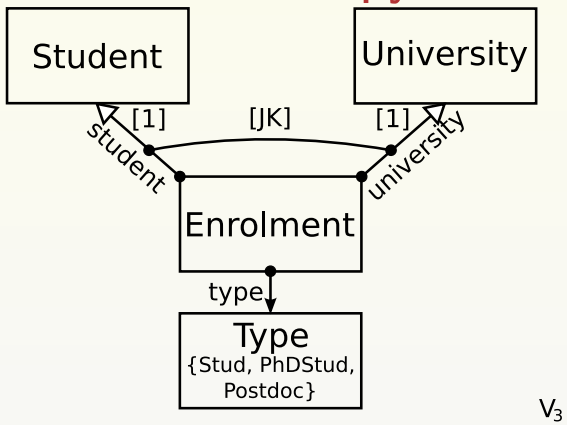

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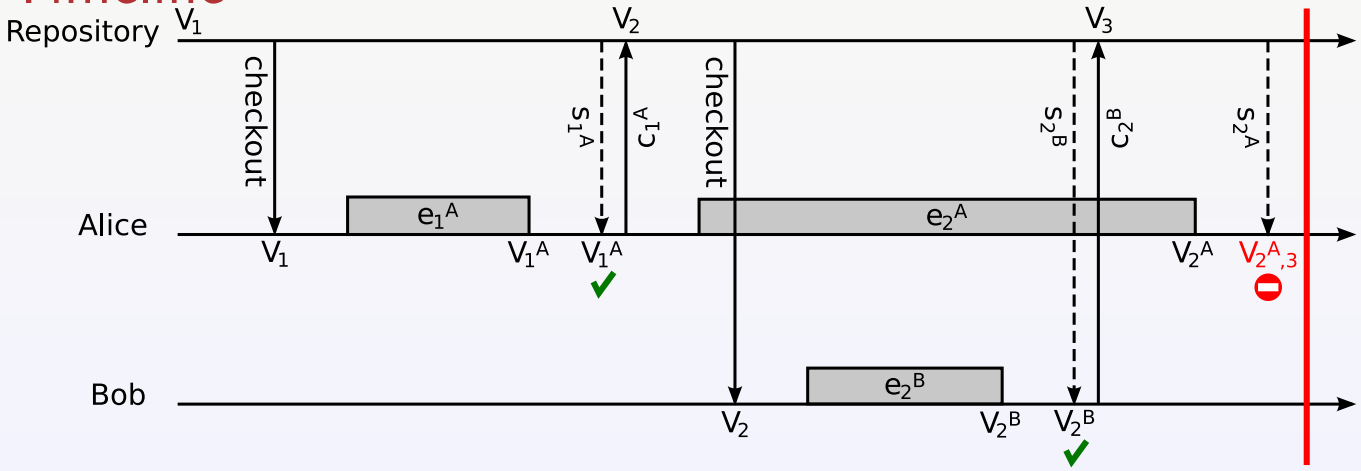


Outline

Common Model

- The development environment must keep track over what is common between subsequent models
- Existing approaches to the identification of mappings/differences
  - *soft-linking*: structurally equivalent elements imply equal elements
  - *hard-linking*: elements with equal identifiers are seen as equal elements

