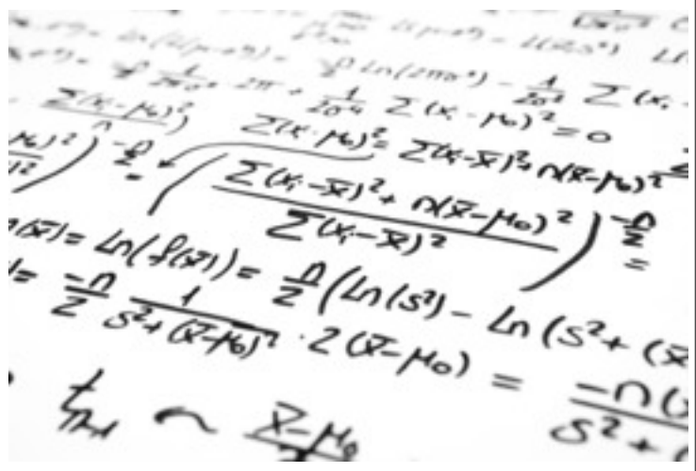
Bug Prediction

SW Wartung und Evolution

Emanuel Giger

University of Zurich
Department of Informatics

Software has Bugs!



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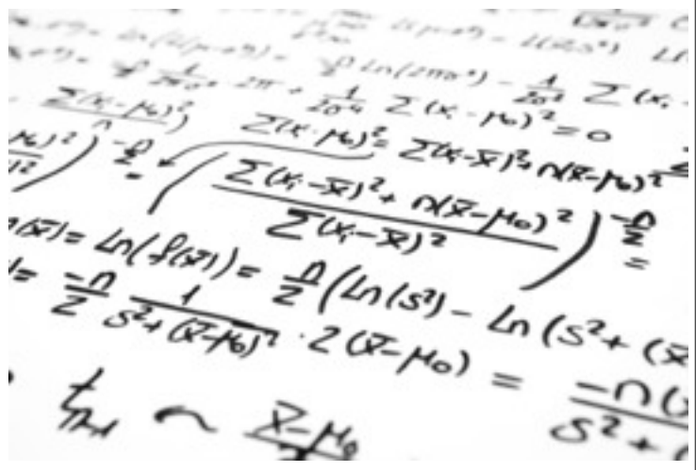

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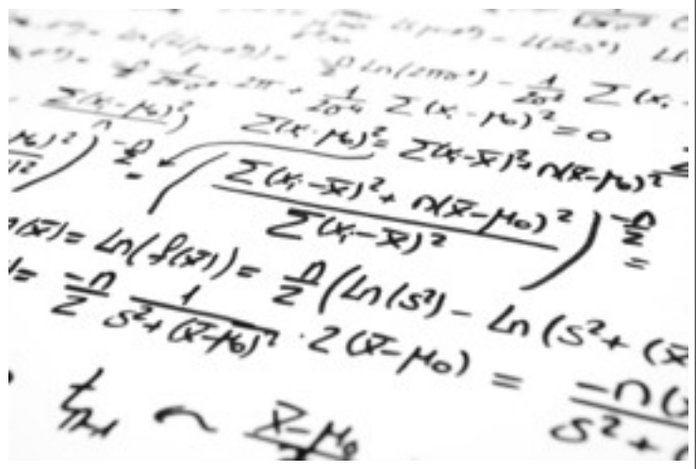

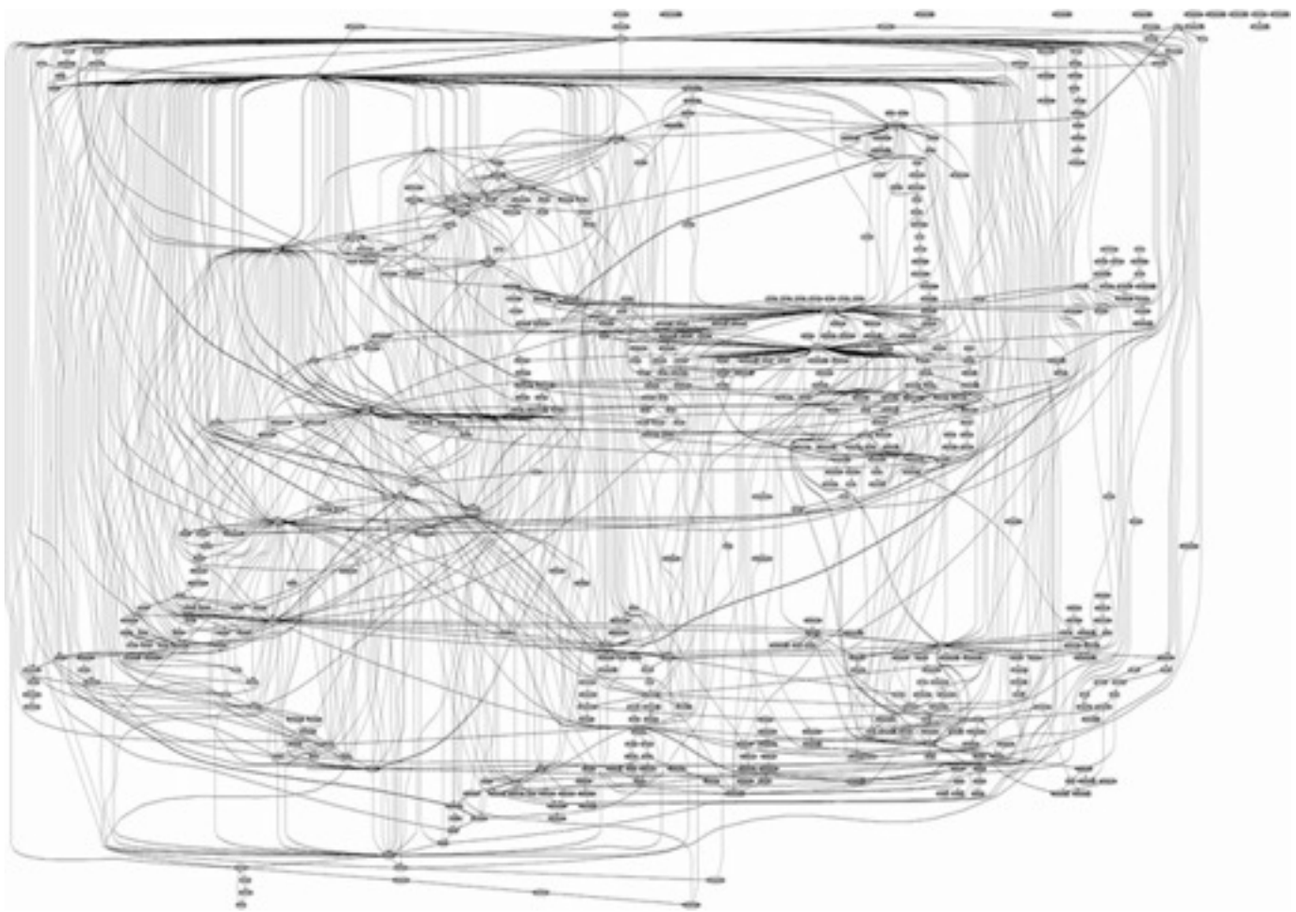

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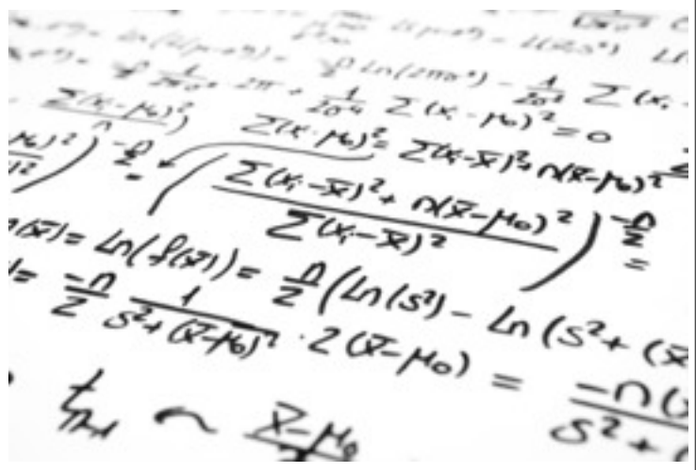

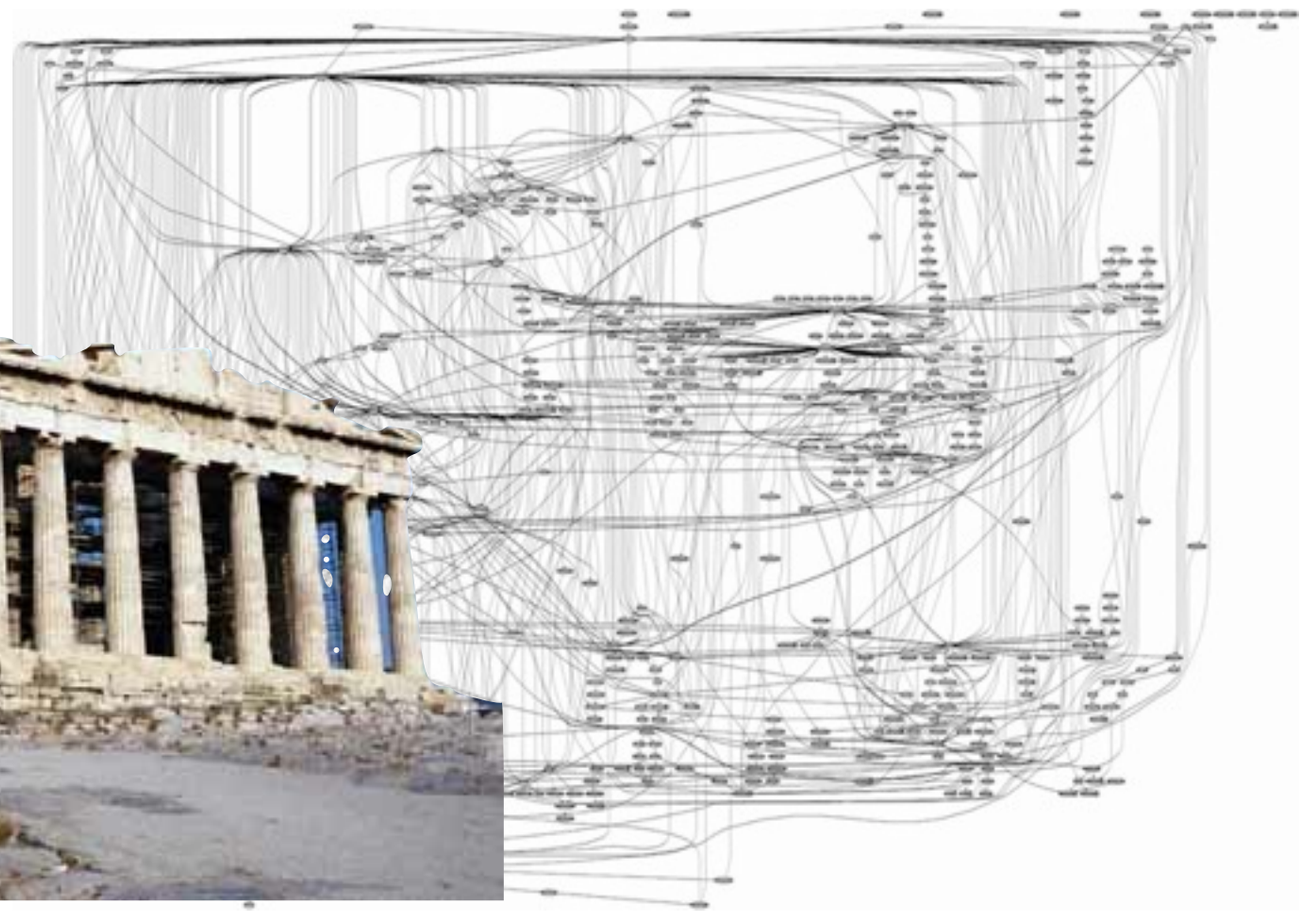

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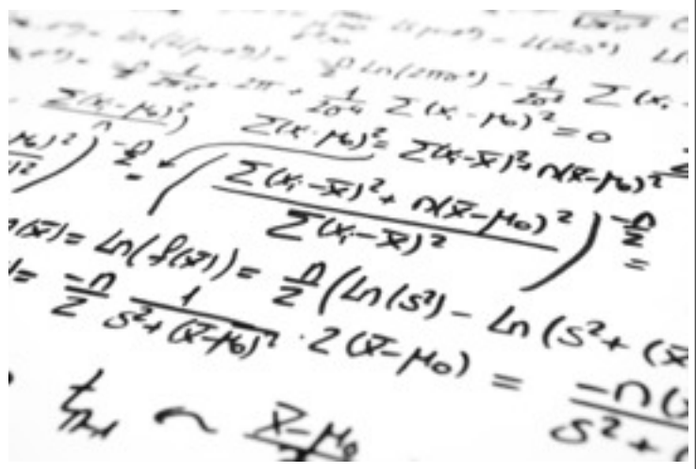

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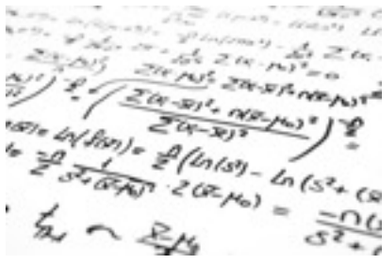

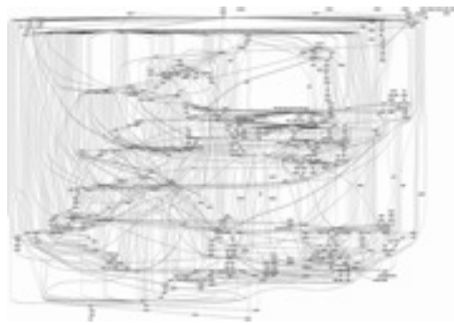

Bugs! Bugs! Bugs! Bugs! Bugs!

Quality Assurance (QA)...

