# Skyscraper
# Decision Problem solved with Constraint Logic Programming

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**Abstract.** This article presents a Constraint Logic Programming approach to define and ultimately solve the puzzle “Skyscraper”. The purposed solution is independent of board size and number of restrictions. The solver can also be presented with a partially-filled board, as is costumary in larger boards. We also dynamically generate “Skyscraper” puzzles, of different sizes and with varying difficulty. Results show that “Skyscraper” is a prime example for being solved with CLP, as the solution's code is brief, efficient, and simple to understand.

**Keywords:** Skyscraper, Constraint Logic Programming, Sicstus, PLOG, FEUP

## 1 Introduction

The “Skyscraper” puzzle consists of an NxN grid with some clues along its sides. The objective is to place a skyscraper (represented by its height) in each square, with a height between 1 and N, so that each row and column contains each digit exactly once. In addition, the number of visible skyscrapers, as viewed from the direction of each clue, is equal to the value of the clue. Note that higher skyscrapers block the view of lower skyscrapers located behind them.

We model the presented puzzle as a Constraint Satisfaction Problem, therefore representing it by a set of domain variables, their domains, and a set of restrictions.

Constraint Logic Programming (CLP) is a merger of two declarative paradigms: constraint solving and logic programming. Viewing the subject rather broadly, constraint logic programming can be said to involve the incorporation of constraints and constraint solving methods in a logic-based language. We refer the reader to [1] for more on this subject.

The article approaches several topics such as: the necessary domain variables, what were the constraints used and their implementation in the program, what is the labeling strategy implemented, what are the results of the developed program and what are the final conclusions obtained from developing the project.

## 2 Problem Description

The “Skyscraper” puzzle consists of an NxN grid with some clues along its sides. The objective is to place a skyscraper (represented by its height) in each square, with a height between 1 and N, so that each row and column contains each digit exactly once. In addition, the number of visible skyscrapers, as viewed from the direction of each clue, is equal to the value of the clue. Note that higher skyscrapers block the view of lower skyscrapers located behind them.

The difficulty of the puzzle can vary according to three factors: the size of the board, the number of restrictions alongthe side of the board, and the possible hints in the board itself.

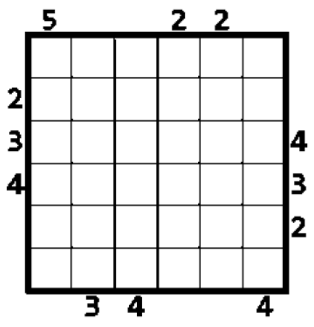


**Fig. 1.** Unsolved 6x6 Skyscraper puzzle

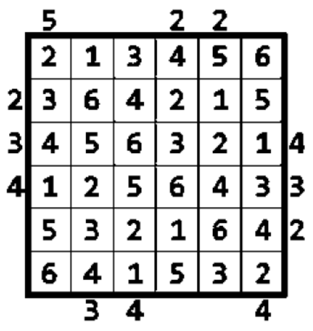


**Fig. 2.** Solved 6x6 Skyscraper puzzle

## 3 Approach

We present a Constraint Logic Programming approach to define and ultimately solve the puzzle "Skyscraper". In order to accomplish this, we use the clp(fd) — Constraint Logic Programming over Finite Domains — library in sicstus Prolog. For more information on this prolog implementation and said library, we refer the reader to [**?**] and [**?**].

Regarding the implementation of Skyscraper in Prolog, the group used a list of lists to represent the grid. The value of each element corresponding to the height of the building it represents. Elements whose value is not known will be represented by a '_', therefore representing in Prolog non-instantiated values.

For the restrictions to the side of the grid, we use a list of lists, the first of which being the top restrictions, and the rest following in counter-clockwise order. If the restriction for a certain row or column is undefined, a '0' is used in its representation.

