Oxiflex - A Constraint Programming Solver for MiniZinc written in Rust

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Constraint Programming Solver for MiniZinc written in Rust

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Constraint Network

A (binary) **constraint network** is a 3-tuple $C = \langle V, \text{dom}, (R_{uv}) \rangle$ such that:

- V is a non-empty and finite set of variables,
- dom is a function that assigns a non-empty and finite domain to each variable $v \in V$, and
- $(R_{uv})_{u,v \in V, u \neq v}$ is a family of binary relations (constraints) over V where for all $u \neq v : R_{uv} \subseteq \text{dom}(u) \times \text{dom}(v)$

Constraint Network

boring...

Constraint Network

- Variables
  - Values to choose from
- Constraints
  - Rules for choosing values

Simple Example

Variables:

$$w = \{1, 2, 3, 4\}$$
$$y = \{1, 2, 3, 4\}$$
$$x = \{1, 2, 3\}$$
$$z = \{1, 2, 3\}$$

Constraints:

$$w = 2 \cdot x$$
$$w < z$$
$$y > z$$

Constraint Programming

var 1..4: w;
var 1..4: y;
var 1..3: x;
var 1..3: z;

constraint $w = 2 \cdot x$;
constraint $w < z$;
constraint $y > z$;

Constraint Programming

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solve satisfy;
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Constraint Programming

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solve satisfy;

$\rightarrow$ MiniZinc!

MiniZinc

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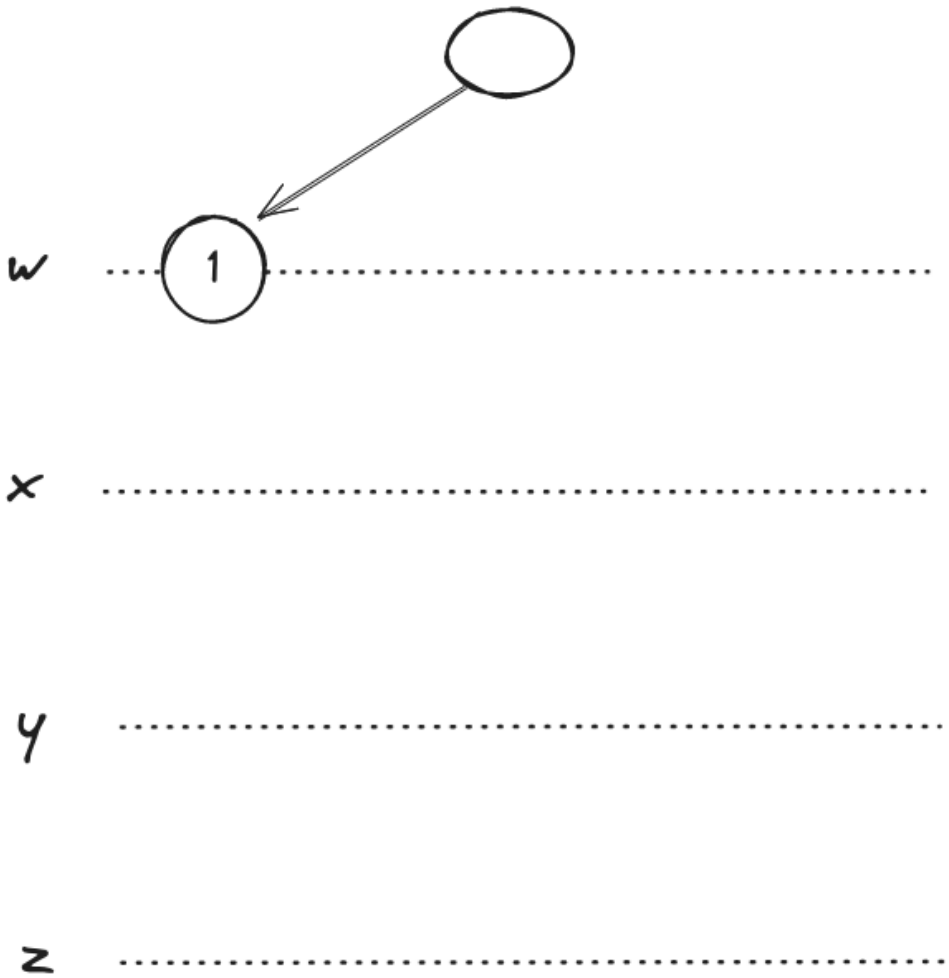
Backtracking

