A template-based approach to automatic program repair of static bugs

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Agenda

- Problem statement
- Background
- The solution - Sonarqube-repair
- Results
- Contributions

Problem statement

Background - Identifying bugs

2 groups of approaches: Static and Dynamic

Static

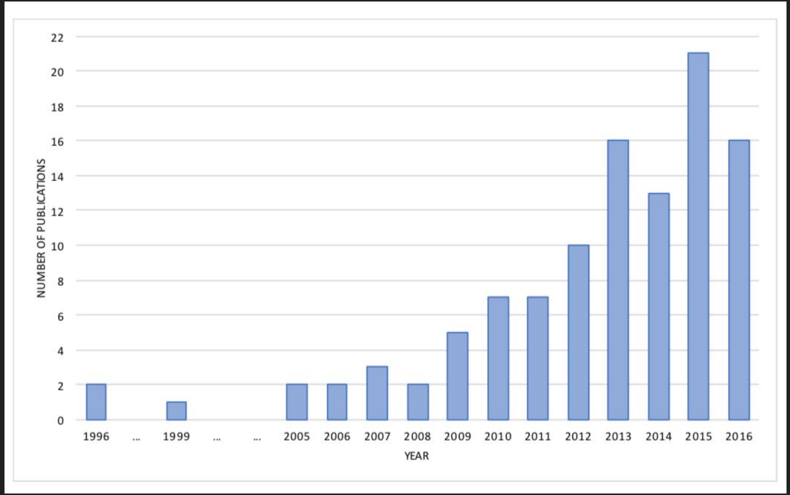
- Manual code-review
- Lint
- Sonarqube

Dynamic

- Test pipeline
- Whitebox-fuzzing
- Blackbox-fuzzing

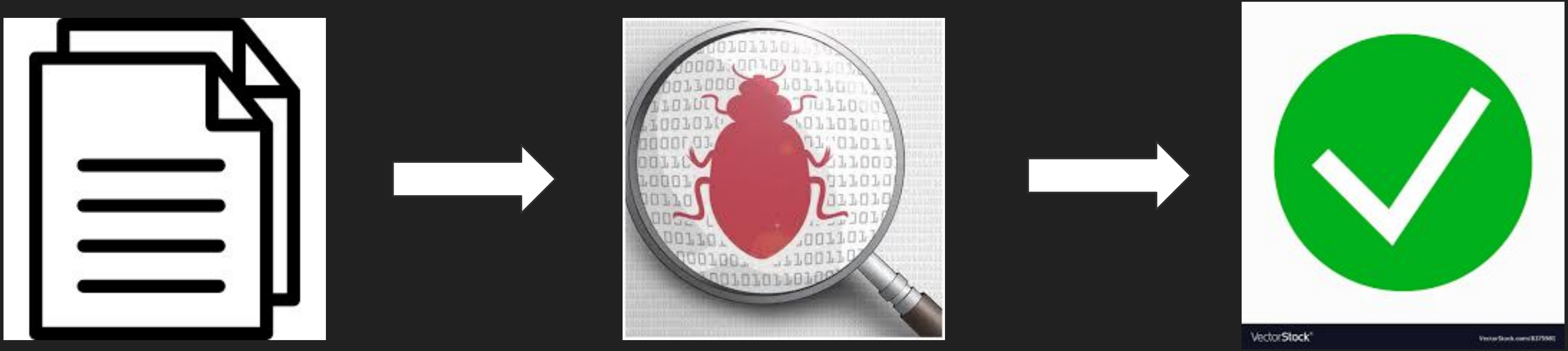
Background - Repairing bugs

- Mainly done by hand (manually)
- Machine learning
- Template-based



Publications on automatic software repair [1]

