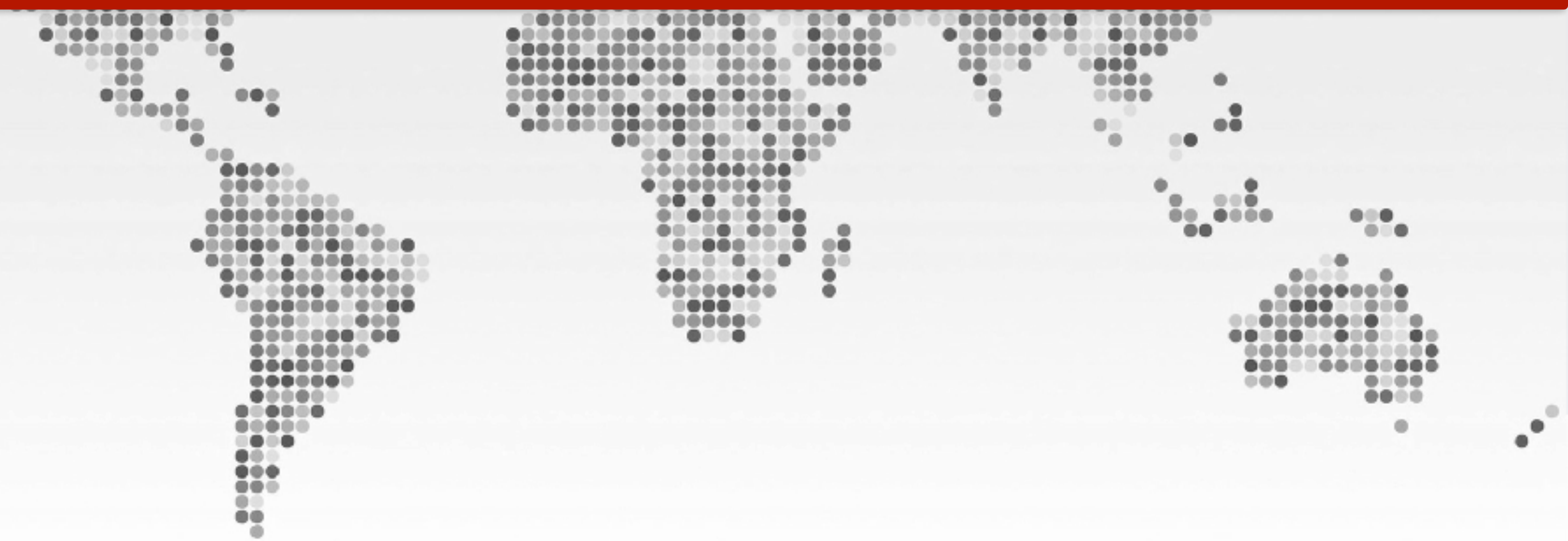
Code smells: detection & refactoring

Slides by Prof. Fabio Palomba



Who I am

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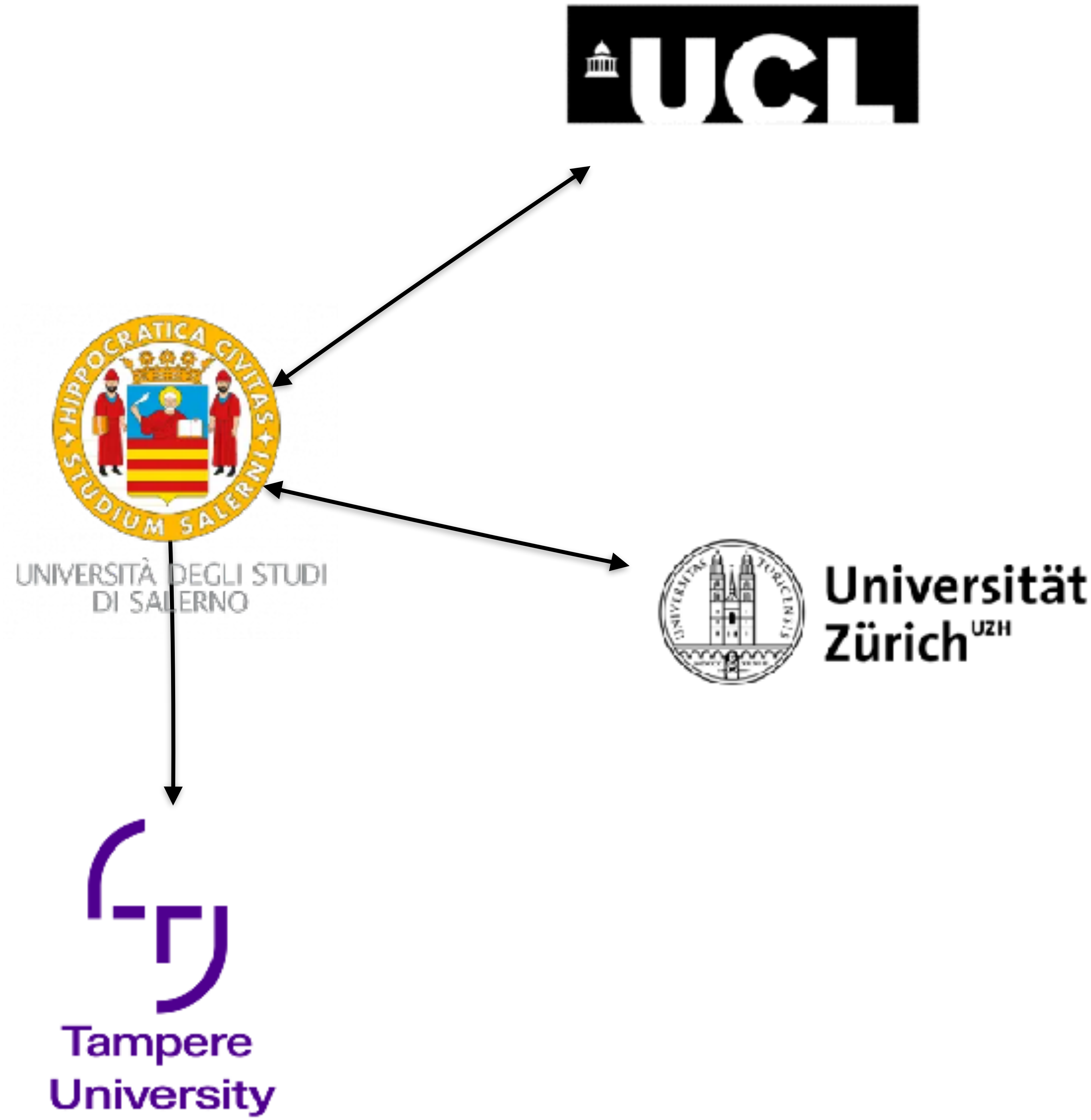
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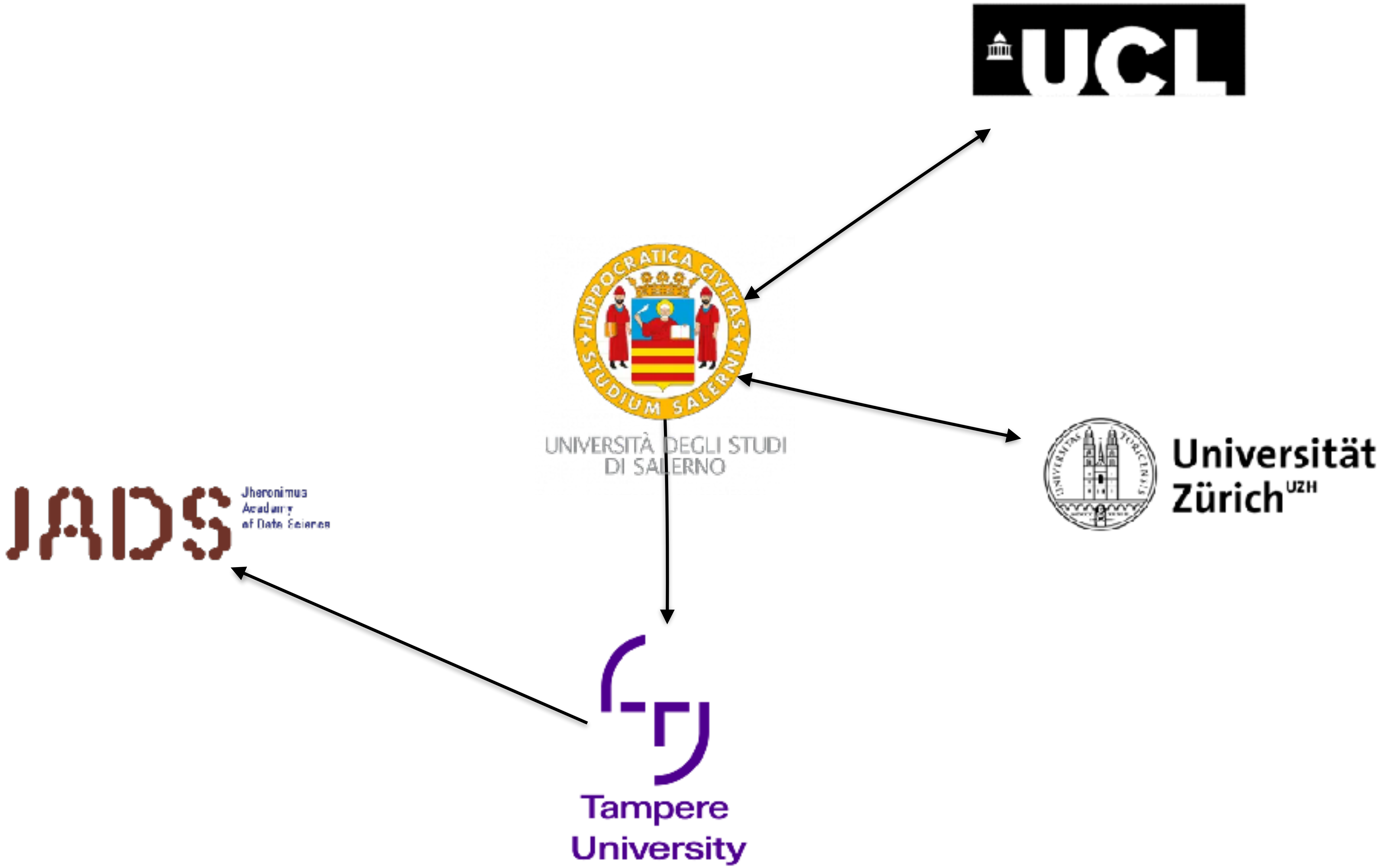
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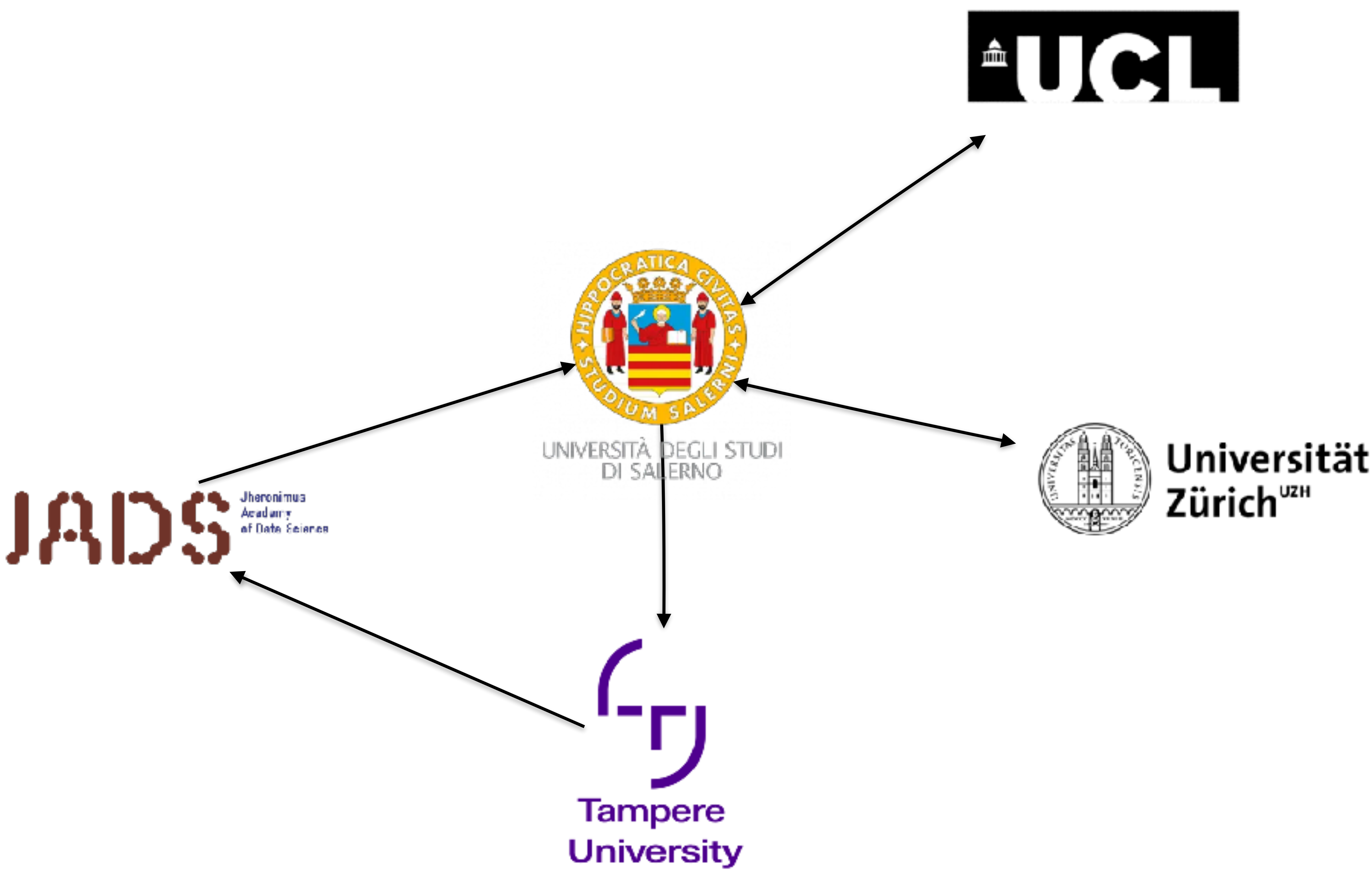
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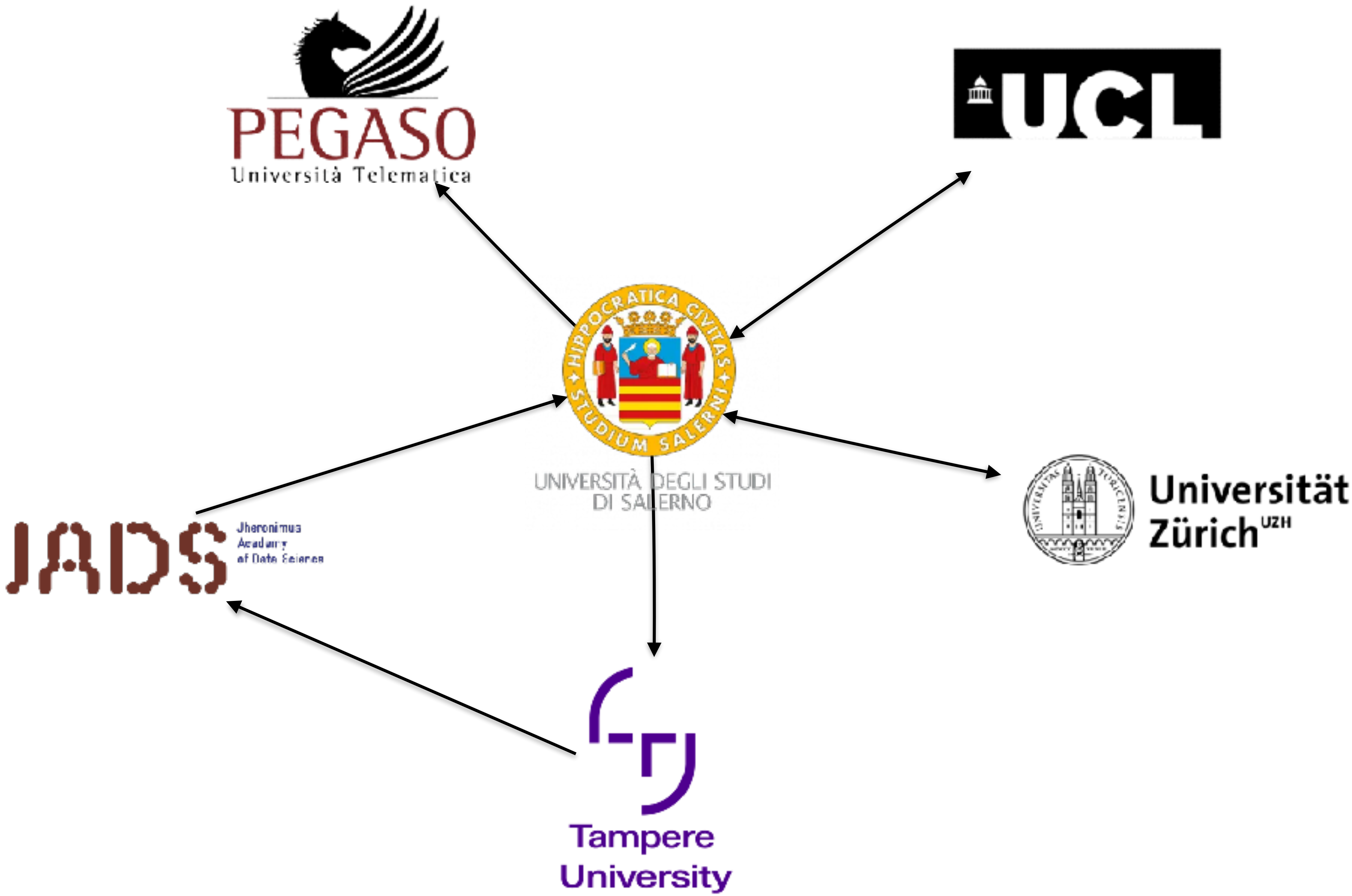
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Informally, technical debt represents *"not quite right code that we postpone to make it right"*. In other words, it is a metaphor that explains the **trade-offs between delivering the most appropriate but still immature product, in the shortest time possible**.

