Combining Verifiers in Conditional Model Checking[1]

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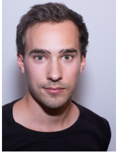
Joint work with Dirk Beyer, Thomas Lemberger, and Heike Wehrheim

LMU Munich, Germany



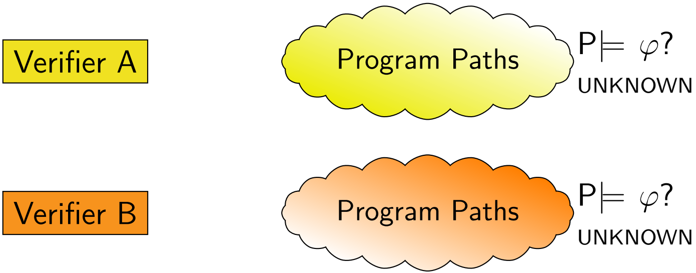
[1] https://www.sosy-lab.org/research/reducer/

Many Verification Tools Available

HipTNT+
VeriAbs
CPA-Seq
ConSequence
MU-CSeq
CPA-kInd
Blast
UTaipan
ESBMC-kind
UKojak
UAutomizer
Ceagle
ESBMC-incr
Lazy-CSeq-Abs
DepthK
ESBMC-falsi
AProVE
ESBMC
InterpChecker
Yogar-CBMC
CPA-BAM-Slicing
CIVL
2LS
Skink
SMACK
Symbiotic
PredatorHP
UL-CSeq
SymDIVINE
VIAP
CBMC
CPA-BAM-BnB
Lazy-CSeq
Map2Check
Forester

Facing Hard Verification Tasks

Question: Program $\mathsf{P} \models \varphi$?



Verifier A

Program Paths

$\mathsf{P} \models \varphi$?

UNKNOWN

Verifier B

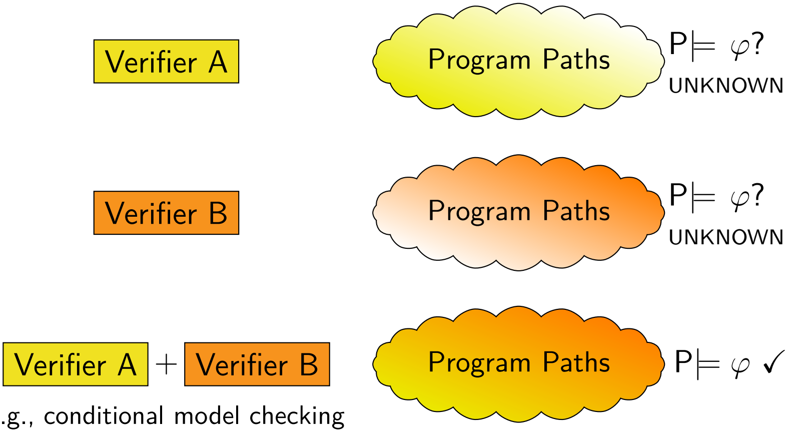
Program Paths

$\mathsf{P} \models \varphi$?

UNKNOWN

Facing Hard Verification Tasks

Question: Program P$\models \varphi$?



Verifier A

Program Paths

P$\models \varphi$?

UNKNOWN

Verifier B

Program Paths

P$\models \varphi$?

