2500. Delete Greatest Value in Each Row

the end of each row, and this enables quick removal and processing.

Matrix Simulation) Heap (Priority Queue) Sorting Easy

Problem Description

columns), filled with positive integers. The primary objective is to continually perform a specific operation on the grid until it becomes empty. The operations can be detailed as follows: • Firstly, we delete the elements with the greatest value from each row. This operation may remove more than one element per row if multiple

In this problem, we are working with a matrix grid with dimensions m \times n (where m is the number of rows and n is the number of

- elements share the greatest value. • Secondly, we identify the maximum of the values deleted in this round and add it to the answer. This step essentially means that after each round of deletions, only the single highest value from among all the rows is added to the running total.
- It is crucial to note that eliminating elements results in the grid having one less column after each operation. Consequently, with

each iteration, the grid's dimensions change, shrinking in the column direction. The task is to return the cumulative total of the maximum values added after each operation has been completed and the grid is empty.

To arrive at a solution for this problem, we should recognize that we are not required to modify the original grid structure. Instead, we need to repeatedly find and sum the largest elements removed based on the current iteration.

Intuition

As we are required to sum the maximum elements of each row, and then take the maximum of these per operation, the key insight is that sorting each row will facilitate easy access to the maximum values. By sorting, we always have the largest value at

To sum the largest elements removed from each row, we utilize Python's zip function combined with an unpacking operator *, which effectively transposes the sorted grid. Transposing the grid after sorting allows us to use the intuitive max function on the columns, which now represent the original rows' maximum elements.

This leads to a concise and efficient process: 1. Sort each row of grid so that the element with the greatest value is at the end of each row (making it easy to identify).

- The final sum is the answer we return. This solution avoids manipulating the matrix extensively. Instead, it leverages Python's
- built-in functions for sorting, transposing, and finding the max to perform the necessary computations efficiently.

2. Transpose the grid, turning rows into columns, effectively grouping the elements to be deleted together.

Solution Approach

3. Sum the maximum elements across what are now the columns, which correspond to the greatest elements of the original rows.

The implementation of the solution follows a straightforward approach that heavily utilizes built-in Python functions to handle the primary operations. Here is a step by step walk-through of the algorithm: **Sorting Rows**: The initial step involves sorting each row in the grid. This is important because, according to the problem

the end of the row, which makes identifying these elements straightforward.

row.sort()

Algorithmically, the sort() method in Python rearranges the elements in each list (which corresponds to a row in the grid) in ascending order in-place, meaning no additional data structures are necessary for this step. for row in grid:

Transposing the Matrix: After sorting, the solution transposes the grid using the zip(*grid) function. In effect, this creates

the grid rows are sorted, the last elements (which are now at the first position in each tuple) are the largest elements from

an iterator of tuples where each tuple contains elements from the rows of the grid that are in the same column position. Since

description, we need to delete the greatest value from each row. Sorting each row guarantees that the largest element is at

each row. Transposing is a pattern that allows us to treat each tuple as a representation of a column, making it easy to find the maximum element across these columns. By following this pattern, we avoid having to manually loop through each row to find and delete the maximum element, which can be computationally expensive.

Summing the Maximum Elements: The final step involves summing the maximum elements of the previously transposed

expression within the sum function. The max function is called on each column, and the return values, which are the largest

'columns' (which, in reality, are representing the maximum elements from each row). This is done using a generator

It's important to note that this approach doesn't change the original grid size since we don't need to keep track of the number of columns decreased after each operation. The zip() function naturally ends when the shortest row (or column after transposition) is exhausted, which aligns with the original grid shrinking in dimensions as the problem statement suggests. The algorithm makes a single pass through each row to sort it and a single pass to sum the maxima, resulting in a time complexity

that is efficient given the constraints of the problem. The spatial complexity is also minimal as no additional data structures are

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required; the sorting and transposition operations are performed in-place (except for the space utilized by zip, which is negligible
as it returns an iterator).
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Step-by-step, we would perform the following actions:

return sum(max(col) for col in zip(*grid))

elements from each original row, are summed up to form the answer.

By carefully using these built-in functions and patterns, we obtain an elegant solution that requires only a few lines of code but still adheres to the requirements of the problem and achieves optimal performance. **Example Walkthrough**

grid = [[3, 1, 2],

[1, 2, 3], [4, 5, 6],

[7, 8, 9]

for row in grid:

(2, 5, 8),

 $\max(1, 4, 7) = 7$

 $\max(2, 5, 8) = 8$

 $\max(3, 6, 9) = 9$

Solution Implementation

Python

class Solution:

row.sort()

```
Transposing the Matrix: After sorting, we transpose the grid to work with the maximum elements more conveniently. The
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transposed grid (zip(*grid)) turns our rows into tuples that act like columns:

This is achieved using the sort() function in Python on all the rows:

Let's take a small example to illustrate the solution approach with a grid that looks as follows:

Sorting Rows: We start by sorting each row of our grid. After sorting, the grid becomes:

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Summing the Maximum Elements: We find the maximum value in each of these tuples (which are our transposed 'columns')
and sum them together. These maximum values are 3, 6, and 9 from the 'columns':
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In Python, this can be done with the following code:

def deleteGreatestValue(self, grid: List[List[int]]) -> int:

Sort each row within the grid to have elements in ascending order

Find the maximum element in each column and calculate their sum

sum_of_max_values = sum(max(column) for column in transposed_grid)

// Method to delete the greatest value in each column of a 2D grid and return

int columnMax = 0; // Store the maximum value of the current column

// Step 3: Iterate through each row for the current column

for (int rowIndex = 0; rowIndex < grid.length; rowIndex++) {</pre>

which after transposing, makes them the end of each column

Return the sum of the greatest values in each column

// Step 1: Sort each row of the grid in ascending order

// Sort each row of the grid in non-decreasing order.

int sumOfMaxValues = 0; // Initialize the sum of max values to 0

int maxInColumn = 0; // Variable to hold the max value in current column

// Iterate through each row of the grid to find the greatest value in the current column.

for (auto& row : grid) {

sort(row.begin(), row.end());

// Iterate through each column of the grid.

for (int j = 0; j < grid[0].size(); ++j) {</pre>

for (int i = 0; i < grid.size(); ++i) {</pre>

// Update maximum value in the column.

// Return the total sum of greatest values from all columns

def deleteGreatestValue(self, grid: List[List[int]]) -> int:

Sort each row within the grid to have elements in ascending order

Transpose the grid to iterate over columns instead of rows

which after transposing, makes them the end of each column

Return the sum of the greatest values in each column

Find the maximum element in each column and calculate their sum

sum_of_max_values = sum(max(column) for column in transposed_grid)

return answer;

for row in grid:

row.sort()

transposed_grid = zip(*grid)

return sum_of_max_values

1. Sorting each row in the grid list.

class Solution:

maxInColumn = max(maxInColumn, grid[i][j]);

This works because after sorting, the maximum elements are at the end of each row,

return sum(max(col) for col in zip(*grid))

respective rows but are now grouped together after transposition.

operations dictated by the problem.

And that's our expected result, a total of 24. This walkthrough demonstrates the usage of sorting rows, transposing the matrix,

and summing the maximum elements, thus achieving the goal of efficiently computing the cumulative total after performing the

The sum of these max values gives us the total: 7 + 8 + 9 = 24. This is the final answer to our problem.

Each tuple contains elements that were previously in the same column. For example, 1, 4, 7 were the first elements of their

for row in grid: row.sort() # Transpose the grid to iterate over columns instead of rows transposed_grid = zip(*grid)

return sum_of_max_values

for (int[] row : grid) {

Arrays.sort(row);

// the sum of all the maximum values removed.

public int deleteGreatestValue(int[][] grid) {

```
int sumOfMaxValues = 0; // This will store the sum of the maximum values removed
// Step 2: Iterate through each column to find the maximum value in that column
for (int colIndex = 0; colIndex < grid[0].length; colIndex++) {</pre>
```

Java

public class Solution {

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// Update columnMax if the current element is greater than columnMax
                columnMax = Math.max(columnMax, grid[rowIndex][colIndex]);
           // Step 4: Add the largest value of the current column to the sumOfMaxValues
            sumOfMaxValues += columnMax;
       // Step 5: Return the sum of all the maximum values removed from the grid
       return sumOfMaxValues;
C++
#include <vector> // Include necessary header for the vector
#include <algorithm> // Include for the std::sort and std::max functions
class Solution {
public:
   // Function to delete the greatest value from each column of a grid
   // and return the sum of those greatest values.
   int deleteGreatestValue(vector<vector<int>>& grid) {
```

```
// Add the greatest value from the current column to the sum.
            sumOfMaxValues += maxInColumn;
        // Return the sum of the greatest values from all columns.
        return sumOfMaxValues;
};
TypeScript
function deleteGreatestValue(grid: number[][]): number {
   // Sort each row of the grid in non-decreasing order
    for (const row of grid) {
        row.sort((a, b) => a - b);
    // Initialize the answer variable to accumulate the greatest values
    let answer = 0;
    // Iterate over each column of the grid
    for (let columnIndex = 0; columnIndex < grid[0].length; ++columnIndex) {</pre>
        // Initialize a variable to keep track of the greatest value in the current column
        let greatestValueInColumn = 0;
       // Iterate over each row to find the greatest value in the current column
        for (let rowIndex = 0; rowIndex < grid.length; ++rowIndex) {</pre>
            greatestValueInColumn = Math.max(greatestValueInColumn, grid[rowIndex][columnIndex]);
       // Accumulate the greatest values of each column
        answer += greatestValueInColumn;
```

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Time and Space Complexity
Time Complexity
  The time complexity of the given code consists of two parts:
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This works because after sorting, the maximum elements are at the end of each row,

The grid size is defined by $m \times n$, where m is the number of rows and n is the number of columns.

For the first part, we sort each row individually. The sort operation on a row of length n has a time complexity of O(n log n). Since there are m such rows, this part of the process has a total time complexity of $0(m * n \log n)$.

2. Finding the maximum value of each column after the rows have been sorted.

sorted rows together. This operation is 0(m) for each column since it involves iterating through every row for the given column to find the max. There are n columns, so the total time complexity for this part is 0(n * m).

Therefore, the total time complexity of the entire code is $0(m * n \log n + n * m)$. Since $m * n \log n$ would likely dominate for

larger values of n, we might consider this the more significant term, and the overall time complexity can be approximated by 0(m

For the second part, after sorting, we find the maximum element in each column using a generator expression that zips the

* n log n). **Space Complexity** For space complexity, we need to consider the additional space used by the algorithm excluding the input itself:

Thus, the additional space is O(n), needed for the in-place sorting of one row at a time, which is the most significant additional

space used by the algorithm.

Sorting is done in-place in the provided grid list, not requiring additional space that depends on the size of the input. However, Python's sort method under the hood may use O(n) space for each row due to the Timsort algorithm it implements. The generator expression used to calculate the sum of maximum values in each column does not require significant additional space; it will take 0(1) space as it evaluates each value on-the-fly and does not store the entire column.

Considering the constraints above, the overall space complexity of the algorithm is O(n).