Backtracking Example



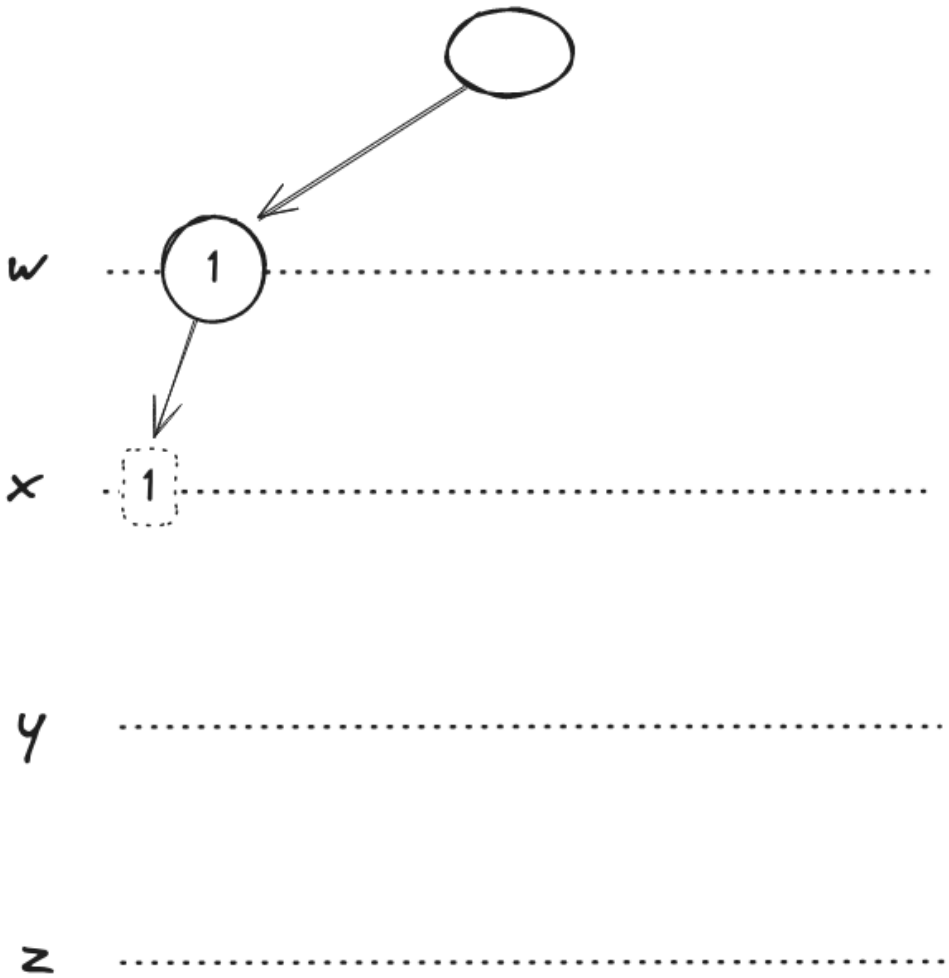
Constraints:

w = 2 * x

w < z

y > z

Backtracking Example



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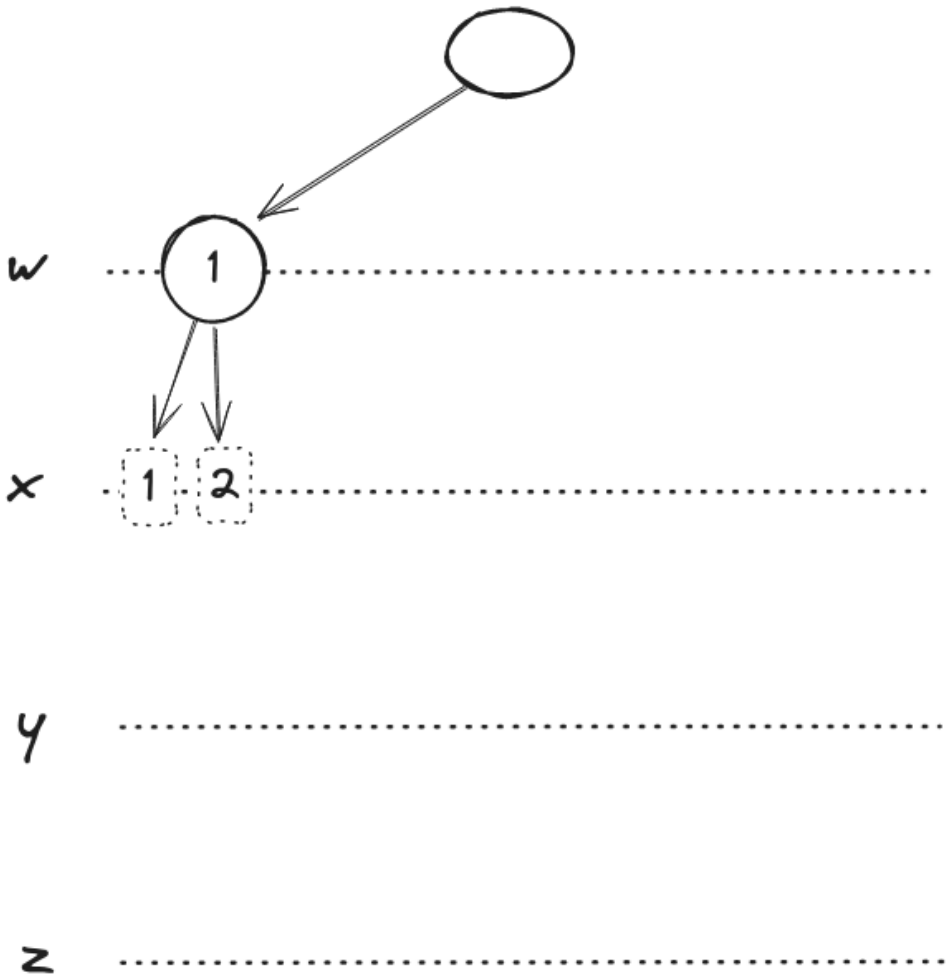