UNKNOWN

Verifier A + Verifier B

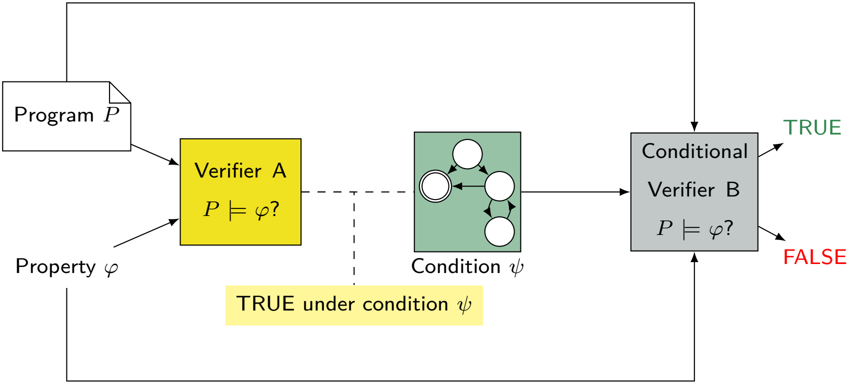
e.g., conditional model checking

Program Paths

P$\models \varphi$ ✓

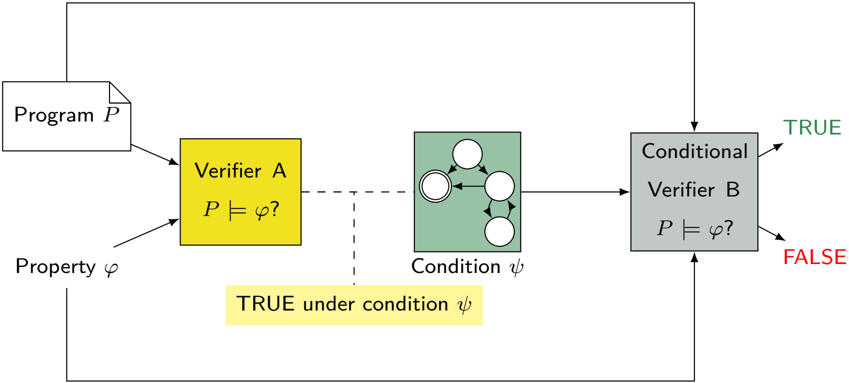
Conditional Model Checking

[Beyer/Henzinger/Keremoglu/Wendler FSE'12]



Conditional Model Checking

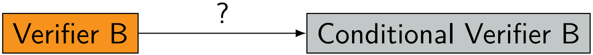
[Beyer/Henzinger/Keremoglu/Wendler FSE'12]



Problem: Often, verifiers are not conditional

Reducer-Based Conditional Verifier Construction

[Beyer/Jakobs/Lemberger/Wehrheim ICSE'18]



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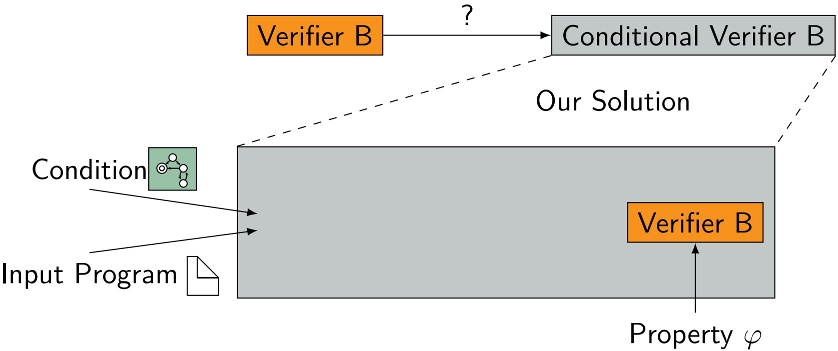

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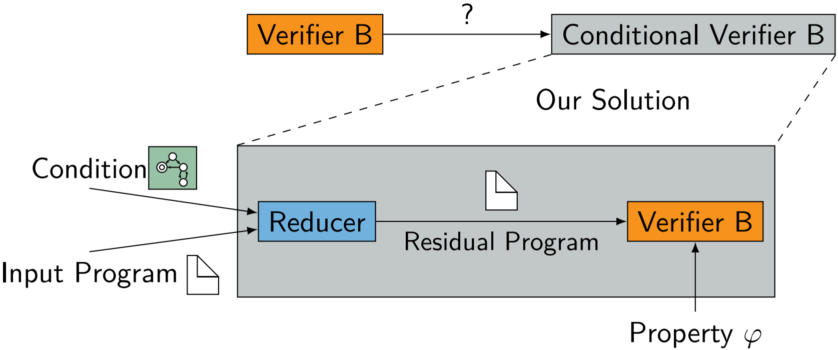
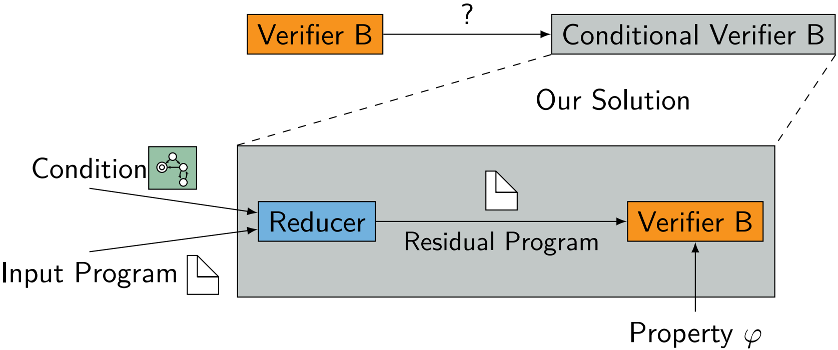


