Lancaster University Leipzig

Examination of Performance Changes (at Code Level)

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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

15.4.2023

Why measure performance? [SSP19]

Which is faster?

```java
StringBuilder buf
  = new StringBuilder(16);
buf.append("Hello World");
return buf.toString();
```

```java
StringBuilder buf
  = new StringBuilder(16);
buf.append("Hello")
  .append(" ")
  .append("World");
return buf.toString();
```

Why measure performance? [SSP19]

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Why measure performance? [SSP19]

Which is faster?

```
StringBuilder bu
  = new StringBu
buf.append("Hell


return buf.toStr
```

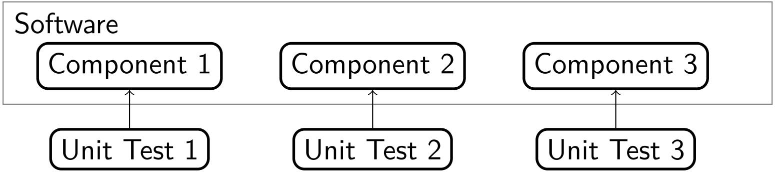
```
er buf
ingBuilder(16);
"Hello")
␣")
World");
toString();
```

Complex behaviour

⇒ impact of changes needs to be measured

Peass Method

Why Unit Test Measurement?



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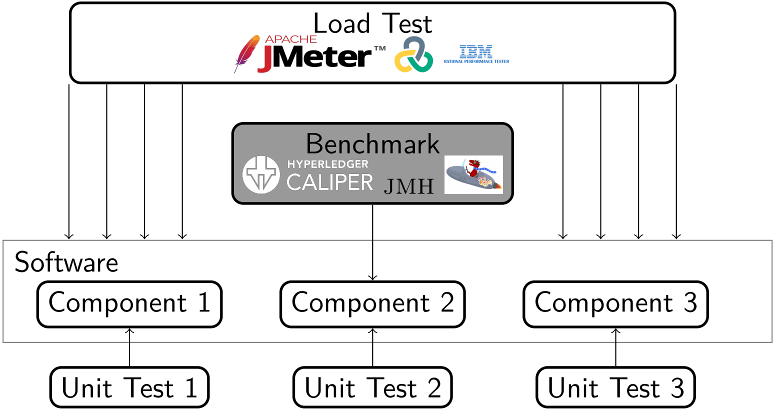

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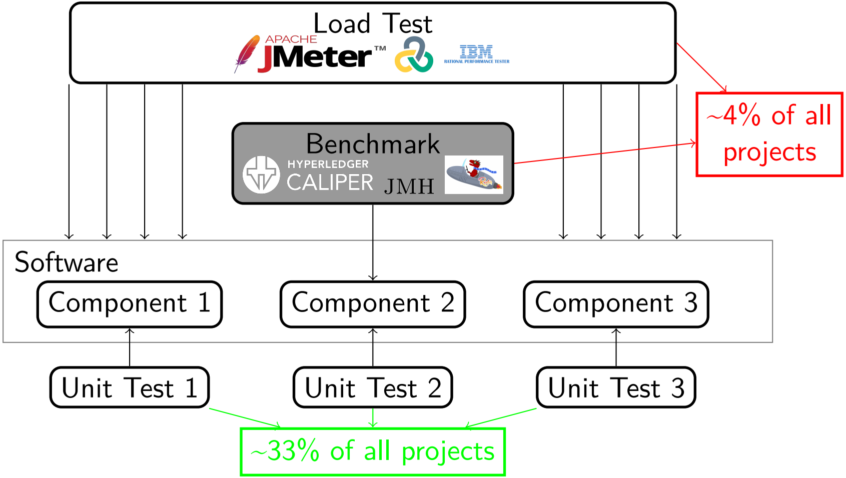

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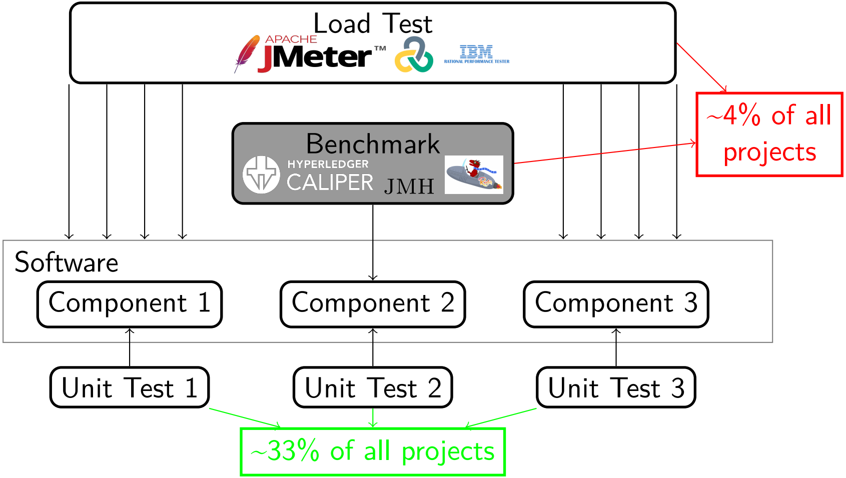
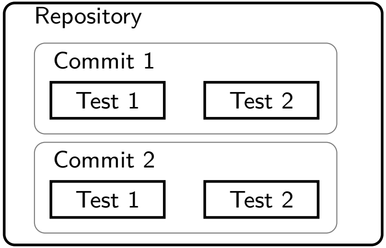


$\Rightarrow$ unit tests are transformed and used for measurement

Peass

- **P**erformance **a**nalysis of **s**oftware **s**ystems
- CLI-Tool: `https://github.com/DaGeRe/peass`
- Jenkins-Plugin: `https://github.com/jenkinsci/peass-ci-plugin`

