# Systematic Source Code Transformations

Gustavo SANTOS

## Presentation

- Bachelor in Computer Science
- Master in Computer Science
- Short visit to RMoD team
- Funded by CAPES (Brazil)
  - Science Without Borders program

## Areas of Interest

- Change Impact Analysis
- Modularization
- Information Retrieval
- Quality Metrics
- …
- Software Evolution

## Introduction

Identifying Systematic Code Transformations
Replaying Systematic Code Transformations

## Software Evolution

- Software is in constant evolution to remain useful [Leh1980]

- Evolution is composed of changes
  - Performed in distinct moments in time
  - By many developers

- Developers need to reason about code changes [Hat2011]

[Leh1980] On Understanding Laws, Evolution, and Conservation in the Large-Program Life Cycle. *JSS*
[Hat2011] Software Evolution Comprehension: Replay to the Rescue. *ICPC*

## Refactoring

- Change made to the internal structure to make it […] cheaper to modify […] without changing its observable behavior [Fow1999]

- Regular and applied to few entities [Avg2013]

[Fow1999] Refactoring: Improving the Design of Existing Code
[Avg2013] Architecture sustainability. *IEEE Software*

## Rearchitecting

- Rearchitecting (large refactoring) [Avg2013]
  - Update APIs
  - Improve the organization

- Less frequent but involves the entire system

- Rearchitecting dataset as product of my Master [San2014]

[Avg2013] Architecture sustainability. *IEEE Software*
[San2014] Remodularization Analysis using Semantic Clustering. *CSMR-WCRE*

## Software Evolution

- Systematic Code Changes
- In Eclipse 2.1 → 3.0, for example:

**move class** C to a package ‘ui.ide’
in the initializer of C, **add invocation** to method ‘setActionId’

Applied **22** times

## Transformation Pattern

- Sequences of transformations that are applied to **similar** code entities

transformation pattern

```
organizeActionInheritance(class C)
        moveClass(C, getPackage(‘ui.ide’))
        addInvocation(C(), getMethod(‘setActionId’))
```

transformation operator

- Operators can be atomic or aggregated

## Conclusions

- Transformation patterns can be:
  - Complex
  - Tedious
  - Error-prone

- Automation is needed

Introduction

## Identifying Systematic Code Transformations

Replaying Systematic Code Transformations

## Related Work

- We found work concerning such activity

| | Application | Destination of changes |
|---|---|---|
| **[Pan2009]** | Bug Fixes | inside methods only |
| **[And2008]** | API evolution | inside methods only |
| **[Kim2013]** | General | files only |
| **[Mil2014]** | General | inside methods only |
| **[Jia2015]** | General | inside classes only |

## Related Work

- No existing work in rearchitecting
- Destination of the changes
  - More complex operators
- Properties of the entities involved
  - More system specific patterns

## Investigative Study

- Identify similar changes semi-automatically

- Rearchitecting dataset
  - Performed manually by the developers
  - Systems before and after rearchitecting