Sonarqube-repair

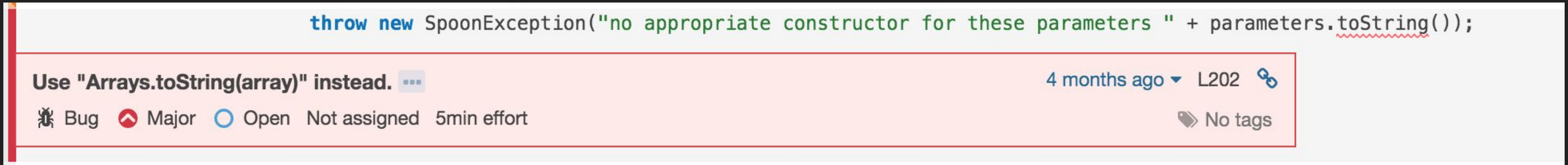


Create repair-templates
of some recurring bugs

Apply them to
buggy code

Submit fixed code

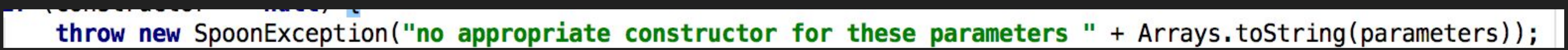
Sonarqube-repair



```
throw new SpoonException("no appropriate constructor for these parameters " + parameters.toString());
```

Use "Arrays.toString(array)" instead. ···

Bug · Major · ○ Open · Not assigned · 5min effort



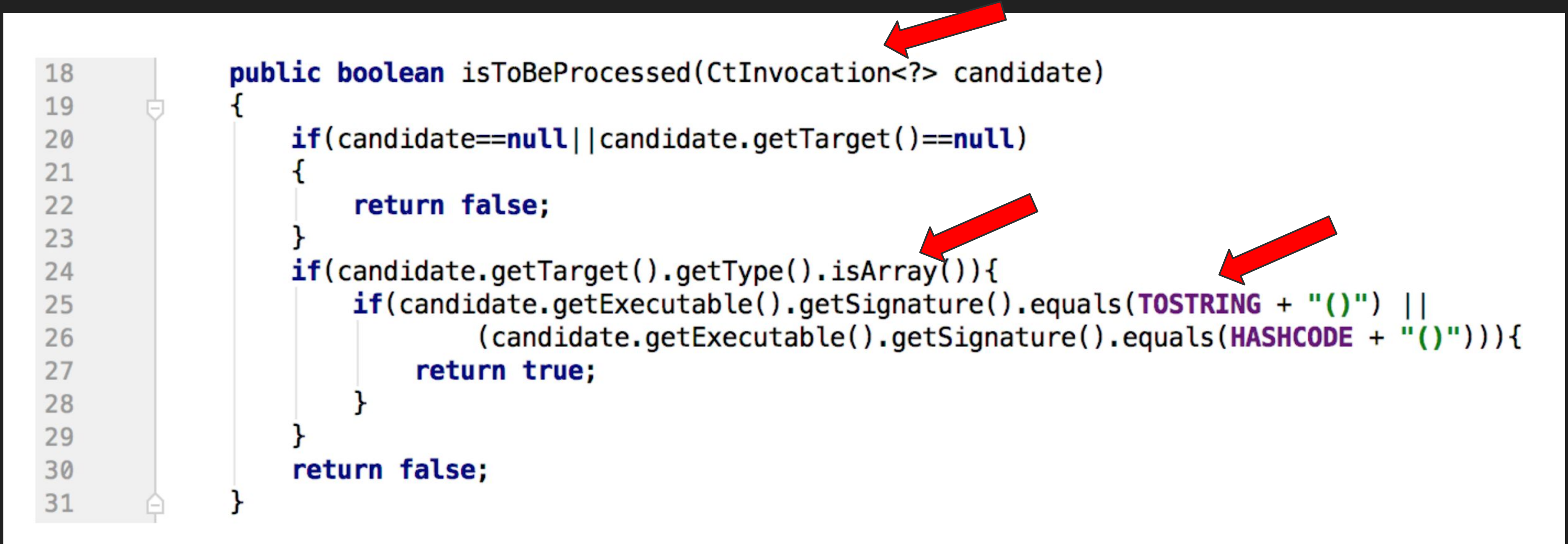
```
throw new SpoonException("no appropriate constructor for these parameters " + Arrays.toString(parameters));
```