Reducer (preprocessor)

- Builds standard input (C program)
- Representing a subset of paths
- Contains at least all non-verified paths

Reducer-Based Conditional Verifier Construction

[Beyer/Jakobs/Lemberger/Wehrheim ICSE'18]



Reducer (preprocessor)

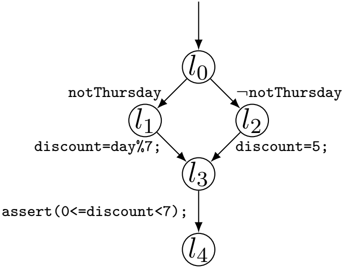
- Builds standard input (C program)
- Representing a subset of paths
- Contains at least all non-verified paths

+ Verifier-unspecific approach   \+ Many conditional verifiers

Example Program and Condition

Program

```
0: if(notThursday)
1:  discount=day%7;
   else
2:  discount=5;
3: assert(0<=discount<7);
4:
```



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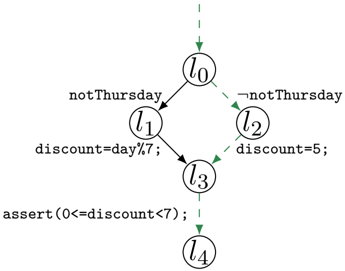

Verifier A only proofs else branch

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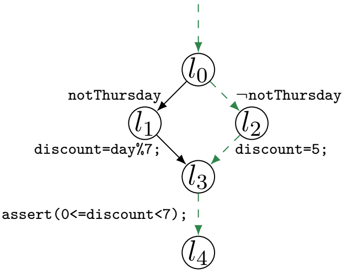
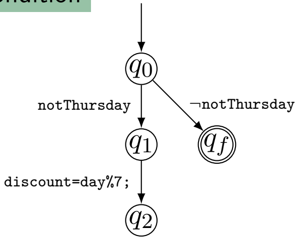


Condition



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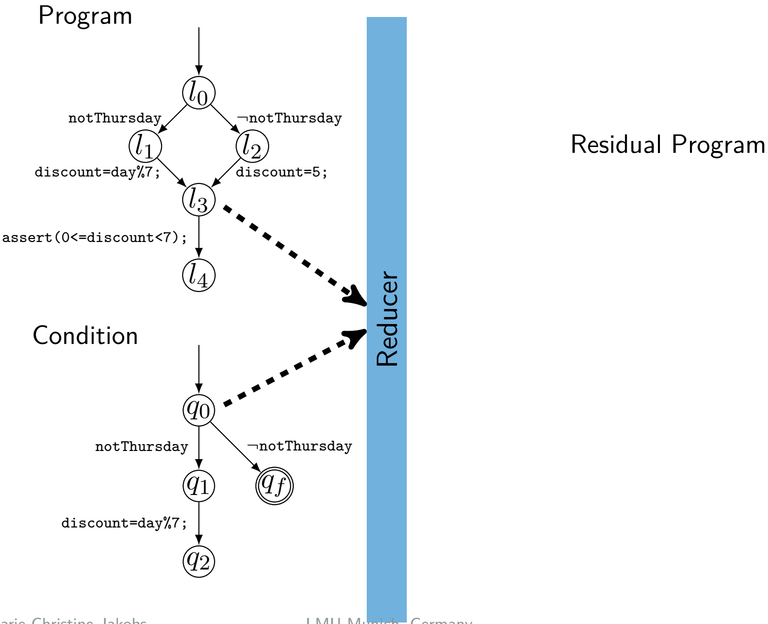
Reducer: Residual Program Construction



