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Induced Intentional Software Views

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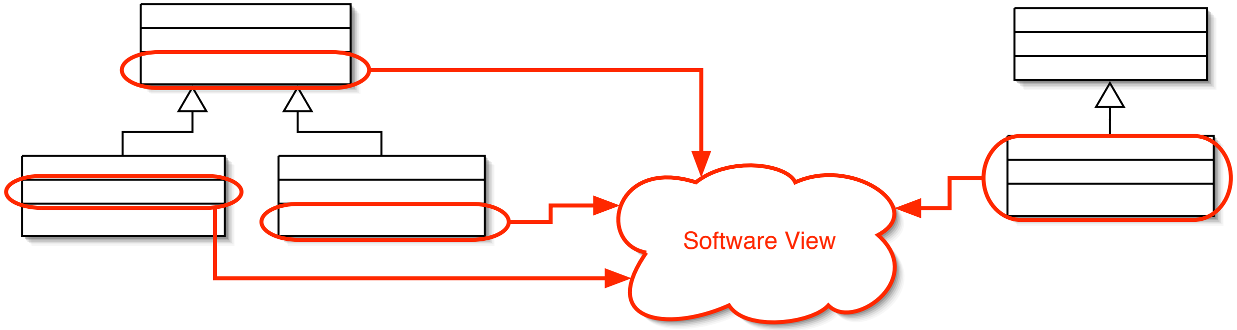
Problems with Software Documentation

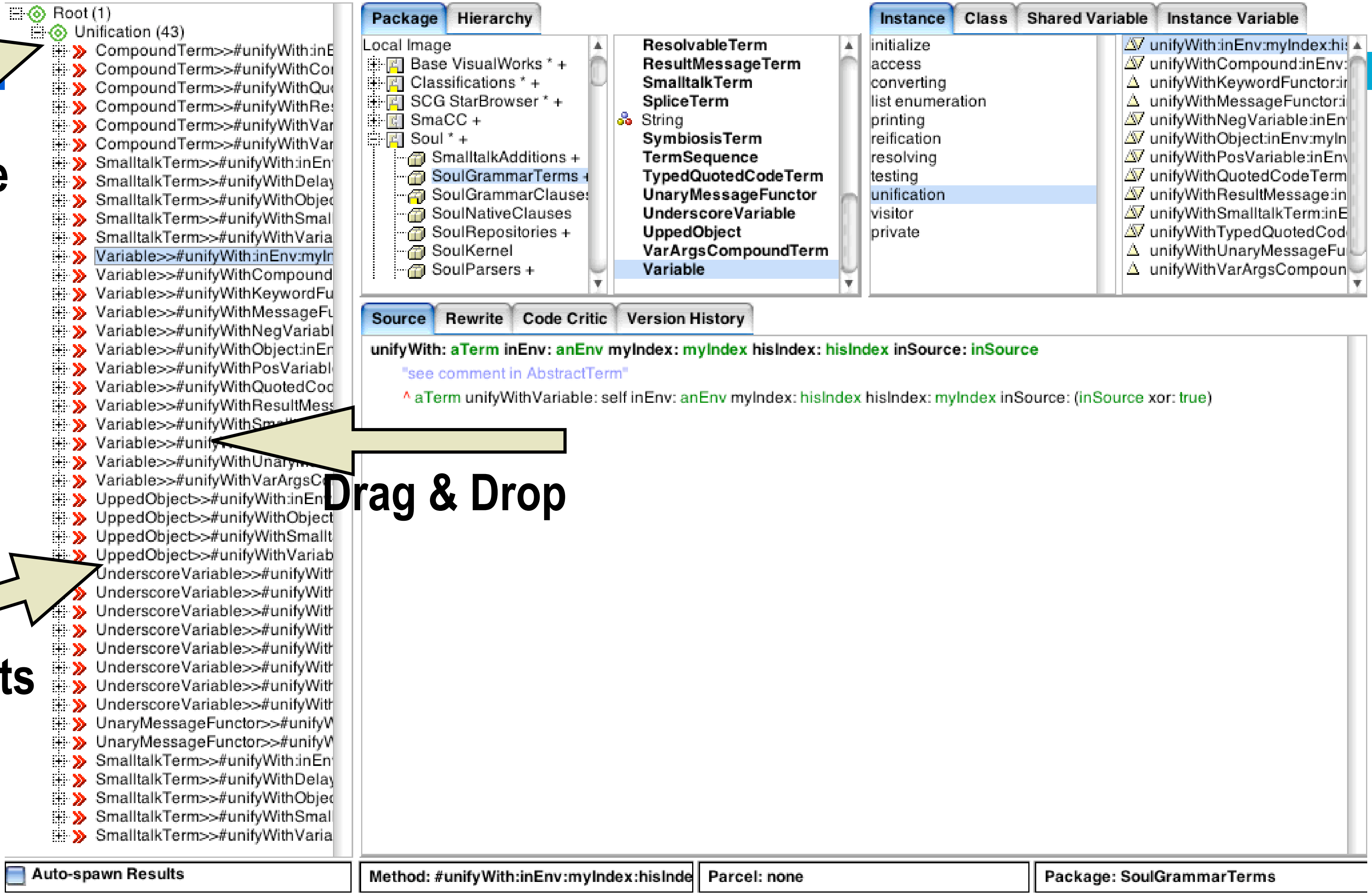
- Software becomes very large, more complex and constantly evolves
- Software documentation is extremely important to cope with these issues
  - avoid design degradation
  - understand inner workings
  - implement correct behaviour
- Documentation is often non existent or outdated
  - not active part of development process
  - documentation and implementation are separated
  - not robust w.r.t. evolution

