Enriching Your Models with OCL

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canarias
OBJETIVO de PROGRESO

Unión Europea
Fondo Social Europeo

Made available under EPL v1.0

Overview

MDT/OCL team

- Why and When OCL
- Introduction to OCL
- OCL within Eclipse
- OCL Use Cases, coming soon

SAP

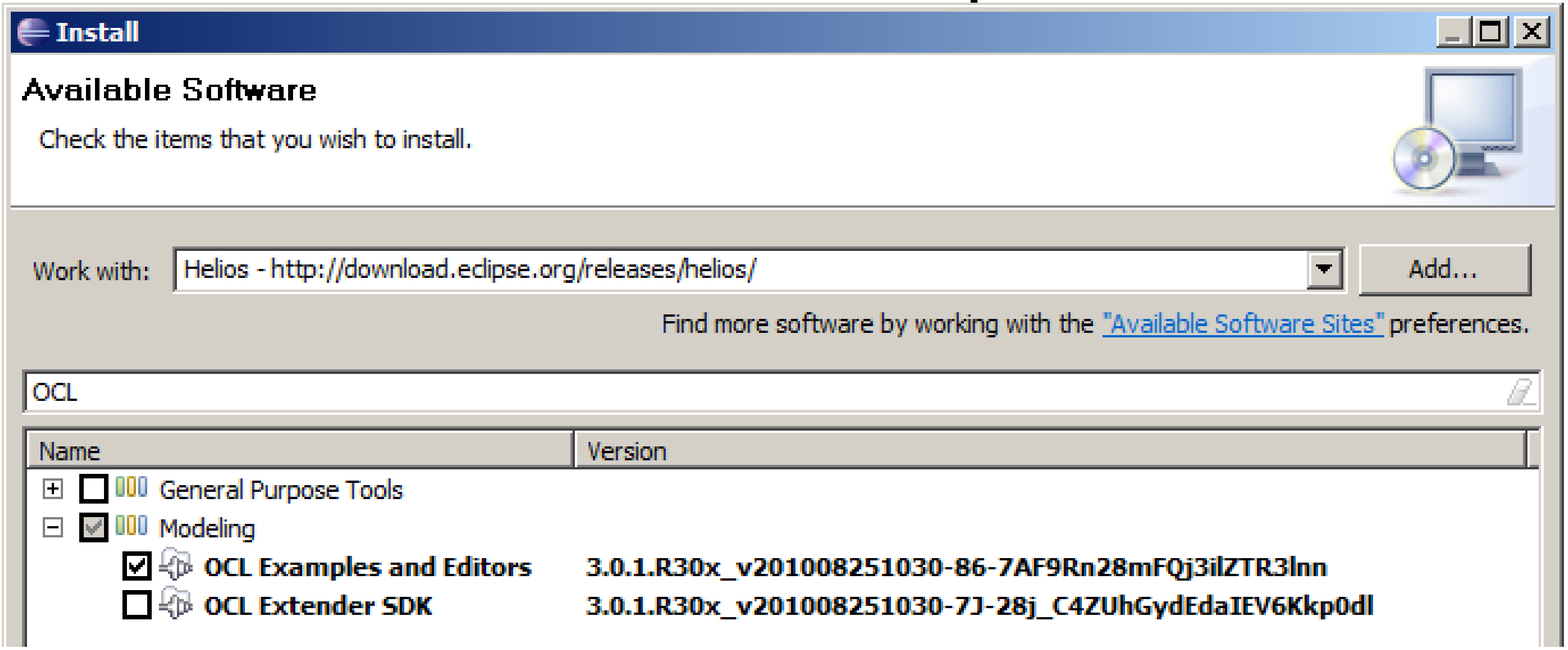
- OCL application

Follow Along

http://www.eclipsecon.org/summiteurope2010/sessions/?page=sessions&id=1710

links to slides and to zip file comprising, model,edit,editor,diagram projects

- Install MDT/OCL 3.0.1 Examples and Editors



Install

Available Software

Check the items that you wish to install.

Work with: Helios - http://download.eclipse.org/releases/helios/

Add...

Find more software by working with the "Available Software Sites" preferences.

OCL

Name	Version
☐ General Purpose Tools	
☑ Modeling	
☑ OCL Examples and Editors	3.0.1.R30x_v201008251030-86-7AF9Rn28mFQj3ilZTR3lnn
☐ OCL Extender SDK	3.0.1.R30x_v201008251030-7J-28j_C4ZUhGydEdaIEV6Kkp0dl

- Import ... Existing Projects from Archive
  - ESEExampleTree/model/People1.ecore
- Run nested Eclipse, Import ESEExampleTree
  - ESEExampleTree/model/default.people_diagram

How Much OCL?

None

- Very simple modeling
- Java augmented modeling

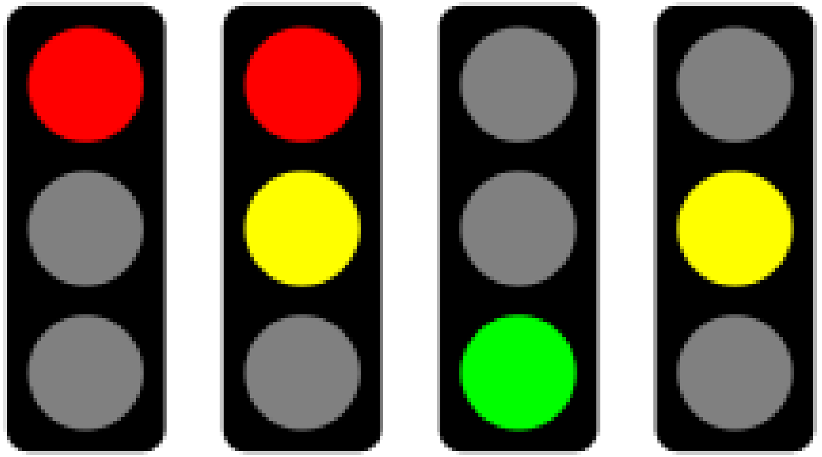
A little

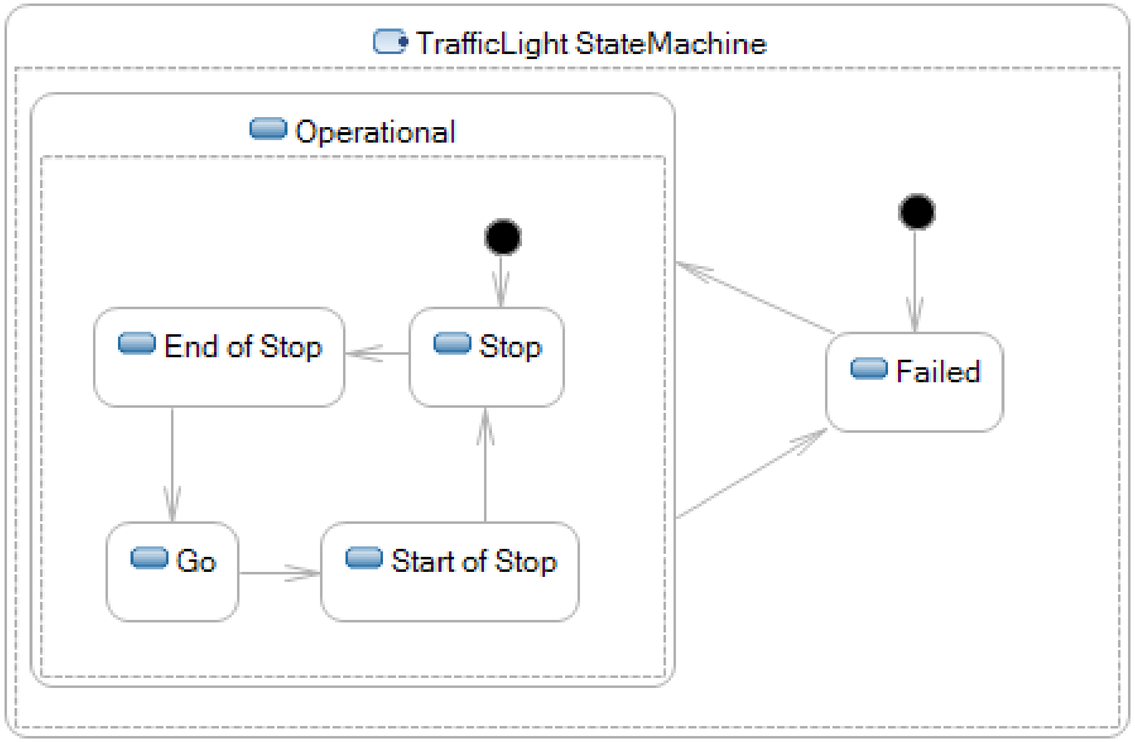
- OCL (and Java) augmented modeling

A lot

- OCL as a powerful formal specification language
  - OMG's UML, OCL, QVT, ... specifications
- OCL as the foundation of a transformation language
  - MOFM2T (Acceleo), QVT
- OCL as a portable implementation language

UML State Machines





- Need to specify behavior
  - amber when End of Stop or Start of Stop
  - transition when signal received/time elapsed

UML Solutions

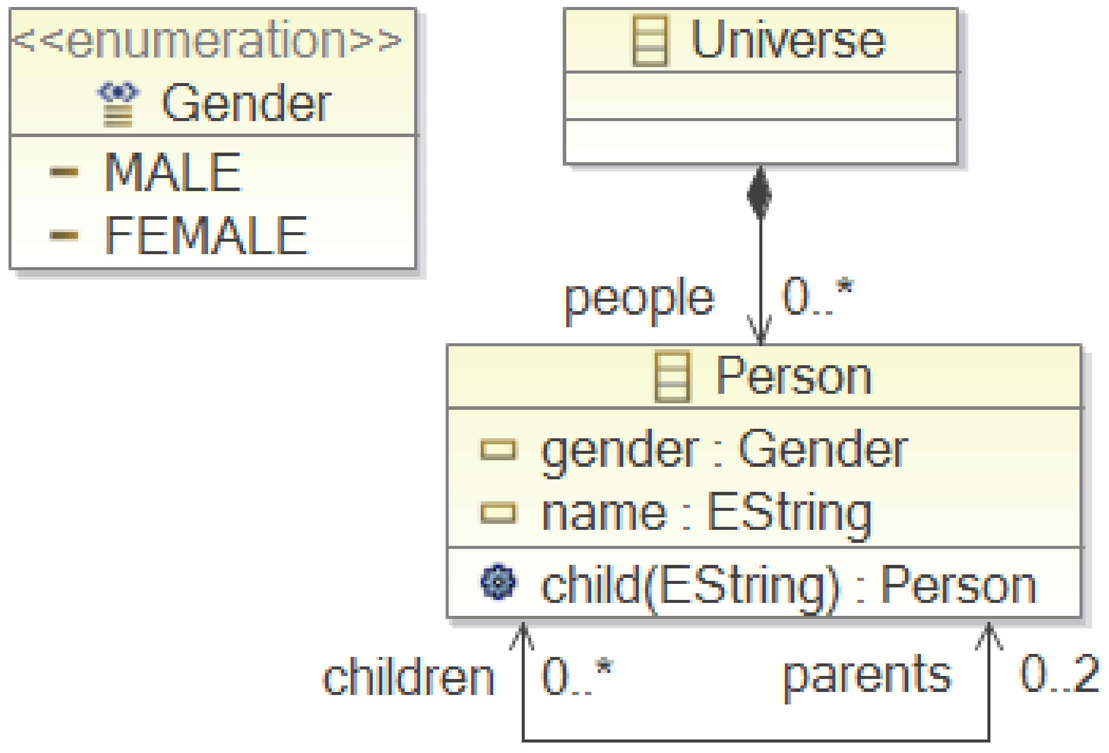
UML 1.x Use your favourite programming language

- Ada/C/...
- Magically inserted by proprietary code generator

UML 2.x Use a neutral specification language

- The Object Constraint Language
  - State machine guards/actions
  - Class invariants
  - Operation bodies, pre/post conditions
  - Property initial/derived values

Simple Meta-Modeling

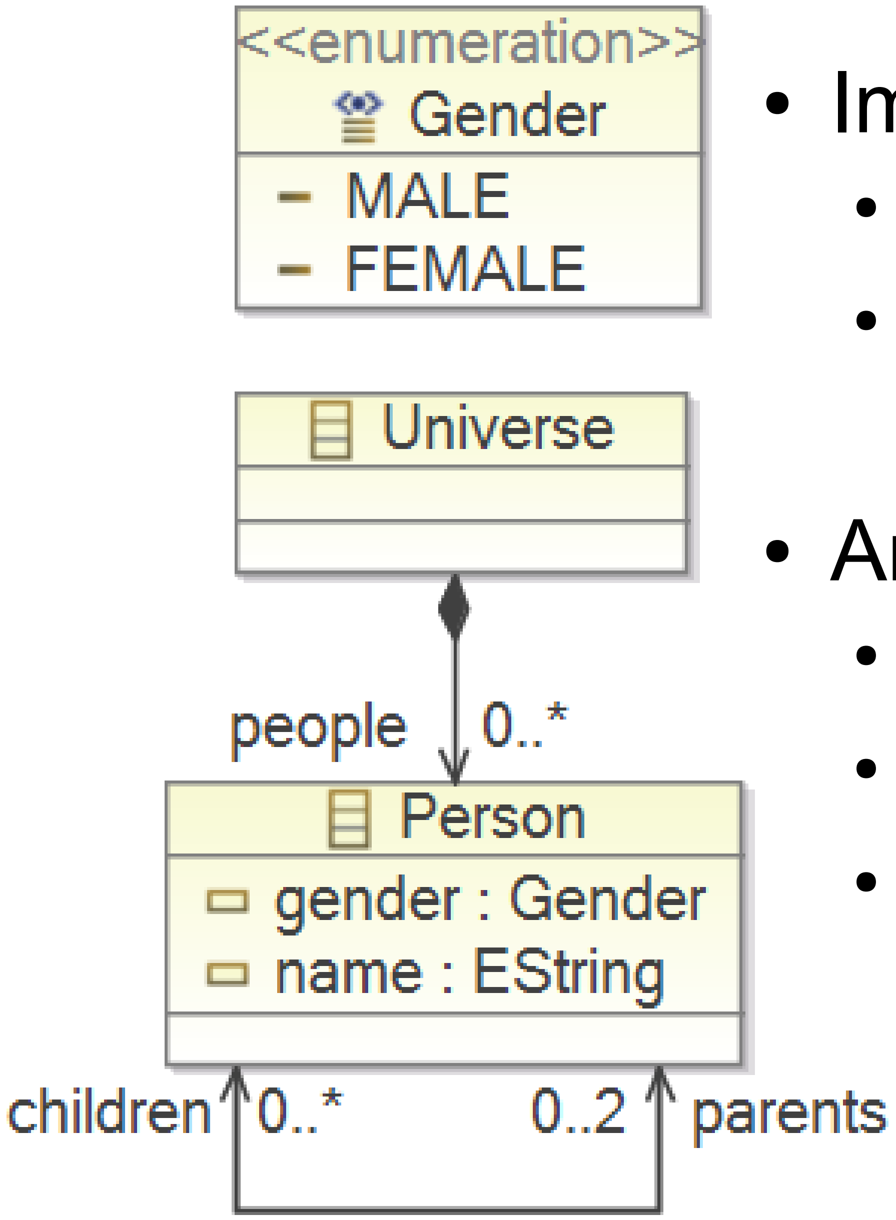


Example Family Tree Meta-Model
Ecore Diagram
(similar to UML Class Diagram)

Graphics
- Box
  - Class, enumeration
- Compartment
  - Property, operation
- Line
  - Association
- Decoration
  - Composition, navigability