Common Model

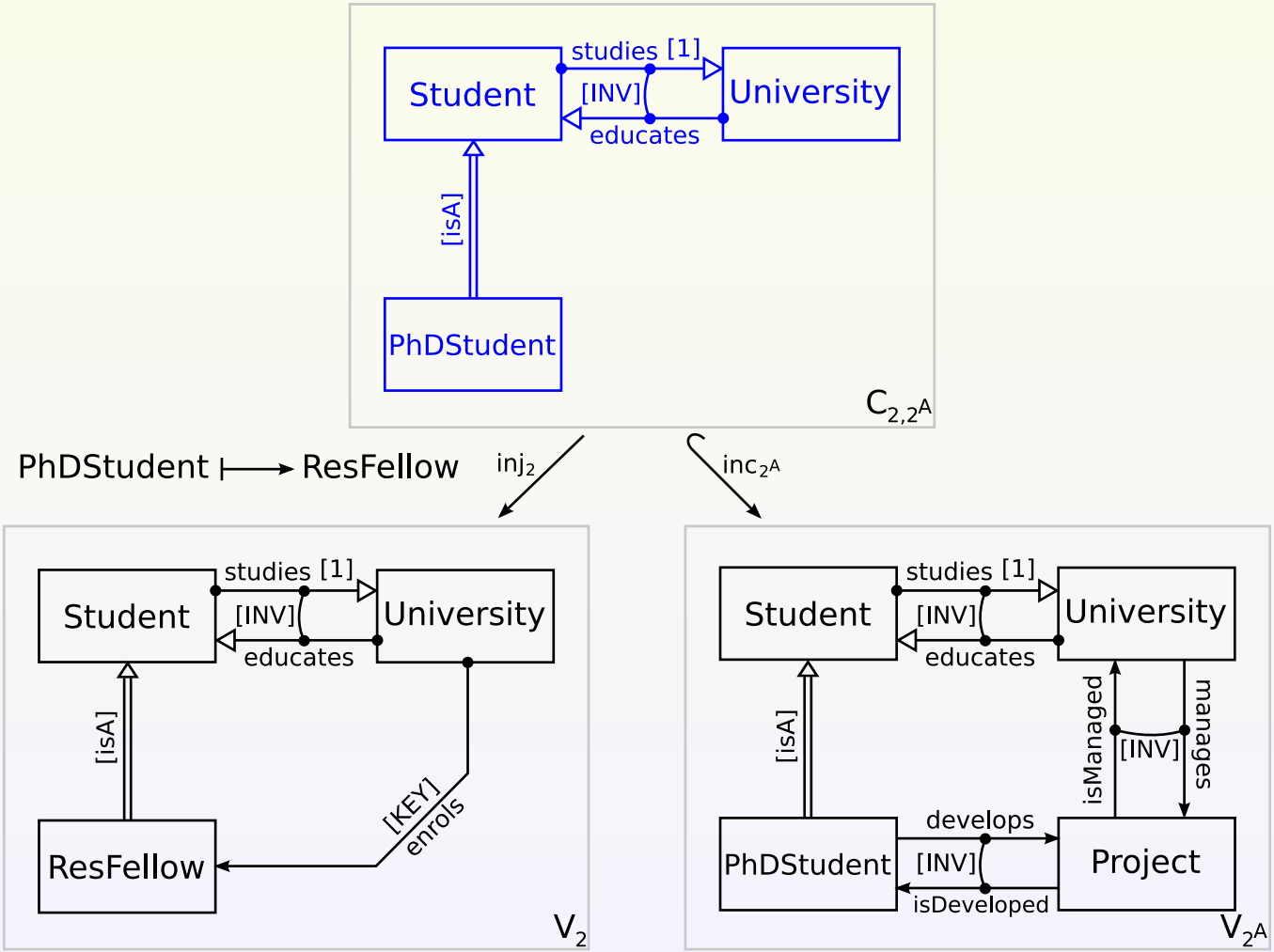
- We tackle the identification of mappings by specifying them explicitly in common models
- "Recording" which elements are kept unmodified addresses the problems of the soft- and hard-linking approaches

Definition

A model C together with the injective morphism inj and the inclusion morphism inc is a *common model* for V_i and V_j.

$$\begin{tikzcd} & C \arrow[dl, "inj"'] \arrow[dr, hook, "inc"] & \\ V_i & & V_j \end{tikzcd}$$

Example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Composition of Common Models

- Common model of non-subsequent models can be obtained by the composition of the "intermediate" common models

Definition

The *composition of commons* $C_{i,k}$ is a special pullback $(C_{i,k},\ inj_{C_{i,j}},\ inc_{C_{j,k}})$ of the diagram $C_{i,j} \xhookrightarrow{inc_{V_j}} V_j \xleftarrow{inj_{V_j}} C_{j,k}$ such that $inc_{C_{j,k}}$ is an inclusion

$$\begin{tikzcd}
 & & C_{i,k} \arrow[dl, hook, "inj_{C_{i,j}}"'] \arrow[dr, hook, "inc_{C_{j,k}}"] \arrow[dddll, bend right, "f"'] \arrow[dddrr, bend left, "g"] & & \\
 & C_{i,j} \arrow[dl, "inj_{V_i}"'] \arrow[dr, hook, "inc_{V_j}"] \arrow[r, phantom, "P.B."] & & C_{j,k} \arrow[dl, "inj_{V_j}"] \arrow[dr, hook, "inc_{V_k}"] & \\
V_i & & V_j & & V_k
\end{tikzcd}$$

