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Mohammed Abu-Hadhoud
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الاستعجال والاعتماد عليه فقط سوف يجعلك تخسر كميه معلومات
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Algorithms & Problem Solving
Level 6

RedBlack Tree Deletion Part 1

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Remember..

- A Red-Black Tree is a type of self-balancing binary search tree
- When insert new node we must make sure the tree is rebalanced if needed and all red black tree properties are met:
  - Color Property: Every node is either red or black.
  - Root Property: The root of the tree is always black.
  - All leaves (NIL nodes) are black.
  - Red Property: If a red node has children, then both are black (no two red nodes appear in a sequence).
  - Depth Property: Every path from a node to its descendant NULL nodes has the same number of black nodes.

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High Level Deletion Strategy

- Step 1 : Find Node.
- Step 2 : Delete Node.
- Step 3 : Fix Tree for any violations.

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Step 1: Find Node.

- Start by locating the node that you want to delete.
- This is done by comparing the value you want to delete with the values in the tree, similar to searching in a regular binary search tree.

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Step 2: Delete Node.

- The actual deletion depends on the node's children:
  - Case 1: Node has no children (it's a leaf). Simply remove the node. If node is red simply remove it. Standard binary search deletion.
  - Case 2: Node has one child. Replace the node with its child then delete the leaf node.
  - Case 3: Node has two children. Find the node's in-order successor (the smallest node in its right subtree), replace the node with this successor, and then delete the successor.

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Step 3: Fix Tree.

- After deletion, the tree might violate the Red-Black properties.
- To fix this, you may need to recolor nodes or perform rotations (left or right) to restore balance.

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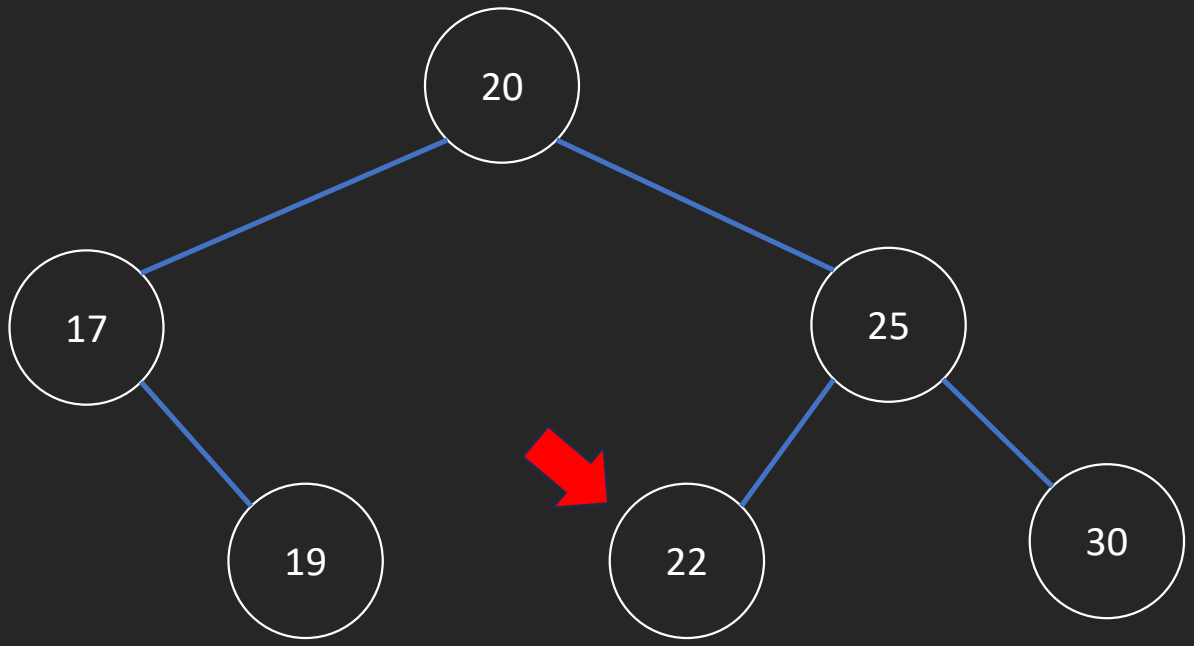
Step 2: Delete Node

Case 1: Node has no children (it's a leaf). Simply remove the node.
If node is red simply remove it. Standard binary search deletion.



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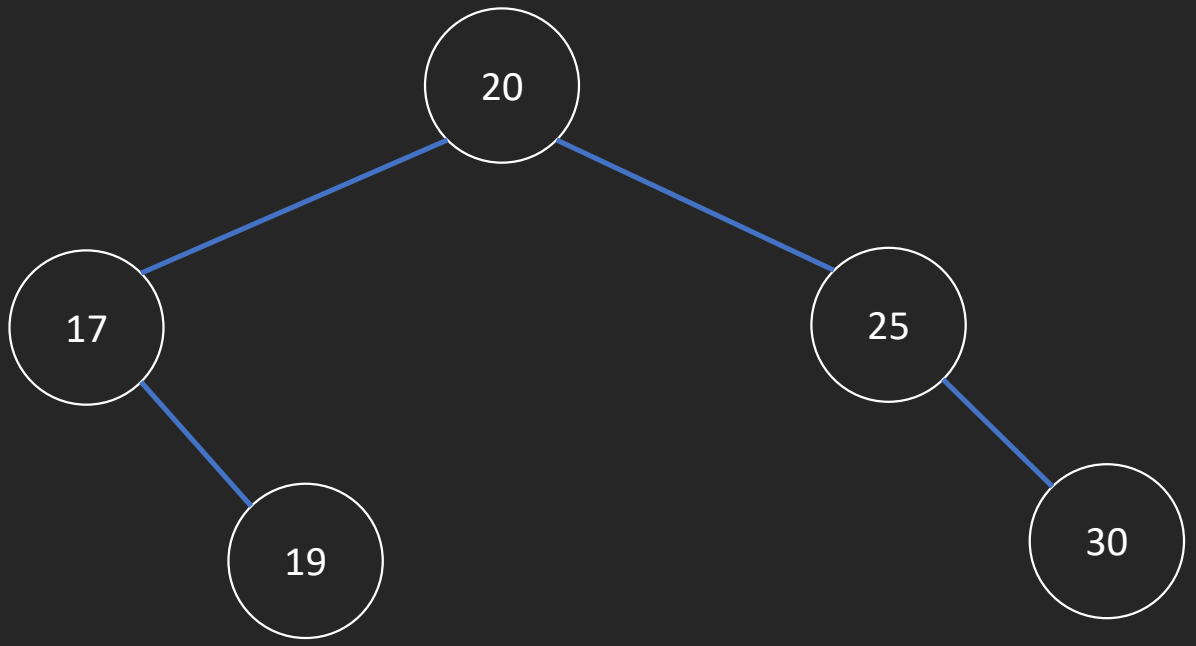

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Step 2: Delete Node

Case 2: Node has one child. Replace the node with its child then delete the leaf node.