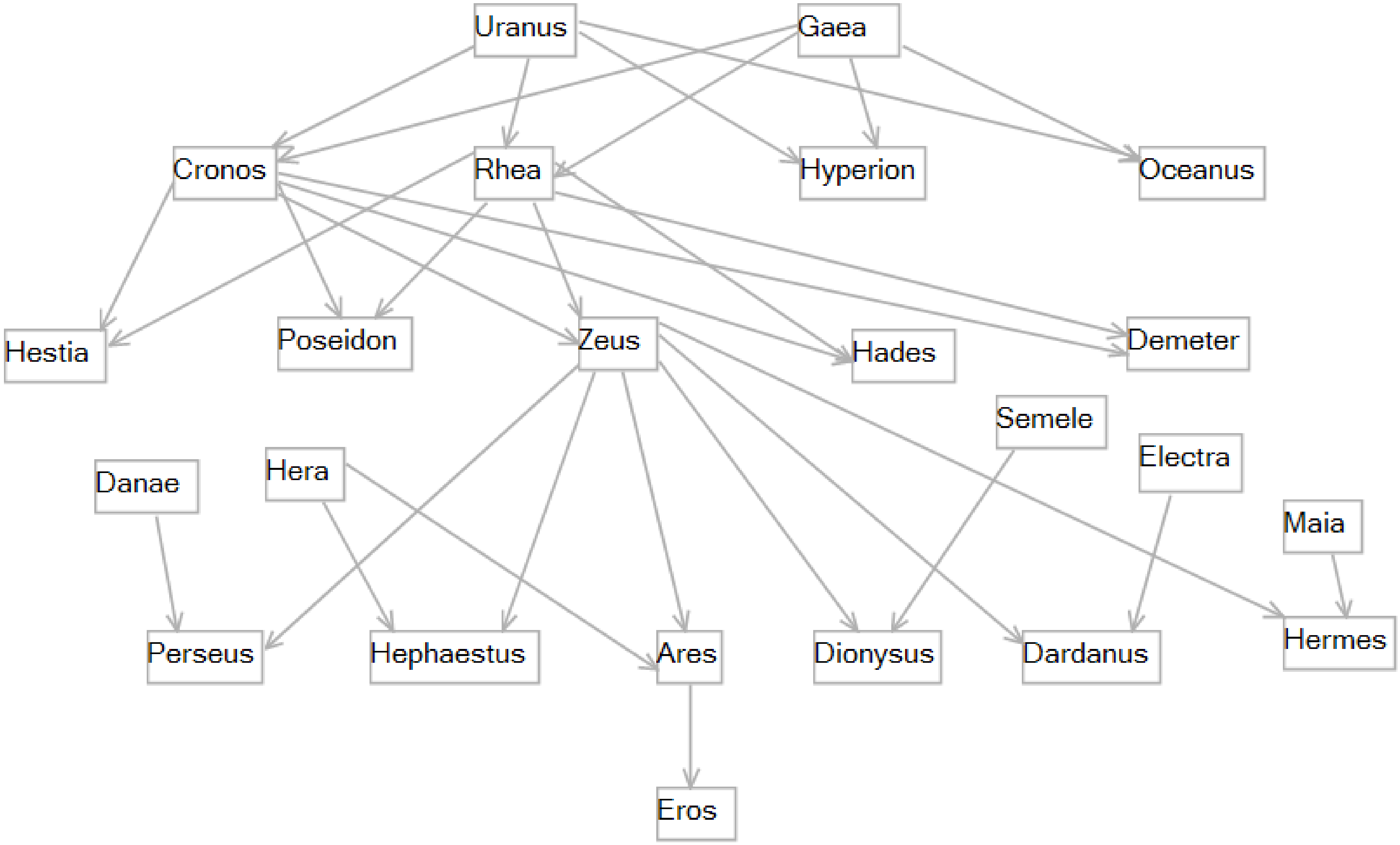
Text
- Name, type, stereotype
- Multiplicity

Richer Meta-Modelling



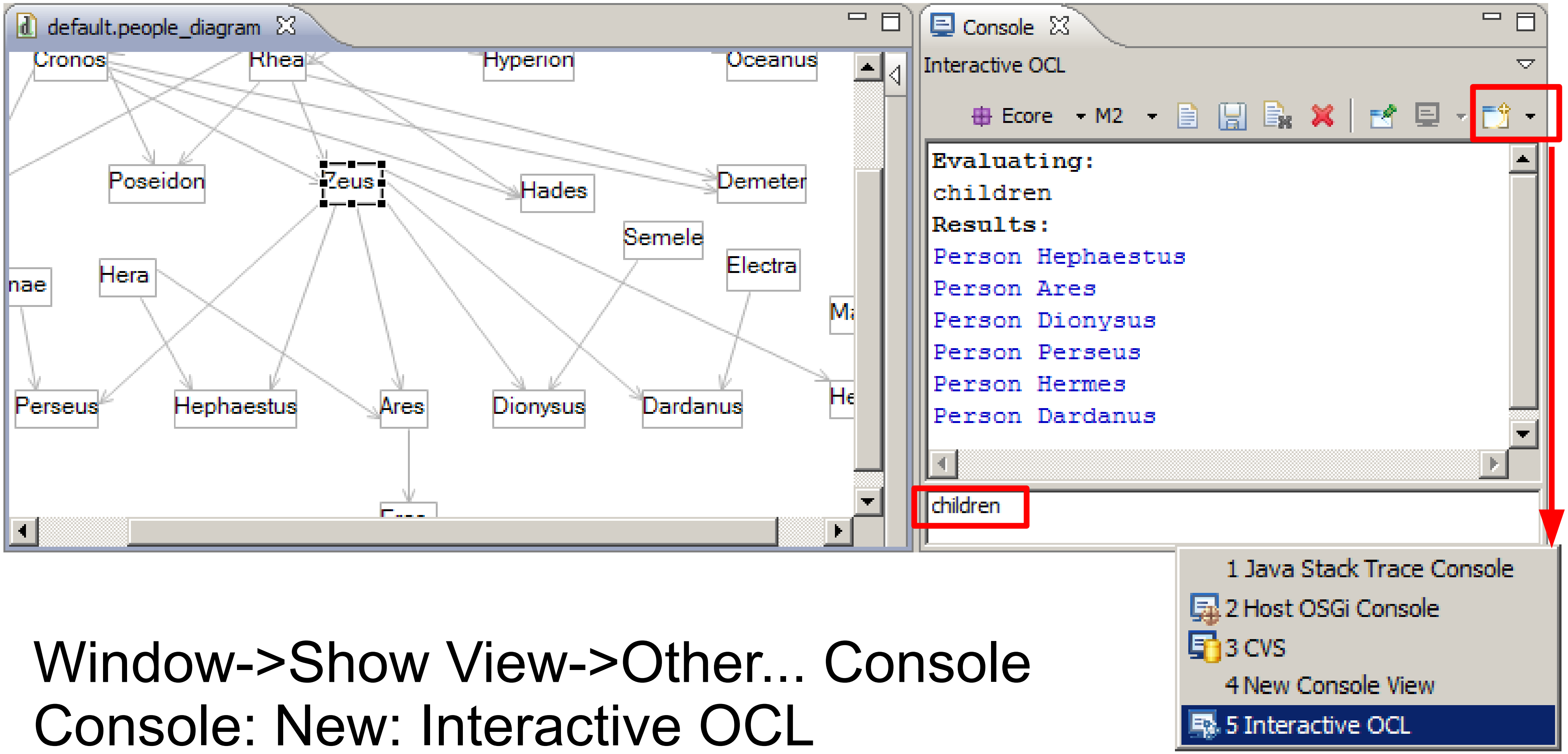
- Implicit constraints
  - Up to 2 parents
  - MALE/FEMALE gender
- Arbitrary constraints
  - At least 5 characters in name
  - 1 MALE, 1 FEMALE parent
  - Self is not an ancestor of self

Example Family Tree Model



Simple GMF Diagram Editor

Simple Query Evaluation



```
Evaluating:
children
Results:
Person Hephaestus
Person Ares
Person Dionysus
Person Perseus
Person Hermes
Person Dardanus
```

```
children
```

Window->Show View->Other... Console
Console: New: Interactive OCL
Select **`Zeus`** as the Model Context (in any model editor)
Type **`children`** then carriage return

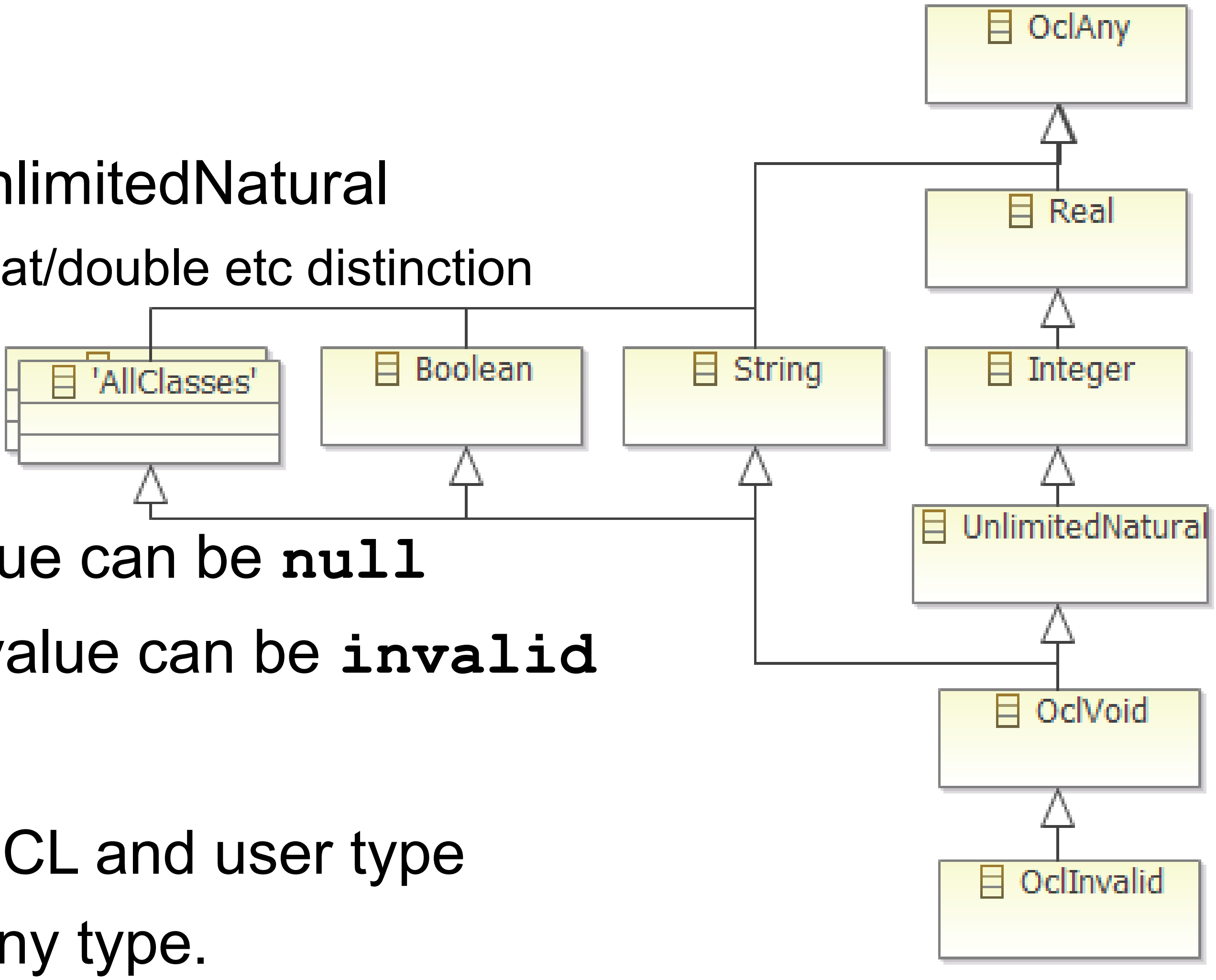
OCL Principles

- Natural/Formal Language compromise
  - natural language error prone
  - formal language unapproachable to many

- Specification (not Programming) Language
  - declarative, modeling language
  - side effect free, no model changes, atomic execution
  - strongly typed, using UML generalization
  - portable

OCL Object Types

- Primitive Types
  - Boolean, String
  - Real, Integer, UnlimitedNatural
    - unlimited; no float/double etc distinction
- Bottom Types
  - OclVoid: any value can be **`null`**
  - OclInvalid: any value can be **`invalid`**
- Top Type
  - OclAny: every OCL and user type conform to OclAny type.



Mathematical Operators

Infix: +, -, *, /
and, or, xor, implies
=, <>, <, >, <=, >= nb =, <>

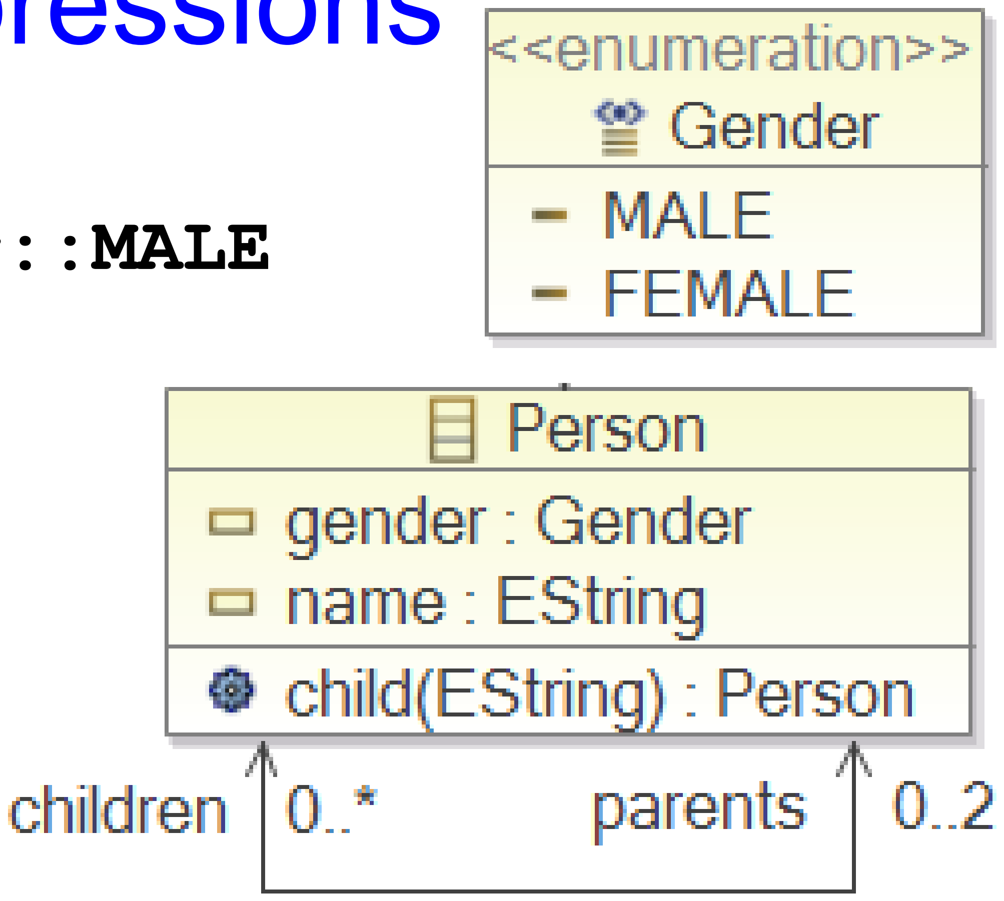
Prefix: not, -

```
4.0 * -5
'a' + 'b'
```

Operators: mod, div, max, min, ...

```
4.max(5)
```

OCL Expressions



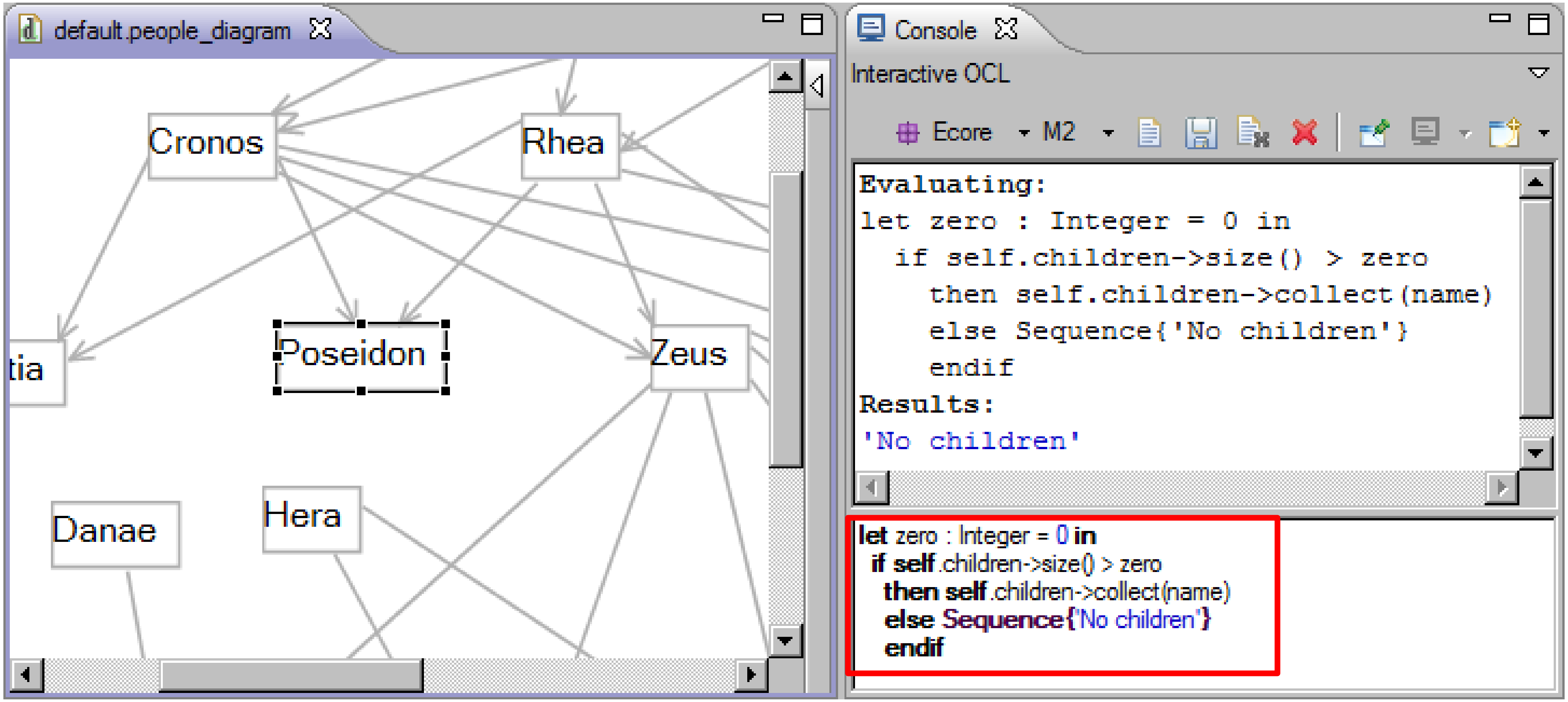
- If Expressions

```
if gender = Gender::MALE
then 'he'
else 'she'
endif
```