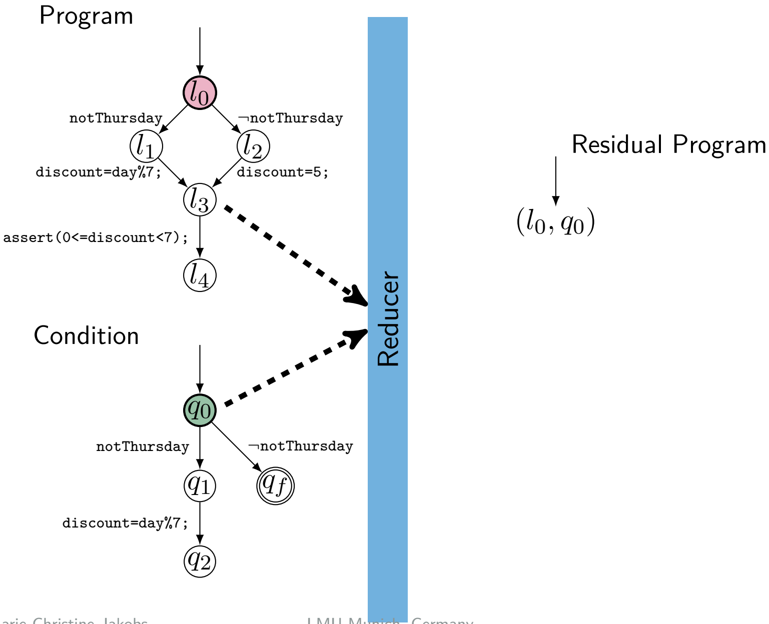
Program

Condition

Reducer

Residual Program

Reducer: Residual Program Construction



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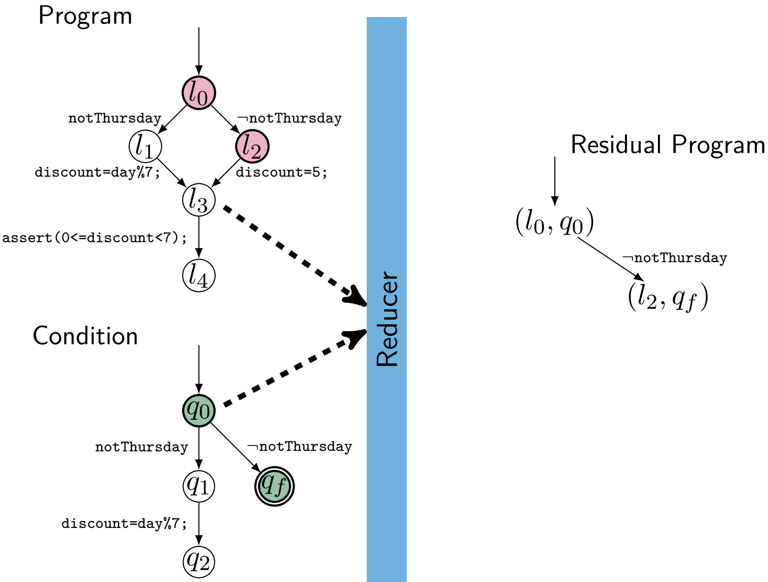

