Oxiflex - A Constraint Programming Solver for MiniZinc written in Rust

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Rust

Why Rust?

- Performance

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Possible Languages

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- Learn Rust

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Constraint Network

Constraint Network

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

Simple Example

Variables:

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

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 $w < z$;
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solve satisfy;

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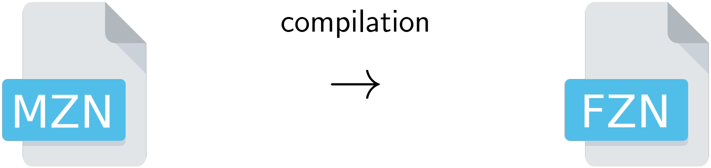
solve satisfy;

$\rightarrow$ MiniZinc!

MiniZinc


MZN
compilation
FZN

FlatZinc

```
array [1..2] of int: x_introduced_2_ = [1,-2];
array [1..2] of int: x_introduced_3_ = [1,-1];
array [1..2] of int: x_introduced_4_ = [-1,1];

var 2..4: w:: output_var;
var 1..4: y:: output_var;
var 1..3: x:: output_var;
var 1..3: z:: output_var;

constraint int_lin_eq(x_introduced_2_,[w,x],0);
constraint int_lin_le(x_introduced_3_,[w,z],-1);
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FlatZinc

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predicate int_lin_eq(array [int] of int: as,
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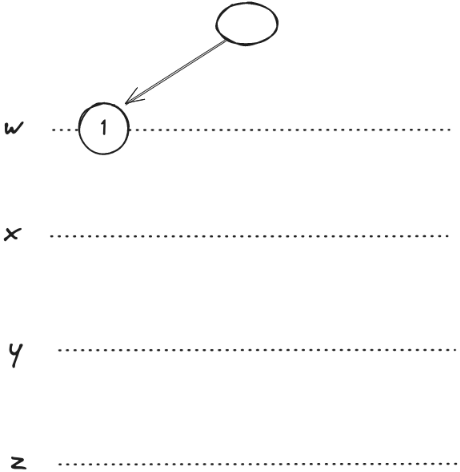
Backtracking

Backtracking Example



Constraints:

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w = 2 * x
w < z
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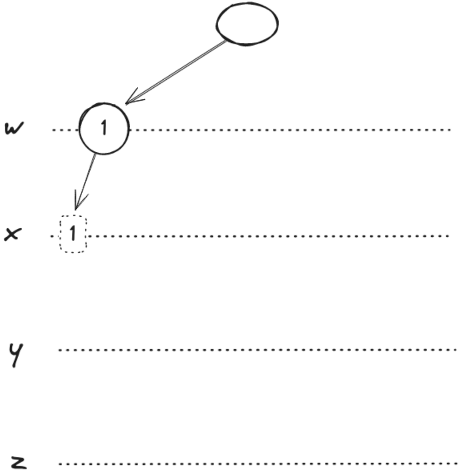

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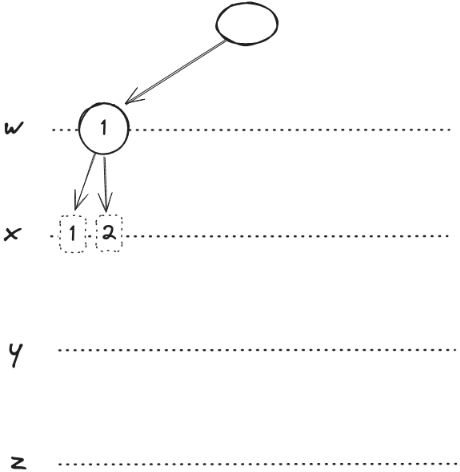

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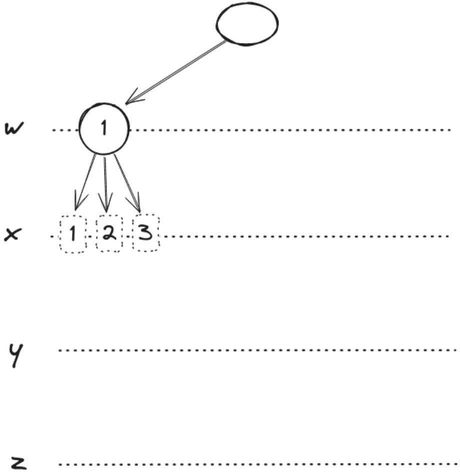