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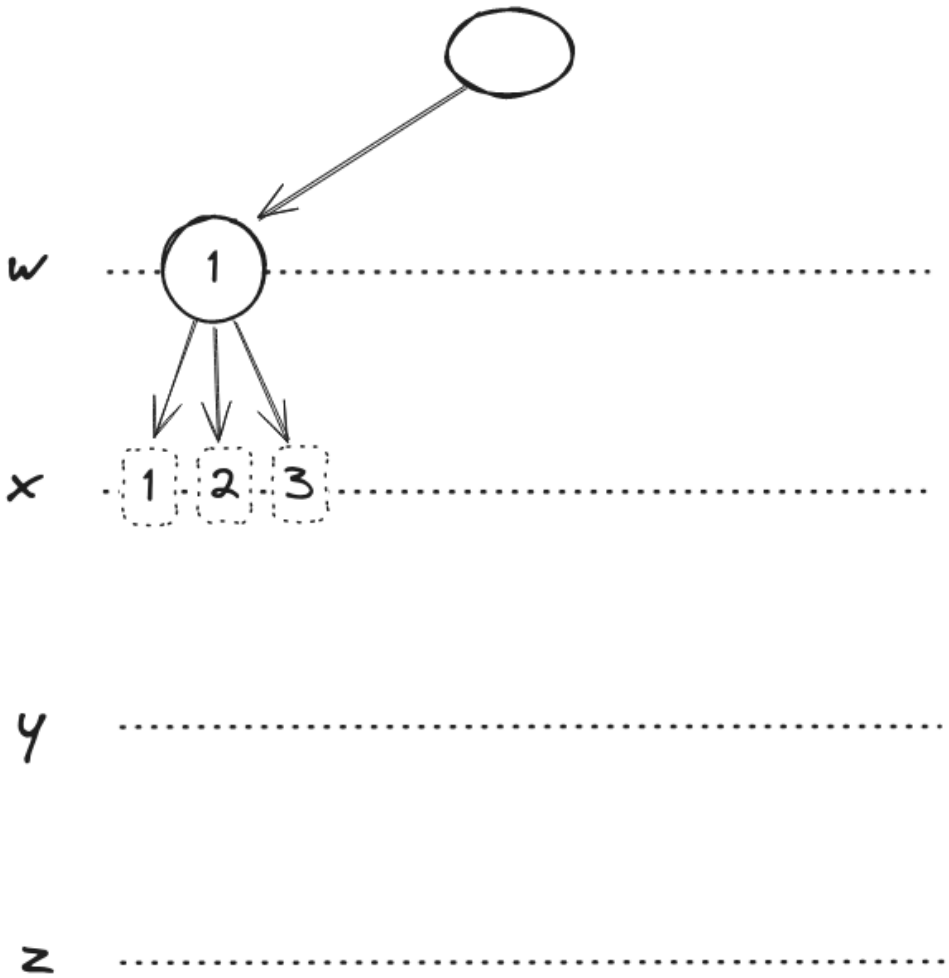

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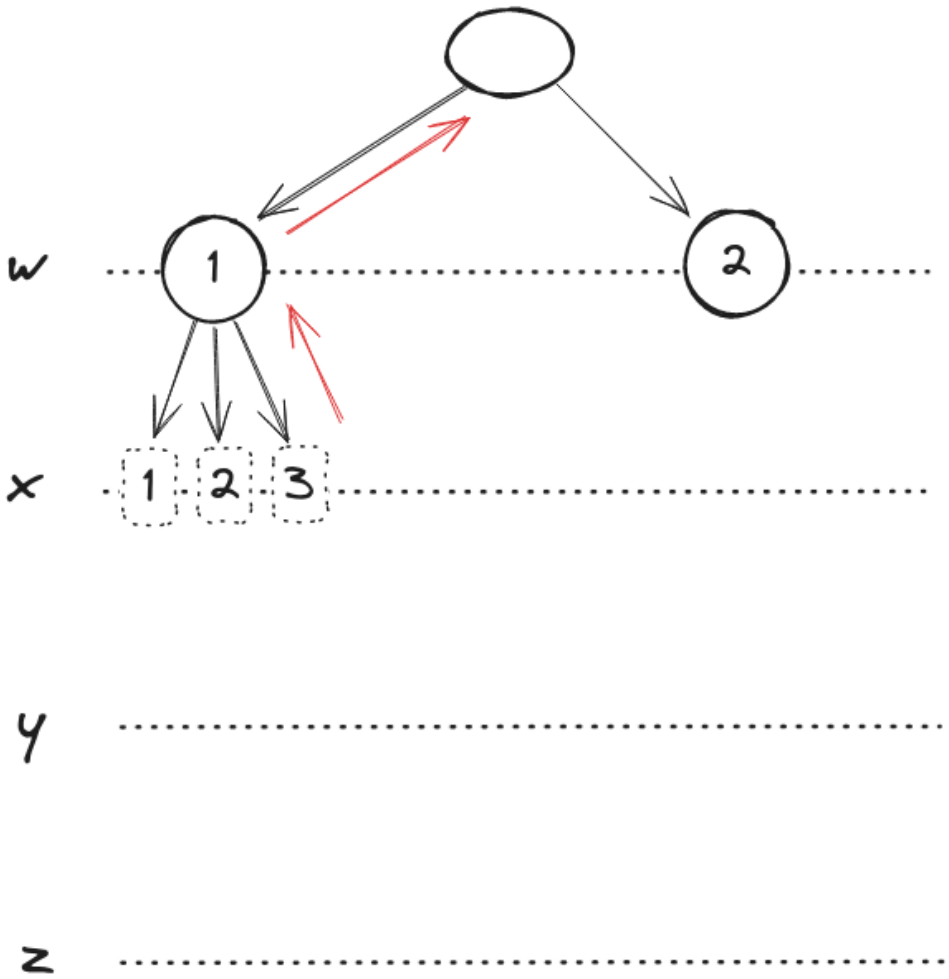