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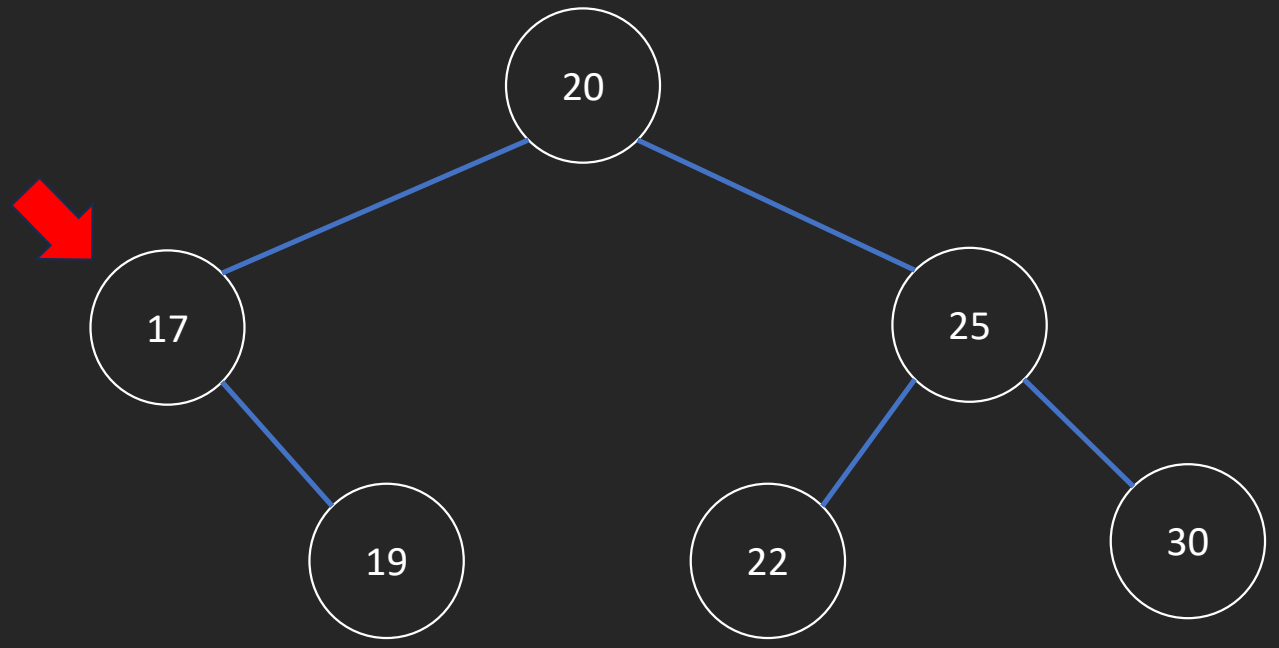

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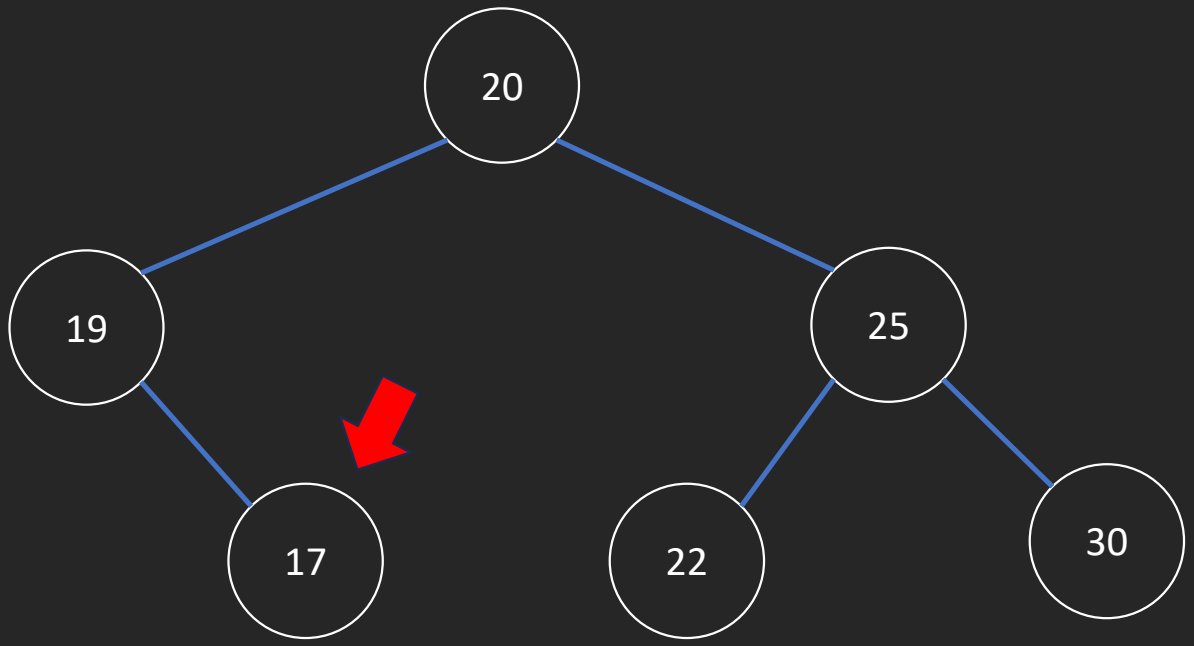

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Step 2: Delete Node

Case 2: Node has one child. Replace the node with its child then delete the leaf node. Note: we don’t delete internal nodes only leaf.

