Domain-specific Performance Optimizations of Pattern Matching in Henshin

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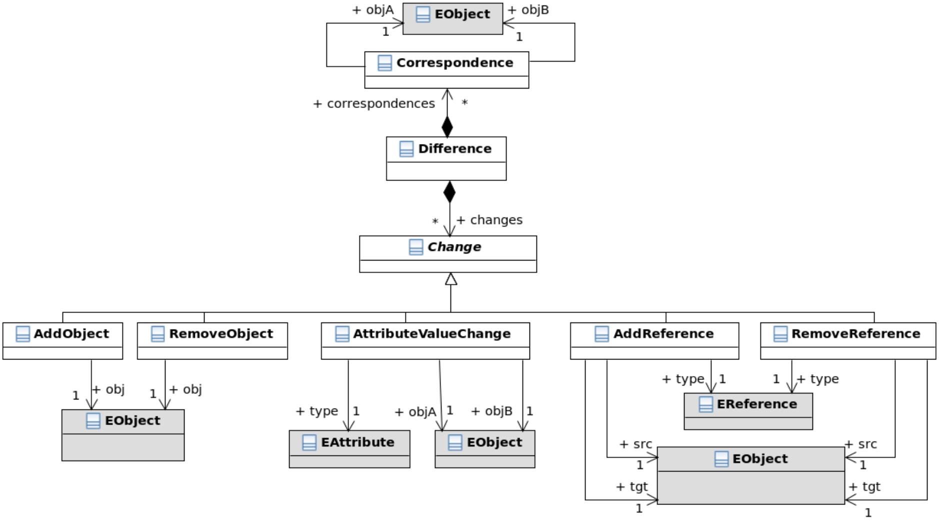
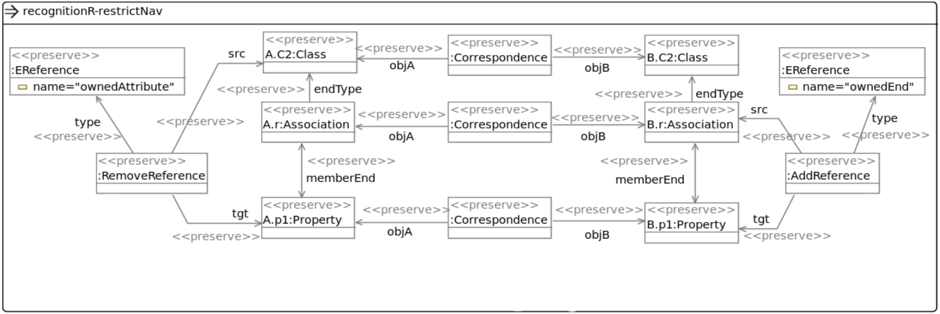
1. Application Domain
2. Performance Optimizations
3. Experiences and Conclusions

Meta-model (Representation of Model Differences)



Change Set Recognition Rules

- Example: “Restrict association navigability” in UML (clipping)
- We use Henshin as pattern matching engine for detecting such change patterns
- Involved changes are finally grouped to so called semantic change sets



Recognition of Semantic Change Sets

Problem description:

- Given a rule set R and a difference D ("difference model")
- For each rule r in R, find all matches in D

Assumptions:

- None of the rules in R modifies our model D, i.e. all rules are parallel independent of each other
- The rule set R is fixed and none of the rules is modified at runtime

Overview

- Parallel execution with a pool of worker threads
- Sorting of LHS nodes
- Reduction of the pre-defined rule set
- Creation of minimal EGraphs

Sorting of LHS Nodes

Two (in general orthogonal) heuristics:

- Number of occurrences of objects of a certain type in a difference
- "Position" of LHS nodes within a rule

Remarks:

- Sorting determines the order in which the recursive constraint solving algorithm locks variables
- Heuristics similar to generic heuristics in Henshin matching engine?

Reduction of the Pre-defined Rule Set

Basic proceeding:

1. Create index on difference D:
   - EClass $\rightarrow$ int, t $\mapsto NoN_t^M$
   - NoN_t^M is the number of objects of type t (or one of its subtypes) in D
2. Create index ("signature") for each rule r in R
   - EClass $\rightarrow$ int, t $\mapsto NoN_t^R$
   - NoN_t^R is the number of objects of type t in R
3. A rule is matchable if its signature can be found in D

Extensions:

- Basic proceeding is extended to domain-specific type definitions
- For instance, tuples such as (AddObject,obj) or (AddReference,src,tgt,type) can be regarded as complex types

Creation of Minimal EGraphs

Basic idea:

- We create a separate EGraph for finding all matches of a rule.

General proceeding:

- Given a rule r, let T_r be the set of all node types used by r
- EGraph $G = \{o \in D \mid (o.type \in T_r) \vee (o.type.allSuperTypes \cap T_r \neq \emptyset)\}$

Remarks:

- Should be already handled by reducing the CSP solution space based on type constraints
- However, basic proceeding is extended to domain-specific definitions of complex types

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Experiences and Conclusions

- **Parallel execution:**
  - Strongly depends on the underlying hardware
- **Sorting of LHS nodes:**
  - Biggest performance gain, even for very small models (from minutes to seconds)
  - Should now already be handled by generic sorting of CSP variables
- **Rule set reduction:**
  - Moderate performance gain for large rule sets ($>$ 500 rules)
  - Generalizable, but current rule set has to be continuously adapted
- **Minimal EGraphs:**
  - Similar to reducing the CSP solution space based on type constraints
  - Generalization option: API or config file for application-specific definitions of complex types