Process of Peass



Process of Peass

Repository

Commit 1

Test 1 Test 2

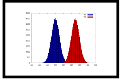
Commit 2

Test 1 Test 2

Measurement

Commit 2

Test 1 Test 2

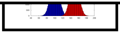


Process of Peass

Repository

Regression Test Selection

Test 1 | Test 2 | Test 3 | Test 4 | Test 5



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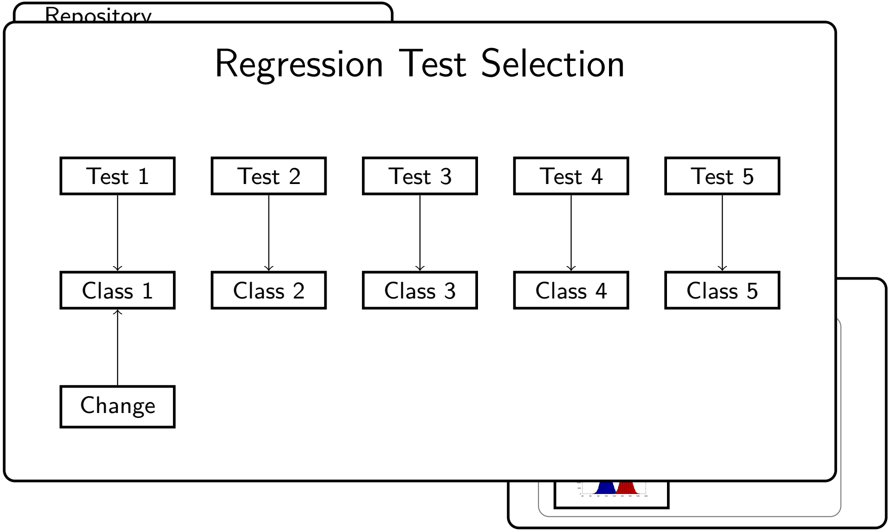

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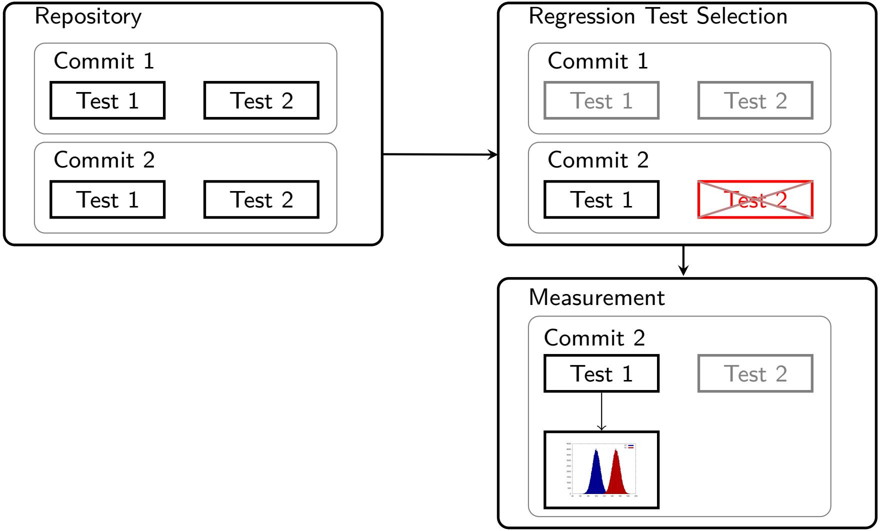

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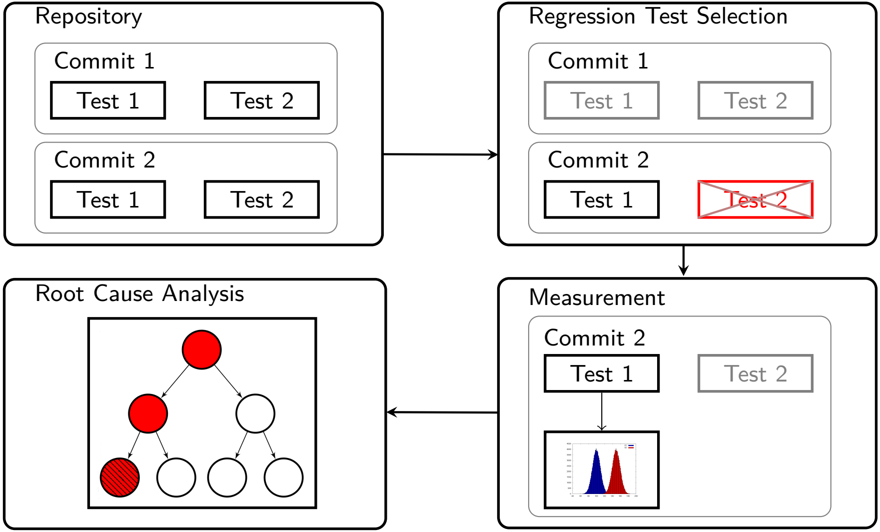

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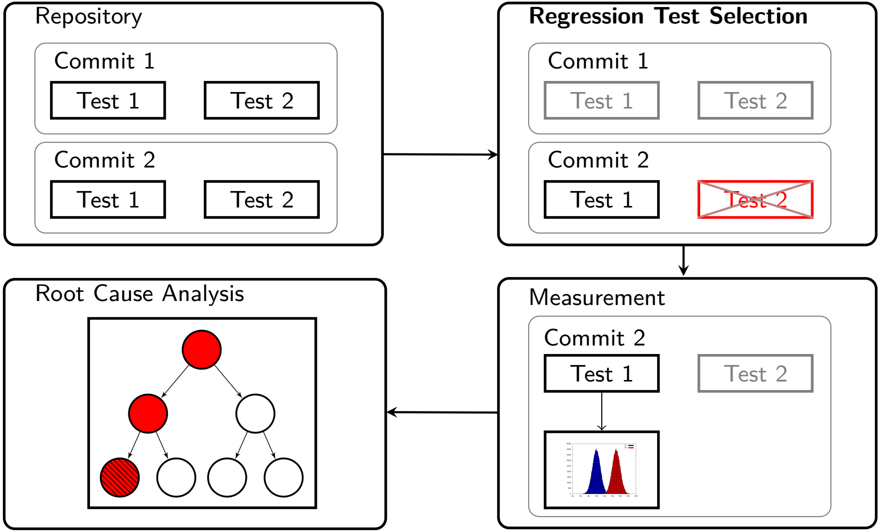