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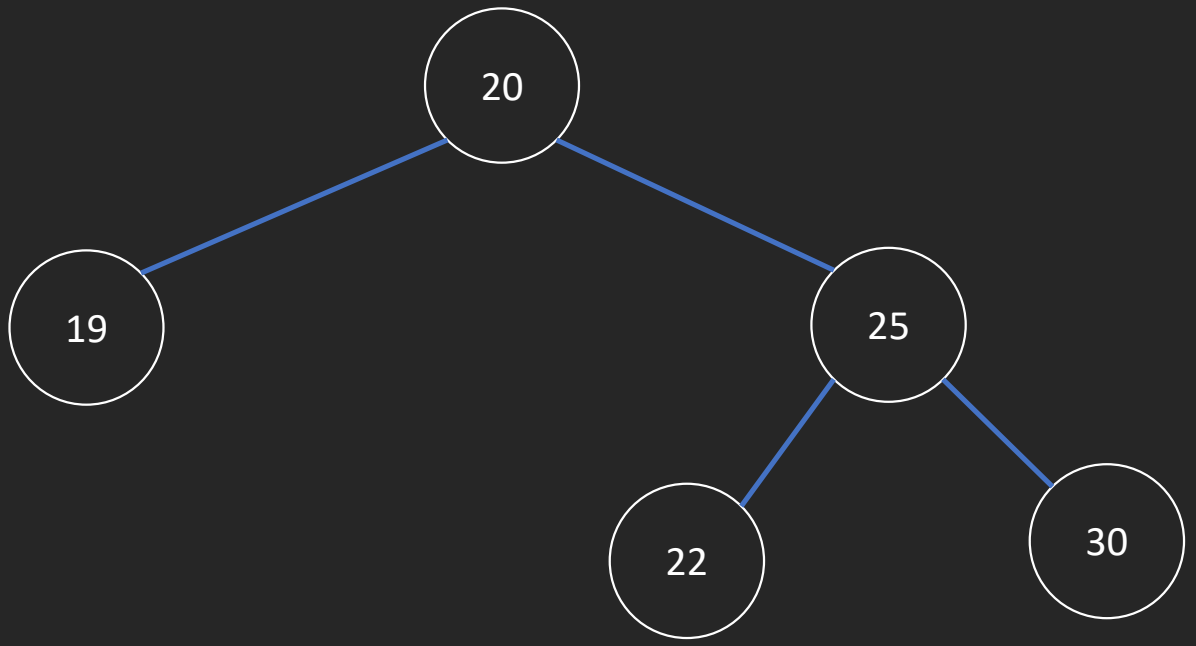

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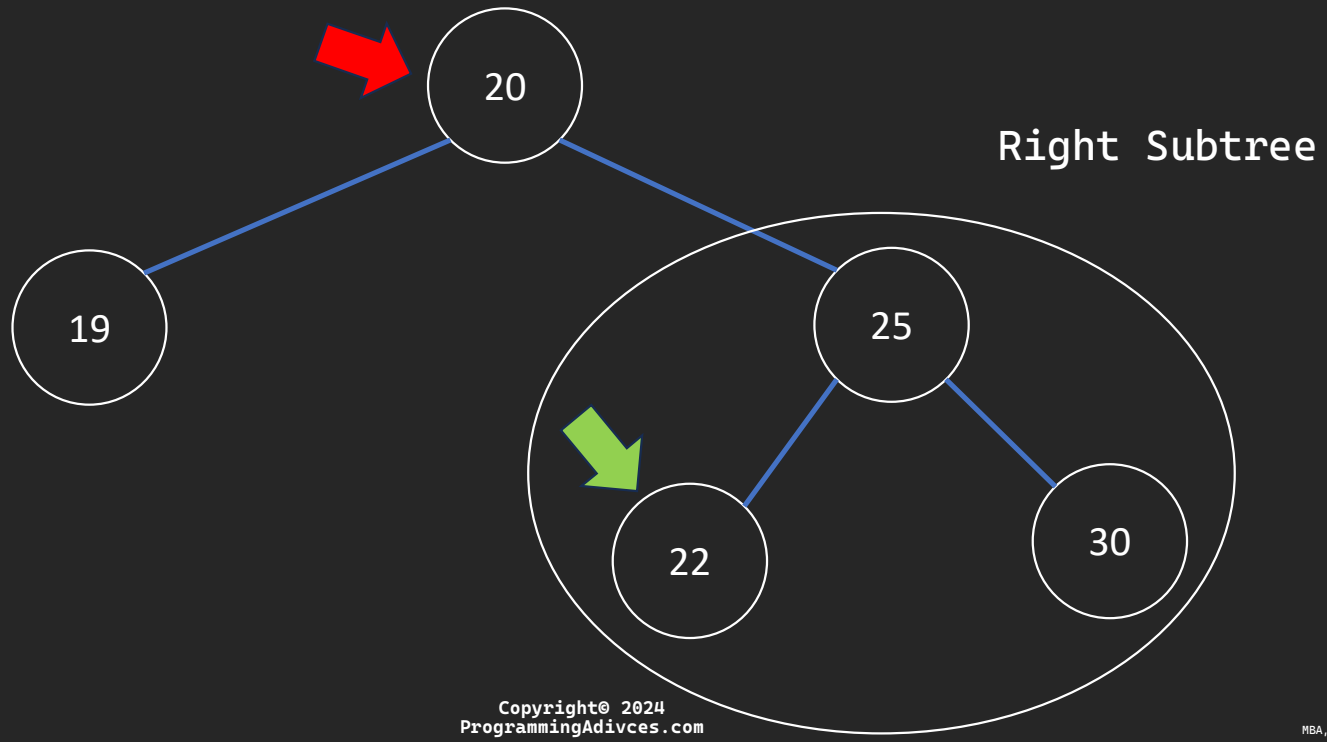
Step 2: Delete Node

Case 3: Node has two children. Find the node's in-order successor (the smallest node in its right subtree), replace the node with this successor, and then delete the successor.



