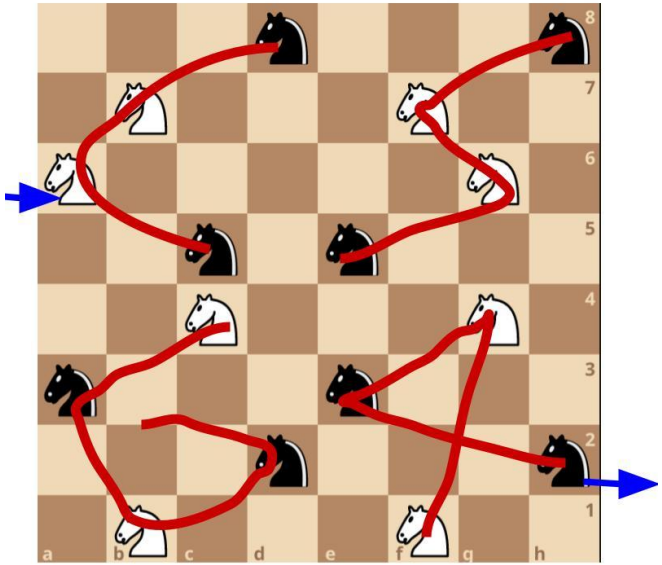
CS64: Computation for Puzzles and Games



Autumn 2022

Lecture 4: Nikoli Puzzles, Part 2

Chess scandal update

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MISSOURI: EASTERN DIVISION

HANS MOKE NIEMANN, *Plaintiff,* v. SVEN MAGNUS ØEN CARLSEN A/K/A MAGNUS CARLSEN, PLAY MAGNUS AS D/B/A PLAY MAGNUS GROUP, CHESS.COM, LLC, DANIEL RENSCH A/K/A "DANNY" RENSCH, AND HIKARU NAKAMURA, *Defendants.*	)	CIVIL ACTION NO. **JURY TRIAL DEMANDED**

*s*** just got real*

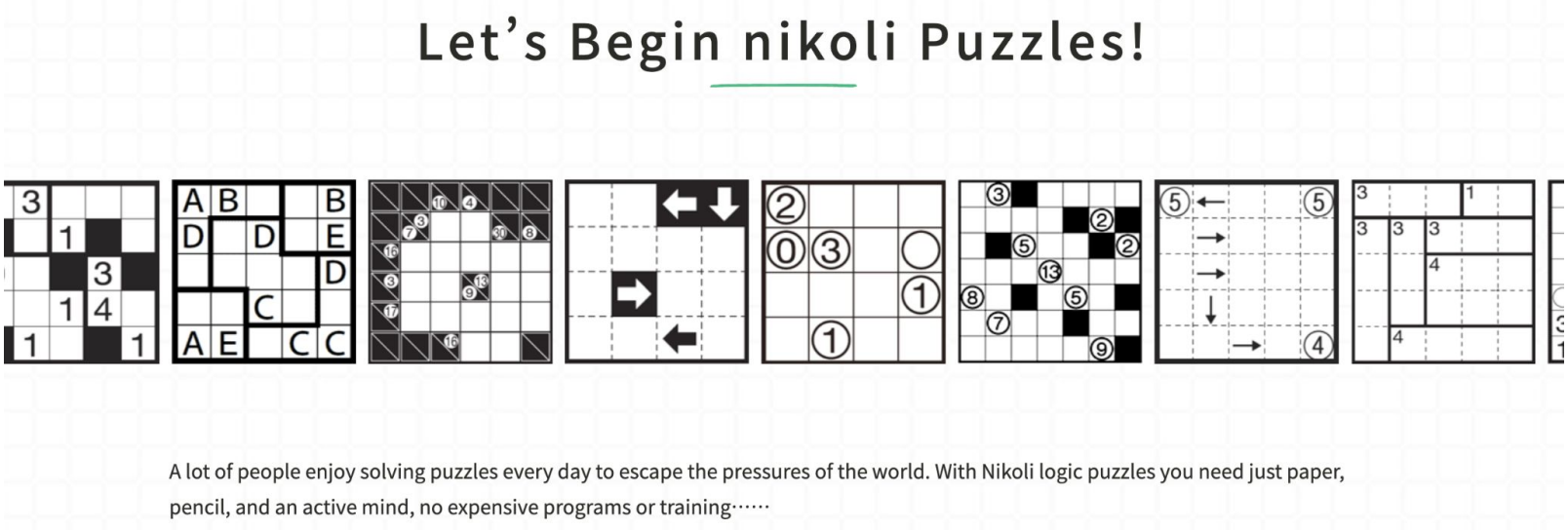
COMPLAINT

Plaintiff Hans Moke Niemann ("Niemann"), by and through his attorneys Oved & Oved

