Rat in a Maze

Rat in a Maze
Consider a rat placed at **(0, 0)** in a square matrix of order **N * N**. It has to reach the destination at **(N – 1, N – 1)**. Find all possible paths that the rat can take to reach from source to destination. The directions in which the rat can move are '**U'(up)**, '**D'(down)**, '**L' (left)**, '**R' (right)**. Value 0 at a cell in the matrix represents that it is blocked and the rat cannot move to it while value 1 at a cell in the matrix represents that rat can travel through it.
Note: In a path, no cell can be visited more than one time.
Print the answer in lexicographical(sorted) order
Examples:

Example 1:

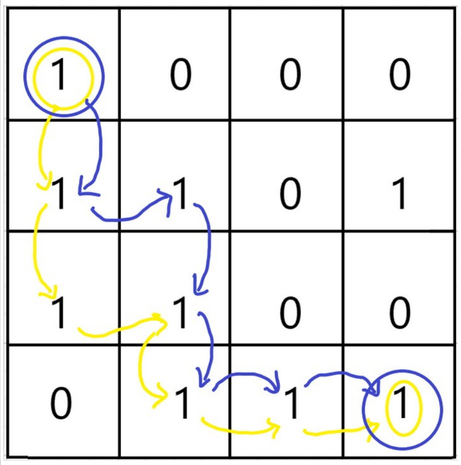
Input:

N = 4

```
m[][] = {{1, 0, 0, 0},
         {1, 1, 0, 1},
         {1, 1, 0, 0},
         {0, 1, 1, 1}}
```

Output: DDRDRR DRDDRR

Explanation:



The rat can reach the destination at (3, 3) from (0, 0) by two paths - DRDDRR and DDRDRR, when printed in sorted order we get DDRDRR DRDDRR.

Example 2:

Input: N = 2

```
m[][] = {{1, 0},
         {1, 0}}
```

Output:

No path exists and the destination cell is blocked.

