CSC320 Project Report

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*Summary:*

We are using java for our project. We found that the original sudoku solvers uses the naive implementation (ie: back tracking/ searching algorithms). In order to have a better sudoku solver, they used some sort of search heuristic or constraint propagation method to deal with the puzzle. However, the task of SAT is to determine if there exists an [interpretation](https://en.wikipedia.org/wiki/Interpretation_(logic)) that [satisfies](https://en.wikipedia.org/wiki/Satisfiability) a given propositional [formula](https://en.wikipedia.org/wiki/Formula_(mathematical_logic)), which is quite different from the sudoku solver. Our program takes the puzzle as a text file, converts it into a boolean formula of clauses to input into Minisat, then it outputs the solved puzzle as a text file. The test cases are referenced from: <https://projecteuler.net/project/resources/p096_sudoku.txt>. Below is the result of our program and the run time.

*Results:*

|  |  |  |
| --- | --- | --- |
| Input Puzzle | Output Puzzle | Runtime |
| Grid 01  003020600  900305001  001806400  008102900  700000008  006708200  002609500  800203009  005010300 | 4 8 3 9 2 1 6 5 7  9 6 7 3 4 5 8 2 1  2 5 1 8 7 6 4 9 3  5 4 8 1 3 2 9 7 6  7 2 9 5 6 4 1 3 8  1 3 6 7 9 8 2 4 5  3 7 2 6 8 9 5 1 4  8 1 4 2 5 3 7 6 9  6 9 5 4 1 7 3 8 2 | 385ms |
| Grid 02  200080300  060070084  030500209  000105408  000000000  402706000  301007040  720040060  004010003 | 2 4 5 9 8 1 3 7 6  1 6 9 2 7 3 5 8 4  8 3 7 5 6 4 2 1 9  9 7 6 1 2 5 4 3 8  5 1 3 4 9 8 6 2 7  4 8 2 7 3 6 9 5 1  3 9 1 6 5 7 8 4 2  7 2 8 3 4 9 1 6 5  6 5 4 8 1 2 7 9 3 | 382ms |
| Grid 03  000000907  000420180  000705026  100904000  050000040  000507009  920108000  034059000  507000000 | 4 6 2 8 3 1 9 5 7  7 9 5 4 2 6 1 8 3  3 8 1 7 9 5 4 2 6  1 7 3 9 8 4 2 6 5  6 5 9 3 1 2 7 4 8  2 4 8 5 6 7 3 1 9  9 2 6 1 7 8 5 3 4  8 3 4 2 5 9 6 7 1  5 1 7 6 4 3 8 9 2 | 361ms |
| Grid 04  030050040  008010500  460000012  070502080  000603000  040109030  250000098  001020600  080060020 | 1 3 7 2 5 6 8 4 9  9 2 8 3 1 4 5 6 7  4 6 5 8 9 7 3 1 2  6 7 3 5 4 2 9 8 1  8 1 9 6 7 3 2 5 4  5 4 2 1 8 9 7 3 6  2 5 6 7 3 1 4 9 8  3 9 1 4 2 8 6 7 5  7 8 4 9 6 5 1 2 3 | 377ms |