Spoon

Code analysis
Code transformation

Spoon Specifics

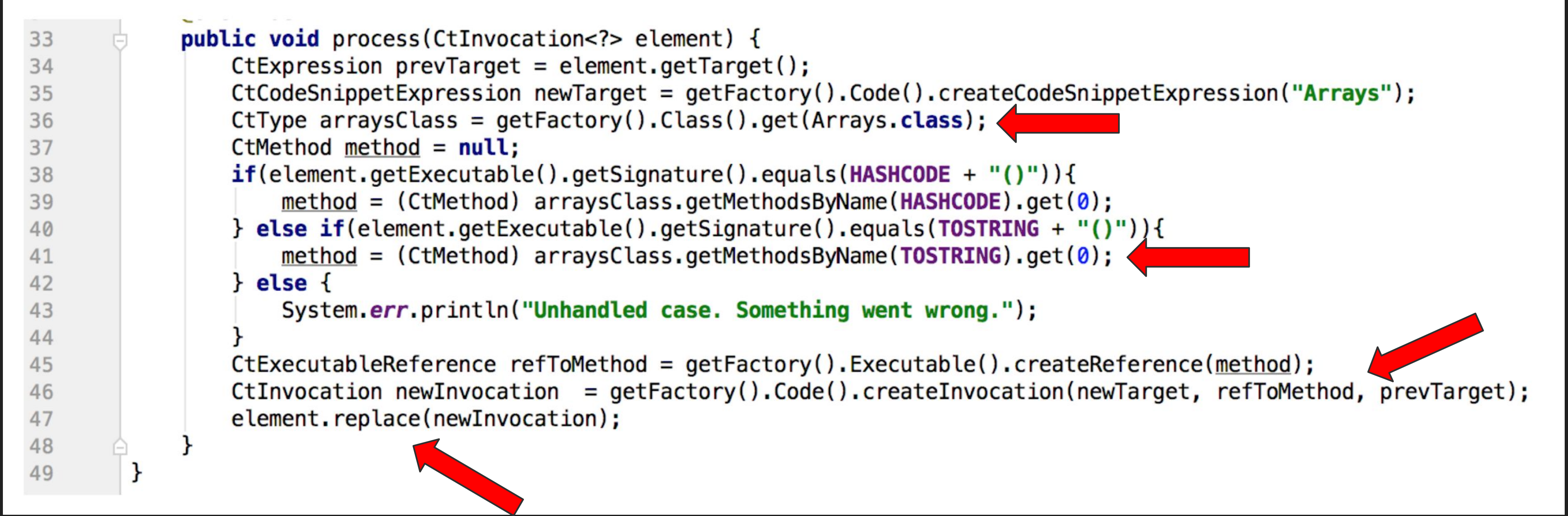
Filter



```
public boolean isToBeProcessed(CtInvocation<?> candidate)
{
    if(candidate==null||candidate.getTarget()==null)
    {
        return false;
    }
    if(candidate.getTarget().getType().isArray()){
        if(candidate.getExecutable().getSignature().equals(TOSTRING + "()") ||
                (candidate.getExecutable().getSignature().equals(HASHCODE + "()"))){
            return true;
        }
    }
    return false;
}
```

Spoon Specifics

Action



```java
    public void process(CtInvocation<?> element) {
        CtExpression prevTarget = element.getTarget();
        CtCodeSnippetExpression newTarget = getFactory().Code().createCodeSnippetExpression("Arrays");
        CtType arraysClass = getFactory().Class().get(Arrays.class);
        CtMethod method = null;
        if(element.getExecutable().getSignature().equals(HASHCODE + "()")){
            method = (CtMethod) arraysClass.getMethodsByName(HASHCODE).get(0);
        } else if(element.getExecutable().getSignature().equals(TOSTRING + "()")){
            method = (CtMethod) arraysClass.getMethodsByName(TOSTRING).get(0);
        } else {
            System.err.println("Unhandled case. Something went wrong.");
        }
        CtExecutableReference refToMethod = getFactory().Executable().createReference(method);
        CtInvocation newInvocation  = getFactory().Code().createInvocation(newTarget, refToMethod, prevTarget);
        element.replace(newInvocation);
    }
}
```