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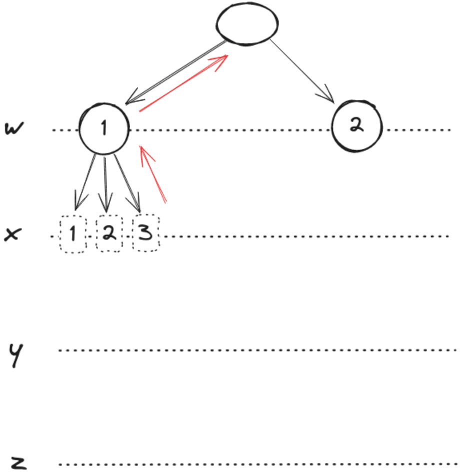

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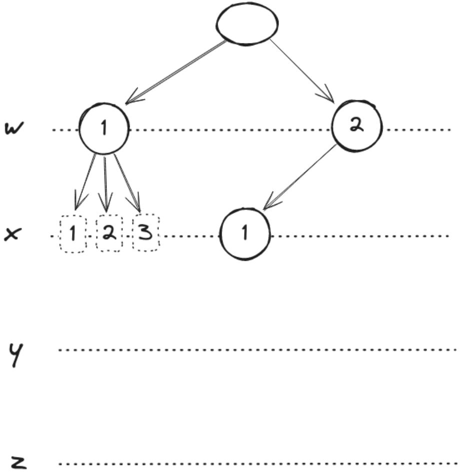

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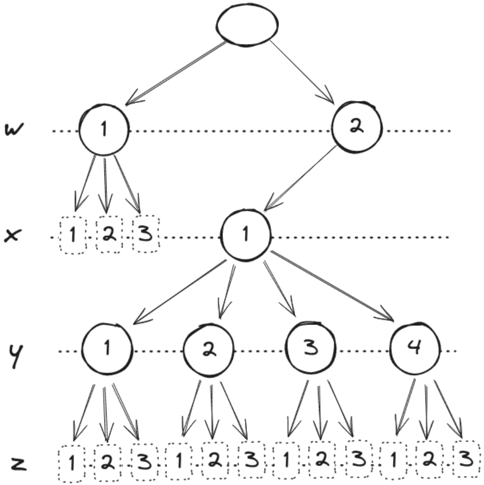

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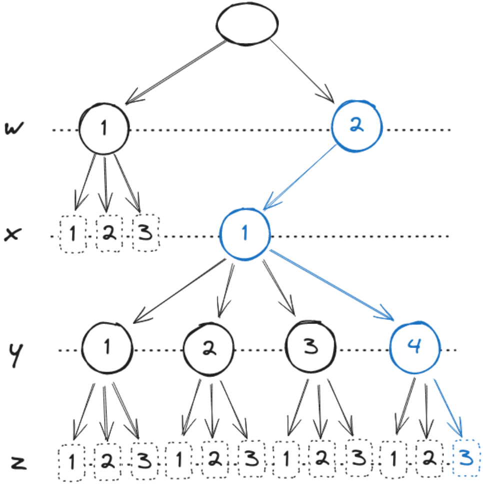

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Solution:

w = 2

x = 1

y = 4

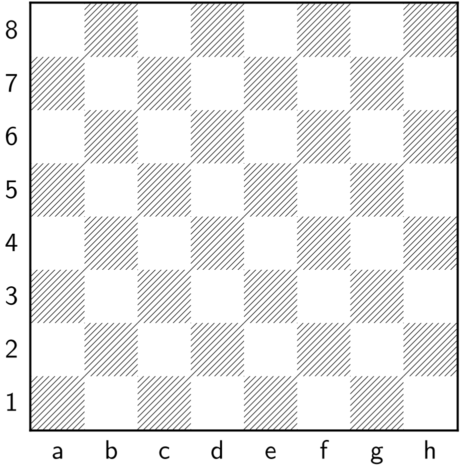
z = 3

Kinda like search...

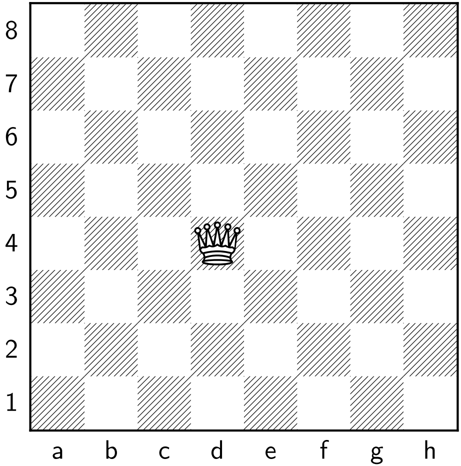
Can we do better?

8-Queens Problem

Chessboard



One Queen



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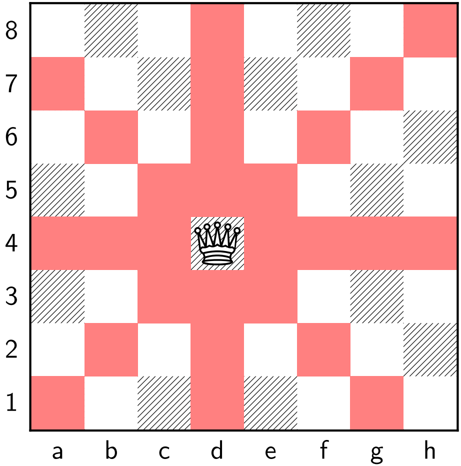
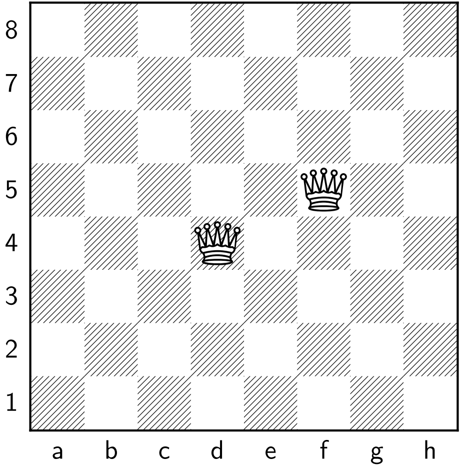


Two Queens



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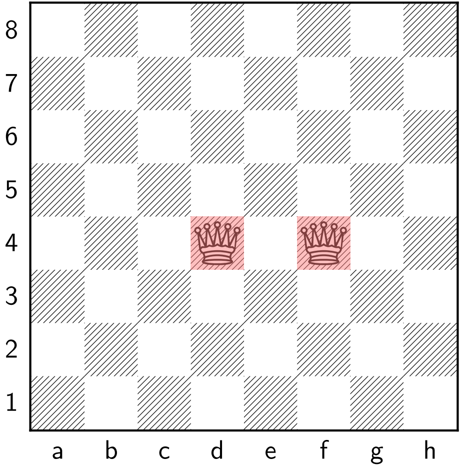