| Grid 05  020810740  700003100  090002805  009040087  400208003  160030200  302700060  005600008  076051090 | 5 2 3 8 1 6 7 4 9  7 8 4 5 9 3 1 2 6  6 9 1 4 7 2 8 3 5  2 3 9 1 4 5 6 8 7  4 5 7 2 6 8 9 1 3  1 6 8 9 3 7 2 5 4  3 4 2 7 8 9 5 6 1  9 1 5 6 2 4 3 7 8  8 7 6 3 5 1 4 9 2 | 396ms |
| Grid 06  100920000  524010000  000000070  050008102  000000000  402700090  060000000  000030945  000071006 | 1 7 6 9 2 3 5 8 4  5 2 4 8 1 7 6 3 9  8 9 3 6 5 4 2 7 1  9 5 7 3 4 8 1 6 2  6 3 8 1 9 2 4 5 7  4 1 2 7 6 5 3 9 8  2 6 5 4 8 9 7 1 3  7 8 1 2 3 6 9 4 5  3 4 9 5 7 1 8 2 6 | 310ms |
| Grid 07  043080250  600000000  000001094  900004070  000608000  010200003  820500000  000000005  034090710 | 1 4 3 9 8 6 2 5 7  6 7 9 4 2 5 3 8 1  2 8 5 7 3 1 6 9 4  9 6 2 3 5 4 1 7 8  3 5 7 6 1 8 9 4 2  4 1 8 2 7 9 5 6 3  8 2 1 5 6 7 4 3 9  7 9 6 1 4 3 8 2 5  5 3 4 8 9 2 7 1 6 | 361ms |
| Grid 08  480006902  002008001  900370060  840010200  003704100  001060049  020085007  700900600  609200018 | 4 8 7 1 5 6 9 3 2  3 6 2 4 9 8 7 5 1  9 1 5 3 7 2 8 6 4  8 4 6 5 1 9 2 7 3  5 9 3 7 2 4 1 8 6  2 7 1 8 6 3 5 4 9  1 2 4 6 8 5 3 9 7  7 3 8 9 4 1 6 2 5  6 5 9 2 3 7 4 1 8 | 399ms |
| Grid 09  000900002  050123400  030000160  908000000  070000090  000000205  091000050  007439020  400007000 | 8 1 4 9 7 6 5 3 2  6 5 9 1 2 3 4 7 8  7 3 2 8 5 4 1 6 9  9 4 8 2 6 5 3 1 7  2 7 5 3 4 1 8 9 6  1 6 3 7 9 8 2 4 5  3 9 1 6 8 2 7 5 4  5 8 7 4 3 9 6 2 1  4 2 6 5 1 7 9 8 3 | 398ms |
| Grid 10  001900003  900700160  030005007  050000009  004302600  200000070  600100030  042007006  500006800 | 7 6 1 9 2 8 4 5 3  9 2 5 7 4 3 1 6 8  4 3 8 6 1 5 9 2 7  3 5 7 4 6 1 2 8 9  8 9 4 3 7 2 6 1 5  2 1 6 5 8 9 3 7 4  6 8 9 1 5 4 7 3 2  1 4 2 8 3 7 5 9 6  5 7 3 2 9 6 8 4 1 | 411ms |
| Grid 11  000125400  008400000  420800000  030000095  060902010  510000060  000003049  000007200  001298000 | 9 7 6 1 2 5 4 3 8  1 5 8 4 3 6 9 2 7  4 2 3 8 7 9 1 5 6  2 3 4 7 6 1 8 9 5  8 6 7 9 5 2 3 1 4  5 1 9 3 8 4 7 6 2  7 8 2 5 1 3 6 4 9  3 9 5 6 4 7 2 8 1  6 4 1 2 9 8 5 7 3 | 425ms |
| Grid 12  062340750  100005600  570000040  000094800  400000006  005830000  030000091  006400007  059083260 | 9 6 2 3 4 1 7 5 8  1 4 8 9 7 5 6 2 3  5 7 3 2 6 8 1 4 9  3 2 1 6 9 4 8 7 5  4 8 7 5 1 2 9 3 6  6 9 5 8 3 7 4 1 2  8 3 4 7 2 6 5 9 1  2 1 6 4 5 9 3 8 7  7 5 9 1 8 3 2 6 4 | 366ms |
