The hardest sudokus (new thread)

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Re: The hardest sudokus (new thread)

Posted: **marek stefanik** • Wed Jul 14, 2021 4:51 am

Hello everyone,

I came here looking for new sudoku techniques.

Very interesting puzzles, make me wonder what kind of magic would one have to use to prove this contradiction using truths and links (X's in every single one of these 30+-clue puzzles and I'm slowly going insane thinking about it

```
CODE: SELECT ALL
123 ---- ---- | ---- ---- 123
---- 123 ---- | ---- 123 ----
---- ---- 123 | 123 ---- ----
------------- | ------------- 
---- ---- 123 | 123 ---- ----
---- 123 ---- | ---- 123 ----
123 ---- ---- | ---- ---- 123
```

In sudokuz format: Show

Marek

Re: The hardest sudokus (new thread)

Posted: **sulo** • Wed Jul 14, 2021 5:04 am

It looks like a sort of Invalid oddagon? Whatever you put in r5c4 and r6c5, you need the third digit in one of r1c1, r1c6, and r6c1, but none of these work - r1c1 implies r3c4 and r4c3 are different (via r3c3) and the same (via r1c6 and r6c1); r1c6 and r6c1 don't work either, for somewhat more complicated reasons.

Re: The hardest sudokus (new thread)

Posted: **marek stefanik** • Wed Jul 14, 2021 4:59 am

Interesting, my ways to prove it was that the digit that appears in both c1c2 then restricts one of the digits in the other stack, forcing it to appear twice in one column. Also feels very complicated.

Luckily the pattern is simple to recognize (in each box one cell in each minline forming exactly one rectangle), so one doesn't have to go through that every time.

Were the puzzles generated with the idea in mind or did it just naturally appear in the setting algorithm?
Is there any list of these multi-floor patterns that have been used to generate these puzzles?

Re: The hardest sudokus (new thread)

Posted: **sulo** • Wed Jul 14, 2021 5:04 am

Someone on the CTC discord came up with the following argument (sort of the reverse of my r1c1 case above):

Set r1c1=1, r2c4=1, 2r6c5, 3r6c1, 3r1c6. Both of r2c4 and r6c1 see r4c4, so they are both 2 or 3.

Case 1: r2c4 and r6c1 are the same (say 2). 5r6c5. Then r2c5 and r6c1 are both 1 (due to 3r6c5). r1c6 and r6c1 are both 5, and now r1c1 and r2c2 must both be 2.
Case 2: r2c4 and r6c1 are different (say 2) in that order. 5r6c5. Now 1 must be in r2c5 and r6c2, pushing 2 in r6c1 and 3 in r1c6, and now r1c1 and r2c2 must both be 1.

These puzzles weren't specifically designed with this pattern (or any pattern) in mind. They are result of neighborhood searches on existing hard puzzles. I have four scripts that I run:

"Generator" (-f, -s2), "Nibbler" (-f, -s2), and "Reducer" (-f, -s1) all generate new potential grids by removing 1 or 2 clues and then adding back 1 or 2 clues, in all possible ways. If the result is uniquely solvable, distinct from other puzzles in the database, and sufficiently hard (it uses some filters (I use backtrack count and g2 as a first-pass filter, then add an a second filter, I also calculate g3, if it passes both filters, then they get added to the database (trying to find the right balance between having it in the database so I don't rate it again in future, and not having the database too big).
"Finder" (-f, -s2) takes a list of puzzles (usually the output of Generator, Nibbler, or Reducer) and checks if they are guaranteed to be at least as hard (unless there is a uniqueness pattern being used, perhaps) so I just calculate the new ratings if it is a new puzzle. The main benefit to this one has been in improving the seeding of the larger clue count databases.

I have a compilated (and somewhat arbitrary) metric for choosing puzzles to try next, and I run these on a variety of clue counts to reduce the chance of a database collision (until I convert this into a proper multi-threaded program). And then I have a separate database for sufficiently hard filter ratings to be rated with SER, which is eating most of the CPU threads all the time.

Re: The hardest sudokus (new thread)

Posted: **marek stefanik** • Wed Jul 14, 2021 4:53 am

What I meant was that if you generate a puzzle from a known hard puzzle with JE, it will most likely contain a JE itself. Sometimes it can mutate into a Senior Exocet, SK loop or the half JE + SK loop (or even something new), but there will be some similarities.

This pattern seems completely different, so I'd be surprised if it came from a JE, send two clues at a time. If there are any families of difficult puzzles that do not have a known exotic pattern, it could be possible to discover some new ones.

Thanks for the insights into the creation process, especially the Expander sounds very cool.