please do not sue CS64

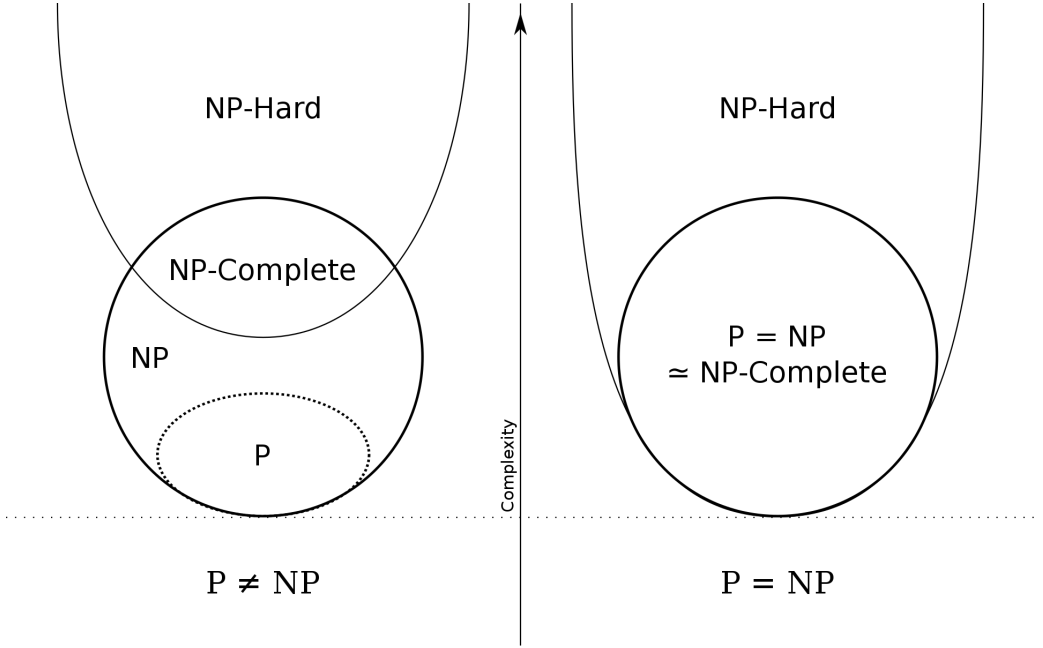
Last time

- Nikoli-style logic puzzles are "**NP-complete**"
  - it's easy to verify a solution (polynomial time)
  - hard to actually solve a puzzle (exponential time)
  - a way to solve any one of the puzzle types efficiently would also let us solve the others



Most logic puzzles are NP-complete, not NP-hard

- NP-hard problems can't even have their solutions checked efficiently
- This would of course be undesirable for logic puzzles (solvers like to know when they have things right!)



Interlude

nikoli

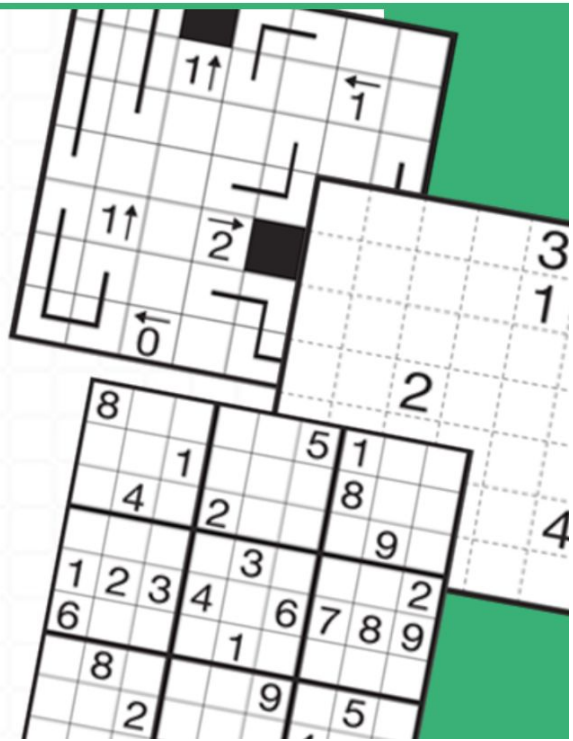
Japanese English

Home Puzzles News nikoli book shop

相変わらず、で世界一。

We are the best in keeping the Nikoli style.