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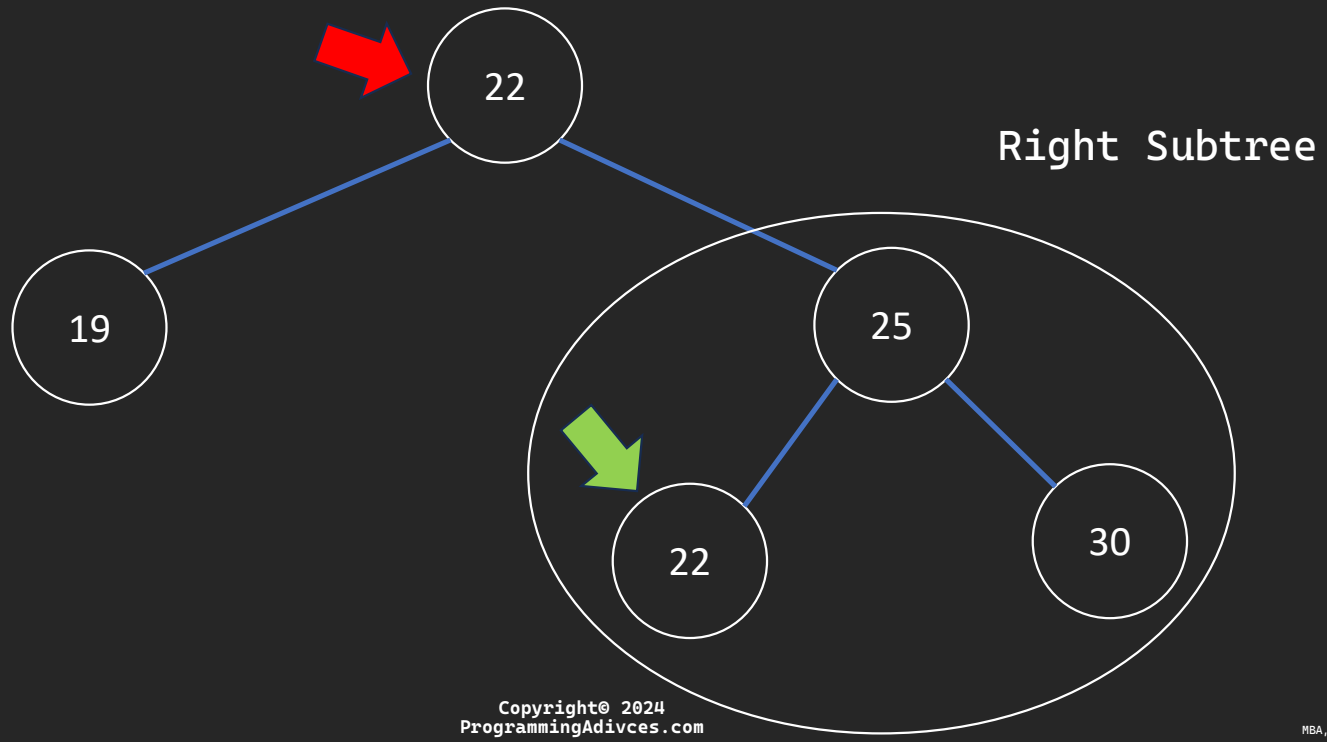

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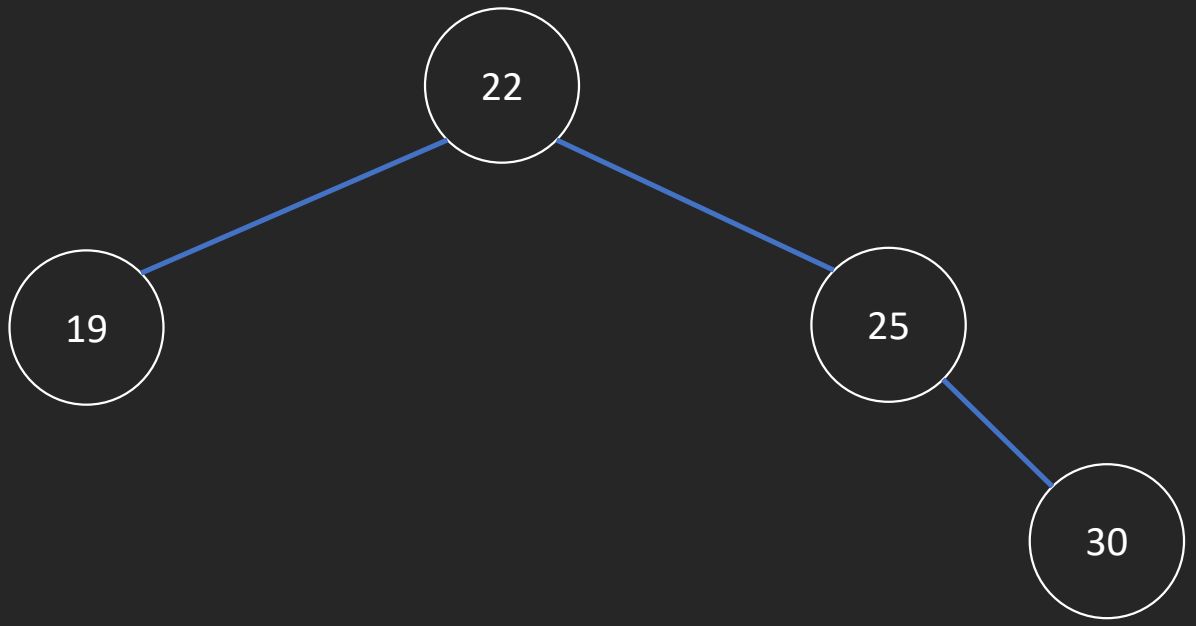

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Step 3: Fix Tree.

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See all Cases

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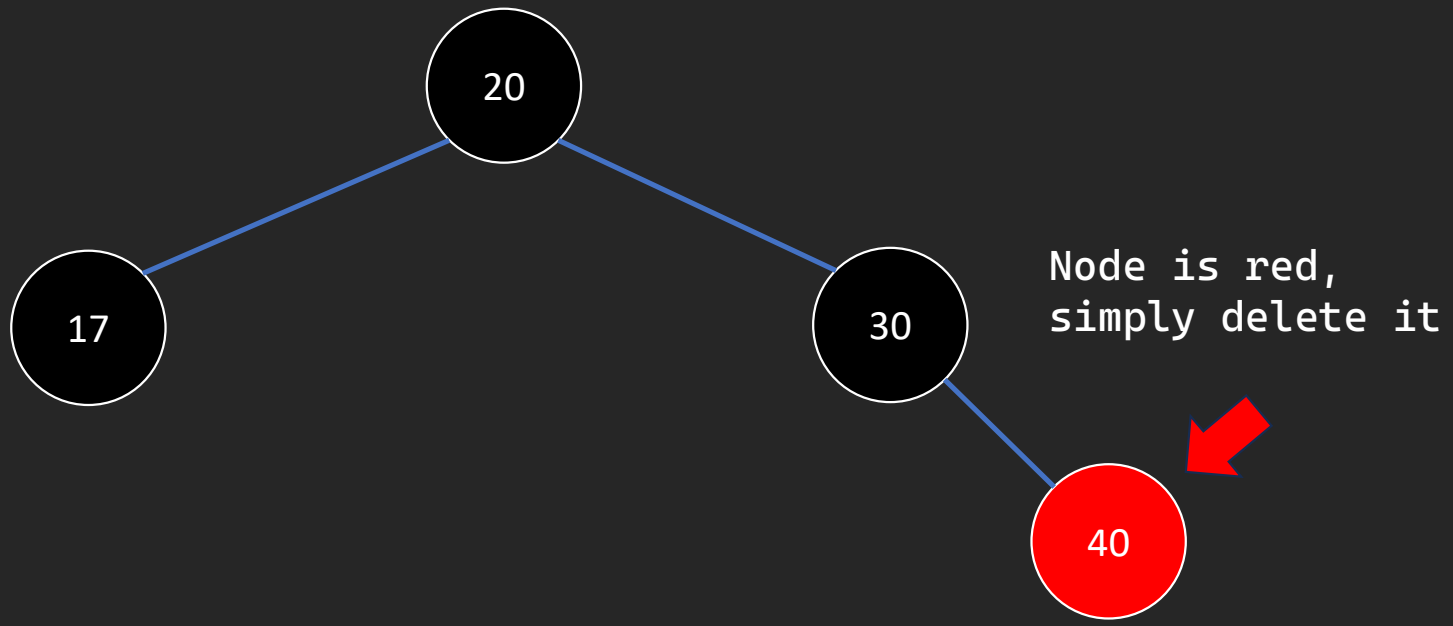
Case 1: No children.



