CSIsat: Interpolation for LA+EUF

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Outline

Definition [Craig 57]

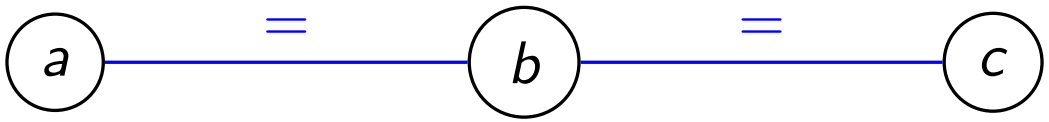
Let A and B be two formulas such that $A \wedge B$ unsat.
An interpolant I has the following properties:

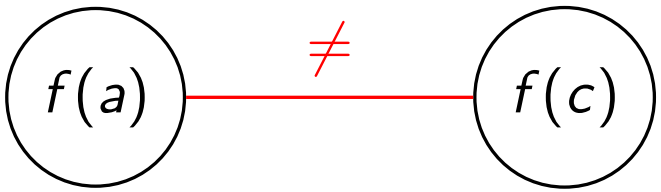
- I contains only AB-common symbols.
- A implies I
- $I \wedge B$ unsat.

Interpolation exists for $\mathrm{LA}+\mathrm{EUF}$.

Interpolant for EUF

A: $a = b \wedge b = c$ B: $f(a) \neq f(c)$





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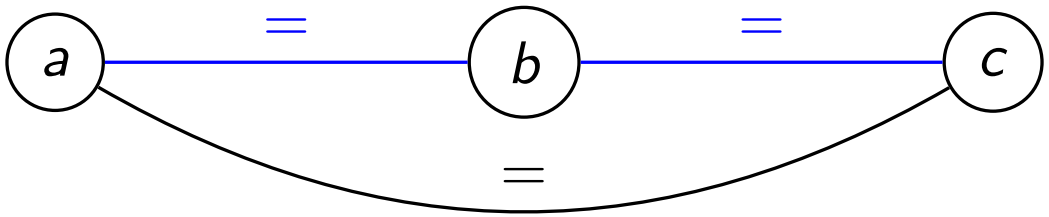

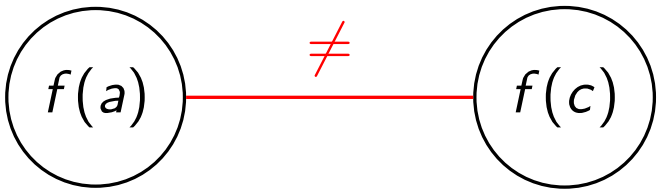

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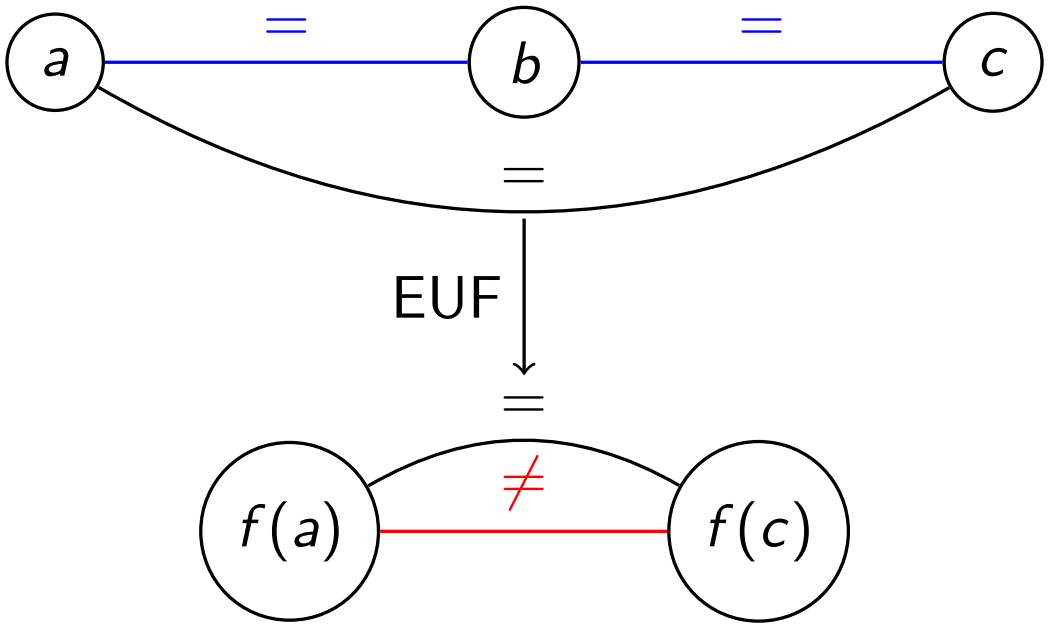