Regression Test Selection - Approach [LTB18]

TestA

void testA1()
void testA2()

TestB

void testB1()
void testB2()

Class α

void methodα1()
void methodα2()

Class β

void methodβ1()
void methodβ2()

Class γ

void methodγ1()
void methodγ2()

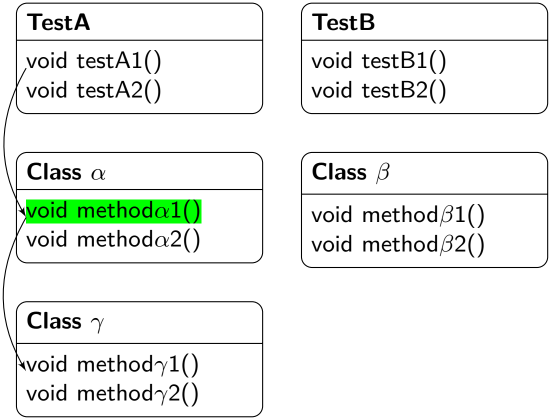
Trace:

TestA.testA1
Classα.methodα1
Classγ.methodγ1
Classα.methodα1
Classγ.methodγ1

Change:

...

Regression Test Selection - Approach [LTB18]



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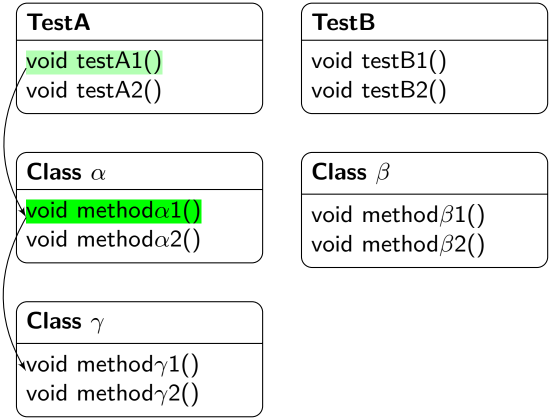

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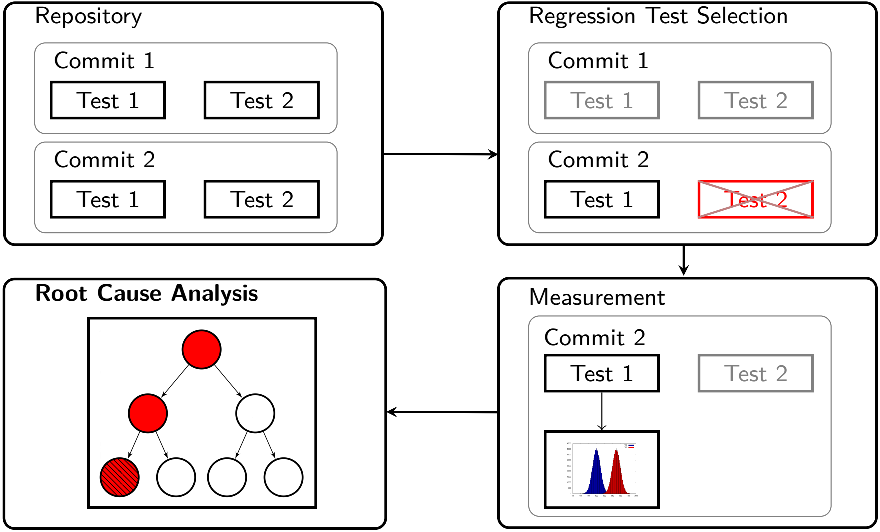
Classα.methodα1
Classγ.methodγ1
Classα.methodα1
Classγ.methodγ1

Change:

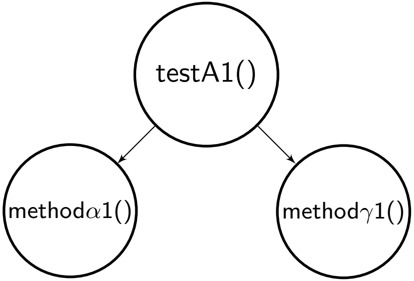
Classα.methodα2

Process of Peass



Root Cause Analysis

- Root cause analysis for performance changes (Heger et al., 2013)
  - Getting the call tree



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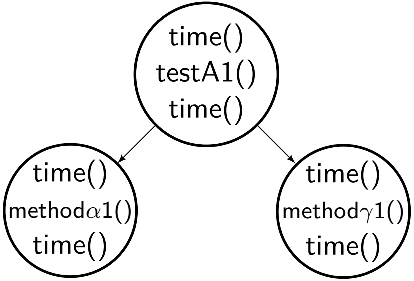

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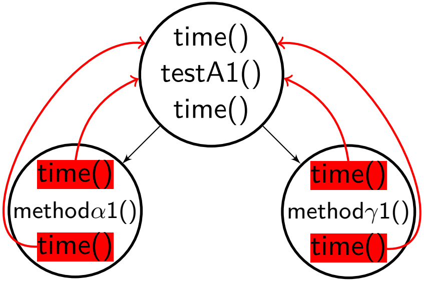

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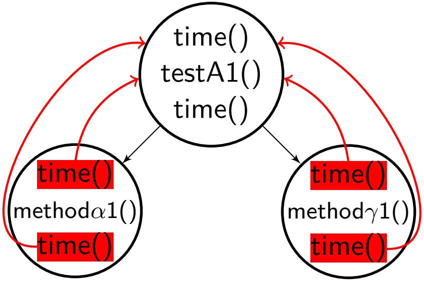

