2562. Find the Array Concatenation Value

Easy Array Two Pointers Simulation

Leetcode Link

Problem Description

This LeetCode problem involves manipulating an array of integers to calculate what is referred to as a "concatenation value". Here's what you need to know:

- You have an array of integers called `nums`, with each element having a 0-based index.
- The term "concatenation" of two numbers here refers to creating a new number by joining the digit sequences of both numbers end to end.
  - For example, concatenating `15` and `49` yields `1549`.
- Initially, the concatenation value is `0`.
- To find the final concatenation value, you go through the following steps:
  1. If `nums` contains more than one number, take the first and last elements.
  2. Concatenate those two elements and add their concatenation's numerical value to the concatenation value of `nums`.
  3. Remove the first and last elements from `nums`.
  4. If only one number exists in `nums`, add its value to the concatenation value and remove it.
- This process repeats until `nums` is empty.
- Your goal is to return the final concatenation value after all elements are combined and removed according to the steps above.

Intuition

To approach the solution to this problem, you start by understanding that you'll be reducing the array from both ends until there are no more elements left to process.

Here's how you arrive at the solution step-by-step:

- Recognize that array elements should be considered from both ends.
- At each step where there are at least two elements, you consider the first and last element for the operation.
  - You convert each number to a string, concatenate those strings, then convert the resulting string back to an integer.
  - Add this integer to the running total of the concatenation value.
- If there's only one element left in the process, simply add its value to the total.
- This process is repeated, updating two pointers (`i` and `j`) that represent the current first and last elements in the array.
- When the pointers meet or cross, you've processed all elements.
- The final concatenation value can be returned after considering all elements in the required manner.

Solution Approach

The implementation of the solution uses a straightforward simulation algorithm with two pointers. Let's go through the specifics:

- We start by initializing an accumulator for the answer, `ans`, to start summing up the concatenation values.
- Two pointers, `i` and `j`, are used to traverse the `nums` array from both ends toward the center.
  - `i` is initialized to `0` as the start of the array.
  - `j` is initialized to the last index of the array, which is `len(nums) - 1`.
- We enter a `while` loop that continues as long as `i < j` indicating there are at least two elements in the current subrange.
  - Inside the loop, we concatenate the numerical strings of `nums[i]` and `nums[j]`, by doing `str(nums[i]) + str(nums[j])`, and then convert this string back to an integer using `int()`.
  - The resultant integer is added to the `ans` accumulator.
- After concatenating and adding to `ans`, we advance `i` forward by one (`i += 1`) and move `j` backward by one (`j -= 1`) to move towards the center of the array.
- If we exit the loop and find that `i == j`, it means there is one remaining element in the array which wasn't processed by the `while` loop because it has no pair element.
  - In that case, we simply add the value of this last remaining element (`nums[i]`) to `ans`.
- The solution approach is completed by returning the `ans` variable which contains the final concatenation value after the simulation.

This problem does not require any complex data structures or algorithms, as it simply utilizes basic array manipulation and integer operations. The core pattern here is the two-pointer technique that allows us to efficiently process elements from both ends of the array.

Example Walkthrough

Let's consider a small example to illustrate the solution approach with the `nums` array `nums = [5,6,2,8]`.

1. Initialize `ans = 0` to keep track of the concatenation value.
2. Initialize two pointers: `i = 0` for the start of the array and `j = len(nums) - 1 = 3` for the end of the array.

Now we start the while loop:

3. First iteration:
   - Since `i < j`, concatenate the first and last elements: `nums[i]` is `5` and `nums[j]` is `8`.
   - Their concatenation as strings is `'5' + '8'` which is `'58'`. Convert this back to an integer to get `58`.
   - Add this to `ans`: `ans = ans + 58`, which makes `ans = 58`.
   - Now, increment `i` so `i = 1` and decrement `j` so `j = 2`.
4. Second iteration:
   - The condition `i < j` still holds true.
   - Concatenate `nums[i]` which is `6` and `nums[j]` which is `2` to get `'62'`.
   - As an integer, it is `62`. Update `ans = 58 + 62`, making `ans = 120`.
   - Move `i` to `i = 2` and `j` to `j = 1`.
5. Now, `i >= j`, and the while loop condition is not met. However, we don't have an element that's unpaired. If there were an unpaired element, we would add its value directly to `ans`.
6. Since all elements have been processed, the final concatenation value is the current value of `ans`, which is `120`. We return `ans`.

Therefore, the final concatenation value for the input array `[5,6,2,8]` using the solution approach provided would be `120`.

