Differential Modular Software Verification

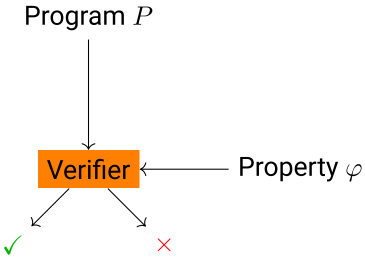
TECHNISCHE UNIVERSITÄT DARMSTADT

CPA'19

2019-10-01

Marie-Christine Jakobs

The Modification Challenge



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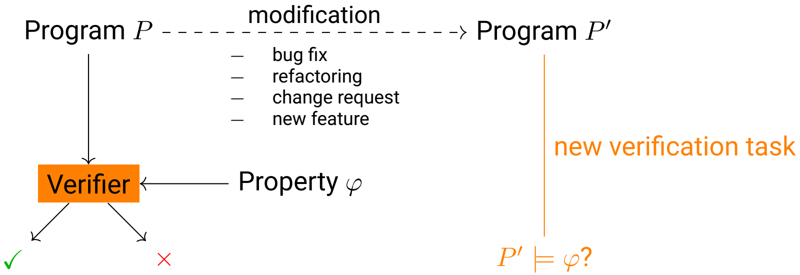

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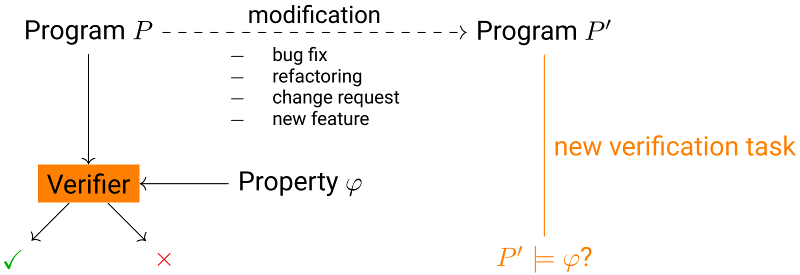

Challenge

- Programs change frequently
- Reverification after each change required
- Reverification must keep up with change rate

$\Longrightarrow$ Verifying modified programs from scratch infeasible

Insights about Program Modification

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Observation: Program modifications typically affect few program executions

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Original program P

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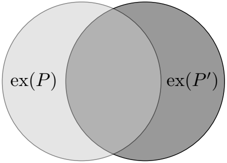

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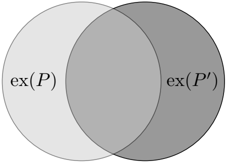
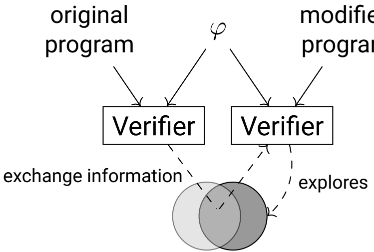


$\Longrightarrow$ verifying unchanged program executions from scratch wastes resources

$\Longrightarrow$ **better** reuse information obtained in previous verification run(s)

Principle of Incremental Verification

General idea: Use information about previous verification run
$\Longrightarrow$ speed up verification of unchanged parts



Weaknesses of Existing Approaches

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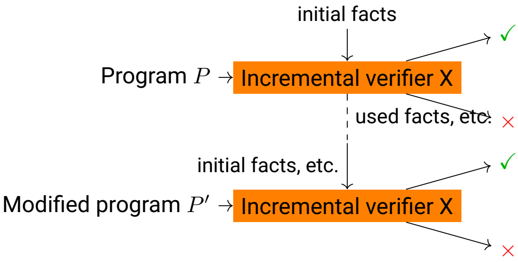

Often,

- Require initial full verification
- Use same verifier in each step
- Tailored to specific verification approach

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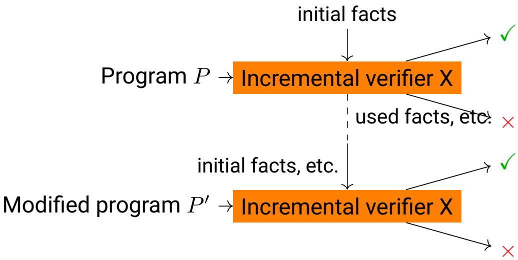

Often,
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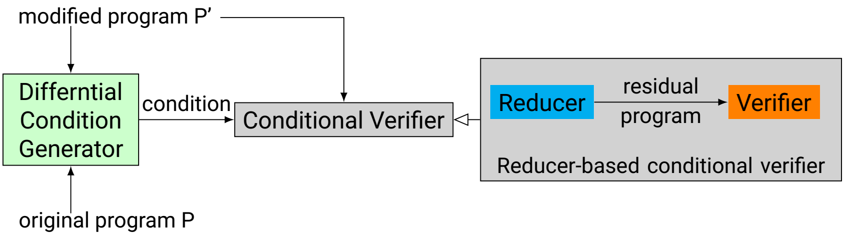
Equivalence checking
- Does not verify property
- Modified program only as correct as original
- Can be expensive

Differential Modular Software Verification
The Basic Idea



Soundness Criterion

Generated condition does not cover any modified execution, i.e., it does not cover executions from $ex(P') \setminus ex(P)$.

