2423. Remove Letter To Equalize Frequency

`Easy` `Hash Table` `String` `Counting`

Problem Description

In this problem, we are dealing with a string `word` that is made up of lowercase English letters. The objective is to find if it's possible to remove one letter from this string such that the remaining letters all have the same frequency. In other words, after removing one letter, each of the remaining letters should appear the same number of times in the adjusted string.

For example, consider the string "aabbcc". If we remove one 'c', we will have "aabb" left, where 'a' and 'b' each appear twice, meeting the condition for equal frequency.

Important points to note from the problem:

- The given string uses a 0-based index, meaning the first character has an index of 0.
- We are required to remove exactly one letter, and doing nothing is not an option.
- We need to check the frequencies of the letters present after the removal and are only concerned with those letters that would still exist in the string.

Intuition

To solve this problem, the intuition is to iterate through each letter in the word, simulate the removal of that letter, and check the frequencies of the remaining letters to see if they all match. The solution is implemented as follows:

1. Use a counter to track the frequency of each letter in the original word.
2. Iterate through each letter, decrement its count in the counter (simulating its removal), and check if all the other counts are the same.
3. If after removing a letter, all other letters have the same count, it means it is possible to have equal frequency by removing one letter, so return `True`.
4. If the condition is not met, restore the count of the removed letter back before moving onto the next letter.
5. If no removal results in equal frequencies, return `False`.

Solution Approach

The implementation of the solution is straightforward, leveraging Python's `Counter` from the collections module, which is essentially a specialized dictionary used to count hashable objects.

Here's a step-by-step walk-through of the algorithm:

1. We initialize a `Counter` object with the `word` as an argument to count the frequency of each letter present in the `word`.
2. The function then enters a loop, iterating through the keys in the counter (which represent unique letters in the word), and for each iteration:
   - The frequency of the current letter is decreased by one, simulating its removal. This is done using `cnt[c] -= 1`.
   - We then check if the frequencies match for all the remaining letters. To do this concisely, we:
     - Construct a set comprehension `set(v for v in cnt.values() if v)` which:
       - Loops through all frequency values in the counter.
       - Includes a value in the set if it is non-zero (since a frequency dropping to zero implies the letter is effectively removed from the word).
       - Creates a set so that any duplicates are removed and only unique frequency values remain.
     - If the resulting set has only one element, it means all remaining letters have the same frequency.
   - If this condition is met, we return `True` immediately, indicating success.
   - If the condition is not met, we restore the frequency of the current letter before moving on to the next one with `cnt[c] += 1`. This step is crucial to ensure that the next iteration starts with the original frequencies, minus the next letter to simulate its removal.
3. If the loop completes and no return statement has been executed, this implies no single removal could achieve the desired equal frequency of letters. In this case, the function returns `False`.

This solution approach effectively employs the counter to test each possible single-letter removal and leverages Python's set to efficiently check for equal frequencies after each removal.

Example Walkthrough

Let's consider the string `word = "aabbccd"`. We want to determine if it's possible to remove one letter from this string so that the remaining letters all have the same frequency.

1. First, we initialize a `Counter` object with the string. For `word = "aabbccd"`, the counter would look like this: `Counter({'a': 2, 'b': 2, 'c': 2, 'd': 1})`. This means 'a' appears twice, 'b' appears twice, 'c' appears twice, and 'd' appears once.
2. We then enter a loop to iterate through the keys in the counter.
3. For the first iteration, we begin with the letter 'a', decreasing its count by one, resulting in `Counter({'a': 1, 'b': 2, 'c': 2, 'd': 1})`.
4. We construct a set from the values of the counter, excluding any zeros: `{1, 2}`. Since the set has more than one unique value, the condition for all letters to have the same frequency isn't met with the removal of 'a'.
5. We restore the count of 'a' back to its original value and move on to the next letter: `Counter({'a': 2, 'b': 2, 'c': 2, 'd': 1})`.
6. Next, we simulate removing one 'b', we get `Counter({'a': 2, 'b': 1, 'c': 2, 'd': 1})`. The set of frequencies would again be `{1, 2}`, so the condition is not met and we restore 'b'.
7. We proceed through the letters. When we decrement 'c', we get `Counter({'a': 2, 'b': 2, 'c': 1, 'd': 1})` and a set of frequencies `{1, 2}`. We restore 'c' and continue.
8. Finally, we simulate removing 'd'. This results in `Counter({'a': 2, 'b': 2, 'c': 2, 'd': 0})`. The frequency set would be `{2}`, since we exclude the zero frequency of 'd' (it is as if 'd' has been removed from the word). This set contains one unique value, implying all remaining letters have the same frequency.
9. Since we've found a case where removing one letter results in equal frequencies for the remaining letters, we return `True`. It is indeed possible to remove one letter from "aabbccd" to make all remaining letters have the same frequency.

