BFS - Breadth First Search

宽度优先搜索

When

Level Order Traversal
Connected Component
Topological Sorting

1 ⇒ BFS in Binary Tree
2 ⇒ BFS in Graph (Topological Sorting)
3 ⇒ BFS in matrix

If one problem can be solved with BFS, do not use DFS !

1. BFS in Binary Tree

129. Sum Root to Leaf Numbers && 1022. Sum of Root To Leaf Binary Numbers
101. Symmetric Tree
662. Maximum Width of Binary Tree
863. All Nodes Distance K in Binary Tree
987. Vertical Order Traversal of a Binary Tree

2. BFS in Graph (Topological Sorting)

127. Word Ladder
133. Clone Graph
210. Course Schedule II
310. Minimum Height Trees
743. Network Delay Time
1129. Shortest Path with Alternating Colors
1311. Get Watched Videos by Your Friends

847. Shortest Path Visiting All Nodes

1345. Jump Game IV

3. BFS in matrix

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407. Trapping Rain Water II
417. Pacific Atlantic Water Flow
529. Minesweeper
542. 01 Matrix
Zombie in Matrix (994. Rotting Oranges)
909. Snakes and Ladders
934. Shortest Bridge

773. Sliding Puzzle
815. Bus Routes
752. Open the Lock
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864. Shortest Path to Get All Keys
1298. Maximum Candies You Can Get from Boxes

1036. Escape a Large Maze
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1391. Check if There is a Valid Path in a Grid
1210. Minimum Moves to Reach Target with Rotations
1263. Minimum Moves to Move a Box to Their Target Location
1284. Minimum Number of Flips to Convert Binary Matrix to Zero Matrix
1293. Shortest Path in a Grid with Obstacles Elimination
1368. Minimum Cost to Make at Least One Valid Path in a Grid

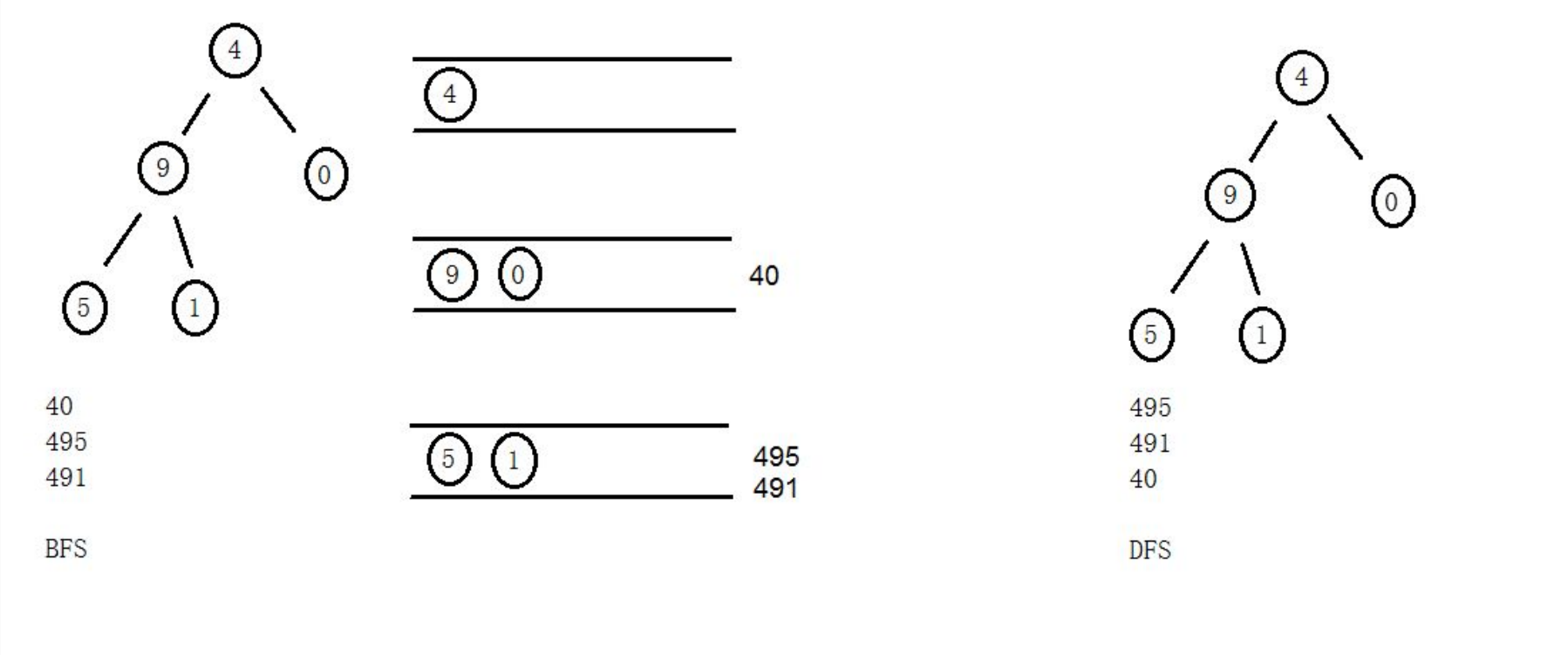
Template - 102. Binary Tree Level Order Traversal

```java
final List<List<Integer>> result = new ArrayList<>();
 if (root == null) {
    return result;
 }
 // 1. create a queue FIFO, then put root in it
 Queue<TreeNode> treeNodeQueue = new LinkedList<>();
 treeNodeQueue.offer(root);
 // 2. while queue is not null, take itself add its children
 while (!treeNodeQueue.isEmpty()) {
    final int currentSize = treeNodeQueue.size();
    final List<Integer> currentLevel = new ArrayList<>();
    for (int i = 0; i < currentSize; i++) {
       TreeNode treeNode = treeNodeQueue.poll();
       currentLevel.add(treeNode.val);
       if (treeNode.left != null) {
          treeNodeQueue.offer(treeNode.left);
       }
       if (treeNode.right != null) {
          treeNodeQueue.offer(treeNode.right);
       }
    }
    result.add(currentLevel);
 }
 return result;
```

```fr
val result = mutableListOf<List<Int>>()
 if (root == null) {
    return result
 }
 val treeNodeQueue: Queue<TreeNode> = LinkedList()
 treeNodeQueue.offer(root)
 while (treeNodeQueue.isNotEmpty()) {
    val currentLevel = mutableListOf<Int>()
    for (i in 0 until treeNodeQueue.size) {
       val current = treeNodeQueue.poll()
       currentLevel.add(current.`val`)
       current.left?.let { treeNodeQueue.offer(it) }
       current.right?.let { treeNodeQueue.offer(it) }
    }
    result.add(currentLevel)
 }
 return result
```

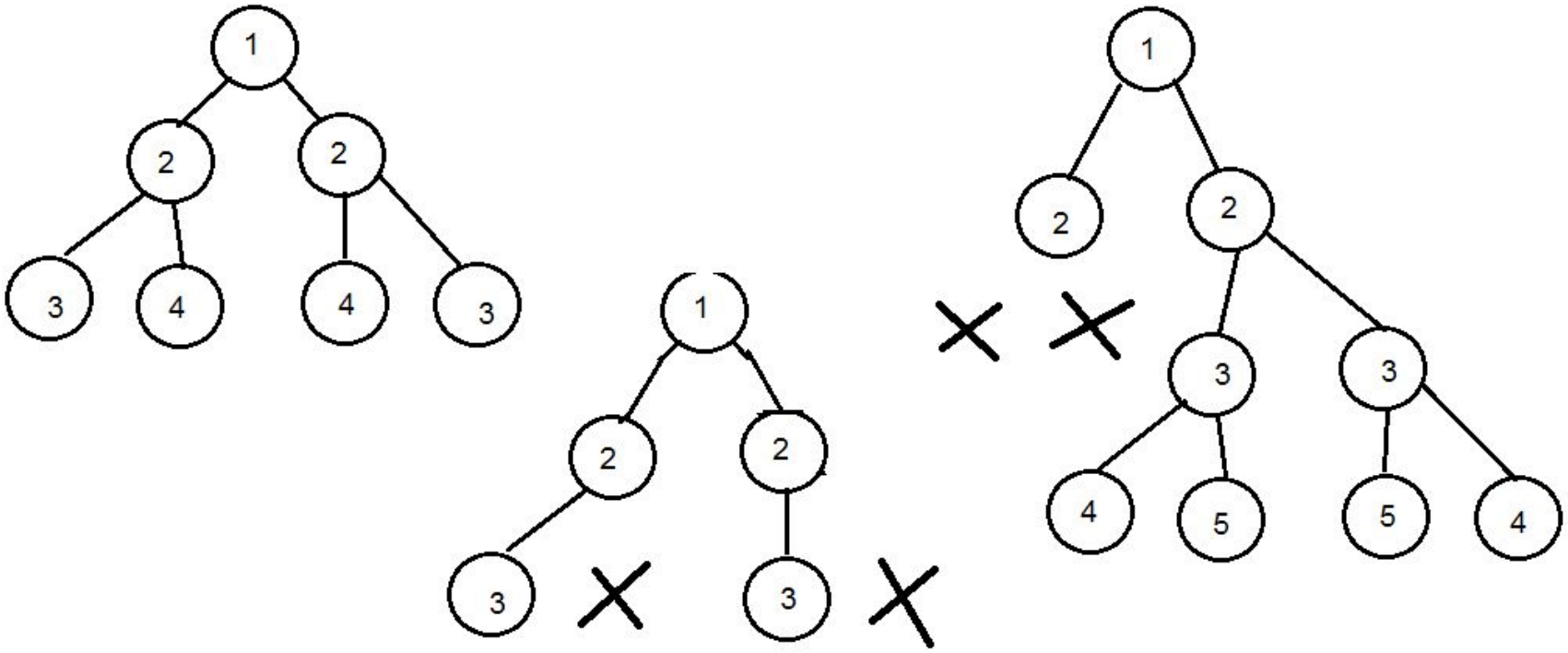
129. Sum Root to Leaf Numbers && 1022. Sum of Root To Leaf Binary Numbers

https://leetcode.com/problems/sum-root-to-leaf-numbers/
https://leetcode.com/problems/sum-of-root-to-leaf-binary-numbers/