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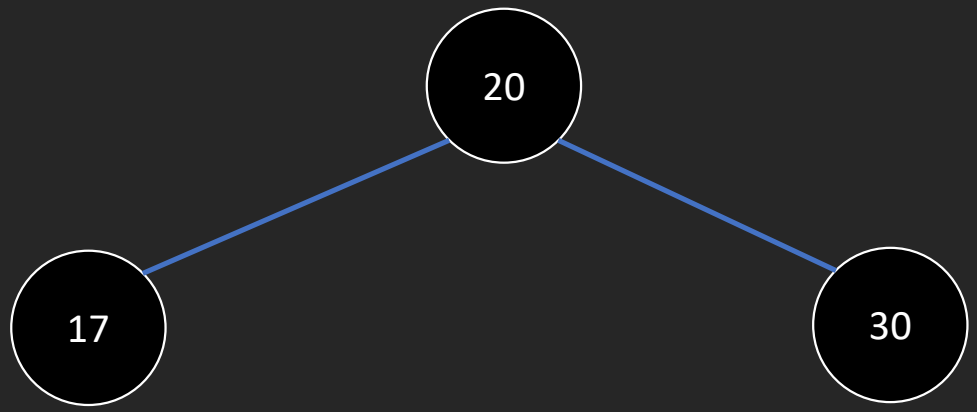

Red Black Tree Properties
are maintained, no fixes.

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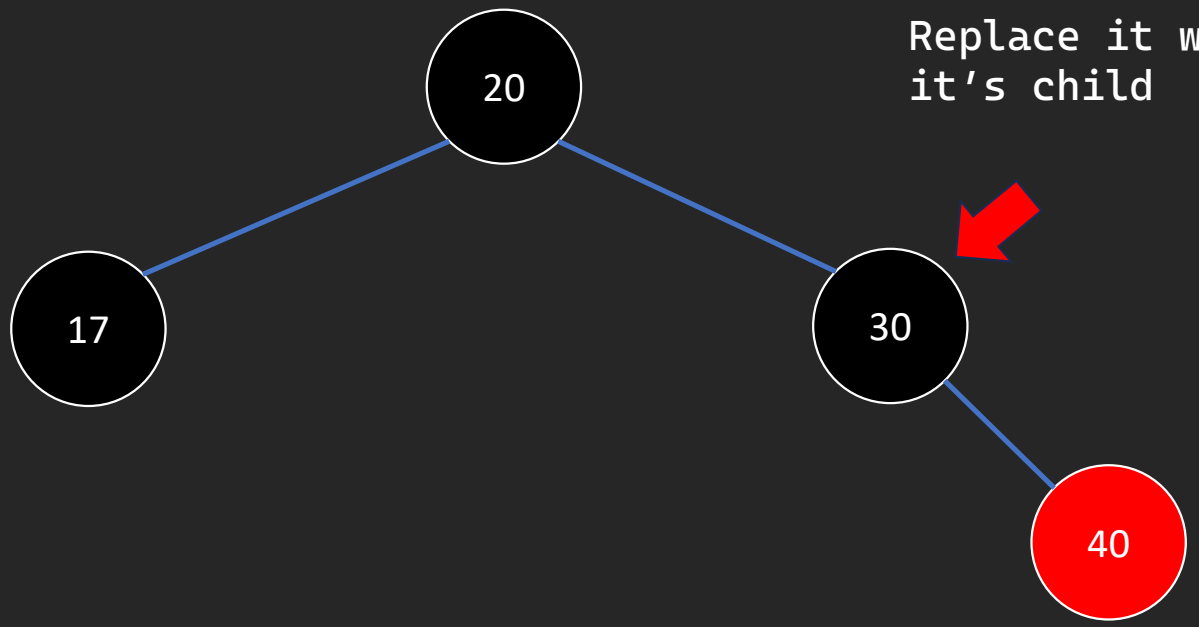
Case 2: one child

We don’t delete internal node
Replace it with
it’s child



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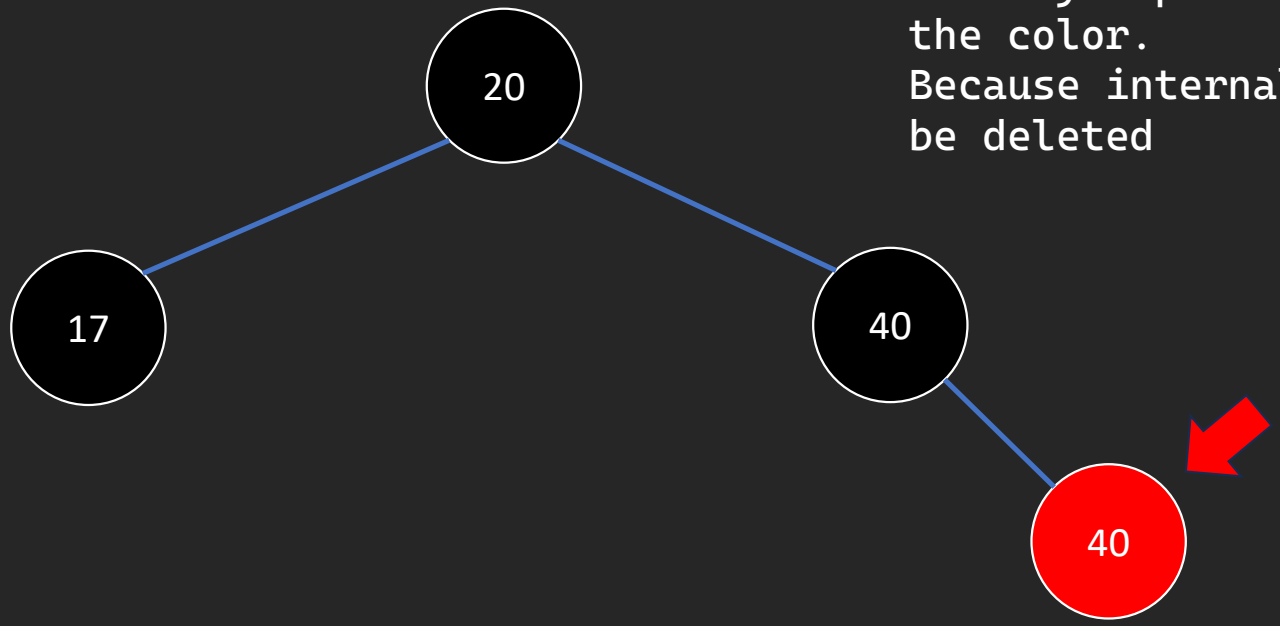
Case 2: one child