| Grid 13  300000000  005009000  200504000  020000700  160000058  704310600  000890100  000067080  000005437 | 3 9 7 6 8 1 5 2 4  6 4 5 2 7 9 8 1 3  2 1 8 5 3 4 9 7 6  8 2 3 9 5 6 7 4 1  1 6 9 7 4 2 3 5 8  7 5 4 3 1 8 6 9 2  4 7 2 8 9 3 1 6 5  5 3 1 4 6 7 2 8 9  9 8 6 1 2 5 4 3 7 | 389ms |
| Grid 14  630000000  000500008  005674000  000020000  003401020  000000345  000007004  080300902  947100080 | 6 3 9 2 1 8 4 5 7  4 7 1 5 3 9 2 6 8  8 2 5 6 7 4 1 3 9  5 6 4 8 2 3 7 9 1  7 9 3 4 5 1 8 2 6  2 1 8 7 9 6 3 4 5  3 5 2 9 8 7 6 1 4  1 8 6 3 4 5 9 7 2  9 4 7 1 6 2 5 8 3 | 399ms |
| Grid 15  000020040  008035000  000070602  031046970  200000000  000501203  049000730  000000010  800004000 | 6 9 7 1 2 8 3 4 5  4 2 8 6 3 5 1 9 7  3 1 5 4 7 9 6 8 2  5 3 1 2 4 6 9 7 8  2 8 6 3 9 7 4 5 1  9 7 4 5 8 1 2 6 3  1 4 9 8 5 2 7 3 6  7 5 2 9 6 3 8 1 4  8 6 3 7 1 4 5 2 9 | 385ms |
| Grid 16  361025900  080960010  400000057  008000471  000603000  259000800  740000005  020018060  005470329 | 3 6 1 7 2 5 9 4 8  5 8 7 9 6 4 2 1 3  4 9 2 8 3 1 6 5 7  6 3 8 2 5 9 4 7 1  1 7 4 6 8 3 5 9 2  2 5 9 1 4 7 8 3 6  7 4 6 3 9 2 1 8 5  9 2 3 5 1 8 7 6 4  8 1 5 4 7 6 3 2 9 | 401ms |
| Grid 17  050807020  600010090  702540006  070020301  504000908  103080070  900076205  060090003  080103040 | 3 5 9 8 6 7 1 2 4  6 4 8 3 1 2 5 9 7  7 1 2 5 4 9 8 3 6  8 7 6 9 2 4 3 5 1  5 2 4 7 3 1 9 6 8  1 9 3 6 8 5 4 7 2  9 3 1 4 7 6 2 8 5  4 6 5 2 9 8 7 1 3  2 8 7 1 5 3 6 4 9 | 421ms |
| Grid 18  080005000  000003457  000070809  060400903  007010500  408007020  901020000  842300000  000100080 | 7 8 6 9 4 5 3 1 2  2 1 9 8 6 3 4 5 7  5 3 4 2 7 1 8 6 9  1 6 5 4 8 2 9 7 3  3 2 7 6 1 9 5 4 8  4 9 8 5 3 7 1 2 6  9 5 1 7 2 8 6 3 4  8 4 2 3 5 6 7 9 1  6 7 3 1 9 4 2 8 5 | 391ms |
| Grid 19  003502900  000040000  106000305  900251008  070408030  800763001  308000104  000020000  005104800 | 7 4 3 5 1 2 9 8 6  5 8 9 3 4 6 2 1 7  1 2 6 9 8 7 3 4 5  9 3 4 2 5 1 7 6 8  6 7 1 4 9 8 5 3 2  8 5 2 7 6 3 4 9 1  3 9 8 6 7 5 1 2 4  4 1 7 8 2 9 6 5 3  2 6 5 1 3 4 8 7 9 | 468ms |
