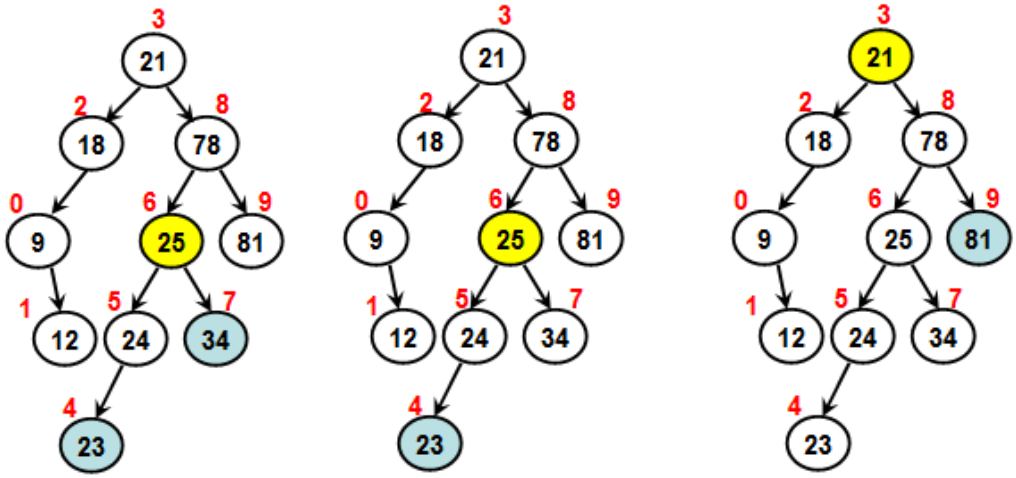
CSC 228 Data Structures and Algorithms, Fall 2019
Instructor: Dr. Natarajan Meghanathan

Project 7: Binary Search Tree: Lowest Common Ancestor Node

Due: November 14th; 11.59 PM (submission through Canvas)

The lowest common ancestor (LCA) for two nodes A and B in a binary search tree (BST) is the node that is the common ancestor for both A and B, and is the farthest away from the root node of the BST. Note that depending on the BST, one of the two nodes A and B could themselves be the LCA of the other node or a third node (that is different from nodes A and B) could be the LCA. The three cases are illustrated in the following figure:



Node '6' with data 25 is the LCA for nodes '4' and '7' with data 23 and 34 respectively
Case (a)

Node '6' with data 25 is the LCA for nodes '4' and '6' with data 23 and 25 respectively
Case (b)

Node '3' with data 21 is the LCA for nodes '3' and '9' with data 21 and 81 respectively
Case (c)

Figure 1

In this project, you will construct a BST based on a randomly generated and sorted array of integers, input the values (i.e., data) for two nodes A and B (that are part of the BST) and find the data corresponding to their LCA. Follow the steps below:
(1) You will first construct a BST using a randomly generated and sorted array (sorted using Selection sort). The code to construct such a BST is given to you.
(2) You will then input the data/values for the two search nodes A and B. Between the two nodes, determine the node whose data is relatively lower and call such a node as the leftSearchNode; the other node will be then called the rightSearchNode.
(3) The third and the major step is to initiate a search process starting from the root node (called say, the prospectiveAncestorNode).

- If the data for the leftSearchNode and rightSearchNode are both lower than that of the prospectiveAncestorNode, then the two nodes should be located in the left sub tree of the prospectiveAncestorNode. Hence, we set the id of the prospective ancestor node to correspond to the id of its left child and continue the search process in its left sub tree.
- If the data for the leftSearchNode and rightSearchNode are both greater than that of the prospectiveAncestorNode, then the two nodes should be in the right sub tree of the

prospectiveAncestorNode. Hence, we set the id of the prospective ancestor node to correspond to the id of its right child and continue the search process in its right sub tree.

- If the data for the leftSearchNode is lower than or equal to that of the prospective ancestor node and the data for the rightSearchNode is greater than or equal to that of the prospective ancestor node, we stop and return the data/value of the prospective ancestor node as the LCA.