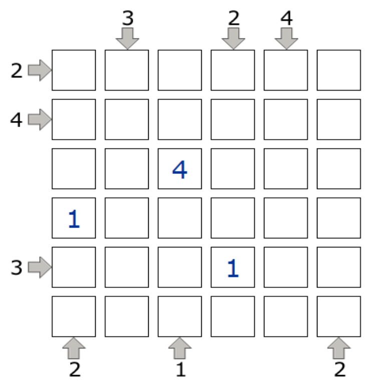


**Fig. 3.** Example of a skyscraper puzzle followed by its representation in PROLOG

**Listing 1.1.** Prolog grid representation

```
testBoard([
  [_, _, _, _, _, _],
  [_, _, _, _, _, _],
  [_, _, 4, _, _, _],
  [1, _, _, _, _, _],
  [_, _, _, 1, _, _],
  [_, _, _, _, _, _]
]).
```

**Listing 1.2.** Prolog representation of border restrictions

```
testRestrictions([
  [0, 3, 0, 2, 4, 0],
  [2, 4, 0, 0, 3, 0],
  [2, 0, 1, 0, 0, 2],
  [0, 0, 0, 0, 0, 0]
]).
```

### 3.1 Decision Variables

The decision variables associated with a skyscraper puzzle are: the lists representing the rows of the grid. Since all the elements in a row and column must have a different value — as it is a skyscraper rule — the domain of the elements in each row will have to be defined between 1 and the length of the board, *N*, and they will also have to be all distinct. The following code presents the application of the referred restrains to the decision variables.

**Listing 1.3.** Row domain restrictions

```
restrictBoardDomain([], _).
restrictBoardDomain([Row |
    Board], N) :-
  length(Row, N),
  domain(Row, 1, N),
  all_distinct(Row),
  restrictBoardDomain(Board, N).
```

**Listing 1.4.** Column all elements distinct

```
all_distinct_columns(_, 0) :- !.
all_distinct_columns(Board, N) :-
  N > 0, !,
  getBoardCol(Board, N, Col),
  all_distinct(Col),
  NewN is N - 1,
  all_distinct_columns(Board, NewN).
```

**TODO** Os side domains tb sao? penso que nao porque nao queremos instanciar nada ai... although it seems in code

### 3.2 Constraints

The restrictions defined for the puzzle are the ones from the rules. The rules that force the inexistence of repeated elements in either a row or a column were already implemented by the way the domains are defined (see section **Decision Variables**). Therefore, the challenge involving the project was the addition of PROLOG restrictions to implement the missing rule: assuring that the number outside the grid would indeed control the number of 'visible buildings'.

Theoretically, what we needed to implement in order to achieve the last rule was an IF CLAUSE, being that: if the element is bigger than the maximum value so far, than the element is the new maximum value, and the elements correspondent building is visible, otherwise, the building is not visible and the maximum value stays the same. However, since in Constraints Logic Programming the elements value would not be instantiated this implementation proved hard. **Um bcd bullshit este texto, mudar? xD ou mm apagar**

The solution we came up to implement that last rule was a *logic XOR (#\)*, because the element being analyzed was either a maximum value and the number of visible buildings would increment, or it was not and the count of visible buildings would stay the same. In the end, we wanted to, when the line was finished being analyzed, the number of visible buildings would be equal to the corresponding border restraining value. The predicate would be called for each line/ column for each of the four possible directions: left to right, right to left, top to bottom and bottom to top.

**Listing 1.5.** Constraint that assures correct number of visible buildings

```
/**
 * Apply restrictions to Row.
 * +Predicate Order in which elements are analyzed - fetches an element.
 * +Num is the number of visible skyscrapers according to the above
     order.
 */
applyToRow(Num, Row, Max, GetElement) :-
  call(GetElement, Row, El, RemainderRow),
  NewNum #>= 0,
  (El #> Max #/\ NewMax #= El #/\ NewNum #= Num - 1) #\/
  (El #=< Max #/\ NewMax #= Max #/\ NewNum #= Num),
  applyToRow(NewNum, RemainderRow, NewMax, GetElement).
applyToRow(0, [], _, _).
```

### 3.3 Evaluation Function

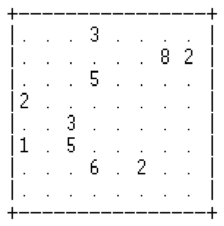
In Skyscraper there is no evaluation of solutions, since the puzzle is solved whenever a solution is found.

### 3.4 Search Strategy

The labeling strategy implemented in the program was the ***ffc***, also known as *most_constrained*. This labeling strategy makes use of the most constrained heuristic: ' a variable with the smallest domain is selected, breaking ties by (a) selecting the variable that has the most constraints suspended on it and (b) selecting the leftmost one'[3]. We opted for this heuristic as it would be the one providing faster and more efficient solutions for the skyscraper puzzle. This was natural having in mind the kind ofconstraints that were applied during the development, namely the constraint that assure the building heights were correct,**ver a frase a partir daqui :/** that is: since the entire board is not instantiated the solution will be faster if the first most constrained values — therefore the ones most unlikely to wrong — are first discovered and snowball from there on.