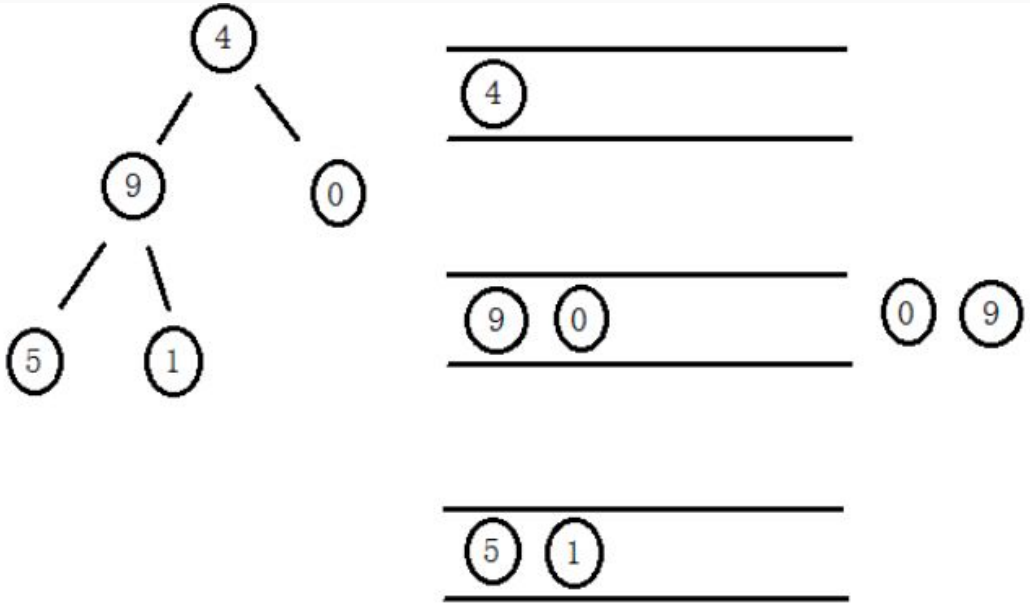
101. Symmetric Tree

https://leetcode.com/problems/symmetric-tree/



103. Binary Tree Zigzag Level Order Traversal & 111. Minimum Depth of Binary Tree

https://leetcode.com/problems/binary-tree-zigzag-level-order-traversal/
https://leetcode.com/problems/minimum-depth-of-binary-tree/

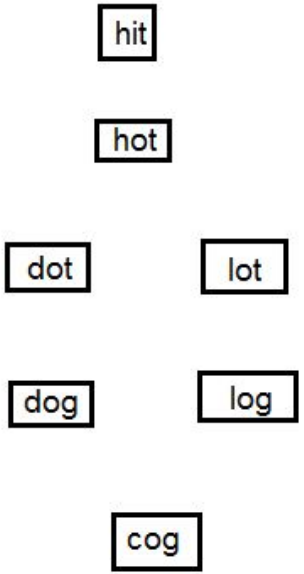


127. Word Ladder

https://leetcode.com/problems/word-ladder/

begin = "hit"
end = "cog"
wordList = ["hot","dot","dog","lot","log","cog"]

```
final int currentSize = queue.size();
for (int k = 0; k < currentSize; k++) {
    final String currentString = queue.poll();
    if (currentString.equals(endWord)) {
        return count;
    }
    for (int index = 0; index < currentString.length(); index++) {
        final StringBuilder str = new StringBuilder(currentString);
        for (char c = 'a'; c <= 'z'; c++) {
            str.setCharAt(index, c);
            final String newStr = str.toString();
            if (wordSet.contains(newStr) && !newStr.equals(currentString)) {
                queue.offer(newStr);
                wordSet.remove(newStr);
            }
        } }}
++count;
```

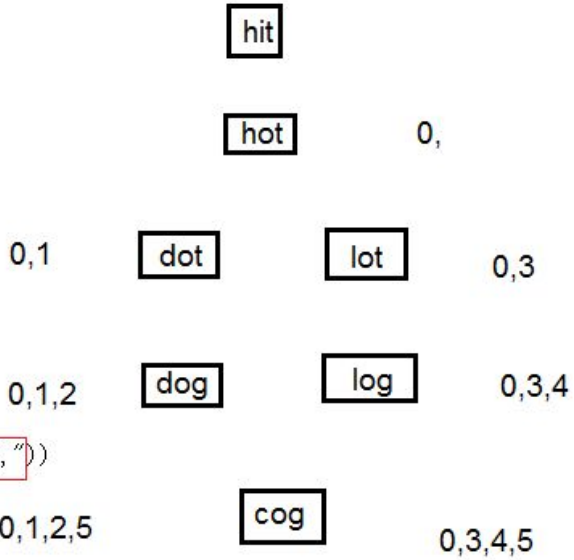


126. Word Ladder II

https://leetcode.com/problems/word-ladder-ii/

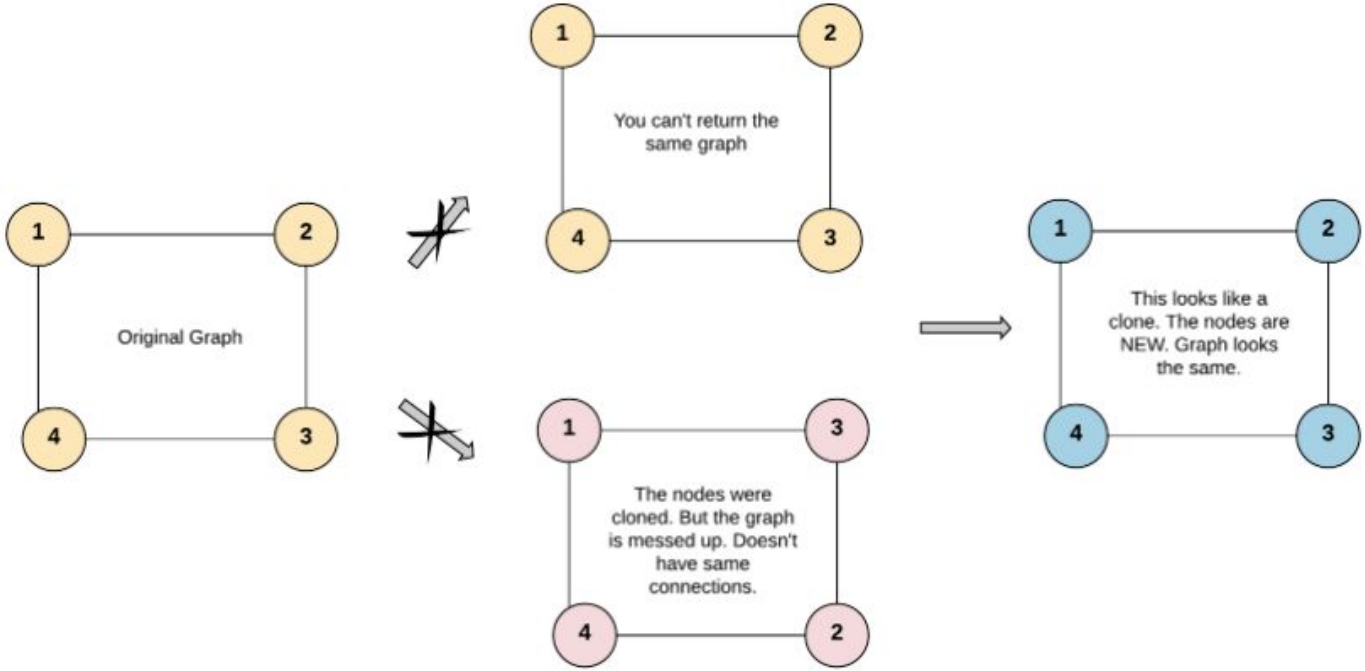
begin = "hit"
end = "cog"
wordList = ["hot","dot","dog","lot","log","cog"]

```
val currentLevelUsedWord: MutableSet<String> = HashSet()

if (wordMap.contains(new) && new != currentPair.first) {
    if (new == endWord) {
        queue.offer(Pair(new, currentPair.second + wordMap.getValue(new)))
    } else {
        currentLevelUsedWord.add(new)
        queue.offer(Pair(new, currentPair.second + wordMap.getValue(new) + ","))
    }
}
```



133. Clone Graph

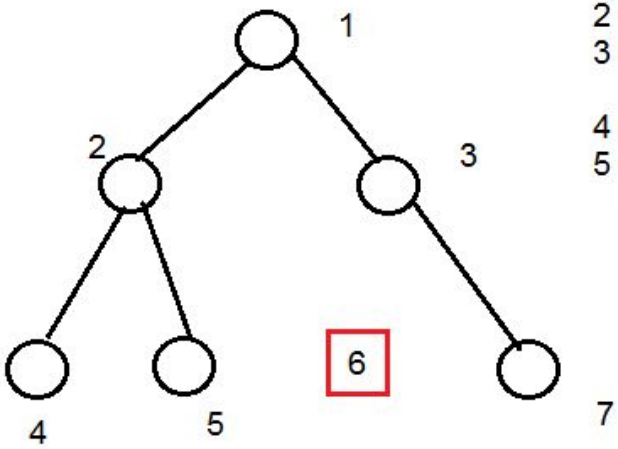
https://leetcode.com/problems/clone-graph/