| Grid 20  000000000  009805100  051907420  290401065  000000000  140508093  026709580  005103600  000000000 | 7 8 2 6 1 4 3 5 9  4 3 9 8 2 5 1 7 6  6 5 1 9 3 7 4 2 8  2 9 3 4 7 1 8 6 5  5 6 8 3 9 2 7 1 4  1 4 7 5 6 8 2 9 3  3 2 6 7 4 9 5 8 1  9 7 5 1 8 3 6 4 2  8 1 4 2 5 6 9 3 7 | 367ms |
| Grid 21  020030090  000907000  900208005  004806500  607000208  003102900  800605007  000309000  030020050 | 4 2 8 5 3 1 7 9 6  3 6 5 9 4 7 1 8 2  9 7 1 2 6 8 4 3 5  2 1 4 8 9 6 5 7 3  6 9 7 4 5 3 2 1 8  5 8 3 1 7 2 9 6 4  8 4 9 6 1 5 3 2 7  7 5 2 3 8 9 6 4 1  1 3 6 7 2 4 8 5 9 | 322ms |
| Grid 22  005000006  070009020  000500107  804150000  000803000  000092805  907006000  030400010  200000600 | 4 2 5 7 8 1 9 3 6  1 7 8 3 6 9 5 2 4  3 6 9 5 2 4 1 8 7  8 9 4 1 5 7 3 6 2  6 5 2 8 4 3 7 9 1  7 1 3 6 9 2 8 4 5  9 8 7 2 1 6 4 5 3  5 3 6 4 7 8 2 1 9  2 4 1 9 3 5 6 7 8 | 336ms |
| Grid 23  040000050  001943600  009000300  600050002  103000506  800020007  005000200  002436700  030000040 | 3 4 8 2 6 7 9 5 1  5 7 1 9 4 3 6 2 8  2 6 9 1 8 5 3 7 4  6 9 7 3 5 1 4 8 2  1 2 3 8 7 4 5 9 6  8 5 4 6 2 9 1 3 7  4 1 5 7 9 8 2 6 3  9 8 2 4 3 6 7 1 5  7 3 6 5 1 2 8 4 9 | 368ms |
| Grid 24  004000000  000030002  390700080  400009001  209801307  600200008  010008053  900040000  000000800 | 1 2 4 9 8 6 7 3 5  8 6 7 4 3 5 9 1 2  3 9 5 7 1 2 6 8 4  4 7 8 3 5 9 2 6 1  2 5 9 8 6 1 3 4 7  6 3 1 2 7 4 5 9 8  7 1 2 6 9 8 4 5 3  9 8 3 5 4 7 1 2 6  5 4 6 1 2 3 8 7 9 | 392ms |
| Grid 25  360020089  000361000  000000000  803000602  400603007  607000108  000000000  000418000  970030014 | 3 6 1 5 2 4 7 8 9  7 8 9 3 6 1 4 2 5  5 2 4 8 7 9 3 6 1  8 9 3 1 5 7 6 4 2  4 1 2 6 8 3 5 9 7  6 5 7 9 4 2 1 3 8  1 4 8 7 9 6 2 5 3  2 3 5 4 1 8 9 7 6  9 7 6 2 3 5 8 1 4 | 402ms |
| Grid 26  500400060  009000800  640020000  000001008  208000501  700500000  000090084  003000600  060003002 | 5 8 1 4 7 9 2 6 3  3 2 9 1 5 6 8 4 7  6 4 7 3 2 8 1 5 9  9 5 6 7 3 1 4 2 8  2 3 8 9 6 4 5 7 1  7 1 4 5 8 2 9 3 6  1 7 2 6 9 5 3 8 4  8 9 3 2 4 7 6 1 5  4 6 5 8 1 3 7 9 2 | 412ms |
| Grid 27  007256400  400000005  010030060  000508000  008060200  000107000  030070090  200000004  006312700 | 3 8 7 2 5 6 4 1 9  4 6 9 7 8 1 3 2 5  5 1 2 4 3 9 8 6 7  1 2 3 5 4 8 9 7 6  7 5 8 9 6 3 2 4 1  6 9 4 1 2 7 5 8 3  8 3 5 6 7 4 1 9 2  2 7 1 8 9 5 6 3 4  9 4 6 3 1 2 7 5 8 | 427ms |
