TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

logics Logical Methods in Computer Science

Microsoft

Satisfiability-Preserving Reasoning in Software Verification

Adrián Rebola-Pardo (TU Wien)

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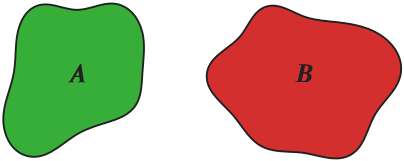
Interpolation for model checking

Craig interpolants $A \wedge B$ unsatisfiable



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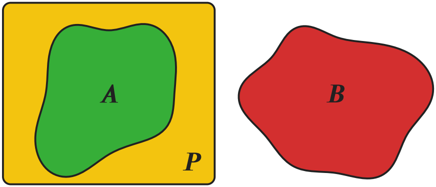
- $A \models P$
- $P \wedge B$ is unsatisfiable
- $\mathrm{var}(P) \subseteq \mathrm{var}(A) \cap \mathrm{var}(B)$



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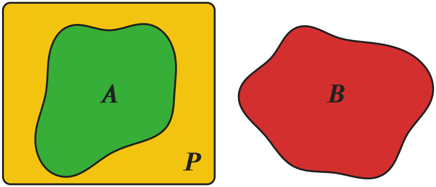
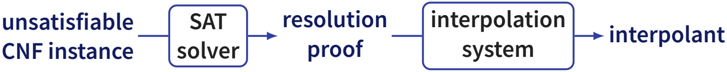


Interpolant-based model checking

- Interpolants help us avoid state space blow-up
- Complete, unbounded model checking through SAT solving is attained

Interpolant generation

The good old times



unsatisfiable CNF instance

SAT solver

resolution proof

interpolation system

interpolant

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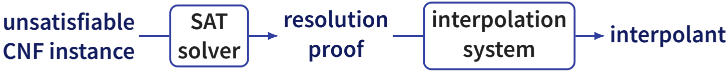

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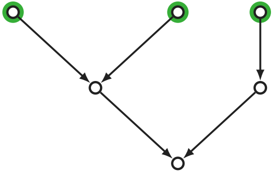

The induction invariant of this recursion depends strongly on soundness.

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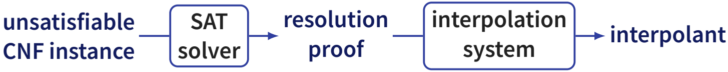
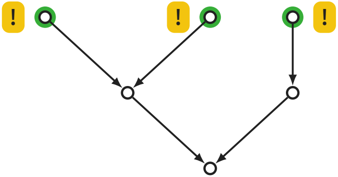


unsatisfiable CNF instance → SAT solver → resolution proof → interpolation system → interpolant

Interpolant generation from resolution proofs



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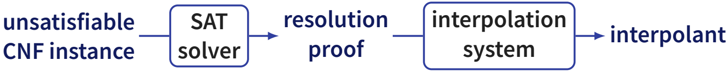

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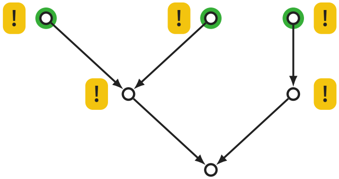

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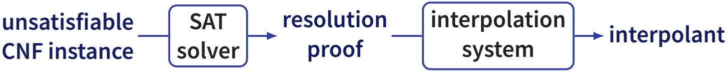

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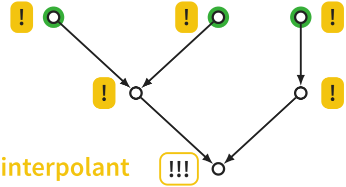

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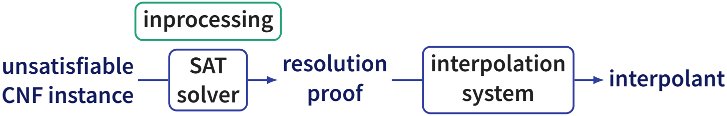

Inprocessing techniques and DRAT proofs

Interpolant generation

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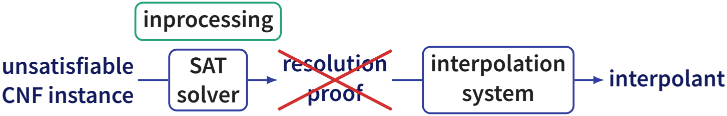

Inprocessing techniques and DRAT proofs

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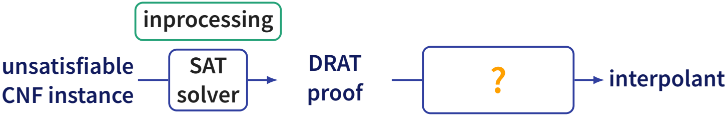

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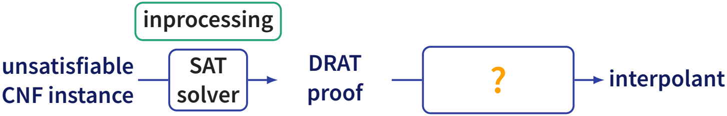
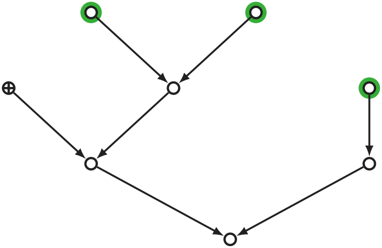


Inprocessing techniques and DRAT proofs

- Inprocessing techniques cannot be expressed by resolution proofs.
- No interpolation system is known for DRAT proofs.
- DRAT proofs can derive clauses that are not implied.

