RELEASeD

REsearch Lab on software Evolution And software Development technology

Prof. Kim Mens

Software Evolution	**Co-evolving** program code & design
	Reverse engineering & program understanding
	Program **querying**
	Source code **mining** and aspect mining
	Enforcing program & design **regularities**
	Diagnosing & resolving detected inconsistencies
Software Development	**Language** engineering (AOP, COP, AmI)
	Program **transformation**
	Generative programming
	Declarative metaprogramming

Dr. Johan Brichau

Sebastián González

Diego Ordóñez

Sergio Castro

Alfredo Cádiz

Programming technology, languages, formalisms and tools
for **software development, maintenance and evolution**

Mining Source Code for design regularities (work in progress)

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Département d’ingénierie Informatique
Université catholique de Louvain

Andy Kellens
Programming Technology Lab
Vakgroep Informatica
Vrije Universiteit Brussel

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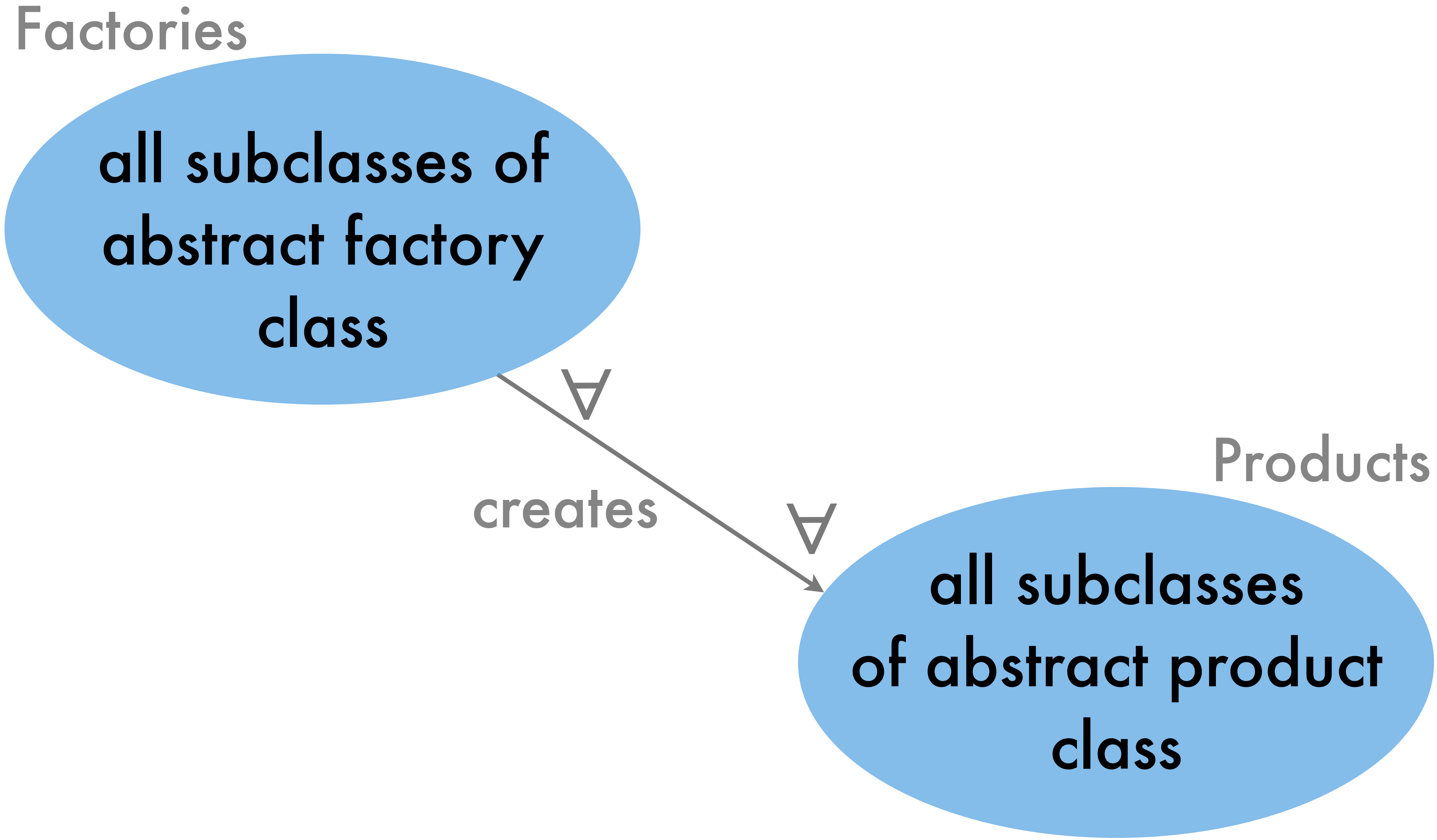
(Gabriela Arevalo, La Plata)

