

Assignment 3 Artificial Intelligence

Project name : Sudoku Solver

Names , ids :

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Overview:

This project is a Python-based Sudoku Solver application that employs **Constraint Satisfaction Problem (CSP)** techniques to solve Sudoku puzzles. It uses a graphical user interface (GUI) built with the tkinter library to allow users to interact with the application. The solver is implemented with both **backtracking** and **Arc-Consistency (AC-3)** algorithms to ensure constraint satisfaction and efficiency.

Data structures used:

Arrays:

Represent the Sudoku board, domains of variables, and arcs in the CSP as A 9x9 list of lists representing the Sudoku grid. Each inner list is a row of the Sudoku board.

Sets:

Purpose: Represent the domain of possible values for each cell and check for unique values in rows, columns, and subgrids it Ensures fast lookup and removal of inconsistent values during the CSP process.

Queues:

Purpose: Manage the queue of arcs to be processed during the AC-3 algorithm.

Sample Runs:

this example from medium game of our sudoku solver
and it can show that you can choose any button to click on
and definitions are:

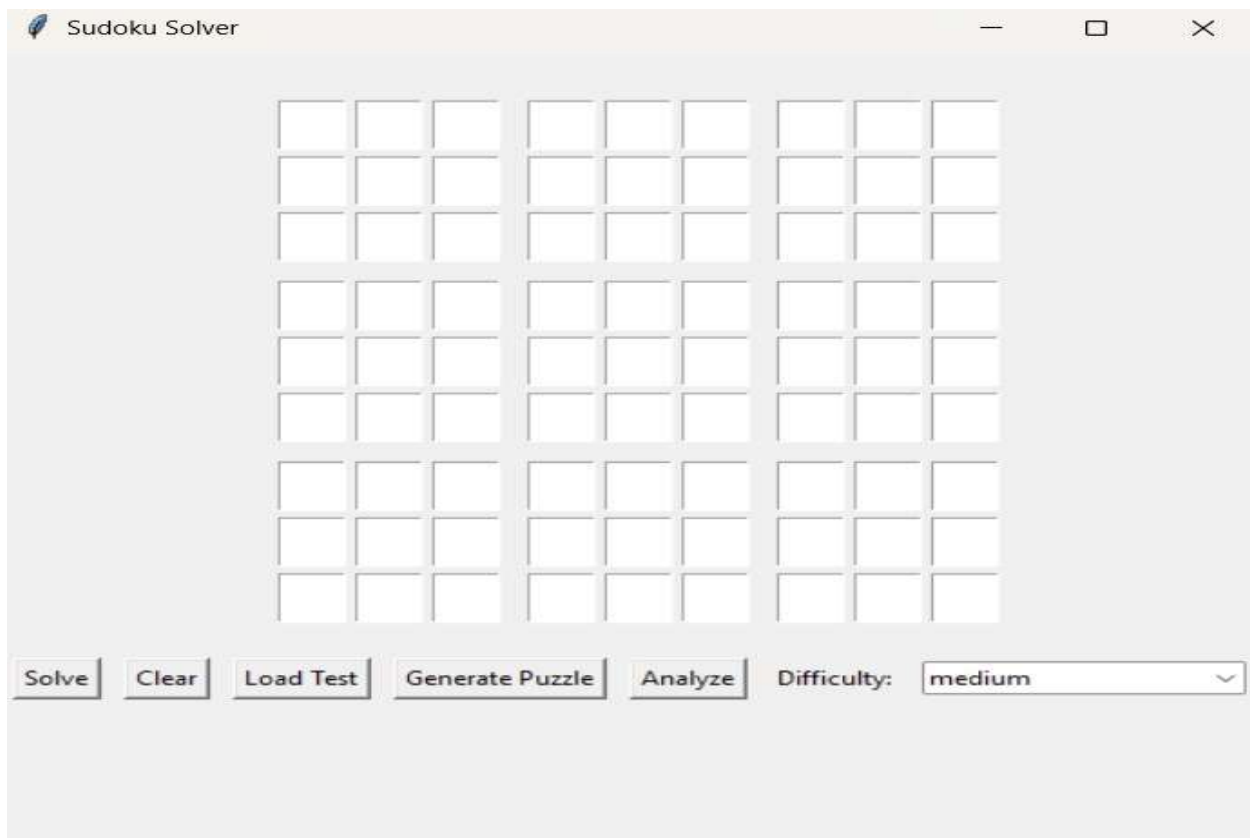
Solve : to solve puzzle.