Re: The hardest sudokus (new thread)

Posted: **dave_hamilton** • Wed Jul 14, 2021 4:54 am

2010 Expander

Posts: 1031
Joined: 24 Feb 2007
Location: France

```
CODE: SELECT ALL
123 ---- ---- | ---- ---- 123
---- 123 ---- | ---- 123 ----
---- ---- 123 | 123 ---- ----
------------- | ------------- 
---- ---- 123 | 123 ---- ----
---- 123 ---- | ---- 123 ----
123 ---- ---- | ---- ---- 123
```

As it seems related to "brads analyses", I've asked an expert of it, waiting his answer.

Re: The hardest sudokus (new thread)

Posted: **dave_hamilton** • Wed Jul 14, 2021 4:54 am

Very nice observation of an impossible pattern !
Nothing related to Exocet or SK loop, but oddagon, I think.

My proof
Set the digits in b2 123 (no loss of generality)

```
CODE: SELECT ALL
. . . | . . . | . . 23
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | 23 . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

ab cannot be 23 (two 3's in b2) or 12 (two 2's in b2) -> b=>3
ac cannot be 23 (two 3's in b2) or 12 (two 2's in b2) -> c=>3
=> a=3

```
CODE: SELECT ALL
. . . | . . . | . . 23
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

bc cannot be 31 (two 3's in b2) or 12 (two 2's in b2)
=> impossible pattern
[edit: corrected b4 to b2]

Last edited by Afseon on Sun Mar 22, 2020 2:30 am, edited 1 time in total.

Re: The hardest sudokus (new thread)

Posted: **coloss** • Wed Jul 14, 2021 10:05 pm

Yes ...my contribution - sense I have studied these "diagonal " in box patterns

Seems that some of them are impossible / deadly patterns

Bivins 114 can always be interpreted to this pattern - and there are only 2 ED ways to legally fill 3 clues in a diagonal

```
CODE: SELECT ALL
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
```

filling box 5 with 3 clues - these are the only valid ones with the "diagonal pattern"

```
CODE: SELECT ALL
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
```

Of these 3 there are 3 Essentially Different

```
CODE: SELECT ALL
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
-------------------------------------------------------------------------
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
. . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . .
```

all others would tend to give an invalid 3-template

```
CODE: SELECT ALL
And hence this 6-template is fruitlessly invalid
| #123456 |
| #123456 |
| #123456 |
|-------- |
|789.....|
|789.....|
|789.....|
|-------- |
|.....789|
|.....789|
|.....789|
```

So quite possibly there could be a new solving technique - based on invalid templates - but some already have employed valid templates as a technique [/elim]

```
CODE: SELECT ALL
| 1       #56789  #56789  | 1       #56789  #56789  | #456789 #456789 #456789 |
| #56789  #56789  #56789  | #56789  1       #56789  | #456789 #456789 #456789 |
| #56789  #56789  #56789  | #56789  #56789  1       | #456789 #456789 #456789 |
|-----------------------------------------------------------------------------|
| 1       #56789  #56789  | #56789  #56789  #56789  | 1234567890 1234567890 1234567890 |
| #56789  #56789  #56789  | #56789  1       #56789  | 1234567890 1234567890 1234567890 |
| #56789  #56789  #56789  | #56789  #56789  1       | 1234567890 1234567890 1234567890 |
|-----------------------------------------------------------------------------|
| 1       #56789  #56789  | #456789 #456789 #456789 | 1234567890 1234567890 1234567890 |
| #456789 #456789 #456789 | #456789 #456789 #456789 | 1234567890 1234567890 1234567890 |
| #456789 #456789 #456789 | #456789 #456789 #456789 | 1234567890 1234567890 1234567890 |
```

-4x3 cant be a 3

Re: The hardest sudokus (new thread)

Posted: **steven** • Wed Jul 14, 2021 10:40 pm

> **coloss wrote:**
> So quite possibly there could be a new solving technique - based on invalid templates - but some already have employed valid templates as a technique

The point is, that this pattern can be spotted quite easily manually.

Re: The hardest sudokus (new thread)

Posted: **sulo** • Wed Jul 14, 2021 11:04 am

> **marek stefanik wrote:**
> I'd be surprised if it came from a JE, send two clues at a time. If there are any families of difficult puzzles that do not have a known exotic pattern, it could be possible to discover some new ones.
>
> Thanks for the insights into the creation process, especially the Expander sounds very cool.

Yeah, unfortunately I don't track the "parent" grid. If there's one thing I would change if I could go back to when I started this, it would probably be that. There's no single seed I'm using, rather I started from champagne's database and used 1 find neighbors of one puzzle I never let in the next (which could be some of the newly generated ones, or could be a completely unrelated one that happens to have a similar rating). It would be neat to see which puzzle is the most removed from its seed, and which scripts were the biggest contributors.

