Overview of the Refactoring Discovering Problem

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ECOOP 2006, Doctoral Symposium and PhD Students Workshop

Introduction

Refactorings are structural transformations that can be applied to a software system to perform design changes without modifying its behaviour.

Current approaches to improve a system design with refactorings focus in:

- Individual refactoring steps.
- Detecting refactoring opportunities.
- Executing the refactoring with a tool.

Some techniques can suggest **wider design changes**:

- Formal Concept Analysis to propose hierarchy reorganization (Prieto et al., 2003).
- Metrics to detect Bad Smells (Crespo et al., 2005).

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Main Goals

1. **To automatically and dinamically generate refactoring sequences (refactoring plans)** that can transform a system, following a redesing proposal, and preserving the system's behaviour.
2. **To provide very high level (big) refactorings** for design improvement, using refactoring plan generation altogether with analysis techniques that suggest redesign proposals.
3. **To support this "refactoring plan" technique with tool prototypes** to provide it as a regular design improving development technique.

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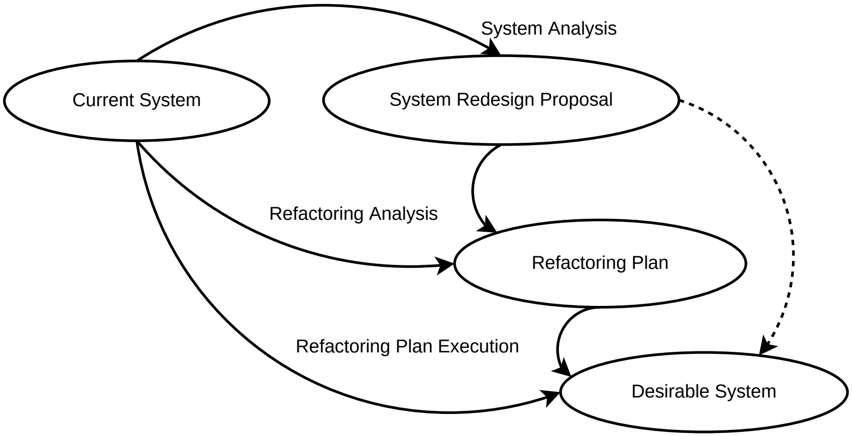

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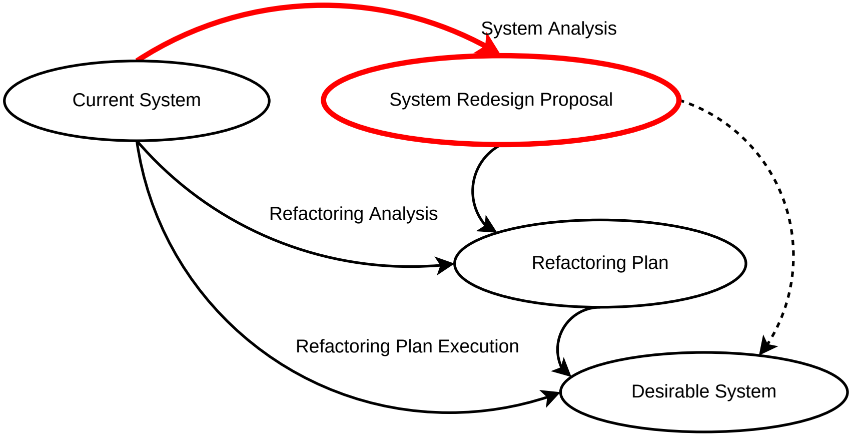

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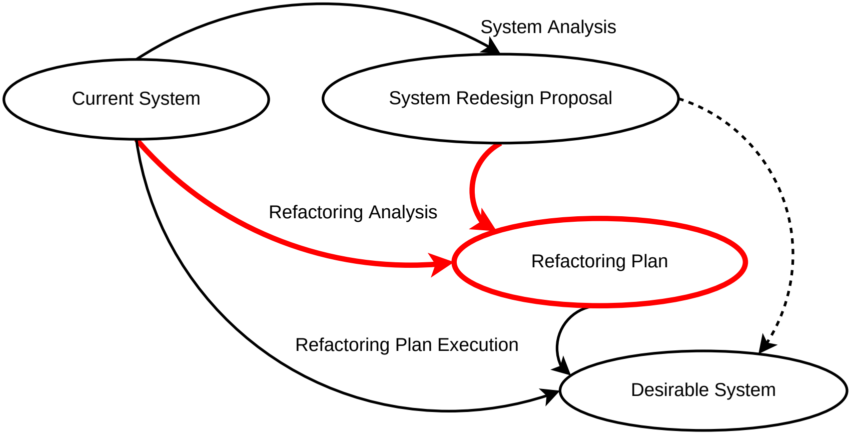