DRAT proofs

DRAT proofs



DRAT proofs

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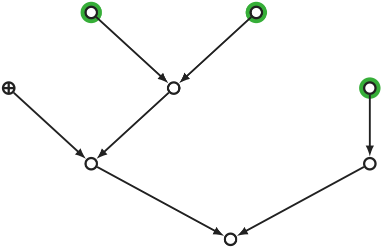

RAT,
not a consequence

DRAT proofs

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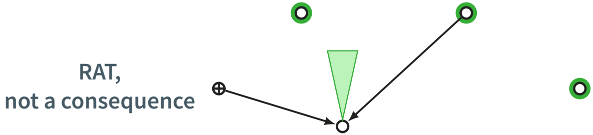

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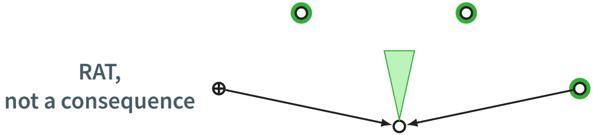

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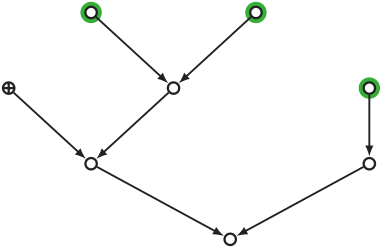

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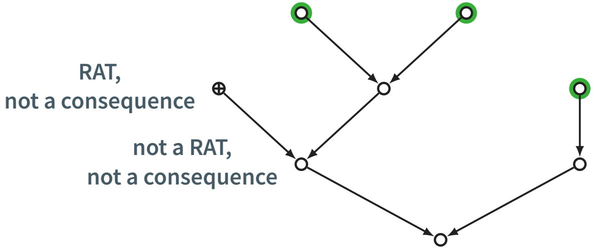

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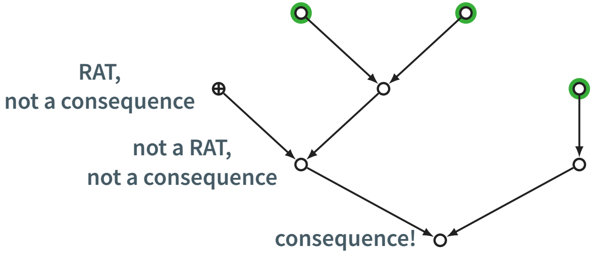

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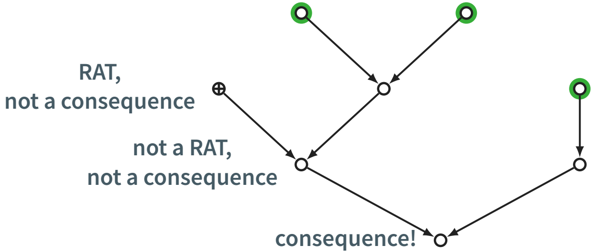

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Some invariant seems to be preserved...

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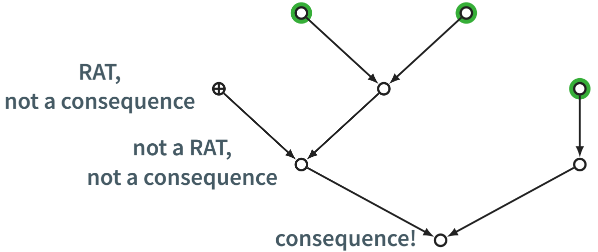

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resolution consequence *[Philipp, Rebola-Pardo: LPAR '17]*

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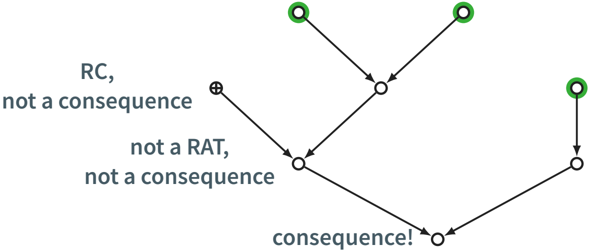

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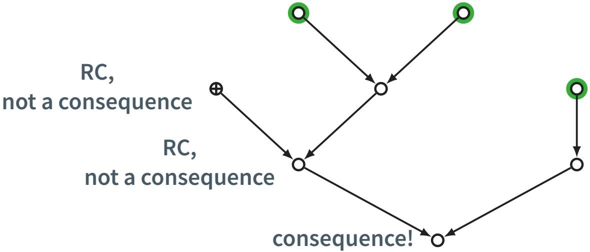