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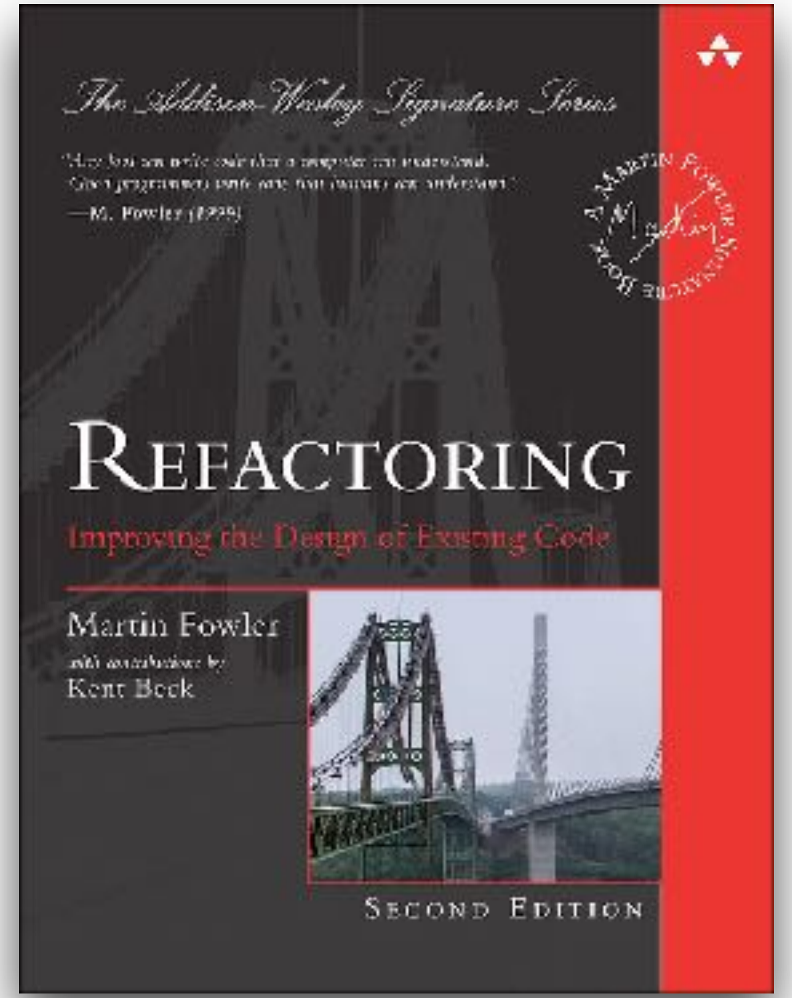

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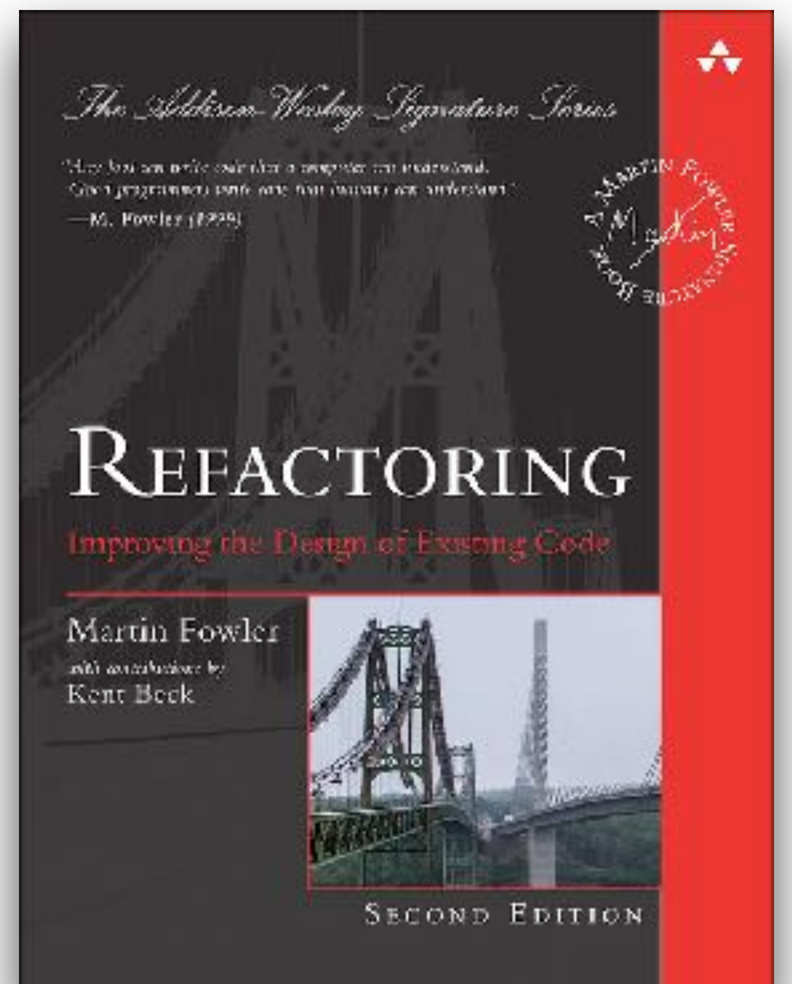

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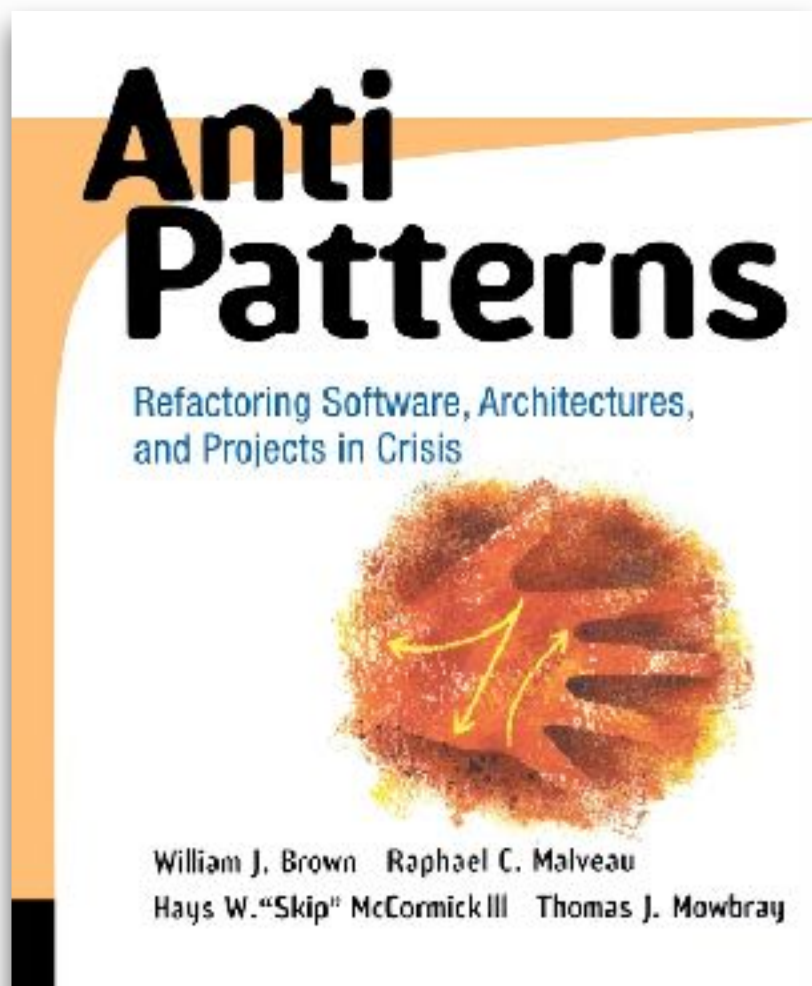

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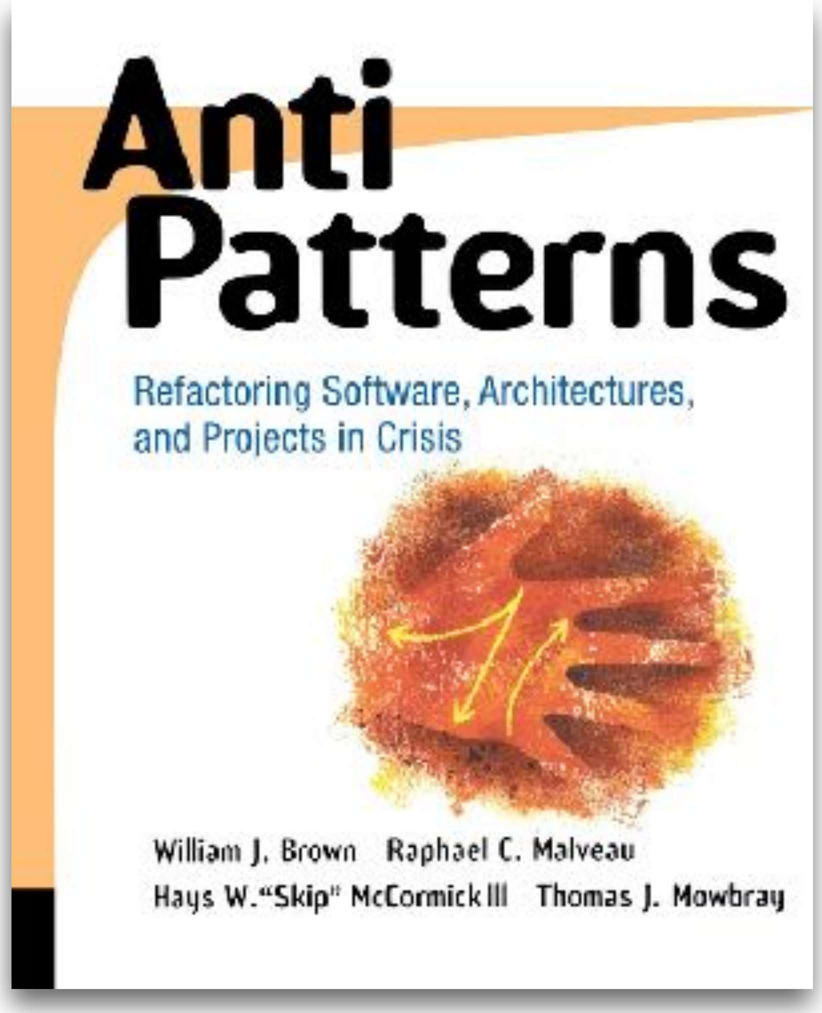

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Code smells are NOT anti-patterns. There is a relation, of course, but code smells are **potential** design problems that can eventually lead to the emergence of bad code.

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Duplicated Code. This smell occurs when the same code structure (block, method) is implemented in more than one place, hence making more complex maintenance activities because of change propagation.

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Feature Envy. This represents a method that is “more interested” to the functionalities implemented in a class different from the one it is actually in.

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- **13% of the projects contain a Message Chains**: this is the coupling-related smell more diffused among those considered.
- **The diffuseness of code smells seems to be independent from the granularity of the design problem**: method- and class-level code smells are roughly equally distributed over the dataset.

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- The refactoring of code smells reduces the change- and defect-proneness of classes.

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- Classes affected by Complex Class or Shotgun Surgery are those **affecting the most both maintenance costs** and **effort.**
- On the contrary, Refused Bequest does not significantly relate to maintenance effort and costs; likely, **this may depend on the intensity of the design problem**.

Bad Code Smells - Is there a connection between actions on code smells and their perception?

The definition of code smells has been given in a **natural language form**. As such, it may sometimes be misunderstood and/or subjectively interpreted by developers. In any case, the way developers act on them **depends on how they are aware of smells**.

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- Some studies have assessed this aspect, either through semi-structured interviews with developers or controlled experiments.
- Key findings reported that most of the code smells **are not perceived as problematic** by developers, e.g., the Class Data Should Be Private.

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The definition of code smells has been given in a **natural language form**. As such, it may sometimes be misunderstood and/or subjectively interpreted by developers. In any case, the way developers act on them **depends on how they are aware of smells**.

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- To sum up, the way developers act on code smell instances depends on various factors, **including their ability to diagnose them**.
- As such, techniques to detect and refactor code smells **are necessary but not sufficient**, as they should integrate awareness methods.

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An Extract Method refactoring allows you to extract the “exceeding” portion of code and create a new method.

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<= In the example, the details are printed in another method.

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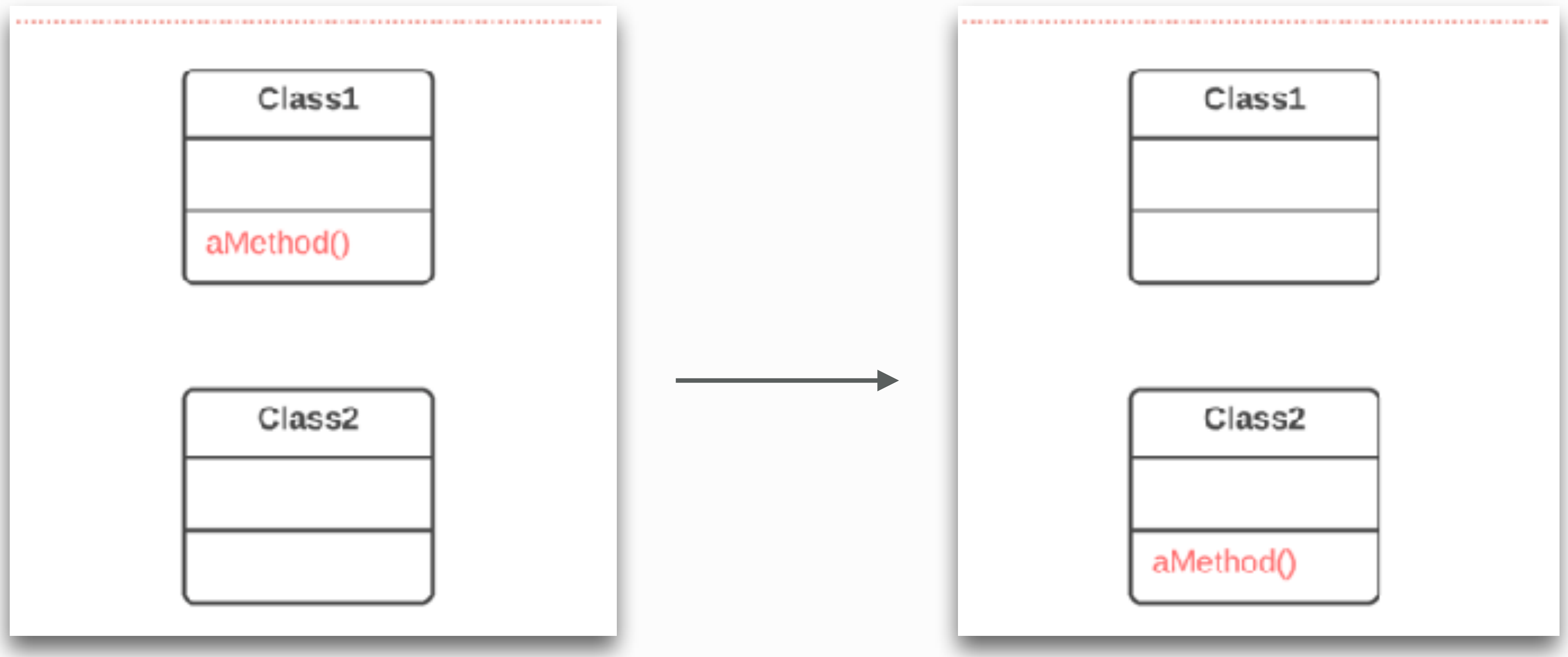

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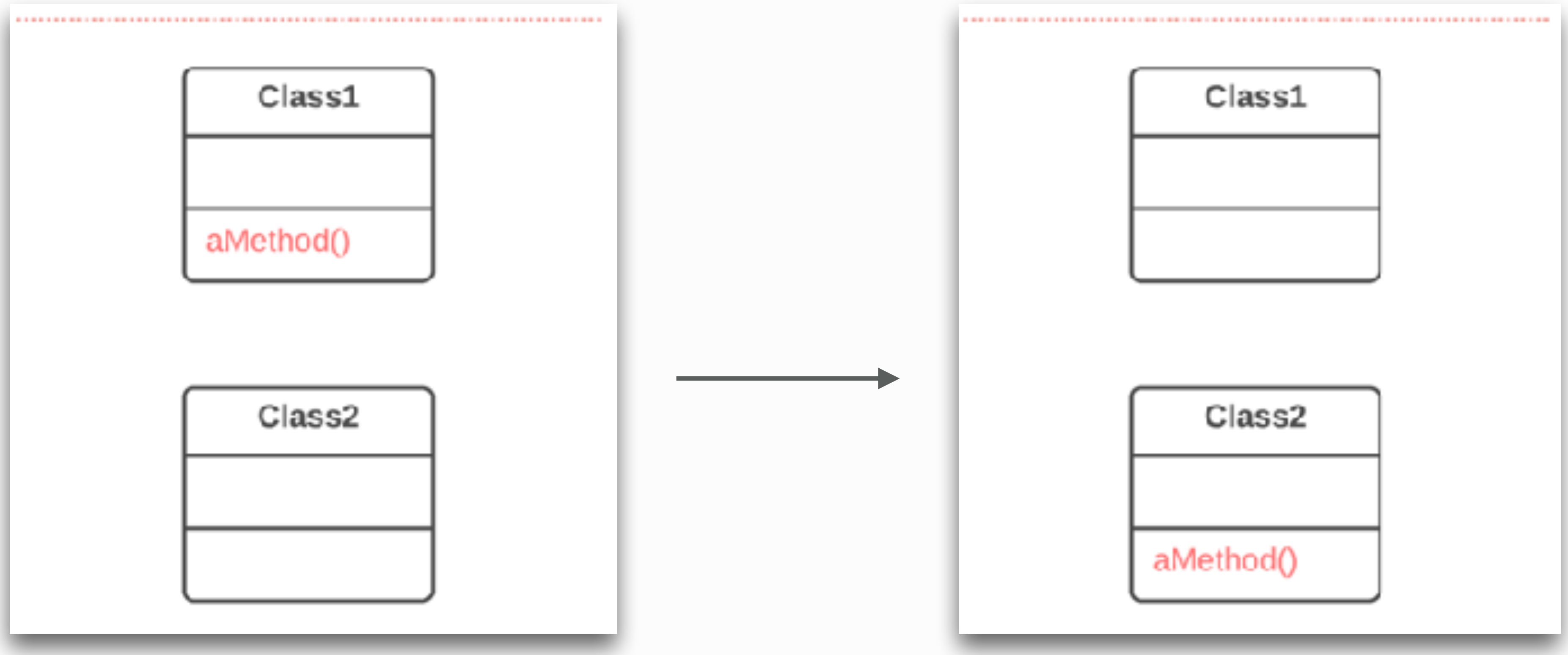

Some precautions

- Make sure that the method **is not** declared in superclasses and subclasses. If this is the case, you will either have to refrain from moving or else implement a kind of polymorphism in the recipient class in order to ensure varying functionality of a method split up among donor classes.

