

Chapter 13: Visualization Techniques

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ECLiPSe ELearning [Overview](#)



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Outline

- 1 Introduction
- 2 Visualization by Annotation
- 3 Visualization Interface
- 4 Conclusions



What we want to introduce

- Why visualize?
- How to visualize constraint programs
- Visualization Interface
- Visualization Tool



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Background

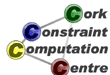
- Gift grant from Cisco Systems/Silicon Valley Community Foundation
- Cisco owns open-sourced ECLiPSe system
- How to expand user-base?
- Self-taught course in constraint programming
- Intended for Cisco engineers/programmers
- Open source/available to community
- Website

<http://4c.ucc.ie/~hsimonis/ELearning/index.htm>



Format

- Video lectures
- Slides
- Handout
- Exercises



Problems Handled in Course

- Must have puzzles!
- Send+More=Money
- Sudoku
- N-queens
- Shikaku



Practical Example Problems

- Test plan generation (BIBD)
- Progressive party problem
- Routing and wavelength assignment
- Optical network design
- Car sequencing
- Costas arrays
- Sports scheduling
- Still to come
 - Production scheduling
 - Nurse rostering
 - Airport stand allocation



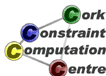
Intention

- Realistic, life like problems
- Must address scalability issues
- Often, problem not completely specified
- Issue: Hard to verify by hand
- Complexity still limited, not real problems
- No attempt at integration



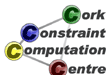
How do we understand behavior?

- Mental model
- Formal analysis
- Debugging
- Tracing
- Life visualization
- Post-mortem analysis



How do we understand behavior?

- Mental model
- Formal analysis
- Debugging
- Tracing
- Life visualization
- **Post-mortem analysis**



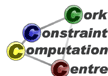
Why Visualize?

- Understand what is done
- Understand what is done in which order
- Understand what is *not* done
- Understand when to give up



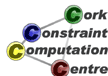
Design Choices

- No deep integration with solver
- Post-mortem visualization
- Intermediate file format
- No view of detailed propagation
 - Tool not intended for debugging constraint engine



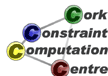
Conceptual Model

- Stable state at defined program points
- Granularity
 - Assign value
 - Post constraint
- Show stable state after propagation
- Do not show individual propagation steps



Visualizers

- Search tree
- Variables
- Constraints

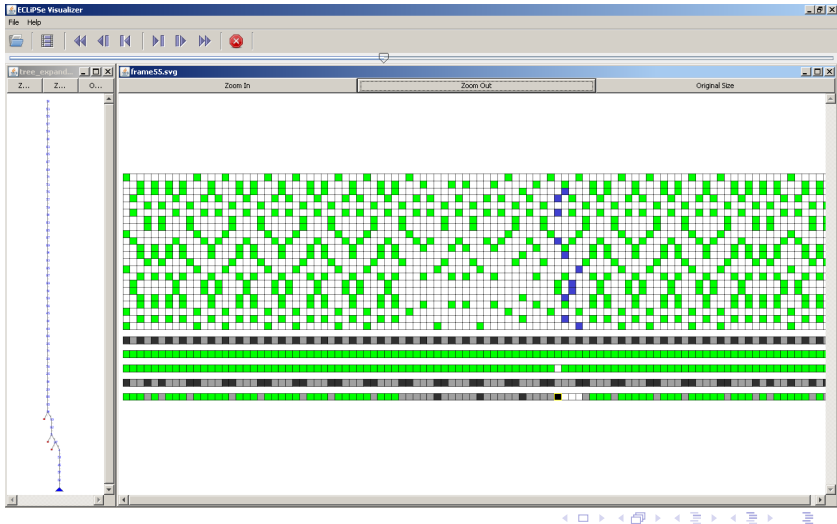


Visualization Tool

- Developed in Java
- Show two panes: tree and state
- Navigate along timeline



Visualization Tool: Car Sequencing



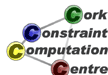
How many visualizers do we need?

- Develop few primitives
 - Cell based view
 - Domain vector
- Allow aggregation
 - Vector/matrix
 - General layout
- Which global constraints require more?
 - Task based view for `cumulative`
 - Matching/flow based representation does not scale



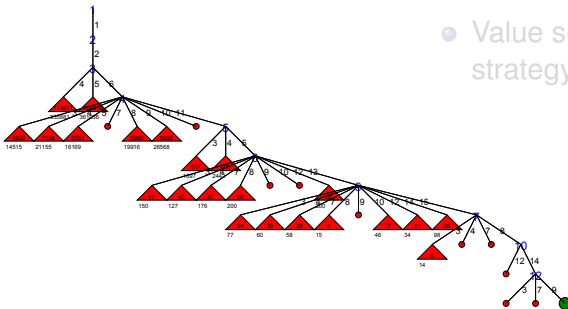
How to Interpret Visualization

- Search tree
 - Good/bad choices
 - Place of backtracking
- State
 - Missing propagation



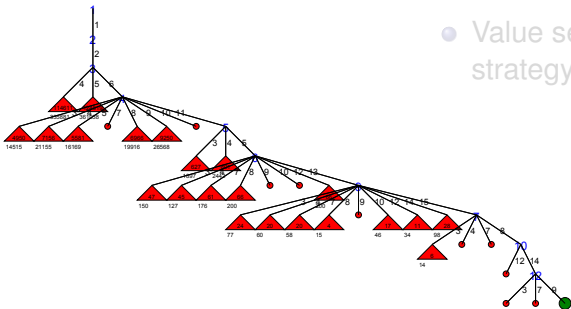
Costas Array Search tree (Size 16)

- Deep backtracking
- Third choice wrong
- Last choice wrong
- Value selection strategy useless



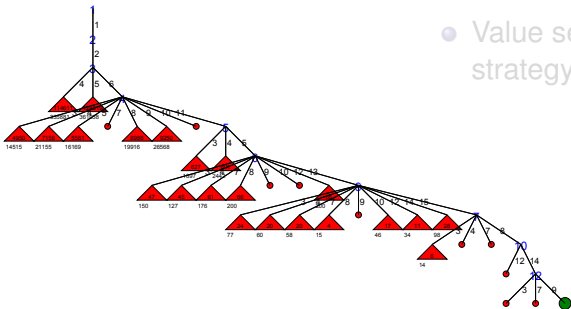
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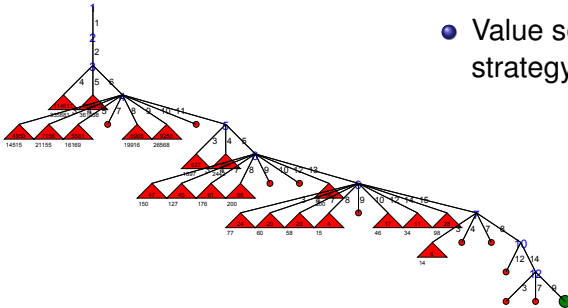
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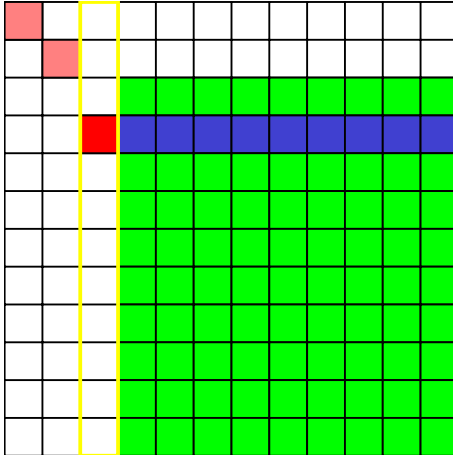


Costas Array Search tree (Size 16)

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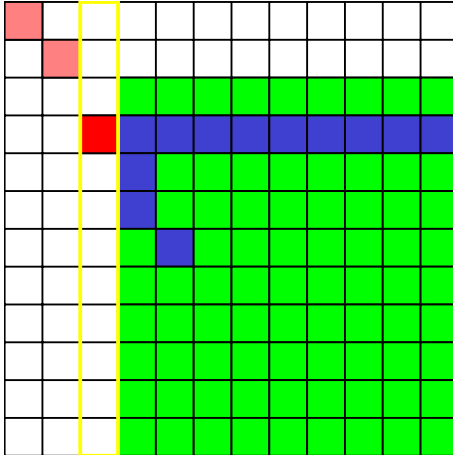


Missing Propagation



The model is
doing this

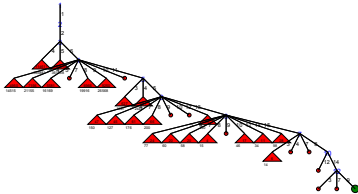
Missing Propagation



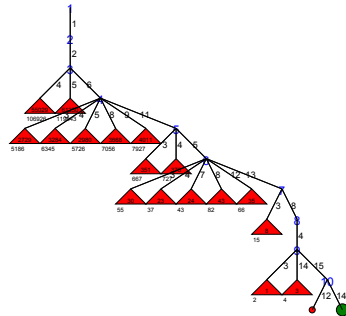
It could be doing that!