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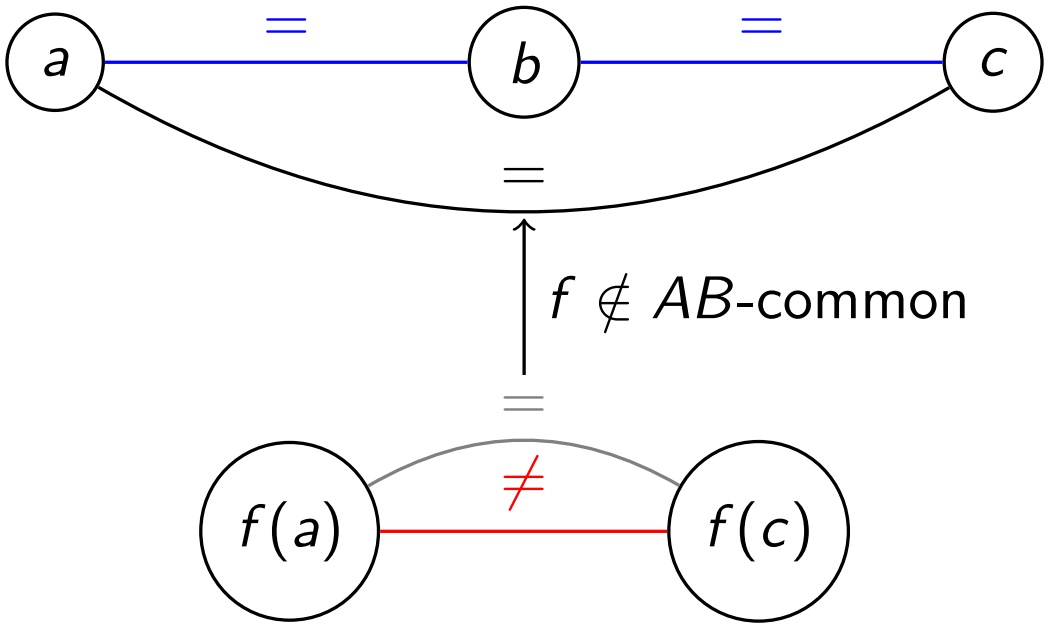