Evaluation

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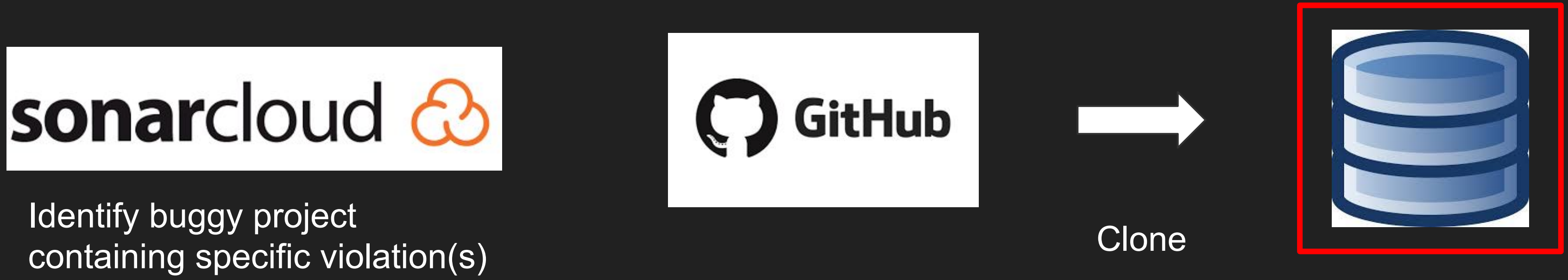
Spoon Powered

The Process

Creating pull-requests

Identify Repair Verify Push

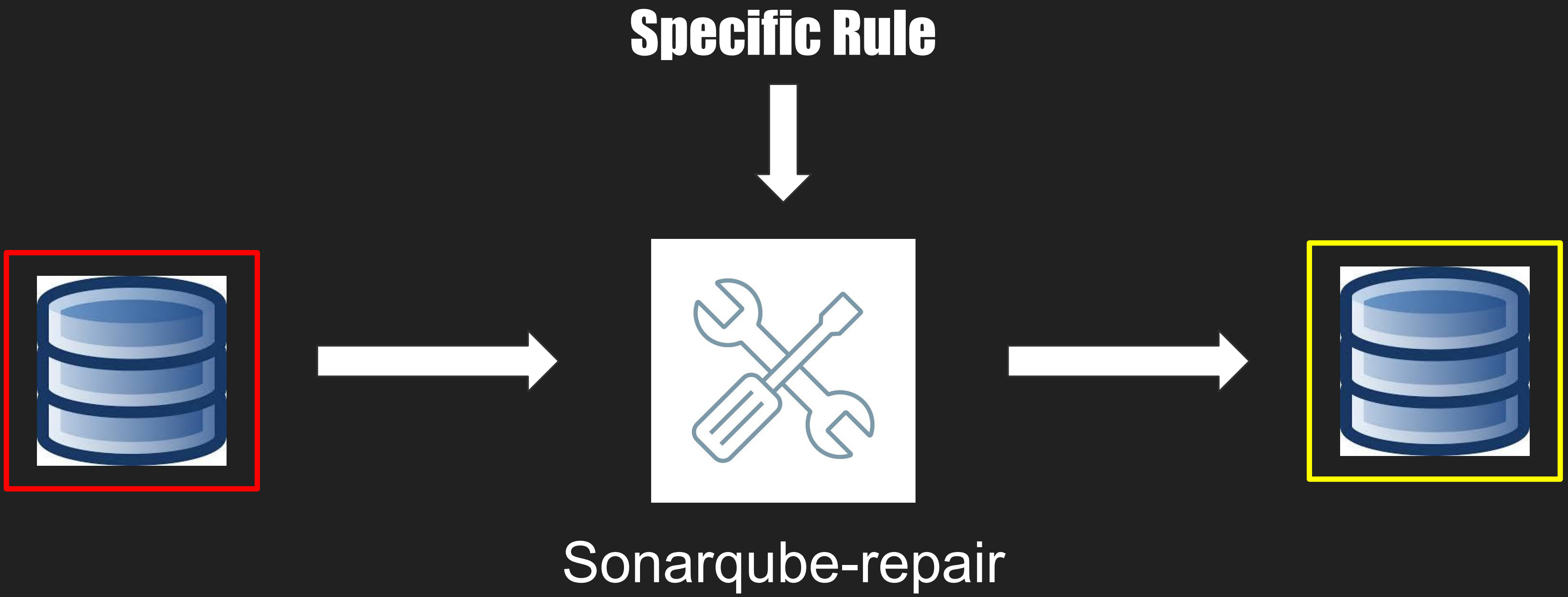
Identify



Identify buggy project containing specific violation(s)