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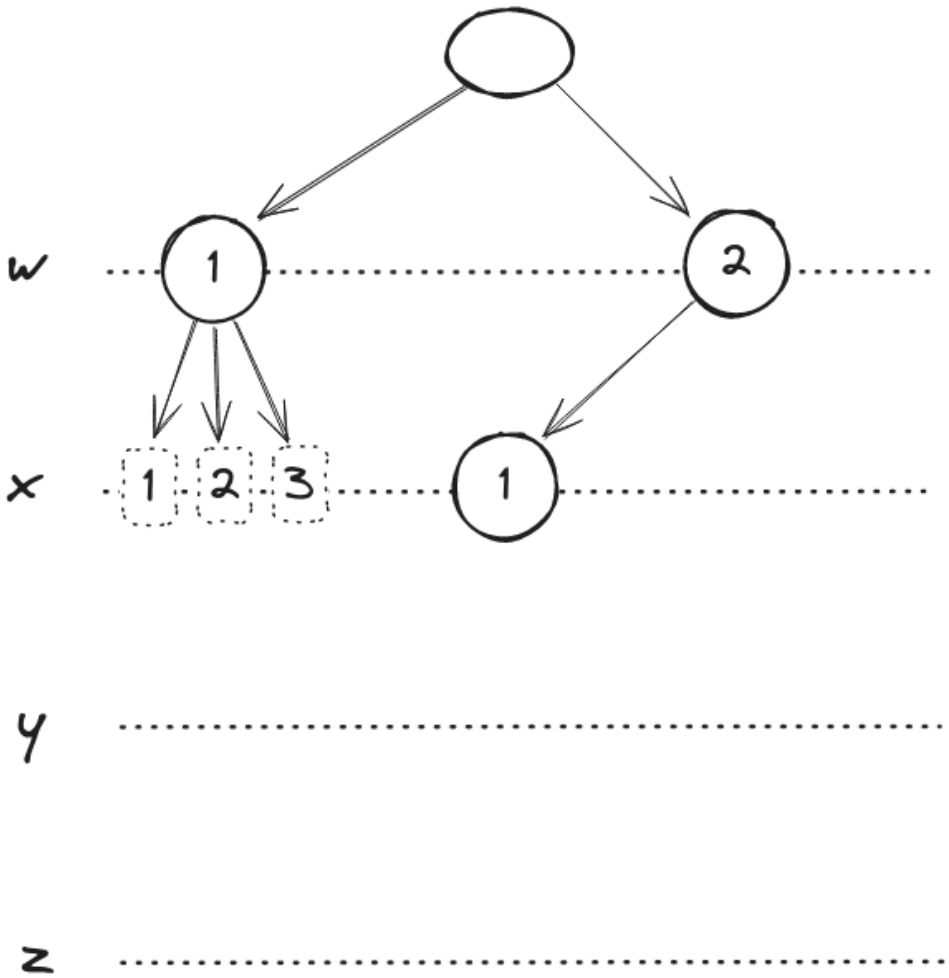

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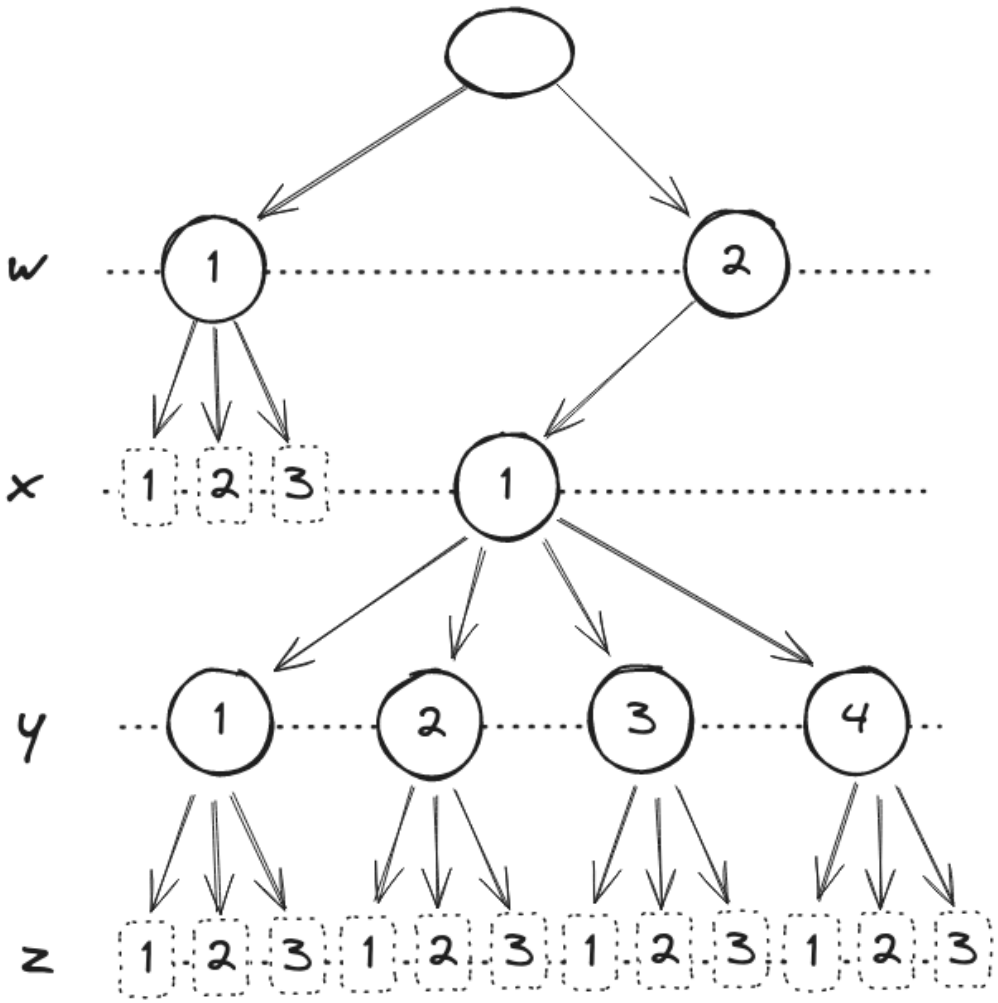

