Batch:T6

Practical No.3

Title of Assignment: Divide and conquer strategy

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Q1) Implement algorithm to Find the maximum element in an array which is first increasing and then decreasing, with Time Complexity *O(Logn)*.

ANS.

Pseudocode:

```
Function findMaximum(arr, n):
   left = 0
   right = n - 1

   While left <= right:
      mid = left + (right - left) // 2

      If mid > 0 and mid < n-1:
         If arr[mid] > arr[mid-1] and arr[mid] > arr[mid+1]:
            Return arr[mid]
         ElseIf arr[mid-1] > arr[mid]:
            right = mid - 1
         Else:
            left = mid + 1
      ElseIf mid == 0:
         Return max(arr[0], arr[1])
      ElseIf mid == n-1:
         Return max(arr[n-1], arr[n-2])

   Return -1
```

CODE:

```cpp
#include <iostream>
using namespace std;

int findMaximum(int arr[], int n) {
    int left = 0, right = n - 1;

    while (left <= right) {
        int mid = left + (right - left) / 2;

        if (mid > 0 && mid < n - 1) {
            if (arr[mid] > arr[mid - 1] && arr[mid] > arr[mid + 1])
{
                return arr[mid];
            } else if (arr[mid - 1] > arr[mid]) {
                right = mid - 1;
            } else {
                left = mid + 1;
            }
        } else if (mid == 0) {
            return max(arr[0], arr[1]);
        } else if (mid == n - 1) {
            return max(arr[n - 1], arr[n - 2]);
        }
    }

    return -1;
}

int main() {
    int n;
    cout << "Enter the number of elements in the array: ";
    cin >> n;

    int arr[n];
    cout << "Enter the elements of the array: ";
    for (int i = 0; i < n; i++) {
        cin >> arr[i];
    }

    int maxElement = findMaximum(arr, n);
```

```
    cout << "The maximum element in the bitonic array is: " <<
maxElement << endl;

    return 0;
}
```

OUTPUT:

```
Enter the number of elements in the array: 5
Enter the elements of the array: 3 5 0 -9 -34
The maximum element in the bitonic array is: 5
PS C:\Users\Parshwa\Desktop\CLG\Sem 5 assign\DAA\22
p -o 1 } ; if ($?) { .\1 }
Enter the number of elements in the array: 4
Enter the elements of the array: 2 344 4 1
The maximum element in the bitonic array is: 344
```

```
Enter the number of elements in the array: 9
Enter the elements of the array: 1 2 3 4 5 6 3 2 1
The maximum element in the bitonic array is: 6
```

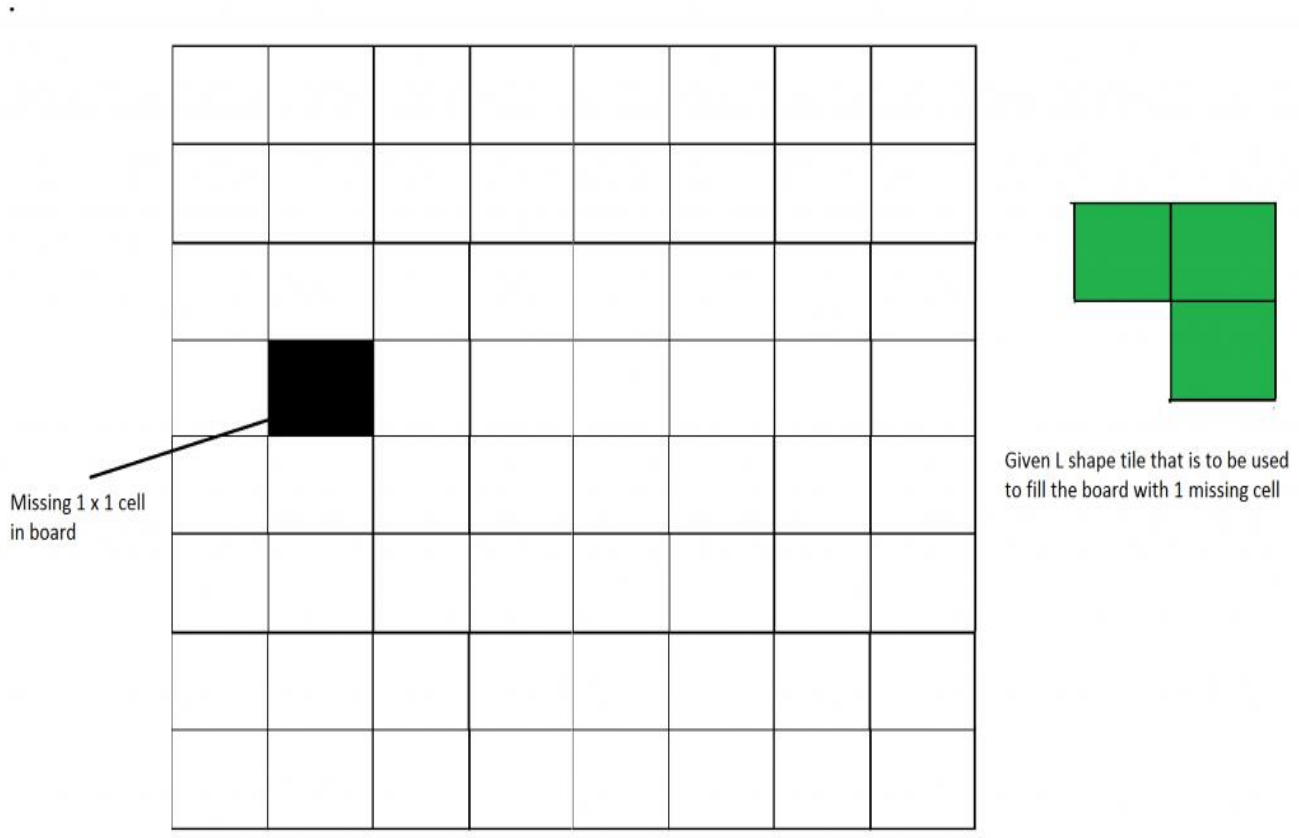
```
Enter the number of elements in the array: 5
Enter the elements of the array: 1 3 5 6 2
The maximum element in the bitonic array is: 6
```

