Sudoku

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

A sudoku puzzle...

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

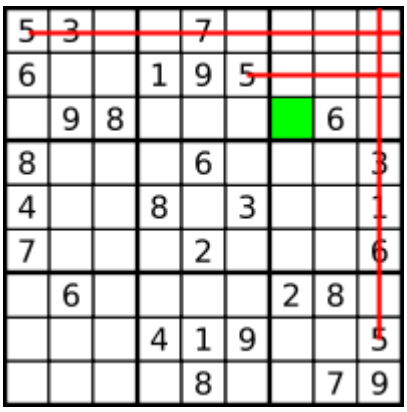
...and its solution numbers marked in red

Sudoku is a logic-based number placement puzzle. The objective is to fill a 9×9 grid so that each column, each row, and each of the nine 3×3 boxes (also called blocks or regions) contains the digits from 1 to 9 only *one* time each. The puzzle setter provides a partially completed grid.

The modern puzzle was invented by an American architect, Howard Garnes, in 1979 and published by Dell Magazines under the name "***Number Place***".[2] It became popular in Japan in 1986, after it was published by Nikoli and given the name Sudoku, meaning *single number* It became an international hit in 2005.

Strategies

The strategy for solving a puzzle may be regarded as comprising a combination of three processes: scanning, marking up, and analyzing. The approach to analysis may vary according to the concepts and the representations on which it is based.



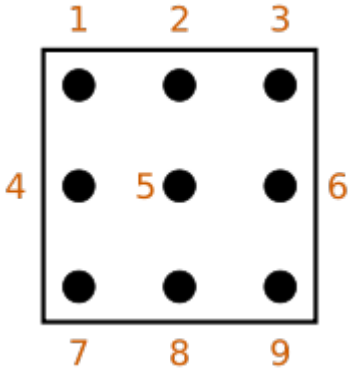
The top right region must contain a 5. By hatching across and up from 5s elsewhere, the solver can eliminate all empty cells in the region which cannot contain a 5. This leaves only one possibility (shaded green).

Scanning

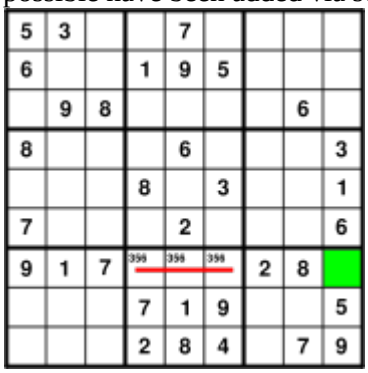
Scanning is performed at the outset and throughout the solution. Scans need be performed only once between analyses. Scanning consists of two techniques:

- **Cross-hatching:** The scanning of rows to identify which line in a region may contain a certain numeral by a process of elimination. The process is repeated with the columns. It is important to perform this process systematically, checking all of the digits 1–9.
- **Counting 1–9 in regions, rows, and columns to identify missing numerals.** Counting based upon the last numeral discovered may speed up the search. It also can be the case, particularly in tougher puzzles, that the best way to ascertain the value of a cell is to count in reverse—that is, by scanning the cell's region, row, and column for values it *cannot* be, in order to see what remains. By doing this it may be possible to reduce a cell's options to a single entry which adds meaning to the term Sudoku.

Advanced solvers look for "contingencies" while scanning, narrowing a numeral's location within a row, column, or region to two or three cells. When those cells lie within the same row *and* region, they can be used for elimination during cross-hatching and counting. Puzzles solved by scanning alone without requiring the detection of contingencies are classified as "easy"; more difficult puzzles are not readily solved by basic scanning alone.



A method for marking likely numerals in a single cell with dots. To reduce marking, this would wait until as many numbers as possible have been added via scanning. Dots are erased as the numerals are eliminated as candidates.



The bottom middle sub-square needs a 3, 5, and 6 in the top row. This creates a contingency which, although unresolved, reveals that the green square must be a 4.

Marking up

Scanning stops when no further numerals can be discovered, making it necessary to engage in logical analysis. One method to guide the analysis is to mark candidate numerals in the blank cells.

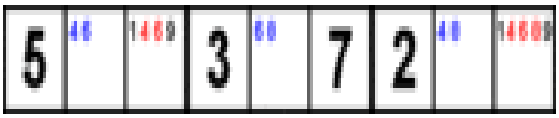
Subscript notation

In subscript notation, the candidate numerals are written in subscript in the cells. Because puzzles printed in a newspaper are too small to accommodate more than a few subscript digits of normal handwriting, solvers may create a larger copy of the puzzle. Using two colours, or mixing pencil and pen marks can be helpful.

Dot notation

The dot notation uses a pattern of dots in each square, where the dot position indicates a number from 1 to 9. The dot notation can be used on the original puzzle. Dexterity is required in placing the dots, since misplaced dots or inadvertent marks lead to confusion and may not be easily erased.

Another technique is to mark the numerals that a cell *cannot* be. The cell starts empty and as more constraints become known, it slowly fills until only one mark is missing. Assuming no mistakes are made and the marks can be overwritten with the value of a cell, there is no longer a need for any erasures.



An analysis in superscript notation, with all possible values written in. There are three squares which contain only three values: 4, 6, and 8. If these numbers were written in any square where they are red, it would be impossible to complete the squares where they are blue. Therefore, the numbers in red can be erased.

analysis

The two main approaches to analysis are "candidate elimination"and "what-if".

Difficulty ratings

The difficulty of a puzzle is based on the relevance and the positioning of the given numbers rather than their quantity. Surprisingly, the number of givens often does not reflect a puzzle's difficulty. Computer solvers can estimate the difficulty for a human to find the solution based on the complexity of the solving techniques required. Some online versions offer several difficulty levels.

Most publications sort their *Sudoku* puzzles into four or five rating levels, although the cut-off points and the names of the levels vary widely. Typically, the levels are "easy", "intermediate", and "hard". Extremely difficult puzzles are known as "diabolical" or "evil". An easy puzzle can be solved using only scanning; an intermediate puzzle may take markup to solve; a hard puzzle will usually take analysis.

Another approach is to rely on the experience of a group of human test solvers. Puzzles can be published with a median solving time rather than an algorithmically defined difficulty level.

Difficulty is a very complex topic, subject to much debate on the Sudoku forums, because it may depend on the concepts and visual representations one is ready to use.