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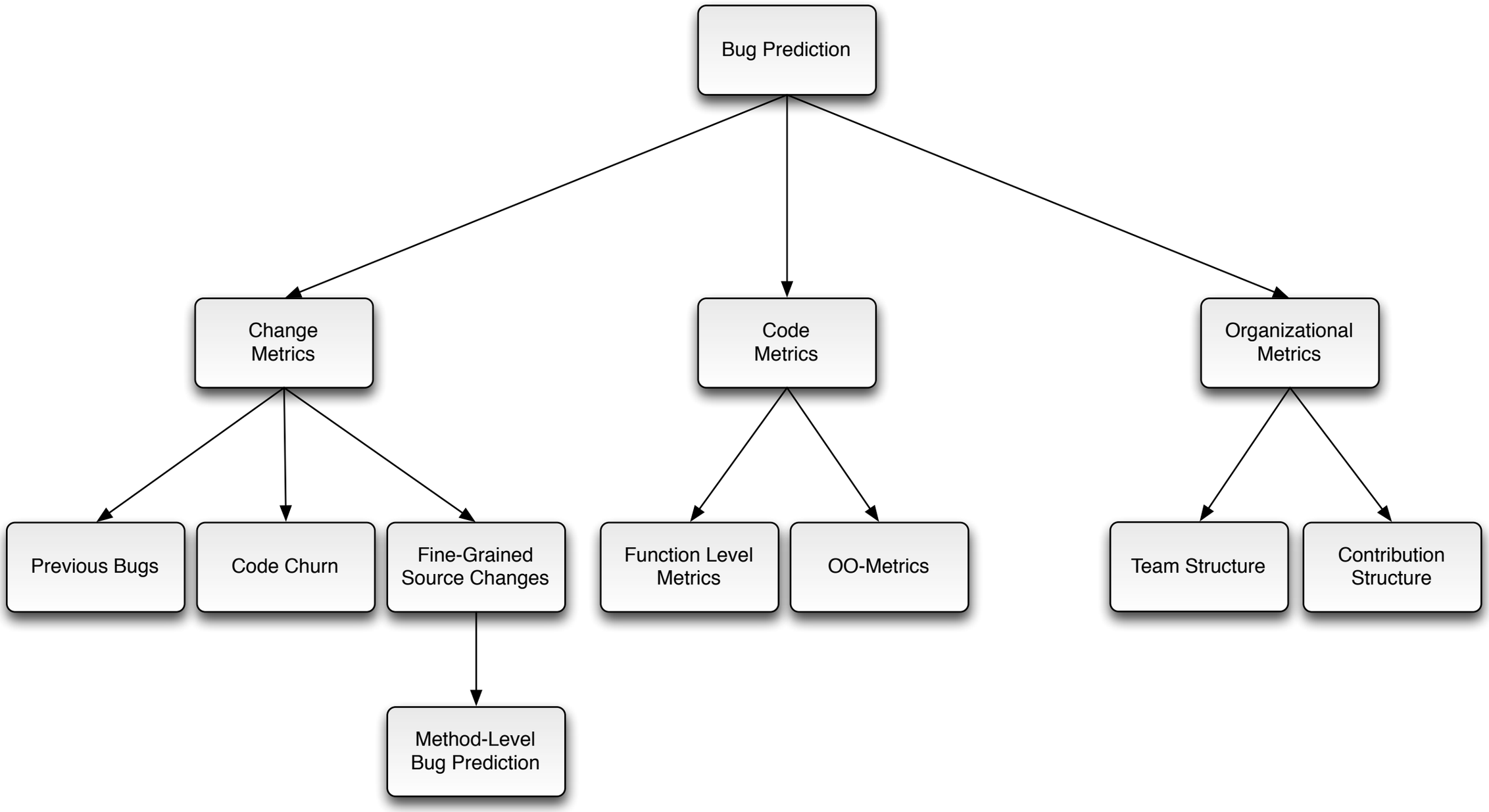
Spend resources with maximum efficiency!
Focus on the components that fail the most!

Bug Prediction Models



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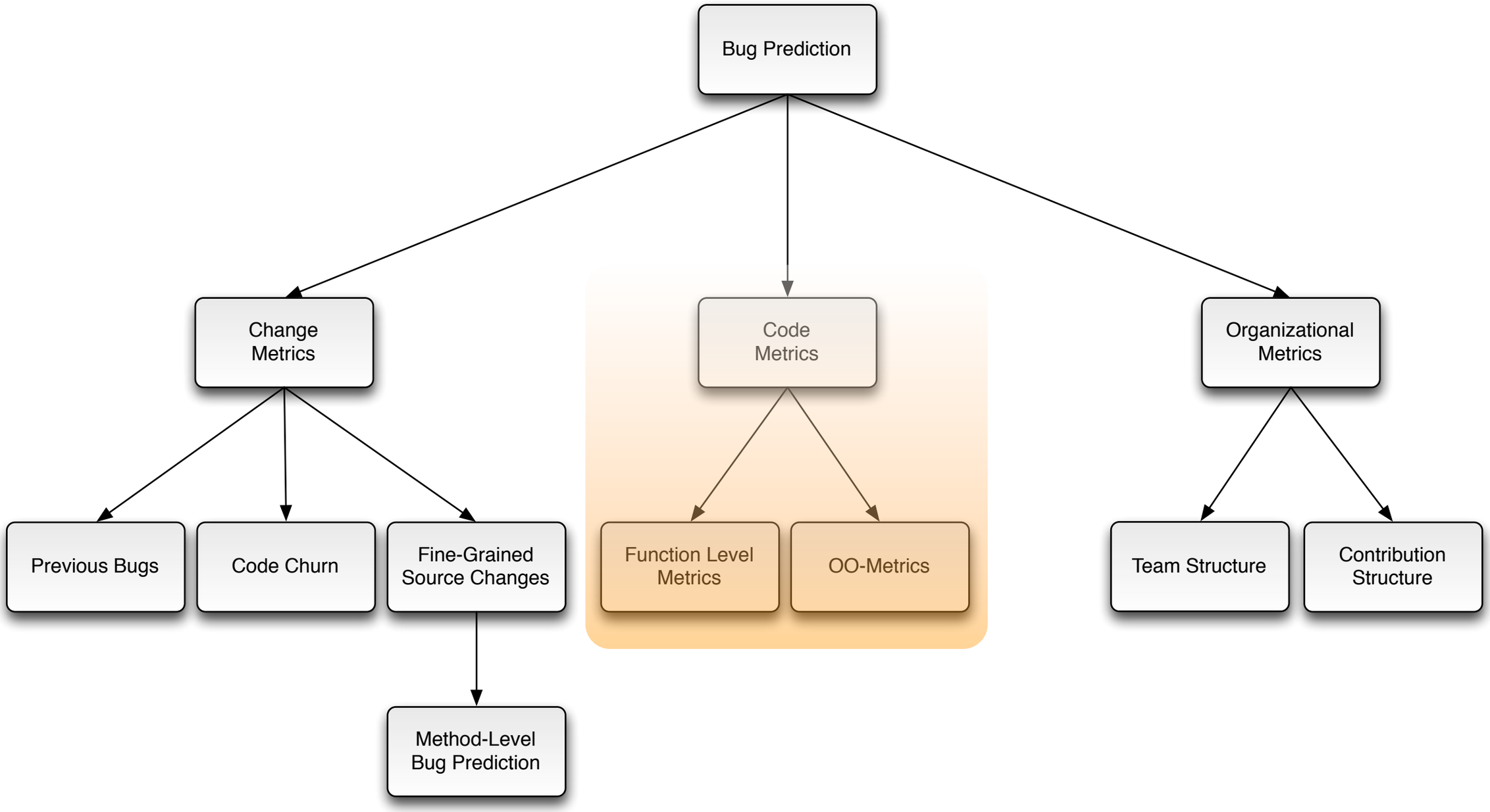

Code Metrics

- Directly calculated on the code itself
- Measure size and complexity of the code

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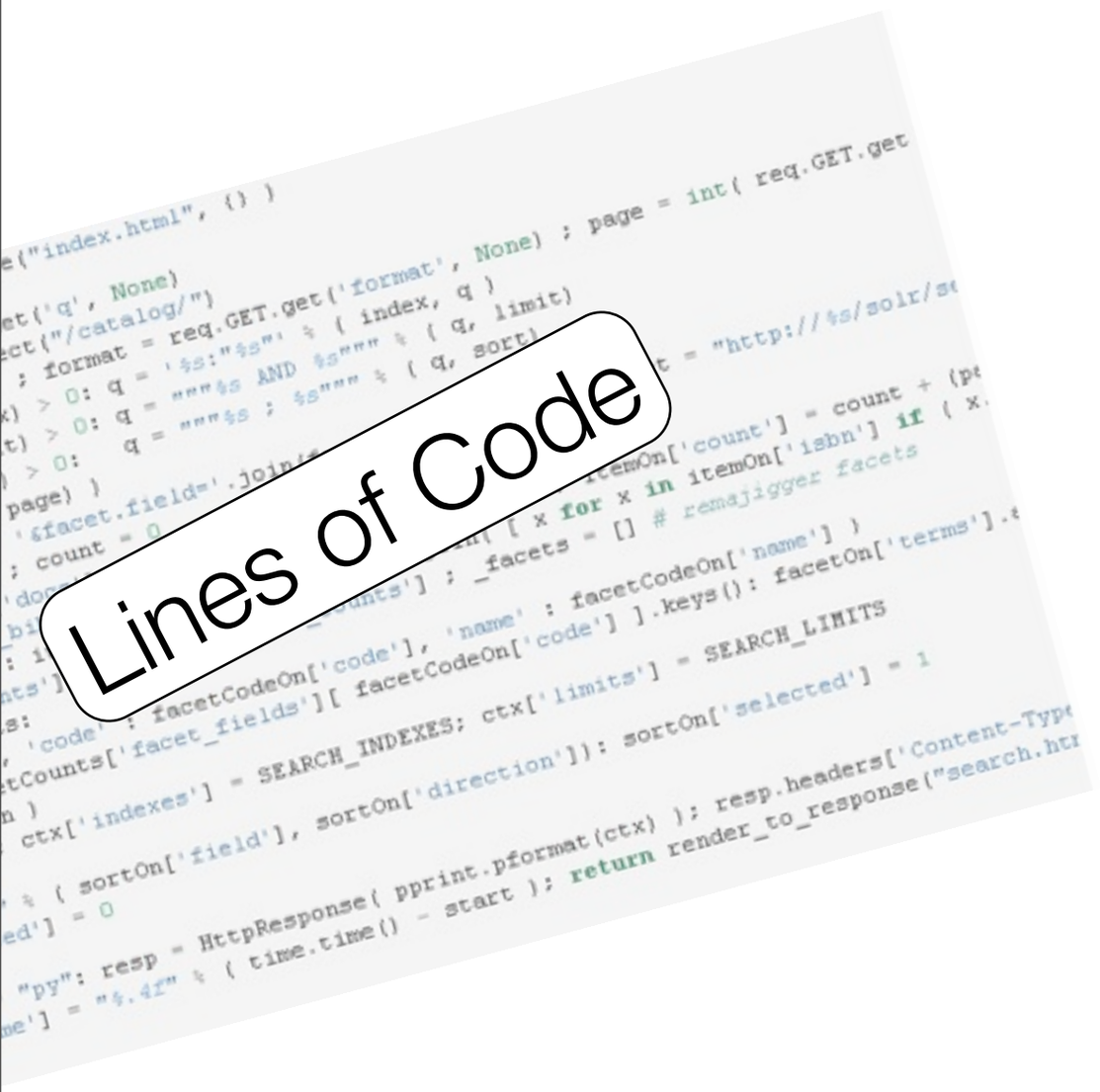

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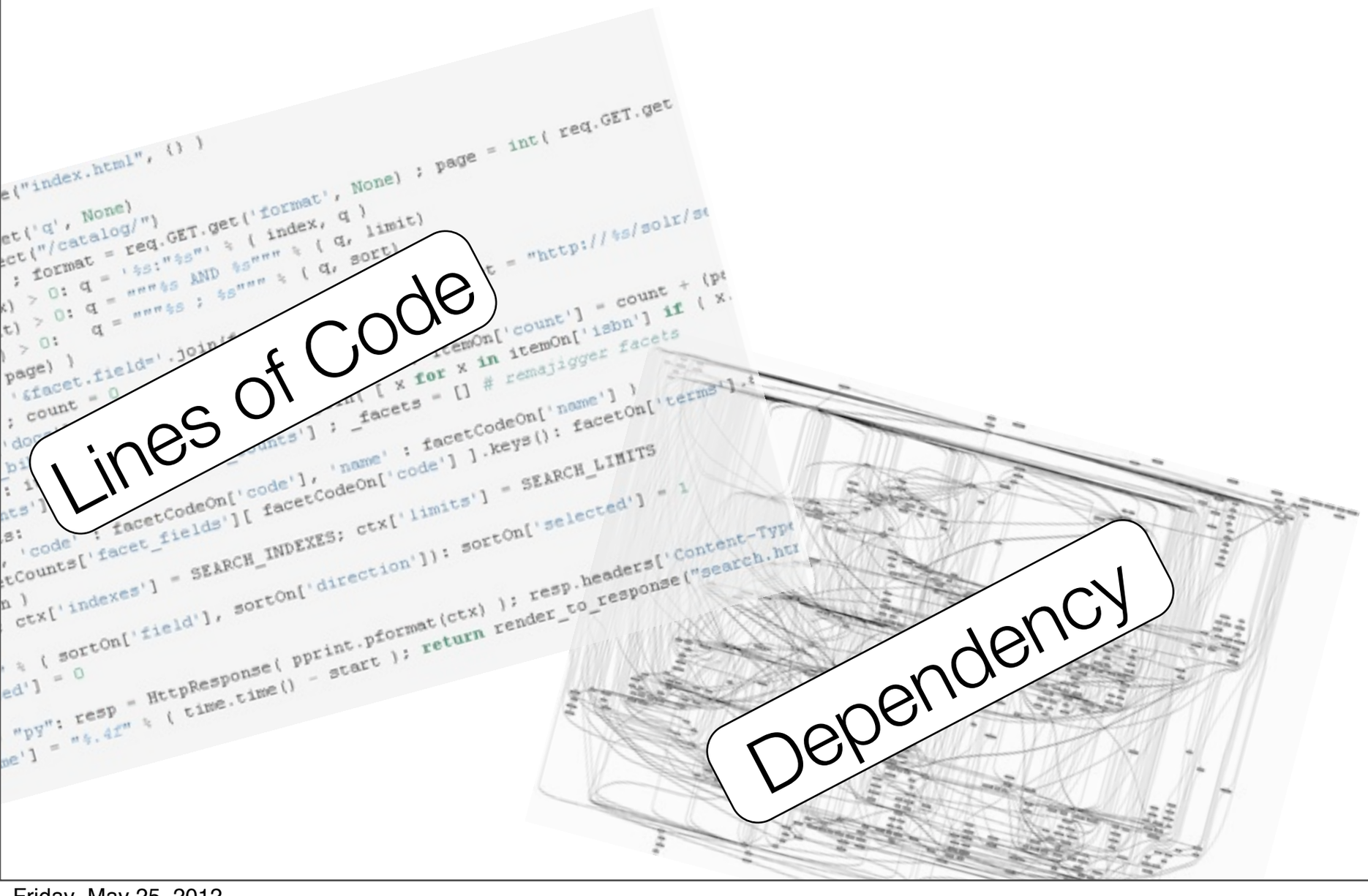

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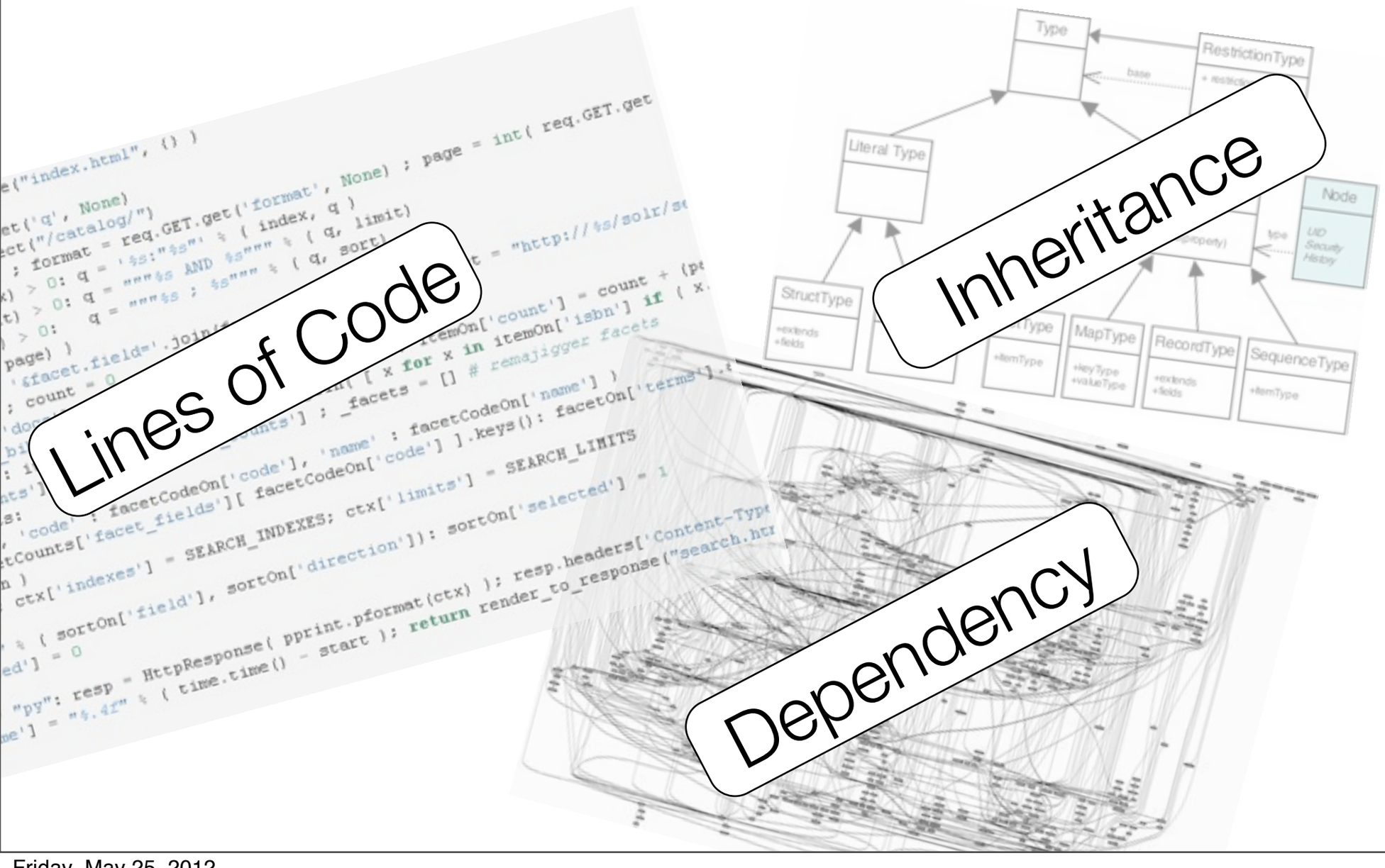

