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CMSC 301
Report on Project 3 Sudoku Solver
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Test result on puz0 - puz9:

puz#	0	1	2	3	4	5	6	7	8	9
Solution (Valid?)	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Correct ?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Runtime (avg. of three trials) (ms)	629	557	507	473	459	419	479	474	495	478

The runtime of all 3x3 Sudoku is within 700 ms, which is efficient. The only one puzzle, puz0, that has invalid solution (or say unsolvable) has a longer runtime of 639 ms than other solvable puzzles, puz1-9, which share an average runtime of 482 ms. This verified the fact that we used a SAT solver to solve the sudoku expressed as a SAT, and the SAT problem is solvable iff the associated sudoku is solvable. For example, using backtracking to solve SAT would also give longer runtime for non-solvable SAT than solvable SAT because any satisfiable assignment would end the program while the program has to test all the assignments considered by the algorithm to say that a SAT is unsatisfiable. (Even though I am not completely sure what technique is used in org.sat4j.core package to solve SAT, it could be argued that the package would most likely produce longer runtime for unsatisfiable SAT than satisfiable ones as backtracking.)

Evidence of correctness testing on puz0-9:

```
henry_chang@HENRY:/mnt/d/MyCodes/cmssc301/proj3$ java -cp ../org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cmssc301/proj3/sudokuPuzzles/puz0
Sudoku problem:
0 0 0 7 0 0 2 0 0
0 2 3 0 0 0 0 7 0
4 0 0 0 0 2 0 0 1
0 0 0 0 0 1 8 4 0
8 0 0 0 2 0 1 9 0
0 0 5 0 0 0 0 0 2
0 5 0 0 6 0 0 0 0
2 0 0 0 0 9 0 0 8
0 0 6 3 0 0 5 0 0

Solution is invalid
Run Time = 412 msec
```

```
henry_chang@HENRY:/mnt/d/MyCodes/cmssc301/proj3$ java -cp ../org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cmssc301/proj3/sudokuPuzzles/puz1
Sudoku problem:
5 4 0 2 0 9 0 0 1
0 0 0 5 0 0 0 0 4
0 0 7 0 0 0 9 0 0
8 0 0 0 3 0 0 6 7
0 0 0 6 0 5 0 0 0
9 3 0 0 1 0 0 0 2
0 0 1 0 0 0 6 0 0
2 0 0 0 6 0 0 0 0
3 0 0 1 0 7 0 4 9

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

Solution is valid
Run Time = 479 msec
```

```
henry_chang@HENRY:/mnt/d/MyCodes/cmssc301/proj3$ java -cp ../org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cmssc301/proj3/sudokuPuzzles/puz2
Sudoku problem:
4 0 0 0 0 0 8 0 5
0 3 0 0 0 0 0 0 0
0 0 0 7 0 0 0 0 0
0 2 0 0 0 0 0 6 0
0 0 0 8 0 4 0 0 0
0 0 0 0 1 0 0 0 0
0 0 0 6 0 3 0 7 0
5 0 0 2 0 0 0 0 0
1 0 4 0 0 0 0 0 0

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

Solution is valid
Run Time = 532 msec
```

```

henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp .:org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz3
Sudoku problem:
0 0 0 0 0 0 0 0 0
0 5 4 0 9 0 0 6 7
0 0 1 0 2 0 0 4 8
0 0 0 6 0 0 0 0 0
7 3 0 0 0 0 0 0 4
5 8 0 0 0 0 0 3 0
0 6 0 9 0 7 0 0 0
0 4 0 8 6 0 0 7 9
0 0 8 0 4 0 0 0 3

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

Solution is valid
Run Time = 480 msec

```

```

henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp .:org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz4
Sudoku problem:
4 0 0 0 0 0 8 0 5
0 3 0 0 0 0 0 0 0
0 0 0 7 0 0 0 0 0
0 2 0 0 0 0 0 6 0
0 0 0 0 8 0 4 0 0
0 0 0 0 1 0 0 0 0
0 0 0 6 0 3 0 7 0
5 0 0 2 0 0 0 0 0
1 0 4 0 0 0 0 0 0

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

Solution is valid
Run Time = 447 msec

```

```

henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp .:org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz5
Sudoku problem:
3 0 0 0 8 0 0 0 0
0 0 0 7 0 0 0 0 5
1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 3 6 0
0 0 2 0 0 4 0 0 0
0 7 0 0 0 0 0 0 0
0 0 0 0 6 0 1 3 0
0 4 5 2 0 0 0 0 0
0 0 0 0 0 0 8 0 0

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

Solution is valid
Run Time = 480 msec

```

```
henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp ../org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz6
Sudoku problem:
0 0 0 5 0 3 0 0 0
0 0 0 0 6 0 7 0 0
5 0 8 0 0 0 0 1 6
3 6 0 0 2 0 0 0 0
0 0 0 4 0 1 0 0 0
0 0 0 0 3 0 0 0 5
6 7 0 0 0 0 2 0 8
0 0 4 0 7 0 0 0 0
0 0 0 2 0 0 5 0 0

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

Solution is valid
Run Time = 466 msec
```

```
henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp ../org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz7
Sudoku problem:
0 0 0 0 1 0 7 8 0
5 0 0 0 0 9 0 0 0
0 0 0 0 0 0 0 4 0
0 2 0 0 0 0 0 0 0
0 0 0 6 0 0 0 0 3
0 7 4 0 8 0 0 0 0
0 0 0 0 0 3 0 0 2
0 8 0 0 4 0 0 1 0
6 0 0 5 0 0 0 0 0

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

Solution is valid
Run Time = 592 msec
```

```
henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp ../org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz8
Sudoku problem:
0 5 2 0 0 6 8 0 0
0 0 0 0 0 7 0 2 0
0 0 0 0 0 0 6 0 0
0 0 4 8 0 0 9 0 0
2 0 0 4 1 0 0 0 0
0 0 1 0 0 0 0 0 8
0 0 6 1 0 0 3 8 0
0 0 0 0 9 0 0 0 6
0 0 0 6 0 0 1 0 9

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

Solution is valid
Run Time = 573 msec
```

```
henry_chang@HENRY:/mnt/d/MyCodes/cm301/proj3$ java -cp ..org.sat4j.core.jar SudokuSolver /mnt/d/MyCodes/cm301/proj3/sudokuPuzzles/puz9
Sudoku problem:
0 2 0 0 0 0 0 0 0
0 0 0 6 0 0 0 0 3
0 7 4 0 8 0 0 0 0
0 0 0 0 0 3 0 0 2
0 8 0 0 4 0 0 1 0
6 0 0 5 0 0 0 0 0
0 0 0 0 1 0 7 8 0
5 0 0 0 0 9 0 0 0
0 0 0 0 0 0 0 4 0

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

Solution is valid
Run Time = 539 msec
```