The (Abridged) Art of the Propagator, Abridged

Alexey Radul

March 23, 2009
International Lisp Conference

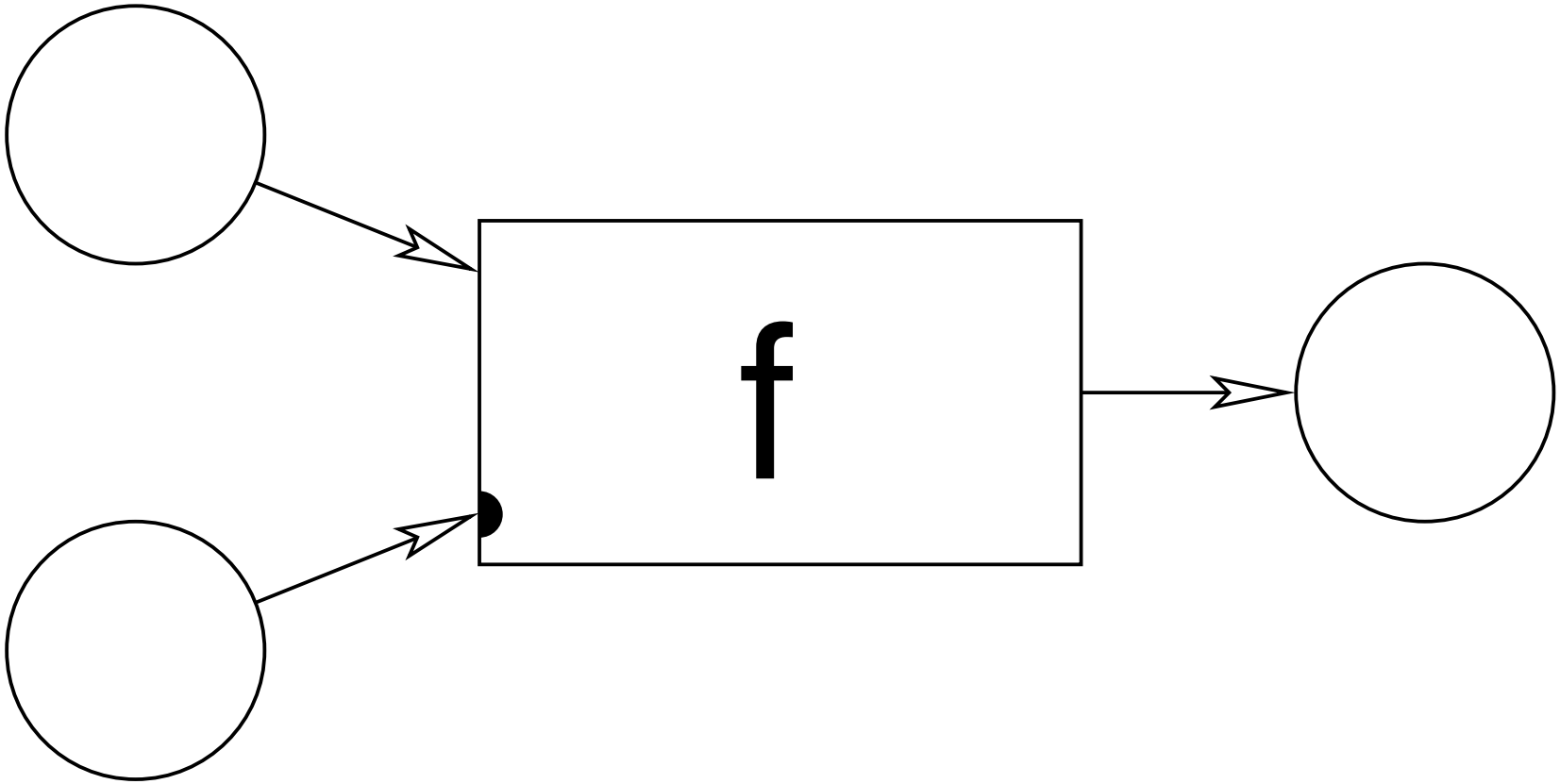
or

Computing with Boxes, Arrows, and Circles

or

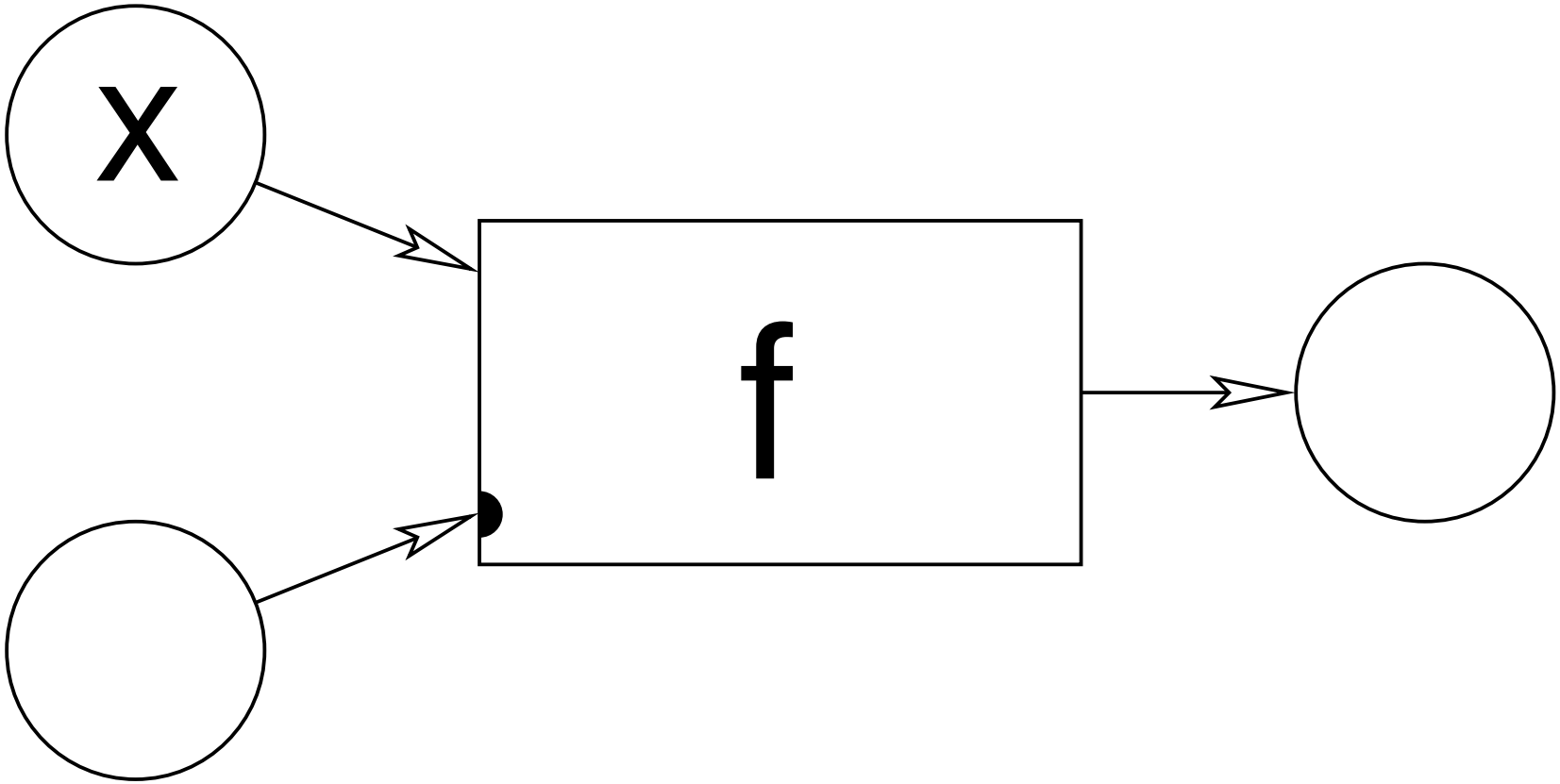
Computing with Boxes, Arrows, and Circles

- Why you might want to
- Something to get right if you try it



A propagator is a machine that reads some cells and can write to some cells

always on, asynchronous, stateless



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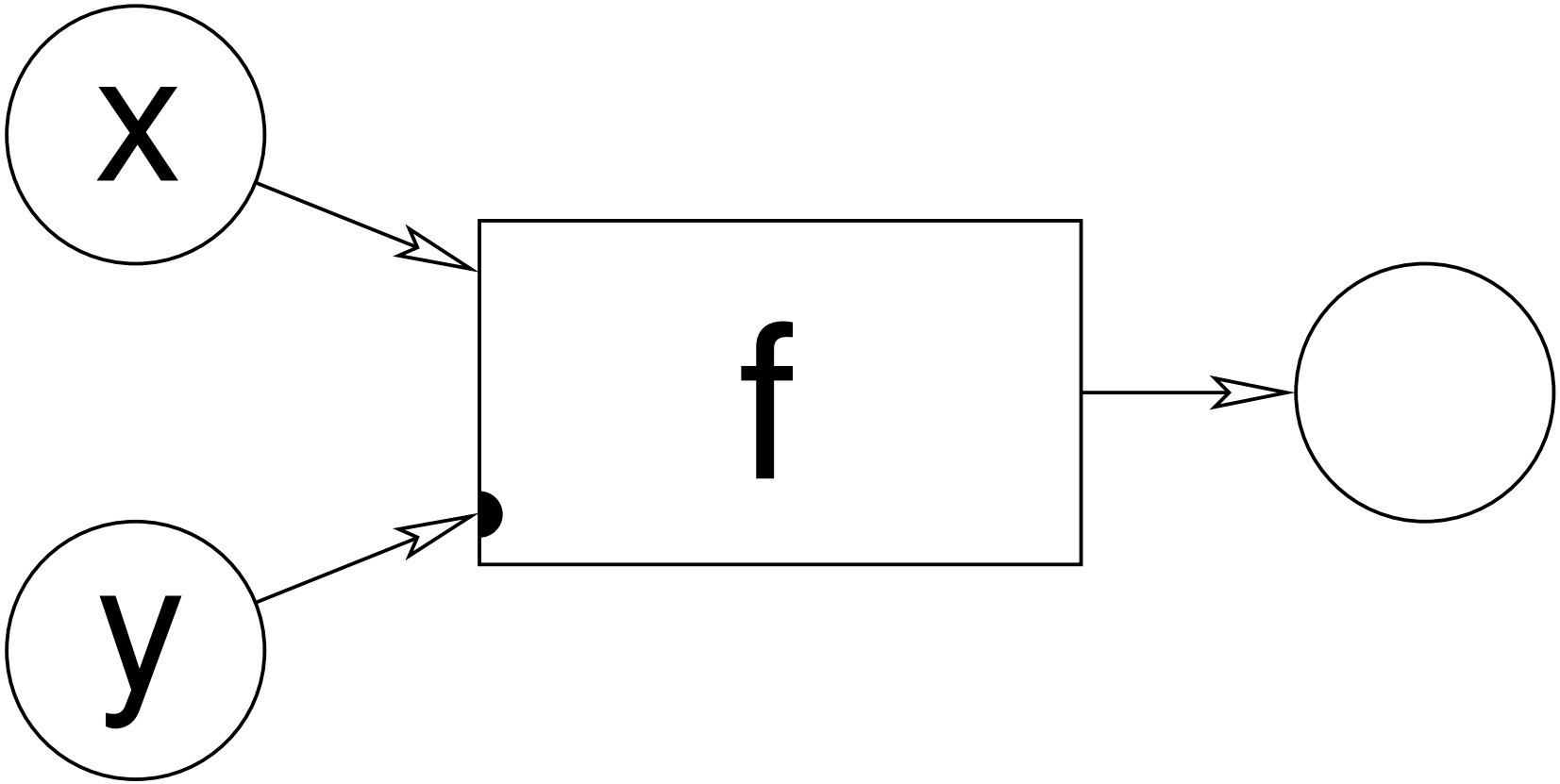

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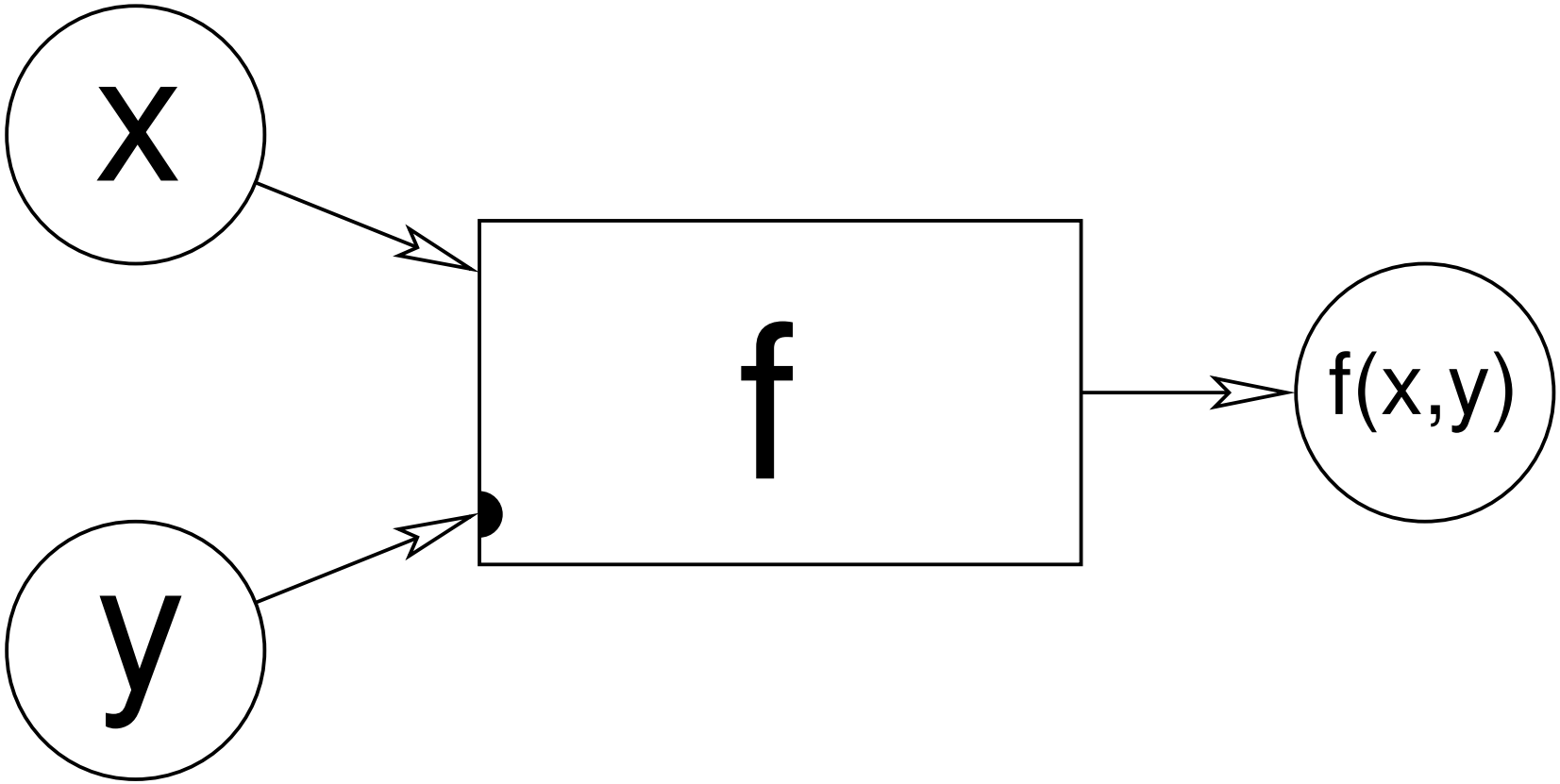

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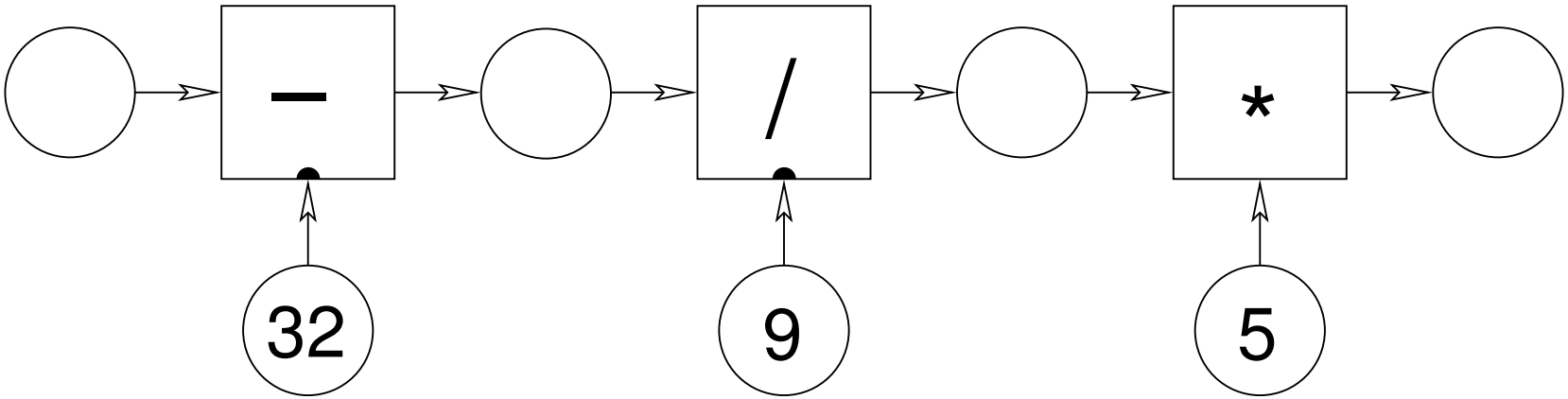
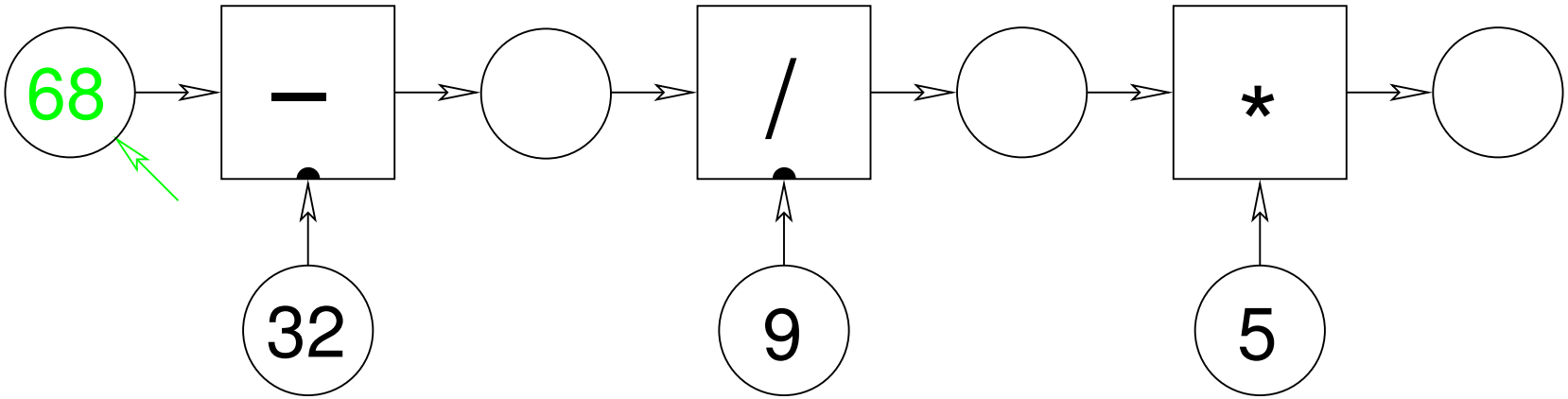


Network them, and values propagate

this distributes naturally



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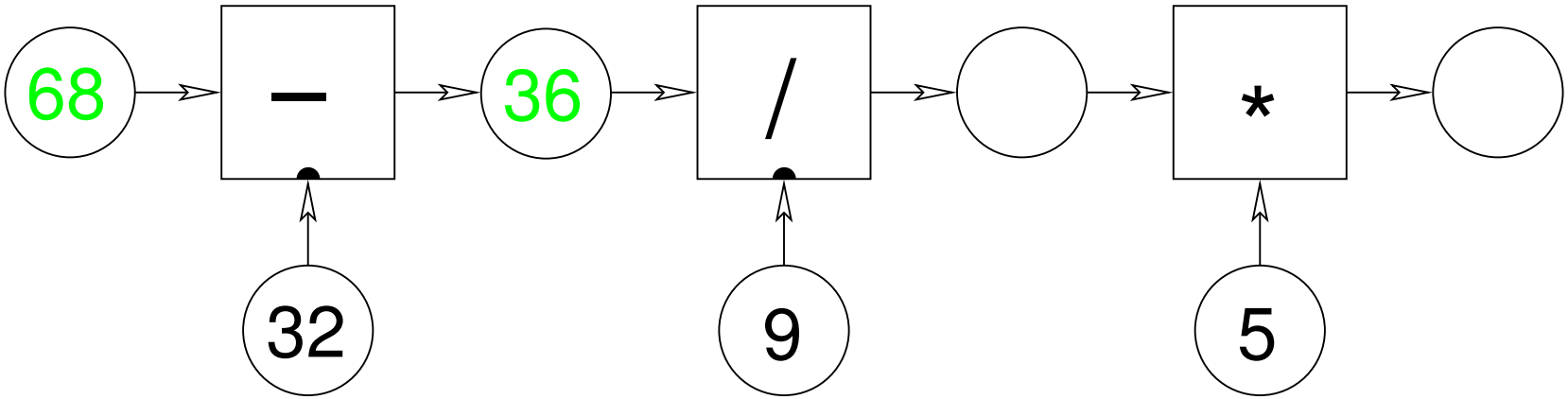

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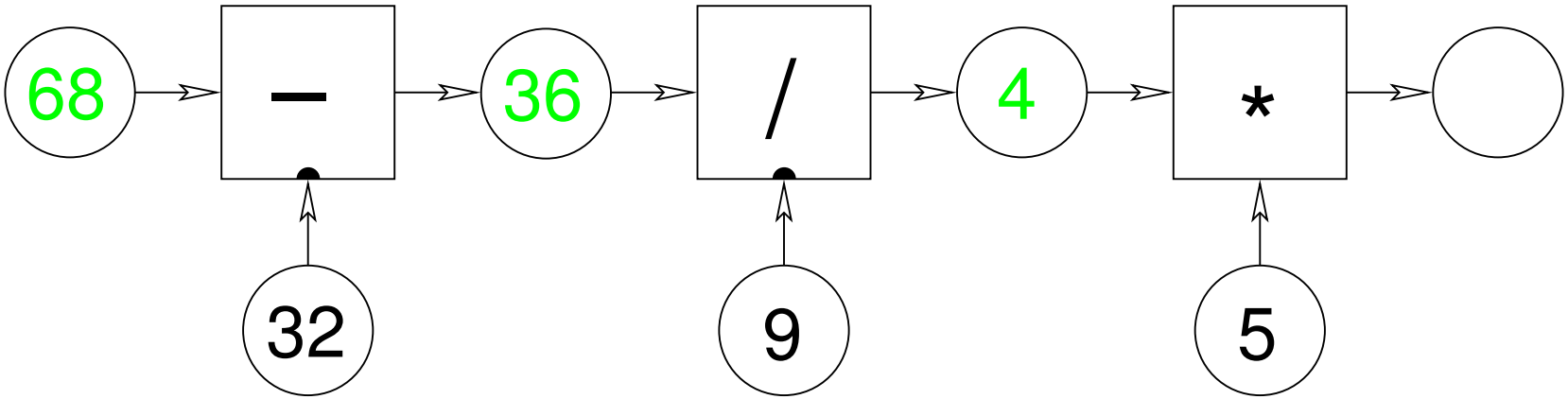

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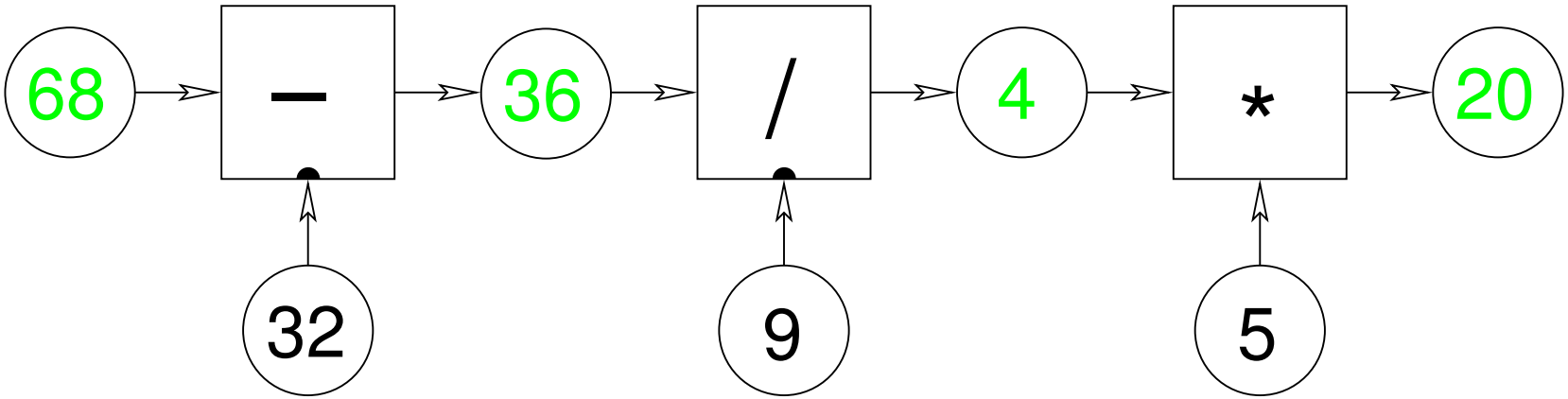