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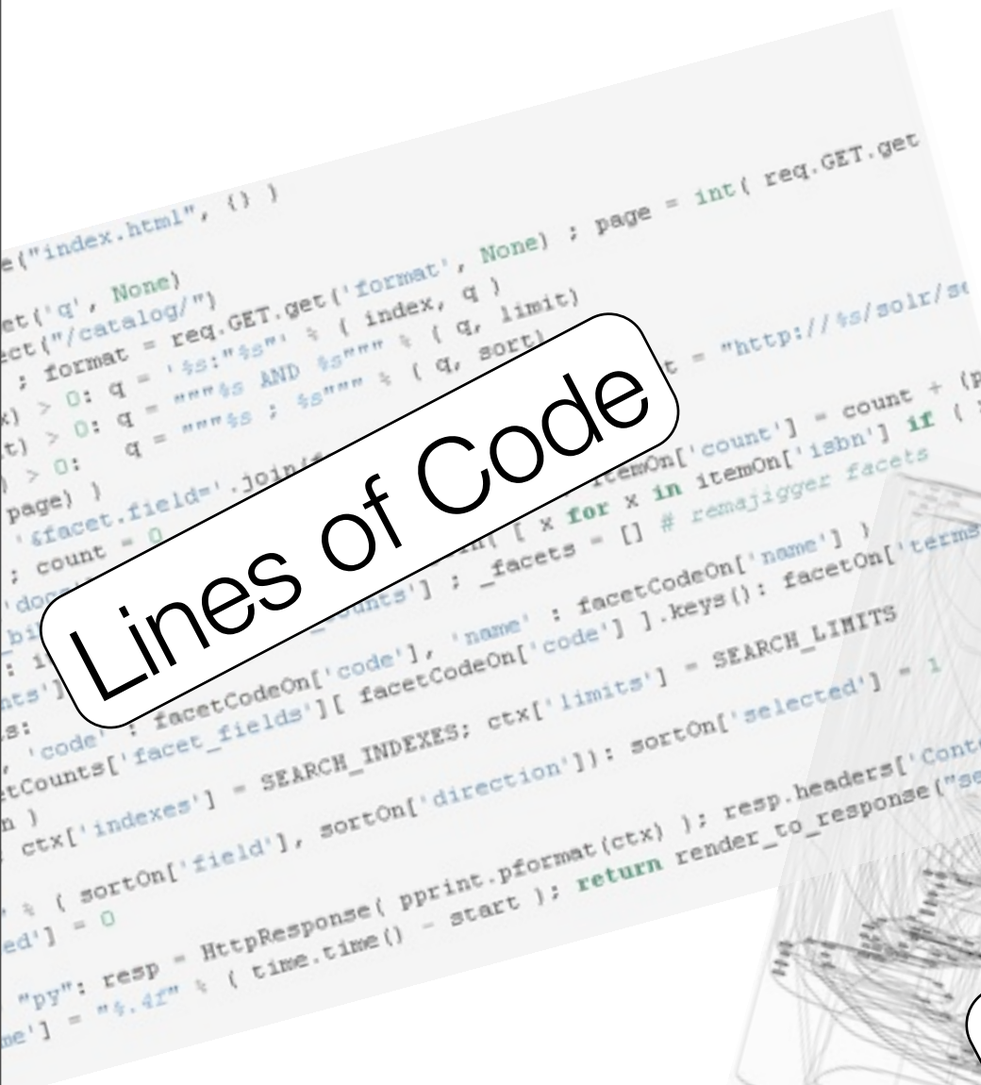
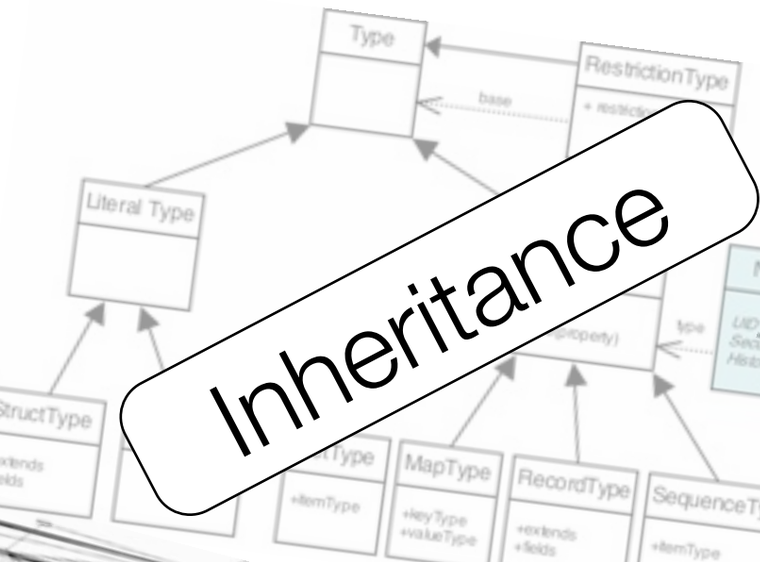
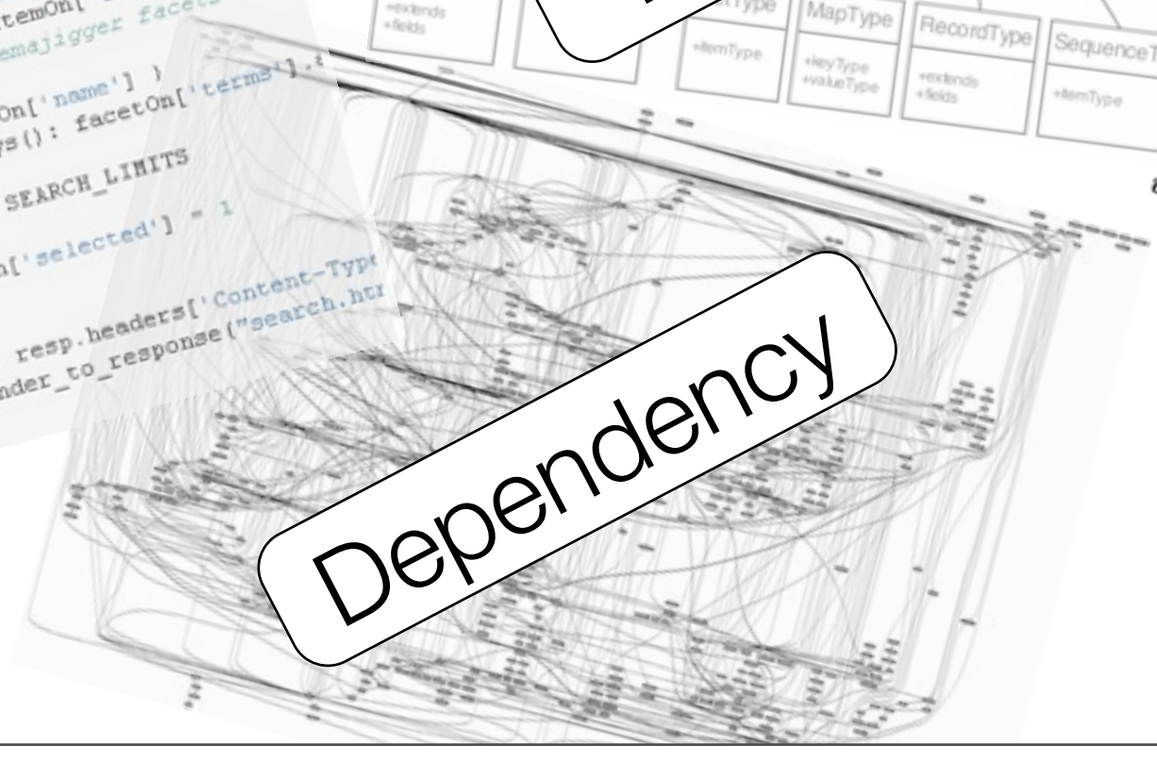
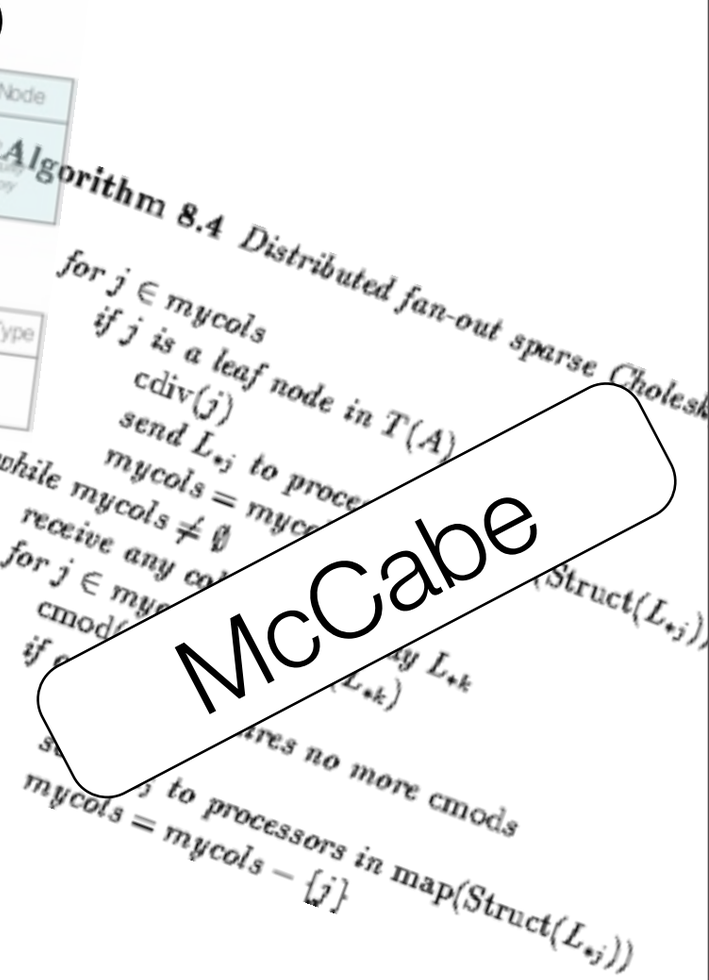




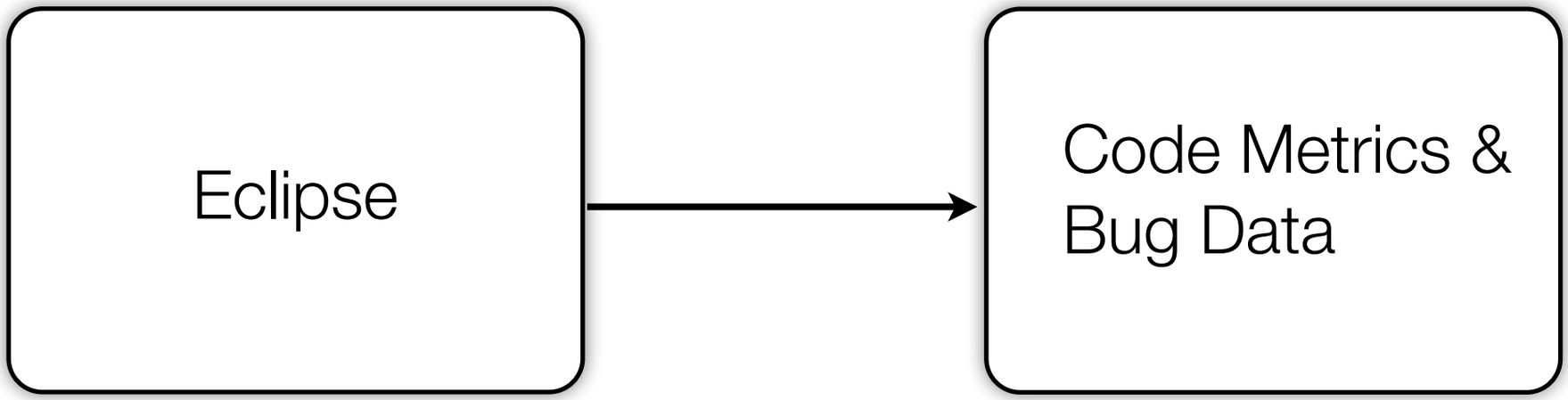




Bug Prediction Setup

Eclipse

Bug Prediction Setup



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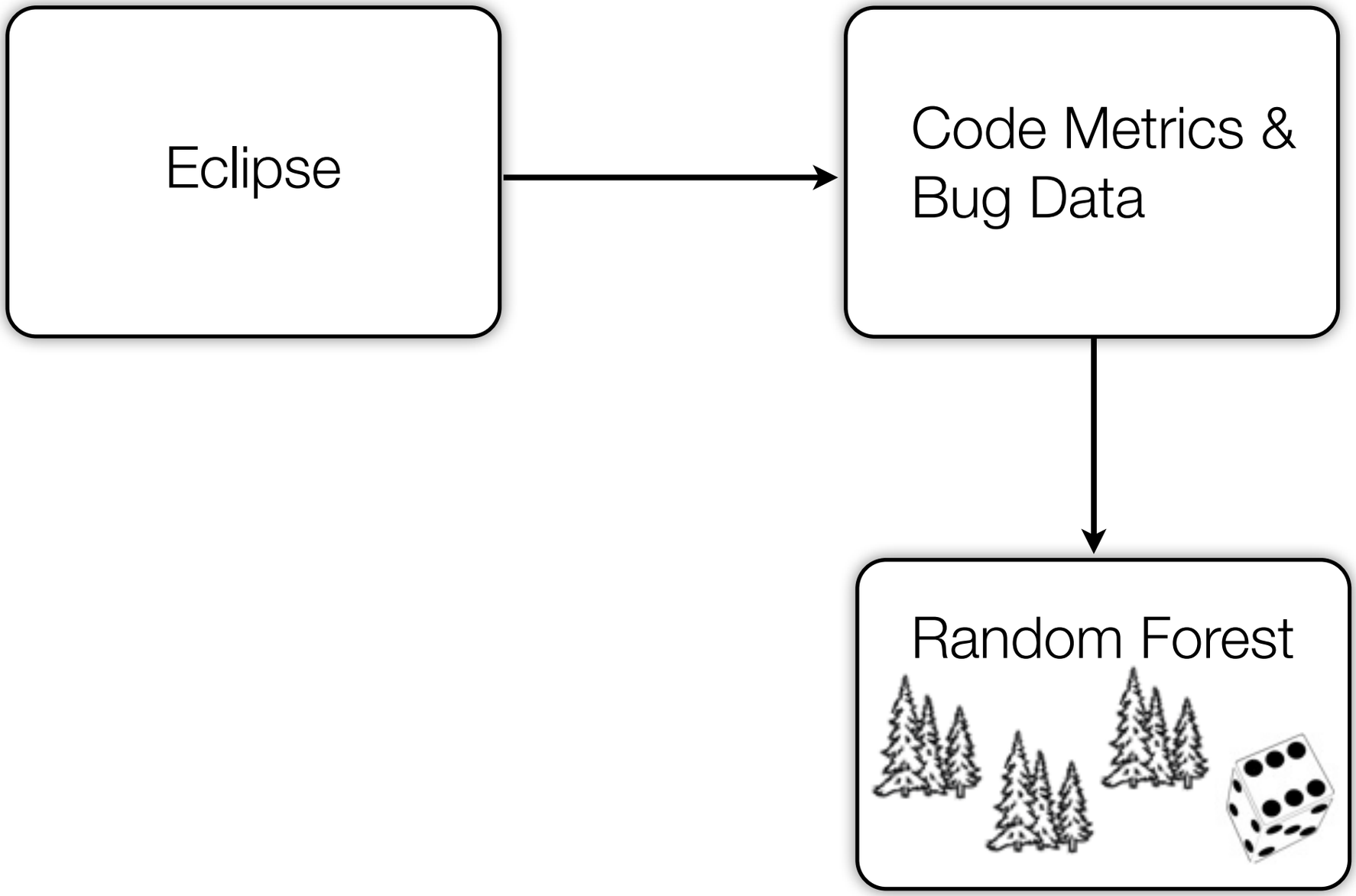