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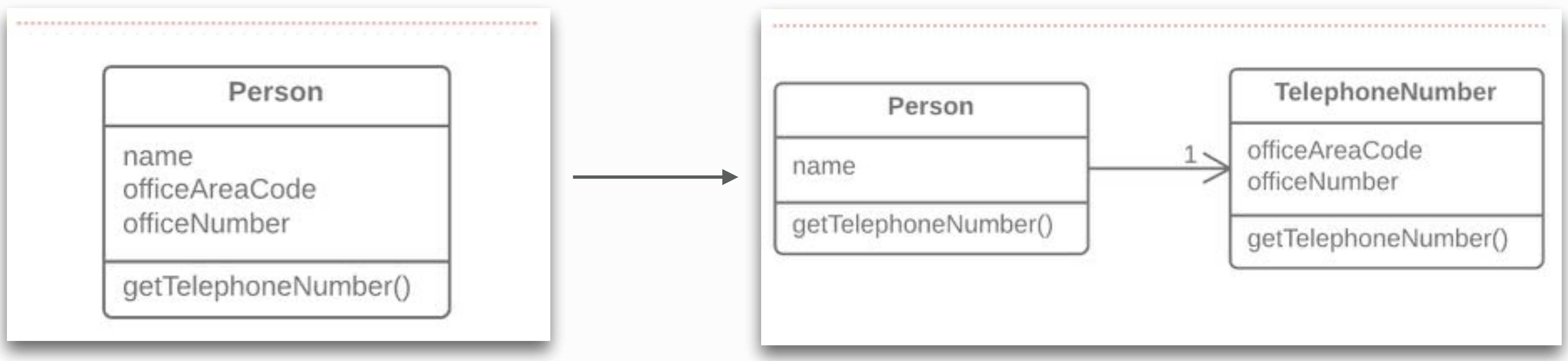

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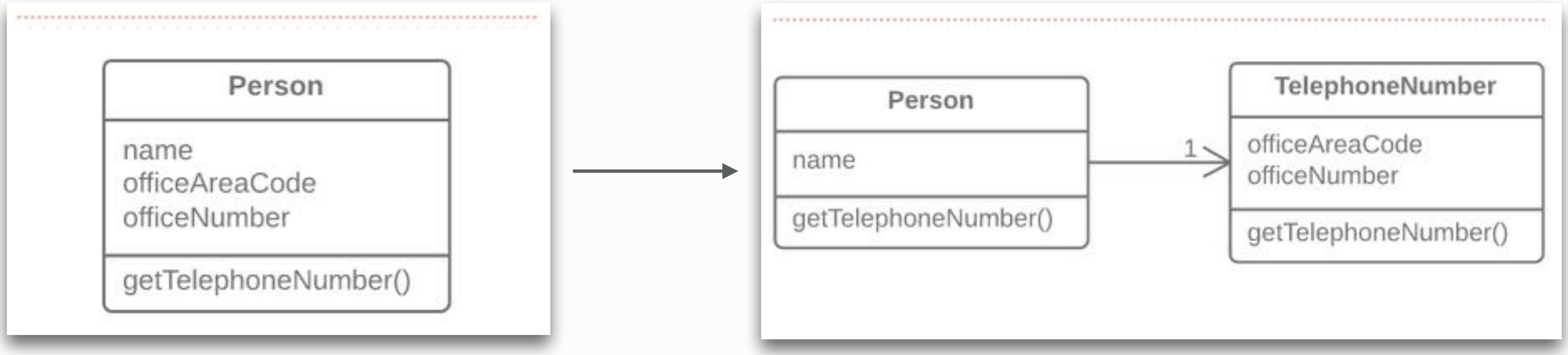

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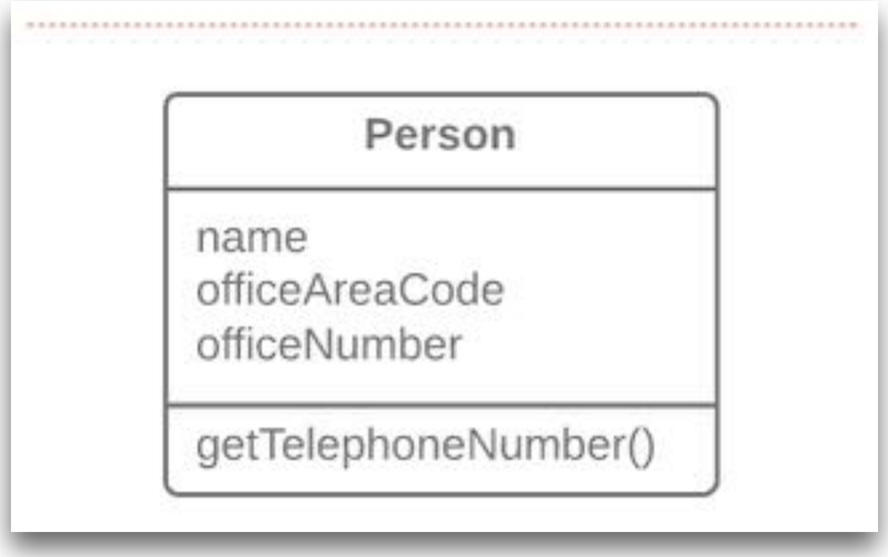

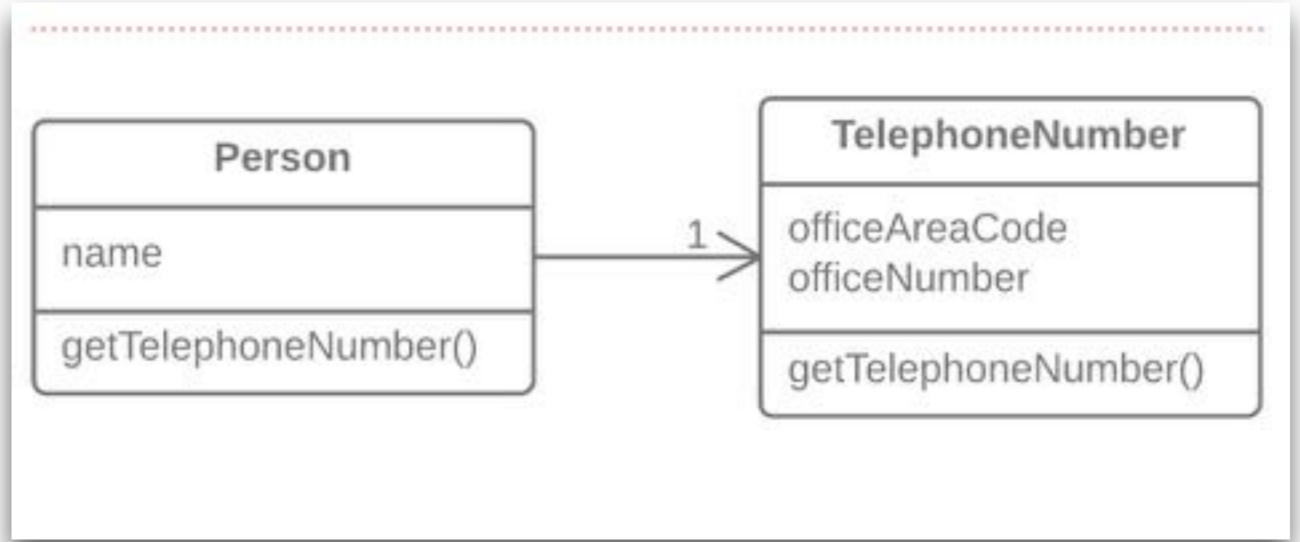

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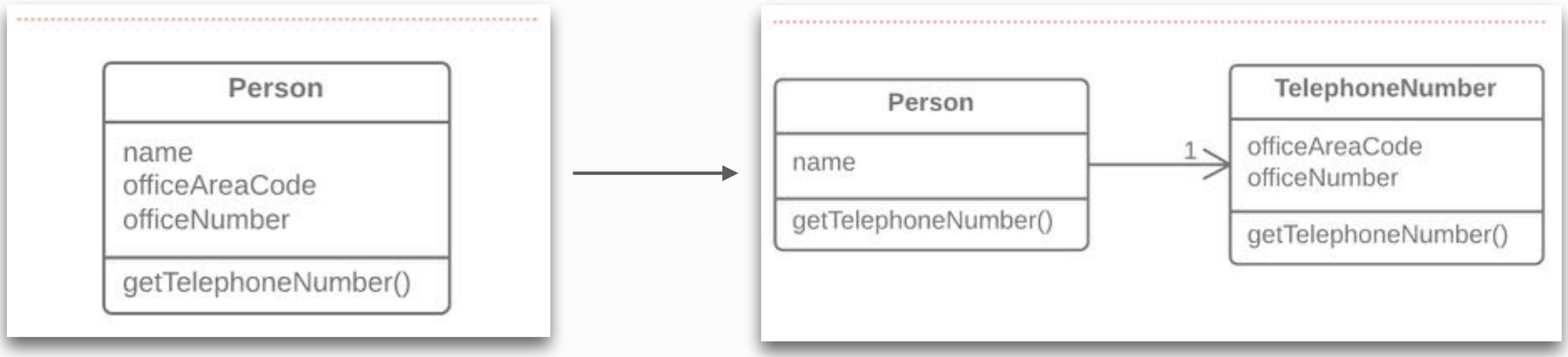

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- An old class with changed responsibilities may be renamed for increased clarity.

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Divergent Change

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A typical refactoring process is composed of the steps below. In this lecture, we focus on the first two: **Where and How to refactor**.

- Where to refactor
- How to refactor?
- Guarantee behavior preservation
- Apply the refactoring
- Assess its effects on quality
- Consistently modify other artifacts

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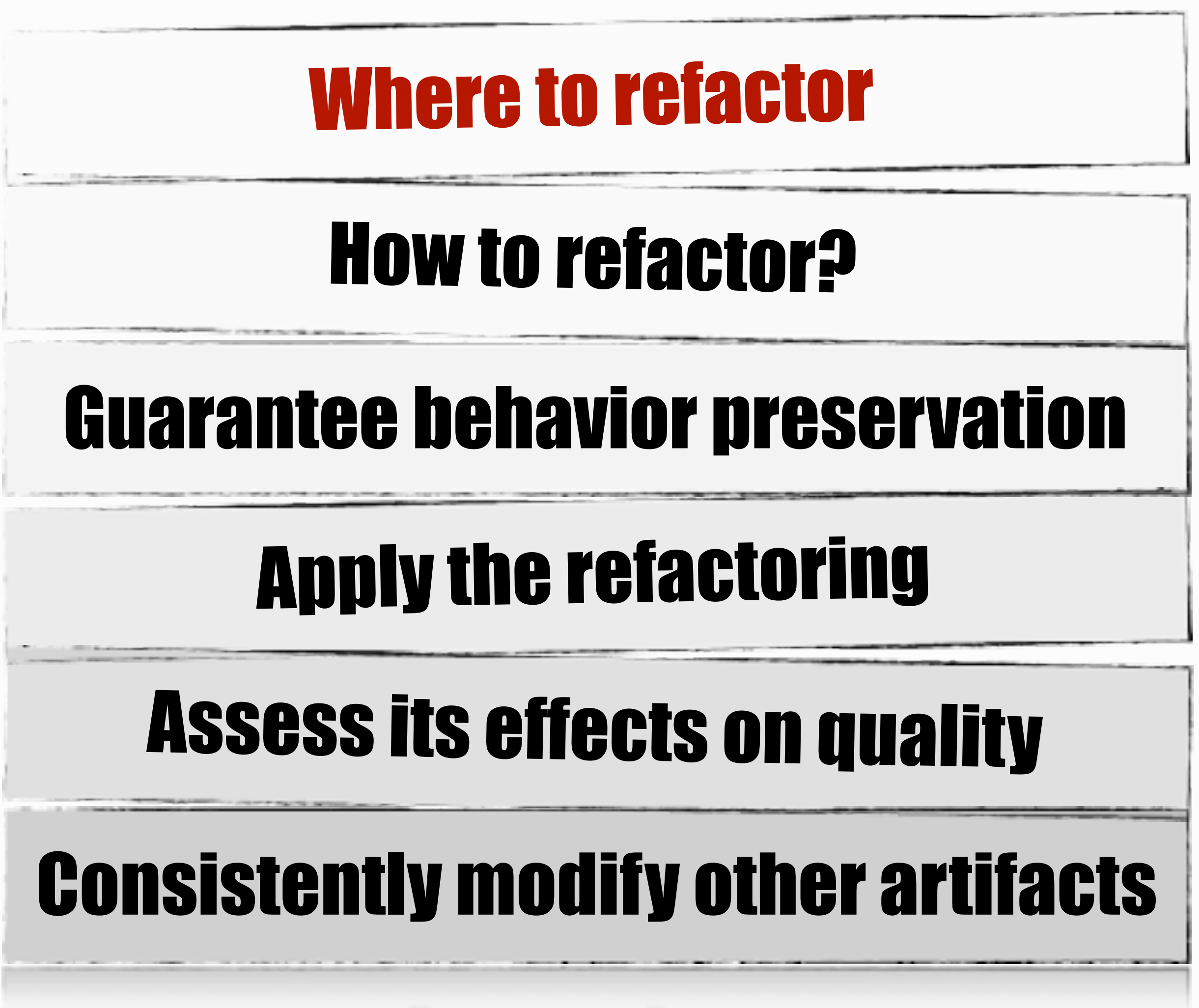

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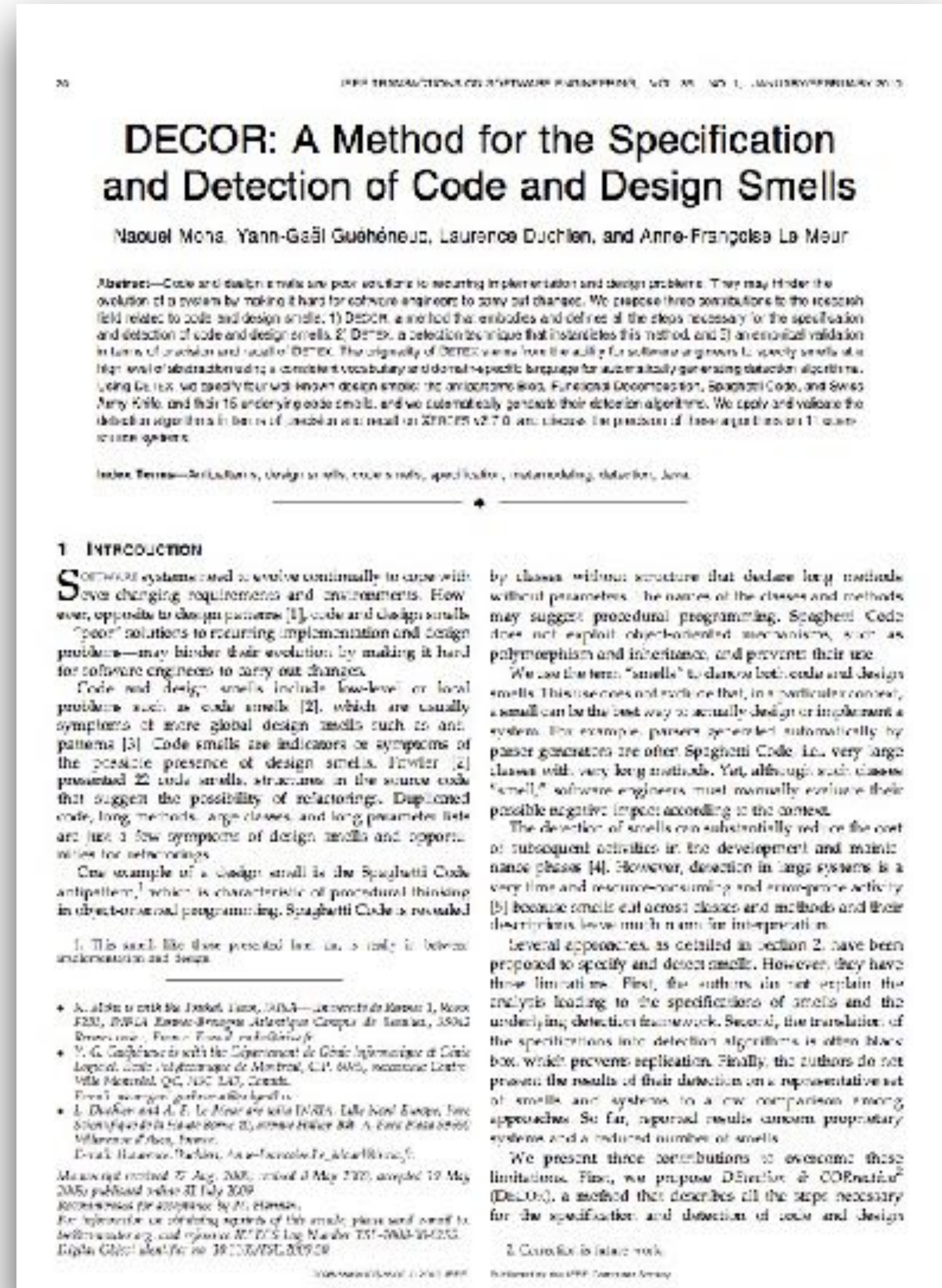
Method

Most of the available detectors are based on heuristics, some of them use machine learning or search-based solutions.

Bad Code Smells

Bad Code Smells - Where to Refactor



DECOR: A Method for the Specification and Detection of Code and Design Smells

Naouel Moha, Yann-Gaël Guéhéneuc, Laurence Duchien, and Anne-Françoise Le Meur

1 Introduction

Text-based descriptions of smells

↓

Domain Analysis

↓

Vocabulary, Taxonomy

↓

Specification

↓

Rule Cards

↓

Algorithm Generation

↓

Detection Algorithm

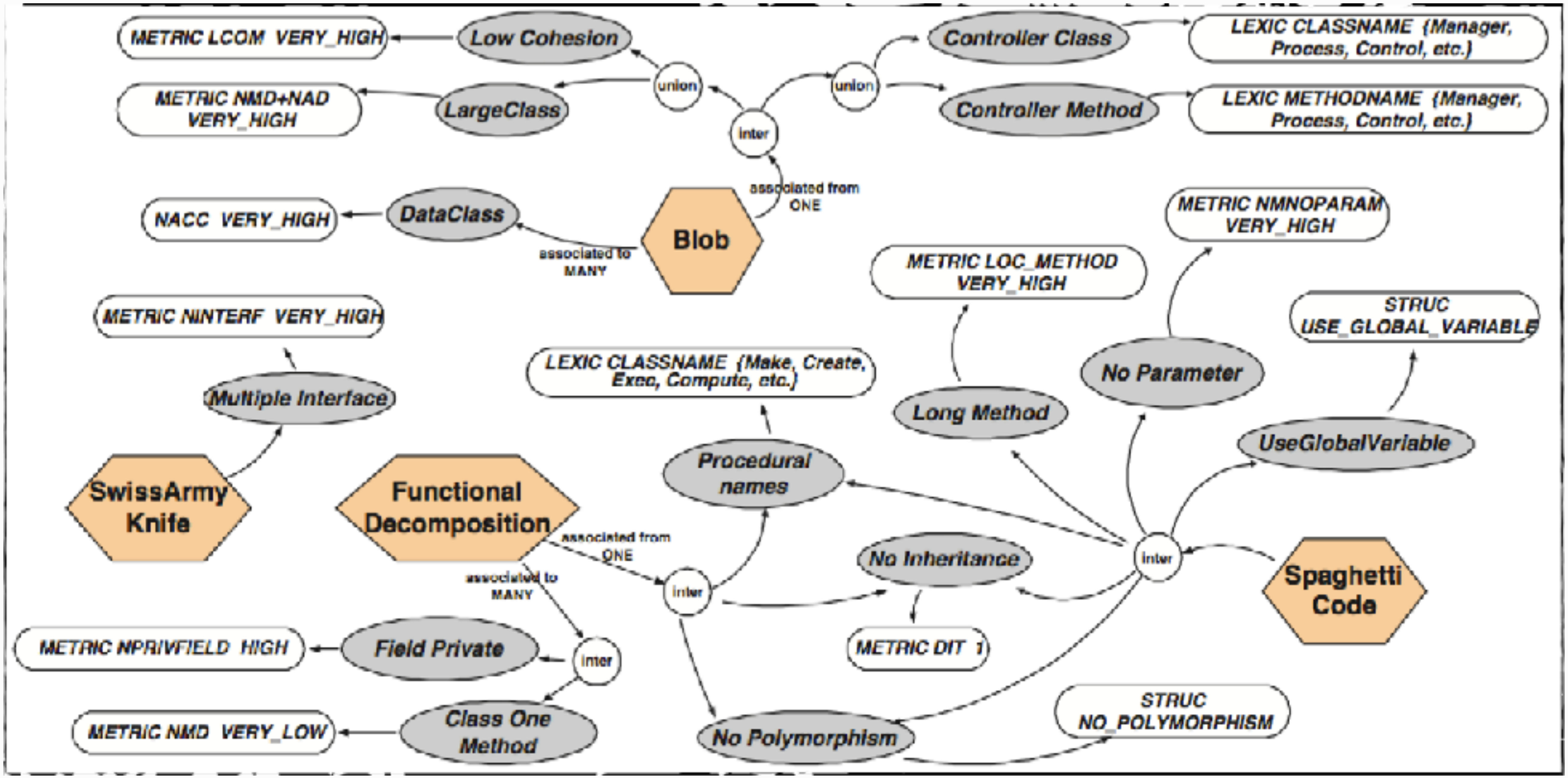
Bad Code Smells - Where to Refactor

- Step I: Input example - A textual description of Blob.

The Blob (also called God class) corresponds to a large controller class that depends on data stored in surrounding data classes. A large class declares many fields and methods with a low cohesion. A controller class monopolizes most of the processing done by a system, takes most of the decisions, and closely directs the processing of other classes. Controller classes can be identified using suspicious names such as Process, Control, Manage, System, and so on. A data class contains only data and performs no processing on these data. It is composed of highly cohesive fields and accessors.