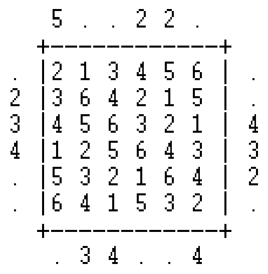
## 4 Solution Presentation

For the solution presentation in text mode the predicate *printBoard* is used. If run as ***printBoard(+Board)***, it only prints the given board in a user friendly way. However, if run as ***printBoard(+Board, +Restrictions)*** it will print the board in a user friendly way while also displaying the boarder restrictions being applied to each row or column. The predicate makes use of helper predicates such as ***printRow(+Row)***, that prints the given row and ***printHBorder(+Length)***, that prints the horizontal border at the top and the bottom. All this predicates are defined in the file ***display.pl***.



```
+----------------+
|. . . 3 . . . . |
|. . . . . . 8 2 |
|. . . 5 . . . . |
|2 . . . . . . . |
|. . 3 . . . . . |
|1 . 5 . . . . . |
|. . . 6 . 2 . . |
|. . . . . . . . |
+----------------+
```

**Fig. 4.** Example of a call to printBoard/1



```
     5 . . 2 2 .
   +-------------+
 . |2 1 3 4 5 6 |  .
 2 |3 6 4 2 1 5 |  .
 3 |4 5 6 3 2 1 |  4
 4 |1 2 5 6 4 3 |  3
 . |5 3 2 1 6 4 |  2
 . |6 4 1 5 3 2 |  .
   +-------------+
     . 3 4 . . 4
```

**Fig. 5.** Example of a call to printBoard/2 with a solved board

## 5 Results

The group tried to make extensive and exhaustive tests to be able to conclude fiercely about the given results.

The results of several tests that the group made the program went through were:

In the end, the conclusions the group came up with were:

- There is an exponential relation between the board size and time taken to solve the puzzle. For smaller boards the difference in board size affects slightly the difference of times (board size 4 to baoard size 5, differences of around 0.05s). However in bigger boards the difference of board sizes affect time fiercely (board size 6 to board size 7, differences of around 10s).

- There is a strong correlation between the number of backtracks (and the other statistics, such as *Resumptions, Entailments, Prunings and Constraints created*) and time. The higher the alue of the statistics the higher the tame ita took the program to solve the puzzle.

- Also worth notice, despiting not being visible in the table because its values are an average, is the fact that puzzle with a higher number of border

**Table 1.** Each of the values is the result of the average of several tests made

| Board Size | Time /s | Backtracks |
|---|---|---|
| 4x4 | 0.0 | 9 |
| 5x5 | 0.047 | 659 |
| 6x6 | 0.291 | 5438 |
| 7x7 | 10.489 | 159196 |
| 8x8 | 18.239 | 315893 |

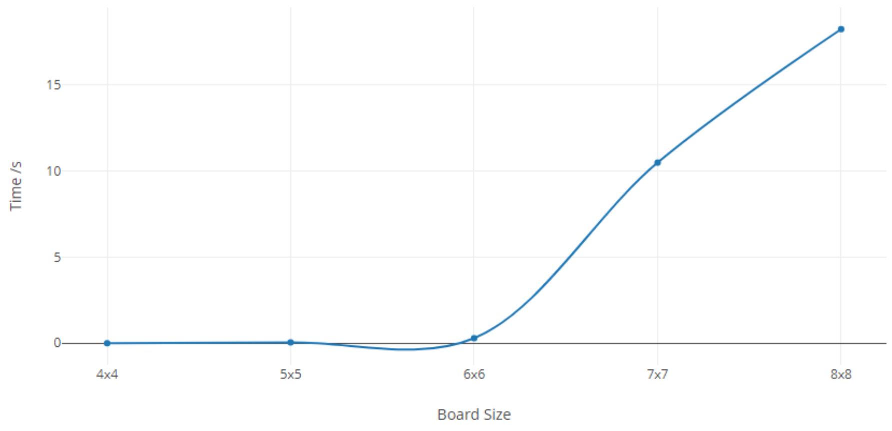


**Fig. 6.** Relation between board size and time taken to find a solution.

restricitons are faster to solve. This is naturally explained since the information received by the solver is bigger and therefore the number of backtracks done is smaller.

