Soufflé is Baked Egg

Building compiler optimizations in Datalog

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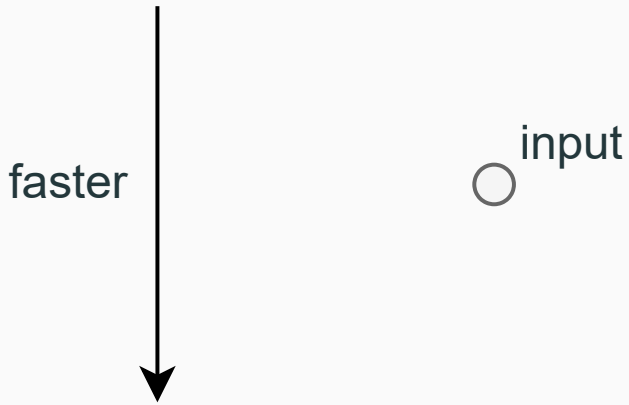
How does a compiler optimize?



Cascade style[1]: explore the space of equivalent programs.

[1] A.k.a. equality saturation.

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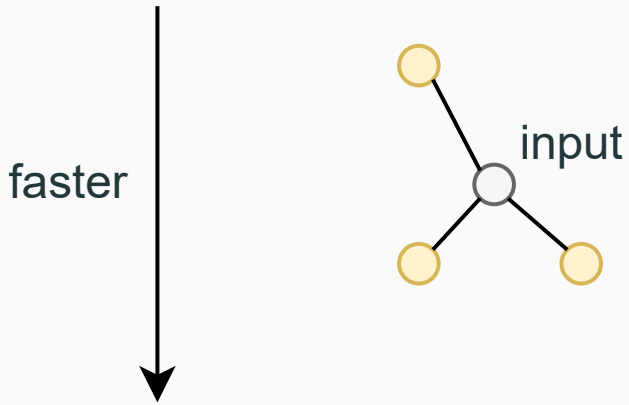

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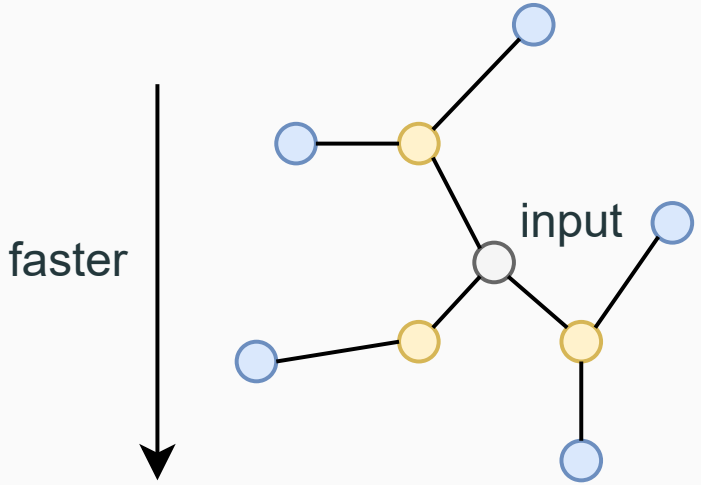

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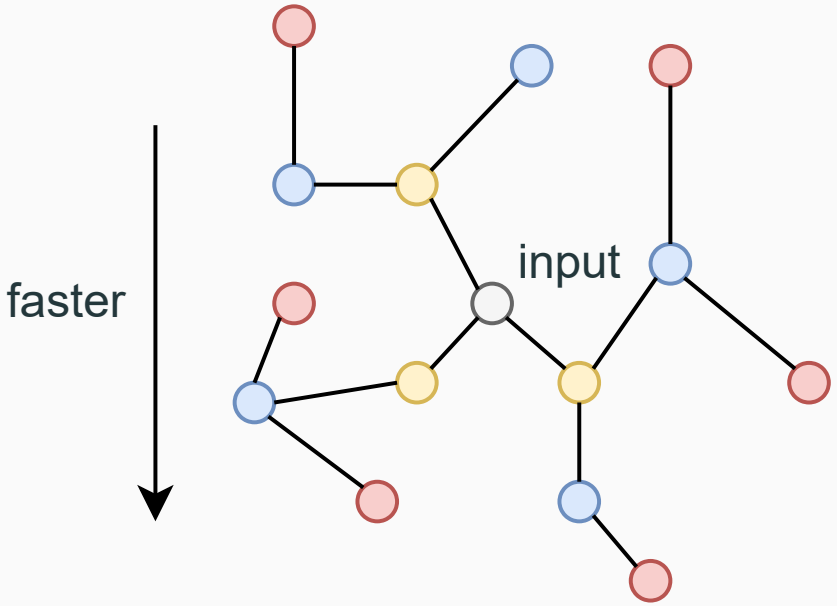

