

## General Idea of the Algorithm for Multiplying Two Strings

The algorithm for multiplying two strings representing numbers does not use large numeric data types (like BigInteger) or directly convert the strings into integers. Instead, it employs a linked list data structure to perform the multiplication. Below are the main steps of the overall idea:

1. **Input Data:** The algorithm receives two strings representing non-negative integers.
2. **Check for Special Cases:** If either string is "0", the result will be "0". This helps reduce unnecessary calculations.
3. **Initialize the Linked List:** A linked list is created to store the result of the multiplication. This list will contain each digit of the result from the least significant to the most significant.
4. **Multiply Each Digit:** Two nested loops are used:
  - The first loop iterates through each digit of the first string (from right to left).
  - The second loop iterates through each digit of the second string (also from right to left) and calculates the product of the corresponding digits.
  - The result of each multiplication is added to the linked list, taking carry into account.
5. **Accumulate the Result:** After the nested loops finish, the linked list will contain the unformatted result. Thus, a step is required to accumulate the digits from the linked list and handle any carry if necessary.
6. **Reverse the Linked List:** Since the linked list stores digits in reverse order, it must be reversed to obtain the final result.
7. **Convert to String:** Finally, the linked list is converted into a string to return the result.

## Idea of Multiplying "123" and "456"

1. **Initialize Variables:**
  - Initialize a linked list to store the final result of the multiplication.
  - Use variables len1 and len2 to store the lengths of the number strings num1 and num2. In this case, len1 = 3 and len2 = 3.
2. **Multiply Each Digit:**
  - Perform a loop from right to left on num1 (starting from digits 3, 2, 1) and num2 (starting from digits 6, 5, 4).
  - Each digit of num1 will be multiplied by all the digits of num2. The results of each multiplication will be stored in a temporary linked list (tempResult).
3. **Adjusting the Digit Positions:**
  - When multiplying a digit from num1 with all digits from num2, the appropriate number of zeros must be appended to the end of the temporary result to adjust the position

accordingly. For example, when multiplying the first digit of num1 (1) with num2, a zero is added to the end to represent the hundreds place.

4. Accumulate the Results:

- After obtaining the temporary result from multiplying each digit, it will be accumulated into the previously initialized linked list result. The addLists function is used to perform the addition of the linked lists.

5. Managing Carry:

- During multiplication, if the result of a multiplication and carry exceeds 9, it needs to be managed, and the carry must be added to the appropriate linked list.

6. Final Result:

- After completing the multiplication of all digits, the result will be stored in the linked list result. The list needs to be reversed to obtain the final result in the correct left-to-right order.

### Detailed Example

- Step 1: Multiply the last digit (3) of "123" with "456":
  - $3 \times 6 = 18 \rightarrow$  record 8 and carry 1
  - $3 \times 5 + 1 = 16 \rightarrow$  record 6 and carry 1
  - $3 \times 4 + 1 = 13 \rightarrow$  record 3 and carry 1
  - Temporary result: 368
- Step 2: Multiply the next digit (2) with "456" (add a zero at the end):
  - Add a zero: 3680
  - Perform multiplication:
    - $2 \times 6 = 12 \rightarrow$  record 2 and carry 1
    - $2 \times 5 + 1 = 11 \rightarrow$  record 1 and carry 1
    - $2 \times 4 + 1 = 9 \rightarrow$  record 9
  - Temporary result: 9120
- Step 3: Multiply the first digit (1) with "456" (add two zeros at the end):
  - Add two zeros: 91200
  - Perform multiplication:
    - $1 \times 6 = 6 \rightarrow$  record 6
    - $1 \times 5 = 5 \rightarrow$  record 5

- $1 \times 4 = 4 \rightarrow$  record 4

- Temporary result: 45600
- Step 4: Add the temporary results together:
  - 368
  - 9120
  - 45600
  - The final result will be 56088.

This detailed breakdown highlights how the algorithm processes each step to achieve the multiplication of two large numbers represented as strings, using linked lists for efficient storage and manipulation of digits.