Context: Intensional Views



Factories

all subclasses of abstract factory class

∀

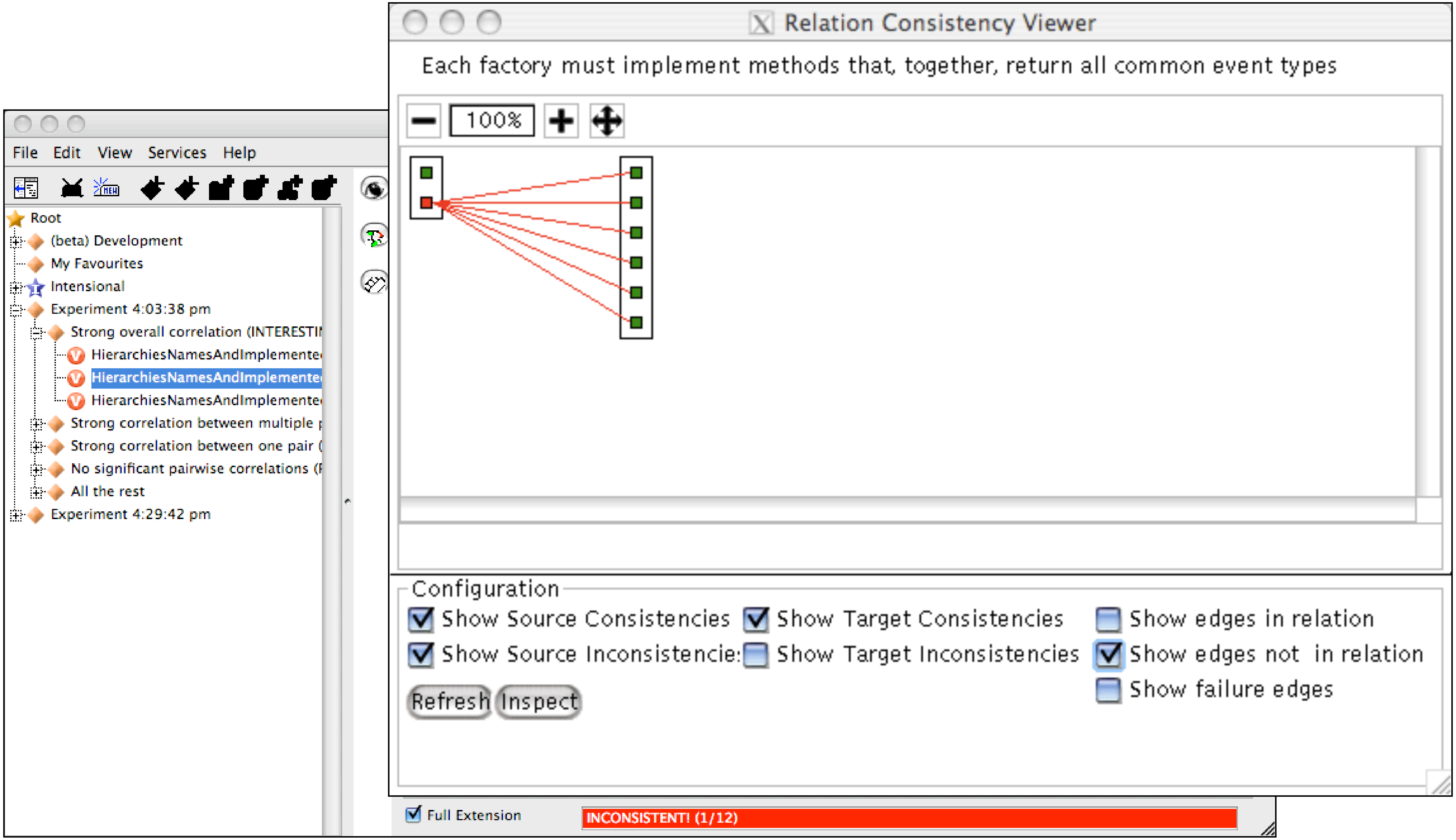
creates

∀

Products

all subclasses of abstract product class

Context: Intensional Views



Root
(beta) Development
My Favourites
Intensional
Experiment 4:03:38 pm
Strong overall correlation (INTERESTI
HierarchiesNamesAndImplemente
HierarchiesNamesAndImplemente
HierarchiesNamesAndImplemente
Strong correlation between multiple
Strong correlation between one pair (
No significant pairwise correlations (F
All the rest
Experiment 4:29:42 pm

Relation Consistency Viewer

Each factory must implement methods that, together, return all common event types