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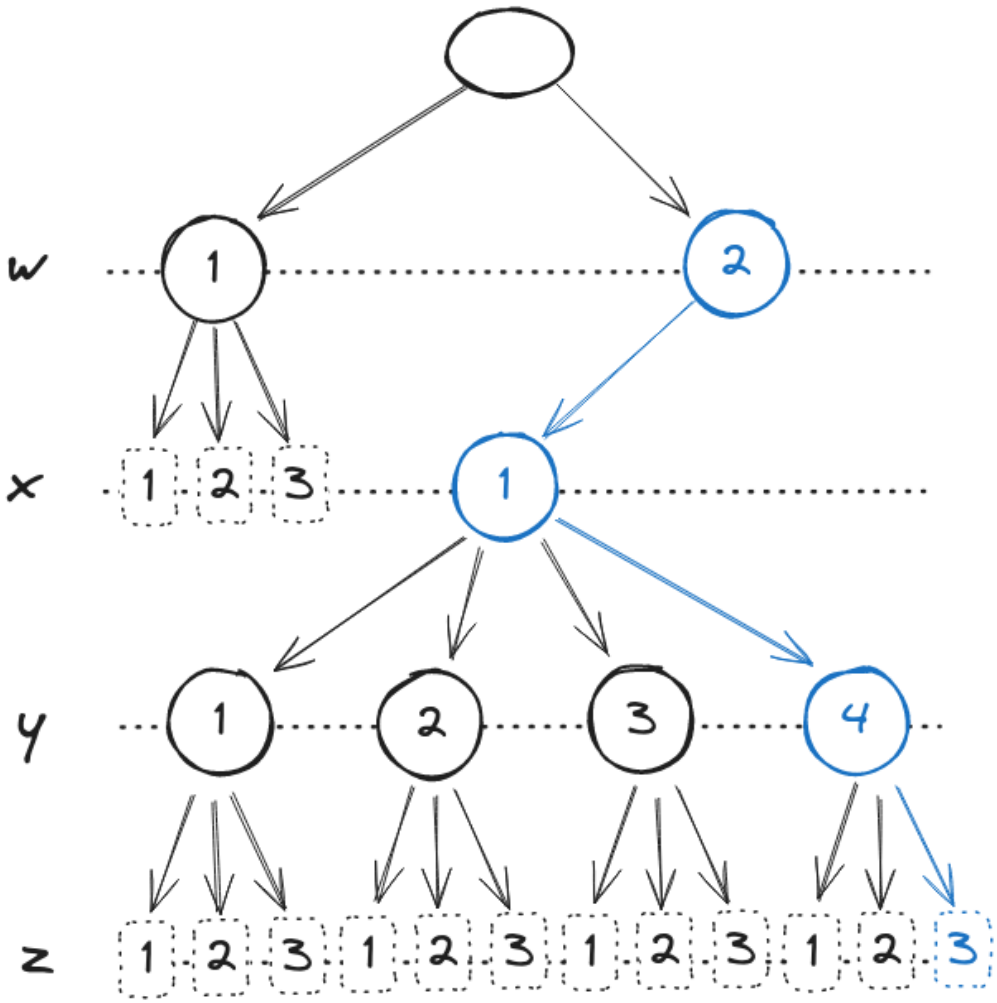
Backtracking Example



Constraints:

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$w < z$

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Solution:

$w = 2$

$x = 1$

$y = 4$

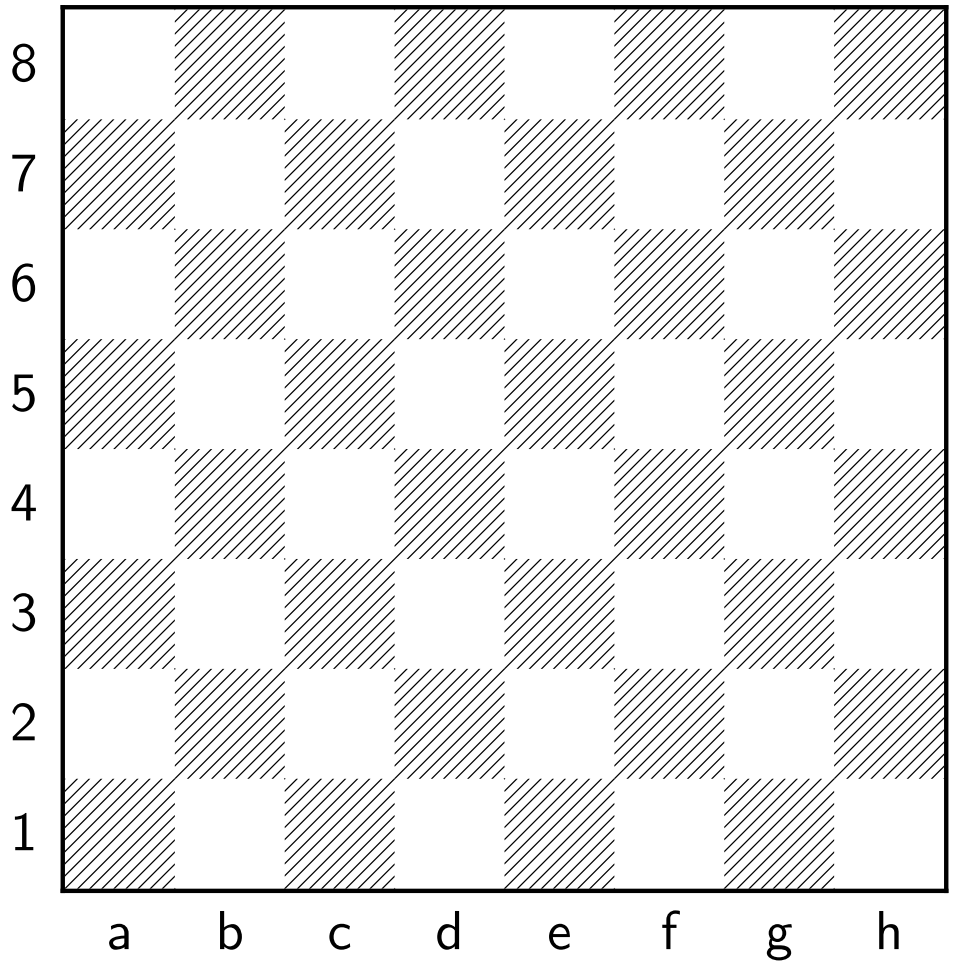
$z = 3$

Kinda like search...