- Let Expressions

```
let jack : Person = child('Jack'),
    jill : Person = child('Jill')
in jack <> null and jill <> null
```

More Complex Query



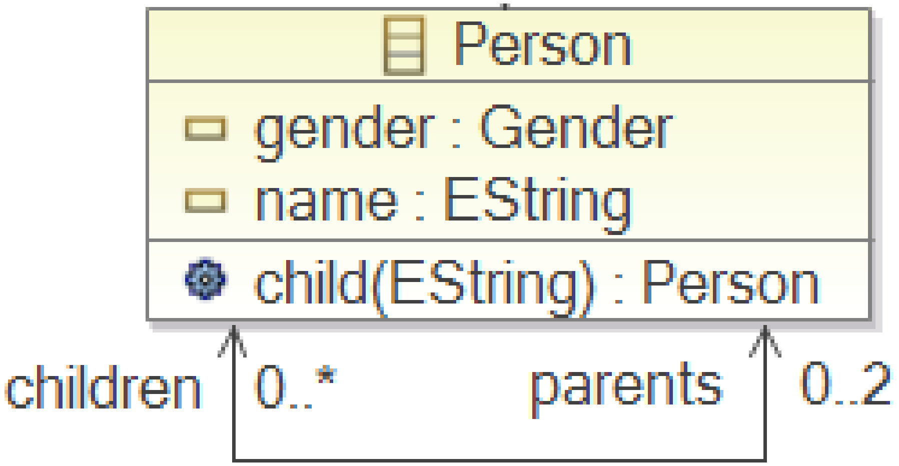
```
Evaluating:
let zero : Integer = 0 in
  if self.children->size() > zero
    then self.children->collect(name)
    else Sequence{'No children'}
    endif
Results:
'No children'
```

```
let zero : Integer = 0 in
  if self.children->size() > zero
   then self.children->collect(name)
   else Sequence{'No children'}
   endif
```

Selecting *Poseidon* defines the implicit context variable

`self : Person =` ***`Poseidon`***

Object Navigation



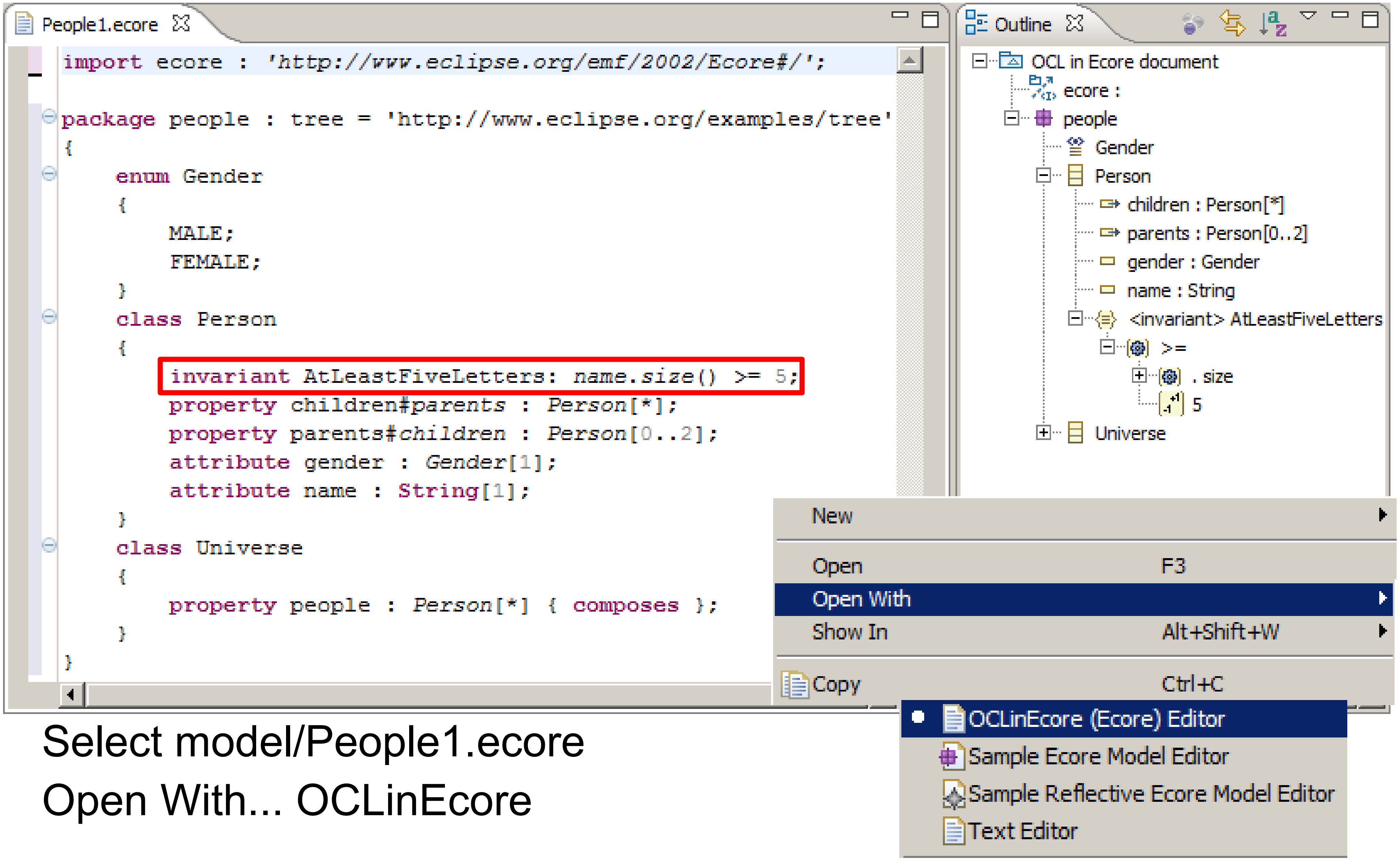
Properties

- **`self.name`** or just **`name`**
  (cf. **`this.getName()`** or **`getName()`**)

Operations

- **`self.child('John')`** or just **`child('John')`**
  (cf. **`this.child('John')`** or **`child('John')`**)

The OCLinEcore Editor



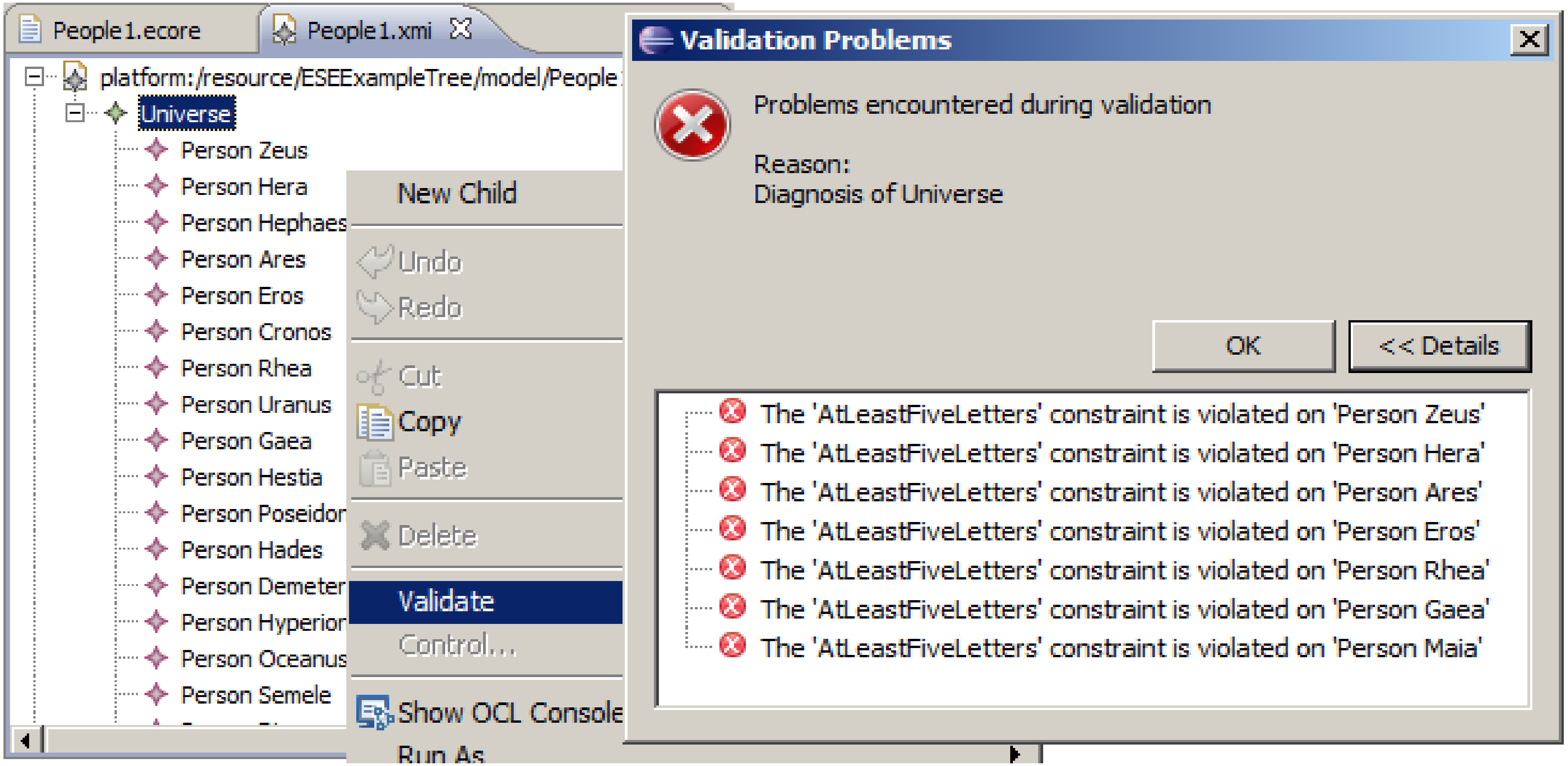
```
import ecore : 'http://www.eclipse.org/emf/2002/Ecore#/';

package people : tree = 'http://www.eclipse.org/examples/tree'
{
    enum Gender
    {
        MALE;
        FEMALE;
    }
    class Person
    {
        invariant AtLeastFiveLetters: name.size() >= 5;
        property children#parents : Person[*];
        property parents#children : Person[0..2];
        attribute gender : Gender[1];
        attribute name : String[1];
    }
    class Universe
    {
        property people : Person[*] { composes };
    }
}
```

Select model/People1.ecore

Open With... OCLinEcore

Example Validation Failure



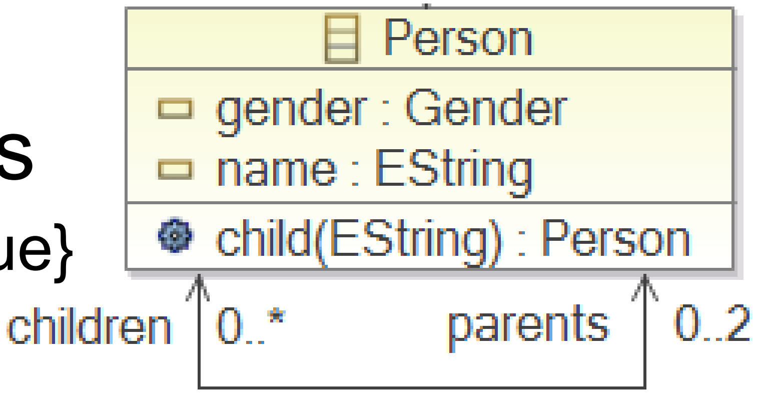
Problems encountered during validation

Reason:
Diagnosis of Universe

The 'AtLeastFiveLetters' constraint is violated on 'Person Zeus'
The 'AtLeastFiveLetters' constraint is violated on 'Person Hera'
The 'AtLeastFiveLetters' constraint is violated on 'Person Ares'
The 'AtLeastFiveLetters' constraint is violated on 'Person Eros'
The 'AtLeastFiveLetters' constraint is violated on 'Person Rhea'
The 'AtLeastFiveLetters' constraint is violated on 'Person Gaea'
The 'AtLeastFiveLetters' constraint is violated on 'Person Maia'

Open model/People1.xmi with Sample Ecore Editor
Select Universe, Right button menu, Validate

Multiplicities and Collections



Meta-models specify multiplicities

- children : Person[*] {ordered,unique}
- parents : Person[0..2] {unique}

• multiplicities are specification concepts; not objects

Implementations (e.g. Ecore) reify multiplicities

- getChildren() returns a UniqueEList<Person>

• 'many' properties have extra implementation objects

- getName() setName(newName)
- getChildren().get(2) getChildren().add(newChild)

OCL needs more than just UML multiplicities

OCL 2.0 Collections

Typed Collections partially reify multiplicities

Collection(T)	Unordered	Ordered
Non-Unique	Bag(T)	Sequence(T)
Unique	Set(T)	OrderedSet(T)

Collections are different to objects

Navigation from a Collection uses ->

- [Navigation from an Object (OclAny) uses .]

Collections have type parameters

Collections have useful operations

Collections have very useful iterations

Example Collection Operations

Collection::size() `self.children->size()`

'get'

Sequence::at(Integer) `self.children->at(1)`

– nb **`1`** is the first index, **`size()`** is the last

'add'

Collection(T)::including(T) : Collection(T)

– returns a new collection with added content

'contains'

Collection(T)::includes(T) : Boolean

– tests existing content

Collection::select iteration

- children

```
self.children
```

- sons

```
self.children->select(gender = Gender::MALE)
self.children->select(child | child.gender = Gender::MALE)
self.children->select(child : Person | child.gender = Gender::MALE)
```

- select(iterator : type | body)
  - filters to select elements for which the body is true
- reject(iterator : type | body)
  - filters to reject elements for which the body is true
- cf multi-line Java loop

Collection::collect iteration

- Children

```
self.children
```

- Grandchildren

```
self.children->collect(children)
self.children->collect(child | child.children)
self.children->collect(child : Person | child.children)
```

- collect(iterator : type | body)
  - creates a new collection comprising all the bodies
- any, exists, forAll, isUnique, iterate, one,