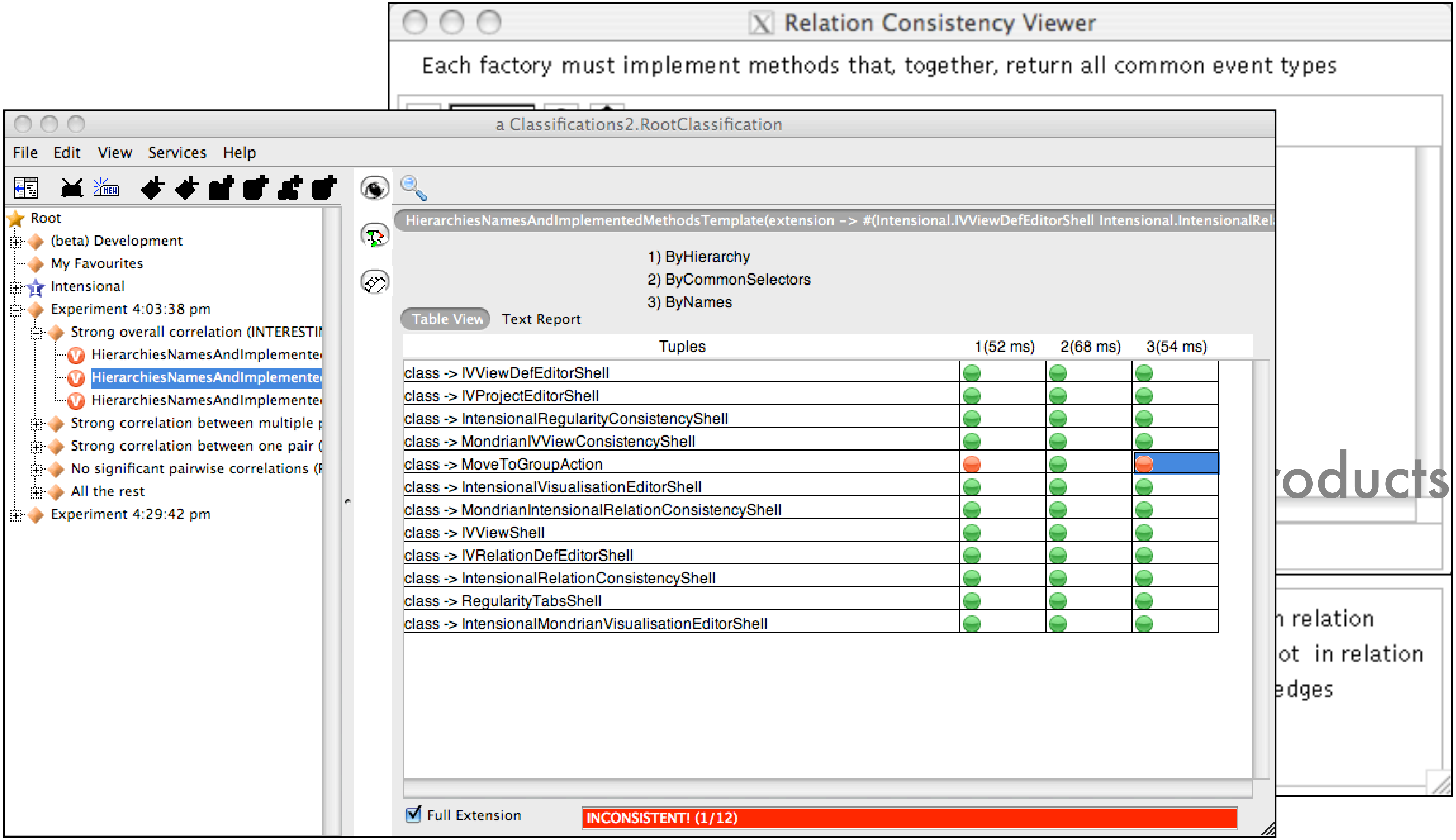
Configuration

☑ Show Source Consistencies ☑ Show Target Consistencies □ Show edges in relation
☑ Show Source Inconsistencie: □ Show Target Inconsistencies ☑ Show edges not in relation
□ Show failure edges

☑ Full Extension

INCONSISTENT! (1/12)

Context: Intensional Views



Relation Consistency Viewer

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roducts

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edges

a Classifications2.RootClassification

- Root
  - (beta) Development
  - My Favourites
  - Intensional
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    - No significant pairwise correlations (
    - All the rest
  - Experiment 4:29:42 pm

HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IVViewDefEditorShell Intensional.IntensionalRel

