Soundy Automated Parallelization of Test Execution

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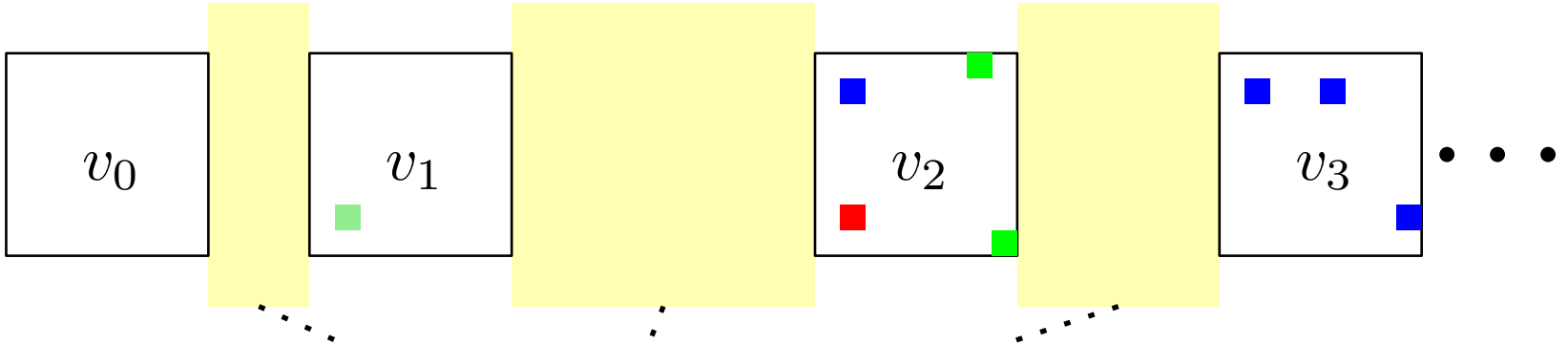
IIT Madras (India), UFPE (Brazil), UFPE (Brazil)



ICSME 2021 (Virtual Event)

September 27 – October 1

Context: software evolution and regression testing



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Regression testing efficiency is important!

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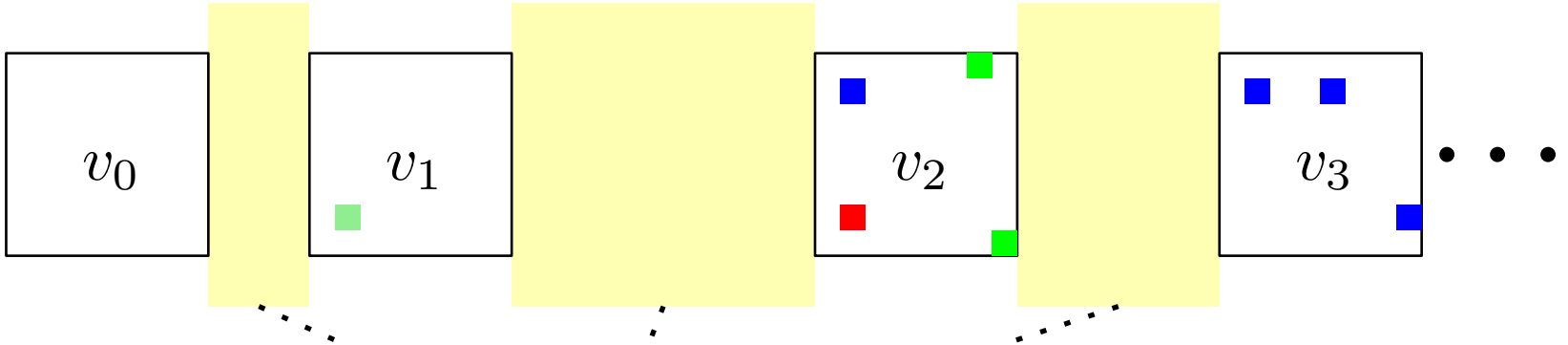

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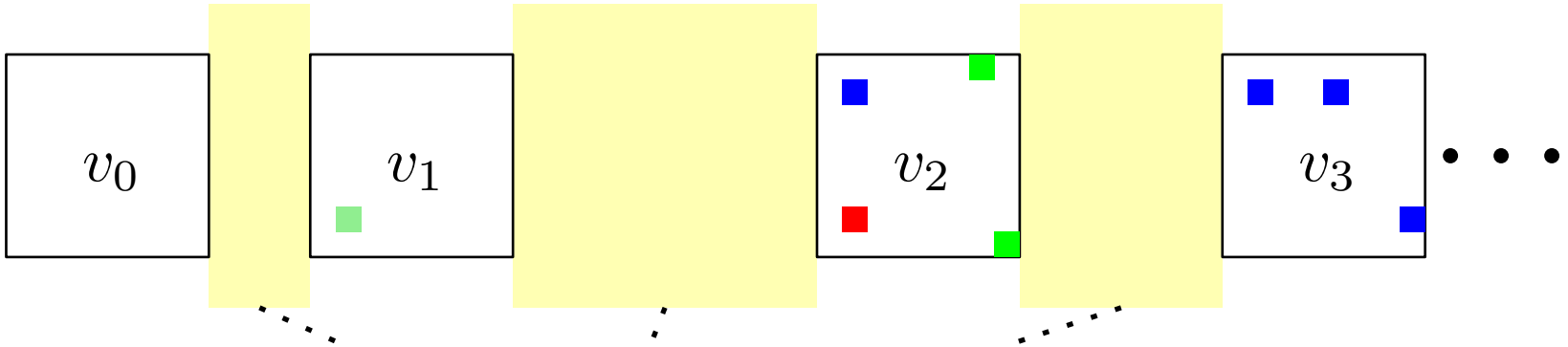

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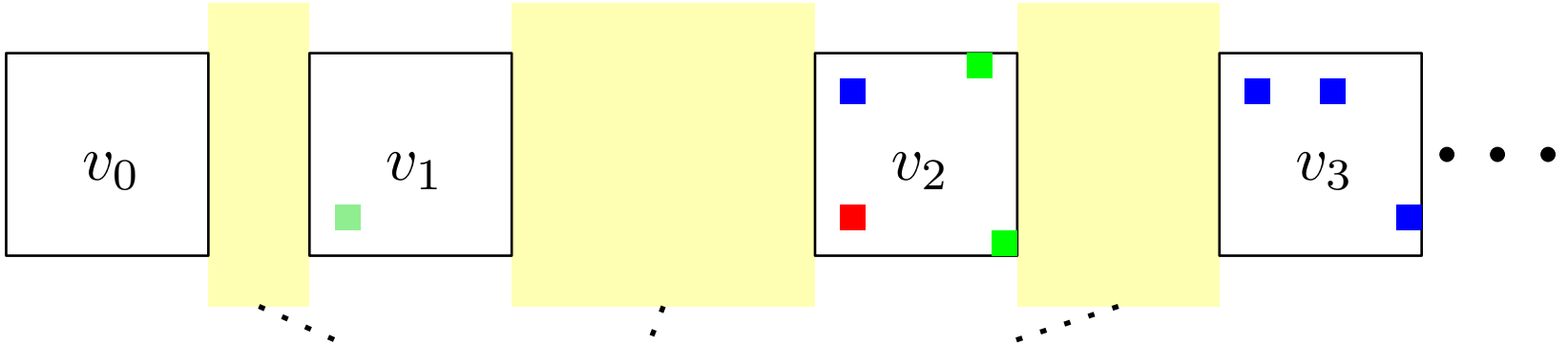

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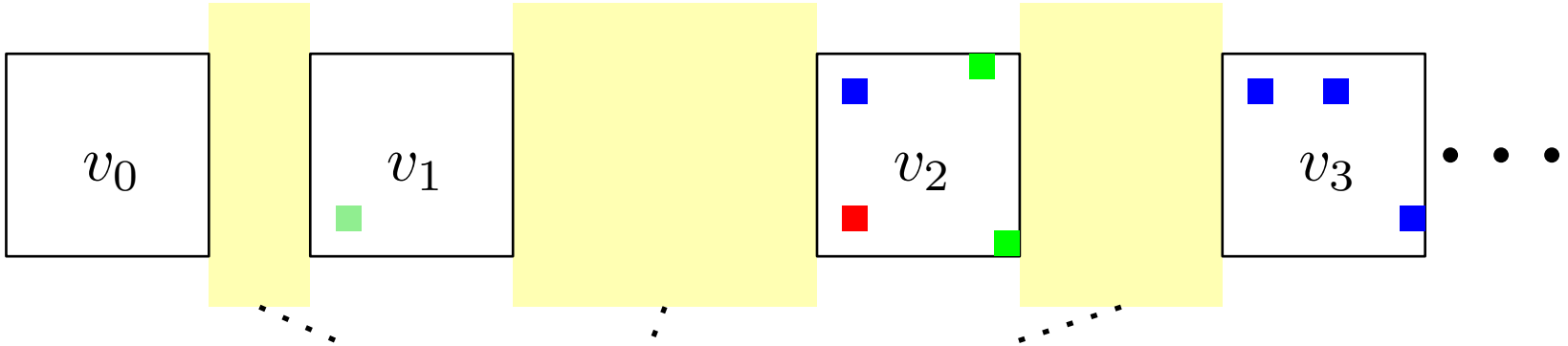