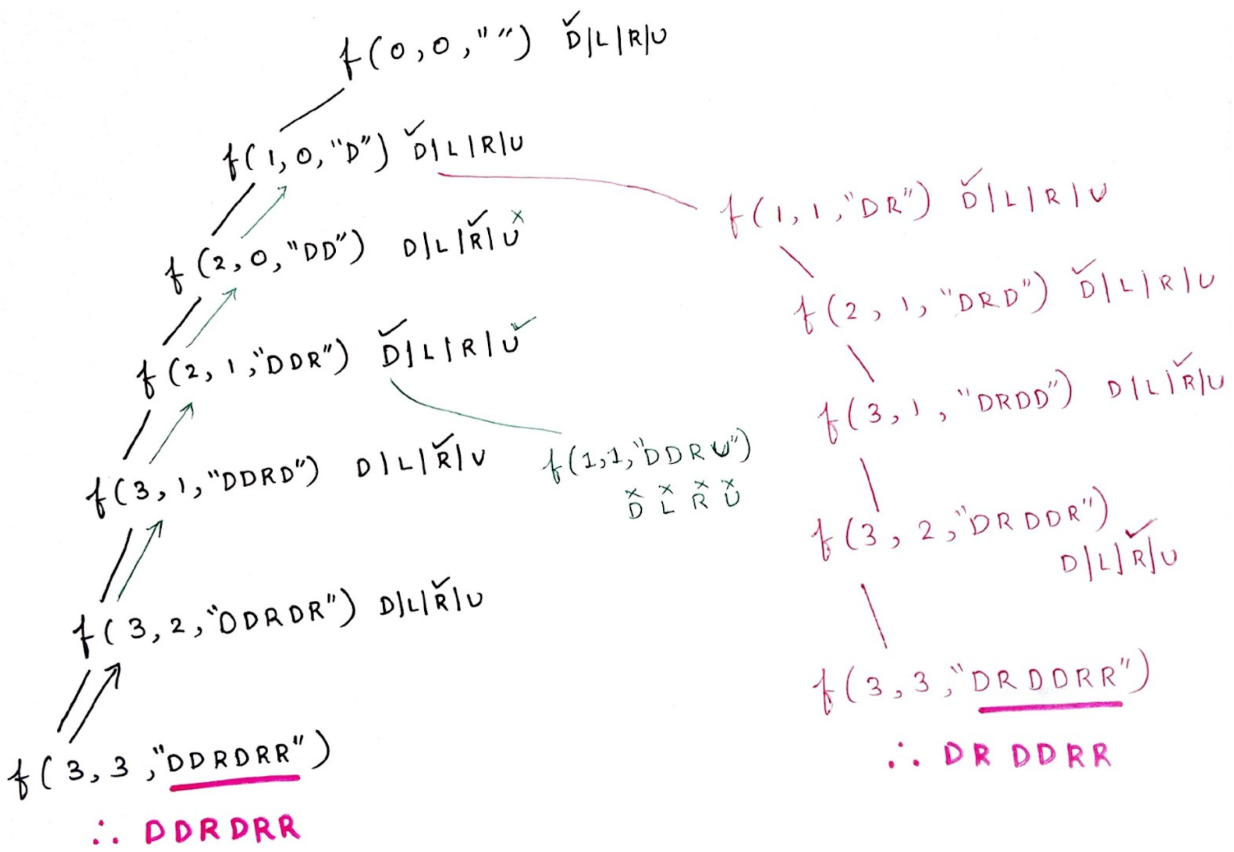
Solution

Disclaimer: *Don't jump directly to the solution, try it out yourself first.*

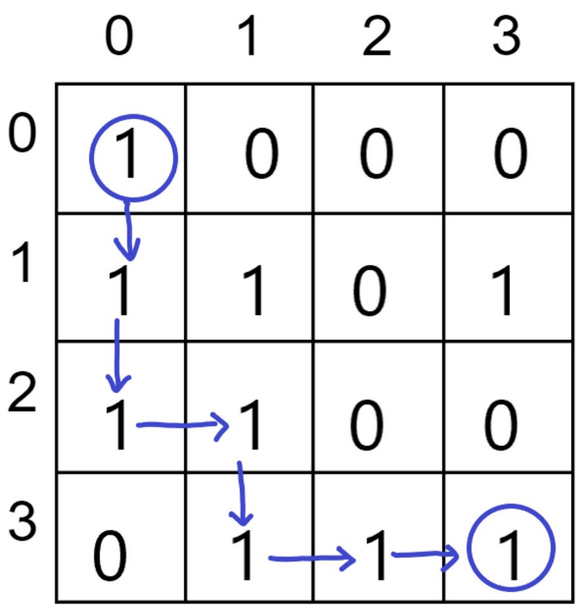
Solution 1: Recursion
Intuition:
The best way to solve such problems is using recursion.
Approach:

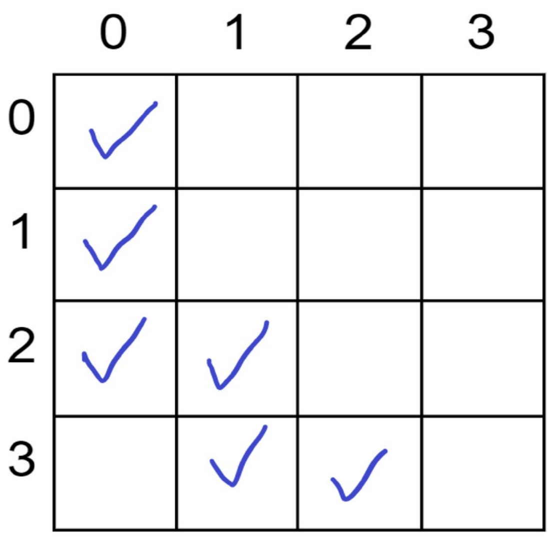
- Start at the source(0,0) with an empty string and try every possible path i.e upwards**(U)**, downwards**(D)**, leftwards**(L)** and rightwards**(R)**.
- As the **answer** should be in lexicographical order so it's better to try the **directions** in lexicographical order i.e (D,L,R,U)
- Declare a 2D-array named visited because the question states that a single cell should be included only once in the path,so it's important to keep track of the visited cells in a particular path.
- If a cell is in path, mark it in the visited array.
- Also keep a check of the "**out of bound"** conditions while going in a particular direction in the matrix.
- Whenever you reach the destination**(n,n)** it's very important to get back as shown in the recursion tree.
- While getting back, keep on unmarking the visited array for the respective direction.Also check whether there is a different path possible while getting back and if yes, then mark that cell in the visited array.

Recursive tree:


f(0,0,"") D|L|R|U
f(1,0,"D") D|L|R|U
f(2,0,"DD") D|L|R|U
f(2,1,"DDR") D|L|R|U
f(3,1,"DDRD") D|L|R|U
f(3,2,"DDRDR") D|L|R|U
f(3,3,"DDRDRR")
∴ DDRDRR
f(1,1,"DDRU")
D L R U
f(1,1,"DR") D|L|R|U
f(2,1,"DRD") D|L|R|U
f(3,1,"DRDD") D|L|R|U
f(3,2,"DRDDR") D|L|R|U
f(3,3,"DRDDRR")
∴ DRDDRR

For "DDRDRR" :


0 1 2 3
0 1 0 0 0
1 1 1 0 1
2 1 1 0 0
3 0 1 1 1



Visited

Code:

- C++ Code
- Java Code
- Python Code

```cpp
#include <bits/stdc++.h>

using namespace std;

class Solution {
  void findPathHelper(int i, int j, vector < vector < int >> & a, int n, vector < string > & ans, string move,
    vector < vector < int >> & vis) {
    if (i == n - 1 && j == n - 1) {
      ans.push_back(move);
      return;
    }

    // downward
    if (i + 1 < n && !vis[i + 1][j] && a[i + 1][j] == 1) {
      vis[i][j] = 1;
      findPathHelper(i + 1, j, a, n, ans, move + 'D', vis);
      vis[i][j] = 0;
    }

    // left
    if (j - 1 >= 0 && !vis[i][j - 1] && a[i][j - 1] == 1) {
      vis[i][j] = 1;
      findPathHelper(i, j - 1, a, n, ans, move + 'L', vis);
      vis[i][j] = 0;
    }

    // right
    if (j + 1 < n && !vis[i][j + 1] && a[i][j + 1] == 1) {
      vis[i][j] = 1;
      findPathHelper(i, j + 1, a, n, ans, move + 'R', vis);
      vis[i][j] = 0;
    }

    // upward
    if (i - 1 >= 0 && !vis[i - 1][j] && a[i - 1][j] == 1) {
      vis[i][j] = 1;
      findPathHelper(i - 1, j, a, n, ans, move + 'U', vis);
      vis[i][j] = 0;
    }
  }
  public:
    vector < string > findPath(vector < vector < int >> & m, int n) {
      vector < string > ans;
      vector < vector < int >> vis(n, vector < int > (n, 0));

      if (m[0][0] == 1) findPathHelper(0, 0, m, n, ans, "", vis);
      return ans;
    }
};

int main() {
  int n = 4;

   vector < vector < int >> m = {{1,0,0,0},{1,1,0,1},{1,1,0,0},{0,1,1,1}};

  Solution obj;
  vector < string > result = obj.findPath(m, n);
  if (result.size() == 0)
    cout << -1;
  else
    for (int i = 0; i < result.size(); i++) cout << result[i] << " ";
  cout << endl;

  return 0;
}
```

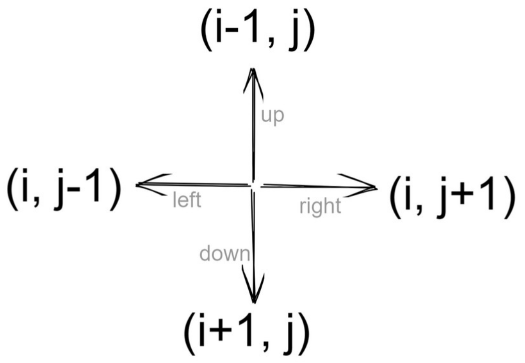
Output:

```
DDRDRR DRDDRR
```

Time Complexity: O(4^(m*n)), because on every cell we need to try 4 different directions.

Space Complexity: O(m*n) ,Maximum Depth of the recursion tree(auxiliary space).

But, writing an individual code for every direction is a lengthy process therefore we truncate the 4 "if statements" into a single for loop using the following approach.



	D	L	R	U
di[ ]	+1	+0	+0	-1
dj[ ]	+0	-1	+1	+0

- C++ Code
- Java Code
- Python Code

```
#include <bits/stdc++.h>

using namespace std;

class Solution {
   void solve(int i, int j, vector < vector < int >> & a, int n, vector < string > & ans, string move,
      vector < vector < int >> & vis, int di[], int dj[]) {
      if (i == n - 1 && j == n - 1) {
         ans.push_back(move);
         return;
      }
      string dir = "DLRU";
      for (int ind = 0; ind < 4; ind++) {
         int nexti = i + di[ind];
         int nextj = j + dj[ind];
         if (nexti >= 0 && nextj >= 0 && nexti < n && nextj < n && !vis[nexti][nextj] && a[nexti][nextj] == 1) {
            vis[i][j] = 1;
            solve(nexti, nextj, a, n, ans, move + dir[ind], vis, di, dj);
            vis[i][j] = 0;
         }
      }

   }
   public:
      vector < string > findPath(vector < vector < int >> & m, int n) {
         vector < string > ans;
         vector < vector < int >> vis(n, vector < int > (n, 0));
         int di[] = {
            +1,
            0,
            0,
            -1
         };
         int dj[] = {
            0,
            -1,
            1,
            0
         };
         if (m[0][0] == 1) solve(0, 0, m, n, ans, "", vis, di, dj);
         return ans;
      }
};

int main() {
   int n = 4;

  vector < vector < int >> m = {{1,0,0,0},{1,1,0,1},{1,1,0,0},{0,1,1,1}};

   Solution obj;
   vector < string > result = obj.findPath(m, n);
   if (result.size() == 0)
      cout << -1;
   else
      for (int i = 0; i < result.size(); i++) cout << result[i] << " ";
   cout << endl;

   return 0;
}
```

Output:

```
DDRDRR DRDDRR
```

Time Complexity: O(4^(m*n)), because on every cell we need to try 4 different directions.

Space Complexity: O(m*n), Maximum Depth of the recursion tree(auxiliary space).