Clear : to clear window.

Load test : sample that's in the graph.

Generate puzzle : use to make random puzzle according to
our difficulty (easy, medium,hard).

Analyze : generate 3 puzzle with 3 different difficulty then
calculate time and put it all in a graph.



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

Solve
Clear
Load Test
Generate Puzzle
Analyze
Difficulty: medium

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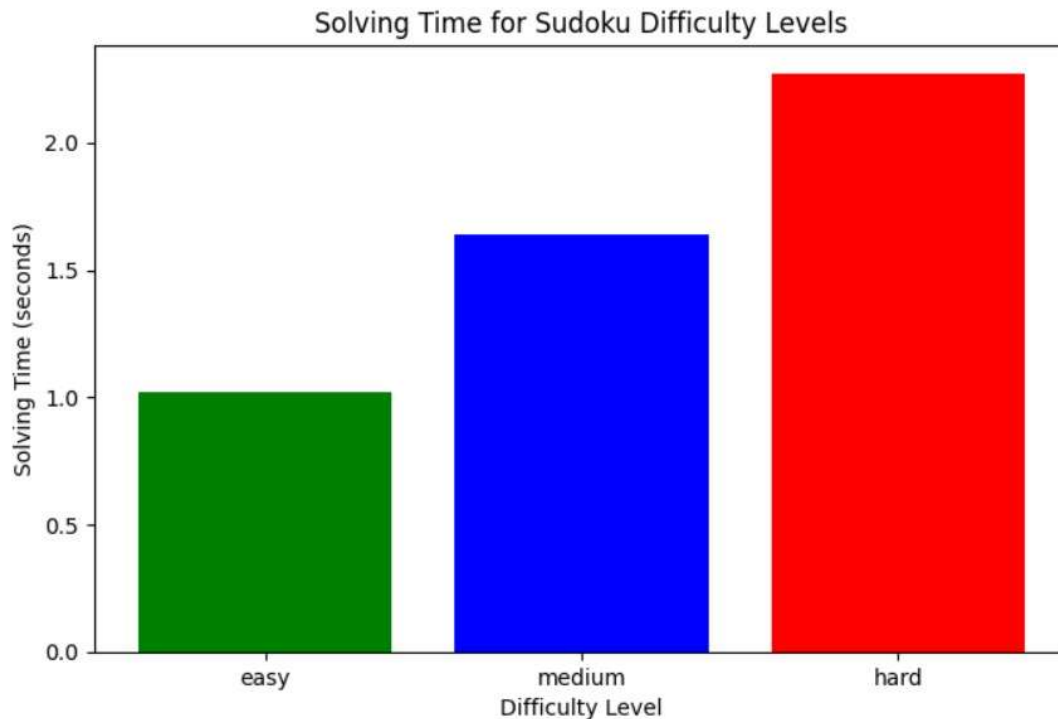
6	8	5	4	9	7	1	3	2
2	3	1	5	6	8	7	9	4
9	7	4	3	2	1	5	6	8
3	9	6	1	8	5	2	4	7
1	2	8	9	7	4	3	5	6
4	5	7	2	3	6	9	8	1
8	4	3	7	1	9	6	2	5
7	6	2	8	5	3	4	1	9
5	1	9	6	4	2	8	7	3

Solve
Clear
Load Test
Generate Puzzle
Analyze
Difficulty: medium

Solved

Time taken: 1.61 seconds

Comparison between the solving time of each difficulty(generated by analyze button):



Example for the terminal prints:

Current domains: {(0, 0): {1, 3, 6, 7}, (0, 1): {3, 6, 7}, (0, 2): {1, 3, 6, 7}, (0, 3): {8}, (0, 4): {4}, (0, 5): {1, 3, 5, 7}, (0, 6): {9}, (0, 7): {3, 7}, (0, 8): {2}, (1, 0): {5}, (1, 1): {2, 3, 4, 6, 7, 9}, (1, 2): {2, 3, 6, 7, 9}, (1, 3): {3, 7}, (1, 4): {3, 6}, (1, 5): {3, 7}, (1, 6): {1}, (1, 7): {3, 4, 7, 8}, (1, 8): {3, 4, 7, 8}, (2, 0): {1, 3, 4, 7}, (2, 1): {8}, (2, 2): {1, 3, 7}, (2, 3): {1, 3, 7}, (2, 4): {9}, (2, 5): {2}, (2, 6): {6}, (2, 7): {3, 4, 7}, (2, 8): {5}, (3, 0): {2, 3, 6, 9}, (3, 1): {1},

$(3, 2): \{5\}, (3, 3): \{4\}, (3, 4): \{8\}, (3, 5): \{3, 9\}, (3, 6): \{7\}, (3, 7): \{2, 3, 6\}, (3, 8): \{3, 6, 9\}, (4, 0): \{2, 3, 9\}, (4, 1): \{2, 3, 9\}, (4, 2): \{8\}, (4, 3): \{2, 3, 5, 9\}, (4, 4): \{7\}, (4, 5): \{6\}, (4, 6): \{4\}, (4, 7): \{1\}, (4, 8): \{3, 9\}, (5, 0): \{2, 3, 6, 7, 9\}, (5, 1): \{2, 3, 6, 7, 9\}, (5, 2): \{4\}, (5, 3): \{1, 2, 3, 9\}, (5, 4): \{2, 3\}, (5, 5): \{1, 3, 9\}, (5, 6): \{5\}, (5, 7): \{2, 3, 6, 8\}, (5, 8): \{3, 6, 8, 9\}, (6, 0): \{1, 2, 3, 4, 6, 7, 8, 9\}, (6, 1): \{2, 3, 4, 5, 6, 7, 9\}, (6, 2): \{1, 2, 3, 6, 7, 9\}, (6, 3): \{2, 3, 5, 7, 9\}, (6, 4): \{2, 3, 5\}, (6, 5): \{3, 4, 5, 7, 9\}, (6, 6): \{2, 8\}, (6, 7): \{4, 5, 6, 7, 8\}, (6, 8): \{1, 4, 6, 7, 8\}, (7, 0): \{2, 4, 7, 8\}, (7, 1): \{2, 4, 5, 7\}, (7, 2): \{2, 7\}, (7, 3): \{6\}, (7, 4): \{1\}, (7, 5): \{4, 5, 7\}, (7, 6): \{3\}, (7, 7): \{9\}, (7, 8): \{4, 7, 8\}, (8, 0): \{1, 2, 3, 4, 6, 7, 9\}, (8, 1): \{2, 3, 4, 5, 6, 7, 9\}, (8, 2): \{1, 2, 3, 6, 7, 9\}, (8, 3): \{2, 3, 5, 7, 9\}, (8, 4): \{2, 3, 5\}, (8, 5): \{8\}, (8, 6): \{2\}, (8, 7): \{2, 4, 5, 6, 7\}, (8, 8): \{1, 4, 6, 7\}$

Processing arc $((8, 2), (8, 4))...$

Current domains: $\{(0, 0): \{1, 3, 6, 7\}, (0, 1): \{3, 6, 7\}, (0, 2): \{1, 3, 6, 7\}, (0, 3): \{8\}, (0, 4): \{4\}, (0, 5): \{1, 3, 5, 7\}, (0, 6): \{9\}, (0, 7): \{3, 7\}, (0, 8): \{2\}, (1, 0): \{5\}, (1, 1): \{2, 3, 4, 6, 7, 9\}, (1, 2): \{2, 3, 6, 7, 9\}, (1, 3): \{3, 7\}, (1, 4): \{3, 6\}, (1, 5): \{3, 7\}, (1, 6): \{1\}, (1, 7): \{3, 4, 7, 8\}, (1, 8): \{3, 4, 7, 8\}, (2, 0): \{1, 3, 4, 7\}, (2, 1): \{8\}, (2, 2): \{1, 3, 7\}, (2, 3): \{1, 3, 7\}, (2, 4): \{9\}, (2, 5): \{2\}, (2, 6): \{6\}, (2, 7): \{3, 4, 7\}, (2, 8): \{5\}, (3, 0): \{2, 3, 6, 9\}, (3, 1): \{1\}, (3, 2): \{5\}, (3, 3): \{4\}, (3, 4): \{8\}, (3, 5): \{3, 9\}, (3, 6): \{7\}, (3, 7): \{2, 3, 6\}, (3, 8): \{3, 6, 9\}, (4, 0): \{2, 3, 9\}, (4, 1): \{2, 3, 9\}, (4, 2): \{8\}, (4, 3): \{2, 3, 5, 9\}, (4, 4): \{7\}, (4, 5): \{6\}, (4, 6): \{4\}, (4, 7):$