Nikoli has been creating puzzles for 40 years and is surely a one-of-a-kind company in the world.
We have created the world's largest crossword puzzle that has been verified by the Guinness World Records ®, and have coined the puzzle, "Sudoku", which is now enjoyed in more than 120 different countries.
Human-crafted puzzles will always have a special place in this tech-dominated world we live in today.



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seems like a reasonable claim ofc

Interlude

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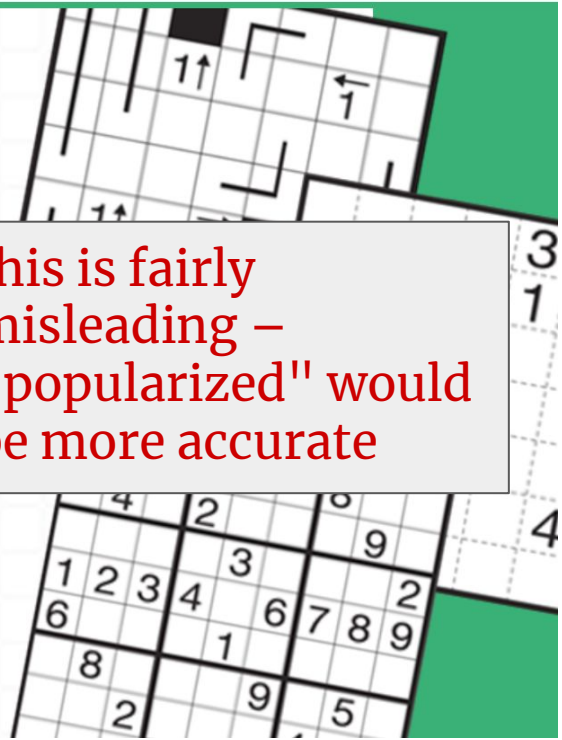


this is fairly misleading – "popularized" would be more accurate

Interlude

パズルを作り続けて40年間、世界で類のない会社です。

世界最大のクロスワードを作り、ギネス世界新記録®でも認定されました。

数独（SUDOKU）と名付けたパズルは世界120カ国以上で楽しまれています。

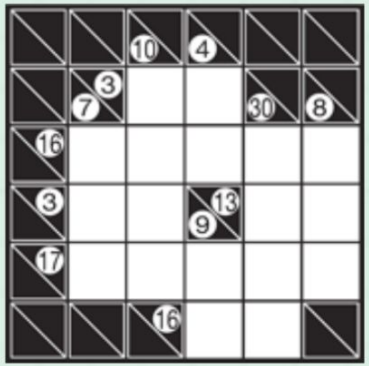
これからは、ヒューマン・クラフテッド・パズルの時代です。

though the original Japanese doesn't make this claim – "the puzzle called / (re)named Sudoku"

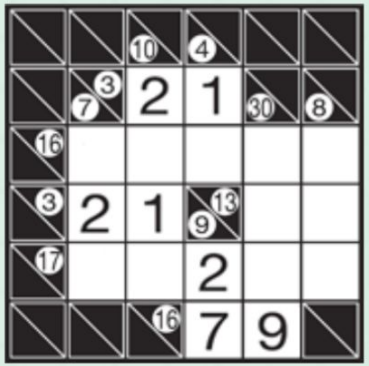
What does it mean to write the Nikoli style well?

Let's look at...

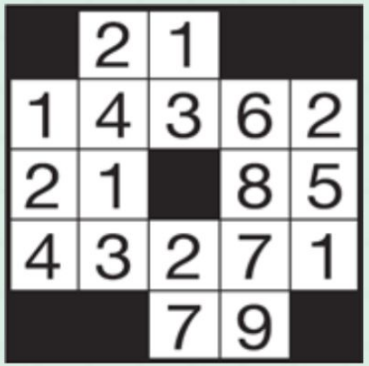
Kakuro



Sample



Progressing

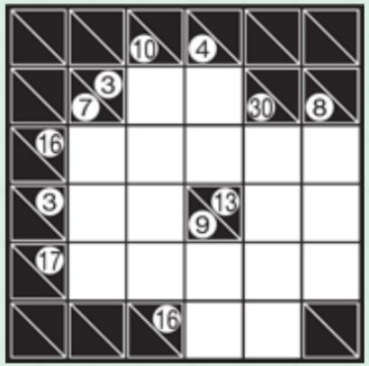


Solution

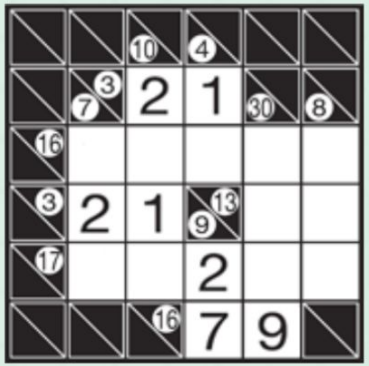
What does it mean to write the Nikoli style well?