1) ByHierarchy
2) ByCommonSelectors
3) ByNames

Tuples	1(52 ms)	2(68 ms)	3(54 ms)
class -> IVViewDefEditorShell	🟢	🟢	🟢
class -> IVProjectEditorShell	🟢	🟢	🟢
class -> IntensionalRegularityConsistencyShell	🟢	🟢	🟢
class -> MondrianIVViewConsistencyShell	🟢	🟢	🟢
class -> MoveToGroupAction	🔴	🟢	🔴
class -> IntensionalVisualisationEditorShell	🟢	🟢	🟢
class -> MondrianIntensionalRelationConsistencyShell	🟢	🟢	🟢
class -> IVViewShell	🟢	🟢	🟢
class -> IVRelationDefEditorShell	🟢	🟢	🟢
class -> IntensionalRelationConsistencyShell	🟢	🟢	🟢
class -> RegularityTabsShell	🟢	🟢	🟢
class -> IntensionalMondrianVisualisationEditorShell	🟢	🟢	🟢

☑ Full Extension

INCONSISTENT! (1/12)

Motivation: Documenting and Verifying Design Regularities

- Context: Intensional views
  - Document & verify design regularities in source code
  - Hard to document all regularities “by hand”
- Need for automation
  - program comprehension techniques to discover these views and regularities
  - Source code mining techniques in particular

Challenge: extracting design regularities from source code

- How to extract views & regularities from code?
- Need for automated code mining techniques
  - Similar to aspect mining
  - Based on data mining / code analysis / program understanding techniques
  - FCA, clustering, clone detection, program slicing ...
- Extra difficulty: extract *intension*, not only extension
  - not only the elements but also *why* they are related

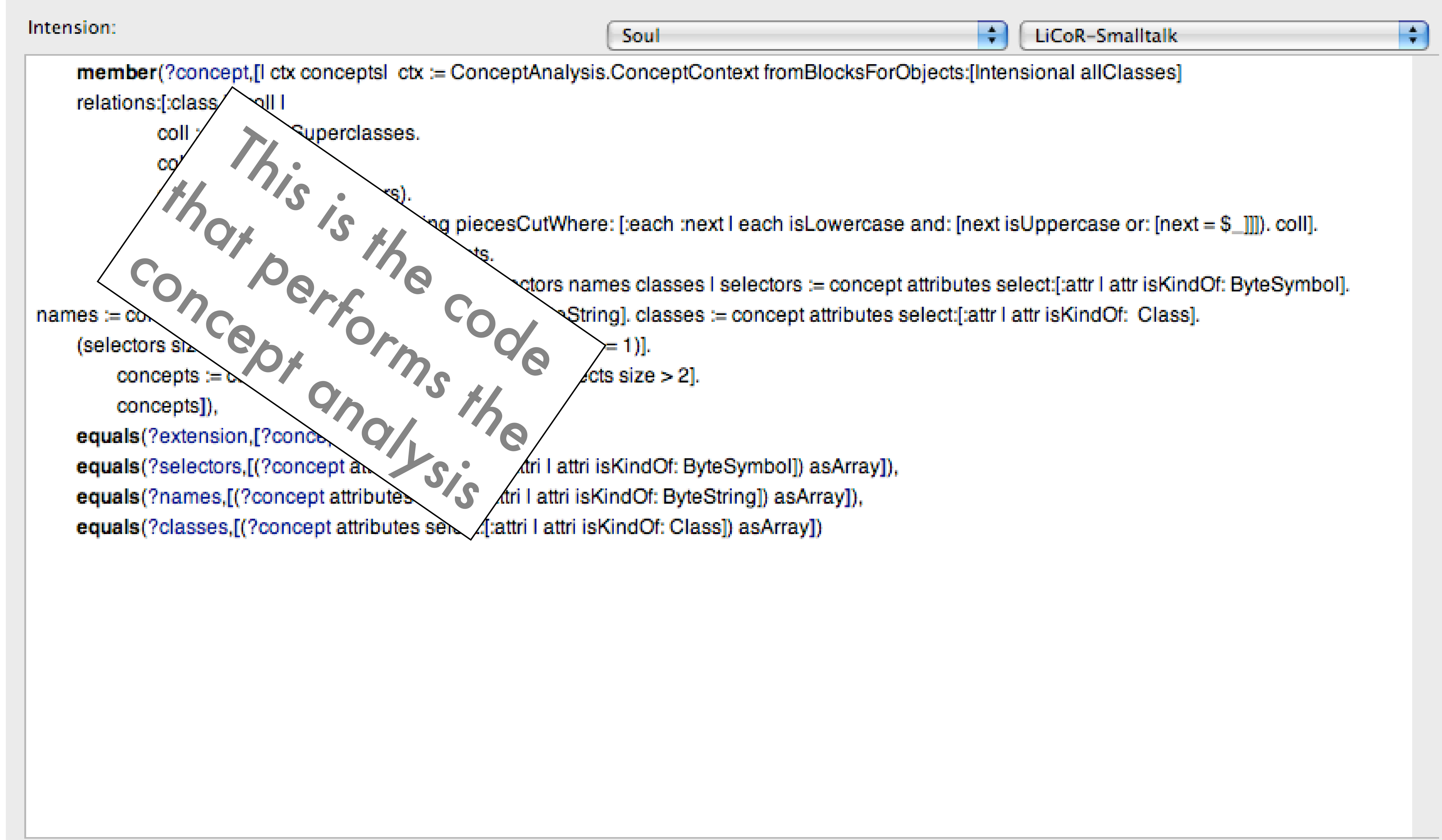
Ongoing experiment

- A clever combination of
  - Formal concept analysis (FCA)
  - Intensional views
    - alternative views
    - parameterized views (to generate views from a template description)
  - Automated classification and filtering
  - Manual analysis, validation and refinement of results