| Grid 28  000000000  079050180  800000007  007306800  450708096  003502700  700000005  016030420  000000000 | 3 4 5 8 7 1 2 6 9  2 7 9 6 5 3 1 8 4  8 6 1 4 2 9 5 3 7  1 9 7 3 4 6 8 5 2  4 5 2 7 1 8 3 9 6  6 8 3 5 9 2 7 4 1  7 3 8 2 6 4 9 1 5  5 1 6 9 3 7 4 2 8  9 2 4 1 8 5 6 7 3 | 431ms |
| Grid 29  030000080  009000500  007509200  700105008  020090030  900402001  004207100  002000800  070000090 | 2 3 5 7 6 1 4 8 9  4 1 9 3 2 8 5 7 6  8 6 7 5 4 9 2 1 3  7 4 6 1 3 5 9 2 8  5 2 1 8 9 6 7 3 4  9 8 3 4 7 2 6 5 1  3 9 4 2 8 7 1 6 5  6 5 2 9 1 3 8 4 7  1 7 8 6 5 4 3 9 2 | 391ms |
| Grid 30  200170603  050000100  000006079  000040700  000801000  009050000  310400000  005000060  906037002 | 2 9 8 1 7 5 6 4 3  6 5 7 3 9 4 1 2 8  1 3 4 2 8 6 5 7 9  8 2 1 6 4 9 7 3 5  5 7 3 8 2 1 4 9 6  4 6 9 7 5 3 2 8 1  3 1 2 4 6 8 9 5 7  7 8 5 9 1 2 3 6 4  9 4 6 5 3 7 8 1 2 | 398ms |
| Grid 31  000000080  800701040  040020030  374000900  000030000  005000321  010060050  050802006  080000000 | 7 6 1 5 4 3 2 8 9  8 3 2 7 9 1 6 4 5  5 4 9 6 2 8 1 3 7  3 7 4 2 1 5 9 6 8  1 2 8 9 3 6 5 7 4  6 9 5 4 8 7 3 2 1  4 1 7 3 6 9 8 5 2  9 5 3 8 7 2 4 1 6  2 8 6 1 5 4 7 9 3 | 421ms |
| Grid 32  000000085  000210009  960080100  500800016  000000000  890006007  009070052  300054000  480000000 | 1 3 2 6 4 9 7 8 5  7 5 8 2 1 3 6 4 9  9 6 4 7 8 5 1 2 3  5 4 3 8 9 7 2 1 6  2 7 6 5 3 1 8 9 4  8 9 1 4 2 6 5 3 7  6 1 9 3 7 8 4 5 2  3 2 7 1 5 4 9 6 8  4 8 5 9 6 2 3 7 1 | 381ms |
| Grid 33  608070502  050608070  002000300  500090006  040302050  800050003  005000200  010704090  409060701 | 6 9 8 1 7 3 5 4 2  3 5 4 6 2 8 1 7 9  1 7 2 5 4 9 3 6 8  5 3 1 8 9 7 4 2 6  9 4 6 3 1 2 8 5 7  8 2 7 4 5 6 9 1 3  7 6 5 9 3 1 2 8 4  2 1 3 7 8 4 6 9 5  4 8 9 2 6 5 7 3 1 | 391ms |
| Grid 34  050010040  107000602  000905000  208030501  040070020  901080406  000401000  304000709  020060010 | 8 5 2 7 1 6 9 4 3  1 9 7 8 4 3 6 5 2  4 6 3 9 2 5 1 8 7  2 7 8 6 3 4 5 9 1  6 4 5 1 7 9 3 2 8  9 3 1 5 8 2 4 7 6  7 8 6 4 9 1 2 3 5  3 1 4 2 5 8 7 6 9  5 2 9 3 6 7 8 1 4 | 474ms |
| Grid 35  053000790  009753400  100000002  090080010  000907000  080030070  500000003  007641200  061000940 | 4 5 3 2 1 8 7 9 6  6 2 9 7 5 3 4 8 1  1 7 8 4 9 6 5 3 2  7 9 6 5 8 2 3 1 4  3 1 4 9 6 7 8 2 5  2 8 5 1 3 4 6 7 9  5 4 2 8 7 9 1 6 3  9 3 7 6 4 1 2 5 8  8 6 1 3 2 5 9 4 7 | 361ms |