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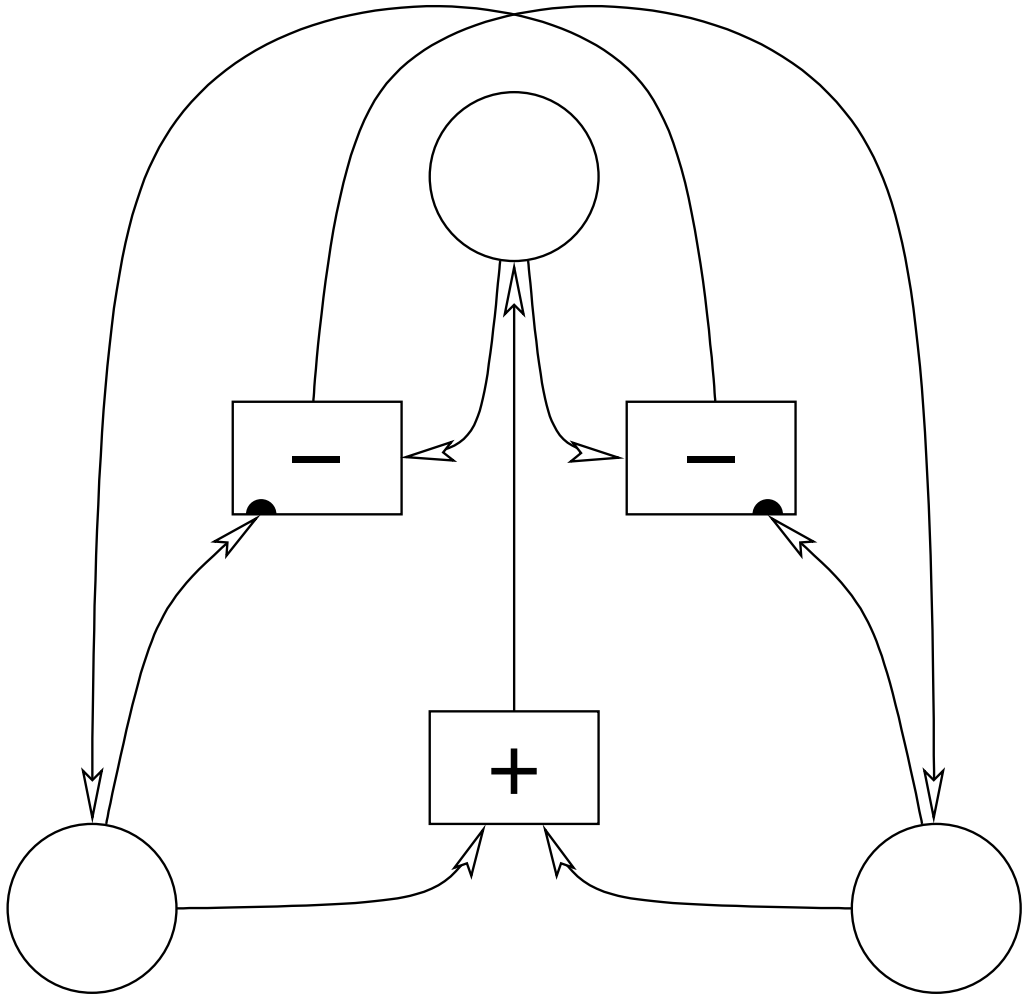
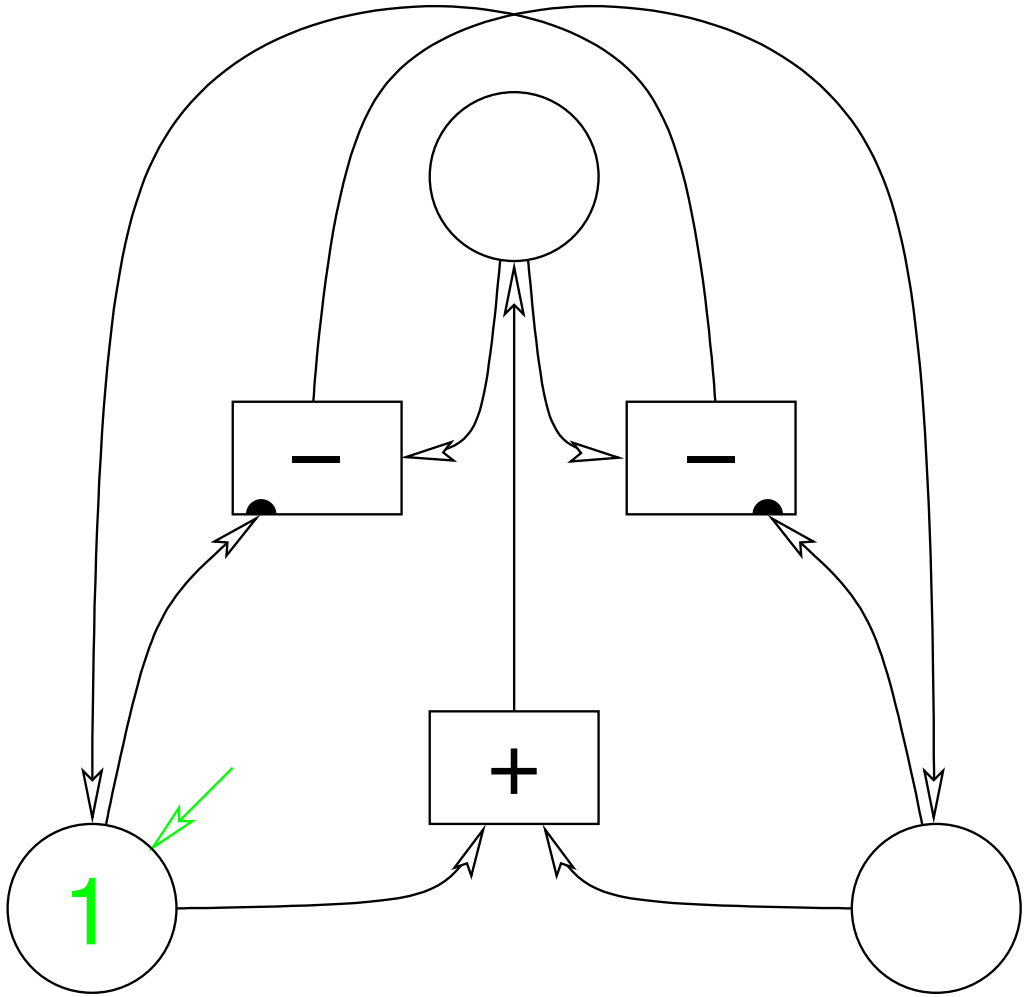


Win: Constraints are just piles of mutually inverse propagators



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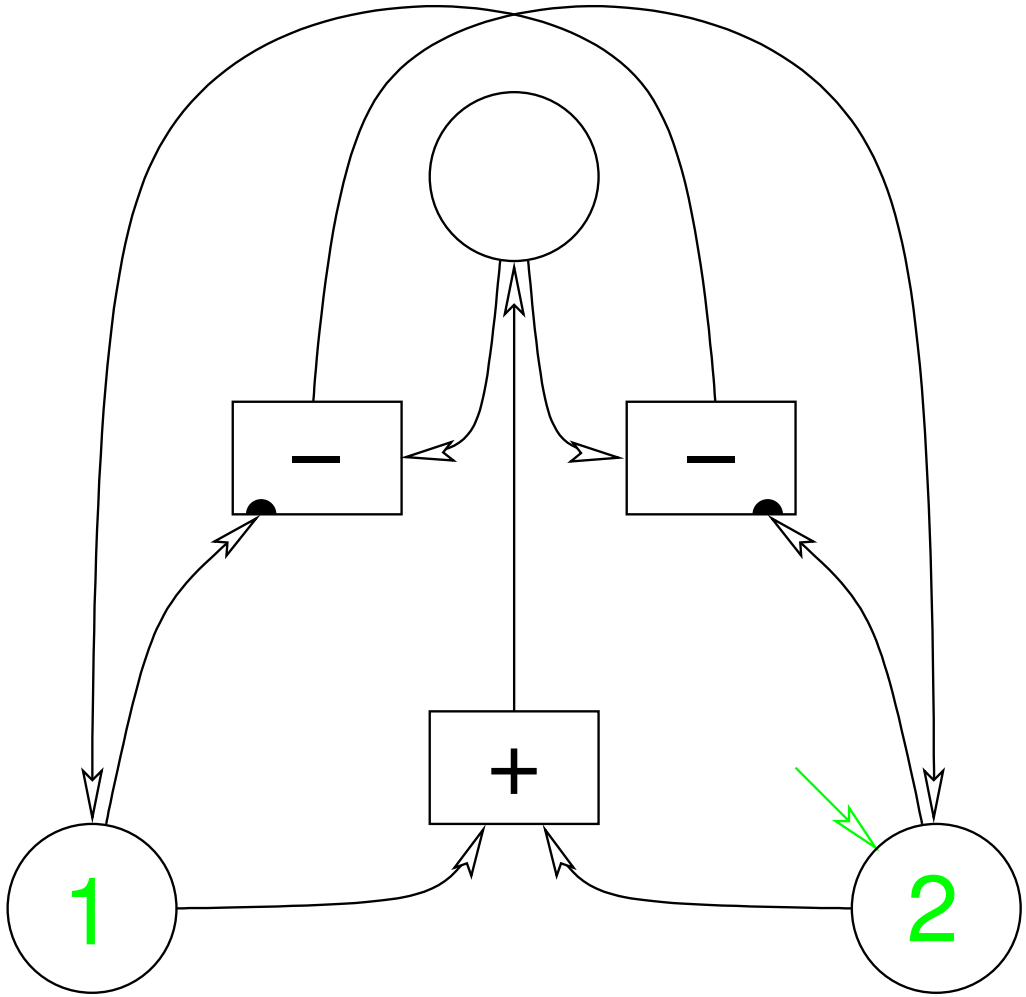

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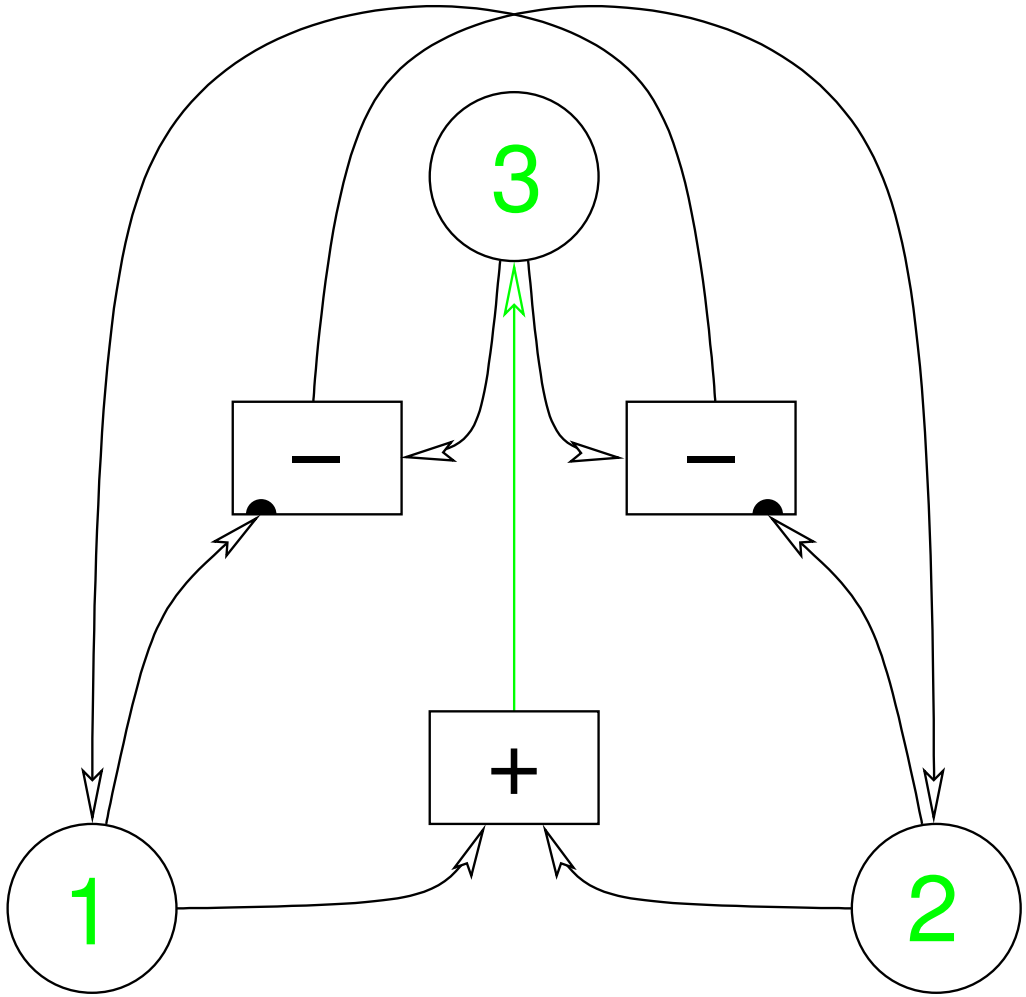

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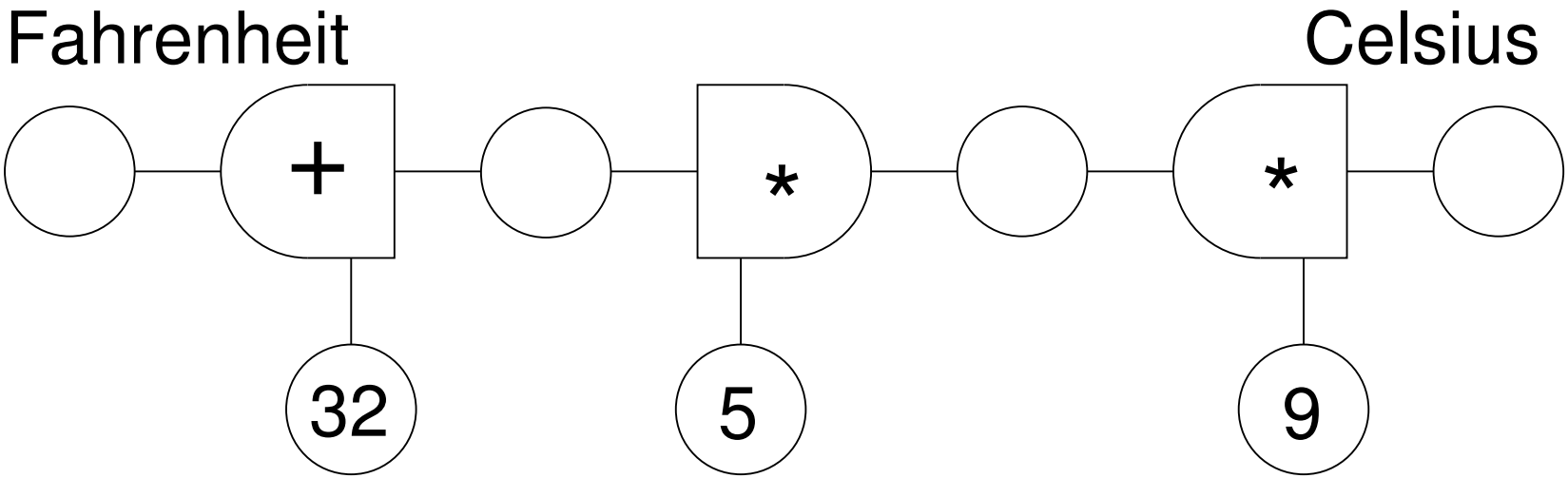

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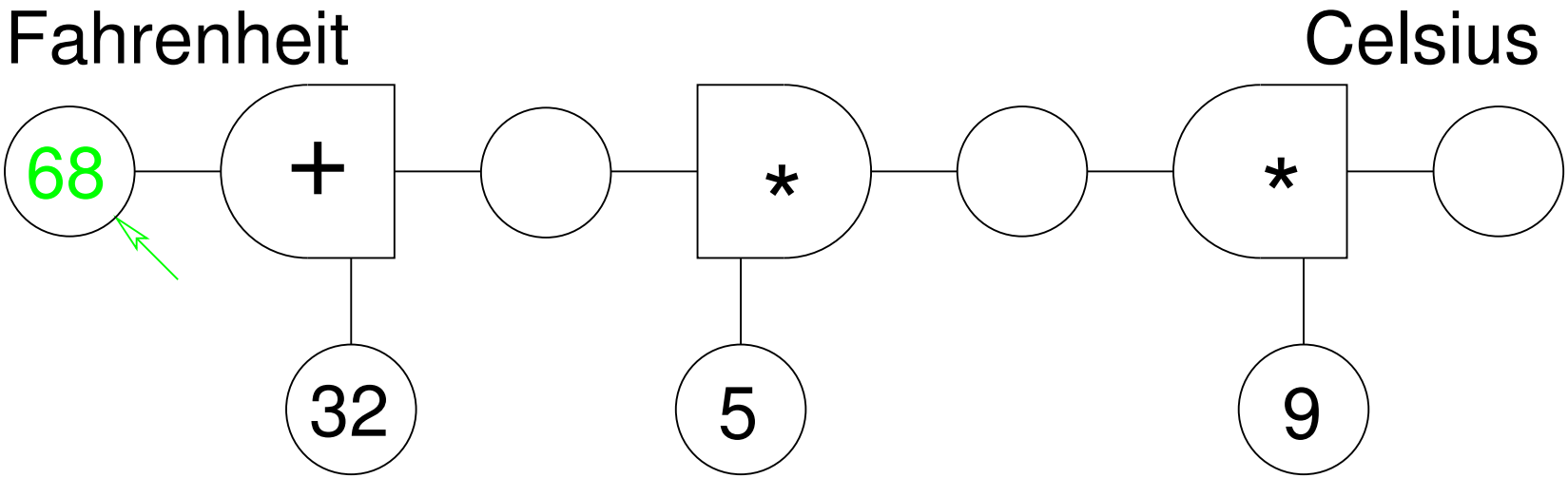

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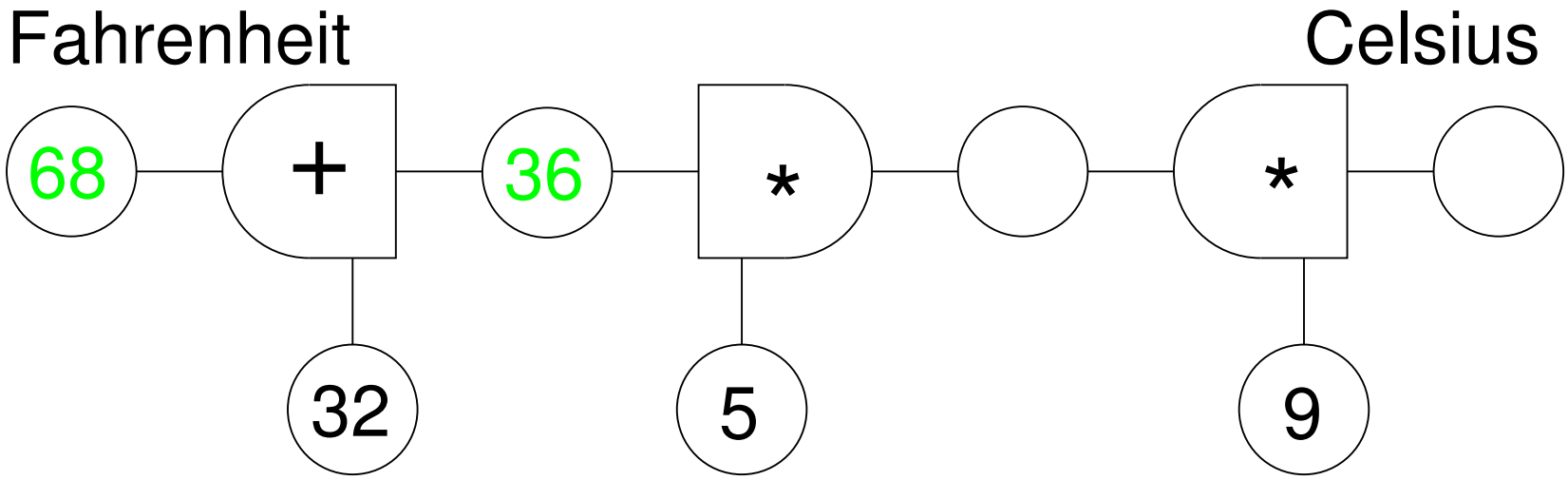

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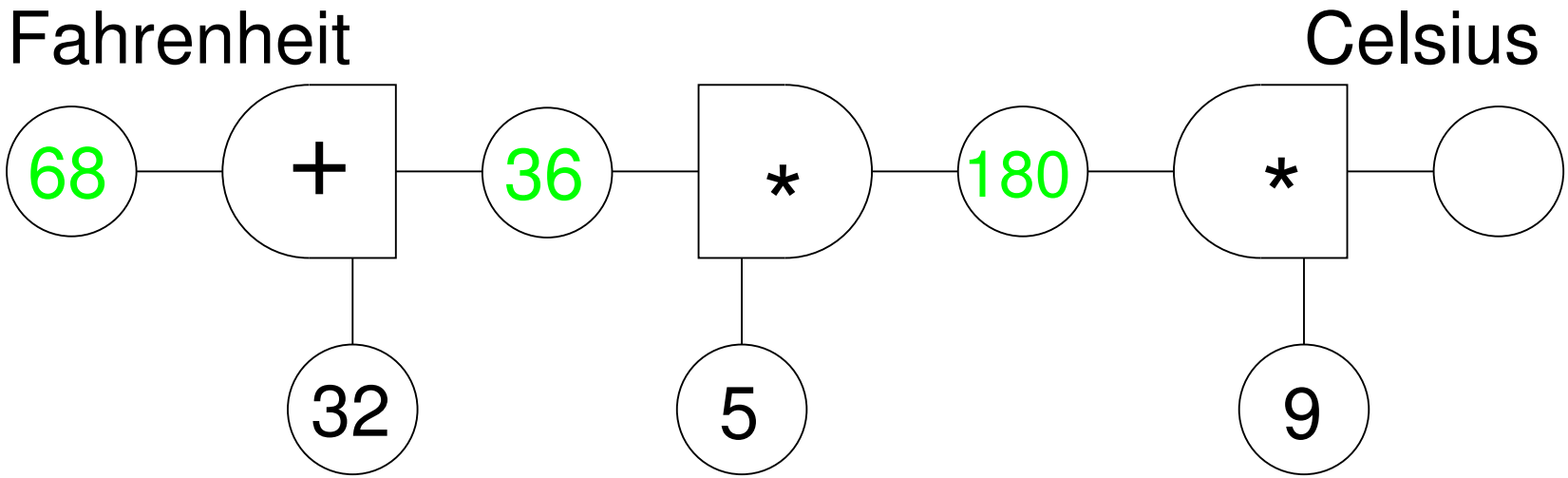

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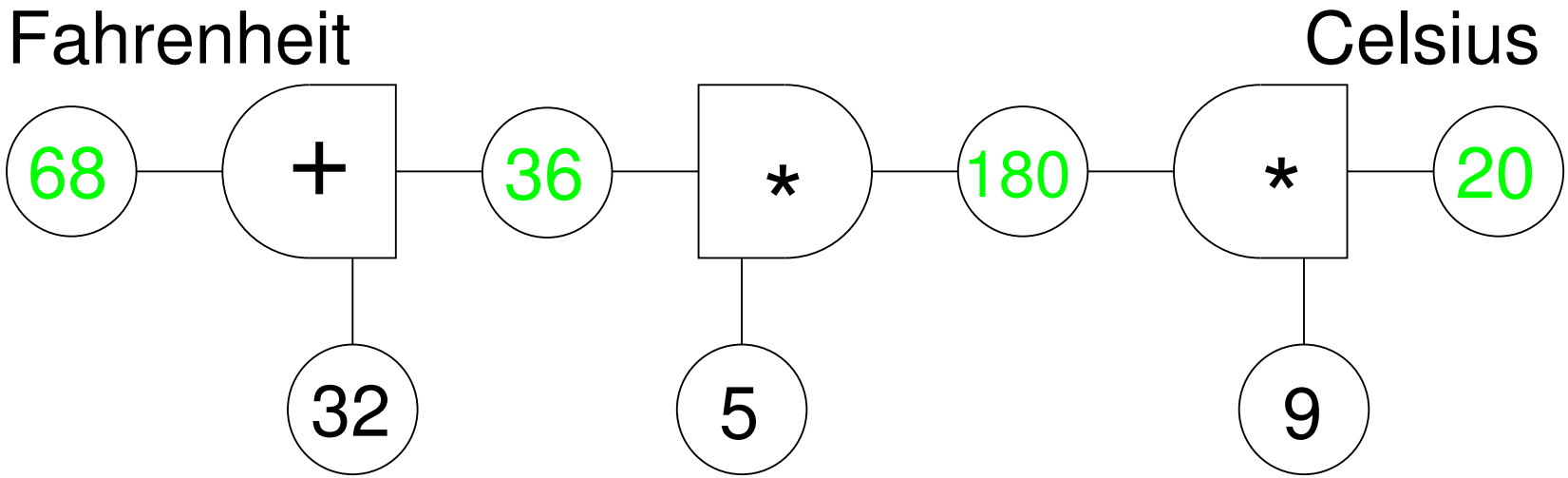

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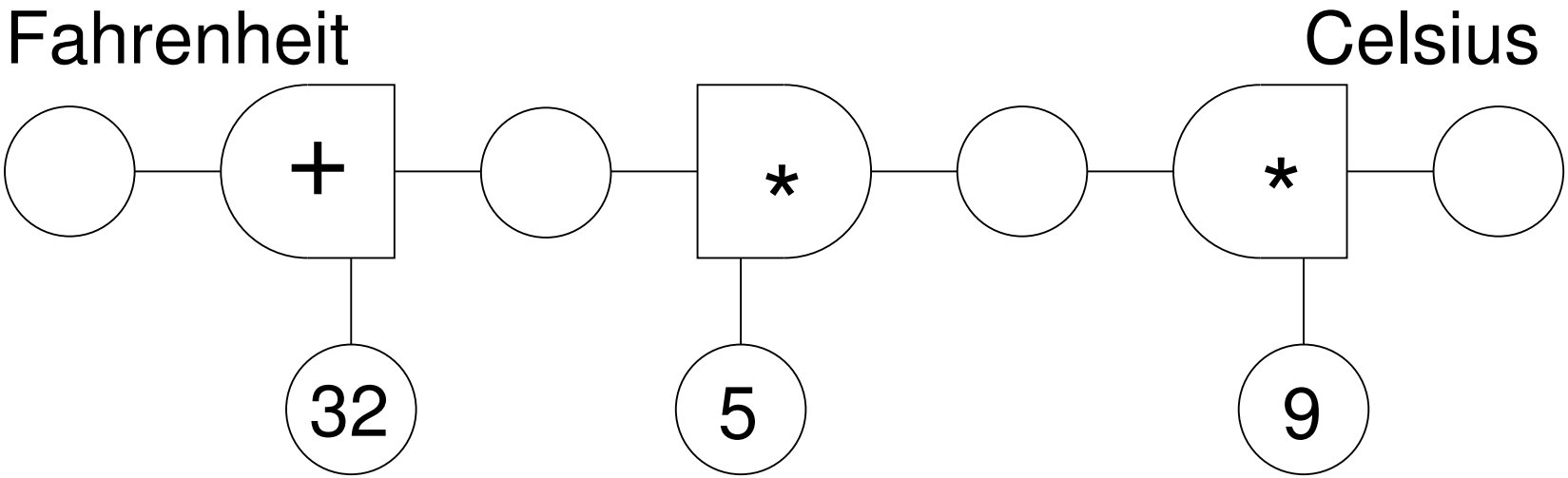

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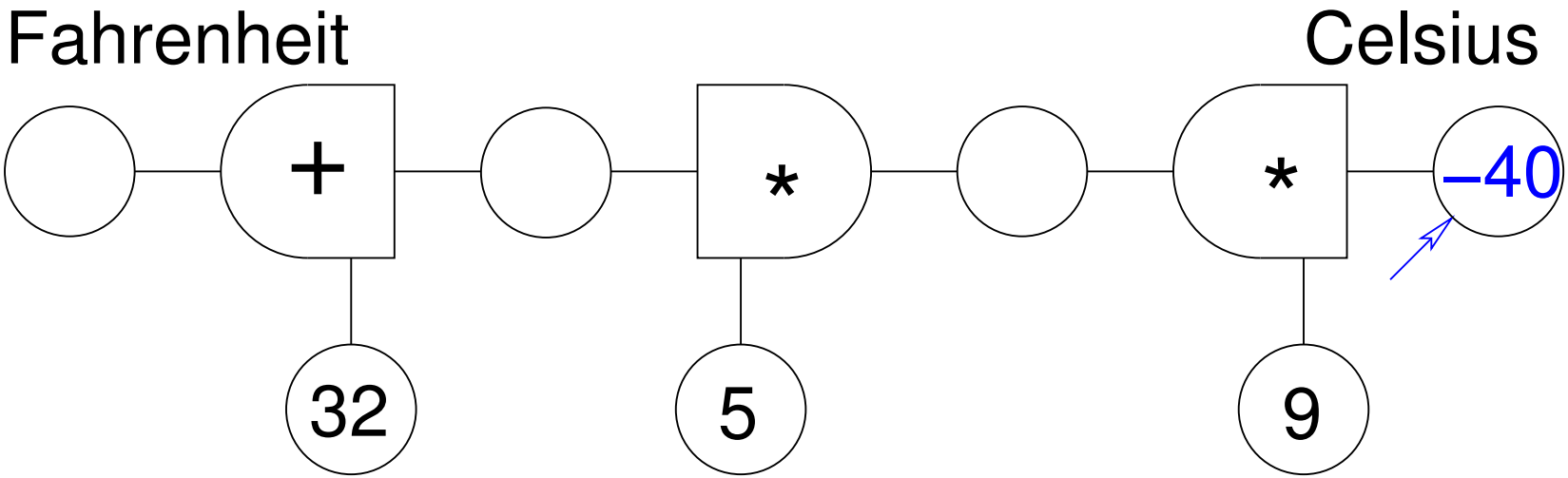