Ongoing experiment: step 1

- Step 1: Formal concept analysis
  - (finds groups of “objects” with shared “properties”)
  - objects: all classes
  - attributes: (we mix 3 kinds of attributes in 1 analysis)
    - have methods with similar name (keyword shared)
    - implement same method (selector shared)
    - in same hierarchy (parent classes shared)

Ongoing experiment: step 1 (details)



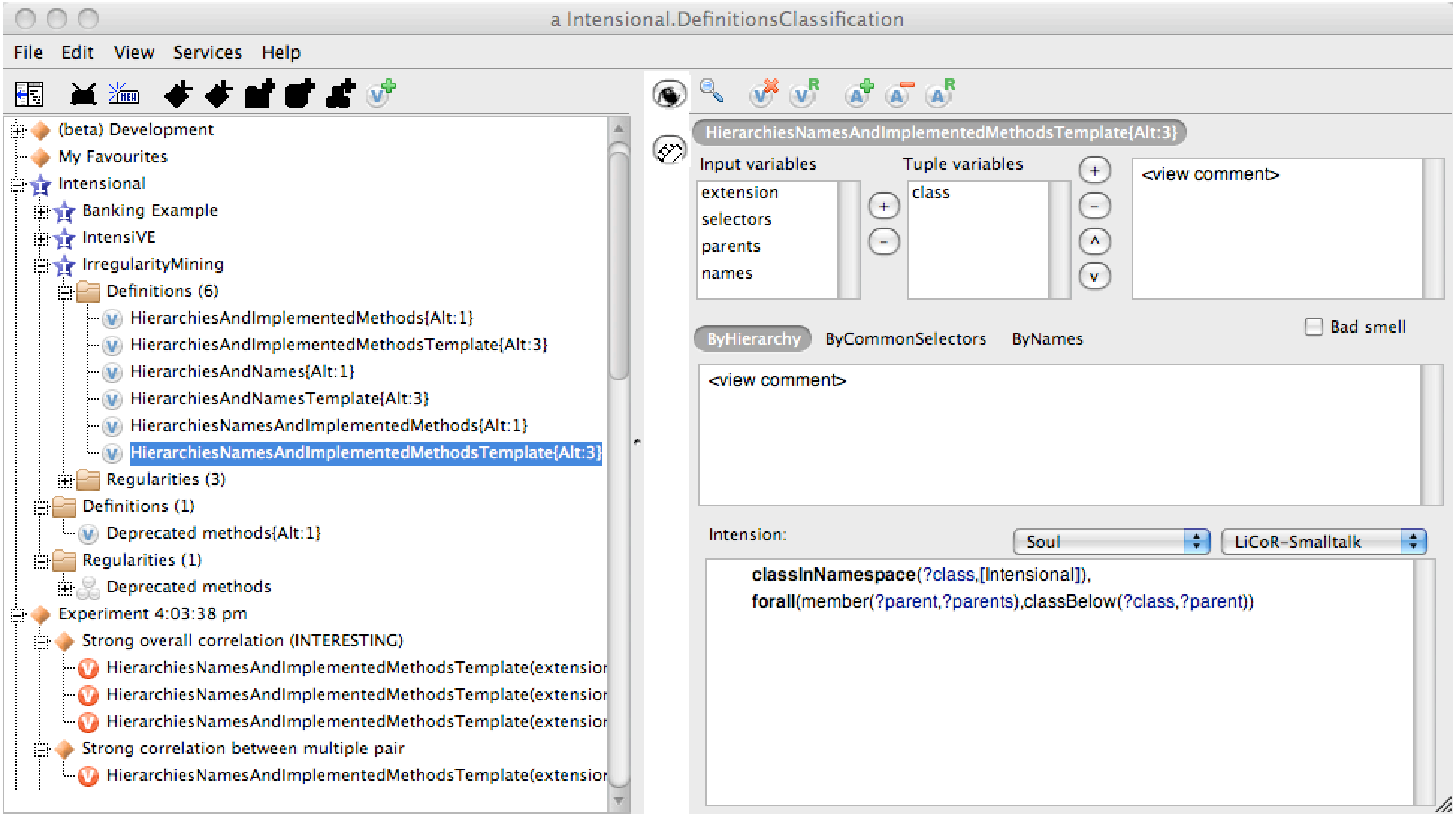
```
	member(?concept,[| ctx concepts|  ctx := ConceptAnalysis.ConceptContext fromBlocksForObjects:[Intensional allClasses]
	relations:[:class | coll |
		coll :              Superclasses.
		co
		                      rs).
		                      ng piecesCutWhere: [:each :next | each isLowercase and: [next isUppercase or: [next = $_]]]). coll].
		                        ts.
		                        ctors names classes | selectors := concept attributes select:[:attr | attr isKindOf: ByteSymbol].
names := co                     String]. classes := concept attributes select:[:attr | attr isKindOf:  Class].
	(selectors si                              = 1)].
		concepts := c                          cts size > 2].
		concepts]),
	equals(?extension,[?conce
	equals(?selectors,[(?concept at              ttri | attri isKindOf: ByteSymbol]) asArray]),
	equals(?names,[(?concept attributes          ttri | attri isKindOf: ByteString]) asArray]),
	equals(?classes,[(?concept attributes sel     :[:attri | attri isKindOf: Class]) asArray])
```