Bad Code Smells - Where to Refactor

- Step II: Taxonomy creation and specification.

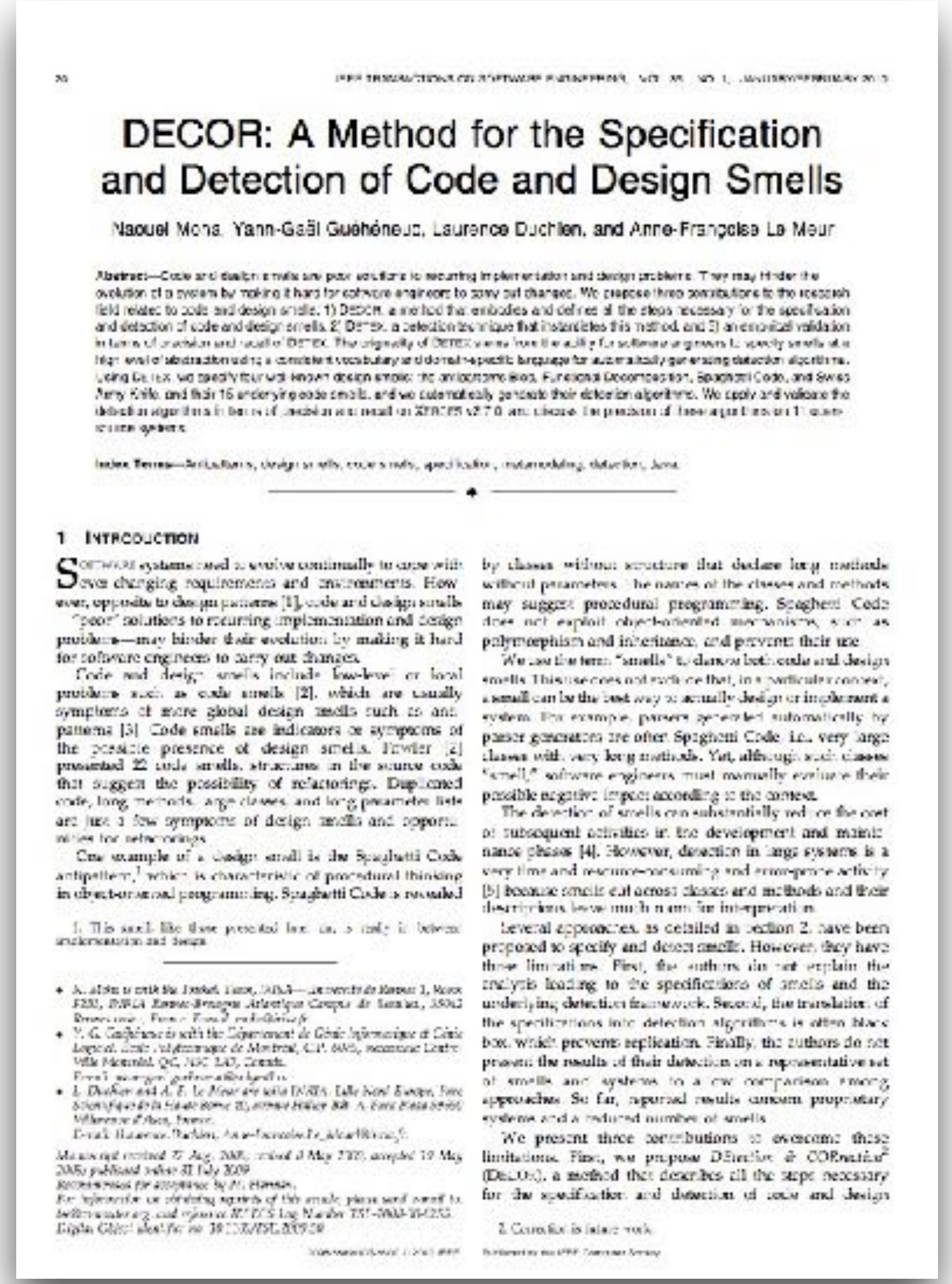


Bad Code Smells - Where to Refactor

- Step III: Algorithm definition and specification.

```
RULE_CARD : Blob {
RULE : Blob {ASSOC: associated FROM : mainClass ONE  TO : DataClass MANY};

RULE : MainClass {UNION LargeClass, LowCohesion, ControllerClass};

RULE : LargeClass {( METRIC : NMD + NAD, VERY_HIGH, 20) } ;

RULE : LowCohesion { ( METRIC : LCOM5, VERY_HIGH , 20) } ;

RULE : ControllerClass { UNION (SEMANTIC : METHODNAME,

{Process, Control , Ctrl , Command , Cmd, Proc, UI, Manage, Drive} )
(SEMANTIC : CLASSNAME, { Process, Control, Ctrl, Command , Cmd, Proc , UI,
Manage, Drive , System, Subsystem } ) } ;

RULE : DataClass {(STRUCT: METHOD_ACCESSOR, 90%)} ;
};
```

Bad Code Smells - Where to Refactor



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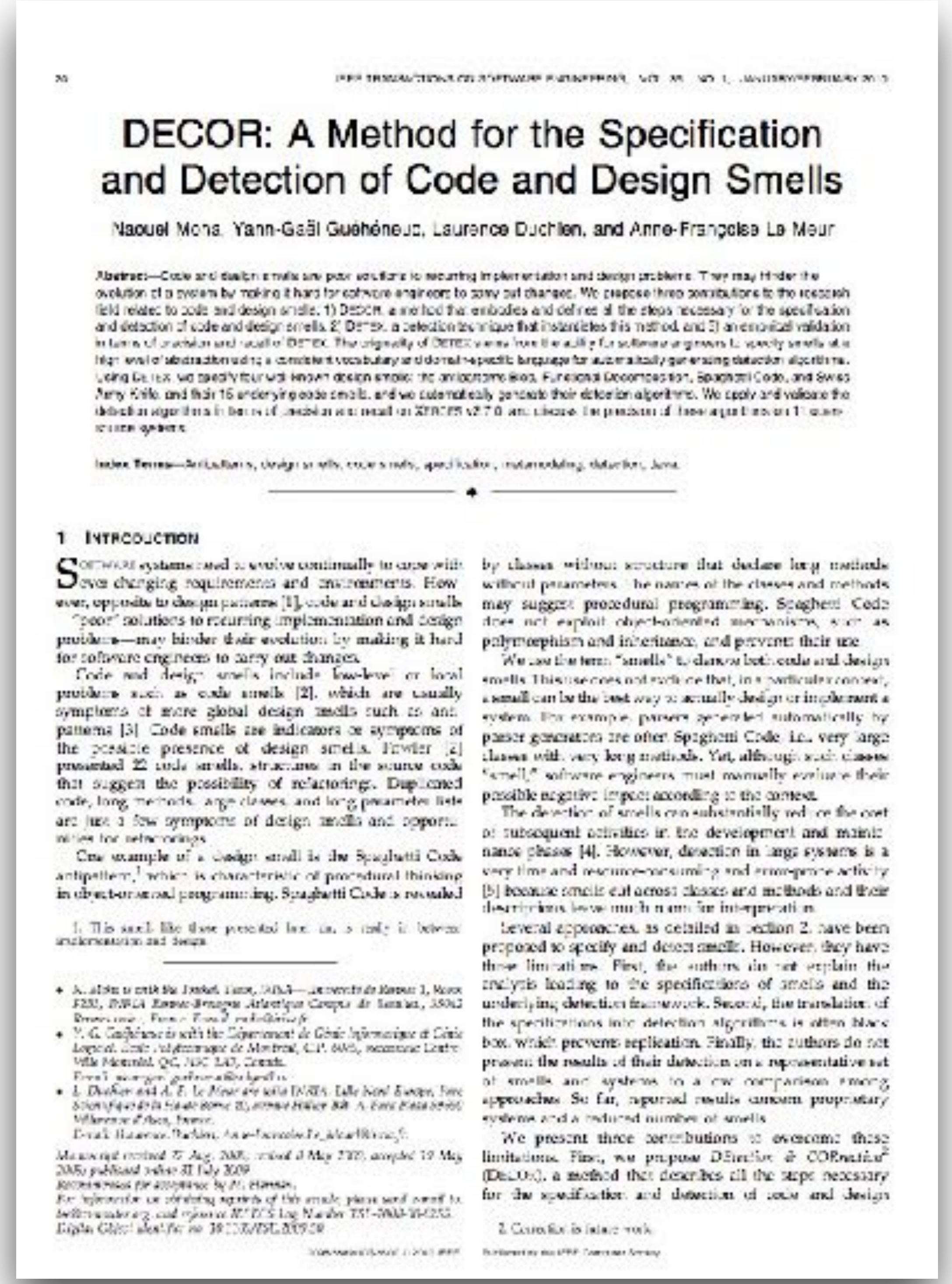

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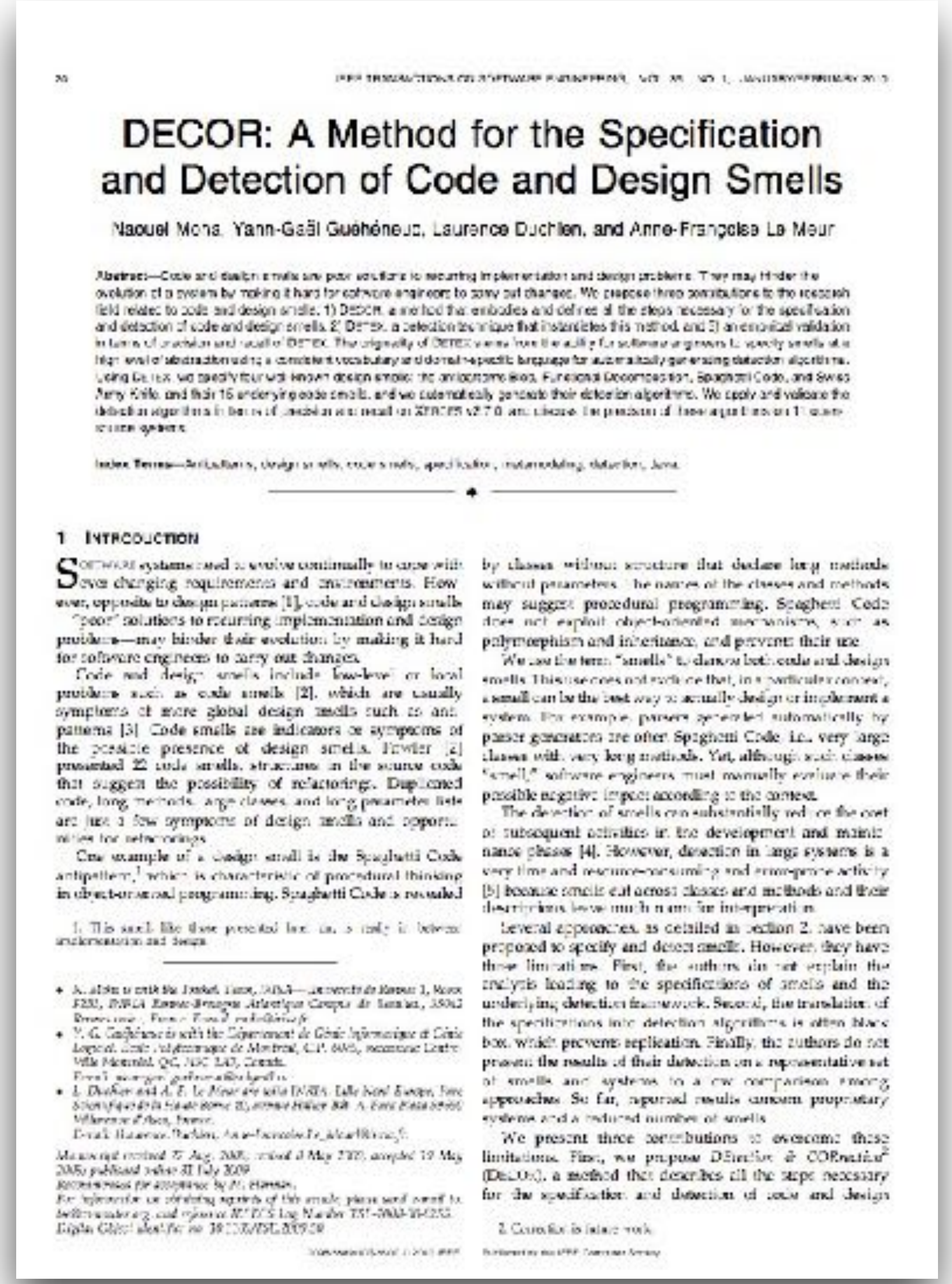

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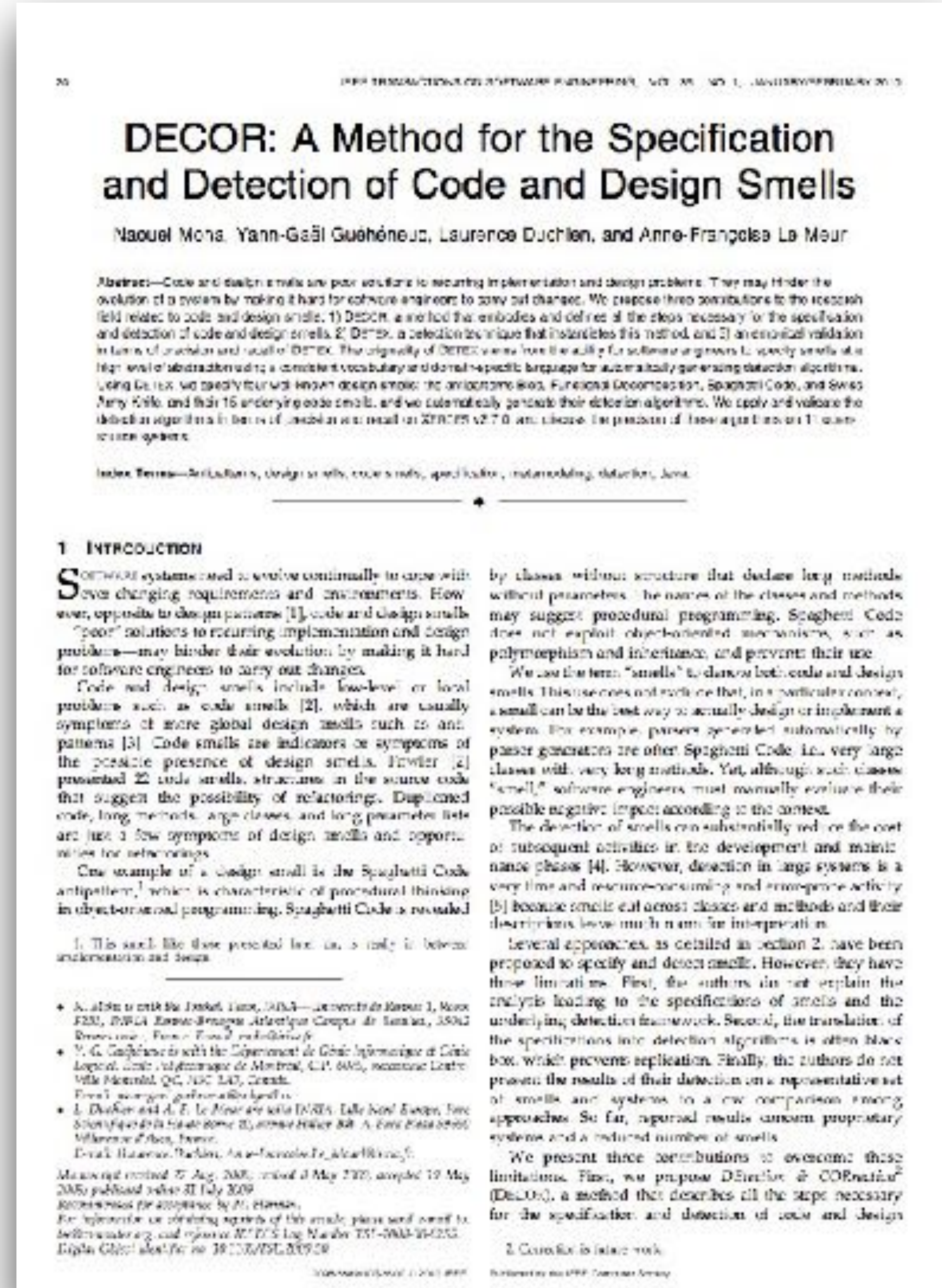
Given the **high extensibility** of the approach, DECOR can be used to include additional perspectives and mix together various sources of information. Also, it may be employed within other detection tools.

Bad Code Smells - Where to Refactor



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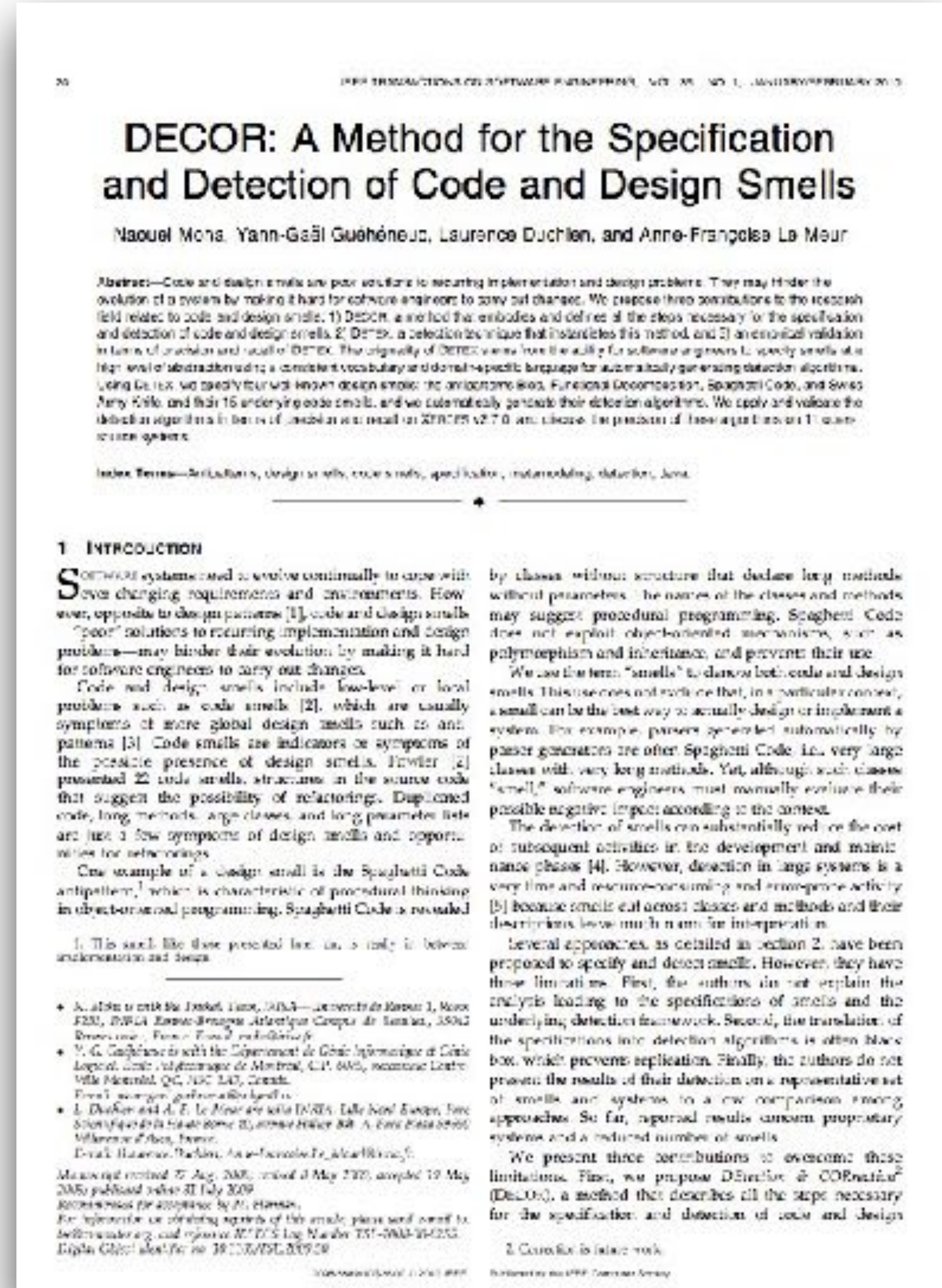

