SORTING

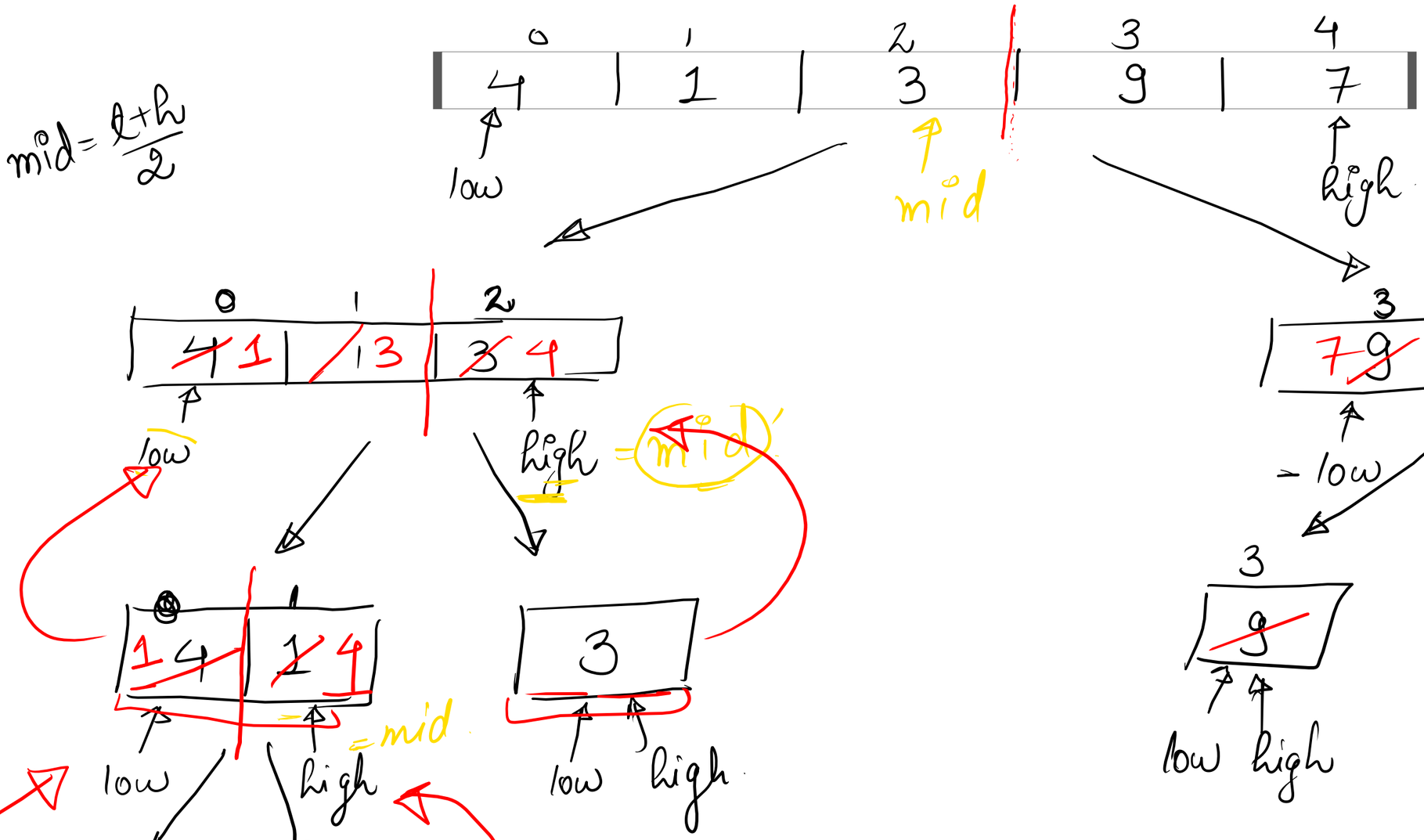
	TC	SC
1. Bubble sort	$O(N^2)$	
2. Insestion sort		
3. Selection sort		
4. Merge sort	—	—
5. Quick sort.	—	—

* Merge Sort

  ↳ Divide and Conquer

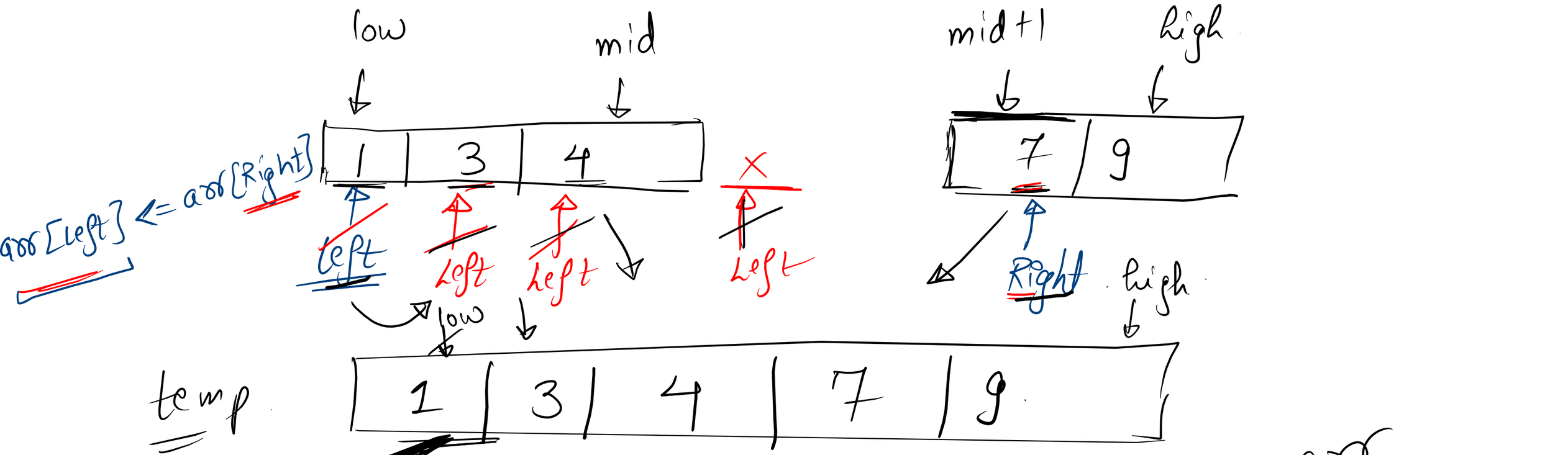
  ↳

$mid = \frac{l+h}{2}$



$\frac{3+4}{2} \Rightarrow 3$

```
f(arr ; low , high) {
  if(low < high) {
      → mid = (low + high) / 2.        ✓
      → f(arr, low, mid);              Left arry pass
      → f(arr, mid+1, high);           Righ arry pass
  }
}
```



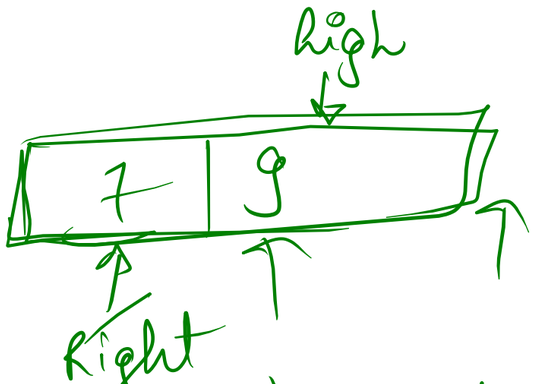

```
while (low <= mid && Right <= high) {
    if(arr[left] <= arr[Right])
        temp.add(arr[left]); left++;
    else
        temp.add(arr[Right]); Right++;
}
```

arr

1	3	4	7	9
0	1	2	3	4

index.

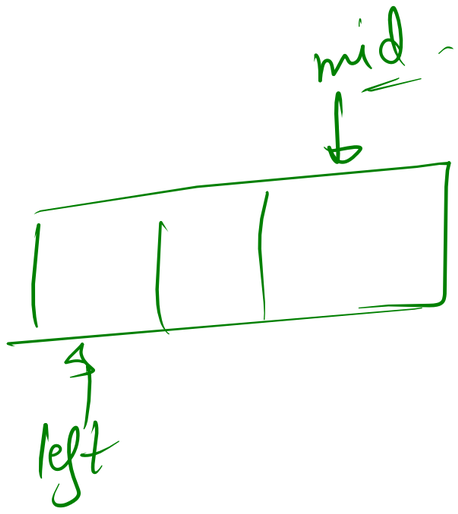
Case-2



$\overline{\times}$

// while (Right <= high) temp.add(arr[Right]) Right++;

Case-3



$\overline{\times}$

while (left <= mid) temp.add(arr[left]) left++;

* Ex- 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, use merge sort.