Properties of Modular Differential Software Verification

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- Unchanged program parts are as correct as before
- Only verify modified program parts
- Applicable to arbitrary verifiers
  due to reducer-based conditional model checking
- Verifier can be newly selected for each modified program

Syntactic Differential Condition Generator

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1. Detect differences
   - Compute the parallel composition of original and modified program
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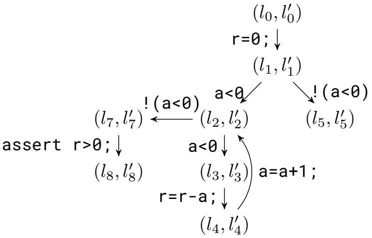

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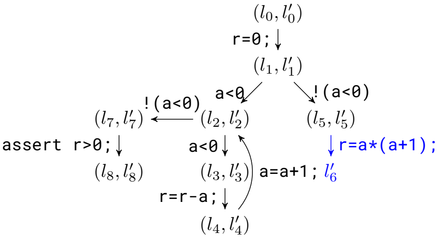

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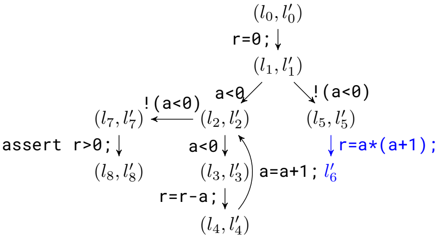

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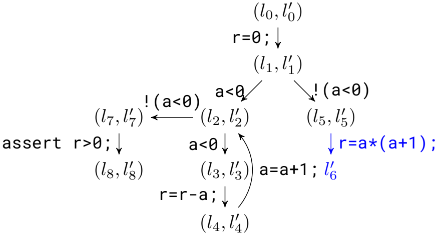

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Theorem (proven): Syntactical generator fulfills soundness criterion

Evaluation Setting

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Environment

- Similar to SV-COMP
- But only granted 4 cores

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Verifiers

- Predicate-based, native conditional model checker
- CPASeq
- Ultimate Automizer

Evaluation Tasks

- Combinations of two SV-COMP tasks

```
void main() {
  if(__VERIFIER_nondet_int())
    main1();
  else
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Evaluation Tasks

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- (1) eca+token, (2) gcd+newton, (3) pals+eca, (4) sfifo+token, (5) square+soft, and (6) ssh (client+server)

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- Program Modification
  - Replace one SV-COMP task by another of same category
  - Either fix an unsafe program or
  - Introduce a bug in a safe program

  $\Longrightarrow$ Full verification and our approach find the same violations

Full vs. Differential (native CMC)

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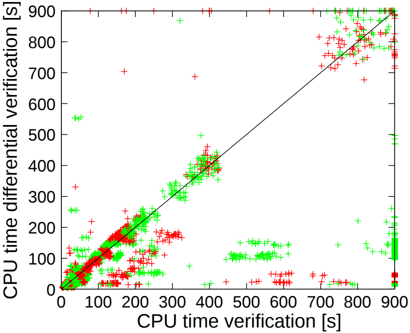
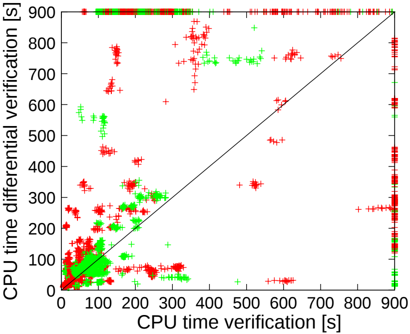


Typically, modular differential software verification similar or better

Full vs. Differential (reducer-based CMC)



- Modular differential software verification can be better
- Full verification often better
  (modular differential software verification suffers from residual programs)

Comparison with Precision Reuse

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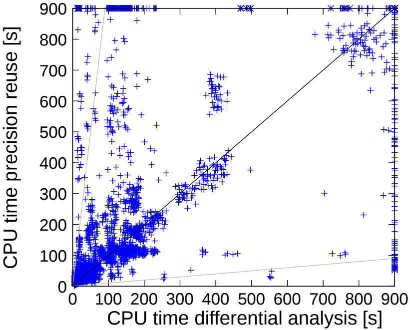

- Modular differential software verification often better than precision reuse
- Combination of two approaches often not beneficial

Conclusion

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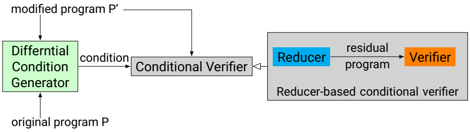
Proposed differential modular software verification



Identified weaknesses

- Evaluation only on artificial benchmarks
- Syntactic difference often too imprecise in practice
- Suffers from residual program structure