165. Compare Version Numbers

Medium | Two Pointers | String

Leetcode Link

Problem Description

The challenge is to compare two version numbers, `version1` and `version2`. A version number is a sequence of numbers separated by dots, with each number called a revision. The task is to compare the version numbers revision by revision, starting from the left (the first revision is revision 0, the next is revision 1, etc.).

Revision comparison is done based on the integer value of each revision, without considering any leading zeros. If a revision is missing in one of the version numbers, it should be treated as `0`. Based on the comparison, if `version1` is less than `version2`, we return `-1`; if `version1` is greater than `version2`, we return `1`; and if both version numbers are the same, we return `0`.

This problem requires careful parsing of the string that represents each version number and a clear understanding of how version numbers are structured and compared.

Intuition

The intuition behind the solution is to simulate the way we compare version numbers in a real-world scenario. We start by comparing the first revision of each version. If they are equal, we proceed to the next one; if not, we determine the result based on which one is greater.

Translating this into code, we iterate through both string representations of the version numbers `version1` and `version2` simultaneously. Using two pointers, `i` for `version1` and `j` for `version2`, we process each revision separately. We consider the end of a revision to be either the end of the string or the character `'.'`.

For each revision, we parse the number, skipping any leading zeroes, by multiplying the current value by `10` and adding the next digit. Once we have the integer values `a` and `b` for the current revisions of `version1` and `version2`, respectively, we compare these values.

If we find a difference between `a` and `b`, we return `-1` if `a` is smaller; otherwise, we return `1`. If `a` and `b` are equal, we move on to the next revision. If we reach the end of both strings without finding any differences, we return `0`.

The solution ensures that we only compare integer values of revisions and handles cases where the versions have a different number of revisions by treating missing revisions as `0`.

Solution Approach

The implementation of the solution employs a straightforward parsing technique to compare version numbers. Here's a step-by-step walk-through:

1. **Initialize pointers and lengths**: Start with defining two pointers, `i` and `j`, for iterating over `version1` and `version2` respectively. Also, determine the lengths of the two versions, `m` and `n`.
2. **Iterate over the version strings**: Use a `while` loop to continue the iteration as long as either `i < m` or `j < n`. This is done to handle scenarios where one version string is longer than the other.
3. **Parse revisions**: Parse the current revision for both versions. This is done in two nested `while` loops, one for each version. A temporary variable (say `a` for `version1` and `b` for `version2`) is set to `0`. For each digit encountered that is not a dot, multiply the current value of `a` or `b` by `10` and add the integer value of the current character. This effectively strips leading zeros and converts the string to an integer. Increments the appropriate pointer, `i` or `j`, when a digit is read.
4. **Compare revisions**: Once both revisions are extracted, compare these integer values. If they are not equal, decide the return value based on which one is less. Return `-1` if the integer from `version1` (`a`) is less than the integer from `version2` (`b`), and return `1` if it's the other way around.
5. **Move to the next revision**: Increment the pointers `i` and `j` to skip the dot and proceed to the next revision.
6. **Return `0` if no differences are found**: If the loop concludes without returning `-1` or `1`, this means all revisions were equal or non-specified revisions were implicitly treated as `0`. Hence, return `0`.

The algorithm avoids the use of additional storage or complex data structures, opting for a simple linear parsing approach. It leverages the properties of integer arithmetic to process revisions, and pointer arithmetic to move through the version strings. Additionally, by treating non-specified revisions as `0`, the algorithm cleverly simplifies the case handling for version numbers with a different number of revisions.

The use of while-loops and conditional logic is quite efficient, ensuring that each character in the version strings is processed exactly once, giving the algorithm a time complexity of O(max(N, M)), where N and M are the lengths of the version strings. There is no reliance on additional significant space, making the space complexity O(1).

This approach to breaking down the problem, iterating through each character, and avoiding unnecessary complexity is a hallmark of many string parsing problems. By focusing on one revision at a time, the solution achieves a balance between clarity and efficiency.

Example Walkthrough

Let's walk through a small example to illustrate how the solution approach works. We will compare two version numbers:

```
version1: "1.02"
version2: "1.2.1"
```

As per the given solution approach:

1. **Initialize pointers and lengths**:
   We set `i = 0`, `j = 0`, `m = length of "1.02" = 4`, and `n = length of "1.2.1" = 5`.
2. **Iterate over the version strings**:
   We start a `while` loop where `i < m` or `j < n`; in this case, `0 < 4` or `0 < 5` is true.
3. **Parse revisions**:
   We begin by parsing the first revision of each:
   - For `version1`, we parse until we encounter a dot. We skip the leading zero, and `a = 1`.
   - For `version2`, we do the same and get `b = 1`.
     The pointers now point to the dots, so `i = 2` and `j = 2`.
4. **Compare revisions**:
   - Since `a (1) == b (1)`, we move forward.
5. **Move to the next revision**:
   - We increment `i` and `j` to skip the dot, so `i = 3` and `j = 3`.
6. **Parse and compare the next revisions**:
   - For `version1`, there is no dot until the end, so parse the next number, getting `a = 2`.
   - For `version2`, we get `b = 2` after parsing until the next dot at `j = 4`.
   - The comparison shows `a (2) == b (2)`, so we move forward.
7. **Move to the next revision**:
   - Increment `i` and `j` to skip the dots. `i` is now `m` (end of `version1`), but `j = 5` is still within `version2`.
8. **Parse remaining revisions**:
   - Since `i` has reached the end, `a` remains `0`.
   - For `version2`, `b` is parsed as `b = 1`.
9. **Final comparison and result**:
   - The next comparison is between `a (0)` and `b (1)`. Since `a` is less, according to our rule, we return `-1`.

