P1 – Solving Sudoku

3.1 – Final Reading

For the type of algorithm I am using to solve this sudoku a normal array would not be suitable. Therefore I created my own data type “cell” in order to do this.

```
void fileToGrid() {
    ifstream file;
    file.open("SUDOKU.txt");

    char buf;


    for(int i=0; i<GRID_SIZE; i++) {

        for(int j=0; j<GRID_SIZE; j++) {

            file >> buf;

            //if unsolved value
            if(buf == 'X') {
                grid[i][j].solved = false;
            }

            //if solved value
            else {
                grid[i][j].solvedVal = atoi(&buf);  //convert from char to int value
                grid[i][j].solved = true;
            }
        }
    }
}
```

```
struct cell {
    bool solved = false;                    //true if original value or solved by algorithm
    int solvedVal = 0;
    int vals[GRID_SIZE] = {1, };    //1 if it is a possible value (anything is possible by default)
};

//sudoku grid 2d array       row, column
cell grid[GRID_SIZE][GRID_SIZE];
```

Whilst its not in a strict 9x9 integer array, it is in a format which will help me later.

3.2 Sudoku Display

```
void displayBoard() {
    char val[1];

    //itterate row
    for(int i=0; i<GRID_SIZE; i++) {

        //draw horizontal line
        if((i % SGRID_SIZE) == 0) {
            for(int x=0; x<(GRID_SIZE * 2) + (GRID_SIZE * 2 / SGRID_SIZE) + 1; x++) {
                cout << "-";
            }
            cout << "\n";
        }

        //itterate collumn
        for(int j=0; j<GRID_SIZE; j++) {

            //draw vertical lines
            if((j % SGRID_SIZE) == 0) {
                cout << "| ";
            }

            //write specific value
            if(grid[i][j].solved == true) {
                /*val[0] = ' ';
                itoa(grid[i][j].solvedVal, val, 10);
                cout << val[0] << " ";*/
                cout << grid[i][j].solvedVal << " ";
            }
            else {
                cout << "x ";
            }
        }
        cout << "|\n";
    }

    //horizontal line finishes grid
    for(int x=0; x<(GRID_SIZE * 2) + (GRID_SIZE * 2 / SGRID_SIZE) + 1; x++) {
        cout << "-";
    }
    cout << "\n";
}
```

```
D:\2020+21\ELEC1204 - Advanced Programming\P1\src\sudokuSolve>main.exe
-------------------------
|   2   | 8     |       |
| 9   1 |       |       |
|   7   | 2 4 6 |       |
-------------------------
| 2   9 |     5 |     4 |
|     5 |   8   |   6   |
|       |   6 1 |       |
-------------------------
|       |       |   5 7 |
| 3     |       | 8     |
|       | 3 2 7 |       |
-------------------------
```