Software Views



- Documentation technique used to highlight important design structures
  - design patterns, framework hotspots, collaborations, ...
- Collection of source code artifacts
  - classes, methods, variables, ...
- Two different kinds of software views
  - Extensional views
  - Intentional views

Extensional Views



View name

Drag & Drop

View artifacts

Root (1)
Unification (43)
CompoundTerm>>#unifyWith:inE
CompoundTerm>>#unifyWithCo
CompoundTerm>>#unifyWithQu
CompoundTerm>>#unifyWithRe
CompoundTerm>>#unifyWithVar
CompoundTerm>>#unifyWithVar
SmalltalkTerm>>#unifyWith:inEn
SmalltalkTerm>>#unifyWithDelay
SmalltalkTerm>>#unifyWithObjec
SmalltalkTerm>>#unifyWithSmal
SmalltalkTerm>>#unifyWithVaria
Variable>>#unifyWith:inEnv:myIn
Variable>>#unifyWithCompound
Variable>>#unifyWithKeywordFu
Variable>>#unifyWithMessageFu
Variable>>#unifyWithNegVariabl
Variable>>#unifyWithObject:inEn
Variable>>#unifyWithPosVariabl
Variable>>#unifyWithQuotedCod
Variable>>#unifyWithResultMess
Variable>>#unifyWithSm
Variable>>#unify
Variable>>#unifyWithUnary
Variable>>#unifyWithVarArgsC
UppedObject>>#unifyWith:inEn
UppedObject>>#unifyWithObject
UppedObject>>#unifyWithSmallt
UppedObject>>#unifyWithVariab
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnderscoreVariable>>#unifyWith
UnaryMessageFunctor>>#unifyW
UnaryMessageFunctor>>#unifyW
SmalltalkTerm>>#unifyWith:inEn
SmalltalkTerm>>#unifyWithDelay
SmalltalkTerm>>#unifyWithObjec
SmalltalkTerm>>#unifyWithSmal
SmalltalkTerm>>#unifyWithVaria

□ Auto-spawn Results

Local Image
Base VisualWorks * +
Classifications * +
SCG StarBrowser * +
SmaCC +
Soul * +
SmalltalkAdditions +
SoulGrammarTerms +
SoulGrammarClauses
SoulNativeClauses
SoulRepositories +
SoulKernel
SoulParsers +

ResolvableTerm
ResultMessageTerm
SmalltalkTerm
SpliceTerm
String
SymbiosisTerm
TermSequence
TypedQuotedCodeTerm
UnaryMessageFunctor
UnderscoreVariable
UppedObject
VarArgsCompoundTerm
Variable

initialize
access
converting
list enumeration
printing
reification
resolving
testing
unification
visitor
private

unifyWith:inEnv:myIndex:his
unifyWithCompound:inEnv:
unifyWithKeywordFunctor:ir
unifyWithMessageFunctor:i
unifyWithNegVariable:inEn
unifyWithObject:inEnv:myIn
unifyWithPosVariable:inEnv
unifyWithQuotedCodeTerm
unifyWithResultMessage:in
unifyWithSmalltalkTerm:inE
unifyWithTypedQuotedCod
unifyWithUnaryMessageFu
unifyWithVarArgsCompoun

```
unifyWith: aTerm inEnv: anEnv myIndex: myIndex hisIndex: hisIndex inSource: inSource
    "see comment in AbstractTerm"
    ^ aTerm unifyWithVariable: self inEnv: anEnv myIndex: hisIndex hisIndex: myIndex inSource: (inSource xor: true)
```