Therefore, for the example given `version1: "1.02"` and `version2: "1.2.1"`, the result of our version number comparison would be `-1`, indicating that `version1` is less than `version2`.

Python Solution

```python
class Solution:
    def compareVersion(self, version1: str, version2: str) -> int:
        # Length of the version strings
        len_version1, len_version2 = len(version1), len(version2)

        # Initialize pointers for each version string
        pointer1 = pointer2 = 0

        # Loop until the end of the longest version string is reached
        while pointer1 < len_version1 or pointer2 < len_version2:
            # Initialize numeric values of the current version parts
            num1 = num2 = 0

            # Parse the version number from version1 until a dot is found or end is reached
            while pointer1 < len_version1 and version1[pointer1] != '.':
                num1 = num1 * 10 + int(version1[pointer1])
                pointer1 += 1

            # Parse the version number from version2 until a dot is found or end is reached
            while pointer2 < len_version2 and version2[pointer2] != '.':
                num2 = num2 * 10 + int(version2[pointer2])
                pointer2 += 1

            # Compare the parsed numbers
            if num1 != num2:
                # If they are not equal, determine which one is larger and return -1 or 1 accordingly
                return -1 if num1 < num2 else 1

            # Move past the dot for the next iteration
            pointer1, pointer2 = pointer1 + 1, pointer2 + 1

        # If no differences were found, the versions are equal
        return 0
```

Java Solution

```java
class Solution {
    public int compareVersion(String version1, String version2) {
        int length1 = version1.length(), length2 = version2.length(); // Store the lengths of the version strings

        // Initialize two pointers for traversing the strings
        for (int i = 0, j = 0; (i < length1) || (j < length2); ++i, ++j) {
            int chunkVersion1 = 0, chunkVersion2 = 0; // Initialize version number chunks

            // Compute the whole chunk for version1 until a dot is encountered or the end of the string
            while (i < length1 && version1.charAt(i) != '.') {
                chunkVersion1 = (chunkVersion1 * 10) + (version1.charAt(i) - '0');
                // Update the chunk by multiplying by 10 (moving one decimal place)
                // and adding the integer value of the current character
                // chunkVersion1 = chunkVersion1 + (version1.charAt(i) - '0');
                i++; // Move to the next character
            }

            // Compute the whole chunk for version2 until a dot is encountered or the end of the string
            while (j < length2 && version2.charAt(j) != '.') {
                chunkVersion2 = (chunkVersion2 * 10) + (version2.charAt(j) - '0');
                j++; // Move to the next character
            }

            // Compare the extracted chunks from version1 and version2
            if (chunkVersion1 != chunkVersion2) {
                // Return -1 if chunkVersion1 is smaller, 1 if larger
                return chunkVersion1 < chunkVersion2 ? -1 : 1;
            }
            // If chunks are equal, proceed to the next set of chunks
        }
        // If all chunks have been successfully compared and are equal, return 0
        return 0;
    }
}
```

C++ Solution

```cpp
#include <string> // Include necessary header

class Solution {
public:
    // Compares two version numbers 'version1' and 'version2'
    int compareVersion(std::string version1, std::string version2) {
        int v1Length = version1.size(), v2Length = version2.size(); // Store the sizes of both version strings

        // Iterate over both version strings
        for (int i = 0, j = 0; i < v1Length || j < v2Length; ++i, ++j) {
            int num1 = 0, num2 = 0; // Initialize version segment numbers for comparison

            // Parse the next version segment from 'version1'
            while (i < v1Length && version1[i] != '.') {
                num1 = num1 * 10 + (version1[i] - '0'); // Convert char to int and accumulate
                ++i; // Move to the next character
            }

            // Parse the next version segment from 'version2'
            while (j < v2Length && version2[j] != '.') {
                num2 = num2 * 10 + (version2[j] - '0'); // Convert char to int and accumulate
                ++j; // Move to the next character
            }

            // Compare the parsed version segments
            if (num1 != num2) {
                return num1 < num2 ? -1 : 1; // Return -1 if 'version1' is smaller, 1 if larger
            }
        }

        // If we get to this point, the versions are equal
        return 0;
    }
};
```

Typescript Solution

```typescript
function compareVersion(version1: string, version2: string): number {
    // Split both version strings by the dot (.) to compare them segment by segment.
    let versionArray1: string[] = version1.split('.');
    versionArray2: string[] = version2.split('.');

    // Iterate through the segments for the maximum length of both version arrays.
    for (let i = 0; i < Math.max(versionArray1.length, versionArray2.length); i++) {
        // Convert the current segment of each version to a number,
        // using 0 as the default value if the segment is undefined.
        let segment1: number = Number(versionArray1[i] || 0),
            segment2: number = Number(versionArray2[i] || 0);

        // If the current segment of version1 is greater than version2, return 1.
        if (segment1 > segment2) return 1;

        // If the current segment of version1 is less than version2, return -1.
        if (segment1 < segment2) return -1;
    }

    // If all segments are equal, return 0.
    return 0;
}
```

Time and Space Complexity

The time complexity of the given code can be considered to be O(max(M, N)), where `M` is the length of `version1` and `N` is the length of `version2`. This is because the code uses two while loops that iterate through each character of both `version1` and `version2` at most once. The inner while loops, which convert the version numbers from string to integer, contribute to the same overall time complexity because they iterate through each subsection of the versions delimited by the period character `'.'`, still not exceeding the total length of the versions.

The space complexity of the code is O(1), since it only uses a fixed number of integer variables and does not allocate any variable-sized data structures dependent on the size of the input.