OCL Navigation Operators

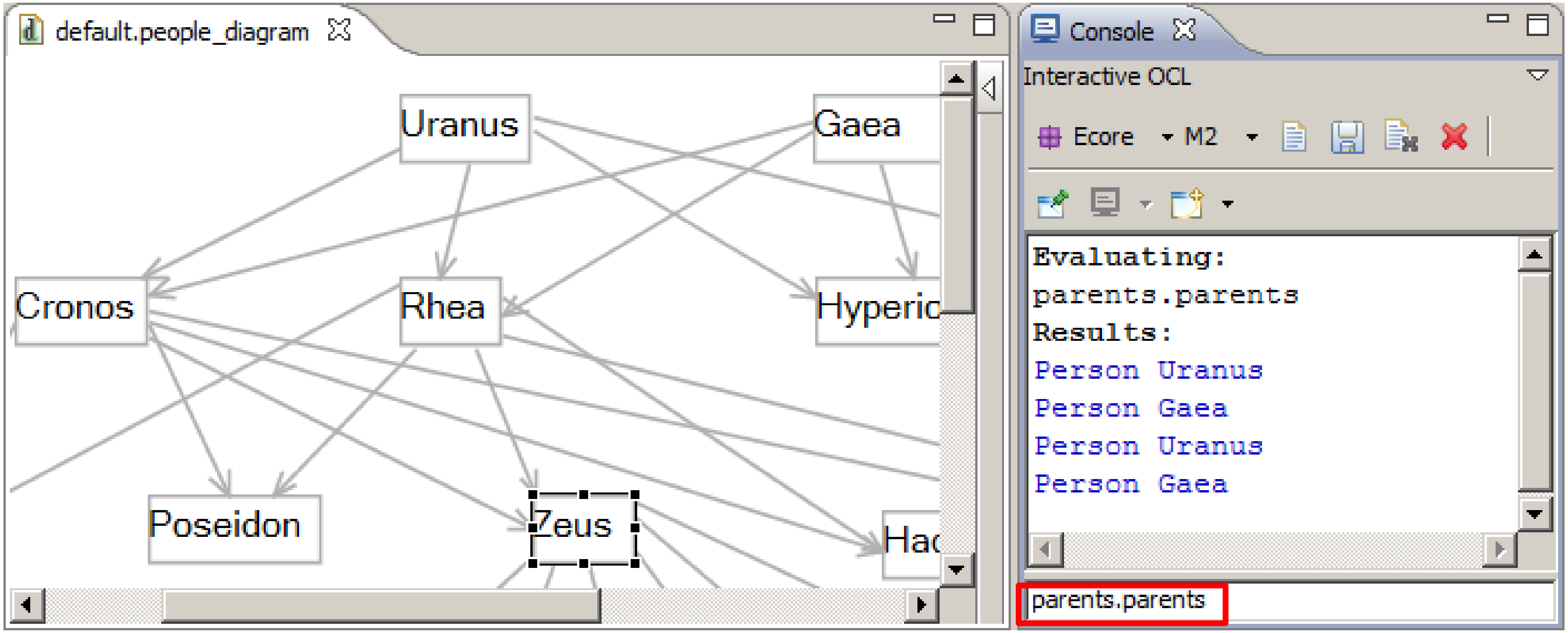
`anObject. ...`	object navigation
`aCollection-> ...`	collection navigation

	Object	Collection
`.`	Navigation	?
`->`	?	Navigation

Shorthands

`aCollection. ...`	implicit collect
`anObject-> ...`	implicit collection

Implicit Collect Query



```
Evaluating:
parents.parents
Results:
Person Uranus
Person Gaea
Person Uranus
Person Gaea
```

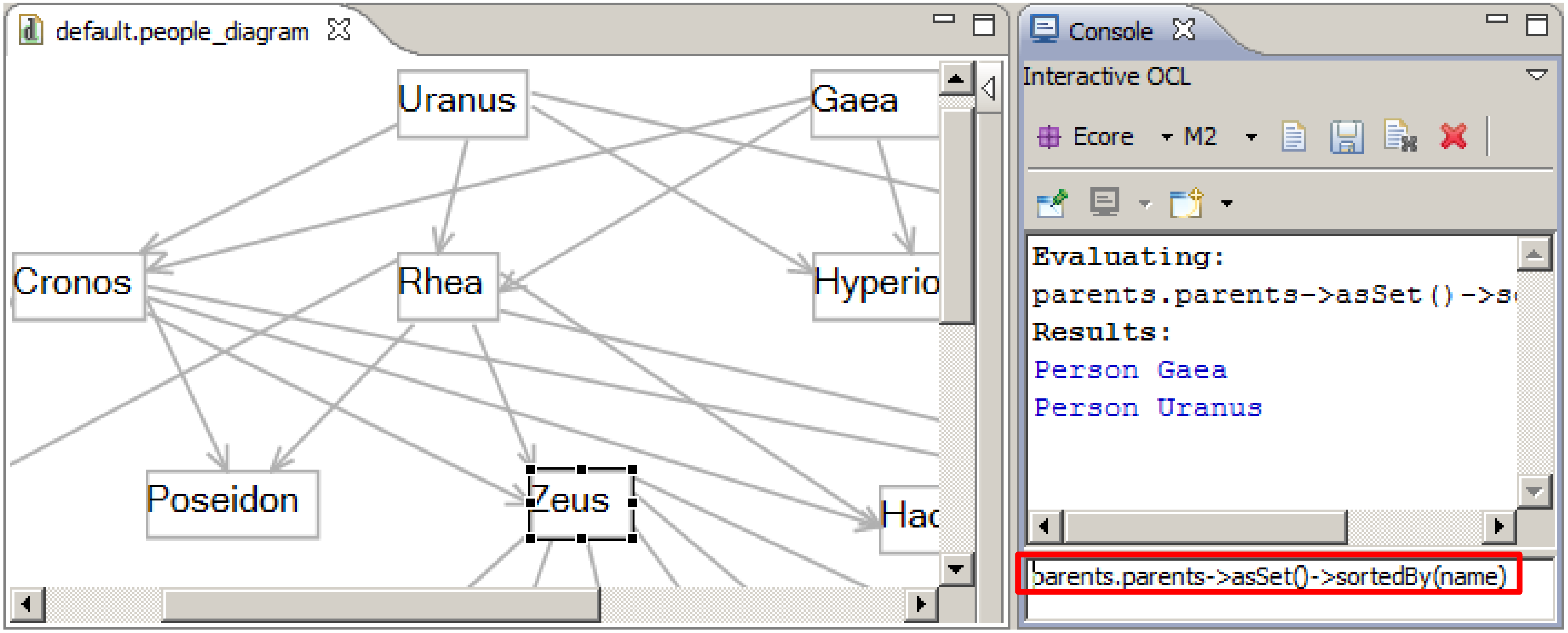
```
parents.parents
```

`parents.parents = parents->collect(parents)`

3 symbols, compared to 4 lines of Java

4 grandparents, but not all different!

Cleaned up query



```
Evaluating:
parents.parents->asSet()->s
Results:
Person Gaea
Person Uranus
```

```
parents.parents->asSet()->sortedBy(name)
```

`parents.parents->asSet()->sortedBy(name)`

`->asSet()` converts to Set(Person), removes duplicates

`->sortedBy(name)` alphabeticizes

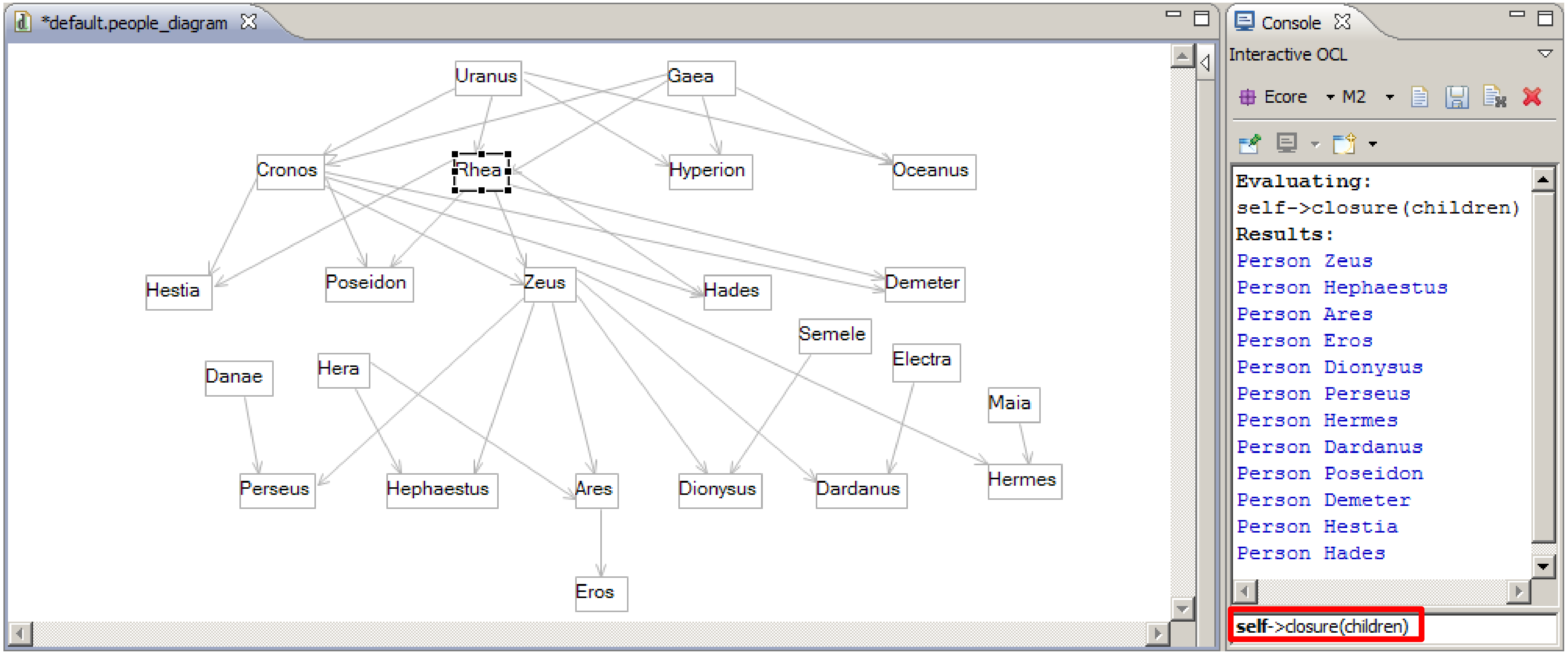
Implicit Collection Conversion

	Object	Collection
.	Navigation	Implicit collect()
->	Implicit Collection	Navigation

self->notEmpty()

- Standard OCL idiom
  - Converts self (if an object) to a Collection of self
  - If self is a defined object
    - Implicit collection is not empty - true
  - If self is an undefined object (null)
    - Implicit collection is empty - false
  - If self is an error (invalid)
    - Implicit collection is also an error - invalid

Collection::closure iteration



```
Evaluating:
self->closure(children)
Results:
Person Zeus
Person Hephaestus
Person Ares
Person Eros
Person Dionysus
Person Perseus
Person Hermes
Person Dardanus
Person Poseidon
Person Demeter
Person Hestia
Person Hades
```

```
self->closure(children)
```

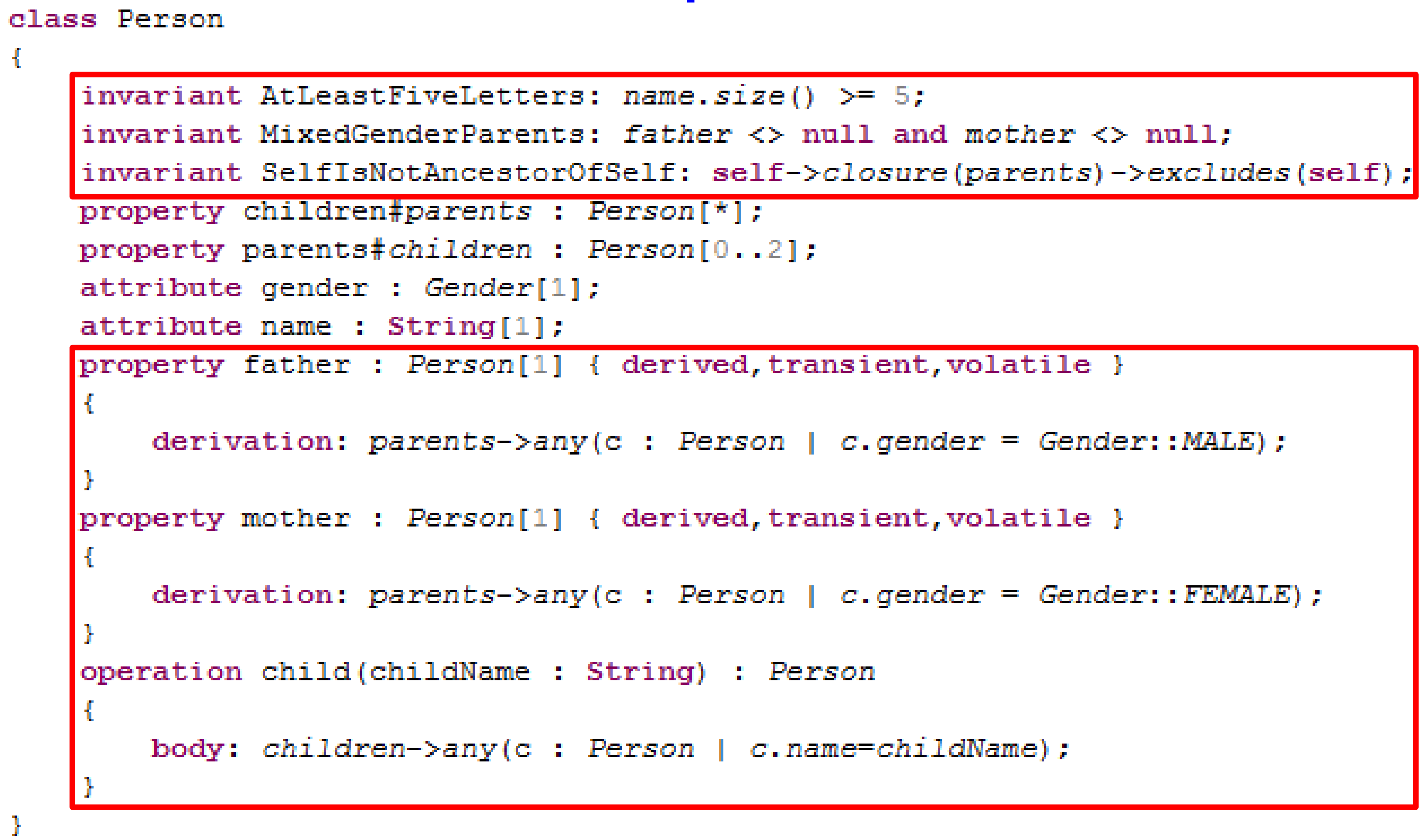
- children, grandchildren, greatgrandchildren etc

```
self->closure(children)
```

- Implicit collection of self, then closure of all children

[closure in MDT/OCL 1.2, probably in OMG OCL 2.3]

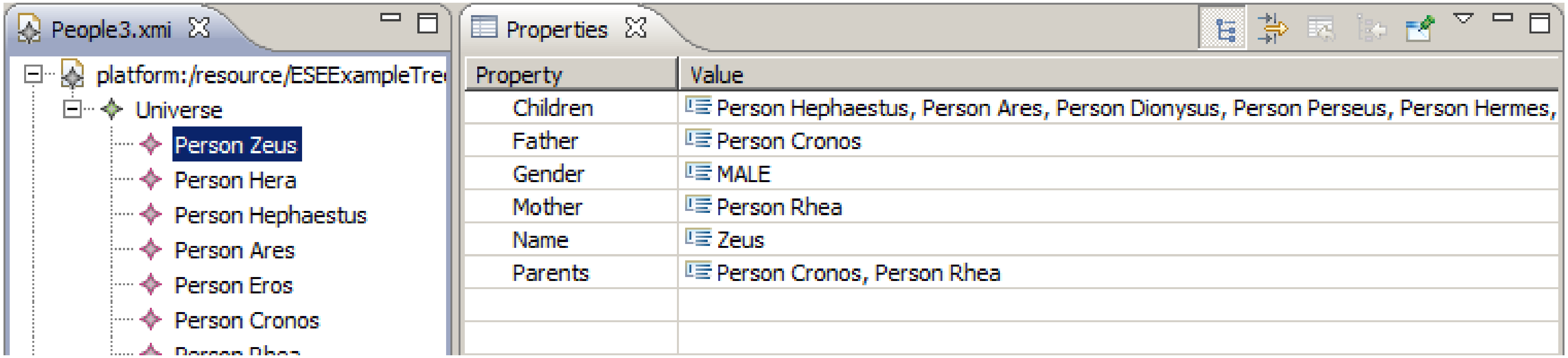
OCL as Implementation



```
class Person
{
    invariant AtLeastFiveLetters: name.size() >= 5;
    invariant MixedGenderParents: father <> null and mother <> null;
    invariant SelfIsNotAncestorOfSelf: self->closure(parents)->excludes(self);
    property children#parents : Person[*];
    property parents#children : Person[0..2];
    attribute gender : Gender[1];
    attribute name : String[1];
    property father : Person[1] { derived,transient,volatile }
    {
        derivation: parents->any(c : Person | c.gender = Gender::MALE);
    }
    property mother : Person[1] { derived,transient,volatile }
    {
        derivation: parents->any(c : Person | c.gender = Gender::FEMALE);
    }
    operation child(childName : String) : Person
    {
        body: children->any(c : Person | c.name=childName);
    }
}
```

`any(x)` iteration selects an arbitrary element for which x is true.