Kakuro

NB: also not originally a Nikoli puzzle ("Cross Sums")



Sample



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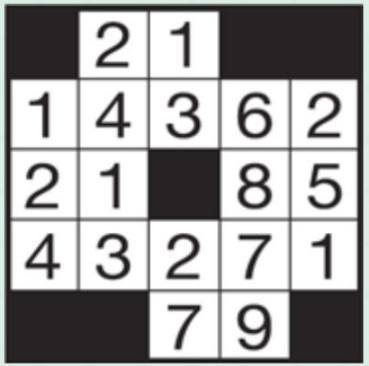
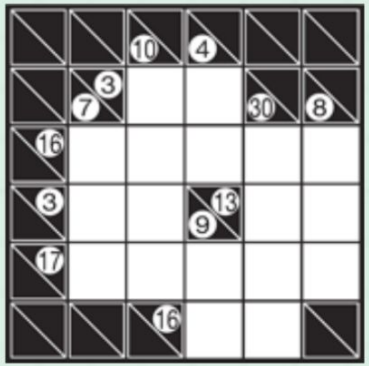


Solution

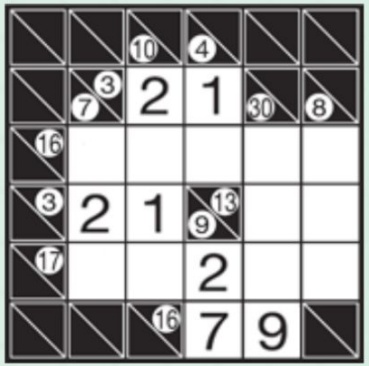
What does it mean to write the Nikoli style well?

Also note: this is an actual math (arithmetic) puzzle!

Kakuro



Sample



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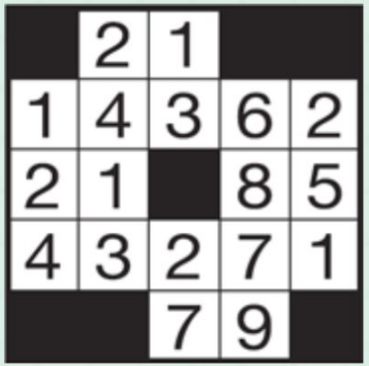

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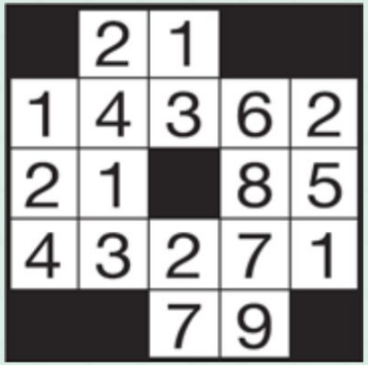


Solution

Bold: in puzzle
Italics: about where I stop having the patterns memorized

Nikoli Kakuro often heavily use a small

3: **12**
4: **13**
5: 14, 23
6: 15, 24
7: 16, 25, 34

6: 123
7: **124**
8: **125**, 134
9: 126, 135, 234
10: 127, 136, 145, 235

10: **1234**
11: 1235
12: 1236, 1245
13: 1237, 1246, 1345

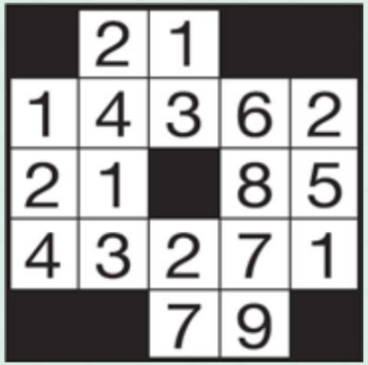
15: 12345
16: **12346**
17: **12347**, 12356
18: 12348, 12357, 12456