$\{1\}$, $(4, 8): \{3, 9\}$, $(5, 0): \{2, 3, 6, 7, 9\}$, $(5, 1): \{2, 3, 6, 7, 9\}$, $(5, 2): \{4\}$, $(5, 3): \{1, 2, 3, 9\}$, $(5, 4): \{2, 3\}$, $(5, 5): \{1, 3, 9\}$, $(5, 6): \{5\}$, $(5, 7): \{2, 3, 6, 8\}$, $(5, 8): \{3, 6, 8, 9\}$, $(6, 0): \{1, 2, 3, 4, 6, 7, 8, 9\}$, $(6, 1): \{2, 3, 4, 5, 6, 7, 9\}$, $(6, 2): \{1, 2, 3, 6, 7, 9\}$, $(6, 3): \{2, 3, 5, 7, 9\}$, $(6, 4): \{2, 3, 5\}$, $(6, 5): \{3, 4, 5, 7, 9\}$, $(6, 6): \{2, 8\}$, $(6, 7): \{4, 5, 6, 7, 8\}$, $(6, 8): \{1, 4, 6, 7, 8\}$, $(7, 0): \{2, 4, 7, 8\}$, $(7, 1): \{2, 4, 5, 7\}$, $(7, 2): \{2, 7\}$, $(7, 3): \{6\}$, $(7, 4): \{1\}$, $(7, 5): \{4, 5, 7\}$, $(7, 6): \{3\}$, $(7, 7): \{9\}$, $(7, 8): \{4, 7, 8\}$, $(8, 0): \{1, 2, 3, 4, 6, 7, 9\}$, $(8, 1): \{2, 3, 4, 5, 6, 7, 9\}$, $(8, 2): \{1, 2, 3, 6, 7, 9\}$, $(8, 3): \{2, 3, 5, 7, 9\}$, $(8, 4): \{2, 3, 5\}$, $(8, 5): \{8\}$, $(8, 6): \{2\}$, $(8, 7): \{2, 4, 5, 6, 7\}$, $(8, 8): \{1, 4, 6, 7\}$

Processing arc $((8, 3), (8, 4))...$

Current domains: $\{(0, 0): \{1, 3, 6, 7\}$, $(0, 1): \{3, 6, 7\}$, $(0, 2): \{1, 3, 6, 7\}$, $(0, 3): \{8\}$, $(0, 4): \{4\}$, $(0, 5): \{1, 3, 5, 7\}$, $(0, 6): \{9\}$, $(0, 7): \{3, 7\}$, $(0, 8): \{2\}$, $(1, 0): \{5\}$, $(1, 1): \{2, 3, 4, 6, 7, 9\}$, $(1, 2): \{2, 3, 6, 7, 9\}$, $(1, 3): \{3, 7\}$, $(1, 4): \{3, 6\}$, $(1, 5): \{3, 7\}$, $(1, 6): \{1\}$, $(1, 7): \{3, 4, 7, 8\}$, $(1, 8): \{3, 4, 7, 8\}$, $(2, 0): \{1, 3, 4, 7\}$, $(2, 1): \{8\}$, $(2, 2): \{1, 3, 7\}$, $(2, 3): \{1, 3, 7\}$, $(2, 4): \{9\}$, $(2, 5): \{2\}$, $(2, 6): \{6\}$, $(2, 7): \{3, 4, 7\}$, $(2, 8): \{5\}$, $(3, 0): \{2, 3, 6, 9\}$, $(3, 1): \{1\}$, $(3, 2): \{5\}$, $(3, 3): \{4\}$, $(3, 4): \{8\}$, $(3, 5): \{3, 9\}$, $(3, 6): \{7\}$, $(3, 7): \{2, 3, 6\}$, $(3, 8): \{3, 6, 9\}$, $(4, 0): \{2, 3, 9\}$, $(4, 1): \{2, 3, 9\}$, $(4, 2): \{8\}$, $(4, 3): \{2, 3, 5, 9\}$, $(4, 4): \{7\}$, $(4, 5): \{6\}$, $(4, 6): \{4\}$, $(4, 7): \{1\}$, $(4, 8): \{3, 9\}$, $(5, 0): \{2, 3, 6, 7, 9\}$, $(5, 1): \{2, 3, 6, 7, 9\}$, $(5, 2): \{4\}$, $(5, 3): \{1, 2, 3, 9\}$, $(5, 4): \{2, 3\}$, $(5, 5): \{1, 3, 9\}$, $(5, 6): \{5\}$, $(5, 7): \{2, 3, 6, 8\}$, $(5, 8): \{3, 6, 8, 9\}$, $(6, 0): \{1, 2, 3, 4, 6, 7,$