1. BFS get all nodes
2. copy all nodes then mapping
3. cope neighbors

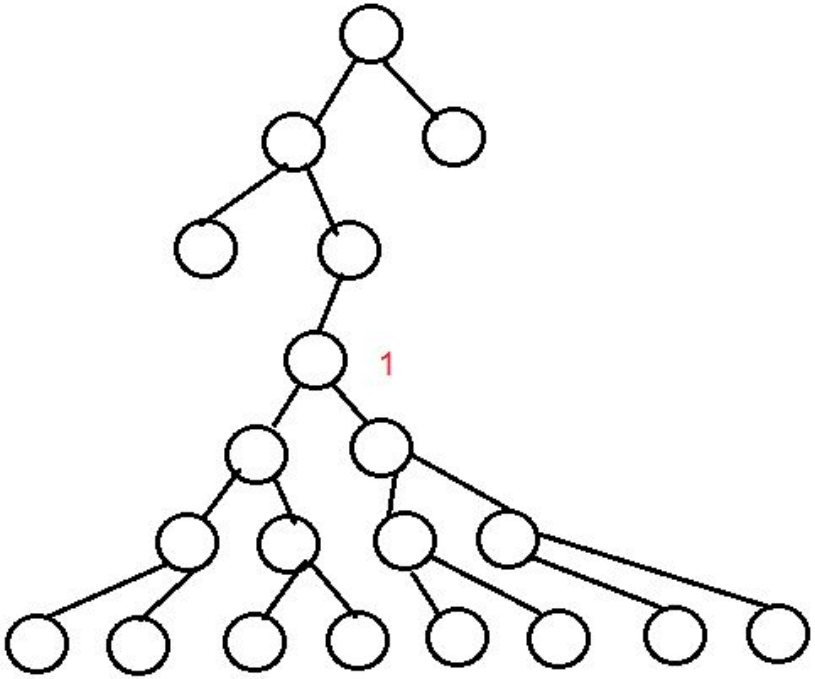
662. Maximum Width of Binary Tree

https://leetcode.com/problems/maximum-width-of-binary-tree/



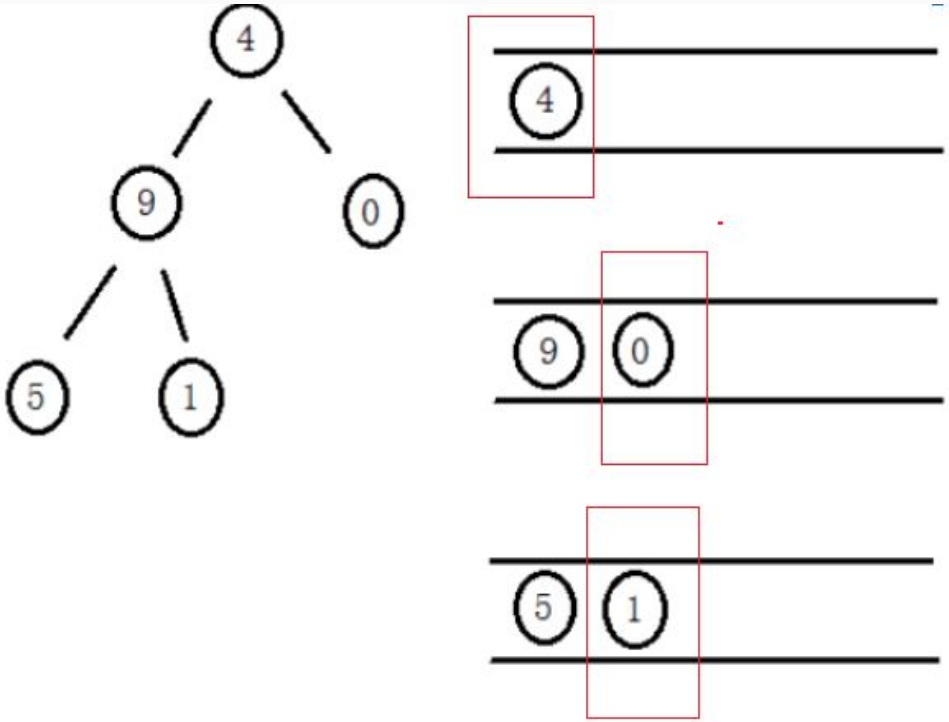
2 = 1 * 2
3 = 1 * 2 + 1

4 = 2 * 2
5 = 2 * 2 + 1



199. Binary Tree Right Side View

https://leetcode.com/problems/binary-tree-right-side-view/



template review!

```
val result: MutableList<Int> = LinkedList()
if (root == null) {
    return result
}
val queue: Queue<TreeNode> = LinkedList()
queue.offer(root)
while (queue.isNotEmpty()) {
    var levelValue = 0
    for (time in 0 until queue.size) {
        val current = queue.poll()
        levelValue = current.`val`
        current.left?.let { queue.offer(it) }
         current.right?.let { queue.offer(it) }
    }
    result.add(levelValue)
}
return result
```

200. Number of Islands

https://leetcode.com/problems/number-of-islands/

```
["1","1","0","0","0"],
["1","1","0","0","0"],
["0","0","1","0","0"],
["0","0","0","1","1"]
```

```
      1    1    0
           1
```

4 directions:

nextX

nextY

1 ==> inBound

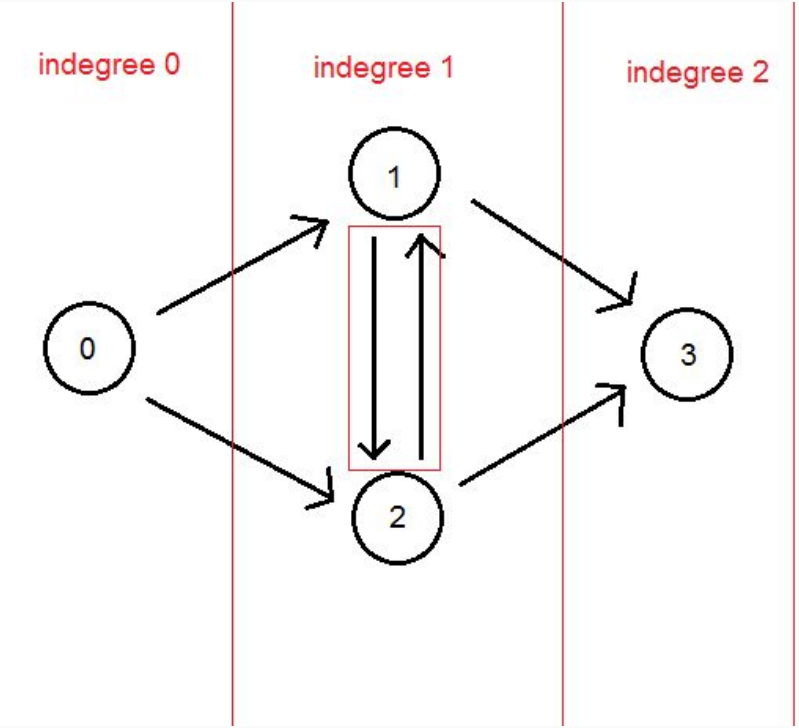
2 ==> grid[nextX][nextY] == '1'

3 ==> visited[nextX][nextY] == 0

```
private void dfs(char[][] grid, int x, int y, int[][] visited) {
    visited[x][y] = 7;
    for (int index = 0; index < deltaX.length; index++) {
        final int nextX = x + deltaX[index];
        final int nextY = y + deltaY[index];
        if (inBound(grid, nextX, nextY) &&
                visited[nextX][nextY] == 0 &&
                grid[nextX][nextY] == '1') {
            visited[nextX][nextY] = 7;
            dfs(grid, nextX, nextY, visited);
        }
    }
}
```

210. Course Schedule II

https://leetcode.com/problems/course-schedule-ii/



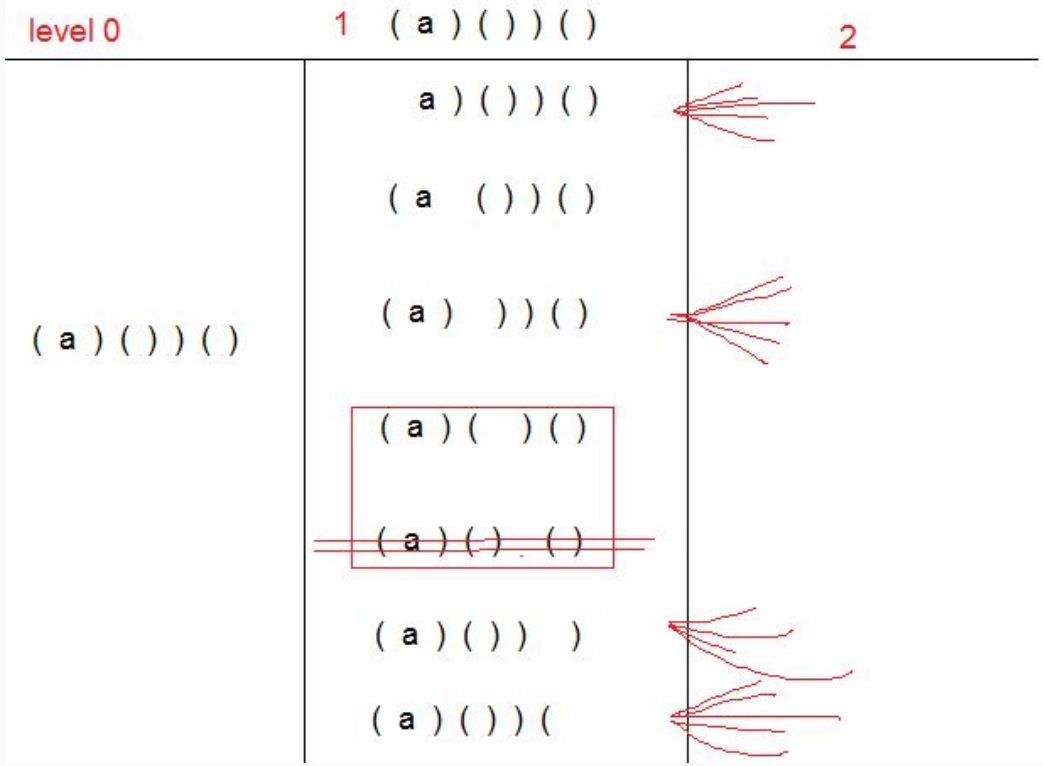

```
while (queue.isNotEmpty()) {
        val current = queue.poll()
        result.add(current)
        graph[current]?.forEach {
            if (--indegrees[it] == 0) {
                queue.offer(it)
            }
        }
    }
```

