Problem Program Initial Propagation (Forward Checking) Improved Reasoning Search Lessons Learned

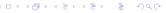
#### Chapter 5: Global Constraints(Sudoku)

#### **Helmut Simonis**

Cork Constraint Computation Centre Computer Science Department University College Cork Ireland

ECLiPSe ELearning Overview





#### Outline

- Problem
- 2 Program
- Initial Propagation (Forward Checking)
- Improved Reasoning
- Search
- 6 Lessons Learned





#### What we want to introduce

- Global Constraints
  - Powerful modelling abstractions
  - Non-trivial propagation
- Consistency Levels
  - Tradeoff between speed and propagation
  - Characterisation of reasoning power
- Example: Alldifferent
  - 3 variants shown





#### Methodology

- Evaluation on Sudoku puzzle
- Comparing
  - Initial setup
  - Search
  - Performance
- Explaining reasoning inside constraint
- Link to general classification of global constraints





#### Outline

- Problem
- Program
- Initial Propagation (Forward Checking)
- 4 Improved Reasoning
- Search
- 6 Lessons Learned





#### **Problem Definition**

#### Sudoku

Fill in numbers from 1 to 9 so that each row, column and block contain each number exactly once

	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4	4 5 6	8	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6
-	7 8 9	)	7 8 9	789	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	a l	-	1 2 3	1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	11	/	4 5 6	4 5 6	4 5 6	4 5 5
/ 0 9	1 0 9	1 0 0	1 2 3	_	/ 0 9	1 0 0	/ 0 9	/ 0 :
4 5 6	4 5 6	4 5 6	4 5 6	0	4 5 6	4 5 6	2	2
7 8 9	7 8 9	7 8 9	7 8 9	0	7 8 9	7 8 9	0	_
1 2 3	1 2 3		1 2 3	1 2 3				1 2 :
4 5 6	4 5 6	6	4 5 6	4 5 6	Q	2	5	4 5 6
7 8 9	7 8 9	٥	7 8 9	7 8 9	0	_	7	7 8 9
1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
4 5 6	q	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	18	4.5
7 8 9	)	7 8 9	7 8 9	789	7 8 9	7 8 9	)	7 8
1 2 3	_	-	_	1 2 3	1 2 3	_	1 2 3	1 2
2 2 2	.3	<i>-</i> /	b	4 5 6	4 0 0	9	4 0 0	12.2
/ 0 9	_			,	7 0 0		7 0 0	7 0
2	7	4 5 6	4 5 6	_	4 5 6	4 5 6	4 5 6	1 2
_	- /	7 0 0	7 0 0	$\circ$	7 0 0	7 0 0	7 0 0	7 0
1 2 3	1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2
4 5 6	4 5 6	4 5 6	4 5 6	1 1	14	4 5 6	4 5 6	4.5
7 8 9	7 8 9	7 8 9	7 8 9	-	۲	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	_	1 2 3	-
4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	6	4 5 6	4
7 8 9	7 8 9	7 8 9	789	7 8 9	7 8 9		7 8 9	т.





#### **Problem Definition**

#### Sudoku

Fill in numbers from 1 to 9 so that each row, column and block contain each number exactly once

_	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2
1 /	4 5 6	Q	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4.5
-	7 8 9	O	789	7 8 9	7 8 9	7 8 9	789	7 8
1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3	1.2
4 5 6	4 5 6	4 5 6	1 1	7	4 5 6	4 5 6	4 5 6	4.5
7 8 9	7 8 9	7 8 9		/	7 8 9	7 8 9	7 8 9	7.8
1 2 3	1 2 3	1 2 3	1 2 3	-	1 2 3	1 2 3		_
4 5 6	4 5 6	4 5 6	4 5 6	0	4 5 6	4 5 6	2	2
7 0 0	7 8 9	7 0 0	7 0 0	0	7 0 0	7 0 0	0	_
1 2 3	1 2 3		1 2 3	1 2 2				
11.22	11 2 2	6	11 2 2	1::::	0	2		11.0
7 0 0	7 8 9	О	7 0 0	7 0 0	0		0	7 0
1 2 2				4 2 3			_	1 2
11.2.3	0	1 2 3	11.2.2	1: : :	1: 2 3	11 2 2	0	11.2
4 5 6	19	4 5 6	4 0 0	4 5 5	4 5 5	200	Ö	2.2
/ 8 9	_	789	/89	789	/ 8 9	/ 8 9		/ 8
1 2 3	_	-	_	1 2 3	1 2 3	$\sim$	1 2 3	1 2
4 5 6	1.3	/	h	4 5 6	4 5 6	9	4 5 6	2.0
7 8 9	_	,	)	7 8 9	7 8 9	~	789	7 8
_	-	1 2 3	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2
17	l /	4 5 6	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5
_	-	7 8 9	7 8 9	~	7 8 9	7 8 9	7 8 9	7 8
1 2 3	1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2
4 5 6	4 5 6	4 5 6	4 5 6	1 1	14	4 5 6	4 5 6	4 5
7 8 9	7 8 9	7 8 9	7 8 9		_	7 8 9	7 8 9	7 8
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3	
4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	16	4 5 6	4
7 8 9	7 8 9	7 8 9	789	7 8 9	7 8 9	U	789	-

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





#### Model

- A variable for each cell, ranging from 1 to 9
- A 9x9 matrix of variables describing the problem
- Preassigned integers for the given hints
- all different constraints for each row, column and 3x3 block





#### Reminder: alldifferent

- Argument: list of variables
- Meaning: variables are pairwise different
- Reasoning: Forward Checking (FC)
  - When variable is assigned to value, remove the value from all other variables
  - If a variable has only one possible value, then it is assigned
  - If a variable has no possible values, then the constraint fails
  - Constraint is checked whenever one of its variables is assigned
  - Equivalent to decomposition into binary disequality constraints





#### **Outline**

- Problem
- 2 Program
- 3 Initial Propagation (Forward Checking)
- Improved Reasoning
- Search
- Lessons Learned





#### **Declarations**

```
:-module (sudoku) .
:-export (top/0) .
:-lib (ic) .

top:-
    problem (Matrix) ,
    model (Matrix) ,
    writeln (Matrix) .
```



#### Data



#### Main Program

```
model (Matrix):-
    Matrix[1...9,1...9] :: 1...9,
     (for(I,1,9),
      param (Matrix) do
         alldifferent (Matrix[I,1..9]),
         alldifferent (Matrix[1..9,I])
     ),
     (multifor([I,J],[1,1],[7,7],[3,3]),
      param (Matrix) do
         alldifferent (flatten (Matrix [I..I+2, J..J+2]))
                                                       onstraint 🕝
    flatten array (Matrix, List),
                                                       omputation
    labeling (List).
```

#### Domain Visualizer

- Problem shown as matrix
- Each cell corresponds to a variable
- Instantiated: Shows integer value (large)
- Uninstantiated: Shows values in domain

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





#### Constraint Visualizer

- Problem shown as matrix
- Currently active constraint highlighted
- Values removed at this step shown in blue
- Values assigned at this step shown in red

4	5 6	8	2 3 5 9	2 3 6 9	2 3 5 6 9	1 5 7	1 6 7 9	1 56 7 9
3 6 9	5 6	5 9	1	7	2 3 5 6 9	4 5 8	4 6 9	5 6 8 9
6 7 9	1 56	5 9	4 5 9	8	5 6	1 4 5 7	3	2
1	4	6	3 7 9	3	8	2	5	3 7 9
5	9	2	3 4 7	4 3	1 3	1 3 4 7	8	1 3 6 7
8	3	7	6	2	5	9	4	1
0	_	1 3	3		1 3	1 3	1	
	-	4 9	4 89	5	6	4 8	4 6	8 9
3 6 7 9	2 5 6 8	4 9 5 9	4 89 23 5 789	5 1	4	4 8 3 5 7 8	4 6 9 2 6 7 9	8 9 3 5 6 7 8 9





#### Outline

- Problem
- Program
- 3 Initial Propagation (Forward Checking)
- 4 Improved Reasoning
- Search
- Lessons Learned



### Initial State (Forward Checking)

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





_	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
1	4 5 6 <b>Q</b>	4 5 6 4 5 6	4 5 6 4 5 6	4 5 6 4 5 6
-	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9 7 8 9
1 2 3	1 2 3 1 2 3		1 2 3 1 2 3	1 2 3 1 2 3
4 5 6	4 5 6 4 5 6	1 7	4 5 6 4 5 6	4 5 6 4 5 6
7 8 9	7 8 9 7 8 9		7 8 9 7 8 9	7 8 9 7 8 9
		4 0 0		789789
		1 2 3		
4 5 6	4 5 6 4 5 6	4 5 6	4 5 6 4 5 6	1.3 1 フ
7 8 9	7 8 9 7 8 9	7 8 9	7 8 9 7 8 9	0 2
1 2 3	1 2 3	1 2 3 1 2 3		1 2 3
4 5 6	4 5 6	4 5 6 4 5 6		<b>5</b> 4 5 6
7 8 9	7 8 9	7 8 9 7 8 9		7 8 9
1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3
4 5 6	<b>A</b> 4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	Q 4 5 6
7 8 9	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9
		1 2 3	1 2 3	1 2 3 1 2 3
1 2 3 4 5 6	2 7	4 5 6	4 5 6	4 5 6 4 5 6
7 8 9	3 1 /	7 8 9	7 8 9	7 8 9 7 8 9
, , ,	1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
	4 5 6			4 5 6 4 5 6
	7 8 9	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9
1 2 3	1 2 3 1 2 3	1 2 3	1 2 3	1 2 3 1 2 3
4 5 6	4 5 6 4 5 6	4 5 6	4 5 6	4 5 6 4 5 6
7 8 9	7 8 9 7 8 9	7 8 9	7 8 9	7 8 9 7 8 9
1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3	1 2 3
4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	4 5 6	4 5 6
7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9 U	7 8 9





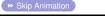


	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
4	4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	4 5 6 4 5 6
	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9 7 8 9
1 2 3	1 2 3 1 2 3		1 2 3 1 2 3	1 2 3 1 2 3
4 5 6	4 5 6 4 5 6	1117	4 5 6 4 5 6	4 5 6 4 5 6
7 8 9	7 8 9 7 8 9		7 8 9 7 8 9	7 8 9 7 8 9
1 2 3	1 2 3 1 2 3	1 2 3	1 2 3 1 2 3	7 0 3 7 0 3
4 5 6	4 5 6 4 5 6	4 5 6 Q	4 5 6 4 5 6	$\Omega$
				1312
7 8 9	7 8 9 7 8 9	7 8 9	7 8 9 7 8 9	
1 2 3	1 2 3	1 2 3 1 2 3		1 2 3
4 5 6	4 5 6	4 5 6 4 5 6	1817	<b>5</b> 4 5 6
7 8 9	7 8 9	7 8 9 7 8 9		7 8 9
1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3
4 5 6	4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	Q 4 5 6
7 8 9	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9
1 2 3		1 2 3	1 2 3	1 2 3 1 2 3
4 5 6	2 7	4 5 6	4 5 6	4 5 6 4 5 6
7 8 9		7 8 9	7 8 9	7 8 9 7 8 9
1 0 3				
	4 2 2	4 0 0		
	1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
2	7 4 5 6	4 5 6 5	1 2 3 1 2 3 4 5 6 4 5 6	1 2 3 1 2 3 4 5 6 4 5 6
2	7 4 5 6 7 8 9	4 5 6 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9
1 2 3	7 4 5 6	4 5 6 5	1 2 3 1 2 3 4 5 6 4 5 6	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3 1 2 3
1 2 3 4 5 6	7 4 5 6 7 8 9	4 5 6 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9
	7 4 5 6 7 8 9	4 5 6 7 8 9 <b>5</b>	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3 1 2 3
4 5 6	7 4 5 6 7 8 9 1 2 3 1 2 3 4 5 6 4 5 6	4 5 6 7 8 9 <b>5</b> 1 2 3 4 5 6 <b>1</b>	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3 4 5 6 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3 1 2 3 4 5 6 4 5 6
4 5 6 7 8 9	7 4 5 6 7 8 9 1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9	4 5 6 7 8 9 1 2 3 4 5 6 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3 4 5 6 7 8 9	1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9 1 2 3 1 2 3 4 5 6 4 5 6 7 8 9 7 8 9









1 2 3	1 2 3	1 2 3 1 2 3	1 2 3	1 2 3	1 2 3
	$\cap$			5 6	
7 9	7 9	7 9 7 9	7 9	7 9	7 9
1 2 3 1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4 5 6 4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9 7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3 1 2 3	1 2 3 1 2 3	1 2 3	1 2 3		
4 5 6 4 5 6	4 5 6 4 5 6	<b>Q</b> 4 5 6	4 5 6	3	つ
7 8 9 7 8 9	7 8 9 7 8 9	7 8 9	7 8 9		_
1 2 3 1 2 3	_ 1 2 3	1 2 3			1 2 3
4 5 6 4 5 6	6 4 5 6	4 5 6 <b>Q</b>	2	5	4 5 6
7 8 9 7 8 9	7 8 9	7 8 9		J	7 8 9
1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3		1 2 3
4 5 6 <b>Q</b>	4 5 6 4 5 6	4 5 6 4 5 6	4 5 6	0	4 5 6
7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9	0	7 8 9
	7 6 3 7 6 3	1 2 3 1 2 3	1 0 3	1 2 3	
1 2 3 4 5 6 <b>2</b>	7 6	4 5 6 4 5 6	$\circ$	4 5 6	1 2 3 4 5 6
	0   /		9	7 8 9	
7 8 9	1 2 3 1 2 3		4 0 0	_	7 8 9 1 2 3
0 7			1 2 3		
		5 4 5 6	4 5 6	4 5 6	
<u> </u>	7 8 9 7 8 9	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3 1 2 3	1 2 3 1 2 3		1 2 3	1 2 3	1 2 3
4 5 6 4 5 6	4 5 6 4 5 6	114	4 5 6	4 5 6	4 5 6
7 8 9 7 8 9	7 8 9 7 8 9	1 7	7 8 9	7 8 9	7 8 9
1 2 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3		1 2 3 4 5 6	
4 5 6 4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	6	4 5 6	1
7 8 9 7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	U	7 8 9	_







1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3
5 6	<b>Q</b> 5 6	5 6 5 6	5 6 5 6	5 6
7 7 9	O 7 9	7 9 7 9	7 9 7 9	7 9
1 3 1 2 3	1 2 3	1 2 3	1 2 3 1 2 3	1 2 3
5 6 4 5 6	4 5 6 1	7 4 5 6	4 5 6 4 5 6	4 5 6
	7 0 0	4 5 6	7 0 0 7 0 0	4 5 6
7 8 9 7 8 9	7 8 91 -	- 1/89	7 8 9 7 8 9	7 8 9
1 3 1 2 3	1 2 3 1 2 3	1 2 3	1 2 3	
5 6 4 5 6	4 5 6 4 5 6	<b>X</b> 4 5 6	4 5 6	ーフェ
7 8 9 7 8 9	7 8 9 7 8 9	7 8 9	7 8 9	_
1 3 1 2 3	1 2 3	1 2 3		1 2 3
5 6 4 5 6	4 5 6 4	4 5 6 <b>Q</b>	2   5	4 5 6
7 8 9 7 8 9	7 8 9	7 8 9 0		7 8 9
1 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3	1 2 3
		4 5 6 4 5 6		4 5 6
5 6 9	1		4 5 6	
7 8 9	7 8 9 7 8 9 7	7 8 9 7 8 9	7 8 9	7 8 9
1 3	-   -	1 2 3 1 2 3	1 2 3	1 2 3
5 6 📆	1/164	4 5 6 4 5 6	4 5 6	4 5 6
7 8 9	1 0	7 8 9 7 8 9	7 8 9	7 8 9
	1 2 3 1 2 3	1 2 3	1 2 3 1 2 3	1 2 3
2   7	4 5 6 4 5 6	<b>5</b> 4 5 6	4 5 6 4 5 6	4 5 6
<b>Z</b>   <b>I</b>	7 8 9 7 8 9	7 8 9	7 8 9 7 8 9	7 8 9
1 3 1 2 3	1 2 3 1 2 3	7 6 3	1 2 3 1 2 3	1 2 3
		$A \mid A \mid$		
5 6 4 5 6	4 5 6 4 5 6	114	4 5 6 4 5 6	4 5 6
7 8 9 7 8 9	7 8 9 7 8 9		7 8 9 7 8 9	7 8 9
1 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3	
5 6 4 5 6	4 5 6 4 5 6 4	4 5 6 4 5 6	6 4 5 6	14
7 8 9 7 8 9	7 8 9 7 8 9 7	7 8 9 7 8 9	7 8 9	_





_		_				_		_	_			_		_	_		_	_		_	_			_		
			1	2	3		_		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Λ			5	6		Q			5	6		5	6		5	6		5	6	ı	5	6	ı	5	6
	4		7		9		U		7		9	7		9	7		9	7		9	7		9	7		9
Н	_	3	÷	2	3	_	2	3	÷	_	Ť	۲	_	Ť	÷	2	3	÷	2	3	۱÷	2	3	÷	2	3
		3			3			- 1		Ä			_	,	١.		- 1	١.		- 1	١.			١.		
	5	6	4	5	6	4	5	6		Ή			/		4	5	6	4	5	6	4	5	6	4	5	6
	8	9		8	9		8	9		-			_			8	9		8	9		8	9		8	9
1		3	1	2	3	1	2	3	1	2	3				1	2	3	1	2	З	Г					
	5	6	4	5	6	4	5	6	4	5	6		О	)	4	5	6	4	5	6	ı	വ	)	ı	വ	)
٦,	8	9	7	8	9	7	8	9	L,	8	9		O	)	Ŀ,	8	9	7		9		J	)	Ι.	_	
۲			÷	_		-	0	-	۲÷	_		H	÷	_	ť		-	۲	_	-	⊢	-	_	H	÷	_
1		3	Į,	2	3				Р.	2	3	Р.	2	3		$\overline{}$			$\overline{}$		ı	_		Р.	2	3
	5	6	4	5	6		h		4	5	6	4	5	6		X			ン	'	Ι.	<u>'</u>	1	4	5	6
7	8	9	7	8	9		V		7	8	9	7	8	9		U	'		<u> </u>			U		7	8	9
1		3	г			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				1	2	3
	5	6		$\cap$		4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	ı	O	)	4	5	6
١,	8	9		$\exists$		7	8	9	7	8	9	7	8	9	Ę	8	9	7	8	9		О	)	Ę	8	9
<del>'</del> -	0		-	_	_	_	0	9	-	0	9	μ.	_	_	<del>-</del>	_		-	0	9	⊢	Ξ	_	μ.	_	
1		3		$\overline{}$			_					1	2	3	1	2	3		$\overline{}$		11	2	3	1	2	3
	5	6		13			/			h		4	5	6	4	5	6		y		4	5	6	4	5	6
7	8	9		V	'		ı			V	'	7	8	9	7	8	9		V		7	8	9	7	8	9
Г			П			1	2	3	1	2	3	Г			1	2	3	1	2	3	1	2	3	1	2	3
	2	)		7	'	4	5	6	4	5	6	ı	匚		4	5	6	4	5	6	I.	5	6	4	5	6
	Z			1		7		9	13	8	9		U	)	7	8	9	ш	8	9	П	8	9	13	8	9
H	_	_	÷	_	_				Ľ÷			⊢	_	_	μ	0	9	H÷			۲÷			Ľ÷		
1		3	1	2	3	1	2	3	1	2	3		a			4		1	2	3	1	2	3	1	2	3
	5	6	4	5	6	4	5	6	4	5	6		1			4	.	4	5	6	4	5	6	4	5	6
7	8	9	7	8	9	7	8	9	7	8	9					Т		7	8	9	7	8	9	7	8	9
1		3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Г			1	2	3			
ľ	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	2	6	ı			4	5	6	ı	Л	
					J	-	J	v	•	0	0	•	8	q		8	q				-	A	q			







1 2	_	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
5 6		5 6 5 6	5 6 5 6	5 6 5 6
7	O	7 9 7 9	7 9 7 9	7 9 7 9
3 2	2 3		2 3 2 3	2 3 2 3
5 6 4 5 6	4 5 6	1 7	4 5 6 4 5 6	4 5 6 4 5 6
8 9 8		<i> </i>		8 9 8 9
1 3 1 2	1 2 3	1 2 3	1 2 3 1 2 3	0 31 0 3
I				$\Omega$
	4 5 6	4 5 6 8		1317
7898	7 8 9	7 8 9	7 8 9 7 8 9	0 2
1 3 1 2		1 2 3 1 2 3		1 2 3
5 6 4 5 6	16	4 5 6 4 5 6		4 5 6
7 8 9 8		7 8 9 7 8 9	0 2	7 8 9
1 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3
5 6	4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	Q 4 5 6
7 8 9	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9
1 3		1 2 3	1 2 3	1 2 3 1 2 3
5 6 2	7	4 5 6	4 5 6	4 5 6 4 5 6
7 8 9	l /	7 8 9	7 8 9	7 8 9 7 8 9
7 6 9	4 0 0			
0 7	1 2 3	1 2 3	1 2 3 1 2 3	
	4 5 6	4 5 6	4 5 6 4 5 6	4 5 6 4 5 6
_ '	7 8 9	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9
1 3 1 2	1 2 3	1 2 3	1 2 3	1 2 3 1 2 3
5 6 4 5 6	4 5 6	4 5 6	4 5 6	4 5 6 4 5 6
7 8 9 8	7 8 9	7 8 9	7 8 9	7 8 9 7 8 9
1 3 1 2	1 2 3	1 2 3 1 2 3	1 2 3	1 2 3
5 6 4 5 6	4 5 6	4 5 6 4 5 6	4 5 6	4 5 6
7 8 9 8	7 8 9	7 8 9 7 8 9	7 8 9	7 8 9 4













_		_	_						_			_		_	_		_	_		_	_			_		_
			1	2			_		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Ι.	Л		ı	5	6		Q			5	6		5	6		5	6		5	6	ı	5	6	ı	5	6
١ '	п		ı				U	)	7		9	7		9	7		9	7		9	7		9	7		9
Н		3	Н	2	_	-	2	3	_		_	H			Ė	2	3	H	2	3	r	2	3	H	2	3
	5	6		5	6	4	5	6		4			7	,	4	5	6	4	5	6	4	5	6	l <sub>4</sub>	5	6
	-		1"		o	"				-1			1		-		- 1	۳.		- 1	Ι"			Ι"		
Ŀ	8	9	H	8	_	H	8	9	H	-		⊢	-	_	H	8	9	H	8	9	⊢	8	9	⊢	8	9
1			1			1			1				_		1			1			ı			ı	_	
	5	6	4	5	6	4	5	6	4	5	6		×		4	5	6	4	5	6	ı	14		ı	ン	<b>'</b>
7		9	ı			7		9	7		9		U	'	7		9	7		9		V	,		_	
1		3	1	2	T	Г		Ī	1	2	3	1	2	3	Г			Г			Г			1	2	3
	5	6	4	5	6		A		4	5	6	4	5	6		Q			വ	)	ı	匚		4	5	6
7	8	9	Ľ	8			U		7	8	9	7	8	9		U	1	L	_	.		U	,	7	8	9
Ť	-	3	Н	-	_	7	2	3	Ť	2	3	Ť	2	3	1	2	3	7	2	3	Н			1	2	3
Ι'	5	6	ı			Ľ	÷	6	L.	5	6	à	5	6	4	5	6	L	5	6	ı	O	)	Ľ	5	6
L			ı	9		-	0	-	2			١.			12		- 1	12		- 1		Ö		Ľ		
_	8	9	⊢	_	_	7	8	9	_	8	9	7	8	9	4	8	9	7	8	9	⊢	_	_	7	8	9
1		3	ı	$\overline{}$			Ξ,	,				1	2	3	1	2	3		$\overline{}$		1	2	3	1	2	3
	5	6	ı	13			_/			h		4	5	6	4	5	6		y		4	5	6	4	5	6
7	8	9		U	_					U		7	8	9	7	8	9		V		7	8	9	7	8	9
Γ	_		Γ			1	2	3	1	2	3	Γ			1	2	3	1	2	3	1	2	3	1	2	3
'	ワ		ı	7		4	5	6	4	5	6	ı	5		4	5	6	4	5	6	4	5	6	4	5	6
- 4	_		ı	1		7	8	9	7	8	9	ı	U	,	7	8	9	7	8	9	7	8	9	7	8	9
1		3	1	2	_	Ť	2	3	Ť	2	3	Н			ŕ	_	_	Ť	2	3	Ħ	2	3	Ť	2	3
١.	5	6	1	5	6	, A	5	6	4	5	6	ı	4			А		À	5	6	l.	5	6	L.	5	6
l,	8	9	Ι,	8	٦	17	8	9	7	8	9	ı	-1			4		7	8	9	I,	8	9	I,	8	9
۴	0		H	_	_	7	0	9	Ţ.	_	_	H	÷	_	H	÷	_	۲	0	9	۲÷	_	_	⊬	0	9
11		3	l¹	2		1	2	3	1	2	3	ľ	2	3	1	2	3	ı			1	2	3	ı	A	
l	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	ı	h		4	5	6	L	4	
7	8	9		8		7	8	9	7	8	9	7	8	9	7	8	9		$\mathbf{\mathcal{C}}$	'	7	8	9	ı		