Merge Sort

Time Complexity : O(N log N)

Space complexity : O(N)

```java
static void mergeSort(int[] arr,int low,int high){

    if(low >= high) return ;
    int mid =(low + high) / 2 ;
    mergeSort(arr,low,mid);  // this is my left array
    mergeSort(arr,mid+1,high);  // this is my right array

    merge(arr,low,mid,high);
}
static void merge(int[]arr , int low , int mid , int high){
    ArrayList<Integer>temp = new ArrayList<>();
    int left = low ;
    int right = mid+1;

    while(left <= mid && right <= high){
        if(arr[left] <= arr[right]){
            temp.add(arr[left]);
            left++;
        }
        else{
            temp.add(arr[right]);
            right++;
        }
    }

    //if elements of left arrays are left(bachai hue hai)
    while(left <= mid){
        temp.add(arr[left]);
        left++;
    }

    //if elements of right arrays are left(bachai hue hai)
    while(right <= high){
        temp.add(arr[right]);
        right++;
    }

    int index = 0 ;
    while(low <= high){
        arr[low] = temp.get(index);
        low++;
        index++;
    }
```

QUICK SORT

.

Approach:

Now, let’s understand how we are going to implement the logic of the above steps. In the intuition, we have seen that the given array should be broken down into subarrays. But while implementing, we are not going to break down and create any new arrays. Instead, we will specify the range of the subarrays using two indices or pointers(i.e. **low** pointer and **high** pointer) each time while breaking down the array.

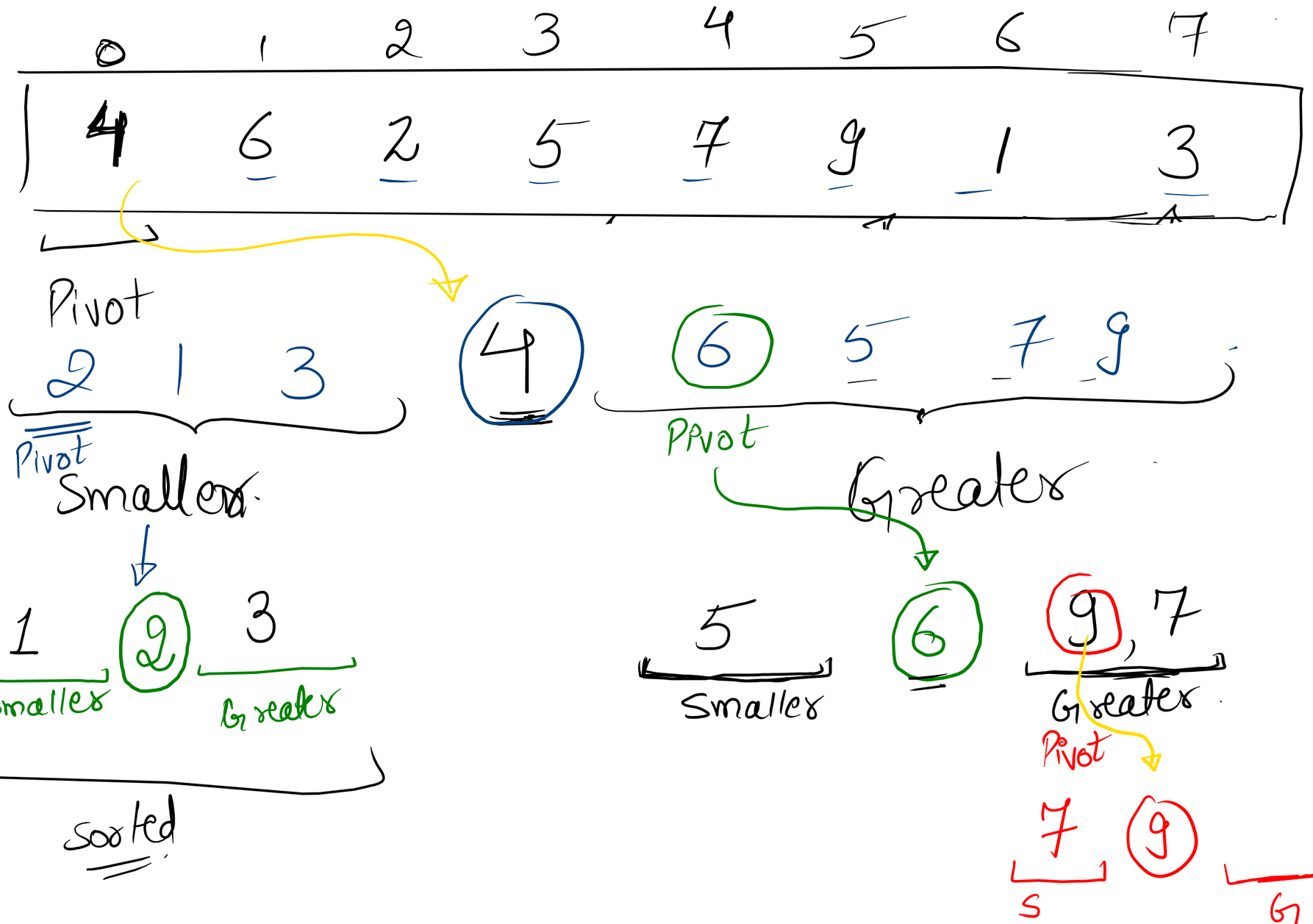
The algorithm steps are the following for the **quickSort()** function:

1. Initially, the **low** points to the first index and the **high** points to the last index(as the range is n i.e. the size of the array).
2. After that, we will get the index(*where the pivot should be placed after sorting*) while shifting the smaller elements on the left and the larger ones on the right using a partition() function discussed later.
   Now, this index can be called the **partition index** as it creates a partition between the left and the right unsorted subarrays.
3. After placing the pivot in the partition index(within the partition() function specified), we need to call the function quickSort() for the left and the right subarray recursively. So, **the range of the left subarray will be [low to (partition index - 1)]** and **the range of the right subarray will be [(partition index + 1) to high].**