1. add value to result
2. nextCourse indegree --
   if == 0
   add it in queue

if it is possible to take all courses, result.size should equal to n

301. Remove Invalid Parentheses

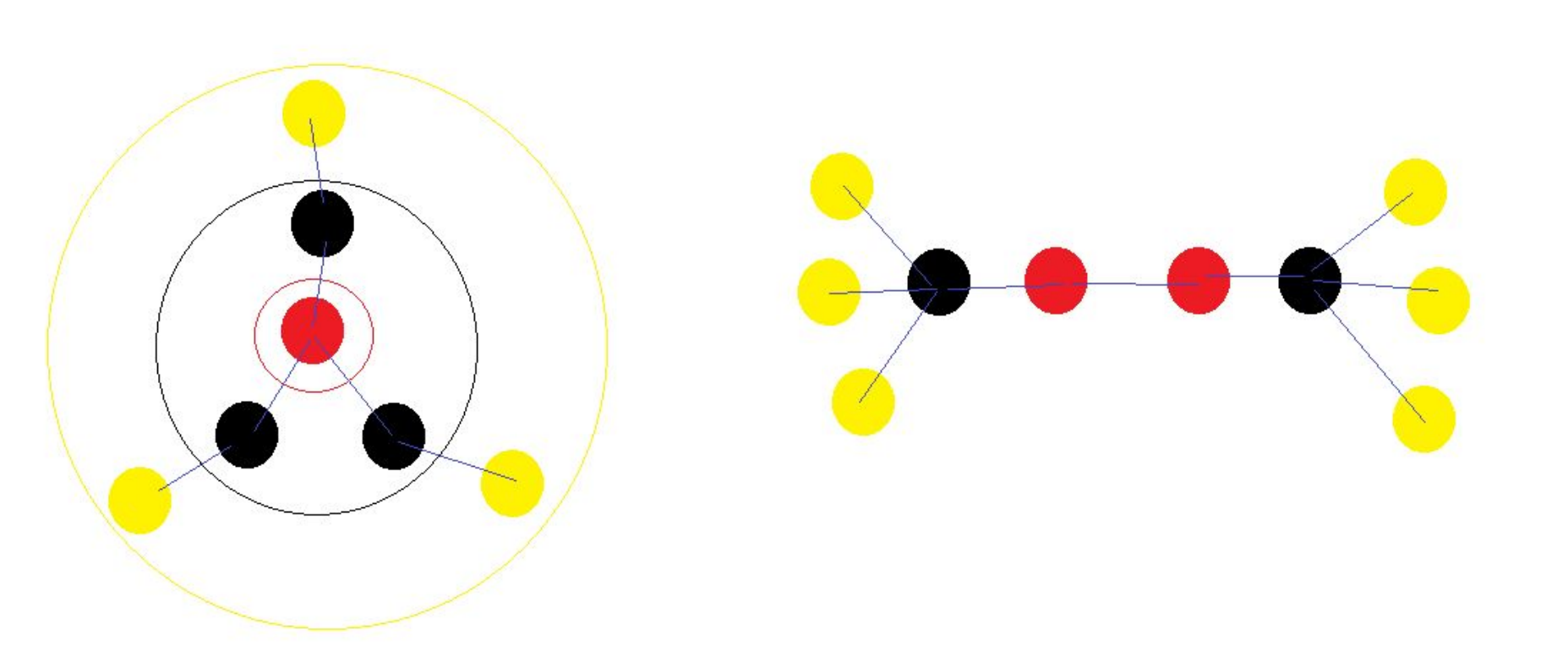
https://leetcode.com/problems/remove-invalid-parentheses/




```
private fun isValid(str: String): Boolean {
    var count = 0
    str.forEach {
        if (it == '(') {
            ++count
        }
        /*
        if (it == ')') {
            --count
        }
         */
        if (it == ')' && --count < 0) {
            return false
        }
    }
    return count == 0
}
```

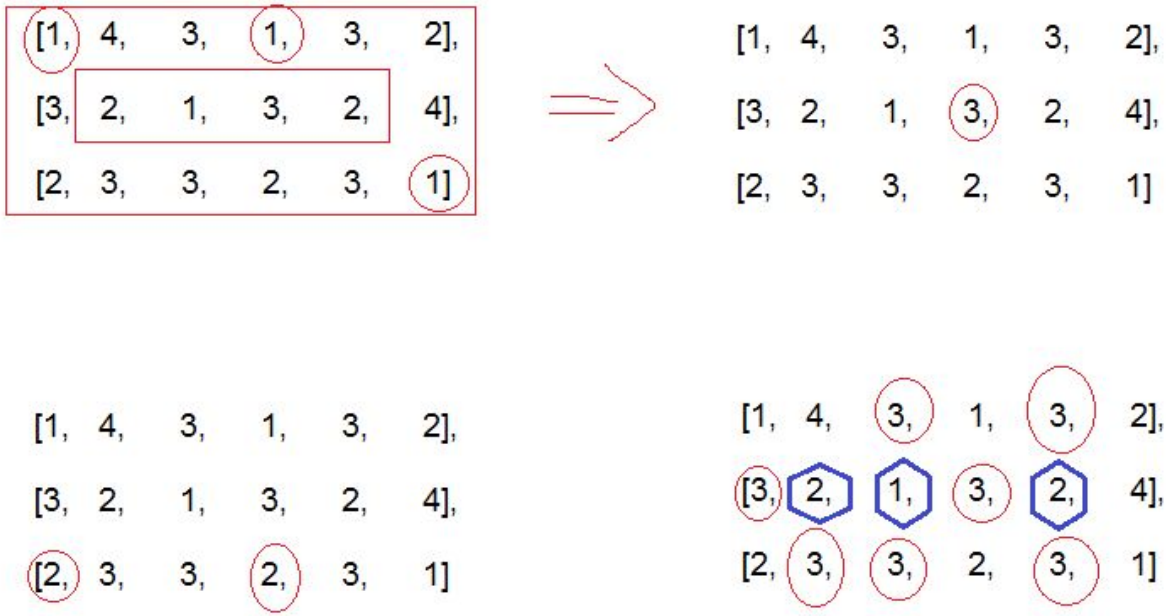
310. Minimum Height Trees

https://leetcode.com/problems/minimum-height-trees/



407. Trapping Rain Water II

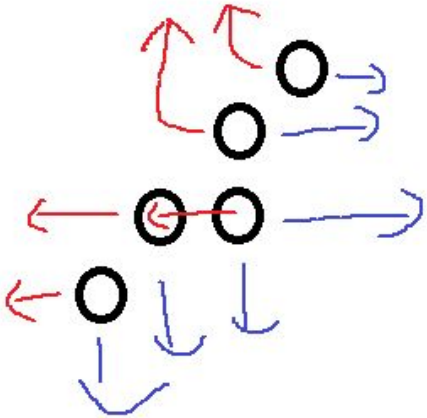
https://leetcode.com/problems/trapping-rain-water-ii/



417. Pacific Atlantic Water Flow

https://leetcode.com/problems/pacific-atlantic-water-flow/

```
Pacific ~  ~  ~  ~  ~
   ~ 1  2  2  3 (5) *
   ~ 3  2  3 (4) (4) *
   ~ 2  4 (5) 3  1  *
   ~ (6) (7) 1  4  5  *
   ~ (5) 1  1  2  4  *
     *  *  *  *  * Atlantic
```



idea: start with the node on the board of matrix, then search where it can reach . it's a treaceback.

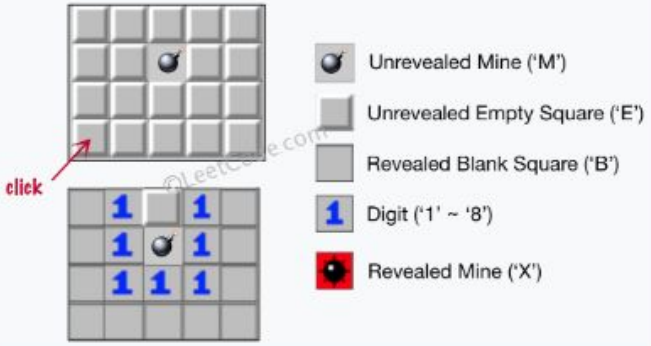
1. visited1 visited2 queue1 queue2
2. add board node in queue and set visited
3. bfs
4. visited1 && visited2

529. Minesweeper

https://leetcode.com/problems/minesweeper/

```
Input:

[['E', 'E', 'E', 'E', 'E'],
 ['E', 'E', 'M', 'E', 'E'],
 ['E', 'E', 'E', 'E', 'E'],
 ['E', 'E', 'E', 'E', 'E']]

Click : [3,0]

Output:

[['B', '1', 'E', '1', 'B'],
 ['B', '1', 'M', '1', 'B'],
 ['B', '1', '1', '1', 'B'],
 ['B', 'B', 'B', 'B', 'B']]
```

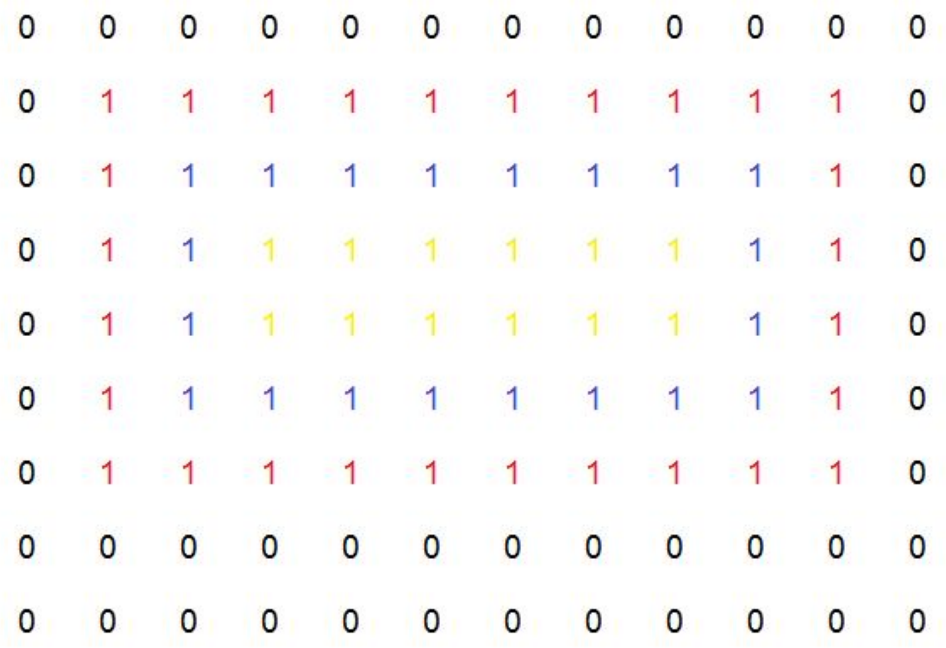
Explanation:



1. for a given position:
   -> with no surrounded mine
      mark as 'B', add all neightbors
   -> with more than one mine
      mark the total numbers

542. 01 Matrix

https://leetcode.com/problems/01-matrix/



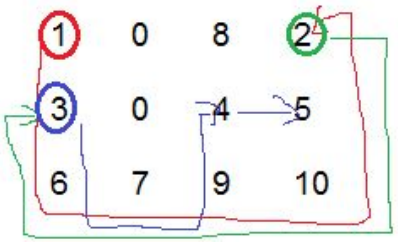
0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

idea: use BFS to set the level value to cell

1. add all cells value 1 surrounded with 0, mark level 1
2. add adjacent cells value 1, mark level 2
3. do the same things until queue is empty

675. Cut Off Trees for Golf Event

https://leetcode.com/problems/cut-off-trees-for-golf-event/



1. find all cells where the value > 1, and add them into a list (value,x,y)

2. sort list by value

3. bfs find the distance between each item, if can not find a path, return -1

bfs

level iterate in matrix

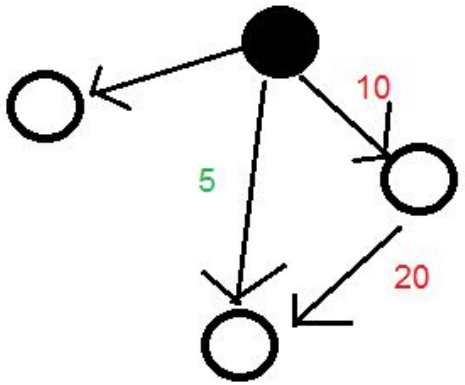
given a start point (x,y)

