Experiment No. 9
To implement N -Queen problem
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Experiment No. 9

Title: To implement N -Queen problem

Aim: To study, implement and Analyze N queen Problem.

Objective: To introduce the N queen Problem and analyzing algorithms

Theory:

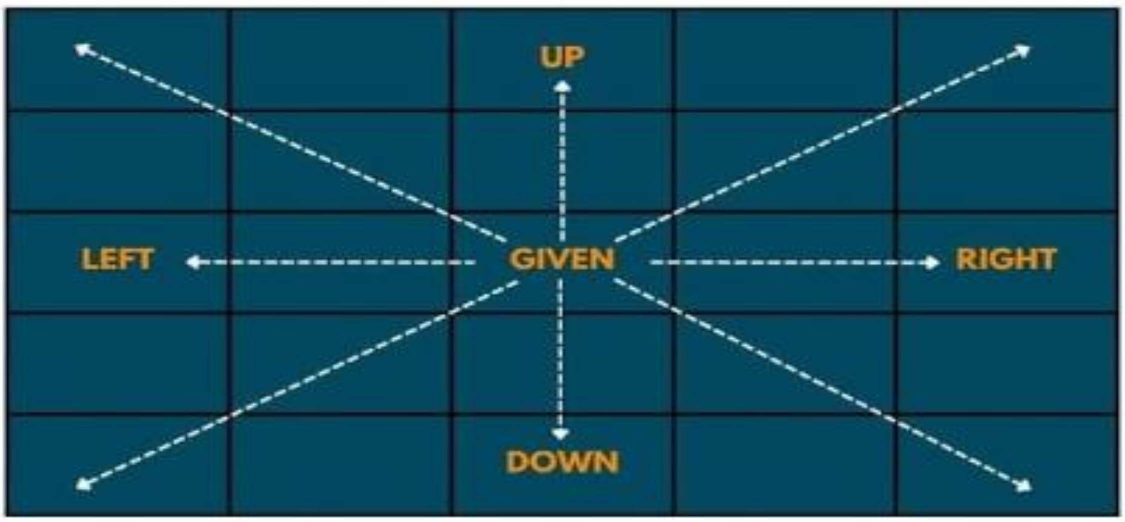
Backtracking is a problem-solving technique that involves recursively trying out different solutions to a problem, and backtracking or undoing previous choices when they don't lead to a valid solution. It is commonly used in algorithms that search for all possible solutions to a problem, such as the famous eight-queens puzzle. Backtracking is a powerful and versatile technique that can be used to solve a wide range of problems.

The N Queen problem demands us to place N queens on a N x N chessboard so that no queen can attack any other queen directly.

Problem Statement:

Find out all the possible arrangements in which N queens can be seated in each row and each column so that all queens are safe.

The queen moves in 8 directions and can directly attack in these 8 directions only.