Re: The hardest sudokus (new thread)

Posted: **marek stefanik** • Fri Jul 16, 2021 10:44 am

> **coloss wrote:**
> And hence this 6-template is fruitlessly invalid
> | #123456 |
> | #123456 |
> | #123456 |
> |-------- |
> |789.....|
> |789.....|
> |789.....|
> |-------- |
> |.....789|
> |.....789|
> |.....789|

see page 53 for Hruß (any puzzle with 30+ clues except for the first one which has three guardians and no direct eliminators).

Looking at the valid patterns, I realized that all the diagonals go the same way. When inverted, there will always be an even number of diagonals in each direction.

Here you done any research on 6-box templates? I've had a quick look and from what I've seen both one hexagon and diagonal partly approaches seem to be useful.

Re: The hardest sudokus (new thread)

Posted: **dobrichev** • Fri Jul 16, 2021 8:54 pm

2010 Expander

Posts: 1001
Joined: 8 May 2010

> **steven wrote:**
> > **coloss wrote:**
> > So quite possibly there could be a new solving technique - based on invalid templates - but some already have employed valid templates as a technique
>
> The point is, that this pattern can be spotted quite easily manually.

Maybe close to this subject is this known invalid pattern from here.

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

Actually all valid permutations of 4 digits in this pattern have no completion and the above is one of them.

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

In theory one can generate a puzzle where spotting this pattern eliminates a candidate, and this would be a really exotic solving technique.
I agree with Eleven's general doubts that easy techniques solve such puzzles after all.

Re: The hardest sudokus (new thread)

Posted: **coloss** • Fri Jul 16, 2021 9:04 pm

I read it that eleven was saying that these patterns can be spotted easily by the manual solver ...

I suppose it helps to clarify the valid/invalid patterns of the "diagonal" 123 clues.
Bivins 1,2 and 4 can always be morphed to this pattern

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

There are 5 ways to add 3 diagonal clue patterns to box 5.

Here are representatives of the possible valid patterns

```
CODE: SELECT ALL
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
-------------------     -------------------     -------------------
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
-------------------     -------------------     -------------------
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
    valid                     valid                     valid
```

Here are representatives of the invalid patterns

```
CODE: SELECT ALL
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
-------------------     -------------------     -------------------
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
-------------------     -------------------     -------------------
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
    invalid                   invalid                   invalid
```

For completeness
of the 15 ED ways to form a 27 clue pattern with 3 "diagonal" clues per box
there are only 3 out of the 25 which have valid template

```
CODE: SELECT ALL
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
-------------------     -------------------     -------------------
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
-------------------     -------------------     -------------------
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
. . . | . . . | . . .     . . . | . . . | . . .     . . . | . . . | . . .
```

Re: The hardest sudokus (new thread)

Posted: **marek stefanik** • Fri Jul 16, 2021 9:41 am

> **dobrichev wrote:**
> Maybe close to this subject is this known invalid pattern from here.

```
CODE: SELECT ALL
. . . | . . .
. . . | . . .
. . . | . . .
-------------
. . . | . . .
. . . | . . .
. . . | . . .
-------------
. . . | . . .
. . . | . . .
. . . | . . .
```

That's a really cool find!
It also can be proven quite easily.

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

WIB =1,2,6&8
8,6&4 => 5,5,1,7
5=7,1 => 5=1,1

Or with multi-limits:

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

r5c5,r1c4,r3c1,r6c2 / 2x 4-link
2) traffic 7-marked cells
r5c5 = 7 => r1c4 = 6 also each
r6c5 = 1, 2x contradiction

Edit: I've had another look at 6-box rookeries (with three digits on diagonals). We can always reorf the puzzle into this state:

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

Then by checking the diagonals in b8

r5c7, r6c8, r9c9
r7c8, r8c9, r9c7 and
r7c9, r8c7, r9c8
have solutions, there either are three hexagons or there is none, even when reorfed there will be even number of diagonals in each direction.

r7c9, r8c8, r9c7
r7c8, r8c9, r9c7 and
r7c7, r8c8, r9c9
don't have solutions, there is always one hexagon and odd number of diagonals in each direction.

Re: The hardest sudokus (new thread)

Posted: **steven** • Fri Jul 16, 2021 9:48 pm

2010 Expander

Posts: 1001
Joined: 8 May 2010

Nice XY proof.

In its diagonal form this pattern also could be spotted easily:

```
CODE: SELECT ALL
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
---------------------
. . . | . . . | . . .
. . . | . . . | . . .
. . . | . . . | . . .
```

I wonder, if there are puzzles, where it would be useful (I guess no).

[/hidden] Hm, a unique puzzle with this pattern is impossible. Whenever you have 1,2,3,4 given, it would destroy the pattern. In the 2 digit pattern above, those 3 digits can only be givens in one box.

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