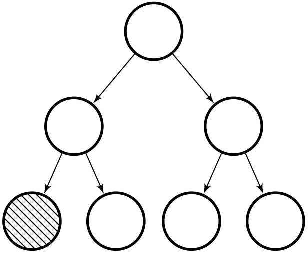

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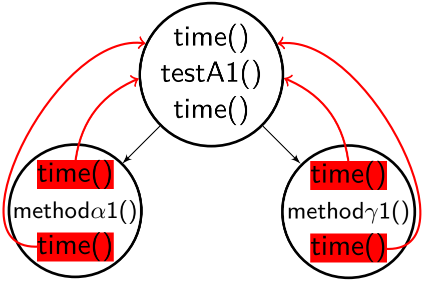

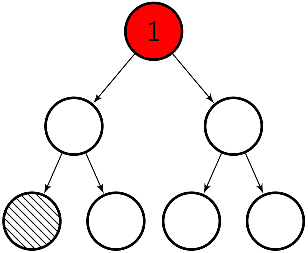

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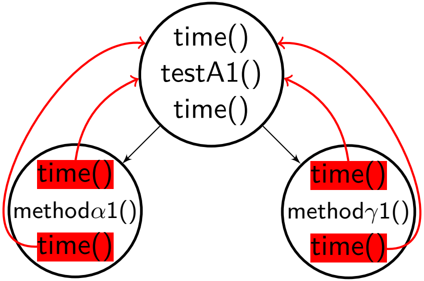

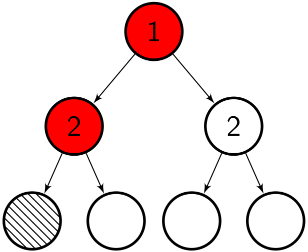

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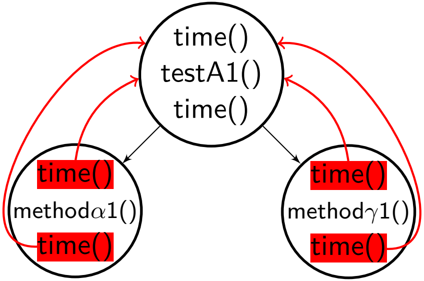

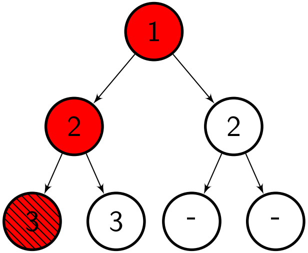

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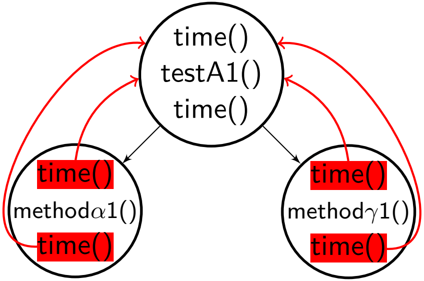

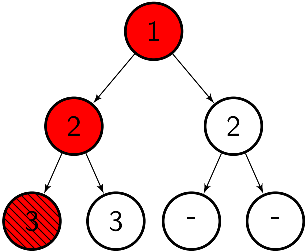

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    $\Rightarrow$ Low overhead necessary
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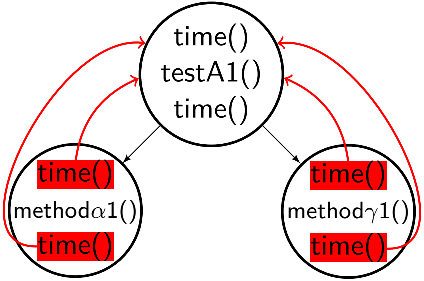

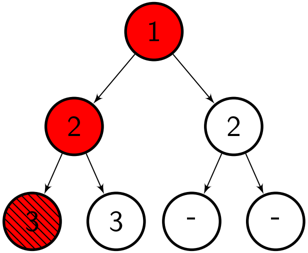

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Kieker Monitoring Process [WOSPC23]

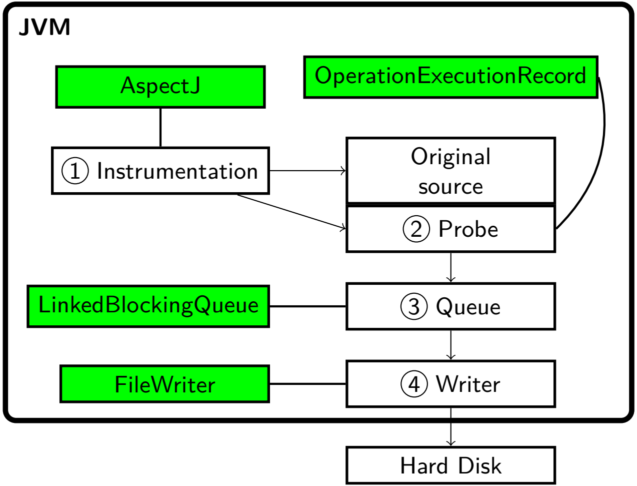

Figure: Monitoring Process in Kieker

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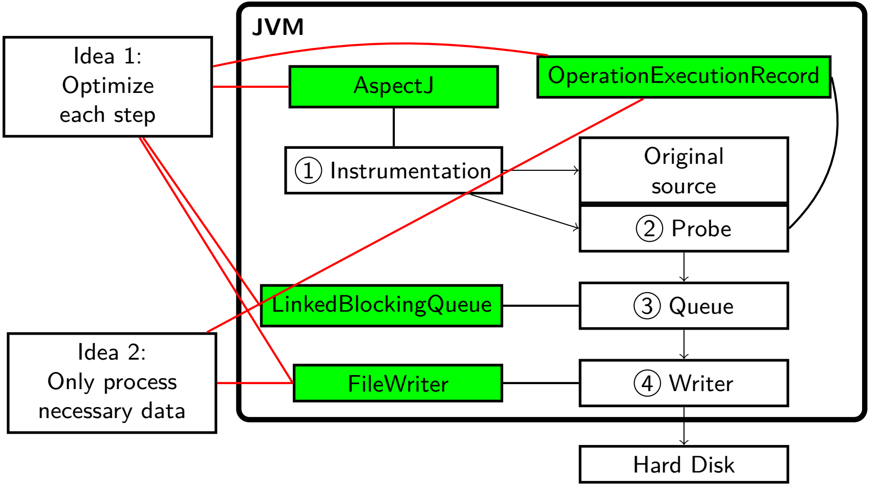

