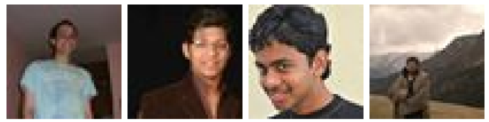
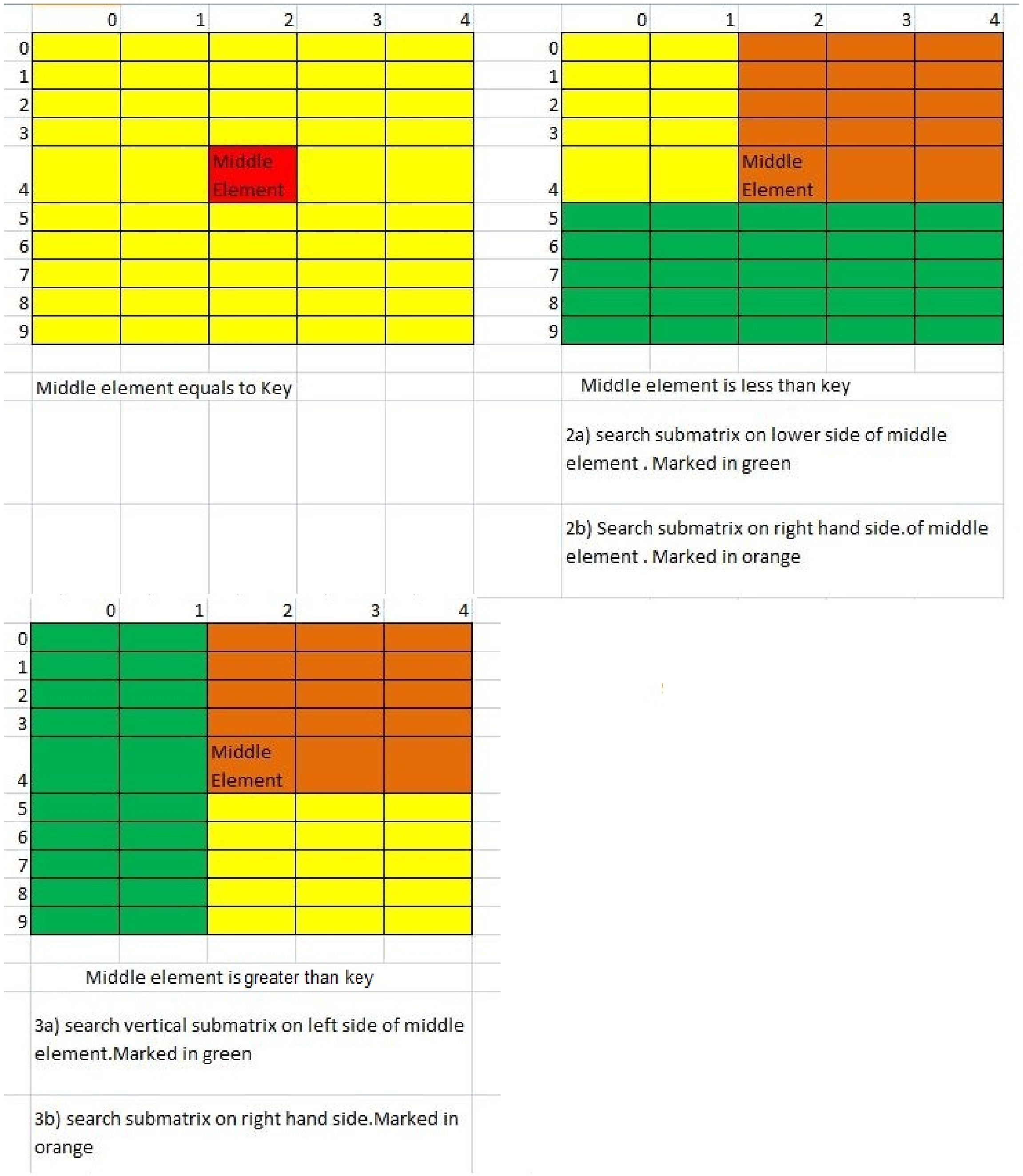
Divide and Conquer | Set 6 (Search in a Row-wise and Column-wise Sorted 2D Array)

Given an n x n matrix, where every row and column is sorted in increasing order. Given a key, how to decide whether this key is in the matrix.