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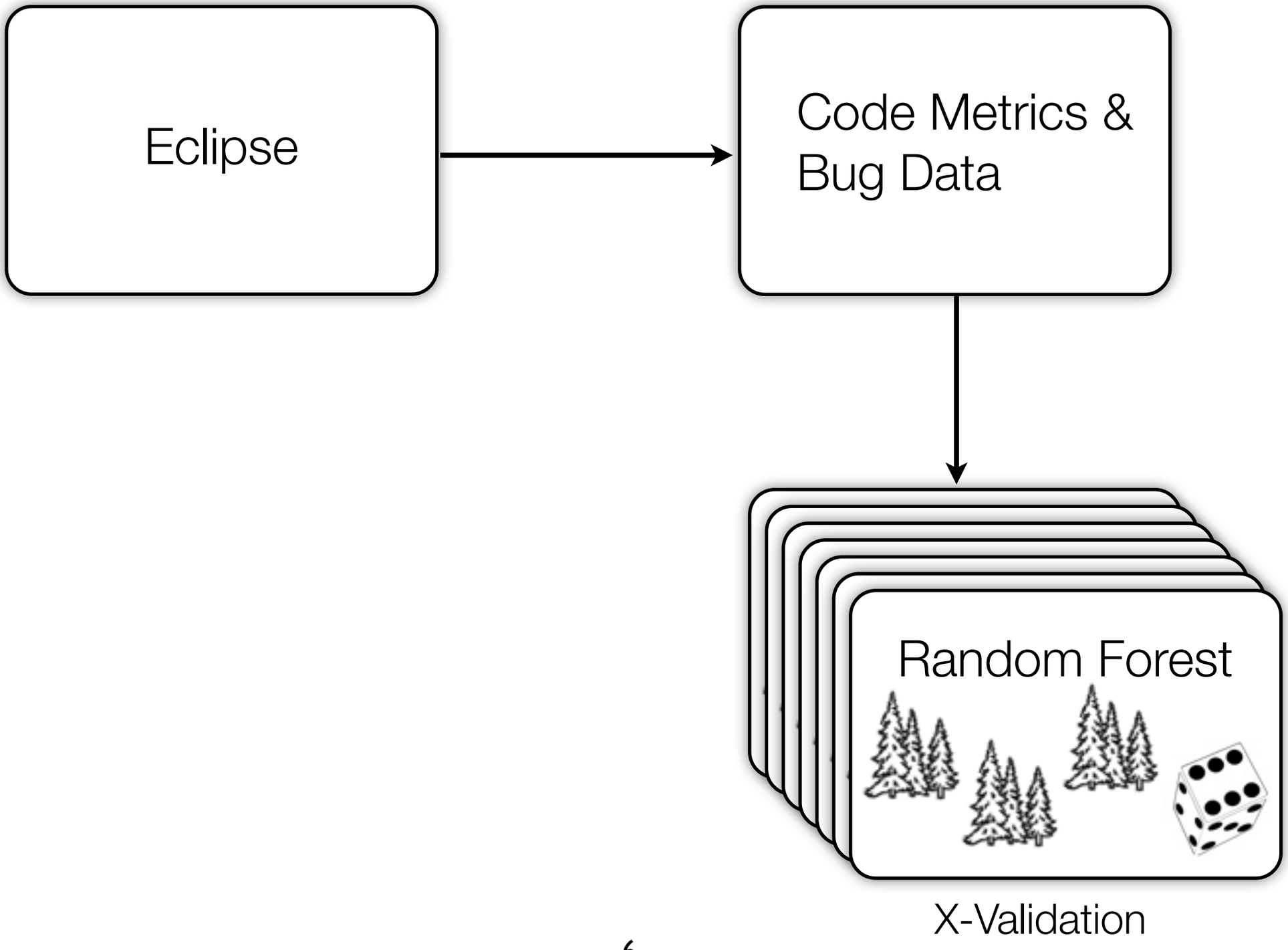

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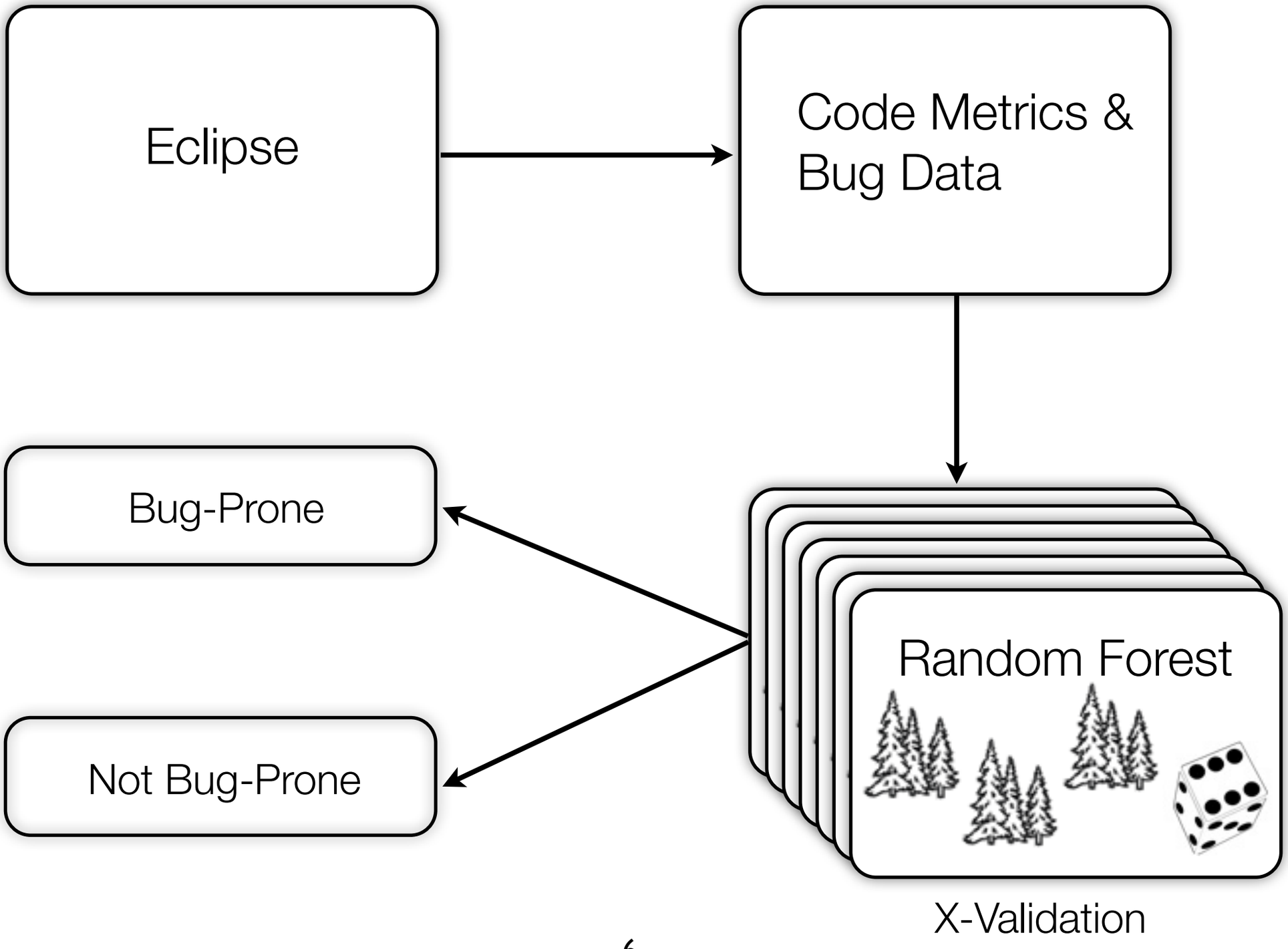

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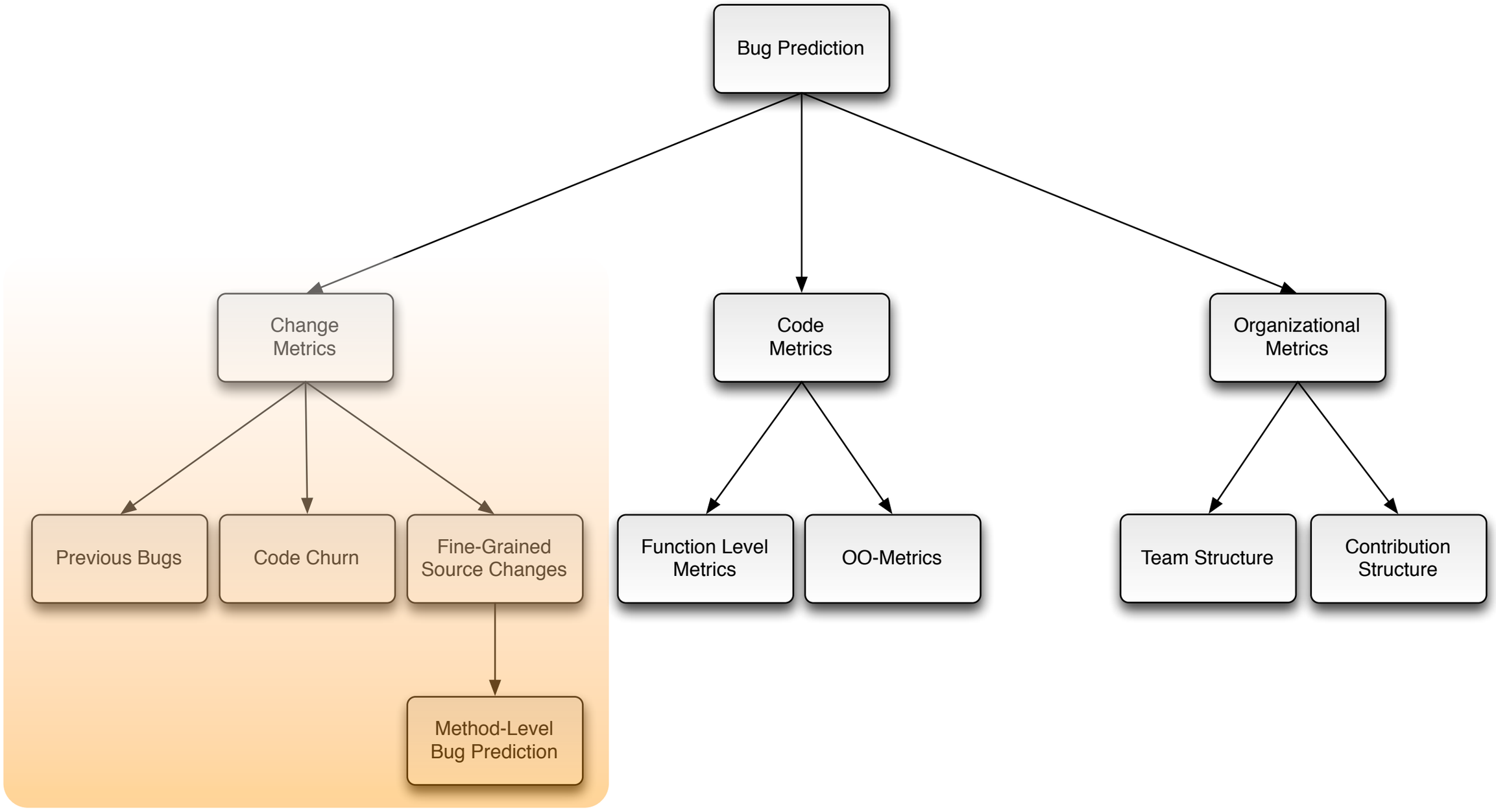

Code Changes

Revisions

Commits to version control systems

Coarse-grained

Files are the units of change

Revisions

There is more than just a file revision

```
    private IStructureComparator fStructureComparator;

    public boolean setInput(ITypedElement newInput, boolean force) {
        boolean changed = false;
        if (force || newInput != fInput) {
            removeDocumentRangeUpdaters();
            if (fInput instanceof IContentChangeNotifier)
                ((IContentChangeNotifier)fInput).removeContentChangeListener(fContentChangedListener);
            fInput= newInput;
            if (fInput == null) {
                if (fStructureComparator instanceof IDisposable) {
                    IDisposable disposable = (IDisposable) fStructureComparator;
                    disposable.dispose();
                }
                fStructureComparator= null;
            } else {
                refresh();
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    /**
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Revisions

Commits to version control systems

Coarse-grained

Files are the units of change

Code Churn

Textual UnixDiff between 2 File Versions

Ignores the structure of code

No change type information

Includes textual changes

Code Churn

Does not reflect the type and the semantics of source code changes

```
/*******************************************************************************
 * Copyright (c) 2000, 2004 IBM Corporation and others.
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 * which accompanies this distribution, and is available at
 * http://www.eclipse.org/legal/epl-v10.html
 *
 * Contributors:
 *     IBM Corporation - initial API and implementation
 *******************************************************************************/
package org.eclipse.compare.structuremergeviewer;

import org.eclipse.swt.events.DisposeEvent;
import org.eclipse.swt.widgets.*;
import org.eclipse.jface.util.PropertyChangeEvent;

import org.eclipse.compare.*;
import org.eclipse.compare.internal.*;


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```

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Code Changes

Revisions

Commits to version control systems

Coarse-grained

Files are the units of change

Code Churn

Textual UnixDiff between 2 File Versions

Ignores the structure of code

No change type information

Includes textual changes

Fine-Grained Changes[1]

