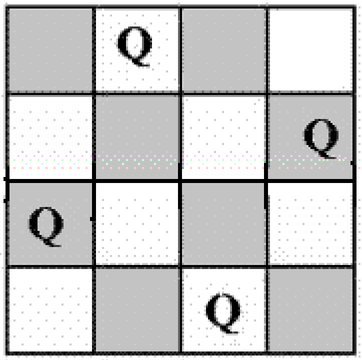
Backtracking | Set 3 (N Queen Problem)

We have discussed Knight's tour and Rat in a Maze problems in Set 1 and Set 2 respectively. Let us discuss N Queen as another example problem that can be solved using Backtracking.

The N Queen is the problem of placing N chess queens on an N×N chessboard so that no two queens attack each other. For example, following is a solution for 4 Queen problem.



The expected output is a binary matrix which has 1s for the blocks where queens are placed. For example following is the output matrix for above 4 queen solution.

```
              { 0,  1,  0,  0}
              { 0,  0,  0,  1}
              { 1,  0,  0,  0}
              { 0,  0,  1,  0}
```

Naive Algorithm

Generate all possible configurations of queens on board and print a configuration that satisfies the given constraints.

```
while there are untried conflagrations
{
   generate the next configuration
   if queens don't attack in this configuration then
   {
      print this configuration;
   }
}
```

Backtracking Algorithm

The idea is to place queens one by one in different columns, starting from the leftmost column. When we place a queen in a column, we check for clashes with already placed queens. In the current column, if we find a row for which there is no clash, we mark this row and column as part of the solution. If we do not find such a row due to clashes then we backtrack and return false.

```
1) Start in the leftmost column
2) If all queens are placed
    return true
3) Try all rows in the current column.  Do following for every tried row.
    a) If the queen can be placed safely in this row then mark this [row,
        column] as part of the solution and recursively check if placing
        queen here leads to a solution.
    b) If placing queen in [row, column] leads to a solution then return
        true.
    c) If placing queen doesn't lead to a solution then umark this [row,
        column] (Backtrack) and go to step (a) to try other rows.
3) If all rows have been tried and nothing worked, return false to trigger
    backtracking.
```

Implementation of Backtracking solution

C/C++

```
/* C/C++ program to solve N Queen Problem using
   backtracking */
#define N 4
#include<stdio.h>

/* A utility function to print solution */
void printSolution(int board[N][N])
{
    for (int i = 0; i < N; i++)
    {
        for (int j = 0; j < N; j++)
            printf(" %d ", board[i][j]);
        printf("\n");
    }
}

/* A utility function to check if a queen can
   be placed on board[row][col]. Note that this
   function is called when "col" queens are
   already placed in columns from 0 to col -1.
   So we need to check only left side for
   attacking queens */
bool isSafe(int board[N][N], int row, int col)
{
    int i, j;

    /* Check this row on left side */
    for (i = 0; i < col; i++)
        if (board[row][i])
            return false;

    /* Check upper diagonal on left side */
    for (i=row, j=col; i>=0 && j>=0; i--, j--)
        if (board[i][j])
            return false;

    /* Check lower diagonal on left side */
    for (i=row, j=col; j>=0 && i<N; i++, j--)
        if (board[i][j])
            return false;

    return true;
}

/* A recursive utility function to solve N
```

```
   Queen problem */
bool solveNQUtil(int board[N][N], int col)
{
    /* base case: If all queens are placed
      then return true */
    if (col >= N)
        return true;

    /* Consider this column and try placing
       this queen in all rows one by one */
    for (int i = 0; i < N; i++)
    {
        /* Check if queen can be placed on
          board[i][col] */
        if ( isSafe(board, i, col) )
        {
            /* Place this queen in board[i][col] */
            board[i][col] = 1;

            /* recur to place rest of the queens */
            if ( solveNQUtil(board, col + 1) )
                return true;

            /* If placing queen in board[i][col]
               doesn't lead to a solution, then
               remove queen from board[i][col] */
            board[i][col] = 0; // BACKTRACK
        }
    }

     /* If queen can not be place in any row in
        this colum col  then return false */
    return false;
}

/* This function solves the N Queen problem using
   Backtracking. It mainly uses solveNQUtil() to
   solve the problem. It returns false if queens
   cannot be placed, otherwise return true and
   prints placement of queens in the form of 1s.
   Please note that there may be more than one
   solutions, this function prints one  of the
   feasible solutions.*/
bool solveNQ()
{
    int board[N][N] = { {0, 0, 0, 0},
        {0, 0, 0, 0},
        {0, 0, 0, 0},
        {0, 0, 0, 0}
    };

    if ( solveNQUtil(board, 0) == false )
    {
      printf("Solution does not exist");
      return false;
    }

    printSolution(board);
    return true;
}

// driver program to test above function
int main()
{
    solveNQ();
    return 0;
}
```