Method: #unifyWith:inEnv:myIndex:hisInde

Parcel: none

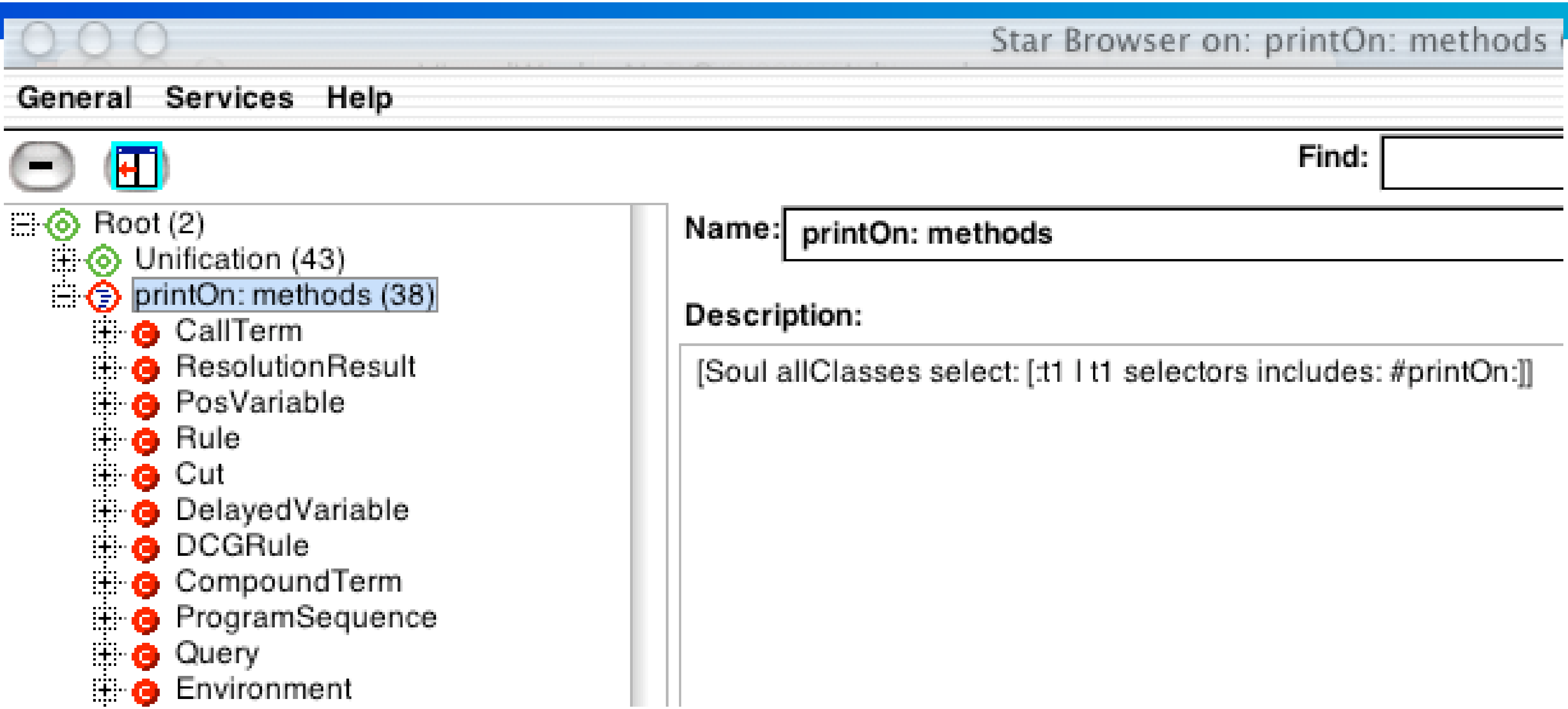
Package: SoulGrammarTerms

Extensional Views

- **Manual enumeration** of source code artifacts
- Advantages
  - easy to define (drag & drop)
- Disadvantages
  - not robust w.r.t. evolution
  - not scalable
  - not intention revealing