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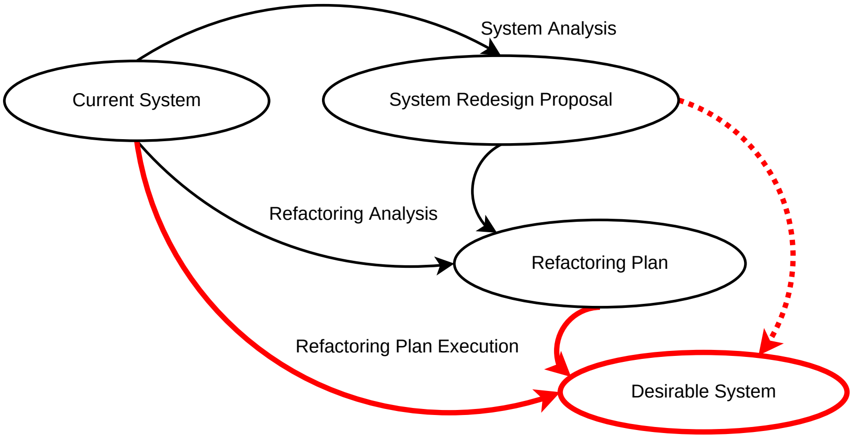

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We pretend to introduce a new concept: **Refactoring Plans**

Definition

A **Refactoring Plan** will be a specification of a refactoring sequence which matches a system redesign proposal, so that it can be automatically executed to modify the system in order to obtain that desirable system redesign without changing the system's behaviour.

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Given **a software system** as the source of the transformation, **a redesign proposal**, and **a set of refactorings** that can be used as transformation operations:

1. Does a refactoring plan, which transforms the source, according to the redesign proposal, using the provided refactorings, exist?
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Subproblems

We have divided the problem of **automatic generation of refactoring plans** in:

- Definition and formalization of the “Refactoring Plan” concept
- Representation of Software
- Formalization of Refactorings
- Elaboration of a “refactoring sequences” discovering algorithm
- Validation of proposed subproblem solutions through existing tools and prototype implementation

Research Strategy

To reduce the problem complexity given by:

- differences between source and redesign proposal representation type, abstraction level, description language, . . .
- uncertainty about what kind of redesign proposal descriptions will we be capable to deal with.

We have planned the **research** to progress **through two stages**:

- First, we will apply some restrictions to the problem and propose a restricted solution.
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Research Strategy: First Stage

We apply some **restrictions to reduce complexity**:

- The transformation source is the current system code.
- The redesign proposal is the modified system code.

Goals of this stage are:

- To propose a solution to the restricted refactoring plan problem.
- To validate this solution.

Results obtained so far **can be applied** to other problems:

- testing if an evolved system preserves the behaviour of the original system.
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- Redesign proposals in the second stage will contain less information than redesign proposal in the first stage (modified system code).

Goals of this stage are:

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Research Strategy: Progress so far

We are at the first stage of the research, and working on these subproblems:

- Software representation
- Refactoring formalization
- “refactoring sequences discovering” algorithm

This presentation introduces the current progress of each one.

Refactoring Formalization

Any refactoring formalization method must allow:

- to deal with **system structure**.
- to **check** behaviour preserving **conditions**.

We will use **Graph Transformations** because:

- Representing and managing structural information is straightforward with graphs.
- This approach has already been validated (Mens et al., 2005).