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Optimization Options [WOSPC23]

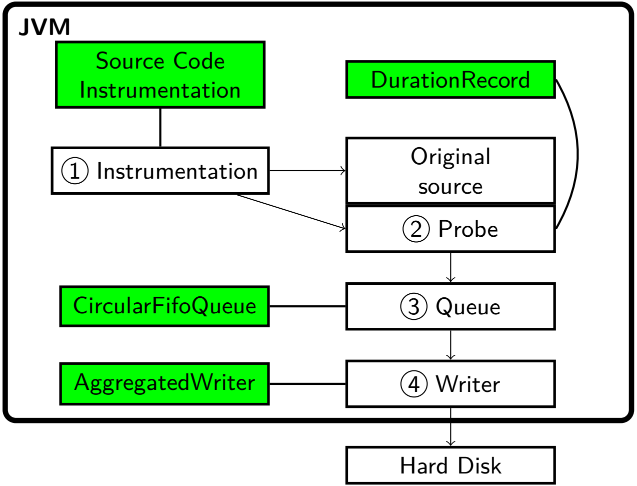

Figure: Possible Monitoring Optimizations

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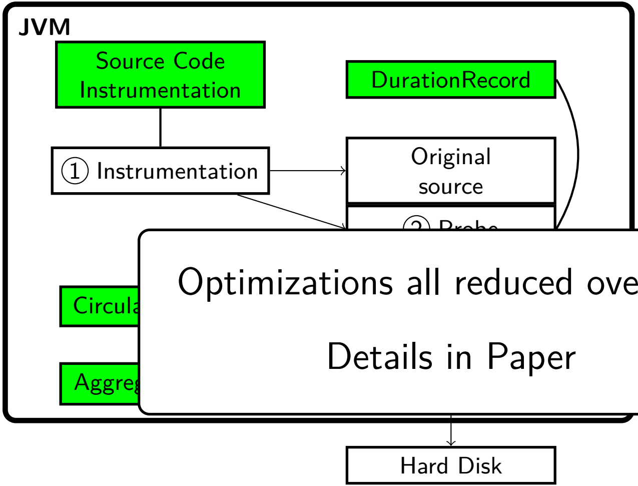


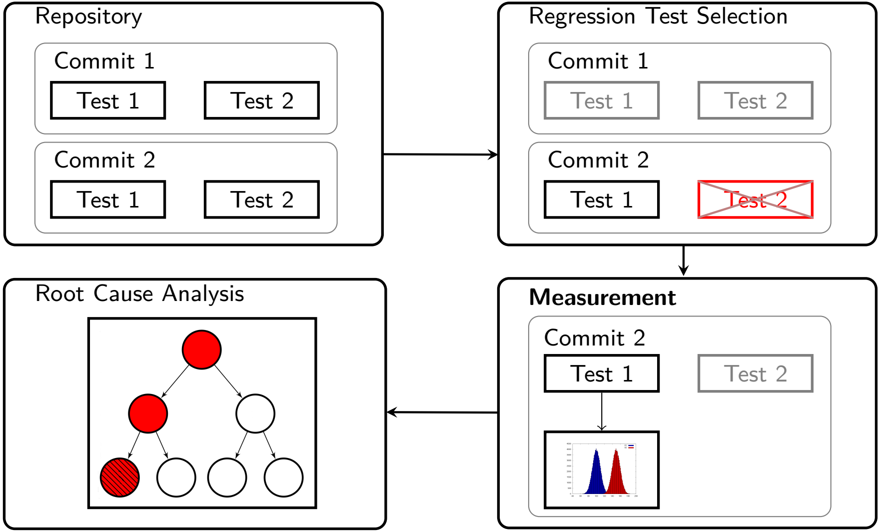
Optimizations all reduced overhead

Details in Paper

Figure: Possible Monitoring Optimizations

Performance Change Detection

Process of Peass



General Measurement Process (Adaption of Georges et al., 2007)

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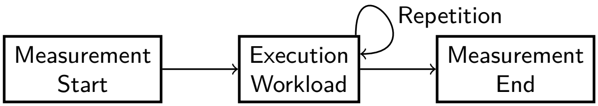

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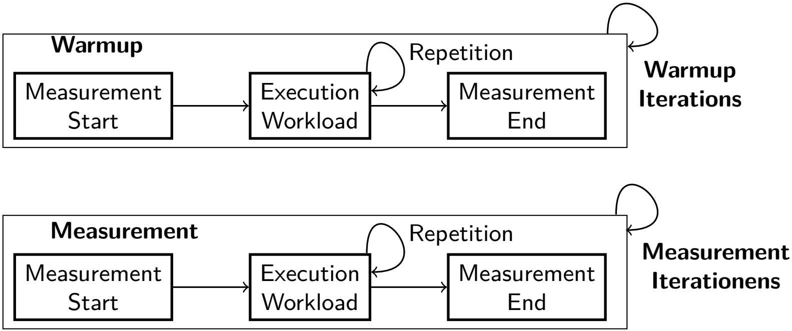

