

(Downloaded from <https://cs.stanford.edu/~knuth/programs.html> and typeset on May 28, 2023)

**1. Intro.** Mike Spivey announced a programming contest in February 2005, asking for a program that solves “sudoku” puzzles (which evidently appear daily in British newspapers). This program takes a sudoku specification in standard input and creates — on standard output — a file that can be piped into DANCE in order to deduce all solutions.

Brief explanation: Each possible placement of a digit corresponds to a row, column, and box where that digit does not yet appear. We want an exact cover of those rows, columns, and boxes.

Apology: I wrote this in a big hurry. But I couldn’t resist the task, because it is such a nice application of exact covering.

```
#include <stdio.h>
char buf[11];
int row[9][10], col[9][10], box[9][10]; /* things to cover */
int board[9][9]; /* positions already filled */
main()
{
    register int j, k, d, x;
    for (k = 0; k < 9; k++) ⟨Input row k 2⟩;
    ⟨Output the column names needed by DANCE 3⟩;
    for (j = 0; j < 9; j++)
        for (k = 0; k < 9; k++)
            if (¬board[k][j]) ⟨Output the possibilities for filling column j of row k 4⟩;
}
```

**2.** In a production system I would of course try to give more informative error messages about malformed input data. Here I simply quit, if the rules haven’t been followed.

```
#define panic(m)
    { fprintf(stderr, "%s!\n%s", m, buf); exit(-1); }
⟨Input row k 2⟩ ≡
{
    fgets(buf, 11, stdin);
    if (buf[9] ≠ '\n') panic("Input_line_should_have_9_characters_exactly!\n");
    for (j = 0; j < 9; j++)
        if (buf[j] ≠ '.') {
            if (buf[j] < '1' ∨ buf[j] > '9') panic("Illegal_character_in_input!\n");
            d = buf[j] - '0';
            if (row[k][d]) panic("Two_identical_digits_in_a_row!\n");
            row[k][d] = 1;
            if (col[j][d]) panic("Two_identical_digits_in_a_column!\n");
            col[j][d] = 1;
            x = ((int)(k/3)) * 3 + ((int)(j/3));
            if (box[x][d]) panic("Two_identical_digits_in_a_box!\n");
            box[x][d] = 1;
            board[k][j] = 1;
        }
}
```

This code is used in section 1.

3. First we print out all the positions, rows, columns, and boxes that need to be covered.

⟨ Output the column names needed by DANCE 3 ⟩  $\equiv$

```

for ( $k = 0$ ;  $k < 9$ ;  $k++$ )
  for ( $j = 0$ ;  $j < 9$ ;  $j++$ )
    if ( $\neg board[k][j]$ ) printf ("␣p%d%d",  $k, j$ );
for ( $k = 0$ ;  $k < 9$ ;  $k++$ )
  for ( $d = 1$ ;  $d \leq 9$ ;  $d++$ ) {
    if ( $\neg row[k][d]$ ) printf ("␣x%d%d",  $k, d$ );
    if ( $\neg col[k][d]$ ) printf ("␣c%d%d",  $k, d$ );
    if ( $\neg box[k][d]$ ) printf ("␣b%d%d",  $k, d$ );
  }
printf ("\n");

```

This code is used in section 1.

4. Then we print out all the possible placements.

⟨ Output the possibilities for filling column  $j$  of row  $k$  4 ⟩  $\equiv$

```

{
   $x = ((\mathbf{int})(k/3)) * 3 + ((\mathbf{int})(j/3))$ ;
  for ( $d = 1$ ;  $d \leq 9$ ;  $d++$ )
    if ( $\neg row[k][d] \wedge \neg col[j][d] \wedge \neg box[x][d]$ ) printf ("p%d%d␣x%d%d␣c%d%d␣b%d%d\n",  $k, j, k, d, j, d, x, d$ );
}

```

This code is used in section 1.

**5. Index.**

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$\langle$  Input row  $k$  2  $\rangle$  Used in section 1.

$\langle$  Output the column names needed by DANCE 3  $\rangle$  Used in section 1.

$\langle$  Output the possibilities for filling column  $j$  of row  $k$  4  $\rangle$  Used in section 1.

# SUDOKU

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