Comparison (Search Tree, size 16)

Initial Model



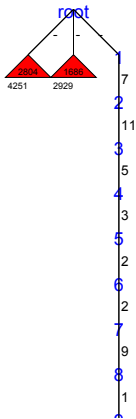
Improved Model



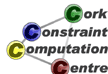
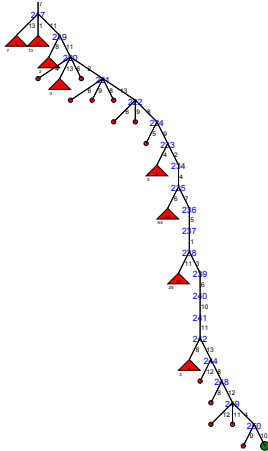
Progressive Party Problem, 9 Time Periods



2 Restarts Before Solution Found

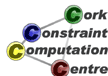


Value Choice Strategy Not Focused



Progressive Party

- Clearly impossible to explore search space
- Either many solutions or good value selection
- Value selection at end rather poor
- Probably many solutions

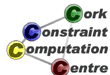


Missing Propagation: Shikaku

1 ₄	9 ₁	9 ₁	29 ₁₃	29 ₁₆	29	29 ₂₂	29 ₂₅	29 ₂₆	33 ₂₉
9 ₁	9 ₁	9 ₆	16 ₁₃	16 ₃	16	29 ₂₂	29 ₂₅	33 ₃₀	33 ₂₉
13 ₉	13 ₁₀	13 ₁₀	13 ₄	22 ₁₆	25 ₂₂	25 ₁₃	25 ₂₂	30 ₂₅	33 ₃₀
10 ₁	10	10 ₄	14 ₁₃	22 ₁₆	30 ₂₂	30 ₁₉	30 ₂₂	30 ₂₅	30 ₄
2	2	2	14 ₁₃	22 ₁₇	22 ₁₉	22 ₁₇	22 ₉	30 ₂₆	34 ₃₀
2	2	2	14 ₁₃	26 ₂₂	26 ₁₇	26 ₁₇	26 ₂₂	31 ₃₀	34 ₂₆
2	2	2	14 ₄	22 ₁₇	22 ₁₉	22 ₁₇	26 ₂₂	31 ₃₀	34 ₂₆
3	5 ₆	5 ₅	5 ₅	17 ₈	19 ₁₇	23 ₂₂	31 ₂₆	31 ₁₉	34 ₃₁
3 ₆	5 ₅	5 ₅	5 ₅	18	19 ₆	31 ₂₃	31 ₂₆	31 ₄	34 ₃₁
3	6 ₉	6 ₆	6 ₆	18 ₄	20 ₁₉	23 ₂₂	32 ₂₇	32 ₃₁	34 ₆
3	6 ₆	6 ₆	6 ₆	18	20 ₄	32 ₂₃	32 ₂₇	32 ₄	35 ₃₄
3	6 ₆	6 ₆	6 ₆	18	23 ₂₀	32 ₂₇	35 ₃₂	35 ₂₃	35 ₂
3	11 ₄	11 ₄	15 ₁₁	15 ₁₁	23 ₂₀	27 ₂₄	27 ₂₃	32 ₂₇	36 ₃₅
15 ₇	15 ₁₁	15 ₁₁	15 ₉	15	27 ₂₃	27 ₂₄	27 ₂₃	32 ₂₇	36 ₂₇
7 ₄	7 ₆	7 ₇	7 ₇	7 ₇	27 ₂₃	27 ₂₄	27 ₂₃	32 ₂₇	36 ₂₇
7 ₄	12 ₇	12 ₇	12 ₂	15 ₁₅	24 ₁₅	24 ₁₅	24 ₂₁	28 ₂₇	36 ₂₈
4 ₄	8 ₄	8 ₄	8 ₄	21 ₁₅	21 ₁₅	21 ₁₅	21 ₁₅	28 ₂₄	36 ₂₈
8 ₄	8 ₄	8 ₄	8 ₄	36 ₈	36 ₂₁	36 ₂₄	36 ₂₈	36 ₂₈	36 ₆

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Sendmore Program Annotated

```
sendmory(L, Output, IgnoreFixed) :-
  L=[S,E,N,D,M,O,R,Y],
  L :: 0..9,
  create_visualization([output:Output,
                       ignore_fixed:IgnoreFixed,
                       width:8,
                       height:10], Handle),
  add_visualizer(Handle,
                 vector(L),
                 [display:expanded]),
  alldifferent(L), draw_visualization(Handle),
  S #\= 0, draw_visualization(Handle),
  M #\= 0, draw_visualization(Handle),
```



Sendmore Program Annotated

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sendmory(L, Output, IgnoreFixed) :-
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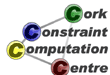
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Sendmore Program Annotated

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  L=[S,E,N,D,M,O,R,Y],
  L :: 0..9,
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  add_visualizer(Handle,
                 vector(L),
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  S #\= 0, draw_visualization(Handle),
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```



Sendmore Program Annotated

```
1000*S + 100*E + 10*N + D +  
1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
name_variables(Handle,L,  
                ['S','E','N','D','M','O','R','Y'],  
                Pairs),  
root(Handle),  
search(Pairs,1,input_order,  
        tree_indomain(Handle,_),  
        complete,[]),  
solution(Handle),  
close_visualization(Handle).
```



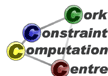
Sendmore Program Annotated

```
1000*S + 100*E + 10*N + D +  
1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
name_variables(Handle,L,  
                ['S','E','N','D','M','O','R','Y'],  
                Pairs),  
  
root(Handle),  
search(Pairs,1,input_order,  
        tree_indomain(Handle,_),  
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Sendmore Program Annotated

```
1000*S + 100*E + 10*N + D +  
1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
name_variables(Handle,L,  
                ['S','E','N','D','M','O','R','Y'],  
                Pairs),  
  
root(Handle),  
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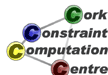
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1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
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1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
name_variables(Handle,L,  
                ['S','E','N','D','M','O','R','Y'],  
                Pairs),  
root(Handle),  
search(Pairs,1,input_order,  
        tree_indomain(Handle,_),  
        complete,[]),  
solution(Handle),  
close_visualization(Handle).
```



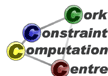
Sendmore Program Annotated

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1000*S + 100*E + 10*N + D +  
1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
name_variables(Handle,L,  
                ['S','E','N','D','M','O','R','Y'],  
                Pairs),  
root(Handle),  
search(Pairs,1,input_order,  
        tree_indomain(Handle,_),  
        complete,[]),  
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```



Sendmore Program Annotated

```
1000*S + 100*E + 10*N + D +  
1000*M + 100*O + 10*R + E #=  
10000*M + 1000*O + 100*N + 10*E + Y,  
name_variables(Handle,L,  
                ['S','E','N','D','M','O','R','Y'],  
                Pairs),  
root(Handle),  
search(Pairs,1,input_order,  
        tree_indomain(Handle,_),  
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close_visualization(Handle).
```

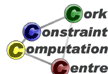


Sudoku Program Annotated

```

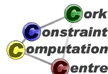
model (Matrix, Method, Output) :-
  Matrix[1..9, 1..9] :: 1..9,
  create_visualization([output:Output,
                       width:9,
                       height:9], Handle),
  add_visualizer(Handle,
                 domain_matrix(Matrix),
                 [display:text]),
  draw_visualization(Handle),
  (for(I, 1, 9),
   param(Matrix, Method, Handle) do
     Method:alldifferent(Matrix[I, 1..9]),
     draw_visualization(Handle, [focus:row(I)]),
     Method:alldifferent(Matrix[1..9, I]),
     draw_visualization(Handle, [focus:col(I)])
  ),

```



Sudoku Program Annotated