A linear time complexity is discussed in the previous post. This problem can also be a very good example for divide and conquer algorithms. Following is divide and conquer algorithm.

1) Find the middle element.
2) If middle element is same as key return.
3) If middle element is lesser than key then
….3a) search submatrix on lower side of middle element
….3b) Search submatrix on right hand side.of middle element
4) If middle element is greater than key then
….4a) search vertical submatrix on left side of middle element
….4b) search submatrix on right hand side.





Following Java implementation of above algorithm.

```
// Java program for implementation of divide and conquer algorithm
// to find a given key in a row-wise and column-wise sorted 2D array
```

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```
class SearchInMatrix
{
    public static void main(String[] args)
    {
        int[][] mat = new int[][] { {10, 20, 30, 40},
                                    {15, 25, 35, 45},
                                    {27, 29, 37, 48},
                                    {32, 33, 39, 50}};
        int rowcount = 4,colCount=4,key=50;
        for (int i=0; i<rowcount; i++)
          for (int j=0; j<colCount; j++)
             search(mat, 0, rowcount-1, 0, colCount-1, mat[i][j]);
    }

    // A divide and conquer method to search a given key in mat[]
    // in rows from fromRow to toRow and columns from fromCol to
    // toCol
    public static void search(int[][] mat, int fromRow, int toRow,
                              int fromCol, int toCol, int key)
    {
        // Find middle and compare with middle
        int i = fromRow + (toRow-fromRow )/2;
        int j = fromCol + (toCol-fromCol )/2;
        if (mat[i][j] == key) // If key is present at middle
          System.out.println("Found "+ key + " at "+ i +
                             " " + j);
        else
        {
            // right-up quarter of matrix is searched in all cases.
            // Provided it is different from current call
            if (i!=toRow || j!=fromCol)
             search(mat,fromRow,i,j,toCol,key);

            // Special case for iteration with 1*2 matrix
            // mat[i][j] and mat[i][j+1] are only two elements.
            // So just check second element
            if (fromRow == toRow && fromCol + 1 == toCol)
              if (mat[fromRow][toCol] == key)
                System.out.println("Found "+ key+ " at "+
                                   fromRow + " " + toCol);

            // If middle key is lesser then search lower horizontal
            // matrix and right hand side matrix
            if (mat[i][j] < key)
            {
                // search lower horizontal if such matrix exists
                if (i+1<=toRow)
```

Tree traversal without recursion and without stack!
Structure Member Alignment, Padding and Data Packing
Intersection point of two Linked Lists
Lowest Common Ancestor in a BST.
Check if a binary tree is BST or not
Sorted Linked List to Balanced BST

```
                search(mat, i+1, toRow, fromCol, toCol, key);
            }

            // If middle key is greater then search left vertical
            // matrix and right hand side matrix
            else
            {
                // search left vertical if such matrix exists
                if (j-1>=fromCol)
                  search(mat, fromRow, toRow, fromCol, j-1, key);
            }
        }
    }
}
```

Time complexity:
We are given a n*n matrix, the algorithm can be seen as recurring for 3 matrices of size n/2 x n/2. Following is recurrence for time complexity

```
T(n) = 3T(n/2) + O(1)
```

The solution of recurrence is O($n^{1.58}$) using Master Method.
But the actual implementation calls for one submatrix of size n x n/2 or n/2 x n, and other submatrix of size n/2 x n/2.

This article is contributed by **Kaushik Lele**. Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above

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In main function why is it there :

for (int i=0; i<rowcount; i++)="" for="" (int="" j="0;" j<colcount;="" j++)="" searc colcount-1,="" mat[i][j]);="">

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It is for testing purpose. Every element is searched one by one.

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int mat[][4] = {{10, 20, 23, 28},

{15, 25, 35, 45},

{27, 29, 37, 48},

{32, 33, 39, 50}};

int flag = search(mat,0,3,0,3,23);

when i do the above changes to your code the segmentation fault com http://www.compileonline.com/c...

and on ideone its run time error.

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Thanks for pointing that out! I made the changes hoping its errc

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third picture should have the caption (middle element is greater than key)

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Thanks for pointing this out. We have updated the caption.

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ravi • 15 days ago

worst case time complexity of the implementation can be written as

T(m, n) = MAX(T(m/2, n), T(m, n/2)) + T(m/2, n/2)

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ravi ravi • 15 days ago

m is number of rows and n is number of columns in input matrix

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