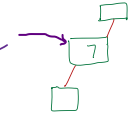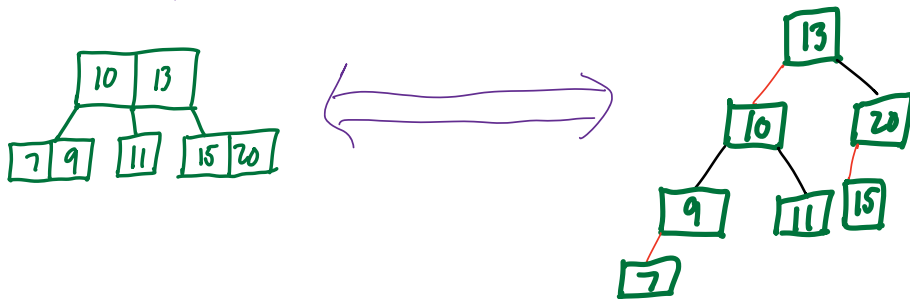# LLRBs

What is it?

- Basically a better representation of B-trees
- Is a one-to-one correspondance 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__ (all non-red links)

   (LLRB 1-1 correspond to B-trees, each path from root to leaf in B-tree has same number of __black links__).

3. Max possible LLRB height $= 2H + 1$, where H is height of corresponding B-tree

4. BST Properties: every node left of node less than node; every node on right of greater than node.

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 <u>left leaning violation.</u>
  - Rotate left parent node of child

rotateLeft (3)
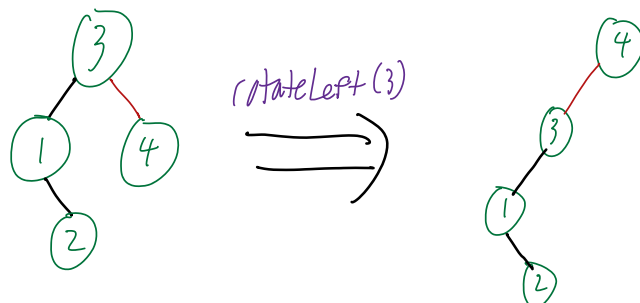
- If there are two consecutive red links of a node x, there is an <u>incorrect 4-node violation</u>
  - rotate right parent node of x

rotateRight (3)

← now right child of 2
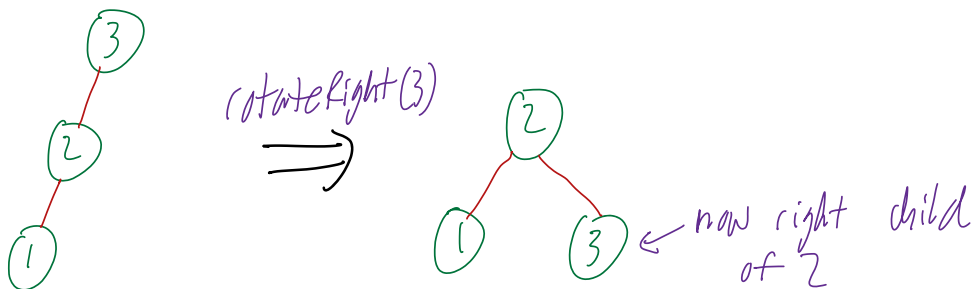
- If there are nodes with two red-linked children, there is a <u>4-node violation.</u>
  - Color flip all links of the parent of the two red-linked children

ColorFlip (10)