Clone

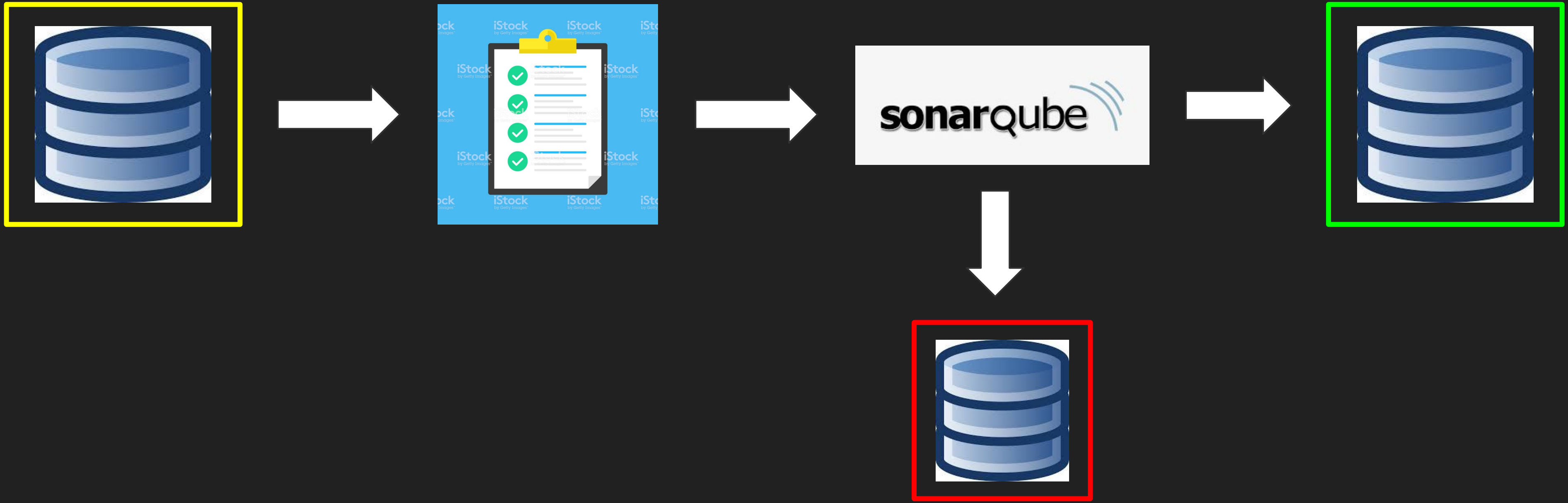
Repair



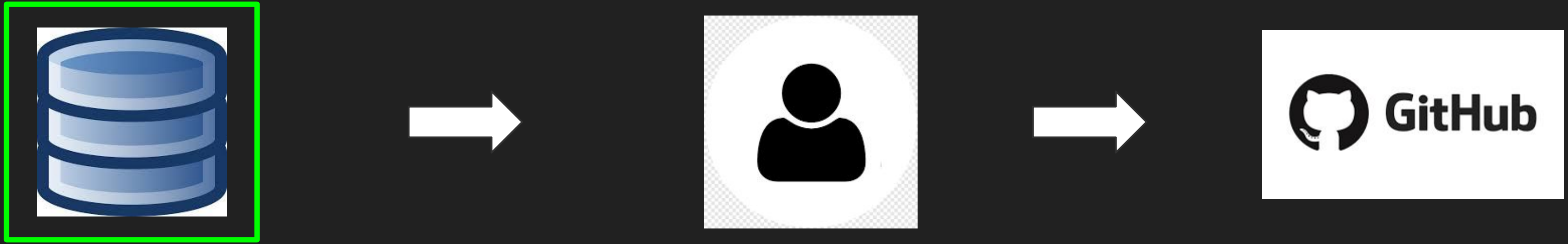
Specific Rule

Sonarqube-repair

Verify

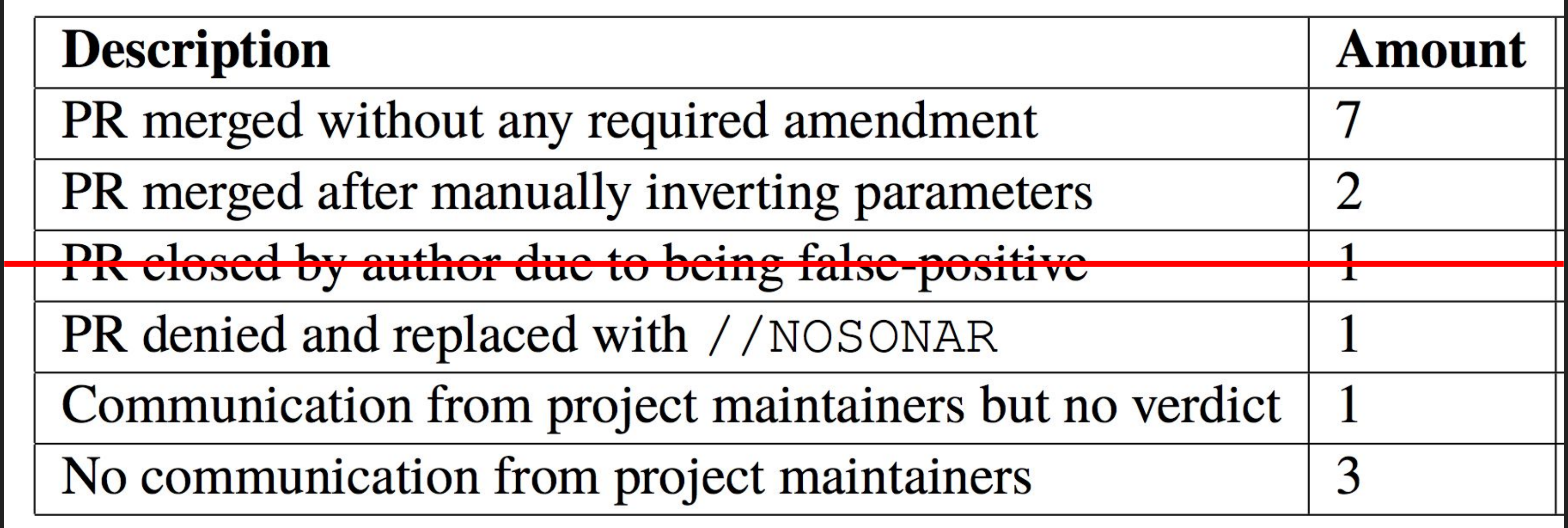


Push



Sanity check

Main Results



Description	Amount
PR merged without any required amendment	7
PR merged after manually inverting parameters	2
~~PR closed by author due to being false-positive~~	~~1~~
PR denied and replaced with `//NOSONAR`	1
Communication from project maintainers but no verdict	1
No communication from project maintainers	3