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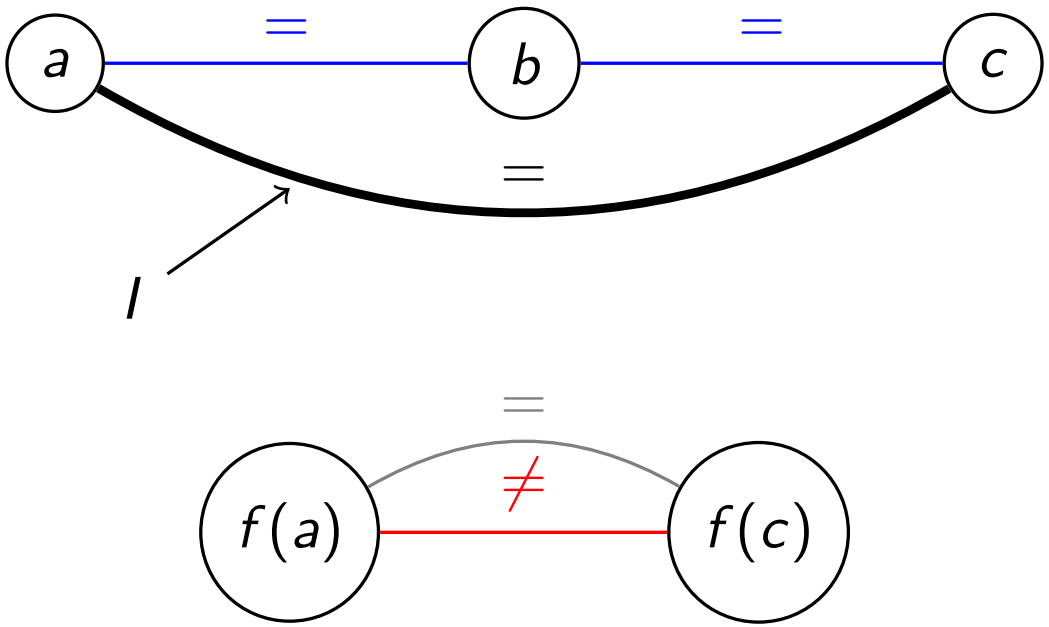
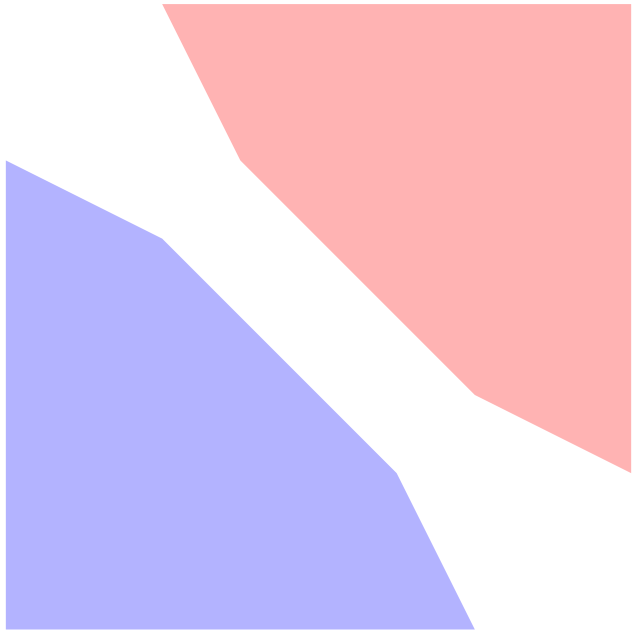


Interpolant for LA

$A\vec{x} \leq \vec{a}$

$B\vec{x} \leq \vec{b}$



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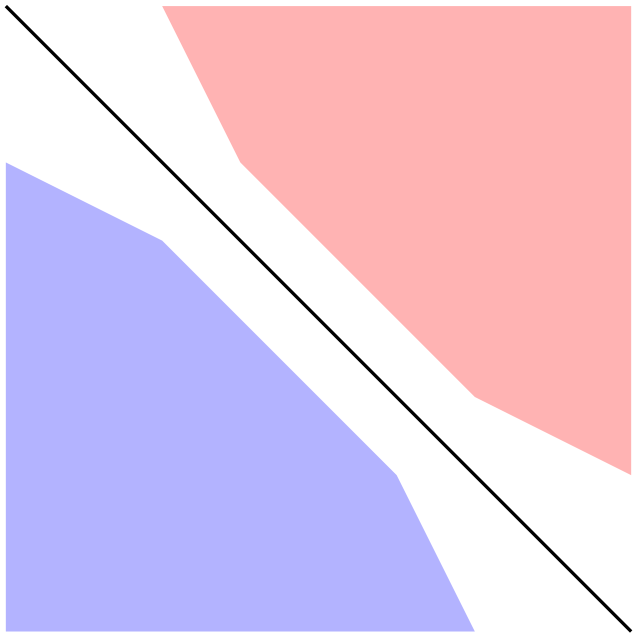