## 6 Conclusion and Future Work

We believe that our knowledge about Logic Programming was deeply increased, with everything we had proposed to do being accomplished in the required time.

The program developed has no limitations regarding board size or problem generation, despite becoming slower with bigger board sizes. Therefore, the only way possible to improve the developed application would be by improving the solver efficiency and time. However, the group tried fiercely to make that improve by trying out several approaches but in the end, the best solution was the one being presented.

The group also agreed in the fact that Logic Programming with Constrains revealed itself to be an extremely powerful tool, able to solve easily certain prob-

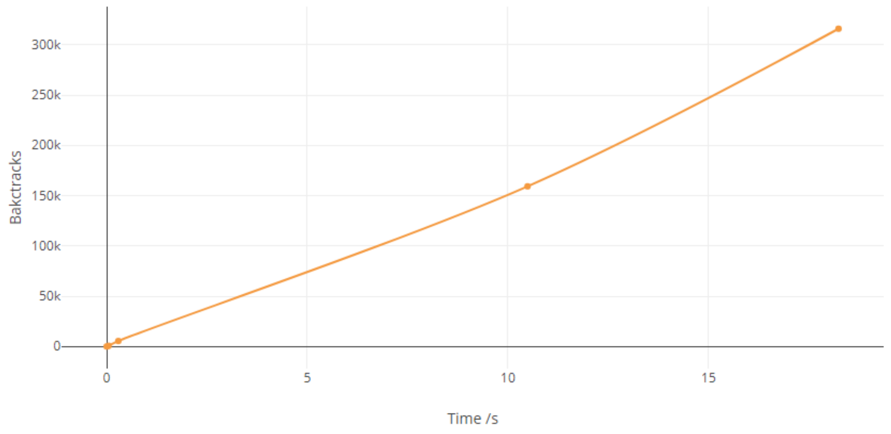


**Fig. 7.** Relation between number of backtracks and time to solve the puzzle

lems (such as the one this work is based in) that would take much more time and effort to solve with other paradigms.

To sum up, despite Logic Programming with Constraints being a totally different paradigm from what the group had ever worked with, we quickly got used to it and learnt to appreciate the cons and pros that it presents, thus having it culminate in a project we are proud of.

## 7 Acknowledgements

This article was written for the course unit “Logic Programming”, from the Master in Informatics and Computing Engineering, a course in the Faculty of Engineering of the University of Porto.

## References

1. J. Jaffar and M. J. Maher, “Constraint logic programming: a survey,” *The Journal of Logic Programming*, vol. 19-20, p. 503581, 1994.

## A Appendix

## skyscraper.pl

```
:- include('solver.pl').
:- include('display.pl').
:- include('test_data.pl').
:- include('generator.pl').

%Predicate to run the default puzzle
skyscraper :-
  nl, write('Skyscraper!'), nl, nl,
  testRestrictions(R),
  R = [Up | _Rest],
  length(Up, Size),
  solveBoard(Size, B, R),
  printBoard(B, R).
```