Total PRs: 14

Merged: 9/14 (64%)

No verdict: 4 (29%)

Accepted/Verdict: 9/10 (90%)

Projects: 6

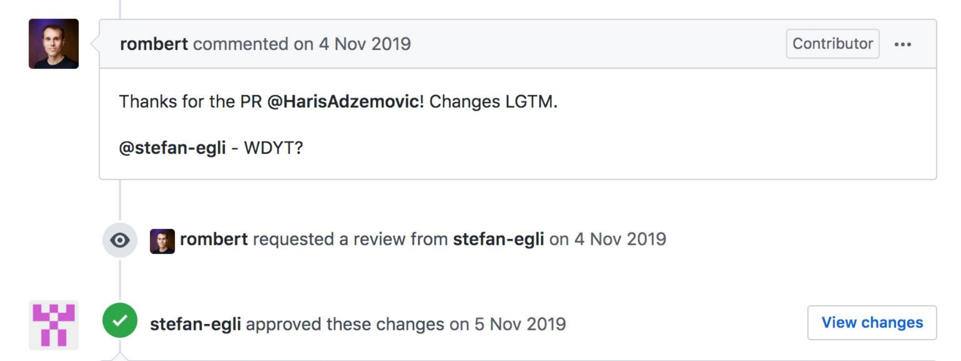
All rules have at least one merged PR

Compared to state-of-the-art

- SpongeBugs
- Code smells
- Rascal

Contributions

- Repaired bugs in widely-used programs
- Investigated characteristics
rules fit for the template-ba
approach



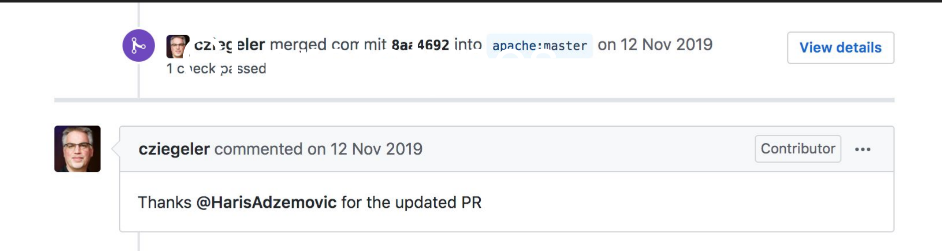
rombert commented on 4 Nov 2019 Contributor ···

Thanks for the PR **@HarisAdzemovic**! Changes LGTM.