Complexity Analysis:

- **Best Time Complexity:** O(1)
- **Worst Time Complexity:** O(log n)
- **Average Time Complexity:** O(log n)
- **Space Complexity:** O(1)

Q2) Implement algorithm for Tiling problem: Given an *n by n* board where n is of form 2^k where *k >= 1* (Basically n is a power of *2* with minimum value as *2*). The board has one missing cell (of size *1 x 1*). Fill the board using L shaped tiles. An *L* shaped tile is a *2 x 2* square with one cell of size *1×1*

missing



ANS.

Pseudocode:

Function tileBoard(board, topX, topY, missingX, missingY, size):

If size == 2:

Place an L-shaped tile covering the 3 other cells and return

halfSize = size // 2

Find the quadrant of the missing cell

Case 1: Missing cell in the top-left quadrant

Place an L-shaped tile at the center excluding the top-left cell

Recurse on the four quadrants

Case 2: Missing cell in the top-right quadrant

Place an L-shaped tile at the center excluding the top-right cell

Recurse on the four quadrants

Case 3: Missing cell in the bottom-left quadrant

Place an L-shaped tile at the center excluding the bottom-left cell

Recurse on the four quadrants

Case 4: Missing cell in the bottom-right quadrant

Place an L-shaped tile at the center excluding the bottom-right cell

Recurse on the four quadrants

CODE:

```
#include <iostream>
#define N 128

using namespace std;

int board[N][N];
int tile = 1;

void tileBoard(int topX, int topY, int missingX, int missingY, int
size) {
    if (size == 2) {
        for (int i = topX; i < topX + size; i++) {
            for (int j = topY; j < topY + size; j++) {
                if (i != missingX || j != missingY) {
                    board[i][j] = tile;
                }
            }
        }
        tile++;
        return;
    }

    int halfSize = size / 2;

    if (missingX < topX + halfSize && missingY < topY + halfSize) {
        tileBoard(topX, topY, missingX, missingY, halfSize);
    } else {
        board[topX + halfSize - 1][topY + halfSize - 1] = tile;
        tileBoard(topX, topY, topX + halfSize - 1, topY + halfSize -
1, halfSize);
    }

    if (missingX < topX + halfSize && missingY >= topY + halfSize) {
```

```
        tileBoard(topX, topY + halfSize, missingX, missingY,
halfSize);
    } else {
        board[topX + halfSize - 1][topY + halfSize] = tile;
        tileBoard(topX, topY + halfSize, topX + halfSize - 1, topY +
halfSize, halfSize);
    }

    if (missingX >= topX + halfSize && missingY < topY + halfSize) {
        tileBoard(topX + halfSize, topY, missingX, missingY,
halfSize);
    } else {
        board[topX + halfSize][topY + halfSize - 1] = tile;
        tileBoard(topX + halfSize, topY, topX + halfSize, topY +
halfSize - 1, halfSize);
    }

    if (missingX >= topX + halfSize && missingY >= topY + halfSize)
{
        tileBoard(topX + halfSize, topY + halfSize, missingX,
missingY, halfSize);
    } else {
        board[topX + halfSize][topY + halfSize] = tile;
        tileBoard(topX + halfSize, topY + halfSize, topX + halfSize,
topY + halfSize, halfSize);
    }
}

int main() {
    int n, missingX, missingY;
    cout << "Enter the size of the board (2^k): ";
    cin >> n;
    cout << "Enter the coordinates of the missing cell (x y): ";
    cin >> missingX >> missingY;

    tileBoard(0, 0, missingX, missingY, n);

    cout << "Tiled board:" << endl;
    for (int i = 0; i < n; i++) {
        for (int j = 0; j < n; j++) {
            cout << board[i][j] << " ";
```

```
        }
        cout << endl;
    }

    return 0;
}
```