→ Skip Animation

	_	_		_	_		_	_		_	_		_	_		_	_		_	_		_	_		_
		1	2					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
I 1		ı	5	6		Q			5	6		5	6		5	6		5	6	ı	5	6	ı	5	6
7		ı				U		7		9	7		9	7		9	7		9	7		9	7		9
	3	г	2		Т	2	3	Т			Т			Т	2	3	Н	2	3	г	2	3	Н	2	3
5	6		5	6		5	Ĭ		4			7	'	4	5	6	١,	5	6	l,	5	6		Ē	6
8	9	Ι.	8	٦	Г.	J	9		1			1		1	8	9	Ι.	8	9	Ι"	8	9	Ι.	8	9
<del>, °</del>	-	-	<u>•</u>	_	Η.	_	9	-	_	_	⊢	_	_	-	0	•	-	<u> </u>	9	⊢	<u> </u>	9	⊢	0	-
l' _		Ľ			Ш	_		Ľ				0		1	_		Ľ.	_		ı			ı	$\overline{}$	- 1
5	6	4	5	6	4	5		4	5	6		X		4	5	6	4	5	6	Ι.	.3		ı	7	- 1
7	9	L			L		9	7		9	L	_		7		9	7		9	_	_			_	
1	3	1	2			_		1	2	3	1	2	3		_		П	_		ı	_		1	2	3
5	6	4	5	6		റ		4	5	6	4	5	6		Я			")	)	ı	5		4	5	6
7 8	9		8			U		7	8	9	7	8	9		U		L	_		L	U		7	8	9
1	3				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				1	2	3
5	6	ш	O		4	5		4	5	6	4	5	6	4	5	6	4	5	6	ı	Q		4	5	6
7 8	9		$\exists$		ľ		9	1	8	9	7	8	9	7	8	9	1	8	9		C	)	1	8	9
1	3	Н			Н		Ť	Ė	Ť	Ť	÷	2	3	÷	2	3	Ė	Ť	Ť	1	2	3	÷	<del>,</del>	3
l ' 5	6		0			7					ľ	5	6	å	É	6	ı			L.	É	6	l,	É	6
7 8	9	١,	J	)		1			O	)	13	8		13	,	- 1		$\Xi$		II.	8	- 71	13	,	-
/ 8	9	⊢	_		-	÷	_	Η.	Ť	_	-	0	9	4	8	9	H	Ť	_	Ľ÷	<u> </u>	9	4	8_	9
			-,		1	2	3	1	2	3		_		1	2	3	ľ	2	3	l¹	2	3	l¹	2	3
レン	<b>7</b>	ı	/		4	5		4	5	6		<u>'</u>		4	5	6	4	5	6	4	5	6	4	5	6
		ш	•		L		9	7	8	9		$\overline{}$		7	8	9	7	8	9	7	8	9	7	8	9
1	3	1	2		1	2	3	1	2	3	Γ	-					1	2	3	1	2	3	1	2	3
5	6	4	5	6	4	5		4	5	6		1			Л		4	5	6	4	5	6	4	5	6
7 8	9	ı	8				9	7	8	9					Т	١	7	8	9	7	8	9	7	8	9
1	3	1	2		1	2	3	1	2	3	1	2	3	1	2	3	Г			1	2	3	Г		
5	6	4	5	6	à	5	1	4	5	6	۵	5	6	4	5	6	ı	C		4	5	6	ı	Λ	- 1
7 8	9	Ľ	8	٦,	ľ	•	9	7	8	9	Ŀ	8	9	L,	8	9	ı	U	)	١ <del>٠</del>	8	9		4	- 1





	_	_	_	_		_	_	_	_				_	_	_	_	_	_	_	_	_	_		_			_
		ï		1	2		ı			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	1	1		ı	5	6	ı	Я			5	6		5	6		5	6		5	6	ı	5	6	ı	5	6
		т		ı			ı	U		7		9	7		9	7		9	7		9	7		9	7		9
Г			3	Г	2		г	2	3	г			Т				2	3	г	2	3	г	2	3	Г	2	3
		5	6	4	5	6	lΔ	5			1			7	'	4	5	6	4	5	6	I_	5	6	l <sub>4</sub>	5	6
ı		8	9	Ľ	8	ŭ	Ι.	Ĭ	9		П			1		ľ	8	9	Ľ	8	9	Ľ	8	9	Ľ	8	9
H	_	_	ů	4			1		-	1		_	-		_	1	<u> </u>	-	1		_	⊢	<u> </u>		⊢		ů
ľ	١,	5		4	5	6	Ľ	5		ш	-	_		0		Ш	5	_	ш	5	_	ı			ı		
l_	٠	0	6	4	э	О	14	э	_	4	5	6		റ		4	Э	6	4	э	6		.1		ı	/	
7	_		9	ᄂ			⊢		9	7		9	_	_		7		9	7		9	ㄴ	_	_	╙		_
1			3	1			ı	_		1		3	1		3	l	_		ı			ı	H		1		3
				4			ı	h		4			4				×			ン	,	ı	<b>h</b>	•	4		
7	7		9					V	_	7		9	7		9		U	'		<u>_</u>			<u> </u>	_	7		9
1			3	Г			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Г			1	2	3
		5	6	ı	O	1	4	5		4	5	6	4	5	6	4	5	6	4	5	6	ı	Q		4	5	6
١,	, ,	8	9	ı	J	•	ı		9	7	8	9	7	8	9	7	8	9	7	8	9		C	)	7	8	9
H	_	_	3	Н			Н		_	_	_	Ť	Ť	2	3	Ť	2	3	r	_	_	1	2	3	Ť	2	3
ľ	١,		6	ı	9		ı	7	•		0		4	5	6	l.	5	6			١.	L	5	6	L	5	6
١.,		8	9	ı	J	)	ı	/			O	)	7	8	9	7	8	9		$\Xi$	1	ļ,	8	9	I,	8	9
_	_	<u> </u>	9	⊢	_		H	÷	_	H	Ť	_	_	0	9	_	_	_	H	Ť	_	H÷	_	_	Ľ.	_	
ı		_		ı	_		ľ	2	3	1	2	3		_	.	1	2	3	ľ	2	3	l¹	2	3	ľ	2	3
ı		/		ı	/		4	5		4	5	6		h		4	5	6	4	5	6	4	5	6	4	5	6
L				Ш	•		L		9	7	8	9		$\overline{}$	_	7	8	9	7	8	9	7	8	9	7	8	9
1	Г		З	1	2		1	2	3	1	2	3	Г	_		Γ	_		1	2	3	1	2	3	1	2	3
ı	- 8	5	6	4	5	6	4	5		4	5	6		1		ı	Л		4	5	6	4	5	6	4	5	6
١,	, 8	8	9	ı	8		ı		9	7	8	9					٦	٠.	7	8	9	7	8	9	7	8	9
Ħ	_	_	3	7	2		1	2	3	Ť	5	3	1	2	3	1	2	3	Ė	_	_	Ħ	2	3	۲	_	_
ľ	١,	_	6	4	5	6	4	5	٦	4	5	6	ı,	5	6	4	2 5		ı			L	5		ı	Л	
ı	, ;		9	Ι,	8	o	ľ		9	7	8	9	7	8	9	7	8	6 9	ı	O	)	4 7	8	6 9	L	4	





1 2	l _	2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
5		5	5 6	5 6	5 6	5 6	5 6
7	O	7 9	7 9	7 9	7 9	7 9	7 9
3 2	2 3			2 3	2 3	2 3	2 3
5 6 4 5	4 5	1	7	4 5 6	4 5 6	4 5 6	4 5 6
8 9 8	9		- /	8 9	8 9	8 9	8 9
1 1	1	$\vdash$		1	1		
5 6 4 5	4 5	4.5	0	4 5 6	4 5 6	2	$\sim$
7 9	9	7 9	O	7 9	7 9	J	
1 3 1	<del>                                     </del>	3	1 3	, ,	, ,		1 3
1' "1	6	l₄ 'l	1 3	0	9		4
7 9 4	O	7 9	7 9	O		$\circ$	7 9
1 3	1 2 3	2 3	1 2 3	1 2 3	1 2 3		1 2 3
	1 2 3	4 5				0	4 5 6
5 6 9		4 5	4 5 6	4 5 6	4 5 6	l a	
7 8 9	9	7 8 9	7 8 9	7 8 9	7 8 9		7 8 9
1 3	_		1 2 3	1 2 3		1 2 3	1 2 3
5 6 3	/	6	4 5 6	4 5 6	9	4 5 6	4 5 6
7 8 9			7 8 9	7 8 9		7 8 9	7 8 9
	1 2 3	2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
ワーフ	4 5	4 5	5	4 5 6	4 5 6	4 5 6	4 5 6
	9	7 8 9	0	7 8 9	7 8 9	7 8 9	7 8 9
1 3 1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6 4 5	4 5	4 5	1	1	4 5 6	4 5 6	4 5 6
7 8 9 8	9	7 8 9	- 1	-	7 8 9	7 8 9	7 8 9
1 3 1 2	1 2 3	2 3	1 2 3	1 2 3		1 2 3	
	4 5	4 5	4 5 6	4 5 6	6	4 5 6	
7 8 9 8	1 9	7 8 9	7 8 9	7 8 9	U	7 8 9	1





1 2		2 3 1 2 3	1 2 3 1 2	3 1 2 3 1	2 3
5 6	Q	5 5 6	5 6 5	5 6	5 6
-	O	7 9 7 9	7 9 7	9 7 9 7	9
3 2	2 3		2 3 2	3 2 3	2 3
5 6 4 5 6	4 5	1 7		6 4 5 6 4	5 6
8 9 8	9	/		9 8 9	8 9
	4	<del></del>	1 1	0 9	0 9
	11.				$\circ$
5 6 4 5 6	4 5 4	4 5 <b>8</b>		8  <u>    3</u>	
7 9	9 7	7 9	7 9 7	9	_
1 3 1		3 1 3		1 _ 1	3
4	6	4 4	21つ	5 4	
7 9	0	79 <mark>79</mark>	0 2	7	9
1 3	1 2 3 4	2 3 1 2 3		3 _ 1	2 3
5 6 <b>Q</b>	4 5 4	45 456	4 5 6 4 5	6 Q 4	5 6
7	l 1	7 7	7 7		
1 3		1 2 3	1 2 3	1 2 3 1	2 3
5 6 2	7	4 5 6	4 5 6	4 5 6 4	5 6
7 8 9 3	/	7 8 9	7 8 9	7 8 9 7	8 9
7 0 3 -	4 0 0				2 3
0 7	1 2 3				
		4 5 5		6 4 5 6 4	5 6
_ '	-	7 8 9		9 7 8 9 7	8 9
1 3 1 2	1 2 3	2 3	1 2	3 1 2 3 1	2 3
5 6 4 5 6	4 5 4	4 5 1	4 5	6 4 5 6 4	5 6
7 8 9 8	9 7	789	7 8	9 7 8 9 7	8 9
1 3 1 2	1 2 3	2 3 1 2 3	1 2 3	1 2 3	
5 6 4 5 6		4 5 4 5 6	4 5 6	4 5 6	1





1 2 2 3 2 3 1 2 3 1 2 3	
	1 2 3 1 2 3
1 5 6 Q 5 6 5 6 5 6	5 6 5 6
	7 9 7 9
3 2 2 3 2 3 2 3	2 3 2 3
5 6 4 5 6 4 5 1 7 4 5 6 4 5 6	4 5 6 4 5 6
	8 9 8 9
1 1 1 1 1 1	0 9 0 9
5 6 4 5 6 4 5 4 5 8 4 5 6 4 5 6	13171
7 9 9 7 9 7 9 7 9	<u> </u>
1 3 1 3 3 3	_ [1 3
4 6 4 4 8 9	<b>5</b> 4
7 9 7 9 9 6	7 9
1 3 _ 1 2 3 2 3 2 3 1 2 3 1 2 3	1 2 3
56 0 45 45 4 6 4 5 6 4 5 6	Q 1 2 3 4 5 6
	O   <sub>7</sub>
1 3 2 3 1 2 3 _	1 2 3 1 2 3
5 6 2 7 6 4 6 4 5 6 0	4 5 6 4 5 6
[7 8 9] 3   7   0   4 9   7 8 9   9	7 0 0 7 0 0
	1 8 9 1 8 9
1 2 3 2 3	1 2 3 1 2 3
7 4 5 4 5 5 4 5 6 4 5 6	4 5 6 4 5 6
9 7 8 9 7 8 9 7 8 9	7 8 9 7 8 9
1 3 1 2 1 2 3 2 3 1 2 3	1 2 3 1 2 3
5645645 45 1 1 456	4 5 6 4 5 6
7 8 9 8 9 7 8 9 7 8 9	7 8 9 7 8 9
	4 0 0
1 3 1 2 1 2 3 2 3 2 3 1 2 3	11 2 31
1 3 1 2 1 2 3 2 3 2 3 1 2 3 5 6 4 5 6 4 5 4 5 4 6 4 5 6	1 2 3 4 5 6





	1 2	_	2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
1	5 6	Q	5	6	5 6	5 6	5 6	5 6
-		O	7 9	9	7 9	7 9	7 9	7 9
3	2	2 3			2 3	2 3	2 3	2 3
5 6	4 5 6	4 5	4	7	4 5 6	4 5 6	4 5 6	4 5 6
	8			/				
8 9		9					8 9	8 9
1	1	1		_	1	1	$\sim$	
5 6	4 5 6	4 5	4 5	X	4 5 6	4 5 6	13	
7 9		9	7 9		7 9	7 9	)	_
1 3	1		3	3				1 3
	4	6	4	4	Q	つ	5	4
7 9		U	7 9	9	O	_	J	7 9
1 3		1 2 3 4 5	2 3	2 3	1 2 3	1 2 3		1 2 3
5 6	a	4 5	4 5	4 6	4 5 6	4 5 6	Q	4 5 6
7	9		7		7	7	O	7
1				2	1 2		1 2	1 2
5	2	7	6	4	4 5	$\circ$	4 5	4 5
8	J	<i>'</i>	O		. 8	9	. 8	. 8
-		1 2 2	2 3	<del></del>	_	1 2 2		1 2 2
0	7	1 2 3		_	1 2 3	1 2 3		1 2 3
	/		4 5	$\mathcal{O}$	4 5 6	4 5 6	4 5 6	4 5 6
_		9	7 8 9		7 8 9	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5	4 5	1	4	4 5 6	4 5 6	4 5 6
7 8 9	8	9	7 8 9		-	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3	2 3	1 2 3		1 2 3	
	4 5 6	4 5	4 5	4 6	4 5 6	6	4 5 6	
5 6								









1 2	_ 2	3 2 3	1 2 3 1 2 3	1 2 3 1 2 3
5 6	<b>Q</b> 5	6	5 6 5 6	5 6 5 6
7	0 7	9 9	7 9 7 9	7 9 7 9
3 2	2 3		2 3 2 3	2 3 2 3
5 6 4 5 6	4.5	7	5 6 4 5 6	4 5 6 4 5 6
8 9 8	9	/	9 8 9	8 9 8 9
1 1	1	_	1 1	1 1 1
5 6 4 5 6	4 5 4 5	0	5 6 4 5 6	$\circ$
				3 2
7 9	9 7	9	7 9 7 9	
1 3 1		3		
4		4	1817	5 4
7 9	7	9 9	)	7 9
1 3	1 2 3 2	3 2 3	1 2 3 1 2 3	Q 1 2 3 4 5 6
5 6 C	4 5 4 5	4 6	5 6 4 5 6	<b>Q</b> 4 5 6
7	7		7 7	0 7
1		2	1 2	1 2 1 2
5 2	7 1 6	4	1 2 5 Q	4 5 4 5
	/   0	) [	9	8 8
	1 2 3 2	3	1 2 3 1 2 3	1 2 3 1 2 3
2 7	1 2 3 2 4 5 4 5		5 6 4 5 6	4 5 6 4 5 6
				7 0 0 7 0 0
	9 7 8	9	7 9 7 8 9	1 8 917 8 9
1 3 1 2	1 2 3 2	3	1 2 3	1 2 3 1 2 3
5 6 4 5 6	4 5 4 5	1 1	4 5 6	4 5 6 4 5 6
7 8 9 8	9 7 8	9	7 8 9	7 8 9 7 8 9
1 3 1 2	1 2 3 2	3 2 3	1 2 3	1 2 3
5 6 4 5 6	4 5 4 5	4 6	5 6 6	4 5 6
7 8 9 8	9 7 8	9 9	7 9	7 8 9





_	1 2 5 6	_	2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
1 /	5 6	Q	5	6	5 6	5 6	5 6	5 6
4		O	7 9	9	7 9	7 9	7 9	7 9
3	2	2 3			2 3	2 3	2 3	2 3
		4 5	4	7				
5 6				/				
8 9	8	9			9	8 9	8 9	8 9
1	1	1		_	1	1	_	
5 6	4 5 6	4 5	4 5	$\mathbf{R}$	5 6	4 5 6	'\	')
7 9		9	7 9		7 9	7 9	J	_
1 3	1	_	3	3				1 3
	4	16	4	4	Q	2	5	4
7 9		O	7 9	9	0	_	S	7 9
1 3		1 2 3 4 5	2 3	2 3	1 2 3	1 2 3		1 2 3
5 6	a	4 5	2 3 4 5	4 6	5 6	1 2 3 4 5 6	Q	1 2 3 4 5 6
7	3	1	7		7	7	O	7
1				2	1 2		1 2	1 2
5	2	7	6	4 <sup>2</sup>	1 2 5	$\cap$	1 2 4 5	1 2 4 5
8	J	<i>                                     </i>	$\mathbf{O}$	, T	,	9	8	8
-	_				_		_	- 8 -
	_	1 3	3	_	1 3	1 3	1 3	1 3
	<b> </b>	4	4	5	6	4 6	4 6	4 6
_	-	9	8 9	)	9	8 9	8 9	8 9
1 3	1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5	4 5	1 1	1 /	4 5 6	4 5 6	4 5 6
7 8 9	8	9	7 8 9		-	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3		2 3	1 2 3		1 2 3	
		4 5	2 3 4 5			C		1
5 6 7 8 9	8		7 8 9	4 6	5 6 7 9	n	4 5 6 7 8 9	4







$\begin{array}{c ccccccccccccccccccccccccccccccccccc$					
7 9 9 7 9 7 9 7 9 7 9 7 9 7 9 7 9 7 9 7	1	1 2			0  0
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	4	O			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			4 7		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			1   /		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1	1 1		1 1	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$					3   2
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		1 _			_ 1 3
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	7 0	4 6	4 4	8   2	5 4
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		1 2 3		1 2 3 1 3	
8     7     0     3     8     8       2     7     1     3     3     5     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     2     4     6     4     6     4     6     4     6     4     6     4     6     4     6     4     6     4     5     6 <th></th> <th>Q 4 5</th> <th>4 5 4 6</th> <th></th> <th><b>Q</b> 4 5 6</th>		Q 4 5	4 5 4 6		<b>Q</b> 4 5 6
8     7     0     3     8     8       2     7     1     3     3     5     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     2     4     6     4     6     4     6     4     6     4     6     4     6     4     6     4     6     4     5     6 <th>7</th> <th>9</th> <th>7</th> <th>7 7</th> <th>7</th>	7	9	7	7 7	7
8     7     0     3     8     8       2     7     1     3     3     5     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     3     1     2     4     6     4     6     4     6     4     6     4     6     4     6     4     6     4     6     4     5     6 <th>1 5</th> <th>2 7</th> <th></th> <th>1 2</th> <th>1 2 1 2</th>	1 5	2 7		1 2	1 2 1 2
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		3 /	O	9	
1 3 1 2 1 2 3 2 3 1 4 5 6 6 4 5 6 6 4 5 6 6 4 5 6 6 4		1 3	3		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	2	4 0	4 5		
7 8 9 8 9 7 8 9 1 4 7 8 7 8 9 7 8 9 1 3 1 2 1 2 3 2 3 2 3 1 2 3 6 1 2 3 5 6 4 5 6 4 5 6 4 5 4 5 4 5 6 5 6 6 4 5 6	1 3				
1 3 1 2 1 2 3 2 3 2 3 1 2 3 6 1 2 3 4 5 6 4 5 6 4 5 4 5 6 5 6 6 4 5 6 4 5 6 4 5 6 6 6 6	5 6	4 5 6 4 5	4 5	4 5	4 5 6 4 5 6
5645645 45 4 6 56 6 456 1					7 8 9 7 8 9
		1 2 1 2 3			





_	1 2	2 3 2	3 1 2 3 1 3	1 2 3 1 2 3
1	5 6 🙎	5	5 6 5	56 56
		7 9	7 9 7	7 9 7 9
3	2 2	3	2 3 3	2 3 2 3
5 6	4 5 6 4 5	1 4 7	5 6 4 5	4 5 6 4 5 6
	8			
8 9	_	9	9 8	8 9 8 9
1	1 1		1 1	
5 6	4 5 6 4 5	4 5	5 6 4 5	ス  フ
7 9		9 7 9	7 9 7	0 2
1 3	1	3	3	1 3
	4	4 4		<b>5</b> 4
7 9		7 9	0 2	7 9
1 3	1 2	3 2 3 2	3 1 2 3 1 3	1 2 3
5 6	1 2 4 5	3 2 3 2 3 4 5 4	5 6 4 5	Q 1 2 3 4 5 6
7	9	7	7 7	O 7
1	-	. 2		1 2 1 2
5	$\sim$		1 2 0	4 5 4 5
	1.5 1 /		1 3 1 9	
8	0			8 8
	<b>1</b>	3 3	1 3 1 3	1 3 1 3
<b>ー</b> フ	4	4	6 4	4 6 4 6
_	/	9 8 9	9 8	8 9 8 9
3	2 2	3 2 3	3	2 3 2 3
5 6	5 6 5	5 4	1 5	5 6 5 6
7 8 9	8	9 7 8 9	4 7 8	7 8 9 7 8 9
1 3			+	
	1 2 1 2 4 5 6 4 5			
5 6 7 8 9	4 5 6 4 5			4 5 6 4
7 8 9		9 7 8 9		7 8 9





1 2 5 6		2 3	2 3	1 2 3	1 3	1 2	1 2 3
5 6	Q	5	6	5 6	5	6	5 6
4	O	7 9	9	7 9	7	7 9	7 9
3 2	2 3			2 3	3	2	2 3
5 6 4 5 6	4 5	4	7	5 6	4 5	4 6	4 5 6
8 9 8	9			9	8	9	8 9
		_	_	4	1	9	0 9
1 1	1		0	1		$\circ$	
5 6 4 5 6	4 5 4	4 5	X	5 6	4 5	.3	
7 9	9 7	7 9		7 9	7		_
1 3 1		3	3			_	1 3
4	6	4	4	Q	2	5	4
7 9	U	7 9	9	O	_		7 9
1 3	1 2 3	2 3	2 3	1 2 3	1 3		1 2 3
5 6		4 5	4 6	5 6	4 5	0	1 2 3 4 5 6
1, ° ° 1 9	· · ·	, ,		7	7	O	7
1		_	2	1 2	_	1 2	4 0
	$\overline{}$		. 4	1 2 5	$\circ$	. 2	1 2 4 5
5 3	/	h	4	5	9	4	
8	-						8
	1 3	3	_	1 3	1 3	1	1 3
フレイ	4 4	4	5	6	4	4 6	4 6
_	9	8 9	$\cup$	9	8	9	8 9
3 2	2 3	2 3			3	2	2 3
5 6 5 6	2 3 5	5	- 4	1	5	6	5 6
7 8 9 8	9 7	7 8 9	- 1	4	7 8	7 9	7 8 9
		2 3	2 3	4 2 2	, ,	1 2	, 5 5
				1 2 3 5 6			1
			4 6		n	4 6	4
7 8 9 8	9 7	789	9	7 9		7 9	







→ Skip Animation

_ 1	5 6		2 3	2 3	1 2 3	1 3	1 2	1 2 3
	5 6	Q	5	6	5 6	5	6	5 6
7		O	7 9	9	7 9	7	7 9	7 9
3	2	2 3			2 3	3	2	2 3
5 6 4	5 6	2 3 4 5	4	7	5 6	4 5	4 6	4 5 6
8 9	8	9			9	8	9	8 9
1 1		1			1	1		- 0 3
				0	٠ - ٥		9	$\circ$
5 6 4	5 6	4 5	4 5	Ö	5 6	4 5	.5	
7 9		9	7 9		7 9	7		
1 3 1			3	3			_	1 3
4		h	4	4	X	ーン	っ	4
7 9		)	7 9	9	)	_	)	7 9
1 3		1 2 3 4 5	2 3	2 3	1 2 3	1 3		1 2 3
5 6	$\mathbf{O}$	4 5	2 3 4 5	4 6	5 6	4 5	Q	1 2 3 4 5 6
7	3		7		7	7	O	7
1			_	2	1 2	_	1 2	1 2
5	$\circ$	7	0	, <sup>2</sup>	1 2 5	$\cap$	1 2	4 5
8	.5	/	$\mathbf{n}$	*	9	9	4	4 5
8	)				_			_ 8
	$\rightarrow$	1 3	3	_	1 3	1 3	1	1 3
		4	4	5	6	4	4 6	4 6
_		9	8 9	)	9	8	9	8 9
3	2	2 3 5	2 3			3	2	2 3
5 6	5 6	5	5	1 1	1	5	6	5 6
7 8 9	8	9	7 8 9		+	7 8	7 9	7 8 9
1 3 1	2	1 2 3	2 3	2 3	1 2 3		1 2	
	5	5	5	_ ~	1 2 3	6		1
5 7 8 9				ا		U	7 0	4
7 8 9	8	9	7 8 9	9	7 9		7 9	