8, 9}, (6, 1): {2, 3, 4, 5, 6, 7, 9}, (6, 2): {1, 2, 3, 6, 7, 9}, (6, 3): {2, 3, 5, 7, 9}, (6, 4): {2, 3, 5}, (6, 5): {3, 4, 5, 7, 9}, (6, 6): {2, 8}, (6, 7): {4, 5, 6, 7, 8}, (6, 8): {1, 4, 6, 7, 8}, (7, 0): {2, 4, 7, 8}, (7, 1): {2, 4, 5, 7}, (7, 2): {2, 7}, (7, 3): {6}, (7, 4): {1}, (7, 5): {4, 5, 7}, (7, 6): {3}, (7, 7): {9}, (7, 8): {4, 7, 8}, (8, 0): {1, 2, 3, 4, 6, 7, 9}, (8, 1): {2, 3, 4, 5, 6, 7, 9}, (8, 2): {1, 2, 3, 6, 7, 9}, (8, 3): {2, 3, 5, 7, 9}, (8, 4): {2, 3, 5}, (8, 5): {8}, (8, 6): {2}, (8, 7): {2, 4, 5, 6, 7}, (8, 8): {1, 4, 6, 7}}

Processing arc ((8, 0), (8, 6))...

Removed 2 from domain of (8, 0) due to constraint with (8, 6).

Domain of (8, 0) reduced to {1, 3, 4, 6, 7, 9}.

Current domains: {(0, 0): {1, 3, 6, 7}, (0, 1): {3, 6, 7}, (0, 2): {1, 3, 6, 7}, (0, 3): {8}, (0, 4): {4}, (0, 5): {1, 3, 5, 7}, (0, 6): {9}, (0, 7): {3, 7}, (0, 8): {2}, (1, 0): {5}, (1, 1): {2, 3, 4, 6, 7, 9}, (1, 2): {2, 3, 6, 7, 9}, (1, 3): {3, 7}, (1, 4): {3, 6}, (1, 5): {3, 7}, (1, 6): {1}, (1, 7): {3, 4, 7, 8}, (1, 8): {3, 4, 7, 8}, (2, 0): {1, 3, 4, 7}, (2, 1): {8}, (2, 2): {1, 3, 7}, (2, 3): {1, 3, 7}, (2, 4): {9}, (2, 5): {2}, (2, 6): {6}, (2, 7): {3, 4, 7}, (2, 8): {5}, (3, 0): {2, 3, 6, 9}, (3, 1): {1}, (3, 2): {5}, (3, 3): {4}, (3, 4): {8}, (3, 5): {3, 9}, (3, 6): {7}, (3, 7): {2, 3, 6}, (3, 8): {3, 6, 9}, (4, 0): {2, 3, 9}, (4, 1): {2, 3, 9}, (4, 2): {8}, (4, 3): {2, 3, 5, 9}, (4, 4): {7}, (4, 5): {6}, (4, 6): {4}, (4, 7): {1}, (4, 8): {3, 9}, (5, 0): {2, 3, 6, 7, 9}, (5, 1): {2, 3, 6, 7, 9}, (5, 2): {4}, (5, 3): {1, 2, 3, 9}, (5, 4): {2, 3}, (5, 5): {1, 3, 9}, (5, 6):