## Methodology

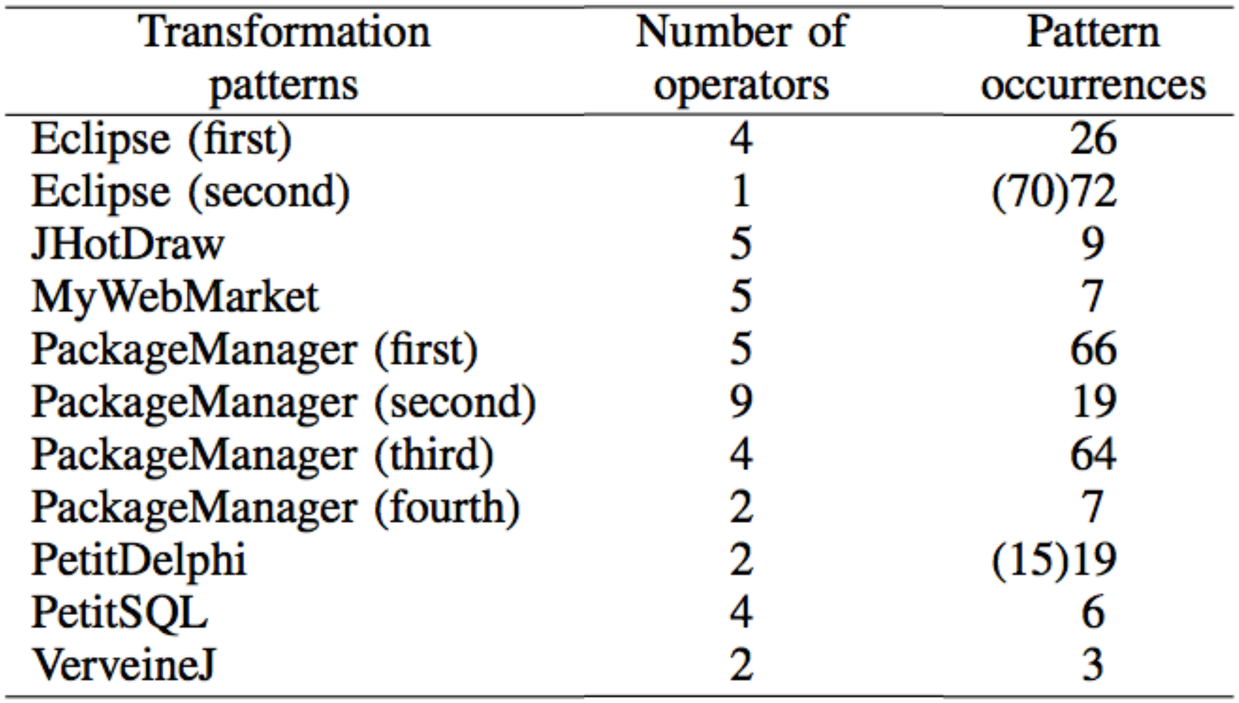
- Identify similar changes semi-automatically
  - Extract the diff between versions
  - Filter groups of similar changes
  - Manually identify similar properties

**move class** C to a package ‘ui.ide’
in the initializer of C, **add invocation** to method ‘setActionId’

C **extends** eclipse.Action

## Transformation Patterns

- Total of eleven patterns in real software systems

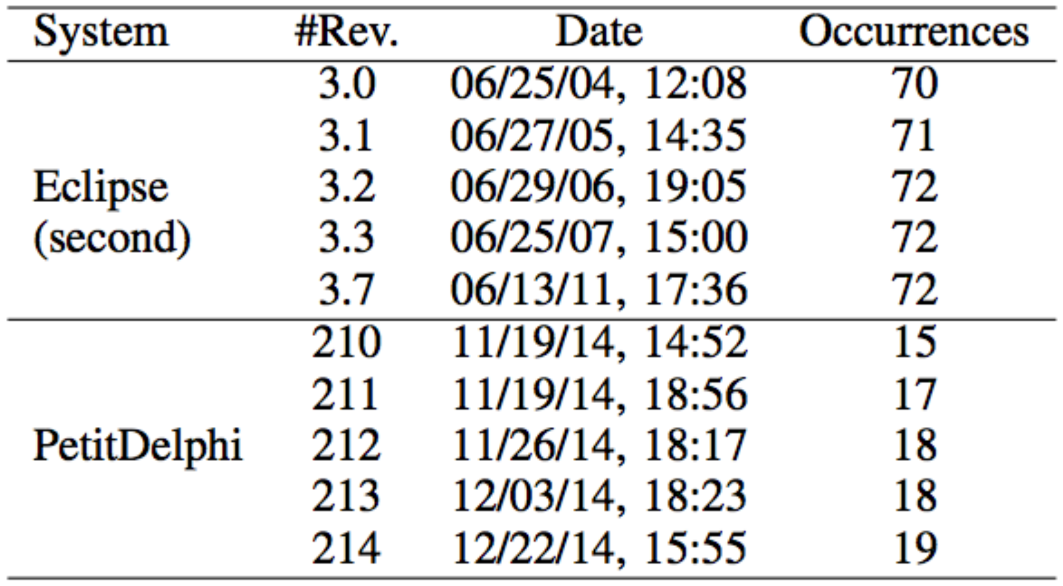


| Transformation patterns | Number of operators | Pattern occurrences |
|---|---|---|
| Eclipse (first) | 4 | 26 |
| Eclipse (second) | 1 | (70)72 |
| JHotDraw | 5 | 9 |
| MyWebMarket | 5 | 7 |
| PackageManager (first) | 5 | 66 |
| PackageManager (second) | 9 | 19 |
| PackageManager (third) | 4 | 64 |
| PackageManager (fourth) | 2 | 7 |
| PetitDelphi | 2 | (15)19 |
| PetitSQL | 4 | 6 |
| VerveineJ | 2 | 3 |