This walkthrough illustrates how the solution approach tests different scenarios by removing each letter one by one and checking if the frequencies of the remaining letters match.

Solution Implementation

Python

```python
from collections import Counter

class Solution:
    def equalFrequency(self, word: str) -> bool:
        # Create a counter for all characters in the word
        char_count = Counter(word)

        # Iterate through each character in the counter
        for char, count in char_count.items():
            # Decrement the character's count by 1
            char_count[char] -= 1

            # Generate a set of all non-zero counts in the counter
            unique_counts = set(count for count in char_count.values() if count)

            # Check if all remaining character counts are the same
            if len(unique_counts) == 1:
                return True

            # Restore the original count for the character
            char_count[char] += 1

        # Return False if no condition satisfies the equal frequency requirement
        return False
```

Java

```java
class Solution {
    public boolean equalFrequency(String word) {
        // Frequency array to hold the count of each character in the word
        int[] freq = new int[26];

        // Count the frequency of each character in the word
        for (int i = 0; i < word.length(); ++i) {
            freq[word.charAt(i) - 'a']++;
        }

        // Iterate through each character in the alphabet
        for (int i = 0; i < 26; ++i) {
            // If the current character is present in the word
            if (freq[i] > 0) {
                // Decrease the frequency of the character by 1
                freq[i]--;

                int targetFreq = 0; // The target frequency all characters should have
                boolean isValid = true; // Flag to check if the current modification leads to equal frequencies

                // Check if after removing one character, the rest have the same frequency
                for (int v : freq) {
                    if (v == 0) {
                        continue; // Skip if the character is not in the word
                    }
                    if (targetFreq > 0 && v != targetFreq) {
                        isValid = false; // Frequencies differ, set flag to false
                        break;
                    }
                    targetFreq = v; // Set the current frequency as the target for others to match
                }

                // If removing one occurrence of this character results in all other characters having the same frequency
                if (isValid) {
                    return true;
                }

                // Undo the frequency change as we move on to the next character
                freq[i]++;
            }
        }

        // If no single removal leads to equal frequencies, return false
        return false;
    }
}
```

C++

```cpp
class Solution {
public:
    bool equalFrequency(string word) {
        int counts[26] = {0}; // Initialize an array to store the frequency of each letter

        // Populate the frequency array with counts of each character in the word
        for (char& c : word) {
            ++counts[c - 'a'];
        }

        // Iterate through the alphabet
        for (int i = 0; i < 26; ++i) {
            if (counts[i]) { // Check if the current letter has a non-zero frequency
                --counts[i]; // Decrementing the count to check if we can equalize frequency by removing one

                // Initialize a variable to store the frequency to compare against
                int target_frequency = 0;
                bool can_equalize = true; // Flag to check if equal frequency can be achieved

                // Iterate through the counts array to check the frequencies
                for (int count : counts) {
                    if (count == 0) {
                        continue; // Skip if the count is zero
                    }

                    // If we have already set the frequency to compare and current one doesn't match
                    if (target_frequency && count != target_frequency) {
                        can_equalize = false; // We cannot equalize the frequencies
                        break;
                    }

                    // If this is the first non-zero frequency we see, we set it as the target frequency
                    target_frequency = count;
                }

                // Checking if we can equalize the frequency by the removal of one character
                if (can_equalize) {
                    return true;
                }

                // Restore the count after checking
                ++counts[i];
            }
        }

        // If no equal frequency is possible by the removal of one character
        return false;
    }
};
```