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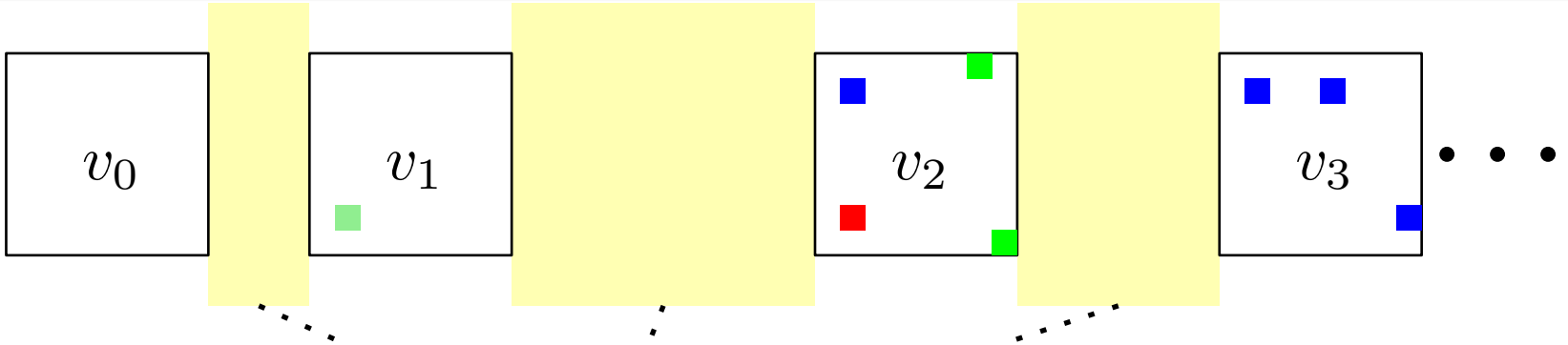

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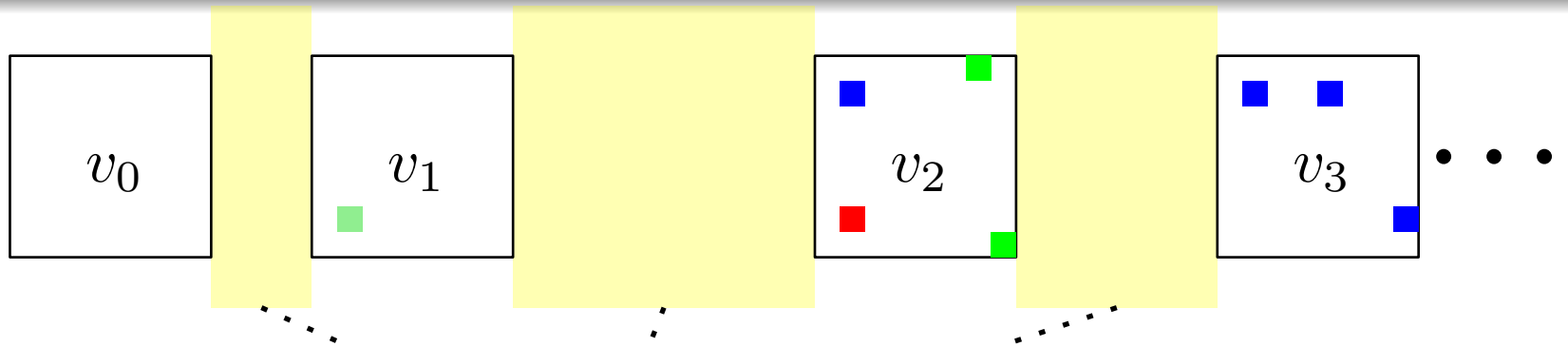

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- ***Test-execution parallelization*** (*is less explored*...).[5]

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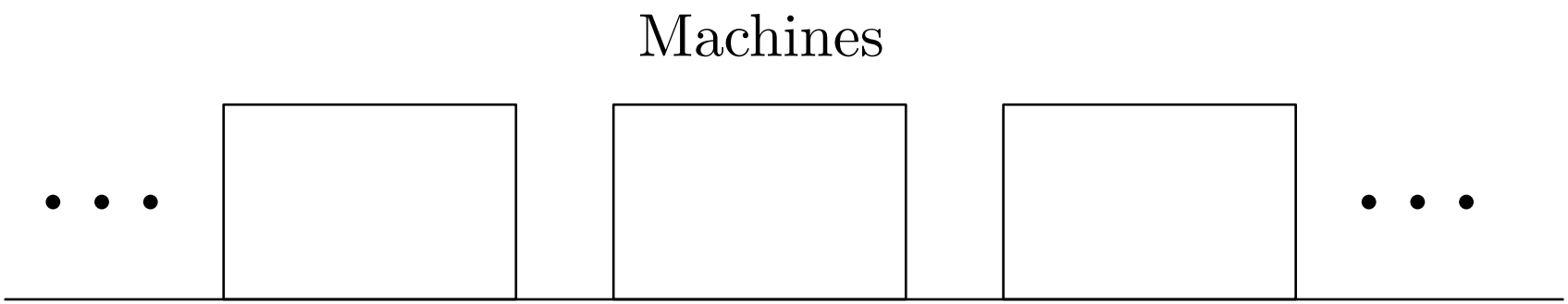
Test parallelization levels



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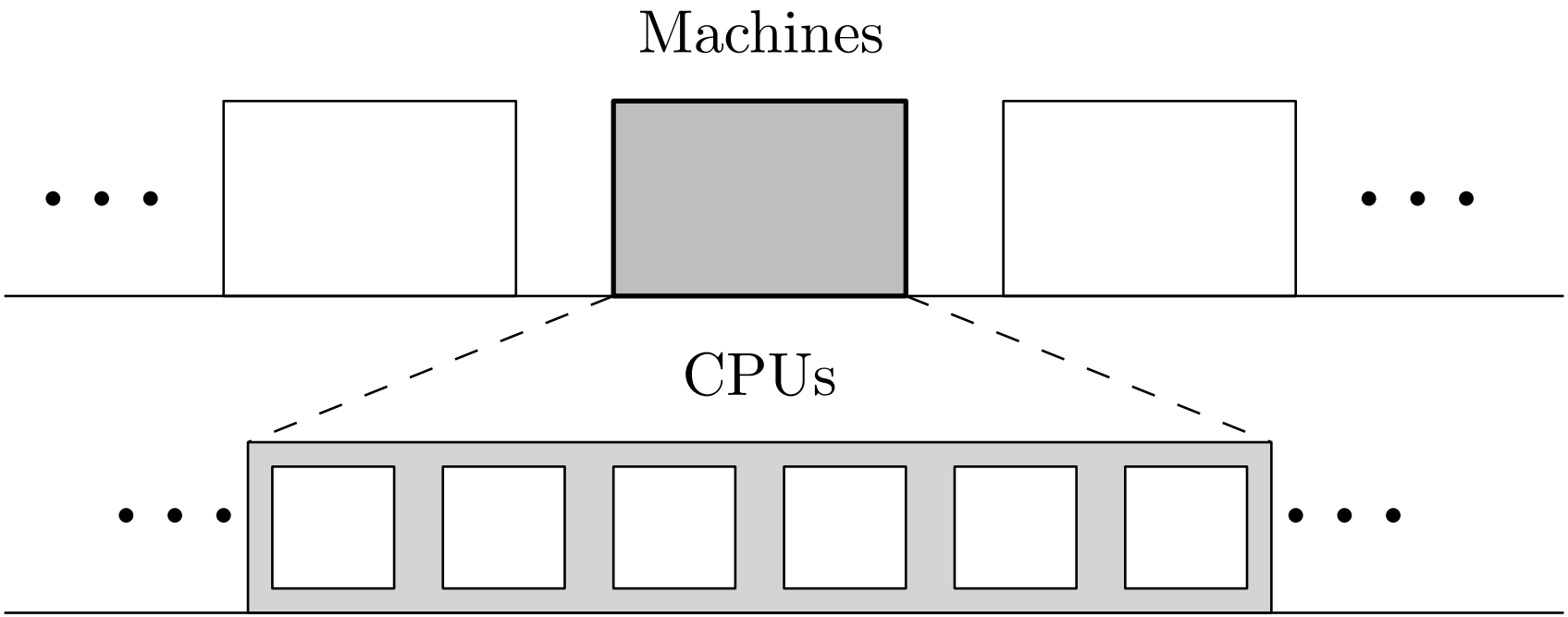