{5}, (5, 7): {2, 3, 6, 8}, (5, 8): {3, 6, 8, 9}, (6, 0): {1, 2, 3, 4, 6, 7, 8, 9}, (6, 1): {2, 3, 4, 5, 6, 7, 9}, (6, 2): {1, 2, 3, 6, 7, 9}, (6, 3): {2, 3, 5, 7, 9}, (6, 4): {2, 3, 5}, (6, 5): {3, 4, 5, 7, 9}, (6, 6): {2, 8}, (6, 7): {4, 5, 6, 7, 8}, (6, 8): {1, 4, 6, 7, 8}, (7, 0): {2, 4, 7, 8}, (7, 1): {2, 4, 5, 7}, (7, 2): {2, 7}, (7, 3): {6}, (7, 4): {1}, (7, 5): {4, 5, 7}, (7, 6): {3}, (7, 7): {9}, (7, 8): {4, 7, 8}, (8, 0): {1, 3, 4, 6, 7, 9}, (8, 1): {2, 3, 4, 5, 6, 7, 9}, (8, 2): {1, 2, 3, 6, 7, 9}, (8, 3): {2, 3, 5, 7, 9}, (8, 4): {2, 3, 5}, (8, 5): {8}, (8, 6): {2}, (8, 7): {2, 4, 5, 6, 7}, (8, 8): {1, 4, 6, 7}}

Processing arc ((8, 1), (8, 6))...

Removed 2 from domain of (8, 1) due to constraint with (8, 6).

Domain of (8, 1) reduced to {3, 4, 5, 6, 7, 9}.

Current domains: {(0, 0): {1, 3, 6, 7}, (0, 1): {3, 6, 7}, (0, 2): {1, 3, 6, 7}, (0, 3): {8}, (0, 4): {4}, (0, 5): {1, 3, 5, 7}, (0, 6): {9}, (0, 7): {3, 7}, (0, 8): {2}, (1, 0): {5}, (1, 1): {2, 3, 4, 6, 7, 9}, (1, 2): {2, 3, 6, 7, 9}, (1, 3): {3, 7}, (1, 4): {3, 6}, (1, 5): {3, 7}, (1, 6): {1}, (1, 7): {3, 4, 7, 8}, (1, 8): {3, 4, 7, 8}, (2, 0): {1, 3, 4, 7}, (2, 1): {8}, (2, 2): {1, 3, 7}, (2, 3): {1, 3, 7}, (2, 4): {9}, (2, 5): {2}, (2, 6): {6}, (2, 7): {3, 4, 7}, (2, 8): {5}, (3, 0): {2, 3, 6, 9}, (3, 1): {1}, (3, 2): {5}, (3, 3): {4}, (3, 4): {8}, (3, 5): {3, 9}, (3, 6): {7}, (3, 7): {2, 3, 6}, (3, 8): {3, 6, 9}, (4, 0): {2, 3, 9}, (4, 1): {2, 3, 9}, (4, 2): {8}, (4, 3): {2, 3, 5, 9}, (4, 4): {7}, (4, 5): {6}, (4, 6): {4}, (4, 7): {1}, (4, 8): {3, 9}, (5, 0): {2, 3, 6, 7, 9}, (5, 1): {2, 3, 6, 7, 9}, (5,