Python Solution

```python
from typing import List

class Solution:
    def findTheArrayConcVal(self, nums: List[int]) -> int:
        # Initialize the answer to 0
        answer = 0

        # Set pointers for the start and end of the array
        left, right = 0, len(nums) - 1

        # Loop until the pointers meet or cross
        while left < right:
            # Concatenate the numbers at the pointers, convert to int and add to the answer
            answer += int(str(nums[left]) + str(nums[right]))

            # Move the pointers towards the center
            left, right = left + 1, right - 1

        # If there is a middle element (odd number of elements), add it to the answer
        if left == right:
            answer += nums[left]

        # Return the final answer
        return answer

```

Java Solution

```java
class Solution {

    /**
     * Calculates the "array conc val" by concatenating pairs of elements
     * from the beginning and end of the array moving towards the center.
     * If there's a middle element (odd number of elements), it adds it as is.
     *
     * @param nums An array of integers.
     * @return The calculated "array conc val".
     */
    public long findTheArrayConcVal(int[] nums) {
        long result = 0; // Initialize the result variable.

        int leftIndex = 0; // Start at the beginning of the array.
        int rightIndex = nums.length - 1; // Start at the end of the array.

        // Loop through the array from both ends until indices meet or cross.
        while (leftIndex < rightIndex) {
            // Concatenate the elements at current indices as strings,
            // convert the result to integer, and add it to the result.
            result += Long.parseLong(nums[leftIndex] + "" + nums[rightIndex]);

            // Move the left index forward and the right index backward.
            leftIndex++;
            rightIndex--;
        }

        // Check if there's a middle element left (in case of odd number of elements).
        if (leftIndex == rightIndex) {
            // Add the middle element directly to the result.
            result += nums[leftIndex];
        }

        return result; // Return the computed "array conc val".
    }
}

```

C++ Solution

```cpp
class Solution {
public:
    // Function to find the array concatenated value
    long long findTheArrayConcVal(vector<int>& nums) {
        long long concatenatedSum = 0; // Initialize sum of concatenated values
        int left = 0; // Starting index from the beginning of the array
        int right = nums.size() - 1; // Starting index from the end of the array

        // Loop through the array from both ends until the pointers meet or cross
        while (left < right) {
            // Concatenate the values at the current indices, convert to number, and add to sum
            concatenatedSum += stoll(to_string(nums[left]) + to_string(nums[right]));

            // Move the left pointer forward and the right pointer backward
            ++left;
            --right;
        }

        // If there is a middle element (odd number of elements), add it to the sum
        if (left == right) {
            concatenatedSum += nums[left];
        }

        // Return the final concatenated sum
        return concatenatedSum;
    }
};

```

Typescript Solution

```typescript
// This function finds a value based on the concatenation of array elements.
// Pairs the first and last elements moving inwards and adds their concatenation.
// If there is an unpaired middle element, it is added directly to the result.
function findTheArrayConcVal(nums: number[]): number {
    // Get the length of the array
    const arrayLength = nums.length;
    // Initialize the answer to zero
    let answer = 0;
    // Initialize the front index
    let frontIndex = 0;
    // Initialize the back index
    let backIndex = arrayLength - 1;

    // Loop until frontIndex is less than backIndex
    while (frontIndex < backIndex) {
        // Concatenate the elements by converting them to strings, adding them, and then converting back to a number
        answer += Number(`${nums[frontIndex]}${nums[backIndex]}`);
        // Increment the front index
        frontIndex++;
        // Decrement the back index
        backIndex--;
    }

    // If there is a middle element, add it to the answer
    if (frontIndex === backIndex) {
        answer += nums[frontIndex];
    }

    // Return the calculated answer
    return answer;
}

```

Time and Space Complexity

The provided Python code calculates a special value based on the input `nums` list. Let's analyze the time and space complexity of this code.

Time Complexity

The time complexity of the algorithm is determined by the while loop, which runs as long as `i < j`. Since the indices `i` and `j` move towards each other with each iteration, the loop executes approximately `n/2` times, where `n` is the total number of elements in `nums`. Inside this loop, the algorithm concatenates the string representations of numbers at indices `i` and `j`, which takes $O(\log M)$ time, where `M` is the maximum value in the array (since the number of digits of a number `x` is proportional to $\log x$).

Thus, the time complexity is $O(n/2 \times \log M)$, which simplifies to $O(n \times \log M)$.

Space Complexity

The space complexity of the algorithm is determined by the extra space needed to store the intermediate string representations created during the concatenation operation. The longest possible string is the concatenation of the two largest numbers in `nums`. Thus, the space complexity is proportional to the length of this string, which is $O(2 \times \log M)$. This simplifies to $O(\log M)$ since constant factors are dropped in Big O notation.