N-Queens Problem

- Scalable

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  - 8-Queens $\rightarrow$ N-Queens

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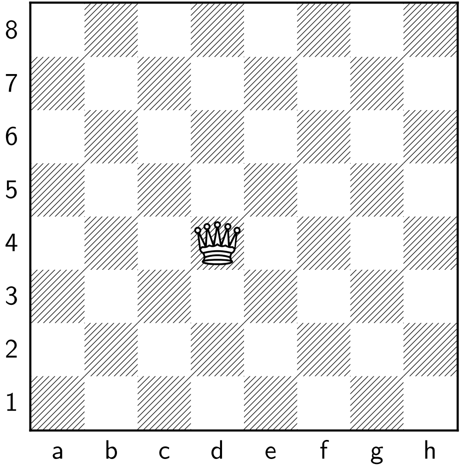
  - n Queens

Inference

Forward Checking

Forward Checking Example



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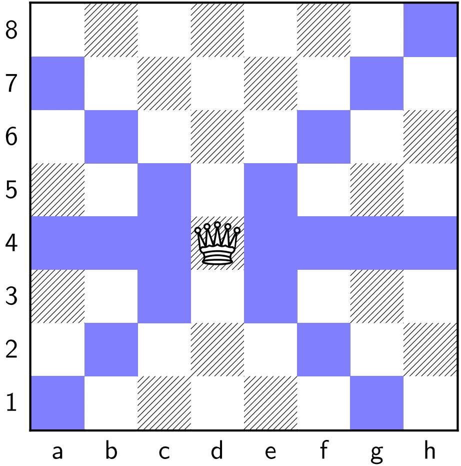

Arc Consistency

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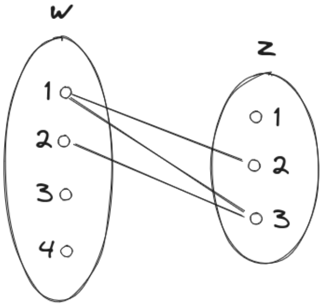

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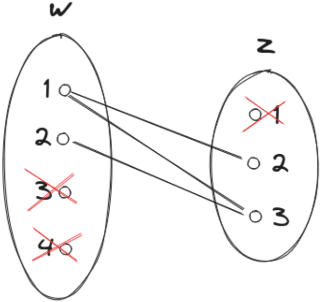

Improvements

- Inference

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- Inference
    - Forward Checking

Improvements

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  - Arc consistency

Improvements

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Improvements

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Improvements