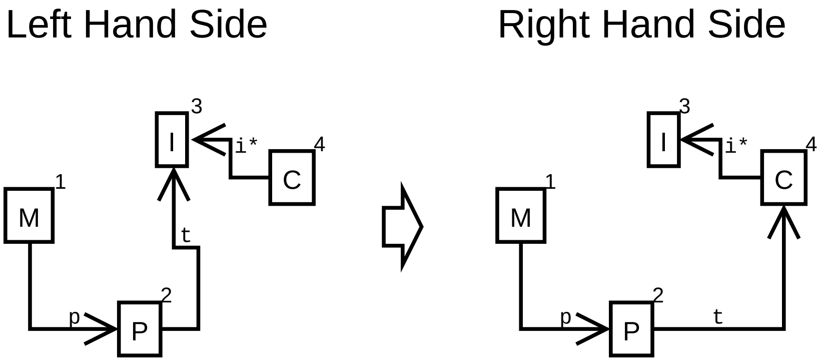
With Graph Transformation:

- **Software** is represented as **graphs**.
- **Refactorings** are represented as **graph transformation rules**.

Other refactoring formalization approaches:

- First Order Logic (Köch, 2002).

Example of a Graph Transformation Rule



Refactoring and Graph Transformation

We have found two main directions within the field of graph transformations, that can be useful:

- Rule Driven Systems
- Programmed Graph Rewriting Systems

Rule Driven Systems

Rule Driven Systems are graph rewriting systems where:

- transformation rules are described by a graph grammar
- transformations follow known derivation sequences
- rules are randomly selected to automatically transform a graph

The **problem** was **modeled as a formal language problem**:

- Current system $\Rightarrow$ starting node
- Refactorings $\Rightarrow$ production rules
- Desirable system $\Rightarrow$ final node
- Does the plan exist? $\Rightarrow$ membership problem
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Rule Driven Systems

We explored this approach and found some issues:

- This approach deals well with problems for which derivation paths are well defined (e.g. visual language parsing).
- A well known derivation tree for refactoring sequences should be needed
- The number of refactorings which can be applied for each derivation step is unpredictable

Programmed Graph Rewriting Systems

PGR Systems present a more general graph rewriting approach:

- graph grammars are also used
- they include structured programming
- transformations can be programmed and organized in modules

The **problem** can be **seen as a state space search problem**:

- Current system $\Rightarrow$ starting state
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Issues found so far:

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Refactoring Formalization with PGR Systems

We have chosen Programmed Graph Rewriting Systems because:

- they offer **programmable control** over the graph transformation process
- they offer **more expressiveness** than the grammar based systems
- **refactorings which take multiple transformation steps** are very difficult to describe with Rule Driven Systems, and they can be described easily with PGR Systems

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A graph representation for Object-Oriented Software is needed. We must represent:

- elements of OO paradigm (classes, fields, methods, ...)
- structural relationships
- method bodies

We have chosen the software representation part from the refactoring formalization of (Mens et al., 2005). This representation:

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- is language independent, lacking specific language constructions.
- has been simplified to be as flexible as possible.

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- pre and postconditions
- transformation process (the refactoring itself)
- transformation relationships between pre and post conditions.

Programmed Graph Rewritings will allow to:

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  `if...then...else`
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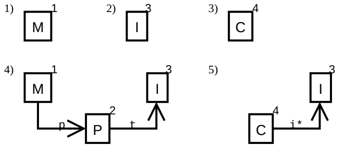
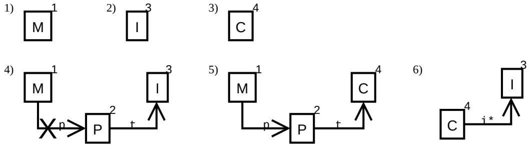
Example: Change Interface Type Parameter

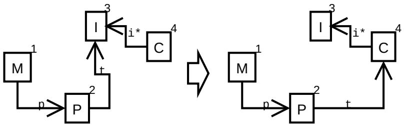
Preconditions:



Postconditions:



Transformation:



pre	→	post
1	→	1
2	→	2
3	→	3
4	→	4,5
5	→	6

Refactoring Sequences Discovering Algorithm

- A basic state space search algorithm is being developed.
- It needs refactoring descriptions to be expressed in terms of preconditions, transformations and postconditions.
- It needs the expressiveness and execution control of programmed graph rewriting.
- The **algorithm main keys** are:
  - The Algorithm is **guided by pre and postconditions**.
  - **To look for preconditions in the source graph** in order to reveal which refactorings can be applied.
  - **To look for postconditions in the target graph** in order to fi nd which refactorings are more likely to be part of the sequence.
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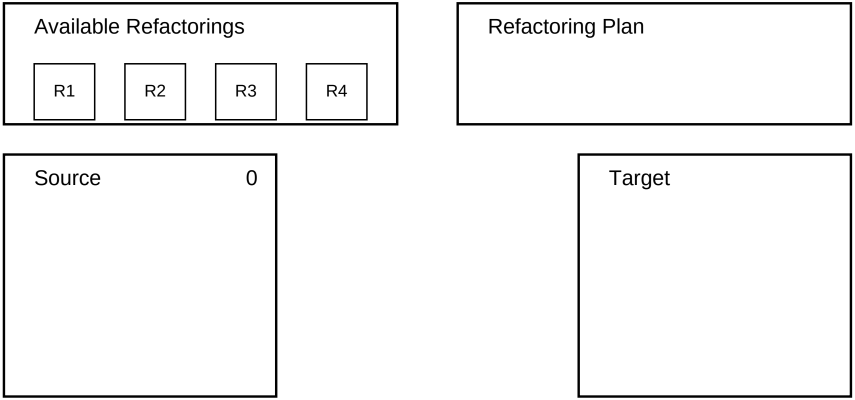
- The **algorithm main keys** are:
  - The Algorithm is **guided by pre and postconditions**.
  - **To look for preconditions in the source graph** in order to reveal which refactorings can be applied.
  - **To look for postconditions in the target graph** in order to fi nd which refactorings are more likely to be part of the sequence.
  - The **source graph** gets **transformed** progressively **into the target graph**.

Refactoring Sequences Discovering Algorithm



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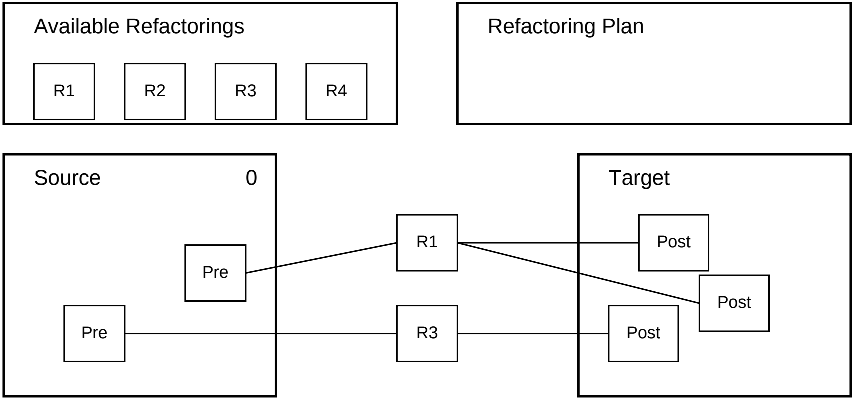

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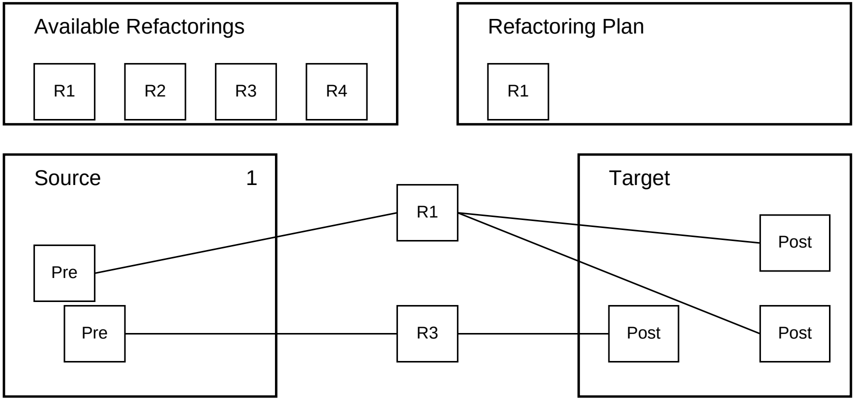