Quick Sort

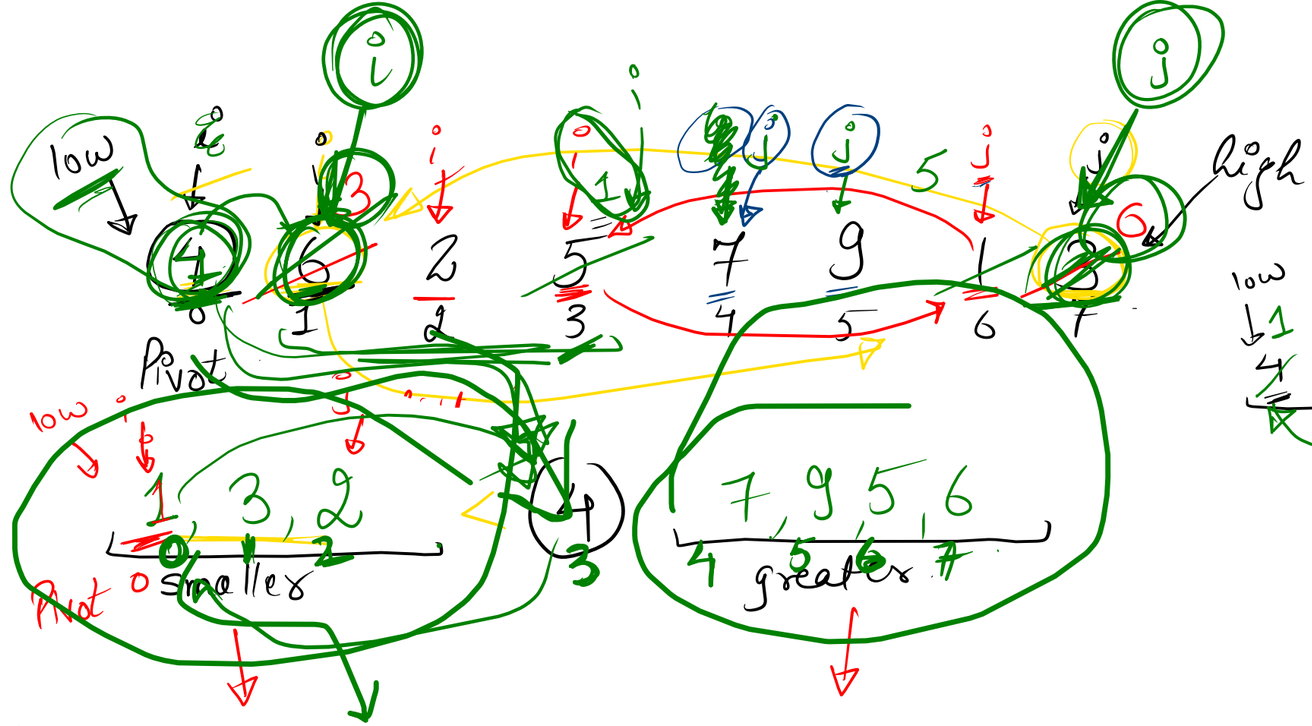
7, 2, 1, 10 → 1, 2, 7, 10

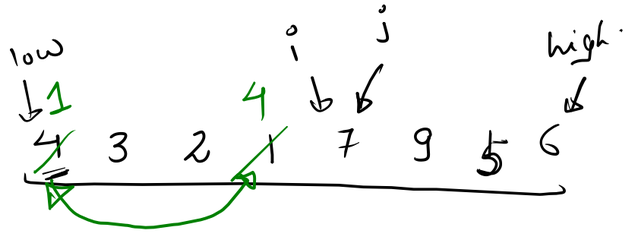
→ Pivot ⇝ sorted place


0 1 2 3 4 5 6 7
4 6 2 5 7 9 1 3
Pivot
2 1 3
4
6 5 7 9
Pivot
Pivot
Smaller
Greater
1
2
3
Smaller
Greater
Sorted
5
6
9 7
Smaller
Greater
Pivot
7
9
S
G

Chosing first element as a pivot
1. pick a pivot and place it in its correct place in the sorted array

2. smaller on the left and greater on the right





sw

```
while (i<=j)
    while( arr[i] <= arr[pivot]) { i++; }
    while (arr[j] > arr[pivot) { j--; }
    swap(arr[i],arr[j])
```

```
swap(arr[low], arr[j])
```

Quick Sort

Time Complexity : O(NlogN)

Space Complexity : O(1) ☆

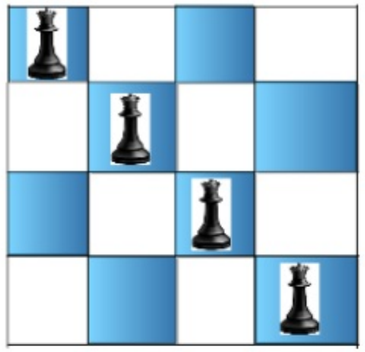
Q Why we prefer Quick Sort over Merge Sort? H/W

```java
static void quickSort(int[] arr){
    int n=arr.length;
    qs(arr,0,n-1);
}
public static void qs(int[] arr,int low,int high){
    if(low<high){
       int partionIndex=partition(arr,low,high);
       qs(arr,low,partionIndex-1);
       qs(arr,partionIndex+1,high);
    }
}
public static int partition(int[] arr,int low,int high){
    int pivot=arr[low];
    int i=low;
    int j=high;

    while(i<j){
       while(arr[i]<=pivot && i<=high-1){
          i++;
       }

       while(arr[j]>pivot && j>=low+1){
          j--;
       }
       if(i<j){
         swap(arr,i,j);
       }
    }
    swap(arr,low,j);
    return j;
}
public static void swap(int[] arr,int i, int j){
    int temp=arr[i];
    arr[i]=arr[j];
    arr[j]=temp;
}
```