| Grid 36  006080300  049070250  000405000  600317004  007000800  100826009  000702000  075040190  003090600 | 5 1 6 2 8 9 3 4 7  8 4 9 1 7 3 2 5 6  7 3 2 4 6 5 9 1 8  6 9 8 3 1 7 5 2 4  3 2 7 9 5 4 8 6 1  1 5 4 8 2 6 7 3 9  9 6 1 7 3 2 4 8 5  2 7 5 6 4 8 1 9 3  4 8 3 5 9 1 6 7 2 | 396ms |
| Grid 37  005080700  700204005  320000084  060105040  008000500  070803010  450000091  600508007  003010600 | 9 4 5 6 8 1 7 2 3  7 8 1 2 3 4 9 6 5  3 2 6 7 5 9 1 8 4  2 6 9 1 7 5 3 4 8  1 3 8 9 4 2 5 7 6  5 7 4 8 6 3 2 1 9  4 5 7 3 2 6 8 9 1  6 1 2 5 9 8 4 3 7  8 9 3 4 1 7 6 5 2 | 432ms |
| Grid 38  000900800  128006400  070800060  800430007  500000009  600079008  090004010  003600284  001007000 | 3 6 5 9 4 2 8 7 1  1 2 8 7 5 6 4 9 3  9 7 4 8 1 3 5 6 2  8 1 9 4 3 5 6 2 7  5 3 7 2 6 8 1 4 9  6 4 2 1 7 9 3 5 8  2 9 6 3 8 4 7 1 5  7 5 3 6 9 1 2 8 4  4 8 1 5 2 7 9 3 6 | 278ms |
| Grid 39  000080000  270000054  095000810  009806400  020403060  006905100  017000620  460000038  000090000 | 1 3 4 5 8 7 2 9 6  2 7 8 1 6 9 3 5 4  6 9 5 2 3 4 8 1 7  3 5 9 8 1 6 4 7 2  8 2 1 4 7 3 5 6 9  7 4 6 9 2 5 1 8 3  9 1 7 3 4 8 6 2 5  4 6 2 7 5 1 9 3 8  5 8 3 6 9 2 7 4 1 | 355ms |
| Grid 40  000602000  400050001  085010620  038206710  000000000  019407350  026040530  900020007  000809000 | 1 9 3 6 7 2 4 8 5  4 6 2 3 5 8 9 7 1  7 8 5 9 1 4 6 2 3  5 3 8 2 9 6 7 1 4  6 7 4 1 3 5 2 9 8  2 1 9 4 8 7 3 5 6  8 2 6 7 4 1 5 3 9  9 4 1 5 2 3 8 6 7  3 5 7 8 6 9 1 4 2 | 234ms |
| Grid 41  000900002  050123400  030000160  908000000  070000090  000000205  091000050  007439020  400007000 | 8 1 4 9 7 6 5 3 2  6 5 9 1 2 3 4 7 8  7 3 2 8 5 4 1 6 9  9 4 8 2 6 5 3 1 7  2 7 5 3 4 1 8 9 6  1 6 3 7 9 8 2 4 5  3 9 1 6 8 2 7 5 4  5 8 7 4 3 9 6 2 1  4 2 6 5 1 7 9 8 3 | 356ms |
| Grid 42  380000000  000400785  009020300  060090000  800302009  000040070  001070500  495006000  000000092 | 3 8 4 5 6 7 9 2 1  1 2 6 4 3 9 7 8 5  7 5 9 8 2 1 3 4 6  5 6 3 7 9 8 2 1 4  8 4 7 3 1 2 6 5 9  9 1 2 6 4 5 8 7 3  2 3 1 9 7 4 5 6 8  4 9 5 2 8 6 1 3 7  6 7 8 1 5 3 4 9 2 | 186ms |