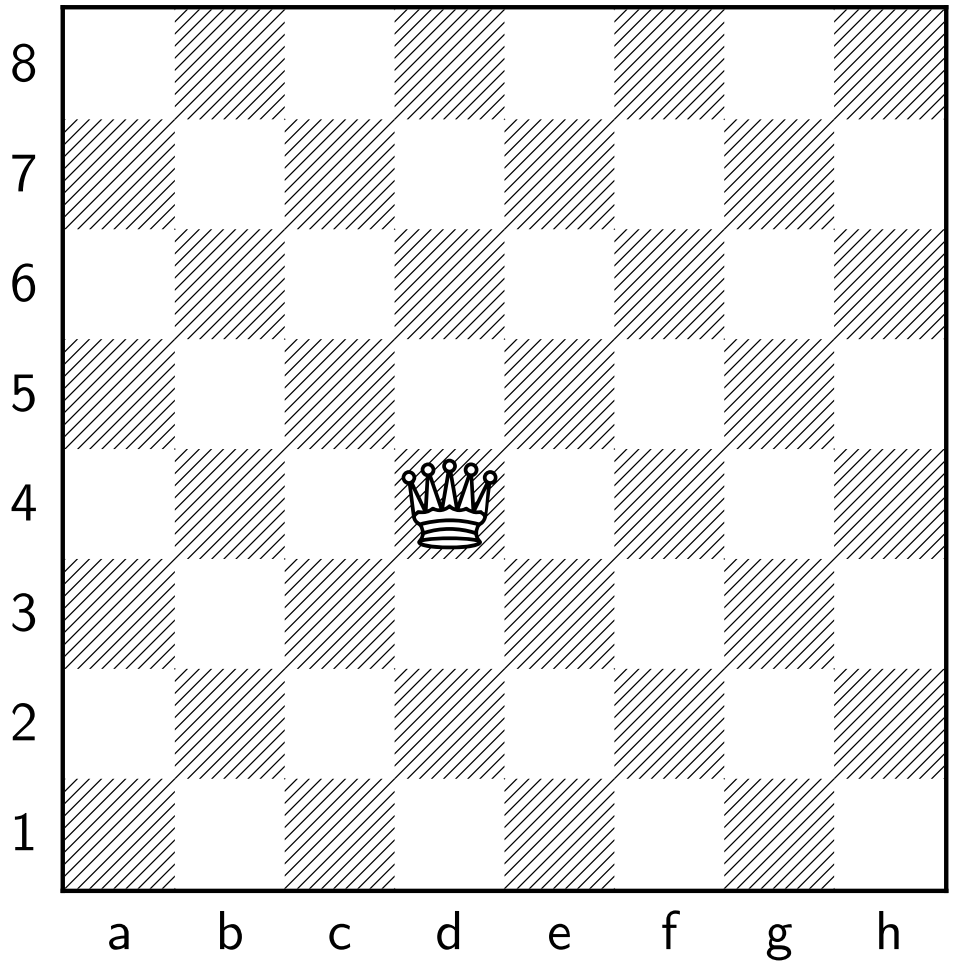
Can we do better?