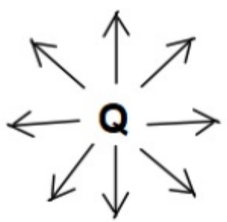
N - Queen

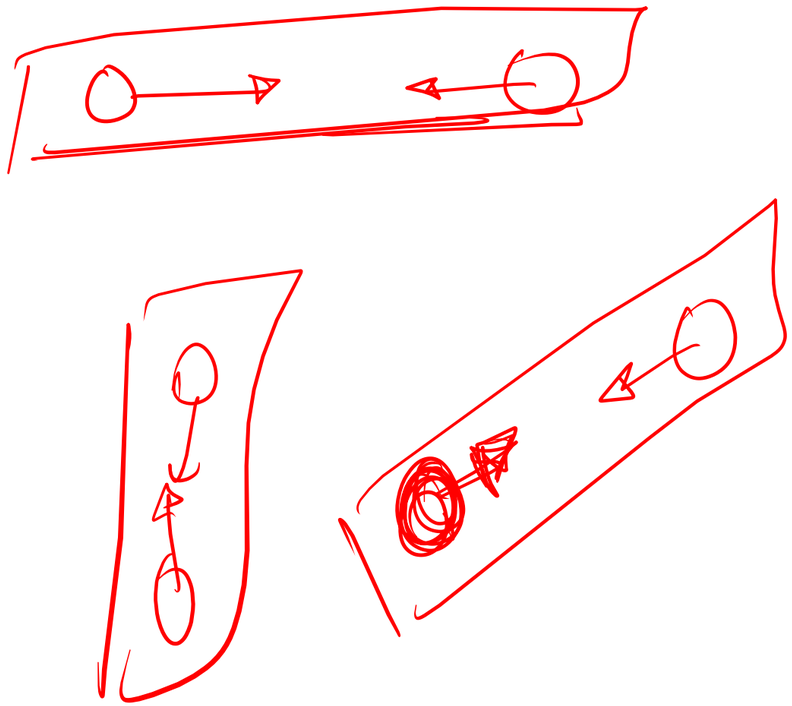


Rules for n-Queen in chessboard

1. Every row should have one Queen
2. Every column should have one Queen
3. No two queens can attack each other

Queen attack can take place in following way

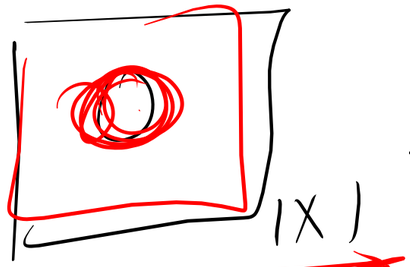




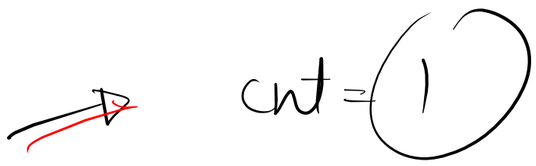
1X1 ⇒ 1

3X3 ⇒ 0

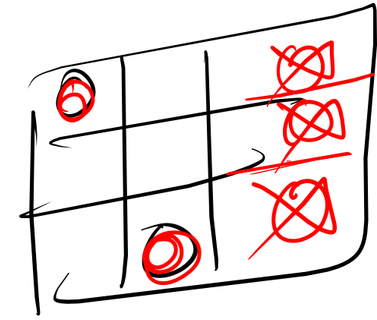
4X4 ⇒ 2

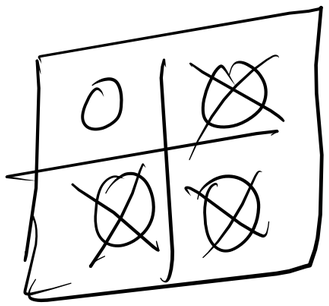


1X1



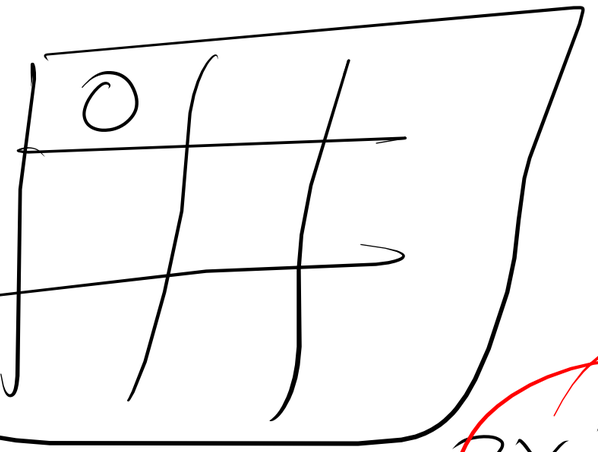
cnt = 1

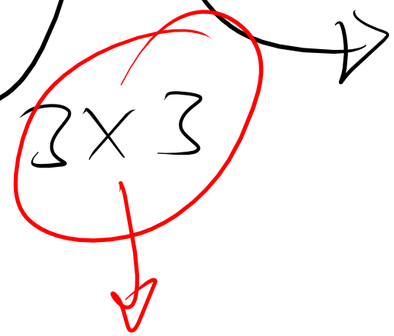




1