We only replace the value not the color.
Because internal node will not be deleted

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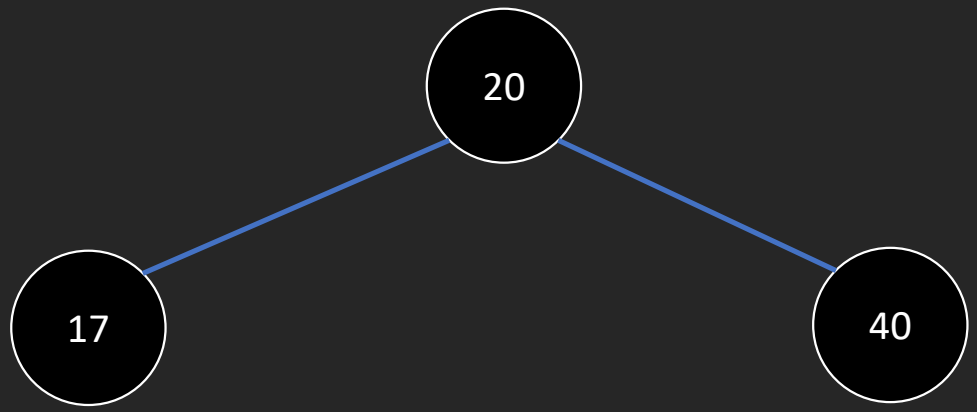
Case 2: one child



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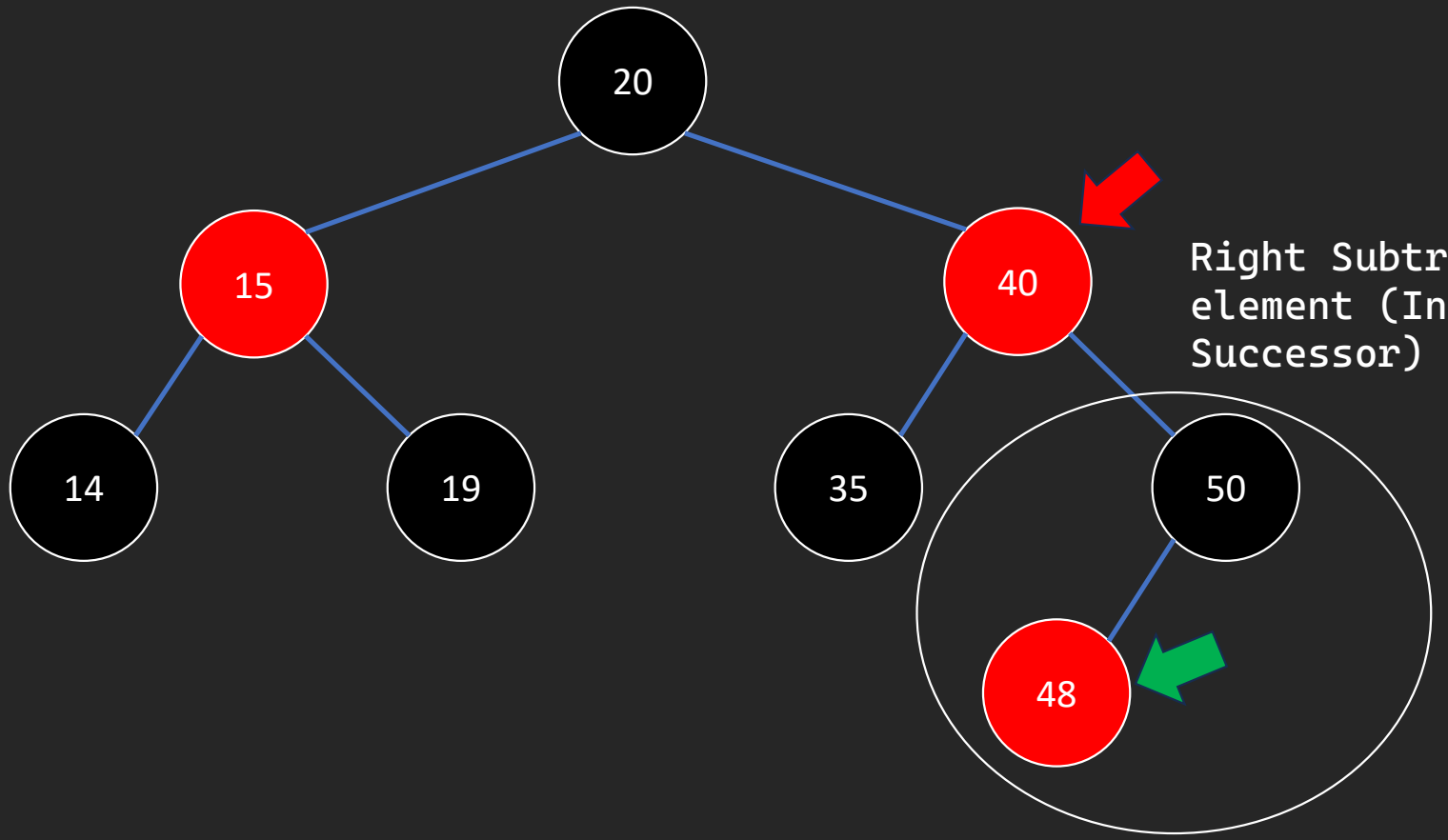
Case 3: Two Children.



Right Subtree, smallest element (In-Order Successor)