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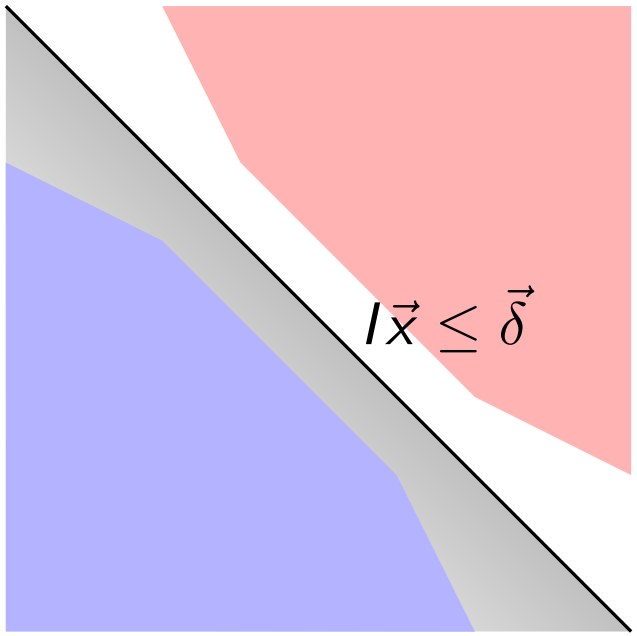

Applications

- Predicate discovery for CEGAR-based model checkers for refinement of abstract states.
- Example: Blast[1] 2.5 is based on CSIsat:

- Open-source software and freely extendable by others.
  - Total of 7500 lines of code written in Ocaml.
  - Includes interpolation code and SMT solver.

[1] http://mtc.epfl.ch/blast/
[2] http://www.kenmcmil.com/foci.html
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Outline

What to give, what to expect

- Input: n formulae $X_1, \ldots, X_n$ such that

$$\bigwedge_{i=1}^{n} X_i \models \bot$$

- Output: $n-1$ interpolants such that

$$\bigwedge_{j=1}^{i} X_j \models I_i$$

$$I_i \wedge \bigwedge_{j=i+1}^{n} X_j \models \bot$$

Syntax

- Formula syntax is very simple and easy to integrate.
- CSIsat supports also Foci syntax.

Example: A: $a = b \wedge b = c$ B: $f(a) \neq f(c)$

```
a = b & b = c    ;    not  f(a) = f(c)
```

Example

Input:

```
a = b;

b = c;

not f(a) = f(c)
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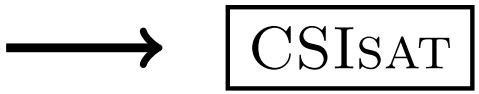

Example

Input:

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a = b;

b = c;

not f(a) = f(c)
```

Output:

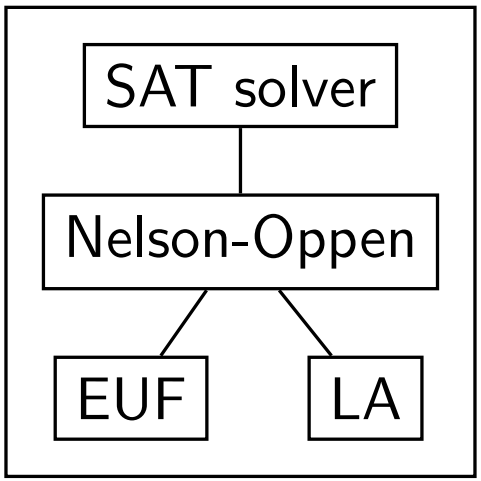
```
a = b

a = c
```

Outline

Architecture

1. Generating a resolution proof of unsatisfiability.



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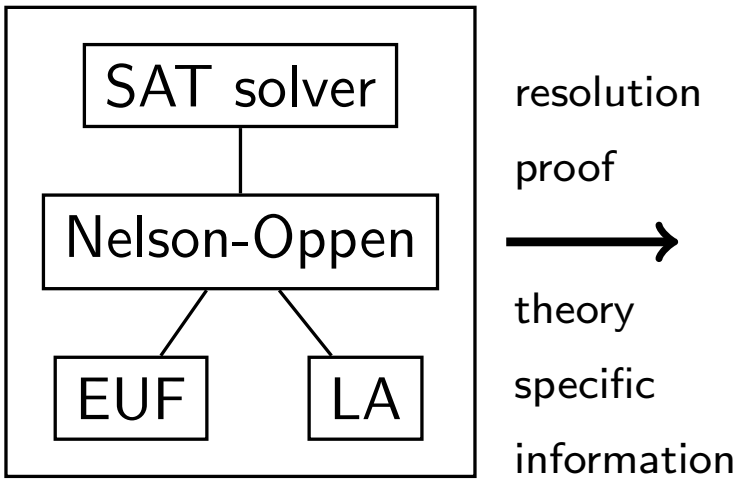

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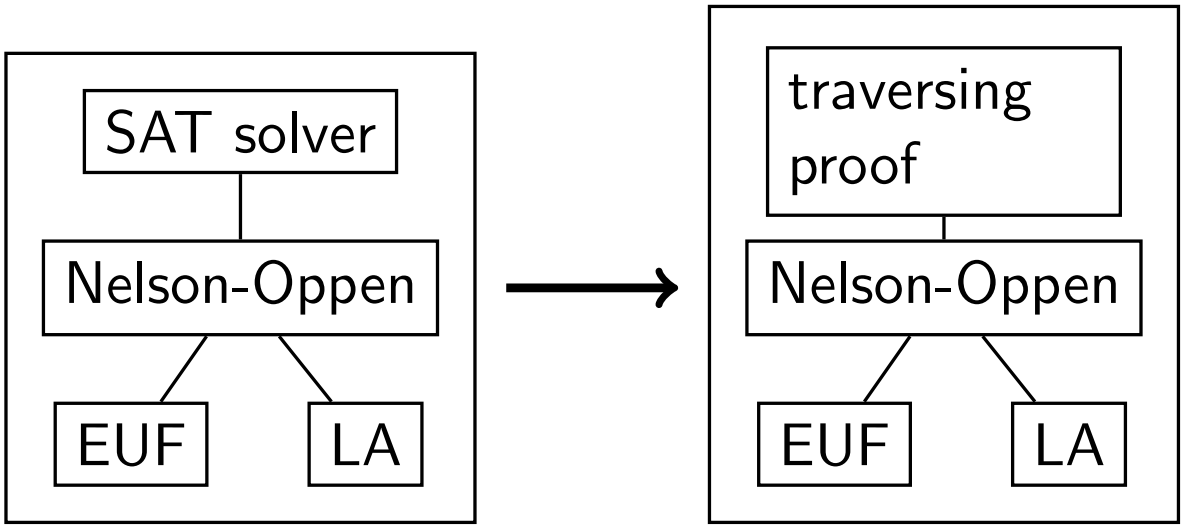

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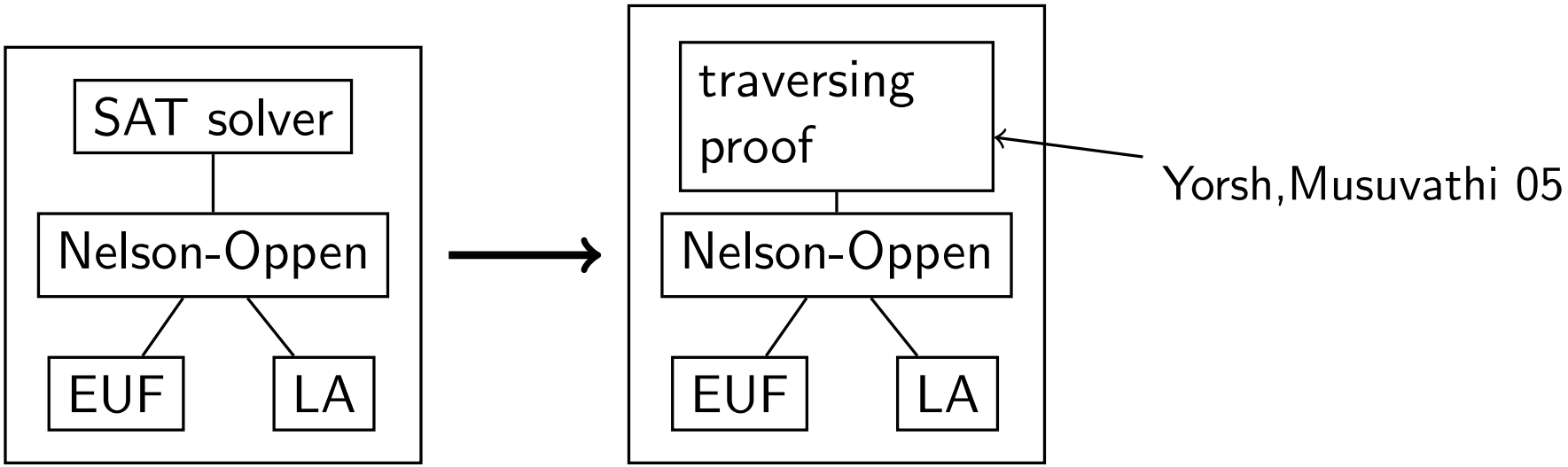