Compares 2 versions of the AST of source code

Very fine-grained

Change type information

Captures all changes

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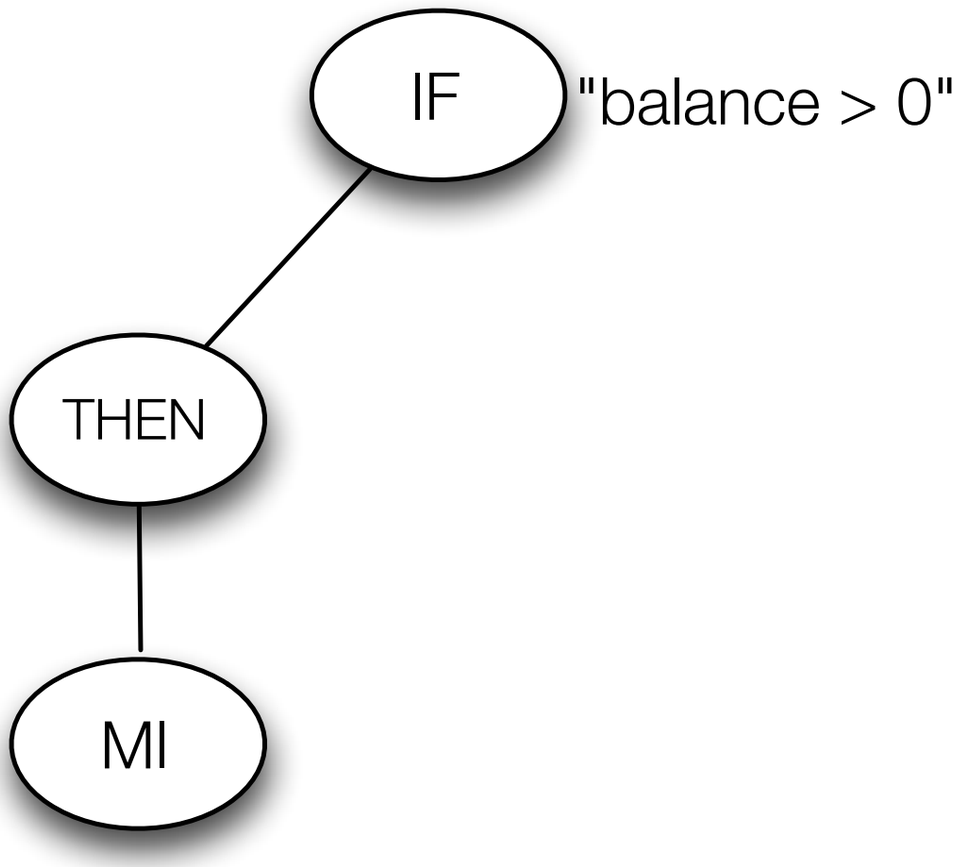
[1][Fluri et al. 2007, TSE]

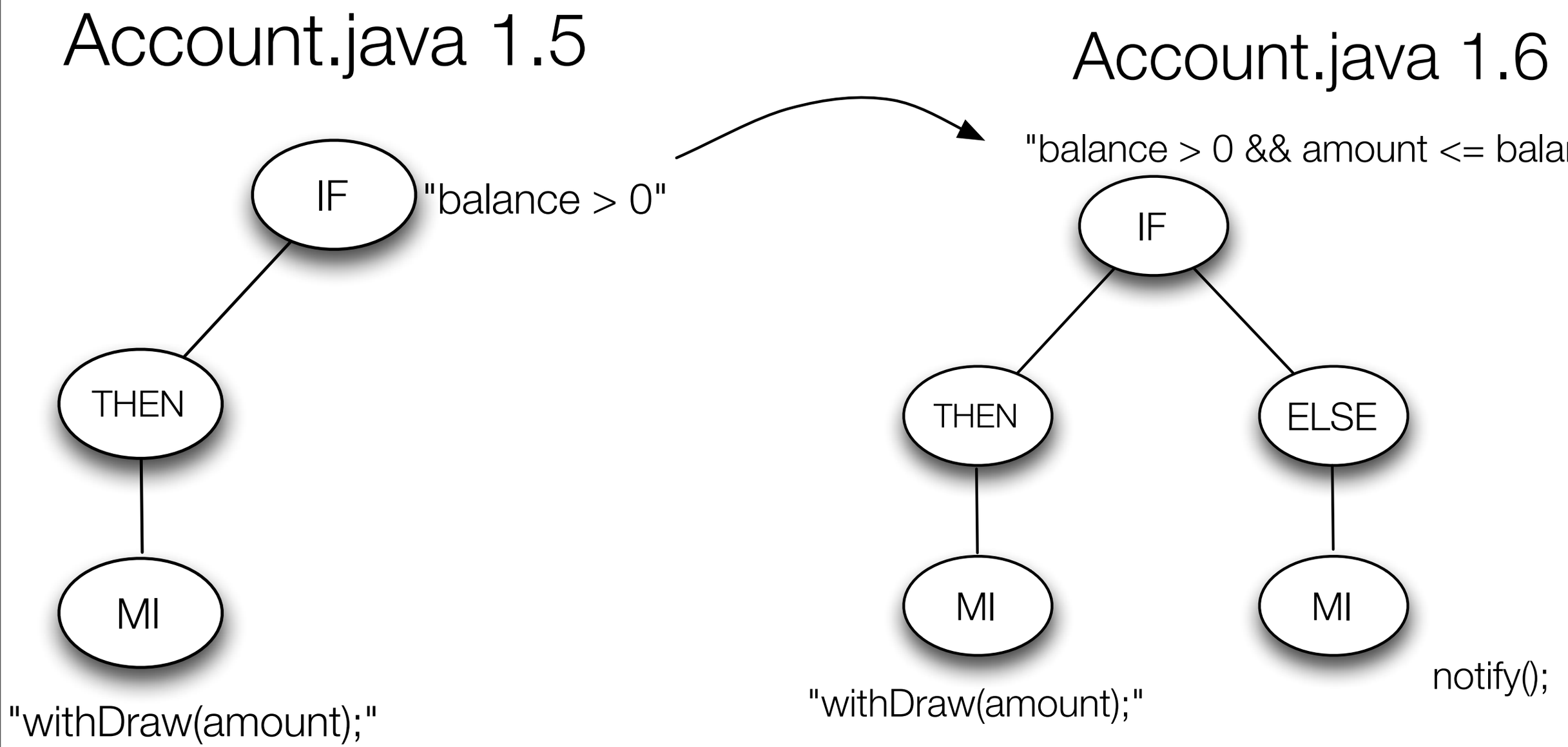
Fine-grained Changes

Account.java 1.5



"withDraw(amount);"

Fine-grained Changes



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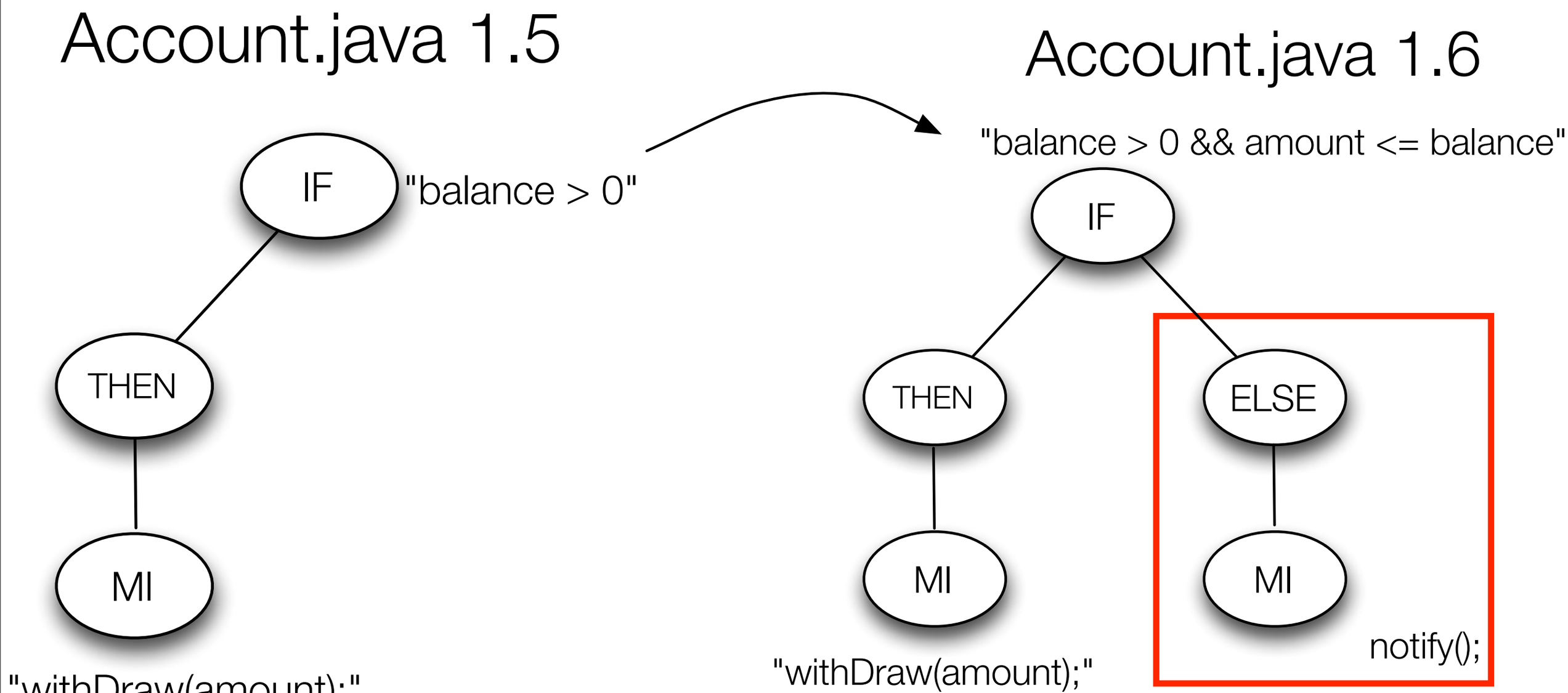

1x condition change, 1x else-part insert, 1x invocation statement insert

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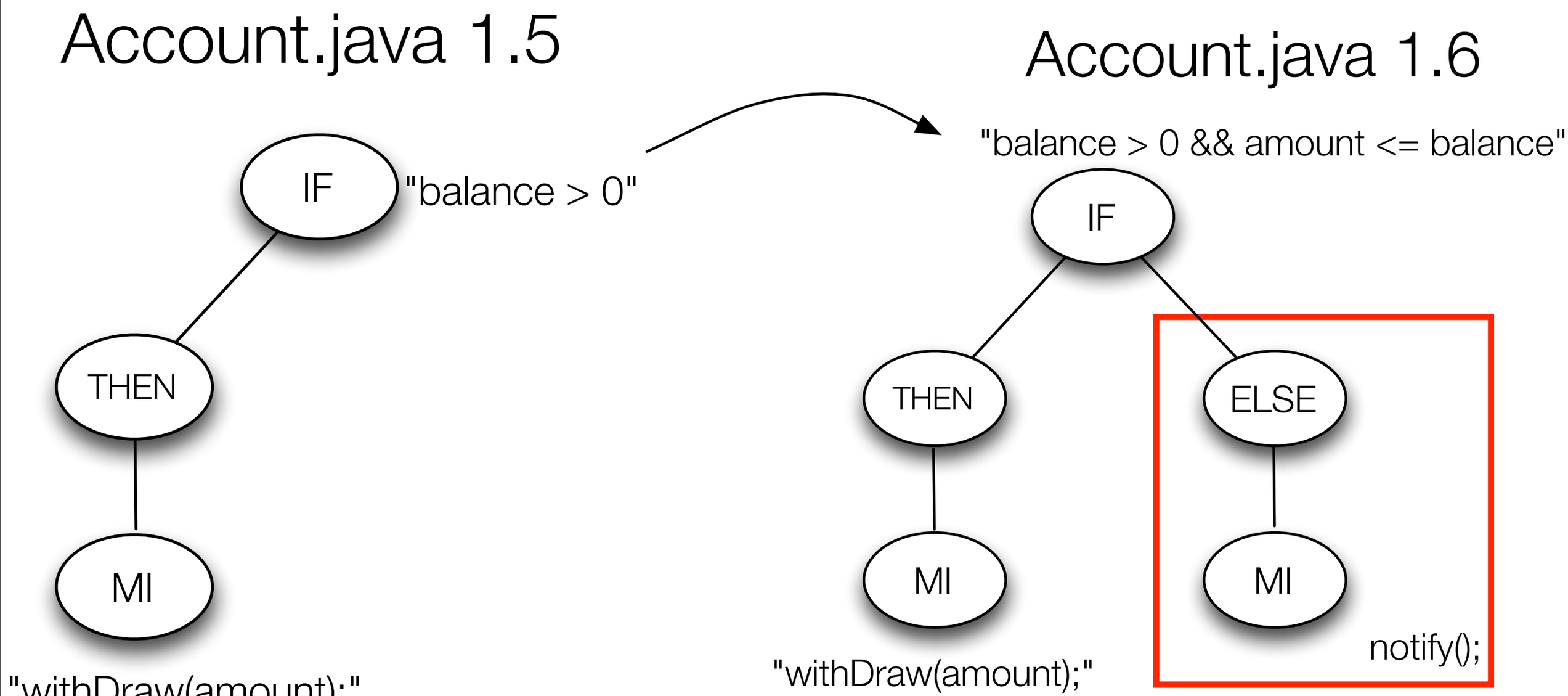

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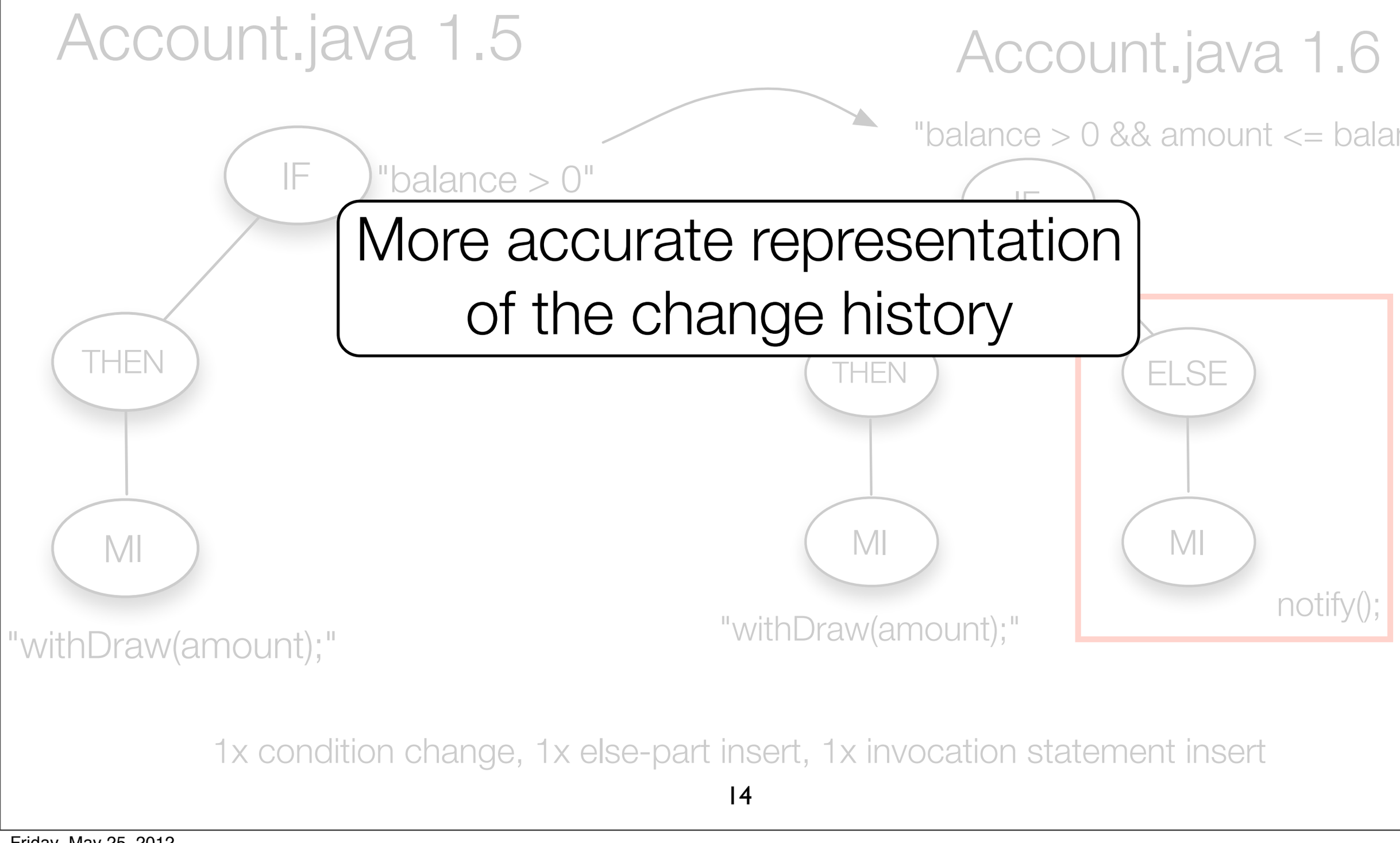
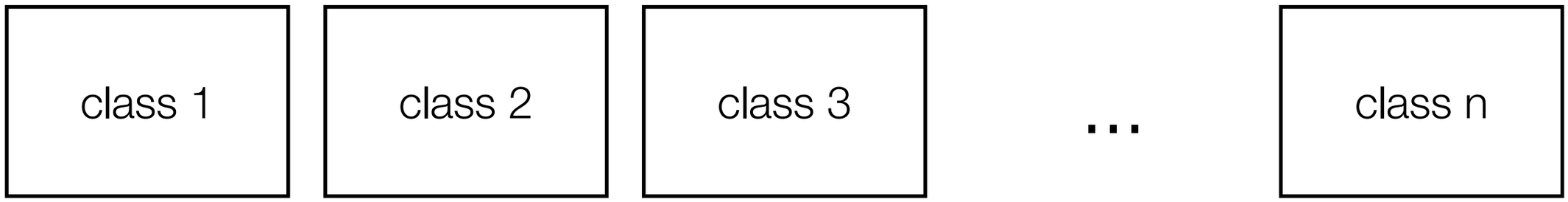