1	1 2 5 6 <b>Q</b>	2 3 2 3 5 6	1 2 3 1 3 5 6 5	1 2 1 3
7		7 9 9	7 9 7	7 9 7 9
3 5 6	2 2 3 4 5 6 4 5	1 7	2 3 3 5 6 4 5	2 3 4 6 5 6
8 9	8 9	1 /	9 8	9 8 9
1 56 7 9	1 1 4 5 6 4 5	4 5 8	1 1 5 6 4 5 7 9 7	3 2
1 3	1	3 3	<del>' '</del>	1 3
7 9	4 6	4 4 7 9 9	8 2	5 7 9
1 3 5 6	O 1 2 3 4 5	2 3 2 3 4 5 4 6	1 2 3 1 3 5 6 4 5	8 1 3 5 6
7		7	7 7	7
1 5 8	3 7	6 4 2	5 9	1 2 1 4 5 8
2	7 4 9	4 8 9 5	1 3 1 3 6 4 9 8	1 1 3 4 6 6 9 8 9
3 5 6 7 8 9	2 2 3 5 6 5 8 9	2 3 5 7 8 9	4 5 7 8	2 3 6 5 6 7 9 7 8 9
1 3 5 7 8 9	1 2 1 2 3 5 5 8 9	2 3 2 3 5 7 8 9 9	1 2 3 5 7 9 <b>6</b>	1 2 4





1	1 2 5 6	Q 2 3	2 3	1 2 3	1 3	1 2	1 3
4	J 5 6	O 7 9		7 9	7	7 9	7 9
3	2	2 3 5 <b>1</b>	_	2 3	3	2	3
5 6 9	5 6			5 6 9	4 5 8	4 6	5 6 8 9
1	1 1	9	+	1	1	9	8 9
5 6	5 6	5 4 5	Q	5 6	4 5	3	2
7 9		9 7 9	O	7 9	7	)	
1 3	1	<b>○</b> . 3	1	0		_	1 3
7 9	4	<b>b</b>   4/7 g	4 9	Ö	2	5	7 9
1 3	_ 1	2 3 2 3 5 4 5		1 2 3	1 3		1 3
5 6	9 4	5 4 5	4 6	5 6	4 5	8	5 6
1			2	1 2	/	1 2	1
5	2	7 6	4	1 2 5	Q	4	5
8	)	1			כו		8
	1	3 3	_	1 3	1 3	1	1 3
2	4	9 8 9	5	6 9	8	4 6	6 8 9
3	2	2 3 2 3		9	3	2	3
5 6	5 6	5 5	1	1	5	- 6	5 6
7 8 9	8	9 7 8 9		۲	7 8	7 9	7 8 9
1 3	1 2 1	2 3 2 3 5 5 5 9 7 8 9	2 3	1 2 3		1 2	4
5 7 8 9	5 8	5 5 9 7 8 9	9	5 7 9	(h)	7 9	4









1 2 5 6		2 3	2 3	2 3	1 3	1 2	1 3
<b>△</b> 5 6	$\mathbf{R}$	5	6	5 6	5	6	5 6
7	O	9	9	9	7	7 9	7 9
3 2	2 3			2 3	3	2	3
5 6 5 6	2 3 5	1	7	5 6	4 5	4 6	3 5 6
9	9		- /	9	8	9	8 9
1 1	1				1	J	
5 6 5 6	5	4 5	0	5 6	4 5	$\circ$	$\circ$
			Ö			.5	
7 9	9	9	_	9	7		
1 3 1		3	3			_	1 3
4	6	4	4	X	ン	5	
7 9	)	7 9	9	)	4	)	7 9
1 3	1 2 3 4 5	2 3	2 3	1 2 3	1 3		1 3
5 6	4 5	2 3 4 5	4 6	5 6	4 5	Q	5 6
7		7		7	7	O	7
1			2	1 2		1 2	1
5 2	7	6	4	1 2 5	$\circ$	4	5
8 3	/	O	7	3	9	T	8
$\circ$	1 3	. 3	_	1 3	1 3	1	1 3
	4	4	5	6	4	4 6	6
_ '	9	8 9	)	9	8	9	8 9
3 2	2 3	2 3			3	2	3
5 6 5 6	5	5	1 1		5	6	5 6
7 8 9 8	9	7 8 9		7	7 8	7 9	7 8 9
	1 2 3		2 3	1 2 3		1 2	
1 3 1 2 5 5 7 8 9 8	1 2 3	2 3 5 7 8 9	- ŭ	1 2 3	6	I	1
7 8 9 8	٠ 9	7 8 9			r 7		4









4	1 2 5 6	8	2 3 5 9	2 3 6 9	2 3 5 6 9	1 5 7	1 6 7 9	1 5 6 7 9
5 6 9	2 5 6	2 3 5 9	1	7	2 3 5 6 9	4 5 8	4 6 9	5 6 8 9
1 5 6 7 9	1 5 6	1 5 9	4 5 9	8	5 6 9	1 4 5 7	ര	2
1	4	6	3 4 7 9	3 4 9	8	2	5	<ol> <li>3</li> <li>9</li> </ol>
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	1 2 5	9	1 2	1 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 9	1 3 4 8	1 4 6 9	1 3 6 8 9
3	2	2 3	2 3			3	2	3
5 6 7 8 9	2 5 6 8	2 3 5 9	5 7 8 9	~	4	5 7 8	6 7 9	5 6 7 8 9





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







4	1 2 5 6	8	2 3 5 9	2 3 6 9	2 3 5 6 9	1 5 7	1 6 7 9	1 5 6 7 9
3 6 9	2 5 6	3 5 9	1	7	2 3 5 6 9	4 5 8	4 6 9	5 6 8 9
6 7 9	1 5 6	1 5 9	4 5 9	8	5 6	1 4 5 7	3	2
1	4	6	3 7 9	3	8	2	5	3 7 9
5	9	2	3 4 7	4	1 3	1 3 4 7	8	1 3 6
					•	1		
8	3	7	6	2	5	9	4	1
8	3 7	7 1 3 4 9	6 4 8 9	<b>2</b> 5	5 1 3 6 9	9	4 1 4 6 9	1 3 6 8 9
8 2 7 9	<b>3 7</b> <sup>2</sup> <sup>5</sup> <sup>6</sup> <sup>8</sup>	4	4	<b>2</b> 5 1	1 3	9	4 6	6









**Helmut Simonis** 

	1 2		2.3	3	2 3	1	1	
4	1 2 5 6	8	2 3 5 9	6	6 9	5 7	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	5 6 8 9
6 7 9	1 5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	ദ	2
1	4	6	3 7 9	3 9	8	2	5	7
5	9	2	3 4 7	4	1 3	7	80	3 6 7
8	3	7	6	2	15	9	4	1
2	7	1 3 4 9	3 4 8 9	5	1 3 6 9	1 3 4 8	1 6 9	3 6 8 9
3 6 7 9	2 5 6 8	3 5 9	2 3 5 7 8 9	1	4	5 7 8	2 6 7 9	3 5 6 7 8 9
3 7 9	1 2 5 8	1 3 5 9	2 3 5 7 8 9	3 9	1 2 3 7 9	6	1 2 7 9	4







				_				
4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	2 5 6	3 5 9	7	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	6	1 4 5 7	က	2
1	4	6	3 7 9	3	8	2	15	7
5	9	2	3 4 7	4	1 3	7	80	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 9	1 3 4 8	1 6 9	3 6 8 9
3 6 9	5 6 8	3 5 9	2 3 5 7 8 9	1	4	5 7 8	2 6 7 9	3 5 6 7 8 9
3 9	1 5 8	1 3 5 9	2 3 5 7 8 9	3	1 2 3 7 9	6	1 2 7 9	4









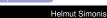
4	1 2 5 6	80	2 3 5 9	3 6 9	2 3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	2 5 6	3 5 9	7	7	2 3 6 9	4 5 8	6	5 6 8 9
6 7 9	1 5 6	1 5 9	4 5 9	8	6	1 4 5 7	3	2
1	4	6	3 7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	3 8 9	5	3 6 9	1 3 4 8	1 6 9	3 6 8 9
3 6 9	5 6 8	3 5 9	2 3 7 8 9	1	4	5 7 8	2 6 7 9	3 5 6 7 8 9
3	1 5 8	1 3 5 9	2 3	3	2 3	6	1 2	4











4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	2 5 6	3 5 9	7	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	6	1 4 5 7	က	2
_	4	6	3 7 9	3	8	2	15	7
5	9	2	3 4 7	4	1 3	7	80	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	3 8 9	5	3 6 9	1 3	1 9	3 8 9
3 6 9	5 6 8	3 5 9	2 3 7 8 9	1	4	5 7 8	7 9	5 7 8 9
3	1 5 8	1 3 5	2 3	3	2 3	6	1 2	4





# After Setup (Forward Checking)

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





#### **Outline**

- 1 Problem
- Program
- Initial Propagation (Forward Checking)
- Improved Reasoning
  - Bounds Consistency
  - Domain Consistency
  - Comparison





#### Can we do better?

- The alldifferent constraint is missing propagation
  - How can we do more propagation?
  - Do we know when we derive all possible information from the constraint?
- Constraints only interact by changing domains of variables





```
:-lib(ic).

top:-
    X :: 1..2,
    Y :: 1..2,
    Z :: 1..3,
    alldifferent([X,Y,Z]),
    writeln([X,Y,Z]).
```





## **Using Forward Checking**

- No variable is assigned
- No reduction of domains
- But, values 1 and 2 can be removed from Z
- This means that Z is assigned to 3





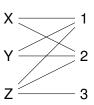
#### Visualization of all different as Graph



- Show problem as graph with two types of nodes
  - Variables on the left
  - Values on the right
- If value is in domain of variable, show link between them
- This is called a bipartite graph



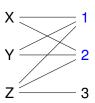




#### Value Graph for



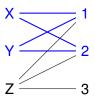




Check interval [1,2]



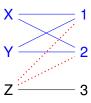




- Find variables completely contained in interval
- There are two: X and Y
- This uses up the capacity of the interval







No other variable can use that interval







Only one value left in domain of Z, this can be assigned





#### Idea (Hall Intervals)

- Take each interval of possible values, say size N
- Find all K variables whose domain is completely contained in interval
- If K > N then the constraint is infeasible
- If K = N then no other variable can use that interval
- Remove values from such variables if their bounds change
- If *K* < *N* do nothing
- Re-check whenever domain bounds change





#### **Implementation**

- Problem: Too many intervals (O(n²)) to consider
- Solution:
  - Check only those intervals which update bounds
  - Enumerate intervals incrementally
  - Starting from lowest(highest) value
  - Using sorted list of variables
- Complexity: O(n log(n)) in standard implementations
- Important: Only looks at min/max bounds of variables





#### **Bounds Consistency**

#### **Definition**

A constraint achieves *bounds consistency*, if for the lower and upper bound of every variable, it is possible to find values for all other variables between their lower and upper bounds which satisfy the constraint.





#### Can we do better?

- Bounds consistency only considers min/max bounds
- Ignores "holes" in domain
- Sometimes we can improve propagation looking at those holes



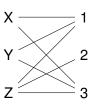


```
:-lib(ic).

top:-
    X :: [1,3],
    Y :: [1,3],
    Z :: 1..3,
    alldifferent([X,Y,Z]),
    writeln([X,Y,Z]).
```



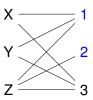




#### Value Graph for



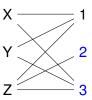




- Check interval [1,2]
- No domain of a variable completely contained in interval
- No propagation







- Check interval [2,3]
- No domain of a variable completely contained in interval
- No propagation



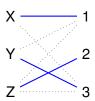




But, more propagation is possible, there are only two solutions



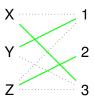




#### Solution 1: assignment in blue



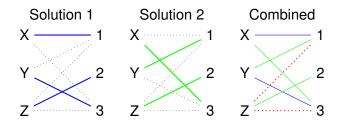




#### Solution 2: assignment in green







Combining solutions shows that Z=1 and Z=3 are not possible.





Can we deduce this without enumerating solutions?





## Solutions and maximal matchings

- A Matching is subset of edges which do not coincide in any node
- No matching can have more edges than number of variables
- Every solution corresponds to a maximal matching and vice versa
- If a link does not belong to some maximal matching, then it can be removed





#### **Implementation**

- Possible to compute all links which belong to some matching
  - Without enumerating all of them!
- Enough to compute one maximal matching
- Requires algorithm for strongly connected components
- Extra work required if more values than variables
- All links (values in domains) which are not supported can be removed
- Complexity: O(n<sup>1.5</sup>d)



### **Domain Consistency**

#### Definition

A constraint achieves *domain consistency*, if for every variable and for every value in its domain, it is possible to find values in the domains of all other variables which satisfy the constraint.

- Also called generalized arc consistency (GAC)
- or hyper arc consistency





#### Can we still do better?

- NO! This extracts all information from this one constraint
- We could perhaps improve speed, but not propagation
- But possible to use different model
- Or model interaction of multiple constraints





### Should all constraints achieve domain consistency?

- Domain consistency is usually more expensive than bounds consistency
  - Overkill for simple problems
  - Nice to have choices
- For some constraints achieving domain consistency is NP-hard
  - We have to live with more restricted propagation





## Improved Propagation in ECLiPSe

- ic\_global library bounds consistent version
- ic\_global\_gac library domain consistent version
- Choose which version to use by using module annotation
- Choice can be passed as parameter





#### **Declarations**

```
:-module(sudoku).
:-export(top/0).
:-lib(ic).
:-lib(ic_global).
:-lib(ic_global_gac).

top:-
    problem(Matrix),
    model(ic_global,Matrix),
    writeln(Matrix).
```





#### Main Program

```
model (Method, Matrix):-
    Matrix[1...9, 1...9] :: 1...9,
     (for(I, 1, 9),
     param (Method, Matrix) do
         Method: alldifferent (Matrix[I,1..9]),
         Method:alldifferent(Matrix[1..9,I])
    ),
     (multifor([I,J],[1,1],[7,7],[3,3]),
     param (Method, Matrix) do
         Method: alldifferent (flatten (Matrix [I..I+2,
                                             J..J+21)
    ),
    flatten array (Matrix, List), labeling (List).
```

## Initial State (Bounds Consistency)

	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4	4 5 6	$\mathbf{R}$	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6
	7 8 9	)	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	1	7	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9		- /	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3		1 2 3			1 2 3		
4 5 6	4 5 6	1 2 3 4 5 6	4 5 6	Q	1 2 3 4 5 6	4 5 6	2	2
7 8 9	7 8 9	7 8 9		0	7 8 9	7 8 9	J	
1 2 3			1 2 3	1 2 3				1 2 3
4 5 6	1 2 3 4 5 6	6	4 5 6	1 2 3 4 5 6	0	9		1 2 3 4 5 6 7 8 9
7 8 9	7 8 9	O	7 8 9	7 8 9	0		$\circ$	7 8 9
	109	1 2 3			1 2 3	1 2 3		
1 2 3 4 5 6	$\circ$					4 5 6	0	1 2 3 4 5 6 7 8 9
	9						Ö	7 8 9
	_	7 8 9	7 8 9		7 8 9	7 8 9		
1 2 3 4 5 6	0	$\neg$		1 2 3 4 5 6	1 2 3 4 5 6	$\circ$	1 2 3	1 2 3 4 5 6
4 5 6	.5	/	h	4 5 6		9	4 5 6	
7 8 9	_			7 8 9		)	7 8 9	7 8 9
	_	1 2 3	1 2 3 4 5 6	_	1 2 3 4 5 6	1 2 3	1 2 3	1 2 3
ン		4 5 6	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5 6
_	- 1	7 8 9	7 8 9	S	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	4 5 6	I 1	14	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9	7 8 9	_	-	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3	
4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	1 2 3 4 5 6	16	4 5 6	
7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	U	7 8 9	_





Bounds Consistency Domain Consistency Comparison

_	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
1	4 5 6	Q	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6
-	7 8 9	O	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	4	7	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9		<i>                                     </i>	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3			4 0 0	<u> </u>			7 8 9	7 8 9
	1 2 3	1 2 3	1 2 3	0			$\sim$	
4 5 6	4 5 6	4 5 6	4 5 6	l X	4 5 6	4 5 6	.3	
7 8 9	7 8 9	7 8 9	7 8 9	)	7 8 9	7 8 9	)	4
1 2 3	1 2 3		1 2 3	1 2 3				1 2 3
4 5 6	4 5 6	16	4 5 6	4 5 6	1 2	(2)	5	4 5 6
7 8 9	7 8 9	U	7 8 9	7 8 9	O	_		7 8 9
1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
4 5 6	$\mathbf{O}$	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	Q	1 2 3 4 5 6
7 8 9	3	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	O	7 8 9
				1 2 3	1 2 3		1 2 3	1 2 3
1 2 3 4 5 6	2	7	6	4 5 6	4 5 6	$\circ$	1 2 3 4 5 6	4 5 6
7 8 9	J	<i>   </i>	O	7 8 9	7 8 9	9	7 8 9	7 8 9
7 6 9	<del>-</del>	4 0 0	4 0 0	1 0 9		4 0 0		_
	7	1 2 3	1 2 3			1 2 3	1 2 3	
	I /	4 5 6	4 5 6	$\Box$	4 5 6	4 5 6	4 5 6	4 5 6
_		7 8 9	7 8 9	)	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	4 5 6	I 1	14	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9	7 8 9			7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3 4 5 6		1 2 3 4 5 6	
1	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6		4 5 6	1 1
4 5 6	4 5 6	4 5 6						







4 4 5 6 8 4 5 6 4	2 3 1 2 3 1 2 3 5 6 4 5 6 4 5 6 8 9 7 8 9 7 8 9 2 3 1 2 3 1 2 3
1     2     3     3     1     2     3     3     1     2     3 <td>8 9 7 8 9 7 8 9 2 3 1 2 3 1 2 3</td>	8 9 7 8 9 7 8 9 2 3 1 2 3 1 2 3
1 2 3 1 2 3 1 2 3 4 5 6 4 5 6 4 5 6 4 5 6 4	2 3 1 2 3 1 2 3
4 5 6 4 5 6 4 5 6 1 7 4 5 6 4	
7 8 9 7 8 9 7 8 9	5 6 4 5 6 4 5 6
	8 9 7 8 9 7 8 9
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1	2 3
4 5 6 4 5 6 4 5 6 4 5 6 9 4 5 6 4	5 6 2 7
7 8 9 7 8 9 7 8 9 7 8 9 0 7 8 9 7	8 9 0 4
1 2 3 1 2 3 _ 1 2 3 1 2 3 _	_ 1 2 3
4 5 6 4 5 6 6 4 5 6 9 4	7   5   4 5 6
7 8 9 7 8 9 0 7 8 9 7 8 9 0 4	$\sim$ $\mid$ $\cup$ $\mid$ $_{7\ 8\ 9}$
1 2 3 1 2 3 1 2 3 1 2 3 1	2 3 1 2 3
4 5 6 0 4 5 6 4 5 6 4 5 6 4	5 6 Q 4 5 6
7 8 9 7 8 9 7 8 9 7 8 9 7 8 9 7	8 9 0 7 8 9
1 2 3 1 2 3 1 2 3	1 2 3 1 2 3
4 5 6 2 7 6 4 5 6 4 5 6	0 4 5 6 4 5 6
7 8 9 3 7 8 9 7 8 9	7 8 9 7 8 9
1 2 3 1 2 3 1 2 3 1	2 3 1 2 3 1 2 3
7 4 5 6 4 5 6 5 4 5 6 4	5 6 4 5 6 4 5 6
<b>4 7 8 9 7 8 9 9 7 9 9 7</b>	8 9 7 8 9 7 8 9
1 2 3 1 2 3 1 2 3 1 2 3	2 3 1 2 3 1 2 3
4 5 6 4 5 6 4 5 6 4 5 6 1 1 4	5 6 4 5 6 4 5 6
7 8 9 7 8 9 7 8 9 7 8 9 7 8 9	
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 4 5 6 4 5 6 4 5 6 4 5 6 4 5 6	1 2 3
4 5 6 4 5 6 4 5 6 4 5 6 4 5 6 4 5 6	4 5 6 /













	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4	5 6	2	5 6	5 6	5 6	5 6	5 6	5 6
	7 9	O	7 9	7 9	7 9	7 9	7 9	7 9
1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	1 1	7	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9			7 8 9	7 8 9	7 8 9	
1 2 3	1 2 3	1 2 3	1 2 3		1 2 3	1 2 3		
4 5 6	4 5 6	4 5 6	4 5 6	0	4 5 6	4 5 6	2	9
				Ö			5	
		7 8 9			7 8 9	7 8 9	_	_
1 2 3	1 2 3		1 2 3	1 2 3			_	1 2 3
4 5 6	4 5 6	h	4 5 6	4 5 6	K		5	4 5 6
7 8 9	7 8 9	)	7 8 9	7 8 9	)	4	)	7 8 9
1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
4 5 6	a	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	R	4 5 6
7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	O	7 8 9
1 2 3 4 5 6				1 2 3	1 2 3		1 2 3	1 2 3
4 5 6	2	7	6	4 5 6	4 5 6	Ω	4 5 6	4 5 6
7 8 9	J	- /	U	7 8 9	7 8 9	3	7 8 9	7 8 9
		1 2 3	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3
7	7	4 5 6	4 5 6		4 5 6	4 5 6	4 5 6	4 5 6
	- /	7 8 9	7 8 9	$\circ$	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	_	7 8 9			1 2 3
				- A	4			
4 5 6	4 5 6	4 5 6	4 5 6		4	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9	7 8 9		_	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3	
4 5 6	4 5 6		4 5 6	4 5 6	4 5 6	16	4 5 6	14
7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	U	7 8 9	









1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1	2 3 1 2 3
5 6	<b>9</b> 5 6	5 6 5 6	5 6	5 6 5 6
7 9	7 9	7 9 7 9	7 9 7	9 7 9
1 3 1 2 3	1 2 3	1 2 3	1 2 3 1	2 3 1 2 3
5 6 4 5 6	4 5 6 4	7 4 5 6	4 5 6 4	5 6 4 5 6
7 8 9 7 8 9	7 0 0	7 0 0	7 0 0 7	0 0 7 0 0
	1 8 9 -	- / 8 9	1 8 9 7	8 917 8 9
1 3 1 2 3	1 2 3 1 2 3	1 2 3	1 2 3	
5 6 4 5 6	4 5 6 4 5 6	4 5 6	4 5 6	3 1 フ
7 8 9 7 8 9	7 8 9 7 8 9	7 8 9	7 8 9	
1 3 1 2 3	1 2 3	1 2 3	_	_ 1 2 3
5 6 4 5 6	4 5 6	4 5 6 <b>Q</b>	2	<b>5</b> 4 5 6
7 8 9 7 8 9	7 8 9	7 8 9		7 8 9
	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3	1 2 3
5 6 0	4 5 6 4 5 6	4 5 6 4 5 6	4 5 6	Q 4 5 6
				$\cap$
	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9	7 8 9
1 3		1 2 3 1 2 3	1	2 3 1 2 3
5 6 4	/ 16	4 5 6 4 5 6	Q 4	5 6 4 5 6
7 8 9	7	7 8 9 7 8 9	7	8 9 7 8 9
	1 2 3 1 2 3	1 2 3	1 2 3 1	2 3 1 2 3
12171	4 5 6 4 5 6	<b>5</b> 4 5 6	4 5 6 4	5 6 4 5 6
	7 8 9 7 8 9	7 8 9	7 8 9 7	8 9 7 8 9
1 3 1 2 3	1 2 3 1 2 3	7 6 3	1 2 3 1	2 3 1 2 3
		A A		
5 6 4 5 6	4 5 6 4 5 6	114	4 5 6 4	5 6 4 5 6
7 8 9 7 8 9	7 8 9 7 8 9		7 8 9 7	8 9 7 8 9
1 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1	2 3
5 6 4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	6 4	5 6
7 8 9 7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	U 17	8 9