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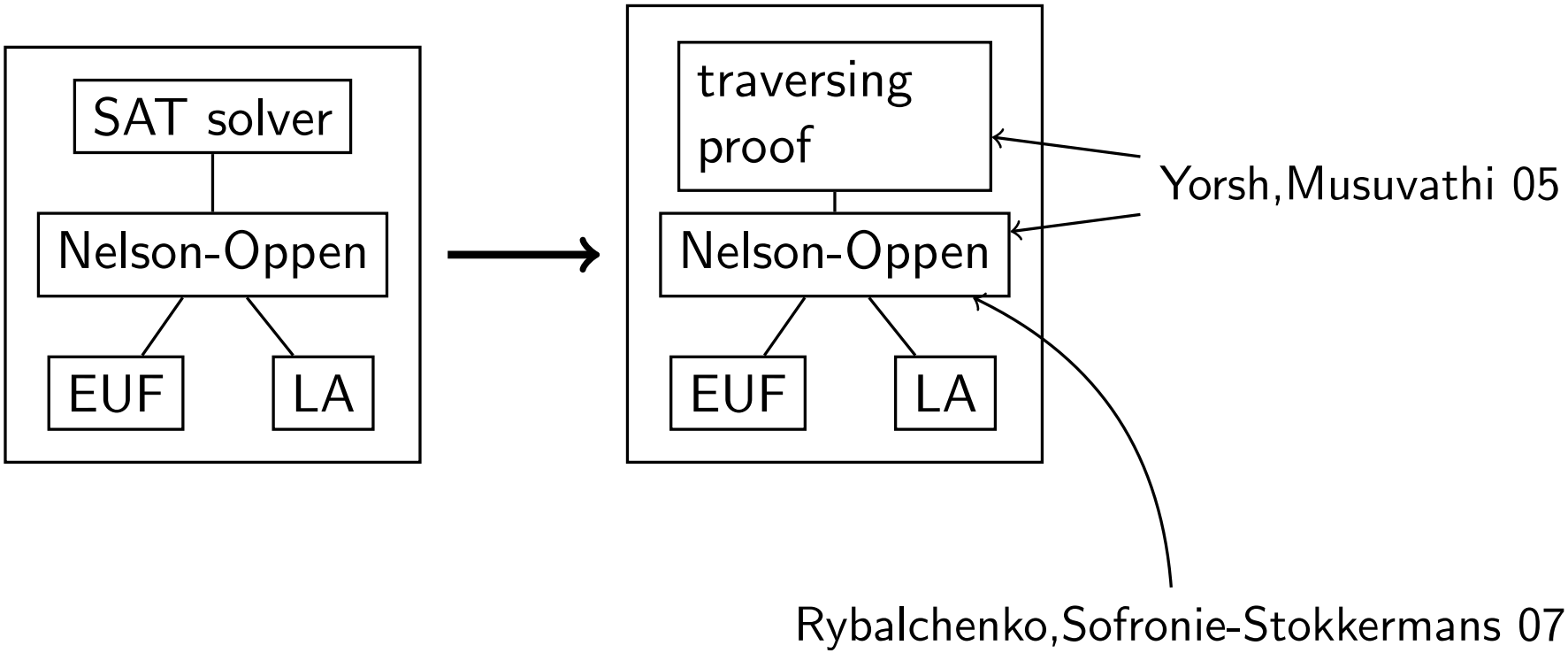