@stefan-egli - WDYT?

rombert requested a review from **stefan-egli** on 4 Nov 2019

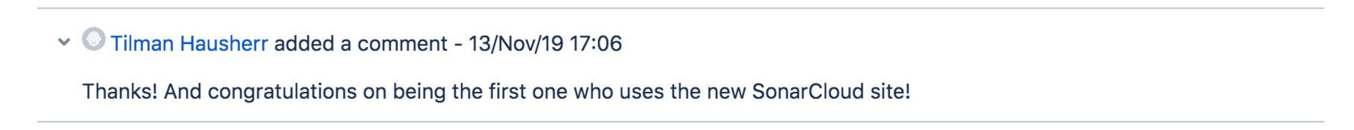
stefan-egli approved these changes on 5 Nov 2019



cziegeler merged commit **8aa4692** into `apache:master` on 12 Nov 2019
1 check passed

cziegeler commented on 12 Nov 2019 Contributor ···

Thanks **@HarisAdzemovic** for the updated PR



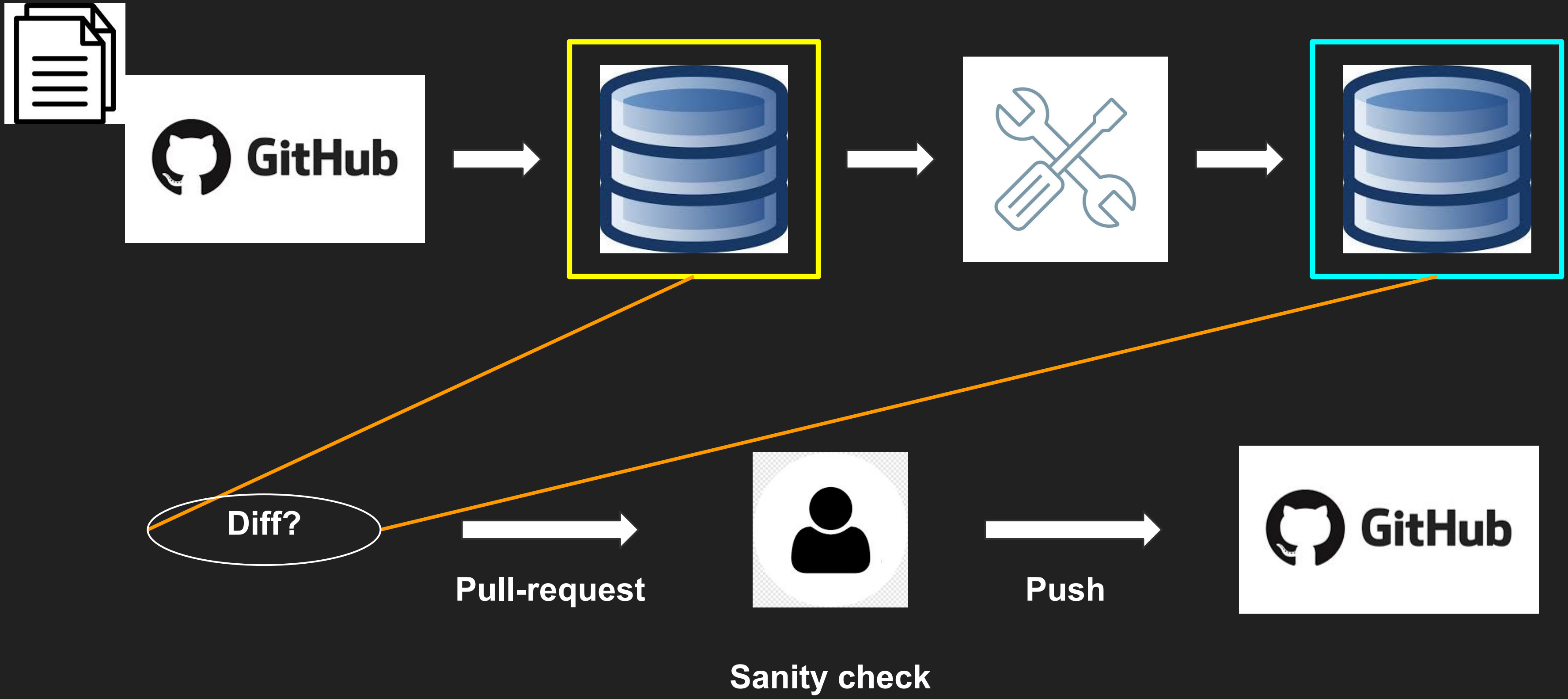
Tilman Hausherr added a comment - 13/Nov/19 17:06

