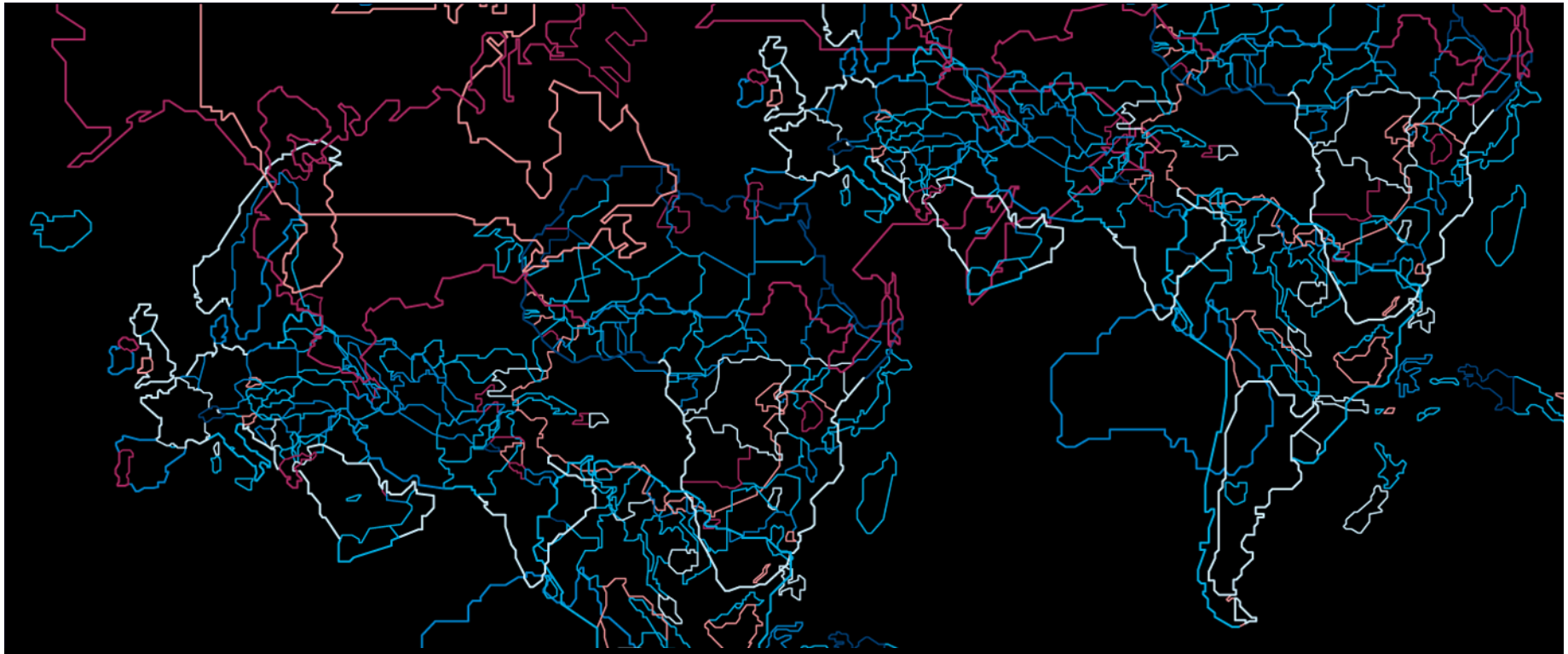


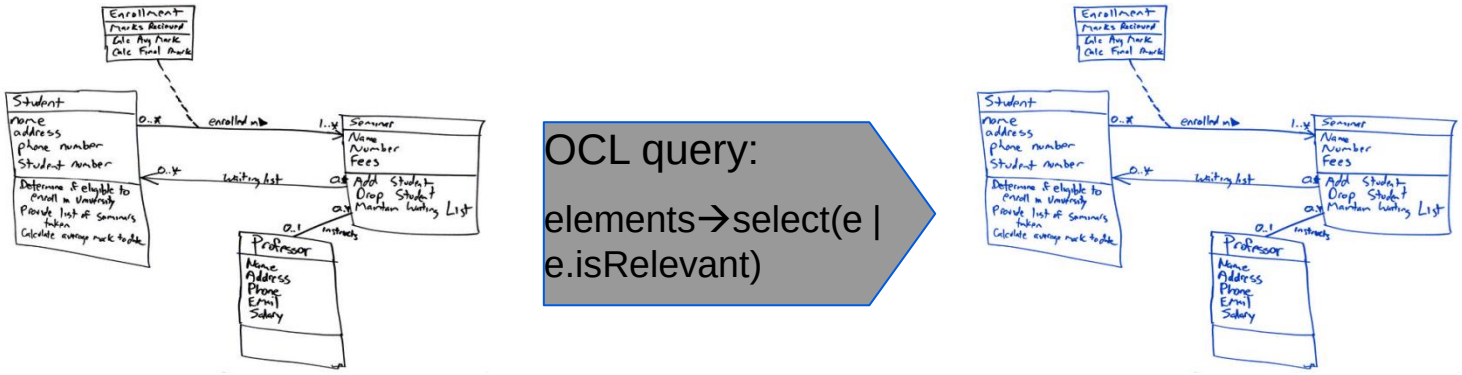
Thomas Goldschmidt, ABB Corporate Research

Axel Uhl, SAP AG

Efficient OCL Impact Analysis

Motivation

- The Object Constraint Language (OCL) is used for different purposes in modelling:
  - Constraints
  - Queries
  - Model Transformation
- Especially when used in model transformations OCL expressions form a kind of implicit dependency



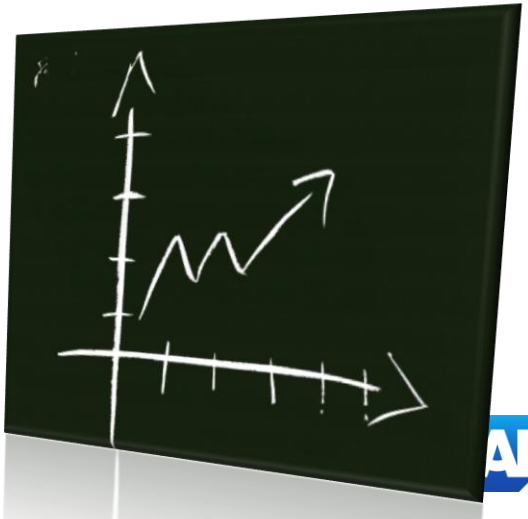
source scope

result

Motivation (2)

- What happens if the source model changes?
- Result may be invalidated.
- OCL expressions needs to be re-evaluated.
- But what happens if things grow large?
  - Huge models.
  - Many, complex constraints.
- Re-evaluating all constraints becomes infeasible.
  - Naive approach:

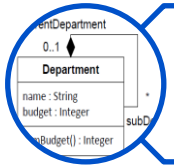
O(|expressions| * |modelElements|)



More Generally

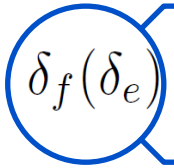
- Given …
  - a set of OCL expressions
  - a set of model elements
  - a model change notification
- Which of the OCL expressions may have changed its value on which context elements?