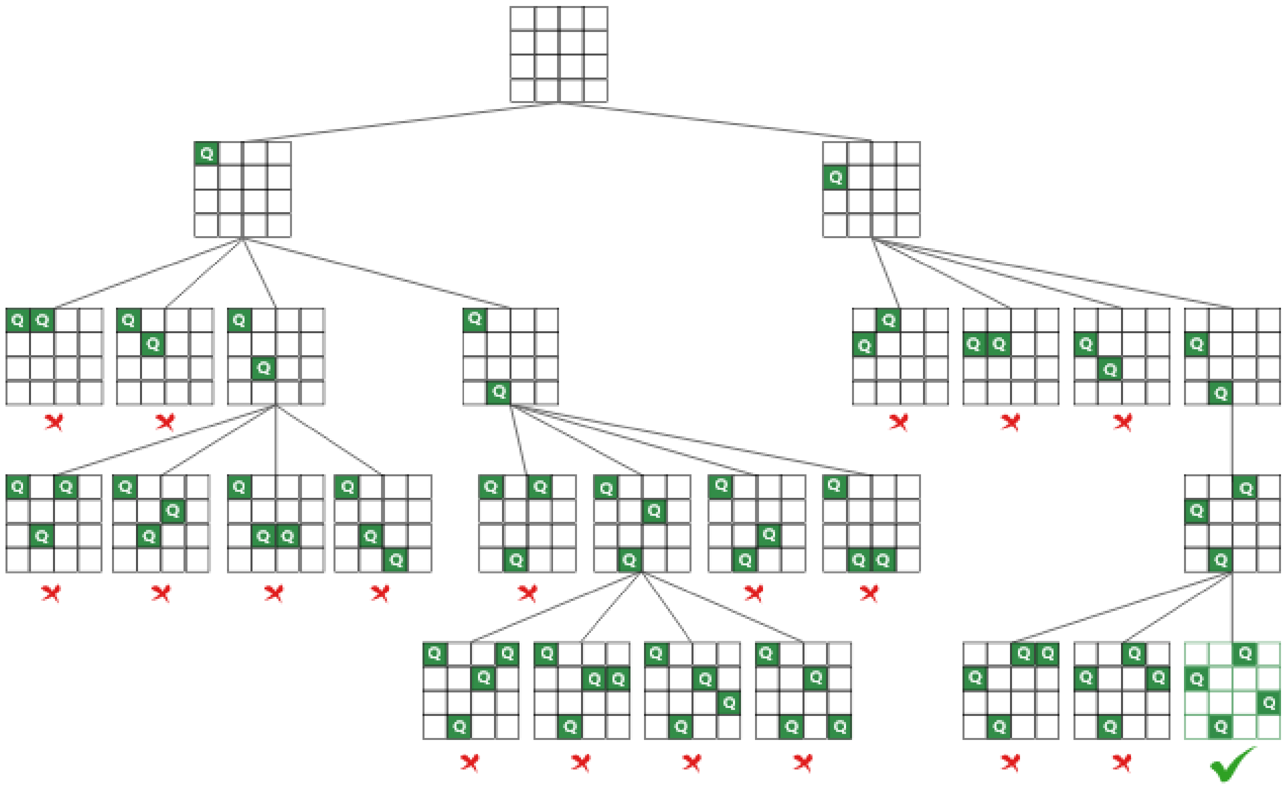


Example:

4 - Queen Problem:

- This problem demands us to put 4 queens on 4 X 4 chessboard in such a way that no 2 or more queens can be placed in the same diagonal or row or column.
- 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**.

Solution to 4 Queen Problem



Algorithm:

Step 1: Start in the leftmost column.

Step 2: If all queens are placed return true.

Step 3: Try all rows in the current column. Do the following for every row.

Step 3.1: If the queen can be placed safely in this row.

Step 3.1.1: Then mark this [row, column] as part of the solution and recursively check if placing queen here leads to a solution.

Step 3.1.2: If placing the queen in [row, column] leads to a solution then return true.

Step 3.1.3: If placing queen doesn't lead to a solution then unmark this [row, column] then backtrack and try other rows.

Step 4: If all rows have been tried and valid solution is not found return false to trigger backtracking.

Time Complexity - O(N!)

- For the first row, we check N columns; for the second row, we check the N - 1 column and so on. Hence, the time complexity will be N * (N-1) * (N-2) …. i.e. O(N!)

Space Complexity - O(N^2)

- O(N^2), where 'N' is the number of queens.
- We are using a 2-D array of size N rows and N columns, and also, because of Recursion, the recursive stack will have a linear space here. So, the overall space complexity will be O(N^2).

Program:

```
#include <stdbool.h>

#include <stdio.h>



int printSolution(int N, int board[N][N])

{

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

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

            if(board[i][j])

                printf("Q ");

            else

                printf(". ");

        }

        printf("\n");

    }

}


bool isSafe(int N, int board[N][N], int row, int col)

{

    int i, j;
```

```
    for (i = 0; i < col; i++)

        if (board[row][i])

            return false;




    for (i = row, j = col; i >= 0 && j >= 0; i--, j--)

        if (board[i][j])

            return false;




    for (i = row, j = col; j >= 0 && i < N; i++, j--)

        if (board[i][j])

            return false;



    return true;

}




bool solveNQUtil(int N, int board[N][N], int col)

{
```

```
if (col >= N)
    return true;



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


    if (isSafe(N, board, i, col)) {


        board[i][col] = 1;


        if (solveNQUtil(N, board, col + 1))
            return true;


        board[i][col] = 0; // BACKTRACK
    }
}
```

```
    return false;
}



bool solveNQ(int N)
{
    int board[N][N];
    for (int i = 0; i < N; i++) {
        for (int j = 0; j < N; j++) {
            board[i][j] = 0;
        }
    }

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

    printSolution(N, board);
    return true;
}
```

```
int main()

{

    int N;

    printf("Enter the size of the chessboard: ");

    scanf("%d", &N);



    solveNQ(N);

    return 0;

}
```

Output:

Output

```
/tmp/Dewyg9IxOB.o
Enter the size of the chessboard: 8
Q . . . . . . .
. . . . . . Q .
. . . . Q . . .
. . . . . . . Q
. Q . . . . . .
. . . Q . . . .
. . . . . Q . .
. . Q . . . . .


=== Code Execution Successful ===
```

Output

```
/tmp/35BvfH2PdB.o
Enter the size of the chessboard: 4
. . Q .
Q . . .
. . . Q
. Q . .


=== Code Execution Successful ===
```

Conclusion:

The N-Queen problem is a classic puzzle where the goal is to place N chess queens on an N×N chessboard in such a way that no two queens threaten each other. In simpler terms, no two queens should be in the same row, column, or diagonal.

Conclusively, the N-Queen problem is a challenging puzzle that requires careful consideration and exploration of various solutions. Its time complexity is typically exponential, O(N!), which means it becomes increasingly difficult to solve efficiently as the size of the chessboard (N) increases. As a result, finding optimal solutions for larger N values becomes impractical for brute-force methods.