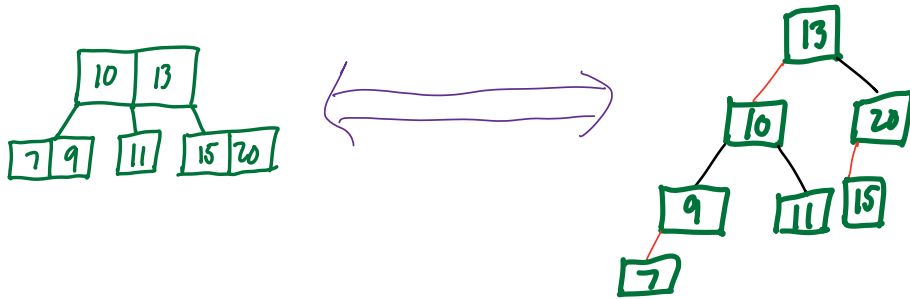


LLRBs

What is it?

- Basically a better representation of B-trees
- Is a one-to-one correspondence with another B-tree
- In a B-tree, if there is a node with two values, then in an LLRB, there is a **left red link** to push down the smaller value



LLRB Properties

- ① No node has two red links
- ② Every path from root to leaf has same number of black links
(LLRB 1-1 correspond to B-trees, each path from root to leaf in B-tree has same number of black links).
- ③ HEIGHT: max height = $2H + 1$

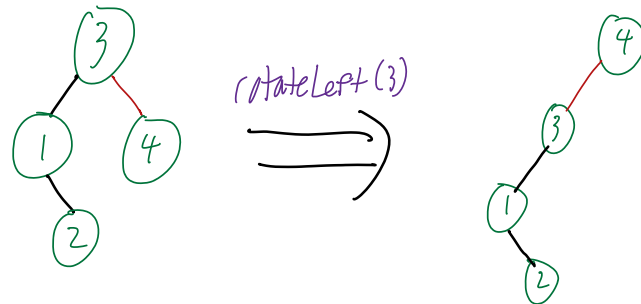


Insertion (LLRB)

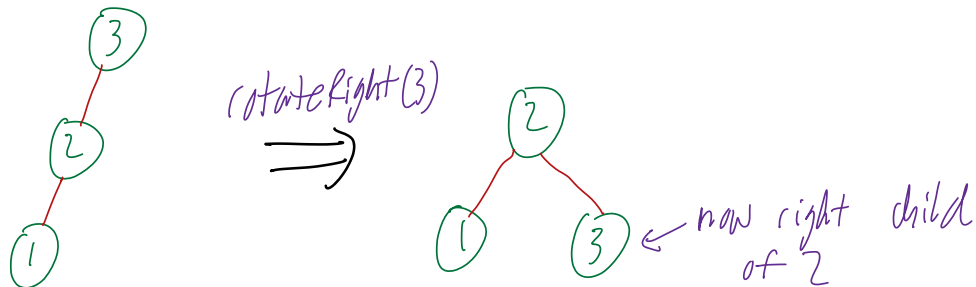
Insertion always adds a node with a red link to the bottom of the tree.

① Add into tree as a leaf node (same procedure as BST) w/ red link

② If there is a right leaning child with red link, we have left leaning violation.
- Rotate left parent node of child



If there are two consecutive red links of a node x , there is an incorrect 4-node violation.
- rotate right parent node of x



If there are nodes with two red-linked children, there is a 4-node violation.
- Color flip all links of the parent of the two red-linked children