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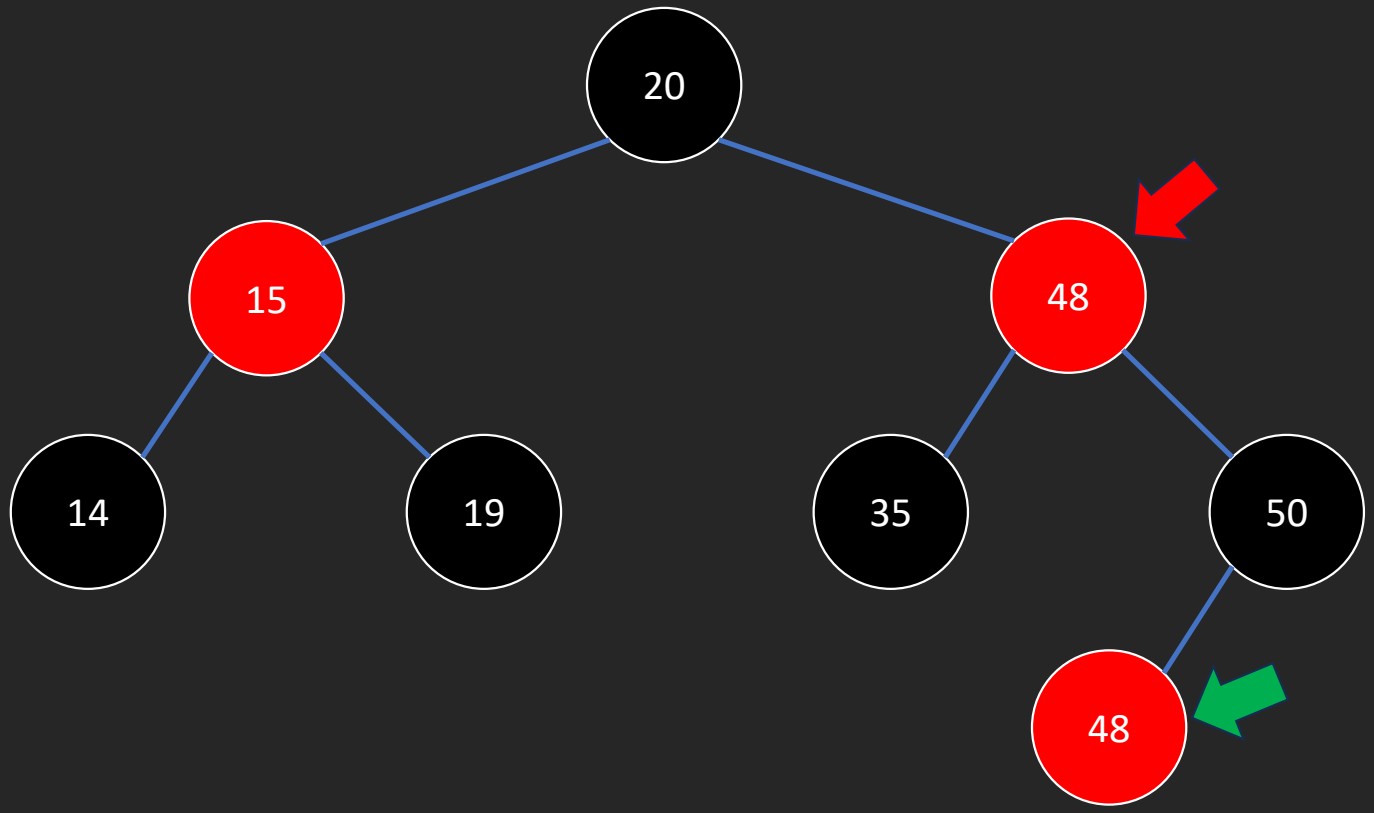
Case 3: Two Children.



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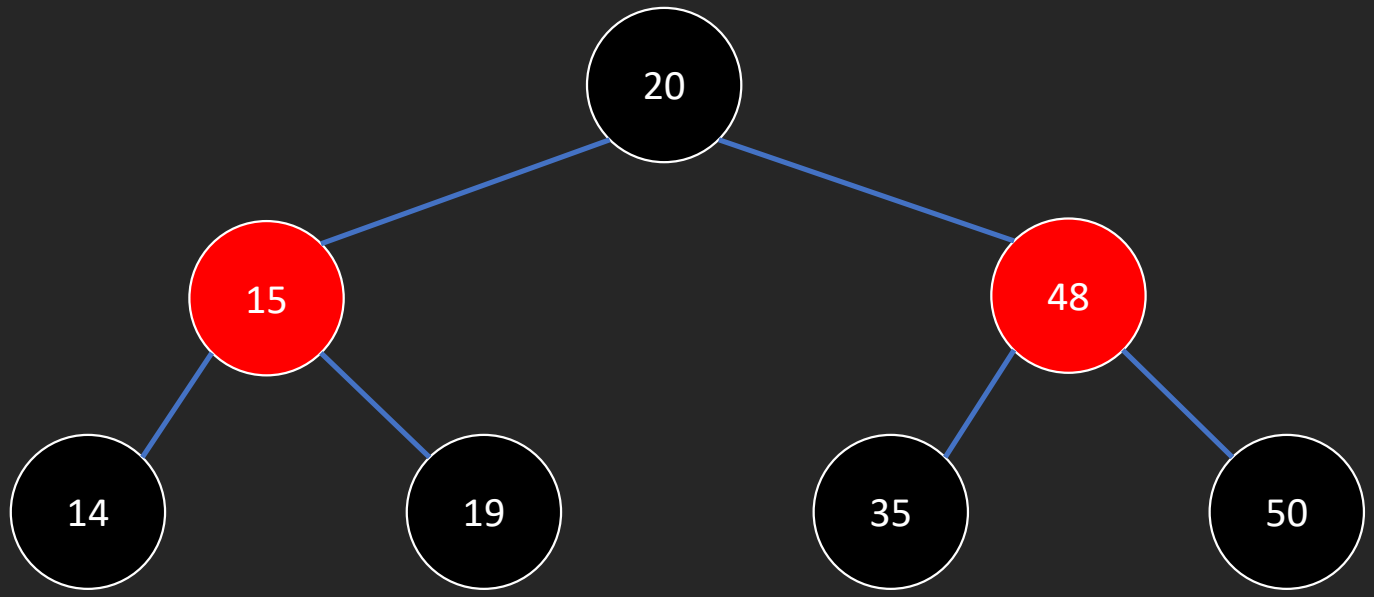