This is the code that performs the concept analysis

Ongoing experiment: step 2

- Result step 1 = many potentially interesting “concepts”
  - groups of classes that may share similar names, selectors and parent classes
- Step 2: generate an intensional view for each of these
  - Elements of the view = all the classes in the group
  - Alternative 1 : all classes with shared keywords
  - Alternative 2 : all classes with shared names
  - Alternative 3 : all classes with shared parents

Ongoing experiment: step 2 (details) Parameterized view with 3 alternatives



- (beta) Development
- My Favourites
- Intensional
  - Banking Example
  - IntensiVE
  - IrregularityMining
    - Definitions (6)
      - HierarchiesAndImplementedMethods{Alt:1}
      - HierarchiesAndImplementedMethodsTemplate{Alt:3}
      - HierarchiesAndNames{Alt:1}
      - HierarchiesAndNamesTemplate{Alt:3}
      - HierarchiesNamesAndImplementedMethods{Alt:1}
      - HierarchiesNamesAndImplementedMethodsTemplate{Alt:3}
    - Regularities (3)
  - Definitions (1)
    - Deprecated methods{Alt:1}
  - Regularities (1)
    - Deprecated methods
- Experiment 4:03:38 pm
  - Strong overall correlation (INTERESTING)
    - HierarchiesNamesAndImplementedMethodsTemplate(extensio
    - HierarchiesNamesAndImplementedMethodsTemplate(extensio
    - HierarchiesNamesAndImplementedMethodsTemplate(extensio
  - Strong correlation between multiple pair
    - HierarchiesNamesAndImplementedMethodsTemplate(extensio