OUTPUT:

```
Enter the size of the board (2^k): 4
Enter the coordinates of the missing cell (x y): 1 0
Tiled board:
1 1 2 2
0 1 2 2
3 3 4 4
3 3 4 4
```

```
Enter the size of the board (2^k): 2
Enter the coordinates of the missing cell (x y): 0 0
Tiled board:
0 1
1 1
```

```
Enter the size of the board (2^k): 16
Enter the coordinates of the missing cell (x y): 9 9
Tiled board:
1 1 2 2 5 5 6 6 17 17 18 18 21 21 22 22
1 1 2 2 5 5 6 6 17 17 18 18 21 21 22 22
3 3 4 4 7 7 8 8 19 19 20 20 23 23 24 24
3 3 4 1 5 7 8 8 19 19 20 17 21 23 24 24
9 9 10 9 13 13 14 14 25 25 26 26 29 29 30 30
9 9 10 10 13 13 14 14 25 25 26 26 29 29 30 30
11 11 12 12 15 15 16 16 27 27 28 28 31 31 32 32
11 11 12 12 15 15 16 1 17 27 28 28 31 31 32 32
33 33 34 34 37 37 38 33 49 49 50 50 53 53 54 54
33 33 34 34 37 37 38 38 49 0 50 50 53 53 54 54
35 35 36 36 39 39 40 40 51 51 52 52 55 55 56 56
35 35 36 33 39 39 40 40 51 51 52 52 53 55 56 56
41 41 42 41 45 45 46 46 57 57 58 57 61 61 62 62
41 41 42 42 45 45 46 46 57 57 58 58 61 61 62 62
43 43 44 44 47 47 48 48 59 59 60 60 63 63 64 64
43 43 44 44 47 47 48 48 59 59 60 60 63 63 64 64
```

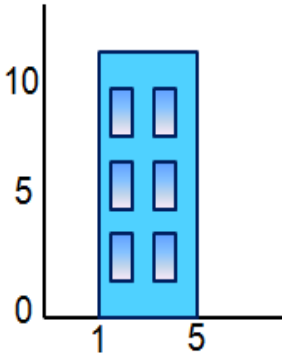
Complexity Analysis:

- **Best Time Complexity:** O(n^2)
- **Worst Time Complexity:** O(n^2)
- **Average Time Complexity:** O(n^2)
- **Space Complexity:** O(n^2) (For storing the board)

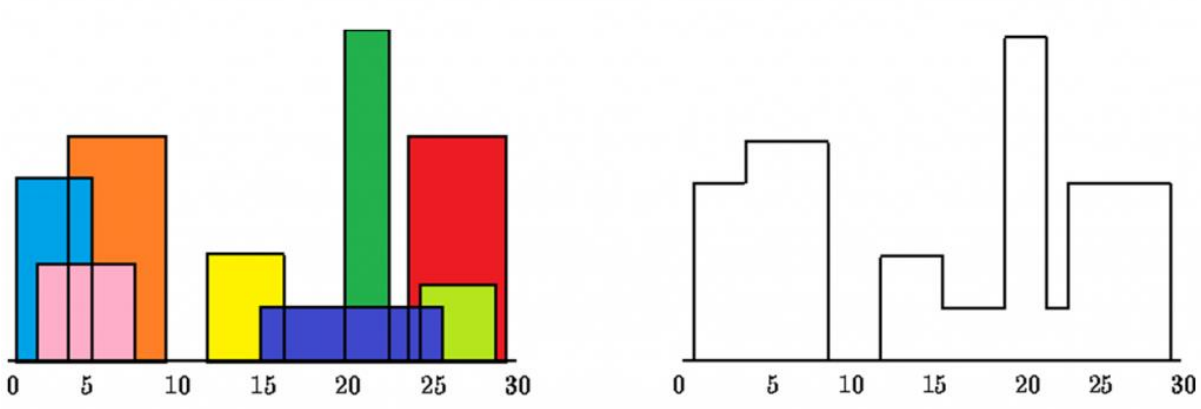
Q3) Implement algorithm for The Skyline Problem: Given n rectangular buildings in a 2-dimensional city, computes the skyline of these buildings, eliminating hidden lines. The main task is to view buildings from a side and remove all sections that are not visible.