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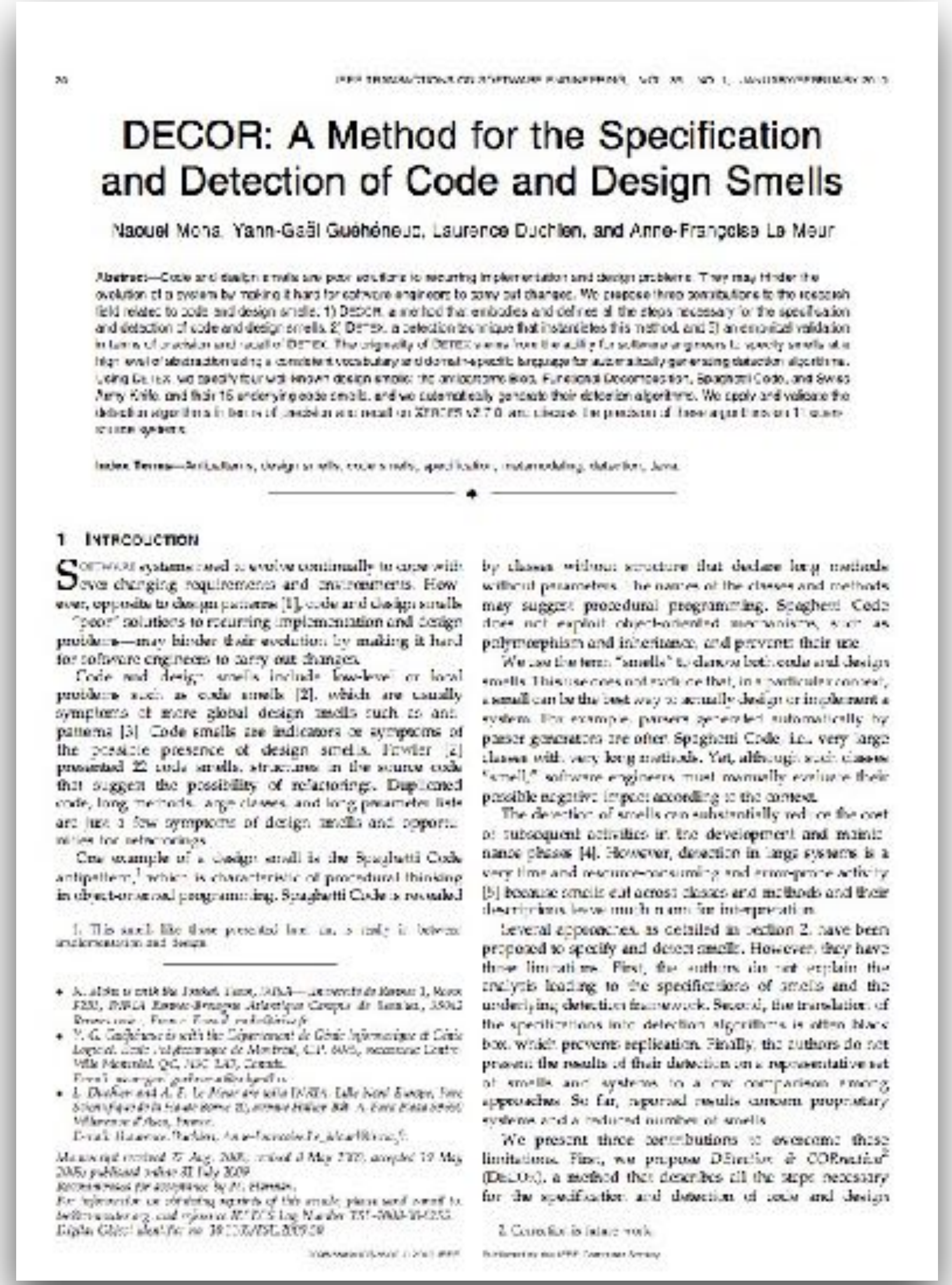
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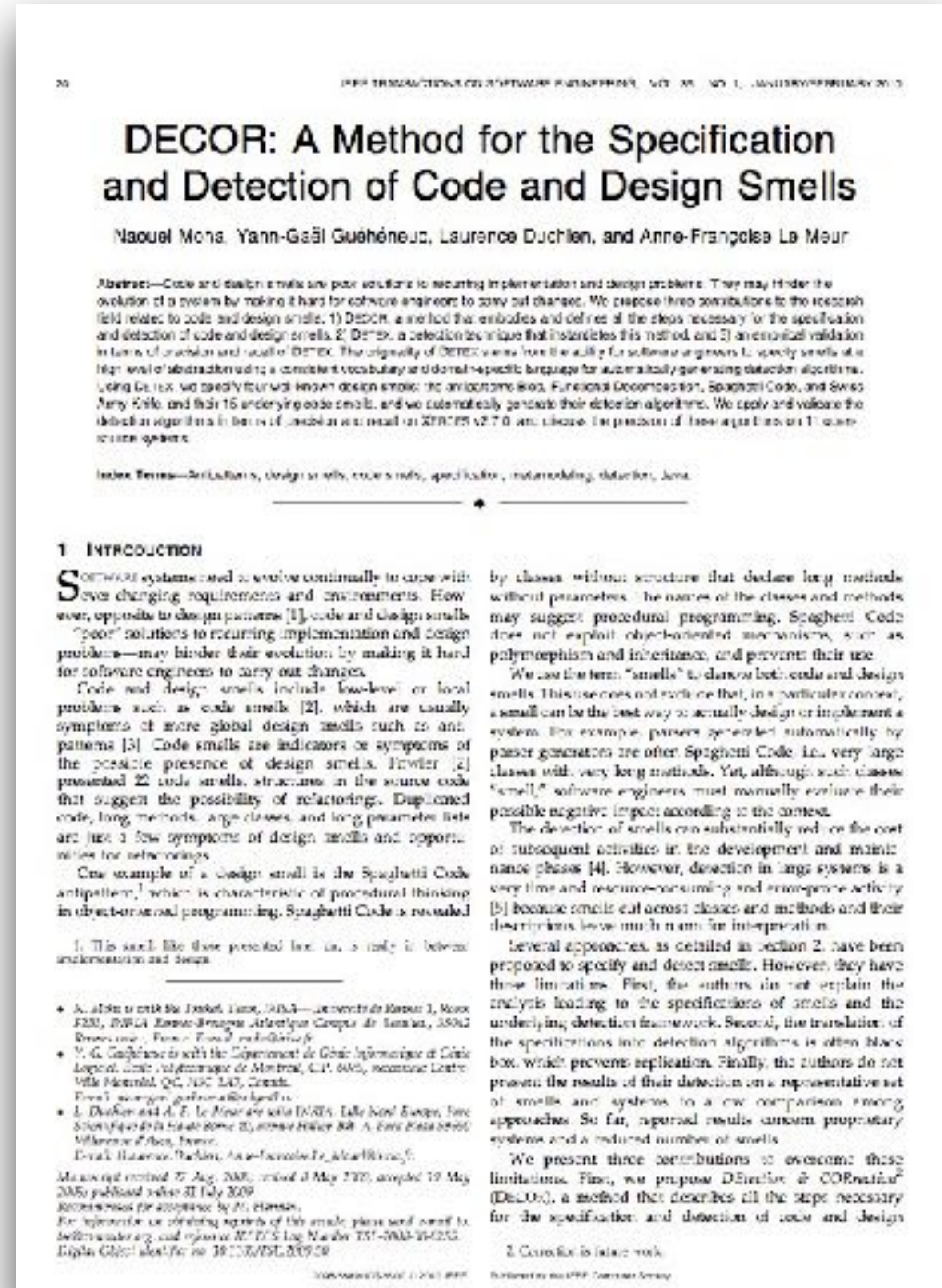
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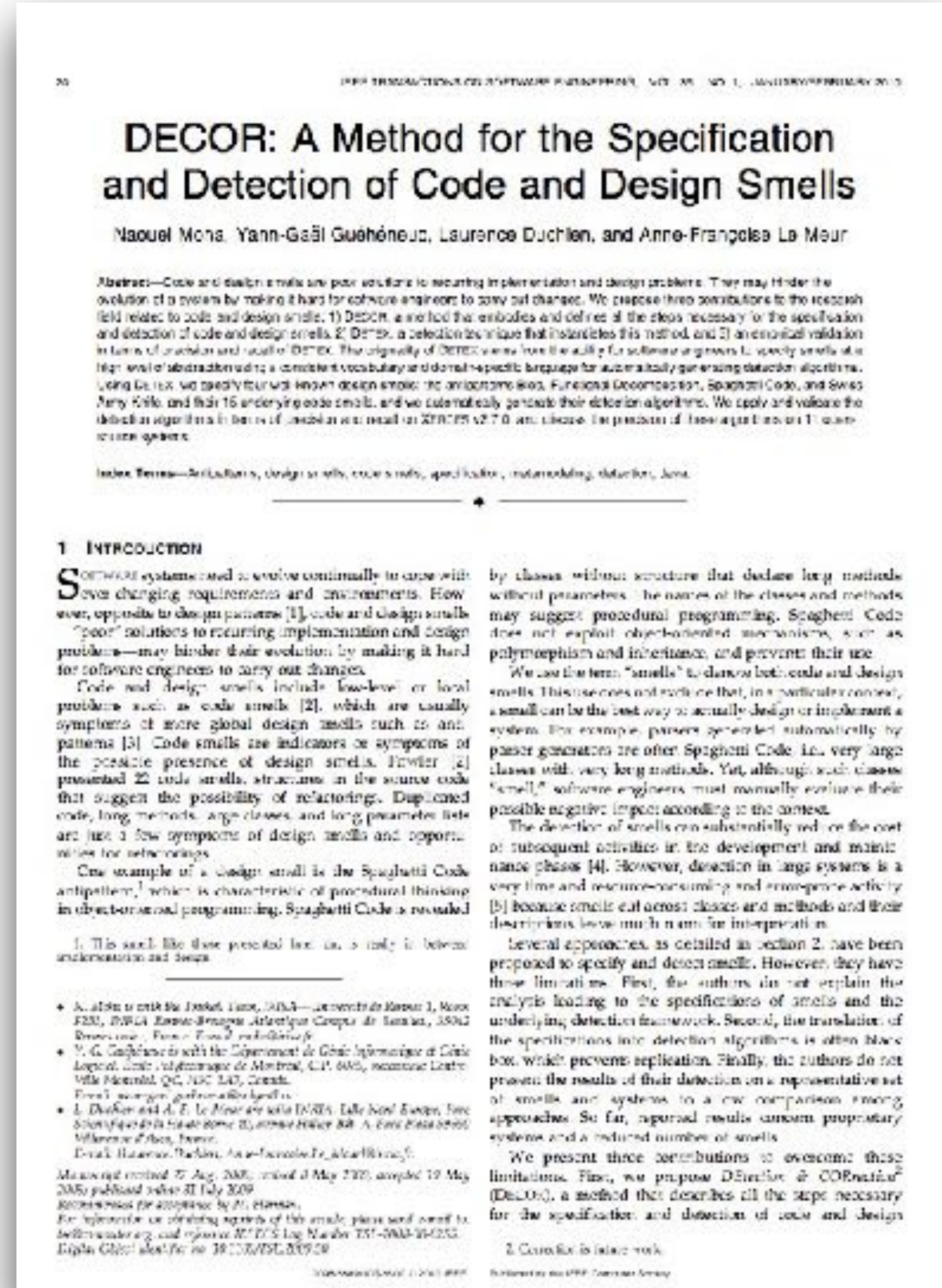

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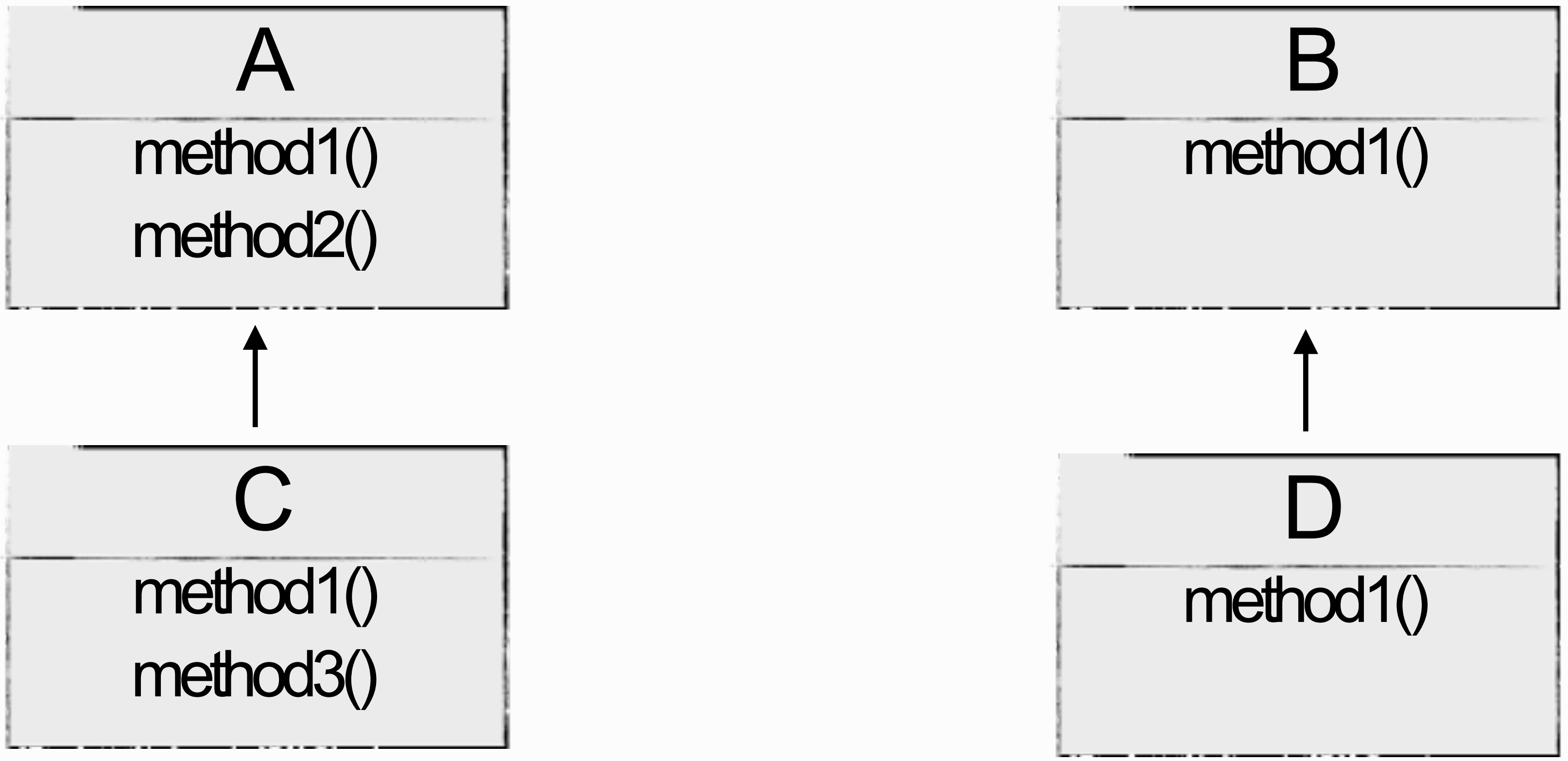

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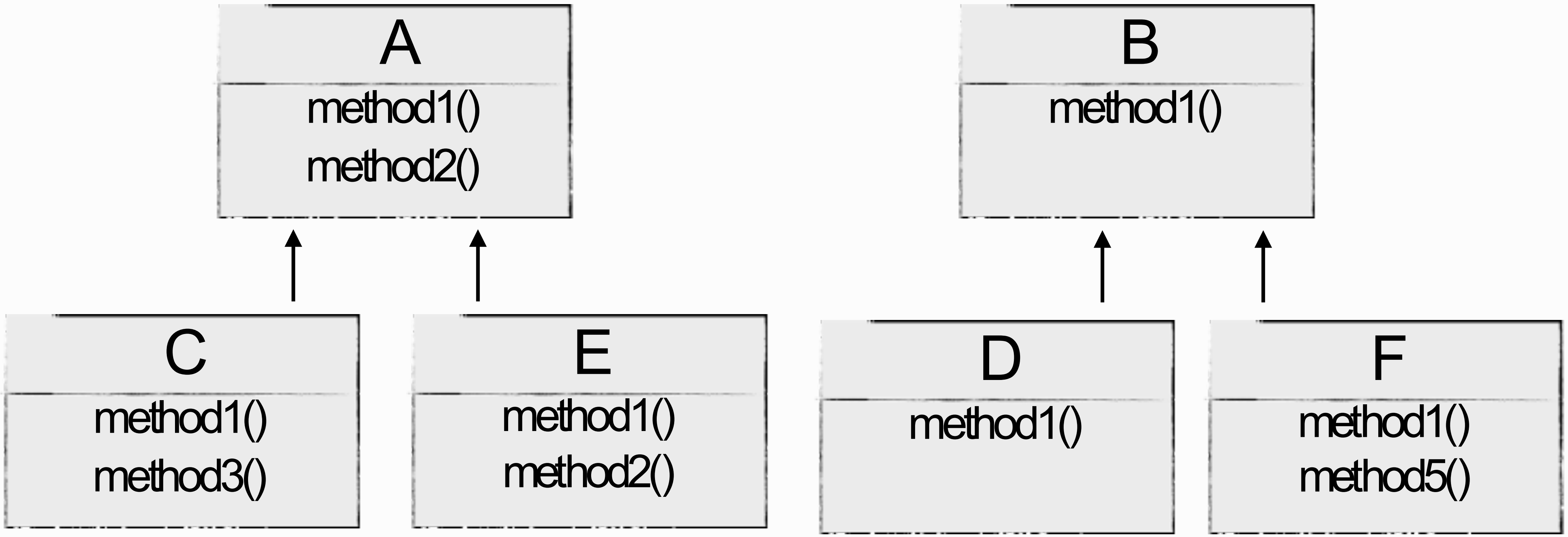