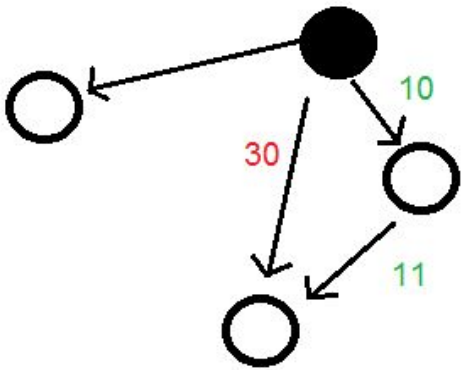
after each size of queue, ++level

if found end point, return level, else -1

743. Network Delay Time

https://leetcode.com/problems/network-delay-time/





1. transform times into a graph
2. build a map, priorityQueue
3. bfs
4. if map.size != N, return -1

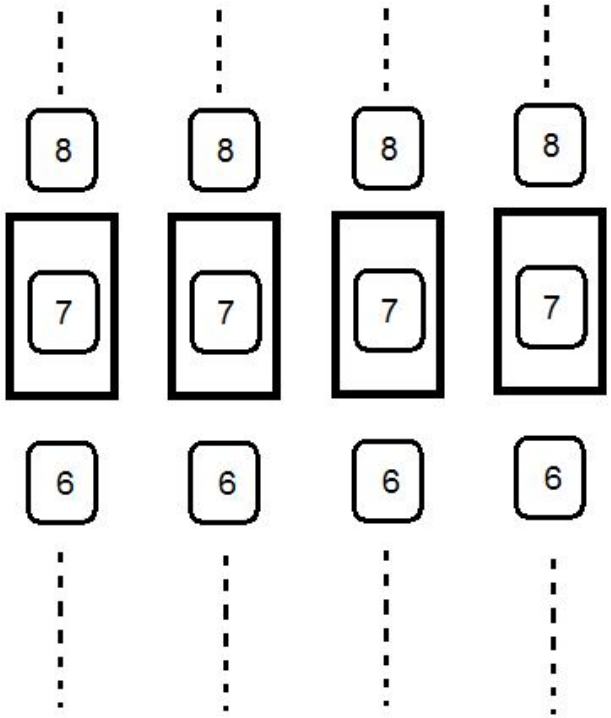
no need to iterate by level because of priority queue

if map not contains current node -> do

if map not contains next node -> add it in queue

752. Open the Lock

https://leetcode.com/problems/open-the-lock/



idea: to search minimum move to unlock use BFS

1. if deadEnds contains "0000" or deadEnds contains all nextMoves of target, return -1

2. create visited, queue, level

3. iterate queue size by leve, if value == target, return level

for each string, it will have 8 next moves,
if not visited, not deadEnds contains => add it into queue, visited true

Zombie in Matrix

https://www.lintcode.com/problem/zombie-in-matrix/description

Input:
[[0,1,2,0,0],
 [1,0,0,2,1],
 [0,1,0,0,0]]
Output:
2

1. create visited, queue

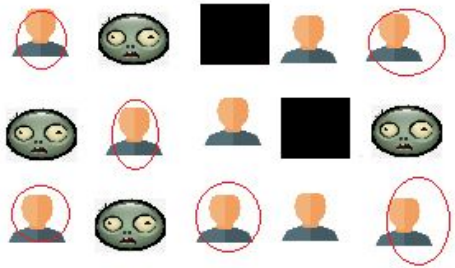
2. add all 1 (zombie) into the queue, and count the number of peoples

3. bfs

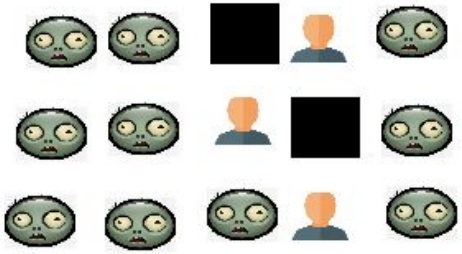
when add to queue, count++

compare count == peoples

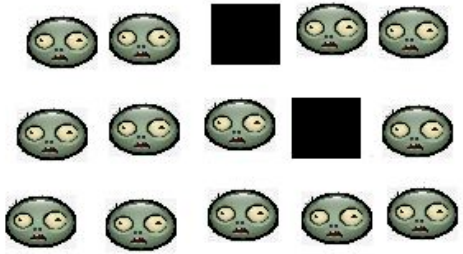
day 0



day 1

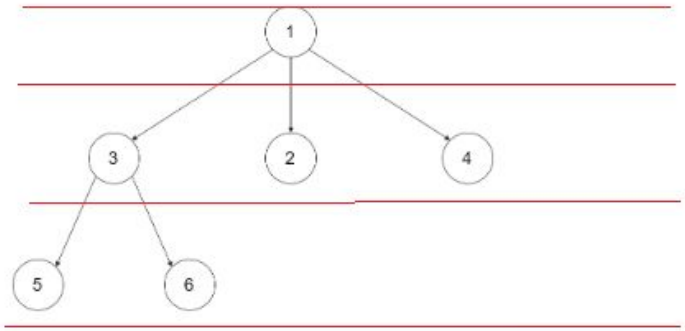


day 2



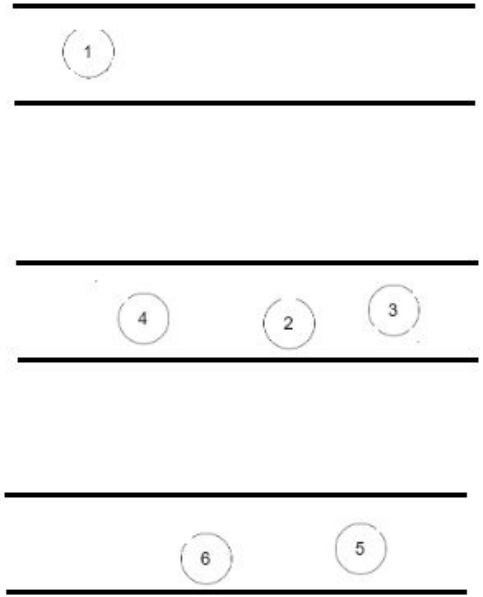
429. N-ary Tree Level Order Traversal

https://leetcode.com/problems/n-ary-tree-level-order-traversal/




```
Input: root = [1,null,3,2,4,null,5,6]
Output: [[1],[3,2,4],[5,6]]
```

use breadth first search



773. Sliding Puzzle

https://leetcode.com/problems/sliding-puzzle/

1	2	3
4	0	5

1 2 3 4 0 5

use Breadth First Search to find the minimum steps :

1. visited queue

2. bfs

1 0 3 4 2 5

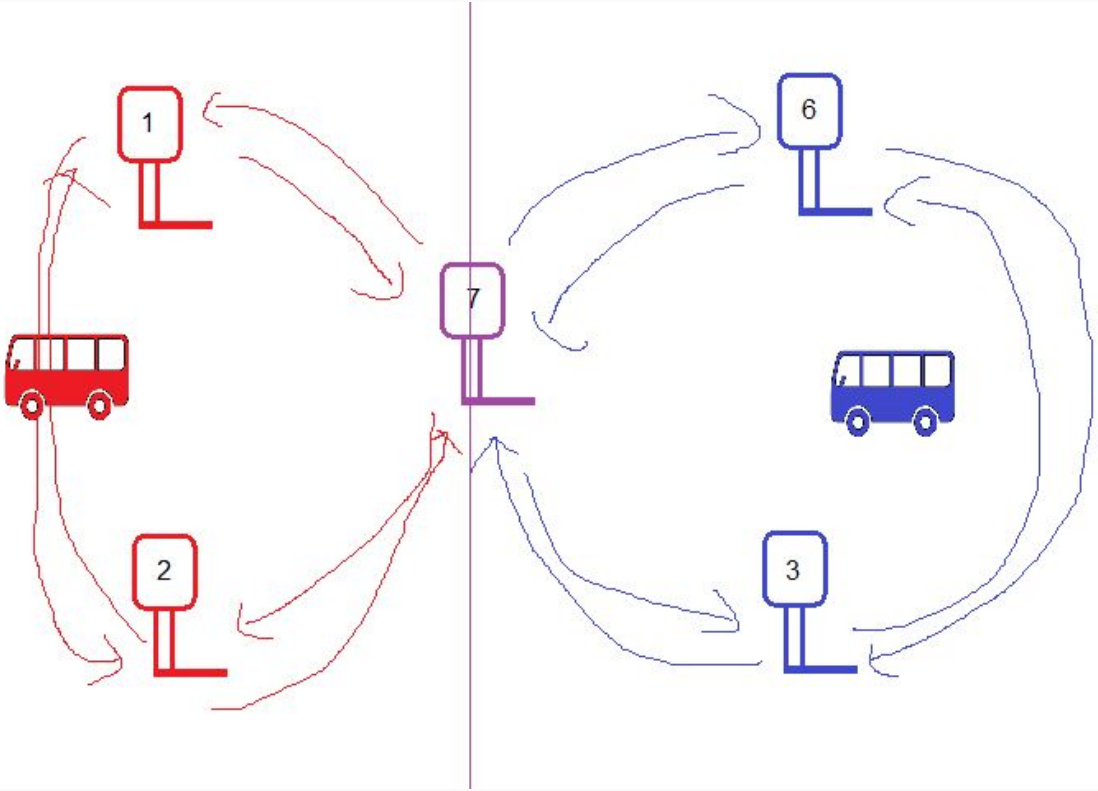
1 2 3 0 4 5

1 2 3 4 5 0

```
0, List.of(
        new int[]{0, 1},
        new int[]{0, 3}
),
1, List.of(
        new int[]{0, 1},
        new int[]{1, 2},
        new int[]{1, 4}
),
2, List.of(
        new int[]{1, 2},
        new int[]{2, 5}
),
3, List.of(
        new int[]{3, 4},
        new int[]{0, 3}
),
4, List.of(
        new int[]{5, 4},
        new int[]{3, 4},
        new int[]{1, 4}
),
5, List.of(
        new int[]{4, 5},
        new int[]{2, 5}
)
```