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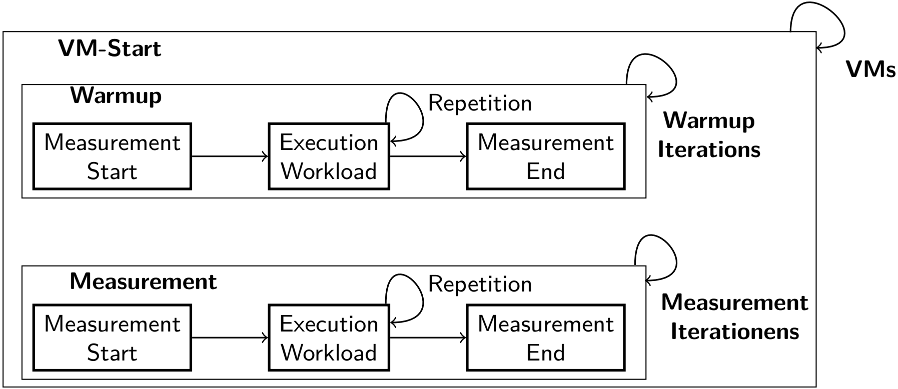

Example Worklods [QRS22]

- Goal: Determine statistical boundaries of performance change detection
- Statistical boundaries depend on
  - Type I error
  - Type II error
  - Standard deviation
  - Effect size (change size in relation to standard deviation)
  - VM count

Example Worklods [QRS22]

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  - Type I error
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  - VM count
- For examination of performance measurements: Usage of example workloads with workload size s
- Used workloads
  - Add-workload: Adding s random numbers
  - RAM-workload: Reservation of s arrays consisting of 3 ints
  - Sysout-workload: Generating s random numbers and printing them to System.out

Example Worklods [QRS22]

- Goal: Determine statistical boundaries of performance change detection
- Statistical boundaries depend on
  - Type I error Decided: 1 %
  - Type II error
  - Standard deviation Empirical: 1 %
  - Effect size (change size in relation to standard deviation)
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- For examination of performance measurements: Usage of example workloads with workload size s

- Used workloads
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Statistical Boundaries of Detecting Changes [QRS22]

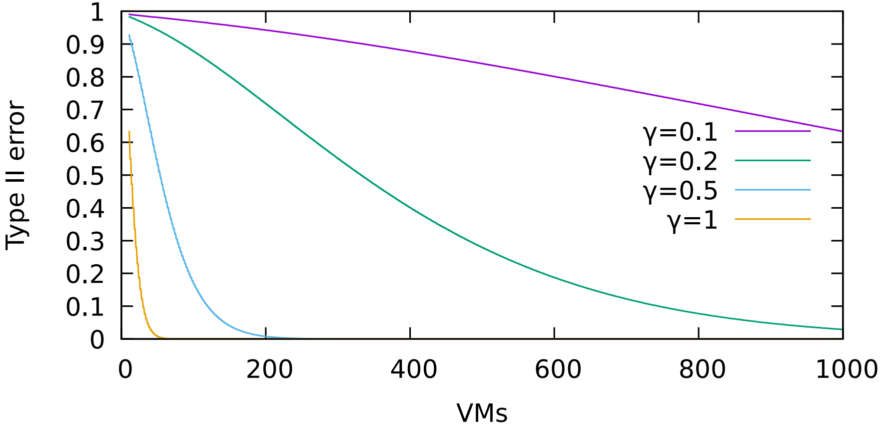

Figure: Type II error in relation to VM count and effect size γ

Statistical Boundaries of Detecting Changes [QRS22]

- Example: Workload size 1,000 will take 97 seconds for 10,000,000 repetitions $\Rightarrow$ at maximum 891 VMs are possible when using 12 hours measurement time
- Boundaries depend on measurement duration; $\gamma = 0.1$ would require 4.808 VMs and will hardly be measurable

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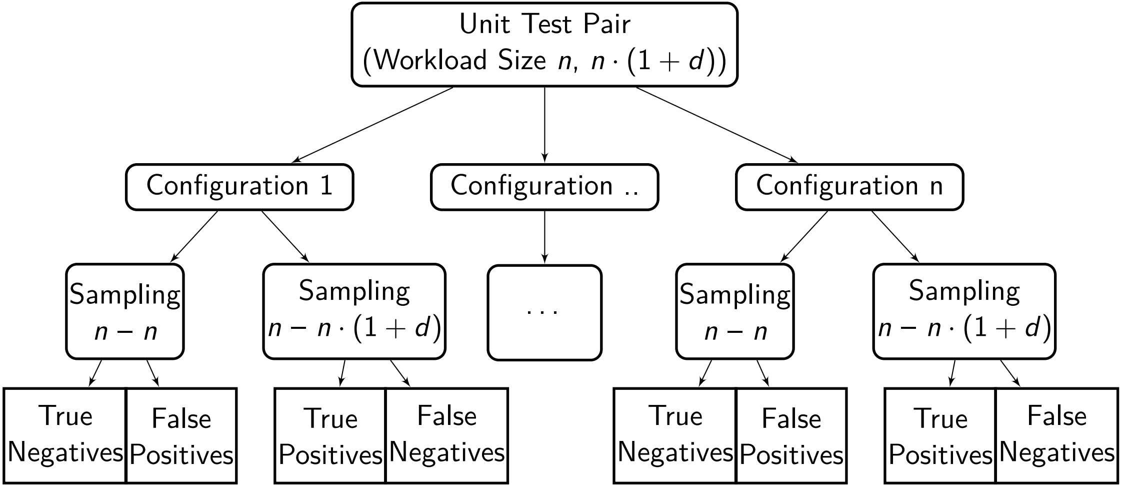
- Boundaries depend on measurement duration; $\gamma = 0.1$ would require 4.808 VMs and will hardly be measurable
- Measurements via monitoring (e.g. with OpenTelemetry, Kieker) or load tests have higher deviation and will only detect more corse-grained performance changes

Approach [QRS22]