Transformation Patterns are frequent

# Transformation Patterns

- In JHotDraw, some operators were not applied
- In other systems, the pattern was not applied at once



| System | #Rev. | Date | Occurrences |
|---|---|---|---|
| Eclipse (second) | 3.0 | 06/25/04, 12:08 | 70 |
| | 3.1 | 06/27/05, 14:35 | 71 |
| | 3.2 | 06/29/06, 19:05 | 72 |
| | 3.3 | 06/25/07, 15:00 | 72 |
| | 3.7 | 06/13/11, 17:36 | 72 |
| PetitDelphi | 210 | 11/19/14, 14:52 | 15 |
| | 211 | 11/19/14, 18:56 | 17 |
| | 212 | 11/26/14, 18:17 | 18 |
| | 213 | 12/03/14, 18:23 | 18 |
| | 214 | 12/22/14, 15:55 | 19 |

Transformation Patterns are complex

## Conclusions

- Automation is needed
  - Perform the transformations correctly
  - Find transformation opportunities
- Generate custom transformations
  - Abstract
  - Replicable
  - System specific
- Submitted paper to ICSME (under review)

Introduction
Identifying Systematic Code Transformations

## Replaying Systematic Code Transformations

## Problem

- Transformation patterns exist
- Generate custom, abstract transformations
  - Replay in different code locations

## Related Work

- Automated Code Transformation

| | Application | Destination of Changes |
|---|---|---|
| **Sydit [Men2011]** | Bug fixes | methods only |
| **Lase [Men2013]** | Bug fixes | methods only |
| **Critics [Zha2015]** | Bug fixes | customizable |

## Solution

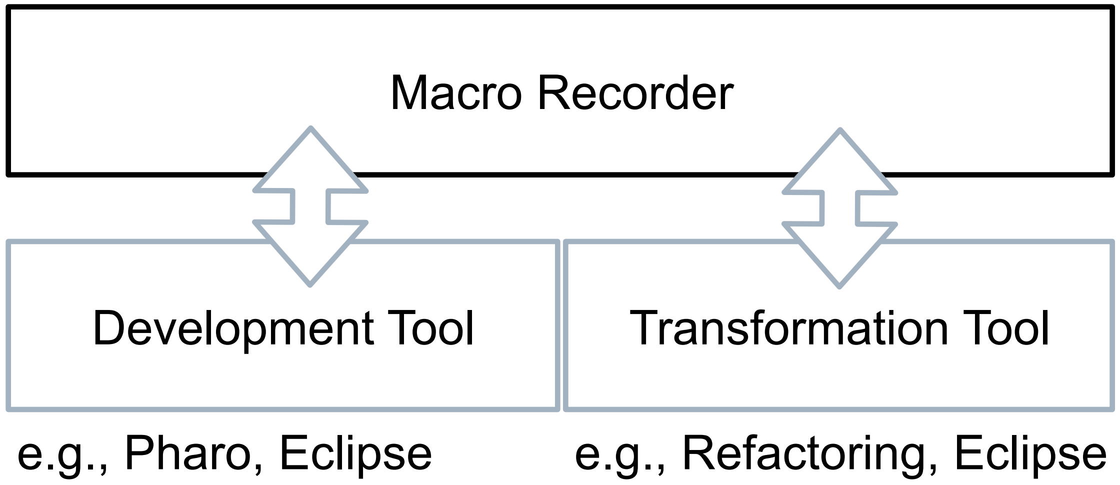
**move class** StoreAction to a package ‘ui.ide’
in StoreAction(), **add invocation** to ‘setActionId’

- What if the developer could…
  - Perform the changes manually **once**
  - Generalize the performed changes
  - Replay the changes in other locations

**execute it** for all class C that **extends** eclipse.Action

## Approach

- MacroRecorder
  - For each recorded event in the development tool, generate an equivalent transformation