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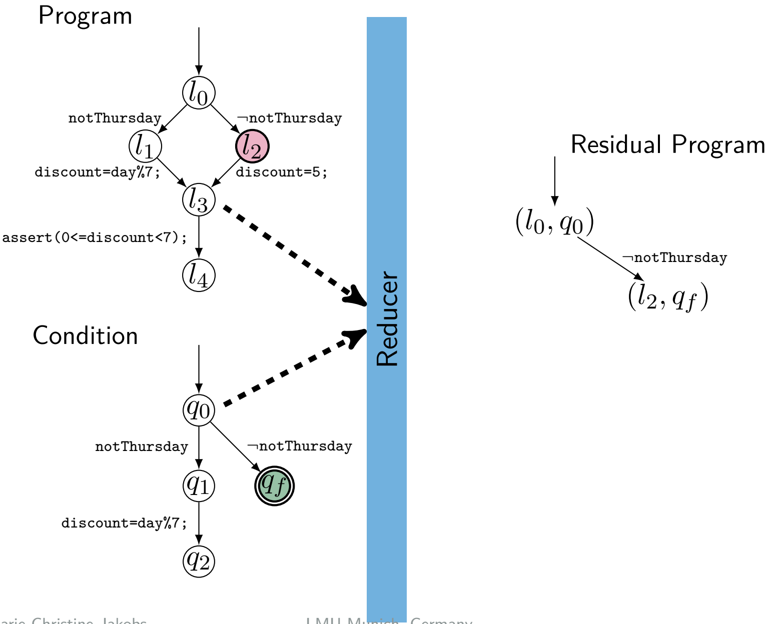

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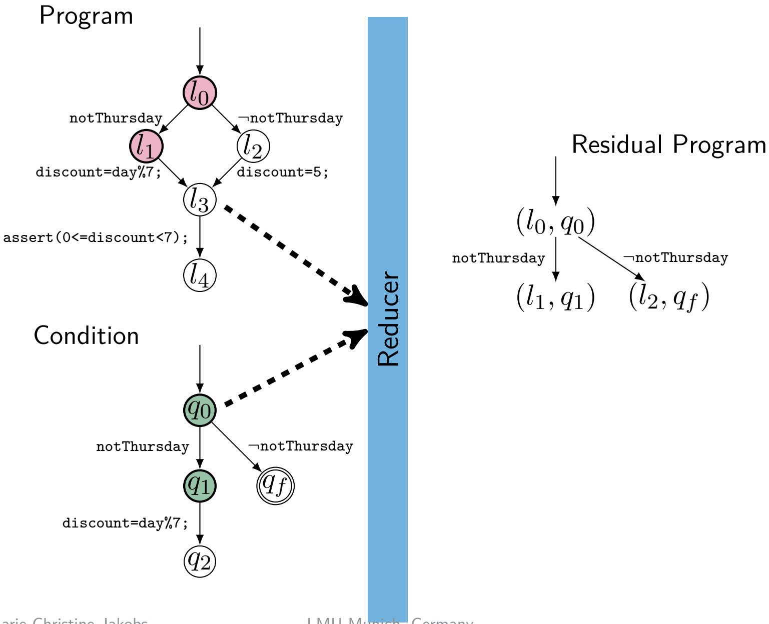

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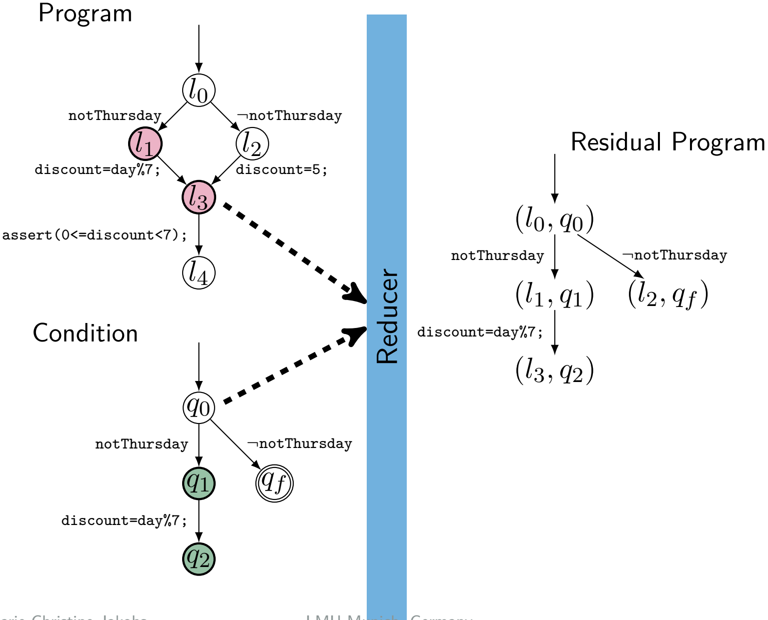