17: 89
16: **79**
15: 69, 78
14: 59, 68
13: 49, **58**, 67

24: 789
23: 689
22: 589, 679
21: 489, 579, 678
20: 389, 479, 569, 578

30: **6789**
29: 5789
28: 4789, 5689
27: 3789, 4689, 5679

35: 56789
34: 46789
33: 36789, 45789
32: 26789, 35789, 45689



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

Solution

Bold: in puzzle
Italics: about where I stop having the patterns memorized

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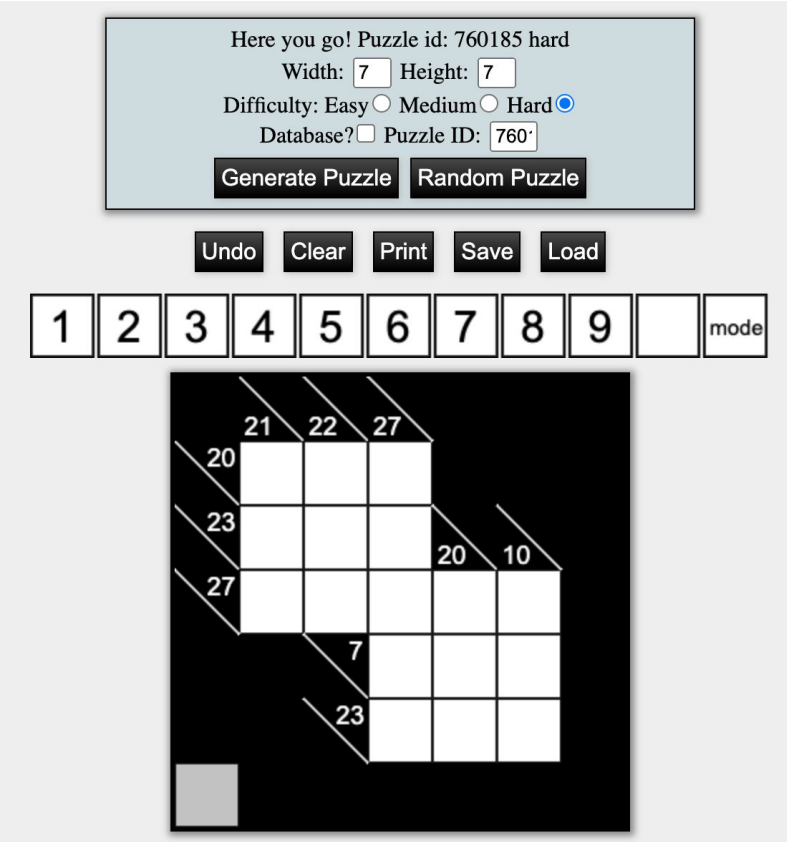
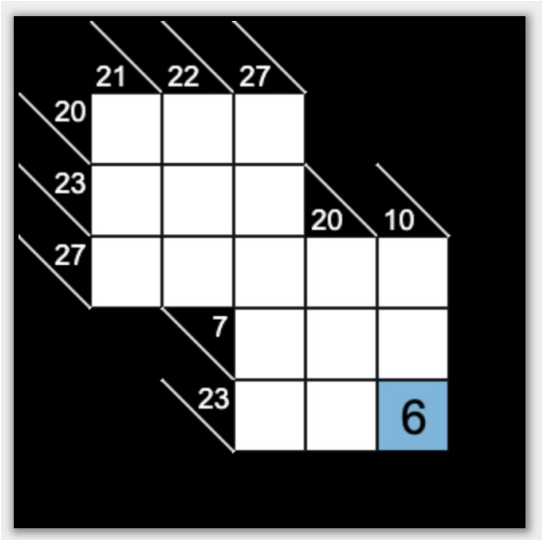
30: **6789**

Although this is an easy puzzle, Nikoli Kakuro generally heavily use a small number of common patterns.

Contrast with this Kakuro generator...

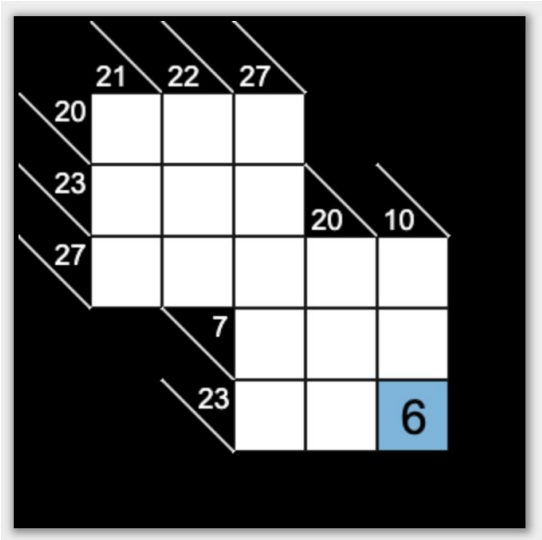


Where to begin?