# solver.pl

```
:- use_module(library(clpfd)).
:- use_module(library(lists)).

/**
 * Domain restriction
 */
sidesDomain(Size, [List | Rest]) :-
  length(List, Size),
  domain(List, 0, Size),
  sidesDomain(Size, Rest).
sidesDomain(_, []).

restrictBoardDomain([], _).
restrictBoardDomain([Row | Board], N) :-
  length(Row, N),
  domain(Row, 1, N),
  all_distinct(Row),
  restrictBoardDomain(Board, N).

all_distinct_columns(_, 0) :- !.
all_distinct_columns(Board, N) :-
  N > 0, !,
  getBoardCol(Board, N, Col),
  all_distinct(Col),
  NewN is N - 1,
  all_distinct_columns(Board, NewN).


% Get the nth1 column of the given Board (1 indexed)
getBoardCol([], _, []).
getBoardCol([Row | Board], N, [El | Col]) :-
  element(N, Row, El),
  getBoardCol(Board, N, Col).


%% Gets the FIRST element of a given row
getFirstElement([Element | RemainderRow], Element, RemainderRow).

%% Gets the LAST element of a given row
getLastElement(Row, Element, RemainderRow) :-
  append(RemainderRow, [Element], Row).


%% LEFT to RIGHT
applyLeftToRight(Num, Row) :-
  applyToRow(Num, Row, 0, getFirstElement).
```

```
%% RIGHT to LEFT
applyRightToLeft(Num, Row) :-
  applyToRow(Num, Row, 0, getLastElement).

/**
 * Apply restrictions to Row.
 * +Predicate Order in which elements are analyzed - fetches an element.
 * +Num is the number of visible skyscrapers according to the above
     order.
 */
applyToRow(Num, Row, Max, GetElement) :-
  call(GetElement, Row, El, RemainderRow),
  NewNum #>= 0,
  (El #> Max #/\ NewMax #= El #/\ NewNum #= Num - 1) #\
  (El #=< Max #/\ NewMax #= Max #/\ NewNum #= Num),
  applyToRow(NewNum, RemainderRow, NewMax, GetElement).
applyToRow(0, [], _, _).

/**
 * Applies restrictions Horizontally along the board
 * +Predicate is the predicate used to apply restrictions on the fetched
     Row.
 */
applyAllHorizontalRestrictions([0 | Rest], [_ | Rows], Predicate) :-
  applyAllHorizontalRestrictions(Rest, Rows, Predicate).
applyAllHorizontalRestrictions([N | Rest], [Row1 | Rows], Predicate) :-
  call(Predicate, N, Row1),
  applyAllHorizontalRestrictions(Rest, Rows, Predicate).
applyAllHorizontalRestrictions([], [], _).

/**
 * Applies restrictions Vertically along the board
 * +Predicate is the predicate used to apply restrictions on the fetched
     Column.
 */
applyAllVerticalRestrictions(Restrictions, Board, Predicate) :-
  applyAllVerticalRestrictions(Restrictions, Board, Predicate, 1).
applyAllVerticalRestrictions([0 | Rest], Board, Predicate, Count) :-
  NewCount is Count + 1,
  applyAllVerticalRestrictions(Rest, Board, Predicate, NewCount).
applyAllVerticalRestrictions([N | Rest], Board, Predicate, Count) :-
  NewCount is Count + 1,
  getBoardCol(Board, Count, Col),
  call(Predicate, N, Col),
  applyAllVerticalRestrictions(Rest, Board, Predicate, NewCount).
applyAllVerticalRestrictions([], _, _, _).


/**
```

```
 *  +Sides -> a list of lists, each of which represents the restrictions
     on the side of the board (number of visible buildings).
 *     -> in order: [TopRestrictions, LeftRestrictions,
     BottomRestrictions, RightRestrictions]
 *     -> elements of list are in range [0,N], 0 meaning an undefined
     restriction
 *     -> elements correspond to restrictions in top->bottom (left/right
     lists) or left->right (top/bottom lists) order
 *  -Board -> a list of lists (a matrix)
 */
solveBoard(Size, Board, Sides) :-
  Sides = [Top, Left, Bottom, Right],
  sidesDomain(Size, Sides),

  % Domain
  length(Board, Size),
  restrictBoardDomain(Board, Size),
  all_distinct_columns(Board, Size),

  % Apply restrictions to board rows/columns
  applyAllHorizontalRestrictions(Left, Board, applyLeftToRight),
  applyAllHorizontalRestrictions(Right, Board, applyRightToLeft),
  applyAllVerticalRestrictions(Top, Board, applyLeftToRight),
  applyAllVerticalRestrictions(Bottom, Board, applyRightToLeft),

  append(Board, FlatBoard),
  append(Sides, FlatSides),
  append(FlatBoard, FlatSides, DomainVariables),
  labeling([ffc], DomainVariables).
```

