Case Study on Verification-Witness Validators

Where We Are and Where We Go

Dirk Beyer and Jan Strejček
LMU Munich, Germany and Masaryk University, Czechia

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

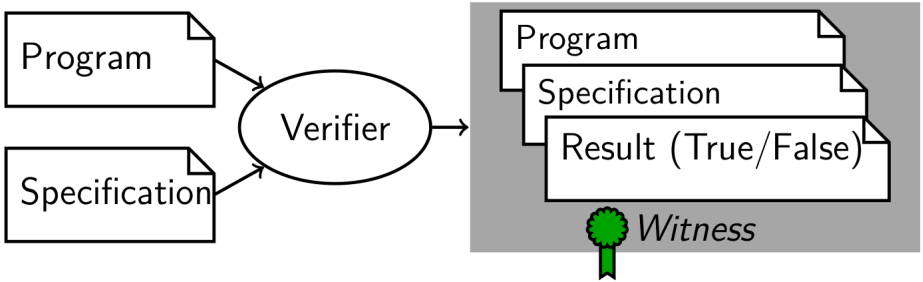
SoSy-Lab Software Systems

Static Analysis

- Goal: Verify correctness of computer programs
- Problem: Programming bugs in analysis tools lead to wrong results
- Solution: Witness-based result validation [3, 1, 2]
- State of the art: Yearly evaluation by SV-COMP gives overview of
  - 76 tools for static analysis (accumulated)
  - 10 validators for verification witnesses

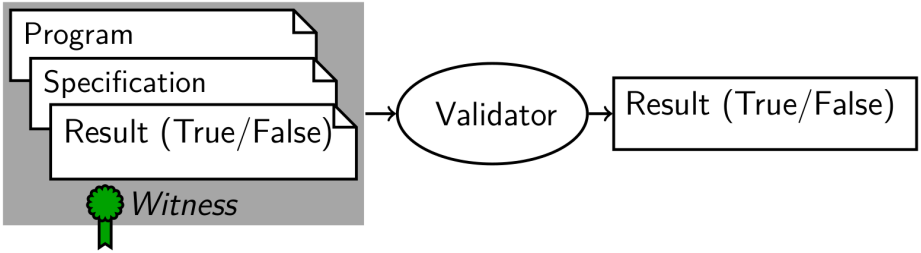
Software Verification with Witnesses

The verification witness explains and justifies the verification result.



[3, Proc. FSE 2015] [1, Proc. FSE 2016]

Witness Validation



- Validate untrusted results
- Easier than full verification

(Some) Validators are Buggy — Violation Witnesses

Category	Witnesses	CPAchecker	CPA-w2t	CProver-w2t	Dartagnan	MetaVal	nitwit	Symbiotic -Witch	uAutomizer
ReachSafety	5177	28	12	2	-	0	10	0	0
MemSafety	2804	0	0	26	-	2	-	0	0
ConcurrencySafety	1293	40	-	-	0	-	-	-	-
NoOverflows	167	0	0	0	-	0	-	0	0
Termination	56	21	-	-	-	0	-	-	0
SoftwareSystems	5903	5	0	27	-	0	0	51	4

Numbers of invalid violation witnesses
(resulting from incorrect verification results)
validated by witness validators

(Some) Validators are Buggy — Correctness Witnesses

Category	Witnesses	CPAchecker	MetaVal	UAutomizer
ReachSafety	894	0	315	3
MemSafety	326	-	0	0
NoOverflows	300	0	36	0
SoftwareSystems	888	0	403	0

Numbers of invalid correctness witnesses
(resulting from incorrect verification results)
validated by witness validators

Current Interpretation of Validator Output in a Compatition

Output for a violation witness

- `false` $\longrightarrow$ witness is confirmed $\longrightarrow$ verifier receives 1 point
- `true` or `unknown` $\longrightarrow$ witness is not confirmed $\longrightarrow$ verifier receives 0 points

Current Interpretation of Validator Output in a Compatition

Output for a violation witness

- `false` $\longrightarrow$ witness is confirmed $\longrightarrow$ verifier receives 1 point
- `true` or `unknown` $\longrightarrow$ witness is not confirmed $\longrightarrow$ verifier receives 0 points

Output for a correctness witness

- `true` $\longrightarrow$ witness is confirmed $\longrightarrow$ verifier receives 2 points
- `false` or `unknown` $\longrightarrow$ witness is not confirmed $\longrightarrow$ verifier receives 0 points

Current Interpretation of Validator Output in a Compatition

Output for a violation witness

- `false` $\longrightarrow$ witness is confirmed $\longrightarrow$ verifier receives 1 point
- `true` or `unknown` $\longrightarrow$ witness is not confirmed $\longrightarrow$ verifier receives 0 points

Output for a correctness witness

- `true` $\longrightarrow$ witness is confirmed $\longrightarrow$ verifier receives 2 points
- `false` or `unknown` $\longrightarrow$ witness is not confirmed $\longrightarrow$ verifier receives 0 points

Validators not used to refute a witness!