Outline

Merge Model

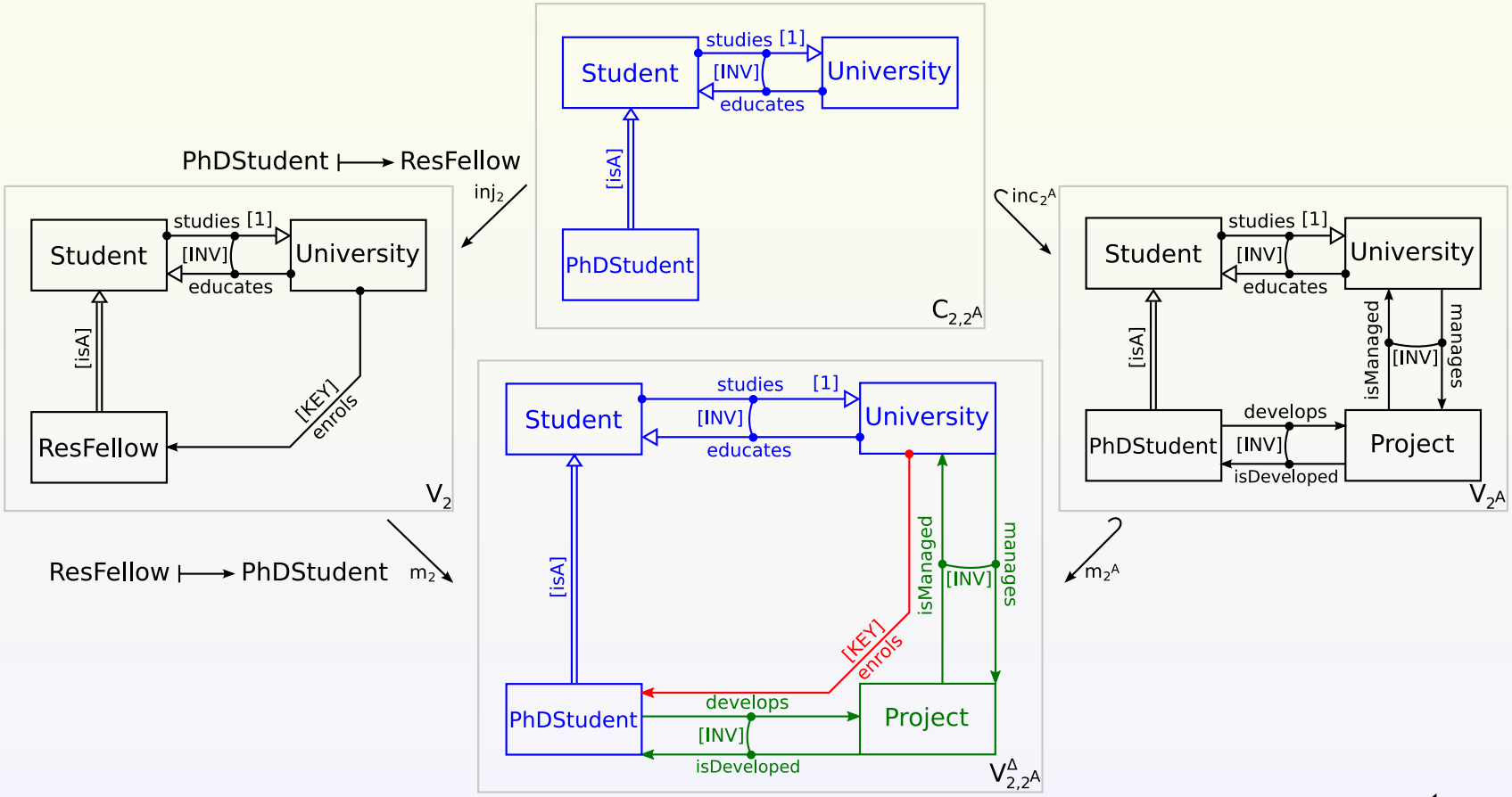
- The merge model must contain the information which is needed to distinguish which model elements come from which "source" model
  - This is exactly one of the properties of pushout

Definition

The *merge model* $V_{i,j}$ is the pushout $(V_{i,j},\ m_i,\ m_j)$ of the diagram $V_i \xleftarrow{inj_{V_i}} C_{i,j} \xhookrightarrow{inc_{V_j}} V_j$ such that m_j is an inclusion.

$$\begin{tikzcd}
 & C_{i,j} \arrow[dl, "inj_{V_i}"'] \arrow[dr, hook, "inc_{V_j}"] & \\
V_i \arrow[dr, "m_i"'] & P.O. & V_j \arrow[dl, hook, "m_j"] \\
 & V_{i,j} &
\end{tikzcd}$$

Example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Outline

Synchronisation and Commit

- A *synchronisation* is a procedure which generates a synchronised local copy V_{jU}, where V_j is the last version in the repository
  - conflicting changes are detected
- A *commit* is an operation which adds the model V_{jU} to the repository and labels it V_{j+1}