All buildings share common bottom and every **building** is represented by triplet (left, ht, right)
'left': is x coordinated of left side (or wall).
'right': is x coordinate of right side
'ht': is height of building.

For example, the building on right side is represented as *(1, 11, 5)*



A **skyline** is a collection of rectangular strips. A rectangular **strip** is represented as a pair (left, ht) where left is x coordinate of left side of strip and ht is height of strip.



With Time Complexity *O(nLogn)*

Pseudocode:

Function mergeSkylines(leftSkyline, rightSkyline):

Initialize newSkyline

Merge the two skylines while maintaining the correct height

Function skyline(buildings, left, right):

If left == right:

Return a skyline with the single building

mid = (left + right) // 2

leftSkyline = skyline(buildings, left, mid)

rightSkyline = skyline(buildings, mid + 1, right)

Return mergeSkylines(leftSkyline, rightSkyline)

CODE:

```
#include <iostream>
#include <vector>
#include <algorithm>
using namespace std;

typedef pair<int, int> Point;

vector<Point> mergeSkylines(vector<Point>& leftSkyline,
vector<Point>& rightSkyline) {
    vector<Point> mergedSkyline;
    int h1 = 0, h2 = 0, currentHeight = 0;
    int i = 0, j = 0;

    while (i < leftSkyline.size() && j < rightSkyline.size()) {
        int x1 = leftSkyline[i].first;
        int x2 = rightSkyline[j].first;
        int x;

        if (x1 < x2) {
            x = x1;
            h1 = leftSkyline[i].second;
            i++;
        } else if (x1 > x2) {
            x = x2;
            h2 = rightSkyline[j].second;
            j++;
```

```
        } else {
            x = x1;
            h1 = leftSkyline[i].second;
            h2 = rightSkyline[j].second;
            i++;
            j++;
        }

        int maxHeight = max(h1, h2);
        if (currentHeight != maxHeight) {
            mergedSkyline.push_back({x, maxHeight});
            currentHeight = maxHeight;
        }
    }

    while (i < leftSkyline.size()) {
        mergedSkyline.push_back(leftSkyline[i++]);
    }

    while (j < rightSkyline.size()) {
        mergedSkyline.push_back(rightSkyline[j++]);
    }

    return mergedSkyline;
}

vector<Point> skyline(vector<vector<int>>& buildings, int left, int
right) {
    if (left == right) {
        return {{buildings[left][0], buildings[left][1]},
{buildings[left][2], 0}};
    }

    int mid = (left + right) / 2;
    vector<Point> leftSkyline = skyline(buildings, left, mid);
    vector<Point> rightSkyline = skyline(buildings, mid + 1, right);

    return mergeSkylines(leftSkyline, rightSkyline);
}

int main() {
```

```
    int n;
    cout << "Enter the number of buildings: ";
    cin >> n;

    vector<vector<int>> buildings(n, vector<int>(3));
    cout << "Enter the buildings in format (left ht right): " <<
endl;
    for (int i = 0; i < n; i++) {
        cin >> buildings[i][0] >> buildings[i][1] >>
buildings[i][2];
    }

    vector<Point> result = skyline(buildings, 0, n - 1);

    cout << "The skyline is: ";
    for (auto p : result) {
        cout << "(" << p.first << ", " << p.second << ") ";
    }
    cout << endl;

    return 0;
}
```

OUTPUT:

```
Enter the number of buildings: 4
Enter the buildings in format (left ht right):
1 11 5
4 10 7
3 17 4
2 20 7
The skyline is: (1, 11) (2, 20) (7, 0)
```

```
Enter the number of buildings: 2
Enter the buildings in format (left ht right):
1 30 5
2 40 6
The skyline is: (1, 30) (2, 40) (6, 0)
```

```
Enter the number of buildings: 4
Enter the buildings in format (left ht right):
0 20 5
2 45 7
1 34 5
3 64 9
The skyline is: (0, 20) (1, 34) (2, 45) (3, 64) (9, 0)
```

Complexity Analysis:

- Best Time Complexity: O(n log n)
- Worst Time Complexity: O(n log n)
- Average Time Complexity: O(n log n)
- Space Complexity: O(n)