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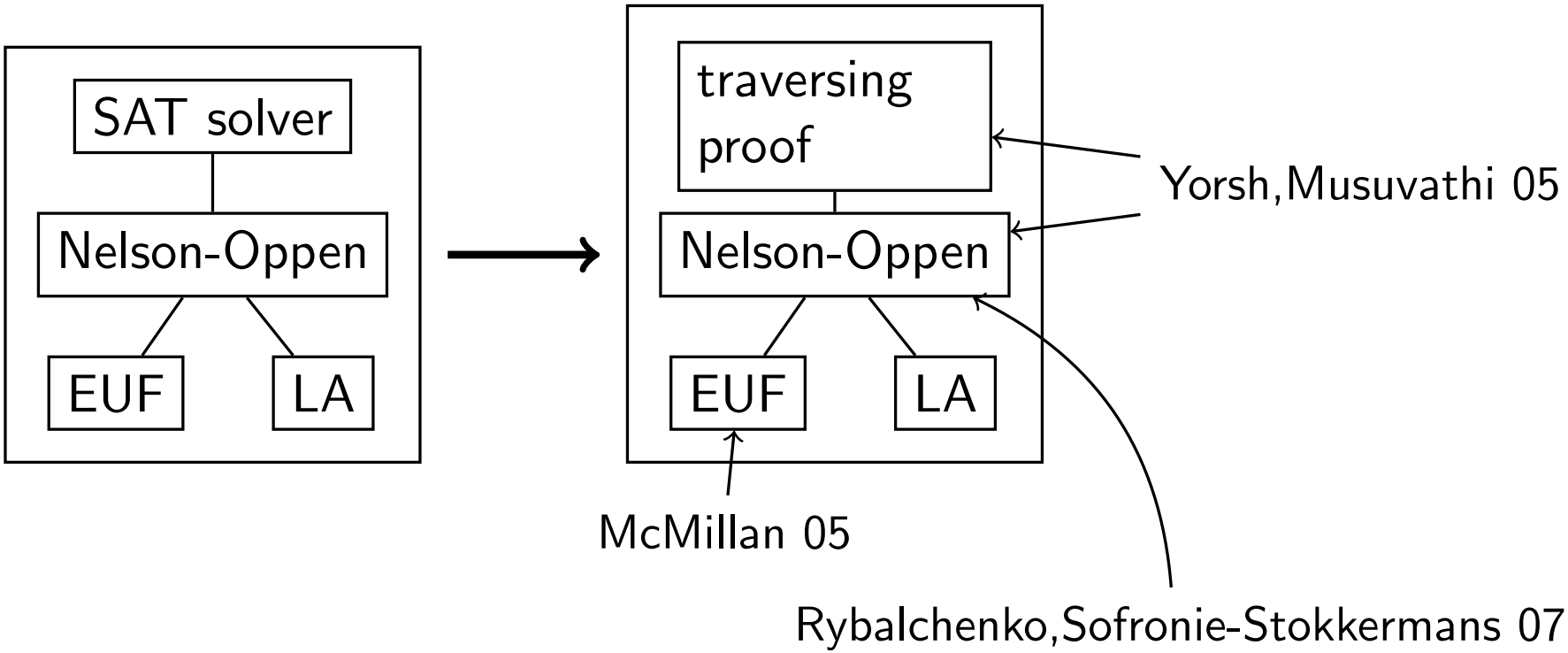