```
(multifor([I,J],[1,1],[7,7],[3,3]),
  param(Matrix,Method,Handle) do
    Method:alldifferent(Matrix[I..I+2,J..J+2]),
    draw_visualization(Handle,
      [focus:block(I,J,3,3)])
),
extract_array(Handle,row,Matrix,NamedList),
root(Handle),
search(NamedList,1,input_order,
  tree_indomain(Handle,_),
  complete,[]),
solution(Handle),
close_visualization(Handle).
```



Propagation Steps (Forward Checking)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4	

▶ Skip Animation

Propagation Steps (Forward Checking)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9	
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Propagation Steps (Forward Checking)

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1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
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1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Forward Checking)

4	1 2 3 5 6 7 9	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	
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1	3	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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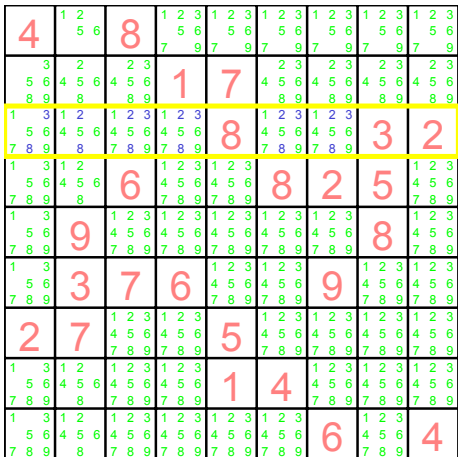
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1	3 9 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 3 7 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
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Propagation Steps (Forward Checking)



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Propagation Steps (Forward Checking)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 6 8 9	1 7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 7	1 5 6 9	1 4 5 6 7	1 4 5 6 7	1 8	1 4 5 6 7	1 4 5 6 7	3 2	
1 7	3 5 6 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1 7	3 5 6 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1 7	3 5 6 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 7	3 5 6 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 7	3 5 6 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9
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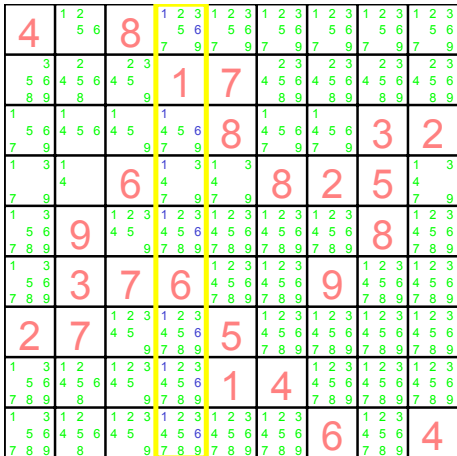
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1	3 5 6 7 8 9	1 2 4 5 6 8	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2 5	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	9	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8
1	3 5 6 7 8 9	3 7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
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1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9
							6	4

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4	1 2 5 6	8	2 3 7 9	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6
	3 5 6 8 9	2 4 5 8	2 3 4 5 9	1	7	2 3 4 5 8 9	2 3 4 5 8 9	2 3 4 5 8 9
1	5 6 7 9	1 4 5 9	1 4 5 9	4 5 7 9	8	1 4 5 7 9	1 4 5 7 9	3 2
1	3 7 9	1 4	6	3 4 7 9	1 3 4	8	2	5
1	3 5 6 7 8 9	9	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	8
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	9	1 2 3 4 5 7 8 9
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
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1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3 2
1	3 7 9	1 4	6	3 4 7 9	1 3 4 7 9	8	2	5 4 7 9
1	3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	8 4 5 6 7
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1 4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9
								4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 7 9	2 3 6 9 7	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	
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1	3 5 6 7 8 9	3	7	6	4 6 9	2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9
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								4	

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Propagation Steps (Forward Checking)

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1 3 7 9	1 4	6 4 7 9	3 4 7 9	3 4 9	8 4 9	2 5 9	5 4 7 9	1 3 4 7 9
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1 5 8	3 8	7 9	6 4	4 4	1 2 4 5 8	9 4 5 8	1 2 4 5 8	1 2 4 5 8
2 7 8 9	7 4 5 6 8	1 2 3 4 5 9 7 8 9	2 3 4 5 7 8 9	5 7 8 9	1 2 3 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 4 5 6 7 8 9	6 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	4 4 5 6 7 8 9

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Propagation Steps (Forward Checking)

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5 6 8 9	3 2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 7 9	1 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 6 7 9	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 7 9	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	2 1 2 5	9	1 2 4 5 8	1 2 4 5 8
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1 3 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
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Propagation Steps (Forward Checking)

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1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 3 4 5 6 7 8 9	4	

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 3 5 6 7 9	1 2 3 5 6 7 9		
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1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 3 4 5 7 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 3 4 5 6 7 8 9	4	

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Propagation Steps (Forward Checking)

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 2 3 5 6 7 9
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1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 4 6 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 8	2 6 4 9 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3 2
1	3 7 9	1 4	6	4 7 9	3 4 9	8	2	5
1 3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 5 6 7	1 3 4 5 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	2 5	1 2 9	1 2 4	1 2 4 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 4 9	1 3 4 6 8 9
	3 5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	3 5 7 8	2 6 7 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 7 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7 9	1 2 6 7 9	1 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 4 6 9	3 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7 9	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 8 9	8	2	5	1 3 7 9
1 3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
1 5 8	3	7	6	4 2	1 2 5	9	1 2 4	1 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 3 4 6 9	1 3 6 8 9
3 5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	5 3 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 7 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 3 5 6 7 9
	3 2 5 6 9	2 3 5 9	1	7	2 3 5 6 7 9	3 4 5 8	2 6 9	3 5 6 8 9
1	5 6 7 9	1 5 6	1 5	4 5 7 9	8	1 5 6 7 9	4 5	3 2
1 3 7 9	1 4	6	4 3 7 9	4 9	8	2	5	1 3 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
1 5 8	3	7	6	4 2	1 2 5	9	1 2 4	1 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 3 4 6 9	1 3 6 8 9
	3 2 5 6 7 8 9	2 3 5 6 8	2 3 5 9	1	4	5 3 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 7 9	6	1 2 7	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5	2 3 6	2 3 5 6	1 3 5	1 2 6	1 3 5 6
3 5 6 9	2 5 6	2 3 5	1	7	2 3 5 6	3 4 5 8	2 4	3 6 5 6 8 9