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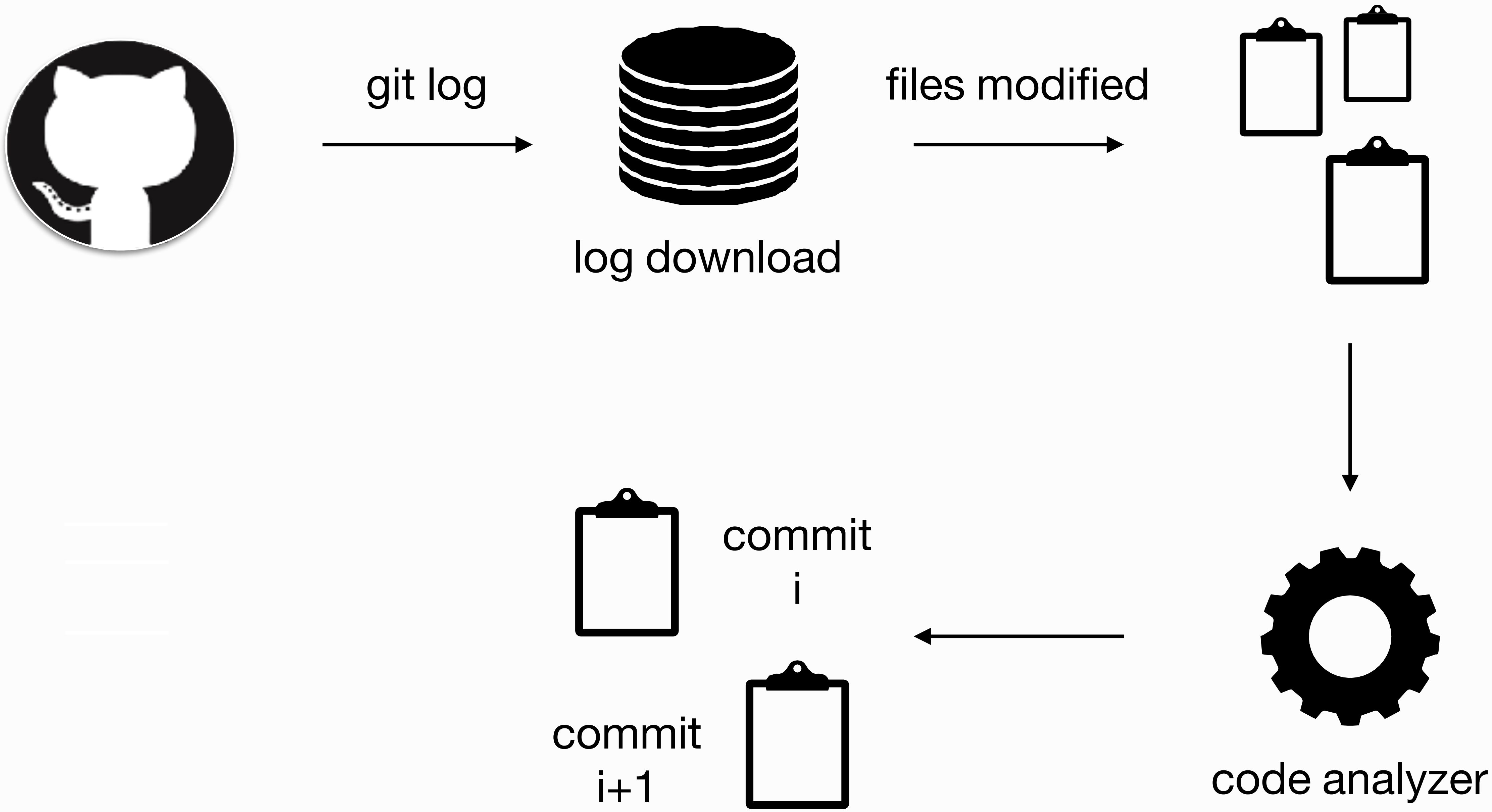

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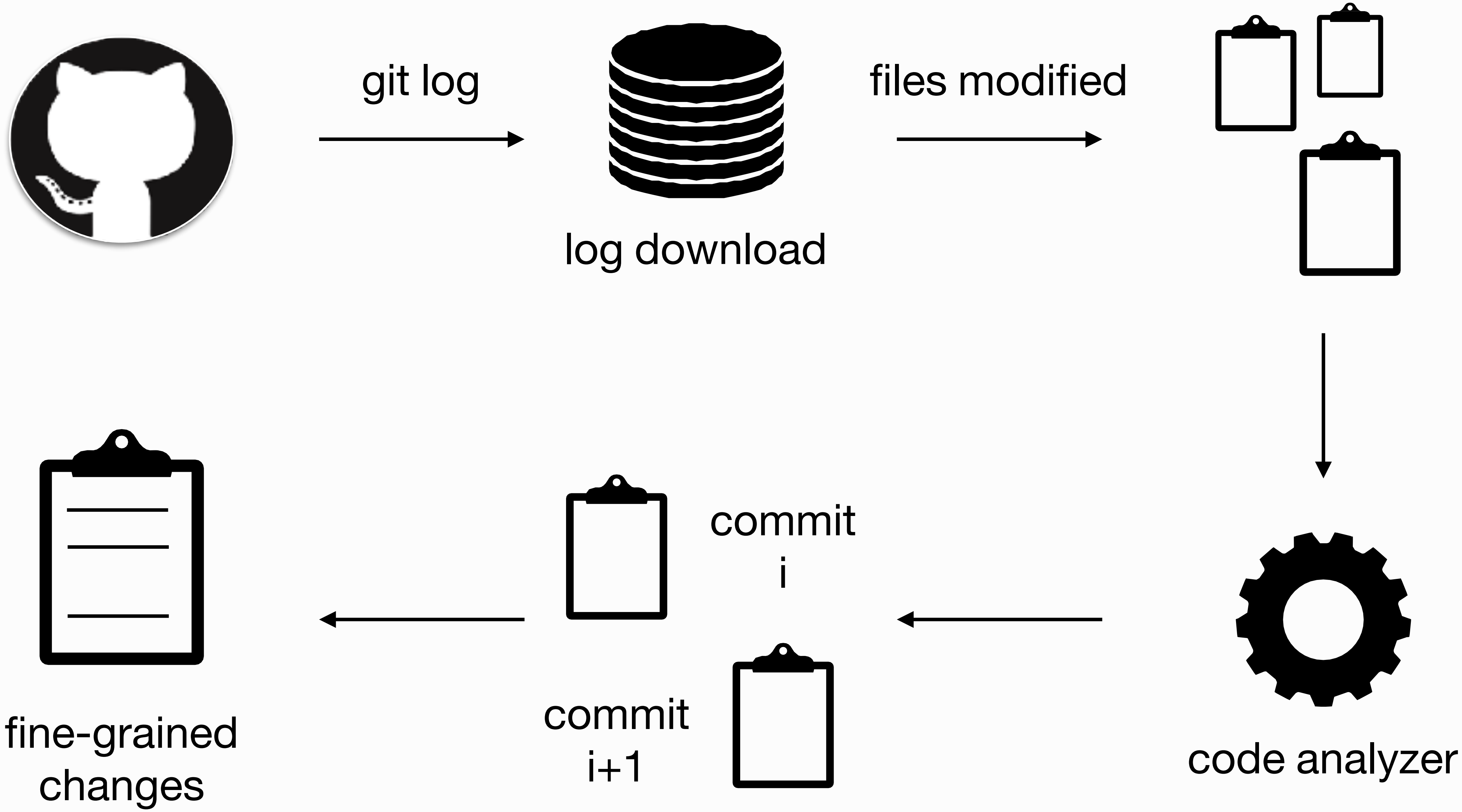

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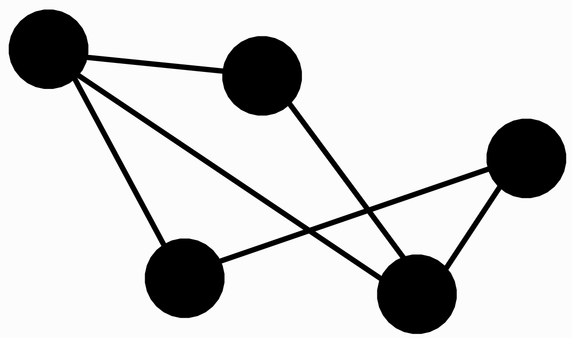
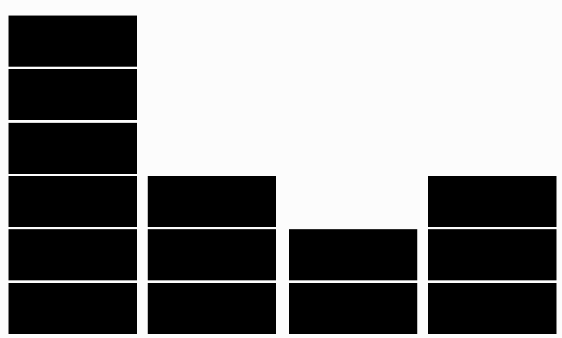


Association rule discovery to capture co-changes between entities



Analysis of change frequency of some specific entities

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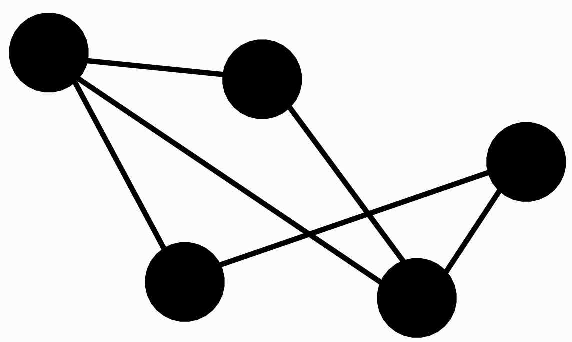

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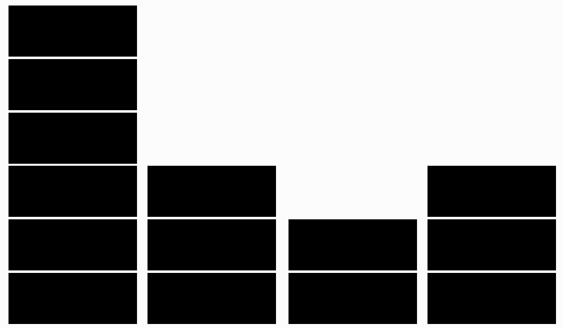

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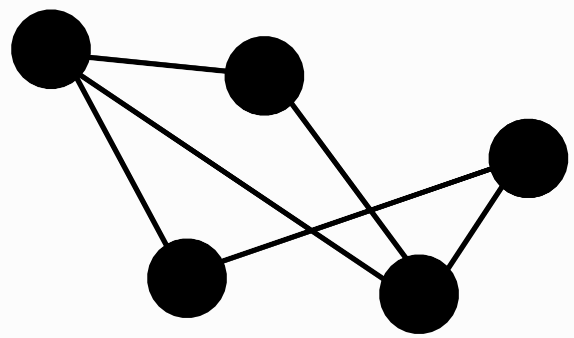

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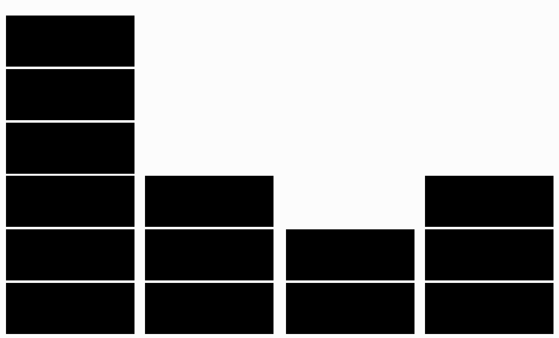

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- Once extracted the fine-grained changes, the detector employs two different strategies to identify code smells
- HIST has been instantiated to identify three code smell types naturally historical: Divergent Change, Shotgun Surgery, and Parallel Inheritance.
- HIST has been also instantiated to identify two traditional code smell types, Blob and Feature Envy, with the aim of understanding the extent to which historical analysis can be used as an alternative of structural one.

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Divergent Change

A class is changed in different ways for different reasons

Solution:
Extract Class Refactoring

Classes containing at least two sets of methods such that:

(i)all methods in the set change together as detected by the association rules
(ii)each method in the set does not change with methods in other sets

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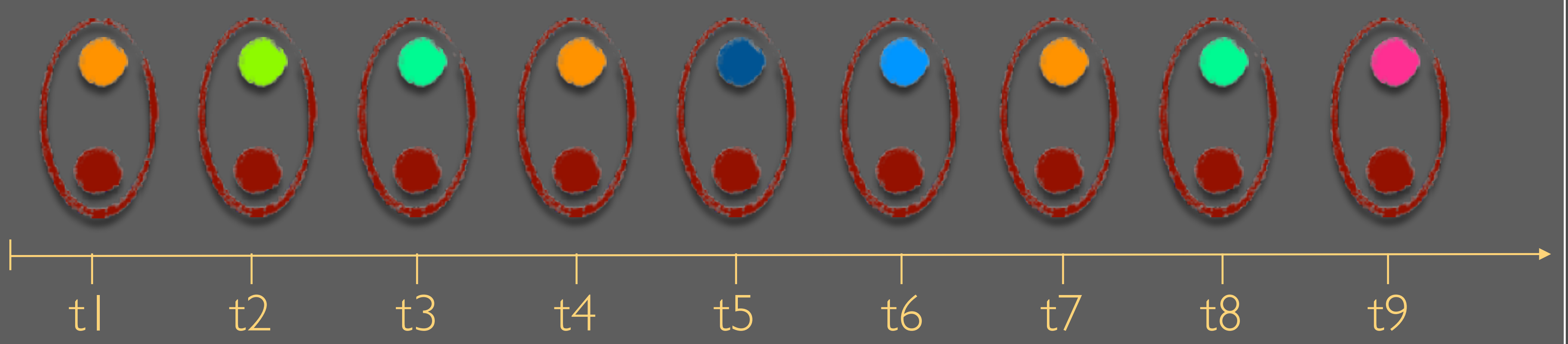
Blob

A large class implementing several responsibilities

Solution:
Extract Class Refactoring

Blobs are identified as classes frequently modified in commits involving at least another class.



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Mining Version Histories for Detecting Code Smells

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1 Introduction

Code smells have been defined by Fowler [14] as symptoms of poor design and implementation choices. In some cases, such symptoms may originate from activities performed by developers while in a hurry, e.g., implementing urgent patches or simply making suboptimal choices. In other cases, smells come from some recurring, poor design solutions, also known as anti-patterns [9]. For example a Blob is a large and complex class that centralizes the behavior of a portion of a system and only uses other classes as data holders. Blob classes can rapidly grow out of control, making it harder and harder for developers to understand them, to fix bugs, and to add new features.

Previous studies have found that smells hinder comprehension [1], and possibly increase change- and fault-proneness [23], [24]. In summary, smells need to be carefully detected and monitored and, whenever necessary, refactoring actions should be planned and performed to deal with them.

There exist a number of approaches for detecting smells in source code to alert developers of their presence [30], [33], [48]. These approaches rely on structural information extracted from source code, for example, by means of constraints defined on some source code metrics. For instance, according to some existing approaches, such as DECOR [33], *LongMethod* or *LargeClass* smells are based on the size of the source code component in terms of LOC, whereas other smells like *ComplexClass* are based on the McCabe cyclomatic complexity [32]. Other smells, such as *Blob*, might use more complex rules.

Although existing approaches exhibit good detection accuracy, they still might not be adequate for detecting many of the smells described by Fowler [14]. In particular, there are some smells that, rather than being characterized by source code metrics or other information extracted from source code snapshots, are *intrinsically characterized by how source code changes over time*. For example, a *Parallel Inheritance* means that two or more class hierarchies evolve by adding code to both classes at the same time. Also, there are smells that are traditionally detected using structural information, where historical information can aid in capturing complementary, additionally useful properties. For example, a Feature Envy

This paper is an extension of "Detecting Bad Smells in Source Code Using Change History Information" that appeared in the Proceedings of the 28th IEEE/ACM International Conference on Automated Software Engineering (ASE 2013), Palo Alto, California, pp. 268-278, 2013 [29].

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Abstract—Code smells are symptoms of poor design and implementation choices that may hinder code comprehension, and possibly increase change- and fault-proneness. While most of the detection techniques just rely on structural information, many code smells are intrinsically characterized by how code elements change over time. In this paper, we propose HIST (Historical Information for Smell deTection), an approach exploiting change history information to detect instances of five different code smells, namely Divergent Change, Shotgun Surgery, Parallel Inheritance, Blob, and Feature Envy. We evaluate HIST in two empirical studies. The first, conducted on twenty open source projects, aimed at assessing the accuracy of HIST in detecting instances of the code smells mentioned above. The results indicate that the precision of HIST ranges between 72% and [illegible]%, and its recall ranges between 58% and 100%. Also, results of the first study indicate that HIST is able to identify code smells that cannot be identified by competitive approaches solely based on code analysis of a single system's snapshot. Then, we conducted a second study aimed at investigating to what extent the code smells detected by HIST (and by competitive code analysis techniques) reflect developers' perception of poor design and implementation choices. We involved twelve developers of four open source projects that recognized more than 75% of the code smell instances identified by HIST as actual design/implementation problems.

Index Terms—Code Smells, Mining Software Repositories, Empirical Studies.

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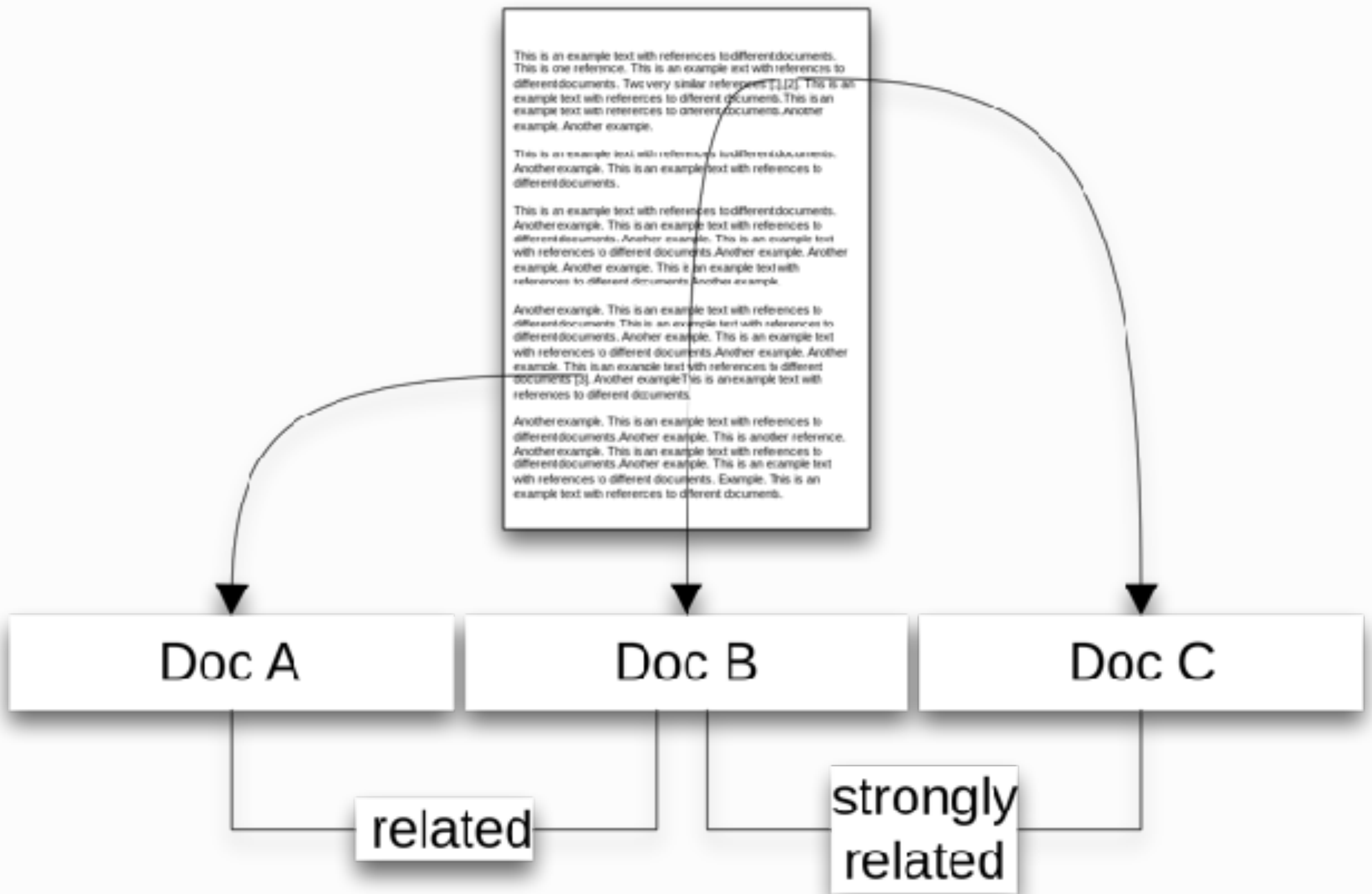

The conjecture is that, if there **unrelated text** in the source code, this may be symptom of the presence of some cohesion-related problems.