Reduces interest of using software views

Intentional Views



Name: printOn: methods

Description:

```
[Soul allClasses select: [:t1 | t1 selectors includes: #printOn:]]
```

Intentional Views

- Defined by means of an **intentional description**
  - executable expression in a programming language
  - view's content is computed from the source code
- Advantages
  - robust w.r.t. evolution
  - scalable
  - intention revealing

Complicates use of Intentional Views

- Disadvantages
  - hard to define (requires meta-programming skills)
  - risk to be overly general
  - requires detailed knowledge of the application's internal structure

Induced Intentional Views

- Combines advantages of extensional and intentional views
  - ease of use of extensional views
  - robustness and scalability of intentional views
- Inducing views
  - manually classify source code artifacts
  - automatically derive intention behind it
- Techniques
  - Logic Metaprogramming
    - to connect views to implementation
  - Inductive Logic Programming (Machine Learning)
    - to derive intention automatically

Logic Meta Programming (LMP)

- Using a logic programming language (Prolog) at the meta level to reason about and manipulate programs at the base level (in Smalltalk)
- Allows to define intentional views in a concise and declarative manner
- SOUL
  - Interpreter integrated in VW
  - Contains extensive library of logic predicates that consult source code

Inductive Logic Programming

- Machine learning technique
  - Discovers a general pattern underlying a number of examples
  - Requires a set of examples and a background theory

Examples	Background Theory	Induced Logic Rules
grandFather(tom,bob). grandFather(tom,jim). grandFather(tom,ellen). grandFather(tom,bart).	father(tom,peter). father(tom,marie). father(peter,bob). father(peter,jim). mother(marie,ellen). mother(marie,bart).	grandFather(?grandfather,?person) if father(?grandfather,?father), father(?father,?person). grandFather(?grandfather,?person) if father(?grandfather,?mother), mother(?mother,?person).

Software Views with LMP

- Extensional
  - Logic facts (enumeration)

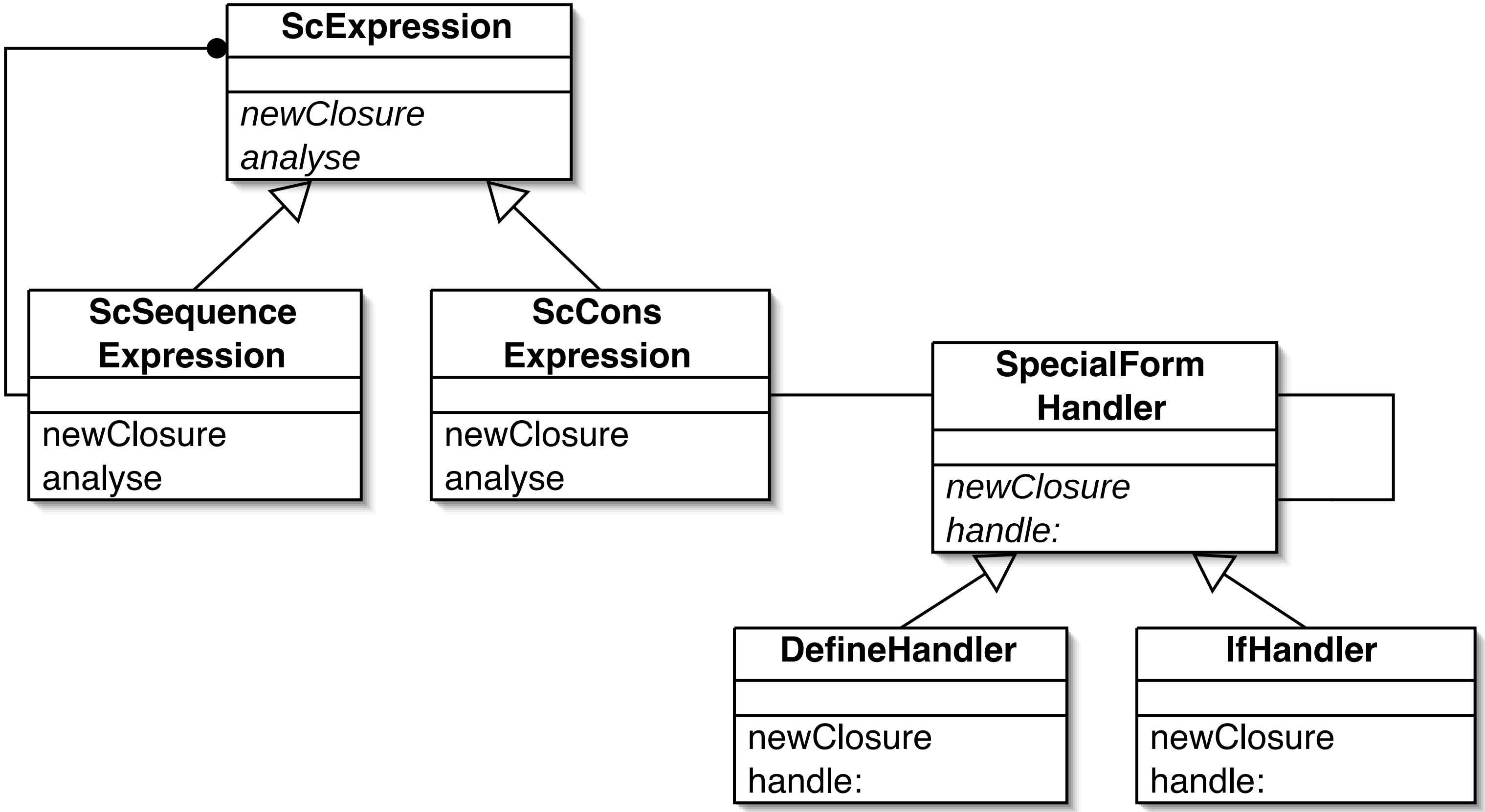
```
class(ScExpression).
class(ScConsExpression).
methodInClass(analyse,ScConsExpression).
...
```