1 5 6 7 9	1 5 6	1 5	4 5 9	8	5 6 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 9	3 8	2	5	1 3 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5	2 3 4 6	1 2 3 5 6	1 3 4 5	8	1 3 5 6 7
1 5 8	3	7	6 4	2 5	1 2 9	1 2 4	1	5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 4 6 9	1 3 6 9	1 3 6 8 9
3 5 6 7 8 9	2 5 6	2 3 5	2 3 5	1	4	5 3 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5 7 8 9	1 2 5	1 2 3 5	2 3 5	2 3 9	1 2 3 5	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	2 3 6 9	2 3 5 6 9 7	1 5 6 9	1 6 7 9	1 5 6 7 9
5 6 9	3 2 5 6	2 3 5 9	1	7	2 3 5 6 9 8	4 5 8 9	4 6 9 8	5 6 8 9
1 5 6 7 9	1 5 6 7 9	1 5 9	4 5 9	8	5 6 9 7	1 4 5 9 7	3	2
1	4	6	4 3 7 9	4 3 9	8	2	5	1 3 7 9
5	9	2	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
8	3	7	6 4	2 1 2 5	9	1 2 4	1 5 8	
2	7	1 3 4 9	3 3 4 8 9	5	1 3 6 4 9 8	1 3 4 6 9	1 3 4 6 9	1 3 6 8 9
5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 9	1	4	5 3 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 9	2 3 9 7	1 2 3 5 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	2 3 6 9	2 3 5 6 9 7	1 5	1 6 9 7	1 5 6 9 9
	3 6 5 6 9	5 3	1 7	2 3 5 6 9 9	4 5 8	4	6 9	5 6 8 9
	1 6 5 6 7 9	1 5	4 5	8	5 6 9 7	1 4 5	3	2
1	4	6	7 9	3 9	8	2	5	3 7 9
5	9	2	4 7	3 4 6 7	3 1 6 4 7	3 1 6 4 7	8	1 3 6
8	3	7	6	2 4	1 2 5	9	1 2 4	1 5
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 4 6 8 9	1 4 6 9	1 3 6 8 9
	3 2 6 5 6 7 9 8	5 3	2 3 5 9	1 4	5 3 7 8	2 7 9	2 6 5 6 7 8 9	3 5 6 7 8 9
	3 1 2 5 7 9 8	1 3 5	2 3 5 9	2 3 9 7	1 2 3 5	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	2 3 6 9	2 3 5 6 9 7	1 5	1 6 9 7	1 5 6 9 9
	3 6 5 6 9	5 3 9	1	7	2 3 5 6 9 9	4 5 8	4 6 9 9	5 6 8 9
	1 6 5 6 7 9	1 5 6 9	4 5 9	8	5 6 9 7	1 4 5 9 7	3	2
1	4	6	3 7 9	3 9	8	2	5	3 7 9
5	9	2	3 4 7	3 4 7	1 3 4 7	1 3 8	1 3 6 7	
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	3 4 8 9	5	1 3 6 4 9 8	1 3 4 9	1 3 6 9 8 9	1 3 6 8 9
	3 2 6 5 6 7 9 8	5 3 9 7 8 9	2 3 5 9	1	4	5 3 7 8	2 6 7 9 7 8 9	3 5 6 7 8 9
	3 1 2 5 7 9 8	1 3 5 7 8 9	2 3 5 9	2 3 5 9	1 2 3 5 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 6 7	1 6 7	5 6 6 9
	3 2 6 5 6 9	5 3 9	1 7	2 3 6 4 5 9 8			6 9	5 6 8 9
	1 6 5 6 7 9	1 5 6 9	4 5 9	8	1 6 4 5 9 7		3 2	
1 4 6			3 7 9	3 9	8 2 5			3 7
5 9 2			3 4 7	3 4 7	1 3 7	3 7	8	3 6 7
8 3 7			6 2 5 9	4 1				
2 7	1 3 4	3 9	4 8 9	5	1 3 6 4 9	1 3 8	1 6 9	3 6 8 9
	3 2 6 5 6 7 9	3 5 9	2 3 5 7 8 9	1 4	3 5 7 8	3 7	2 6 9	3 5 6 7 8 9
	3 1 2 5 7 9	1 3 5 9	2 3 5 7 8 9		3 1 2 3 9 7 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 6 7	1 6 7	5 6 6 9
	3 6 9	2 5 6	5 3 9	1 7	2 3 6 9	4 5 8	6 9	5 6 8 9
	1 6 9	1 5 6	1 5 9	4 5 9	8	1 6 9	4 5 7	3 2
1	4	6	3 7 9	3 9	8	2	5	3 7
5	9	2	3 4 7	3 4	1 3 7	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	3 4 8 9	3 5	1 3 9	1 3 6 8	1 6 9	3 6 8 9
	3 6 9	5 6 8	5 9	2 3 5 9	1 4	3 5 7	2 6 7	3 5 6 8 9
	3 1 9 8	1 3 5	2 3 5 9	3 5	1 2 3 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 6 7	1 6 7	5 6 6 9
	3 6 9	2 5 6	5 3 9	1 7	2 3 6 9	4 5 8	6 9	5 6 8 9
	6 7 9	1 5 6	1 5 9	4 5 9	8	1 6 4 5 9 7	3	2
1	4	6	3 7 9	3 9	8	2	5	3 7
5	9	2	3 4 7	3 4 7	1 3 7	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	3 8 9	5	3 1 6 4 9	3 1 8	1 6 9	3 6 8 9
	3 6 9	5 6 8	5 3 7 8 9	2 3 7 8 9	1 4	5 3 7 8	2 6 7	3 5 6 7 8 9
	3 1 9 8	1 3 5 9	2 3 7 8 9	3 9	2 3 7 9	6	1 2 7 9	4

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Propagation Steps (Forward Checking)

4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 7 9	1 7 9	6 7 9	5 6 7 9
	3 6 9	2 5 6	5 3 9	1 7	2 3 6 9	4 5 8		6 9	5 6 8 9
	1 6 9	1 5 6	5 4 5 9	8		1 6 4 5 9 7	3	2	
1	4	6	3 7 9	3 9	8	2	5	3 7	
5	9	2	3 4 7	3 4 7	1 3 7	3 7	8	3 7 6	
8	3	7	6	2	5	9	4	1	
2	7	1 3 4 9	3 8 9	5	3 1 6 9	3 1 8	1 9	3 8 9	
	3 6 9	5 6 8	5 3 7 8 9	2 3 8 9	1 4	5 3 7 8	2 7 9	3 7 8 9	5 8 9
	3 1 9 8	1 3 5	2 3 7 8 9	3 9	2 3 7 9	6	1 2 7 9	4	

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After Setup (Forward Checking)

4	^{1 2} 5 6	8	^{2 3} 5 9	3	^{2 3} 6 9	¹ 5 7	1	⁶ 7 9	^{5 6} 7 9
³ 6 9	² 5 6	³ 5 9	1	7	^{2 3} 6 9	^{4 5} 8	⁶ 7 9	^{5 6} 8 9	
⁷ 6 9	¹ 5 6	¹ 5 9	^{4 5} 7 9	8	^{6 4 5} 7 9	¹ 5 7	3	2	
1	4	6	^{7 9} 3	⁹ 3	8	2	5	⁷ 3	
5	9	2	^{4 7} 3	^{4 7} 3	^{1 3} 7	³ 7	8	^{3 6} 7	
8	3	7	6	2	5	9	4	1	
2	7	^{1 3} 4 9	³ 8 9	5	^{3 1 3} 6 9	¹ 8	¹ 9	³ 8 9	
³ 6 9	^{5 6} 8	⁵ 9	^{3 2 3} 7 8 9	1	4	⁵ 7 8	^{3 2} 7 9	³ 7 8 9	
^{3 1} 9	⁵ 8	^{1 3} 5 9	^{2 3} 7 8 9	3	^{2 3} 7 9	6	^{1 2} 7 9	4	

Propagation Steps (Bounds Consistency)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4	

▶ Skip Animation

Propagation Steps (Bounds Consistency)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4	1 2 3 4 5 6 7 8 9

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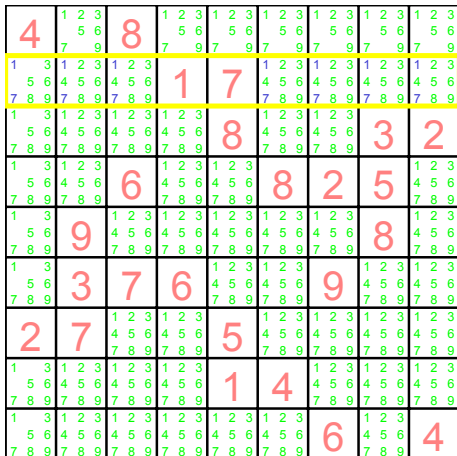
Propagation Steps (Bounds Consistency)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)



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Propagation Steps (Bounds Consistency)

4	1 2 3 5 6 7 9	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 2 3 4 5 6 8 9	2 3 4 5 6 8 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	3 1 2 3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2
1	3 1 2 3 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1	3 9 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 3 7 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 1 2 3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 1 2 3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 6 8 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 5 6 7 8 9	3 4 5 6 8	1 2 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3 2
1 5 6 7 8 9	3 4 5 6 8	1 2 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5
1 5 6 7 8 9	3 4 5 6 7 8 9	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 5 6 7 8 9	3 4 5 6 8	1 2 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 5 6 7 8 9	3 4 5 6 8	1 2 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 6 8 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	1 5 6 7 9	1 4 5 6 7 9	1 4 5 6 7 9	1 4 5 6 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1	3 5 6 7 8 9	1 2 4 5 6 8	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	1 4 5 6 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3 2
1	3 5 6 7 8 9	1 2 4 5 6 8	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2 5	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	9	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8
1	3 5 6 7 8 9	3 7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2 7	1 2 3 4 5 9	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9
								4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	1 5 6 7 9	1 4 5 6 9	1 4 5 6 9	1	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1	3 7 9	1 4	6	1 4 7 9	3 4 7 9	1 4 7 9	8	2	5
1	3 5 6 7 8 9	9	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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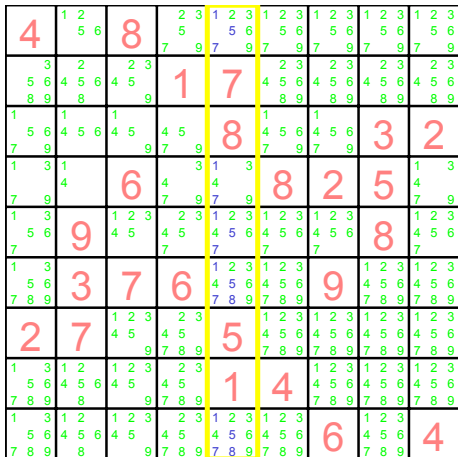
Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 7 9	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1	3 7 9	1 4	6	4 7 9	3 4 7 9	1 3 8	2	5	1 3 4 7 9
1	3 5 6 7 8 9	9	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)



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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 5 7 9	2 3 6 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1	3 7 9	1 4	6	4 7 9	3 4	8	2	5	1 3 4 7 9
