

# CS2233: Data Structures

## Assignment 4

2nd October, 2018

### Problem Statement

- Input: A sequence  $a_1, a_2, \dots, a_n$  of natural numbers that indicates the **pre-order** traversal of a BST. Additionally, several requests to restructure  $B$  or print relevant data.
- Goal: Build a Binary Search Tree  $B$  that has its pre-order traversal as the input sequence. In addition to the requests specified in Assignment 2B and 3, serve the following requests with respect to  $B$ :
  1. Print children of a specified node.
  2. Print Uncle of a specified node.
  3. Left rotate at a specified node.
  4. Right rotate at a specified node.

### Input Format

Input lines start with one of the following symbols:

- 'N', '+', '>', '-', 'S', 'P' from assignment 2B and 3.
- 'C' (Print children)
- 'U' (Print Uncle)
- 'B' (Build the BST specified by the pre-order traversal)
- 'L' (Left rotate)
- 'R' (Right rotate)

**Format in detail:** For lines starting with 'N', '+', '>', '-', 'S', or 'P', refer to format specification in Assignment 2B and 3. For the remaining, if the input line starts with:

- 'C', 'U', 'L', or 'R': It is followed by an  $a \in \mathbb{N}$
- 'B': It is followed by a sequence  $a_1, \dots, a_n$  of distinct natural numbers as a space-separated list.
- End of input is indicated by EOF.

All input lines end with a `\n` character.

## Output Format

If the input line was:

- ‘N’, ‘+’, ‘>’, ‘-’, ‘S’, or ‘P’ , the output format is exactly as per specification in Assignment 2B and 3.
- “C  $a$ ”: If value  $a$  does not exist in the set, then output  $-1$ .  
Else, let node  $A$  hold value  $a$ . Output the values of the two children of  $A$  separated by a space. If a child does not exist, output “Nil” in its place.
- “U  $a$ ”: If a node with value  $a$  does not exist in the set or its uncle does not exist, then output  $-1$ .  
Else, let node  $A$  hold value  $a$ . Output the value of the uncle (sibling of parent) of  $A$ .
- “B  $a_1 a_2 \dots a_n$ ”: No output. You are expected to construct a BST whose pre-order traversal is precisely  $a_1, a_2, \dots, a_n$ .
- “L  $a$ ”: No output. If a node  $A$  with value  $a$  exists and left rotation is possible at  $A$ , then perform the left rotation. Else do nothing.
- “R  $a$ ”: No output. If a node  $A$  with value  $a$  exists and right rotation is possible at  $A$ , then perform the right rotation. Else do nothing.

## Implementation rules

In addition to rules specified in Assignment 2B and 3:

- Write your own sorting procedure with running time not more than  $O(n^2)$ .

## Other Remarks

- All numbers in the test cases will fit into `int`.
- To build a BST from the pre-order traversal, use the fact that inorder traversal of a BST is always sorted. Then use the recursive procedure we discussed in class.
- You are encouraged to use and modify your own code from previous assignments.
- **Deadline:** 8th October, 2018.

### Example

Input:

Output:

-----	-----
B 12 9 8 3 10 15 14 34 78	-1
S 16	10
S 14	14
> 12	12
> 11	14 34
C 15	Nil 34
- 14	Nil 78
C 15	Nil Nil
C 34	15 78
L 15	9 34
C 15	9 15
C 34	15
C 12	-1
L 12	78
C 12	8 10
U 9	Nil 10
U 34	3 9
U 12	3 9
C 9	34 12 8 3 9 10 15 78
R 9	
C 9	-----
C 8	
R 9	
C 8	
P	
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Note: The BST constructed in the first line is the same as the one in the example of Assignment 3.