Derived Properties

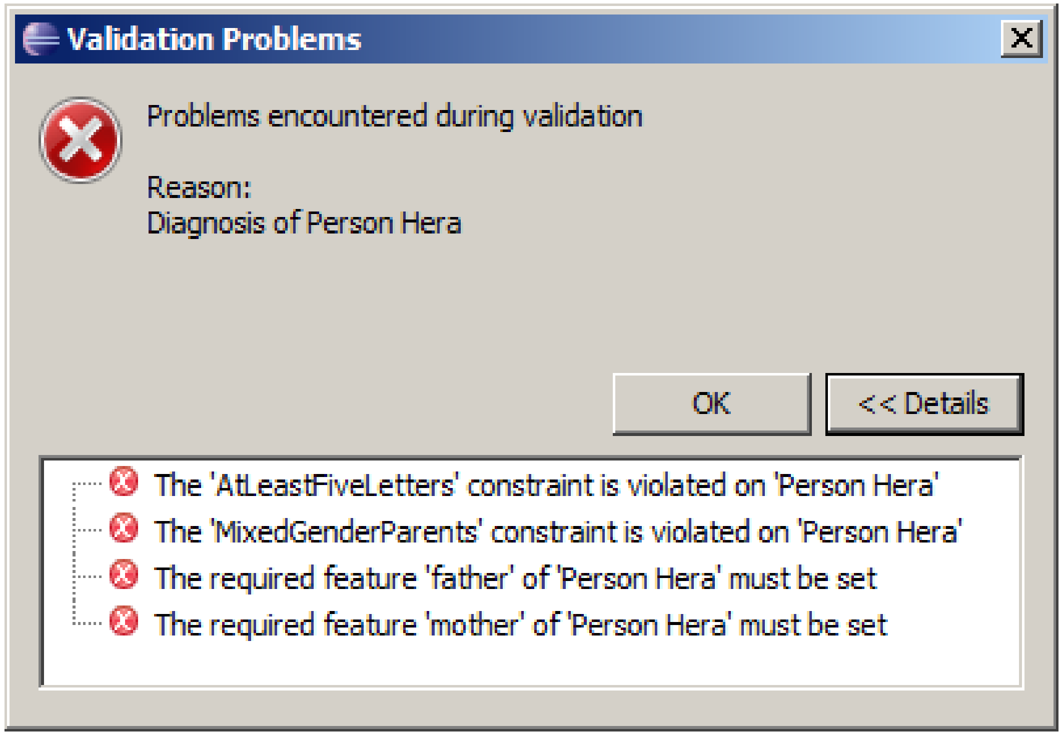


People3.xmi

- platform:/resource/ESEExampleTre
  - Universe
    - Person Zeus
    - Person Hera
    - Person Hephaestus
    - Person Ares
    - Person Eros
    - Person Cronos

Properties

Property	Value
Children	Person Hephaestus, Person Ares, Person Dionysus, Person Perseus, Person Hermes,
Father	Person Cronos
Gender	MALE
Mother	Person Rhea
Name	Zeus
Parents	Person Cronos, Person Rhea



Validation Problems

Problems encountered during validation

Reason:
Diagnosis of Person Hera

- The 'AtLeastFiveLetters' constraint is violated on 'Person Hera'
- The 'MixedGenderParents' constraint is violated on 'Person Hera'
- The required feature 'father' of 'Person Hera' must be set
- The required feature 'mother' of 'Person Hera' must be set

For Hera

```
invariant MixedGenderParents:
father.gender <>
mother.gender;
```

fails because father is **`null`** and mother is **`null`**

Other OCL Capabilities

No time to mention

- Other iterators, operations
- Tuples
- Association Classes/Qualifiers
- @pre values
- Messages
- States

OMG OCL Progress

OCL 2.2 (current) Collections are objects!

- Collection conforms to OclAny
- No need for Collection/Object polymorphic operations
- Collections can mix Object/Collection content

? OCL 2.4 Specification defined by models

- Auto-generated by Acceleo
- Fix too many consistency/typo/realizability issues
- Aligned with UML 2.4, MOF 2.4, XMI 2.4

Eclipse committers active on OMG RTF

Eclipse MDT/OCL

OMG OCL 1.x
EMFT/OCL 1.0

- Original code contribution by IBM
- Java callable API
  - Parse/evaluate OCL 1.x against Ecore meta-models

OMG OCL 2.0
MDT/OCL 1.2

- Ecore or UML meta-models
- OCL 2.0 (in so far as possible)
- Example Interactive Console

OMG OCL 2.2
MDT/OCL 3.0

- towards OCL 2.2
- Example Xtext editors (Ecore only)

Validation History

Use of OCL to define model validation

Eclipse 3.2

- EMF Validation Framework
  - Embed OCL in XML CDATA

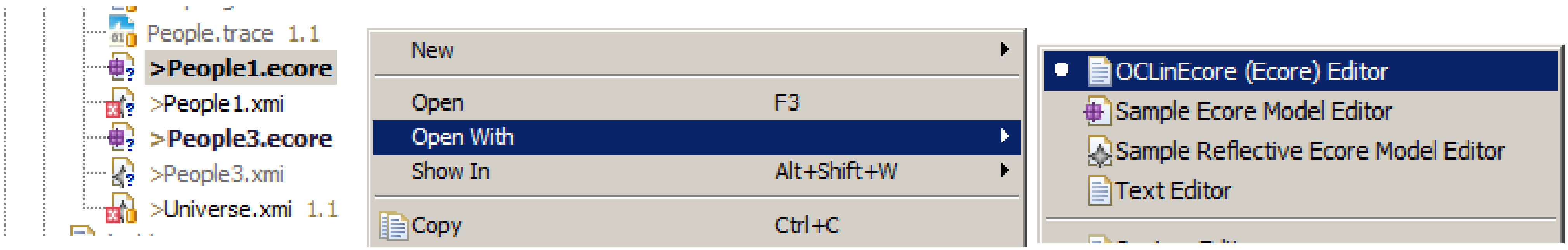
Eclipse 3.3

- EMF, OCL EAnnotations
  - Embed OCL in EAnnotation
  - Genmodel to integrate

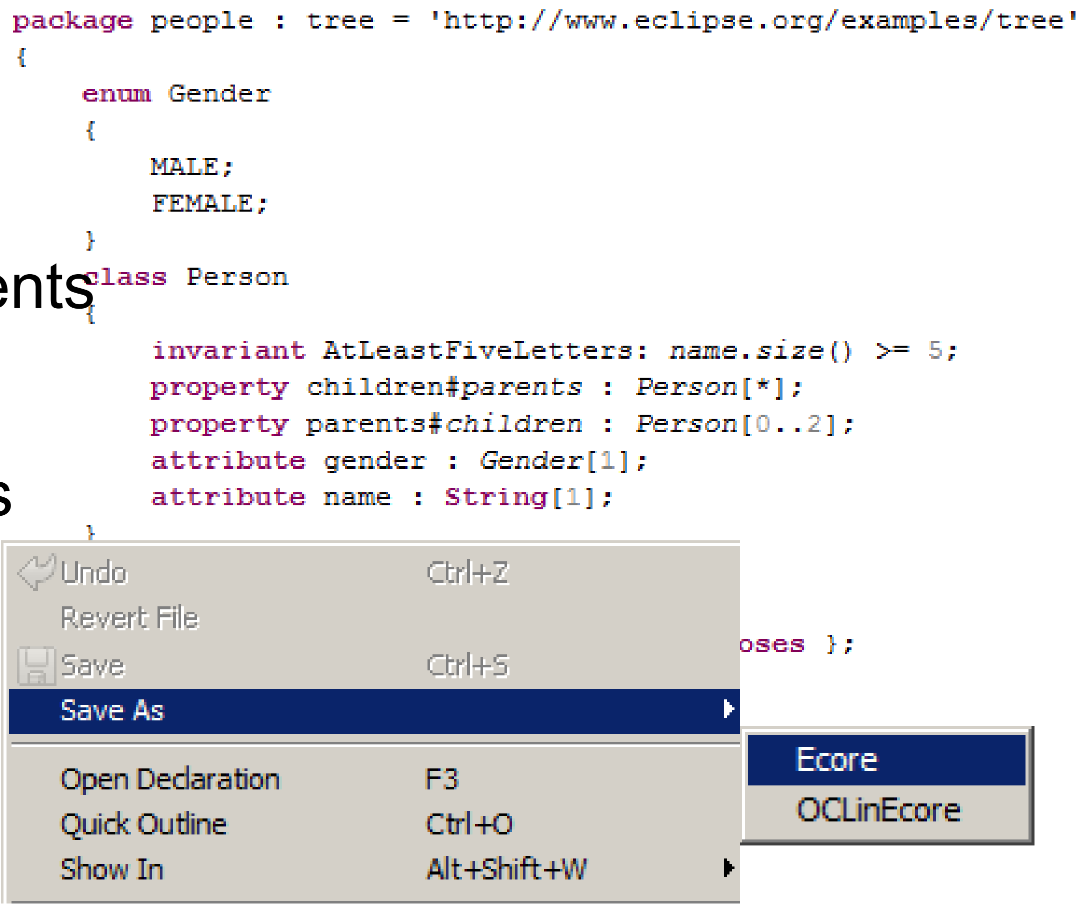
Eclipse 3.6
EMF 2.6
MDT/OCL 3.0

- Delegates
  - Embed OCL in EAnnotation
  - EObject.eInvoke() for dynamic invocation
  - OCLinEcore editor for semi-validated editing

OCLinEcore Editor

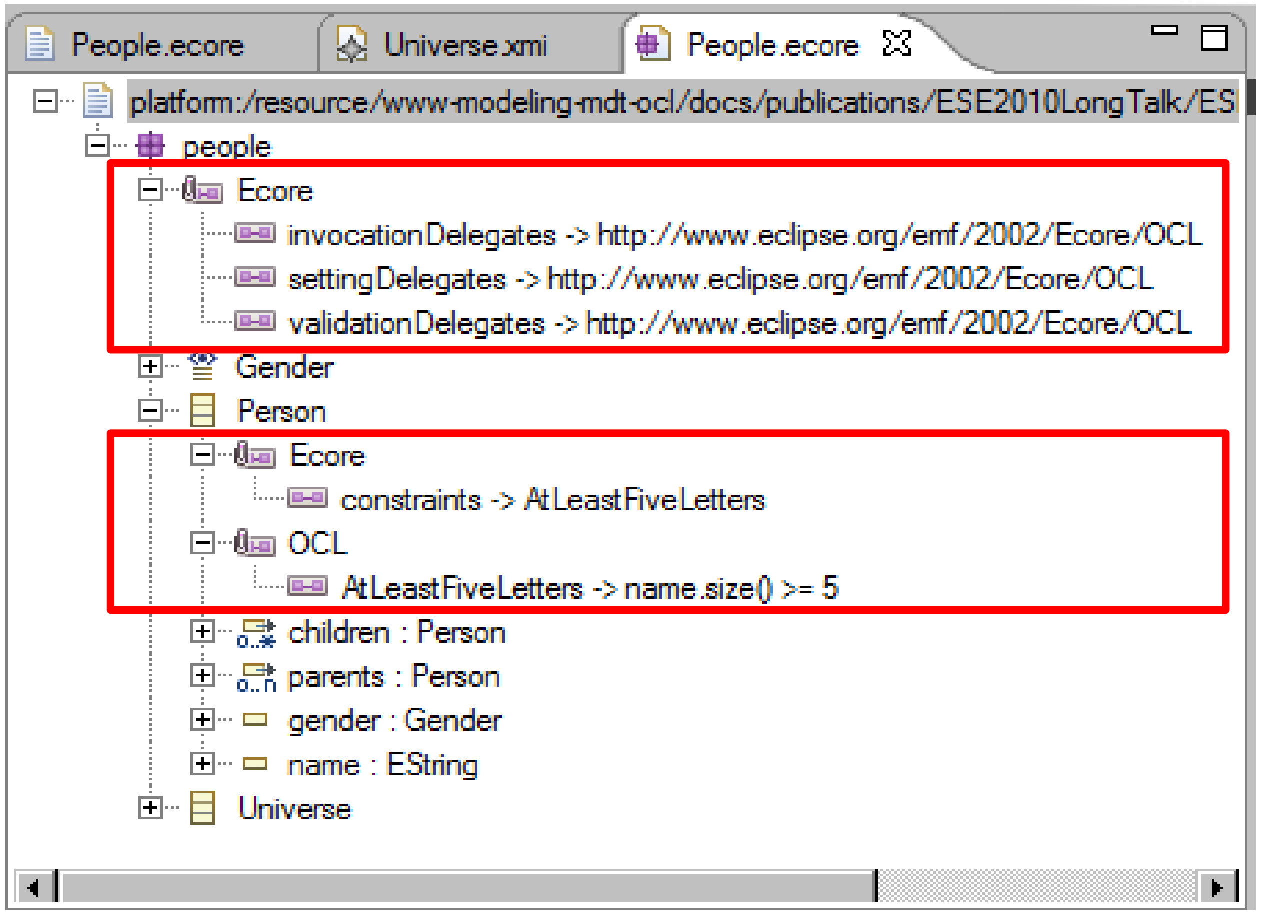


- Open with -> OCLinEcore
- Save As *.ecore
  - Loses formatting and comments
- Save As *.oclinecore
  - Text file preserves comments
- Useful for plain Ecore too:
  - Printable/reviewable text
  - Searchable/replaceable text



```
package people : tree = 'http://www.eclipse.org/examples/tree'
{
    enum Gender
    {
        MALE;
        FEMALE;
    }
    class Person
    {
        invariant AtLeastFiveLetters: name.size() >= 5;
        property children#parents : Person[*];
        property parents#children : Person[0..2];
        attribute gender : Gender[1];
        attribute name : String[1];
    }
                                                    oses };
```

Validation in Sample Ecore Editor


People.ecore | Universe.xmi | People.ecore

```
platform:/resource/www-modeling-mdt-ocl/docs/publications/ESE2010LongTalk/ES
  people
    Ecore
      invocationDelegates -> http://www.eclipse.org/emf/2002/Ecore/OCL
      settingDelegates -> http://www.eclipse.org/emf/2002/Ecore/OCL
      validationDelegates -> http://www.eclipse.org/emf/2002/Ecore/OCL
    Gender
    Person
      Ecore
        constraints -> AtLeastFiveLetters
      OCL
        AtLeastFiveLetters -> name.size() >= 5
      children : Person
      parents : Person
      gender : Gender
      name : EString
    Universe
```

OCLinEcore editor maintains EAnnotations automatically
OCLinEcore editor provides OCL syntax checking
OCLinEcore editor will provide OCL semantic checking

(Example) Tools and Tips

OCLinEcore editor for Ecore/embedded OCL

CompleteOCL editor for OCL documents

EssentialOCL editor for OCL Expressions (Papyrus)

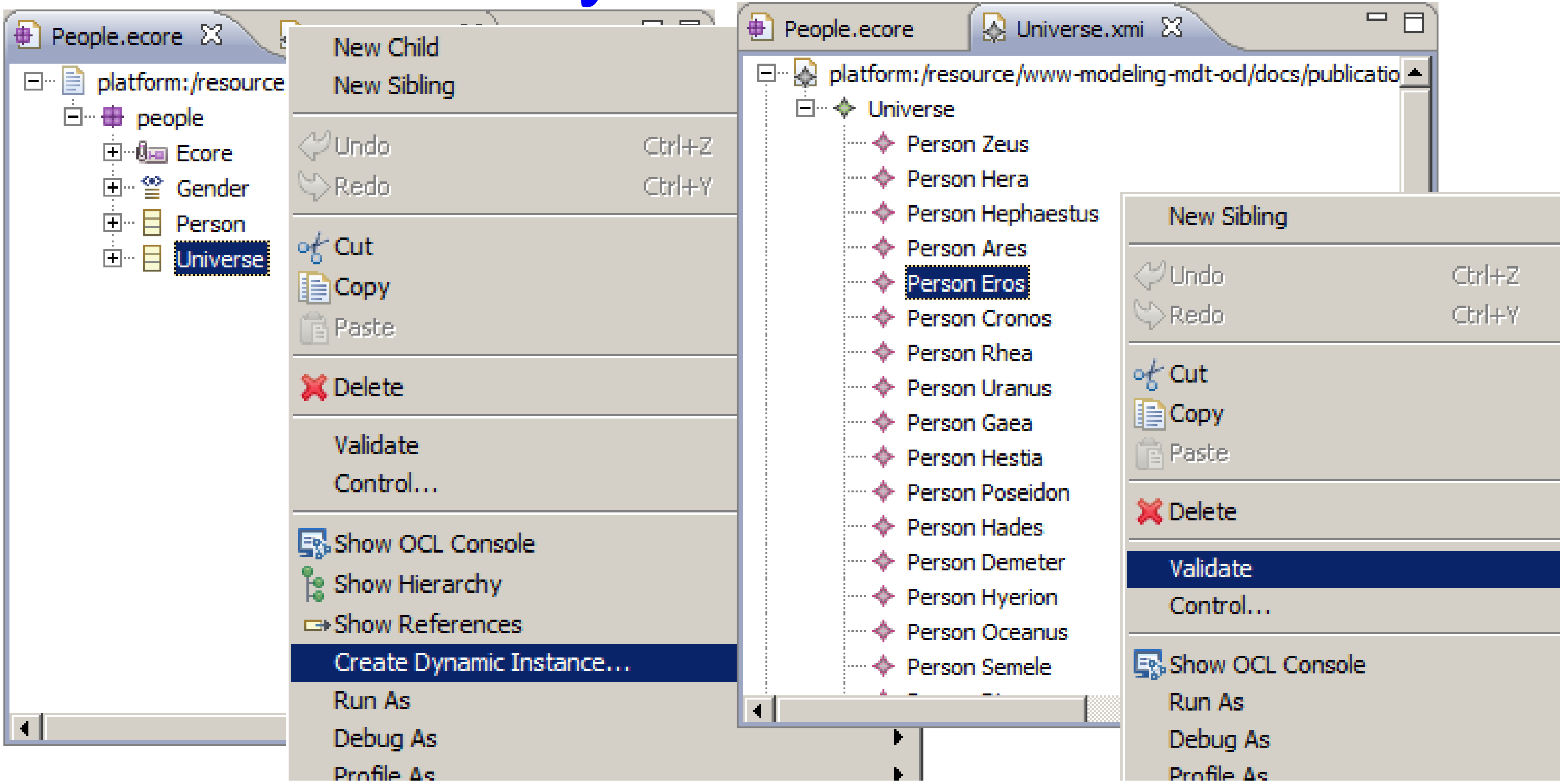
OCL Interactive Console

- Invaluable ability to practice non-trivial expressions
- Page Up/Page Down to reuse expressions