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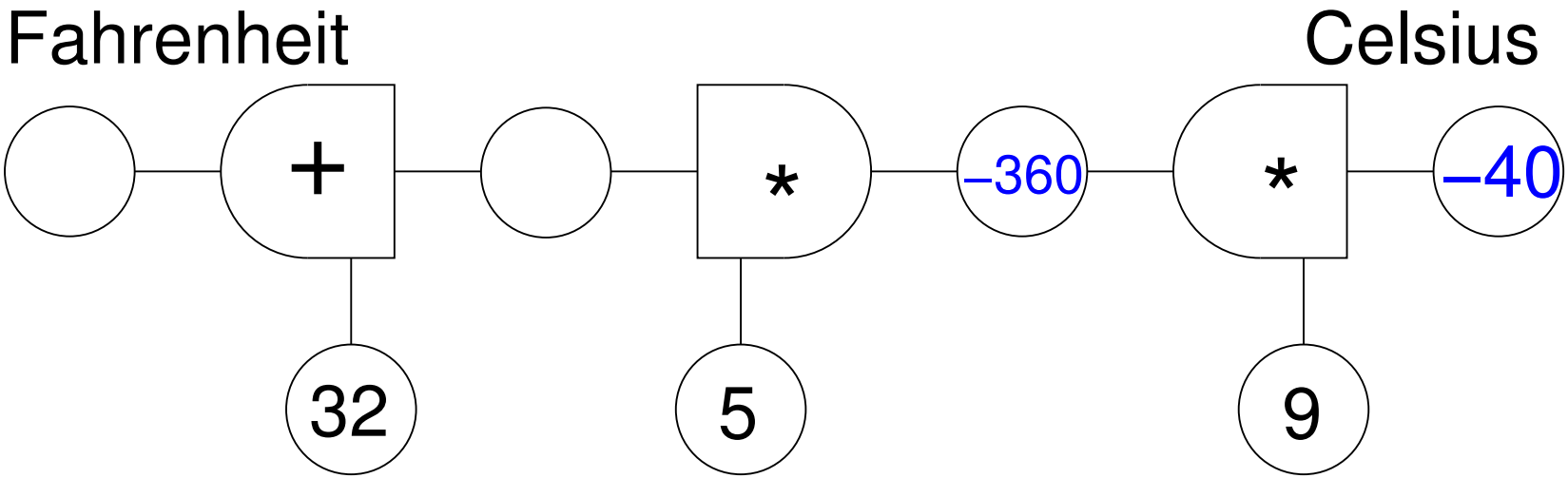

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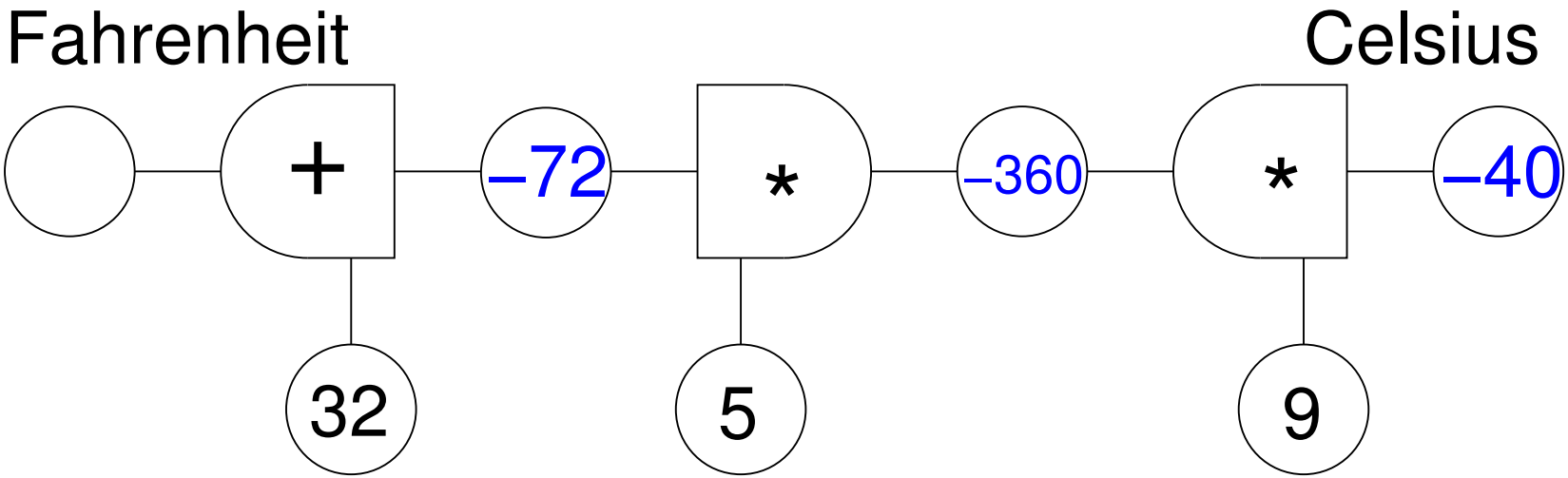

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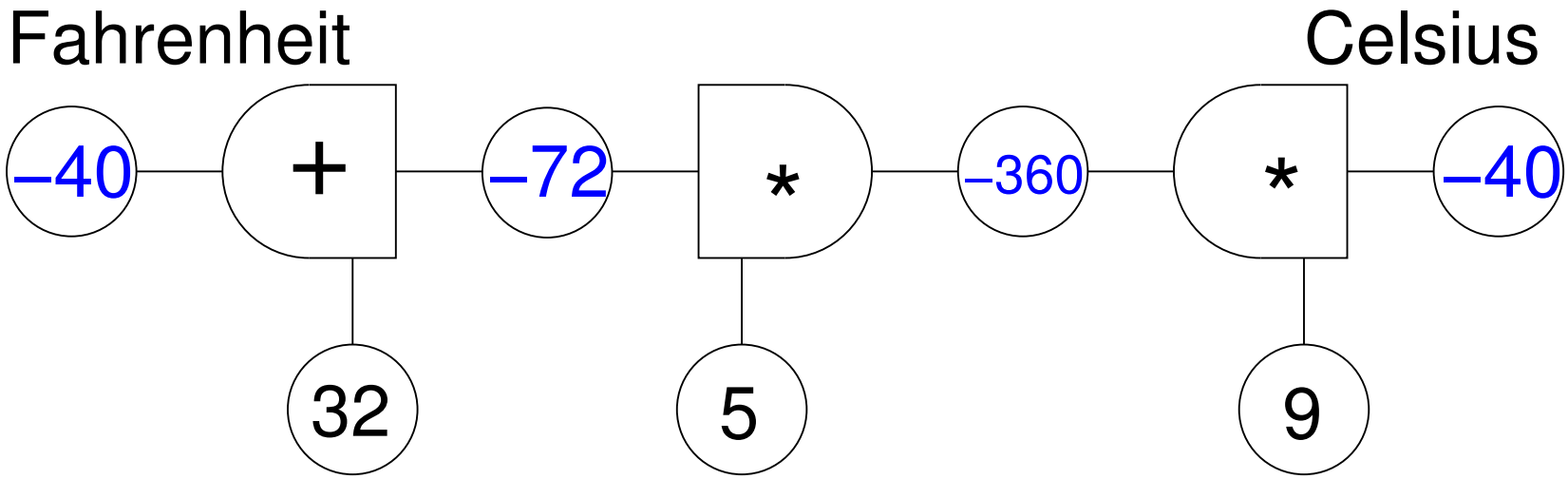

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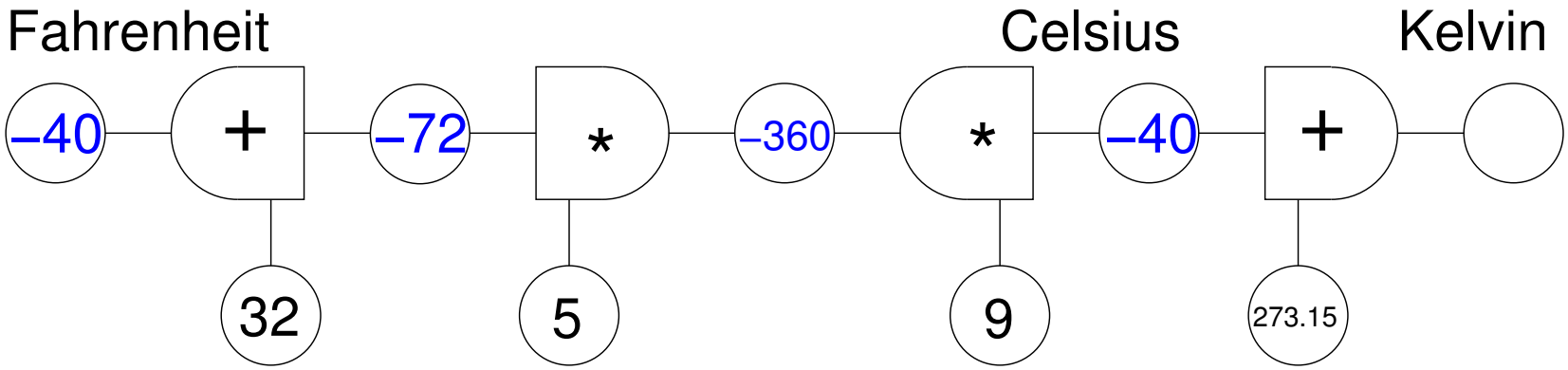

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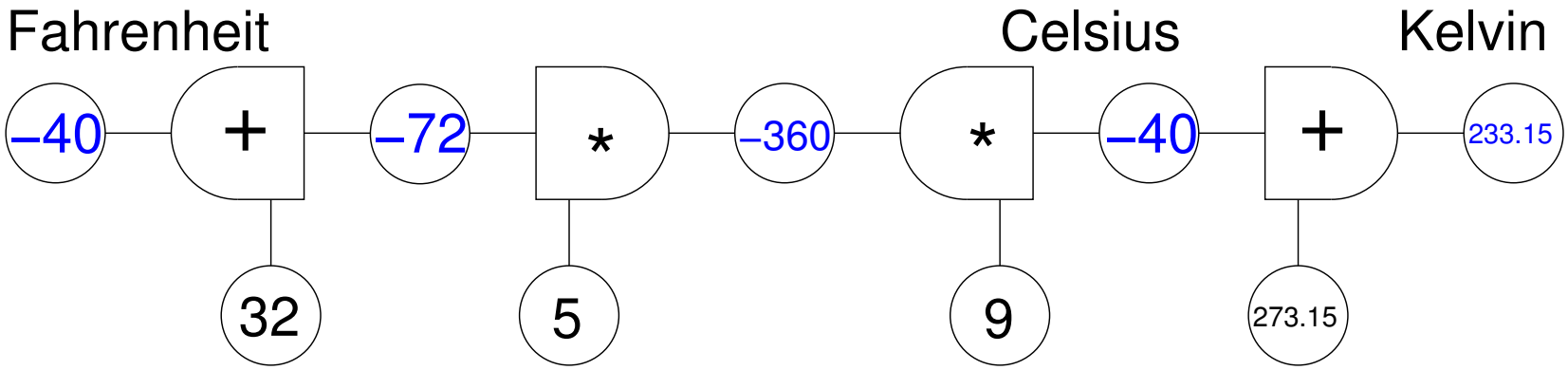

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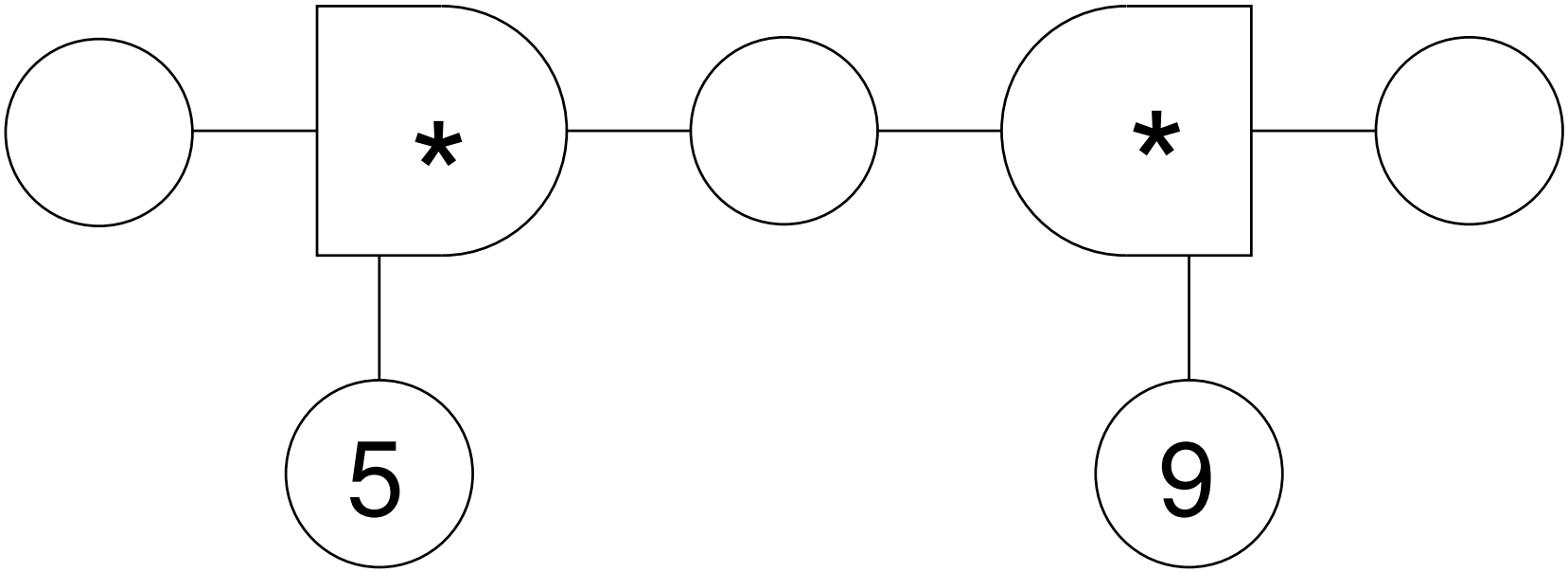
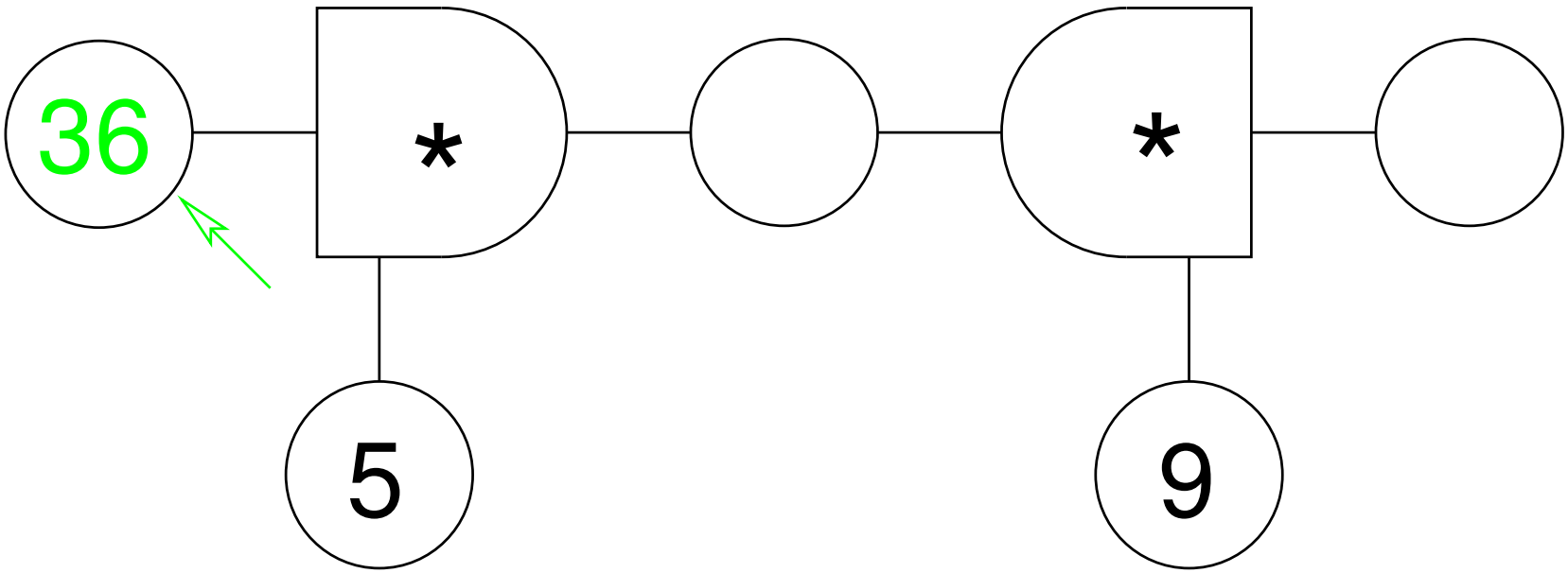


But: A cell can get stuff from multiple sources

Is this bad?



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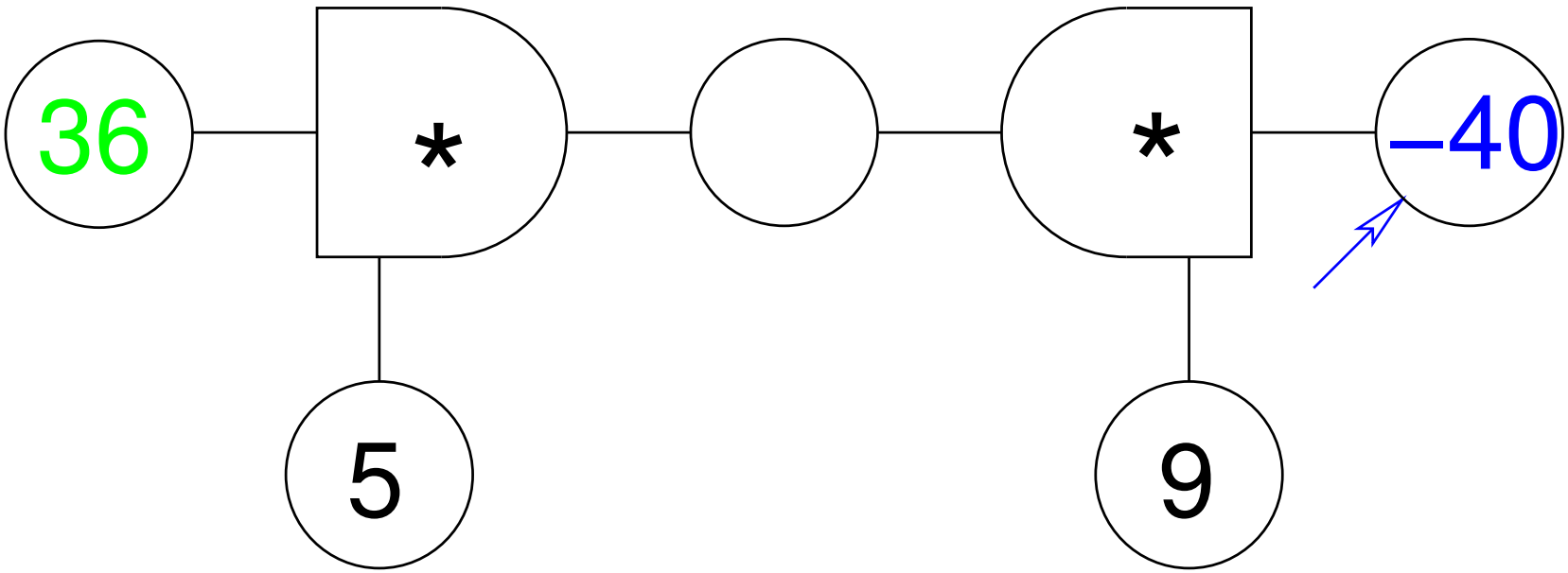

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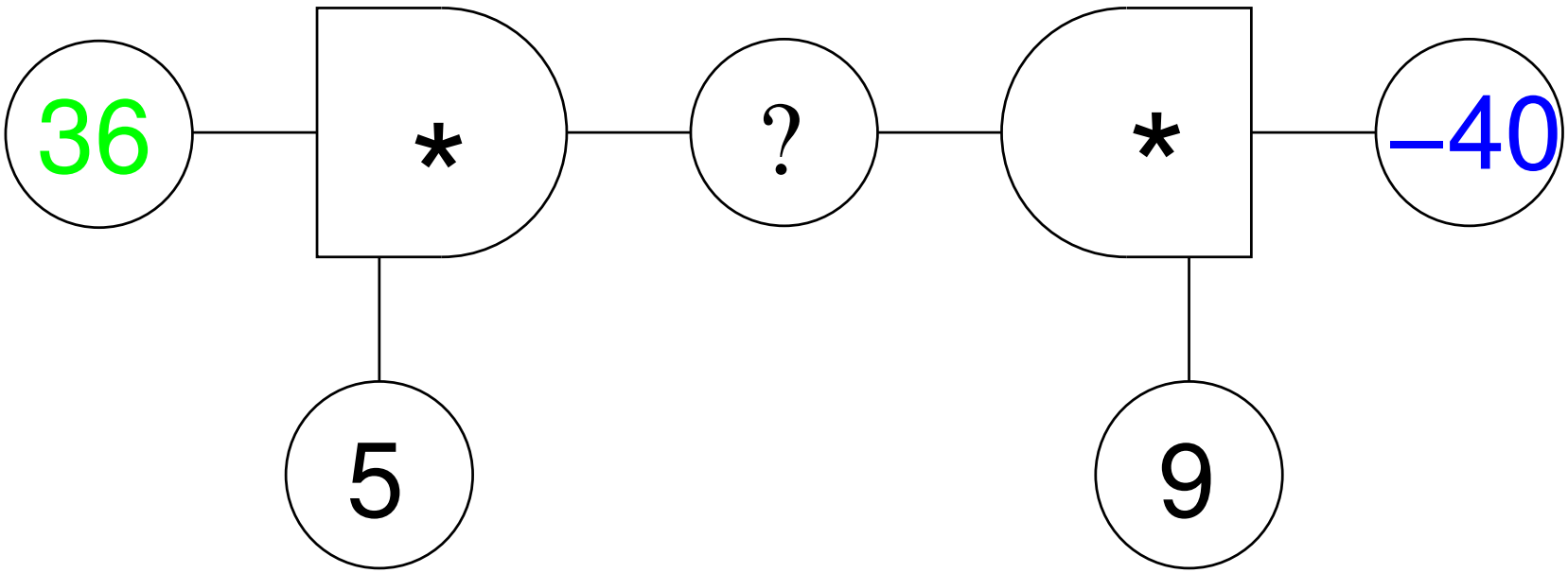

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Leads to all kinds of trouble

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- infinite reactions and fights
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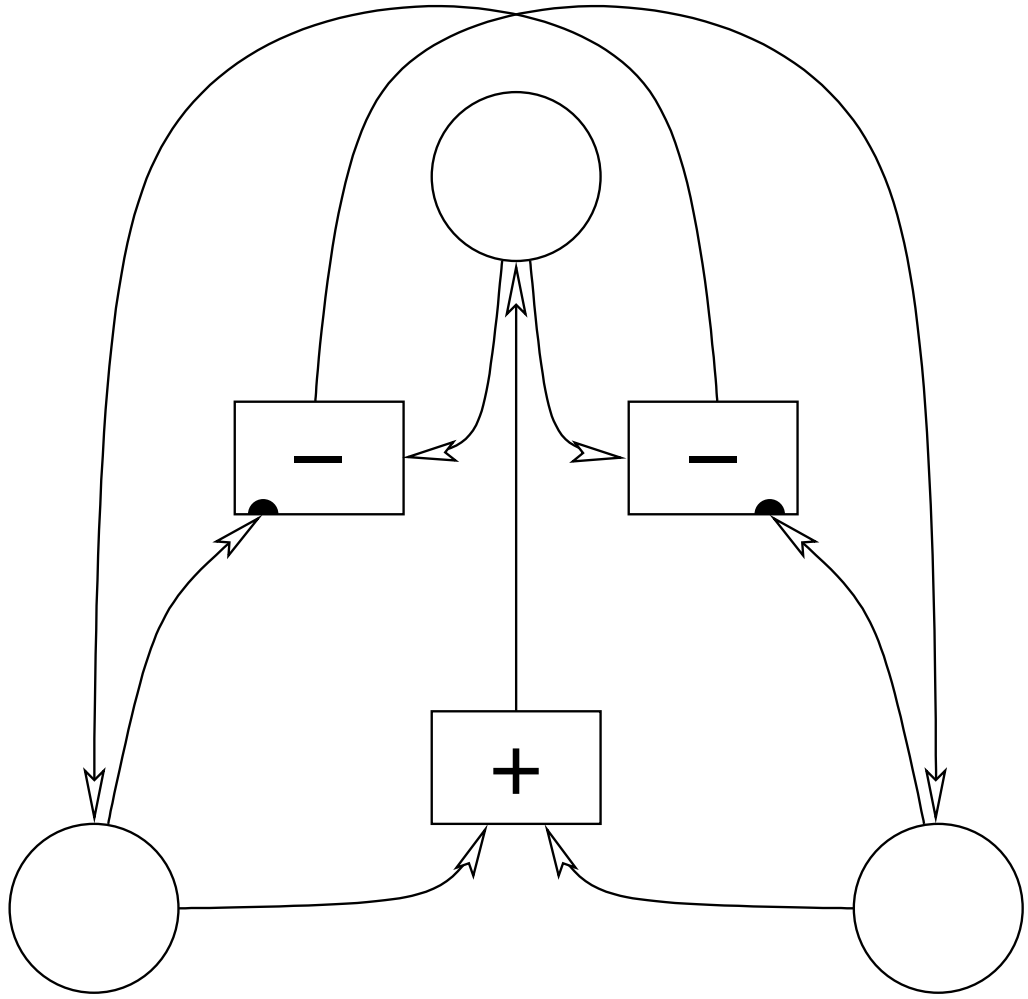
- loss of essence