2): {4}, (5, 3): {1, 2, 3, 9}, (5, 4): {2, 3}, (5, 5): {1, 3, 9}, (5, 6): {5}, (5, 7): {2, 3, 6, 8}, (5, 8): {3, 6, 8, 9}, (6, 0): {1, 2, 3, 4, 6, 7, 8, 9}, (6, 1): {2, 3, 4, 5, 6, 7, 9}, (6, 2): {1, 2, 3, 6, 7, 9}, (6, 3): {2, 3, 5, 7, 9}, (6, 4): {2, 3, 5}, (6, 5): {3, 4, 5, 7, 9}, (6, 6): {2, 8}, (6, 7): {4, 5, 6, 7, 8}, (6, 8): {1, 4, 6, 7, 8}, (7, 0): {2, 4, 7, 8}, (7, 1): {2, 4, 5, 7}, (7, 2): {2, 7}, (7, 3): {6}, (7, 4): {1}, (7, 5): {4, 5, 7}, (7, 6): {3}, (7, 7): {9}, (7, 8): {4, 7, 8}, (8, 0): {1, 3, 4, 6, 7, 9}, (8, 1): {3, 4, 5, 6, 7, 9}, (8, 2): {1, 2, 3, 6, 7, 9}, (8, 3): {2, 3, 5, 7, 9}, (8, 4): {2, 3, 5}, (8, 5): {8}, (8, 6): {2}, (8, 7): {2, 4, 5, 6, 7}, (8, 8): {1, 4, 6, 7}}

Processing arc ((8, 2), (8, 6))...

Removed 2 from domain of (8, 2) due to constraint with (8, 6).

Domain of (8, 2) reduced to {1, 3, 6, 7, 9}.

Current domains: {(0, 0): {1, 3, 6, 7}, (0, 1): {3, 6, 7}, (0, 2): {1, 3, 6, 7}, (0, 3): {8}, (0, 4): {4}, (0, 5): {1, 3, 5, 7}, (0, 6): {9}, (0, 7): {3, 7}, (0, 8): {2}, (1, 0): {5}, (1, 1): {2, 3, 4, 6, 7, 9}, (1, 2): {2, 3, 6, 7, 9}, (1, 3): {3, 7}, (1, 4): {3, 6}, (1, 5): {3, 7}, (1, 6): {1}, (1, 7): {3, 4, 7, 8}, (1, 8): {3, 4, 7, 8}, (2, 0): {1, 3, 4, 7}, (2, 1): {8}, (2, 2): {1, 3, 7}, (2, 3): {1, 3, 7}, (2, 4): {9}, (2, 5): {2}, (2, 6): {6}, (2, 7): {3, 4, 7}, (2, 8): {5}, (3, 0): {2, 3, 6, 9}, (3, 1): {1}, (3, 2): {5}, (3, 3): {4}, (3, 4): {8}, (3, 5): {3, 9}, (3, 6): {7}, (3, 7): {2, 3, 6}, (3, 8): {3, 6, 9}, (4, 0): {2, 3, 9}, (4, 1): {2, 3, 9}, (4, 2): {8}, (4, 3): {2, 3, 5, 9}, (4, 4): {7}, (4, 5): {6}, (4, 6): {4}, (4, 7):

{1}, (4, 8): {3, 9}, (5, 0): {2, 3, 6, 7, 9}, (5, 1): {2, 3, 6, 7, 9}, (5, 2): {4}, (5, 3): {1, 2, 3, 9}, (5, 4): {2, 3}, (5, 5): {1, 3, 9}, (5, 6): {5}, (5, 7): {2, 3, 6, 8}, (5, 8): {3, 6, 8, 9}, (6, 0): {1, 2, 3, 4, 6, 7, 8, 9}, (6, 1): {2, 3, 4, 5, 6, 7, 9}, (6, 2): {1, 2, 3, 6, 7, 9}, (6, 3): {2, 3, 5, 7, 9}, (6, 4): {2, 3, 5}, (6, 5): {3, 4, 5, 7, 9}, (6, 6): {2, 8}, (6, 7): {4, 5, 6, 7, 8}, (6, 8): {1, 4, 6, 7, 8}, (7, 0): {2, 4, 7, 8}, (7, 1): {2, 4, 5, 7}, (7, 2): {2, 7}, (7, 3): {6}, (7, 4): {1}, (7, 5): {4, 5, 7}, (7, 6): {3}, (7, 7): {9}, (7, 8): {4, 7, 8}, (8, 0): {1, 3, 4, 6, 7, 9}, (8, 1): {3, 4, 5, 6, 7, 9}, (8, 2): {1, 3, 6, 7, 9}, (8, 3): {2, 3, 5, 7, 9}, (8, 4): {2, 3, 5}, (8, 5): {8}, (8, 6): {2}, (8, 7): {2, 4, 5, 6, 7}, (8, 8): {1, 4, 6, 7}}