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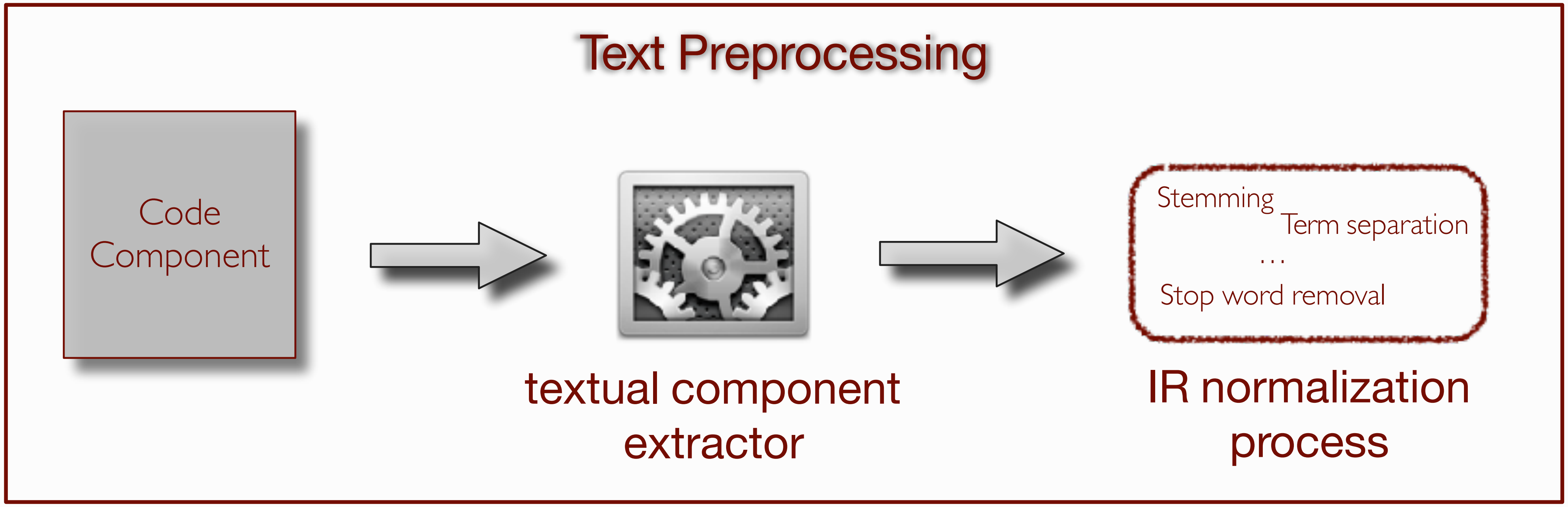

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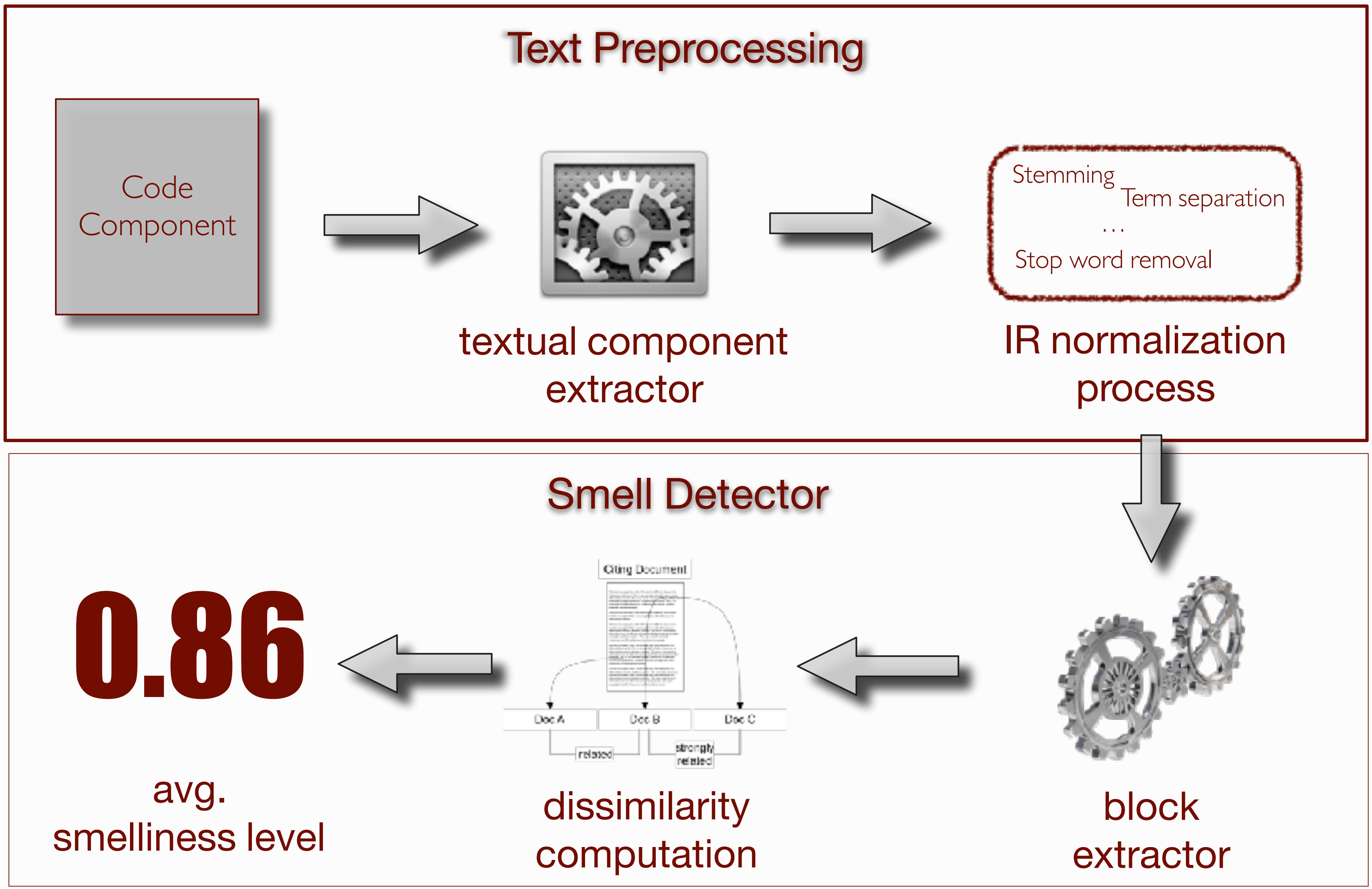

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A Textual-based Technique for Smell Detection

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Abstract—In this paper, we present TACO (Textual Analysis for Code Smell Detection), a technique that exploits textual analysis to detect a family of smells of different nature and different levels of granularity. We run TACO on 10 open source projects, comparing its performance with existing smell detectors purely based on structural information extracted from code components. The analysis of the results indicates that TACO's precision ranges between 67% and 77%, while its recall ranges between 72% and 84%. Also, TACO often outperforms alternative structural approaches confirming, once again, the usefulness of information that can be derived from the textual part of code components.

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Some more definitions needed

Misplaced Class. This code smell indicates a class that is in a package that contains other classes not related to it.

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Question: Is there a way/technique that can lead to solve them all?

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Question: Does it work?

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Detecting Code Smells using Machine Learning Techniques: Are We There Yet?

Dario Di Nucci[1,2], Fabio Palomba[3], Damian A. Tamburri[4], Alexander Serebrenik[4], Andrea De Lucia[1]

[1]University of Salerno, Italy — [2]Vrije Universiteit Brussel, Belgium

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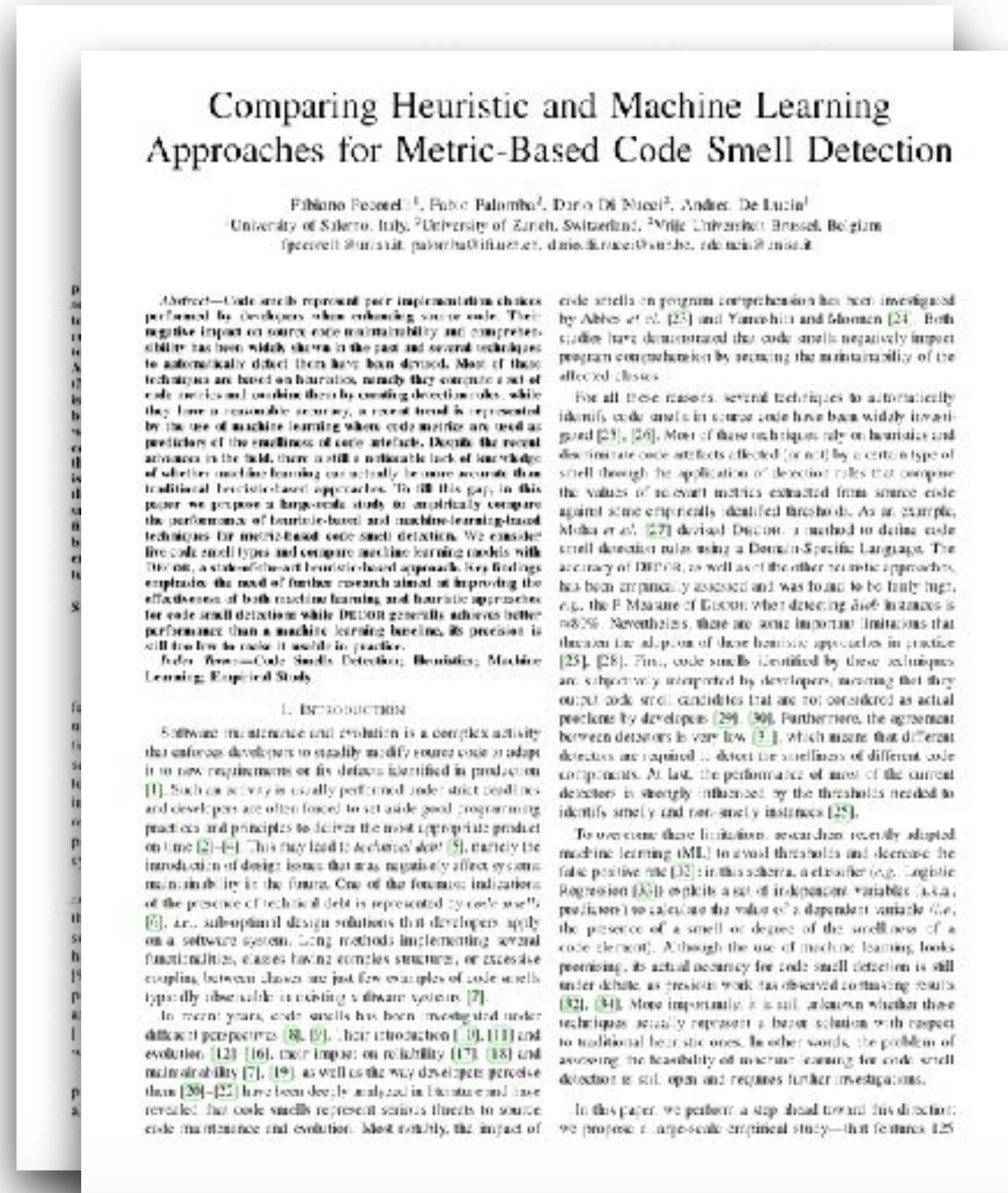
Comparing Heuristic and Machine Learning Approaches for Metric-Based Code Smell Detection

Fabiano Pecorelli[1], Fabio Palomba[1], Dario Di Nucci[2], Andrea De Lucia[1]

I. Introduction

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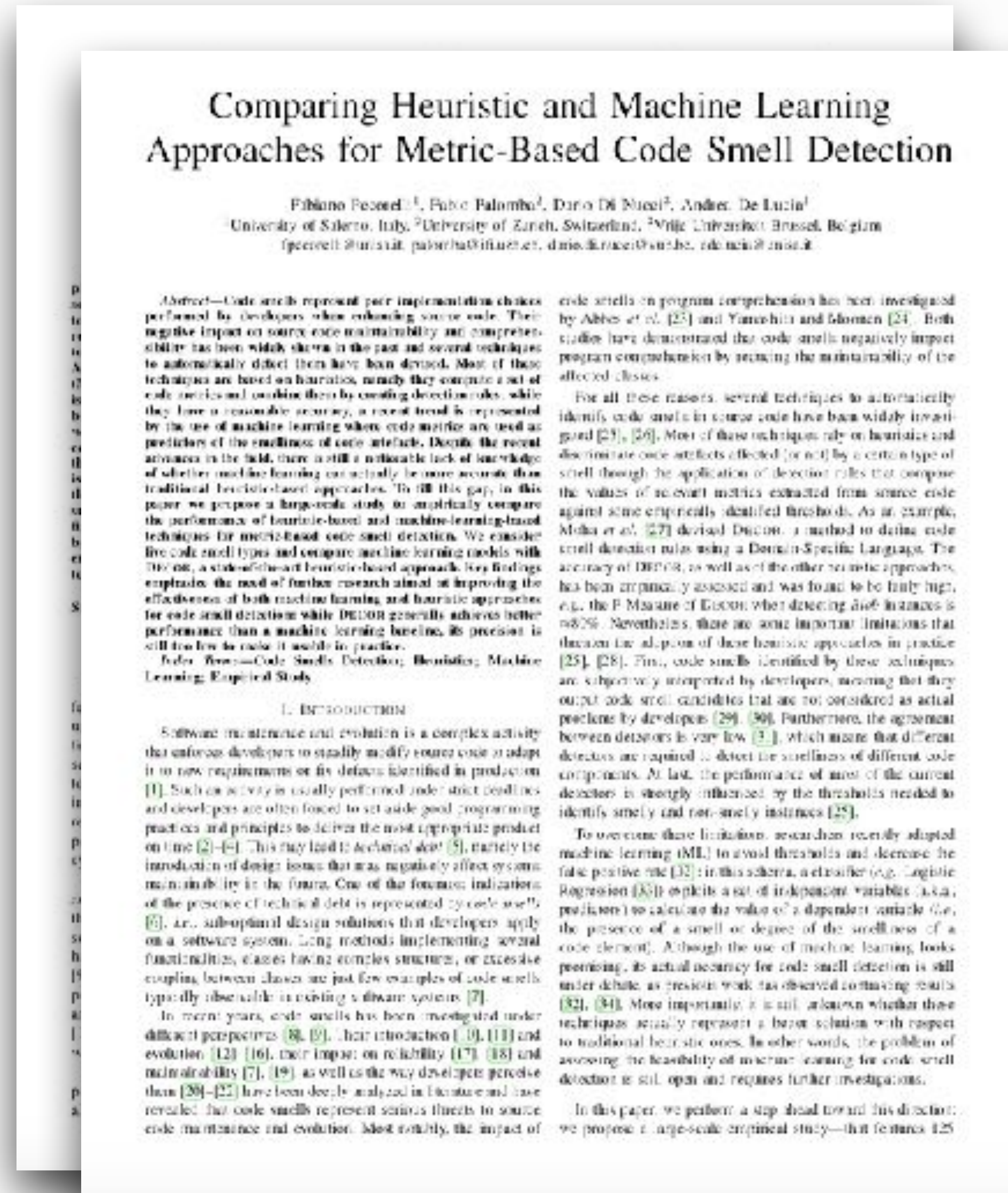