Agenda

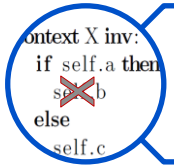


Running example

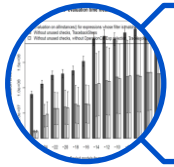
The *traceback* function



Partial evaluation and delta propagation

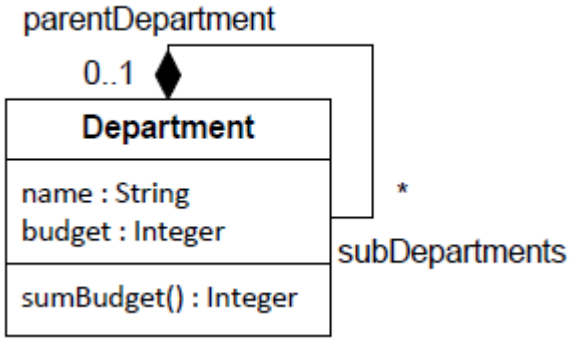


Changes in unused subexpressions



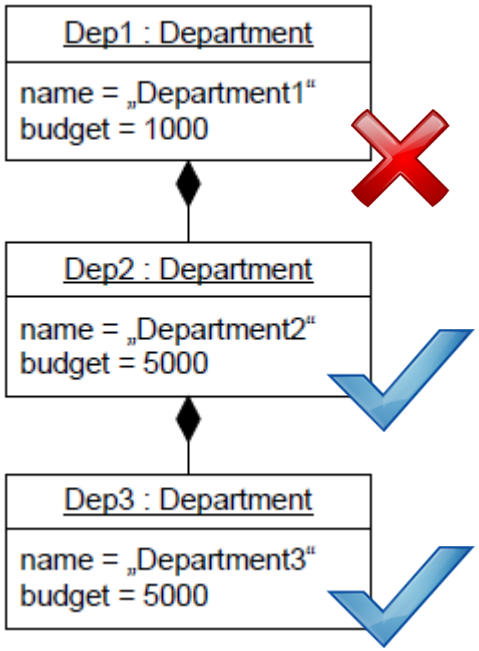
Evaluation

Running Example




```
context Department::sumBudget():Integer
  if self.subDepartments->size() >= 1 then
      self.subDepartments->iterate(department;
        result : Integer = 0 | result + department.sumBudget())
        + self.budget
  else
      self.budget
  endif

context Department
inv: self.sumBudget() < 10000
```



Metamodel

Example Model

The *traceback* function

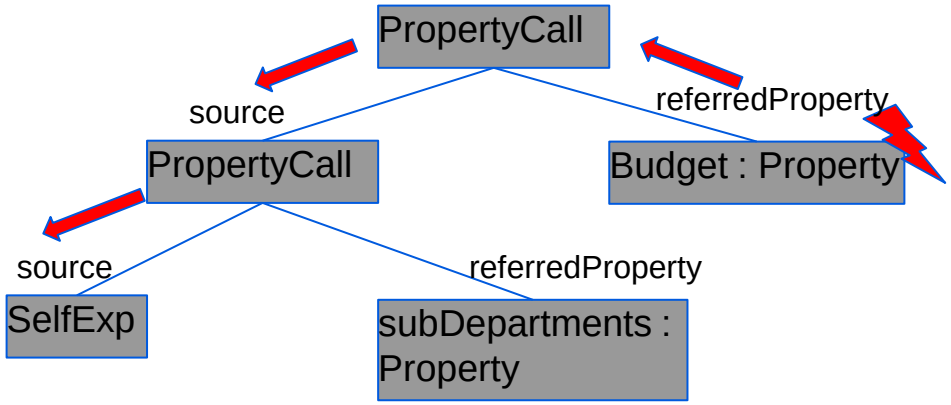
- Goal: Compute all context objects „***self“***, that for which a given expression **e** evaluates to a different result than before the change.
- **Example:**
  - Expression: `self.subDepartments.budget`
  - Change: c_1 = `(dep2.budget` from `5000` to `5001)`
- *traceback* : Given a model change determine all expressions which navigate to that property.
  - *traceback*$_{\texttt{self.subDepartments.budget}}$(`dep2`) = `{dep1}`

The *traceback* function (2)

- Defined for each type of OCL expression.
- For example: PropertyCallExp (simplified):

```
traceback_n(s) := let t' =
  `n.source.type` . allInstances()->select(
    `n.referredProperty` = s)->select(x |
      x.oclIsKindOf( `n.source.type`) ) in
sourceObjects->collect(so | traceback_n.source(so; t')))
```

Example: `self.subDepartments.budget`



Delta Propagation

- In some cases changes cannot have caused an expression to change its result.
- Example: `self.subDepartments->select(d | d.x)`
  - Where `x` is of type `Boolean`
  - Adding an element to reference `b` which has `x` set to `false` will not change the result of the expression.
- For complex expressions early determination of empty change sets could reduce computation effort.