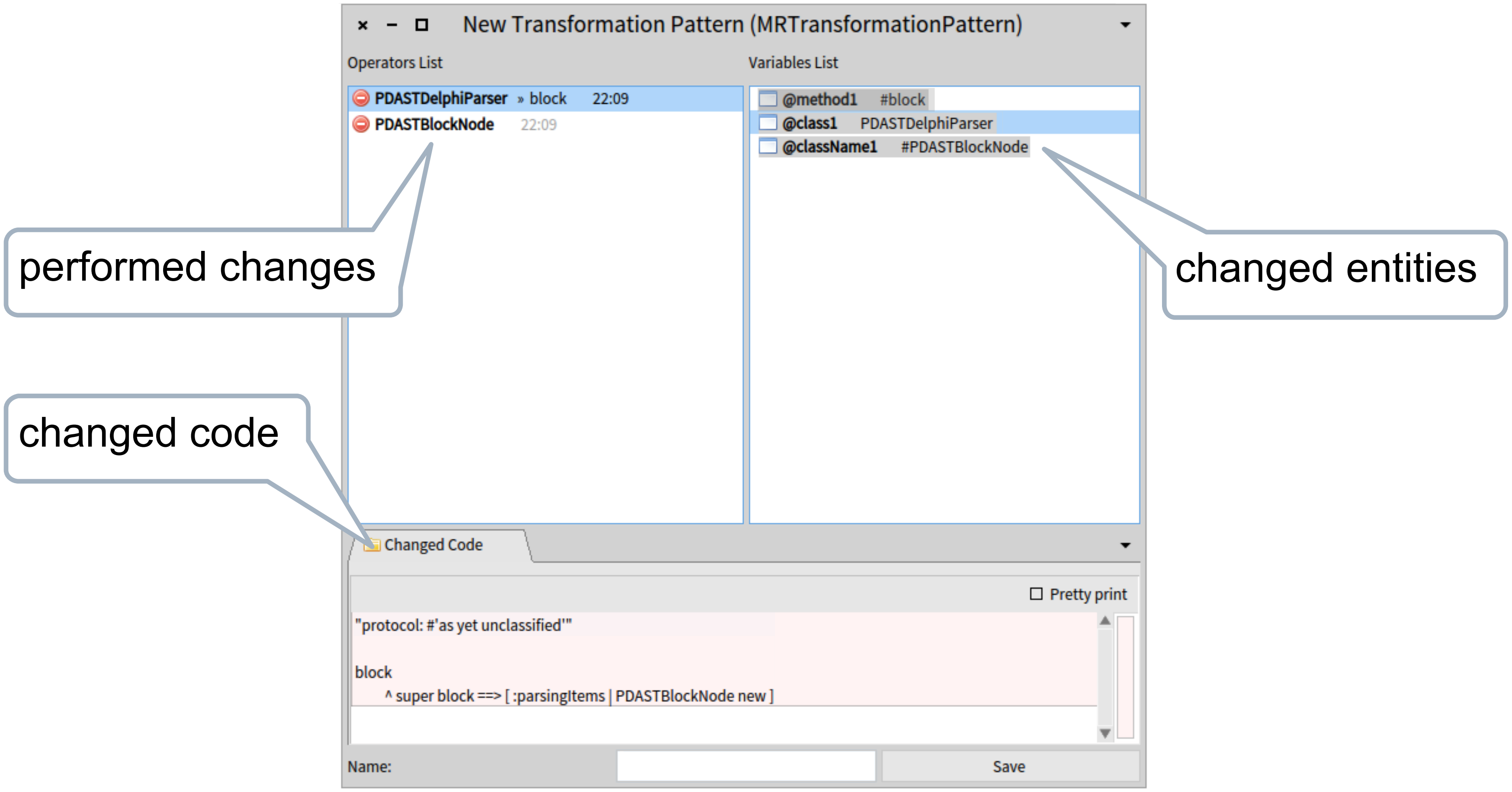


## Illustrating Example

**remove method** blockNode in class Parser
**remove class** BlockNode

- Enable recording
- Then perform the change manually
- Stop recording

# Illustrating Example - Record

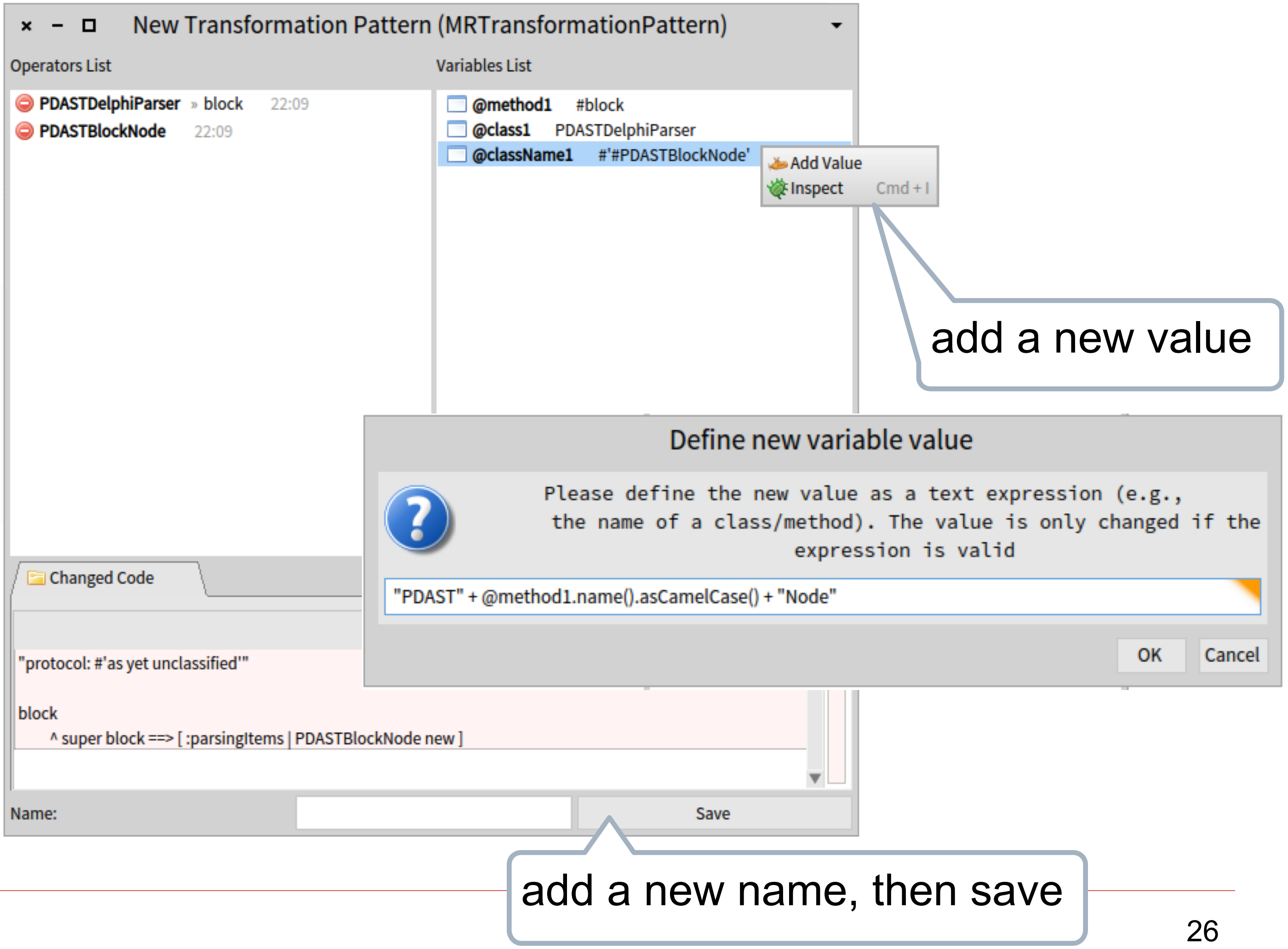


| | | |
|---|---|---|
| PDASTDelphiParser » block | 22:09 | |
| PDASTBlockNode | 22:09 | |

| | |
|---|---|
| @method1 | #block |
| @class1 | PDASTDelphiParser |
| @className1 | #PDASTBlockNode |

```
"protocol: #'as yet unclassified'"

block
	^ super block ==> [ :parsingItems | PDASTBlockNode new ]
```

# Illustrating Example - Generalize



New Transformation Pattern (MRTransformationPattern)

Operators List

| | | |
|---|---|---|
| PDASTDelphiParser » block | | 22:09 |
| PDASTBlockNode | | 22:09 |