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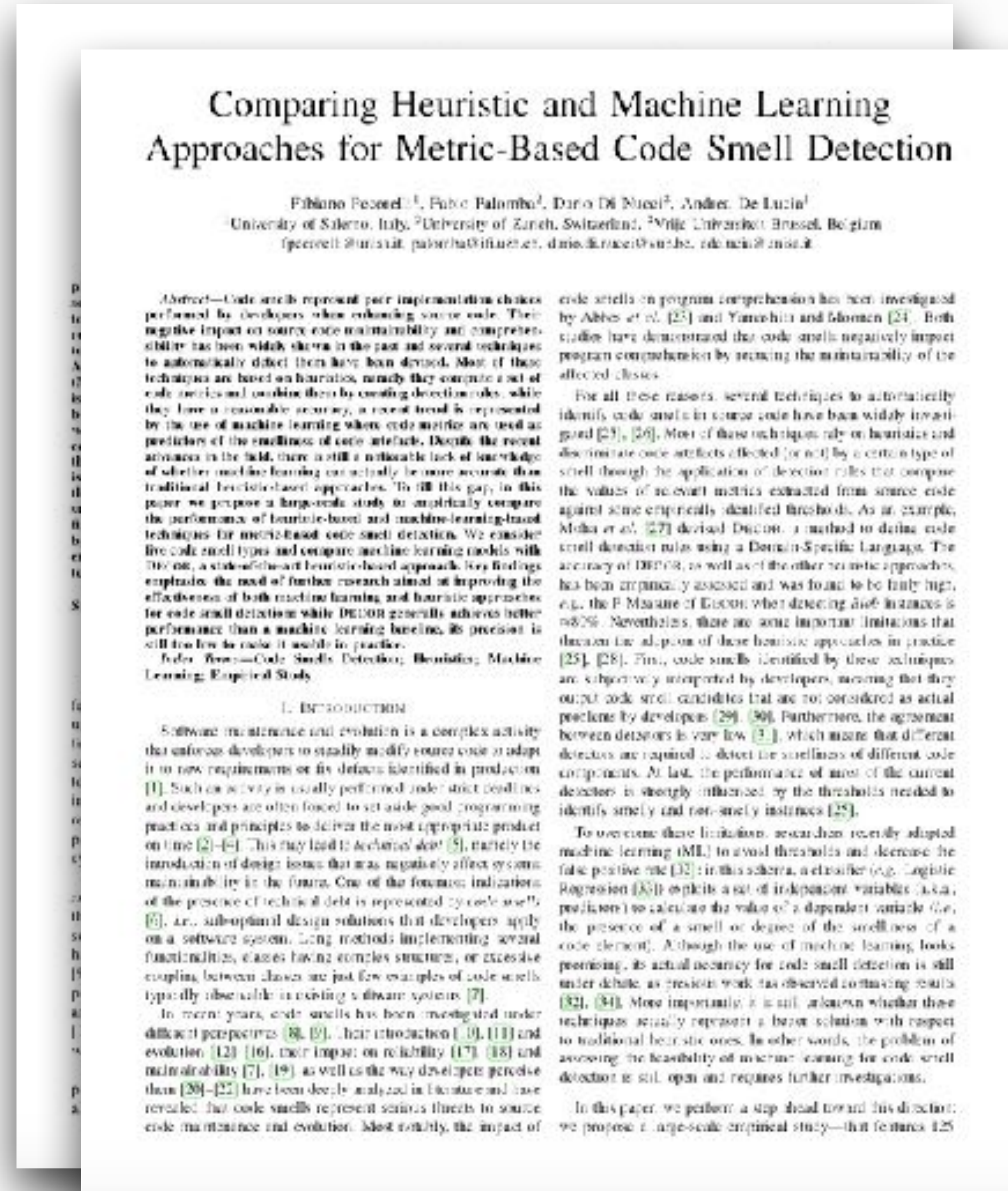
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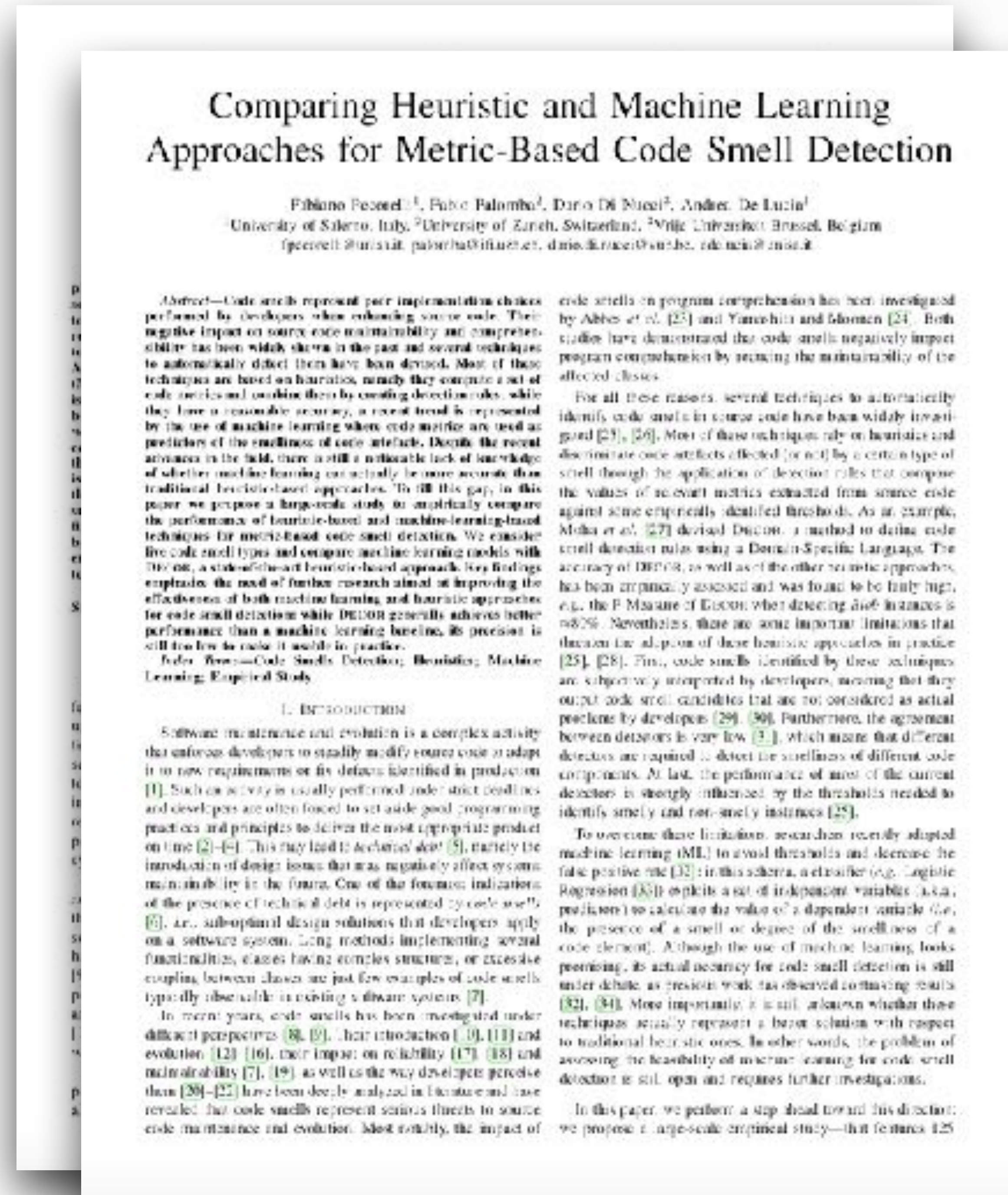
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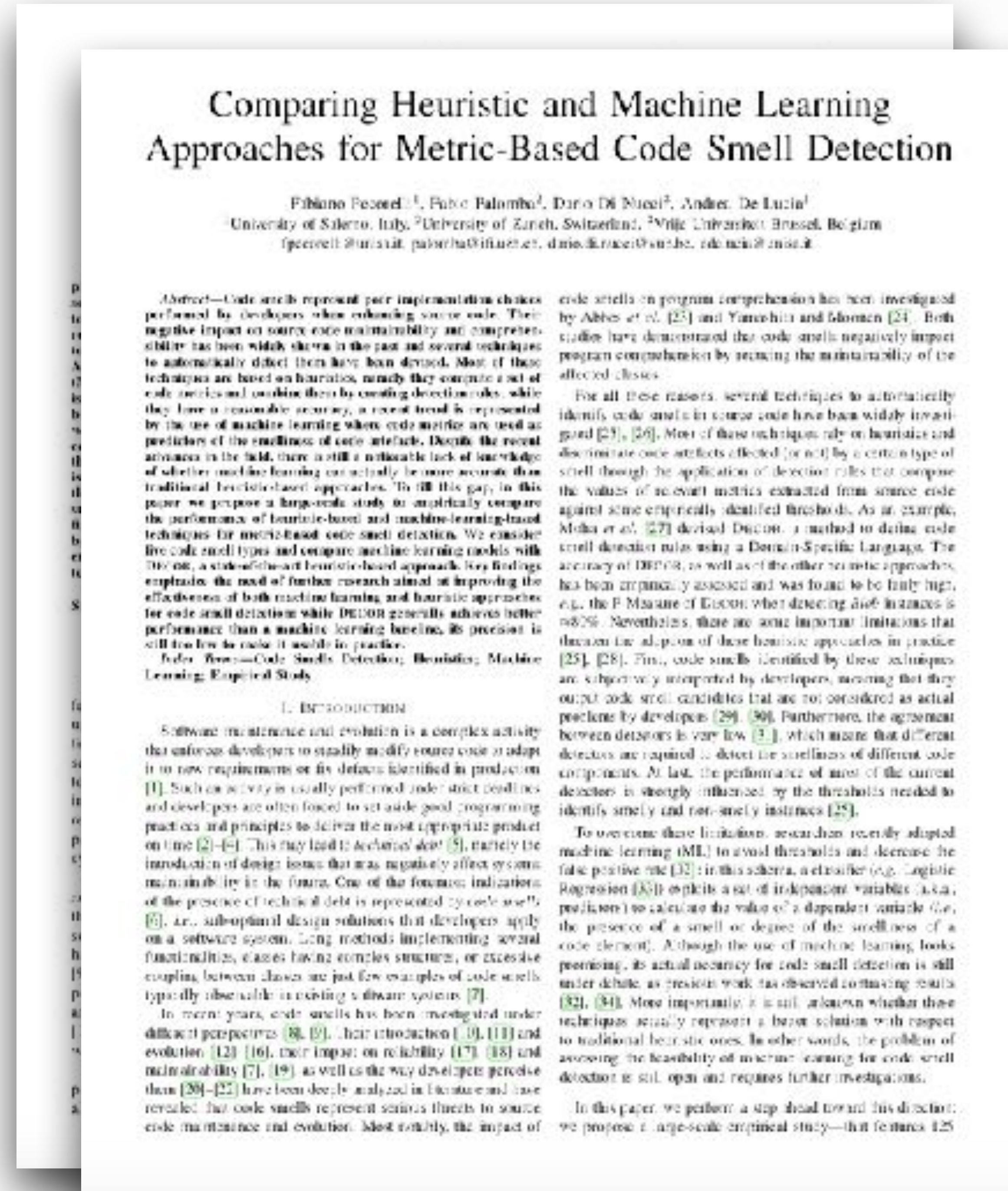

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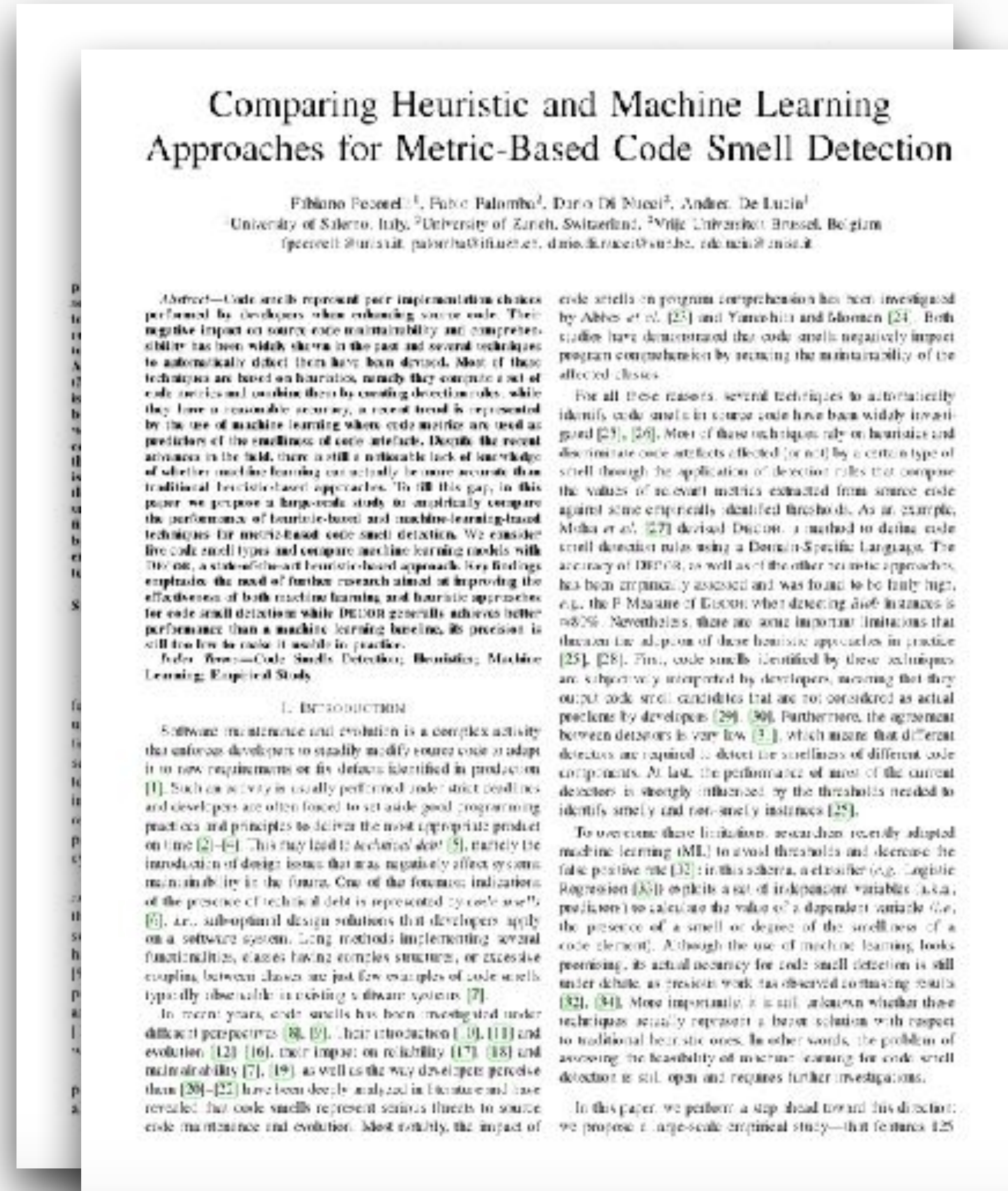
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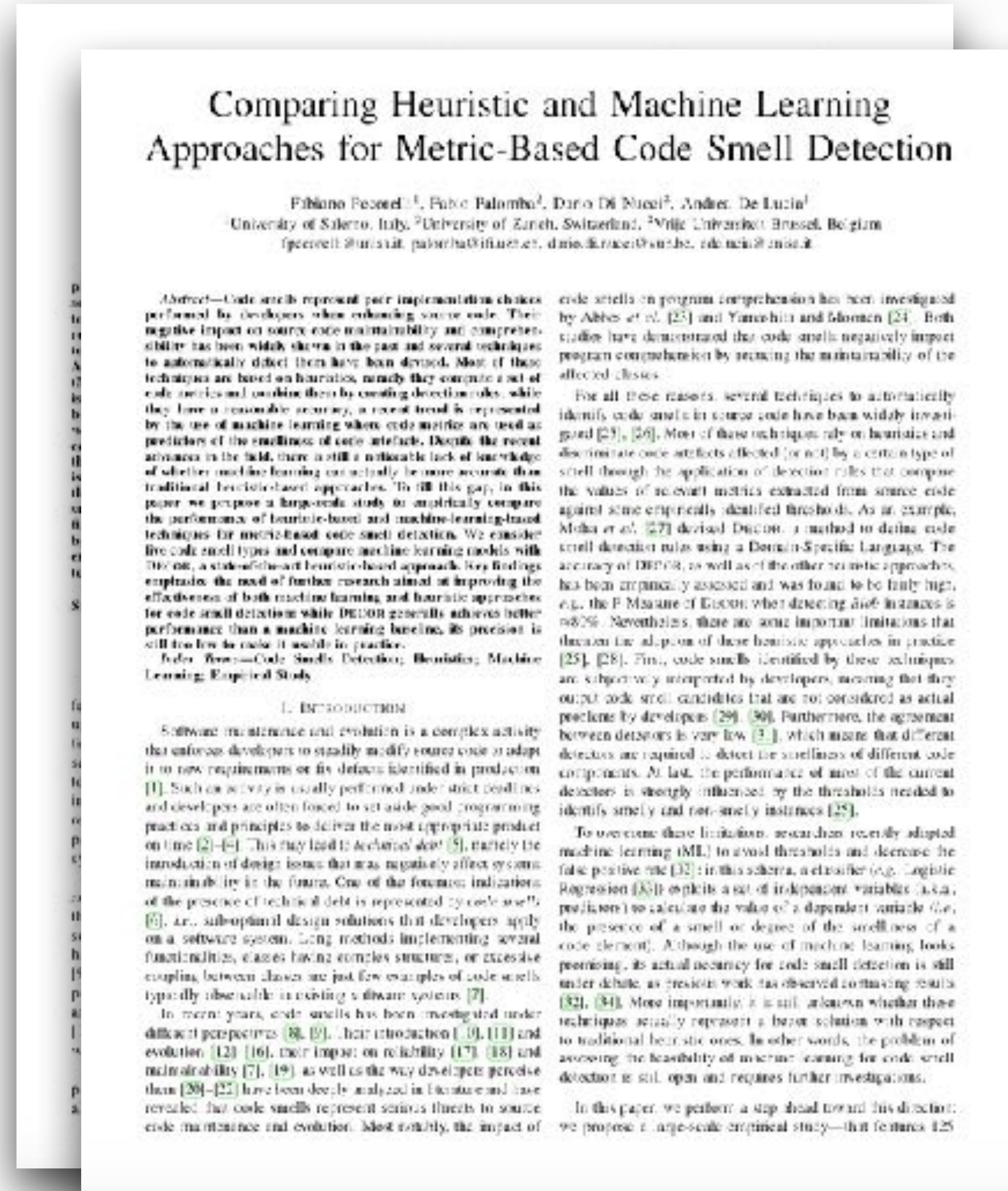
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- Machine learning algorithms **often fail** to learn the features characterizing smelly elements.
- Data balancing techniques **often fail** when it comes to code smell prediction.

Bad Code Smells - Summing Up

Bad code smells (a.k.a., code smells or simply smells) represent **symptoms of the presence of poor design and/or implementation choices** that may lead to additional unforeseen software development costs.

- They can be detected in multiple ways and using different metrics.

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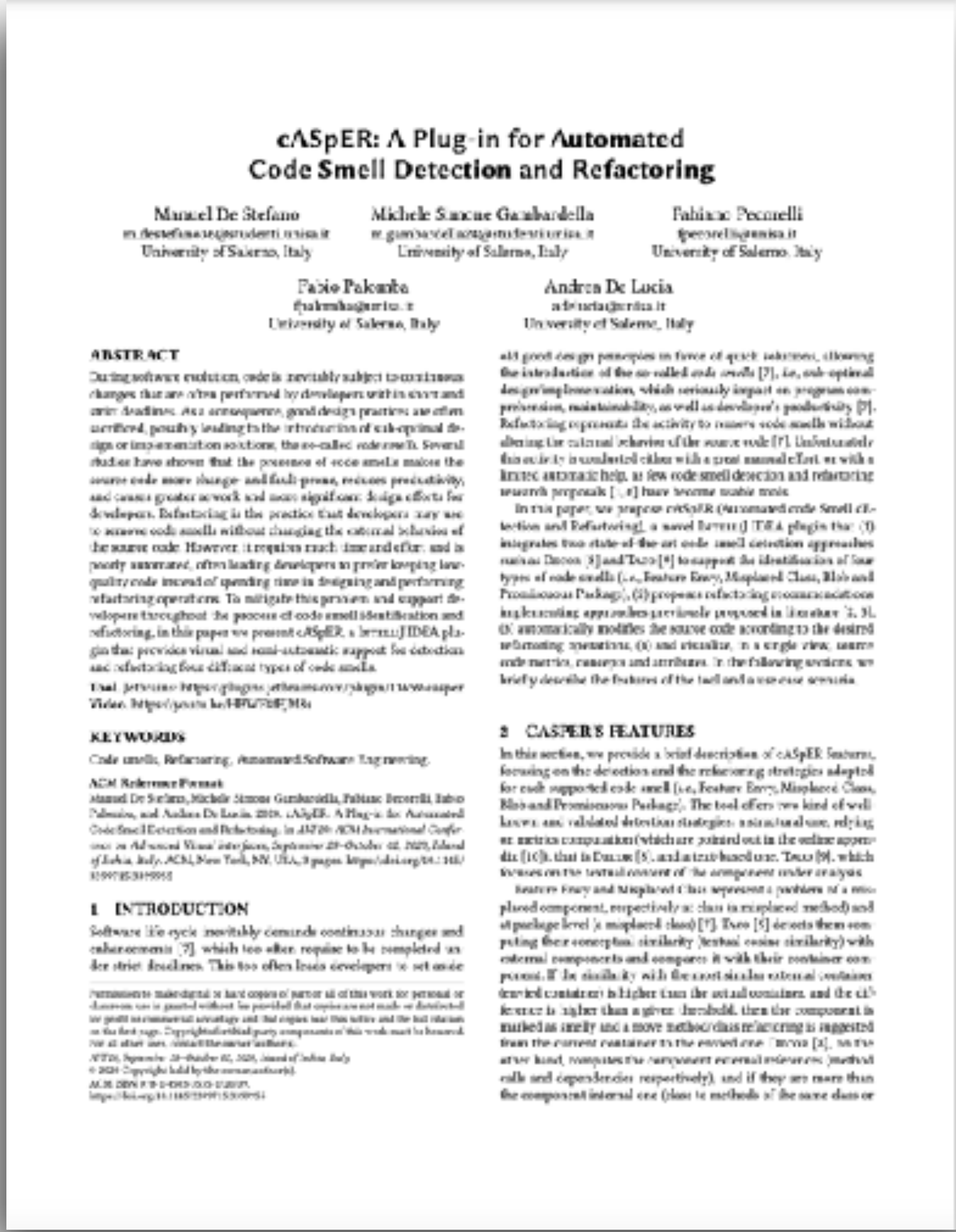
- The problems of heuristic-based approaches **are still there**, even though practitioners may be more confident with respect to their output.
- Mixing together different sources of information seems to provide **more meaningful recommendations** without necessarily decrease the detection performance.

Bad Code Smells - cASpER (Automated code Smell dEtection and Refactoring)

cASpER is an IntelliJ plug-in for the automatic detection and refactoring of Code Smells.



cASpER: A Plug-in for Automated Code Smell Detection and Refactoring

Manuel De Stefano, University of Salerno, Italy
Michele Simone Gambardella, University of Salerno, Italy
Fabiano Pecorelli, University of Salerno, Italy
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ABSTRACT

KEYWORDS

1 INTRODUCTION

2 CASPER'S FEATURES

https://www.youtube.com/watch?v=HBWF8fFJM8s#t=1m10s

https://mdestefano.github.io/files/C1.pdf

Code smells: detection & refactoring

Slides by Prof. Fabio Palomba