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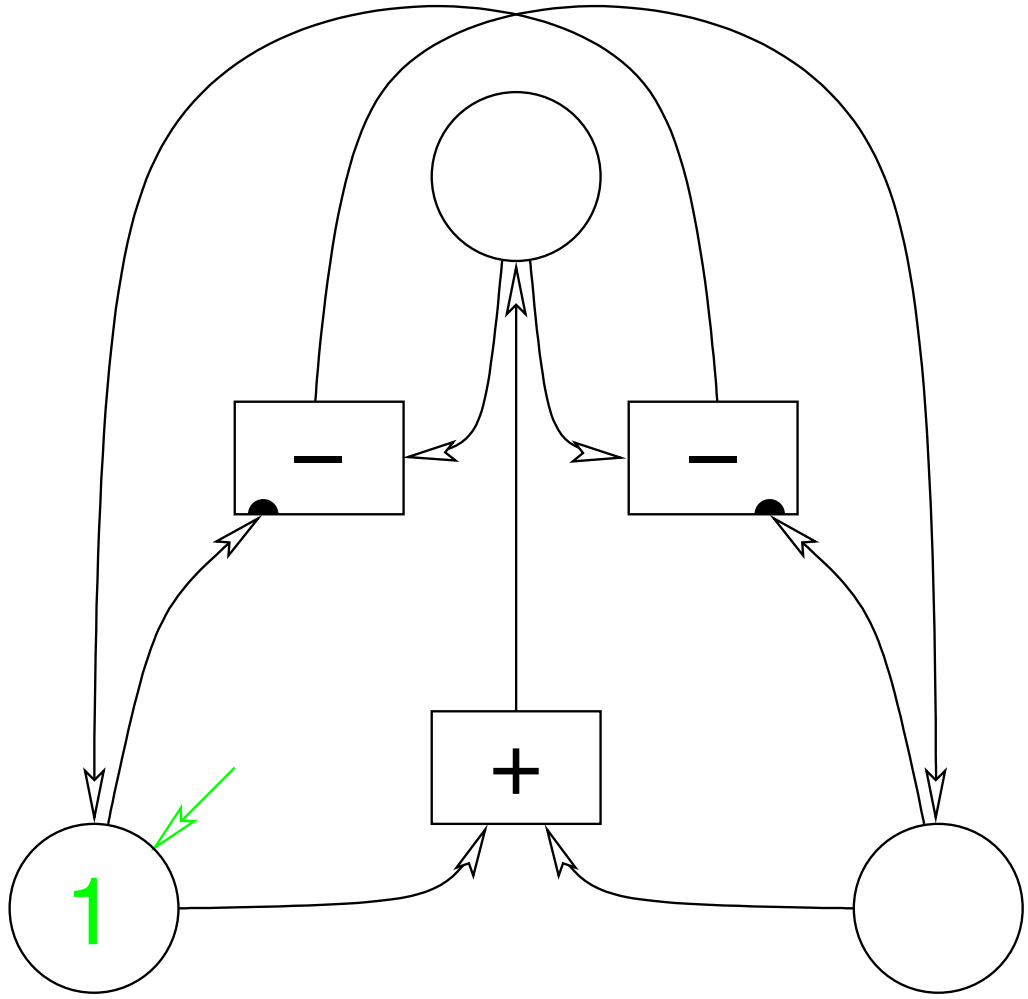

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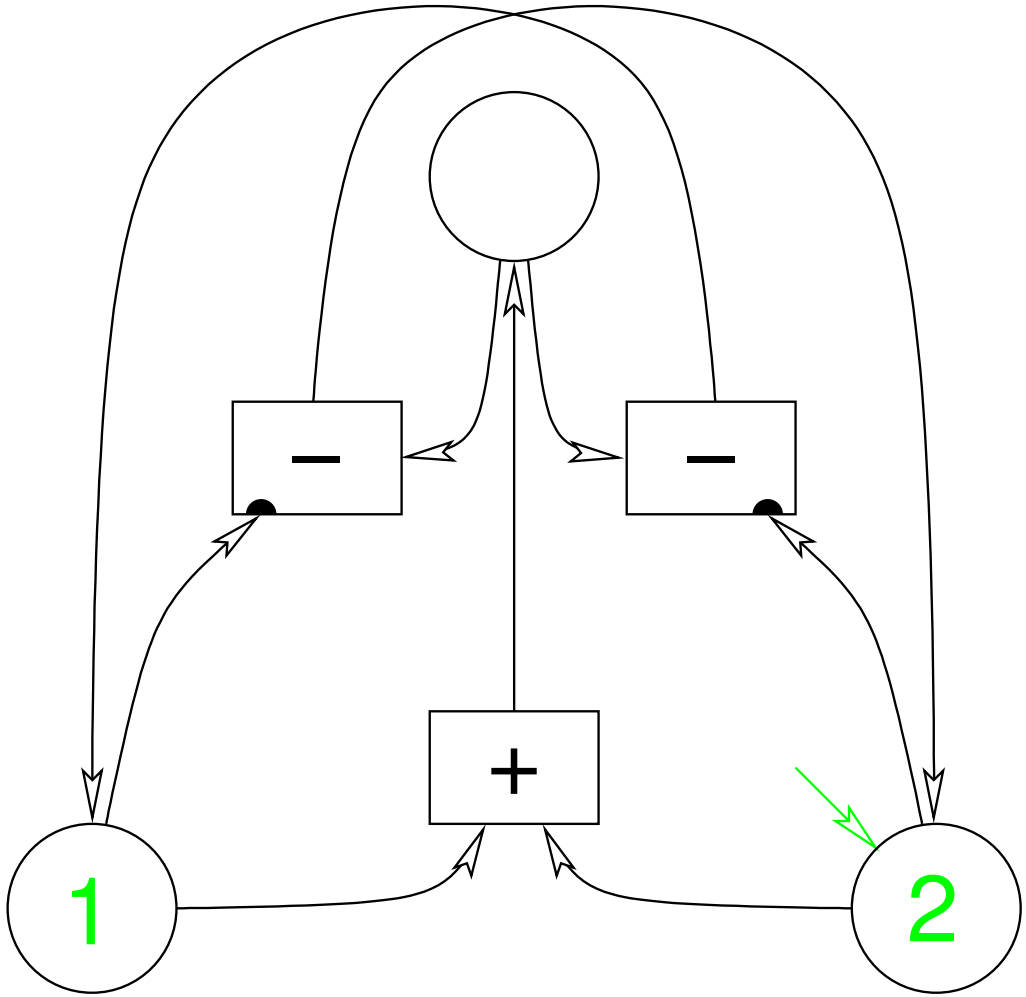

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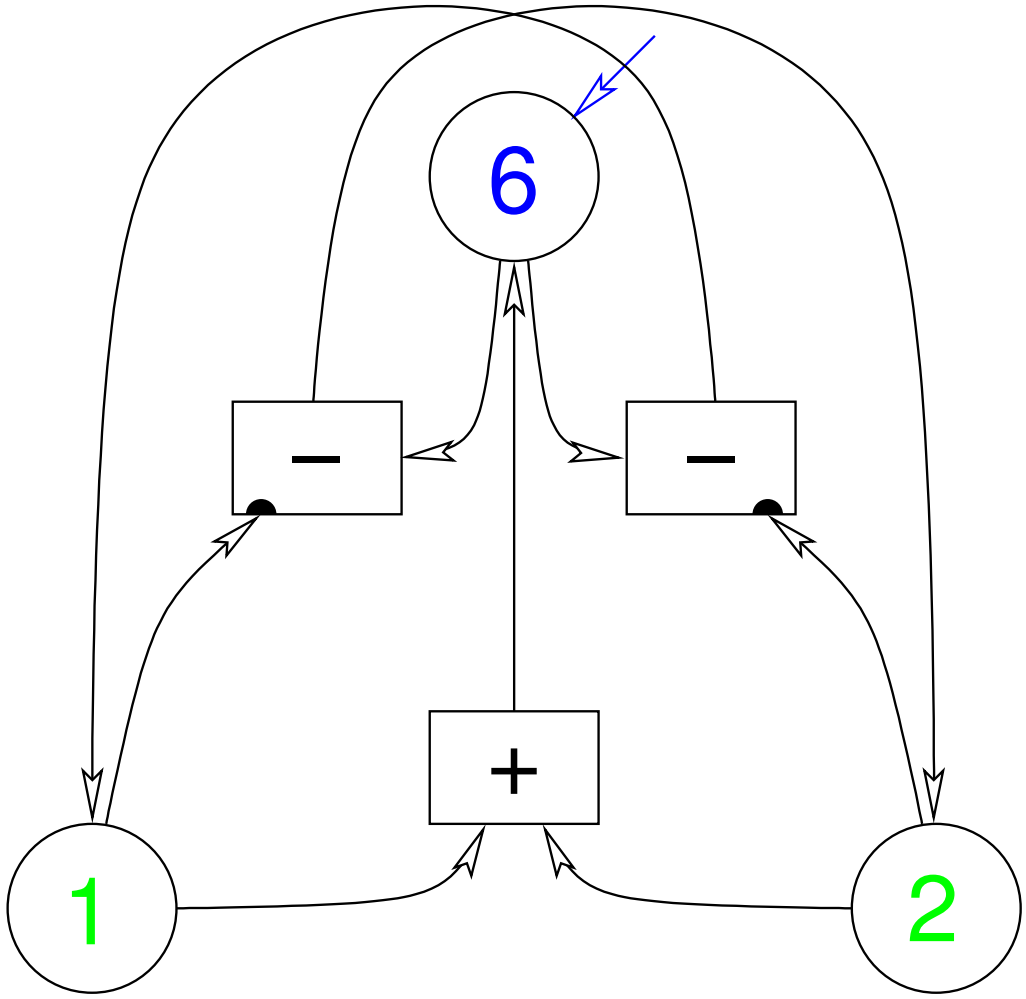

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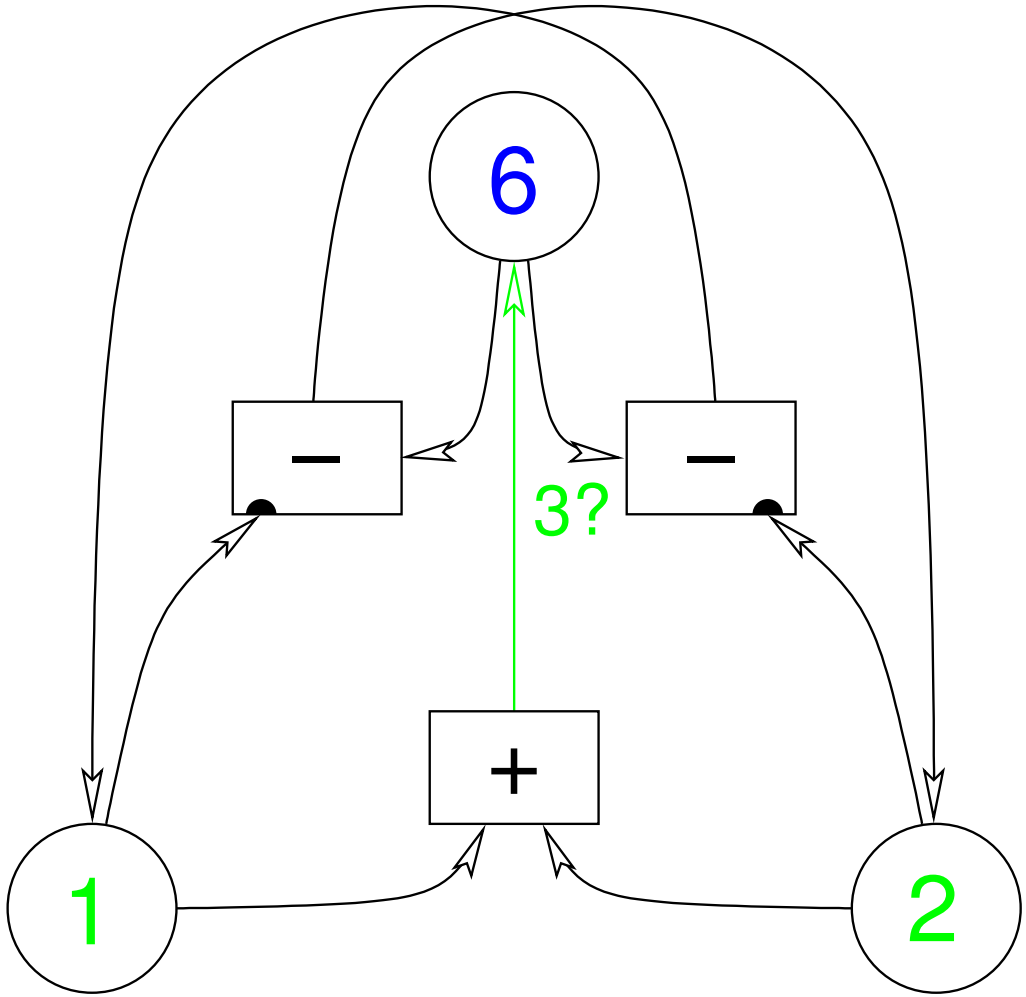

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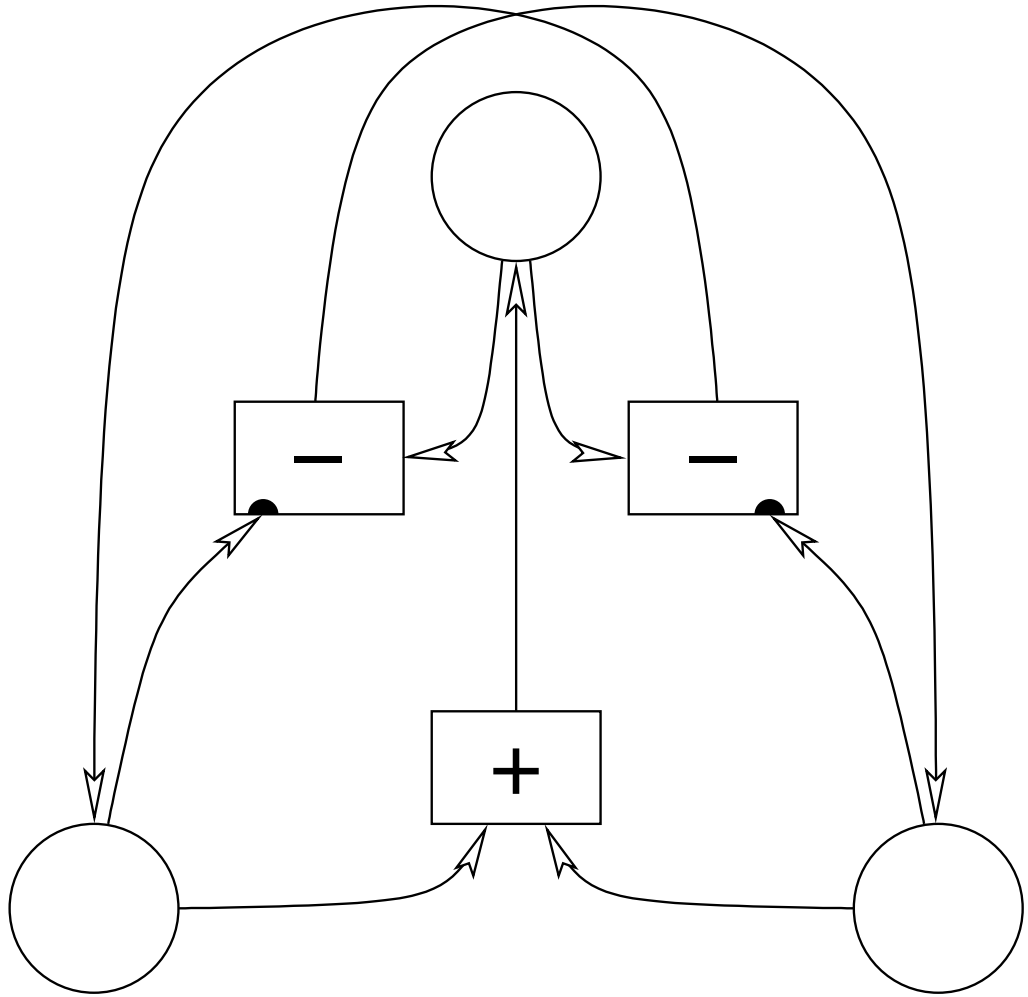
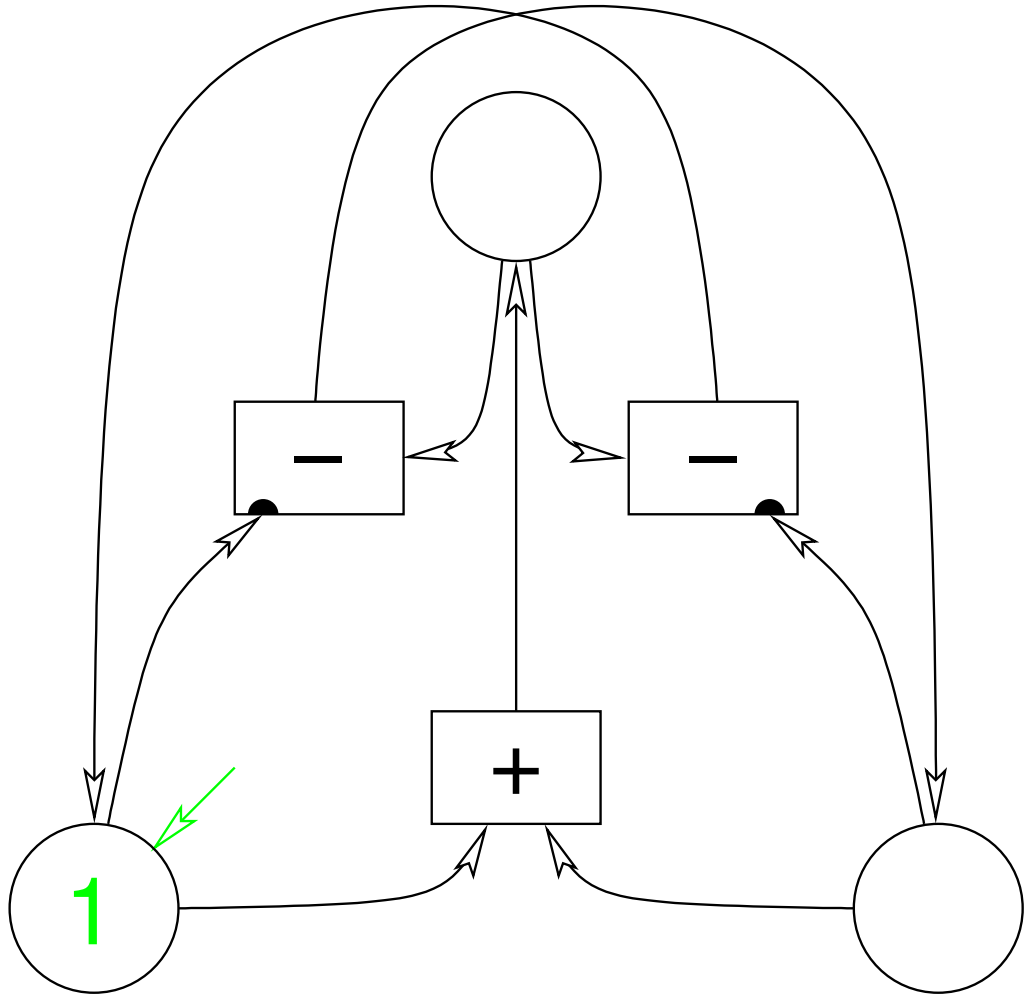


Loops may buzz forever



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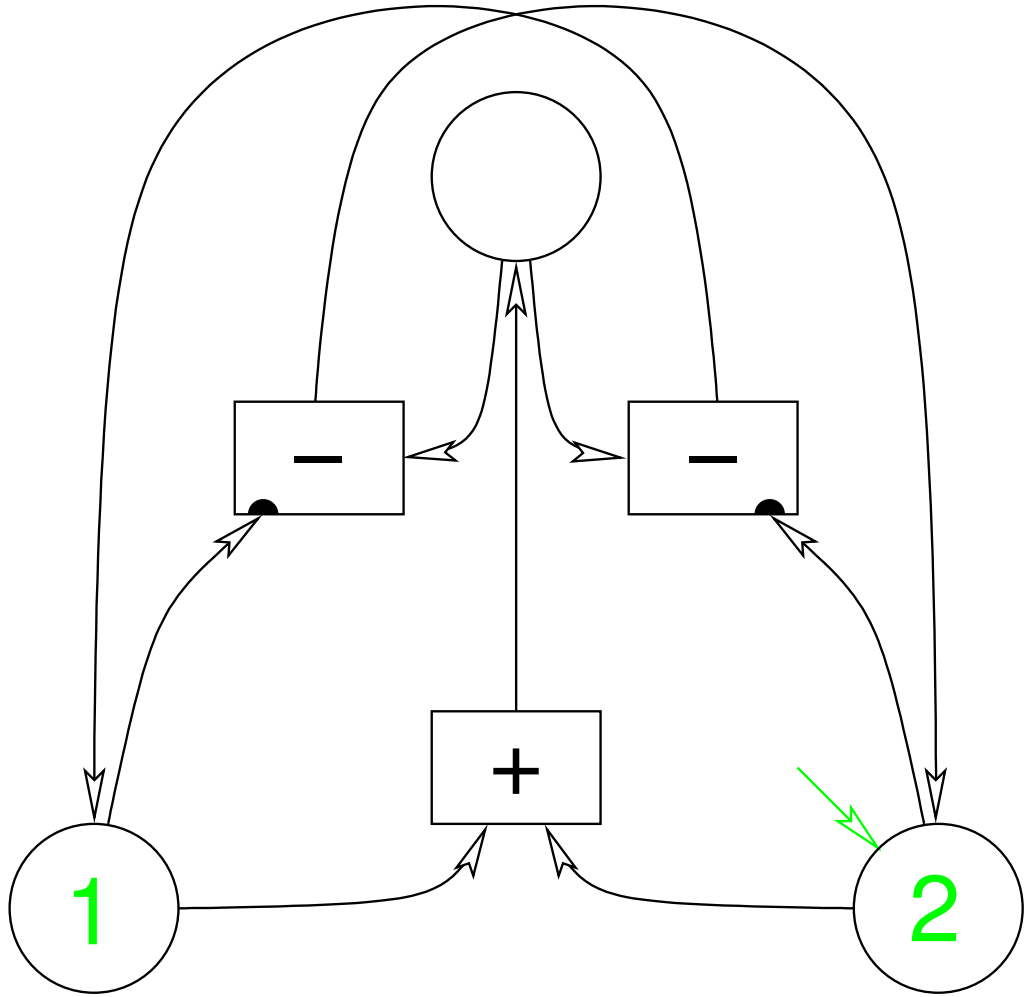

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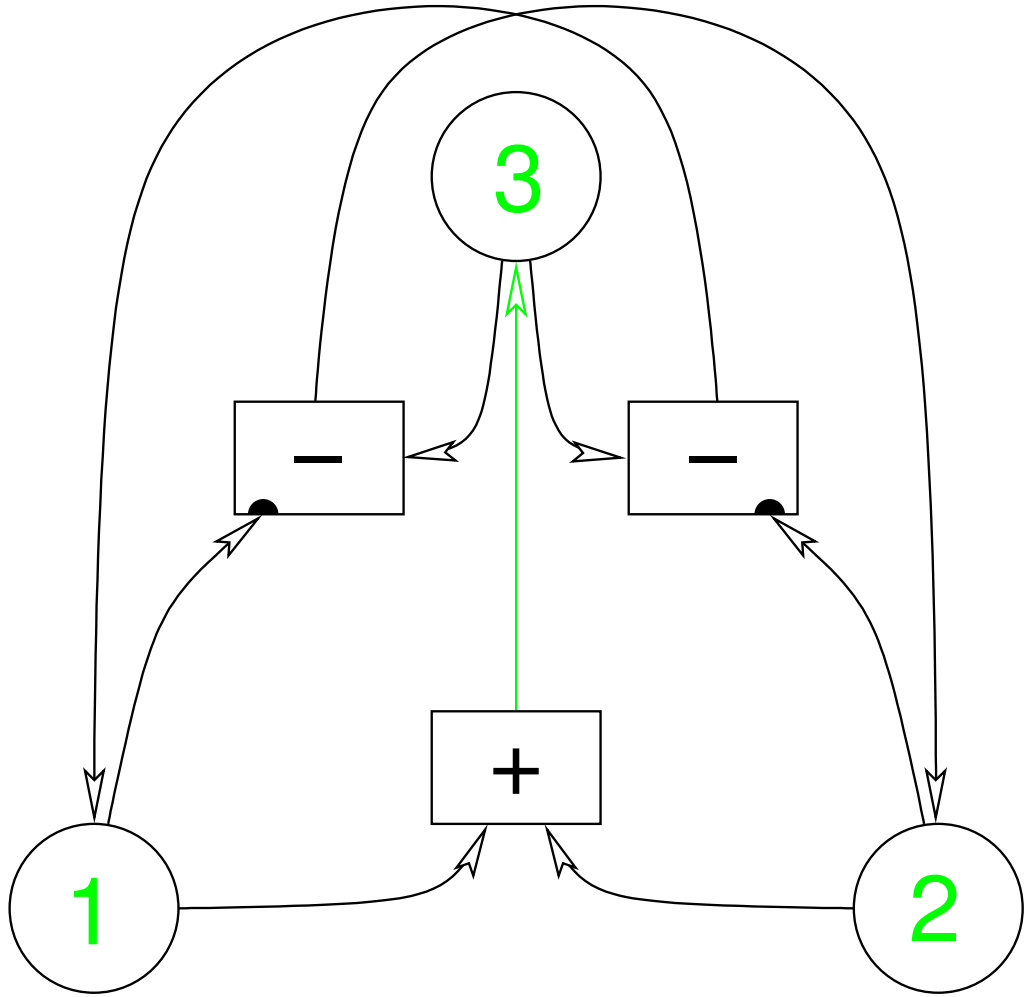

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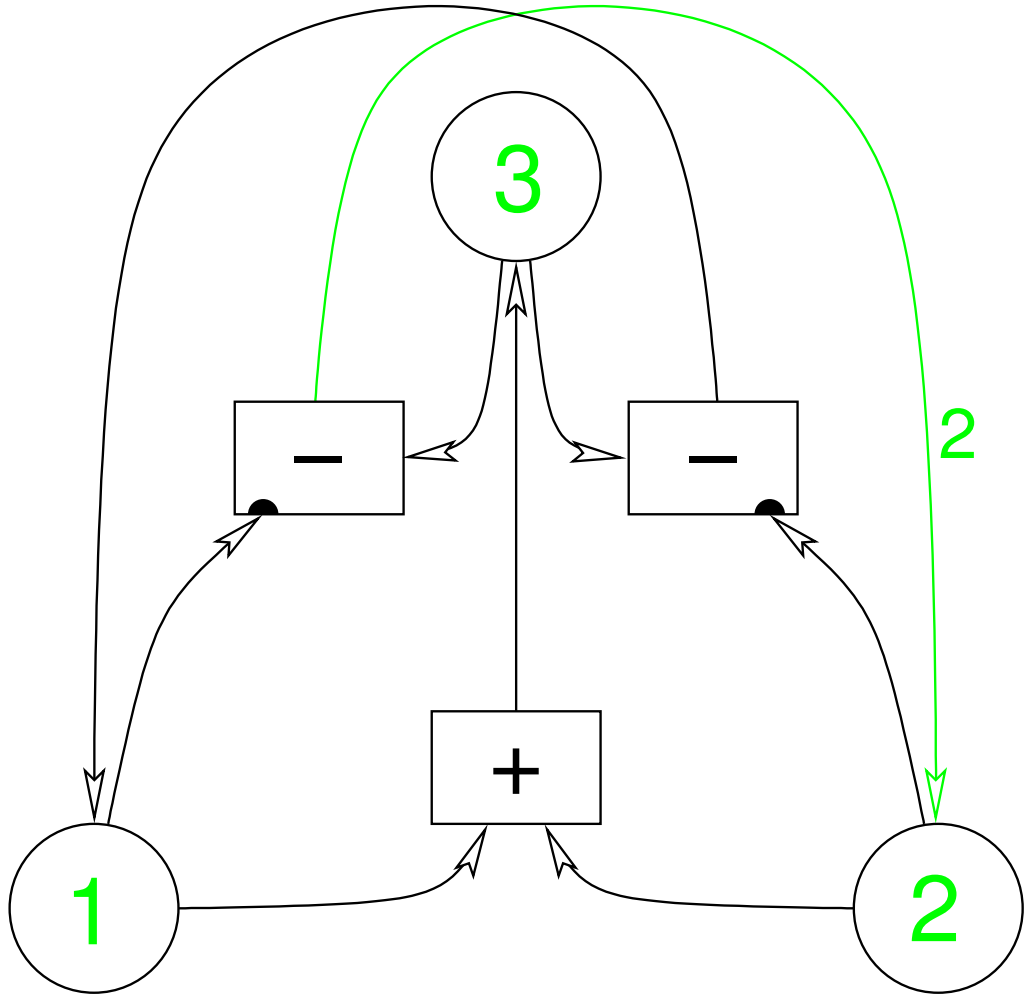