Method-Level Bug Prediction



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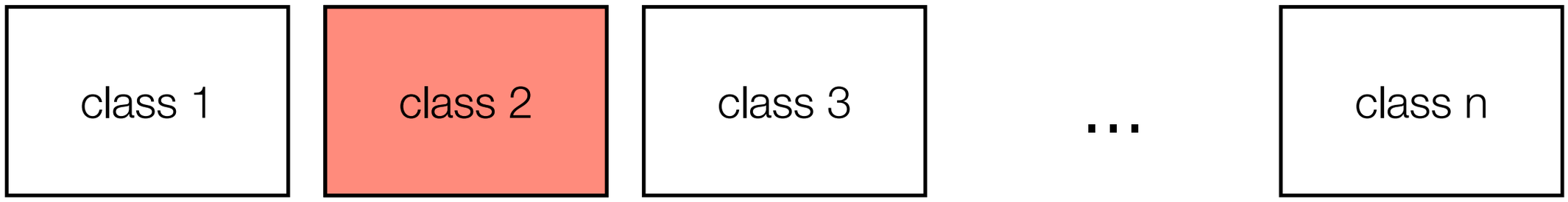

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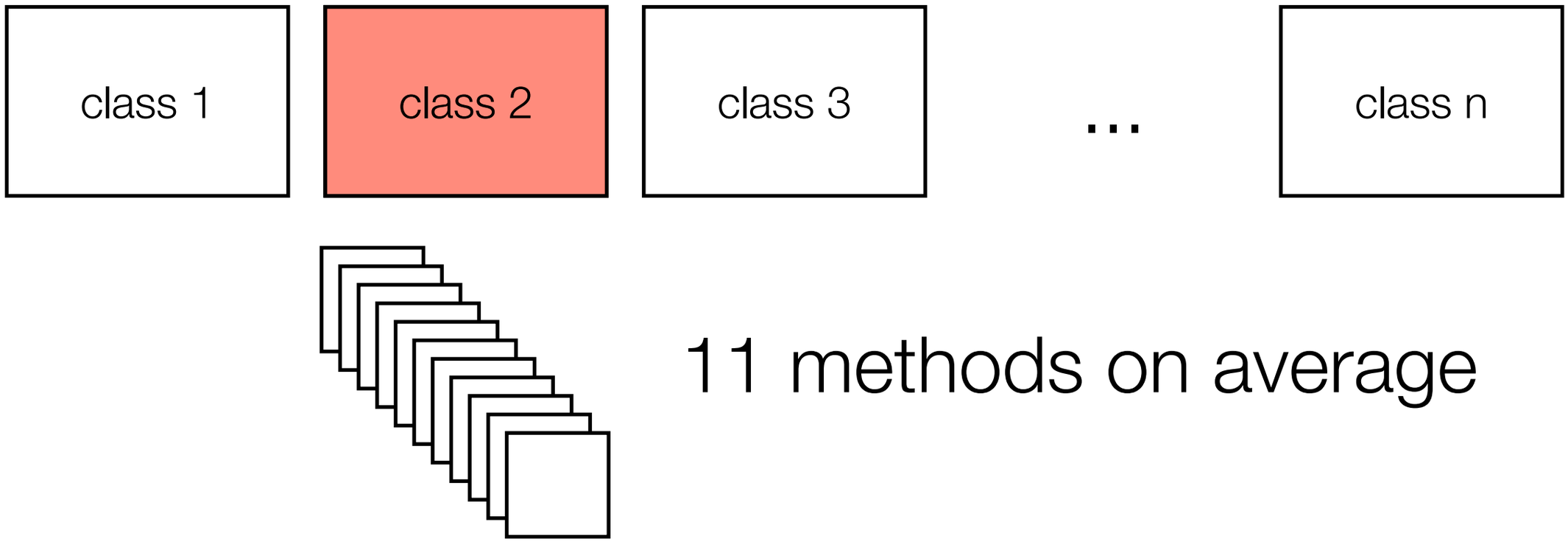
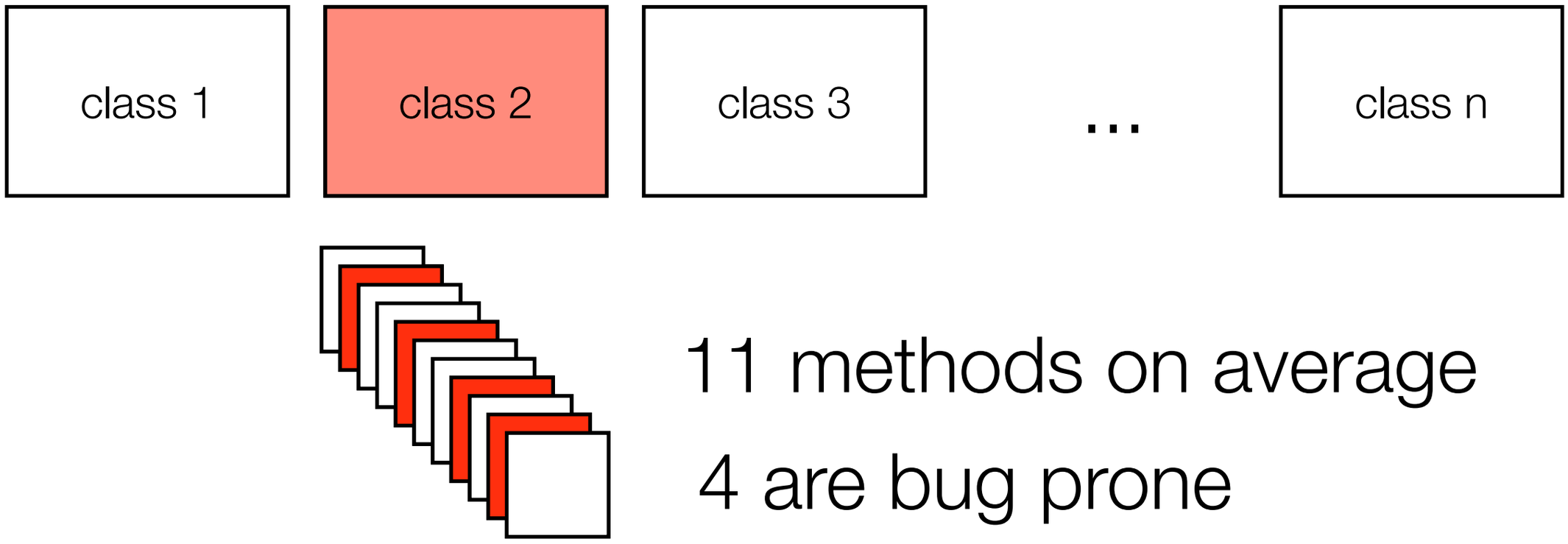


11 methods on average

Method-Level Bug Prediction



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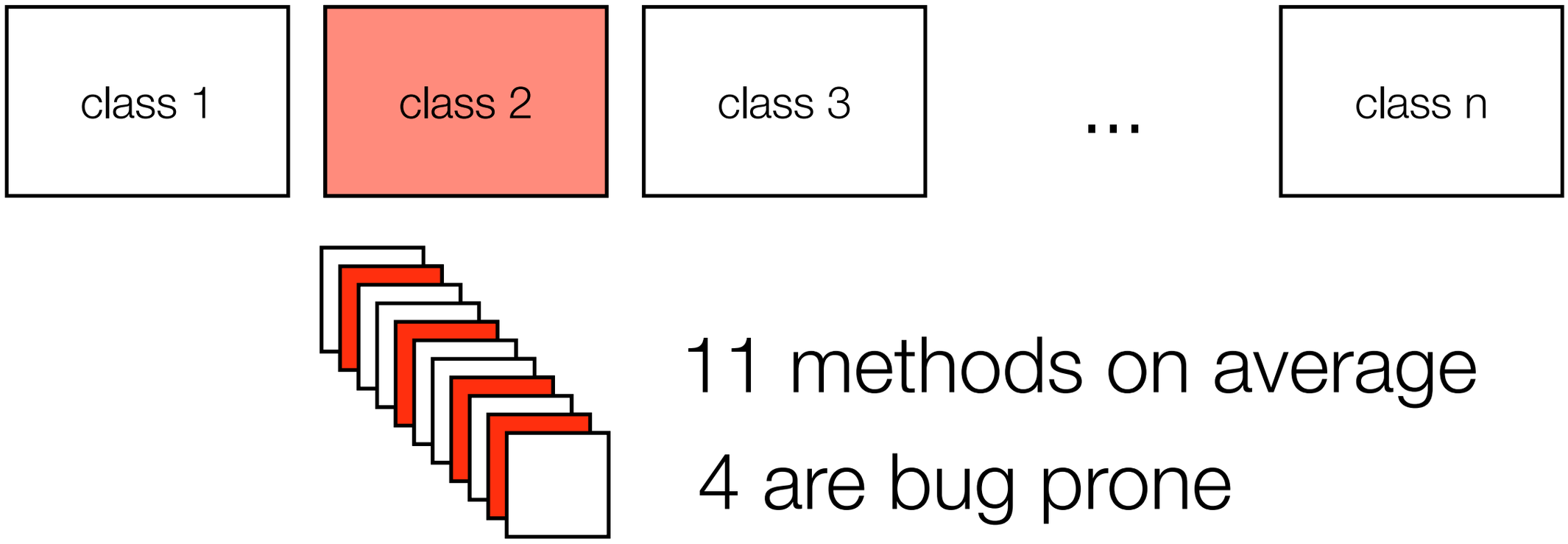

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Retrieving bug-prone methods saves manual inspection steps and improves testing effort allocation

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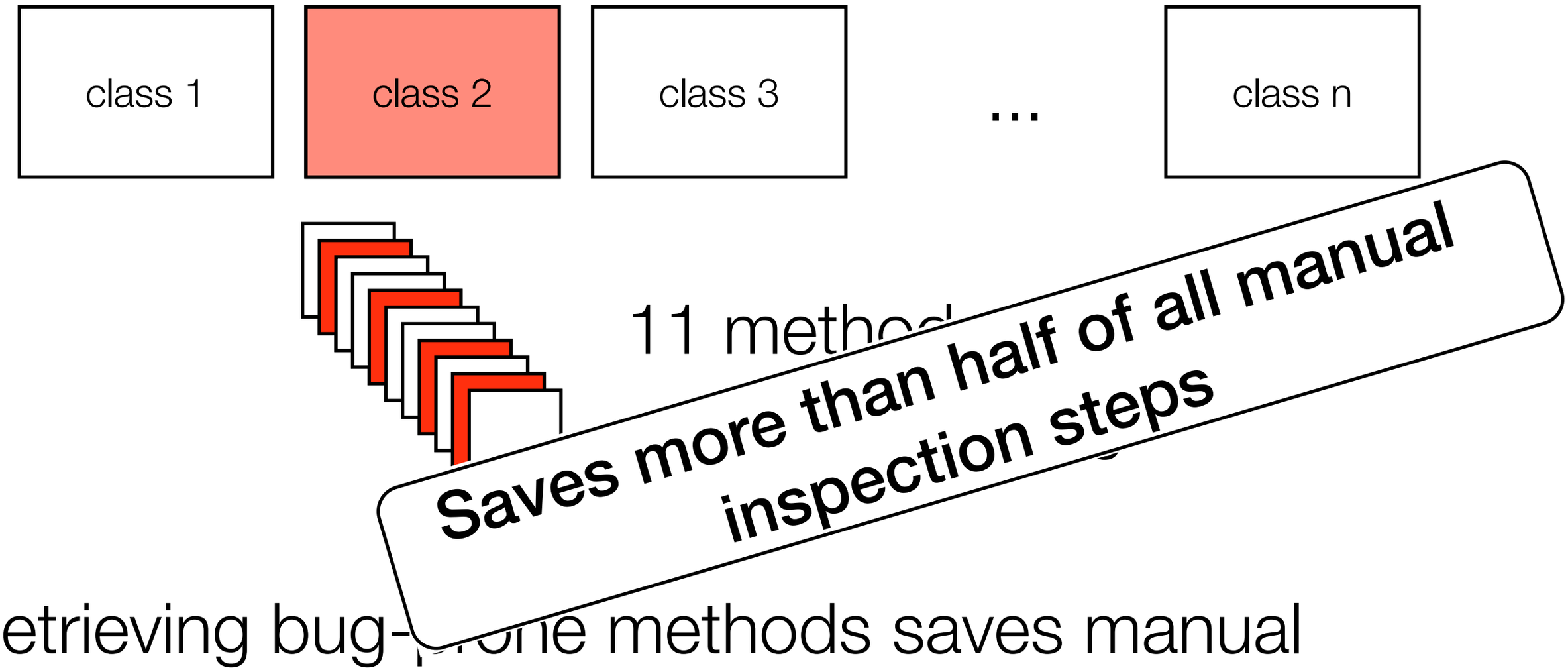