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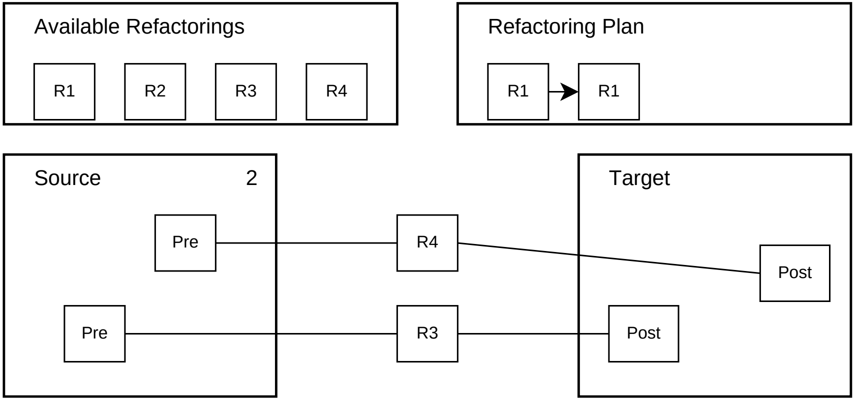

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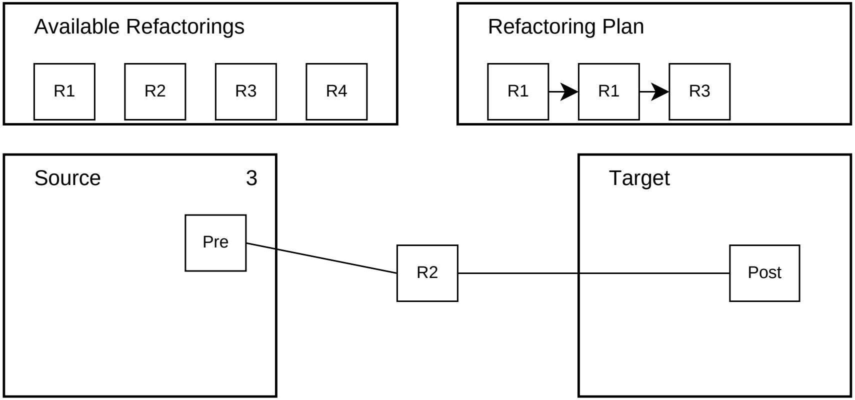

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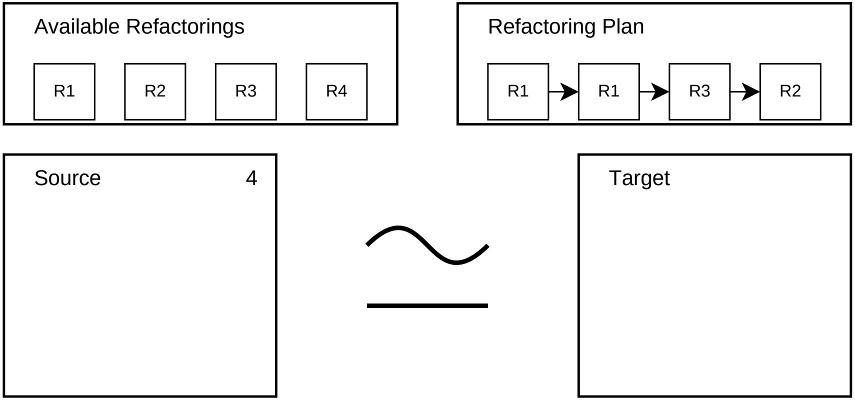
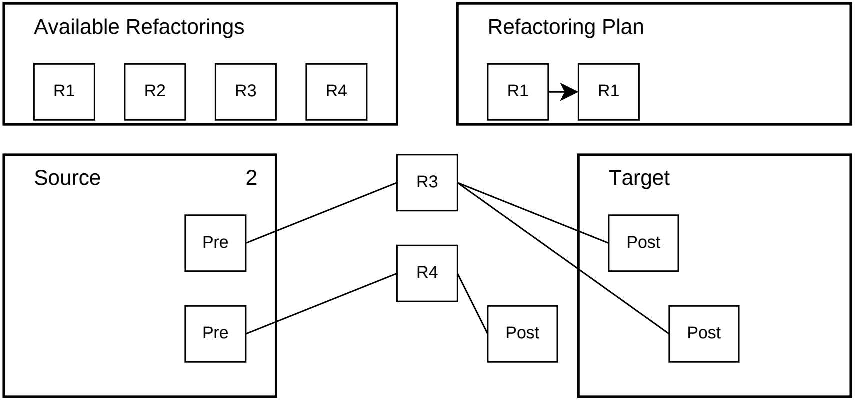