_			_			_		_	_		_	_		_	_		_	_		_	_		_	_		_
			1	2	3				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	И			5	6		Q			5	6		5	6		5	6		5	6		5	6	ı	5	6
	Н	•	7		9		U		7		9	7		9	7		9	7		9	7		9	7		9
г		3	1	2	3	_	2	3	Т			Т				2	3	Н	2	3		2	3	Н	2	3
	5	6	L	5	6	4	5	6		4			7	'		5	6	١,	5	6		5	6		5	6
ı			ľ	_ =		7				1			/		7		- 1	Ι".		- 1	Г.		- 1	Ι"		
H	8	9	٠,	8	9	÷	8	9	Η.	÷	_	⊢	-	_	H	8	9	H	8	9	⊢	8	9	⊢	8	9
l,		3	1	2	3	1	2	3	Р.	2	3		$\overline{}$		1	2	3	Р.	2	3		$\overline{}$		ı	$\overline{}$	
ı	5	6	4	5	6	4	5	6	4	5	6	١.	×		4	5	6	4	5	6		[3		ı	ン	'
7	8	9	7	8	9	7	8	9	7	8	9		V	'	7	8	9	7	8	9		V	_		<u> </u>	
1		3	1	2	3			Ī	1	2	3	1	2	3	1			Ι			Ι	Ξ	. 7	1	2	3
ı	5	6	4	5	6		ദ		4	5	6	4	5	6		Q			り	)		5		4	5	6
17	8	9	7	8	9		U		7	8	9	7	8	9		U	'		_	.		U	'	7	8	9
1		3	Т			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Т			1	2	3
1	5	6		-	١	4	5	6	1	5	6	À	5	6	À	5	6	À	5	6		0		À	5	6
1,	8	9		ਹ	,	7	8	9	Ė	8	9	Ė	8	9	ļ,	8	9	Ė	8	9		O	)	Ė	8	9
H		3	•	-	_	÷		-	ŕ		•	1	_	3	÷	_	3	۲		-	-	_	3	H	2	3
Ι,	-						7	.				Ш	2		Ш	2		Ι.			Ш	2		ш	5	_
1_	5	6		. 1	)		/			n		14		6	4		6		У		4		6	4		6
7	8	9		_		_	-	_	╙	$\overline{}$		7	8	9	7	8	9	╙	_		7	8	9	7	8	9
ı						1	2	3	1	2	3	ı			1	2	3	1	2	3	1	2	3	1	2	3
	~	,		_/		4	5	6	4	5	6	Ι.	<u>'</u>		4	5	6	4	5	6	4	5	6	4	5	6
	_					7	8	9	7	8	9		U	_	7	8	9	7	8	9	7	8	9	7	8	9
1		3	1	2	3	1	2	3	1	2	3	Γ			Г			1	2	3	1	2	3	1	2	3
ı	5	6	4	5	6	4	5	6	4	5	6		1		l	Л		4	5	6	4	5	6	4	5	6
17	8	9	7	8	9	7	8	9	7	8	9		П			7	١.	7	8	9	7	8	9	7	8	9
Ħ	_	3	ī	5	3	Ť	2	3	Ť	2	3	1	2	3	1	2	3	г	_		1	2	3	Г	_	
Ι.	5	6	ľ	- 5	6	À	5	6	4	5	6	4	5	6	4	5	6	ı	6		4	5	6	ı	Л	







_			-			_		_	_			_		_	_		_	_		_	_		_	_		_
П			1	2		ı			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
П	Δ		ı	5	6	ı	Я			5	6		5	6		5	6	ı	5	6		5	6	ı	5	6
П	п		ı			ı	U	'	7		9	7		9	7		9	7		9	7		9	7		9
г		3	Т	2		Г	2	3				Г				2	3	Г	2	3		2	3	Г	2	3
П	5	6	L	-	6	4	5	6		4			7	'	4	5	6	4	5	6	4	5	6	l <sub>a</sub>	5	6
	٥	۸	Г	٥	۰	Ι.	۰	q		1			1		Г.		۸	Γ.		ă	Г.	۰	9	Ι.	٥	6
1	•	3	l,	2		4	2	3	4	2	3	Н			4	2	3	4	2	3	H	•	9	-	۰	9
Г'			Ľ	5		I !	-		Ľ	5			0		Ľ	-	-	Ľ	-	- 1		$\overline{}$		ı		
	5	6	14	5	6	14	5	6	4	5	6		X		4	5	6	4	5	6		.3		ı	7	
7	8	9	L	8		7	8	9	7	8	9	L	_		7	8	9	7	8	9	L	_		ш	_	
1		3	1	2		1			1	2	3	1	2	3										1	2	3
П	5	6	4	5	6	ı	A		4	5	6	4	5	6		Q			ワ	1		勽		4	5	6
7	8	9	ı	8		ı	U	'	7	8	9	7	8	9		U	'		_			U	'	7	8	9
1		3	Т			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				1	2	3
П	5	6	ı	0	1	l <sub>a</sub>	5	6	4	5	6	4	5	6	4	5	6	4	5	6		0		l <sub>4</sub>	5	6
١,	. 8	9	ı	$\overline{c}$	,	Ŀ	8	9	Ė	8	9	Ŀ	8	9	ļ,	8	9	Ė	8	9		O	)	Ŀ	8	9
H	_	3	۰			۲	_	Ť	÷	Ů	Ť	Ė	2	3	÷	2	3	۲	_	Ť	-	2	3	H	2	3
Ι,	5		ı	0		ı	_	,				ш	-	~	Ш	-	6	Ι.			Ш	-	٠,	Ľ	5	6
1_		6	ı	.5	)	ı	/			n		14	0	6	4	0	- 7		9		4	0	6	12	0	~
7	8	9	╄	_	_	┖	-	_	╙	$\overline{}$		7	8	9	7	8	9	╙	$\overline{}$		7	8	9	7	8	9
1			ı	_		1	2	3	1	2	3	ı	_		1	2	3	1	2	3	1	2	3	1	2	3
1	1	,	ı	_/		4	5	6	4	5	6	ı	h		4	5	6	4	5	6	4	5	6	4	5	6
	_		L			7	8	9	7	8	9		U	_	7	8	9	7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3	1	2	3	Γ			Г			1	2	3	1	2	3	1	2	3
1	5	6	14	5	6	4	5	6	4	5	6	ı	1		l	Л		4	5	6	4	5	6	4	5	6
1,	8	9	ı	8		7	8	9	7	8	9	ı	ш		1	۲		7	8	9	7	8	9	7	8	9
Ħ	Ť	3	t	2		Ħ	2	3	Ħ	2	3	4	2	3	1	2	3	Ė	_	_	Ť	2	3	r	_	_
Ι'	5	6	Ľ	5	6	ľ	5	6	4	5	6	Ľ	5	6	4	5	6	Ι.			Ľ	5	6	ı	А	
١.,	8		ľ		0	Ľ	8		14	•		14	8		14	8		ı	O	)	4	8		L	4	
11/	8	9		8		1	ರ	9	- /	8	9	1	ರ	9	- /	ರ	9		_		7	ರ	9	ı		







→ Skip Animation



_	1 2	_	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
1 /	5 6	Q	5 6	5 6	5 6	5 6	5 6	5 6
-		O	7 9	7 9	7 9	7 9	7 9	7 9
3	2	2 3			2 3	2 3	2 3	2 3
5 6	4 5 6	4 5 6	4	7	4 5 6	4 5 6	4 5 6	4 5 6
				<i>-</i> /				
8 9	. 8				8 9	8 9	8 9	8 9
1		1	1		1	1	_	
5 6	4 5 6	4 5 6	4 5 6	X	4 5 6	4 5 6	- 3	·ソ
7 9		7 9	7 9	)	7 9	7 9	)	_
1 3	1 2		1 2 3	1 2 3				1 2 3
5 6	4 5 6	6	4 5 6	4 5 6	Q	2	5	4 5 6
7 8 9	8	U	7 8 9	7 8 9	O		$\mathbf{O}$	7 8 9
1 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		
5 6	$\cap$	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	0	1 2 3 4 5 6
	9						Ö	
7 8 9	_	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9		7 8 9
1 3		-	_	1 2 3	1 2 3		1 2 3 4 5 6	1 2 3
5 6	٦ ٢		6	4 5 6	4 5 6	u	4 5 6	4 5 6
7 8 9	)	- 1	O	7 8 9	7 8 9	)	7 8 9	7 8 9
		1 2 3	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3
2	7	4 5 6	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5 6
	/	7 8 9	7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	1 2 3		. 5 5	1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5 6	4 5 6	4	1	4 5 6	4 5 6	4 5 6
		4 5 6			14			
7 8 9		7 8 9	7 8 9		<u> </u>	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	1 2 3	1 2 3	1 2 3 4 5 6		1 2 3	4
5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	l h	4 5 6	4
7 8 9	8	7 8 9	7 8 9	7 8 9	7 8 9	U	7 8 9	







→ Skip Animation



		_		_	_		_	_			_		_	_		_	_		_	_		_	_		_
		1	2					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
I /		ı	5	6		Q			5	6		5	6		5	6		5	6	ı	5	6	ı	5	6
¬	۲.	ı				U	'	7		9	7		9	7		9	7		9	7		9	7		9
	3	✝	2		Т	2	3	Т			г				2	3	Н	2	3	г	2	3	Н	2	3
5		L	5	6		5	Ĭ		4			7	'		5	6	١,	-	6	l,	Ē	6		-	6
8		ľ	8	٦	Ι"	J	9		1			/		Г.	8	9	Ι"	8	9	Ι"	8	- 1	Ι"	8	9
_	9	١,	0	_	-		9	-	-		⊢	-	_	-	0	9	-	0	9	⊢	Ö	9	⊢	0	9
1		Ľ			Ш			Ľ				0		Ľ			Ľ.	_		ı	$\overline{}$		ı		
5		4	5	6	4	5		4	5	6		X		4	5	6	4	5	6	ı	[3		ı	ン	'
7	9	L			L		9	7		9	L	V		7		9	7		9	Ц	V		L	_	
1	3	1	2					1	2	3	1	2	3										1	2	3
5	6	4	5	6		ദ		4	5	6	4	5	6		Q			7	)	ı	5		4	5	6
7 8	9	ı	8			U		7	8	9	7	8	9		U	'		_	.	ı	U	'	7	8	9
1	3	i			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				1	2	3
5	6	ı			l.	5	Ĭ	l.	-	6	L.	-	6	l.	-	6	L.	-	6	ı	O		L.	-	6
7 8		ı	$\Xi$		Ι"	J	9	13	8	-	13	,		13	,	9	13	8	9	ı	O	)	13	,	9
/ 8	_	⊢	_	_	⊢	_	9	4	0	9	μ.	<u> </u>	9	Ľ.	<u> </u>	-	-	0	9	H	Ť	_	μ.	8	-
1	3	ı	$\overline{}$			_			$\overline{}$		1	2	3	1	2	3				11	2	3	1	2	3
5	6	ı	13			/			h		4	5	6	4	5	6		U		4	5	6	4	5	6
7 8	9	L	V	<b>'</b>					V		7	8	9	7	8	9		V	_	7	8	9	7	8	9
	. –	ľ	Ξ	. 7	1	2	3	1	2	3	Γ	Ξ	П	1	2	3	1	2	3	1	2	3	1	2	3
1.5	)	ı	7		4	5		4	5	6	ı	勽		4	5	6	4	5	6	4	5	6	4	5	6
4		ı	1				9	7	8	9	ı	U	'	7	8	9	7	8	9	7	8	9	7	8	9
1	3	1	2		1	2	3	1	2	3	г					Ť	Ť	2	3	Ť	2	3	Ť	2	3
l 5		L	5	6	4	5	1	<u>.</u>	5	6	ı	4		l	А		À	5	6	L	5	6	۱	5	6
7 8	9	ľ	8	٦	ľ	J	9	Ę	8	9	ı	-			4		Ę	٥	9	Ę	٥	9	Ę	٥	9
<del>۲°</del>	_	╁	_	_	-	_	_	۲	_	_	┢	÷	_	Η,	÷	_	۲	_	-	۲	÷	_	۲		-
Γ' _	3	1	2		Ľ	2	3	Ľ	2	3	Ľ	2	3	Ľ	2	3	ı			Ľ	2	3	ı	A	
5		4	5	6	4	5		4	5	6	4	5	6	4	5	6	ı	n		4	5	6		4	
7 8	9	ı	8				9	7	8	9	7	8	9	7	8	9	ı	<u> </u>	' I	7	8	9	ı		







→ Skip Animation

	1 2	_	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
1 /	5 6	Q	5 6	5 6	5 6	5 6	5 6	5 6
-		O	7 9	7 9	7 9	7 9	7 9	7 9
	2	2 3	_		2 3	2 3	2 3	2 3
5		2 3 4 5	4	7	4 5 6	4 5 6	4 5 6	4 5 6
				/				
	8	. 9				8 9	8 9	8 9
1	1	1	1	_	1	1	_	
5 (		4 5	4 5 6	X	4 5 6	4 5 6	- 3	ーン
7	)	9	7 9	U	7 9	7 9	)	
1 :	1		1 3	1 3				1 3
	4	16	4	4	Q	2	5	4
7 9	ď	U	7 9	7 9	O		J	7 9
1 :		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
5 (		4 5	4 5 6	4 5 6	4 5 6	4 5 6	0	1 2 3 4 5 6
7 8	_	] 9	7 8 9	7 8 9	7 8 9	7 8 9	0	7 8 9
1 :		-	7 0 3	1 2 3	1 2 3	1 0 3	1 2 3	1 2 3
		7				$\circ$		
5 (	- 1	/	h			9		
7 8 9		-		7 8 9	7 8 9	)	7 8 9	7 8 9
	_	1 2 3	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
1つ	1 7	4 5	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5 6
_	<i> </i>	9	7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9
1 :	1 2	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3
5 (		4 5	4 5 6	1	1	4 5 6	4 5 6	4 5 6
7 8		9	7 8 9		4	7 8 9	7 8 9	7 8 9
1 :	-	1 2 3	1 2 3	1 2 3	1 2 3	. ,	1 2 3	
			1 2 3			0	4 5 6	1
5 (			4 5 6		4 5 6	n		4
7 8 9	8	9	7 8 9	7 8 9	7 8 9		7 8 9	•









			_	_			_		_	_			_		_	_	_	_	_		_	_		_	_		
		ı		1	2		ı				2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ı	/	1		ı	5	6	ı	Q			5			5	6		5	6		5	6	ı	5	6		5	6
ı		т		ı			ı	U		7		9	7		9	7		9	7		9	7		9	7		9
г			3	Н	2		г	2	3	Т			г				2	3	Н	2	3	г	2	3	Т	2	3
		5	6		5	6	l,	5	Ĭ		4			7	,		5	6	١,	5	6	l,	Ē	6		-	6
		8	9	Ι"	8	٠	Ι"	J	9		1			1		Г.	8	9	Ι"	8	9	Ι"	8	9	Ι.	8	9
H	_	<u> </u>	9	H	0		H		9	⊢	-		⊢	-	_	H	0	9	H	0	9	⊢	0	9	⊢	0	9
Ľ				11			Ľ						ı			11			п	_		ı	$\overline{}$		Ι.		
ı		5	6	4	5	6	14	5		4	5			X		4	5	6	4	5	6	ı	.3			7	
7	_		9	ᆫ			ᆫ		9	7		9	ᆫ	_	_	7		9	7		9	ᆫ	$\overline{}$	_	_	_	_
1			3	1			Γ			l		3	1		3	1			Γ			Γ	Ξ	. 7	1		3
ı				4			ı	A		4			4				Q			7	)	ı	5		4		
7			9	L			L	U		7		9	7		9		U	,	L	_		L	U		7		9
1			3	Г	_		1	2	3	Г	2	3	1	2	3	1	2	3	1	2	3	Г	_		1	2	3
		5	6	ı	വ	1	4	2		4	5		4	5	6	4	5	6	4	5	6	ı	Q		4	5	6
7	, ,	8	9	ı	J	1	ı		9	7	8	9	7	8	q	7	8	q	7	8	9	ı	U	)	7	8	q
Ė		_	3	-			1		_	r	Ŭ	Ŭ	4	2	3	1	2	3	r	Ŭ	_	4	2	3	4	2	3
Ι.	٠,	5	6	ı	9		ı	7	,				Li.	Ē	6	l.	Ē	6				Li	Ē	6	l.	Ē	6
١.,		B	9	ı	J	)	ı	/			O	)	13	8	9	13	8	9		$\Xi$		13	8	9	Ι.,	8	9
Ľ	_	<u> </u>	9	⊢	Ĭ		H	÷	_	⊢	Ť	_	۲	_	9	4	<u>.</u>	-	H	Ť	_	H÷	<u> </u>	9	H.	<u> </u>	9
1	-	_		ı	_		ľ	2	3	ı	2	3	ı	_	.	1	2	3	ľ	2	3	ľ	2	3	1	2	3
1		/		ı	/		4	5		4	5		ı	h		4	5	6	4	5	6	4	5	6	4	5	6
L				Ш	-		L		9	7	8	9	L	$\overline{}$	_	7	8	9	7	8	9	7	8	9	7	8	9
1			З	1	2		1	2	3	Γ	2	3	Γ	_		Γ	_		1	2	ω	1	2	3	1	2	3
1		5	6	4	5	6	4	5		4	5		ı	1		ı	Л		4	5	6	4	5	6	4	5	6
7	. 8	8	9	ı	8		ı		9	7	8	9	ı				7	٠.	7	8	9	7	8	9	7	8	9
1			3	1	2		1	2	3	Г	2	3	1	2	3	1	2	3	г			1	2	3	Т		
ľ	٠,	5	6	4	5	6	4	5	1	4	5	-	À	5	6	٨	5	6	ı	6		4	5	6	ı	Л	
1		8	9	Ι,	8	J	Ι,	J	9	7	8	9	17	8	9	Г.	8	9			)	17	8	9	- 4	4	







1 2	_	2 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
5 6	Q	5 5 6	56 56	5 6 5 6
-	O	7 9 7 9	7 9 7 9	7 9 7 9
3 2	2 3		2 3 2 3	2 3 2 3
5 6 4 5 6	4 5	1 7	4 5 6 4 5 6	4 5 6 4 5 6
8 9 8	9	/	8 9 8 9	8 9 8 9
-	. 9			89 89
1 1	1		1 1	
5 6 4 5 6	4 5	4 5	4 5 6 4 5 6	13171
7 9	9	7 9	7 9 7 9	
1 3 1		3 1 3		1 3
4	6	4 4	2 7	<b>5</b> 4
7 9	U	7 9 7 9	0 2	7 9
1 3	1 2 3	2 3 1 2 3	1 2 3 1 2 3	1 2 3
5 6	1 2 3 4 5	4 5 4 5 6	4 5 6 4 5 6	Q 1 2 3 4 5 6
7	1	7 7	7 7	O 7
1 3 _		1 2 3	1 2 3	1 2 3 1 2 3
5 6 2	7	A 5 6	4 5 6	4 5 6 4 5 6
7 8 9 3	/	7 8 9	7 8 9 9	7 8 9 7 8 9
7 8 9				
0 7	1 2 3	2 3	1 2 3 1 2 3	1 2 3 1 2 3
	4 5	4 5 5	4 5 6 4 5 6	4 5 6 4 5 6
	9	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9
1 3 1 2	1 2 3	2 3	1 2 3	1 2 3 1 2 3
5 6 4 5 6	4 5	4 5	4 5 6	4 5 6 4 5 6
7 8 9 8	9	7 8 9	7 8 9	7 8 9 7 8 9
1 3 1 2	1 2 3	2 3 1 2 3	1 2 3	1 2 3
	4 5	4 5 4 5 6	4 5 6	4 5 6
7 8 9 8	9	7 8 9 7 8 9	7 8 9	7 8 9







	1 2	_	2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
1.7	5 6		5	6	5 6	5 6	5 6	5 6
	1	O	7 9	9	7 9	7 9	7 9	7 9
	3 2	2 3			2 3	2 3	2 3	2 3
5	1	4 5	4	7	4 5 6	4 5 6	4 5 6	4 5 6
8		9		<i>   </i>	8 9	8 9	8 9	8 9
	4 8	4 9	<u> </u>	<u> </u>	8 9	8 9	8 9	8 9
1	. []	11.			1	11	$\sim$	
5 (		4 5	4 5	l X	4 5 6	4 5 6	-3	
7 9		9	7 9	)	7 9	7 9	)	_
1 :	1		3	3				1 3
	4	6	4	4	Q	つ	5	4
7 9		U	7 9	9	O	_		7 9
1 :	3	1 2 3	2 3	2 3	1 2 3	1 2 3		1 2 3
5 (		1 2 3	2 3	4 6	4 5 6	4 5 6	Q	1 2 3 4 5 6
7	3		7		7	7	O	7
1 3	1			2 3	1 2 3		1 2 3	1 2 3
5		7		4 6	4 5 6	$\cap$	1 2 3 4 5 6	4 5 6
		<i>                                     </i>	n		4 5 6	9	7 0 0	4 5 6
7 8 9			_	9	7 8 9	_	7 8 9	7 8 9
	_	1 2 3	2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
レン	1 /	4 5	4 5	5	4 5 6	4 5 6	4 5 6	4 5 6
_		9	7 8 9	)	7 8 9	7 8 9	7 8 9	7 8 9
1 :	3 1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 (	4 5 6	4 5	4 5	1 1		4 5 6	4 5 6	4 5 6
7 8		9	7 8 9		+	7 8 9	7 8 9	7 8 9
1 :		1 2 3	2 3	2 3	1 2 3		1 2 3	
5			4 5	4 6	4 5 6	6		1
						Ö		4
7 8 9	8	9	7 8 9	9	7 8 9	_	7 8 9	









4	1 2 5 6		2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
4	5 6	l X	5	6	5 6	5 6	5 6	5 6
			7 9	9	7 9	7 9	7 9	7 9
3	2	2 3 4 5		_	2 3	2 3	2 3	2 3
5 6	4 5 6	4 5	1	7	4 5 6	4 5 6	4 5 6	4 5 6
8 9	8	9		- 1	8 9	8 9	8 9	8 9
1	1	1			1	1		
5 6	4 5 6	4 5	4 5	Q	4 5 6	4 5 6	3	つ
7 9	l	9	7 9	O	7 9	7 9	J	_
1 3	1		3	3		_		1 3
	4	16	4	4	Q	つ	5	4
7 9	l	U	7 9	9	O	_	J	7 9
1 3		1 2 3	2 3	2 3	1 2 3	1 2 3		1 2 3
5 6	a	4 5	4 5	4 6	4 5 6	4 5 6	Q	1 2 3 4 5 6
7	9		7		7	7	O	7
1				2	1 2	_	1 2	1 2
5	2	<b>17</b>	6	4	4 5	a	1 2 4 5	4 5
8	<b>O</b>	<i>I</i>	U		8	J	8	8
		1 2 3	2 3		1 2 3	1 2 3	1 2 3	1 2 3
12	<b>1</b> 7	1 2 3	4 5	5	4 5 6	4 5 6	4 5 6	4 5 6
_	/	9	7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5	4 5	1	1	4 5 6	4 5 6	4 5 6
7 8 9	8	9	7 8 9		4	7 8 9	7 8 9	7 8 9
1 3	1 2	_		2 3	1 2 3			
5 6	4 5 6		2 3 4 5	4 6	1 2 3 4 5 6	6	1 2 3 4 5 6	1









	1 2	_	2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
1 /	5 6		5	6	5 6	5 6	5 6	5 6
_	1	O	7 9	9	7 9	7 9	7 9	7 9
3	2	2 3			2 3	2 3	2 3	2 3
5 6	4 5 6	4 5	4	7	5 6	4 5 6	4 5 6	4 5 6
	8			<i>   </i>				
		9	_	_	9	8 9	8 9	8 9
1	1	11	l		1	1	$\sim$	
5 6	4 5 6	4 5	4 5	l X	5 6	4 5 6	13	7
7 9		9	7 9	)	7 9	7 9	)	_
1 3	1		3	3				1 3
	4	16	4	4	Q	7	5	4
7 9		U	7 9	9	O	_	)	7 9
1 3		1 2 3	2 3	2 3	1 2 3	1 2 3		1 2 3
5 6		4 5	4 5	4 6	5 6	4 5 6	Q	1 2 3 4 5 6
7	3		7		7	7	O	7
1	-	-	_	2	1 2	_	1 2	1 2
5	2	7	6	, <sup>2</sup>	1 2 5		1 2 4 5	4 5
8	1.5	/	n	*	3	9		
8	_		-				8	8
		1 2 3 4 5	2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
ン	I /	4 5	4 5	5	5 6	4 5 6	4 5 6	4 5 6
		9	7 8 9	9	7 9	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5	4 5	1 1		4 5 6	4 5 6	4 5 6
7 8 9	8	9	7 8 9		+	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3	2 3	1 2 3	<del></del>	1 2 3	
5 6	4 5 6	4 5	4 5	4 6	5 6	6	4 5 6	1
						ט ו		4
7 8 9	8	9	7 8 9	9	7 9		7 8 9	







→ Skip Animation

_		_	_			_		_	_		_			_		_						_	_		
			1	2		Г	_			2	3	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Л		ı	5	6	ı	Q			5			6	ı	5	6		5	6		5	6		5	6
1	4	٠.	ı			ı	U	)	7		9		9	7		9	7		9	7		9	7		9
Н	_	3	⊢	2	_	Н	2	3	Ė	_	Ť	-	Ť	H	2	3	÷	2	3	÷	2	3	Ė	2	3
	_	- 1	١.	5	_	١.	5	٦		Ä		-	7	ı	5		١.			١.		- 1	١.		
	5	6	4		6	14	5			П		<b> </b>		ı	5	6	4	5	6	4	5	6	4	5	6
_	8	9	ᆫ	8		ᆫ		9	┖	-		_		ᆫ		9	_	8	9	_	8	9	ᆫ	8	9
1			1			1						_		1			1							_	
	5	6	4	5	6	4	5		4	5		2	2	ı	5	6	4	5	6		2			り	
7		9	ı			ı		9	7		9		)	7		9	7		9		U	'		_	
Ħ		3	1			Г			Г		3		3	Г			_			Т			1		3
1		1	۱			ı	6		4		-	4	ŭ	ı	0			9	)				l.		-
١,		9	Ι"			ı	U	)	7		9	7	9	ı	O	)		Z			U	)	7		9
ı÷			⊢			H	÷	_	_	_		Η.	_	H	÷	_	H	_	_	_	_	_	Ľ.	_	
1		3	ı			1	2	3		2 5	3	2		11	2	3	1	2	3		$\overline{}$		1	2 5	3
	5	6	ı	U	)	4	5		4	5		4	6	ı	5	6	4	5	6		×		4	5	6
7				V					7					7			7				U		7		
1			Г	_		Г				_		2		1	2		г	_	$\neg$	1	2		1	2	
	5		ı	2		ı	7	'		A		4		ı	2 5			O	١	4	5		4	5	
	8		ı	J	)	ı	1		1	U	1			ı				J	'		8			8	
Н	Ť	_	⊢			1		3	Н		3	-		1		-	7		-	7	Ť	3	1	Ť	2
			ı	$\overline{}$		Ľ		٥	١.		3			ľ		٥	Ľ		0	Ľ		- 1	Ľ		3
	_		ı	/		ľ			4				)	ı		6	4		6	4		6	4		6
ш		_	⊢	-		╙	_	9	╙	8	9	_		⊢		9	_	8	9	_	8	9	╙	8	9
1		3	1	2		1	2	3		2	3			ı			1	2	3	1	2	3	1	2	3
1	5	6	4	5	6	4	5		4	5		- 1		L	Δ		4	5	6	4	5	6	4	5	6
7	8	9	ı	8		ı		9	7	8	9			ı	Т		7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3		2	3	2	3	1	2	3	Т			1	2	3	Г		
1	5	6	4	5	6	4	5	1	4	5	-	4	6	ľ	5	6				4	5	6	ı	1	
L	8	9	ľ	8	o	ľ	3	9	7	8	_	Ι"	9	I,	3	9		O	)	7	8	9	1	4	
1/	o	9		o				<b>9</b>	- /	o	9		9	- /		ਤ		_		- /	o	∌∣		-	