23-in-3 is always 6, 8, 9

8 or 9 can't be part of
10-in-3 (too big)

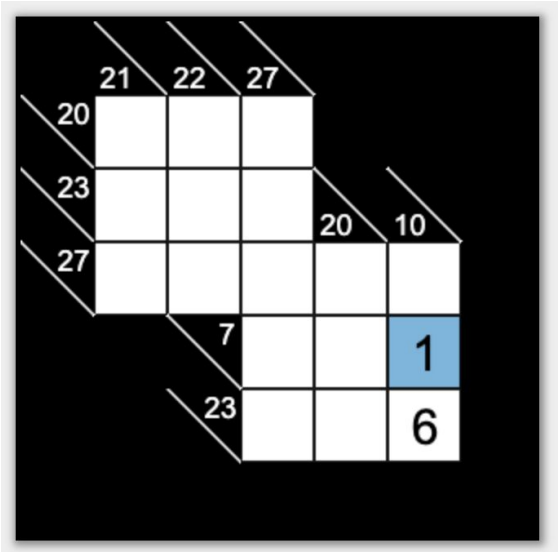


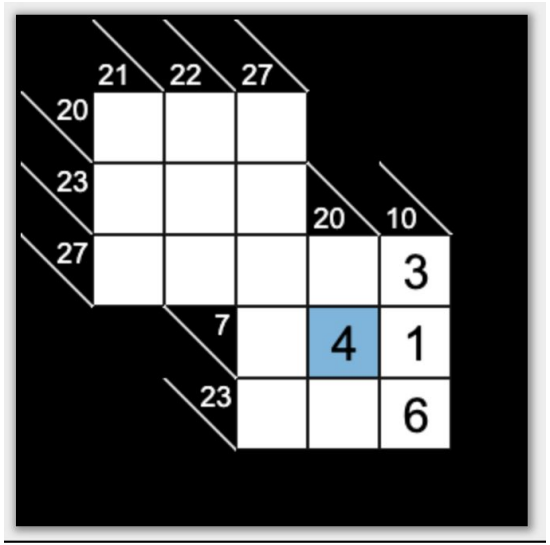
23-in-3 is always 6, 8, 9

8 or 9 can't be part of
10-in-3 (too big)

4 total left over in the
10-in-2

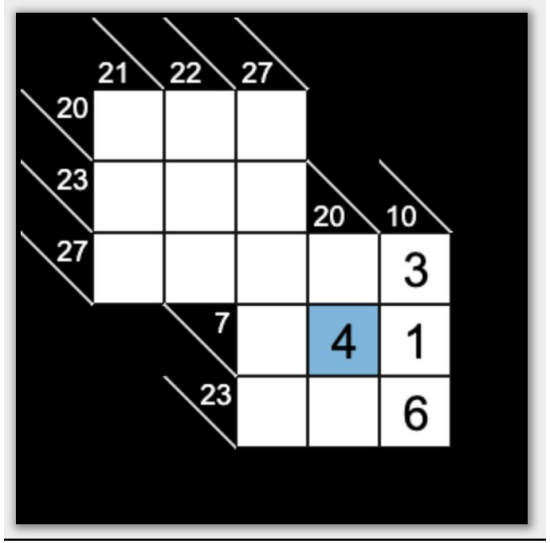
4-in-2 is always 1, 3
7-in-3 is always 1, 2, 4





We have a 2 and 4 left in the 7-in-3.

The 2 can't go in the 20-in-3 column, since there is no 18-in-2. So the 4 must be there.



