Longest Common Extension / LCE | Set 1 (Introduction and Naive Method)

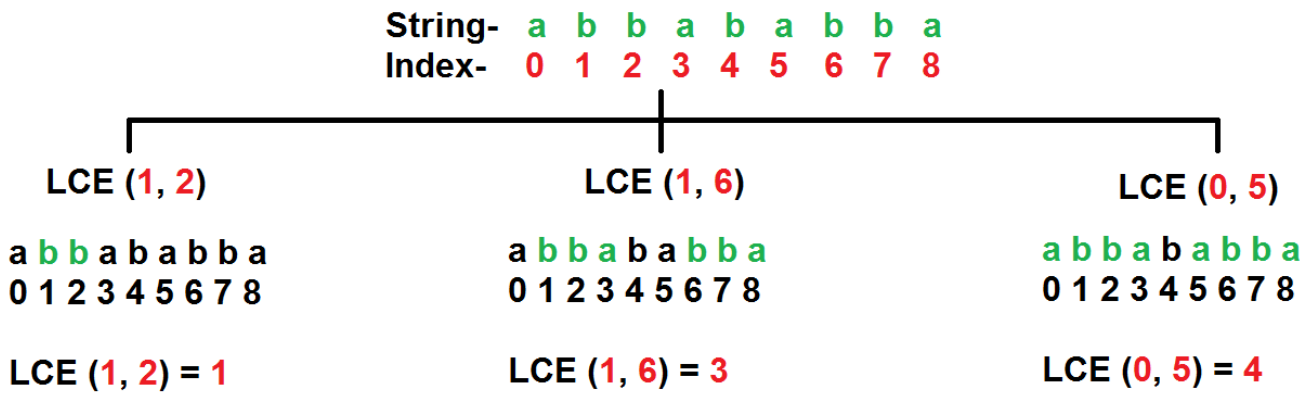
The Longest Common Extension (LCE) problem considers a string **s** and computes, for each pair (L , R), the longest sub string of **s** that starts at both L and R. In LCE, in each of the query we have to answer the length of the longest common prefix starting at indexes L and R.

Example:

String : "abbababba"
Queries: LCE(1, 2), LCE(1, 6) and LCE(0, 5)

Find the length of the Longest Common Prefix starting at index given as, **(1, 2), (1, 6) and (0, 5)**.

The string highlighted "green" are the longest common prefix starting at index- L and R of the respective queries. We have to find the length of the longest common prefix starting at index- **(1, 2), (1, 6) and (0, 5)**.



Algorithm (Naive Method)

1. For each of the LCE queries of the form – LCE(L, R) do the following:
   - Initialise the LCE 'length' as 0
   - Start comparing the prefix starting from index- L and R character by character.
   - If the characters matches, then this character is in our Longest Common Extension. So increment 'length' (length++).
   - Else if the characters mismatch, then return this 'length'.

2. The returned 'length' will be the required LCE(L, R).

Implementation :

Below is C++ implementation of above Naive algorithm.

```
// A C++ Program to find the length of longest
// common extension using Naive Method
#include<bits/stdc++.h>
using namespace std;

// Structure to represent a query of form (L,R)
struct Query
{
    int L, R;
};

// A utility function to find longest common
// extension from index - L and index - R
int LCE(string str, int n, int L, int R)
{
    int length = 0;

    while (str[L+length] == str[R+length] &&
            R+length < n)
        length++;

    return(length);
}

// A function to answer queries of longest
// common extension
void LCEQueries(string str, int n, Query q[],
                                        int m)
{
    for (int i=0; i<m; i++)
    {
        int L = q[i].L;
        int R = q[i].R;

        printf("LCE (%d, %d) = %d\n", L, R,
                        LCE(str, n, L, R));
    }
    return;
}

// Driver Program to test above functions
int main()
{
    string str = "abbababba";
    int n = str.length();

    // LCA Queries to answer
    Query q[] = {{1, 2}, {1, 6}, {0, 5}};
    int m = sizeof(q)/sizeof(q[0]);

    LCEQueries(str, n, q, m);

    return (0);
}
```

Run on IDE

Output:

```
LCE(1, 2) = 1
LCE(1, 6) = 3
LCE(0, 5) = 4
```

Analysis of Naive Method

Time Complexity: The time complexity is O(Q.N), where
Q = Number of LCE Queries
N = Length of the input string

One may be surprised that the although having a greater asymptotic time complexity, the naive method outperforms other efficient method(asymptotically) in practical uses. We will be discussing this in coming sets on this topic.

Auxiliary Space: O(1), in-place algorithm.

Applications:

1. K-Mismatch Problem->Landau-Vishkin uses LCE as a subroutine to solve k-mismatch problem
2. Approximate String Searching.
3. Palindrome Matching with Wildcards.
4. K-Difference Global Alignment.

In the next sets we will discuss how LCE (Longest Common Extension) problem can be reduced to a RMQ (Range Minimum Query). We will also discuss more efficient methods to find the longest common extension.

Reference :

- http://www.sciencedirect.com/science/article/pii/S1570866710000377

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