Variables List

| | |
|---|---|
| @method1 | #block |
| @class1 | PDASTDelphiParser |
| @className1 | #'#PDASTBlockNode' |

Changed Code

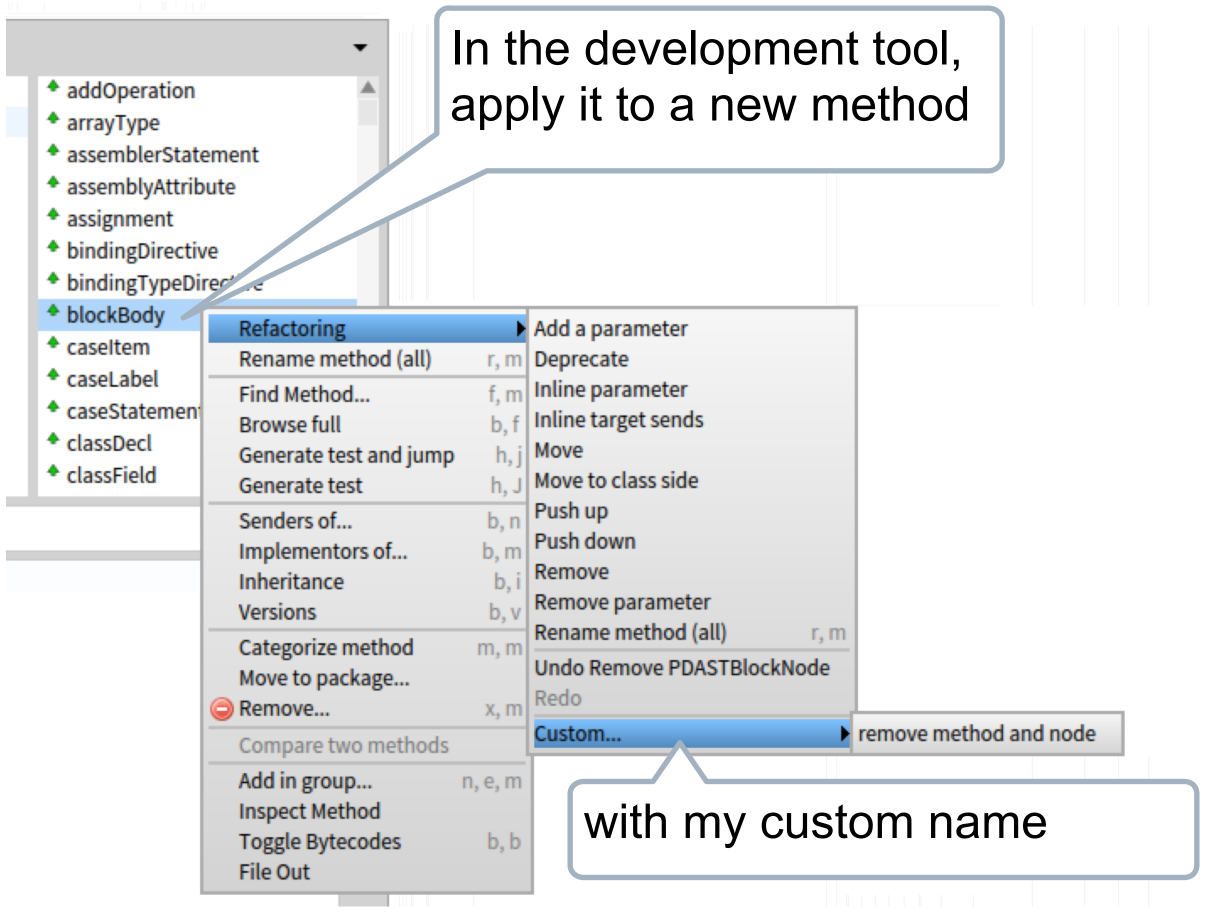
```
"protocol: #'as yet unclassified'"

block
	^ super block ==> [ :parsingItems | PDASTBlockNode new ]
```