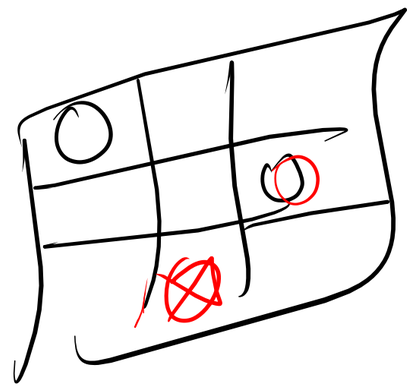
2X2

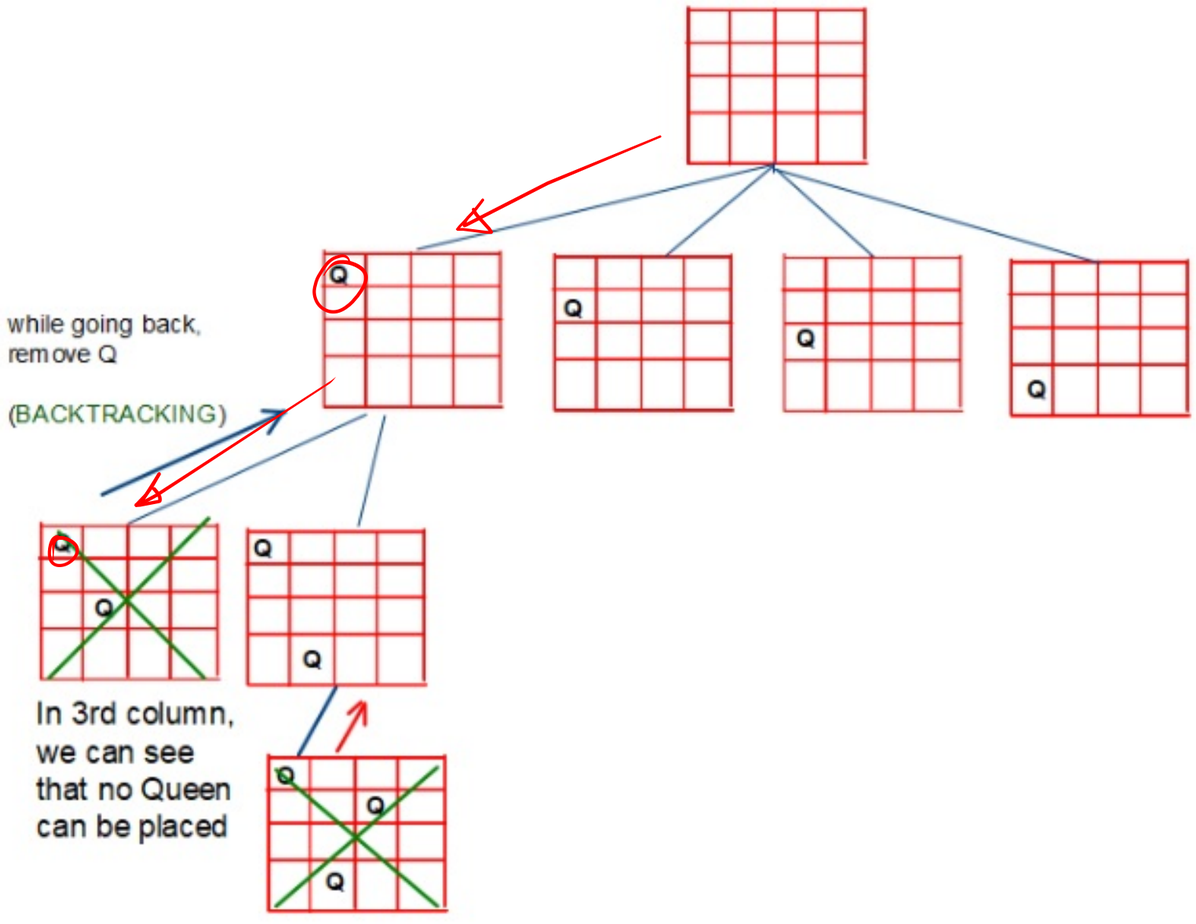


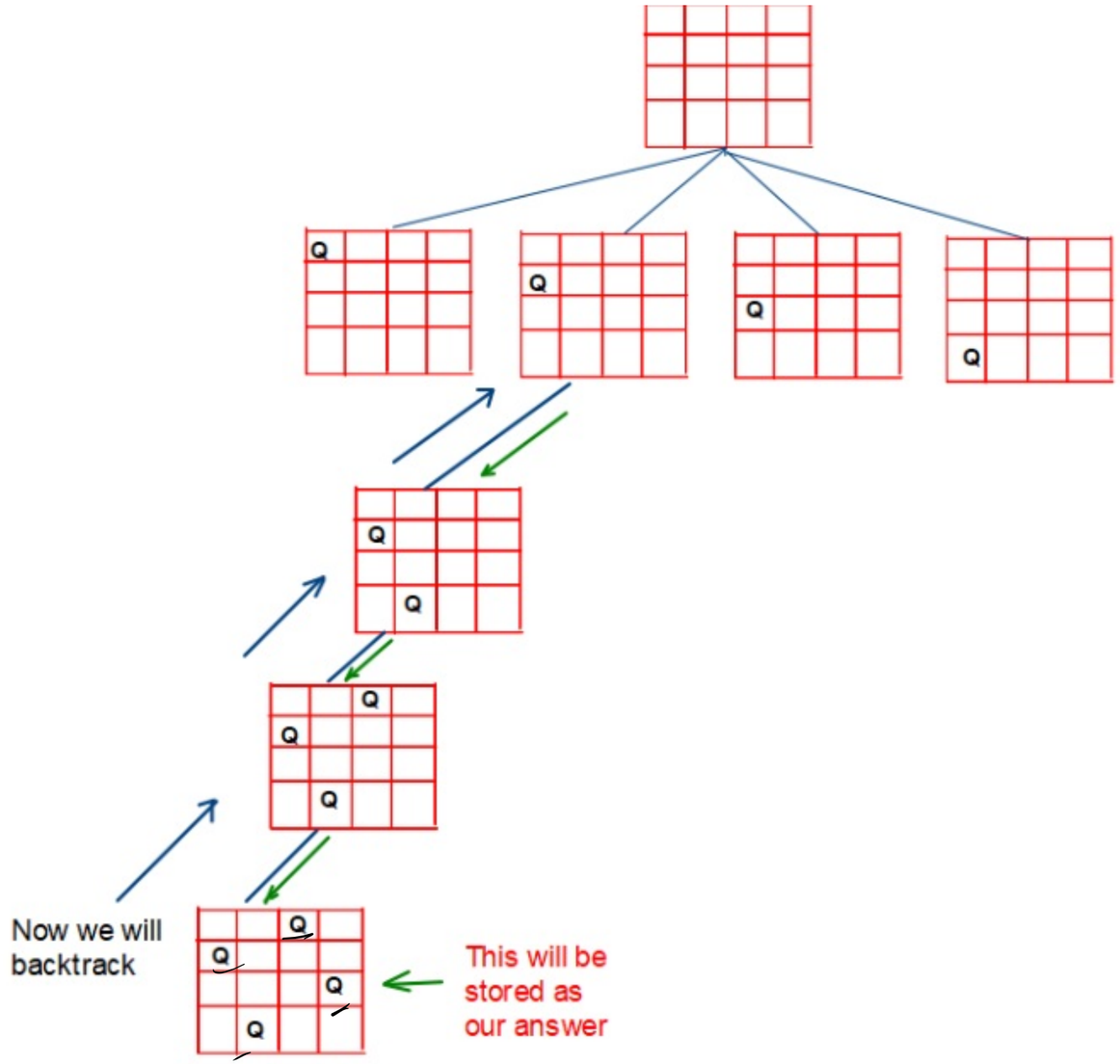


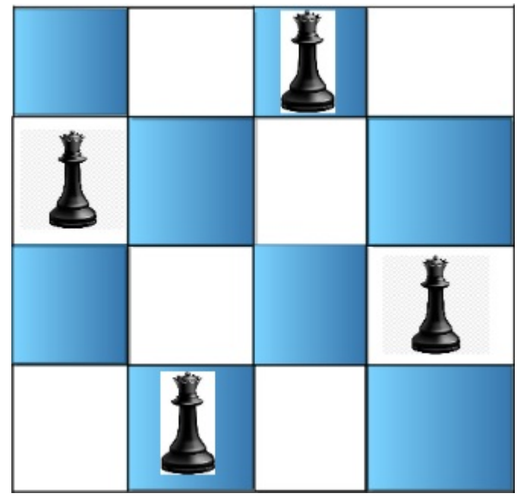
3X3

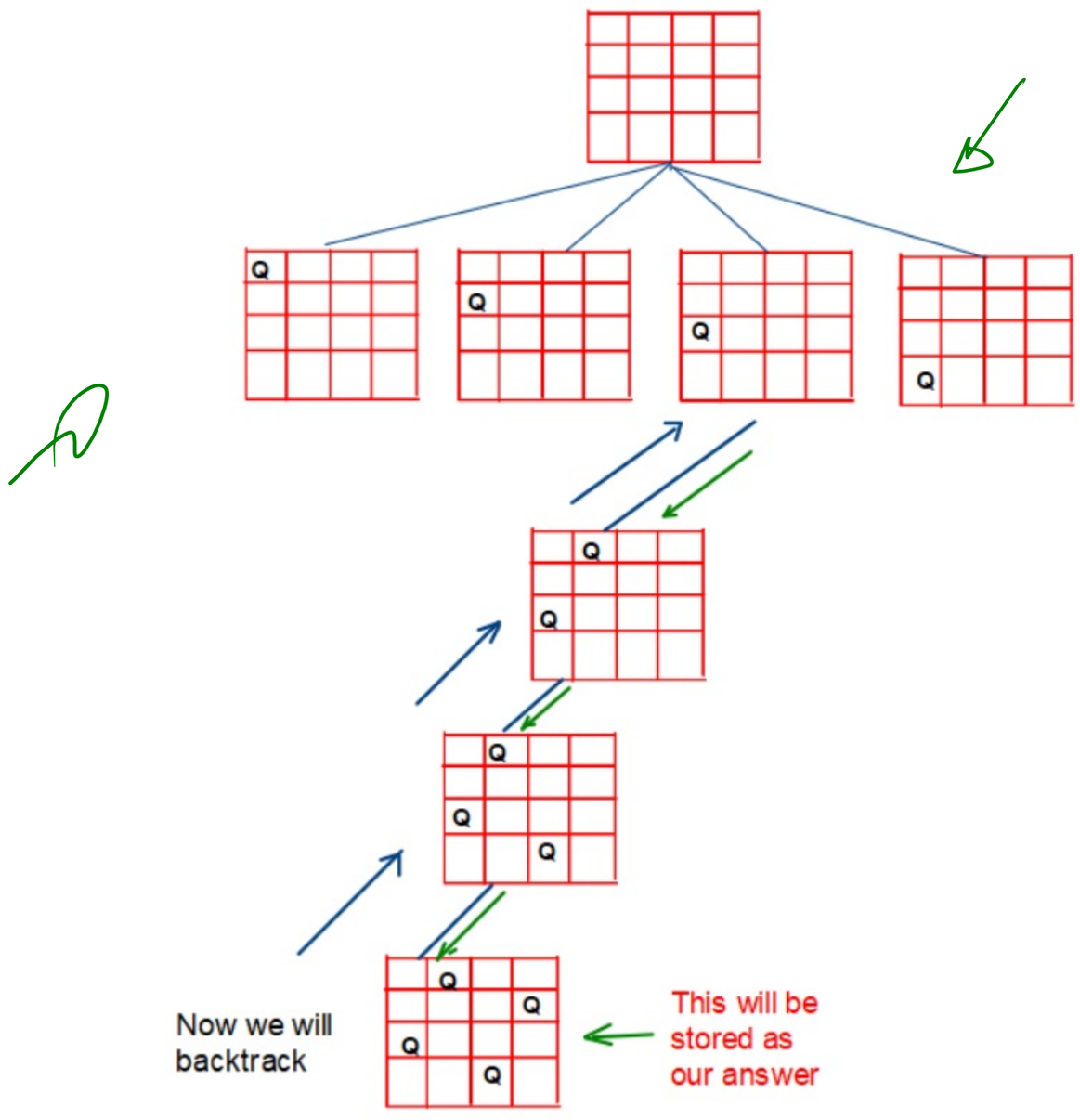
ans = 0

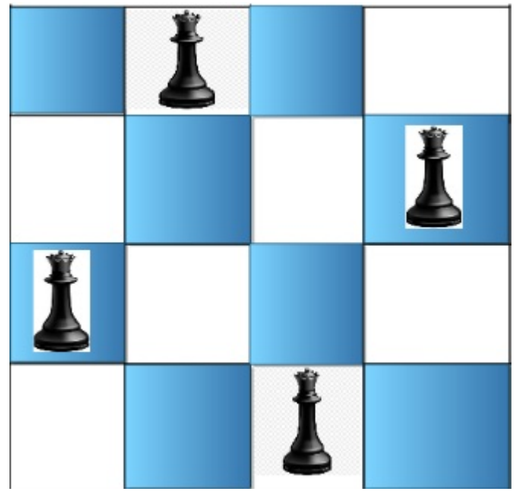



Q
Q
Q
Q
while going back,
remove Q
(BACKTRACKING)
Q
Q
Q
Q
In 3rd column,
we can see
that no Queen
can be placed

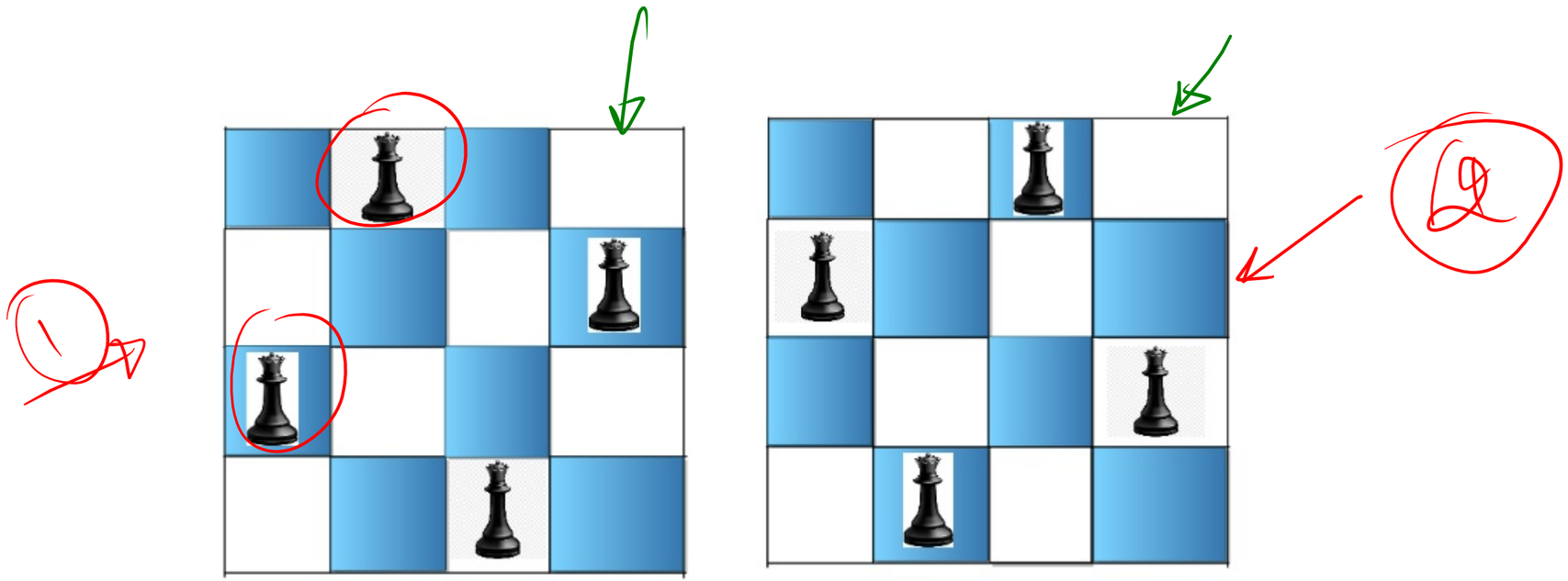

Q
Q
Q
Q
Q
Q
Q
Q
Q
Q
Q
Q
Now we will backtrack
This will be stored as our answer




Q
Q
Q
Q
Q
Q
Q
Q
Q
Q
Q
Q
Now we will backtrack
This will be stored as our answer



4X4 → 4 Queen.