1	3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6	1 2 3 4 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1	3 5 6 7 8 9	3	7	6	2 3 4 6 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 5 7	2 3 6 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1 7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1 7 9	3 4		6	4 7 9	3 4	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4 2	1 2 4 5 8	9	1 2 4 5 8	1 2 4 5 8	1 2 4 5 8
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 7 8 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 7 8 9	2 3 4 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 5 9	2 3 6 9	1 2 3 5 6 9	1 2 3 5 6 9	1 2 3 5 6 9	1 2 3 5 6 9
5 6 8 9	3 4 5 6 8	2 4 5 6 9	2 3 4 5 9	1 7	2 3 5 6 9	2 3 4 5 6 9	2 3 4 5 6 9	2 3 4 5 6 9
1 7 9	1 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 9	1 4 5 6 9	3	2
1 7 9	3 4	6	4 5 7 9	4 3	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5 9	2 3 4 5 9	2 3 4 6 7	1 2 3 5 6 9	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4 2	1 2 5 9	9	1 2 4 5 8	1 2 4 5 8
2	7	1 2 3 4 5 9	2 3 4 5 9	5	1 2 3 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
1 3 5 6 7 8 9	1 2 4 5 6 8 9	1 2 3 4 5 9	2 3 4 5 9	1	4	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
1 3 5 6 7 8 9	1 2 4 5 8	1 2 3 4 5 9	2 3 4 5 9	2 3 4 6 9	1 2 3 5 6 9	6	1 2 3 4 5 6 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 6 7 9	3	2	
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9	
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7	
1 5 8	3	7	6	4	1 2 5	9	1 2 4 5 8	1 2 4 5 8	
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 6 4 8 9	1 3 6 4 8 9	1 3 6 4 8 9	
1 3 5 6 7 8 9	1 2 4 5 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
1 3 5 6 7 8 9	1 2 4 5 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 3 4 5 6 7 8 9	4	

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7	1 3 5 7	1 2 3 5 6 7	1 2 3 5 6 7
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	2 1 2 5	9	1 2 4 5 8	1 2 4 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 4 8	1 3 4 6 4 8 9	1 3 4 6 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 3 4 5 7 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 9	1 3 5 9	1 2 3 5 6 9	1 2 3 5 6 9
	3 2 5 6 8 9	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 3 4 5 8 9	2 3 4 5 8 9
1	5 6 7 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 9	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 2 3 4 5 7
1 5 8	3	7	6 4	2 5	1 2 5	9	1 2 4 5 8	1 2 4 5 8
2	7	1 3 4	3 3 4 9	5	1 3 6 4 9	1 3 4 8	1 3 4 9	1 3 4 6 8 9
	3 2 5 6 7 8 9	2 3 5 9	2 3 5 7 8 9	1	4	3 5 7 8	2 3 5 6 7 8 9	2 3 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 9	6	1 2 3 4 5 7 8 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 4 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	1 2 5	9	1 2 4	1 2 4 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 4 6 9	1 3 4 6 8 9
3 5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	3 5 7 8	2 6 7 9	2 3 5 6 7 8 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 7 9	6	1 2 7	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 5 9	2 3 6 9	1 2 3 5 6 9	1 3 5 9	1 2 6 9	1 3 5 6 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 4 6 9	3 5 6 8 9
7	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 7 9
1 3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
1 5 8	3	7	6 4	2 5	1 2 5	9	1 2 4	1 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 4 9	1 3 8	1 3 4 6 9	1 3 6 8 9
3 5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	5 3 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 9	6	1 2 7 9	4

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Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 3 5 6 7 9
	3 2 5 6 9	2 3 5 9	1	7	2 3 5 6 9	4 5 8	3 2 4 6 9 8 9	3 5 6 8 9
7	1 5 6	1 5 9	4 5 9	8	1 5 6 9	1 4 5	3	2
1 3 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 7 9
1 3 5 6	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
1 5 8	3	7	6	4	2 1 2 5	9	1 2 4	1 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 9	1 3 4 8	1 3 4 6 9	1 3 6 8 9
	3 2 5 6 8 9	2 3 5 6 9	2 3 5 7 8 9	1	4	5 3 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 7 9	6	1 2 7 9	4

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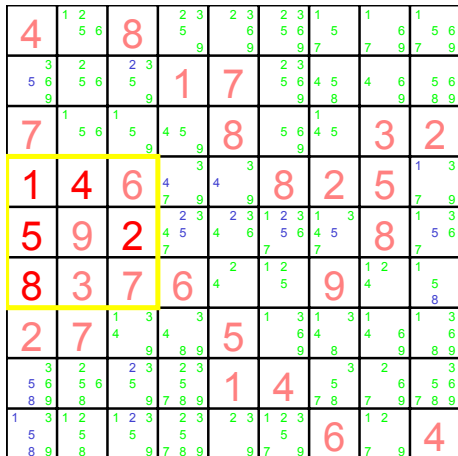
Propagation Steps (Bounds Consistency)

4	1 2 5 6	8	2 3 5	2 3 6	2 3 5 6	1 3 5	1 2 6	1 3 5 6
	3 2 5 6 9	2 3 5	1	7	2 3 5 6	3 4 5 8	2 4	3 6 5 6 8 9
7	1 5 6	1 5	4 5 9	8	5 6 9	1 4 5	3	2
1 3 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 7 9
1 3 5 6	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
1 5 8	3	7	6	4	1 2 5	9	1 2 4	1 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 3 4 6 9	1 3 6 8 9
	3 2 5 6 8 9	2 3 5 6	2 3 5	1	4	5 3 7 8	2 6	3 5 6 7 8 9
1 3 5 8 9	1 2 5 8	1 2 3 5 9	2 3 5 9		2 3 5 9	1 2 3 5 9	6	1 2 7 9

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Propagation Steps (Bounds Consistency)



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Propagation Steps (Bounds Consistency)

4	^{1 2} _{5 6}	8	5	6	^{2 3} _{5 6}	¹ ₅	¹ ₆	¹ _{5 6}
³ ₆	² _{5 6}	³ ₉	1	7	^{2 3} _{5 6}	^{4 5} ₈	⁴ ₉	^{5 6} _{8 9}
7	6	¹ ₅	4	8	9	¹ _{4 5}	3	2
1	4	6	³ _{7 9}	³ ₉	8	2	5	³ _{7 9}
5	9	2	⁴ ₇	³ _{4 6}	1	^{1 3} _{4 7}	8	6
8	3	7	6	2	5	9	4	1
2	7	4	⁴ _{8 9}	³ _{5 6}	^{1 3} _{4 8}	¹ ₄	^{1 3} _{6 9}	³ _{8 9}
6	² _{5 6}	³ ₉	^{2 3} _{5 9}	1	4	^{5 3} _{7 8}	² _{7 9}	³ _{5 6}
³ ₉	^{1 2} _{5 8}	¹ ₅	^{2 3} _{5 9}	^{2 3} ₉	7	6	^{1 2} _{7 9}	4

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Propagation Steps (Bounds Consistency)

4	^{1 2}	8	5	6	^{2 3}	¹	¹		
³	²	³	1	7	^{2 3}	^{4 5}	⁶	⁵	
₉	₅	₉			₈	₉	₈	₉	
7	6	¹	4	8	9	¹	5	3	2
	₅	₉				₅	₉		
1	4	6	³	³	8	2	5	³	
	₇	₉	₉	₉			₇	₉	
5	9	2	³	³	1	³	8	6	
	₇	₄	₃	₃	₄	₇			
8	3	7	6	2	5	9	4	1	
			³			^{1 3}	¹		³
2	7	4	_{8 9}	5	6	₈	₉	_{8 9}	
6	²	³	^{2 3}	1	4	³	²	³	
	₅	₉	_{7 8 9}			₅	₂	₃	
₉	₈	₅	₈	₉	₇	₈	₇	₉	_{7 8 9}
³	^{1 2}	¹	²	³	7	6	^{1 2}	4	
₉	₅	₅	₈	₉					

Propagation Steps (Bounds Consistency)

4	^{1 2}	8	5	6	^{2 3}	¹	¹		
	³ ₉	² ₅	³ ₉	1	7	^{2 3}	^{4 5} ₈	⁶ ₉	⁵ _{8 9}
7	6	¹ ₅	4	8	9	¹ ₅	3	2	
1	4	6	³ _{7 9}	³ ₉	8	2	5	³ ₇	
5	9	2	³ ₇	⁴ ₃	1	³ ₇	8	6	
8	3	7	6	2	5	9	4	1	
2	7	4	³ _{8 9}	5	6	^{1 3} ₈	¹ ₉	³ _{8 9}	
6	² _{5 8}	³ ₉	^{2 3} _{7 8 9}	1	4	⁵ _{7 8}	³ _{7 9}	² _{5 7 8 9}	
	³ ₉	^{1 2} _{5 8}	¹ ₅	² ₈	³ ₉	7	6	^{1 2} ₄	

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Propagation Steps (Bounds Consistency)

4	^{1 2}	8	5	6	^{2 3}	¹	¹	
	³ ₉	² ₅	³ ₉	1	7	^{2 3}	^{4 5} ₈	⁶ ₉ ⁵ _{8 9}
7	6	¹ ₅	4	8	9	¹ ₅	3	2
1	4	6	⁷ ₉	³ ₉	³ ₉	8	2	5
5	9	2	⁷ ₉	³ ₉	⁴ ₉	³ ₉	1	⁸ ₇ 6
8	3	7	6	2	5	9	4	1
2	7	4	³ _{8 9}	5	6	¹ ₈ ³ ₉	¹ ₉ ³ _{8 9}	³ ₉
6	⁵ ₈	³ ₉	^{2 3} _{7 8 9}	1	4	⁵ _{7 8} ³ ₉	² _{7 9} ³ _{7 8 9}	⁵ _{7 8 9}
	³ ₉ ¹ ₅	¹ ₅	² ₈	³ ₉	7	6	^{1 2}	4

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Propagation Steps (Bounds Consistency)

4	^{1 2}	8	5	6	^{2 3}	¹	¹		
³	²	³	1	7	^{2 3}	^{4 5}	⁶	⁵	
⁹	⁵	⁹	⁹	⁹	⁸	⁹	⁸	⁹	
7	6	¹	4	8	9	¹	3	2	
⁵	⁵	⁵	^{7 9}	⁹	⁹	⁵	⁷	³	
1	4	6	³	³	8	2	5	³	
⁷	⁷	³	⁴	³	¹	³	8	6	
5	9	2	⁷	⁴	1	⁷	8	6	
8	3	7	6	2	5	9	4	1	
2	7	4	³	5	6	^{1 3}	¹	³	
^{8 9}	^{8 9}	^{8 9}	^{8 9}	^{8 9}	^{8 9}	^{8 9}	^{8 9}	^{8 9}	
6	⁵	³	^{2 3}	1	4	^{5 3}	²	³	
⁸	⁹	⁹	^{8 9}	^{8 9}	^{7 8}	^{7 9}	^{7 8 9}	⁵	
^{3 1}	⁵	^{1 5}	²	³	7	^{1 2}	6	4	
⁹	⁸	⁸	⁹	⁹	⁹	⁹	⁹	⁹	

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Propagation Steps (Bounds Consistency)

4	¹ 2	8	5	6	² 3	¹	¹	
	₃ ₉	² 5	₃ 9	1	7	² 3	₄ 5 ₈	₆ 7 ₉ 8 9
7	6	¹ 5	4	8	9	¹ 5	3	2
1	4	6	₇ 9	₃ 9	₃ 9	8	2	5
5	9	2	₇ 3	⁴ 3	³ 7	³ 1	8	6
8	3	7	6	2	5	9	4	1
2	7	4	₈ 9	₃ 5	6	¹ 3 ₈	¹ 9	₃ 8 9
6	₅ 8	₃ 9	² 3 8 9	1	4	₅ 3 ₇ 8	² 7 9	₃ 5 7 8 9