815. Bus Routes

https://leetcode.com/problems/bus-routes/



1. List<Set<Int>> buses : index => stops

2. build the graph, bus connect to bus

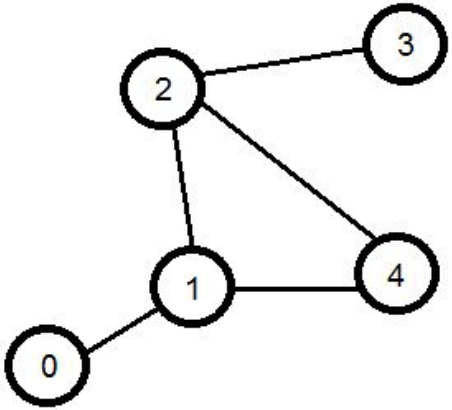
3. visited, queue, endSet
   (this steps int means bus number)

4. add start to queue and visited,
   add end to endSet

5. bfs

847. Shortest Path Visiting All Nodes

https://leetcode.com/problems/shortest-path-visiting-all-nodes/



N = 5

_ _ _ _ _

1 1 1 1 1 = 31 = (1 << 5) - 1 endKey

0 , (00001) -> 1 , (00011)
1 , (00010) -> 0 , (00011) ~~-> 1 , (00011)~~
2 , (00100)
3 , (01000)
4 , (10000)

1. endKey, visited, queue
2. put all nodes into the queue
3. bfs

854. K-Similar Strings

https://leetcode.com/problems/k-similar-strings/

1. find the first index that current string char != target string char

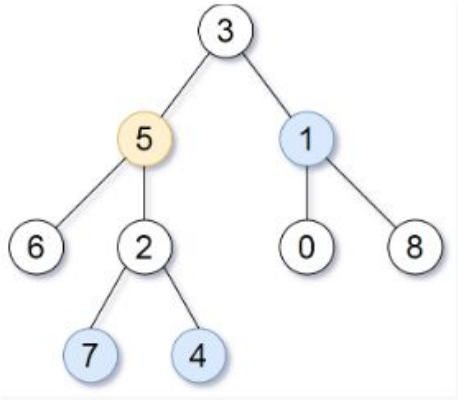
2. find next chat in current string that equls target char

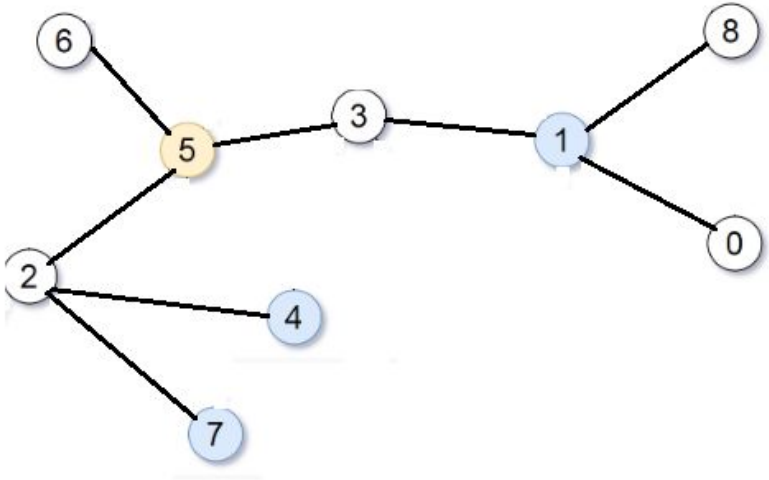
3. exchange

```
private List<String> getNexts(String current, String target) {
    final List<String> results = new ArrayList<>();
    int i = 0;
    while (i < target.length() &&
            current.charAt(i) == target.charAt(i)) {
        ++i;
    }
    for (int j = i + 1; j < target.length(); j++) {
        if (target.charAt(j) == current.charAt(i)) {
            final StringBuilder newSb = new StringBuilder(current);
            final char temp = current.charAt(i);
            newSb.setCharAt(i, current.charAt(j));
            newSb.setCharAt(j, temp);
            results.add(newSb.toString());
        }
    }
    return results;
}
```

863. All Nodes Distance K in Binary Tree

https://leetcode.com/problems/all-nodes-distance-k-in-binary-tree/





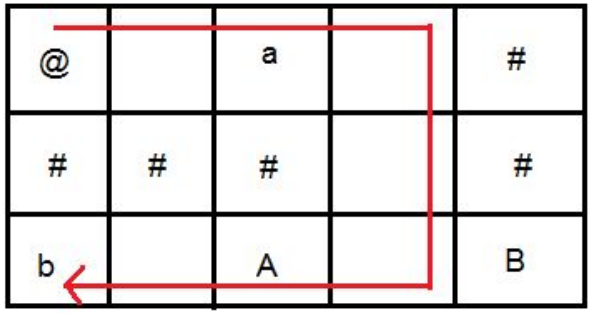
1. build graph

2. visited queue

3. breadth first search

864. Shortest Path to Get All Keys

https://leetcode.com/problems/shortest-path-to-get-all-keys/



a b c d e f

_ _ _ _ _ _

1 1 1 1 1 1 endKey

1. calculate count,start,x,y endKey

2. visited, queue

```
visited[startX][startY][0] = true
```

3. bfs

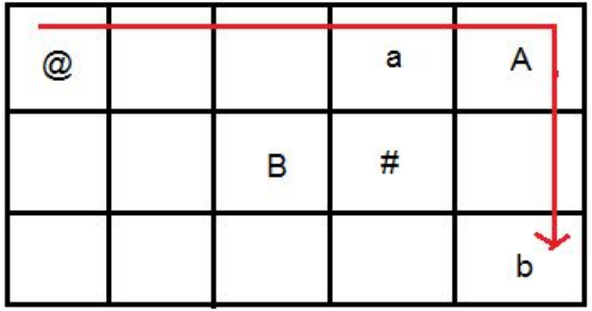
```
if (inBound(myGrid, nextX, nextY) && myGrid[nextX][nextY] != '#')
```

nextChar in 'a' .. 'f' -> calculate nextstate

nextChar in 'A' .. 'F' ->

```
val currentLockIndex = nextChar - 'A'
val unLock = 1.and(current[2].shr(currentLockIndex))
```

nextChar '.' ->



1 1 0 0
d c b a

c ? == 2

1 1 0 0 >> 2
1 1
& 1

= 1

909. Snakes and Ladders

https://leetcode.com/problems/snakes-and-ladders/

N * N

N = 6

row = 4

8 -1 / 6 = 1

N - 1 - 1 = 4

row = N - (number -1) / N -1

column = 4

row % 2 == N % 2 ?

true N - 1 - (8 - 1) % 6

false (8 - 1) % 6

1. visited, queue

2. BFS

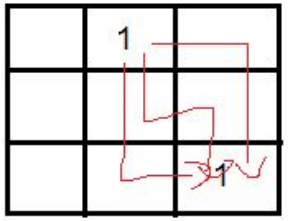
each time, we can move current + 6

if have a ladder or a snake (next != -1), then go to destination.

934. Shortest Bridge

https://leetcode.com/problems/shortest-bridge/

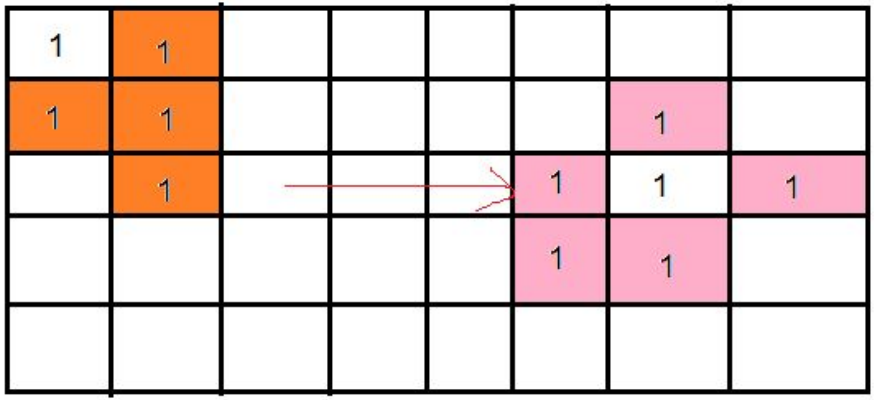
0 1 0
0 0 0
0 0 1



1. find one island, then mark whole island visited, add ~~those cells that surrounded with 0~~ all into the queue

2. BFS until a level that reached a cell '1', return level

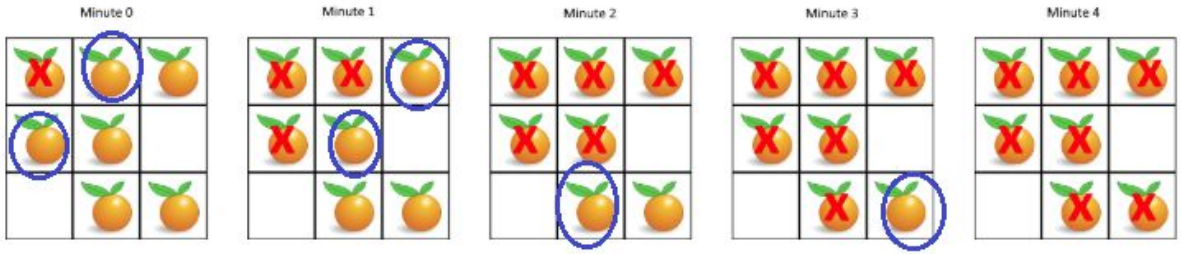
1 1 1 1 1
1 0 0 0 1
1 0 1 0 1
1 0 0 0 1
1 1 1 1 1



994. Rotting Oranges

https://leetcode.com/problems/rotting-oranges/

Example 1:



count frensh oranges

1. visited, queue add rotten oranges

2. bfs

if in bound, not visited, is a fresh orange, add it into the queue

if transform numbers == fresh oranges

return level

else return -1

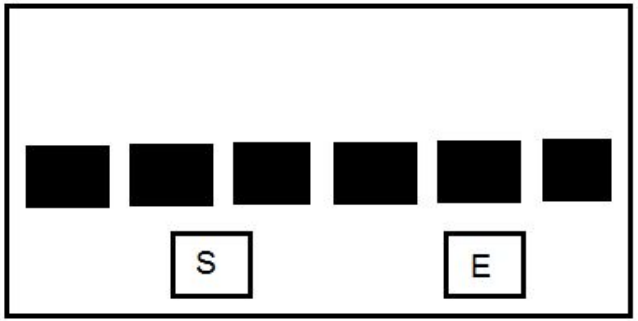
1036. Escape a Large Maze

https://leetcode.com/problems/escape-a-large-maze/

main idea is to check if source or target is surrounded by blocked cells.