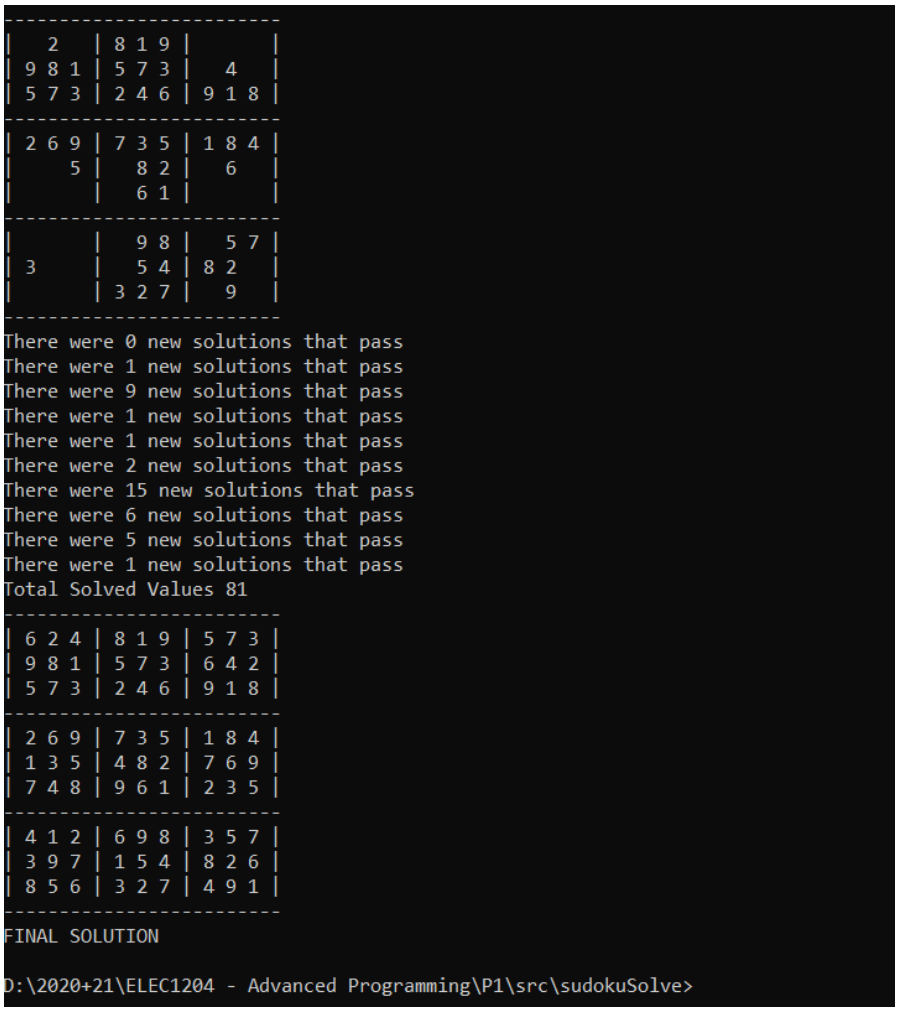
3.3 Sudoku Solving

On implementing my algorithm into my program it initially shows promising signs, but on testing the sudoku it gets stuck. It runs through deleting all the potential possible values in each the rows, columns and sub cells and then sees if there are any cells where only one possible solution is possible. This can be seen working below.

The only problem is that it gets to a state where it cannot continue since all the unsolved cells contain more than one possible value (as can be seen above). This means that a brute force method of trial an error must be used but this isn't all bad news. Due to the way my algorithm works, each cell has an array of the possible values that could go there. This helps brute force solving quicker since in some cells there may only be 2 or 3 possible values that can go there so we don't need to check all 9 possible numbers which can go there. This

helps to reduce iterations and therefore quickens the process. To implement this easier I added two more variables. In the cell data type I added numSolutions which holds the number of possible solutions left for that cell. Also, I added a zeroError Boolean which will flag true if there is a cell with 0 solutions, this means a clash has occurred since every cell must have a solution.

On implementing this it works. This uses the same algorithm to do the actual solving except if it cannot solve it in the initial passes then it goes onto this combinational method. This tests a value to see if it works in that position if there is a zero-solution flag then the value cannot legally go there so it passes onto the next possible value. Once it goes through each of the values it should find one which helps the algorithm which I have written to solve the sudoku. This can be seen working below.



