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Experiment No.:	11
Title:	15 Puzzle.
Date of Performance:	
Date of Submission:	
Marks:	
Sign of Faculty:	

Experiment No. 11

Title: 15 Puzzle.

Aim: To study and implement 15 puzzle problem

Objective: To introduce Backtracking and Branch-Bound methods

Theory:

The 15 puzzle problem is invented by sam loyd in 1878.

- In this problem there are 15 tiles, which are numbered from 0 – 15.
- The objective of this problem is to transform the arrangement of tiles from initial arrangement to a goal arrangement.
- The initial and goal arrangement is shown by following figure.

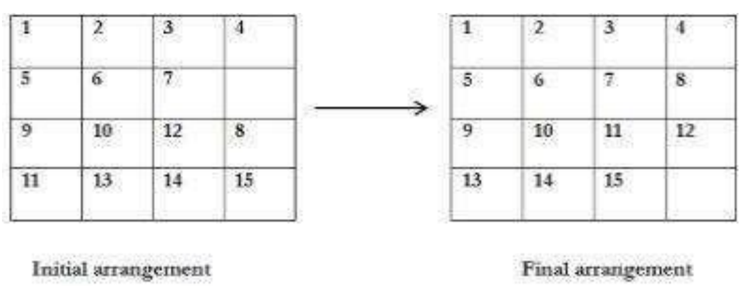
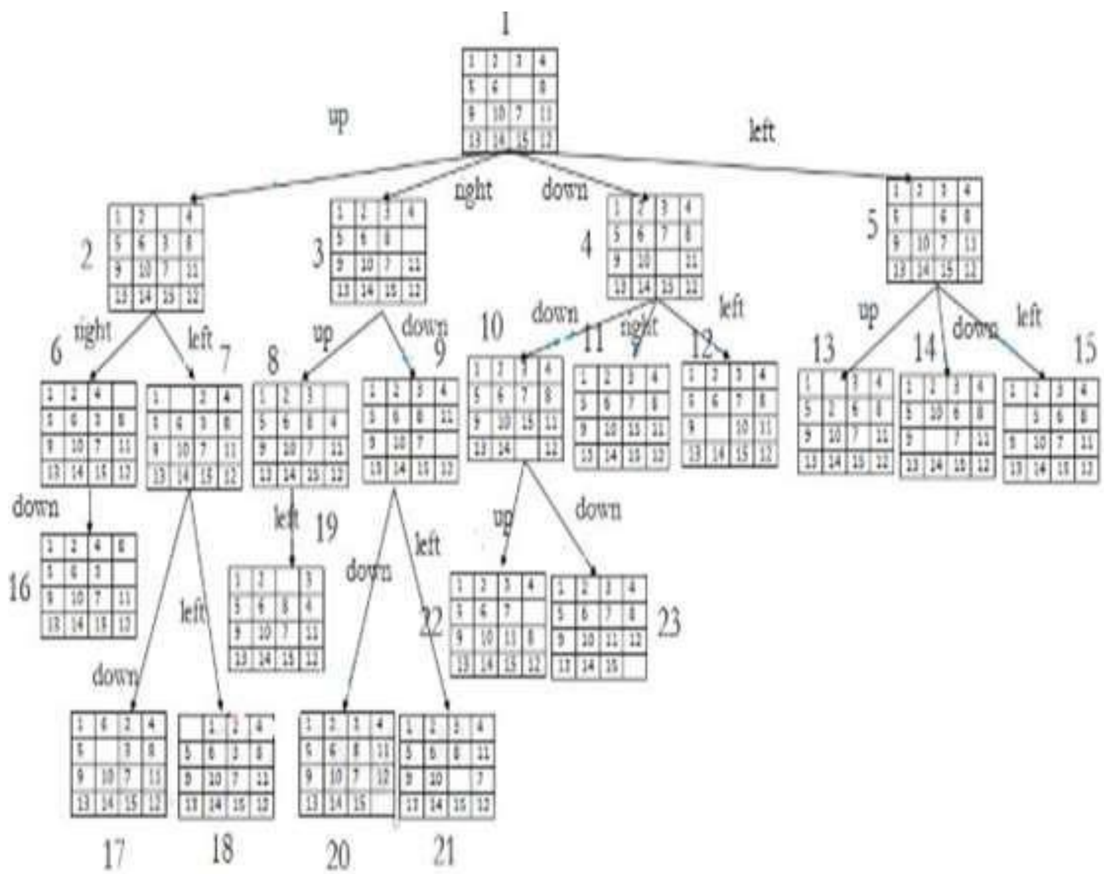