Define new variable value

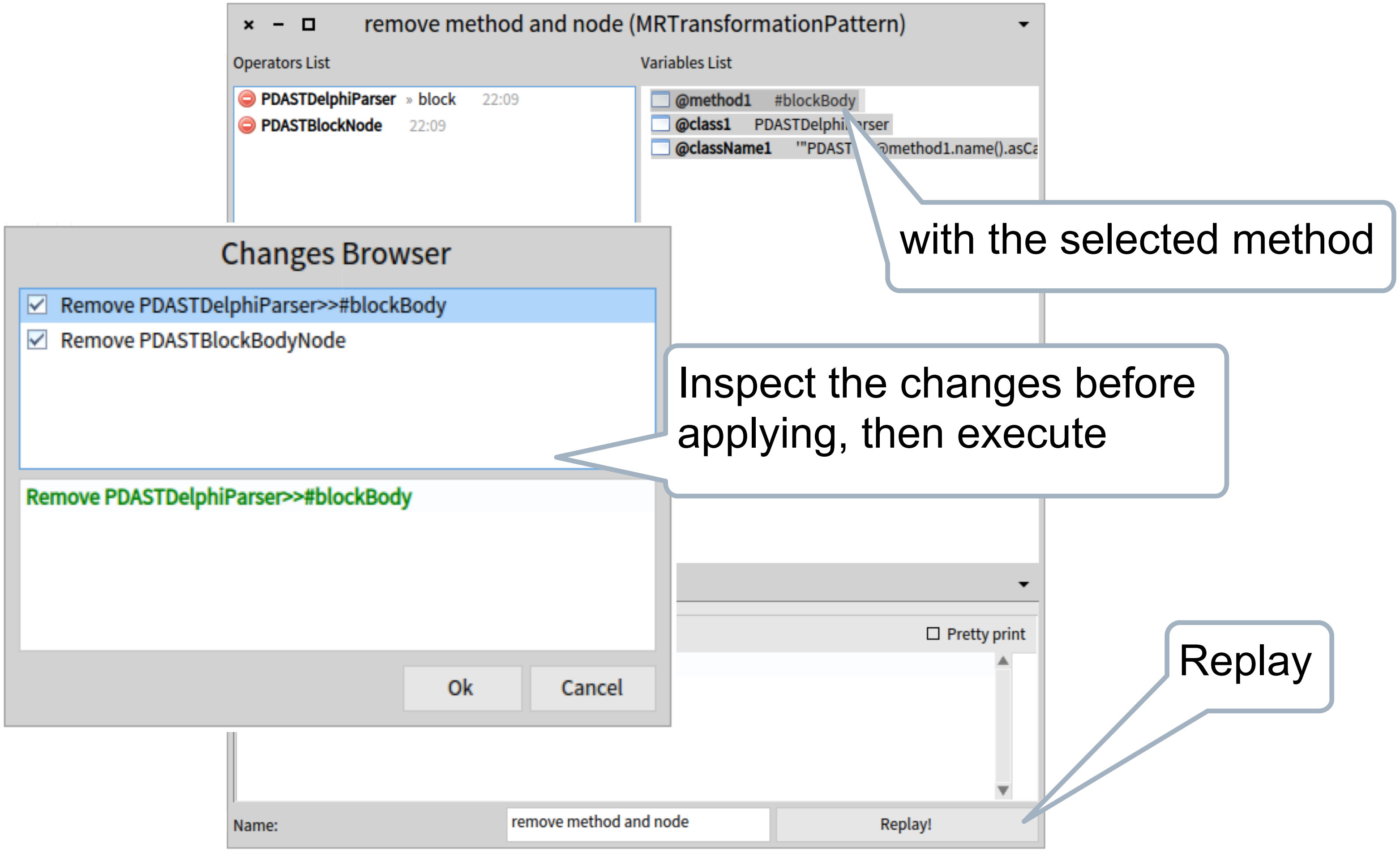
Please define the new value as a text expression (e.g., the name of a class/method). The value is only changed if the expression is valid

"PDAST" + @method1.name().asCamelCase() + "Node"

## Illustrating Example - Replay



## Illustrating Example - Replay



PDASTDelphiParser » block 22:09
PDASTBlockNode 22:09

@method1 #blockBody
@class1 PDASTDelphiParser
@className1 '"PDAST @method1.name().asCa

☑ Remove PDASTDelphiParser>>#blockBody
☑ Remove PDASTBlockBodyNode

Remove PDASTDelphiParser>>#blockBody

remove method and node

## Future Work

- Use MacroRecorder on the patterns we found before
- Check if the examples are correct