The execution of the LCA search process is illustrated in the example below:

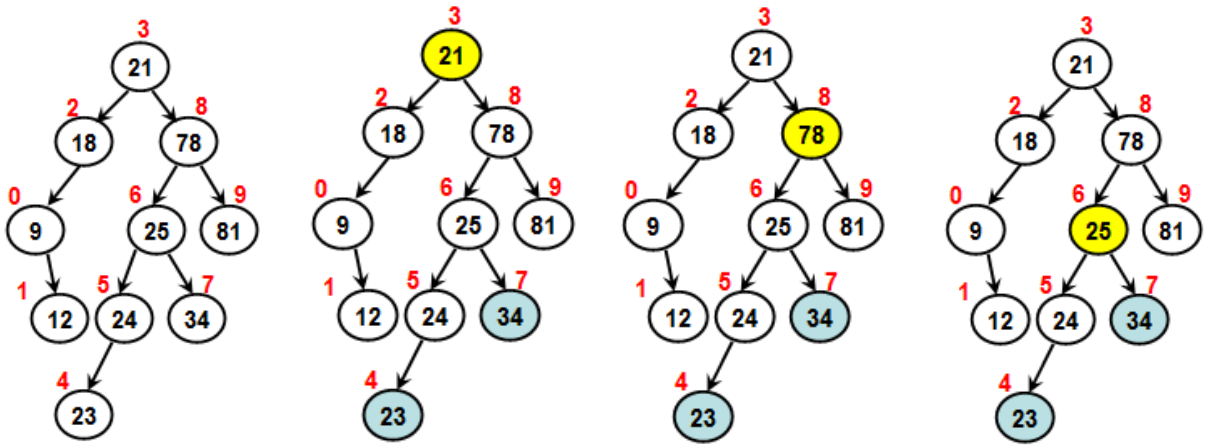


Figure 2

Let nodeA be node '4' with data 23 and nodeB be node '7' with data 34. Between these two nodes, nodeA has the lower data and hence nodeA is the leftSearchNode and nodeB is the rightSearchNode.

Start with the root node '3' with data 21 as the prospectiveAncestorNode; the data for the leftSearchNode and rightSearchNode are 23 and 34 respectively.

Iteration 1: The data for both the leftSearchNode (23) and rightSearchNode (34) are greater than that of the prospectiveAncestorNode (21). Hence, we set the new id of the prospectiveAncestorNode to that of the id of its right child (node id '8' with data 78).

Iteration 2: The data for both the leftSearchNode (23) and rightSearchNode (34) are lower than that of the prospectiveAncestorNode (78). Hence, we set the new id of the prospectiveAncestorNode to that of the id of its left child (node id '6' with data 25).

Iteration 3: The data for the leftSearchNode (23) is less than that of the prospectiveAncestorNode (25) and the data for the rightSearchNode (34) is greater than that of the prospectiveAncestorNode (25). Hence, we stop and return 25 as the data of the LCA for nodes with data 23 and 34.

You are given the code for constructing a BST based on a randomly generated and sorted array of integers. The main function runs for four trials. In each trial, you will input two integers, corresponding to the data for nodeA and nodeB, and the code will decide which of the two is the leftSearchNode and rightSearchNode, and then call the LCA function on the binary search tree object.

What to submit:

(1) The complete code (.cpp file) with the following addition to the given code: A member function findLCA(...) implemented in the class BinarySearchTree, and is called with the leftSearchNode and rightSearchNode as the two arguments. The findLCA function should implement the procedure described above and return the data corresponding to the LCA.

(2) A PDF file that puts together the following:
(i) Run your code with 10 as the array size and 50 as the maximum value for any element in the array. Note down the sorted array that is output (as part of in order traversal) and is used to construct the Binary Search Tree. Capture the screenshot of the output/in order traversal. Then, using this sorted array, draw the BST manually in your document.
(ii) For each of the four trials, test with data for nodes A and B as follows:

For the first three trials, input data values for two nodes (from the above sorted array) corresponding to the cases (a), (b) and (c) shown in Figure 1. For each case/trial, capture the screenshot of the output. The LCA data obtained should match with the LCA of the two node data values in your BST drawn for (part 2-(i)). As part of your documentation, clearly state the cases [(a), (b) or (c)] that your two inputs are referring to and the corresponding output obtained.

For the fourth trial, input data values for two nodes that does not exist in the sorted array of (part 2). Capture the screenshot of the output obtained with this trial too and explain why you got such an output for this trial.