1

2

4X4

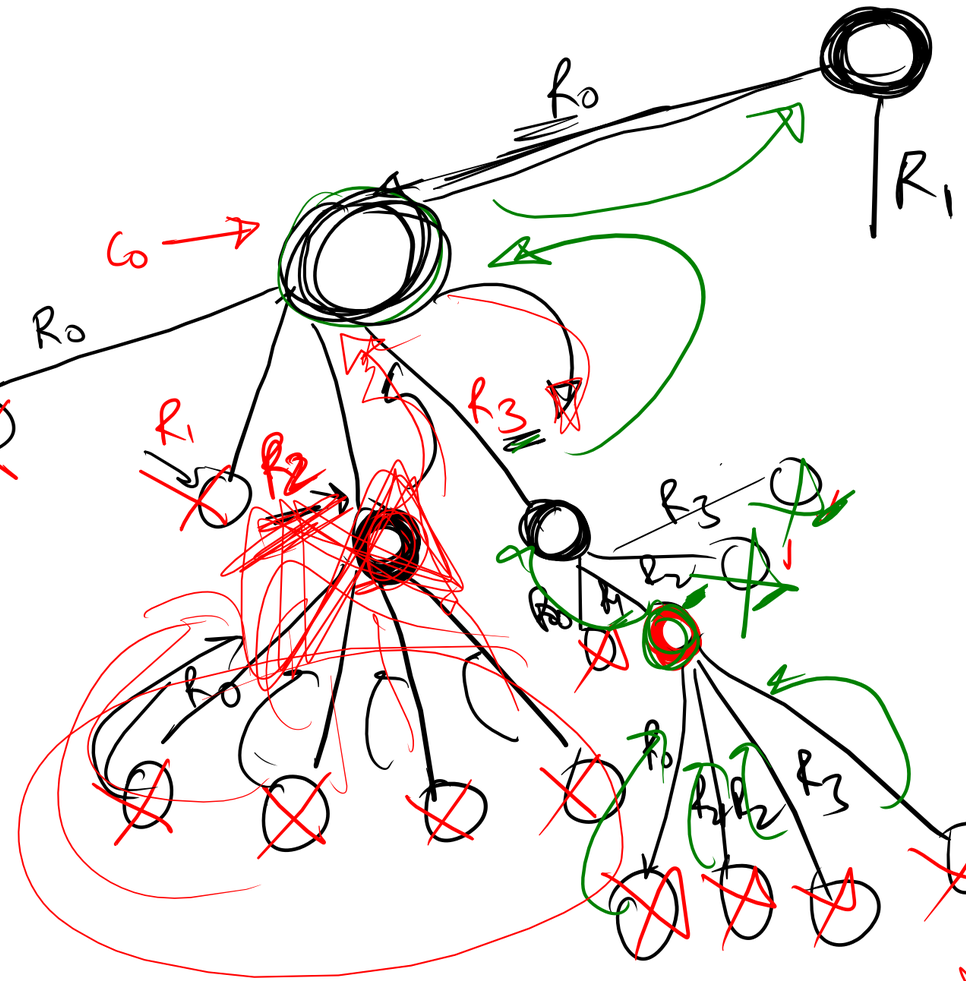
Two arrangements possible for 4 queens

4X2

$R_0\ C_0$

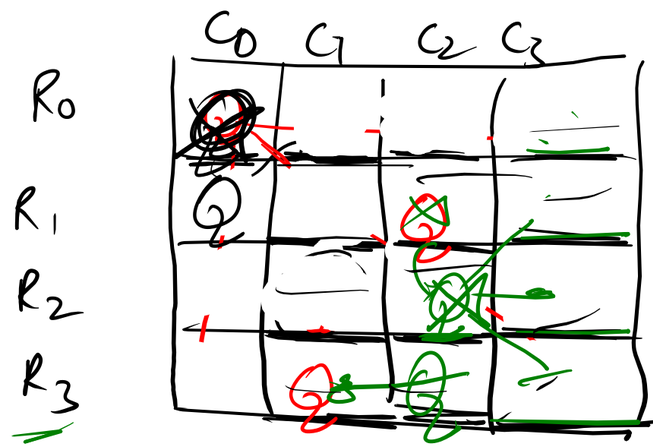
C_0

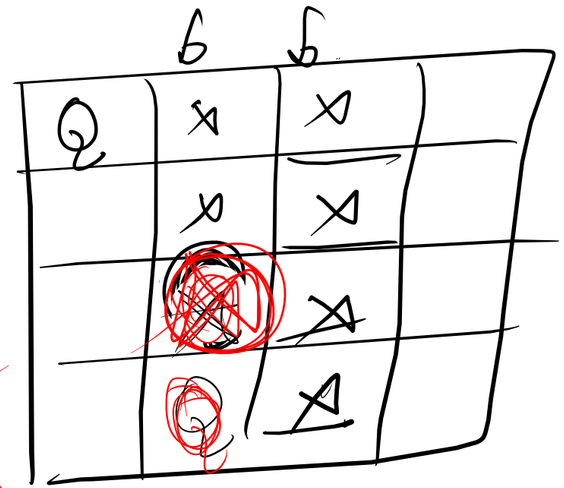
C_1



C_1

4×4 ← 4Q





// boardCopy[row][col] = 'Q'

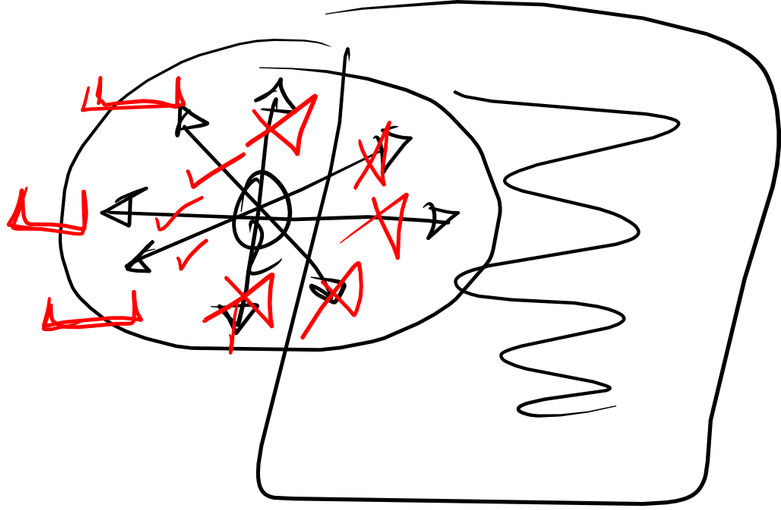
R_2

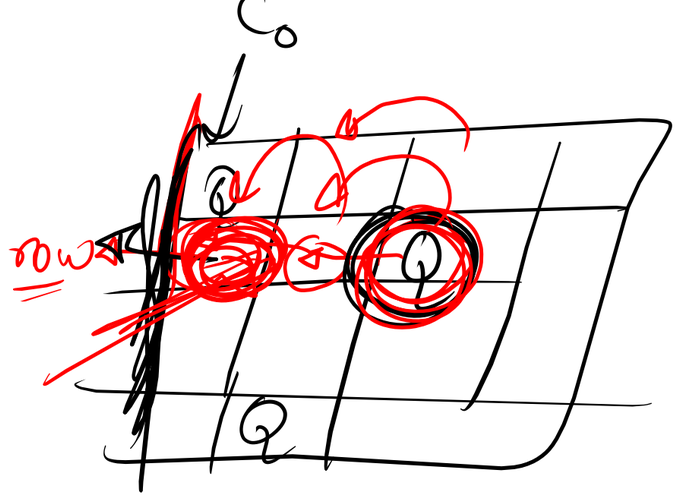
new R_3

* isSafe (board, row, col)

① left side

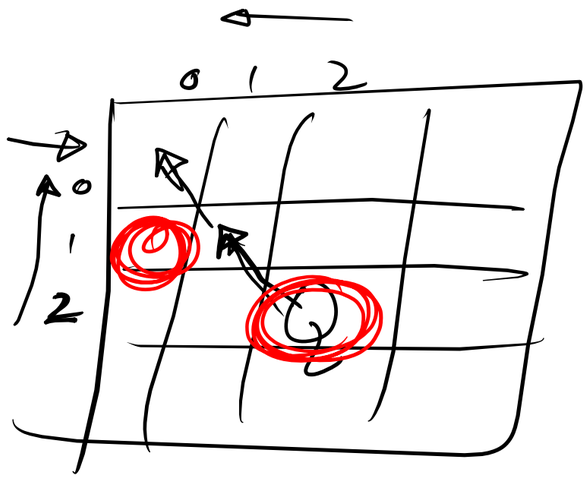
```
while (col >= 0) {
    if (board[row][col] == 'Q') {
        return false;
    }
    col--;
}
return true;
```