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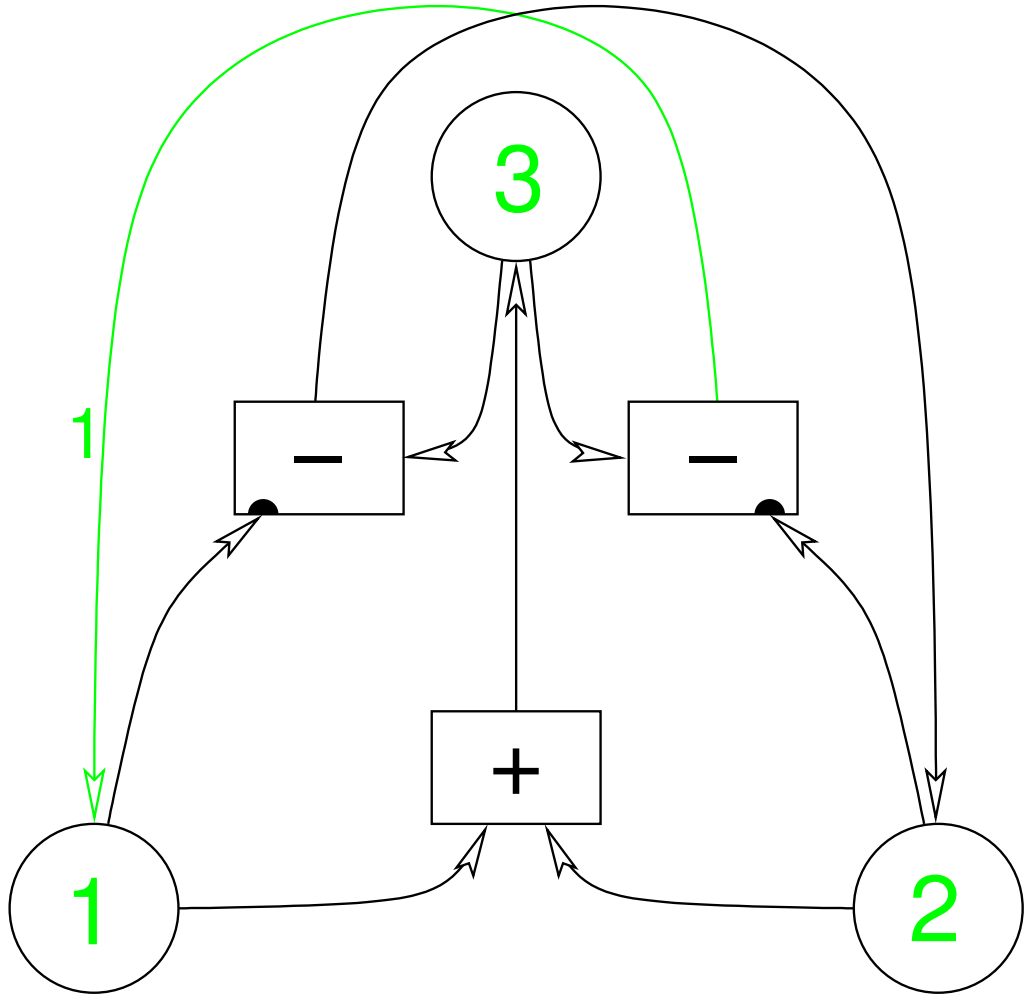

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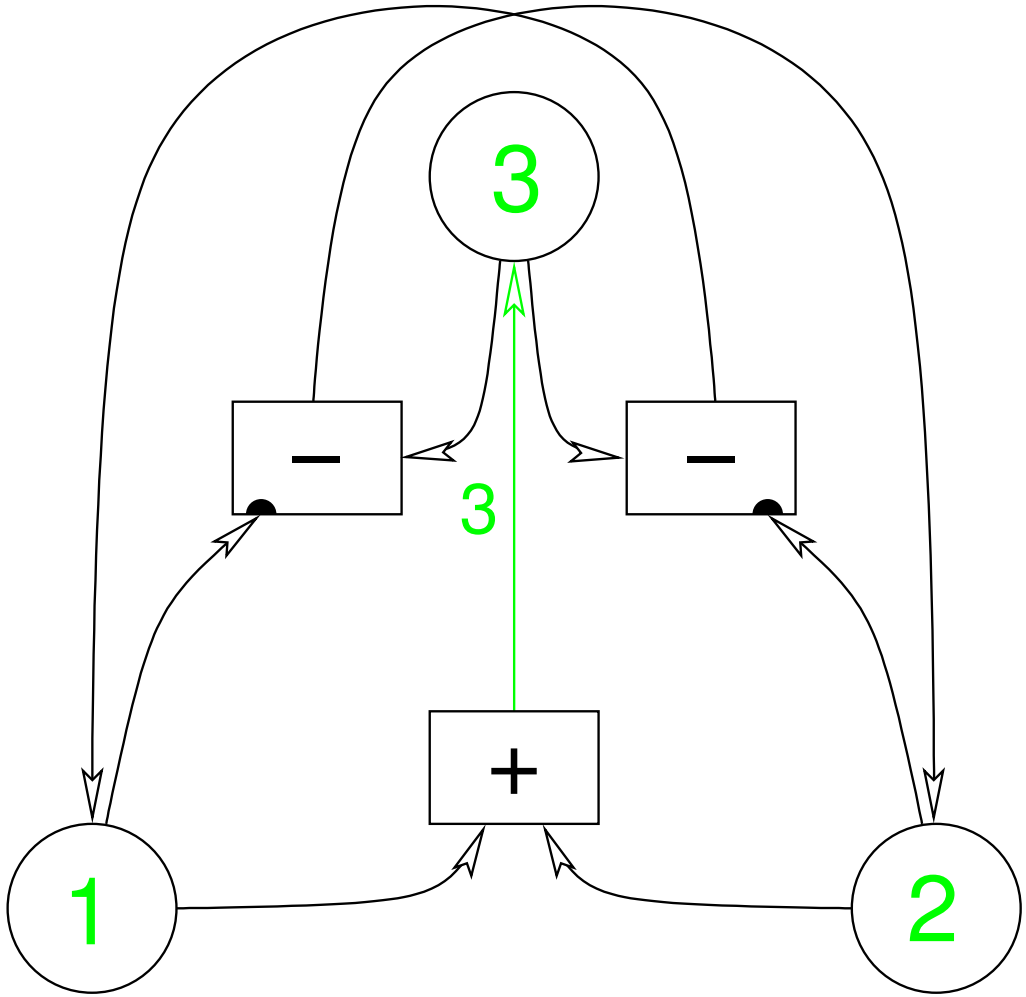

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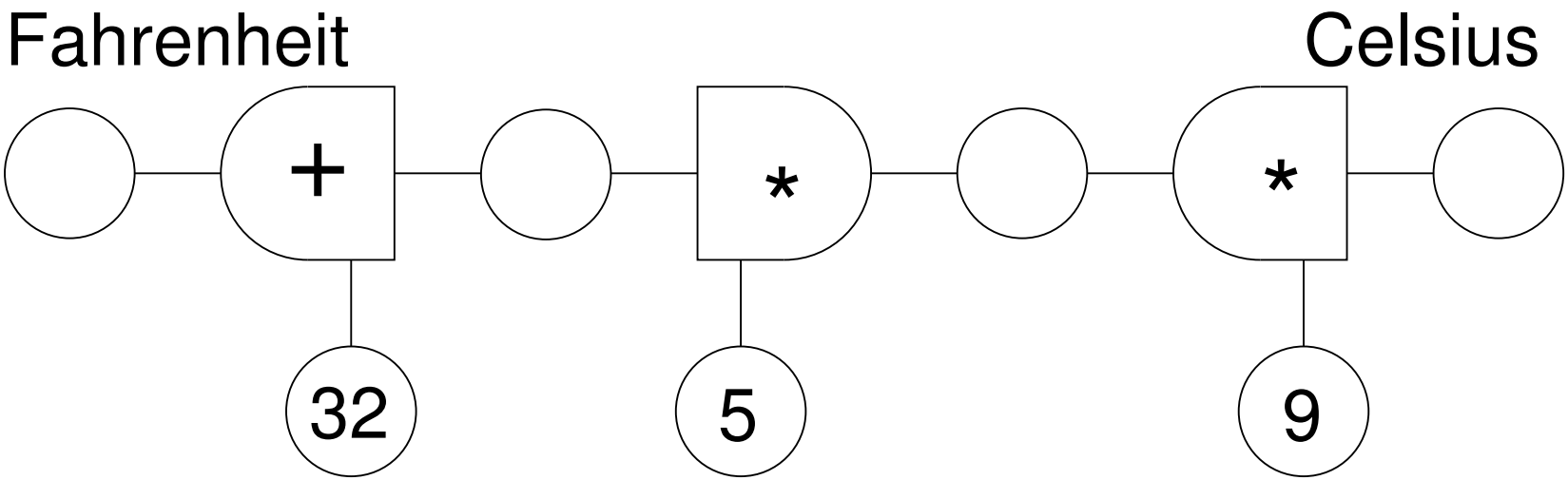

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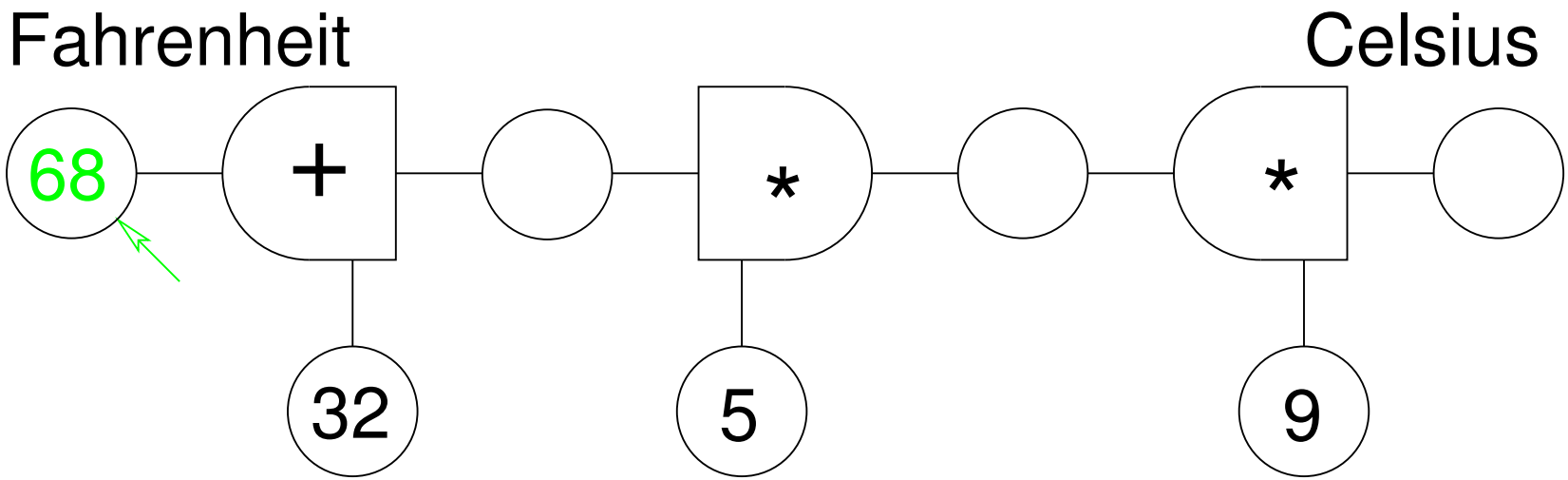

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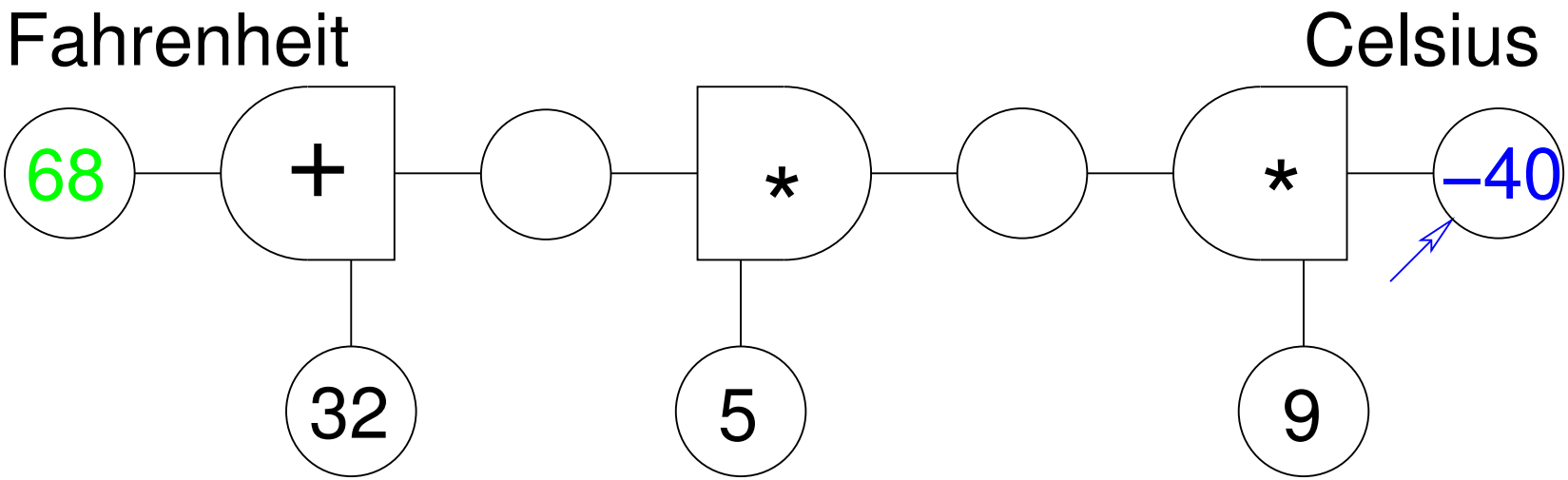

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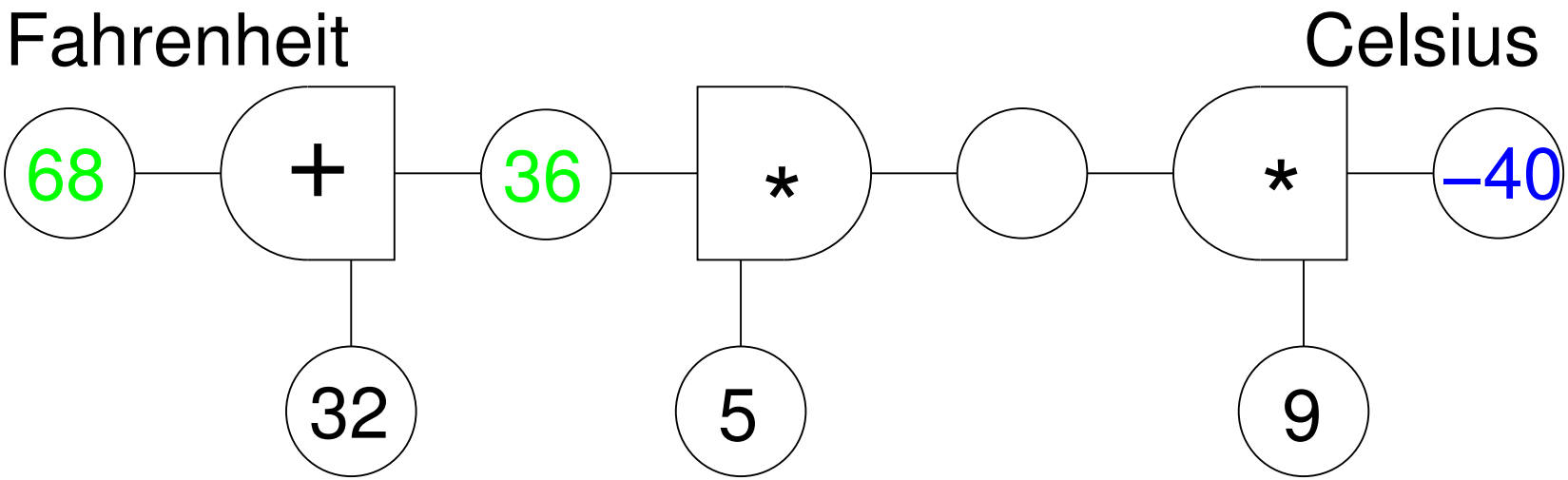

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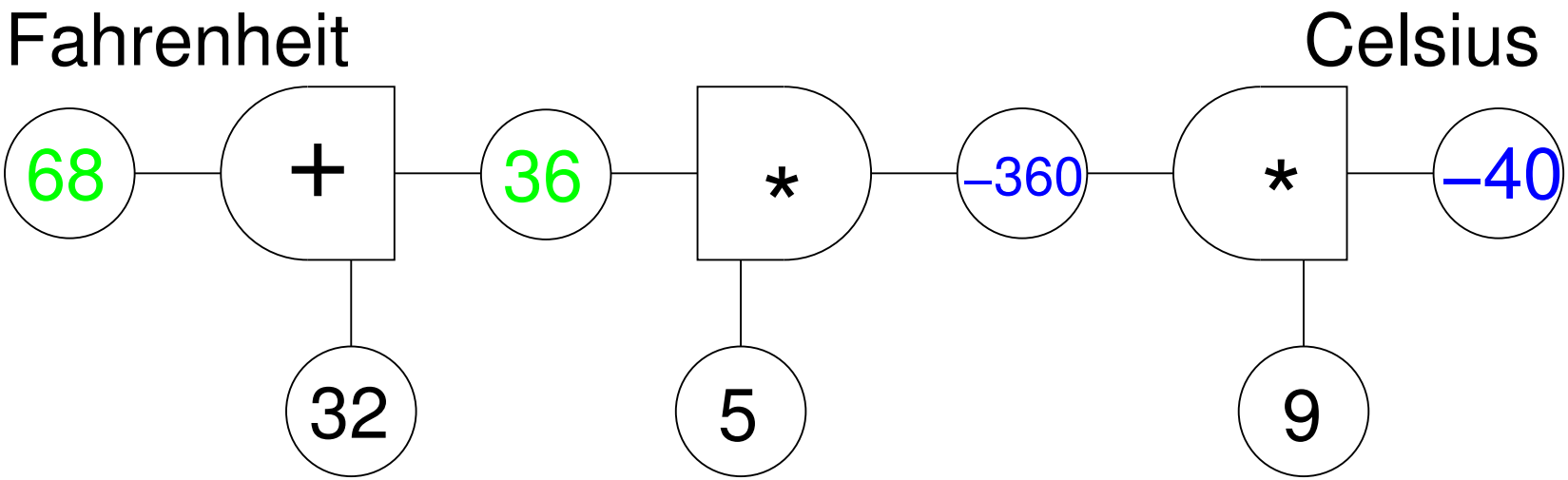

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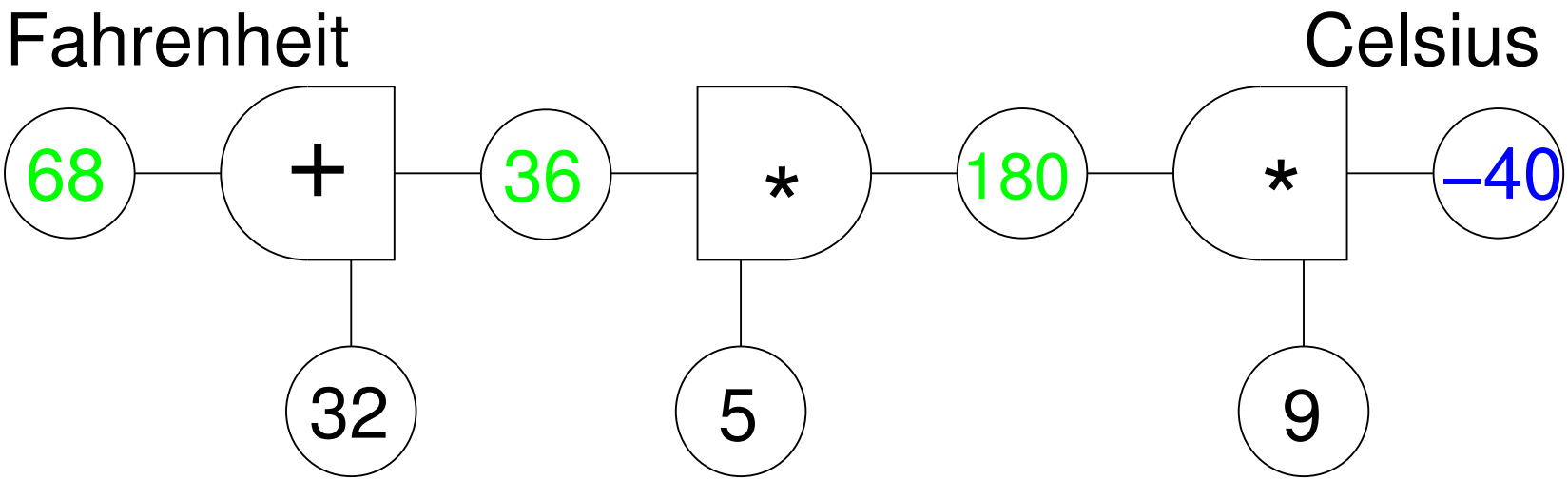

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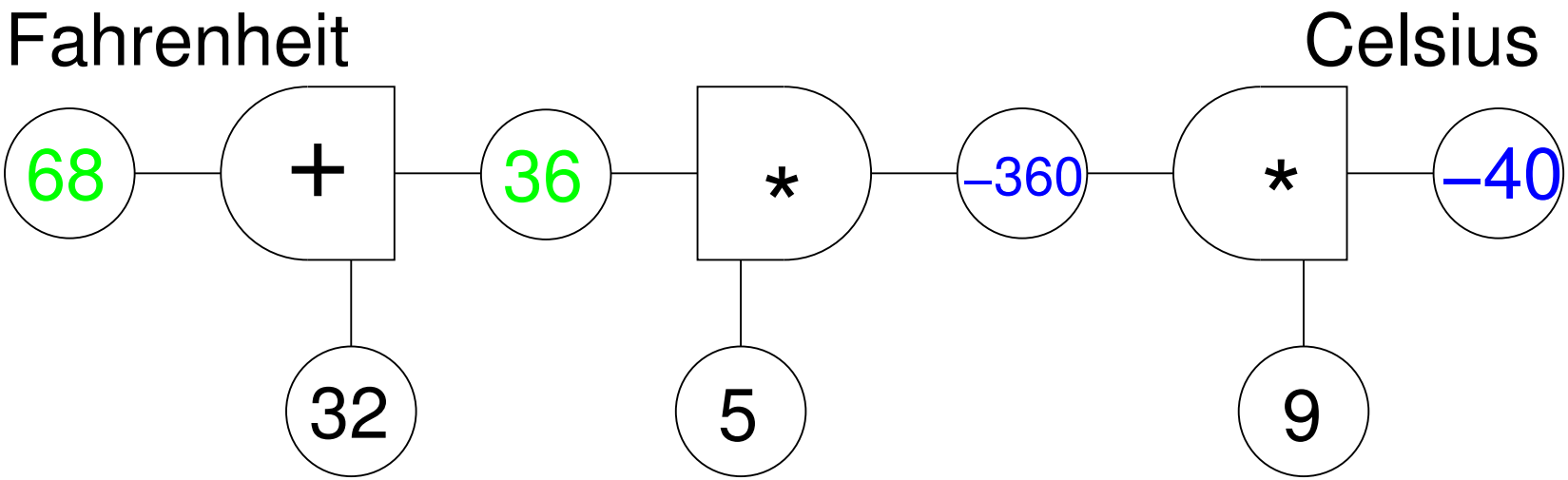

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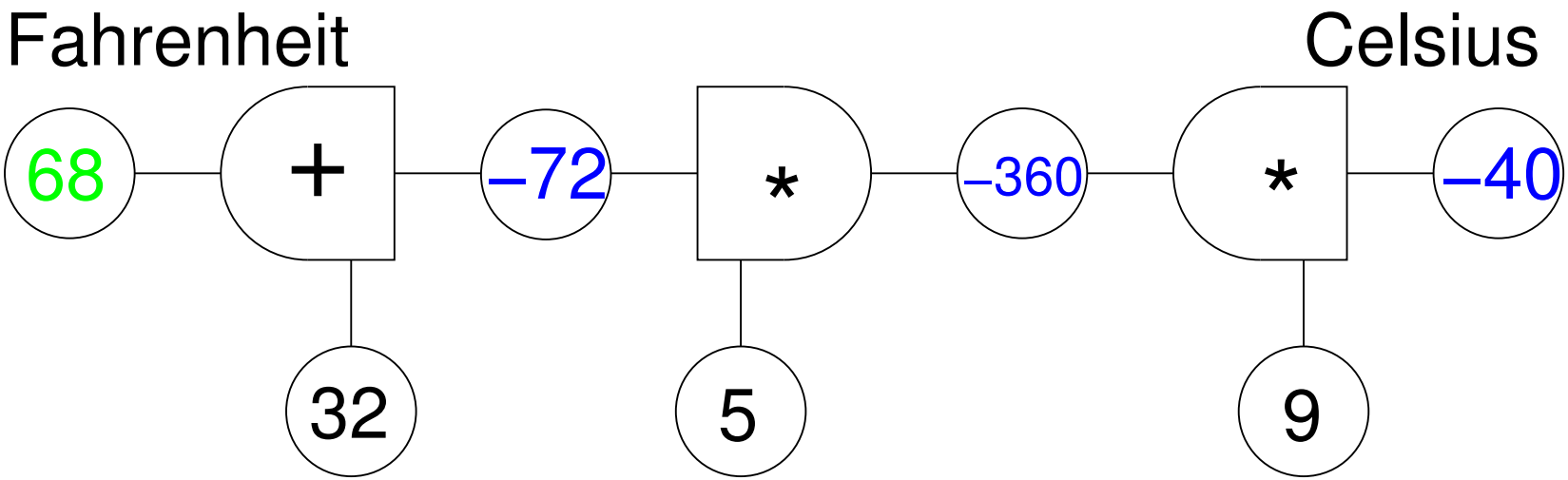