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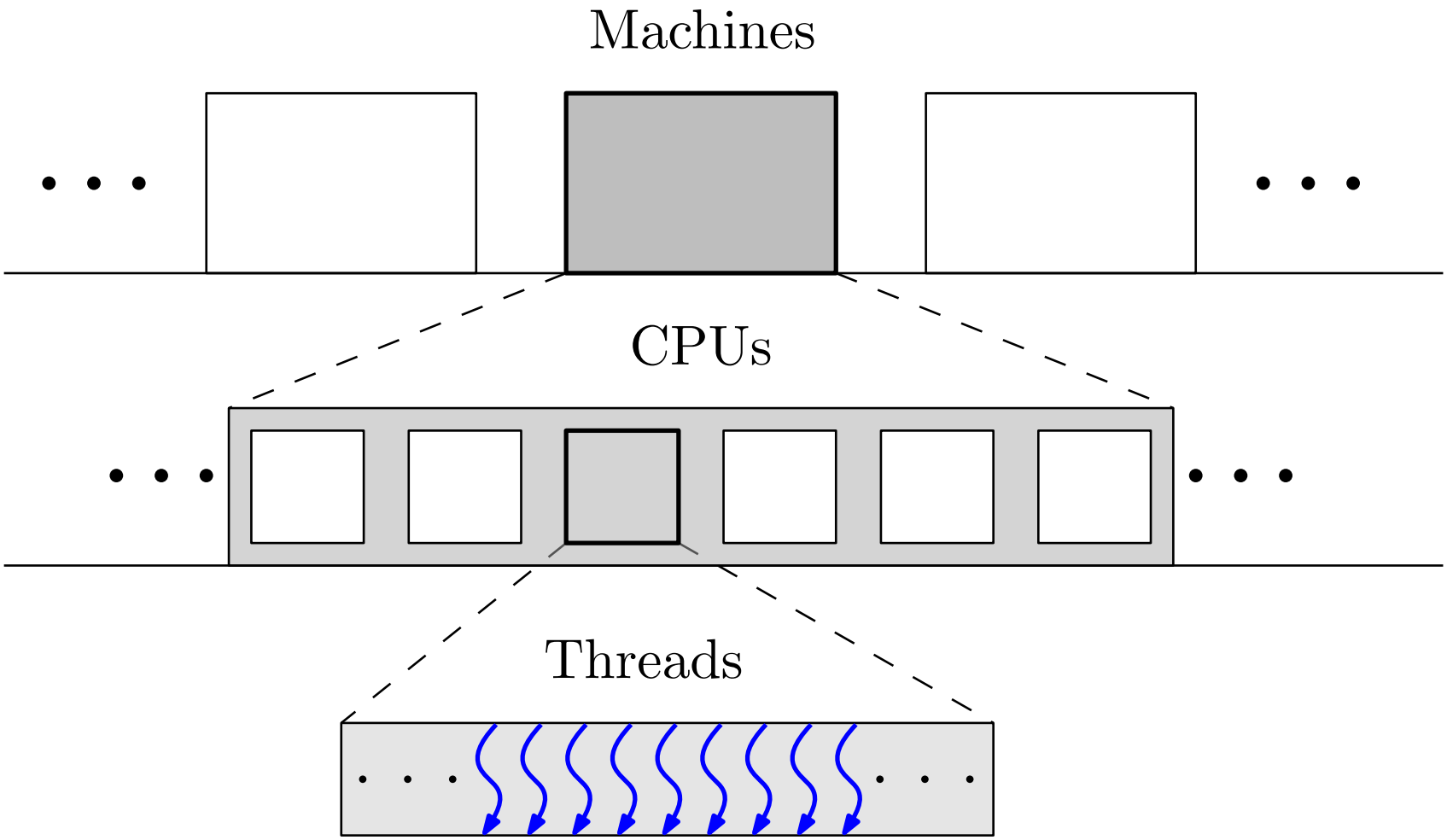

In this work, we focus on *CPU* and *thread* level parallelism.

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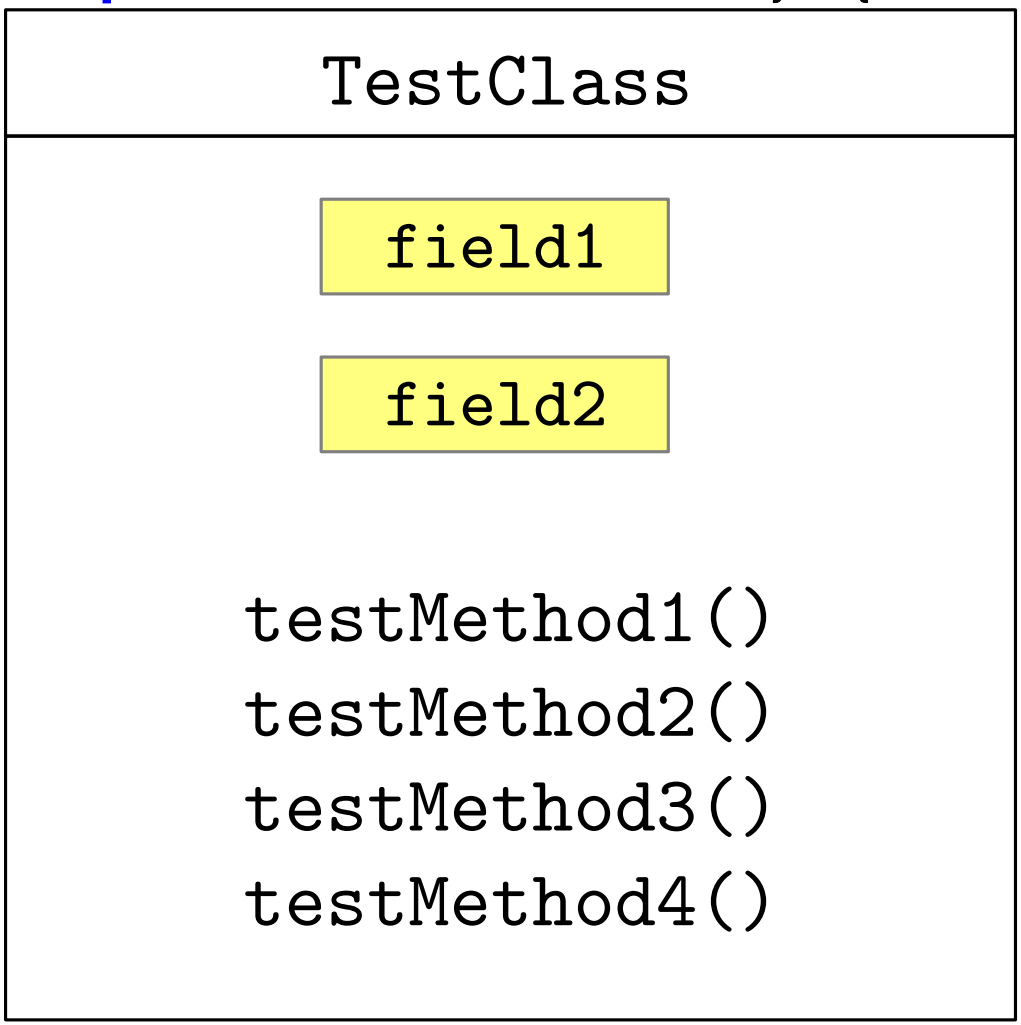
Test flakiness: a major issue due to parallelization

{**Test dependencies**, **Data-races**}→{**flakiness**}



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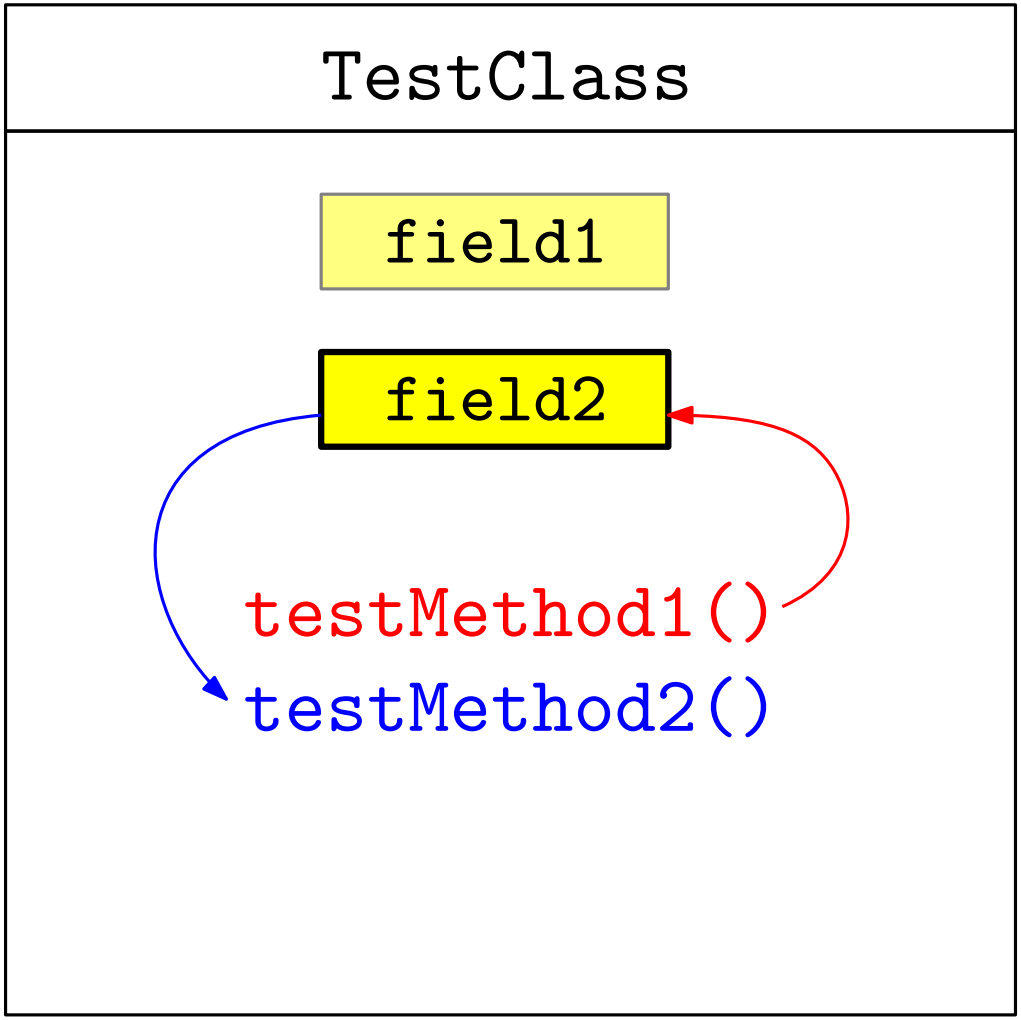