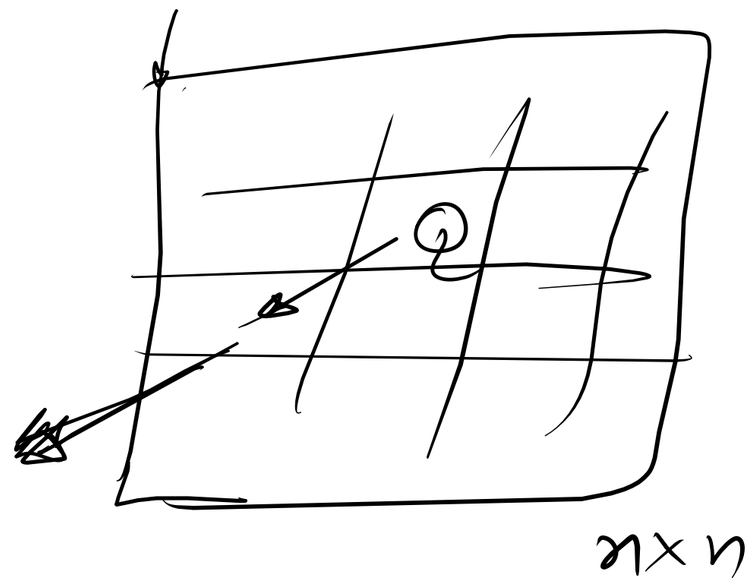
(2) // checking left diagonal

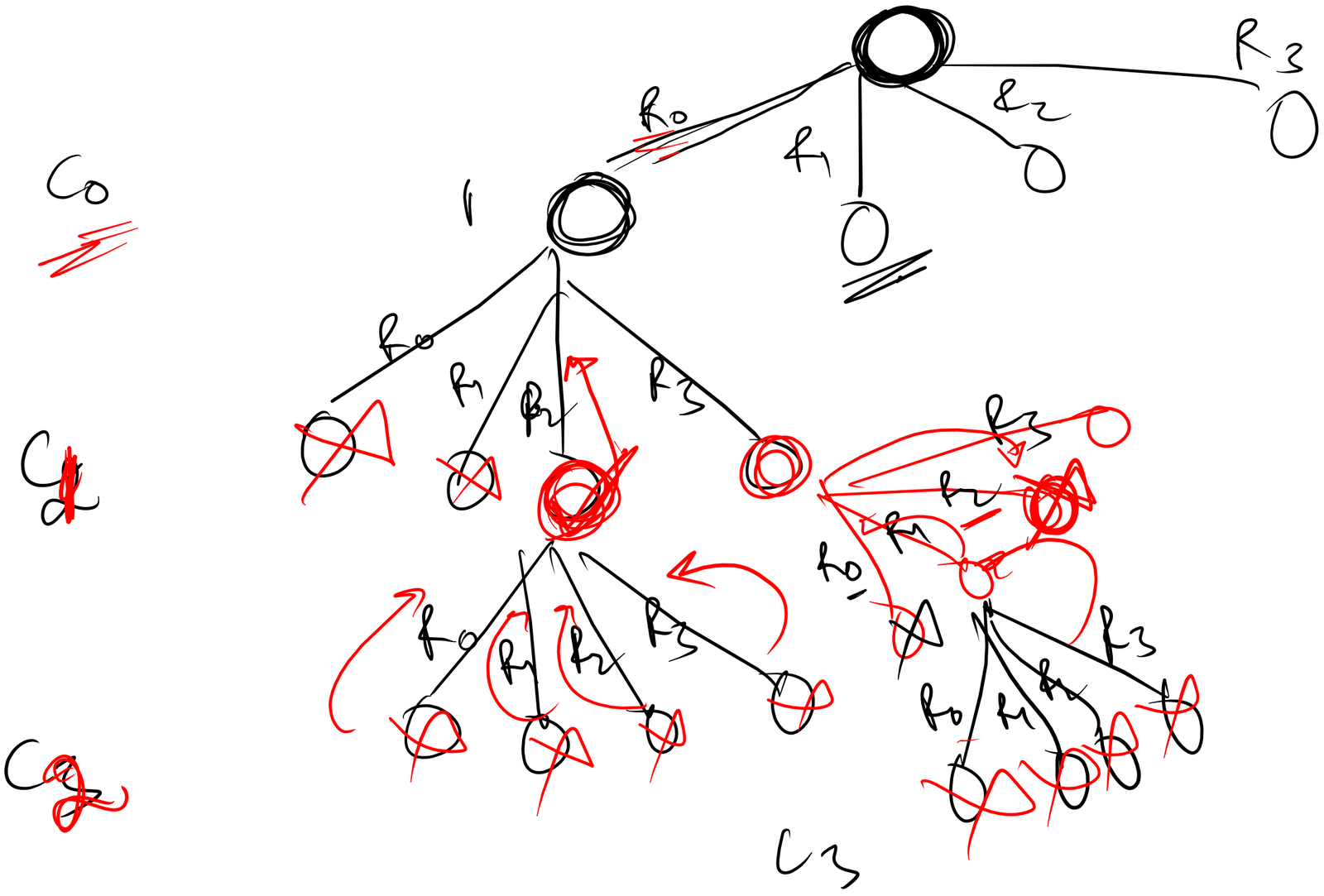
```
while( row >=0 && col >=0){
    if(board[r][c] == 'Q'){
        return false;
    }
    r--;
    col--;
}
return true;
```

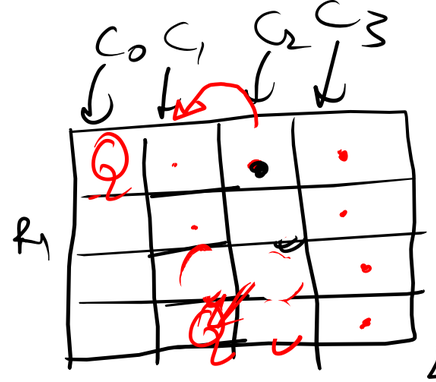


③ // check left bottom diagonal

```
while(row < n && col >= 0) {
    if(b[r][c] == 'Q') return false;
    col--;
    row++;
}
return true;
```