Thanks! And congratulations on being the first one who uses the new SonarCloud site!

Thank you!

[1] L. Gazzola, D. Micucci and L. Mariani. ‘Automatic Software Repair: A Survey’. In: IEEE Transactions on Software Engineering 45.1 (Jan. 2019), pp. 34–67. doi: 10.1109/TSE.2017.2755013

CI method 1 flow-scheme



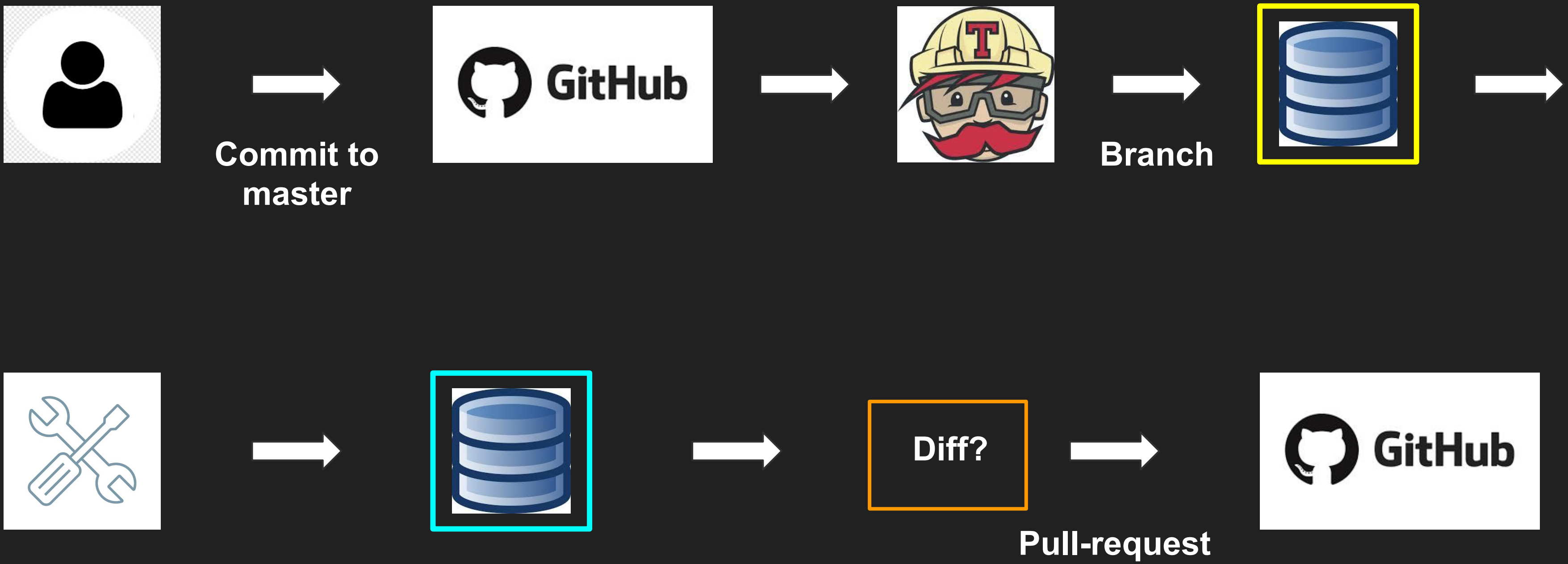
Diff?

Pull-request

Push

Sanity check

CI method 2 flow-scheme



Commit to master

Branch

Diff?

Pull-request