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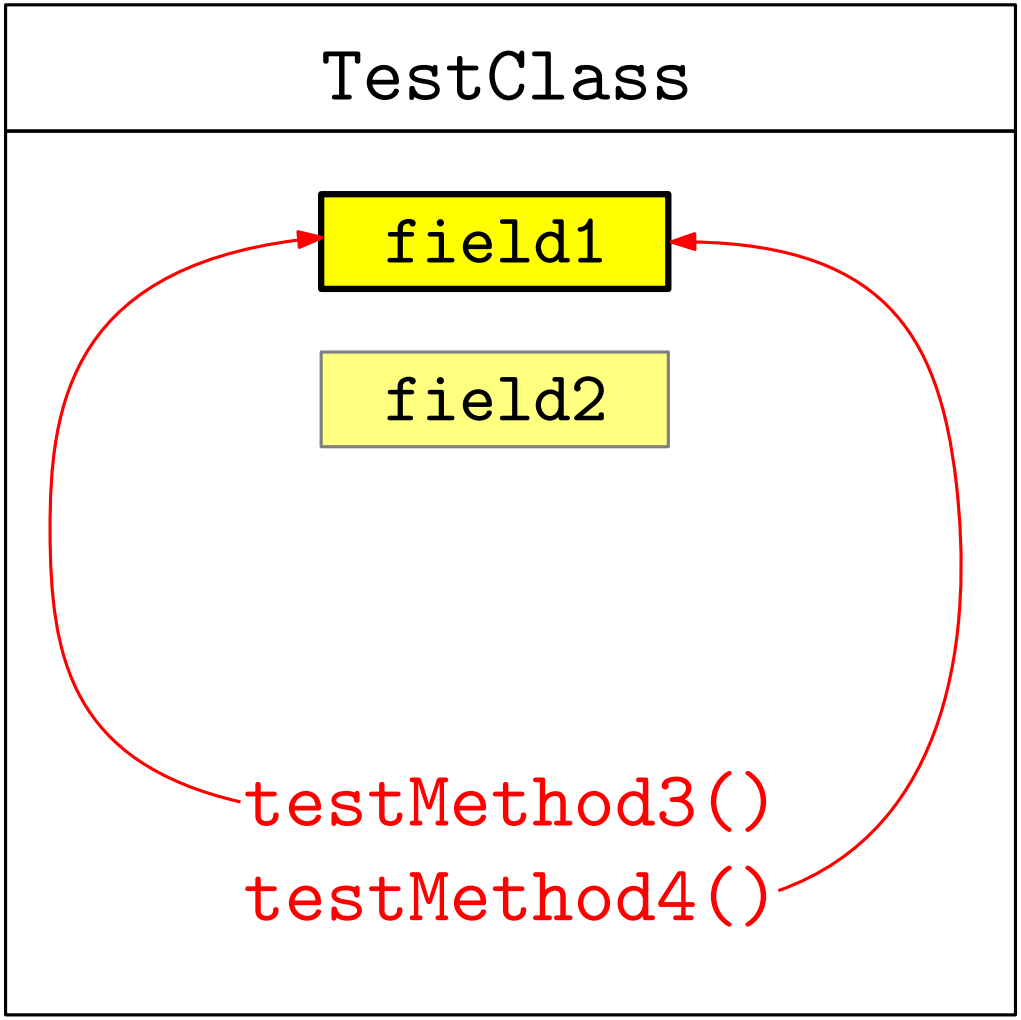

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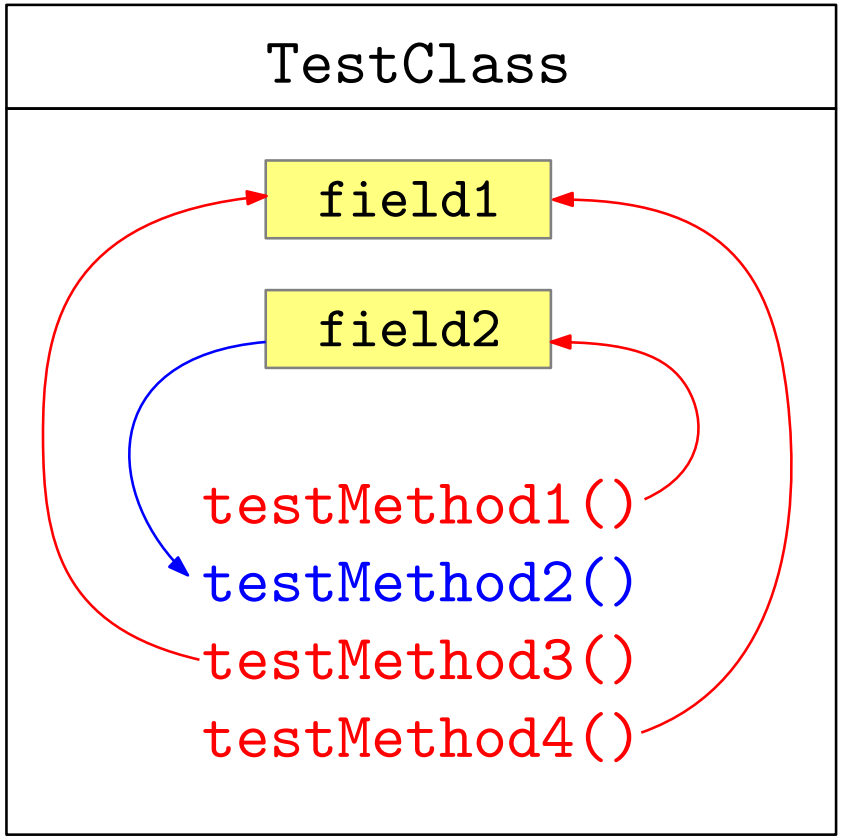

Run 1:	P P P P
Run 2:	P F P P
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Run 4:	P P F P
Run 5:	F P P F

Test dependency detection: *can it aid test parallelization*?

Test dependency detection can be costly!

State-of-the-art dependency detector: PRADET (ICST 2018).

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Step 2 (costs y): Dynamic data-flow analysis collect data dependencies.

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The overhead of PRADET was **substantially higher than sequential execution itself** ($y + z > x$).
NOT practical *to use PRADET* to aid test parallelization!

Our approach: **PASTE**
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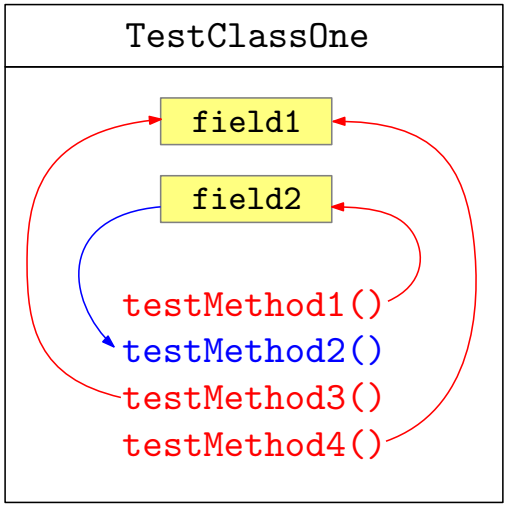
PASTE builds on the observation:
broken test dependencies that are manifested in parallel runs ***involve test cases from the same test class***.