HierarchiesNamesAndImplementedMethodsTemplate{Alt:3}

Input variables	Tuple variables
extension	class
selectors	
parents	
names	

<view comment>

□ Bad smell

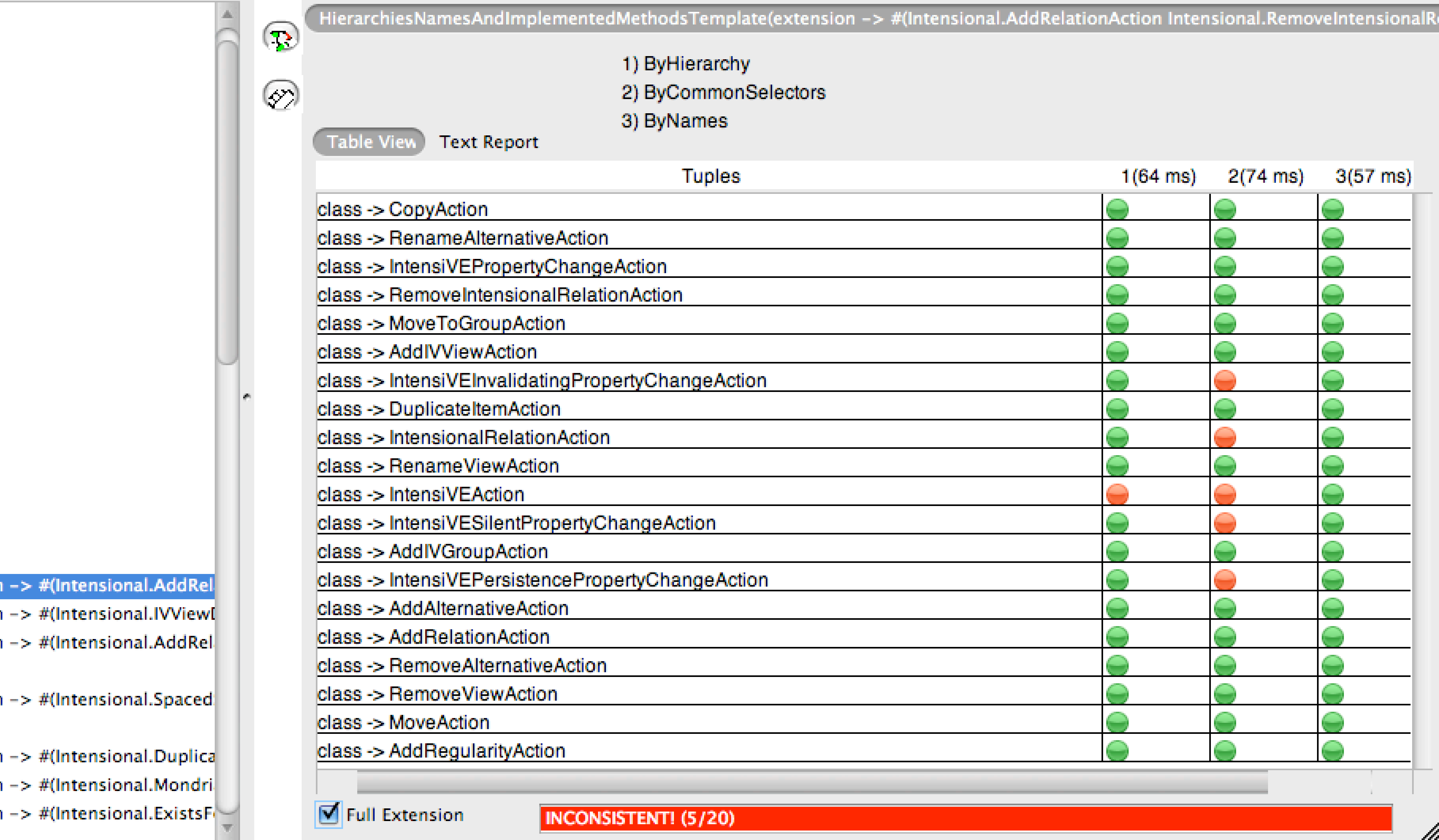
ByHierarchy ByCommonSelectors ByNames

<view comment>

Intension: Soul LiCoR-Smalltalk

```
classInNamespace(?class,[Intensional]),
forall(member(?parent,?parents),classBelow(?class,?parent))
```

Ongoing experiment: step 2 (details)
Analyze the generated views



n -> #(Intensional.AddRel
n -> #(Intensional.IVViewI
n -> #(Intensional.AddRel
n -> #(Intensional.Spaced
n -> #(Intensional.Duplica
n -> #(Intensional.Mondri
n -> #(Intensional.ExistsF

HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.AddRelationAction Intensional.RemoveIntensionalR

1) ByHierarchy
2) ByCommonSelectors
3) ByNames

Tuples	1(64 ms)	2(74 ms)	3(57 ms)
class -> CopyAction	🟢	🟢	🟢
class -> RenameAlternativeAction	🟢	🟢	🟢
class -> IntensiVEPropertyChangeAction	🟢	🟢	🟢
class -> RemoveIntensionalRelationAction	🟢	🟢	🟢
class -> MoveToGroupAction	🟢	🟢	🟢
class -> AddIVViewAction	🟢	🟢	🟢
class -> IntensiVEInvalidatingPropertyChangeAction	🟢	🔴	🟢
class -> DuplicateItemAction	🟢	🟢	🟢
class -> IntensionalRelationAction	🟢	🔴	🟢
class -> RenameViewAction	🟢	🟢	🟢
class -> IntensiVEAction	🔴	🔴	🟢
class -> IntensiVESilentPropertyChangeAction	🟢	🔴	🟢
class -> AddIVGroupAction	🟢	🟢	🟢
class -> IntensiVEPersistencePropertyChangeAction	🟢	🔴	🟢
class -> AddAlternativeAction	🟢	🟢	🟢
class -> AddRelationAction	🟢	🟢	🟢
class -> RemoveAlternativeAction	🟢	🟢	🟢
class -> RemoveViewAction	🟢	🟢	🟢
class -> MoveAction	🟢	🟢	🟢
class -> AddRegularityAction	🟢	🟢	🟢