Finished code

```
#include <iostream>
#include <fstream>
#include <string.h>

using namespace std;

//one side of the grid (default 9)
#define GRID_SIZE 9

//sub grid size (default 3)
#define SGRID_SIZE 3

struct cell {
    bool solved = false;                    //true if original value or solved
 by algorithm
    int solvedVal = 0;
    int numSolutions = 0;
    int vals[GRID_SIZE] = {1, 1, 1, 1, 1, 1, 1, 1, 1};    //1 if it is a possi
ble value (anything is possible by default)
};

//sudoku grid 2d array       row, column
cell grid[GRID_SIZE][GRID_SIZE];

bool zeroError = false;


void fileToGrid(const char * fileName);
void displayBoard(void);


bool isSolved(int row, int column);
void handleSolution(int row, int column);

bool solveGrid(void);

void deleteFromRow(int row, int num);
void deleteFromColumn(int column, int num);
void deleteFromSubcell(int row, int column, int num);

int main(int argc, char *argv[]) {

    if(argc != 2) {
        fileToGrid("SUDOKU.txt");
    }
    else {
        fileToGrid(argv[1]);
```

```
    }


    displayBoard();

    int totalSolutions = 0;
    int newSolutions = 5;


    if(solveGrid()) {
        displayBoard();
        cout << "FINAL SOLUTION\n";
    }
    else {
        displayBoard();
        cout << "Initial Pass Failes\n";
    }



    cell savedGrid[GRID_SIZE][GRID_SIZE];

    memcpy(savedGrid, grid, sizeof(grid));      //save the last status of the
solved grid


    //perform combination solve
    for(int row=0; row<GRID_SIZE; row++) {

        for(int column=0; column<GRID_SIZE; column++) {

            //finds the not solved cells
            if(!grid[row][column].solved) {

                for(int x=0; x<GRID_SIZE; x++) {

                    //if its a possible value
                    if(savedGrid[row][column].vals[x] == 1) {

                        //reset grid to last know good point
                        memcpy(grid, savedGrid, sizeof(savedGrid));

                        grid[row][column].solvedVal = (x + 1);
                        grid[row][column].solved = true;

                        //test solution
                        if(solveGrid()) {
                            cout << "Value " << (x + 1) << " in cell " << row
<< "," << column << " WORKS\n";
```

```
                            displayBoard();
                            cout << "FINAL SOLUTION\n";
                            return 1;
                        }
                        else {
                            if(zeroError) {
                                zeroError = false;
                                cout << "Value " << (x + 1) << " in cell " <<
row << "," << column << " failed\n";
                                //memcpy(grid, savedGrid, sizeof(savedGrid));
                            }
                            else {
                                cout << "Value " << (x + 1) << " in cell " <<
row << "," << column << " maybe\n";
                            }

                        }

                        displayBoard();
                    }


                }

            }
        }
    }

}




bool solveGrid() {
    int totalSolutions = 0;
    int newSolutions = 0;

    int passNumber = 0;

    while((totalSolutions != (GRID_SIZE * GRID_SIZE)) && (newSolutions != 0 ||
 passNumber < 5)) {
        newSolutions = 0;
        totalSolutions = 0;

        for(int r=0; r<GRID_SIZE; r++) {

            //iterate through columns
            for(int c=0; c<GRID_SIZE; c++) {
```

```
                //test to see if solved (previously solved or newly solved)
                if(isSolved(r, c)) {
                    if(zeroError) {
                        //zeroError = false;
                        return false;
                    }
                    totalSolutions++;
                    newSolutions = (grid[r][c].solved) ? newSolutions : newSol
utions + 1;

                    handleSolution(r, c);
                }
            }
        }

        passNumber++;

        //displayBoard();
        cout << "There were " << newSolutions << " new solutions that pass\n";



    }

    //true if there is a full grid of solutions

    cout << "Total Solved Values " << totalSolutions << "\n";
    return (bool) (totalSolutions == (GRID_SIZE * GRID_SIZE));

}



void fileToGrid(const char * fileName) {
    char buf;

    ifstream file;
    file.open(fileName);


    for(int i=0; i<GRID_SIZE; i++) {

        for(int j=0; j<GRID_SIZE; j++) {

            file >> buf;

            //if unsolved value
            if(buf == 'X') {
                grid[i][j].solved = false;
```

```
            }

            //if solved value
            else {
                grid[i][j].solvedVal = atoi(&buf);  //convert from char to int
 value
                grid[i][j].solved = true;
            }
        }
    }
}


//only for 9 x 9 grid
void displayBoard() {
    char val[1];

    //itterate row
    for(int i=0; i<GRID_SIZE; i++) {

        //draw horizontal line
        if((i % SGRID_SIZE) == 0) {
            for(int x=0; x<(GRID_SIZE * 2) + (GRID_SIZE * 2 / SGRID_SIZE) + 1;
 x++) {
                cout << "-";
            }
            cout << "\n";
        }

        //itterate collumn
        for(int j=0; j<GRID_SIZE; j++) {

            //draw vertical lines
            if((j % SGRID_SIZE) == 0) {
                cout << "| ";
            }

            //write specific value
            if(grid[i][j].solved == true) {
                /*val[0] = ' ';
                itoa(grid[i][j].solvedVal, val, 10);
                cout << val[0] << " ";*/
                cout << grid[i][j].solvedVal << " ";
            }
            else {
                cout << "  ";
            }
        }
        cout << "|\n";
```

```
    }

    //horizontal line finishes grid
    for(int x=0; x<(GRID_SIZE * 2) + (GRID_SIZE * 2 / SGRID_SIZE) + 1; x++) {
        cout << "-";
    }
    cout << "\n";
}


void deleteFromRow(int row, int num) {

    //iterates through each cell in row
    for(int i=0; i<GRID_SIZE; i++) {

        //checks to see if not already solved
        if(!grid[row][i].solved) {

            grid[row][i].vals[num - 1] = 0;
        }
    }
}

void deleteFromColumn(int column, int num) {

    //iterates through each cell in column
    for(int i=0; i<GRID_SIZE; i++) {

        //checks to see if not already solved
        if(!grid[i][column].solved) {

            grid[i][column].vals[num - 1] = 0;
        }
    }
}

void deleteFromSubcell(int row, int column, int num) {
    int subCellRow = (int) row / SGRID_SIZE;
    int subCellColumn = (int) column / SGRID_SIZE;


    for(int ir=0; ir<SGRID_SIZE; ir++) {

        for(int ic=0; ic<SGRID_SIZE; ic++) {

            grid[(subCellRow * SGRID_SIZE) + ir][(subCellColumn * SGRID_SIZE)
+ ic].vals[num - 1] = 0;
        }
    }
```

```
}

bool isSolved(int row, int column) {
    int total = 0;

    //if already existing solution
    if(grid[row][column].solved) {
        return true;
    }

    //if total is one then theres only one solution
    for(int i=0; i<GRID_SIZE; i++) {
        total = (grid[row][column].vals[i] == 1) ? total + 1: total;
    }

    //cout << "Possible Solutions for " << row << "," << column << ": " << tot
al << endl;
    grid[row][column].numSolutions = total;

    if(total > 1) {
        return false;
    }
    else if(total == 1) {
        return true;
    }
    else {
        cout << "ERROR 0 possible values\n";
        zeroError = true;
        return false;
    }

}

void handleSolution(int row, int column) {

    //if there is a new solution but the cell has not been set to true
    if(!grid[row][column].solved) {
        grid[row][column].solved = true;

        //cout << "New Solution!\n";

        for(int i=0; i<GRID_SIZE; i++) {

            //finds the last remaining possible solution
            if(grid[row][column].vals[i] == 1) {
                grid[row][column].solvedVal = i + 1;
            }
```

```
        }
    }

    deleteFromColumn(column, grid[row][column].solvedVal);

    deleteFromRow(row, grid[row][column].solvedVal);

    deleteFromSubcell(row, column, grid[row][column].solvedVal);
}
```