Delta Propagation (2)

- An expression `e` is ***monotonic*** iff:
  - It is a CallExp expression with upper multiplicity > 1
  - It‘s source expression `s` has an upper multiplicity > 1
  - Adding an element to `s`‘s result either
    - Leaves e‘s result collection unchanged **or**
    - Adds one or more elements to `e`‘s result
- For each ***monotonic*** expression (such as `select`, `collect`, `if-then-else`, etc.) we define a function δ_e which indicates the change in the `e`‘s set of elements.
- Recursively applied this allows for early determination of changes that do not affect the result of an expression.

Partial Evaluation

- For some expressions a „look to the right“ during change analysis can also avoid unnecessary computations:
- **Example**: `self.name = ‚abc‘`
  - Not affected by a name change from ‚x‘ to ‚y‘

- **Combination of Delta Propagation and Partial Evaluation:**
  - Use partial evaluation to determine old and new values of call expressions
  - If delta propagates to an empty set using delta propagation the expression isn‘t affected by the change.

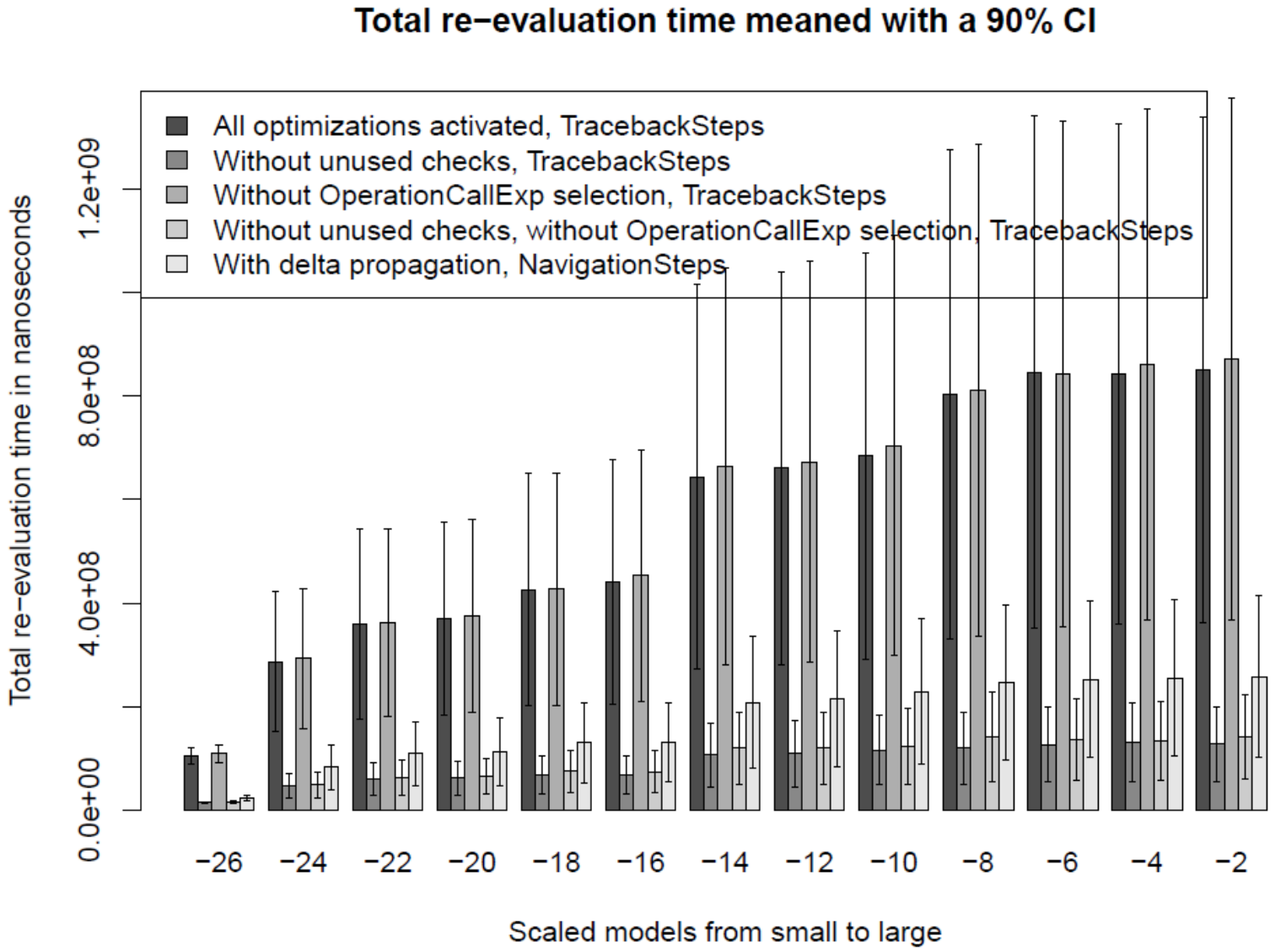
Changes in Unused Subexpressions

- If subexpressions are **not used** to determine the result of the overall expressions changes to them do not impact the overall result.
- Example:

```
context Department inv: if self.name = 'Boss'
then self.budget < 20 000
else self.sumBudget() < 10 000
endif
```