_			_					_	_					_					_	_		_	_		_
	-		1	2 5			_			2	3		2 3	1	2	3	1		3	1	2	3	1	2	3
	4	.		5	6		X			5			6		5	6		5			5	6		5	6
L	_ •		╙			_	<u> </u>		7		9	_	9	7		9	7			7		9	7		9
		3		2			2	3		á		-	,		2	3			3		2	3		2	3
	5	6	4	5	6	4	5			1					5	6	4	5		4	5	6	4	5	6
H	8	9	Ļ	8		Ļ		9	⊢	÷		_		Ļ		9	Ļ	8	_	╙	8	9	⊢	8	9
1			1			1			١.				`	ľ			11			١.,	$\overline{}$		Ι.	$\overline{}$	
L	5	6	4	5	6	4	5		4	5		ح ا	<b>ጎ</b>	L	5	6	4	5		Ι,	.3			/	
7		9	Ļ			L		9	7		9	_	_	7		9	7			⊢	$\overline{}$	_	Ľ		_
1		3	1						١.		3		3		0		Ι.				_		1		3
L			4				n	)	4		_	4			റ		Ι.	_			<b>:</b>		4		
4		9	⊢			Η.	Ť	_	7	_	9		9	Ļ	Ţ	_	Η.		_	⊢	~	_	4	_	9
1	-	3	Ι.			1	2	3	١.	5	3		2 3	ľ	5	3	п	2	3	١.	0		1	2	3
L	5	6		9		4	5		4	5		4	6	L	5	6	4	5			റ		4	5	6
Ľ.		_	⊢	Ĭ		⊢		_	7		_	_	_	¥.	_	_	7		_	Ļ	Ť	_	4	_	-
Р	-			0			_		Ι.			L.	2	1	2		Ι.			11	5		11	2	
	5 8			J	)		/			O		4			Э			9		4	8		4	8	
Н	- 0	_	⊢	Ĭ		-	÷	3	⊢	Ĭ	3	-		Ļ		3	┝	Ť	3	-	0	_	Н	0	_
				$\overline{}$		Ľ		3	l.		3	1		ľ		6	Ľ		3	Ľ		3 6	Ľ		6
	_		ı	/		4			4		_	1	)			- 1	4			4		٥	4		٥
1		3	4	2		1	2	9	H	2	3			H		9	1	8	3	1	2	3	4	2	3
ľ	5	6	Ľ	5	6	4	5	٥		2	٥		1	ı	А		Ľ	5	٥	Ľ	2	6	Ľ	-	9
١,	8	٥	Ι*	٥	o	1	3	9	Ę	8	۸	l	ı	ı	4		١,	8		١,	٥	٥	Ę	٥	Š
4	8	3	4	2		4	2	3	-	2	3		2 3	4	-	3	<del>-</del>	0		4	2	3	<del>-</del>	0	9
ľ	5	6	4	2	6	4	2	3	١,	5	3	۱, ۱	23 6	ľ	5	6	L	C		Ľ	5	6	ı	Ä	
Ļ	8	9	l*	8	0	1*	э	9	7	8	9	*	9	Ļ	9	9	ı	O	)	7	8	9	1	4	
	0	9		0				<b>3</b>	• •	o	J		9			9		_		•	o	9			- 1











_		_	_			_		_	_		_	_		_	_		_	_						_		_
1	4		1	2 5			_		ı	2	3	ı	2	3	1	2	3	1		3	1	2	3	1	2	3
1	4		ı	5	6		X		ı	5		ı		6	l	5	6	ı	5			5	6		5	6
L							U		7		9			9	7		9	7			7		9	7		9
		3	Г	2			2 5	3		7		Ι.				2 5	3	Г		3		2	3		2	3
	5	6	4	5	6	4	5			1			7			5	6	4	5		4	5	6	4	5	6
	8	9	ı	8				9		4			I				9	ı	8			8	9		8	9
1			1			1									1			1			г			Т		
	5	6	4	5	6	4	5		4	5			Q			5	6	4	5			2			7	)
17		9	ı					9	7		9	(	U		7		9	7				J	)		_	
Ħ		3	1			Т		Ť	Г		3	Т		3	Т			Ė			Т		_	1		3
1			4				6		4			4				Q		ı	2	)		匚		4		
7		9	ľ				U		7		9	ľ		9		O	)	L	_			U	)	7		9
1		3	Г	_		1	2	3	П	2	3	П	2	3	1	2	3	1		3	г	_	T	1	2	3
	5	6	ı	O	1	4	5		4	2 5		4		6		5	6	4	5			Q		4	5	6
7			ı	J	,				7						7			7				U	,	7		
1			Г			Г						$\overline{}$	2		1	2		Г			1	2		1	2	
	5		ı	2			7	'		A		4				2 5		ı	O	1	4	5		4	5	
	8		ı	J	)		1			U	1	l i						ı	J	,		8			8	
H	_	$\neg$	Н			1		3	Н		3	Н			1		3	1		3	1	Ť	3	1	_	3
1	2		ı	7		۱		1	4		-		二		1		6	À		Ĭ	4		6	4		6
1.	_		ı	1		ľ		9	ľ	8	9	,	U		l		9	ľ	8		Г	8	9	Г	8	9
$\vdash$		3	Н	2		Н	2	3	$\vdash$	2	3	$\vdash$		_	$\vdash$		•	Н	-	3	_	2	3	-	2	3
1	5	6	ı	5	6		5	٦	ı	5	٦	ı	4		l	A		ı	5	٦		5	6		5	6
1,	8	9	ı	8	o		3	9	7	8	9	ı	1		-	4		7	8		١,	8	9	7	8	9
H	0		۲		_	Ι,	_	_	۲			⊢	÷	_	Ι,	÷	_	۲		_	4			-		9
T,	_	3	1	2 5		1	2	3	١.	2 5	3	١.	2	3	1	2 5	3	ı			1	2 5	3		А	
1_	5 8	6	4	5 8	6	4	5		7	5 8		4		6	_	5	6	ı	n	)	4	5 8	6 9		4	
								q.			q						q				7					









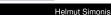


_		_	_		_	_			_			_		_		_	_		_	_		_	_		
1			1	5		ı	_		ı	2	3	2	3	1	2	3	1		3	1	2		1	2	3
	Δ	.	ı	5	6	Ι.	Я			5			6	ı	5	6		5				6		5	6
	7	•	ı				U	'	7		9		9	7		9	7			7		9	7		9
Г		3		2			2	3						Г	2	3			3		2			2	3
	5	6	4	5	6	4	5			1		7	7	ı	2	6	4	5		4		6	4	5	6
	8	9	Ľ	8	- T	1	7	9		ш		_ /		ı	7	9	l i	8		1		9	1	8	9
4	_	_	4	_		4		Ť	Н			-		1		_	4	Ů		Н		_	_	_	_
Ι'	5	_	Ľ	5	6	Ш	5			5		C		Ι'	5		Ш	5							
L	э	6	4	э	٥	4	э		4	э	_	7	Ó	L	э	6	4	э			വ		Ι.	_	
1	_	9	⊢	_	_	⊢	_	9	7	_	9	$\vdash$	_	╙	_	9	4	_	_	⊢	$\overline{}$	_	Ľ		_
1		3	1			ı			ı		3	ı	3	ı	$\overline{}$		ı	$\overline{}$		ı	_		1		3
			4				h		4			4		ı	X			ン	'	Ι.	h		4		
7		9					V	_	7		9		9		U	'	-	<u> </u>			U		7		9
1		3				1	2	3		2	3	2	3	1	2	ß	1		3				1	2 5	3
	5	6		O	ш	4	5		4	5		4	6	ı	2	6	4	5			Q		4	5	6
17				J					7					7			7			1	U		7		
Ħ			Н			Н			Ė			2		ī	2		Ė			1	2		Ť	2	
I.	5			2			7	,				<sub>4</sub> -		ľ	2 5			0		À	-		À	5	
	8			J	)		/			U	)	Ι.		ı	ŭ			$\exists$		Г.			Ι.	8	
$\vdash$		-	⊢	-	-	-	÷	_	⊢	-	_	-		١,		_	-	-	_	-		-	-	<u> </u>	_
1				_		Γ!		3	١.		3	_		ľ		3	Ľ		3	Ľ			Ľ		3
1		<b>'</b>	ı	/		4			4				)	ı		6	4			4		6	4		6
$\vdash$		_	ᆫ	-		╙		9	ᆫ	8	9	_	_	╙		9	╙	8		╙		9	_	8	9
1		3	ı	2		ı	2	3	ı	2	3			ı			ı		3	ı	2		ı	5	3
1	5	6	ı	5	6	ı	5		ı	5		- 1		Ι.	4		ı	5		ı		6	ı	5	6
7	8	9	L	8		L		9	7	8	9			L	т		7	8		7		9	7	8	9
1		3	1	2		1	2	3	Г	2	3	2	3	11	2	3				1	2				
	5	6	4	2	6	4	2		4	5		4	6	ı	2	6	ı	A		4		6	١.	Л	
7	8	9	Ι'	8	1	Ι'	-	9	L.	8	9	1	9	I _	-	9		U	)	Lů,		9		4	









$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$								
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		1 2		2 3		1 3	1 2	1 2 3
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1 /1	5 6	<b>Q</b> 5	6	5 6	5	6	5 6
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			$O_{7}$	9	7 9	7	7 9	7 9
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	3	2	2 3			3	_	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		4 5 6 4	5 1	7				
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				/				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1	_	-	+-	1			- 6 3
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	٠ - ٥		- 4-	0			2	$\circ$
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		4 5 6 4		lδ			.5	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		oxdot			7 9	7		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 3	1	$\sim 1$	3			_	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		4	6 I4	4	l X	ーン	っ	4
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	7 9			9	)	_		7 9
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 3	1	2 3 2 3	2 3	1 2 3	1 3		1 2 3
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	5 6	$\bigcirc$ 4	5 4 5		5.6	4 5	Q	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	7	9			7		O	7
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	4	-		2	1 2	_	1 2	
2 7 4 9 4 9 5 6 4 4 6 4 8 8 9 8 8 9 8 9 8 8 9 9 8 9 9 8 8 9 9 8 9 9 8 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 9 8 9 9 9 8 9 9 9 8 9 9 9 9 8 9	8	' <u>-</u> '	2	7 6	1, 2	l'	$\cap$	L' -	
2 7 1 3 4 3 5 1 3 1 3 1 6 4 6 8 9 8 9	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		5	I		3	9	4	
2 7 4 9 4 8 9 5 6 4 8 4 6 4 6 8 9	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	- 6			+	-		<u> </u>	
<b>2</b>	3 2 2 3 2 3 3 4 5 5 6 5 6 5 7 8 9 8 9 7 8 9 1 4 7 8 7 9 7 8 9 1 3 1 2 1 2 3 2 3 2 3 1 2 3			3	·		1 3	1	1 3
	3     2     2     3     2     3     2     3     2     3     2     3     2     3     2     3     2     3     5     6     5     6     5     6     5     6     5     6     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     8     9 <th></th> <th>4</th> <th>4</th> <th>15</th> <th></th> <th>4</th> <th></th> <th></th>		4	4	15		4		
3 2 2 3 2 3 3 2 2 3 5 6 5 6 5 6 5 6	5 6     5 6     5 6     5 5     5 7 8 9     1     4     5 6     7 8 9	_				9	8	9	
56 56 5 5 5 1 1 1 5 6 56	7 8 9 8 9 7	3	2	2 3 2 3	3		3	2	2 3
	7 8 9 8 9 7	5 6	5 6	5 5	1.1	1 /	5	6	5 6
789 8 9 789 1 78 7 9 789	1 3 1 2 1 2 3 2 3 2 3 1 2 3 1 2 3	7 8 9	8	9 7 8 9		-	7 8	7 9	7 8 9
						1 2 3			
					1 - 1	5	6	I	1
	7 8 9 8 9 7 8 9 9 7 9 0 7 9 7	5 7 8 9			ه ا		U	7 0	4









							_		_			_		_	_		_	_		_	_		_
	- 1	1 2						2	3	2	3	1	2	3	1		3	1	2		1		3
1	- 1	5	6		Q			5			6	ı	5	6		5				6		5	6
<b>—</b>	- 1			1	U		7		9		9	7		9	7			7		9	7		9
	3	2		Н	2	3	_			-	_	H	2	3	Ė		3	Ė	2		Ė		3
_ ا		4 5	6	4	2	٦		4		-	7	ı	2 5	6	١.	-	٦	4	-			-	6
5	٧.		٥	4	э			н		<b> </b> /		ı	э		4	5		4		6		5	
8	9	8	_	_		9	_	-		_		╙		9	_	8	_	╙		9	ᆫ	8	9
_		1		1						_		1			1				_			_	
7	- 1	4 5	6	4	5		4	5		<u> </u>	2	ı	5	6	4	5			''			')	
						9	7		9	-	,	7		9	7				U	'	-	_	
1	3	1							3		3	г									1		3
1.	Ĭ	,			0		4		Ĭ	4	ŭ	ı	O			9				١.	Ľ		Ĭ
7	9	7			O		7		9	7	9	ı	O		Ι.	_	.		U	)	٦,		9
-			_	Η.	÷	_	-	_		_		H	÷	_	-		_	-	_	_	÷		
11	3	_		1	2 5	3		2	3	2	3	11	2	3	1		3		_		1		3
5	6	Q		4	5		4	5		4	6	ı	5	6	4	5		١.	×			5	6
7		0					7					7			7				U	_	7		
1	Т							_		2		1	2			_		1	2		1		
5	- 1	-2			7			മ		4		ı	2			റ	ш	4				5	
8	- 1	J			1		1	U	)			ı				J		1				8	
Ť	╅			1		3	Н		3	-		1		3	4		3	1		_	4	Ť	3
0	- 1	7		Ľ.		٦	١.		3	_		ľ			Ľ.		٦	Ľ			Ι'.		
	- 1	_ /		4			4				)	ı		6	4			4		6	ı		6
	4			Щ		9	ᆫ	8	9	_	_	╙		9	╙	8		╙		9	ᆫ	8	9
1	3	2			2	3		2	3			ı			ı		3		2		ı		3
5	6	5	6		5			5		- 1		ı	Л		ı	5				6	ı	5	6
7 8	9	8				9	7	8	9			Ι'	7	١.	7	8		7		9	7	8	9
1		1 2		1	2	3	Т	2	3	2	3	1	2	3	Т	_		ī	2		Г	_	
5	ĭl	5		Ι'	2 5	۲			٦	l -	٠	ľ	2 5	٠	١.			ľ	-		ı	А	
	۱	5 8			3		١.,	5 8			_	l.	э			O	)	L			1	4	
7 8	9	- 8				9	17	ದ	9		9	. /		9		_		- /		9			









4	1 2 5 6	8	2 3 5 7 9	2 3 6 9	1 2 3 5 6 7 9	1 3 5 7	1 2 6 7 9	1 3 5 6 7 9
5 6 9	2 5 6	2 3 5 9	1	7	2 3 5 6 9	3 4 5 8	2 4 6 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	1	6	3 4 7 9	3 4 9	8	2	15	<ol> <li>3</li> <li>9</li> </ol>
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	1 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 9	1 3 4 8	1 4 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	4	5 7 8	2 6 7 9	3 5 6 7 8 9
1 3 5	1 2 5 8	1 2 3	2 3 5 7 8 9	2 3	1 2 3 5 9	6	1 2	4









1	1 2 5 6	0	2 3	2 3	2 3 5 6	1 3	1 2	1 3 5 6
4	3 0	0	9	9	9	7	7 9	7 9
3	2 5 6	2 3 5	4	7	2 3 5 6	3	2	3
5 6 9	5 6	5 9			5 6 9	4 5 8	4 6	5 6 8 9
_	1	1		(		1		
	5 6	5 9	4 5 9	8	5 6 9	4 5	3	2
1 3	1		3	3			_	1 3
9	4	6	4 7 9	4 9	8	2	5	7 9
1 3		1 2 3 4 5	2 3 4 5	2 3	1 2 3 5 6	1 3	)	1 3
5 6	9	4 5	4 5 7	4 6	56 7	4 5 7	8	5 6 7
1		7		2	1 2 5		1 2	1
5 8	3	/	6	4	5	9	4	5 8
0	7	1 3	. 3		1 3	1 3	1	1 3
	/	4 9	8 9	C	6 9	8	4 6	6 8 9
3	2	2 3 5	2 3	4	4	3	2	3
5 6 8 9	5 6 8	5 9	5 7 8 9	1	4	5 7 8	7 9	5 6 7 8 9
1 3	1 2	1 2 3	2 3	2 3	1 2 3		1 2	
5 8 9	5 8	5 9	5 7 8 9	9	5 7 9	6	7 9	4
			7 8 9					







1	1 2 5 6	Q	2 3	2 3	2 3 5 6	1 5	1 6	1 5 6
-		O	9	9	9	7	7 9	7 9
3 5 6	2 5 6	2 3 5	1	7	2 3 5 6	4 5	4 6	5 6
9		9		I	9	8	9	8 9
7	1 5 6	1 5 9	4 5 9	80	5 6 9	1 4 5	3	2
1	4	6	3 4 7 9	3 4 9	8	2	15	<ol> <li>3</li> <li>9</li> </ol>
5	တ	2	2 3 4 5 7	2 3 4 6	1 2 3 5 6 7	1 3 4 5 7	00	1 3 5 6 7
8	3	7	6	4	1 2 5	9	1 2	1 5 8
2	7	1 3 4 9	3 4 8 9	5	1 3 6 9	1 3 4 8	1 4 6 9	1 3 6 8 9
5 6 8 9	2 5 6 8	2 3 5 9	2 3 5 7 8 9	1	4	5 7 8	2 6 7 9	5 6 7 8 9
1 3	1 2 5	1 2 3	2 3 5 7 8 9	2 3	1 2 3		1 2	









4	1 2 5 6	8	5	6	2 3 5 6 9	1 5 7	1 6 7 9	1 56 7 9
3 6 9	2 5 6	3 5 9	1	7	2 3 5 6 9	4 5 8	4 6 9	5 6 8 9
7	6	1 5 9	4	8	9	1 4 5	က	2
1	4	6	3 7 9	3 9	8	2	15	3 7 9
5	9	2	3 4 7	3 4 6	1	1 3 4 7	80	6
8	$\mathcal{S}$	7	6	2	5	9	4	1
2	7	4	3 4 8 9	5	6	1 3 4 8	1 4 6 9	1 3 6 8 9
6	2 5 6 8	3 5 9	2 3 5 7 8 9	1	4	5 7 8	2 6 7 9	3 5 6 7 8 9
3	1 2 5 8	1 3 5	2 3 5 7 8 9	2 3	7	6	1 2	1









		_				_		
4	1 2	8	5	6	2 3	7	7 9	7 9
3	2 5	3	1	7	2 3	4 5	6	5 8 9
7	6	1 5	4	8	9	1 5	3	2
1	4	60	3 7 9	3	8	2	5	3 7 9
5	9	2	7	4	1	3 4 7	80	6
8	3	7	6	2	5	9	4	1
2	7	4	3 8 9	5	6	1 3	1 9	3 8 9
6	2 5 8	3	2 3 7 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	1 2 5 8	1 5	2	3	7	6	1 2	4











	1 2				2 3	4	4	
4	1 2	8	5	6	2 3	7	7 9	7 9
3	2 5	3	1	7	2 3	4 5	6	5 8 9
7	6	1 5	4	8	9	1 5	ദ	2
1	4	6	3 7 9	3	8	2	5	7
5	တ	2	7	4	~	7	00	6
8	3	7	6	2	5	တ	4	1
2	7	4	3 8 9	5	6	1 3	1 9	3 8 9
6	2 5 8	3 9	2 3 7 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	1 2 5 8	1 5	2	3	7	6	1 2	4









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











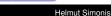
4	1 2	8	5	6	2 3	7	1 7 9	7 9
3	2 5	3	1	7	2 3	4 5	6	5 8 9
7	6	1 5	4	8	9	1 5	က	2
1	4	6	3 7 9	3	8	2	15	7
5	တ	2	7	4	$ \leftarrow $	7	00	6
8	3	7	6	2	5	9	4	1
2	7	4	3 8 9	5	6	1 3 8	1 9	3 8 9
6	5 8	3	2 3 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	1 5 8	1 5	2	3 9	7	6	1 2	4











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







## After Setup (Bounds Consistency)

		_						_
4	1 2	8	5	6	2 3	7	1 7 9	7 9
3	2 5	3	1	7	2 3	4 5	6	5 8 9
7	6	1 5	4	8	9	1 5	ന	2
1	4	60	3 7 9	3	80	2	15	7
5	9	2	7	4	~	7	8	6
8	3	7	6	2	5	9	4	~
2	7	4	8 9	5	6	1 3	1 9	3 8 9
6	5 8	3	2 3 8 9	7	4	5 7 8	2 7 9	5 7 8 9
3	1 5 8	1 5	2	3	7	6	1 2	4





#### Initial State (Domain Consistency)

1 2	3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4 5	6 X	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6
7 8	9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3 1 2 4 5 6 4 5	3 1 2 3 6 4 5 6	l a	_	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6
		1-1	<i>                                     </i>				
7 8 9 7 8 1 2 3 1 2	9 7 8 9	4 0 0	<u> </u>	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3 1 2 4 5 6 4 5	3 1 2 3 6 4 5 6	1 2 3 4 5 6	0	1 2 3 4 5 6	1 2 3 4 5 6	2	0
7 8 9 7 8	9 7 8 9	7 8 9	Ö	7 8 9	7 8 9	J	
1 2 3 1 2	3	1 2 3	1 2 3	1 0 9	1 0 9		1 2 3
4 5 6 4 5	6 6	4 5 6	4 5 6	0	2	_	1 2 3 4 5 6
7 8 9 7 8		7 8 9	7 8 9	0	_	$\mathbf{S}$	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		
4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	Q	1 2 3 4 5 6
7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	O	7 8 9
1 2 3			1 2 3	1 2 3		1 2 3	1 2 3
4 5 6	17	16	4 5 6	4 5 6	a	4 5 6	4 5 6
7 8 9	- 1	0	7 8 9		)	7 8 9	7 8 9
	1 2 3	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
1 フ 1 7	4 5 6	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5 6
_ '	7 8 9	7 8 9		7 8 9	7 8 9	7 8 9	7 8 9
1 2 3 1 2	3 1 2 3	1 2 3		4	1 2 3	1 2 3	1 2 3 4 5 6
4 5 6 4 5	6 4 5 6	4 5 6	I 1	1	4 5 6	4 5 6	
7 8 9 7 8	9 7 8 9	7 8 9	<u> </u>		7 8 9	7 8 9	7 8 9
		7 8 9 1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	7 8 9	7 8 9 1 2 3 4 5 6	7 8 9





Bounds Consistency Domain Consistency Comparison

_	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
1	4 5 6	Q	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6
-	7 8 9	O	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	4	7	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9		<i>                                     </i>	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3			4 0 0	<u> </u>			7 8 9	7 8 9
	1 2 3	1 2 3	1 2 3	0			$\sim$	
4 5 6	4 5 6	4 5 6	4 5 6	l X	4 5 6	4 5 6	.3	
7 8 9	7 8 9	7 8 9	7 8 9	)	7 8 9	7 8 9	)	4
1 2 3	1 2 3		1 2 3	1 2 3				1 2 3
4 5 6	4 5 6	16	4 5 6	4 5 6	12	(2)	5	4 5 6
7 8 9	7 8 9	U	7 8 9	7 8 9	O	_		7 8 9
1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
4 5 6		4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	Q	1 2 3 4 5 6
7 8 9	3	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	O	7 8 9
				1 2 3	1 2 3		1 2 3	1 2 3
1 2 3 4 5 6	2	7	6	4 5 6	4 5 6	$\circ$	1 2 3 4 5 6	4 5 6
7 8 9	J	<i>   </i>	O	7 8 9	7 8 9	9	7 8 9	7 8 9
7 6 9	⊢—	4 0 0	4 0 0	1 0 9		4 0 0		_
	7	1 2 3	1 2 3			1 2 3	1 2 3	
	I /	4 5 6	4 5 6	$\Box$	4 5 6	4 5 6	4 5 6	4 5 6
_		7 8 9	7 8 9	)	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	4 5 6	I 1	14	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9	7 8 9			7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3 4 5 6		1 2 3 4 5 6	
1	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6		4 5 6	1 1
4 5 6	4 5 6	4 5 6						