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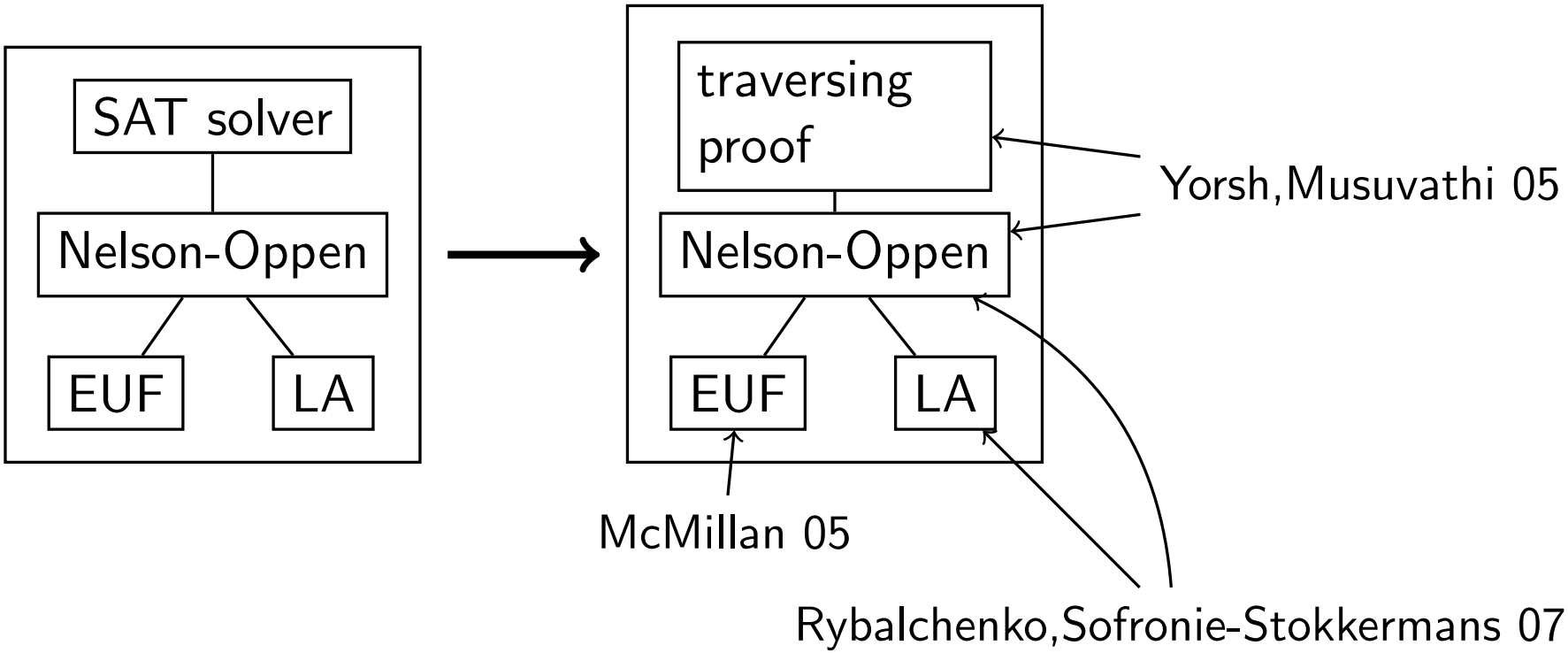

Performance

Program	#queries	Foci	CLPprover	CSIsat
Blast[4]				
floppy	235	1.17 s	1.55 s	**0.55 s**
cdaudio	130	0.60 s	0.70 s	**0.26 s**
ssh	6881	29 s	—	**17 s**
ARMC[5]				
magill	9860	—	30 s	**21 s**

Related work: the new version of MathSAT [CAV 08] can generate interpolants.

[4] http://mtc.epfl.ch/blast/
[5] http://www.mpi-sws.mpg.de/~rybal/armc/

Try it out!

CSIsat is freely available online:

- Project web page:
  `http://www.cs.sfu.ca/~dbeyer/CSIsat`
- Sources and bug reports:
  `http://csisat.googlecode.com`
- Feedback very welcome!

- Questions?