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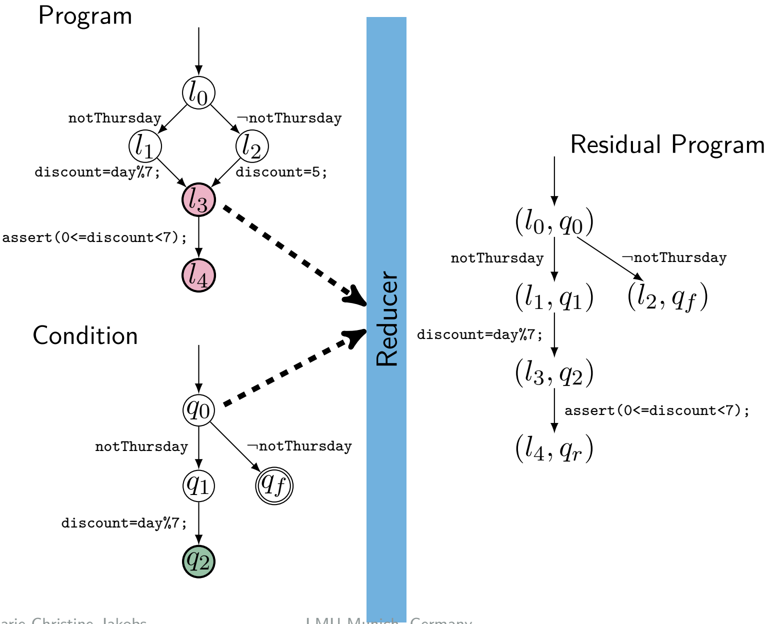
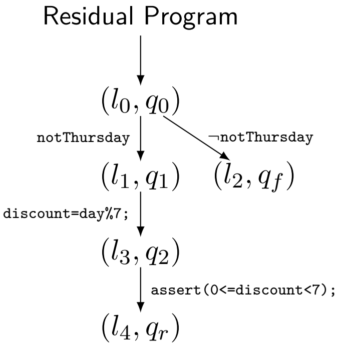
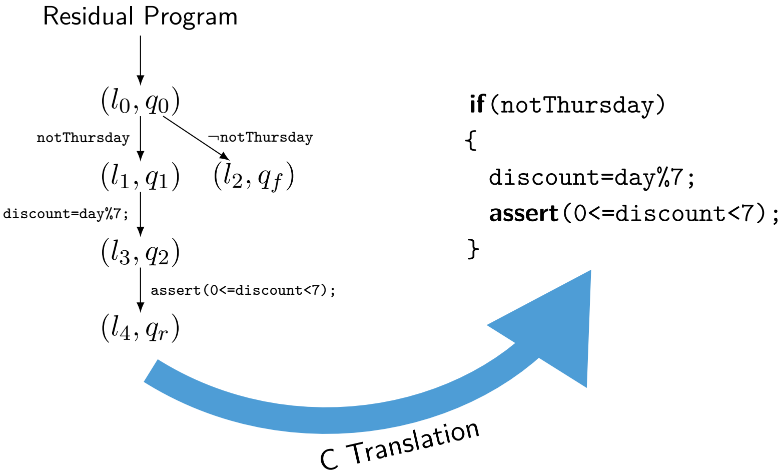


Reducer: C Transformation



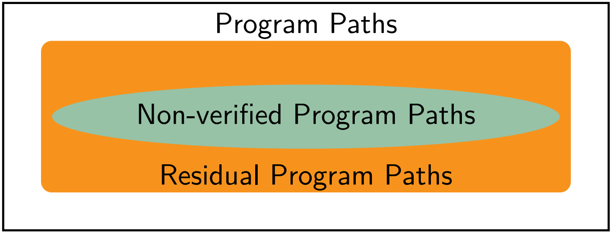
Reducer: C Transformation



```
if(notThursday)
{
  discount=day%7;
  assert(0<=discount<7);
}
```