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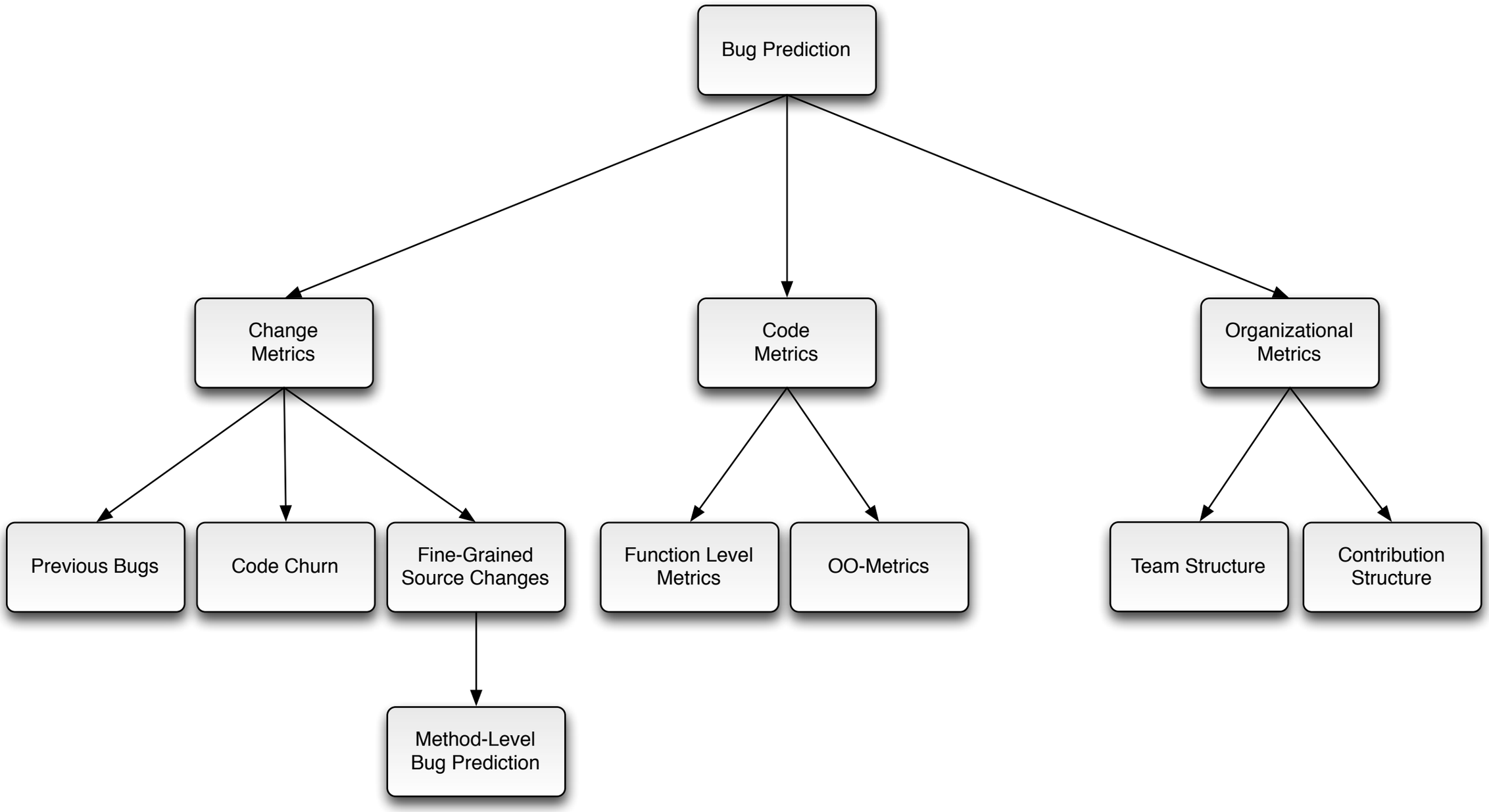
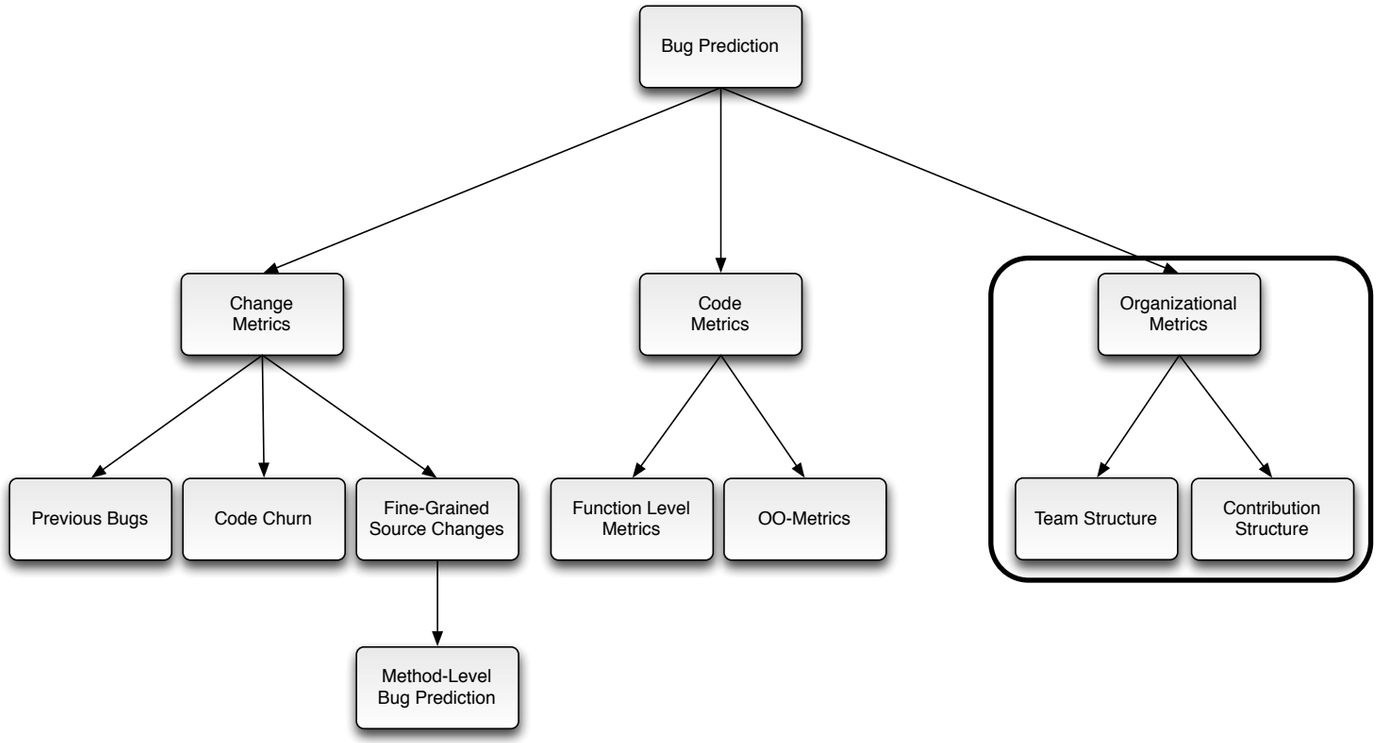
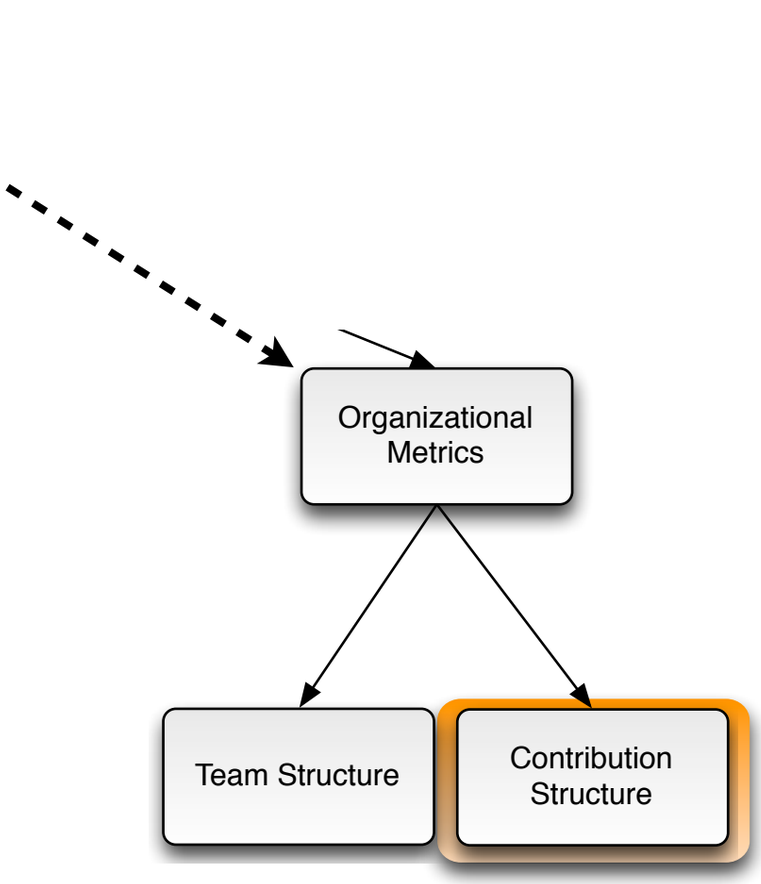
Bug Prediction Models



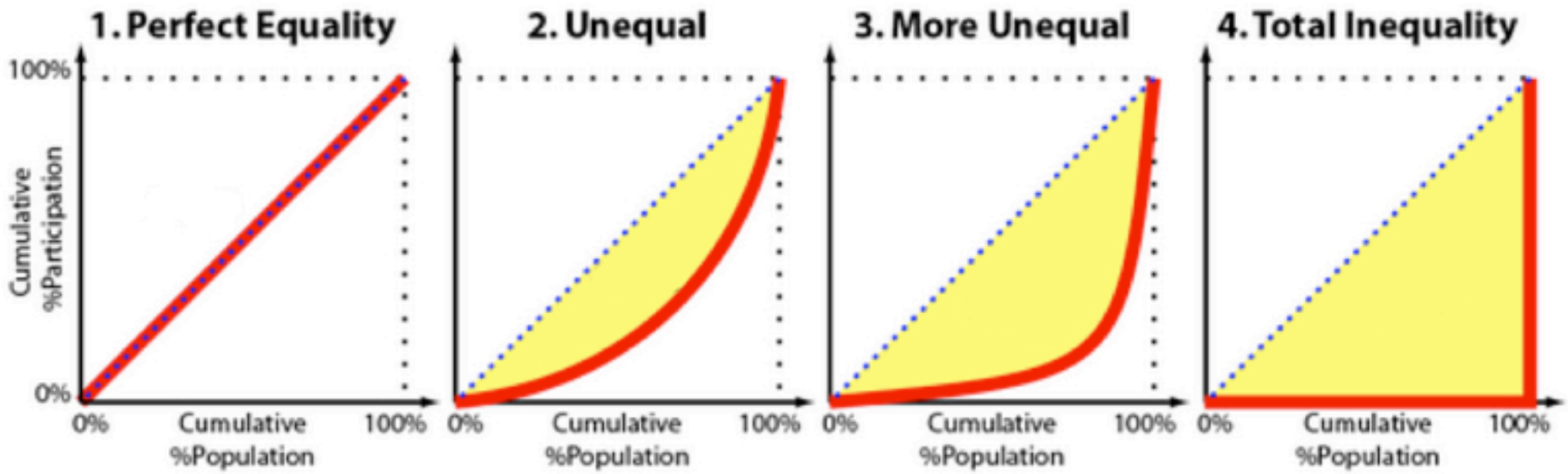
Bug Prediction Models



Using the Gini Coefficient for Bug Prediction

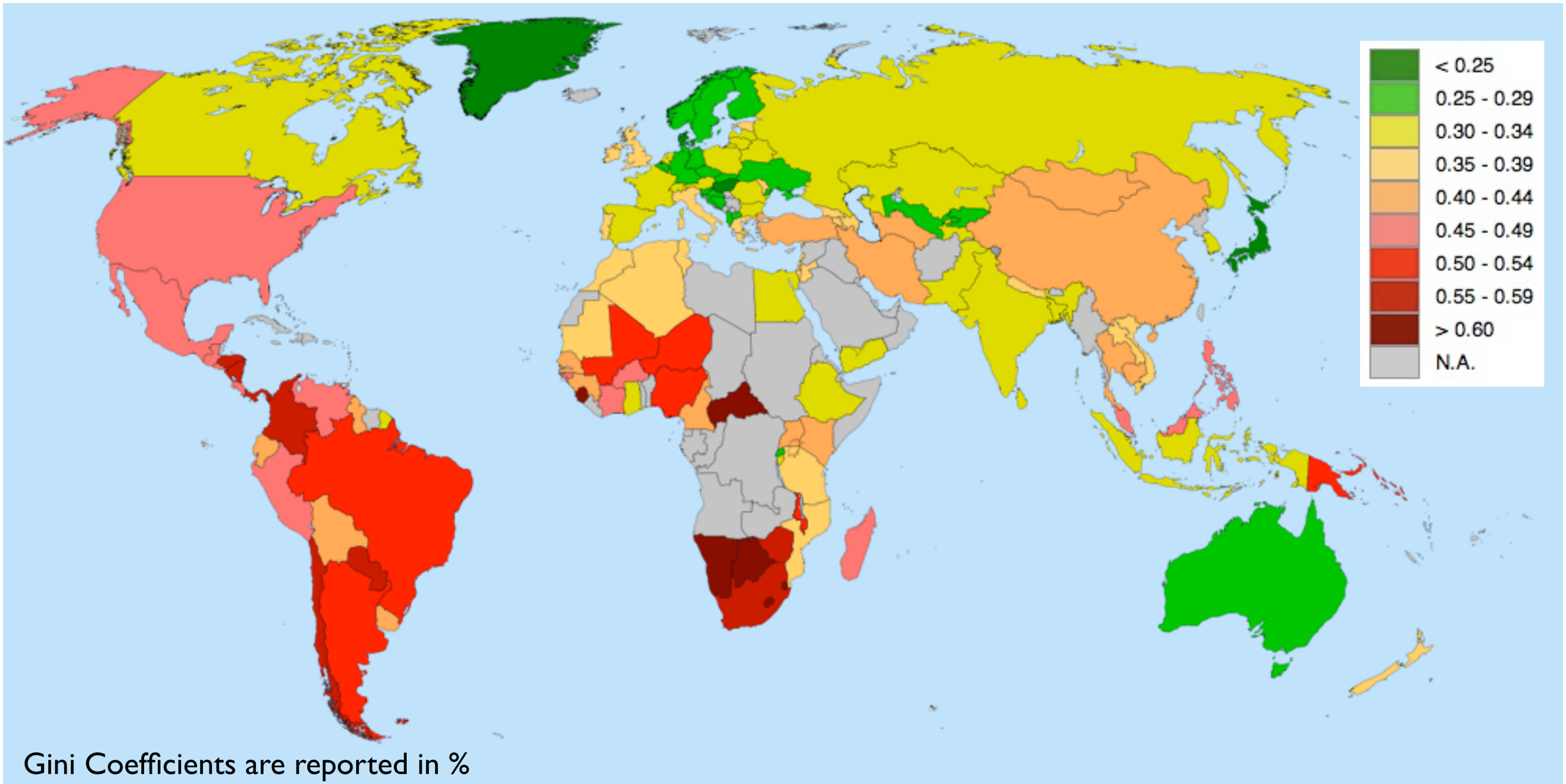


Gini Coefficient



- The Lorenz curve plots the cumulative % of the total participation against the cumulative % of the population
- Gini Coefficient summarizes the curve in a number