Synchronisation Procedure

$$
\begin{tikzcd}
 & C_{i,iU} \arrow[dl, hook, "inc_{V_{iU}}"'] \arrow[dr, "inj_{V_i}"] & & C_{i,j} \arrow[dl, "inj_{V_i}"'] \arrow[dr, hook, "inc_{V_j}"] & \\
V_{iU} \arrow[dr, hook] & & V_i \arrow[ll, Rightarrow, "e_{iU}"'] \arrow[rr, Rightarrow, "\cdots"] \arrow[dl, "mu_i"] \arrow[dr, "mr_i"'] & & V_j \arrow[dl, "mr_j"] \arrow[d, equal] \\
 & V_{i,iU} \arrow[rr, phantom, "P.O."] \arrow[dr, "mu_{iU,i}"'] & P.O. & V_{i,j} \arrow[dl, "mr_{i,j}"] & V_{j+1} \\
 & & V_{iU,j} \arrow[r, dashed] & V_{jU} \arrow[ur, Rightarrow, "c_{iU}"'] &
\end{tikzcd}
$$

Outline

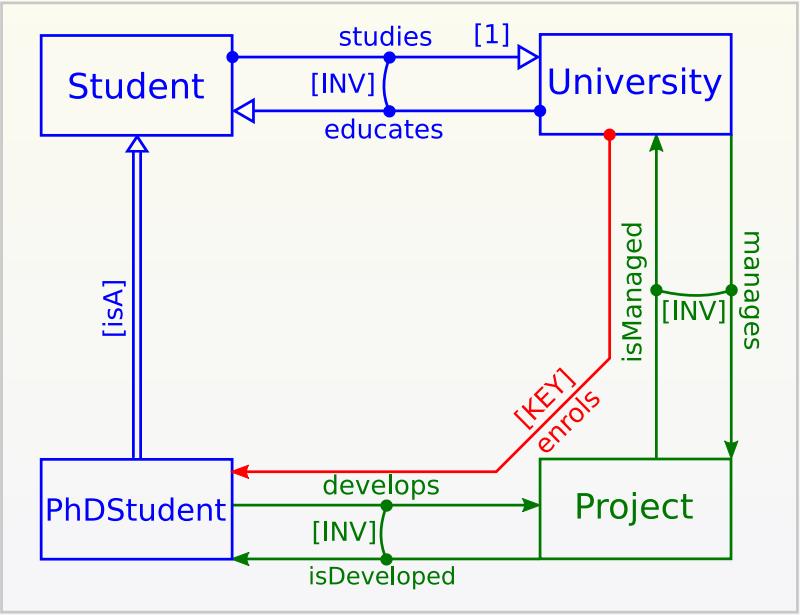
Difference

- Need to identify the differences between two models
- In a merge model $V_{i^U,j}$ we can distinguish common elements, V_{i^U}-elements and V_j-elements from each other
- We can identify which elements are *common*, *added*, *deleted*, *renamed* and *moved*
- We define a signature Σ_Δ
  - predicates: `[common]`, `[add]`, `[delete]`, `[rename]`, `[move]`, and `[conflict]`

Conflict

- The merge models will be decorated by predicates from the signature Σ_Δ
  - detection of conflicts in the decorated merge model $V_{i^U,j}$
  - reduction of $V_{i^U,j}$ to V_{j^U}
- Rules:
  - [common] $\wedge$ [common] $\rightarrow$ [common]
  - [delete] $\wedge$ [delete] $\rightarrow$ [delete]
  - [common] $\wedge$ [delete] $\rightarrow$ [delete]
  - [move] $\wedge$ [move] $\rightarrow$ [conflict]
  - [add] (arrow) $\wedge$ [delete] (node) $\rightarrow$ [conflict]
  - [rename] $\wedge$ [rename] $\rightarrow$ [conflict]

Example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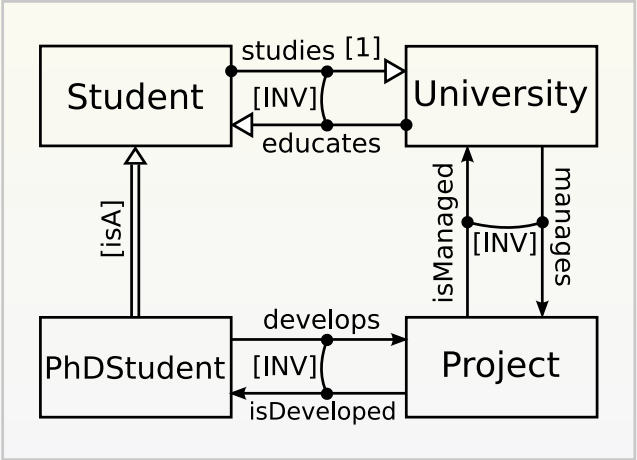
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Outline

Summary

- The copy-modify-merge paradigm can be exploited for version control of graph-based structures
- Formalisation of the concepts of the copy-modify-merge paradigm in MDE by means of category-theoretical constructions
- Explicit specification of model elements' mappings in common models
- Diagrammatic language for the representation of model differences
- Rules for the detection of syntactic conflicts

Future Work

- Semantic conflicts
- Prototype implementation

Thank you!

Questions?