Reducer: Soundness

Residual Condition



Reducer: Soundness

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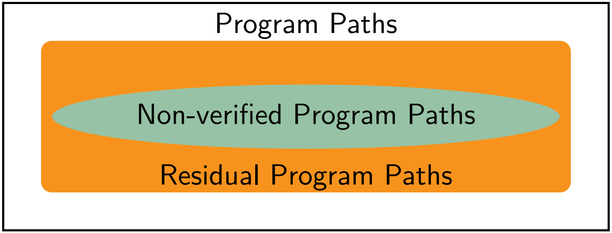
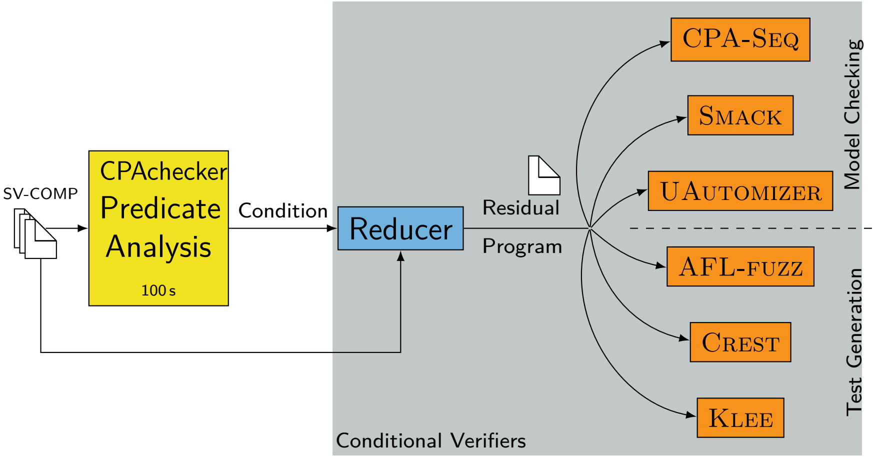


Theorem

Presented reducer fulfills residual condition.

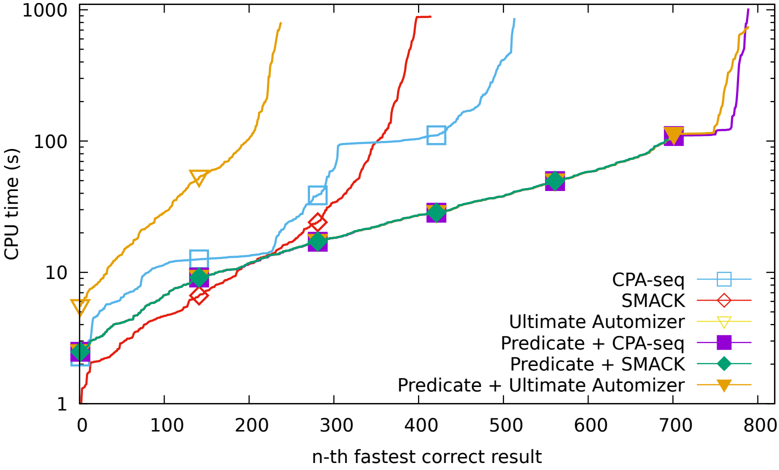
Evaluation Setup



Small Extract of Results

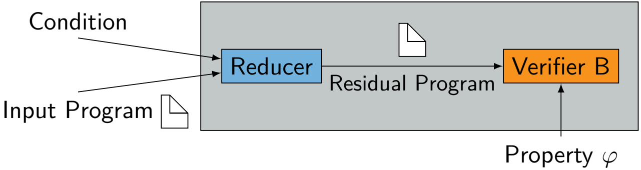
		CPA-Seq		UAutomizer		Predicate +Reducer +CPA-Seq		Predicate +Reducer +UAutomizer	
Task	R	S	t(s)	S	t(s)	S	t(s)	S	t(s)
P15l01	T	✗	910	✗	900	✓	120	✓	130
flood4	T	✗	910	✗	910	✓	450	✗	1100
newt3_6	F	✗	950	✗	490	✗	910	✓	260