| Grid 43  000158000  002060800  030000040  027030510  000000000  046080790  050000080  004070100  000325000 | 4 6 9 1 5 8 3 7 2  7 1 2 4 6 3 8 5 9  5 3 8 2 9 7 6 4 1  9 2 7 6 3 4 5 1 8  3 8 5 7 1 9 4 2 6  1 4 6 5 8 2 7 9 3  6 5 3 9 4 1 2 8 7  2 9 4 8 7 6 1 3 5  8 7 1 3 2 5 9 6 4 | 354ms |
| Grid 44  010500200  900001000  002008030  500030007  008000500  600080004  040100700  000700006  003004050 | 3 1 6 5 4 9 2 7 8  9 8 7 3 2 1 6 4 5  4 5 2 6 7 8 9 3 1  5 9 4 2 3 6 8 1 7  2 3 8 4 1 7 5 6 9  6 7 1 9 8 5 3 2 4  8 4 5 1 6 2 7 9 3  1 2 9 7 5 3 4 8 6  7 6 3 8 9 4 1 5 2 | 364ms |
| Grid 45  080000040  000469000  400000007  005904600  070608030  008502100  900000005  000781000  060000010 | 5 8 6 1 2 7 9 4 3  7 2 3 4 6 9 8 5 1  4 9 1 8 5 3 2 6 7  1 3 5 9 7 4 6 2 8  2 7 9 6 1 8 5 3 4  6 4 8 5 3 2 1 7 9  9 1 7 2 4 6 3 8 5  3 5 2 7 8 1 4 9 6  8 6 4 3 9 5 7 1 2 | 258ms |
| Grid 46  904200007  010000000  000706500  000800090  020904060  040002000  001607000  000000030  300005702 | 9 5 4 2 1 3 6 8 7  6 1 7 5 4 8 9 2 3  8 3 2 7 9 6 5 4 1  7 6 3 8 5 1 2 9 4  1 2 8 9 7 4 3 6 5  5 4 9 3 6 2 1 7 8  2 8 1 6 3 7 4 5 9  4 7 5 1 2 9 8 3 6  3 9 6 4 8 5 7 1 2 | 418ms |
| Grid 47  000700800  006000031  040002000  024070000  010030080  000060290  000800070  860000500  002006000 | 1 5 9 7 4 3 8 6 2  2 7 6 5 8 9 4 3 1  3 4 8 6 1 2 7 5 9  6 2 4 9 7 8 3 1 5  9 1 7 2 3 5 6 8 4  5 8 3 1 6 4 2 9 7  4 3 5 8 2 1 9 7 6  8 6 1 4 9 7 5 2 3  7 9 2 3 5 6 1 4 8 | 354ms |
| Grid 48  001007090  590080001  030000080  000005800  050060020  004100000  080000030  100020079  020700400 | 8 6 1 3 5 7 2 9 4  5 9 7 4 8 2 3 6 1  4 3 2 6 1 9 7 8 5  9 1 6 2 7 5 8 4 3  3 5 8 9 6 4 1 2 7  2 7 4 1 3 8 9 5 6  7 8 9 5 4 1 6 3 2  1 4 3 8 2 6 5 7 9  6 2 5 7 9 3 4 1 8 | 358ms |
| Grid 49  000003017  015009008  060000000  100007000  009000200  000500004  000000020  500600340  340200000 | 2 9 4 8 6 3 5 1 7  7 1 5 4 2 9 6 3 8  8 6 3 7 5 1 4 9 2  1 5 2 9 4 7 8 6 3  4 7 9 3 8 6 2 5 1  6 3 8 5 1 2 9 7 4  9 8 6 1 3 4 7 2 5  5 2 1 6 7 8 3 4 9  3 4 7 2 9 5 1 8 6 | 244ms |
| Grid 50  300200000  000107000  706030500  070009080  900020004  010800050  009040301  000702000  000008006 | 3 5 1 2 8 6 4 9 7  4 9 2 1 5 7 6 3 8  7 8 6 9 3 4 5 1 2  2 7 5 4 6 9 1 8 3  9 3 8 5 2 1 7 6 4  6 1 4 8 7 3 2 5 9  8 2 9 6 4 5 3 7 1  1 6 3 7 9 2 8 4 5  5 4 7 3 1 8 9 2 6 | 245ms |