Induction algorithm

- Intentional
  - Logic rules (program)

```
class(?method) if
  methodInClass(analyse,?method).
...
```

Proof of concept experiment



Classified Items

```
analyser(classImplementsMethodNamed(ScExpression,analyse)).
analyser(classImplementsMethodNamed(ScConsExpression,analyse)).
analyser(classImplementsMethodNamed(ScSequenceExpression,analyse)).
...
analyser(classImplementsMethodNamed(SpecialFormHandler,handle:)).
analyser(classImplementsMethodNamed(DefineHandler,handle:)).
analyser(classImplementsMethodNamed(IfHandler,handle:)).
```

Derived Rules

```
intention(analyser,<?class,?selector>) if
    analyser(classImplementsMethodNamed(?class,?selector)).
```

defines intention in terms of derived rules

```
analyser(classImplementsMethodNamed(?class, handle:)) if
    methodSendsMessage(?class, handle:, newConverterFor:),
    methodSendsMessage(?class, handle:, newClosure),
    methodSendsMessage(?class, handle:, analyse),
    classInHierarchyOf(?class,Scheme.SpecialFormHandler),
    classInHierarchyOf(?class,Scheme.SpecialFormHandlerWithSuccessor),
    classInHierarchyOf(?class, ?class).
```

Redundant

Derived Rules

```
analyser(classImplementsMethodNamed(?class, analyse)) if
    methodSendsMessage(?class, analyse, newClosure),
    classInHierarchyOf(?class,Scheme.ScExpression),
    classInHierarchyOf(?class, ?class).
```