“Postcondition” Heuristic

- Prioritize refactorings whose postconditions hold on the target graph.



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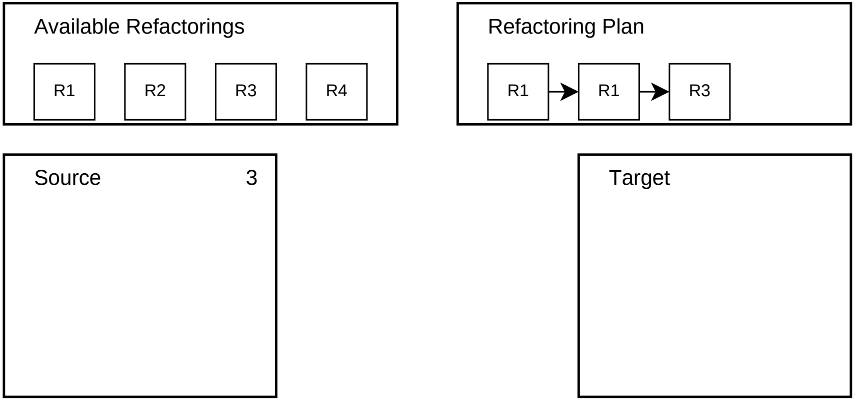
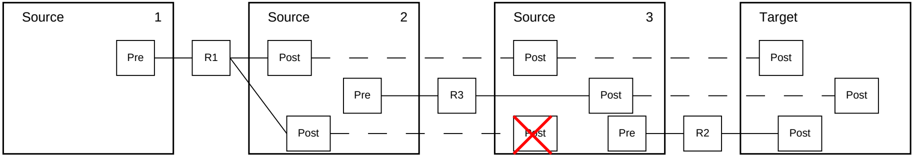


“Awaiting Postcondition” Heuristic

- Prioritize refactorings which make that the previous selected. refactorings can hold their awaiting postconditions



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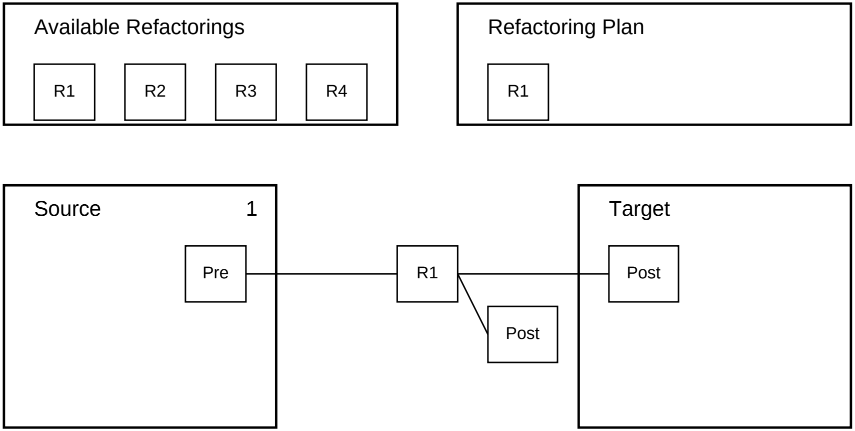