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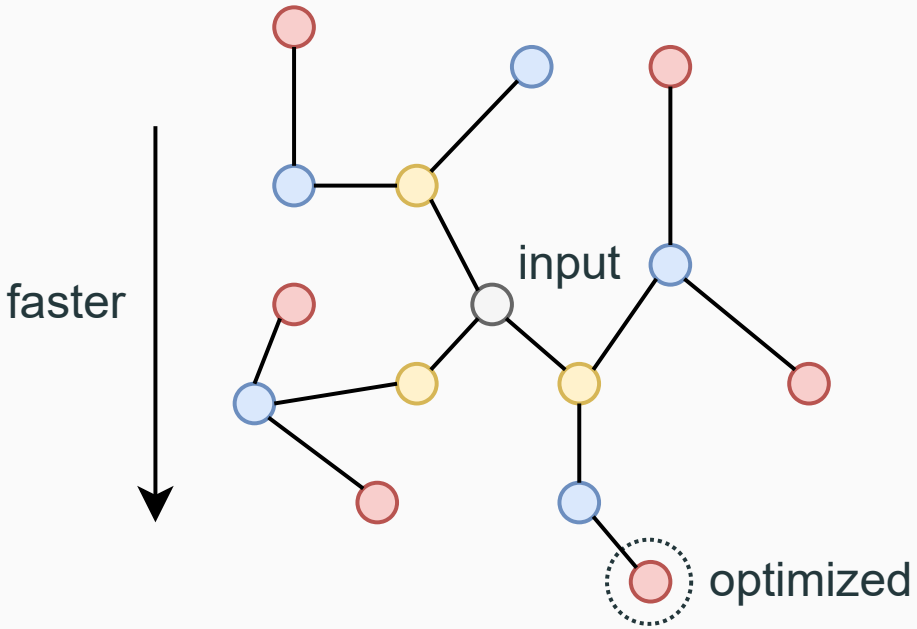

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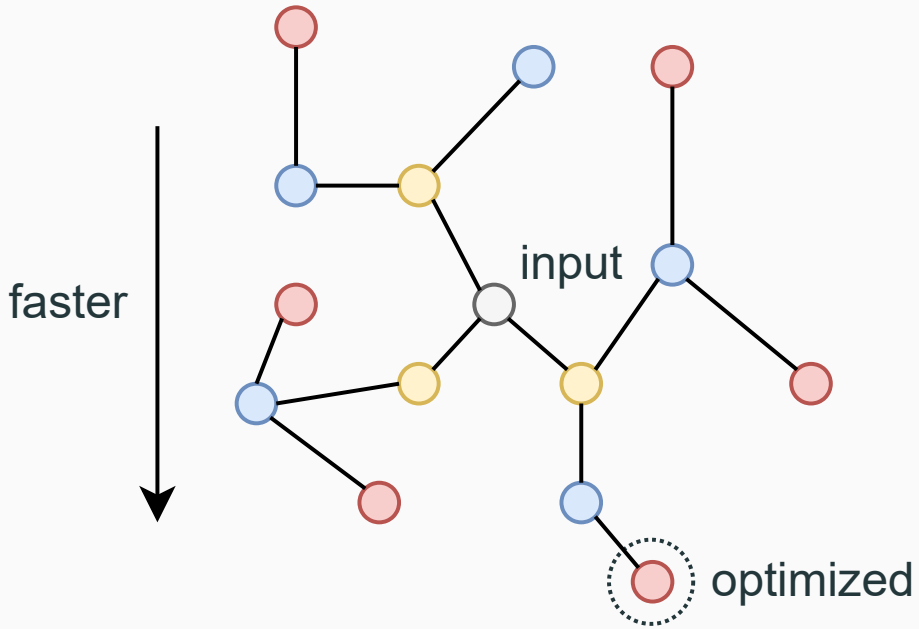

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Main loop: match rewrite rules on programs to grow the set.

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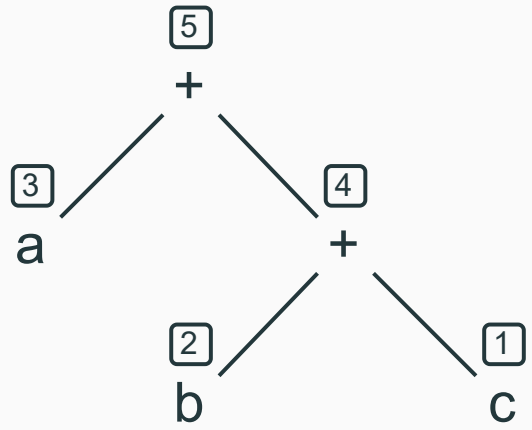
Datalog does that all day, every day!