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- Examination of unit test sized workloads
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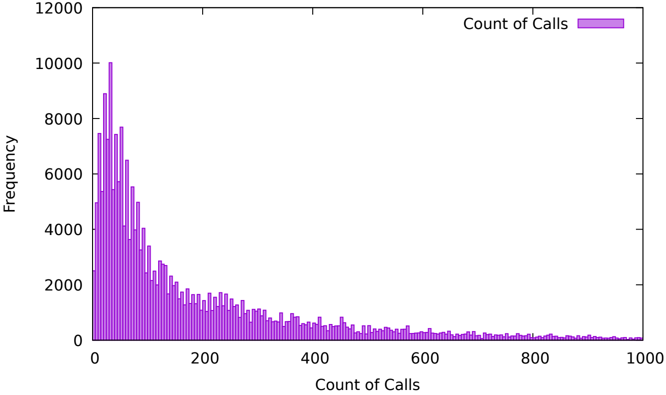


Example: Comparison of Statistical Tests [QRS22]

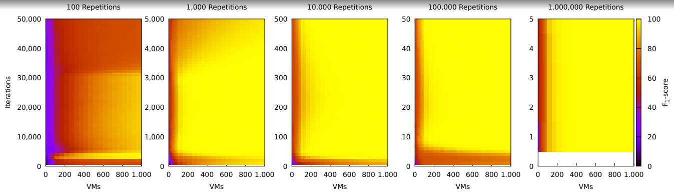
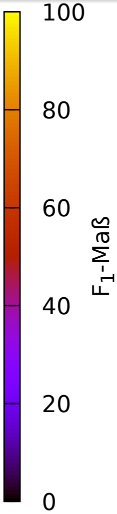


Figure: Average F_1-Score With T-Test



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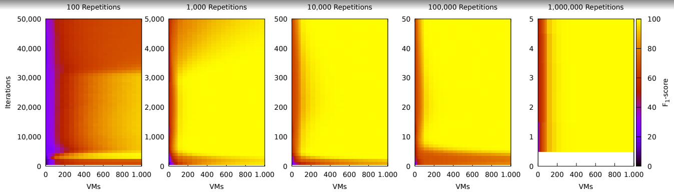

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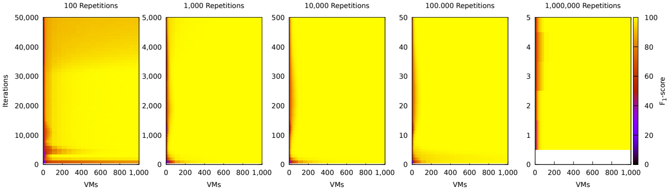
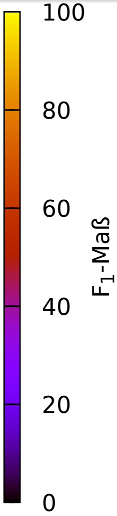


Figure: Average F_1-Score With Mann-Whitney-Test



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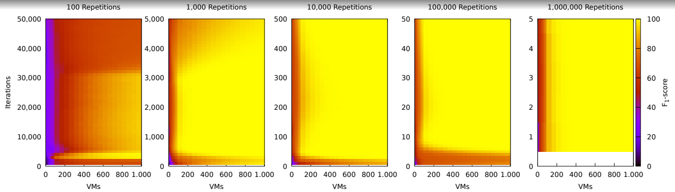
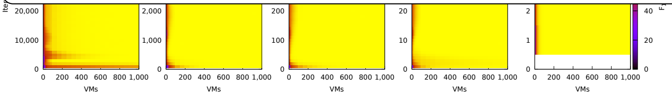
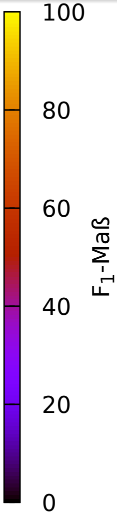


30 VMs, 49 iterations, 100,000 repetitions and Mann-Whitney-Test are an efficient configuration

for typical unit tests





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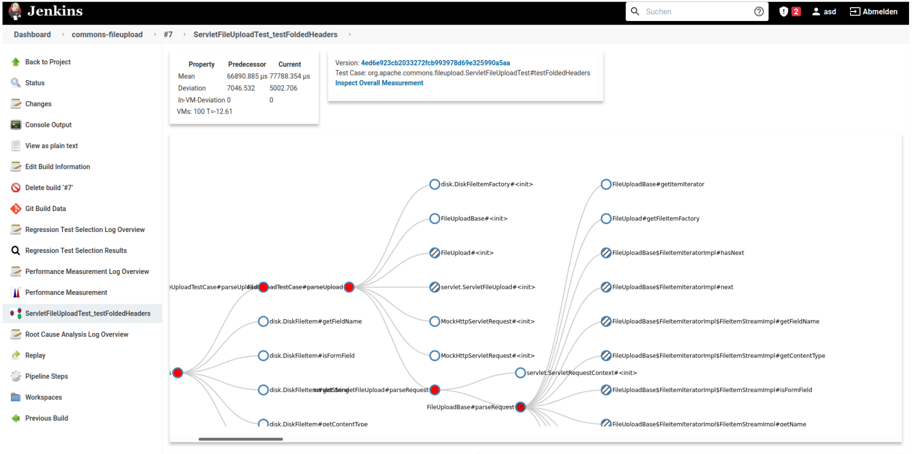
Example Usage: Peass-CI



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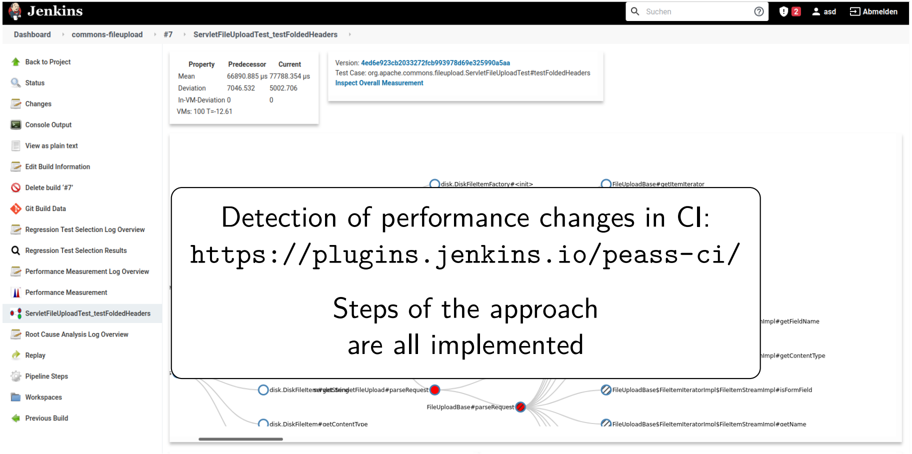