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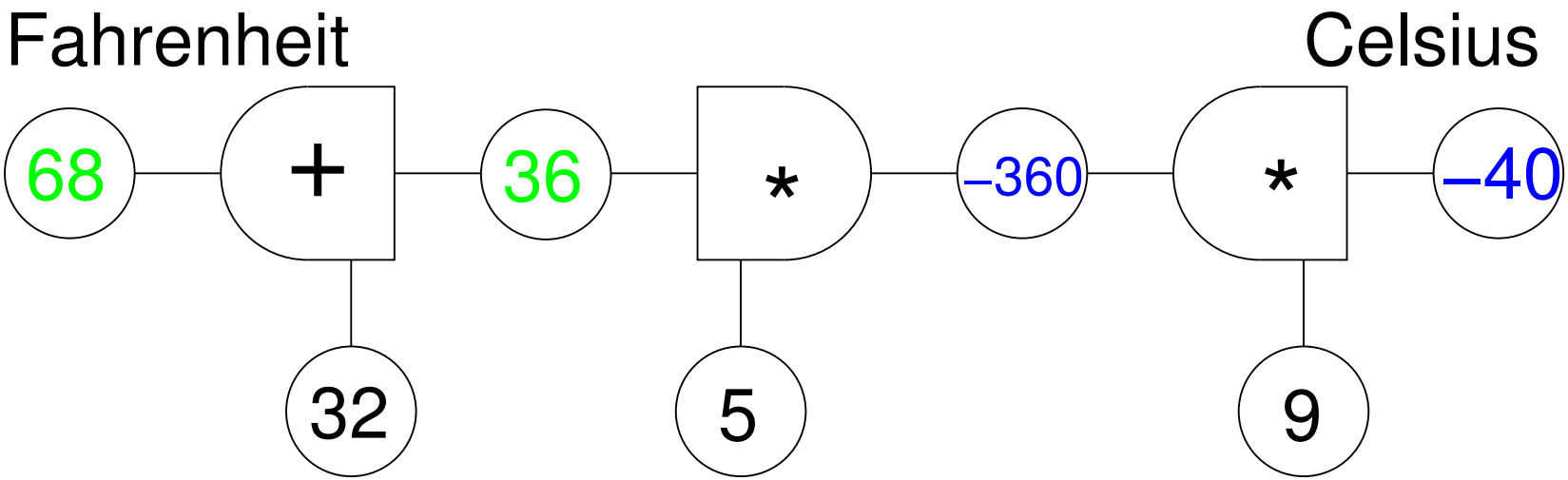

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New View: Cells hold **information about** values

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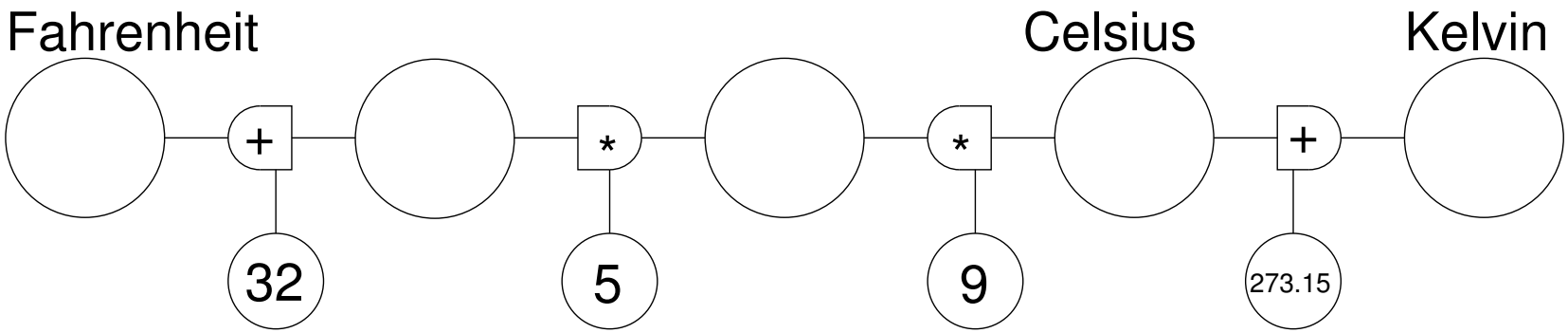
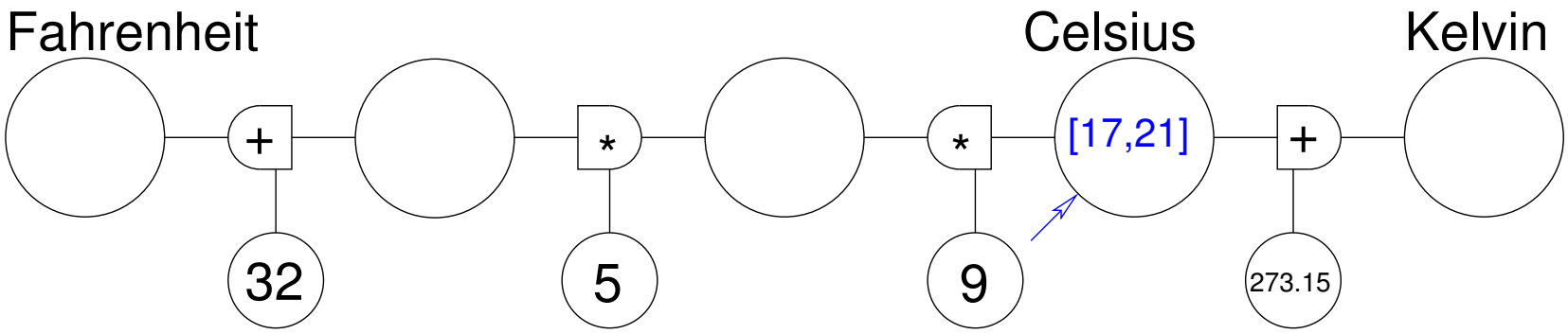
and merge it as it comes in from many sources



E.g. interval arithmetic is partial information



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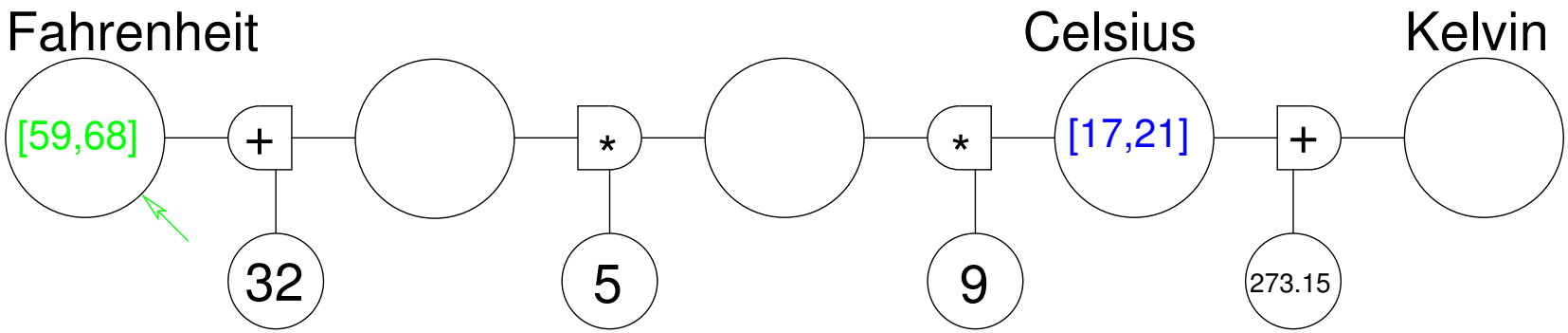

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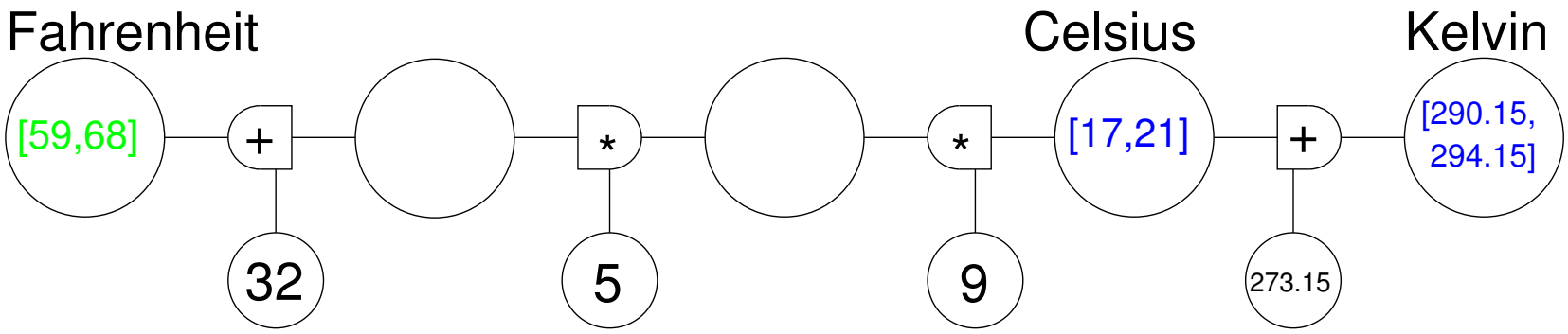

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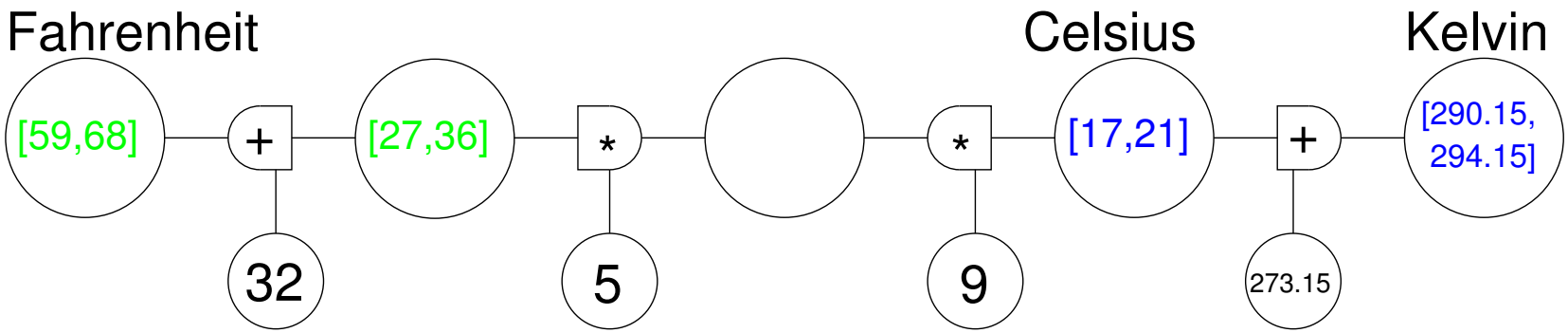

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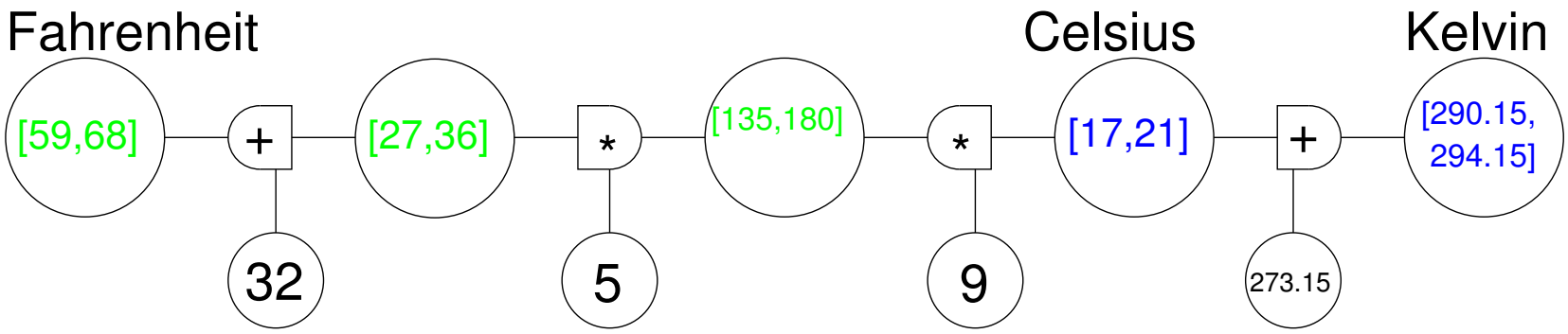

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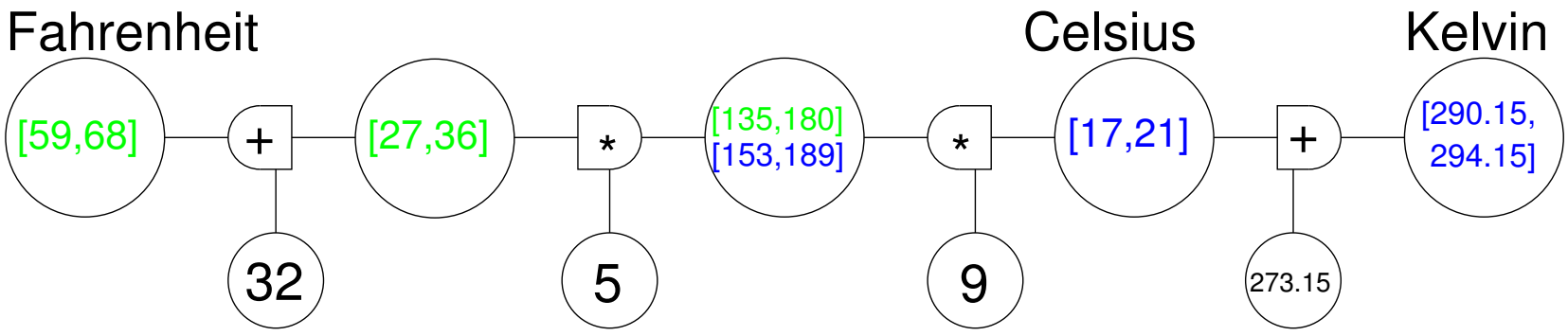

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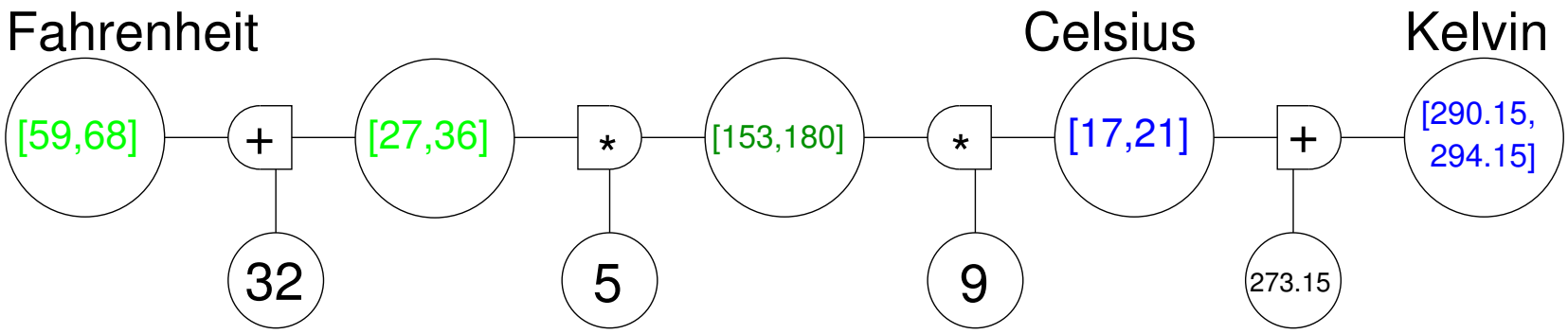

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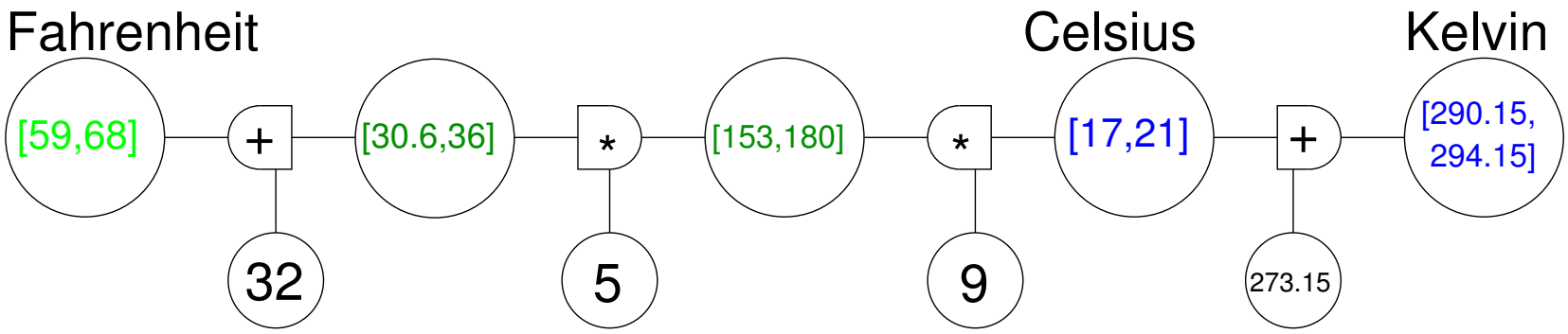

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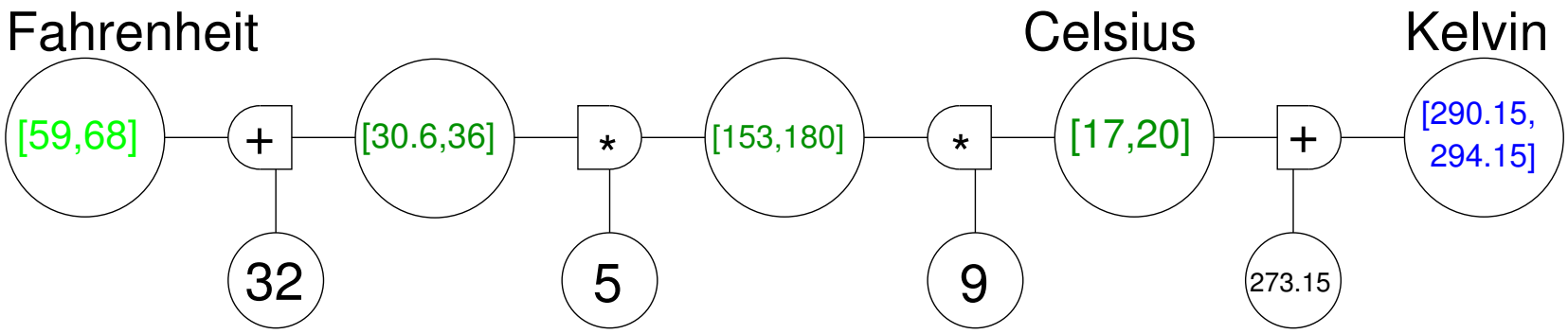

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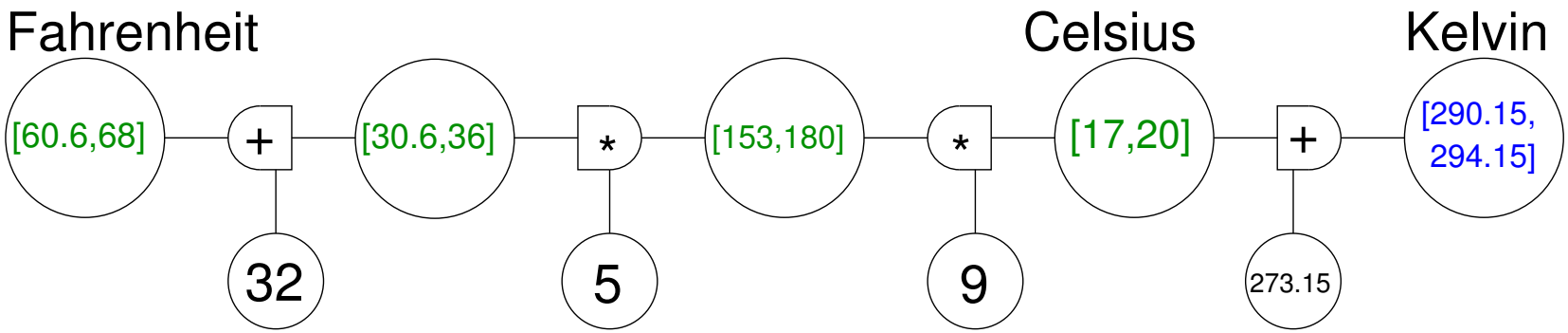

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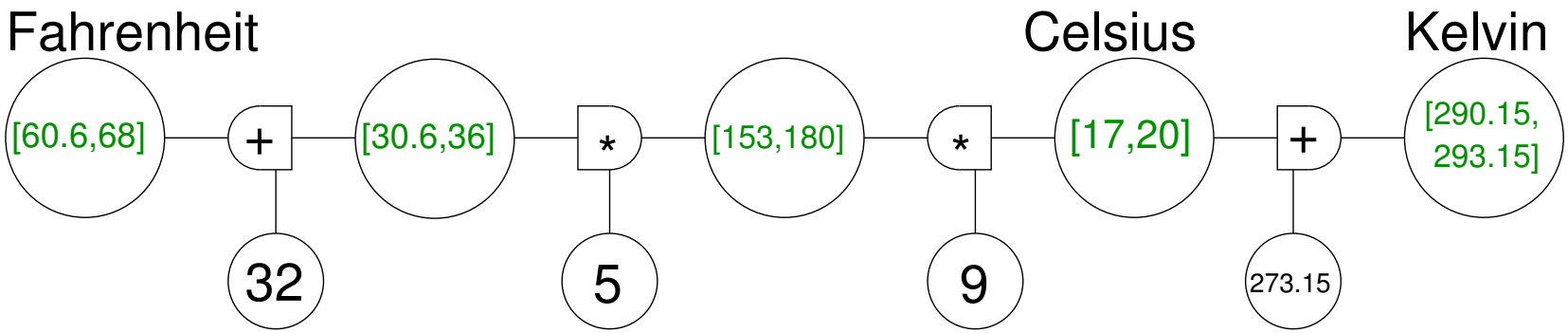
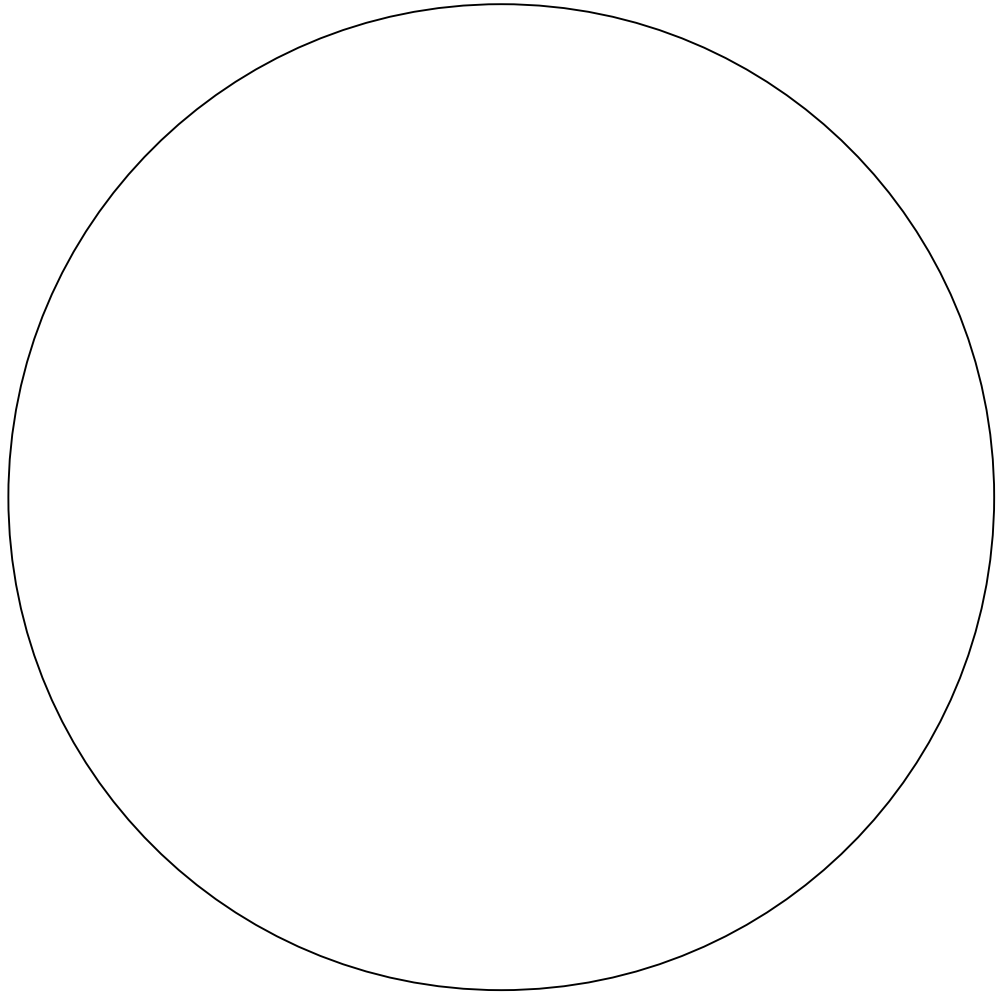
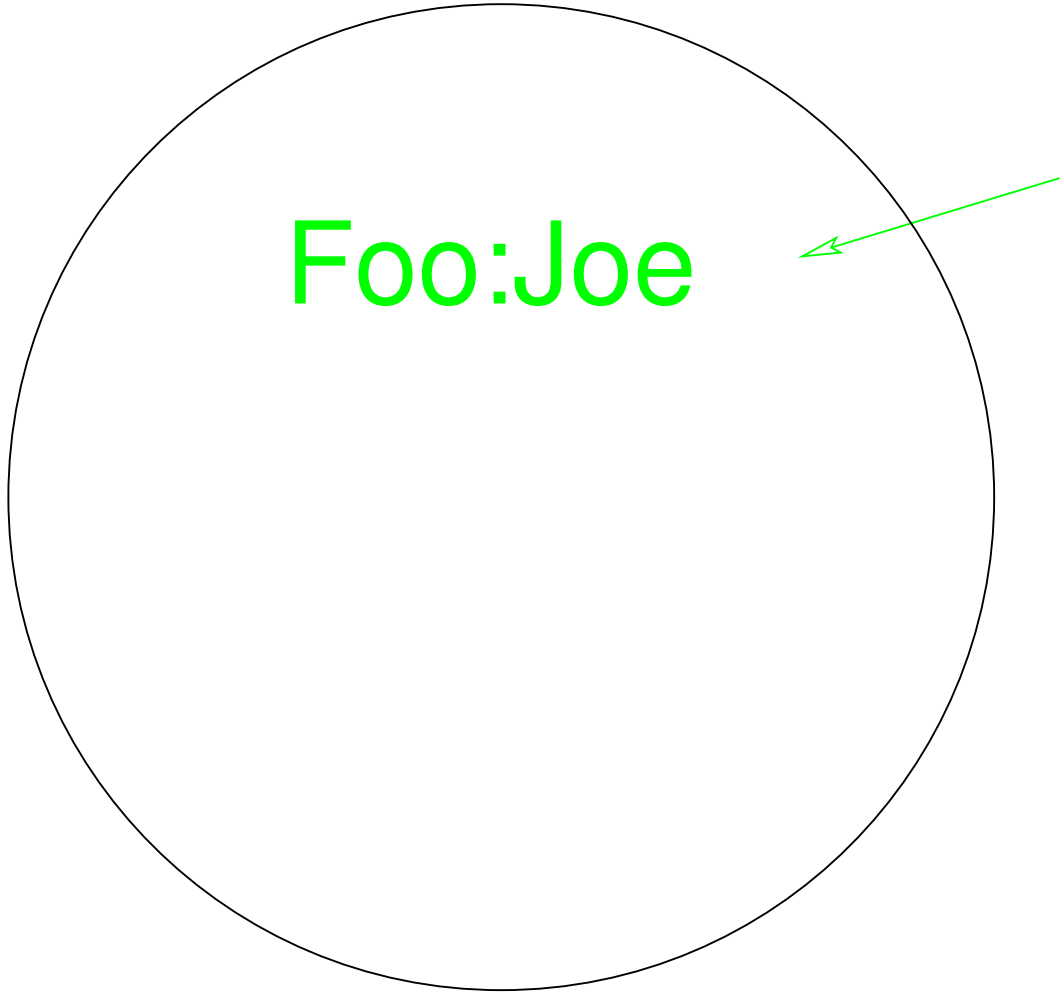