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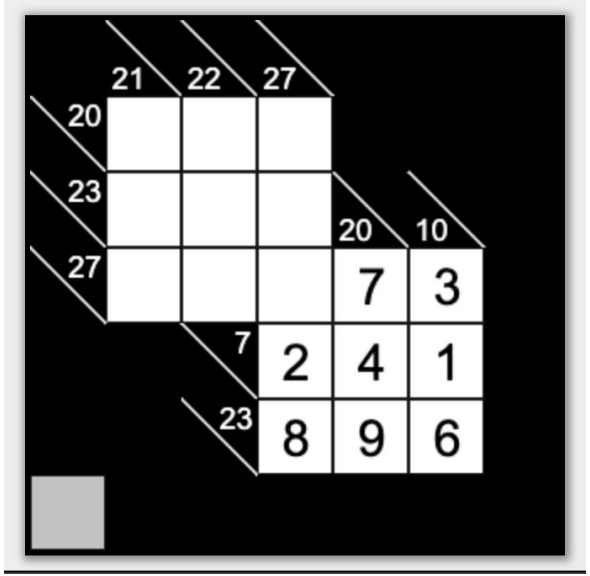
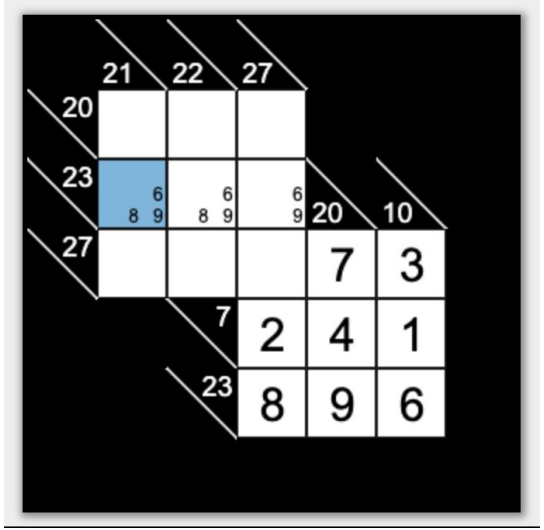
And so on. This part was easy for me (an experienced Nikoli Kakuro solver) to fill in. But now what?



Now it's a very different puzzle



Who has all the 27-in-5s memorized? *Not me*

Can fill in candidates for 23-in-3 but it only helps so much

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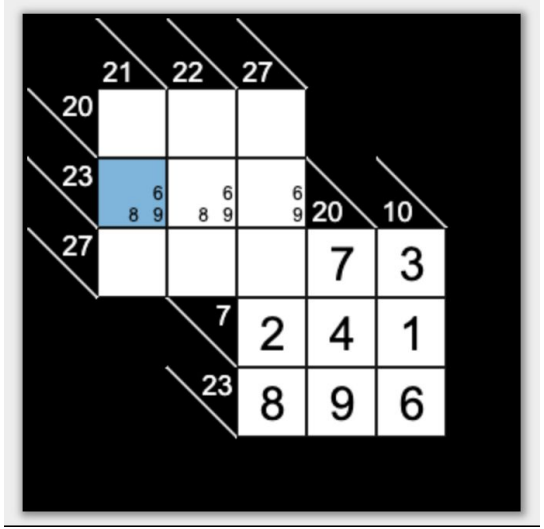
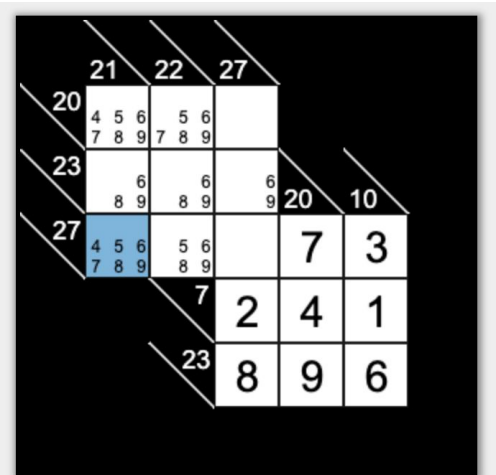


Who has all the 27-in-5s memorized? *Not me*

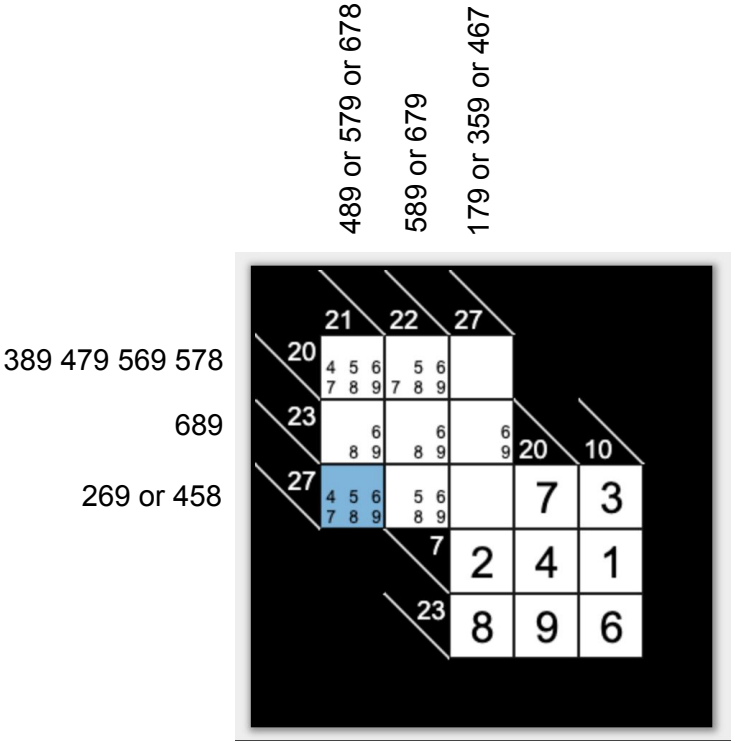
Can fill in candidates for 23-in-3 but it only helps so much