	₃ 9	¹ 5	² 8	₃ 9	7	6	¹ 2	4

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After Setup (Bounds Consistency)

4	^{1 2}	8	5	6	^{2 3}	¹	¹	
₃	₂ ₅	₃	1	7	_{2 3}	_{4 5} ₈	₆ ₉	₅ _{8 9}
7	6	¹ ₅	4	8	9	¹ ₅	3	2
1	4	6	_{7 9} ₃	₃	8	2	5	₃
5	9	2	₇ ₃	₄ ₃	1	₇ ₃	8	6
8	3	7	6	2	5	9	4	1
2	7	4	_{8 9} ₃	5	6	^{1 3} ₈	¹ ₉	₃ _{8 9}
6	₅ ₈	₃ _{2 3}	₉ _{8 9}	1	4	_{7 8} _{5 3}	_{7 9} _{2 3}	₅ _{7 8 9}
₃ ₉	₁ ₅	¹ ₅	₂ ₈	₃	7	6	^{1 2}	4

Propagation Steps (Domain Consistency)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4	1 2 3 4 5 6 7 8 9

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Propagation Steps (Domain Consistency)

4	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4	

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Propagation Steps (Domain Consistency)

4	1 2 3 4 5 6 7 9	8	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3 2	
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8 2	5	1 2 3 4 5 6 7 8 9	
1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	3 7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
2 7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 3 5 6 7 9	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
1	3	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3	1 2 3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2
1	3	1 2 3 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1	3	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3	1 2 3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3	1 2 3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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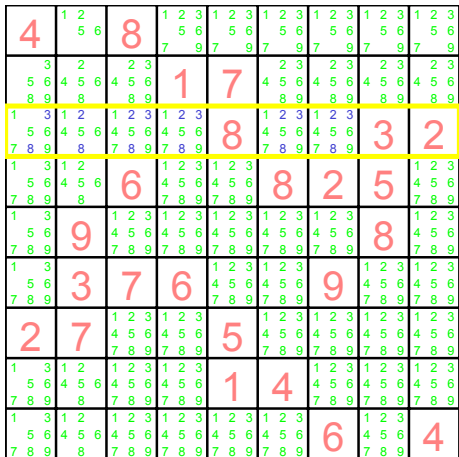
Propagation Steps (Domain Consistency)

4	1 2 3 5 6 7 9	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 4 5 6 8 9	2 3 4 5 6 8 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	3	2
1	3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)



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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 6 8 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	1 5 6 7 9	1 4 5 6 7 9	1 4 5 6 7 9	1 4 5 6 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1	3 5 6 7 8 9	1 2 4 5 6 8	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	1 5 6 7 9	4 5 6 4 5 9	1 4 5 6 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1	3 5 6 7 8 9	1 2 4 5 6 8	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	2	5
1	3 5 6 7 8 9	9	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9
								4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	1 5 6 7 9	1 4 5 6 9	1 4 5 6 9	1	8	1 4 5 6 7 9	1 4 5 6 7 9	3 2
1	3 7 9	1 4	6	1 4	3 7 9	1 4	8 2 5	1 4 7 9
1	3 5 6 7 8 9	9	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8
1	3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9
								4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6	1 2 3 5 6
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1 7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3 2
1 3 7 9	1 4	6	4 7 9	3 4 7 9	1 3 8	2 8	5 5	1 3 4 7 9
1 3 5 6 7 8 9	9	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	8
1 3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2 7	1 2 3 4 5 9	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	1 2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1 3 7 9	1 4	6	3 4 7 9	1 3 4 7 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1 3 5 6 7 8 9	3	7	6	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 4 5 6 7 9	1 4 5 6 7 9	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1 3 5 6 7 8 9	3	7	6	2 3 4 6 9	1 2 3 4 5 6 7 8 9	9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 5 7	2 3 6 9	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6
	3 2 5 6 8 9	2 3 4 5	1	7	2 3 4 5 8 9	2 3 4 5 8 9	2 3 4 5 8 9	2 3 4 5 8 9
1	1 5 6 7 9	1 4 5 9	4 5 7 9	8	1 4 5 7 9	1 4 5 7 9	3	2
1 3 7 9	1 4	6	4 3 7 9	3	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 4 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4 2	1 2 4 5 8	9	1 2 4 5 8	1 2 4 5 8
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 9	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 4 5 6 7 8 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 9	1 2 3 5 6 9	1 2 3 5 6 9	1 2 3 5 6 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 6 9	3 2
1	3 7 9	1 4	6	4 7 9	3 4	8	2 5	1 3 4 7 9
1	3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
1	5 8	3	7	6	4	2 1 2 5	9	1 2 4 5 8
2	7	1 2 3 4 5 9	2 3 4 5 7 8 9	5	1 2 3 5 6 7 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 9	6	1 2 3 4 5 6 7 8 9
							4	

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1	5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 6 9	3	2
1	3 7 9	1 4	6	4 7 9	3 4	3 4	8	2	5
1	3 5 6 7	9	1 2 3 4 5 7	2 3 4 5 7	2 3 4 6 7	1 2 3 5 6 7	1 2 3 4 5 6 7	8	1 2 3 4 5 6 7
1	5 8	3	7	6	4	2 5	9	1 2 4 5 8	1 2 4 5 8
2	7	1 3 4	3 4 9	3 4 8 9	5	1 3 6 4 9	1 3 6 4 8 9	1 3 6 4 8 9	1 3 6 4 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1	3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 3 5 6 7 9	1 2 3 5 6 7 9
	3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 3 4 5 6 8 9
1	1 5 6 7 9	4 5 6	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	2 5	9	1 2 4 5 8	1 2 4 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 9	1 3 4 8	1 3 4 6 8 9	1 3 4 6 8 9
1 3 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	1	4	1 3 4 5 7 8	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6	1 2 3 5 6 7 9	1 3 5	1 2 3 5 6 7 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 3 4 5 6 8 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 9	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6 4	2 5	1 2 9	1 2 4 5 8	1 2 4 5 8	1 2 4 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 4 9	1 3 4 8	1 3 6 4 8 9	1 3 4 6 8 9
3 5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	3 5 7 8	2 3 5 6 7 8 9	2 3 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 3 4 5 6 7 8 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 4 6 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	2 5	9	1 2 4	1 2 4 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 4 6 9	1 3 4 6 8 9
3 5 6 7 8 9	2 5 6 8	2 3 5	2 3 5 7 8 9	1	4	5 3 7 8	2 6 7 9	2 3 5 6 7 8 9
1 3 5 6 7 8 9	1 2 4 5 6 8	1 2 3 4 5 9	2 3 4 5 7 8 9	2 3 4 6 9	1 2 3 5 6 7 9	6	1 2 4 6 7 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 9	1 2 3 5 6 7 9
3 5 6 8 9	2 4 5 6 8	2 3 4 5 9	1	7	2 3 5 6 9	3 4 5 8	2 4 9	2 3 4 5 6 8 9
1 5 6 7 9	1 4 5 6 9	1 4 5 9	4 5 7 9	8	1 5 6 7 9	1 4 5 7	3	2
1 3 7 9	1 4	6	4 3 7 9	4 3 9	8	2	5	1 3 4 7 9
1 3 5 6 7	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 2 3 4 5 6 7
1 5 8	3	7	6	4	1 2 5	9	1 2 4	1 2 4 5 8
2	7	1 3 4	3 4 8 9	5	1 3 6 4 9	1 3 8	1 4 6 9	1 3 4 6 8 9
3 5 6 7 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	3 5 7 8	2 6 7 9	2 3 5 6 7 8 9
1 3 5 7 8 9	1 2 5 8	1 2 3 5 9	2 3 5 7 8 9	2 3 9	1 2 3 5 7 9	6	1 2 7 9	4

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Propagation Steps (Domain Consistency)

4 <small>1 2 5 6</small>	8 <small>2 3 5 6</small>	<small>2 3 7 9</small>	<small>2 3 6 9</small>	<small>1 2 3 7 9</small>	<small>1 3 5 6</small>	<small>1 2 7 9</small>	<small>1 3 5 6</small>	<small>1 3 7 9</small>	<small>1 3 5 6</small>
<small>3 5 6 8 9</small>	<small>2 4 5 6 8</small>	<small>2 3 4 5 9</small>	1	7	<small>2 3 5 6 9</small>	<small>3 4 5 8</small>	<small>2 4 6 9</small>	<small>3 5 6 8 9</small>	<small>3 5 6 8 9</small>