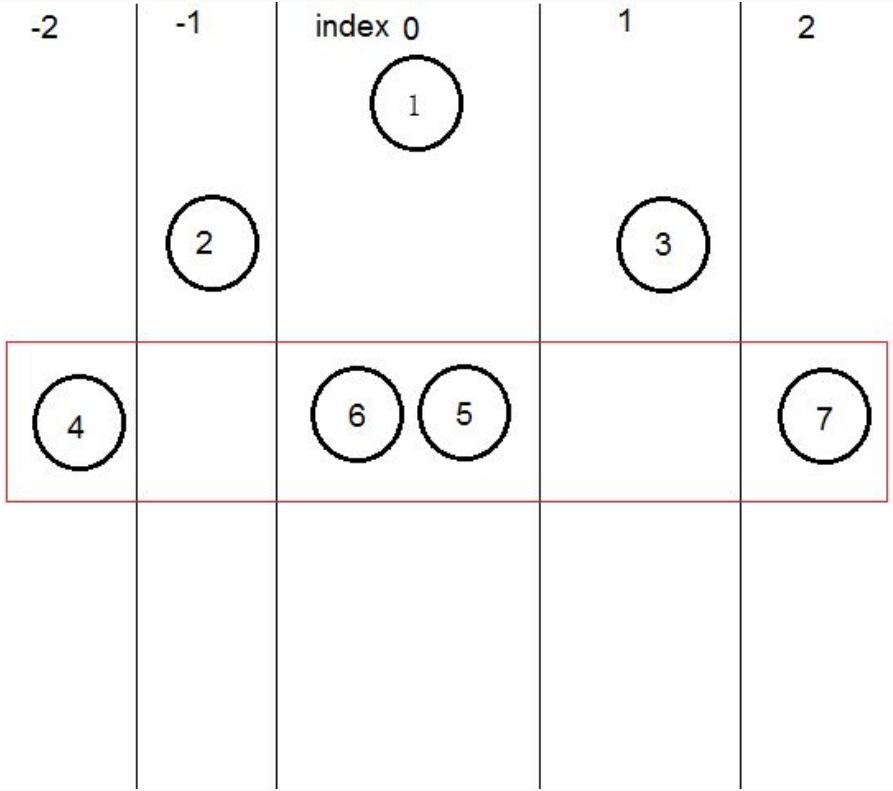
start with (source or target), can move blocked.length ?

notice that if source and target are surrounded with blocked cells but they are connected, return true



987. Vertical Order Traversal of a Binary Tree

https://leetcode.com/problems/vertical-order-traversal-of-a-binary-tree/



idea: use breadth frist search,
for every layer
maintean a map index -> list

at the end of each level, sort the list,
add to another map

at the end, sort the map by index, map to results.

-2 -> 4
0 -> 6,5 ==sort()==> 0 -> 5,6
2 -> 7

at the end of level,
add to map

-2 -> 4
0 -> 1,5,6
2 -> 7

1091. Shortest Path in Binary Matrix

https://leetcode.com/problems/shortest-path-in-binary-matrix/

Output: 4

0	0	0
1	1	0
1	1	0

breadth first search

1. queue visited, if[0][0] == 1 return -1 else add it in queue and in visited

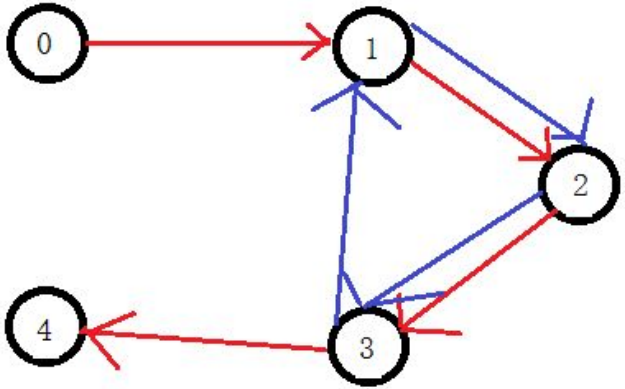
2. for each level,
    for each cell, we have 8 next cells to check
        if inBound
            not visited
            value == 0
                add next in queue and in visited

level start at 1

1129. Shortest Path with Alternating Colors

https://leetcode.com/problems/shortest-path-with-alternating-colors/

0 -> 1 1 -> 2 2 - > 3 3 -> 1 1 -> 2 2 -> 3 3 -> 4



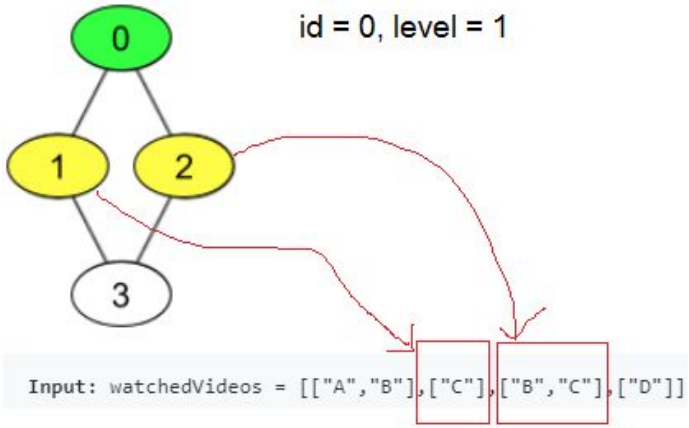
1. convert array to two graphs
- BLUE, RED constant variables, why 0 1? visited is a 2 dimensions array so we can use it like visited[index][color]
- resultArray, set default value to -1, if we could access the index, we would update the value.

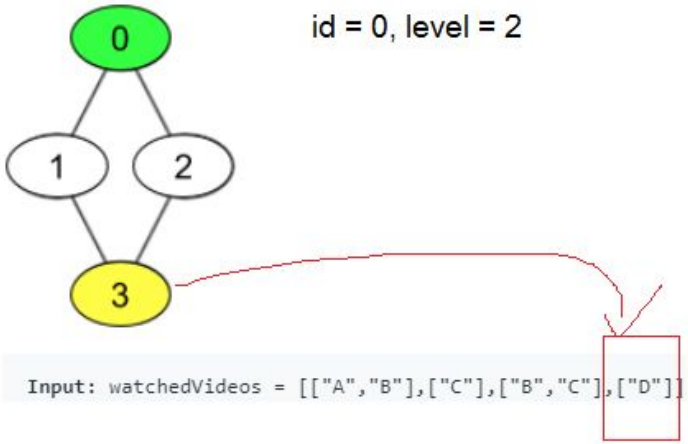
2. BFS template
- our state is (index,color)
- for each level, for each state, we update resultArray with current level,
- then we change color and check if we have met the state (nextIndex, nextColor) before

resultArray = [0 1 2 3 7]

1311. Get Watched Videos by Your Friends

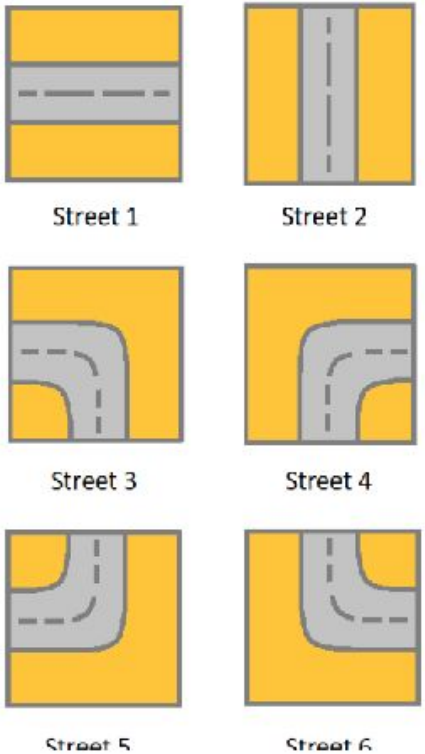
https://leetcode.com/problems/get-watched-videos-by-your-friends/





1391. Check if There is a Valid Path in a Grid

https://leetcode.com/problems/check-if-there-is-a-valid-path-in-a-grid/

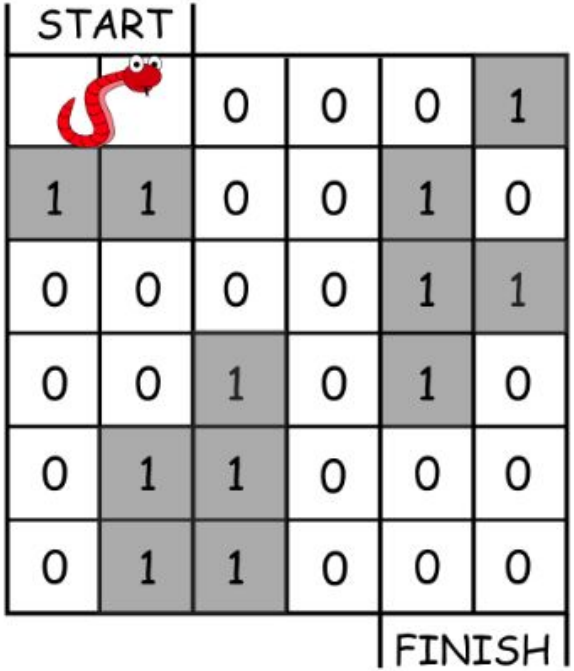


1 which means a street connecting the left cell and the right cell.
2 which means a street connecting the upper cell and the lower cell.
3 which means a street connecting the left cell and the lower cell.
4 which means a street connecting the right cell and the lower cell.
5 which means a street connecting the left cell and the upper cell.
6 which means a street connecting the right cell and the upper cell.