1	1 2 3 4 5 6 <b>Q</b>	1 2 3 1 2 3 4 5 6 4 5 6	1 2 3 1 2 3 4 5 6 4 5 6	1 2 3 1 2 4 5 6 4 5
4	7 8 9	7 8 9 7 8 9	7 8 9 7 8 9	7 8 9 7 8
1 2 3	1 2 3 1 2 3	4 7	1 2 3 1 2 3	1 2 3 1 2
7 8 9	4 5 6 4 5 6 7 8 9 7 8 9		7 8 9 7 8 9	4 5 6 4 5 7 8 9 7 8
1 2 3	1 2 3 1 2 3	1 2 3	1 2 3 1 2 3	0 0
4 5 6 7 8 9	4 5 6 4 5 6 7 8 9 7 8 9	4 5 6 8 9	4 5 6 4 5 6 7 8 9 7 8 9	3 2
1 2 3	1 2 3	1 2 3 1 2 3	0 0 0	_ 1 2
4 5 6 7 8 9	4 5 6 6 7 8 9	4 5 6 4 5 6 7 8 9 7 8 9	8   2	5 4 5 7 8
1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2 3	1 2
4 5 6	<b>Q</b> 4 5 6	4 5 6 4 5 6	4 5 6 4 5 6	8 4 5
7 8 9	7 8 9	7 8 9 7 8 9 1 2 3	7 8 9 7 8 9 1 2 3	1 2 3 1 2
4 5 6	3 7	6 4 5 6	4 5 6 Q	4 5 6 4 5
7 8 9	5	7 8 9	7 8 9	7 8 9 7 8
	1 2 3	1 2 3	1 2 3 1 2 3	1 2 3 1 2
	4 5 6 7 8 9	4 5 6 7 8 9 <b>5</b>	4 5 6 4 5 6 7 8 9 7 8 9	4 5 6 4 5 7 8 9 7 8
1 2 3	1 2 3 1 2 3	1 2 3	1 2 3	1 2 3 1 2
4 5 6	4 5 6 4 5 6	4 5 6	4 5 6	4 5 6 4 5
7 8 9	7 8 9 7 8 9	7 8 9	7 8 9	7 8 9 7 8
1 2 3 4 5 6	1 2 3 1 2 3 4 5 6	1 2 3 1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6
	4 5 6 4 5 6	4 5 6 4 5 6		







	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4	5 6	2	5 6	5 6	5 6	5 6	5 6	5 6
	7 9	O	7 9	7 9	7 9	7 9	7 9	7 9
1 2 3	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3	1 2 3
4 5 6	4 5 6	4 5 6	1	7	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9			7 8 9	7 8 9	7 8 9	
1 2 3	1 2 3	1 2 3	1 2 3		1 2 3	1 2 3		
4 5 6	4 5 6	4 5 6	4 5 6	0	4 5 6	4 5 6	2	9
				Ö			5	
		7 8 9			7 8 9	7 8 9	_	_
1 2 3	1 2 3		1 2 3	1 2 3			_	1 2 3
4 5 6	4 5 6	h	4 5 6	4 5 6	K		5	4 5 6
7 8 9	7 8 9	)	7 8 9	7 8 9	)	4	)	7 8 9
1 2 3		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
4 5 6	a	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	R	4 5 6
7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	O	7 8 9
1 2 3 4 5 6				1 2 3	1 2 3		1 2 3	1 2 3
4 5 6	2	7	6	4 5 6	4 5 6	Ω	4 5 6	4 5 6
7 8 9	J	- /	U	7 8 9	7 8 9	3	7 8 9	7 8 9
		1 2 3	1 2 3		1 2 3	1 2 3	1 2 3	1 2 3
7	7	4 5 6	4 5 6		4 5 6	4 5 6	4 5 6	4 5 6
	- /	7 8 9	7 8 9	$\circ$	7 8 9	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	_	7 8 9			1 2 3
				- A	4			
4 5 6	4 5 6	4 5 6	4 5 6		4	4 5 6	4 5 6	4 5 6
7 8 9	7 8 9	7 8 9	7 8 9		_	7 8 9	7 8 9	7 8 9
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3	
4 5 6	4 5 6		4 5 6	4 5 6	4 5 6	16	4 5 6	14
7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	U	7 8 9	











		_				_	
1 2	3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
<u> </u>	6 2	5 6	5 6	5 6	5 6	5 6	5 6
7	9	7 9	7 9	7 9	7 9	7 9	7 9
1 3 1 2	3 1 2 3		ı	1 2 3	1 2 3	1 2 3	1 2 3
5 6 4 5	6 4 5 6	4	7	4 5 6	4 5 6	4 5 6	4 5 6
7 8 9 7 8	0 7 8 0		/	7 9 0	7 9 0	7 8 9	7 9 0
1 3 1 2	3 1 2 3	1 2 3		1 2 3	1 2 3	7 0 3	7 0 3
	V - V					$\circ$	0
5 6 4 5	6 4 5 6	4 5 6	18	4 5 6	4 5 6	.3	
7 8 9 7 8	9 7 8 9	7 8 9		7 8 9	7 8 9	)	_
1 3 1 2	3	1 2 3	1 2 3			_	1 2 3
5 6 4 5	6 6	4 5 6	4 5 6	Q	9	5	4 5 6
7 8 9 7 8	9	7 8 9	7 8 9	O	_		7 8 9
1 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
5 6 C	4 5 6	4 5 6	4 5 6	4 5 6	4 5 6	0	4 5 6
7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	7 8 9	0	7 8 9
1 3	7 0 3	1 0 3	1 2 3	1 2 3	7 0 3	1 2 3	1 0 3
					$\circ$		1 2 3
5 6	5   /	n	4 5 6	4 5 6	9	4 5 6	4 5 6
7 8 9			7 8 9	7 8 9	)	7 8 9	7 8 9
	1 2 3	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
フーフ	4 5 6	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5 6
_	7 8 9	7 8 9		7 8 9	7 8 9	7 8 9	7 8 9
1 3 1 2	3 1 2 3	1 2 3			1 2 3	1 2 3	1 2 3
5 6 4 5	6 4 5 6	4 5 6	I 1	1	4 5 6	4 5 6	4 5 6
7 8 9 7 8	9 7 8 9	7 8 9		4	7 8 9	7 8 9	7 8 9
1 3 1 2	3 1 2 3	1 2 3	1 2 3	1 2 3	, 3 3	1 2 3	, , ,
	-1						4
5 6 4 5 7 8 9 7 8	6 4 5 6	4 5 6	4 5 6 7 8 9	4 5 6 7 8 9	n	4 5 6 7 8 9	4
7 8 9 7 8	9 7 8 9	7 8 9	7 8 9	7 8 9		7 8 9	











_		_	_						_	_	_		_		_	_	_	_	_	_	_	_	_	_	_	_	_
1				1	2	3				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	/	1			5	6		Q		ı	5	6	ı	5	6	ı	5	6	ı	5	6	ı	5	6	ı	5	6
	T	t		7		9		U		7		9	7		9	7		9	7		9	7		9	7		9
Н			3	۲	2	3	_	2	3	Ė		_	H		_	r	2	3	Ė	2	3	Ė	2	3	Ė	2	3
ı	5		6	4	5	6	4	5	6		4			7	•	l,	5	6	١,	5	6	l,	5	6		5	6
	8		9	Г	8	9	Г.	8	9		1		ı	1		ľ	8	9	Ι.	8	9	ľ	8	9	Ι.	8	9
H		_	3	-	2	3	-	2	3	-	2	3	⊢	_	_	┢	2	3	-	2	3	⊢	<u> </u>	9	⊢	0	<u>, , , , , , , , , , , , , , , , , , , </u>
Ľ			3	Ľ		3	Ľ		- "	Ľ	_		ı	0		Ľ		- 1	Ľ		- 1	ı					
ı	5		ь	4	5	ь	4	5	6	4	5	6		റ		14	5	6	4	5	6	ı	.1		ı	/	
7	8	3	9	7	8	9	7	8	9	7	8	9	╙	$\overline{}$	_	7	8	9	7	8	9	╙	$\overline{}$		Ľ		
1			3	1	2	3		_		1	2	3	1	2	3	ı	_		ı	_		ı	_		1	2	3
ı	5	5	6	4	5	6		h		4	5	6	4	5	6	ı	Я			ソ	,	ı	Һ		4	5	6
7	8		9	7	8	9		U	'	7	8	9	7	8	9		U	'		<u>_</u>			U	'	7	8	9
1			3	г			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	П			1	2	3
	5	5	6		O	1	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	ı	Q		4	2	6
1,	8	ì	9		J	,	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	ı	U	)	7	8	9
Ħ			3	Т		_	Ė	_		Ė	_	_	Ť	2	3	ī	2	3	r	_		1	2	3	Ť	2	3
Ι.	5		6		9	)		7	•				À	5	6	L	5	6	ı			L	5	6	À	5	6
1,	٤		9		J	)		1			O		7	8	9	17	8	9		$\exists$		17	8	9	Ę	8	9
Ľ		_	9	-	_	_	-	÷	_	Η.	÷	_	۲	<u> </u>	9	H÷	_	_	-	÷	3	H	_	_	ť.	_	3
	-	1			-	,	Ľ	2	3	Ľ	2	3	ı	_		Ľ	2	3	Ľ	2	- 1	Ľ	2	3	Ľ	2	
1		/					4	5	6	4	5	6	ı	n	)	4	5	6	4	5	6	l <sup>4</sup>	5	6	4	5	6
L			_	_	4	_	7	8	9	7	8	9	L	$\sim$	_	7	8	9	7	8	9	7	8	9	7	8	9
1			3	1	2	3	1	2	3	1	2	3	ı	4		ı			1	2	3	1	2	3	1	2	3
1	5	5	6	4	5	6	4	5	6	4	5	6	ı	1		L	Δ	.	4	5	6	4	5	6	4	5	6
7	8	3	9	7	8	9	7	8	9	7	8	9				L	7		7	8	9	7	8	9	7	8	9
1		Ī	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Г	_		1	2	3	Г		
1	5	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	2	6	ı	A		4	2	6	ı	Л	
1,	8		9	7	8	9	7	8	9	7	8		7	8	9	17	8	9	ı	U	,	17	8	9	Ι'	7	٠.











_		_	_	_		_		_	_	_	_	_	_	_	_	_	_	_	_	$\overline{}$	_	_	_	_	_	_
1	-		<b> </b> 1	2		ı	_		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Ι.	Δ		ı	5	6	ı	Я		ı	5	6	ı	5	6	l	5	6	ı	5	6	ı	5	6	ı	5	6
	┪	٠.	ı			ı	U	'	7		9	7		9	7		9	7		9	7		9	7		9
г		3	Н	2		Г	2	3	Г			г			Т	2	3	Н	2	3	Г	2	3	Н	2	3
	5	6	4	5	6	4	5	6		4			7		4	5	6	4	5	6	4	5	6	4	5	6
	8	ň	Ι.	۰	۰	Ι.	۰	q		1			1		Г.	٥	a	Ι.	٥	Ä	Ι.	۰	9	Γ.		q
1	۰	3	,	2			2	3	-	0	0	-			-	2	_	-	0	9	-	•	9		•	9
Ľ		3	Ľ	5		Ш	-	- 1	Ľ	2	3		0		Ľ	-	3	Ľ.	2	3	ı	$\overline{}$		ı		
	5	6	14	5	6	14	5	6	4	5	6		X		4	5	6	4	5	6	ı	.3		ı	7	
7	8	9	L	8		7	8	9	7	8	9	L	$\overline{}$		7	8	9	7	8	9	L	$\overline{}$		L	_	
1		3	1	2		ı	_		1	2	3	1	2	3		_		П	_		ı			1	2	3
1	5	6	4	5	6	ı	ß		4	5	6	4	5	6	l	Я		ı	")	)	ı	5		4	5	6
7	8	9	ı	8		ı	U	'	7	8	9	7	8	9	ı	U	'		_	.	ı	U	'	7	8	9
1		3	Г			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Г			1	2	3
1	5	6	ı	0	١.	l.	5	6	1	5	6	À	5	6	À	-	6	À	5	6	ı	0		À	5	6
١,	8	9	ı	$\forall$	1	Ŀ	8	9	Ė	۰	9	Ŀ	Ö	9	ļ,	۰	9	Ė	8	9	ı	O	)	Ė	8	9
H		3	⊢	-	_	۲		-	ŕ		_	ť	2	3	÷	2	3	۲		-	┢	2	3	H	-	3
l'	_		ı			ı	-	,				Ľ	_	~	Ш	_					I!	_		Ш	-	~
	5	6	ı	.1		ı	/			h	)	4	5	6	4	5	6		У		14	5	6	4	5	6
7	8	9	┖	_	_	┕	•		$\perp$	$\overline{}$	_	7	8	9	7	8	9	┕	$\overline{}$		7	8	9	7	8	9
1			l	_		1	2	3	1	2	3	ı	_		1	2	3	1	2	3	1	2	3	1	2	3
1	ン	'	ı	_/		4	5	6	4	5	6	ı	h		4	5	6	4	5	6	4	5	6	4	5	6
	_		L	1		7	8	9	7	8	9		U	•	7	8	9	7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3	1	2	3	Г			Г			1	2	3	1	2	3	1	2	3
1	5	6	4	5	6	4	5	6	4	5	6	ı	1		l	Л		4	5	6	4	5	6	4	5	6
1,	8	9	ľ	8	1	Ė	8	9	Ė	8	9	ı			1	4	٠.	Ė	8	9	ŀ	8	9	ŀ	8	9
Ħ	_	3	1	2		Ħ	2	3	Ħ	2	3	4	2	3	1	2	3	ŕ	_	Ť	Ħ	2	3	۲	_	Ť
ľ	-		Ľ	5	_	Ľ	5	- "	Ľ	5		Ľ	-	-	Ľ	-	- 1	ı			Ľ	5	- 1	ı	A	
1_	5	6	14		6	14		6	4		6	14	0	6	4	5	6	ı	n	)	Iª.		6		4	
17	8	9	ı	8		I 7	8	9	7	8	9	17	8	9	17	8	9		$\overline{}$	.	I 7	8	9			











_	_		_	_		_							_			_		_	_		_	_		_	_		
ı				1	2					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ı		4		ı	5	6		Q			5	6		5	6		5	6		5	6		5	6	ı	5	6
ı	ı	Т	١.	ı				U	,	7		9	7		9	7		9	7		9	7		9	7		9
r			3	Н	2	_	Т	2	3	_			г			Т	2	3	Н	2	3		2	3	Н	2	3
ı		5	6	4	5	6	4	5	6		4		ı	7		4	5	6	4	5	6	4	5	6	4	5	6
ı		8	9	Г	8	٠	г	8	9		-1			1		Ι.	8	9	Ι.	8	9	Г.	8	9	Γ.	8	9
Н	_	<u> </u>	9	-	•	_	-	0	<u> </u>	-	_	_	⊢	_	_	-	•	-	-	<u> </u>	9	⊢	<u> </u>	9	⊢	<u> </u>	<u> </u>
ľ	۱			Ľ	_		1		_	Ľ						1			Ľ.	_			$\overline{}$		ı		
ı		5	6	4	5	6	4	5	6	4	5	6		X		4	5	6	4	5	6		.3		ı	7	
1	7_		9	ᆫ		_	7		9	7		9	ᆫ	_	_	7		9	7		9		$\overline{}$	_	ш	_	_
1	1		3	1	2					1	2	3	1	2	3				ı				_		1	2	3
ı		5	6	4	5	6		6		4	5	6	4	5	6		Я			")	)		5		4	5	6
ŀ	7	8	9	ı	8			U	'	7	8	9	7	8	9		U	'		_	.		V	'	7	8	9
Г	1		3	Г		T	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				1	2	3
ı		5	6	ı	$\mathbf{C}$	١.	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6		0		4	2	6
Ŀ	,	8	9	ı	J	,	7	8	9	7	8	9	Ė	8	9	7	8	9	7	8	9		O	)	1	8	9
H	_	Ť	3	⊢		_	÷	_	Ť	۲	_	_	Ė	2	3	÷	2	3	۲	_	Ť	-	-	3	÷	2	3
Ľ	١	5	6	ı		,		-	,				Ш	5		Ш	5	6				Ш	2	6	ш	5	6
I.				ı	.5			/			n	)	14		6	4		- 1		9		4			4		
4	<u>_</u>	8	9	⊢	$\overline{}$		_	-	_	_	$\overline{}$		7	8	9	7	8	9	⊢	$\overline{}$		7	8	9	7	8	9
ı		_		ı	_		1	2	3	1	2	3	ı	_		1	2	3	1	2	3	1	2	3	1	2	3
ı	ď	ン		ı	_/		4	5	6	4	5	6	ı	5	1	4	5	6	4	5	6	4	5	6	4	5	6
L	-			Ш	1		7	8	9	7	8	9		<u> </u>	_	7	8	9	7	8	9	7	8	9	7	8	9
П	1		3	1	2		1	2	3	1	2	3	Γ						1	2	3	1	2	3	1	2	3
ı		5	6	4	5	6	4	5	6	4	5	6	ı	1			Л		4	5	6	4	5	6	4	5	6
Ŀ	7	8	9	ı	8		7	8	9	7	8	9	ı				7	•	7	8	9	7	8	9	7	8	
F	1	Ť	3	7	2	_	Ť	2	3	Ť	5	3	1	2	3	1	2	3	Ė	_	_	Ť	_	3	Ė	_	Ť
Г	٠.	5	6	4	5	6	ı,	5	6	ı,	5	6	L	5	6	4	2 5	6	ı		١.	L.	2	6	ı	А	
1		8	9	Ι,	8	U	7	8	9	7	8	9	Ľ	8	9		8	9	ı		)	7	8	9		4	











_		_	_	_		_		_	_	_	_	_	_	_	_	_	_	_	_	$\overline{}$	_	_	_	_	_	_
			1	2		ı			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
١.	Л		ı	5	6	ı	Q			5	6		5	6		5	6		5	6	ı	5	6	ı	5	6
	┑	٠.	ı			ı	U		7		9	7		9	7		9	7		9	7		9	7		9
		3	Н	2		г	2	3	Т			г			Т	2	3	Н	2	3	г	2	3	Н	2	3
	5	6	L	5	6	l,	5	Ĭ		4			7	•	4	5	6	١,	-	6	l,	Ē	6		-	6
	8	9	ľ	8	٠	ľ	J	9		-1		ı	1		7	8	9	Ι.	8	9	ľ	8	9	Ι.	8	9
-	<u> </u>	9	١,	<u> </u>	_	┝	_	<u> </u>	-	_	_	⊢	_	_	-	<u> </u>	-	-	<u> </u>	9	⊢	<u> </u>	9	⊢	<u> </u>	<u> </u>
1	_		Ľ			Ľ			Ľ						Ш	_		Ľ.	_		ı	$\overline{}$		ı		
	5	6	14	5	6	4	5		4	5	6		X		4	5	6	4	5	6	ı	.3		ı	7	
7		9	L			L		9	7		9	L	_		7		9	7		9	Ц	_			_	
1		3	1	2		ı	_		1	2	3	1	2	3		_		П	_		ı			1	2	3
	5	6	4	5	6	ı	R		4	5	6	4	5	6		Q			7	)	ı	勽		4	5	6
7	8	9	ı	8		ı	U		7	8	9	7	8	9		U	'		_	.	ı	U	'	7	8	9
1		3	i			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3				1	2	3
-	5	6	ı	0	١.	À	5		1	5	6	À	5	6	4	-	6	À	5	6	ı	0		À	5	6
١,	8	9	ı	$\exists$	1	Г	٠	9	7		9	Ę		9	7	۰	9	Ę	8	9	ı	О	)	7	8	9
÷		3	⊢	-	_	⊢	_	-	ŕ		_	ť	<del>-</del>	÷	÷	-	3	۲		-	┢	_	3	H	-	÷
1	2		ı			ı	-	,				Ľ		3	Ш						I!	-	- 1	Ш	-	3
	5	6	ı	.1		ı	/			n	)	4	5	6	4	5	6		У		14	5	6	4	5	6
7	8	9	┖	_	_	L	•		Н	_	_	7	8	9	7	8	9	┕	$\overline{}$		7	8	9	7	8	9
1	_		ı	_		1	2	3	1	2	3	ı			1	2	3	1	2	3	1	2	3	1	2	3
	ン	'	ı	_/		4	5		4	5	6	ı	4		4	5	6	4	5	6	4	5	6	4	5	6
	_		L	1				9	7	8	9		U	,	7	8	9	7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3	1	2	3	Г						1	2	3	1	2	3	1	2	3
1	5	6	4	5	6	4	5		4	5	6	ı	1			Л		4	5	6	4	5	6	4	5	6
7	8	9	ľ	8	-	ľ	Ť	9	7	8	9	ı	П			4		7	8	9	17	8	9	7	8	9
Ė	_	3	1	2		1	2	3	Ħ	2	3	4	2	3	4	2	3	ŕ	_	Ť	Ħ	2	3	۲	_	_
١.	5	6	Ľ	5	6	l۵	5	٦	4	5	- 7	Ľ	ź	6	Ľ	ź	6	ı		١.	Ľ	5	6		1	
L			ľ	~	Ö	ľ	5			~	6	14	0		14	8		ı	O	)	Ľ				4	
17	8	9		8				9	7	8	9	- 7	8	9	· 7	- 8	9		_		- 7	8	9			









**Helmut Simonis** 

	1 2	_	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
1 /	5 6	Q	5 6	5 6	5 6	5 6	5 6	5 6
-		O	7 9	7 9	7 9	7 9	7 9	7 9
	2	2 3	_		2 3	2 3	2 3	2 3
5		2 3 4 5	4	7	4 5 6	4 5 6	4 5 6	4 5 6
				/				
	8	. 9				8 9	8 9	8 9
1	1	1	1	_	1	1	_	
5 (		4 5	4 5 6	X	4 5 6	4 5 6	- 3	ーン
7	)	9	7 9	U	7 9	7 9	)	
1 :	1		1 3	1 3				1 3
	4	16	4	4	Q	2	5	4
7 9	ď	U	7 9	7 9	O		J	7 9
1 :		1 2 3	1 2 3	1 2 3	1 2 3	1 2 3		1 2 3
5 (		4 5	4 5 6	4 5 6	4 5 6	4 5 6	0	1 2 3 4 5 6
7 8	_	] 9	7 8 9	7 8 9	7 8 9	7 8 9	0	7 8 9
1 :		-	7 0 3	1 2 3	1 2 3	1 0 3	1 2 3	1 2 3
		7				$\circ$		
5 (	- 1	/	h			9		
7 8 9		-		7 8 9	7 8 9	)	7 8 9	7 8 9
	_	1 2 3	1 2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
1つ	1 7	4 5	4 5 6	5	4 5 6	4 5 6	4 5 6	4 5 6
_	<i> </i>	9	7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9
1 :	1 2	1 2 3	1 2 3			1 2 3	1 2 3	1 2 3
5 (		4 5	4 5 6	1	1	4 5 6	4 5 6	4 5 6
7 8		9	7 8 9		4	7 8 9	7 8 9	7 8 9
1 :	-	1 2 3	1 2 3	1 2 3	1 2 3	. ,	1 2 3	
			1 2 3			0	4 5 6	1
5 (			4 5 6		4 5 6	n		4
7 8 9	8	9	7 8 9	7 8 9	7 8 9		7 8 9	•











4	1 2	_	2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4	5 6	l X	5	5 6	5 6	5 6	5 6	5 6
		0	7 9	7 9	7 9	7 9	7 9	7 9
3	2	2 3			2 3	2 3	2 3	2 3
5.6	4 5 6	4 5	1	7	4 5 6	4 5 6	4 5 6	4 5 6
8 9	8	9			8 9	8 9	8 9	8 9
1	4	4		-	4	4	0 3	0 3
	l:	11.			l:	l:	$\circ$	
5 6	4 5 6	4 5	4 5	l X	4 5 6	4 5 6	.3	
7 9		9	7 9	)	7 9	7 9	)	_
1 3	1		3	1 3				1 3
	4	16	4	4	$\mathbf{g}$	(2)	5	4
7 9	l	U	7 9	7 9	O	_		7 9
1 3	i	1 2 3	2 3	1 2 3	1 2 3	1 2 3	i	1 2 3
5 6	$\circ$	1 2 3	4.5	4 5 6	4 5 6	4 5 6	0	4 5 6
7 8 9	9	9	7 9 0	7 9 0	7 9 0	7 9 0	0	7 9 0
1 3			7 0 3	1 2 3	1 2 3	7 0 3	1 2 3	1 2 3
	0	_				$\circ$		. 2 0
5 6	1.5	/	n	4 5 6	4 5 6	9	4 5 6	4 5 6
7 8 9		-	)	7 8 9	7 8 9	)	7 8 9	7 8 9
		1 2 3	2 3	_	1 2 3	1 2 3	1 2 3	1 2 3
しつ	<i>7</i>	4 5	4 5	5	4 5 6	4 5 6	4 5 6	4 5 6
_	<i>    </i>	9	7 8 9		7 8 9	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5	4 5	4	1	4 5 6	4 5 6	4 5 6
7 8 9	8	9	7 8 9		14	7 8 9	7 8 9	7 8 9
	_	_		<del>                                     </del>	<del></del>	1 8 9		1 8 9
1 3	1 2	1 2 3 4 5	2 3	1 2 3	1 2 3		1 2 3	4
5 6	4 5 6		4 5	4 5 6	4 5 6	h	4 5 6	4
7 8 9	8	9	7 8 9	7 8 9	7 8 9	$\mathbf{O}$	7 8 9	-