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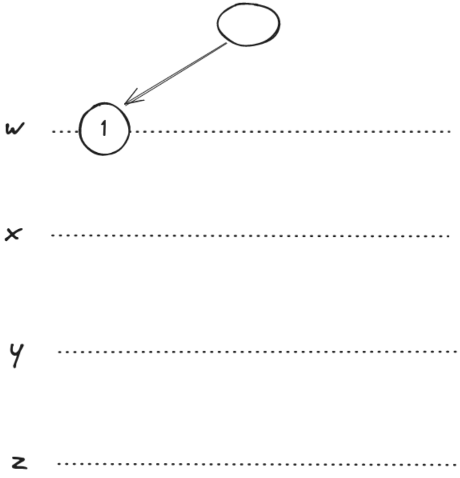
- Dynamic Variable Ordering

Dynamic Variable Ordering



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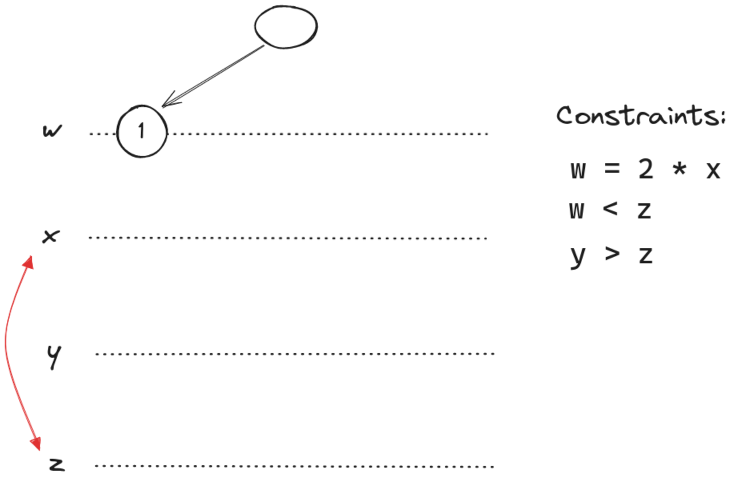

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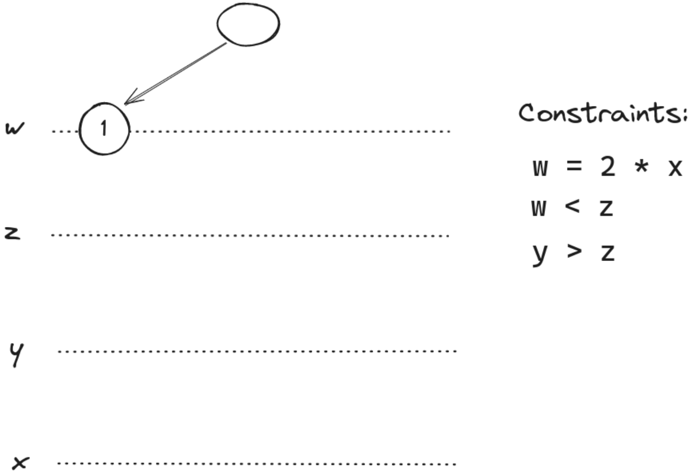

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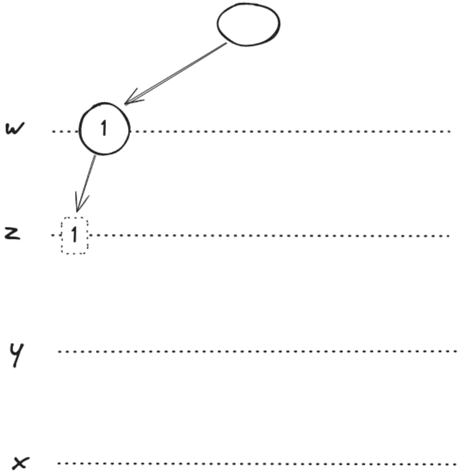

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Oxiflex

Demo

Limitations

- FlatZinc builtins

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  - IntLinEq
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- No minimize / maximize
- Only one solution

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Benchmarks

N-Queens Problem

Queens Time

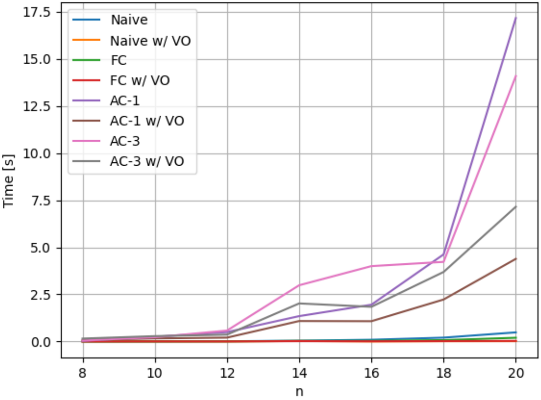
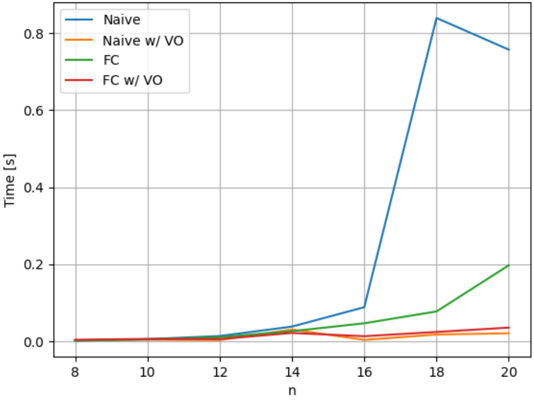