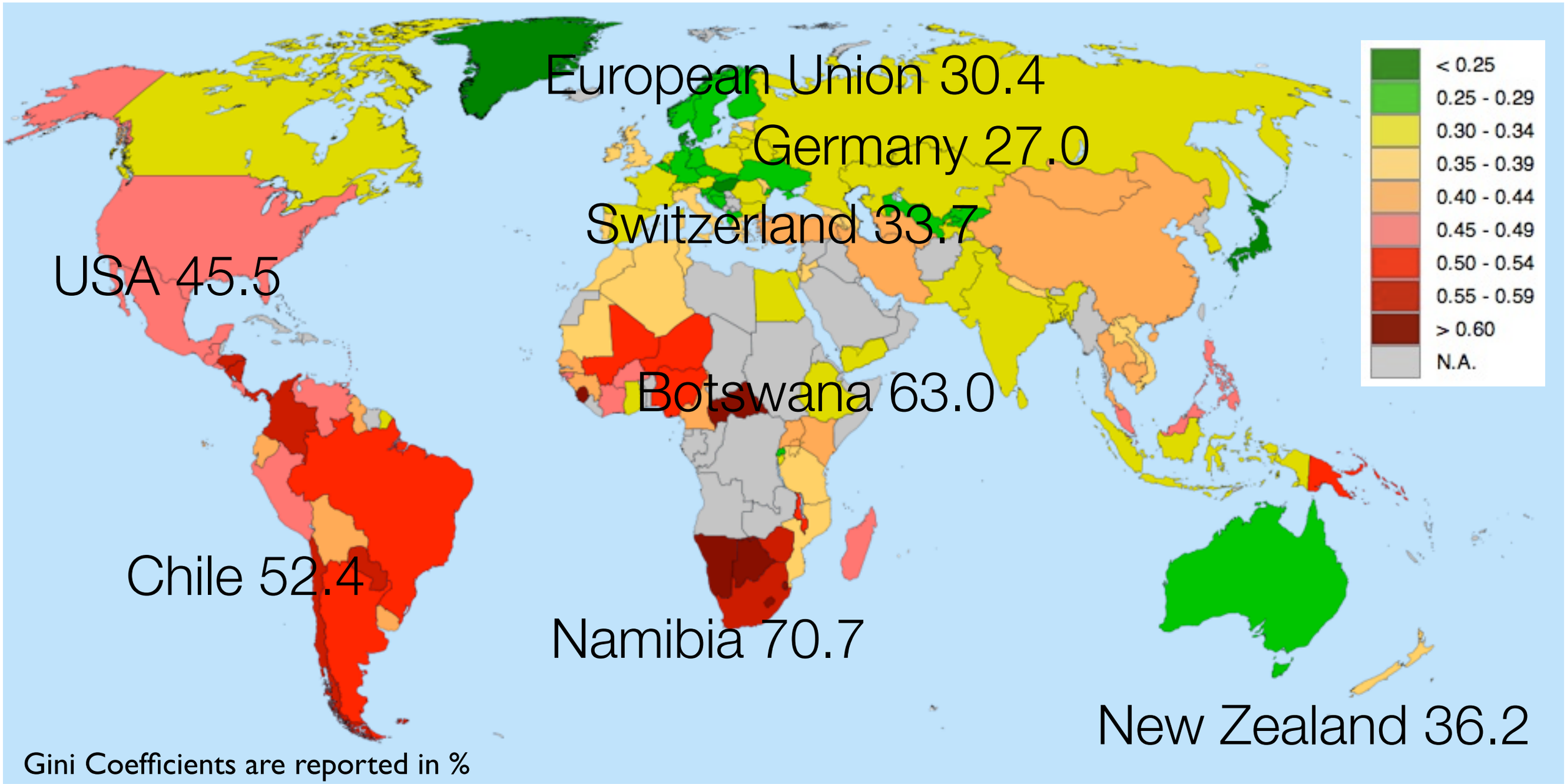
Income Distribution



Gini Coefficients are reported in %

[1]CIA - The World Factbook, **DISTRIBUTION OF FAMILY INCOME - GINI INDEX**, *https://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html*

Income Distribution



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What about Software?

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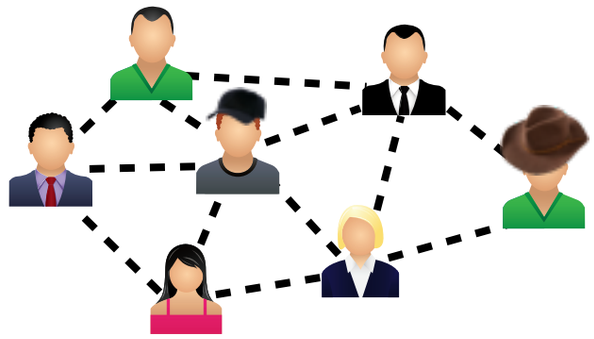

Developers = Population

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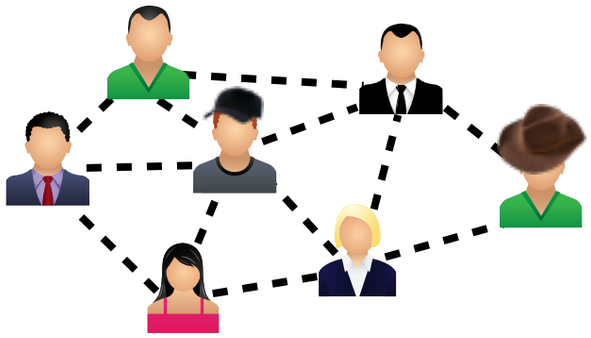

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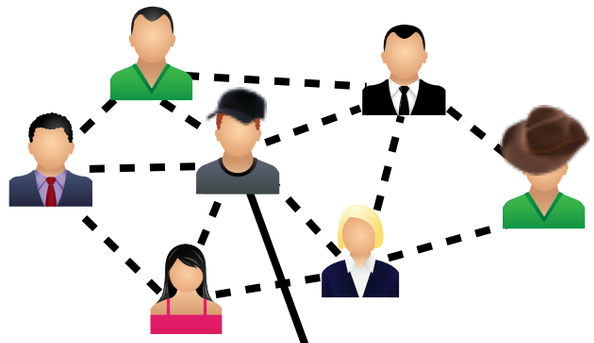

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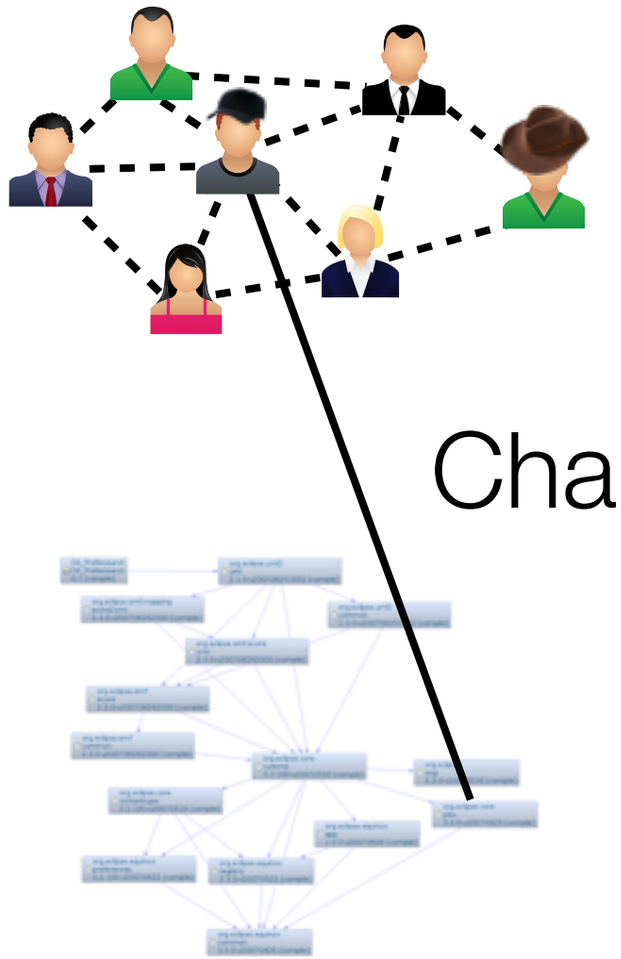

Developers = Population

Changing a file = “being owner”

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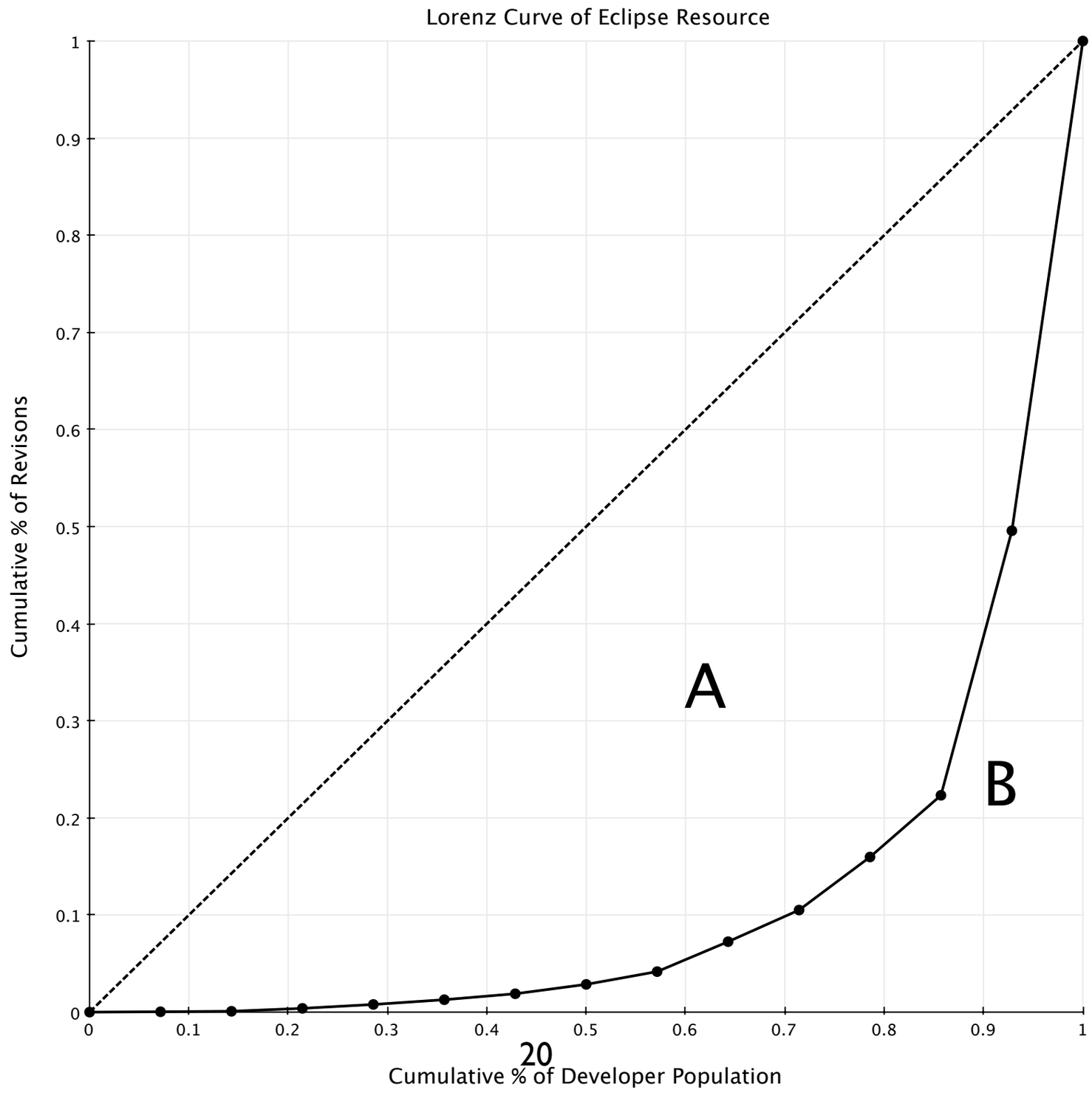
How are changes of a file distributed among the developers and how does this relate to bugs?

Eclipse Resource



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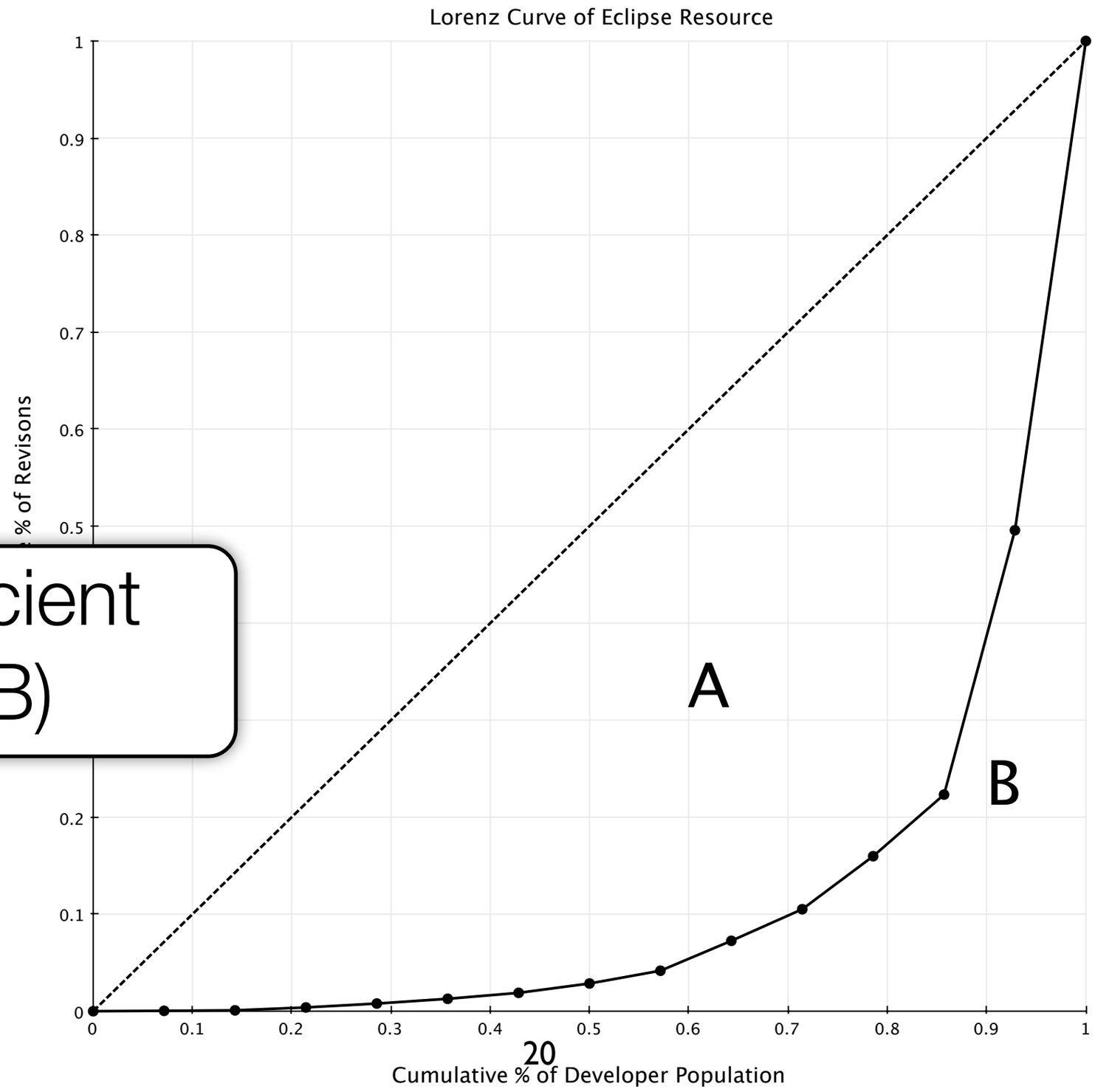

Gini Coefficient
= A / (A + B)

Study

- Eclipse Dataset
- Avg. Gini coefficient is 0.9
- Namibia has a coefficient of 0.7
- Negative Correlation of ~-0.55
- Can be used to identify bug-prone files

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The more changes of a file are done by a few dedicated developers the less likely it will be bug-prone!

Economic Phenomena

- Economic phenomena of code ownership
- Economies of Scale (Skaleneffekte)
- I’m an expert (in-depth knowledge)
- Profit from knowledge

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Costs to acquire knowledge can be split, e.g., among several releases if you stay with a certain component

Diseconomies of Scale

- Negative of effect of code ownership?
- Loss of direction and co-ordination
- Are we working for the same product?

Another Phenomena

- Economies of Scope (Verbundseffekte)
- Profiting from breadth-knowledge
- Knowledge of different components helps in co-ordinating
- Danger of bottlenecks!

Implications & Conclusions

- How much code ownership & expertise?
- What is your bus number?
- What is better? In-depth- or breadth-knowledge?
- What' is the optimal team size?