  - If a department's name is „Boss", a change to the subDepartments property will not affect the result of the constraint

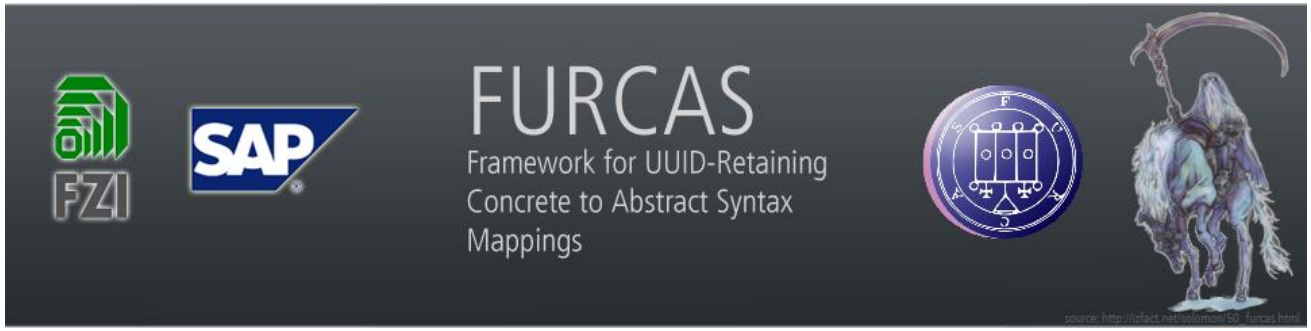
Evaluation



Evaluation (2)

- Results at a glance:
  - Traceback implementation significantly faster than naive approach.
  - Partial Evaluation and Delta Propagation have a great positive impact on performance.
  - Unused Subexpressions Check requires a lot of additional partial evaluations which do not amortise

Application Scenario



- FURCAS language workbench (www.furcas.org) [1]
- OCL-based attribute grammar
- OCL used for queries and attribute computation
- Changes in one part of the model need to be propagated to dependent parts using Impact Analysis
- Other features of FURCAS:
  - View-based modelling for textual languages
  - Decorator model for textual views allows for separation of model content and textual representation

Conclusions & Future Work

- OCL Impact Analysis allows to efficiently re-evaluate OCL expressions over larger models.
- Optimisations additionally positively influence IA performance.
- Impact Analysis implementation available at:
  - Indigo Update Site:
    - Modeling – OCL Examples and Editors
  - Then see bundle org.eclipse.ocl.examples.impactanalyzer
- Future Work
  - Promote from examples/ to plugins/ after Eclipse Indigo
  - Extract OCL attribute grammar component from FURCAS

References

[1] Thomas Goldschmidt. View-Based Textual Modelling. PhD thesis, Karlsruhe Institute of Technology, 2010. to appear