Meta-model reload after change

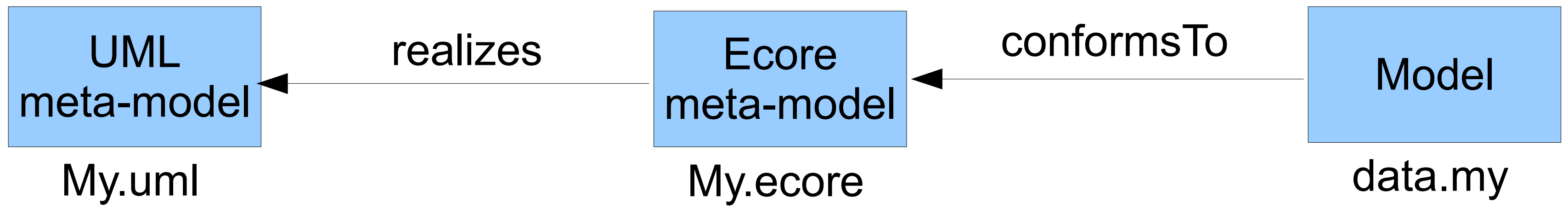
Genmodel settings for embedded OCL

EMF Dynamic Instances



Create/update Ecore meta-model
Create XMI instance of EClass in meta-model
Update XMI model, validate OCL constraints

Meta-model Update



Edit UML/Ecore meta-model in UML/Ecore editor

- manual export of UML to Ecore in workspace
- manual save of Ecore to workspace

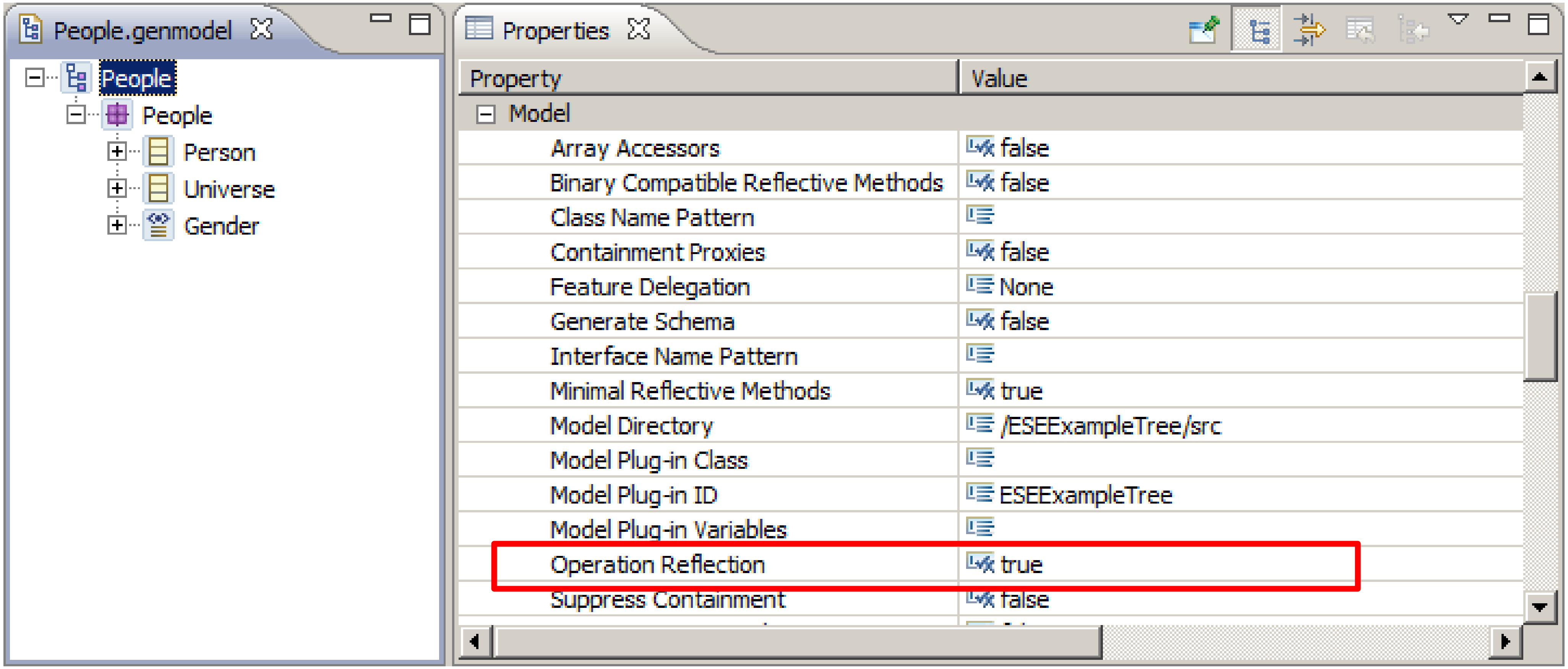
Create Dynamic Instance/Load Model in editor

- validate/evaluate OCL constraints

EMF does not support meta-model mutation

- Model.eClass() reverts to an unresolved proxy
- must exit and re-enter model editor

Genmodel settings for OCL



Property	Value
Model	
Array Accessors	false
Binary Compatible Reflective Methods	false
Class Name Pattern	
Containment Proxies	false
Feature Delegation	None
Generate Schema	false
Interface Name Pattern	
Minimal Reflective Methods	true
Model Directory	/ESEExampleTree/src
Model Plug-in Class	
Model Plug-in ID	ESEExampleTree
Model Plug-in Variables	
Operation Reflection	true
Suppress Containment	false

If not set to true

- MDT/OCL 3.0.0 OCL operation bodies not invoked
- MDT/OCL 3.0.1 Error Log as dynamic fallback used

Eclipse MDT/OCL Futures

3.1 Core (Indigo)

- Minor maintenance

3.1 Examples (Indigo)

- New Ecore/UML blind pivot meta-model
- Extensible modelled Standard Library
- Xtext editors
- Super-compliant - anticipating OMG OCL resolutions

4.0 Core + Tools + Examples (Indigo+1)

- 3.1 Examples promoted to Core or Tools
    - preserved external APIs, significant revision of internal APIs
- OCL to Java code generation

Which OCL Use Cases work When

	Validate	Evaluate	Console	Editor
Static Java For Ecore	🟩 1.0	🟩 1.0	🟧 1.0 Examples	🟧 3.0 Examples
Static Java For UML	🟩 1.2	🟩 1.2	🟥 3.1 Examples	🟥 3.1 Examples
Complete OCL For Ecore	🟥 3.1 Examples	🟥 3.1 Examples	🟥 3.1 Examples	🟧 3.0 Examples
Complete OCL For UML	🟥 3.1 Examples	🟥 3.1 Examples	🟥 3.1 Examples	🟥 3.1 Examples
Embedded OCL in Ecore	🟩 3.0	🟩 3.0	🟧 3.0 Examples	🟧 3.0 Examples
Embedded OCL in UML	🟥 3.1 Examples	🟥 3.1 Examples	🟥 3.1 Examples	🟥 3.1 Examples

🟩 Released in Helios 🟧 Example functionality in Helios

🟥 Example functionality in Indigo, release in Indigo+1

OCL 'Standard' Library

Problems: OMG

- library is not a model
- uses non-UML concepts (Iterator)
- no reflection for OclAny::oclType()

Problems: MDT/OCL

- hard coded, difficult to extend
- UML/Ecore differences, long generic template lists
- Ecore/EMOF discrepancies : EClass/Class

Solution: OMG

- library is a model defined by the new OCL meta-model

Benefit: MDT/OCL

- variants, extensible, unified, compliant

OCL Models

Problems: OMG

- OCL is not fully UML-aligned
- OCL modifies UML models (OclAny)
- Complete OCL modifies UML models
- OCL requires a modified sub-UML @ run-time

Problems: MDT/OCL

- UML/Ecore implementation differences, Ecore extension
- Ecore/EMOF discrepancies

Solution: OMG

- Pivot meta-model defines UML @ run-time
- Pivot model realises OCL-defined merges

Benefit: MDT/OCL

- unified, compliant, Ecore/EMOF hidden

Evaluation

Problems: MDT/OCL:

- OCL interpreted by Java
- OperationCallExp visit is very inefficient
- Slightly hard to extend for QVTo, Acceleo
- OCL within genmodelled Java is just a String
  - significant first time parsing costs

Solution: MDT/OCL

- OCL to Java code generation
- Library model references a Java class per feature
- Code efficiency

Benefit: MDT/OCL

- extensible, faster (10 to 100 times ... iteration strategies)
- Java in genmodelled Java

Beyond OCL

OMG OCL is a powerful expression language

- Declarative, First Order Predicate Calculus/Logic
- Model-oriented, UML navigation, multiplicities, ...

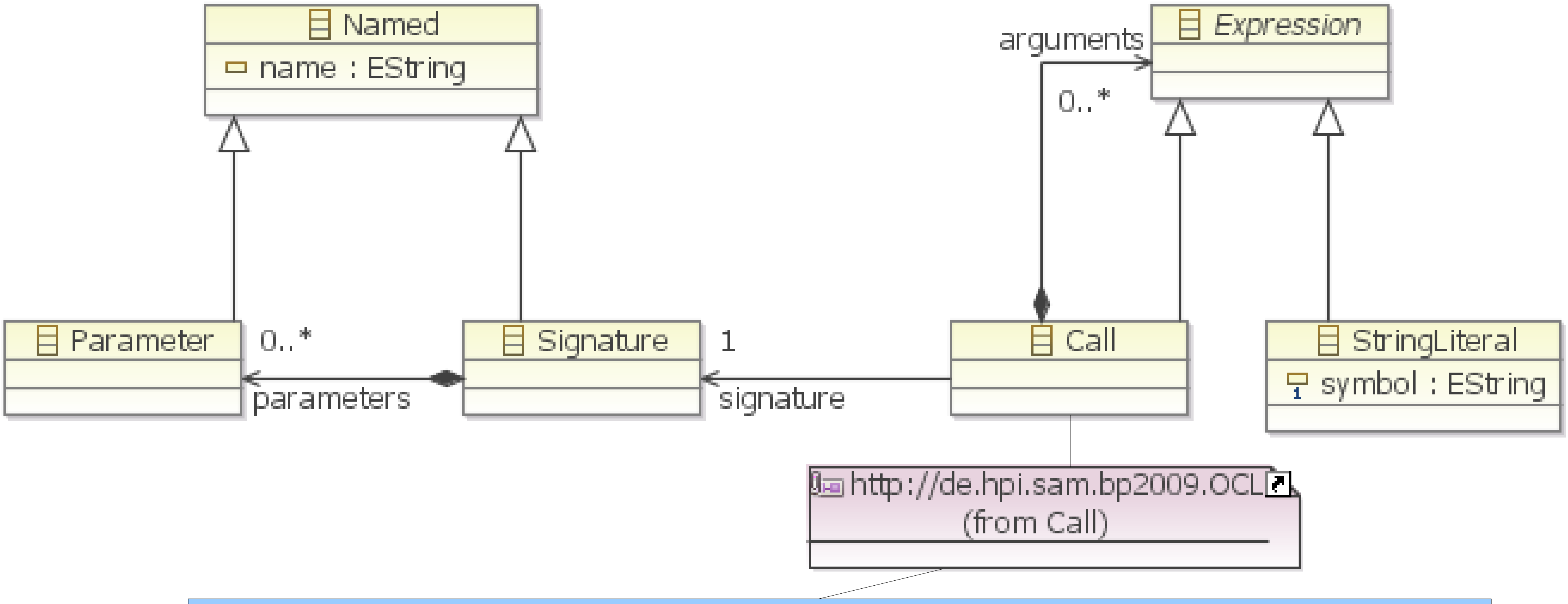
Formal language supports formal analysis
analysis supports optimisation

OCL's usefulness calls for scalable implementation

The Re-Evaluation Problem

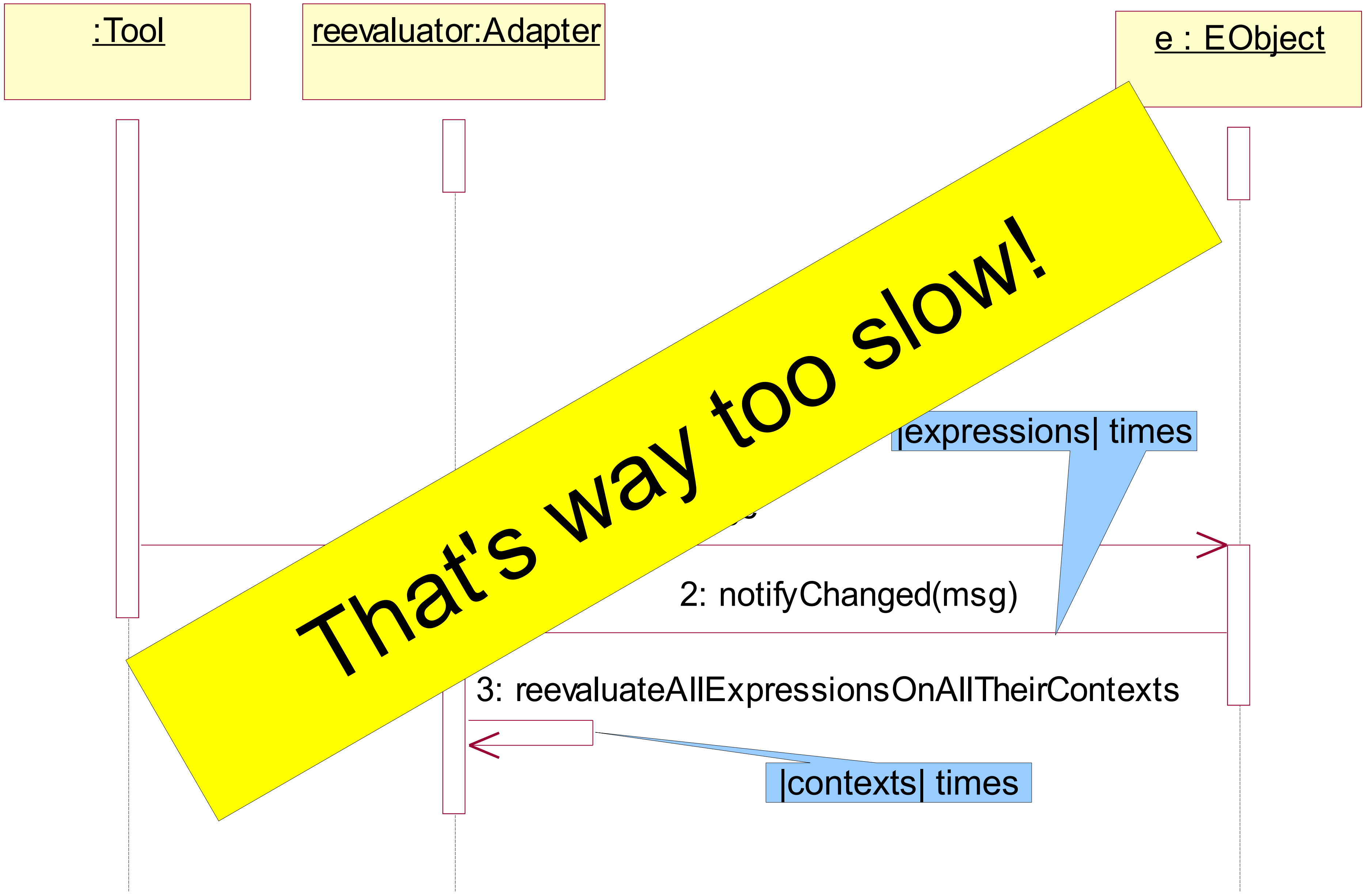
- A set of OCL expressions
- A set of model elements
- A model change notification
- Which of the OCL expressions may have changed its value on which context elements?
- Naïve approach
  - re-evaluate all expressions for all their contexts
  - takes O(|expressions| * |modelElements|)