Run 1:	P	P	P	P
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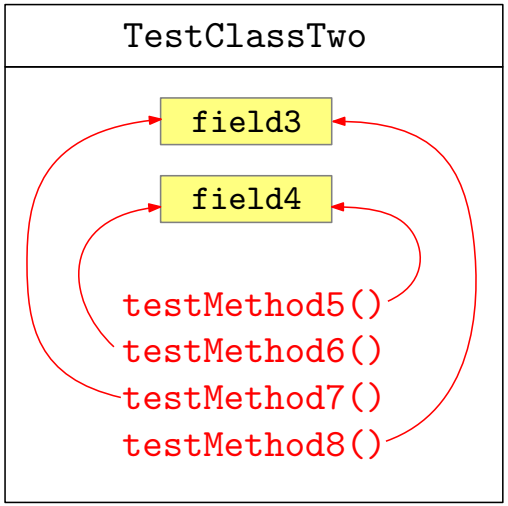

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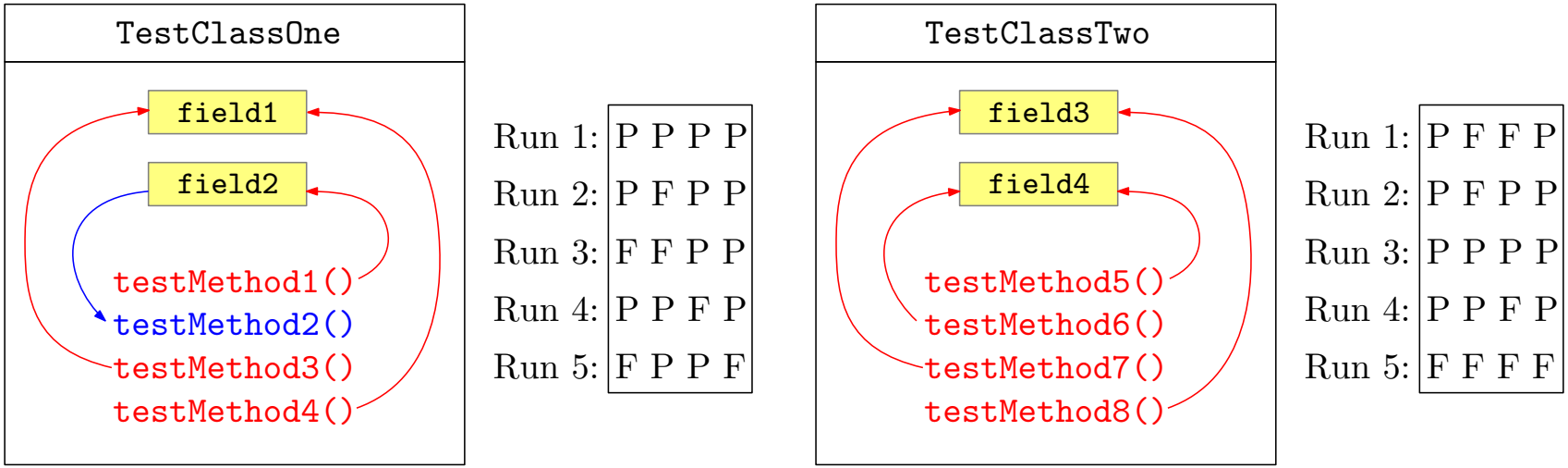
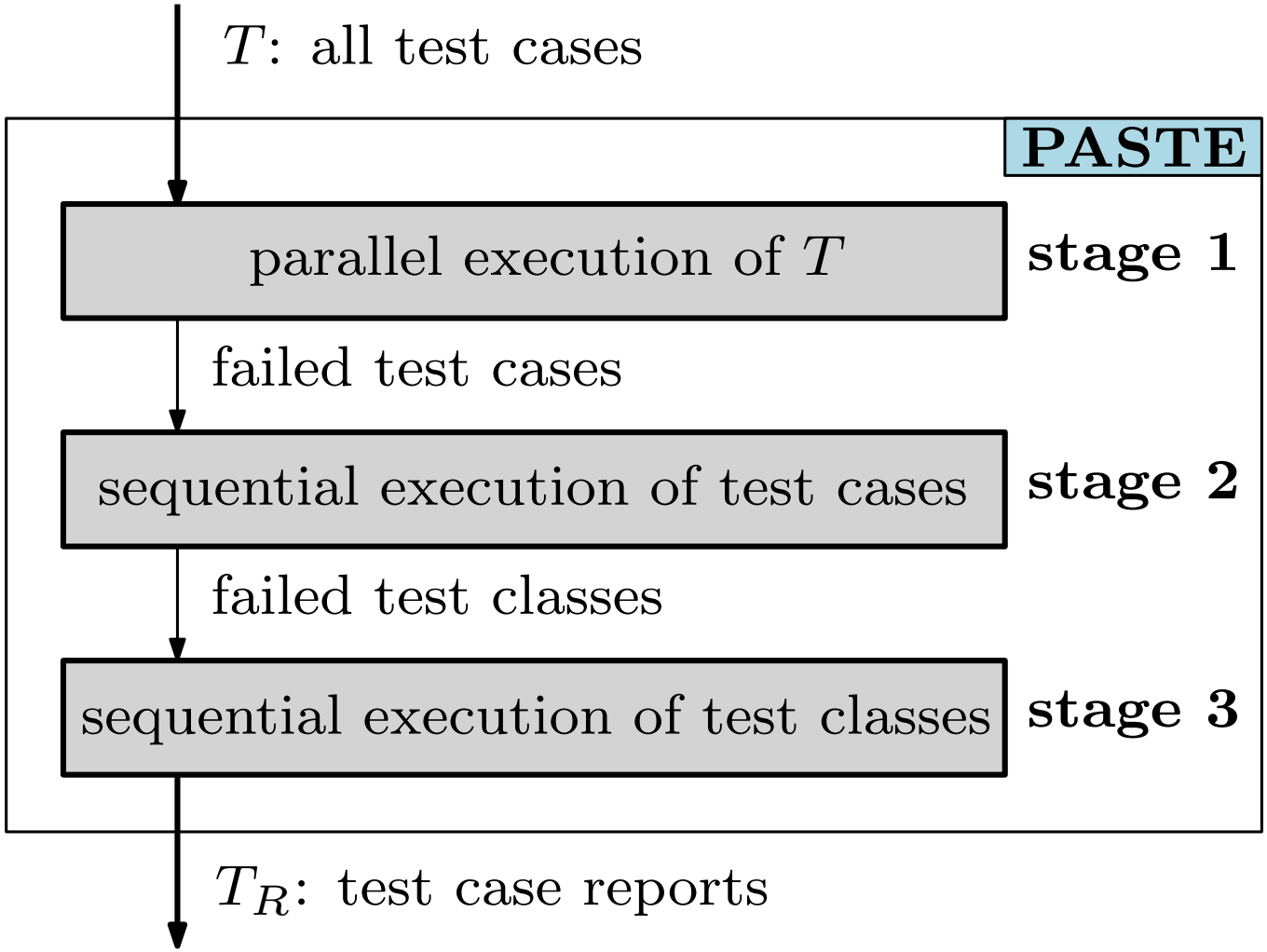


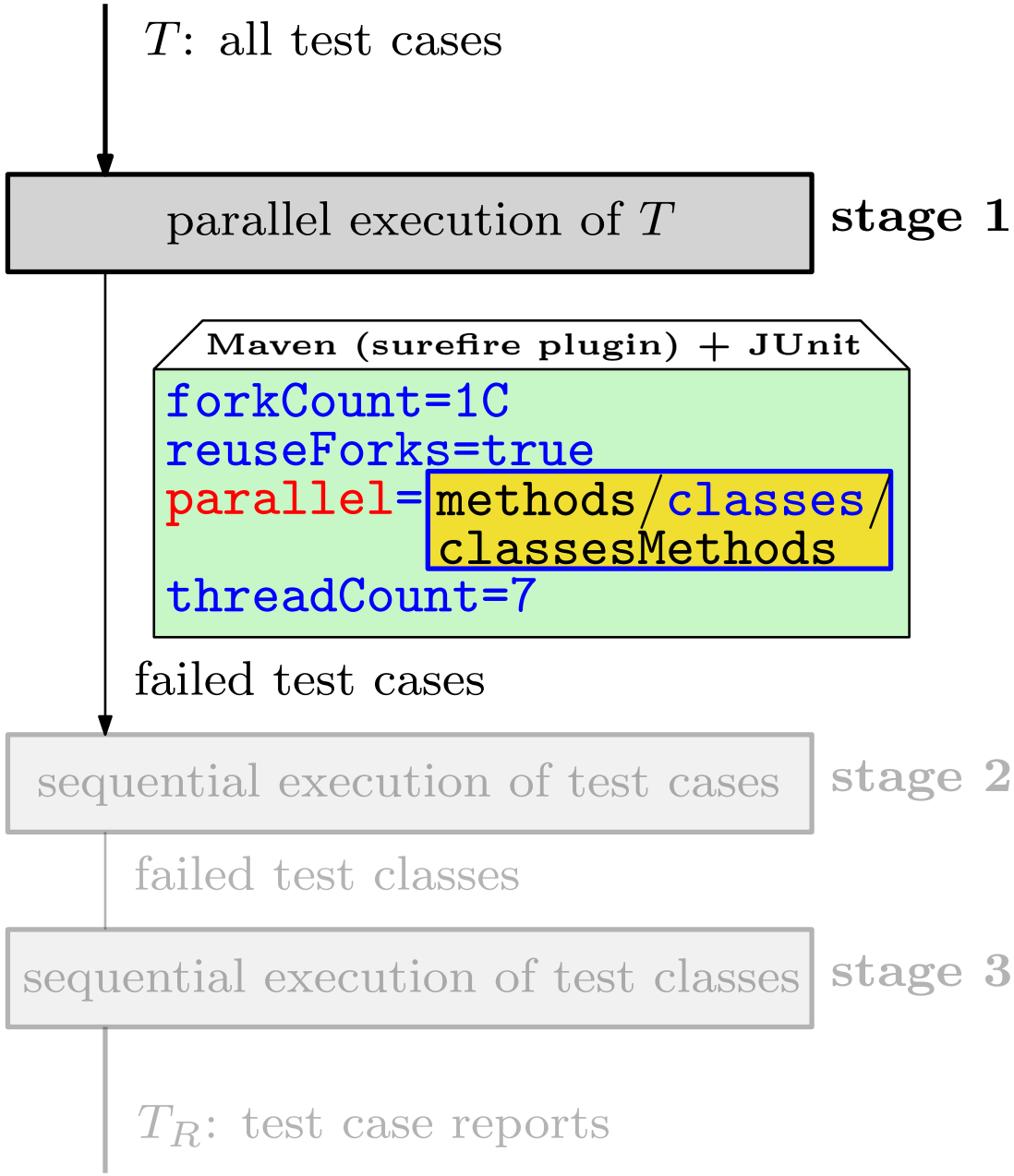
Handle flakiness in test suites through:

- **sequential re-execution** of **test cases**
  (*to avoid* ***data races***).
- **sequential re-execution** of **test classes**
  (*to avoid* ***broken test dependencies***).