21-in-3 and 22-in-3 have a smaller number of options, but this isn't helping much



A good idea

- Write every possibility for every row/column
- Look at each, one at a time
- See if any numbers are forced by the constraints of just the crossing clues, and if so, fill them in (and update the possibilities)
- Keep looping until the puzzle is done



A good idea that may not work

- Write every possibility for every row/column
- Look at each, one at a time
- See if any numbers are forced by *the constraints of just the crossing clues*, and if so, fill them in (and update the possibilities)
- Keep looping until the puzzle is done

May not be enough!

389 479 569 578

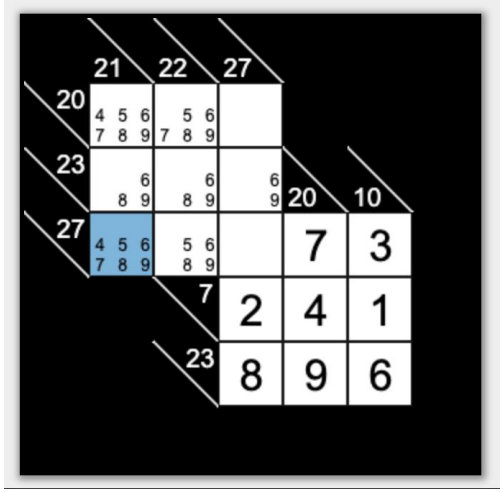
689

269 or 458

489 or 579 or 678

589 or 679

179 or 359 or 467



What about paint by numbers / nonograms

Example [edit]

empty Nonogram

				2	2			
	0	9	9	2	2	4	4	0
0								
4								
6								
2 2								
2 2								
6								
4								
2								
2								
2								
0								

solved Nonogram

				2	2			
	0	9	9	2	2	4	4	0
0								
4		■	■	■	■			
6		■	■	■	■	■	■	
2 2		■	■			■	■	
2 2		■	■			■	■	
6		■	■	■	■	■	■	
4		■	■	■	■			
2		■	■					
2		■	■					
2		■	■					
0								

Bummer:

It isn't necessarily sufficient to just keep checking individual rows to see if any cells can be filled in.

Don't get too excited, Mario, it's NP-complete!

Complexity Theory
Bowser wins again

The dreaded "bifurcation"

- AKA "guess and check" – when you're not sure which of two branches to take, try one and be prepared to backtrack
- Many solvers (including me) don't like having to do this. e.g., "I had to bifurcate twice on that tournament puzzle". Why not?
    - Harder for many humans to backtrack (chess, Go, etc. players are good at it, I'm not)
    - Feels less satisfying to have to "guess" instead of finding an intended path

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    - Harder for many humans to backtrack (chess, Go, etc. players are good at it, I'm not)
    - Feels less satisfying to have to "guess" instead of finding an intended path
- Counterpoint: But some solvers might like it! (And may find Nikoli's reliance on common patterns dull)

But isn't guessing the solver's fault?

- "A puzzle should be a battle of wits that the author expects to lose" - Dan Katz

But isn't guessing the solver's fault?

- "A puzzle should be a battle of wits that the author expects to lose" - Dan Katz
- So what if it's true that the solver didn't *have* to guess?
  - When things go well, it's because the solver is awesome
  - When things don't go well, it's generally blamed on the puzzle
    - and it's not fun

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- So what if it's true that the solver didn't *have* to guess?
  - When things go well, it's because the solver is awesome
  - When things don't go well, it's generally blamed on the puzzle
    - and it's not fun
- Puzzle authors may need to do some ego management / stroking. Posing an intellectual challenge is inherently stressful and can back the insecure solvers among us into a corner ("oh no! I'm supposed to be smart, and yet I can't solve this!")

stuff below this line rarely shows up even in Sudoku championships