E.g. interval arithmetic is partial information

Partial information makes no sense without multiple sources



Win: Truth maintenance is partial information



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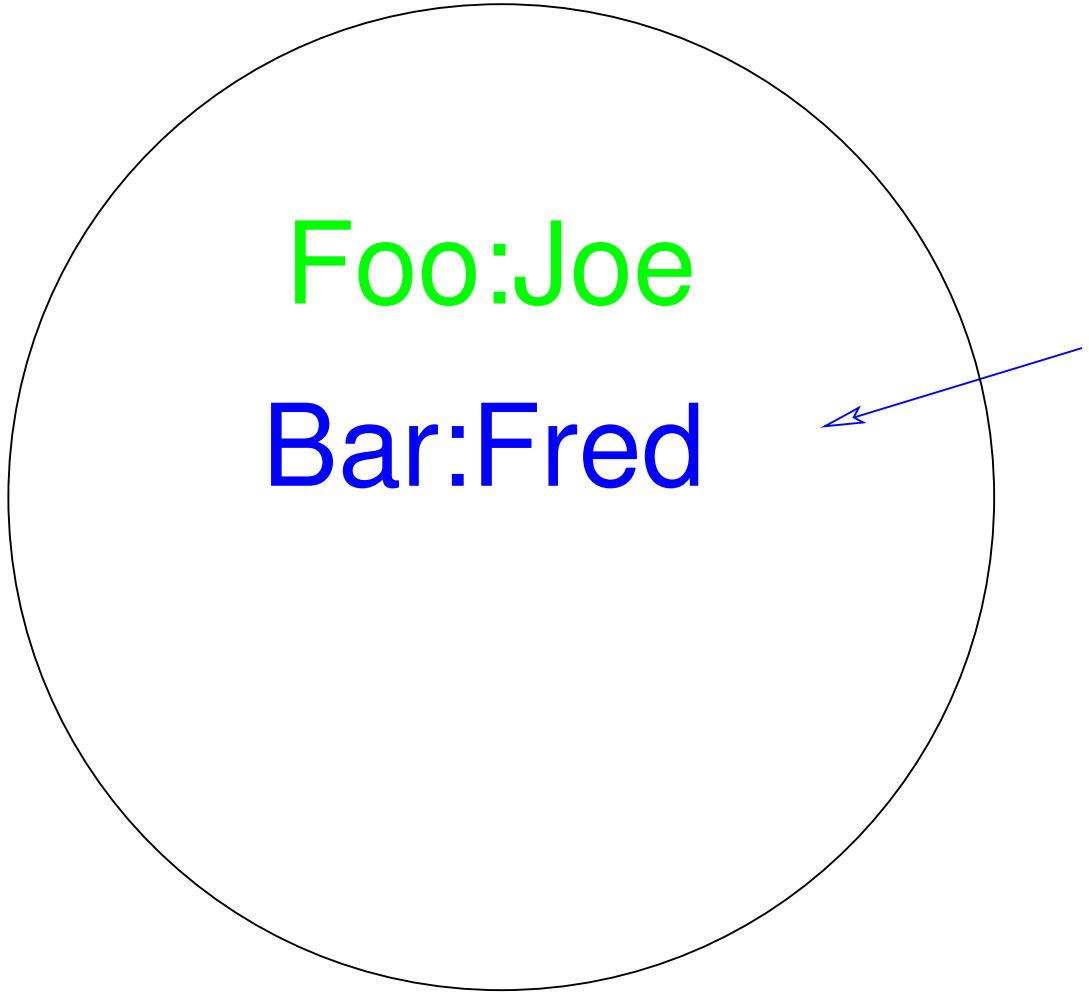
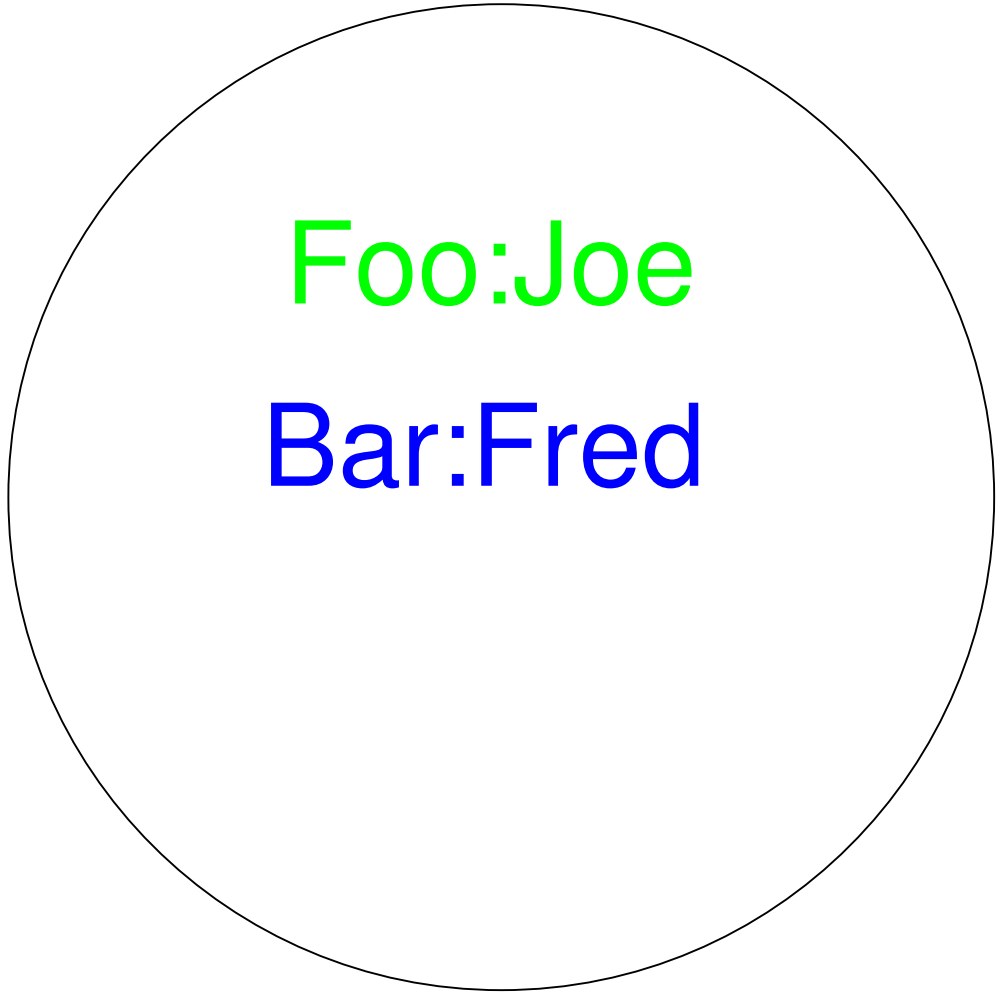


Win: Truth maintenance is partial information



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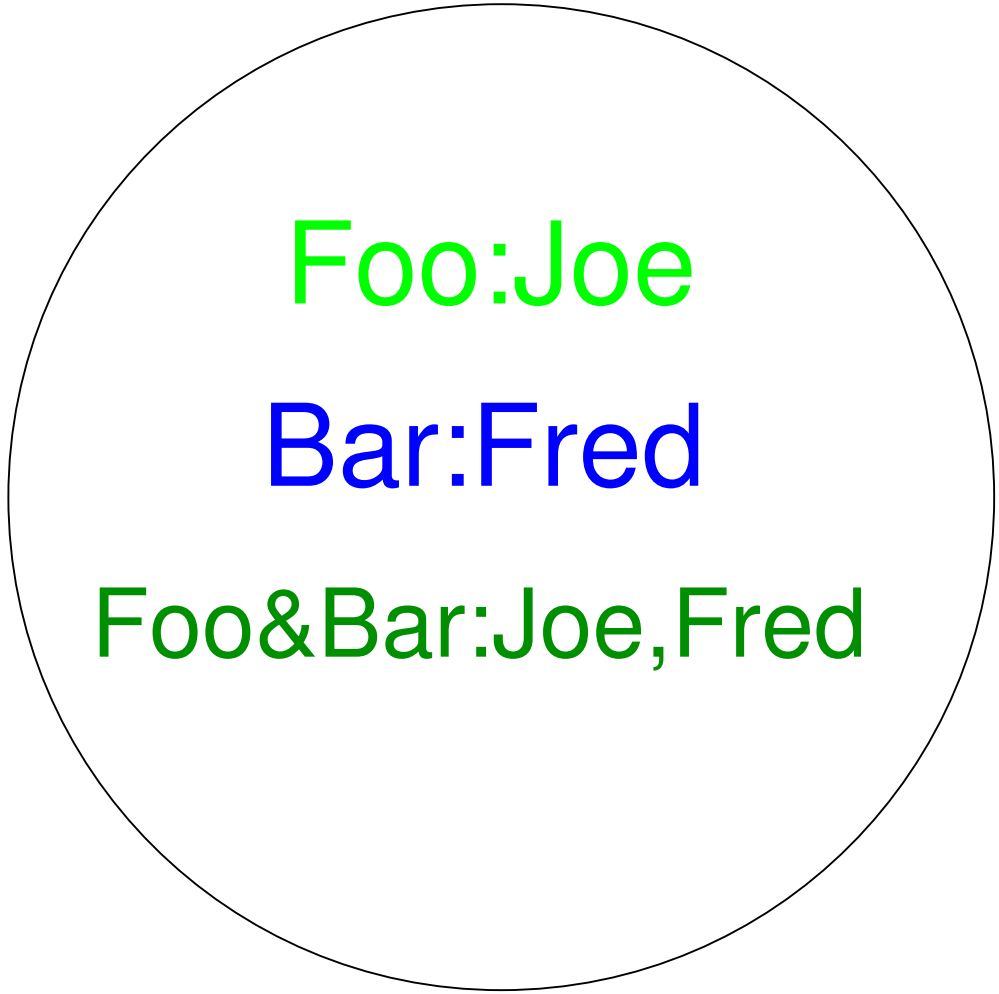

Win: Truth maintenance is partial information

Win: Making `merge` generic decouples the accident of kind of accumulator from the essence of propagation

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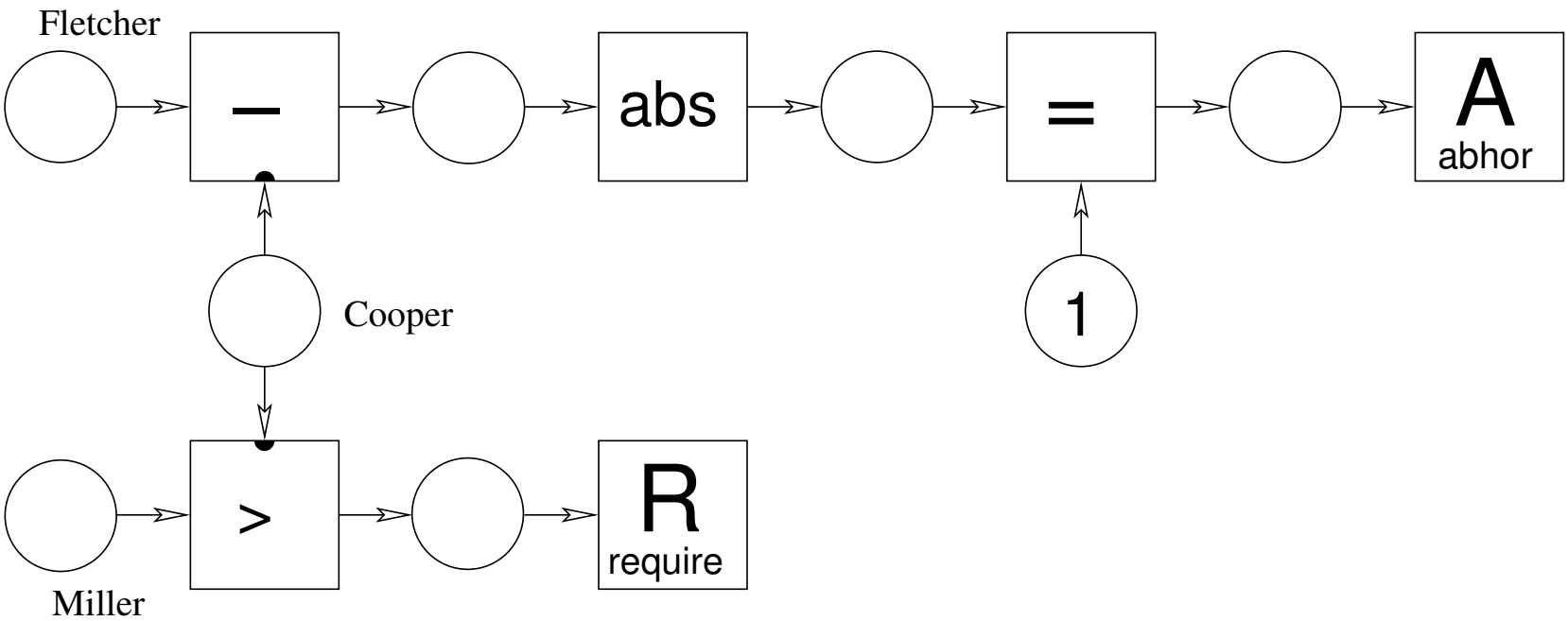
and now we can use many different kinds of accumulators

Example: Implicit Search

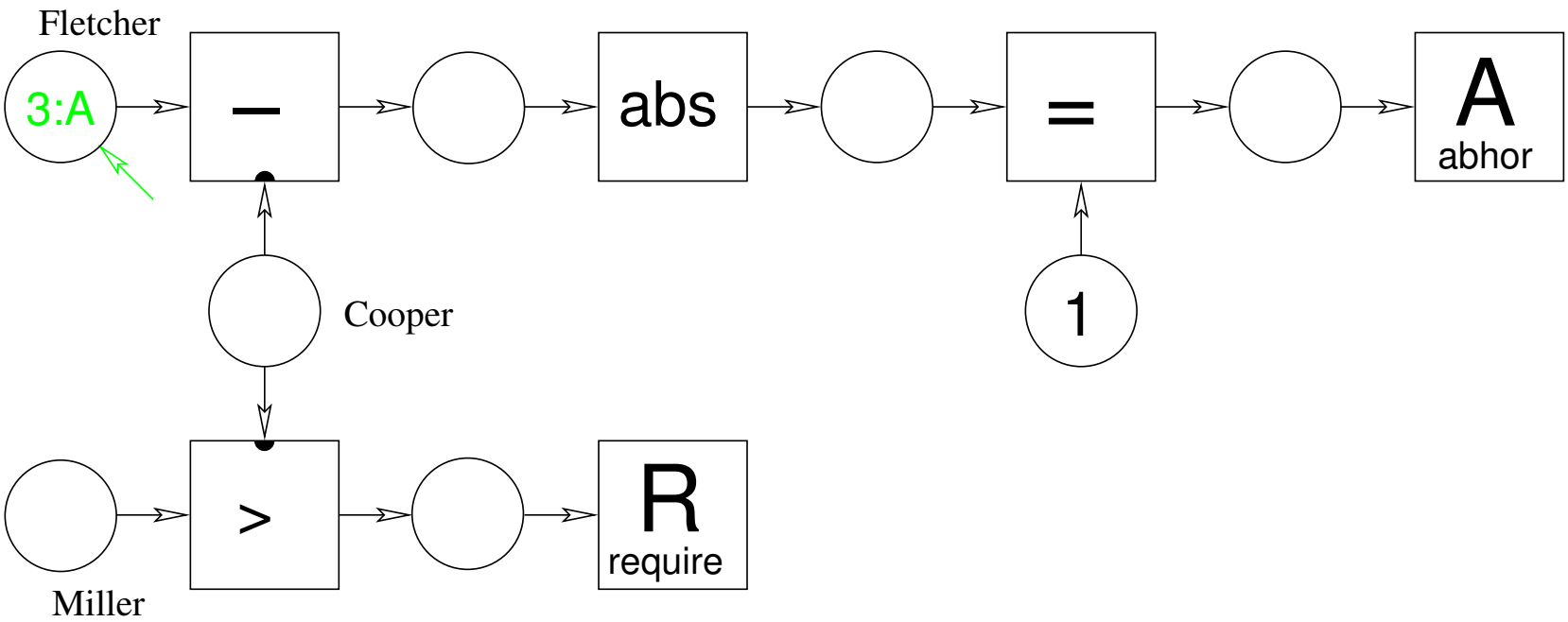
Baker, Cooper, Fletcher, Miller, and Smith live on the first five floors of this apartment house. Baker does not live on the fifth floor. Cooper does not live on the first floor. Fletcher does not live on either the fifth or the first floor. Miller lives on a higher floor than does Cooper. Smith does not live on a floor adjacent to Fletcher's. Fletcher does not live on a floor adjacent to Cooper's.

We can write a program like this

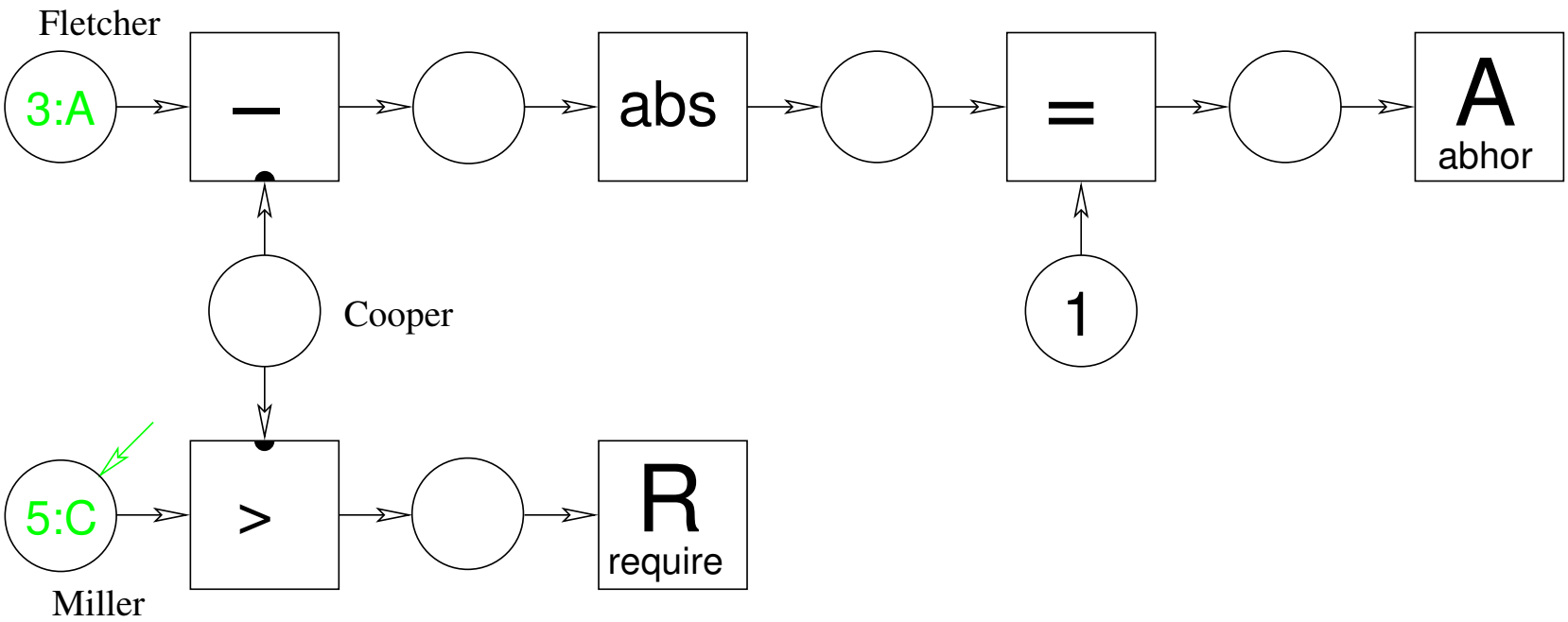
```
(define (multiple-dwelling)
  (let ((baker (one-of 1 2 3 4 5))
        (cooper (one-of 1 2 3 4 5))
        (fletcher (one-of 1 2 3 4 5))
        (miller (one-of 1 2 3 4 5))
        (smith (one-of 1 2 3 4 5)))
    (require-distinct
     (list baker cooper fletcher miller smith))
    (abhor (= baker 5))     (abhor (= cooper 1))
    (abhor (= fletcher 5))  (abhor (= fletcher 1))
    (require (> miller cooper))
    (abhor (= 1 (abs (- smith fletcher))))
    (abhor (= 1 (abs (- fletcher cooper))))
    (list baker cooper fletcher miller smith)))
```



Compile it to a network like this



Track which guesses
a value depends on



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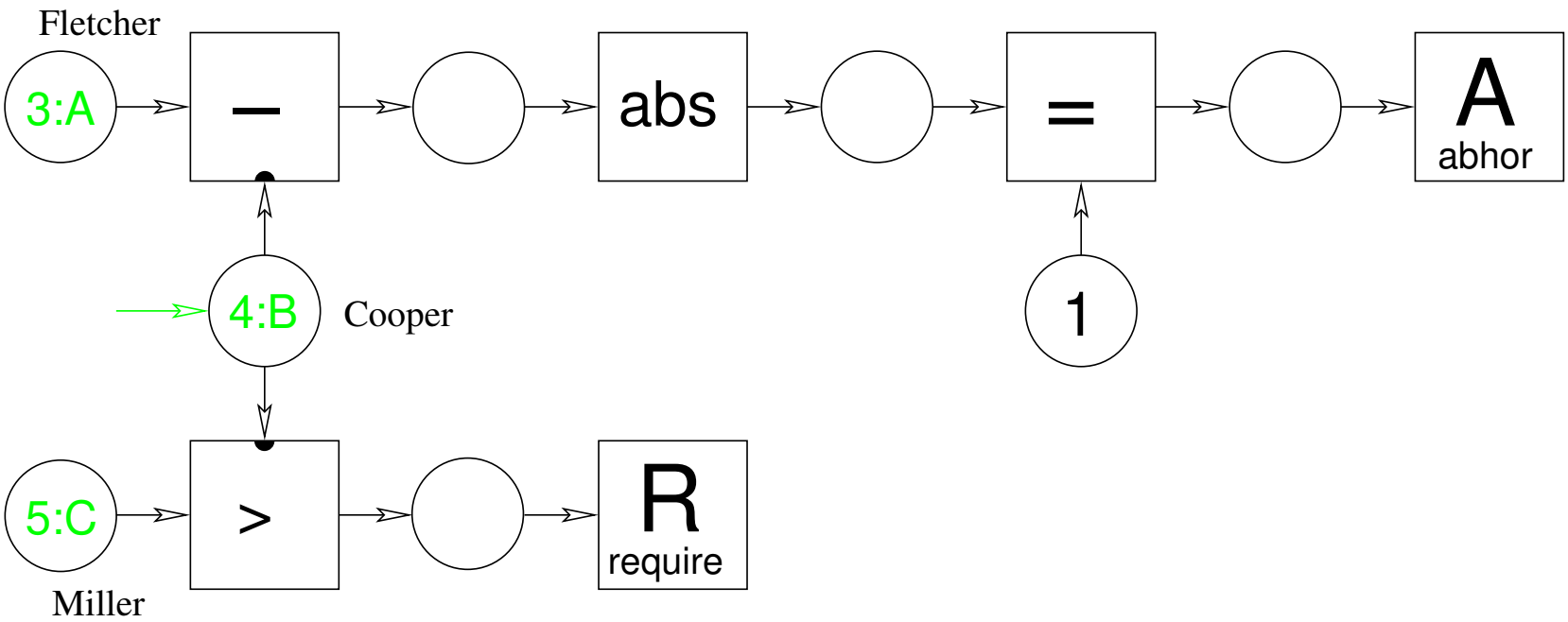

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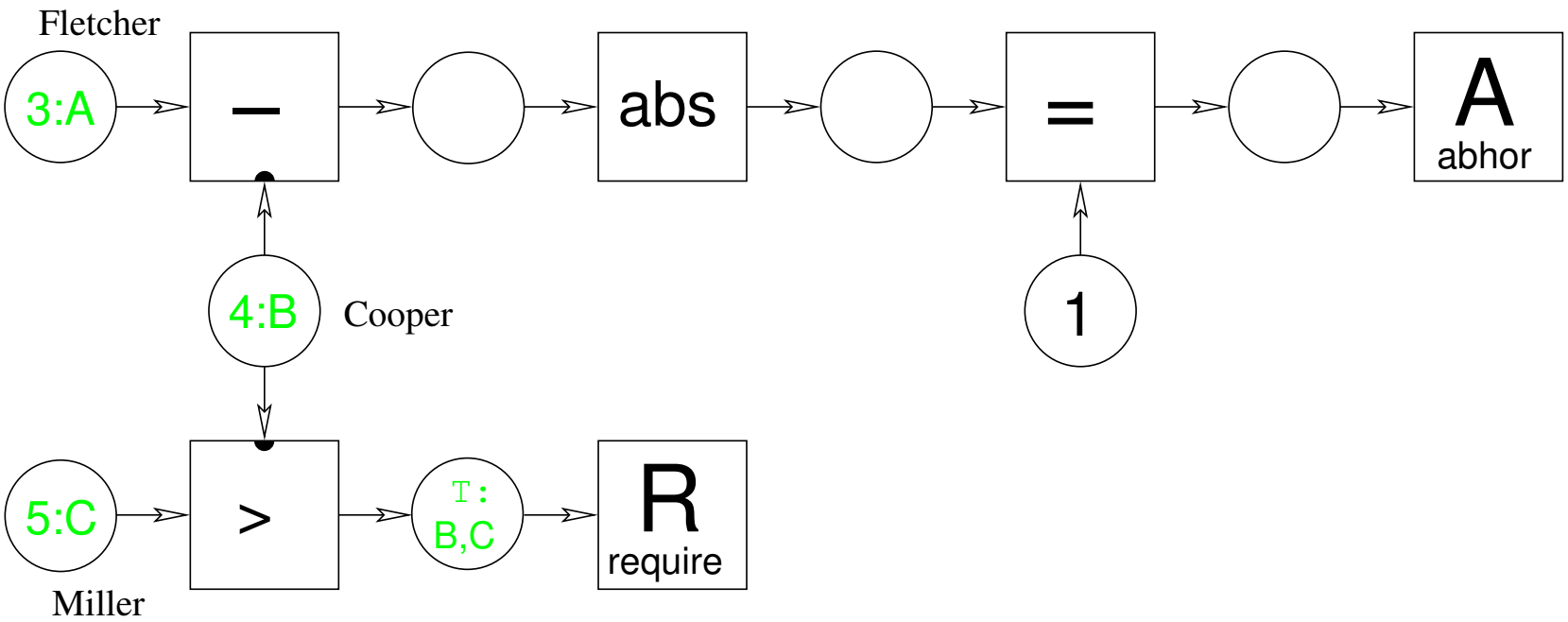