_			_	_		_	_			_		_				_		_	_		_	_		_	_		_
ı		4		1	2 5			_		ı	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	4	4	.	ı	5	6	Ι.	Я		ı	5			5	6		5	6		5	6	ı	5	6		5	6
L	_	7						U	'	7		9	7		9	7		9	7		9	7		9	7		9
Γ			3	Г	2			2	3	Г			Г			Г	2	3	Г	2	3	Г	2	3		2	3
		5	6	4	5	6	4	5		ı	1			7		4	5	6	4	5	6	4	5	6	4	5	6
		8	9	ı	8				9	ı	п			1			8	9		8	9	ı	8	9		8	9
F	1			1			1			Г			Т			1			1			Г			Г		
ı		5	6	4	5	6	4	5		4	5			Q		4	5	6	4	5	6	ı	2			റ	
Ь	7		9	ı					9	7		9		U	)	7		9	7		9	ı	J	)		_	
F	1		3	1			Т			Н		3	1		3	Ė			Ė			H			1		3
				4				A		4			4				Q			7	)	ı	ᆮ		4		
Ь	7		9	Г				U	'	7		9	7		9		U	)		_	.	ı	U	'	7		9
7	1		3	Г			1	2	3	Г	2	3	1	2	3	1	2	3	1	2	3	Г			1	2	3
		5	6	ı	O	١	4	5		4	5		4	5	6	4	5	6	4	5	6	ı	Q		4	2	6
Ь	7			ı	J	'				7			7			7			7			ı	U	)	7		
F	1		3	Г			Г			г			1	2	3	1	2	3	Т			1	2	3	1	2	3
		5	6	ı	2			7	'	Ι.	C		4	5	6	4	5	6		O		4	5	6	4	5	6
Ь	7	8	9	ı	J	)		1		ı	U	)	7	8	9	7	8	9		J	,	17	8	9	7	8	9
r		-		Н			1	2	3	Н	2	3	-	_		Ť	2	3	1	2	3	Ť	2	3	Ť	2	3
1	1	7		ı	7	•	۵	2	1	I_	2 5	1		匚		4	5	6	۵	5	6	۱	5	6	۱	5	6
1	1	4		ı	1		ľ	٠	9	7	8	9		U	)	7	8	9	7	8	9	ŀ	8	9	7	8	9
t	1		3	1	2	$\overline{}$	1	2	3	ŕ		3	_		_	÷	_	Ť	Ť	2	3	Ħ	2	3	Ħ	2	3
1	٠.	5	6	à	5	6	4	5	٦	4	2	J		4			А		À	5	6	L	5	6	الما	5	6
1.	,	8	9	ľ	8	٦	ľ	,	9	7	8	9		1			4		7	8	9	ļ,	8	9	7	8	9
۲	<del>′</del>	0	3	1	2	_	1	_	3	۲	2	3	1	2	3	-	-	3	۲	•	-	H		3	۲	0	3
1	1	5	- 1	4	5	6	4	2		4	5	3	4	5	6	Ľ	5	6				Ľ	2 5	6	ı	A	
			6	- 4		·οι																					









_		_	_		_	_		_	_	_	_	_		_	_	_	_	_	_	_	_	_	_		_	_
			1	2		ı				2	3		2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Л		ı	5	6	ı	Q			5				6		5	6		5	6		5	6	ı	5	6
'	┑	٠.	ı			ı	U		7		9			9	7		9	7		9	7		9	7		9
г		3	Н	2		г	2	3				Т				2	3	Т	2	3	Т	2	3	Н	2	3
	5	6	4	5	6	l <sub>a</sub>	5	Ĭ		4			7	٠	4	5	6	4	5	6	4	5	6	4	5	6
	8	9	Γ.	8	۲,	Ι.	٠	9		н			1		Г.	8	9	Γ.	8	9	Ι.	8	9	Γ.	8	9
H	8	9	H	0	_	H		9	⊢	-	_	⊢	-	_	H	0	9	÷	0	9	⊢	8	9	⊢	0	9
ľ			11			Ľ			L				<u></u>		11			п				$\overline{}$				
	5	6	4	5	6	4	5		4	5			X		4	5	6	4	5	6		[3		ı	ン	'
7		9						9	7		9		V	'	7		9	7		9		V	_		<u> </u>	
1		3	1			Γ					3	Γ		3	1			Γ			Γ	Ξ		1		3
			4			ı	A		4			4				Q			り	)		勽		4		
7		9	ı			ı	U	'	7		9			9		U	'		_	.		U	'	7		9
1		3	Г			1	2	3		2	3		2	3	1	2	3	1	2	3				1	2	3
	5	6	ı	വ	ш	4	5		4	5		4		6	4	5	6	4	5	6		Q		4	2	6
7			ı	J		ı			7						7			7				U	)	7		
'n		3	1			•							2	3	1	2	3	Ė			1	2	3	i	2	3
Ľ	5	6	ı	9		ı	7	,	١.			١,	-	6	l.	Ē	6		0		l.	Ē	6	L.	Ē	6
7	8	- 1	ı	ฉ	)	ı	/			n		1"			2	5	0		У		-	0	0	12	5	0
	8	9		_			-			_				9	/	8	9		_		7	8	9	/	8	9
1			ı	_	,	I1	2	3		2	3		_		1	2	3	1	2	3	1	2	3	1	2	3
1	ン	'	ı	/		4	5		4	5			h		4	5	6	4	5	6	4	5	6	4	5	6
	<u> </u>		Ш	•				9	7	8	9		<u> </u>		7	8	9	7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3		2	3				Г			1	2	3	1	2	3	1	2	3
1	5	6	4	5	6	4	5		4	5			1		l	Л		4	5	6	4	5	6	4	5	6
17	8	9	ľ	8	1	ľ		9	7	8	9					+		7	8	9	7	8	9	7	8	9
Ħ	_	3	1	2		1	2	3	Т	2	3	Т	2	3	1	2	3	Т	_		1	2	3	Г	_	
ľ	5	6	4	5	6	4	5	٦	4	5	٦	4	-	6	L.	5	6			١.	4	5	6	ı	А	
l,	8	9	ľ	8	٥	ľ	3	9		8	9	ľ		9	Ι,	8	9		O	)	7	8	9		4	
1/	o	∌∣		o				ଅ	7	o	9			ଅ	7	o	9		_		- /	o	∌∣		-	







**Helmut Simonis** 

4	1 2 5 6		2 3	2 3	1 2 3	1 2 3	1 2 3	1 2 3
14	5 6	R	5	6	5 6	5 6	5 6	5 6
		)	7 9	9	7 9	7 9	7 9	7 9
3	2	2 3 4 5			2 3	2 3	2 3	2 3
5 6	4 5 6	4 5	1	7	4 5 6	4 5 6	4 5 6	4 5 6
8 9	8	9		- /	8 9	8 9	8 9	8 9
1	1	1			1	1		
5 6	4 5 6	4 5	4 5	Q	4 5 6	4 5 6	2	2
7 9		9	7 9	O	7 9	7 9	J	
1 3	1		3	3				1 3
	4	6	4	4	Q	2	5	4
7 9	1	O	7 9	9	O	_	J	7 9
1 3	_	1 2 3	2 3	2 3	1 2 3	1 2 3		1 2 3
5 6	a	4 5	4 5	4 6	4 5 6	4 5 6	Q	4 5 6
7	9		7		7	7	O	7
1				2	1 2		1 2	1 2
5	2	7	6	4	4 5	Ω	4 5	4 5
8	J	/	O		8	9	8	8
		1 2 3	2 3		1 2 3	1 2 3	1 2 3	1 2 3
2	7	4 5	4 5	5	4 5 6	4 5 6	4 5 6	4 5 6
_	/	9	7 8 9	J	7 8 9	7 8 9	7 8 9	7 8 9
1 3	1 2	1 2 3	2 3			1 2 3	1 2 3	1 2 3
5 6	4 5 6	4 5	4 5	4	1	4 5 6	4 5 6	4 5 6
7 8 9	8	9	7 8 9		4	7 8 9	7 8 9	7 8 9
1 3	1 2	_	2 3	2 3	1 2 3	, 3 3		, 5 5
5 6	4 5 6	1 2 3	2 3 4 5	4 6	4 5 6	C	1 2 3 4 5 6	1







_		_	_			_		_	_	_	_	_				_				_			_			_
			1	2		ı				2	3		2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Л		ı	5	6	ı	Q			5				6		5	6		5	6		5	6		5	6
'	┑	٠.	ı			ı	U	'	7		9			9	7		9	7		9	7		9	7		9
г		3	Н	2		г	2	3				Т				2	3	Н	2	3	Т	2	3	Т	2	3
	5	6	4	5	6	l <sub>a</sub>	5	Ĭ		4			7	١.		5	6	4	5	6	4	5	6	4	5	6
	8	9	Γ.	8	۰	Ι.	٠	9		н			/			ŭ	9	Ι.	8	9	Ι.	8	9	Γ.	8	9
-	<u> </u>	9	-	<u> </u>	_	┢	_	<u> </u>	⊢	_	_	⊢	_	_	Η,	_	,	-	<u> </u>	9	⊢	<u> </u>	9	⊢	<u> </u>	<u>, , , , , , , , , , , , , , , , , , , </u>
l'	_		Ľ	_		I !			L			Ι.	$\overline{}$		'			Ľ.	_			$\overline{}$		Ι.		
	5	6	4	5	6	14	5		4	5			X			5	6	4	5	6		.3			7	'
7		9	ᆫ			ᆫ		9	7		9	_	$\overline{}$		7		9	7		9	Ц	$\overline{}$	_	_	_	
1		3	1			ı					3			3				ı	_			_		1		3
			4			ı	6		4			4				Я			ワ	)		5		4		
7		9	ı			ı	U	'	7		9			9		U	'		_	.		V	'	7		9
1		3	г			1	2	3		2	3		2	3	1	2	3	1	2	3				1	2	3
	5	6	ı	0	١.	l <sub>a</sub>	5		4	5		4		6		5	6	4	5	6		0		4	5	6
7	-	- 1	ı	J	1	Г	-		7	7		l i			7	7	-	1	7	- 1		O	)	7	7	
H			⊢			Н		_	Ė			⊢	2	_	Ť	_	$\overline{}$	۲		_	4	2	_	÷	2	
Ι'	5		ı			ı	7	,	١.			١,	-		١.	2 5		ı			ľ	5		L	5	
			ı	J	)	ı	/			n		Г.				9			9		1			-	5	
_	8			_			-			_									_		L	8			8	
			ı	٠,	,	I1	2	3		2	3	ı	_		1	2	3	1	2	3	1	2	3	1	2	3
	ン	'	ı	/		4	5		4	5			<b>'</b>		l	5	6	4	5	6	4	5	6	4	5	6
	_		L	-		L		9	7	8	9	Ľ	V		7		9	7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3		2	3							1	2	3	1	2	3	1	2	3
1	5	6	4	5	6	4	5		4	5			1		l	Л		4	5	6	4	5	6	4	5	6
7	8	9	ı	8		ı		9	7	8	9				1	۲		7	8	9	7	8	9	7	8	9
Ħ	_	3	4	2		4	2	3	H	2	3	Н	2	3	1	2	3	Ė	_	_	Ť	2	3	H	_	_
ľ	5	6	4	5	6	١ż	5	٦	4	5	٦	١,	-	6	ľ	5	6	ı		١.	L	5	6	ı	А	
١.,	8		Ι,	8	o	Ι"	3		٠.	8		Ι".		9	١.,	3	9	ı	O	)	Ľ	8	9	1	4	
1/	ರ	9		ರ				9	7	ರ	9			91	- /		9		_		- /	ರ	9			







**Helmut Simonis** 

_		_	_			_		_	_		_			_		_						_	_		
			1	2		Г	_			2	3	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Л		ı	5	6	ı	Q			5			6	ı	5	6		5	6		5	6		5	6
1	4	٠.	ı			ı	U	)	7		9		9	7		9	7		9	7		9	7		9
Н	_	3	⊢	2	_	Н	2	3	Ė	_	Ť	-	Ť	H	2	3	÷	2	3	÷	2	3	Ė	2	3
	_	- 1	١.	5	_	١.	5	٦		Ä		-	7	ı	5		١.			١.		- 1	١.		
	5	6	4		6	14	5			П		<b> </b> /		ı	5	6	4	5	6	4	5	6	4	5	6
_	8	9	ᆫ	8		ᆫ		9	┖	-		_		ᆫ		9	_	8	9	_	8	9	ᆫ	8	9
1			1			1						_		1			1							_	
	5	6	4	5	6	4	5		4	5		2	2	ı	5	6	4	5	6		2			り	
7		9	ı			ı		9	7		9		)	7		9	7		9		U	'		_	
Ħ		3	1			Г			Г		3		3	Г			Т			Т			1		3
1		1	۱			ı	6		4		-	4	ŭ	ı	0			9	)				l.		-
١,		9	Ι"			ı	U	)	7		9	7	9	ı	O	)		Z			U	)	7		9
ı÷			⊢			H	÷	_	_	_		Η.	_	H	÷	_	H	_	_	_	_	_	Ľ.	_	
1		3	ı			1	2	3		2 5	3	2		11	2	3	1	2	3		$\overline{}$		1	2 5	3
	5	6	ı	U	)	4	5		4	5		4	6	ı	5	6	4	5	6		×		4	5	6
7				V					7					7			7				U	_	7		
1			Г	_		Г				_		2		1	2		г	_	$\neg$	1	2		1	2	
	5		ı	2		ı	7	'		A		4		ı	2 5			O	١	4	5		4	5	
	8		ı	J	)	ı	1		1	U	1			ı				J	'		8			8	
Н	Ť	_	⊢			1		3	Н		3	-		1		-	7		-	7	Ť	3	1	Ť	2
			ı	$\overline{}$		Ľ		٥	١.		3			ľ		٥	Ľ		0	Ľ		- 1	Ľ		3
	_		ı	/		ľ			4				)	ı		6	4		6	4		6	4		6
ш		_	⊢	-		╙	_	9	╙	8	9	_		⊢		9	_	8	9	_	8	9	╙	8	9
1		3	1	2		1	2	3		2	3			ı			1	2	3	1	2	3	1	2	3
1	5	6	4	5	6	4	5		4	5		- 1		L	Δ		4	5	6	4	5	6	4	5	6
7	8	9	ı	8		ı		9	7	8	9			ı	Т		7	8	9	7	8	9	7	8	9
1		3	1	2		1	2	3		2	3	2	3	1	2	3	Т			1	2	3	Г		
1	5	6	4	5	6	4	5	1	4	5	-	4	6	ľ	5	6				4	5	6	ı	Л	
L	8	9	ľ	8	o	ľ	3	9	7	8	_	ļ.,	9	I,	3	9		O	)	7	8	9	1	4	
1/	o	91		o				<b>9</b>	- /	o	9		9	- /		ਤ		_		- /	o	∌∣		-	









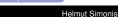


_			_					_	_					_					_	_		_	_		_
	-		1	2 5			_			2	3		2 3	1	2	3	1		3	1	2	3	1	2	3
	4	.		5	6		X			5			6		5	6		5			5	6		5	6
L	_ •		╙			_	<u> </u>		7		9	_	9	7		9	7			7		9	7		9
		3		2			2	3		á		-	,		2	3			3		2	3		2	3
	5	6	4	5	6	4	5			1					5	6	4	5		4	5	6	4	5	6
H	8	9	Ļ	8		Ļ		9	⊢	÷		_		Ļ		9	Ļ	8	_	╙	8	9	⊢	8	9
1			1			1			١.				`	ľ			11			١.,	$\overline{}$		Ι.	$\overline{}$	
L	5	6	4	5	6	4	5		4	5		ح ا	<b>ጎ</b>	L	5	6	4	5		Ι,	.3			/	
7		9	Ŀ			L		9	7		9	_	_	7		9	7			⊢	$\overline{}$	_	Ľ		_
1		3	1						١.		3		3		0		Ι.				_		1		3
L			4				n	)	4		_	4			റ		Ι.	_			<b>:</b>		4		
4		9	⊢			Η.	Ť	_	7	_	9		9	Ļ	Ţ	_	Η.		_	⊢	~	_	4	_	9
1	_	3	Ι.			1	2	3	١.	5	3		2 3	ľ	5	3	п	2	3	١.	0		1	2	3
L	5	6		9		4	5		4	5		4	6	L	5	6	4	5			റ		4	5	6
Ľ.		_	⊢	Ĭ		⊢		_	7		_	_	_	¥.	_	_	7		_	Ļ	Ť	_	4	_	-
Р	-			0			_		Ι.			L.	2	1	2		Ι.			11	5		11	2	
	5 8			J	)		/			O		4			Э			9		4	8		4	8	
Н	- 0	_	⊢	Ĭ		-	÷	3	⊢	Ĭ	3	-		Ļ		3	┝	Ť	3	-	0	_	Н	0	_
				7		Ľ		3	l.		3	1		ľ		6	Ľ		3	Ľ		3 6	Ľ		6
	_		ı	/		4			4		_	1	)			- 1	4			4		٥	4		٥
1		3	4	2		1	2	9	H	2	3			H		9	1	8	3	1	2	3	4	2	3
ľ	5	6	Ľ	5	6	4	5	٥		2	3		1	ı	А		Ľ	5	٥	Ľ	2	6	Ľ	-	9
١,	8	٥	Ι*	٥	o	1	3	9	Ę	8	۸	l	ı	ı	4		١,	8		١,	٥	٥	Ę	٥	Š
4	8	3	4	2		4	2	3	-	2	3		2 3	4	-	3	<del>-</del>	0		4	2	3	<del>-</del>	0	9
ľ	5	6	4	5	6	4	2	3	١,	5	3	۱, ۱	23 6	ľ	5	6	L	C		Ľ	5	6	ı	Ä	
Ļ	8	9	l*	8	0	1*	э	9	7	8	9	*	9	Ļ	9	9	ı	O	)	7	8	9	1	4	
	0	9		0				<b>3</b>	• •	o	J		9			9		_		•	o	9			- 1









						_								_	_						_		
	- 1	1 2		ı				2	3	2	3	1	2	3	1		3	1	2	3	1	2	3
1.7	- 1	5	6	ı	Q			5			6	ı	5	6		5			5	6		5	6
	- 1				U	'	7		9		9	7		9	7			7		9	7		9
	3	2		Н	2	3	Ė					r	2	3	Ė		3	_	2	3	_	2	3
5	6	2 4 5	6	4	2	Ĭ		4		7	7	ı	5	6	١,	5	٦	4	5	6	4	5	6
8		4 5 8	0	Ι"	9			н		l /		ı	9		7			*	8		4		- 1
_	9			Ļ		9	Н	-		_	_	H		9	-	8	_	_	8	9	_	8	9
1	- 1	1		11								1			1				_			$\overline{}$	
5	6	4 5	6	4	5		4	5		×		ı	5	6	4	5			3			ン	
7	9					9	7		9	)	•	7		9	7				V			<u>_</u>	
1	3	1		Г			Г		3		3	Г			Г			Т		_	1		3
	- 1	4			മ		4			4		ı	Q			つ			ᆮ		4		
7	9			ı	U	'	7		9		9		U	1		_			U	'	7		9
1	3			1	2	3		2	3	2	3	1	2	3	1		3				1	2	3
5	6	$\mathbf{C}$	1	4	2		4	2 5		4	6	ı	2	6	4	5			Q		4	2	6
7	1	ਹ	,	Г	7		7	7				۱,	7		1	7			O		7	7	1
4	╅			⊢		$\overline{}$	Ė			2	_	Ħ	_		÷		_	1	2	_	Ť	_	$\dashv$
Ι' -	- 1				7		١.			٠, ٢		Ι'	2 5		١.			4	2 5		4	2	
5	- 1		)	ı	/			n		4		ı	э			У		4			4		
8	4	_	_	╙	-	_	_	_				╙		_	_	~	_	_	8	_	_	8	_
1	- 1			1		3			3	_	.	1		3	1		3	1		3	1		3
レン	- 1	_/		4			4			<i> </i> -		ı		6	4			4		6	4		6
_						9		8	9	)	,			9		8			8	9		8	9
	3	2		Г	2	3		2	3			Г					3		2	3	Г	2	3
5	6	5	6	ı	2 5			5		1		ı	Л			5			5	6		5	6
7 8	9	8	Ĭ	ı	Ĭ	9	7	8	9	l		ļ '	4	١.	7	8		7	8	9	7	8	9
1	_	1 2		1	2	3		2	3	2	3	1	2	3				1	2	3	Т		
5		45	6	l.	5	- 1	4	5	-	4	6	ľ	2	6	١.	C		4				Л	
7 8	9	- 3 8	٥	Ι,	J	9	7	8	9	7	9	۱,	٥	9		U		7	5 8	6 9		4	١.







	á		1	2			$\overline{}$			2	3	2		1		-	1		3	1	2		1		3
Z	4	.	ı	5	6	Ι.	X			5				ı	5	- 1		5				- 1		5	6
	4		Ц			Ш	$\overline{}$	_	7		9		9	7			7			7		9	7		9
		3	ı	2			2	3		4		_		ı	2	3			3		2			2	3
	5	6	4	5	6	4	5			1		7		ı	5	6	4	5		4		6	4	5	6
	8	9		8				9		4		-				9		8				9		8	9
Г			1			1								1			1				_			_	
	5	6	4	5	6	4	5		4	5		Q	)	ı	5	6	4	5			ጊ			n	)
7		9	ı					9	7		9		,	7		9	7				U	'	-	_	
Г		3	1			П					3		3	Г			Т	_		П			1		3
		Ġ	4			ı	A		4			4		l	Q			7	)		勽		4		
7		9	ı				U		7		9		9	ı	U	)		_	.		U	'	7		9
Г		3	Г			1	2	3		2	3	2	3	1	2	3	1		3				1	2	3
	5		ı	വ	١	4	5		4	5		4		ı	5		4	5			Q		4	5	6
7			ı	J	'				7					7			7			1	U	'	7		
Т			Г			Г			Г			2		1	2		Т			1	2		1	2	
	5		ı	2			7	'		A		4		ı	5			വ	М	4			4	5	
	8		ı	U	)		1			U				l				J						8	
	_		Г			1		3	Т		3			1		3	1		3	1			1		3
4	7	)	ı	7	'	4			4		Ť			1			4		1	4		6	4		6
4	4	.	ı	1		ľ		q	ľ	8	q	Ü	)	ı			ľ	R		ľ			ľ	8	9
_		3	Н	2	$\overline{}$	Н	2		Н			-		Н		Ť	Н	_	3	$\vdash$	2	Ť	_		3
	5	- 1	ı	5	6		5	1			Ĭ	- 4		ı	1			5	1	ĺ	-	6		5	6
,	т.	- 1	ı		٦	ı	٠	q	7		q				4		7			7		- 1	7		9
ī	,		1			1	2		ŕ			2	3	1	2	3	ŕ	,		1	2	_	ŕ	_	_
		- 1	4	÷	_	4	Ξ.	٦,	L	5	٦	4	6	ľ	Ξ.	6	١.			I:	-	_	ı	А	
	5	6			6																	6			
	7	8 5 7 7 5 8 8 2 2 7 8	5 6 8 9 5 6 7 9 5 6 7 8 9 5 6 7 8 9	5 6 4 8 9 1 5 6 4 7 9 1 4 7 9 1 3 1 4 7 9 1 3 5 6 7 8 9	5 6 4 5 8 9 8 8 1 5 6 4 5 5 6 8 9 8 8 9 8 8 8 1 8 1 8 1 1 1 1 1 1 1 1	3 2 5 6 4 5 6 8 9 8 8 9 8 8 9 8 9 8 9 9 8 9 9 9 9 9	3 4 5 6 4 8 9 8 8 1 5 6 4 5 6 4 7 9 3 1 3 1 4 7 9 4 5 6 9 4 2 7 4 2 7 4	3 4 5 6 4 5 8 9 8 8 9 8 8 9 8 8 9 8 8 9 8 8 9 8 9	3 2 2 3 4 5 6 4 5 9 4 5 6 4 5 9 4 5 6 4 5 9 4 5 6 4 5 9 4 5 6 4 5 9 4 5 6 4 5 9 4 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	3 2 2 3 5 6 4 5 6 4 5 9 5 6 4 5 6 4 5 9 5 6 4 5 6 4 5 9 7 9 1 6 4 5 4 7 9 1 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	3	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	4 5 6 8 7 5 9 6 7 5 9 7 5 5 5 6 8 7 5 9 7 9 8 7 5 9 7 5 9 7 5 9 8 9 7 9 9 8 1 5 6 4 5 8 8 1 5 6 4 5 8 1 5 8 1 5 6 4 5 8 1 5 8	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$