Figure: Averaged over > 10 runs

Queens Time



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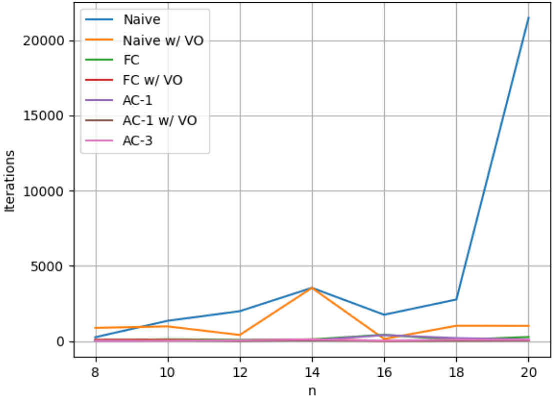

Figure: Averaged over 5 runs

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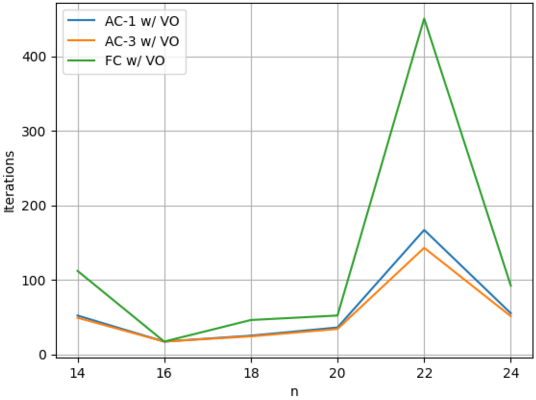

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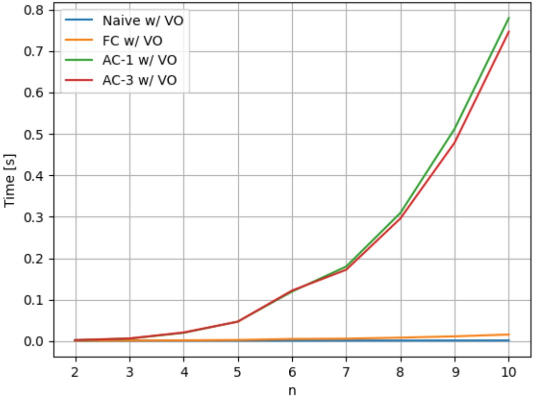
Slow Convergence

Slow Convergence for small n



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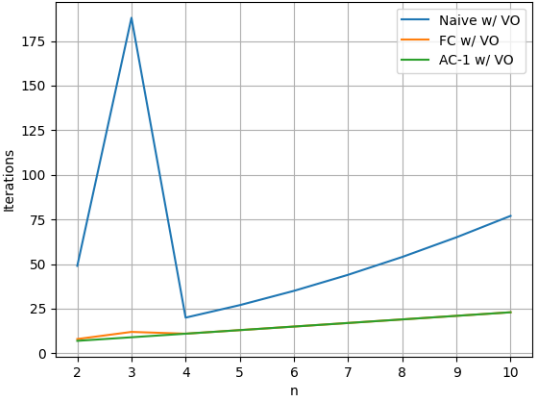

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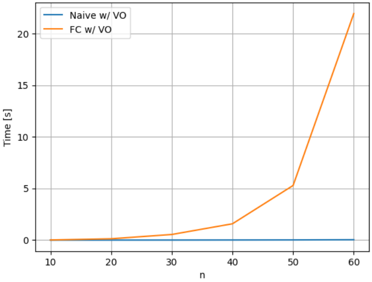
Slow Convergence Comparison



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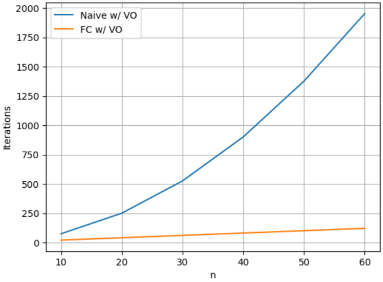

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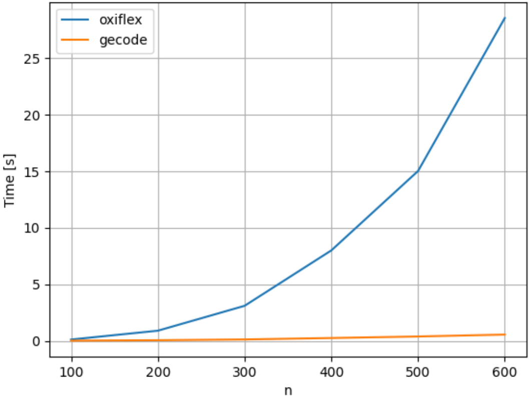
Oxiflex vs Gecode



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Conclusion

The end