# generator.pl

```
:- use_module(library(lists)).
:- use_module(library(random)).
:- include('solver.pl').

% Restrict the number of constraints shown , according to the probability
restrictVarsInSides([], _).
restrictVarsInSides([First | Rest], Probability) :-
  restrictVarsInRow(First, Probability),
  restrictVarsInSides(Rest, Probability).

% Restrict the number of constraints shown , according to the probability
restrictVarsInRow([], _).
restrictVarsInRow([V1 | Vars], Probability) :-
  maybe(Probability), !,
  V1 #\= 0,
  restrictVarsInRow(Vars, Probability).
restrictVarsInRow([_ | Vars], Probability) :-
  restrictVarsInRow(Vars, Probability).

/**
 * Generates boards of differente difficulty according the given
     probability.
 * +The probability will control the amount of Restrictions that are
     shown.
 */
generateBoardEasy(Size, Board, Sides) :-
  generateBoard(Size, Board, Sides, 0.95).
generateBoardMedium(Size, Board, Sides) :-
  generateBoard(Size, Board, Sides, 0.8).
generateBoardHard(Size, Board, Sides) :-
  generateBoard(Size, Board, Sides, 0.65).
generateBoard(Size, Board, Sides, Probability) :-
  setrand(100),
  length(Sides, 4),
  sidesDomain(Size, Sides),
  restrictVarsInSides(Sides, Probability),

  solveBoard(Size, Board, Sides).

/*
generateBoardUniqueSol(Size, Board, Sides) :-
  setrand(200),
  length(Sides, 4),
  sidesDomain(Size, Sides),
  Probability = 1,
  restrictVarsInSides(Sides, Probability),
  findall(B, solveBoard(Size, B, Sides), [Board]).
```

```
*/ % badbadnotgood backtracking

% Size = 8, generateBoardEasy(Size, B, S), printBoard(B, S),
    solveBoard(Size, SB, S), printBoard(SB, S).
% Size = 8, generateRandomBoard(Size, Board, Sides), printBoard(Board,
    Sides), solveBoard(Size, SameBoard, Sides), printBoard(SameBoard,
    Sides), Board = SameBoard.
% Size = 6, generateRandomBoard(Size, Board, Sides), printBoard(Board,
    Sides), solveBoard(Size, SameBoard, Sides), Board = SameBoard.
```

# display.pl

```
%Dictionary for user friendly visualization of elements
translate(0, '.').
translate(P, P).

% printBoard(+Board)
%% prints the given board on the screen
printBoard(Board) :-
  Board = [Row | _],
  length(Row, RowLength),
  printHBorder(RowLength),
  printBoardAux(Board),
  printHBorder(RowLength).

printBoardAux([]) :- !.
printBoardAux([Row | Board]) :-
  printRow(Row), nl,
  printBoardAux(Board).

% printBoard(+Board, +Restrictions)
%% prints the given board, and all the provided side restrictions
printBoard(Board, Restrictions) :- !,
  Restrictions = [Top, Left, Bottom, Right],
  write('  '), printRowAux(Top), nl,
  length(Top, RowLength),
  write(' '), printHBorder(RowLength),
  printBoard(Board, Left, Right),
  write(' '), printHBorder(RowLength),
  write('  '), printRowAux(Bottom), nl, nl.

% printBoard(+Board, +LeftRestrictions, +RightRestrictions)
%% prints the given board, and the provided side restrictions for left
    and right
printBoard([], [], []) :- !.
printBoard([Row | Board], [L1 | Left], [R1 | Right]) :-
  translate(L1, SymbL), translate(R1, SymbR),
  write(SymbL), write(' '),
  printRow(Row),
  write(' '), write(SymbR), nl,
  printBoard(Board, Left, Right).

% printRow(+Row)
%% prints the provided list/row and adds '|' after and before the list
printRow(Row) :-
  write('|'),
  printRowAux(Row),
  write('|'), !.
printRowAux([]) :- !.
printRowAux([El | Row]) :-
  translate(El, Symb),
  write(Symb), write(' '),
  printRowAux(Row).

% printHorizontalBorder(+Length)
%% prints the top or bottom border for the board, example of a boarder:
     '+-------+'
printHBorder(Length):-
  write('+'),
  printHBorderAux(Length),
  write('+'), nl, !.
printHBorderAux(0) :- !.
printHBorderAux(Length) :-
  write('--'),
  NewLength is Length - 1,
  printHBorderAux(NewLength).
```