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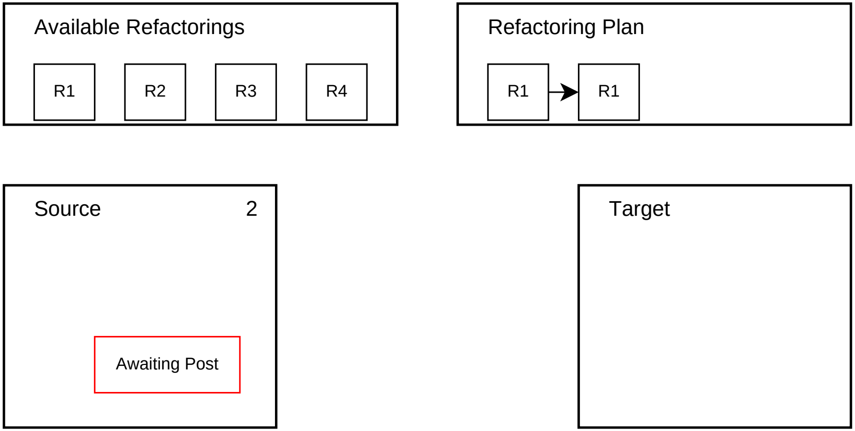

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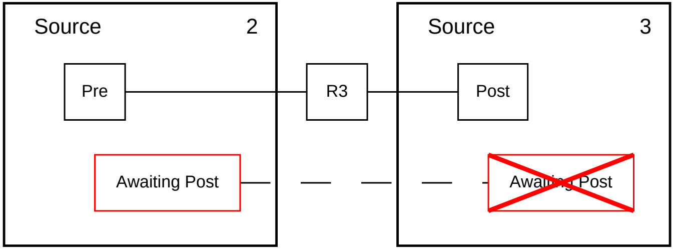

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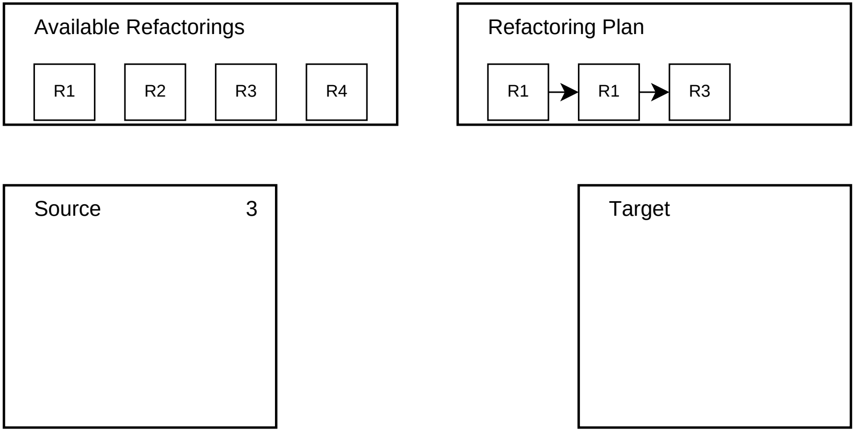

Conclusions

- Automatic generation of refactoring plans will provide very high level refactorings to improve the design of existing code.
- The Main subproblems and the research strategy have been introduced.
- Graph transformation can be used as the underlying formalism, specifically the programmed graph rewriting approach.
  - Representing Java programs with Java Program Graphs.
  - Describing refactoring rules with programmed graph transformation rules in terms of pre, postconditions and transformations.
- The problem can be modeled as a state space search problem.
  - Using a “refactoring sequences discovering” algorithm guided by pre and postconditions, to fi nd a refactoring plan, .
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Detected Problems

Correction and completeness of the algorithm:

- Heuristics could not be enough to prevent the algorithm getting lost in the search.
- The number of applicable refactorings on each step is expectable to be very big.
- The algorithm can get stuck selecting “wrong” refactorings.

Future Work

Main future tasks will be directed to:

- Further definition of the “Refactoring Plan” concept.
- Extend the available set of formalized refactorings.
- Validate proposals implementing the algorithm with a PGR tool.
- Analyse termination and correctness conditions of the refactoring discovering algorithm.
- Analyse, improve and extend heuristics of the state space search algorithm.

Overview of the Refactoring Discovering Problem

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ECOOP 2006, Doctoral Symposium and PhD Students Workshop