$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$								
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		1 2		2 3		1 3	1 2	1 2 3
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		5 6	<b>Q</b> 5	6	5 6	5	6	5 6
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			$O_{7}$	9	7 9	7	7 9	7 9
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	3	2	2 3			3	_	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		4 5 6 4	5 1	7				
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				/				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1	_	-	+-	1			- 6 3
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	٠ - ٥		- 4-	0			2	$\circ$
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		4 5 6 4		lδ			.5	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		oxdot			7 9	7		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 3	1	$\sim 1$	3			_	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		4	6 I4	4	l X	ーン	っ	4
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	7 9			9	)	_		7 9
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 3	1	2 3 2 3	2 3	1 2 3	1 3		1 2 3
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	5 6	$\bigcirc$ 4	5 4 5		5.6	4 5	Q	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	7	9			7		O	7
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	4	-		2	1 2	_	1 2	
2 7 4 9 4 9 5 6 4 4 6 4 8 8 9 8 8 9 8 9 8 8 9 9 8 9 9 8 8 9 9 9 8 8 9 9 8 9 9 8 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 8 9 9 9 8 9 9 9 8 9 9 9 8 9 9 9 8 9 9 9 9 8 9	8	' <u>-</u> '	2	7 6	1, 2	l'	$\cap$	L' -	
2 7 1 3 4 3 5 1 3 1 3 1 6 4 6 8 9 8 9	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		5	I		3	9	4	
2 7 4 9 4 8 9 5 6 4 8 4 6 4 6 8 9	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	- 6			+			<u> </u>	
<b>2</b>	3 2 2 3 2 3 3 4 5 5 6 5 6 5 7 8 9 8 9 7 8 9 1 4 7 8 7 9 7 8 9 1 3 1 2 1 2 3 2 3 2 3 1 2 3		<b>→</b> 1	3	·		1 3	1	1 3
	3     2     2     3     2     3     2     3     2     3     2     3     2     3     2     3     2     3     5     6     5     6     5     6     5     6     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     7     8     9     9     8     9 <th></th> <th>4</th> <th>4</th> <th>15</th> <th></th> <th>4</th> <th></th> <th></th>		4	4	15		4		
3 2 2 3 2 3 3 2 2 3 5 6 5 6 5 6 5 6	5 6     5 6     5 6     5 5     5 7 8 9     1     4     5 6     7 8 9	_				9	8	9	
56 56 5 5 5 1 1 1 5 6 56	7 8 9 8 9 7	3	2	2 3 2 3	3		3	2	2 3
	7 8 9 8 9 7	5 6	5 6	5 5	1.1	1 /	5	6	5 6
789 8 9 789 1 78 7 9 789	1 3 1 2 1 2 3 2 3 2 3 1 2 3 1 2 3	7 8 9	8	9 7 8 9		-	7 8	7 9	7 8 9
						1 2 3			
					1 - 1	5	6	I	1
	7 8 9 8 9 7 8 9 9 7 9 0 7 9 7	5 7 8 9			ه ا		U	7 0	4









	1 2 5 6	_	2 3	2 3	1 2 3	1 3	1 2	1 3
1	5 6	Q	5	6	5 6	5	6	5 6
7		O	7 9	9	7 9	7	7 9	7 9
3	2	2 3				3	2	3
		2 3 4 5	4	7				
5 6				/		4 5	4 6	
8 9	8	9			9	8	9	8 9
	1	1			1	1		
7	4 5 6	4 5	4 5	$\mathbf{Q}$	5 6	4 5	''	')
<i> </i>		9	7 9	O	7 9	7	$\cup$	
1 3			3	3				1 3
	1		4	4	0	2	_	
7 9	4	O	7 9	9	0	_	$\circ$	7 9
1 3	_	1 2 3		2 3	1 2 3	1 3		1 3
		1 2 3 4 5			1 2 3 5 6			
5 6	9	4 5		4 6	5 6	4 5	K	5 6
7	)		7		7	7	)	7
1				2	1 2 5	_	1 2	1
5	3	7	6	4	5	a	4	5
8	9	- /	U			9		8
		1 3	3		1 3	1 3	1	1 3
$\sim$	7	ا ا	I₄ ઁ	5	6	4	4 6	. 6
	<i>-</i> /	9	8 9	$\circ$	9	- 8	9	8 9
	_				9			0 9
3	2	2 3 5	2 3	4	4	3	2	3
5 6	5 6		5	1	4	5	6	5 6
7 8 9	8	9	7 8 9		Т	7 8	7 9	7 8 9
			2 3	2 3	1 2 3		1 2	
1 3	1 2	1 2 3	2 3					
	1 2 5	1 2 3	5 7 8 9	2 3	1 2 3	6	l' -	1







**Helmut Simonis** 

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







	1 2 5 6		2 3	2 3	2 3	1 3	1 2	1 3
14	5 6	$\mathbf{R}$	5	6	5 6	5	6	5 6
		)	9	9	9	7	7 9	7 9
3	2 5 6	2 3 5			2 3	3	2	3 5 6
5 6	5 6	5	1	7	5 6	4 5	4 6	5 6
9	l	9		- /	9	8	9	8 9
	1	1		_		1		
<b>  7</b>	5 6	5	1	Q	5 6	5	2	2
- /	l	9	_	O	9		)	_
1 3			3	3		_		1 3
	1 /	6			Q	2	5	
9		U	7 9	9	O	_		7 9
1 3		1 2 3 4 5	2 3	2 3	1 2 3	1 3		1 3
5 6	a	4 5	2 3 5	4 6	1 2 3 5 6	4 5	Q	5 6
	9		7		7	7	O	7
1				2	1 2 5	_	1 2	1
5	2	7	6	4	5	a	4	5
8	J	- /	O			9		8
		1 3	3		1 3	1 3	1	1 3
1つ	7	4		5	6	4	4 6	6
_	<i>'</i>	9	8 9	$\cup$	9	8	9	8 9
3	2	2 3	2 3			3	2	3
5 6	5 6	5	5	1 1	1	5	6	5 6
8 9	8	9	7 8 9		7	7 8	7 9	7 8 9
1 3		1 2 3		2 3	1 2 3		1 2	
5	1 2 5	1 2 3	2 3 5 7 8 9		1 2 3	16	ı	
8 9		- 9	7 8 9	9	7 9	U	7 9	-









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









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







4	2	8	5	6	3	1	7 9	7 9
3	5	3 9	~	7	2	4	60	8
7	6	~	4	8	9	5	3	2
1	4	6	3 7 9	3	8	2	5	3 7 9
5	9	2	7	4	1	3 7	8	6
8	3	7	6	2	5	9	4	1
2	7	4	3	5	6	8	1	3 9
6	8	3	2	1	4	7	7 9	5
3	1	5	8	3	7	6	2	4











4	2	8	5	6	3	1	7 9	7 9
3	5	3 9	~	7	2	4	60	80
7	6	~	4	8	9	5	ന	2
1	4	6	3 7 9	3	8	2	15	7
5	9	2	7	4	1	7	8	6
8	3	7	6	2	5	9	4	1
2	7	4	3 9	5	6	8	1	3
6	8	3 9	2	1	4	7	7 9	5
3 9	1	5	8	3	7	6	2	4











4	2	8	5	6	3	1	7 9	7 9
3	5	3	1	7	2	4	60	8
7	6	$\leftarrow$	4	8	9	5	ന	2
1	4	6	3 7 9	3	8	2	15	7
5	9	2	7	4	1	7	80	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	7	7 9	5
3 9	1	5	8	3 9	7	6	2	4



4	2	8	5	6	3	1	7 9	7 9
3	5	3	1	7	2	4	60	8
7	6	$\leftarrow$	4	8	9	5	ന	2
1	4	6	3 7 9	3	8	2	15	7
5	9	2	7	4	1	7	80	6
8	3	7	6	2	5	9	4	1
2	7	4	3	5	6	8	1	3 9
6	8	3	2	1	4	7	7 9	5
3 9	1	5	8	3	7	6	2	4



4	2	8	5	6	3	1	7 9	7 9
3	5	3 9	~	7	2	4	60	80
7	6	$\leftarrow$	4	8	9	5	ന	2
1	4	6	3 7 9	3	8	2	15	7
5	9	2	7	4	1	7	80	6
8	3	7	6	2	5	9	4	1
2	7	4	3	5	6	8	1	3 9
6	8	3	2	1	4	7	7 9	5
3	1	5	8	3	7	6	2	4





## After Setup (Domain Consistency)

4	2	8	5	6	3	1	7 9	7 9
3 9	5	3 9	~	7	2	4	60	8
7	6	$\overline{}$	4	8	9	5	ന	2
1	4	6	7 9 3	3	8	2	5	7
5	9	2	7	4	~	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	2	1	4	7	7 9	5
3	1	5	8	3	7	6	2	4





#### Comparison

#### Forward Checking

4	1 2 5 6	8	2 3 5 9	8 9	2 3 6 9	1 5 7	1 6 7 9	5 6
- 3 - 6 - 9	5 6	5 9	1	7	2 3 6 9	4 5	6 9	5 6
, 6	5 6	5 9	4 5 9	8	6	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	4 7	4 3	1 3	7	8	, 6
8	3	7	6	2	5	9	4	1
2	7	1 3	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6	5 9	23 789	1	4	5 7 8	7 9	5 7 8 9
3	5 8	1 3	2 3 7 8 9	3	23 79	6	12 7 9	4

#### **Bounds Consistency**

4	1 2	8	5	6	2 3	,	1 7 9	7 9
3	5	9 9	1	7	2 3	4 5 8	00	5 8
7	6	5	4	8	9	5	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	7	4	1	, 3	8	6
8	3	7	6	2	5	9	4	1
2	7	4	8 9	5	6	1 3	1 9	8 9
6	5 8	3	2 3	1	4	5 7 8	2 7 9	5 7 8 9
3	5	1 5	2	3	7	6	1 2	4

#### **Domain Consistency**

		_	-		-		_		
4	4	2	8	5	6	3	1	7 9	7 9
	3	5	e e	1	7	2	4	6	8
1	7	6	1	4	8	9	5	3	2
	1	4	6	7 9	3	8	2	5	7
1	5	9	2	7	4	1	, 3	8	6
8	8	3	7	6	2	5	9	4	1
4	2	7	4	3	5	6	8	1	3
(	6	8	3	2	1	4	7	7 9	5
Г	3	1	5	8	3	7	6	2	4





#### Typical?

- This does not always happen
- Sometimes, two methods produce same amount of propagation
- Possible to predict in certain special cases
- In general, tradeoff between speed and propagation
- Not always fastest to remove inconsistent values early
- But often required to find a solution at all





#### Outline

- Problem
- Program
- Initial Propagation (Forward Checking)
- Improved Reasoning
- Search
  - Solution









#### Simple search routine

- Enumerate variables in given order
- Try values starting from smallest one in domain
- Complete, chronological backtracking





Solution

### Search Tree (Forward Checking)

2

4	1 2 5 6	8	2 3 5 9	3 6 9	2 3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	2 3 6 9	4 5	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	3 5 9	2 3 7 8 9	1	4	3 5 7 8	2 7 9	5 7 8 9
3	1 5 8	1 3	23	3	2 3	6	1 2	4





2

4	1	8	2 3 5 9	3 6 9	2 3 6 9	1 5	1 6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	2 3 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3 9	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	5 7 8	2 7 9	3 5 7 8 9
3	1 5 8	1 3 5 9	23	3	23	6	12	4





4	1	8	2	3 6 9	2 3 6 9	5	6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	2 3 6 9	4 5	6 9	5 6 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	5 7 8	2 7 9	3 5 7 8 9
3	5	1 3 5 9	23	3	23	6	12	4





4	1	8	2	3	3 6 9	5	6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	3 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3 9	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	ദ	7	6	2	5	တ	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 8
3 6 9	5 6 8	5 9	3 7 8 9	1	4	5 7 8	2 7 9	3 5 7 8 9
3	5	1 3 5 9	789	3	2 3 7 9	6	12	4



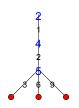




4	1	8	2	6	3 6 9	5 7	6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	3 6 9	4 5 8	6	5 6 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	3 7 8 9	1	4	5 7 8	2 7 9	3 5 7 8 9
3	5	1 3	780	3	2 3	6	12	4



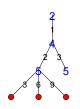




4	1	8	2	9	3 6 9	5 7	6 7 9	5 6 7 9
3 6 9	5 6	5 9	1	7	3 6 9	4 5 8	6	5 6 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3 9	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	3 7 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	5 8	1 3 5 9	789	3	23	6	12	4



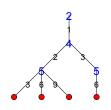




4	1	8	3	3 6 9	2 3 6 9	5	6 7 9	5 6 7 9
3 6 9	2 6	5 9	1	7	2 3 6 9	4 5 8	6 9	5 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	ദ	7	6	2	5	တ	4	1
2	7	1 3 4 9	3 8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	5	1 3 5	23	3	23	6	12	4



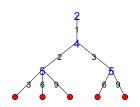




4	1	8	3	6	2 6 9	5 7	6 7 9	5 6 7 9
3 6 9	2 6	5 9	~	7	2 6 9	4 5 8	6 9	5 8
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	4	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 7 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	5	1 3	2	3	2 3	6	1 2	4



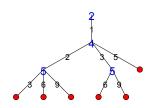




4	1	8	3	9	2 6 9	5	6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	2 6 9	4 5	6	5 6 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	4	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	3 5 9	2 7 8 9	1	4	5 7 8	2 7 9	3 5 7 8 9
3	5	1 3	2	3	2 3	6	1 2	4



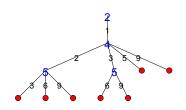




4	1	8	<b>5</b> .	3 6 9	2 3 6 9	5	6 7 9	5 6 7 9
3 6 9	5 6	5 9	~	7	2 3 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6	5 9	2 3 7 8 9	1	4	3 5 7 8	2 7 9	3 5 7 8 9
3	5 .	1 3	2 3	3	2 3	6	1 2	4



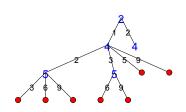




4	1	8	<b>9</b> °	3 6 9	2 3 6 9	5	6 7 9	5 6 7 9
3 6 9	2 6	5 9	~	7	2 3 6 9	4 5 8	6 9	5 8 9
6 7 9	5	5 9	4 5 9	80	6 9	1 4 5 7	3	2
1	4	6	7 9	3 9	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	3 8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	5 7 8	2 7 9	5 7 8 9
3	5	1 3 5	23	3	23	6	12	4



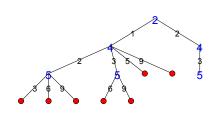




4	2	8	2 3 5 9	3 6 9	2 3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	2 5 6	5 9	1	7	2 3 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	ദ	7	6	2	5	တ	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	3 5 9	2 3 7 8 9	1	4	3 5 7 8	2 7 9	3 5 7 8 9
3	1 5 8	1 3 5	23	3	23	6	12	4



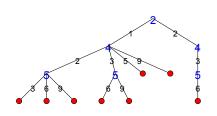




4	2	8	3	3 6 9	3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	5 6	5 9	1	7	2 3 6 9	4 5	6 9	5 6 8 9
6 7 9	1 5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6	5 9	23	1	4	5 7 8	2 7 9	3 5 7 8 9
3	1 5 8	1 3	23	3	2 3	6	1 2	4



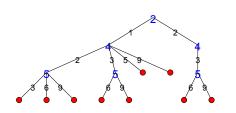




	_	_	_	_		_	_	_
4	2	8	3	6	6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	5 6	5 9	1	7	2 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	4	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	3 5 9	2 7 8 9	1	4	5 7 8	2 7 9	3 5 7 8 9
3	1 5 8	1 3	2 7 8 9	3	2 3	6	12	4



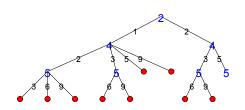




4	2	8	3	9	6	1 5 7	1 6 7 9	5 6 7 9
3 6 9	5 6	5 9	1	7	2 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 7 8 9	1	4	3 5 7 8	2 7 9	3 5 7 8 9
3	1 5 8	1 3 5 9	2 7 8 9	3	2 3 7 9	6	12	4



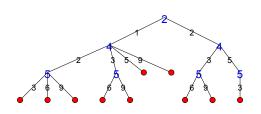




4	2	8	5	3 6 9	3 6 9	1 5 7	1 6 7 9	5 6 7 9
3 6 9	5 6	5 9	1	7	2 3 6 9	4 5	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 5 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	3 5 7 8	2 7 9	3 5 7 8 9
3	1 5 8	1 3 5 9	2 3 7 8 9	3	2 3 7 9	6	12	4



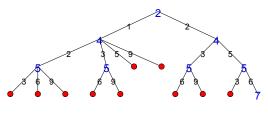




4	2	8	5	3	3 6 9	7	1 6 7 9	6 7 9
3 6 9	5 6	5 9	1	7	2 3 6 9	4 5 8	6 9	5 6 8 9
6 7 9	5 6	1 5 9	4 9	8	6 9	1 4 5 7	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 4 7	4	1 3	3 7	8	3 6 7
8	3	7	6	2	5	9	4	1
2	7	1 3 4 9	8 9	5	3 6 9	1 3	1 9	8 9
3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	3 5 7 8	2 7 9	5 7 8 9
3	1 5 8	1 3 5 9	2 3 7 8 9	3	2 3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



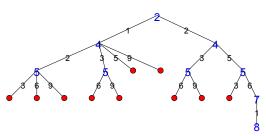




٠,									
	4	2	8	5	6	3	1 7	1 6 7 9	7 9
	3 6 9	5 6	5 9	1	7	2	4 5	6 9	5 6
	6 7 9	5 6	1 5 9	4	8	9	1 4 5 7	3	2
	_	4	6	7 9	3	8	2	5	7
	5	9	2	3 4 7	4	1	3 7	8	7
	00	3	7	6	2	5	9	4	1
	2	7	1 3 4 9	8 9	5	6	1 3	1 9	8 9
ĺ	3 6 9	5 6 8	5 9	2 3 7 8 9	1	4	5 7 8	7 9	5 7 8 9
	3 9	1 5 8	1 3 5 9	2 3 7 8 9	3	7	6	12	4



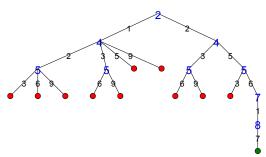




-				_					_
	4	2	8	5	6	3	1	1 7 9	7 9
	3 6 9	5 6	5 9	1	7	2	4 5 8	6 9	5 6 8 9
	6 7	5 6	5	4	8	9	1 5 7	3	2
	1	4	6	7 9	3	8	2	5	7
	5	9	2	7	4	1	3 7	8	3 6 7
	8	3	7	6	2	5	9	4	1
	2	7	1 3 4 9	8 9	5	6	1 3	1 9	8 9
	3 6 9	5 6 8	5 9	2 3	1	4	3 5 7 8	2 7 9	5 7 8 9
	3	1 5 8	1 3 5 9	2 3 8 9	3	7	6	1 2	4







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





2

4	1 2	8	5	6	2 3	7	1 7 9	7 9
3	5	3	1	7	2 3	4 5	6 9	5 8 9
7	6	5	4	8	9	5	3	2
1	4	6	7 9	3	8	2	5	7
5	9	2	3 7	4	1	7	8	6
8	3	7	6	2	5	9	4	$\leftarrow$
2	7	4	3 8 9	5	6	1 3	1 9	3 8 9
6	5 8	3	2 3	1	4	5 7 8	7 9	3 5 7 8 9
3	1 5 8	5	2	3	7	6	1 2	4





2

4	12	8	5	6	2 3	7	1 7 9	7 9
3 9	2 5	3 9	1	7	2 3	4 5	6 9	5 8 9
7	6	1 5	4	8	9	5	3	2
_	4	6	7 9	3	8	2	5	7
5	9	2	3 7	4	1	7	8	6
8	3	7	6	2	5	9	4	1
2	7	4	3 8 9	5	6	1 3	1 9	3 8 9
6	5 8	3	2 3 8 9	1	4	5 7 8	7 9	5 7 8 9
3 9	1 5 8	5	2 8	3 9	7	6	1 2	4





















## Search Tree (Domain Consistency)

8

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





## Search Tree (Domain Consistency)

87

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





#### Observations

- Search tree much smaller for bounds/domain consistency
- Does not always happen like this
- Smaller tree = Less execution time
- Less reasoning = Less execution time
- Problem: Finding best balance
- For Sudoku: not good enough, should not require any search!





Solution

#### Solution

4	2	80	5	6	3	1	7	9
3	5	တ	~	7	2	4	60	80
7	6	~	4	8	9	5	3	2
1	4	60	3	9	80	2	5	7
5	9	2	7	4	~	3	8	6
8	3	7	6	2	15	9	4	1
2	7	4	9	5	60	80	$\leftarrow$	ദ
6	8	3	2	1	4	7	9	5
9	1	5	8	3	7	6	2	4





#### Outline

- Problem
- Program
- Initial Propagation (Forward Checking)
- 4 Improved Reasoning
- Search
- 6 Lessons Learned



Problem Program Initial Propagation (Forward Checking) Improved Reasoning Search Lessons Learned

#### **Global Constraints**

- Powerful modelling abstractions
- Efficient reasoning





### **Consistency Levels**

- Defined levels of propagation
- Tradeoff speed/reasoning
- Characterisation of power of constraint





#### **Alldifferent Variants**

- Forward Checking
  - Only reacts when variables are assigned
  - Equivalent to decomposition into binary constraints
- Bounds Consistency
  - Typical best compomise speed/reasoning
  - Works well if no holes in domain
- Domain Consistency
  - Extracts all information from single constraint
  - Cost only justified for very hard problems





Problem Program Initial Propagation (Forward Checking) Improved Reasoning Search Lessons Learned

### End of Chapter 5

Thank you!

Some optional material follows



#### Outline

- Omplete Example: Domain Consistent Alldifferent
- 8 Generic Model
- 9 Exercises





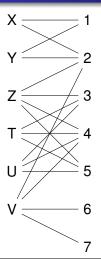
#### Bigger Example

```
:-lib(ic).
:-lib(ic_global_gac).

top:-
        [X,Y] :: 1..2,
        Z :: 2..5,
        [T,U] :: 3..5,
        V :: [2,4,6,7],
        ic_global_gac:alldifferent([X,Y,Z,T,U,V]).
```

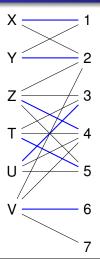
©onstraint Computation Centre

#### Making constraint domain consistent



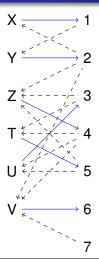
Problem shown as bipartite graph





Find maximal matching (in blue)

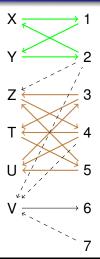




Orient graph (edges in matching from variables to values, all others from values to variables), mark edges in matching

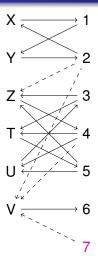






Find strongly connected components (green and brown), mark their edges

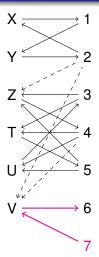




Find unmatched value nodes (here node 7, magenta)

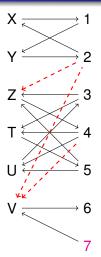






Find alternating paths from such nodes (in magenta), mark their edges





All unmarked edges can be removed





 $\gamma \leq 2$ 



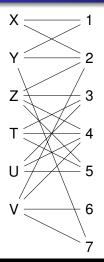
Resulting graph, constraint is domain consistent



#### Extended Example

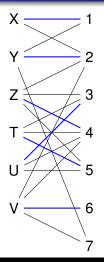
```
:-lib(ic).
:-lib(ic global gac).
top:-
    X :: 1..2.
    Y :: [1,2,7],
    Z :: 2..5,
    [T,U] :: 3...5,
    V :: [2,4,6,7],
    ic_global_gac:alldifferent([X,Y,Z,T,U,V])
                                                 Computation
```

entre



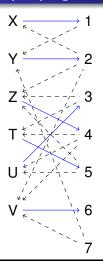
Problem shown as bipartite graph





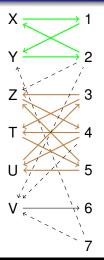
Find maximal matching (in blue)





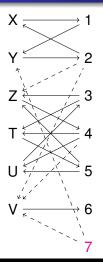
Orient graph (edges in matching from variables to values, all others from values to variables), mark edges in matching





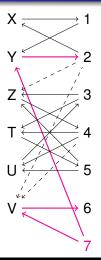
Find strongly connected components (green and brown), mark their edges





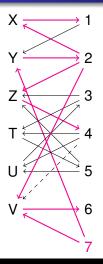
Find unmatched value nodes (here node 7, magenta)





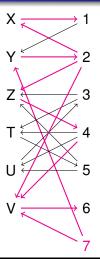
Find alternating paths from such nodes (in magenta), mark their edges





Continue with alternating paths





Continue with alternating paths, all edges marked, no propagation, constraint is domain consistent



#### Observation

- A lot of effort for no propagation
- Problem: Slows down search without any upside
- Constraint is woken every time any domain is changed
- How often does the constraint do actual pruning?





#### Outline

- Complete Example: Domain Consistent Alldifferent
- 8 Generic Model
- 9 Exercises





## Generalize Program for different sizes

- How to generalize program for different sizes (4,9,16,25,36...)
- Add parameter R (Order, number of blocks in a row/column)
- Size N is square of R
- Remove explicit integer bounds by expressions
- Useful to do this change as rewriting of working program





#### Main Program

```
model(R,M,Matrix):-
    N is R*R, Matrix[1...N, 1...N] :: 1...N,
     (for(I,1,N),
     param (N, M, Matrix) do
         M: alldifferent (Matrix[I,1..N]),
         M:alldifferent(Matrix[1..N, I])
    ),
     (multifor([I,J],[1,1],[N-R+1,N-R+1],[R,R]),
     param (R, M, Matrix) do
         M:alldifferent (flatten (Matrix [I..I+R-1,
                                      J..J+R-1))
    ),
    flatten array (Matrix, List), labeling (List).
```

#### Outline

- Complete Example: Domain Consistent Alldifferent
- 8 Generic Model
- 9 Exercises





#### **Exercises**