7 <small>1 4 5 6</small>	<small>1 4 5 6 9</small>	<small>4 5 7 9</small>	<small>4 5 7 9</small>	8	<small>1 5 6 7 9</small>	<small>1 4 5 7</small>	3	2	
<small>1 3 7 9</small>	4	6 <small>4 3 7 9</small>	<small>4 3 7 9</small>	8	2	5	<small>1 3 7 9</small>	<small>1 3 7 9</small>	<small>1 3 7 9</small>
<small>1 3 5 6 7</small>	9	<small>1 2 3 4 5 7</small>	<small>2 3 4 5 7</small>	<small>2 3 4 6 7</small>	<small>1 2 3 5 6 7</small>	<small>1 3 4 5 7</small>	8	<small>1 3 5 6 7</small>	<small>1 3 5 6 7</small>
<small>1 5 8</small>	3	7	6 <small>4</small>	<small>2 4</small>	<small>1 2 5</small>	9	<small>1 2 4</small>	<small>1 5 8</small>	<small>1 5 8</small>
2	7	<small>1 3 4</small>	<small>3 4 8 9</small>	5	<small>1 3 6 4 9</small>	<small>1 3 8</small>	<small>1 3 4 6 9</small>	<small>1 3 6 8 9</small>	<small>1 3 6 8 9</small>
<small>3 5 6 7 8 9</small>	<small>2 5 6 8</small>	<small>2 3 5 9</small>	<small>2 3 5 7 8 9</small>	1	4	<small>3 5 6 7 8</small>	<small>2 6 9 7 9</small>	<small>3 5 6 7 8 9</small>	<small>3 5 6 7 8 9</small>
<small>1 3 5 7 8 9</small>	<small>1 2 5 8</small>	<small>1 2 3 5 9</small>	<small>2 3 5 7 8 9</small>	<small>2 3 5 9</small>	<small>1 2 3 5 9</small>	6	<small>1 2 7 9</small>	4	

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 7 9	2 3 5 6	1 2 3 7 9	1 3 5 6	1 2 7 9	1 3 5 6
	3 2 5 6 9	2 3 5 9	1	7	2 3 5 6 9	4 5 8	3 2 4 6 9 8 9	3 5 6 8 9
7	1 5 6 9	1 5 9	4	8	1 5 6 9	1 4 5	3	2
1 3 9	4	6	7 9	3 9	8	2	5	1 3 7 9
1 3 5 6	9	1 2 3 4 5	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	8	1 3 5 6 7
1 5 8	3	7	6 4	2 1 2 5	9	1 2 4	1 5 8	
2	7	1 3 4 9	4 8 9	3 5	1 3 6 4 9 8	1 3 4 6 9	1 3 6 8 9	
3 2 5 6 8 9	2 3 5 8	2 3 5 9	2 3 7 8 9	1 4	5 3 7 8	2 6 7 9	3 5 6 7 8 9	
1 3 5 8 9	1 2 5 8	1 2 3 5 9	2 3 5 9	2 3 7 9	1 2 3 5 9	6	1 2 7 9	4

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Propagation Steps (Domain Consistency)

4	1 2 5 6	8	2 3 5	2 3 6	2 3 5 6	1 3 5	1 2 6	1 3 5 6	
	3 5 6 9	2 5 6	2 3 5	1	7	2 3 5 6	3 4 5 8	2 6 9	3 5 6 8 9
7	1 5 6	1 5	4	8	5 6 9	1 5	3	2	
1 3 9	4	6	7 9	3 9	8	2	5	1 3 7 9	
1 3 5 6	9	1 2 3 4 5	2 3 5	2 3 4	2 3 6	1 2 3 5 6	1 3 4 5	8	1 3 5 6
1 5 8	3	7	6	4	2 5	1 2 5	9	1 2 4	1 5 8
2	7	1 3 4	3 9	8 9	5	1 3 9	1 3 8	1 3 4	1 3 6 9
	3 5 6 8 9	2 5 6 8	2 3 5	2 3 5	1	4	5 7 8	3 6 9	2 5 6 7 8 9
1 3 5 8 9	1 2 5	1 2 3 5	2 3 5	2 3 9	2 3 7	1 2 3 5	6	1 2 7	4 9

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Propagation Steps (Domain Consistency)

4	^{1 2} _{5 6}	8	^{2 3} _{5 9}	^{2 3} _{6 9}	^{2 3} _{5 6 9}	^{1 5} _{7 9}	^{1 6} _{7 9}	^{1 5 6} _{7 9}
³ _{5 6 9}	² _{5 6}	^{2 3} _{5 9}	1	7	^{2 3} _{5 6 9}	^{4 5} _{8 9}	^{4 6} _{9 8 9}	^{5 6} _{8 9}
7	¹ _{5 6}	¹ _{5 9}	4	8	^{5 6} ₉	¹ ₅	3	2
1	4	6	^{7 9} ₃	³ ₉	8	2	5	^{1 3} _{7 9}
5	9	2	^{2 3} _{5 7}	^{2 3} _{4 6}	^{1 2 3} _{5 6 7}	^{1 3} _{4 5 7}	8	^{1 3} _{5 6 7}
8	3	7	^{6 4} ₂	^{1 2} ₅	⁹ ₄	^{1 2} _{5 8}	¹ ₅	³ ₈
2	7	4	³ _{8 9}	5	^{1 3} _{6 9}	^{1 3} _{4 8}	^{1 6} ₉	^{1 3} _{6 8 9}
³ _{5 6 8 9}	² _{5 6 8}	^{2 3} _{5 9}	^{2 3} _{5 7 8 9}	¹ _{5 7 8 9}	4	^{5 3} _{7 8}	^{2 6} _{7 9}	^{3 5 6} _{7 8 9}
¹ _{5 8 9}	^{1 2} _{5 8}	^{1 2 3} _{5 9}	^{2 3} _{5 7 8 9}	^{2 3} _{5 9}	^{1 2 3} _{5 7 9}	6	^{1 2} _{7 9}	4

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Propagation Steps (Domain Consistency)

4	2	8	5	6	3	1	¹ ₇	⁶ ₉	¹ ₇	⁵ ₉	⁶ ₉
³ ₉	5	⁵ ₉	³ ₉	1	7	2	4	6	8		
7	6	1	4	8	9	5	3	2			
1	4	6	³ ₇	³ ₉		8	2	5	³ ₇	⁹ ₉	
5	9	2	³ ₇		4	1	¹ ₇	³ ₄	8	6	
8	3	7	6	2	5	9	4	1			
2	7	4	³ ₈	⁹ ₉	5	6	8	1	¹ ₈	³ ₉	⁶ ₉
6	8	⁵ ₉	2	1	4	⁵ ₇	³ ₈	² ₇	⁶ ₉	5	
³ ₉	1	5	8	² ₉	³ ₉	7	6	2	4		

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Propagation Steps (Domain Consistency)

4	2	8	5	6	3	1		
	5		1	7	2	4	6	8
7	6	1	4	8	9	5	3	2
1	4	6			8	2	5	
5	9	2		4	1		8	6
8	3	7	6	2	5	9	4	1
2	7	4		5	6	8	1	
6	8		2	1	4			5
	1	5	8		7	6	2	4

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Propagation Steps (Domain Consistency)

4	2	8	5	6	3	1	⁷	⁹	⁷	⁹
³	5	³	1	7	2	4	6	8		
⁹		⁹								
7	6	1	4	8	9	5	3	2		
1	4	6	³	³	8	2	5	³		
			⁷	⁹	⁹			⁷		
5	9	2	³	4	1	³	8	6		
			⁷		⁷					
8	3	7	6	2	5	9	4	1		
2	7	4	³	5	6	8	1	³		
			⁹					⁹		
6	8	³	2	1	4	³		5		
			⁷		⁷	⁹				
³	1	5	8	³	7	6	2	4		
⁹			⁹							

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Propagation Steps (Domain Consistency)

4	2	8	5	6	3	1	<small>7 9 7 9</small>	
<small>3 9</small>	5	<small>3 9</small>	1	7	2	4	6	8
7	6	1	4	8	9	5	3	2
1	4	6	<small>7 9 3 9</small>	<small>3 9</small>	8	2	5	<small>3 7</small>
5	9	2	<small>7 3</small>	4	1	<small>7 3</small>	8	6
8	3	7	6	2	5	9	4	1
2	7	4	<small>3 9</small>	5	6	8	1	<small>3 9</small>
6	8	<small>3 9</small>	2	1	4	<small>7 7 9 3</small>		5
<small>3 9</small>	1	5	<small>3 9</small>	8	7	6	2	4

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Propagation Steps (Domain Consistency)

4	2	8	5	6	3	1	<small>7 9 7 9</small>	
<small>3 9</small>	5	<small>3 9</small>	1	7	2	4	6	8
7	6	1	4	8	9	5	3	2
1	4	6	<small>7 9 3 9</small>	<small>3 9</small>	8	2	5	<small>3 7</small>
5	9	2	<small>7 3</small>	4	1	<small>7 3</small>	8	6
8	3	7	6	2	5	9	4	1
2	7	4	<small>3 9</small>	5	6	8	1	<small>3 9</small>
6	8	<small>3 9</small>	2	1	4	<small>7 7 9 3</small>		5
<small>3 9</small>	1	5	8	<small>3 9</small>	7	6	2	4

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Propagation Steps (Domain Consistency)

4	2	8	5	6	3	1	7	9	7	9
³ ₉	5	³ ₉	1	7	2	4	6	8		
7	6	1	4	8	9	5	3	2		
1	4	6	³ _{7 9}	³ ₉	8	2	5	³ ₇		
5	9	2	³ ₇	4	1	³ ₇	8	6		
8	3	7	6	2	5	9	4	1		
2	7	4	³ ₉	5	6	8	1	³ ₉		
6	8	³ ₉	2	1	4	³ _{7 9}		5		
³ ₉	1	5	8	³ ₉	7	6	2	4		

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After Setup (Domain Consistency)

4	2	8	5	6	3	1		
	5		1	7	2	4	6	8
7	6	1	4	8	9	5	3	2
1	4	6			8	2	5	
5	9	2		4	1		8	6
8	3	7	6	2	5	9	4	1
2	7	4		5	6	8	1	
6	8		2	1	4			5
	1	5	8		7	6	2	4

Comparison

Forward Checking

4	1 2 5 6	8	2 3 5 6 9	3 6 9	2 3 5 6 7 9	1 5 6 7 8 9	1 6 5 6 8 9
6	3 5 6 8 9	5	1 7	2 3 4 5 6 8 9	4 5 6 7 8 9	6 5 8 9	6 5 8 9
7	1 5 6 8 9	5 8 9	4 5 9	8	1 5 6 7 8 9	3 2	3 2
1	4 6 7 8 9	6	7 8 9	3 8 2 5	3 8 2 5	5	3
5	9 2 4 7 8 9	2	4 7 8 9	7 8	1 5 3 3 8	8	7 8 9
8	3 7 6 2 5 9 4 1	3 7 6 2 5 9 4 1	2 5 9 4 1	2 5 9 4 1	2 5 9 4 1	4 1	3
2	7 4 5 6 8 9	7 4 5 6 8 9	5	6 8 9	1 3 3 1 3 1	5	3
3	6 5 6 5 7 8 9	6 5 7 8 9	1 4	5 7 8 9	2 3 2 3 2 3 2 3 2 3	2 3 2 3 2 3 2 3 2 3	3
5	8 9 7 8 9	8 9 7 8 9	3 2 3	6	7 8 9	1 2 3 4 5 6 7 8 9	3
9	5 8 9 7 8 9	5 7 8 9	5 7 8 9	6	7 8 9	4	3

Bounds Consistency

4	1 2	8 5 6	2 3 1 1	1 1			
3	2 5 6 8 9	3 1 7	2 3 4 5 6 7 8 9	4 5 6 7 8 9	6 5 8 9		
7	6	4 8 9	1 5 3 2	1 5 3 2	3 2		
1	4 6 7 8 9	6 7 8 9	8 2 5	8 2 5	5		
5	9 2 7 8 9	2 7 8 9	1 8 6	1 8 6	6		
8	3 7 6 2 5 9 4 1	3 7 6 2 5 9 4 1	2 5 9 4 1	2 5 9 4 1	4 1		
2	7 4 5 6 8 9	7 4 5 6 8 9	5 6	5 6	1 3 3 1 3 1		
6	5 8 9 7 8 9	5 8 9 7 8 9	1 4	5 7 8 9	2 3 2 3 2 3 2 3 2 3		
3	6 5 6 5 7 8 9	6 5 7 8 9	1 4	5 7 8 9	2 3 2 3 2 3 2 3 2 3		
9	5 8 9 7 8 9	5 8 9 7 8 9	7 6	7 6	4		

Domain Consistency

4	2 8 5 6 3 1	2 8 5 6 3 1	7 8 9 7 8 9				
3	5 1 7 2 4 6 8	5 1 7 2 4 6 8	7 8 9 7 8 9				
7	6 1 4 8 9 5 3 2	6 1 4 8 9 5 3 2	7 8 9 7 8 9				
1	4 6 7 8 9 8 2 5	4 6 7 8 9 8 2 5	7 8 9 7 8 9				
5	9 2 7 8 9 4 1 8 6	9 2 7 8 9 4 1 8 6	7 8 9 7 8 9				
8	3 7 6 2 5 9 4 1	3 7 6 2 5 9 4 1	7 8 9 7 8 9				
2	7 4 5 6 8 1	7 4 5 6 8 1	7 8 9 7 8 9				
6	8 2 1 4 7 8 9 5	8 2 1 4 7 8 9 5	7 8 9 7 8 9				
3	1 5 8 7 6 2 4	1 5 8 7 6 2 4	7 8 9 7 8 9				
9	1 5 8 7 6 2 4	1 5 8 7 6 2 4	7 8 9 7 8 9				

Instrumented indomain