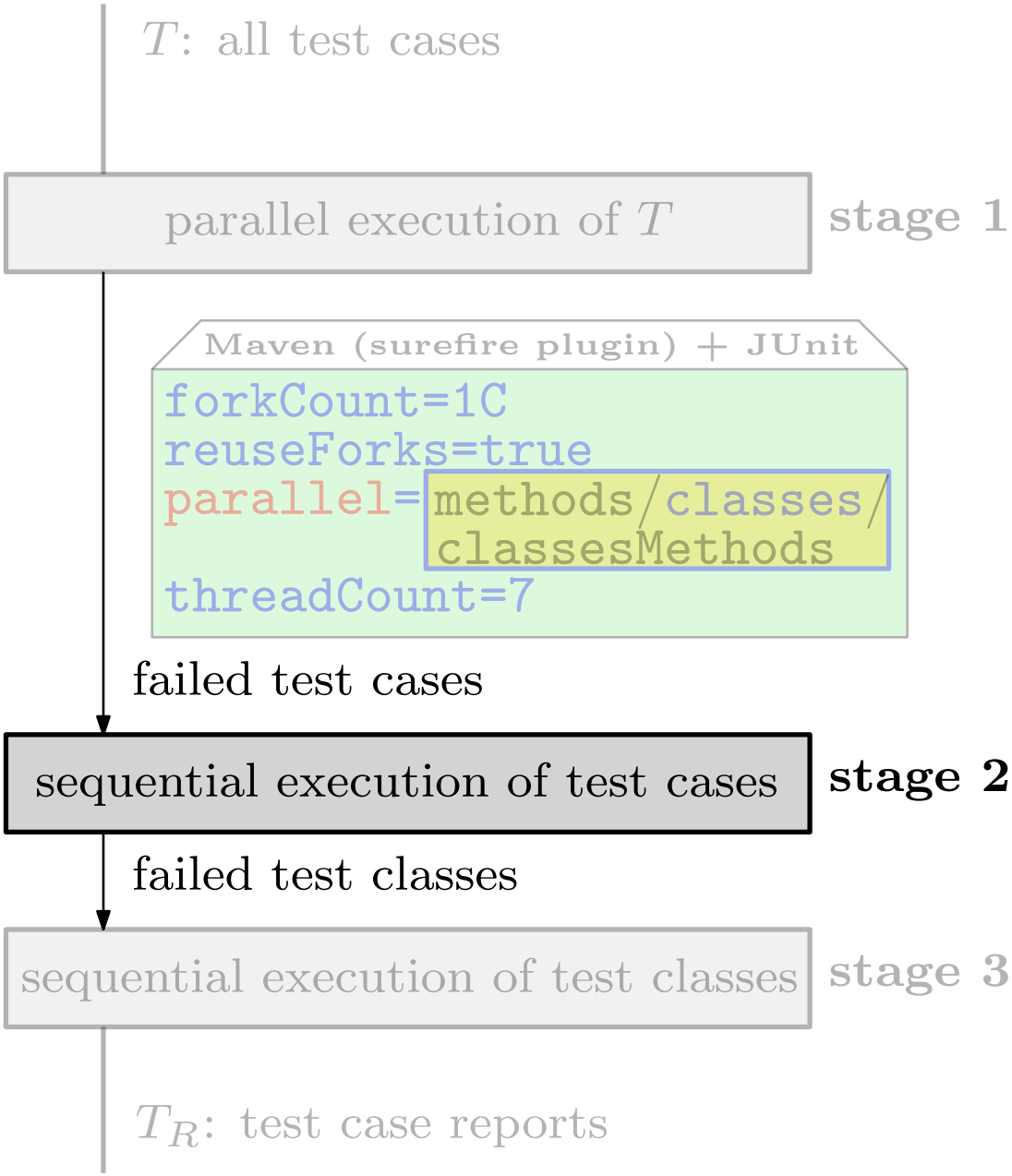
PASTE: the three-staged pipeline of test execution



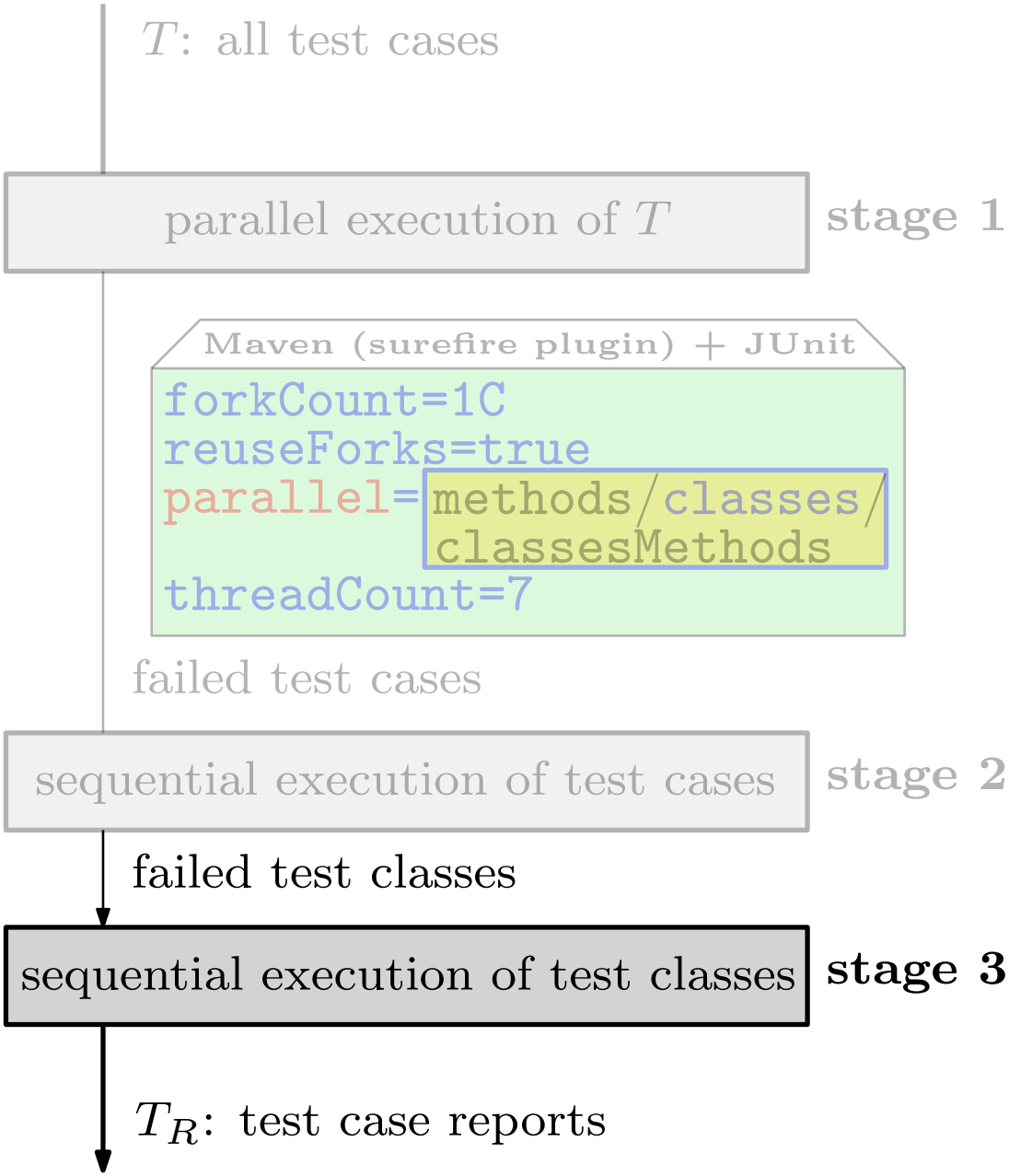
Stage 1: parallel execution



Stage 2: sequential re-execution of failed test cases



Stage 3: sequential re-execution of failed test classes



The spectrum of soundness in parallelization

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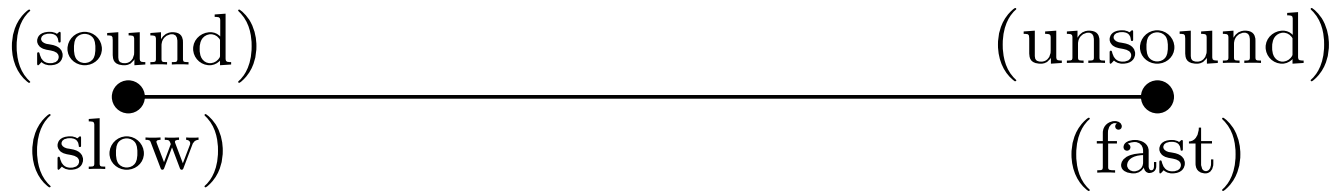
Sound: time invariant verdicts agree with sequential execution.