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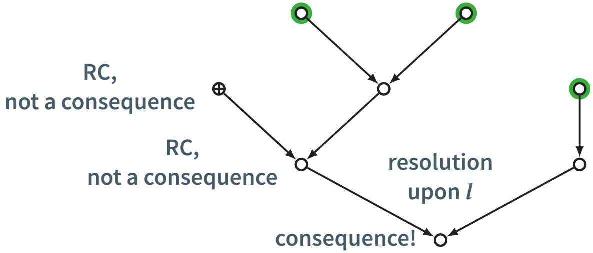

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Interpolation from DRAT proofs

Idea convert DRAT proofs to resolution proofs

[Rebola-Pardo, Weissenbacher: manuscript]

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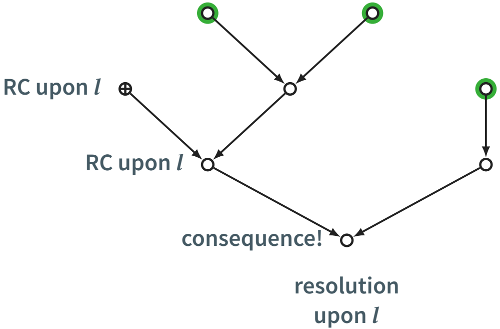
RAT elimination



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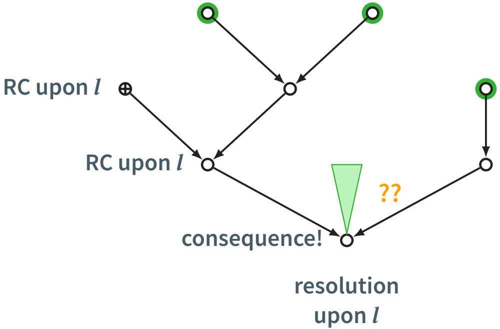

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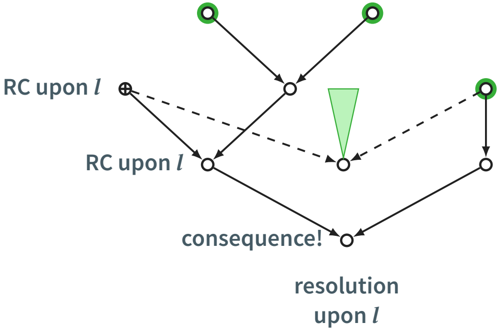

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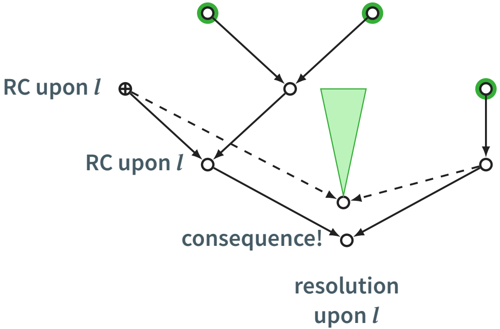

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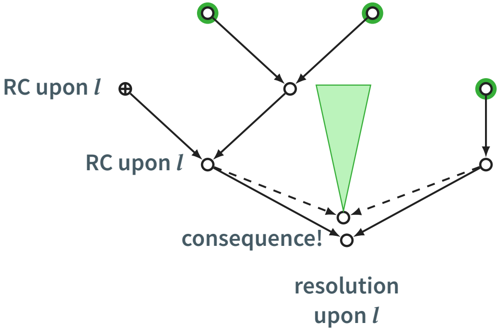

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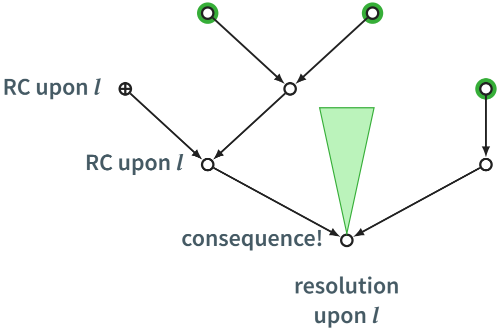

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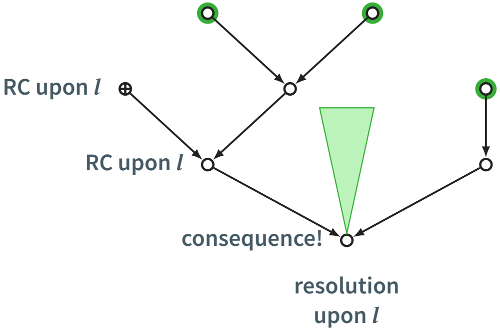

Good news an interpolant can be generated from a resolution proof

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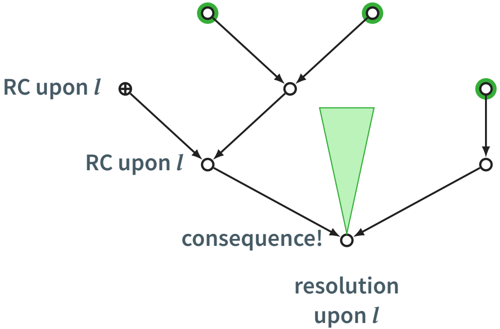

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Bad news converting DRAT proofs to resolution proofs is exponential...