Run on IDE

Java

```java
/* Java program to solve N Queen Problem using
   backtracking */
public class NQueenProblem
{
    final int N = 4;

    /* A utility function to print solution */
    void printSolution(int board[][])
    {
        for (int i = 0; i < N; i++)
        {
            for (int j = 0; j < N; j++)
                System.out.print(" " + board[i][j]
                                 + " ");
            System.out.println();
        }
    }

    /* A utility function to check if a queen can
       be placed on board[row][col]. Note that this
       function is called when "col" queens are already
       placeed in columns from 0 to col -1. So we need
       to check only left side for attacking queens */
    boolean isSafe(int board[][], int row, int col)
    {
        int i, j;

        /* Check this row on left side */
        for (i = 0; i < col; i++)
            if (board[row][i] == 1)
                return false;

        /* Check upper diagonal on left side */
        for (i=row, j=col; i>=0 && j>=0; i--, j--)
            if (board[i][j] == 1)
                return false;

        /* Check lower diagonal on left side */
        for (i=row, j=col; j>=0 && i<N; i++, j--)
            if (board[i][j] == 1)
                return false;

        return true;
    }

    /* A recursive utility function to solve N
       Queen problem */
    boolean solveNQUtil(int board[][], int col)
    {
        /* base case: If all queens are placed
           then return true */
        if (col >= N)
            return true;

        /* Consider this column and try placing
           this queen in all rows one by one */
        for (int i = 0; i < N; i++)
        {
            /* Check if queen can be placed on
               board[i][col] */
            if (isSafe(board, i, col))
            {
                /* Place this queen in board[i][col] */
                board[i][col] = 1;

                /* recur to place rest of the queens */
                if (solveNQUtil(board, col + 1) == true)
                    return true;

                /* If placing queen in board[i][col]
                   doesn't lead to a solution then
                   remove queen from board[i][col] */
                board[i][col] = 0; // BACKTRACK
            }
        }

        /* If queen can not be place in any row in
           this colum col, then return false */
        return false;
    }

    /* This function solves the N Queen problem using
       Backtracking.  It mainly uses  solveNQUtil() to
       solve the problem. It returns false if queens
       cannot be placed, otherwise return true and
       prints placement of queens in the form of 1s.
       Please note that there may be more than one
       solutions, this function prints one of the
       feasible solutions.*/
    boolean solveNQ()
    {
        int board[][] = {{0, 0, 0, 0},
            {0, 0, 0, 0},
            {0, 0, 0, 0},
            {0, 0, 0, 0}
        };

        if (solveNQUtil(board, 0) == false)
        {
            System.out.print("Solution does not exist");
            return false;
        }

        printSolution(board);
        return true;
    }

    // driver program to test above function
    public static void main(String args[])
    {
        NQueenProblem Queen = new NQueenProblem();
        Queen.solveNQ();
    }
}
// This code is contributed by Abhishek Shankhadhar
```

Run on IDE

Output: The 1 values indicate placements of queens

```
0  0  1  0
1  0  0  0
0  0  0  1
0  1  0  0
```

Sources:

http://see.stanford.edu/materials/icspacs106b/H19-RecBacktrackExamples.pdf

http://en.literateprograms.org/Eight_queens_puzzle_%28C%29

http://en.wikipedia.org/wiki/Eight_queens_puzzle

Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above.