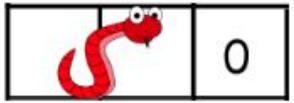
```
private void next() {
    final int nextX = x + deltaX[direction];
    final int nextY = y + deltaY[direction];
    if (inBound(grid, nextX, nextY) &&
            !visited[nextX][nextY] &&
            map.get(direction).contains(grid[nextX][nextY])
    ) {
        queue.offer(new int[]{nextX, nextY});
        visited[nextX][nextY] = true;
    }
}
```

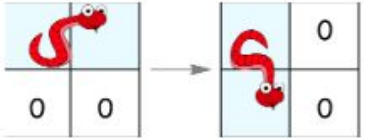
1210. Minimum Moves to Reach Target with Rotations

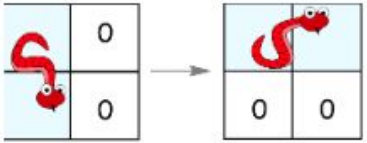
https://leetcode.com/problems/minimum-moves-to-reach-target-with-rotations/




```
for HORIZONTAL:
- go HORIZONTAL next
- go VERTICAL next
- rotate clockwise
for VERTICAL:
- go HORIZONTAL next
- go VERTICAL next
- rotate counterclockwise
```

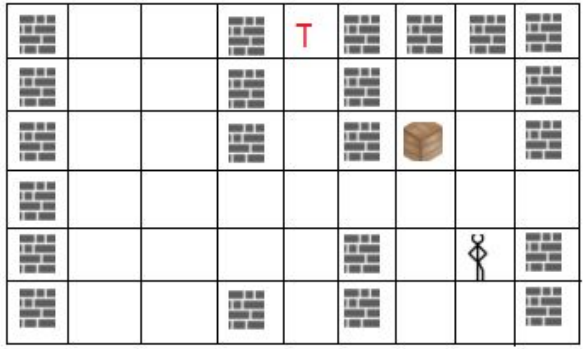






1263. Minimum Moves to Move a Box to Their Target Location

https://leetcode.com/problems/minimum-moves-to-move-a-box-to-their-target-location/

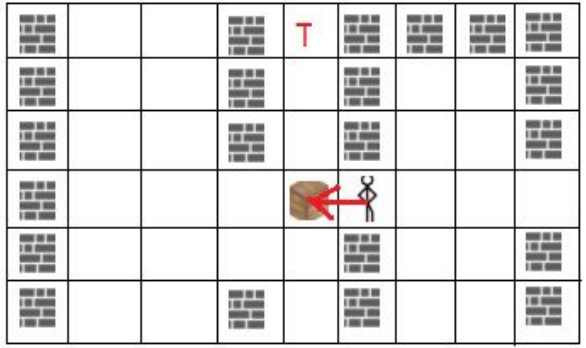


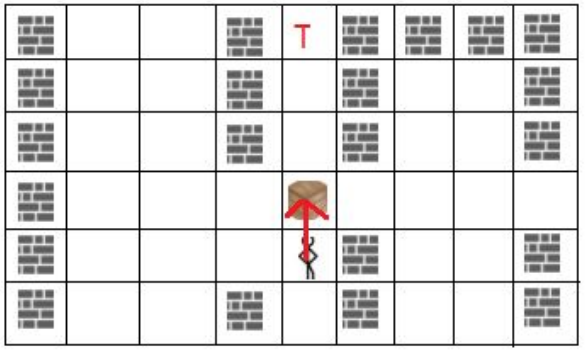
1. visited array is 3 dimentional, box x,y index and last move direction.

2. as we have 4 direcitons, when ierate, just use index as direction.

3. for each next move, we need to check next box position and next player position is in bound.

4.an additional bfs function to check the player can mvoe the target player postion or not.





1284. Minimum Number of Flips to Convert Binary Matrix to Zero Matrix

https://leetcode.com/problems/minimum-number-of-flips-to-convert-binary-matrix-to-zero-matrix/

```
[0 0]    [1 0]    [0 1]    [0 0]
[0 1]    [1 0]    [1 1]    [0 0]

0001     1010     0111     0000
```

val currentX = aimIndex / n
val currentY = aimIndex % n

```
[0 1]
[2 3]
[4 5]
```

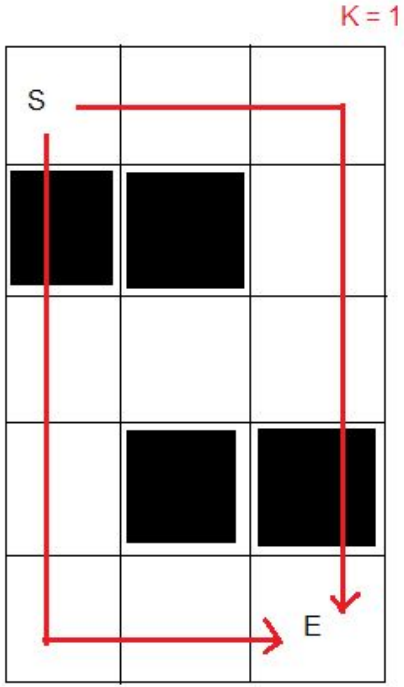
for element at bottom right, index in string = 5
so x = 5/2 = 2
y = 5%2 = 1

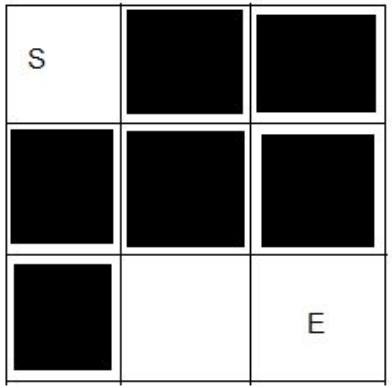
vice versa,
given a coordinate (2,1), index in string = 2*2 +1 = 5

```
private void change(StringBuilder stringBuilder, int i) {
    if (stringBuilder.charAt(i) == '0') {
        stringBuilder.setCharAt(i, '1');
    } else {
        stringBuilder.setCharAt(i, '0');
    }
}
```

1293. Shortest Path in a Grid with Obstacles Elimination

https://leetcode.com/problems/shortest-path-in-a-grid-with-obstacles-elimination/





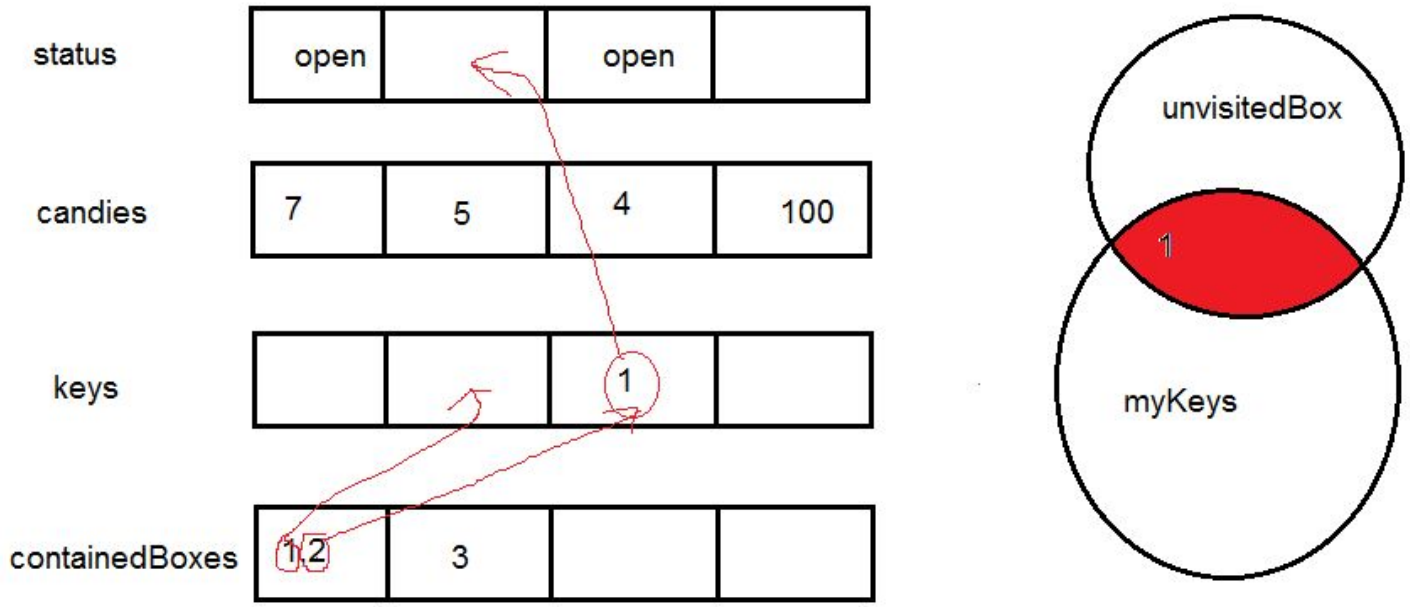

```
final boolean[][][] visited =
        new boolean[grid.length][grid[0].length][k + 1];
```

for each next cell, it should be in bound,

1. if next cell is 0, do a normal check visited
2. if next cell is 1, check if current k >=1,
   then check visited with k-1

1298. Maximum Candies You Can Get from Boxes

https://leetcode.com/problems/maximum-candies-you-can-get-from-boxes/



1345. Jump Game IV

https://leetcode.com/problems/jump-game-iv/

[7777777777777777777777777777777777777777777777777777,last]

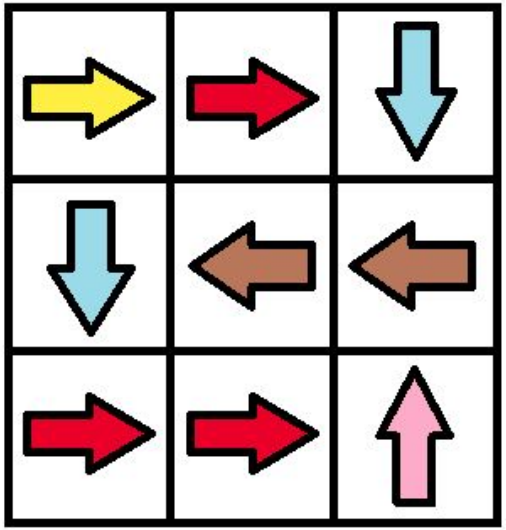
```
final Map<Integer, Set<Integer>> graph = new HashMap<>();
```

7 -> ...
last -> length -1

```
if (graph.containsKey(arr[current])) {
    graph.get(arr[current]).forEach(
            it -> {
                if (!visited[it]) {
                    queue.offer(it);
                    visited[it] = true;
                }
            }
    );
    // if not, time limit exceeded
    graph.remove(arr[current]);
}
```

1368. Minimum Cost to Make at Least One Valid Path in a Grid

https://leetcode.com/problems/minimum-cost-to-make-at-least-one-valid-path-in-a-grid/



idea is always check firstly the stata(x,y,cost) with the lowest cost in queue.

```
for (int index = 0; index < 4; index++) {
    final int nextX = current[0] + deltaX[index];
    final int nextY = current[1] + deltaY[index];
    if (inBound(grid, nextX, nextY)) {
        if (index + 1 == grid[current[0]][current[1]]) {
            priorityQueue.offer(new int[]{nextX, nextY, current[2]});
        } else {
            priorityQueue.offer(new int[]{nextX, nextY, current[2] + 1});
        }
    }
}
```

```
final PriorityQueue<int[]> priorityQueue = new PriorityQueue<>(
        (Comparator.comparingInt(ints -> ints[2]))
);
```

```
val priorityQueue = PriorityQueue { i1: IntArray, i2: IntArray -> compareValues(i1[2], i2[2]) }
```