Example



```
self.signature.parameters->size() = self.arguments->size()
```

Naïve Re-Evaluation Sequence



Idea: Find out from Notification which OCLExpressions may have changed

Example: OCLExpression

```
self.arguments->size() = self.signature.parameters->size()
```

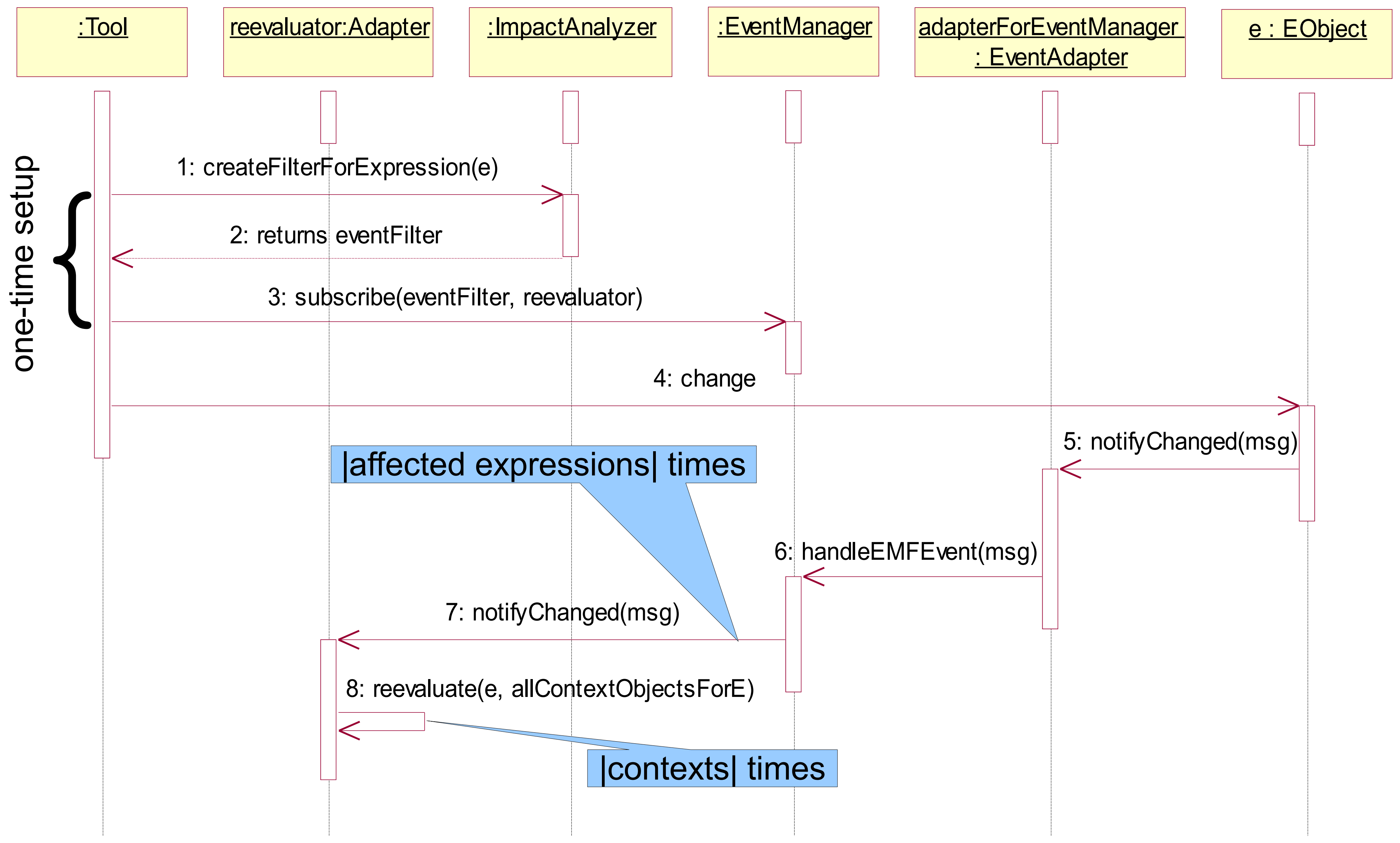
generates **`Notification`** filter

```
(containment AND ((new value filter incl subs for: Call) OR
                  (old value filter incl subs for: Call))) OR
((wantedClass conformsTo: Signature) AND (feature: parameters)) OR
((wantedClass conformsTo: Call) AND (feature: signature)) OR
((wantedClass conformsTo: Call) AND (feature: arguments))
```

Many expressions cause

- many adapters
- with one (often non-trivial) **`Notification`** filter each
- which need evaluation for each change **`Notification`**

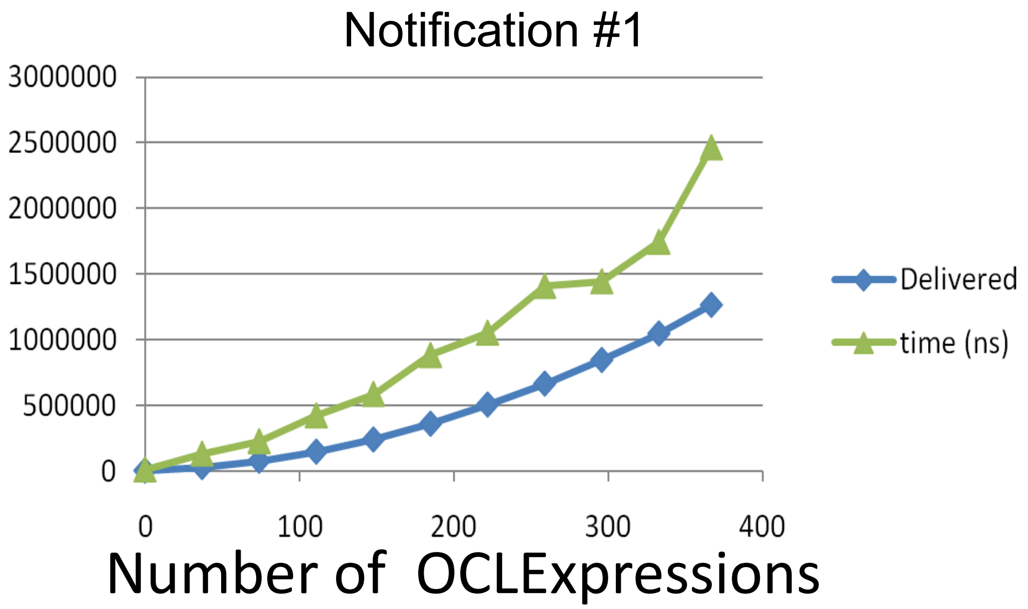
Filter Events for OCLExpressions

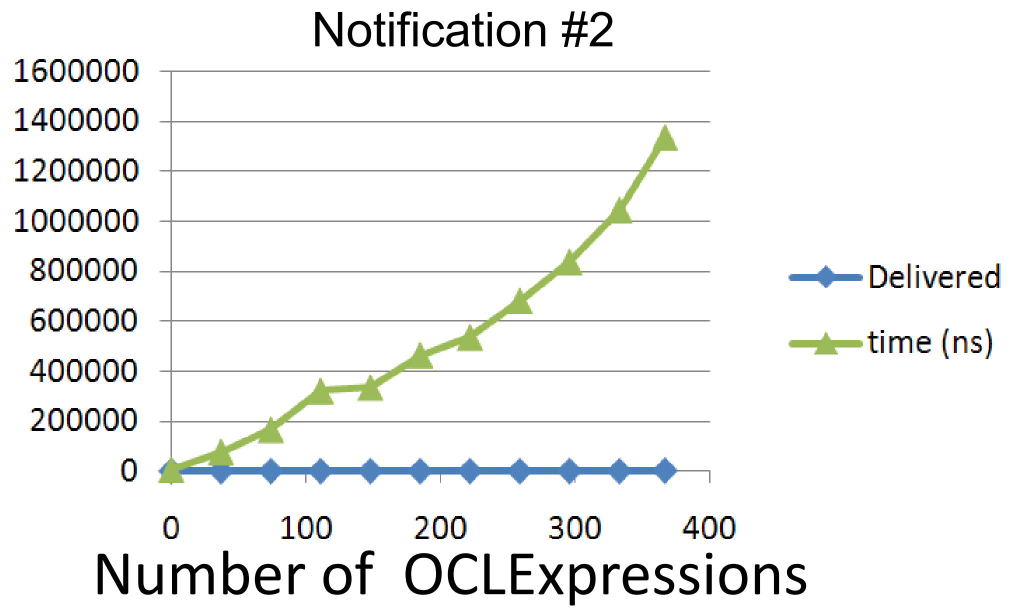


Scaling up Event Filtering

Effort for event propagation still O(|expressions|)

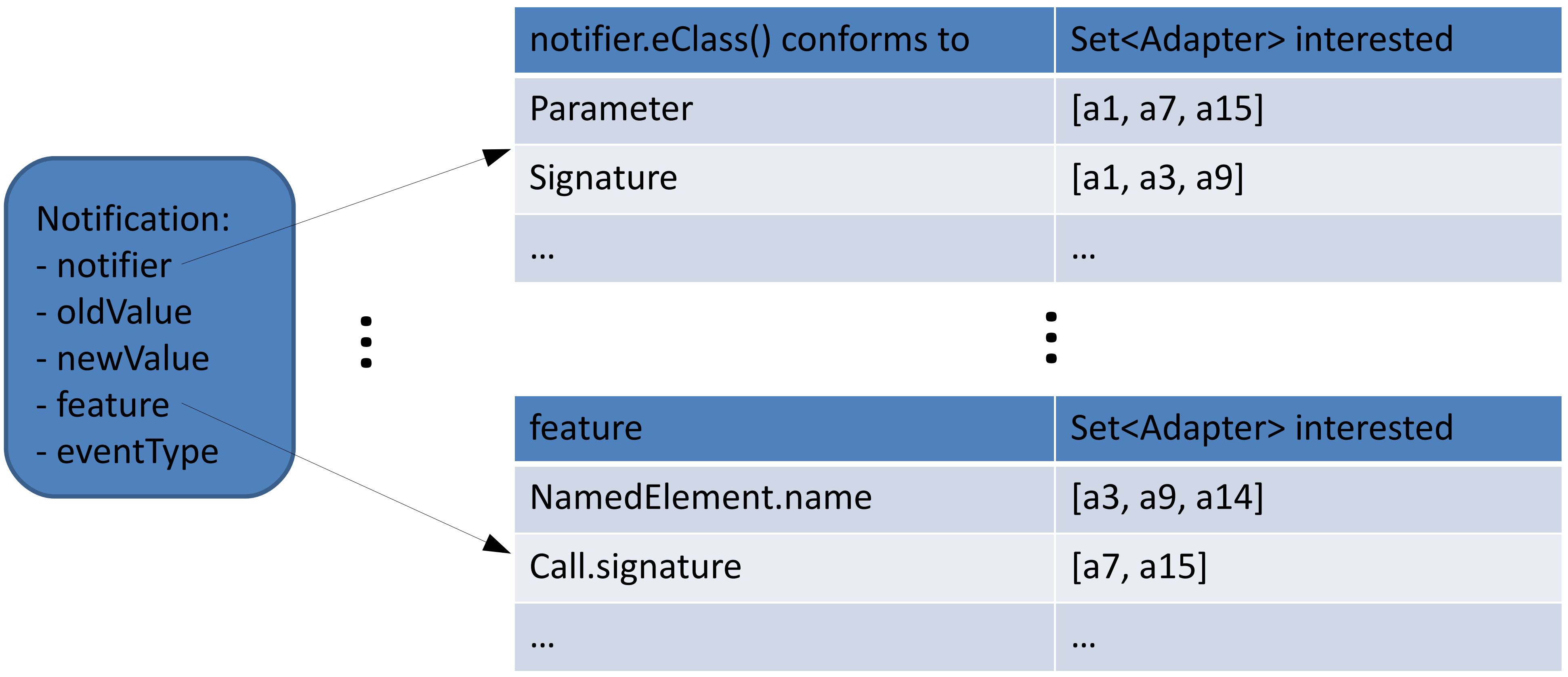
- slowed down even if no `Notification` delivered





Idea: Use HashMaps

to map **`Notification`** to **`Set<Adapter>`**



Notification:
- notifier
- oldValue
- newValue
- feature
- eventType

notifier.eClass() conforms to	Set<Adapter> interested
Parameter	[a1, a7, a15]
Signature	[a1, a3, a9]
…	…

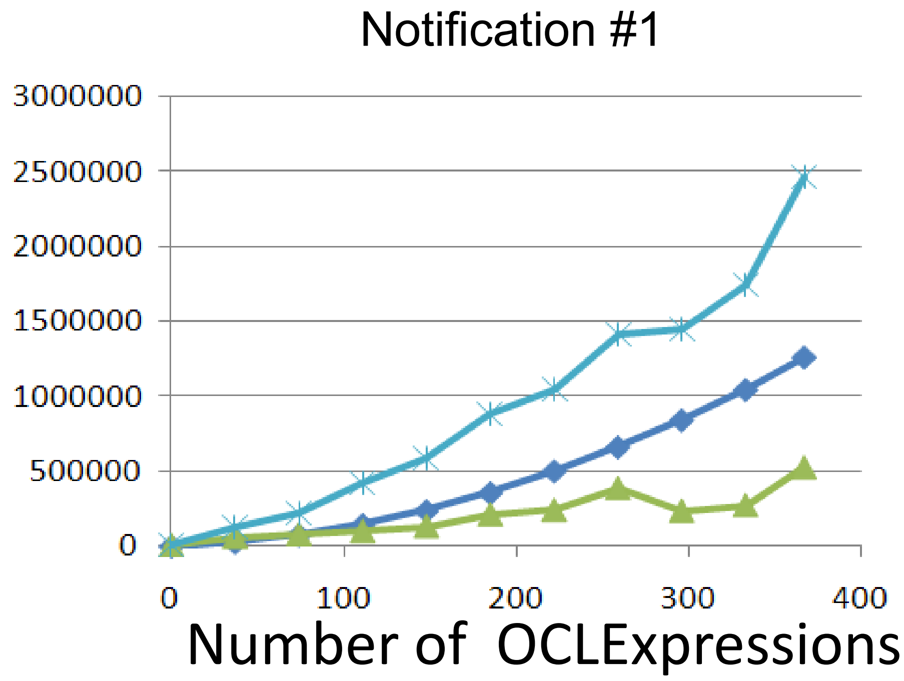
⋮ ⋮

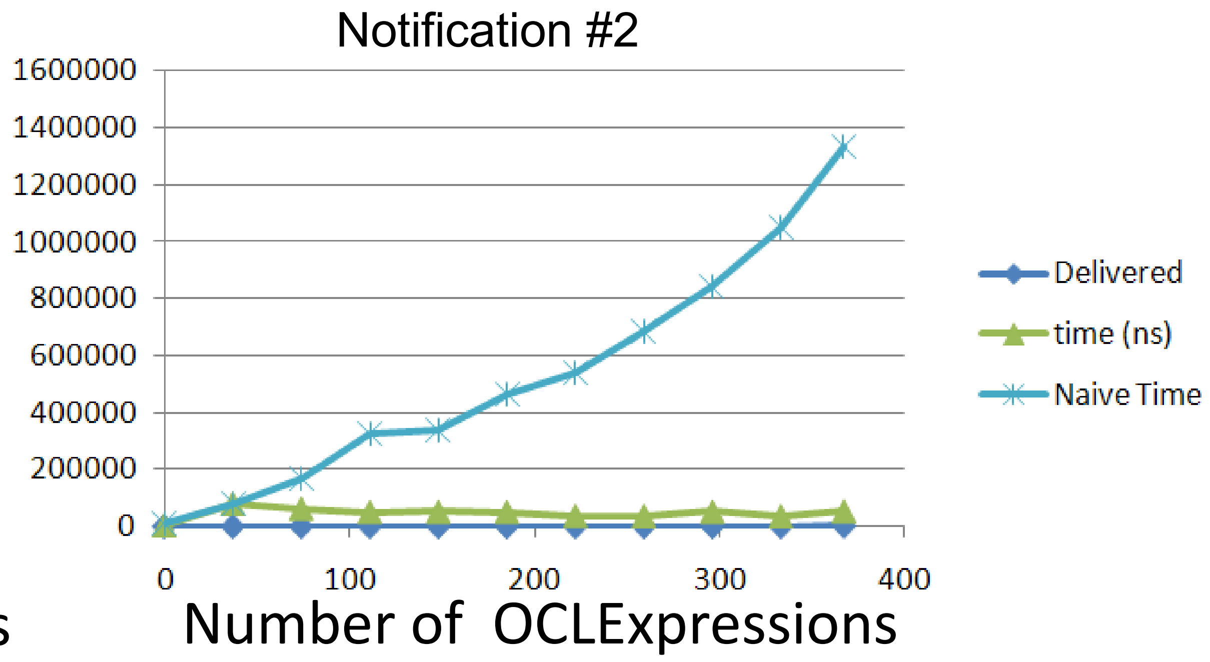
feature	Set<Adapter> interested
NamedElement.name	[a3, a9, a14]
Call.signature	[a7, a15]
…	…