```
tree_indomain_generic(Term, Handle, Handle, Type) :-
    Handle = visualization{ignore_fixed:IgnoreFixed,
                          var_arg:VarArg,
                          name_arg:NameArg,
                          focus_arg:FocusArg},

    arg(VarArg, Term, X),
    ((integer(X), IgnoreFixed = yes) ->
     true
    ;
     arg(NameArg, Term, Name),
     arg(FocusArg, Term, Focus),
     get_domain_as_list(X, L),
     get_domain_size(X, Size),
     reorganize_domain(X, L, Type, K),
     try_value(Handle, X, K, Name, Size, Focus)
    ).
```

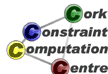


Instrumented indomain

```

try_value(Handle, X, [V|_], Name, Size, Focus) :-
  ((X = V, true) ->
    try(Handle, Name, Size, V),
    focus_option(Focus, FocusOption),
    draw_visualization(Handle, FocusOption)
  ;
  failure(Handle, Name, Size, V),
  fail_option(Focus, V, FailOption),
  draw_visualization(Handle, FailOption),
  fail
).

try_value(Handle, X, [_|R], Name, Size, Focus) :-
  try_value(Handle, X, R, Name, Size, Focus).
  
```

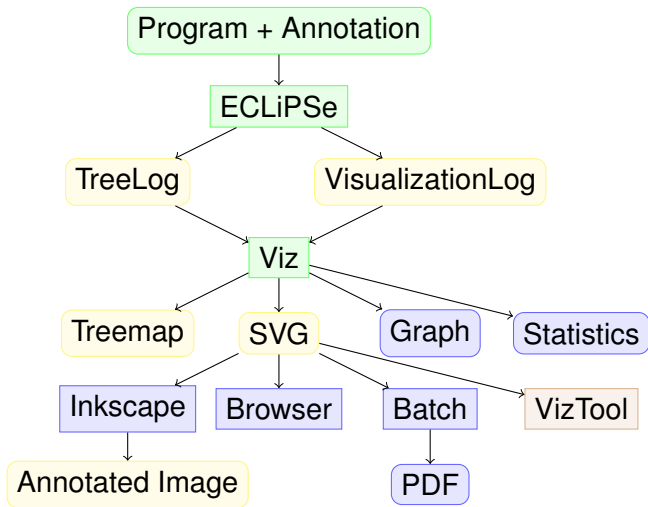


Outline

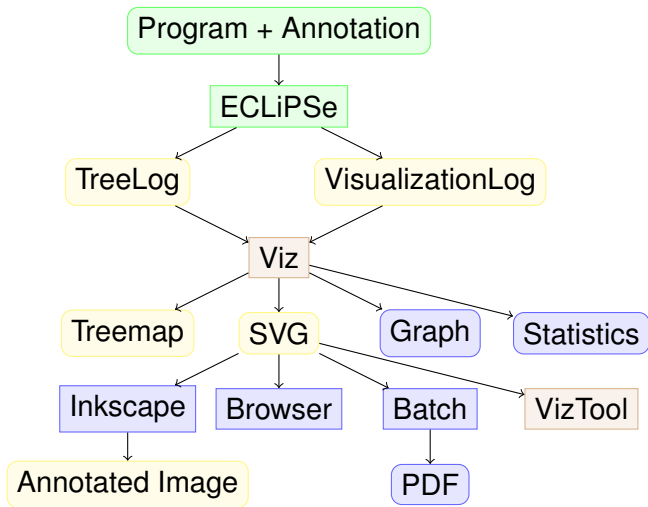
- 1 Introduction
- 2 Visualization by Annotation
- 3 Visualization Interface**
 - TreeLog Format
 - VisualizerLog Format
- 4 Conclusions



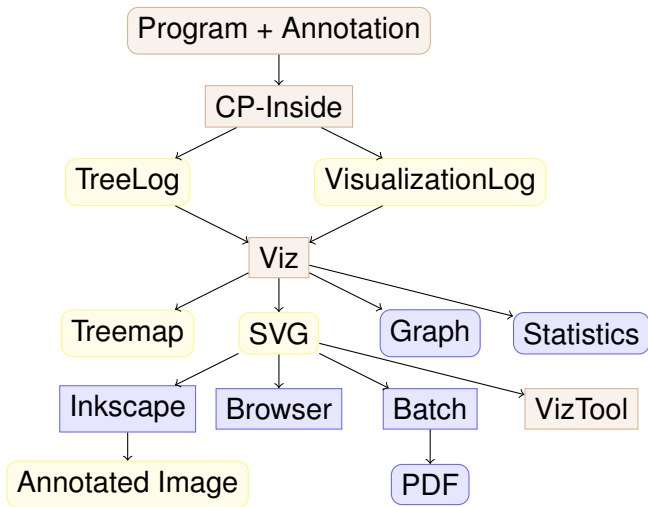
Architecture (Current)



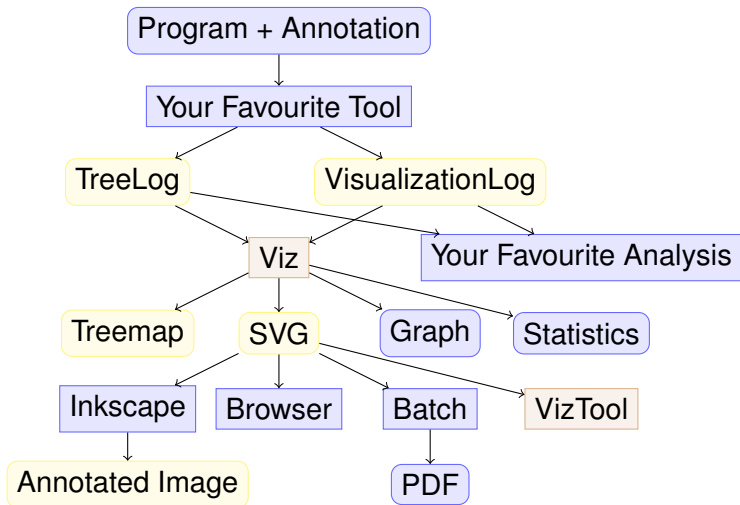
Architecture (Planned)



CP-Inside



Generic Tool



TreeLog Format

- XML based description
- Record information about nodes in search tree
 - Choices
 - Failures
 - Success
- Redundant information to ease generation



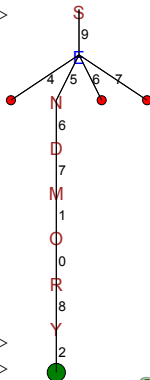
TreeLog Example

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<tree version="1.0" >
<root id="0"/>
<try id="1" parent="0" name="S" size="1" value="9" />
<fail id="2" parent="1" name="E" size="4" value="4" />
<try id="3" parent="1" name="E" size="4" value="5" />
<try id="4" parent="3" name="N" size="1" value="6" />
<try id="5" parent="4" name="D" size="1" value="7" />
<try id="6" parent="5" name="M" size="1" value="1" />
<try id="7" parent="6" name="O" size="1" value="0" />
<try id="8" parent="7" name="R" size="1" value="8" />
<try id="9" parent="8" name="Y" size="1" value="2" />
<succ id="9"/>
<fail id="10" parent="1" name="E" size="4" value="6" />
<fail id="11" parent="1" name="E" size="4" value="7" />
</tree>
```



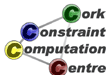
TreeLog Example

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<tree version="1.0" >
<root id="0"/>
<try id="1" parent="0" name="S" size="1" value="9" />
<fail id="2" parent="1" name="E" size="4" value="4" />
<try id="3" parent="1" name="E" size="4" value="5" />
<try id="4" parent="3" name="N" size="1" value="6" />
<try id="5" parent="4" name="D" size="1" value="7" />
<try id="6" parent="5" name="M" size="1" value="1" />
<try id="7" parent="6" name="O" size="1" value="0" />
<try id="8" parent="7" name="R" size="1" value="8" />
<try id="9" parent="8" name="Y" size="1" value="2" />
<succ id="9"/>
<fail id="10" parent="1" name="E" size="4" value="6" />
<fail id="11" parent="1" name="E" size="4" value="7" />
</tree>
```



VisualizerLog Format

- XML based description
- Describe state of variables and/or constraints at specific stages
 - Where annotated in program
 - For every node in tree
- Linked to search tree log



VisualizerLog Example

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<visualization version="1.0" >
<visualizer id="1" type="vector" display="expanded" x="0" y="0"
  width="8" height="10" group="1" min="0" max="9" />
<state id="1" tree_node="-1" >
<visualizer_state id="1" >
<dvar index="1" domain="0 .. 9" />
<dvar index="2" domain="0 .. 9" />
<dvar index="3" domain="0 .. 9" />
<dvar index="4" domain="0 .. 9" />
<dvar index="5" domain="0 .. 9" />
<dvar index="6" domain="0 .. 9" />
<dvar index="7" domain="0 .. 9" />
<dvar index="8" domain="0 .. 9" />
</visualizer_state>
</state>
...
```



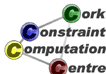
VisualizerLog Example

```
...  
<state id="2" tree_node="-1" >  
<visualizer_state id="1" >  
<dvar index="1" domain="1 .. 9" />  
<dvar index="2" domain="0 .. 9" />  
<dvar index="3" domain="0 .. 9" />  
<dvar index="4" domain="0 .. 9" />  
<dvar index="5" domain="0 .. 9" />  
<dvar index="6" domain="0 .. 9" />  
<dvar index="7" domain="0 .. 9" />  
<dvar index="8" domain="0 .. 9" />  
</visualizer_state>  
</state>  
...
```



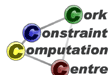
VisualizerLog Example

```
...  
<state id="5" tree_node="1" >  
  <visualizer_state id="1" >  
    <integer index="1" value="9" />  
    <dvar index="2" domain="4 .. 7" />  
    <dvar index="3" domain="5 .. 8" />  
    <dvar index="4" domain="2 .. 8" />  
    <integer index="5" value="1" />  
    <integer index="6" value="0" />  
    <dvar index="7" domain="2 .. 8" />  
    <dvar index="8" domain="2 .. 8" />  
    <focus group="-" index="1" />  
  </visualizer_state>  
</state>  
...
```



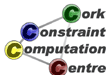
VisualizerLog Example

```
...  
<state id="6" tree_node="2" >  
<visualizer_state id="1" >  
<integer index="1" value="9" />  
<dvar index="2" domain="4 .. 7" />  
<dvar index="3" domain="5 .. 8" />  
<dvar index="4" domain="2 .. 8" />  
<integer index="5" value="1" />  
<integer index="6" value="0" />  
<dvar index="7" domain="2 .. 8" />  
<dvar index="8" domain="2 .. 8" />  
<failed group="-" index="2" value="4" />  
</visualizer_state>  
</state>  
...
```



VisualizerLog Example

```
...  
<state id="14" tree_node="9" >  
  <visualizer_state id="1" >  
    <integer index="1" value="9" />  
    <integer index="2" value="5" />  
    <integer index="3" value="6" />  
    <integer index="4" value="7" />  
    <integer index="5" value="1" />  
    <integer index="6" value="0" />  
    <integer index="7" value="8" />  
    <integer index="8" value="2" />  
  </visualizer_state>  
</state>  
...  
</visualization>
```



Outline

- 1 Introduction
- 2 Visualization by Annotation
- 3 Visualization Interface
- 4 Conclusions



Conclusions

- New ELearning course for ECLiPSe
- Open source material, Creative Commons BY-NC-SA license
 - Application driven
 - Modelling with global constraints
 - Customizing search
- Effort only justifiable through Cisco grant



Visualization

- Design choice: System independent
- Provide enough information to user of system, not to tool developer
- Relatively few primitives, extensible for specific global constraints
- XML intermediate format, open for specific analysis