New Interpretation of Validator Output

Output for a violation witness

- `false` $\longrightarrow$ witness is confirmed
- `true` $\longrightarrow$ witness is refuted
- `unknown` $\longrightarrow$ witness is not confirmed/refuted

A violation witness should be refuted if it represents no program execution violating the considered property.

New Interpretation of Validator Output

Output for a violation witness

- `false` $\longrightarrow$ witness is confirmed
- `true` $\longrightarrow$ witness is refuted
- `unknown` $\longrightarrow$ witness is not confirmed/refuted

A violation witness should be refuted if it represents no program execution violating the considered property.

Output for a correctness witness

- `true` $\longrightarrow$ witness is confirmed
- `false` $\longrightarrow$ witness is refuted
- `unknown` $\longrightarrow$ witness is not confirmed

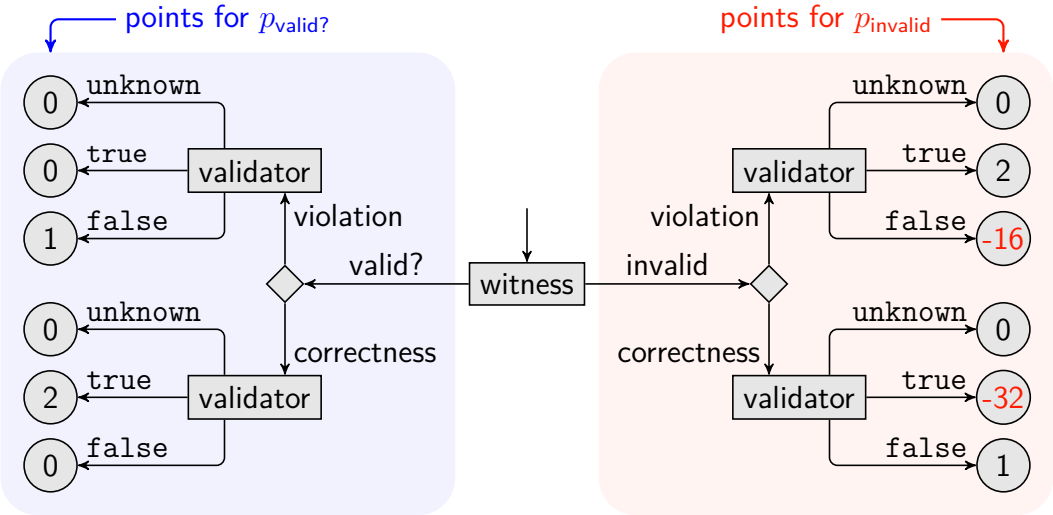
A correctness witness should be refuted if it contains an invariant that does not hold or if the program violates the considered property.

Competition Track for Witness Validators in SV-COMP 2023

Benchmark set:

- Witnesses from SV-COMP 2023 itself
- Invalid witnesses = witnesses of incorrect verification results
- Valid? witnesses = witnesses of correct verification results (may be incorrect)

Scoring Schema for One Category



Competition Track for Witness Validators in SV-COMP 2023

Competition track:

- Same deadlines and schedule as SV-COMP 2023
- Pre-runs of verifiers produce benchmarks for preruns of validators
- Officially only one category **Overall**
- Overall score computed by the same procedure as in SV-COMP from scores in individual categories

Conclusion

- Validators are an important part of the verification eco system
- They include bugs, just like verifiers
- We proposed a competition track on validators
  $\rightarrow$ community accepted the proposal, and SAS reviewers accepted the paper
- From SV-COMP 2023, there will be a yearly evaluation of validators
- Paper [4] in Proc. SAS 2022: doi:10.1007/978-3-031-22308-2_8

References I

[1] Beyer, D., Dangl, M., Dietsch, D., Heizmann, M.: Correctness witnesses: Exchanging verification results between verifiers. In: Proc. FSE. pp. 326–337. ACM (2016). https://doi.org/10.1145/2950290.2950351

[2] Beyer, D., Dangl, M., Dietsch, D., Heizmann, M., Lemberger, T., Tautschnig, M.: Verification witnesses. ACM Trans. Softw. Eng. Methodol. **31**(4), 57:1–57:69 (2022). https://doi.org/10.1145/3477579

[3] Beyer, D., Dangl, M., Dietsch, D., Heizmann, M., Stahlbauer, A.: Witness validation and stepwise testification across software verifiers. In: Proc. FSE. pp. 721–733. ACM (2015). https://doi.org/10.1145/2786805.2786867

[4] Beyer, D., Strejček, J.: Case study on verification-witness validators: Where we are and where we go. In: Proc. SAS. pp. 1–15. LNCS 13790, Springer (2022). https://doi.org/10.1007/978-3-031-22308-2_8