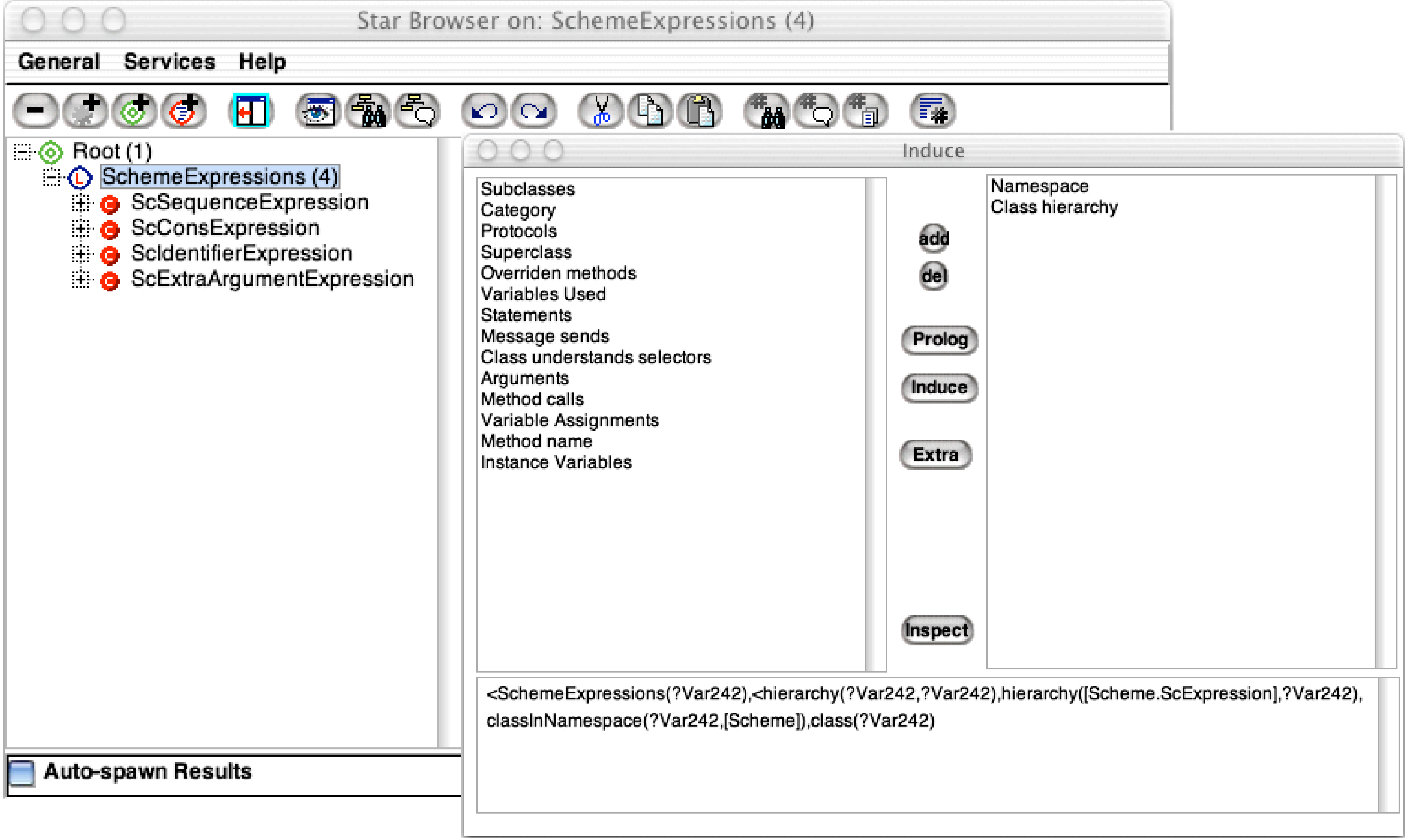
Redundant

```
analyser(classImplementsMethodNamed(Scheme.DefineRelHandler,handle:)).
```

Discussion

- Results show that intentions are discovered
- Problems encountered
  - algorithm is sensitive to order of examples presented
  - sufficient number of examples is needed
    - rules are either too restrictive or too general
  - performance issues
- Scalability
  - only two small experiments, no large-scale study yet

Prototype Tool Support



- Root (1)
  - SchemeExpressions (4)
    - ScSequenceExpression
    - ScConsExpression
    - ScIdentifierExpression
    - ScExtraArgumentExpression

Subclasses
Category
Protocols
Superclass
Overriden methods
Variables Used
Statements
Message sends
Class understands selectors
Arguments
Method calls
Variable Assignments
Method name
Instance Variables

Namespace
Class hierarchy

```
<SchemeExpressions(?Var242),<hierarchy(?Var242,?Var242),hierarchy([Scheme.ScExpression],?Var242),
classInNamespace(?Var242,[Scheme]),class(?Var242)
```

Conclusion

- Induced intentional views combine advantages of extensional and intentional views, while removing their respective disadvantages
- Can be used to tackle software documentation problems
  - explicit link between source code and documentation by means of LMP
  - robust w.r.t. evolution
- Can be integrated easily into already existing development tools