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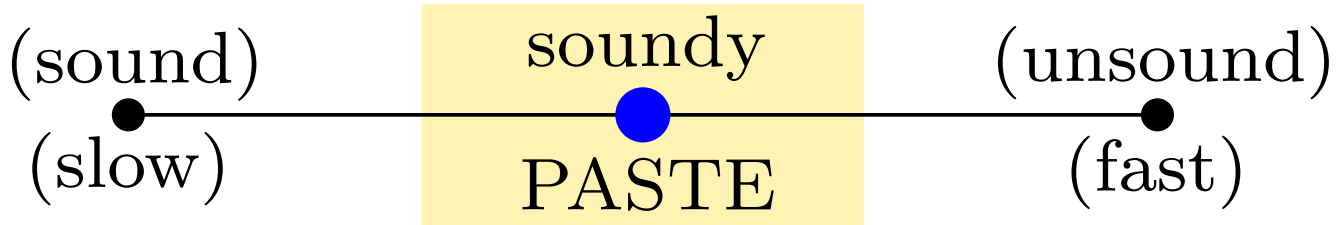

PASTE does not provide the soundness guarantee but is reasonable enough to yield end-to-end acceleration!

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- **Parallel configuration**: parameters in **Maven** and **JUnit**.

Research Questions

RQ1 (feasibility #1)

Is it feasible to use parallelization options provided by the build system "out of the box" to run test suites?

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In 44% of the projects, no parallel configurations enabled a clean execution. Searching for the **parallel configuration for a clean execution is INFEASIBLE in general**.

RQ2 (feasibility #2)

Is it practical to use a test dependency analyzer to partition test sets as to enable sound parallel execution?

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The runtime overhead of PRADET was substantially higher than that of the sequential execution itself. **NOT PRACTICAL to use PRADET to aid test parallelization**.

RQ3 (effectiveness #1)

How reliable is* PASTE*?

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Effective to circumvent the test flakiness provoked by test parallelization. There were **no cases of provoked failure that "survived" the third stage** of PASTE.

RQ4 (effectiveness #2)

What are the speedups obtained with* PASTE*?

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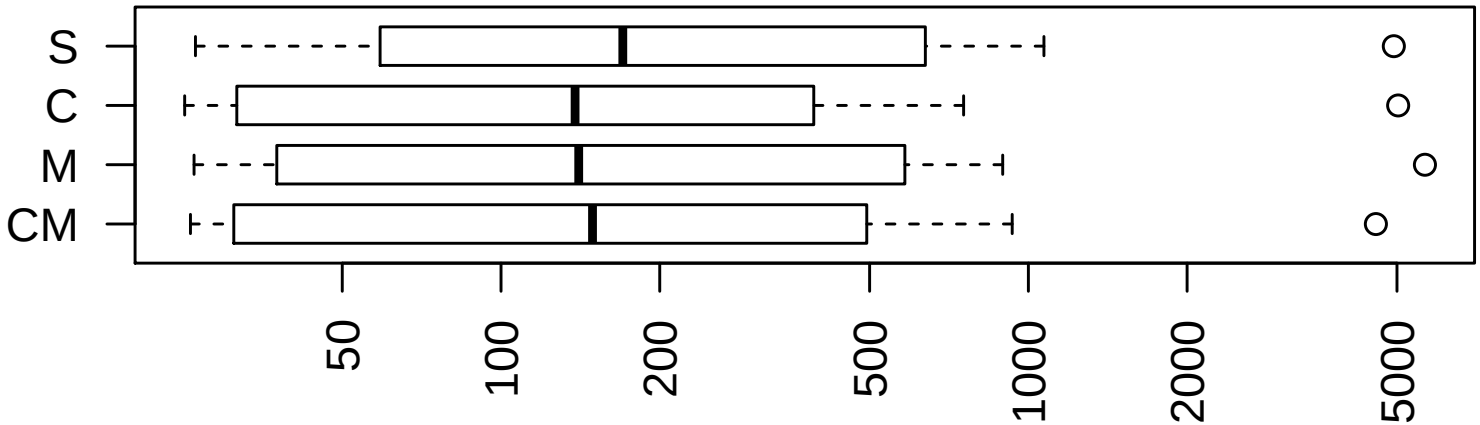
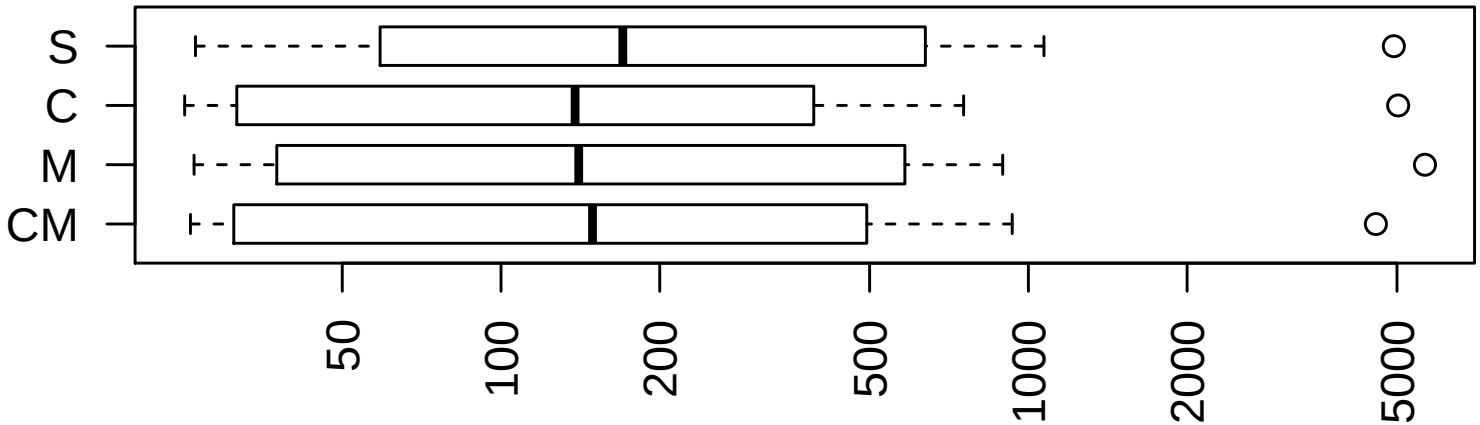
We observed speedups in 52% of the projects. The **configuration `classes`** performed the best: **median 1.59x** (best: 2.28x, average: 1.47x, worst: 0.93x).

RQ4 (effectiveness #2)



Distribution of **PASTE running times (seconds)** for Sequential (S) and each configuration (Classes (C), Methods (M), ClassesMethods (CM)).

RQ4 (effectiveness #2)



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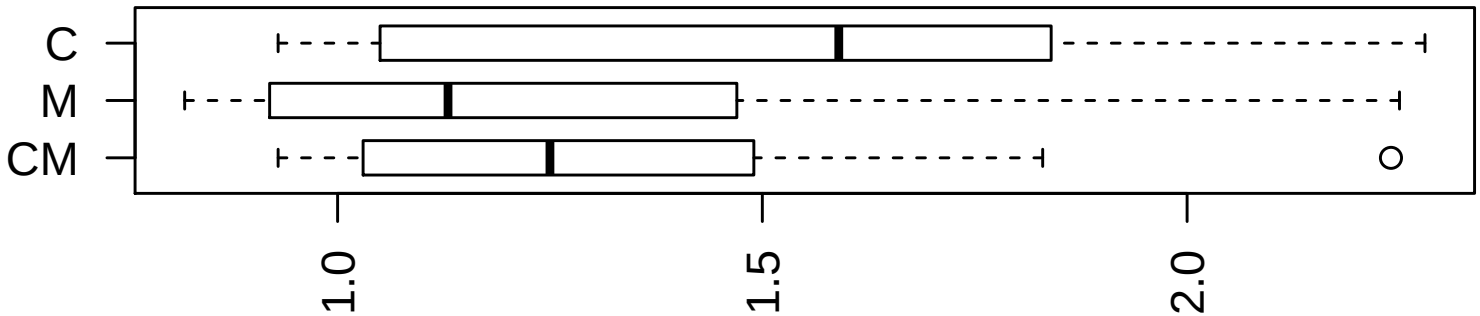