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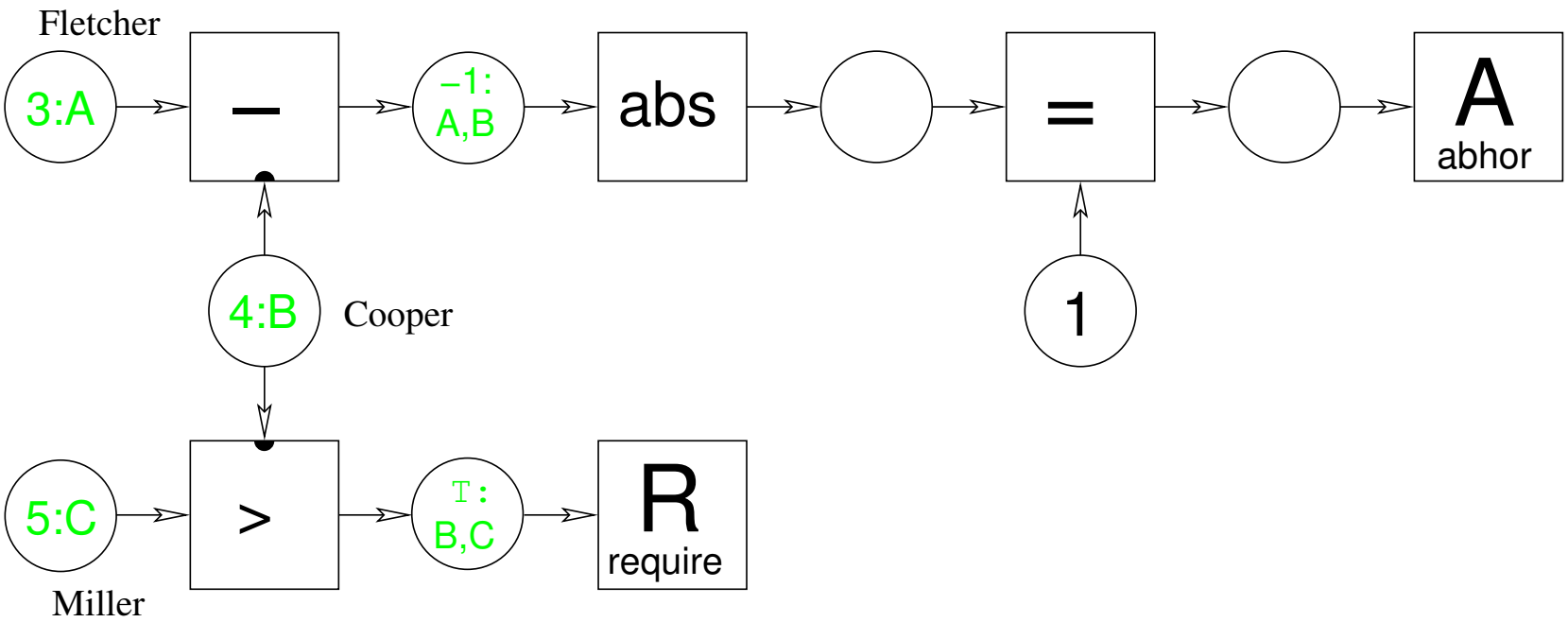

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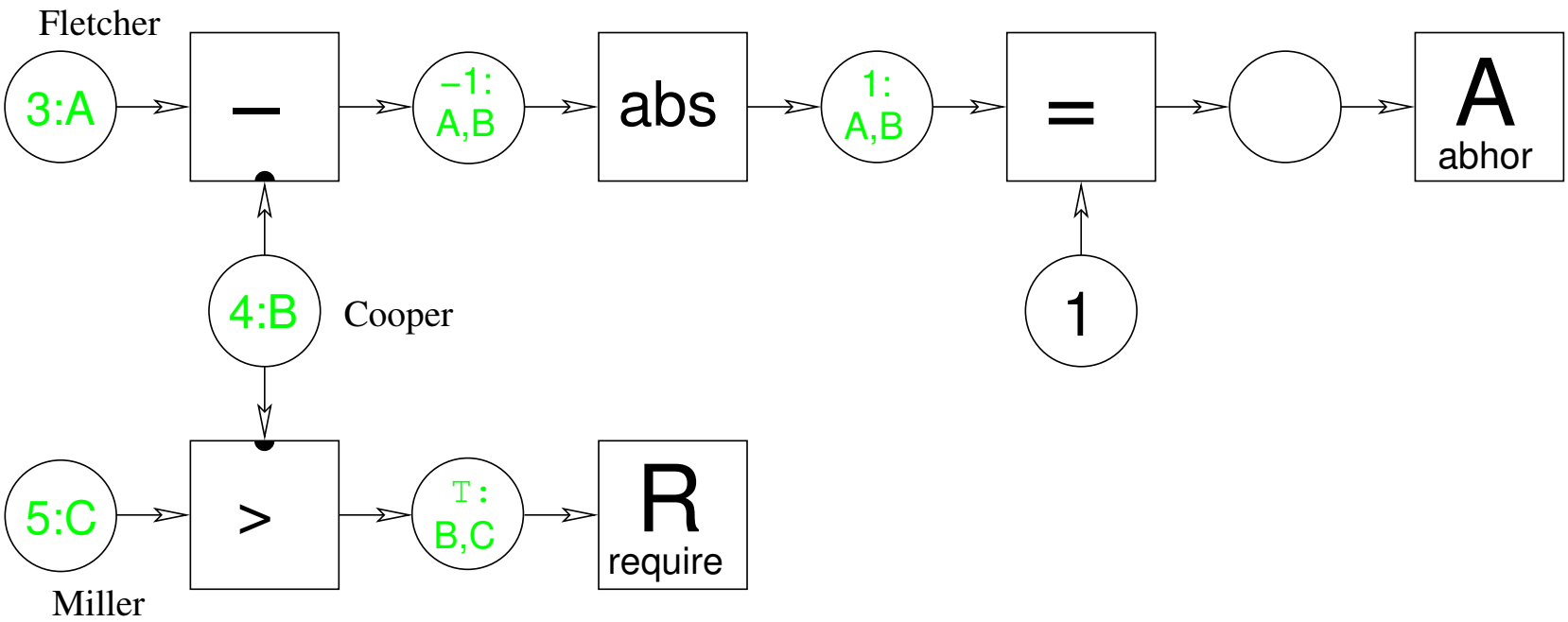

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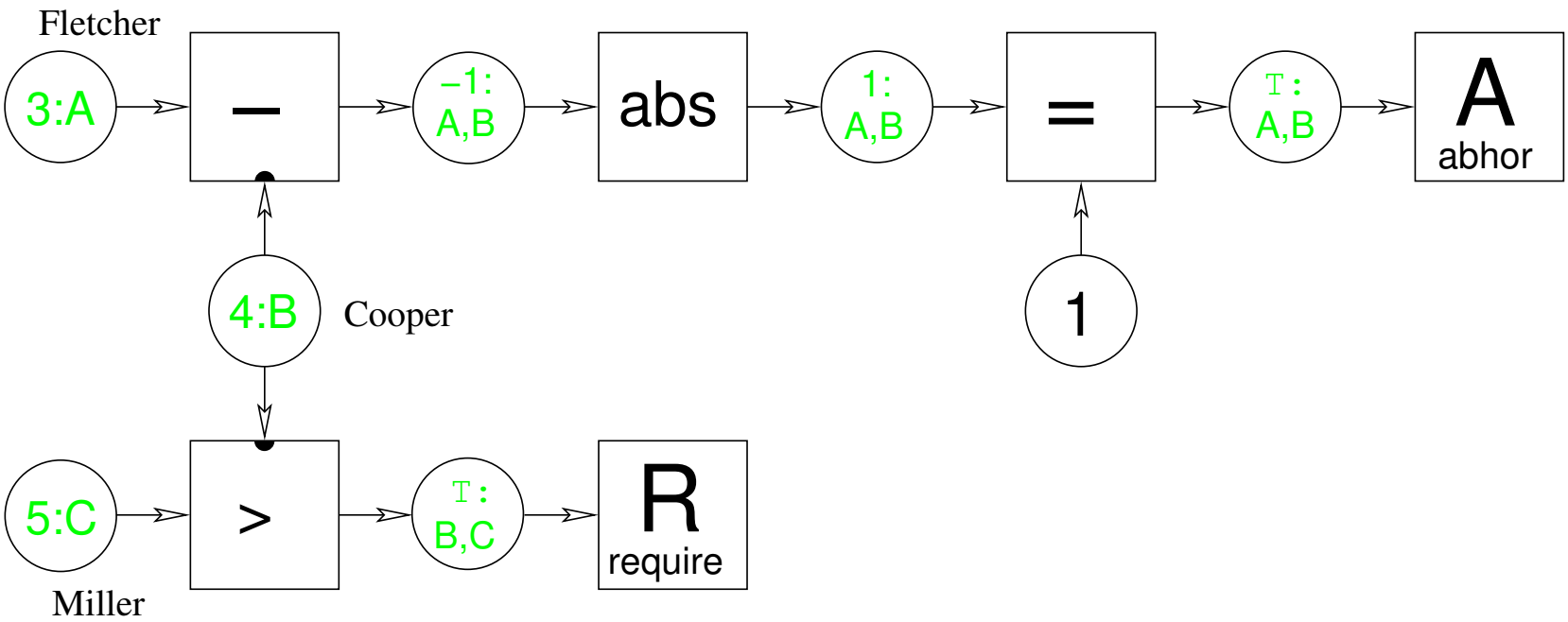

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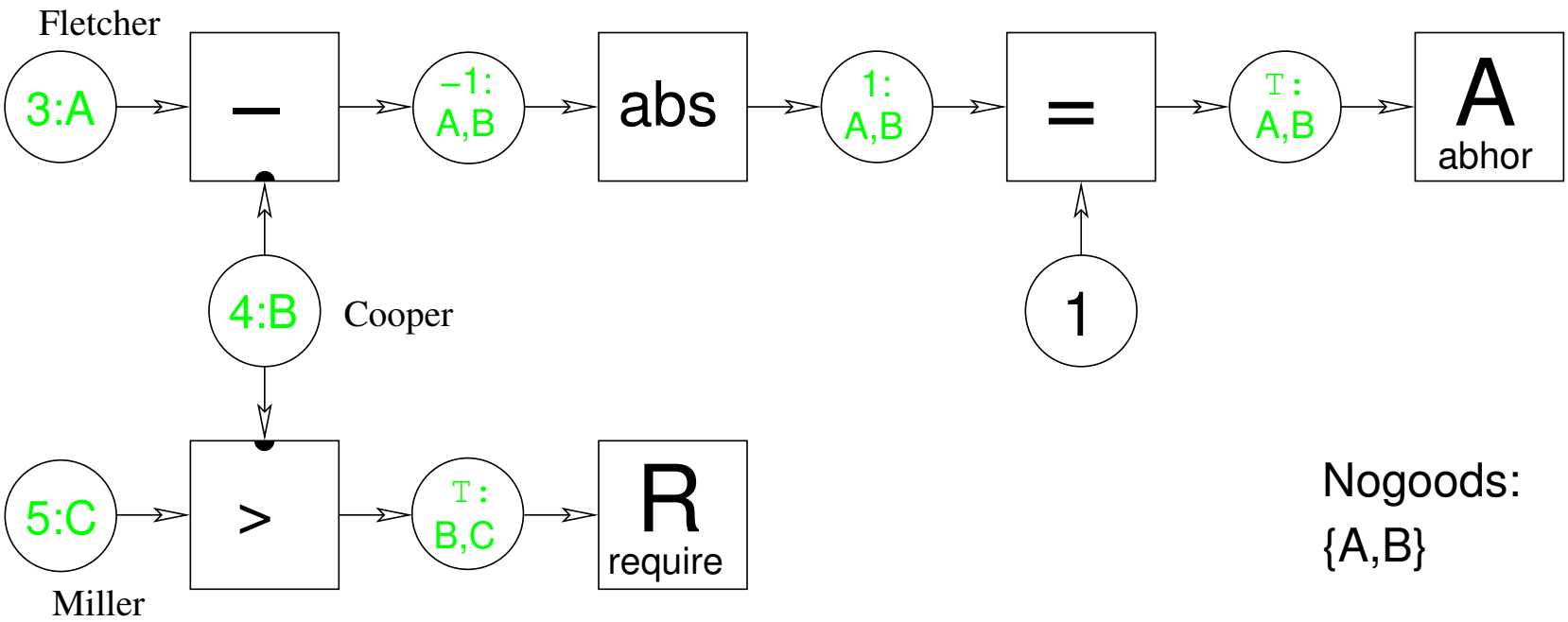
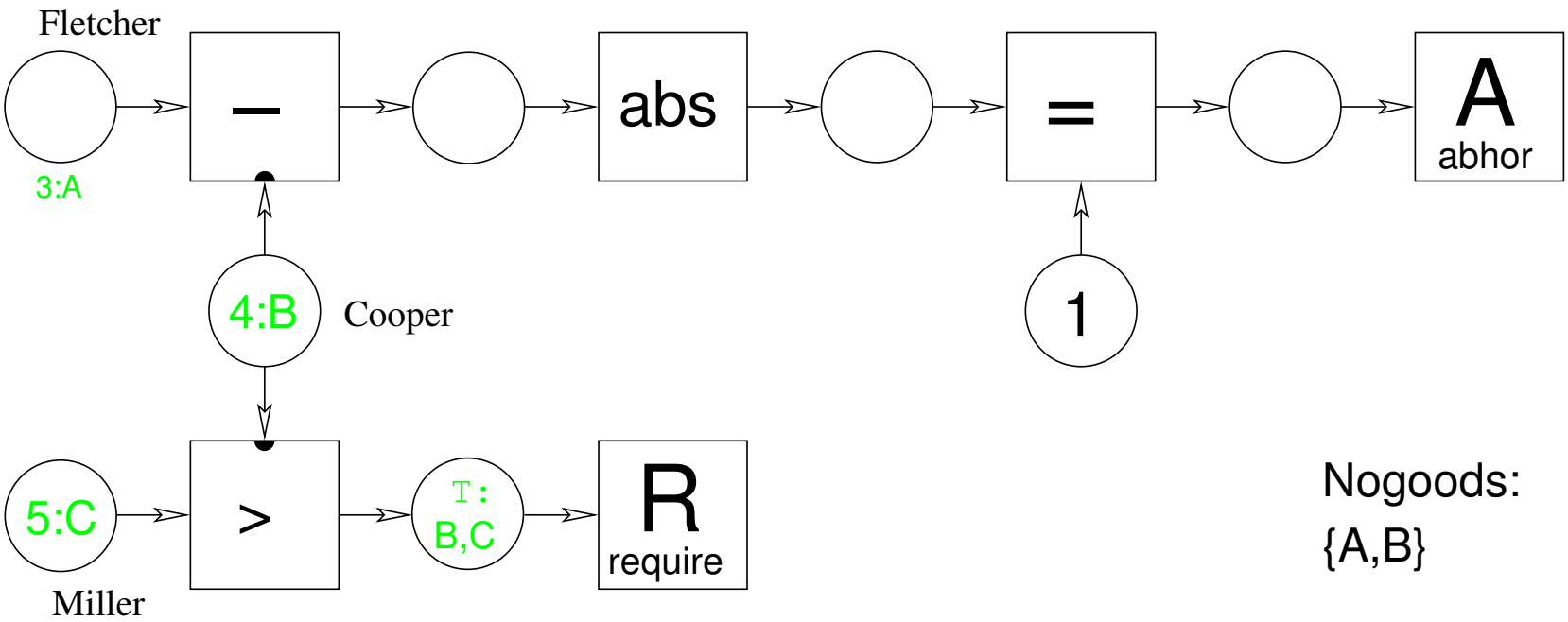


Nogoods:
{A,B}

And use that for accurate backtracking



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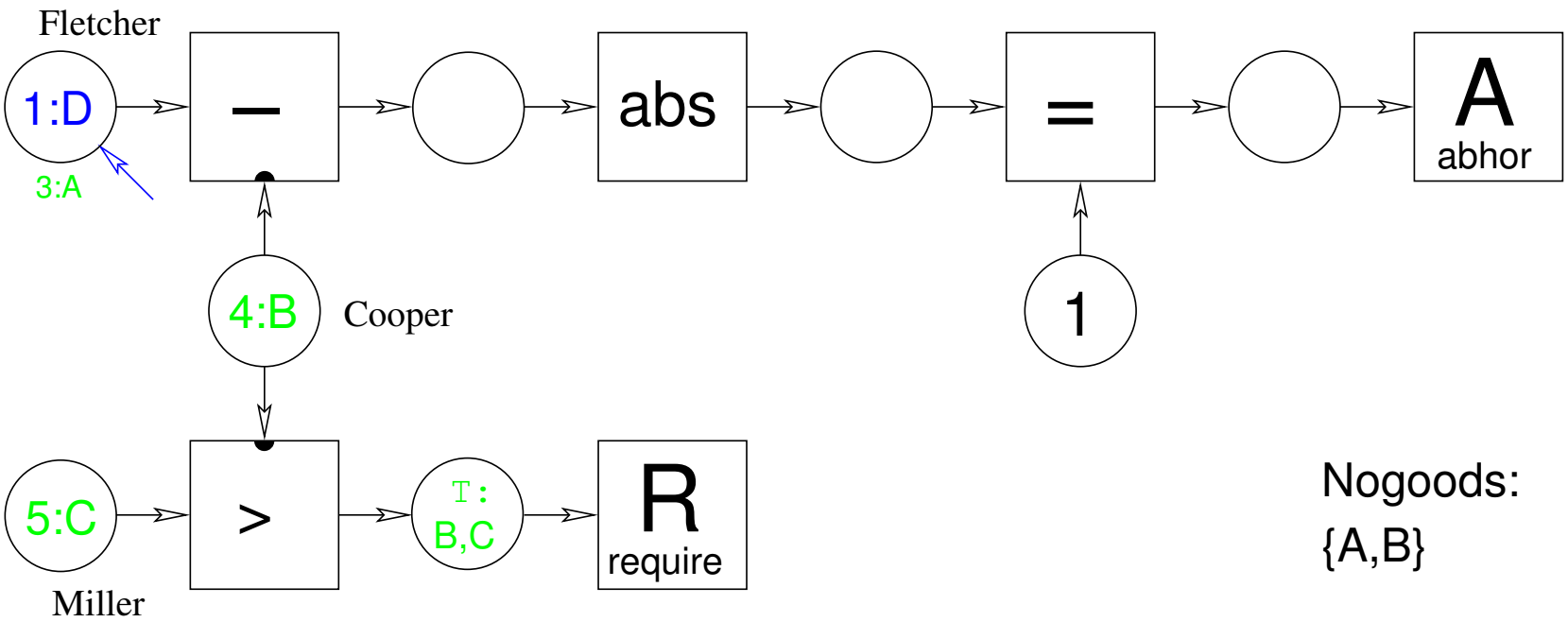
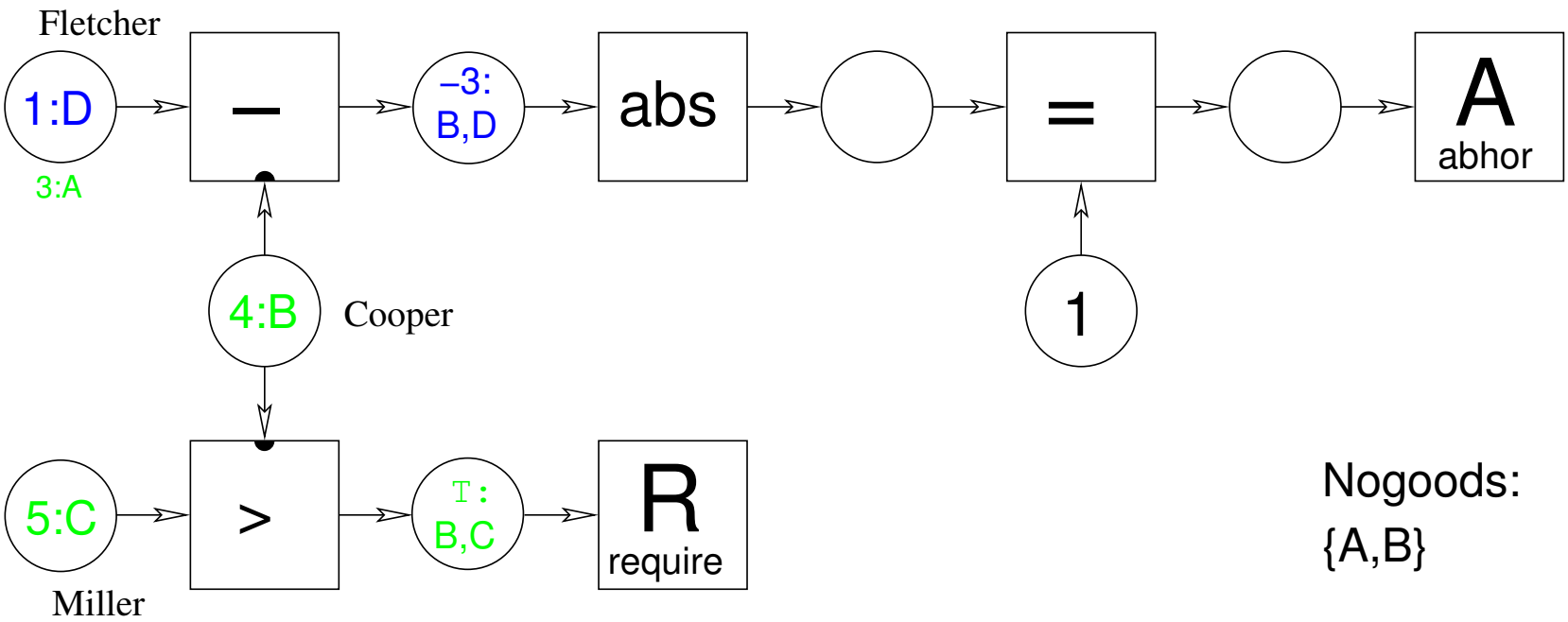


Without recomputing anything unrelated



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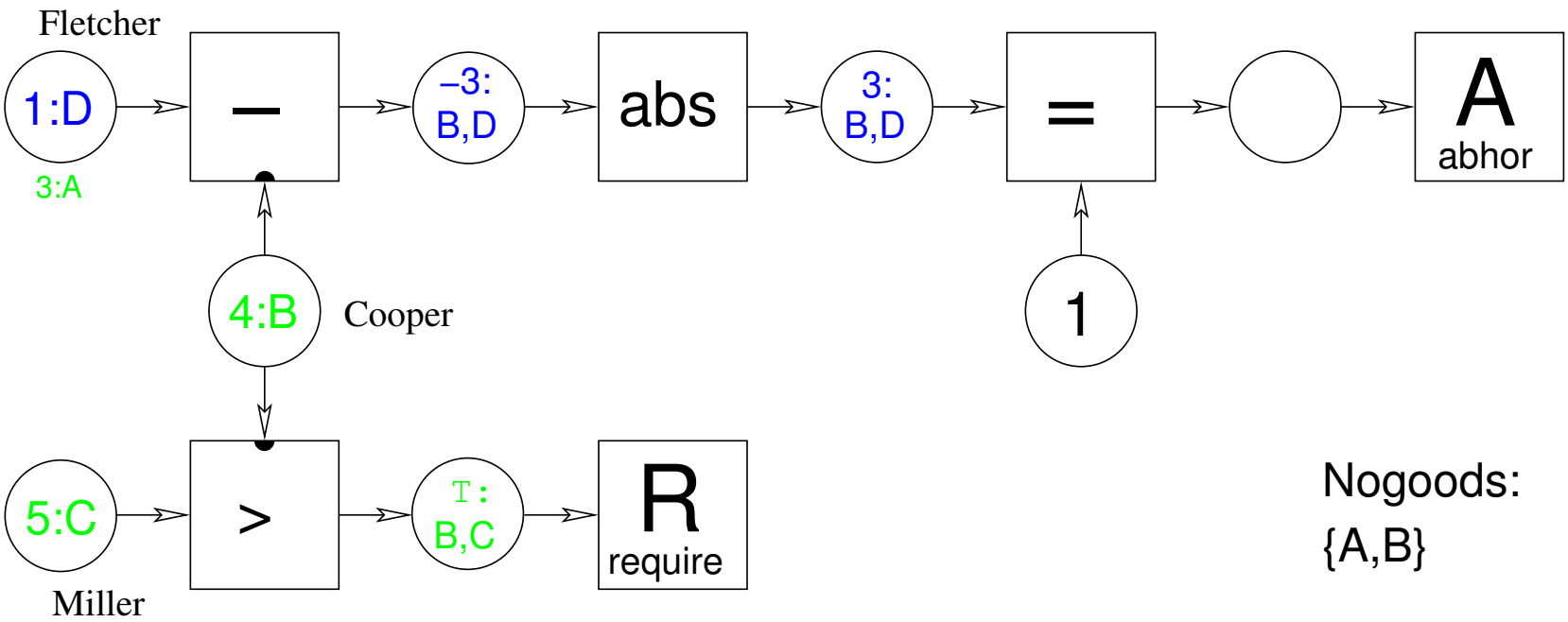

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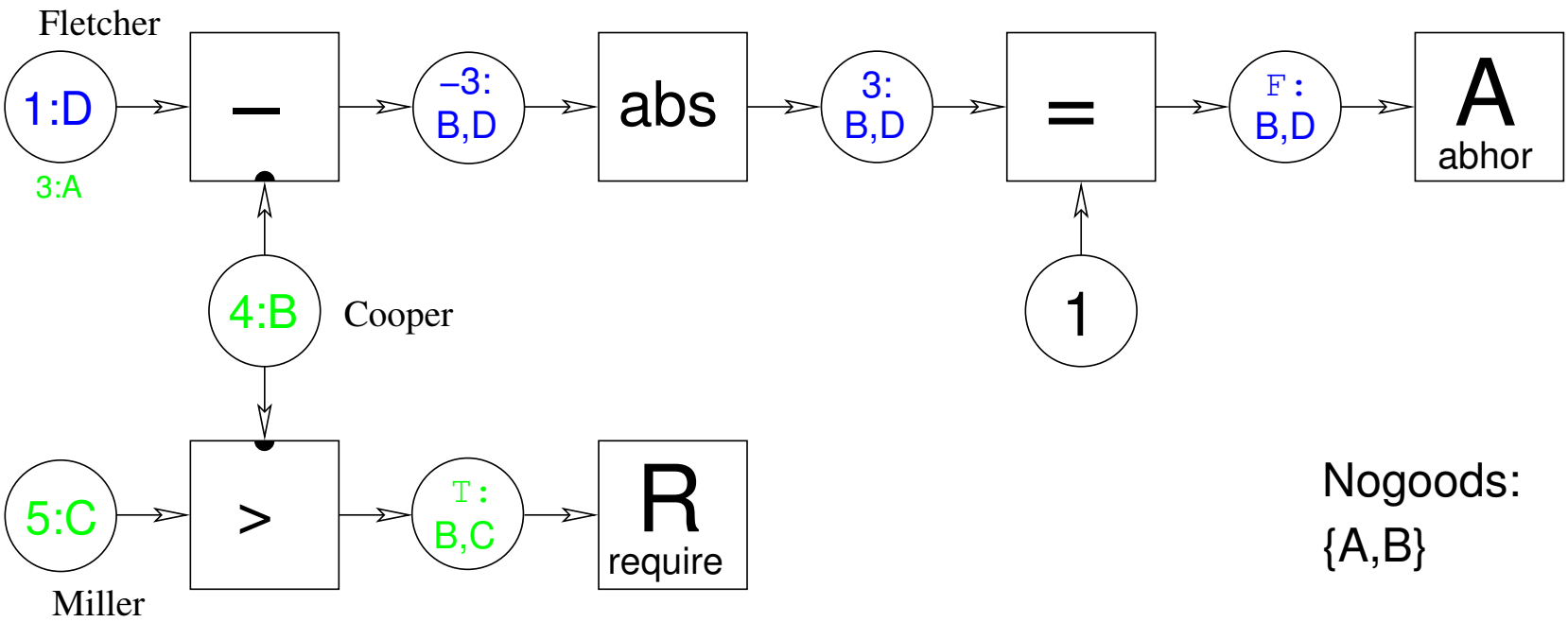

To solve that problem in
63 backtracks instead of 500

Pick the knowledge representation for your own problem, but

Partial information and propagator networks are essentially intertwined