# test_data.pl

```
:- use_module(library(system)).

/** Test Boards **/
%% https://www.brainbashers.com/skyscrapers.asp

%% 6 by 6 board -- given example -- 166199 backtracks, 6311 with ffc
testRestrictions([
  [5, 0, 0, 2, 2, 0],
  [0, 2, 3, 4, 0, 0],
  [0, 3, 4, 0, 0, 4],
  [0, 0, 4, 3, 2, 0]
]).

%% 5 by 5 board
testRestrictions2([
  [4, 0, 1, 2, 3],
  [0, 2, 0, 4, 0],
  [0, 0, 4, 0, 0],
  [0, 0, 0, 0, 2]
]).

%% 4 by 4 board
testRestrictions3([
  [4, 0, 0, 2],
  [0, 3, 0, 0],
  [0, 0, 4, 0],
  [0, 0, 0, 3]
]).

%% 8 by 8 board
testRestrictions4([
  [0, 0, 5, 3, 0, 2, 0, 4],
  [3, 3, 0, 3, 0, 3, 0, 0],
  [2, 4, 0, 0, 4, 0, 0, 0],
  [0, 0, 2, 0, 4, 4, 0, 1]
]).

board4([
  [_, _, _, 3, _, _, _, _],
  [_, _, _, _, _, _, 8, 2],
  [_, _, _, 5, _, _, _, _],
  [2, _, _, _, _, _, _, _],
  [_, _, 3, _, _, _, _, _],
  [1, _, 5, _, _, _, _, _],
  [_, _, _, 6, _, 2, _, _],
  [_, _, _, _, _, _, _, _]
]).
```

```
%% 6 by 6 board
testRestrictions5([
  [0, 1, 3, 0, 0, 0],
  [0, 0, 4, 2, 2, 0],
  [3, 0, 0, 0, 0, 0],
  [3, 3, 2, 0, 2, 4]
]).

board5([
  [1, _, _, _, _, _],
  [_, 4, _, _, _, _],
  [_, _, _, _, _, _],
  [_, _, 2, _, _, _],
  [_, _, _, _, _, _],
  [_, _, _, _, _, _]
]).

%% 7 by 7 board
testRestrictions6([
  [0, 0, 0, 0, 0, 3, 4],
  [0, 0, 4, 2, 0, 0, 5],
  [0, 2, 0, 2, 0, 4, 0],
  [0, 0, 0, 2, 5, 2, 0]
]).

board6([
  [_, _, _, _, _, _, _],
  [4, 3, _, _, _, _, _],
  [2, _, _, _, _, _, 1],
  [_, _, _, _, _, _, _],
  [_, _, _, _, _, _, _],
  [_, _, 1, _, _, _, _],
  [_, _, _, 3, _, _, _]
]).

% 8 by 8 board
testRestrictions7([
  [0, 0, 5, 3, 0, 2, 0, 4],
  [3, 3, 0, 3, 0, 3, 0, 0],
  [2, 4, 0, 0, 4, 0, 0, 0],
  [0, 0, 2, 0, 4, 4, 0, 1]
]).

board7([
  [_, _, _, 3, _, _, _, _],
  [_, _, _, _, _, _, 8, 2],
  [_, _, _, 5, _, _, _, _],
  [2, _, _, _, _, _, _, _],
  [_, _, 3, _, _, _, _, _],
  [1, _, 5, _, _, _, _, _],
  [_, _, _, 6, _, 2, _, _],
  [_, _, _, _, _, _, _, _]
]).

% Functions to get duration time
reset_timer:- statistics(walltime, _).
print_time:-
  statistics(walltime, [_, T]),
  TS is ((T/10)*10)/1000,
  nl, write('Time: '), write(TS), write('s'), nl.

% Print stats for the given restricitons and the given, if HasBoard is
    'yes'
% Otherwise only Restrictions are used and board starts empty
% getTestStats(+Restrictions, +HasBoard, +Board)
getTestStats(Restrictions, no, _):-
  call(Restrictions, R),
  R = [Up | _Rest],
  length(Up, Size),
  reset_timer,
  solveBoard(Size, _B, R),
  write('Solved for Restrictions: '), write(Restrictions), nl,
  print_time, fd_statistics, nl.

getTestStats(Restrictions, yes, Board):-
  call(Restrictions, R),
  R = [Up | _Rest],
  length(Up, Size),
  call(Board, B),
  reset_timer,
  solveBoard(Size, B, R),
  write('Solved for Restriction: '), write(Restrictions), nl,
  write('Solved for Board: '), write(Board), nl,
  print_time, fd_statistics, nl.

%Prints the stats of each test
getAllTestsStats:-
  getTestStats(testRestrictions, no, _),
  getTestStats(testRestrictions2, no, _),
  getTestStats(testRestrictions3, no, _),
  getTestStats(testRestrictions4, yes, board4),
  getTestStats(testRestrictions5, yes, board5),
  getTestStats(testRestrictions6, yes, board6),
  getTestStats(testRestrictions7, yes, board7).
```