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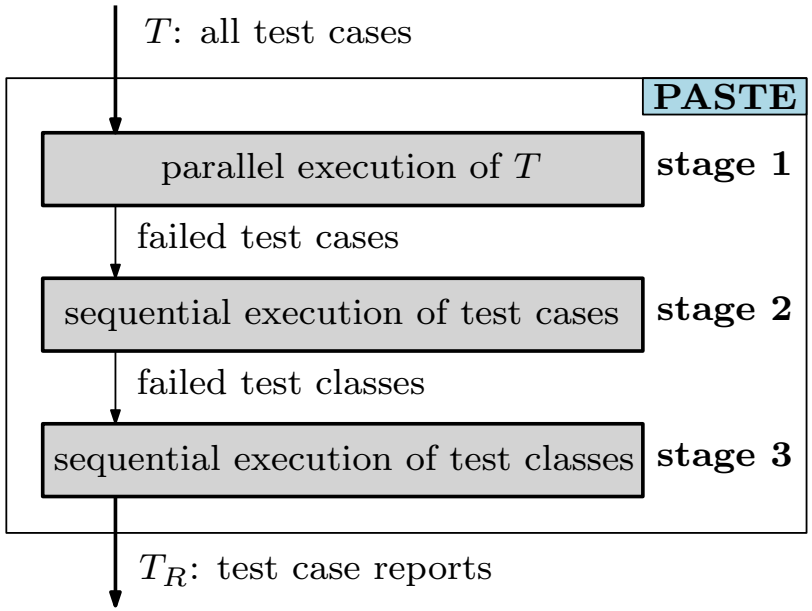
Related Work

Some recent approaches towards test parallelization

Work–venue	Languages used	Speedup	Machine type
ElectricTest–FSE 2015	Java	Avg. 16.00×	Amazon EC2
ParTeCL (GPU)–ISSTA 2017	OpenCL and C (subset)	Avg. 16.00×	GPU
Candido et al.–ASE 2017 (multi-core)	Java	Avg. 3.53× Avg. 4.20×	8 cores @ 3.60 GHz 80 cores @ 2.20 GHz
Mahtab–JSS 2019 (multi-core)	C++, LLVM, and C	Avg. 5.17× G.M. 4.72×	40 cores @ 2.40 GHz 40 cores @ 2.40 GHz

Conclusions

We discussed **PASTE**, a lightweight approach to parallelize execution of test suites through the sequential re-execution of *test cases* (*to avoid data races*) and the sequential re-execution of *test classes* (*to avoid broken test dependencies*).



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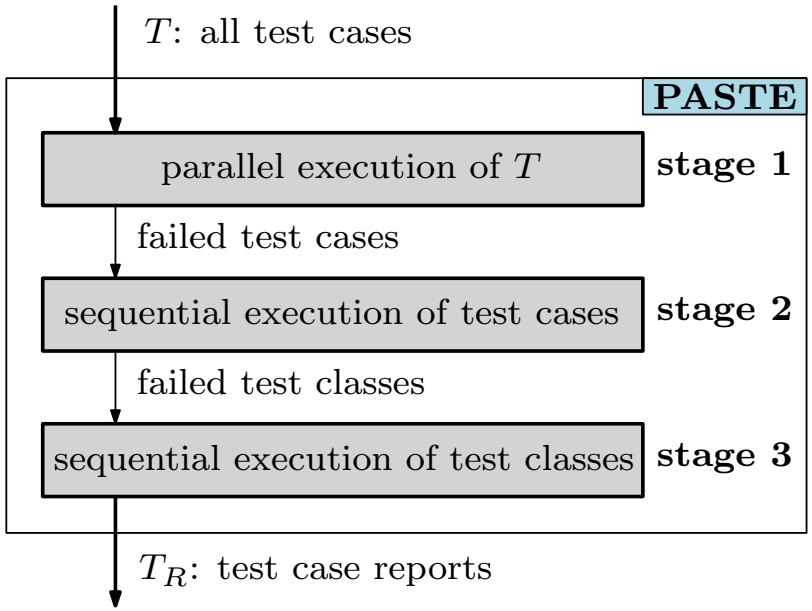

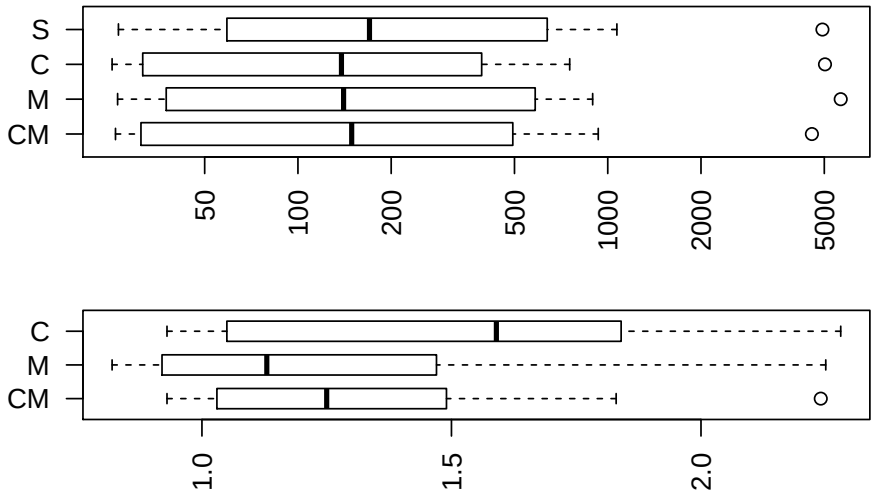

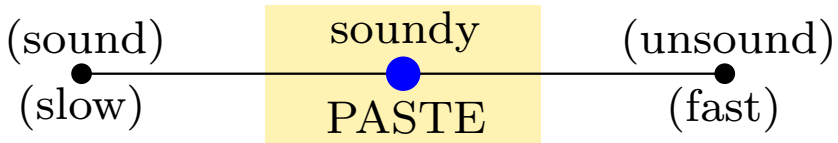

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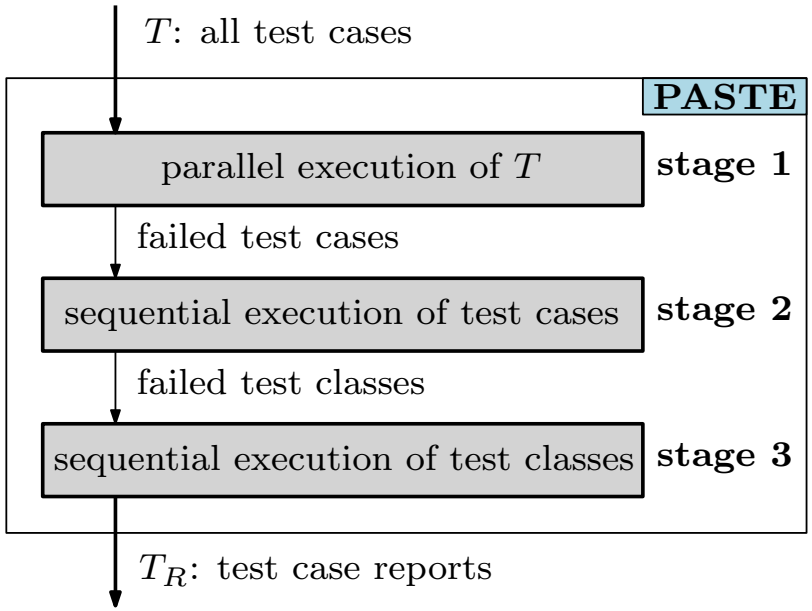

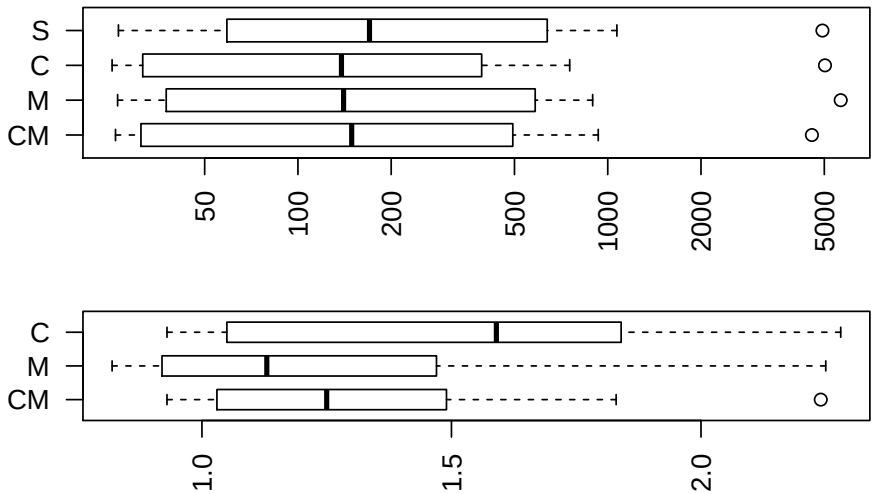

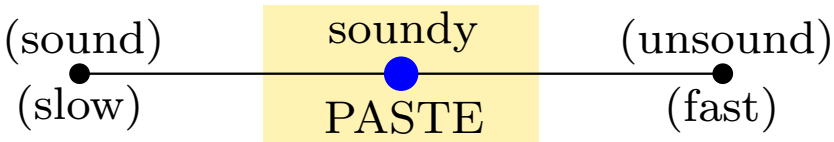

Thank You

Artifacts: https://github.com/STAR-RG/paste