Effects of HashMap-Based Eventing

Faster delivery for Notifications matched by event filters

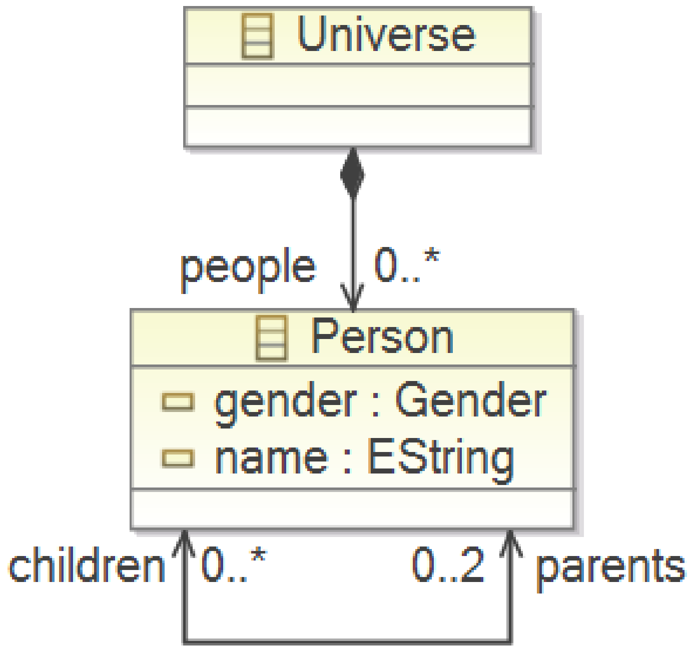
No time increase for expressions whose filters don't match a Notification



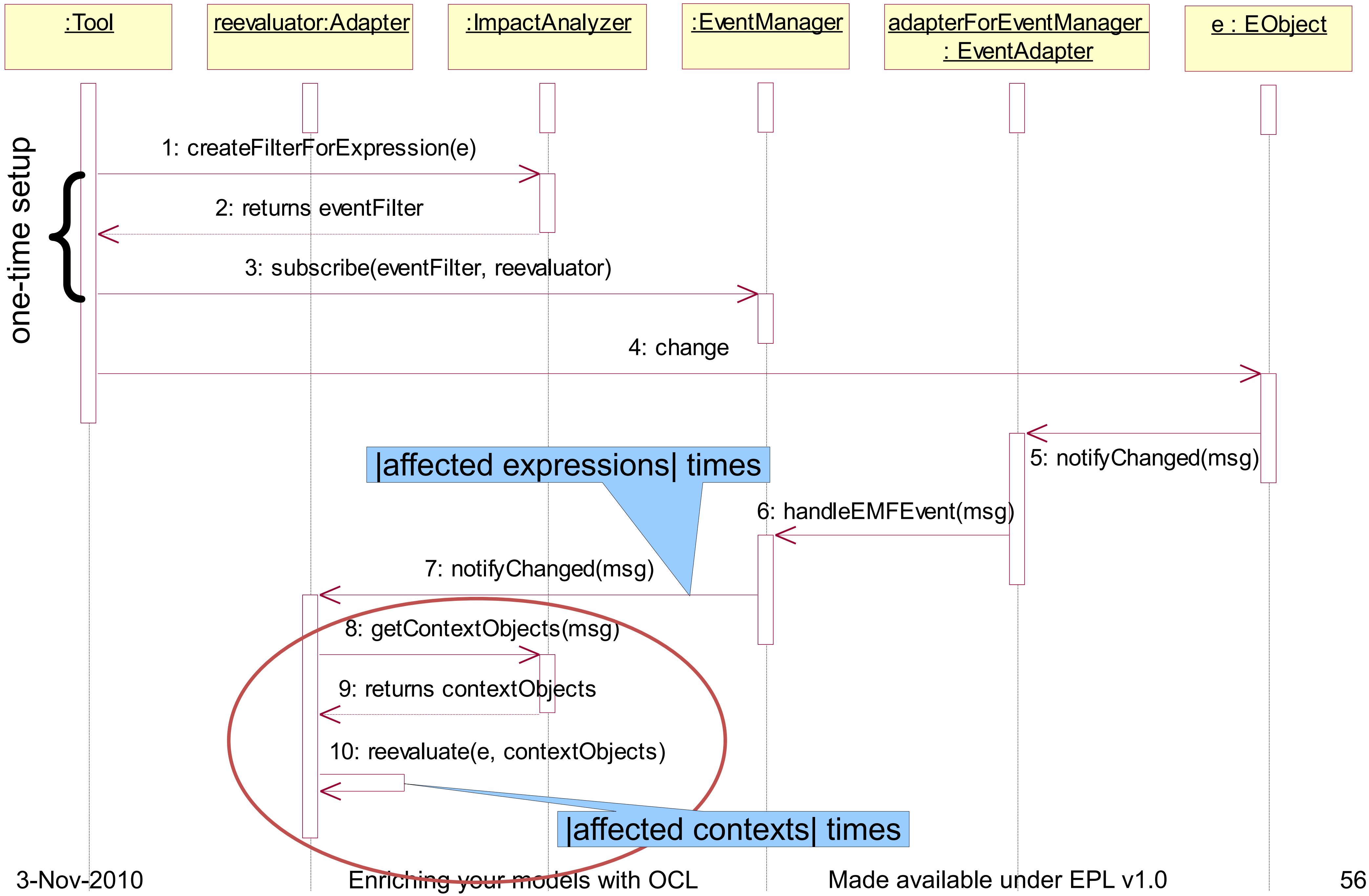


Reducing Contexts for Re-Evaluation

- Use partial evaluation to prove value unchanged
  - **`self.name='abc'`** not affected by name change from 'x' to 'y'
- Use **`Notification`** object (**`notifier, oldValue, newValue`**) to navigate “backwards” to affected context objects
  - **`self.children.children.name`**
  - change attribute **`name`** on **`x:Person`**
  - contexts for re-evaluation:
    - **`x.parents.parents`**
- Tricky for iterators and recursive operations, but solved.



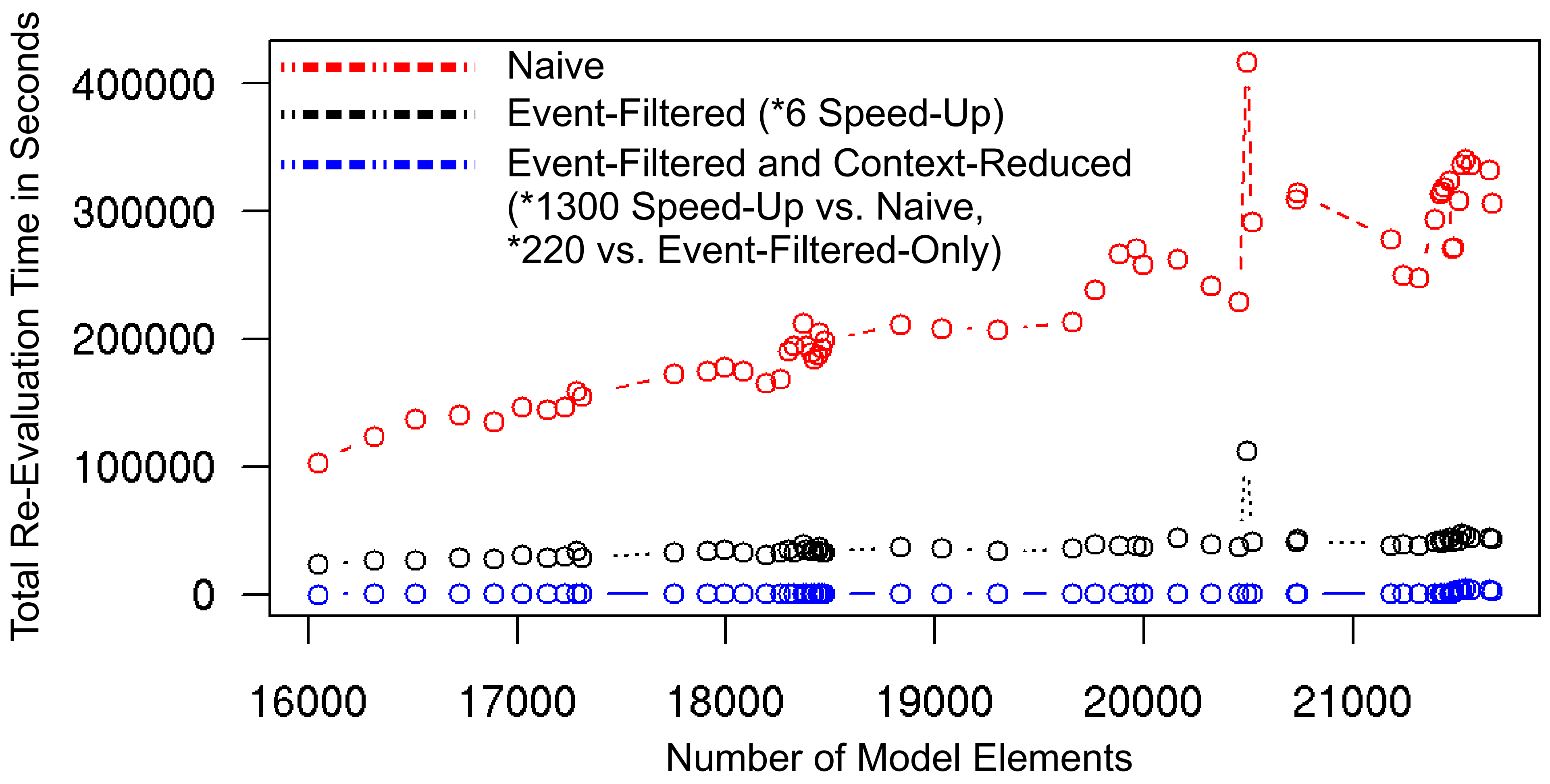
Reduce Set of Context Elements


:Tool
reevaluator:Adapter
:ImpactAnalyzer
:EventManager
adapterForEventManager : EventAdapter
e : EObject
one-time setup
1: createFilterForExpression(e)
2: returns eventFilter
3: subscribe(eventFilter, reevaluator)
4: change
5: notifyChanged(msg)
6: handleEMFEvent(msg)
|affected expressions| times
7: notifyChanged(msg)
8: getContextObjects(msg)
9: returns contextObjects
10: reevaluate(e, contextObjects)
|affected contexts| times

API Usage Example

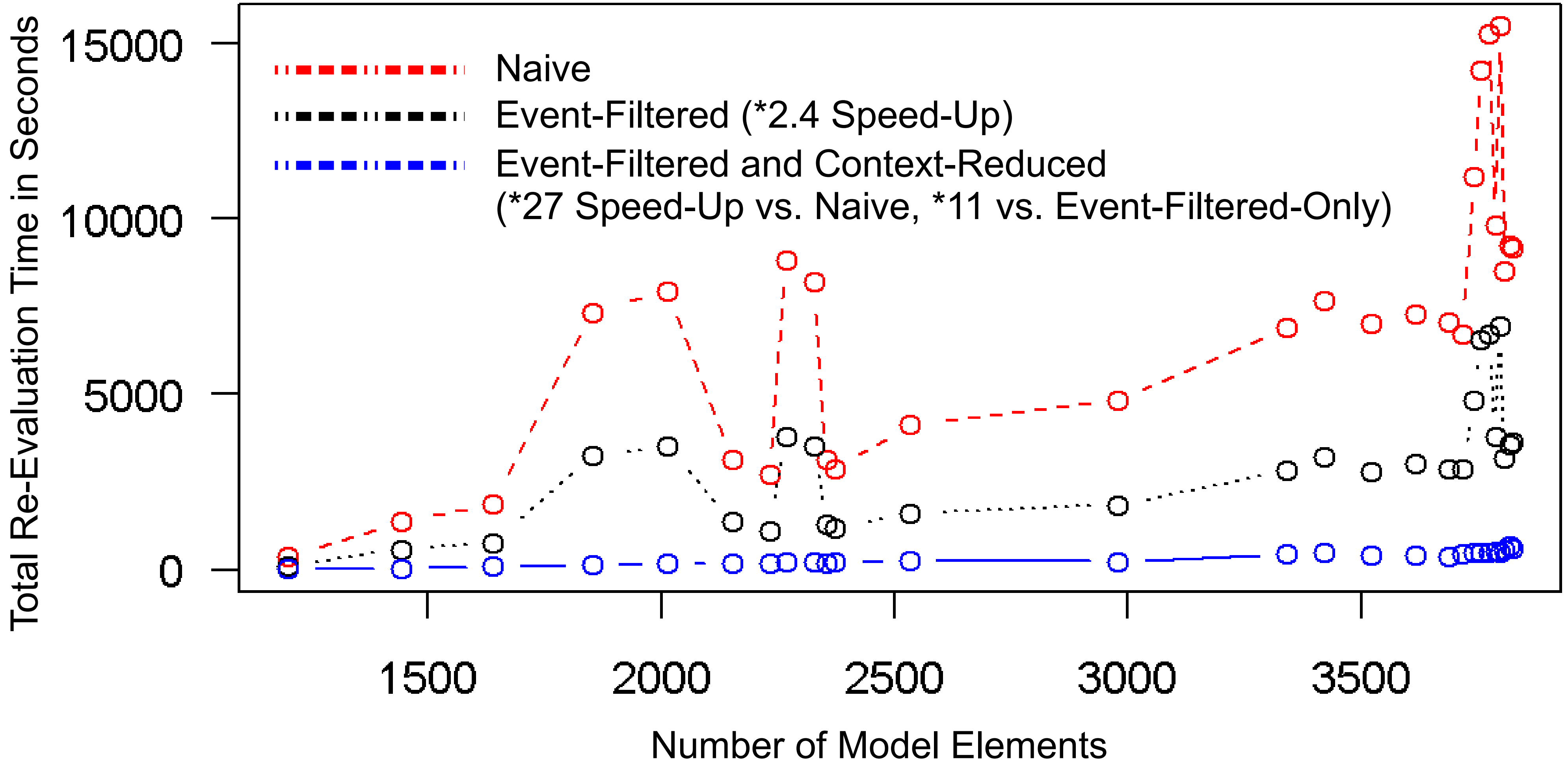
```
EventManager eventManager =
              EventManagerFactory.eINSTANCE.createEventManagerFor(
                                            editingDomain.getResourceSet());
final OCLExpression invariant = OCL.newInstance().createOCLHelper().
       createQuery(“self.signature.parameters->size()=self.arguments->size()“);
final ImpactAnalyzer impactAnalyzer =
       ImpactAnalyzerFactory.INSTANCE.createImpactAnalyzer(invariant,
              /* notifyOnNewContextElements */ true, oppositeEndFinder);
Adapter adapter = new AdapterImpl() {
   @Override
   public void notifyChanged(Notification msg) {
      // revalidate invariant on context objects delivered by impact analysis:
      Collection<EObject> revalidateOn = impactAnalyzer.getContextObjects(msg);
      if (revalidateOn != null && !revalidateOn.isEmpty()) {
          revalidate(invariant, revalidateOn);
      }
   }
};
eventManager.subscribe(impactAnalyzer.createFilterForExpression(), adapter);
```

Benchmark Context Reduction (Average Case)



Benchmark Context Reduction (Worst Case)

(apply changes to very central elements, referenced by all other model packages)



Summary

MDT/OCL originally focussed on Java API

Interactive Modeling Tools require OCL IDE

- EMF, Xtext, Acceleo, QVTo, OCL support richer OCL development environment

Extensibility required by QVTo, Acceleo

Efficiency required for serious use

IDE starting to appear

- Console, Editors

Expect/Demand much more

Contributions welcome

OCL Resources

- OCL 2.2 Specification http://www.omg.org/spec/OCL/2.2
  - Clause 7 is quite readable (many typos)
- The Object Constraint Language: Getting Your Models Ready For MDA Jos B. Warmer, Anneke Kleppe
- Eclipse MDT/OCL project http://www.eclipse.org/projects/project_summary.php?projectid=modeling.mdt.ocl
- Impact analysis

  SVN: https://www.hpi.uni-potsdam.de/giese/gforge/svn/bp2009
  Accounts: https://www.hpi.uni-potsdam.de/giese/gforge/