Effectiveness on Hard Tasks



Conclusion

- Template-based conditional verifier construction



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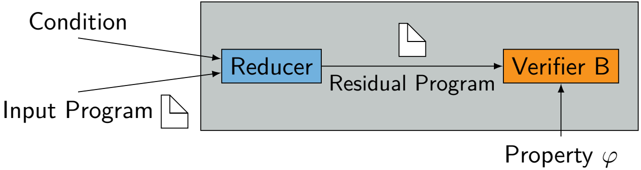

- One Reducer
  - Proven sound
  - Used in many conditional verifiers

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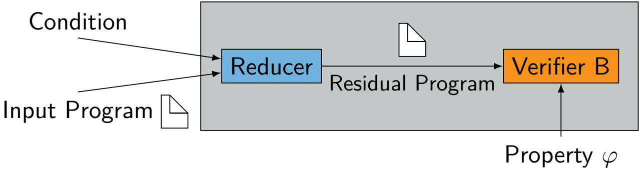

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- Effective on hard tasks for verifiers and test tools

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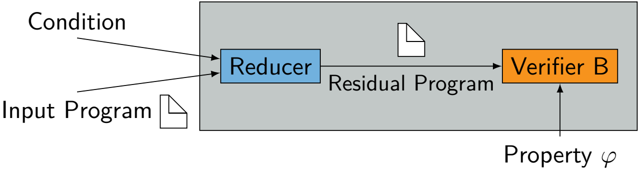
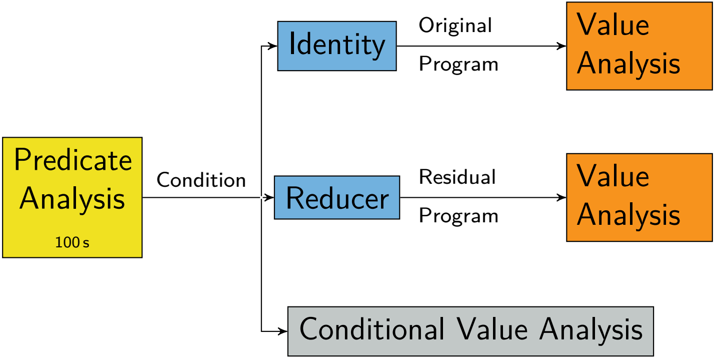
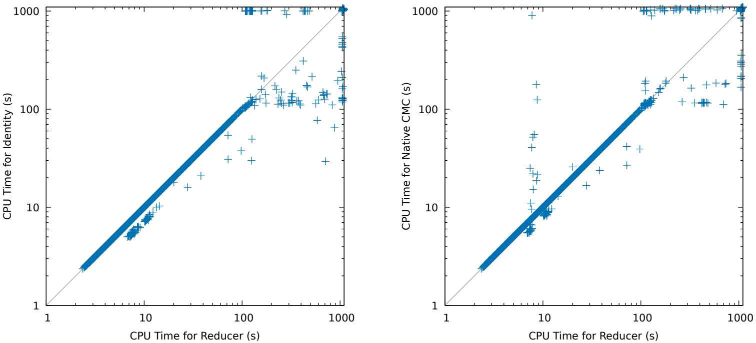


- One Reducer
  - Proven sound
  - Used in many conditional verifiers
- Effective on hard tasks for verifiers and test tools
- Future Work
  - More reducers
  - Using conditions from other tools

Comparison Setup



Comparison Results



(a) Identity vs.reducer

(b) Native vs. reducer-based

References I

- D. Beyer, T. A. Henzinger, M. E. Keremoglu, and P. Wendler. Conditional Model Checking: A Technique to Pass Information Between Verifiers. In *Proc. FSE*. ACM, 2012.

- D. Beyer, M.-C. Jakobs, T. Lemberger, and H. Wehrheim. Reducer-Based Construction of Conditional Verifiers. In *Proc. ICSE*. ACM, 2018.