8-Queens Problem

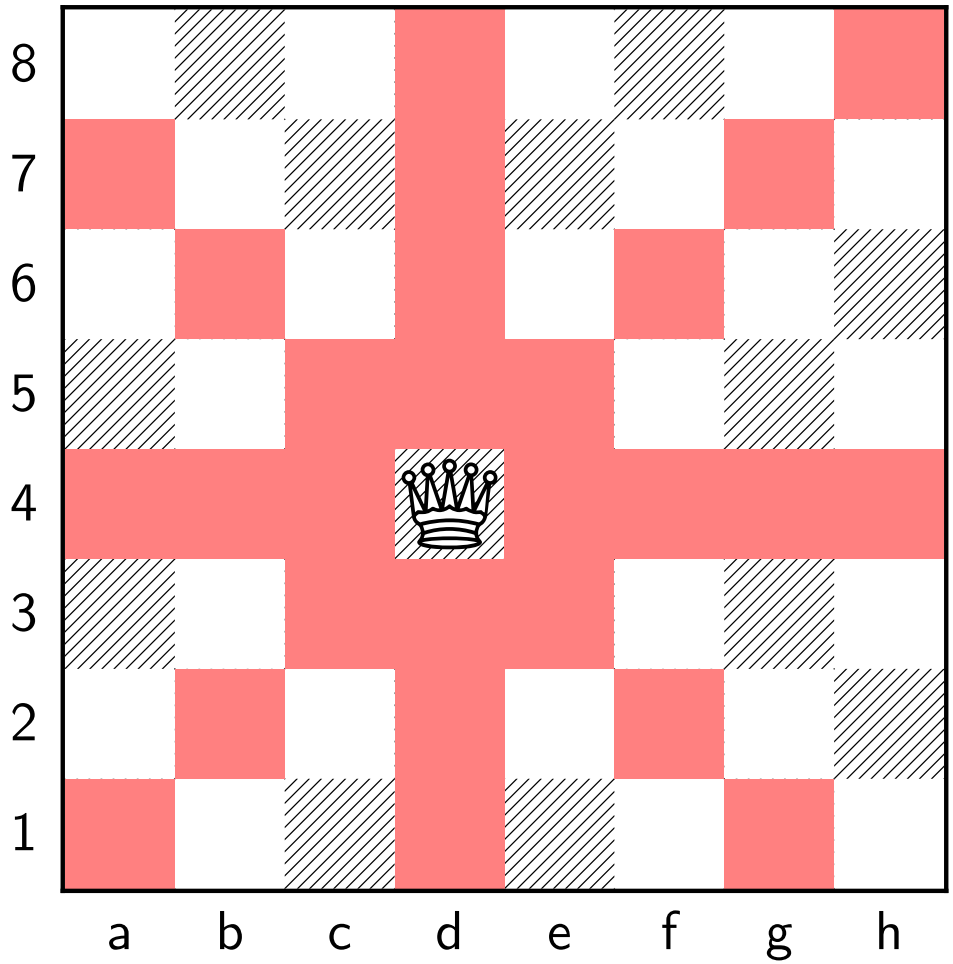
Chessboard



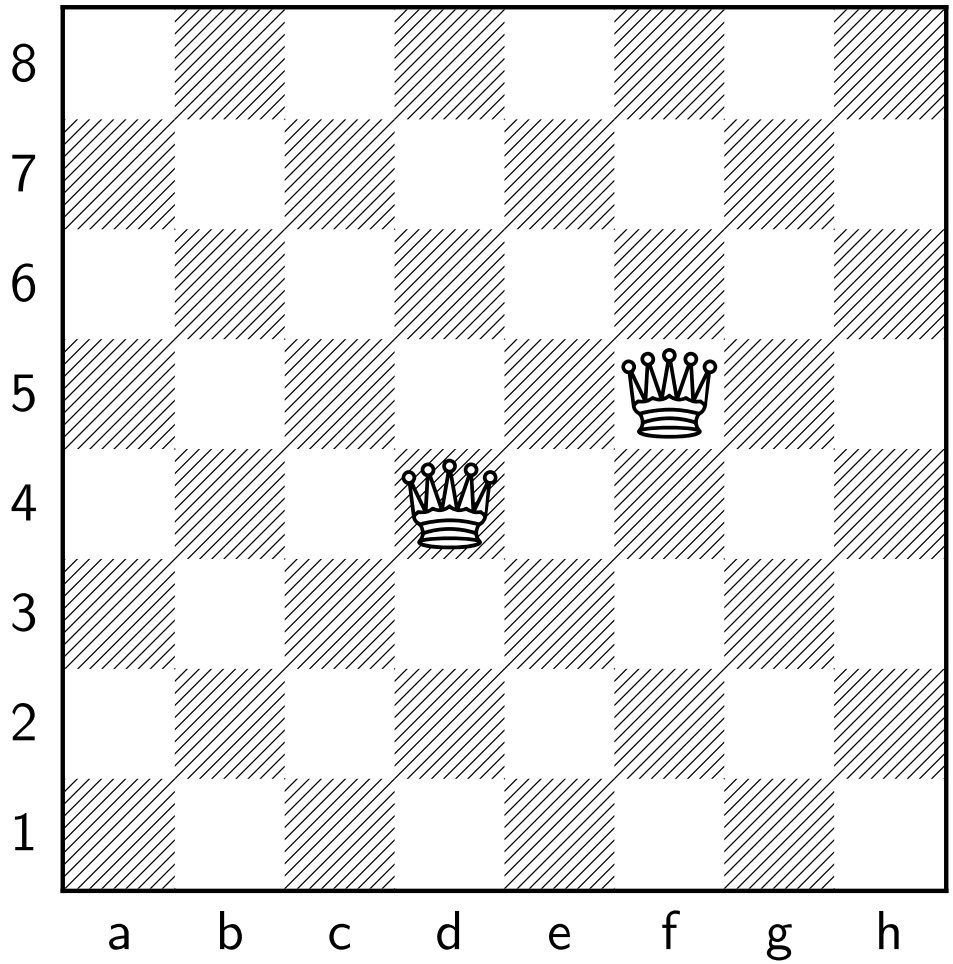
One Queen



One Queen



Two Queens



N-Queens Problem

- Scalable

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  - 8-Queens $\rightarrow$ N-Queens