Figure 12

- There is always an empty slot in the initial arrangement.
- The legal moves are the moves in which the tiles adjacent to ES are moved to either left, right, up or down.
- Each move creates a new arrangement in a tile.
- These arrangements are called as states of the puzzle.
- The initial arrangement is called as initial state and goal arrangement is called as goal state.
- The state space tree for 15 puzzle is very large because there can be 16! Different arrangements.
- A partial state space tree can be shown in figure.

- In state space tree, the nodes are numbered as per the level.
- Each next move is generated based on empty slot positions.
- Edges are label according to the direction in which the empty space moves.
- The root node becomes the E – node.
- The child node 2, 3, 4 and 5 of this E – node get generated.
- Out of which node 4 becomes an E – node. For this node the live nodes 10, 11, 12 gets generated.
- Then the node 10 becomes the E – node for which the child nodes 22 and 23 gets generated.
- Finally we get a goal state at node 23.
- We can decide which node to become an E – node based on estimation formula.

Example:

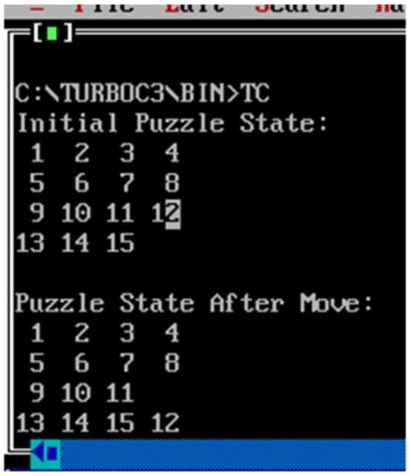


Implementation:

```
#include <stdio.h>
#include <stdlib.h>

#define N 4
#define EMPTY_TILE 0


void printPuzzle(int puzzle[N][N]) {
int i,j;
    for (i = 0; i < N; i++) {
    for (j = 0; j < N; j++) {
            if (puzzle[i][j] == EMPTY_TILE) {
                printf("   ");
            } else {
                printf("%2d ", puzzle[i][j]);
            }
        }
        printf("\n");
    }
}

int isSolved(int puzzle[N][N]) {
    int count = 1;
    int i,j;
    for (i = 0; i < N; i++) {
    for (j = 0; j < N; j++) {
        if (puzzle[i][j] != count && (i != N - 1 || j != N - 1)) {
                return 0;
            }
            count++;
        }
    }
    return 1;
}

void moveTile(int puzzle[N][N], int moveX, int moveY) {
    int emptyX, emptyY,i,j;
```

```c
    for (i = 0; i < N; i++) {
    for (j = 0; j < N; j++) {
            if (puzzle[i][j] == EMPTY_TILE) {
                emptyX = i;
                emptyY = j;
                break;
            }
        }
    }
    puzzle[emptyX][emptyY] = puzzle[emptyX + moveX][emptyY + moveY];
    puzzle[emptyX + moveX][emptyY + moveY] = EMPTY_TILE;
}

int main() {
    int puzzle[N][N] = {
        {1, 2, 3, 4},
        {5, 6, 7, 8},
        {9, 10, 11, 12},
        {13, 14, 15, EMPTY_TILE}
    };

    printf("Initial Puzzle State:\n");
    printPuzzle(puzzle);

    moveTile(puzzle, -1, 0);
    printf("\nPuzzle State After Move:\n");
    printPuzzle(puzzle);

    if (isSolved(puzzle)) {
        printf("\nPuzzle Solved!\n");
    } else {
        printf("\nPuzzle Not Solved Yet.\n");
    }

    return 0;
}
```

Output:



Conclusion: The implementation of the 15 puzzle problem in C demonstrated the fundamental mechanics of puzzle manipulation and state checking. While the provided code offers a basic framework, further extensions could include implementing solving algorithms such as A* search to find optimal solutions efficiently.