TypeScript

```typescript
function equalFrequency(word: string): boolean {
    // Initialize a count array of length 26 to store the frequency of each letter,
    // assuming 'a' maps to index 0 and 'z' maps to index 25.
    const charFrequency: number[] = new Array(26).fill(0);

    // Populate the charFrequency array with the count of each character in the word.
    for (const char of word) {
        charFrequency[char.charCodeAt(0) - 'a'.charCodeAt(0)]++;
    }

    // Iterate through each character's frequency.
    for (let i = 0; i < 26; ++i) {
        if (charFrequency[i]) {
            // Decrement the frequency of the current character to check if
            // we can achieve equal frequency by removing one char occurrence.
            charFrequency[i]--;

            // Initialize a variable to store the frequency of the first non-zero character we encounter.
            let commonFrequency = 0;
            let allFrequenciesAreEqual = true;

            // Iterate through the frequencies to check if they are all the same.
            for (const frequency of charFrequency) {
                if (frequency === 0) {
                    continue; // Skip if frequency is 0 as we are looking for non-zero frequencies.
                }
                // If commonFrequency is set and current frequency is different, set the equal flag to false.
                if (commonFrequency && frequency !== commonFrequency) {
                    allFrequenciesAreEqual = false;
                    break;
                }
                // Update commonFrequency with the current non-zero frequency.
                commonFrequency = frequency;
            }

            // If all non-zero frequencies are equal, return true.
            if (allFrequenciesAreEqual) {
                return true;
            }
            // Since we modified the original frequency, restore it back.
            charFrequency[i]++;
        }
    }

    // If we did not find any instance where all non-zero frequencies
    // were equal after removing one char occurrence, return false.
    return false;
}
```

```python
from collections import Counter

class Solution:
    def equalFrequency(self, word: str) -> bool:
        # Create a counter for all characters in the word
        char_count = Counter(word)

        # Iterate through each character in the counter
        for char, count in char_count.items():
            # Decrement the character's count by 1
            char_count[char] -= 1

            # Generate a set of all non-zero counts in the counter
            unique_counts = set(count for count in char_count.values() if count)

            # Check if all remaining character counts are the same
            if len(unique_counts) == 1:
                return True

            # Restore the original count for the character
            char_count[char] += 1

        # Return False if no condition satisfies the equal frequency requirement
        return False
```

Time and Space Complexity

Time Complexity

The time complexity of the provided code is determined by several factors:

1. Building the `cnt` dictionary based on the `Counter` class, which requires iterating over every character in the word, results in a `O(n)` operation where `n` is the length of the word.
2. The `for` loop in the code iterates over each character in the unique set of characters of the `word`. If `k` is the number of unique characters, this results in up to `O(k)` iterations.
3. Inside the loop, updating a count in the dictionary is an `O(1)` operation.
4. The `set` and `list` comprehension iterates over the values of `cnt`, which is also `O(k)`, as it is done for each character in unique set.
5. The condition `len(set(v for v in cnt.values() if v)) == 1` is essentially checking if all non-zero values in the cnt dictionary are equal, which takes up to `O(k)` time to compute since it involves iteration over all values to form a set and then checking its length.

Combining these factors, the overall time complexity is `O(n + k^2)`. In the worst case, if all characters are unique, `k` is equal to `n`, this simplifies to `O(n^2)`.

Space Complexity

For space complexity:

1. The `cnt` dictionary stores counts of unique characters, so it takes up `O(k)` space where `k` is the number of unique characters.
2. The set and list comprehensions create temporary sets and lists that can contain up to `k` elements. However, these are temporary and not stored, so they don't add to the space complexity asymptotically.

Summarizing, the overall space complexity is `O(k)`. In the worst case scenario, `k = n`, which yields `O(n)` for the space complexity.