4X4

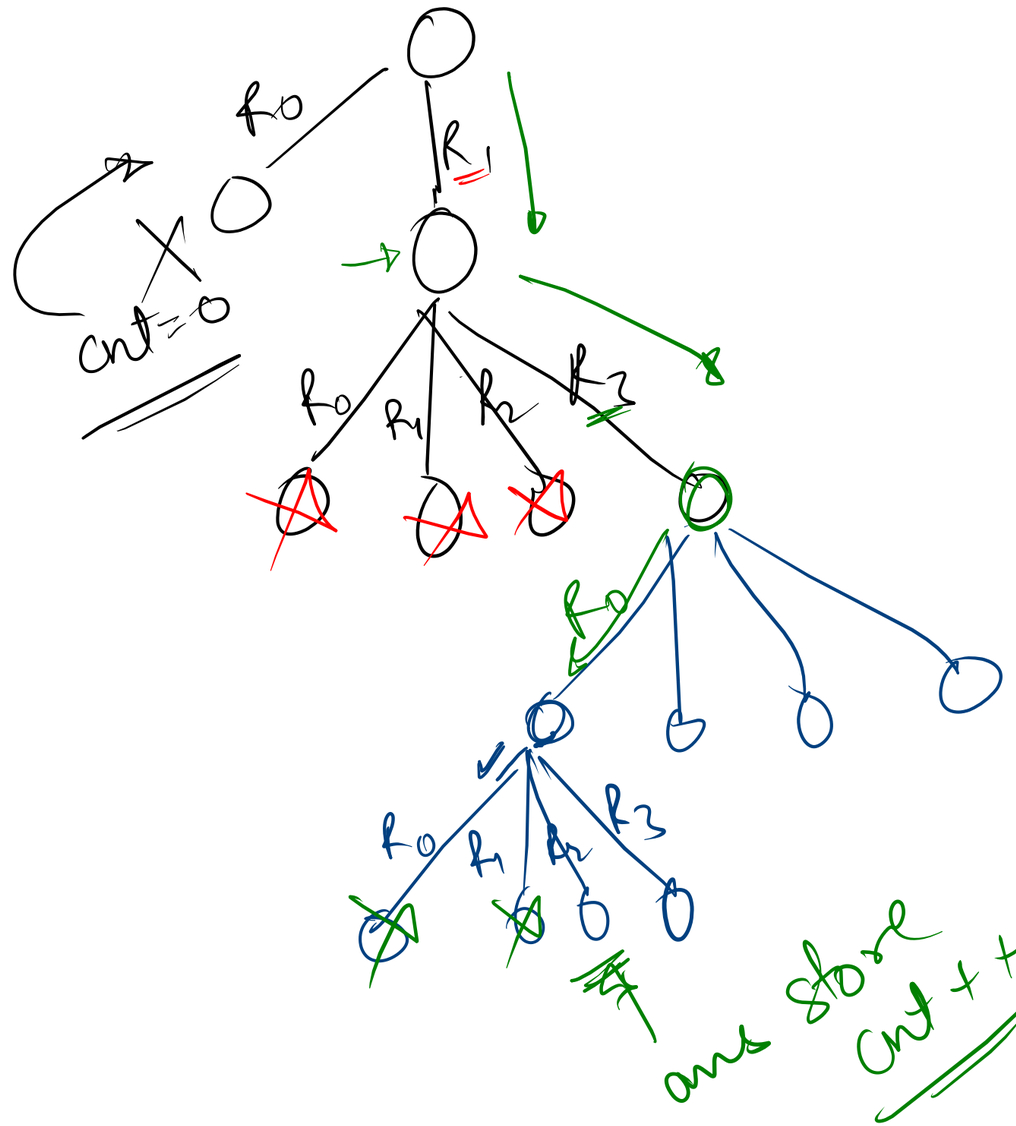
4Q

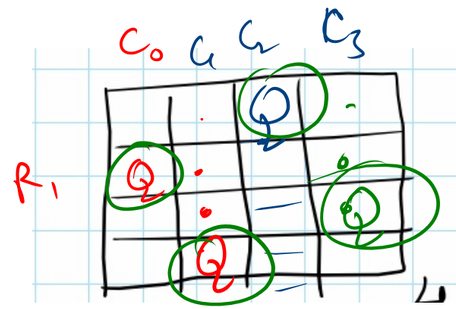
C_0

C_1

C_2

C_3



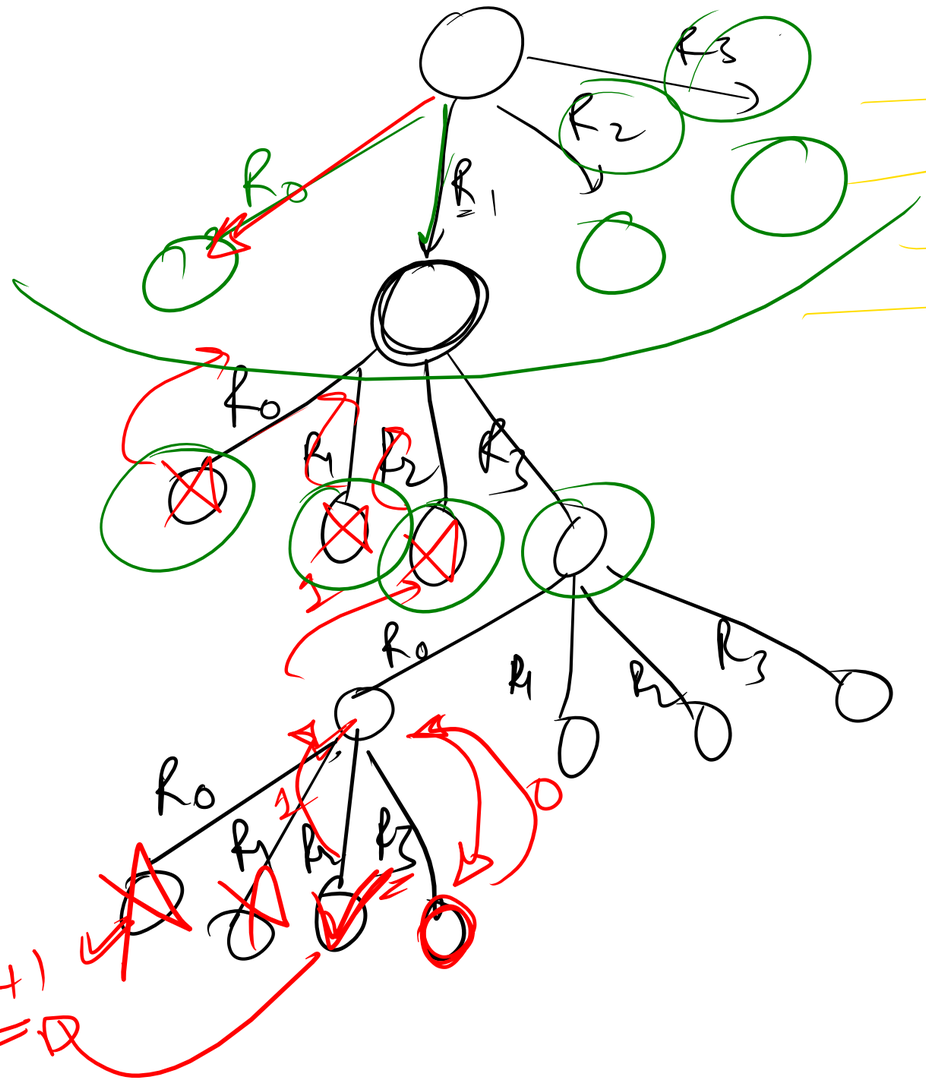


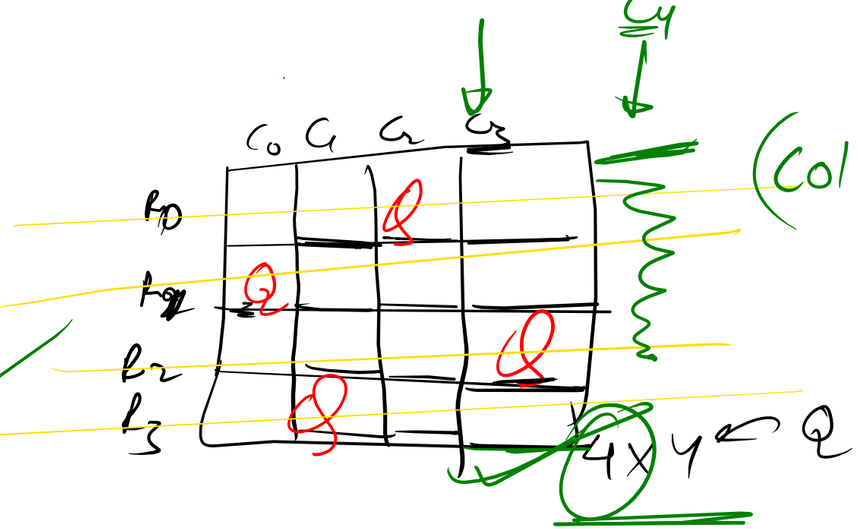
$[(R_1, C_0), (R_3, C_1), (R_0, C_2)(R_2, C_3)]$

C1

C2

C3

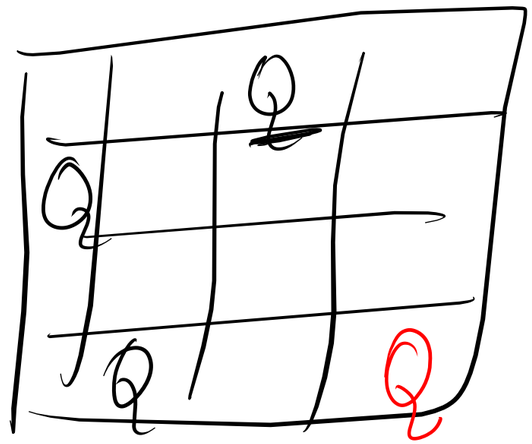




length board

(col == n)

↳ return 1



char[][] board

N Queen

```java
public static int totalNQueens(int n) {
    char [][]board = new char[n][n];
    for(int i = 0 ; i<n ; i++){
        for(int j = 0 ; j<n ; j++){
            board[i][j] = '.';
        }
    }
   return solve(0, board);
}

public static int solve(int col , char[][]board){

   //base case
   if(col == board.length) return 1 ;

   int cnt = 0 ;
   //col = 1 ;
   for(int row = 0 ; row < board.length ; row++){
    if(isSafe(board,row,col)){
      board[row][col] = 'Q';
      cnt += solve(col+1,board);
      board[row][col] ='.';    // backtracking
    }
   }
   return cnt ;
}
```

```java
public static boolean isSafe(char[][]board , int row , int col){

    int duprow = row ;
    int dupcol = col ;

    //left isSafe
    while(col >= 0 ){
        if(board[row][col] == 'Q') return false;
        col--;
    }


    row = duprow ;
    col = dupcol ;
    //upper left diagonal
    while( row >= 0 && col >= 0){
        if(board[row][col] == 'Q') return false;
        row--;
        col--;
    }

    row = duprow ;
    col = dupcol ;

    //bottom left diagonal
    while( row < board.length && col>= 0 ){
        if(board[row][col] == 'Q') return false;
        row++;
        col--;
    }
     return true ;
}
```