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  - $n \times n$ chessboard

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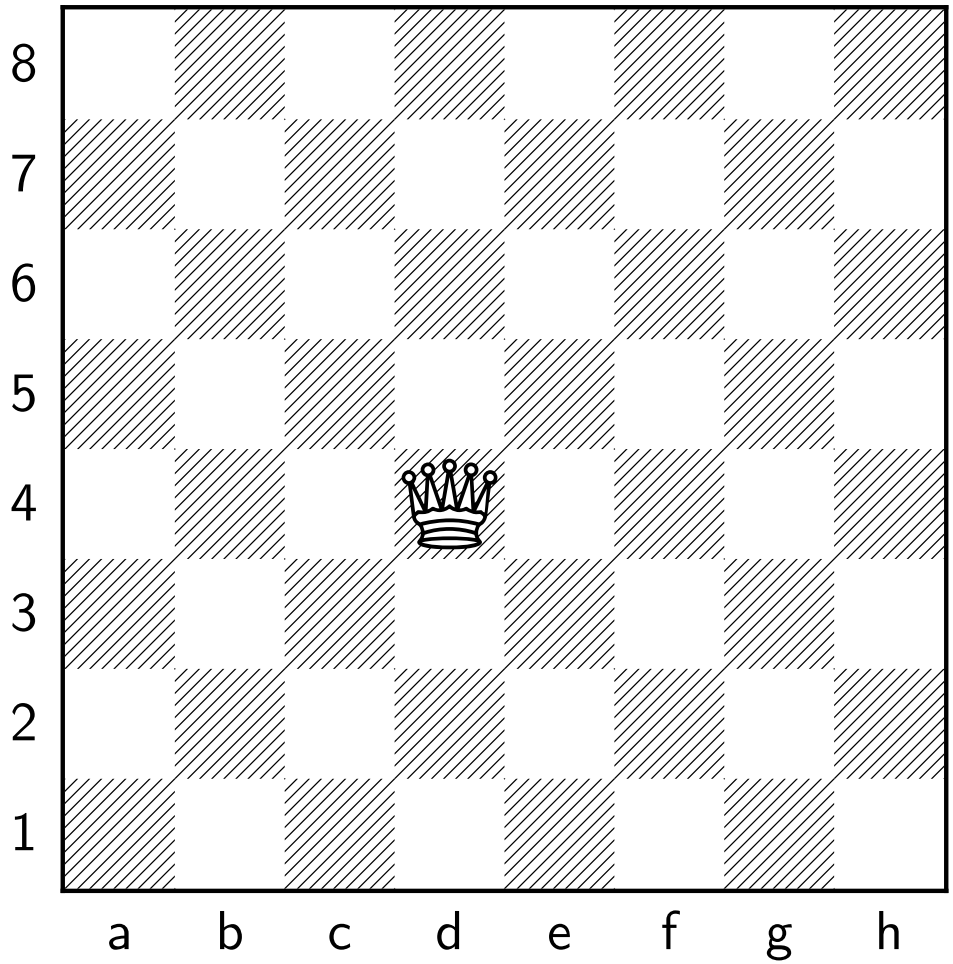
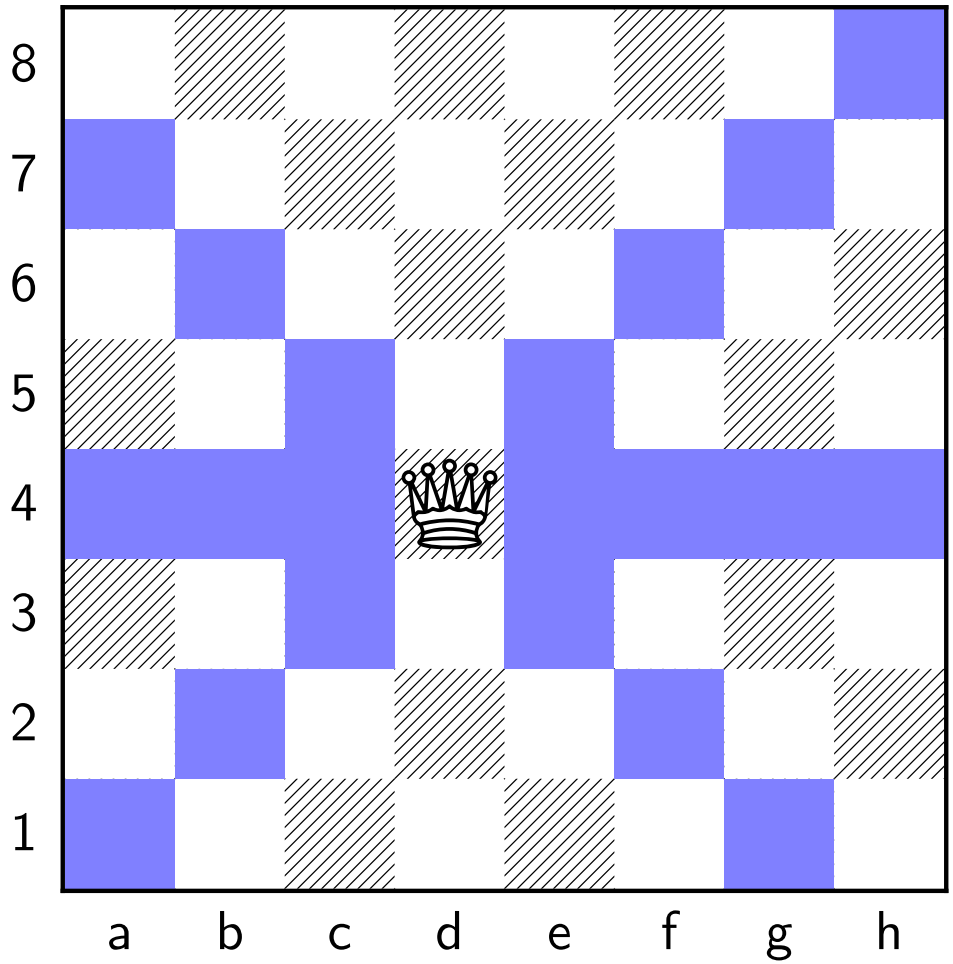
  - 8-Queens $\rightarrow$ N-Queens
  - $n \times n$ chessboard
  - n Queens

Inference

Inference Example



Inference Example



Improvements

- Inference

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- Inference
  - Forward Checking

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- Inference
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  - Arc consistency

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  - Arc consistency
    - AC-1

Improvements

- Inference
  - Forward Checking
  - Arc consistency
    - AC-1
    - AC-3

Improvements

- Inference
  - Forward Checking
  - Arc consistency
    - AC-1
    - AC-3
- Variable Ordering: fail early

Oxiflex

Demo

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Solver

- Performance

Solver

- Performance
  - fast

Solver

- Performance
  - fast
  - like real fast

Solver

- Performance
  - fast
  - like real fast
- $\rightarrow$ no abstractions, no garbage collector, no JIT

Possible Language

Assembly

Possible Language

Assembly

or

Solver

- Performance
  - fast
  - like real fast

Solver

- Performance
  - fast
  - like real fast
- Correctness
  - Prevent bugs

Rust

Rust

- Performance
  - fast
  - like real fast
- Correctness
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Rust

- Performance
  - fast
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- Ease of use

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  - Library manager - Cargo

Rust

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  - fast
  - like real fast
- Correctness
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- Ease of use
  - Library manager - Cargo
  - Functional

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Benchmarks

The end