Detection of performance changes in CI:
`https://plugins.jenkins.io/peass-ci/`

Steps of the approach
are all implemented

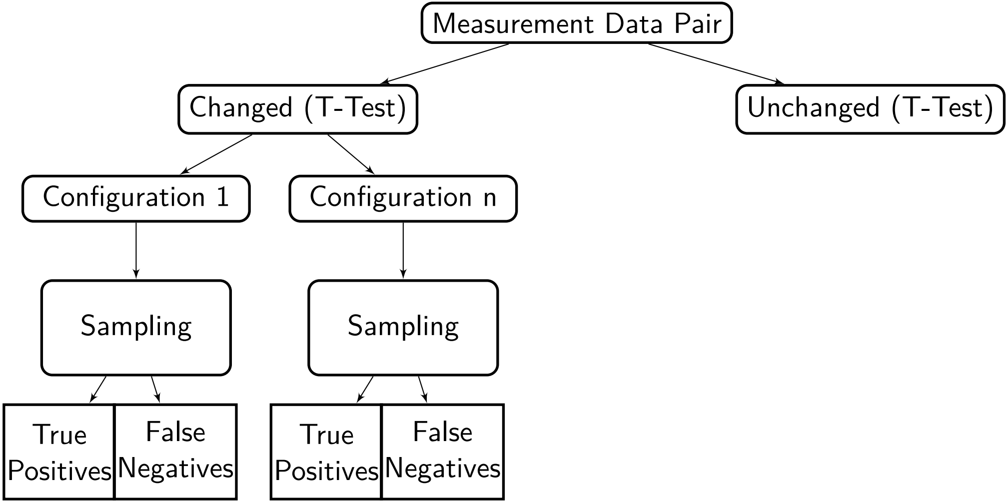
Application to GraalVM Data

Application to GraalVM Data – Idea

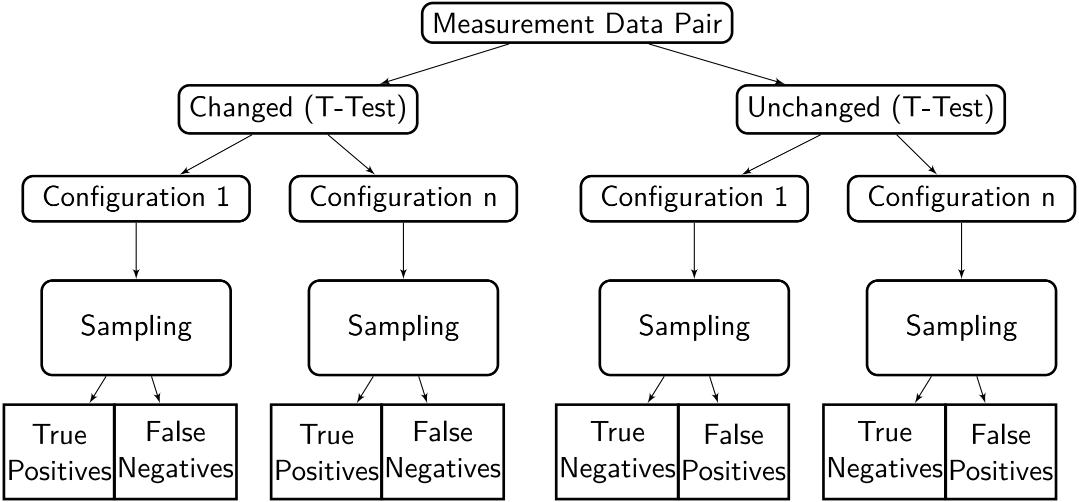
- Problem: GraalVM benchmarks might be executed to often
- Goal: Determination of suitable VM count and iteration / run count

- Problem: Artificial benchmark pairs and option to repeat them more often than necessary not available $\Rightarrow$ Approach: Sample from existing data

Application to GraalVM Data – Approach



Application to GraalVM Data – Approach



Application to GraalVM Data – Preleminary Results

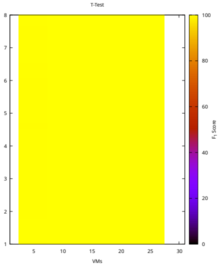


Figure: Difference 48994

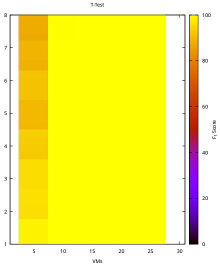


Figure: Difference 49001

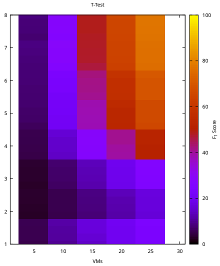


Figure: Difference 50180

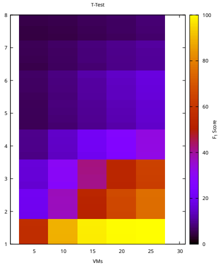


Figure: Difference 50405

Summary and Outlook

Summary and Outlook

- Previous research
  - Definition of a method for performance change detection using unit tests: `https://github.com/DaGeRe/peass`
  - Regression test selection by trace analysis
  - Root cause analysis implementation using Kieker
- Performance change detection
  - Basic idea: Sample from artificial / known performance changes and derive measurement configuration
  - Current goal: Check configuration generation on GraalVM data

Thanks for your attention!

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