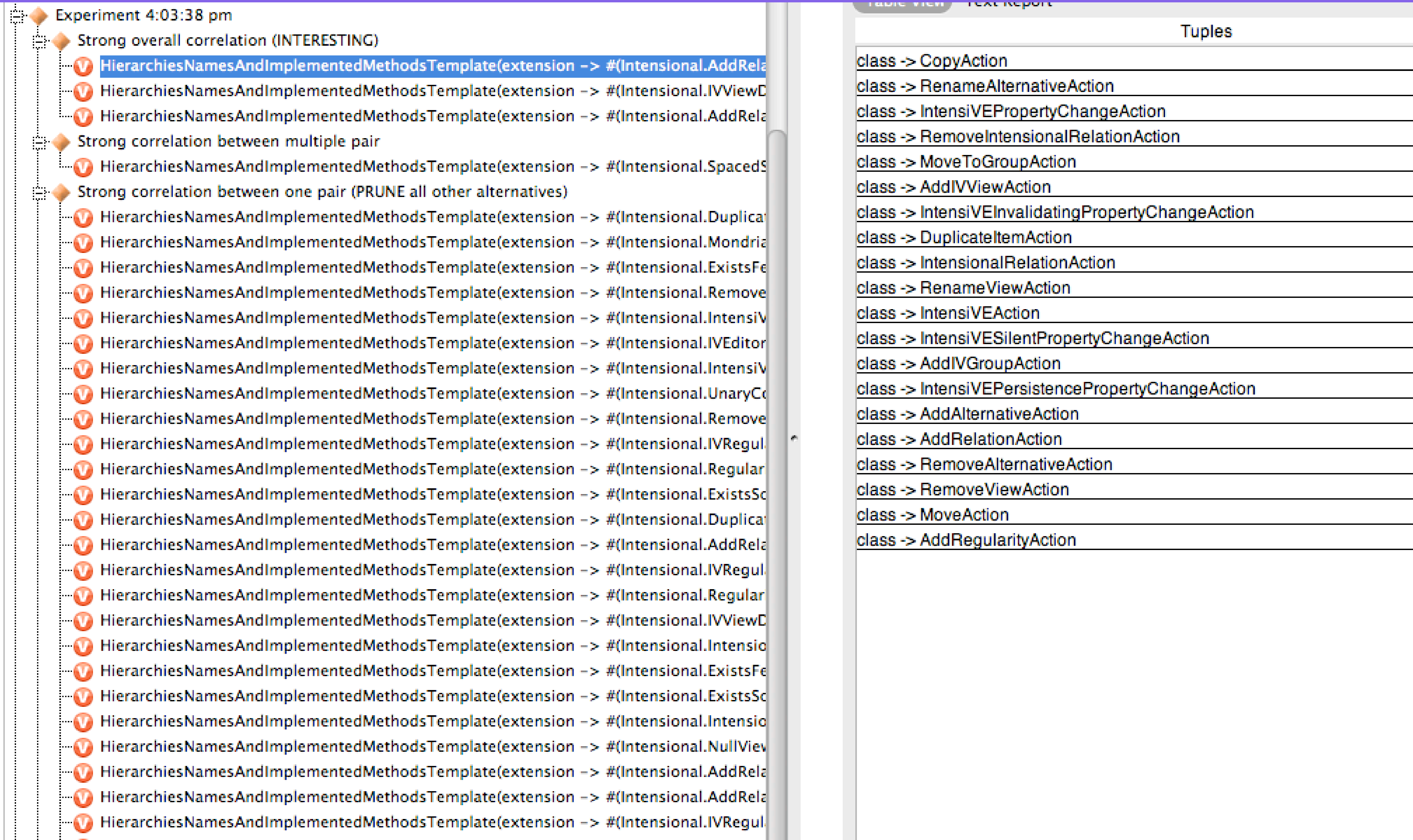
☑ Full Extension

INCONSISTENT! (5/20)

Ongoing experiment: step 3

- Result step 2 = many views
  - some with strongly correlated properties
  - others with much less correlation (less interesting)
- Step 3: automatically separate interesting views from less interesting ones based on % of correlation
- Step 4: analyse resulting views manually to confirm or discard interesting regularities in the source code

Ongoing experiment: step 3 (details) Automatic classification



- Experiment 4:03:38 pm
  - Strong overall correlation (INTERESTING)
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.AddRela
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IVViewD
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.AddRela
  - Strong correlation between multiple pair
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.SpacedS
  - Strong correlation between one pair (PRUNE all other alternatives)
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.Duplica
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.Mondria
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.ExistsFe
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.Remove
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IntensiV
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IVEditor
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IntensiV
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.UnaryCo
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.Remove
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IVRegul
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.Regular
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.ExistsSo
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.Duplica
    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.AddRela
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    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.NullView
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    - HierarchiesNamesAndImplementedMethodsTemplate(extension -> #(Intensional.IVRegul

Tuples
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class -> IntensiVESilentPropertyChangeAction
class -> AddIVGroupAction
class -> IntensiVEPersistencePropertyChangeAction
class -> AddAlternativeAction
class -> AddRelationAction
class -> RemoveAlternativeAction
class -> RemoveViewAction
class -> MoveAction
class -> AddRegularityAction

Conclusion

- Discovering, documenting design regularities
  - scaleable to large industrial software systems
- Requires techniques that mine the source code for design regularities
- So that we can codify these regularities intensionally and co-evolve them with the source code
- Prior experience with aspect mining and first experiments make us hopeful that it can be done