Optimization in Datalog: Encoding Terms

"Flat" representation of terms:



$\Rightarrow$

var	id_{var}
c	1
b	2
a	3

arg_1	arg_2	id_+
2	1	4
3	2	5

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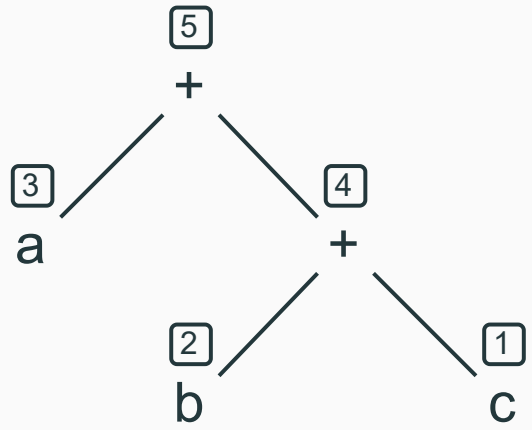

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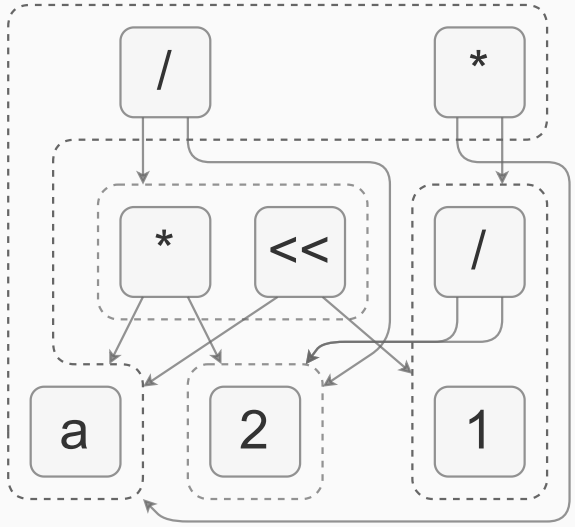
In Soufflé:

```
.type Exp = Add{x:Exp,y:Exp} | Var{n:symbol}
.decl add(x:Exp,y:Exp,id:Exp)
.decl var(v:symbol,id:Exp)
add(x,y,id) :- id=$Add(x,y).
```

Optimization in Datalog: Encoding Terms

Group equivalent subexpressions into **equivalent classes**:



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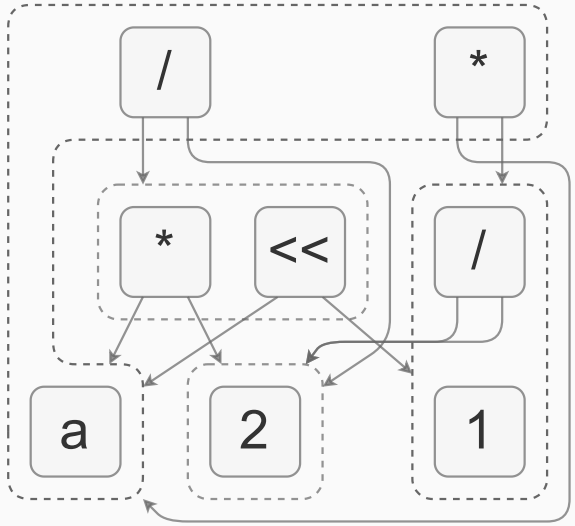


```
.decl eql(x:Exp,y:Exp) eqrel
// keep only canonical Exp
add(x,y,z) <= add(a,b,c) :-
  eql(x,a), eql(y,b), eql(z,c),
  a<=x, b<=y, c<=z.
```

Optimization in Datalog: Encoding Rewrites

A rewrite can add new terms and new equalities:

```
// comm-add
eql(xy,yx), add(x,y,xy) :-
  add(y,x,yx), xy=$Add(x,y).
```

Optimization in Datalog: Encoding Rewrites

A rewrite can add new terms and new equalities:

```
// comm-add
eql(xy,yx), add(x,y,xy) :-
  add(y,x,yx), xy=$Add(x,y).

// assoc-add
eql(xy_z,x_yz), add(xy,z,xy_z), add(x,y,xy) :-
  add(y,z,yz), add(x,yz,x_yz),
  xy = $Add(x,y), xy_z = $Add(xy,z).
```

Optimization in Datalog: What's the Point?

Performance:

- Join algorithms for e-matching [ZWWT22].
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Expressiveness:

- Composable lattice-style program analyses (Flix [MYL16])
- Leverage existing analysis (DOOP [BS09])

Optimization in Datalog: What's Left?

Performance:

- Actually efficient equivalence relation (`eqrel` in Soufflé [NZSS19]).
- Congruence algorithms [WNW$^+$21] (semi-naïve?).

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Performance:

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Expressiveness: what to do with this new-found power??

- Improve precision of analyses [Ste96]?
- Composing transformation & analyses[LGC02]?
- Decompiler [GBSS19]?
- Relations other than equivalence (e.g. implication)?
- ...

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