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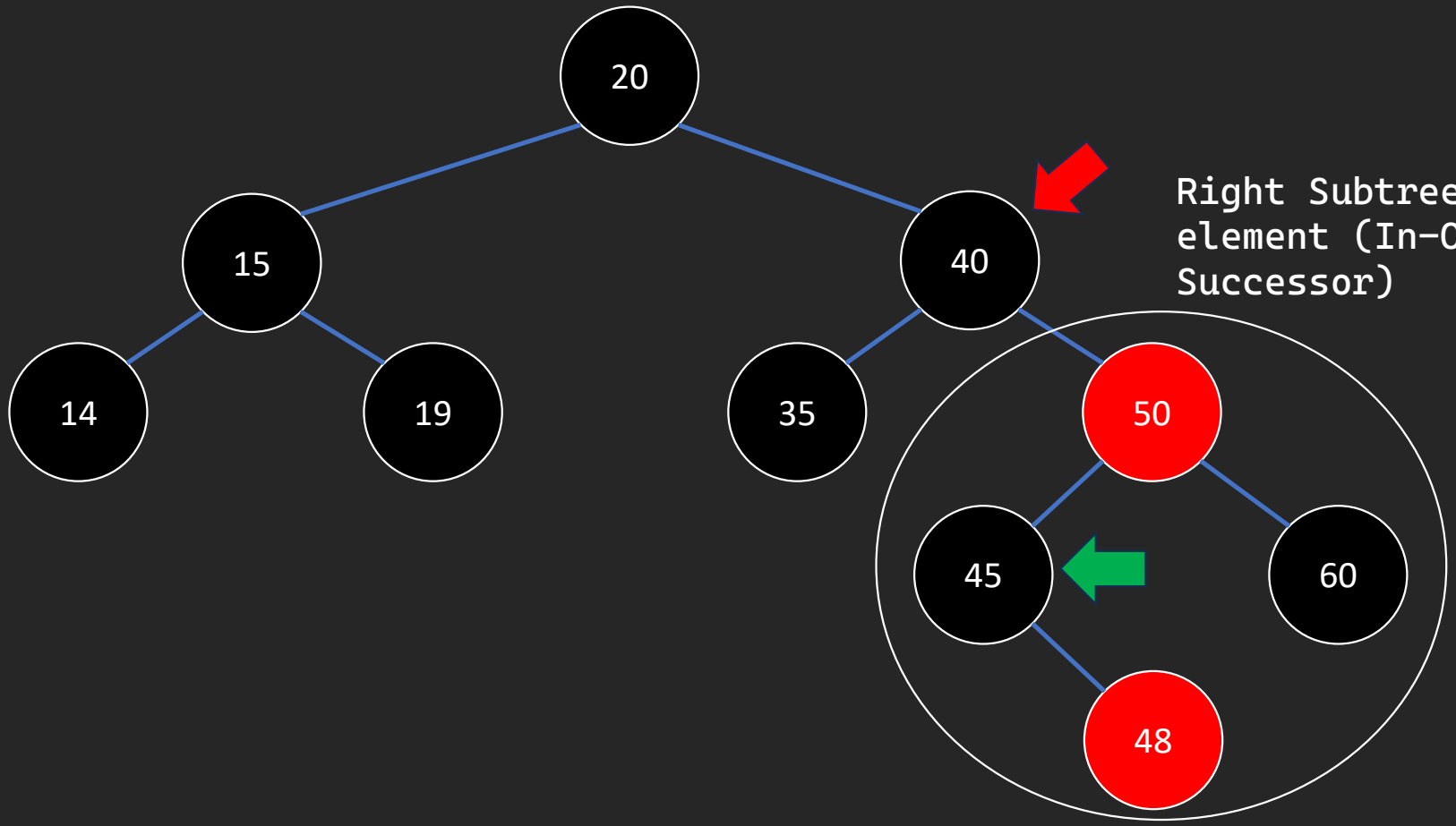
Case 3: Example 2, Two Children.



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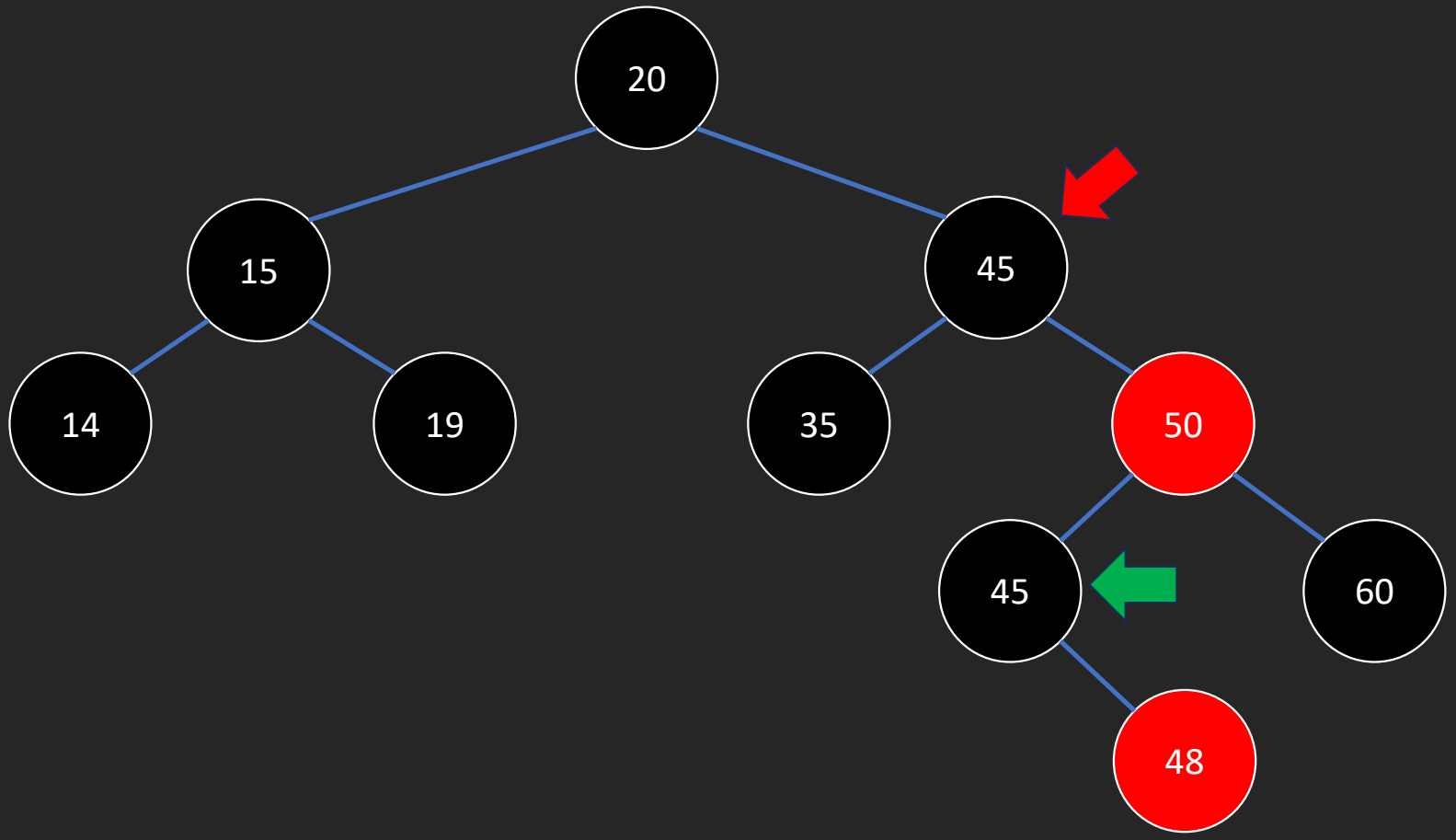

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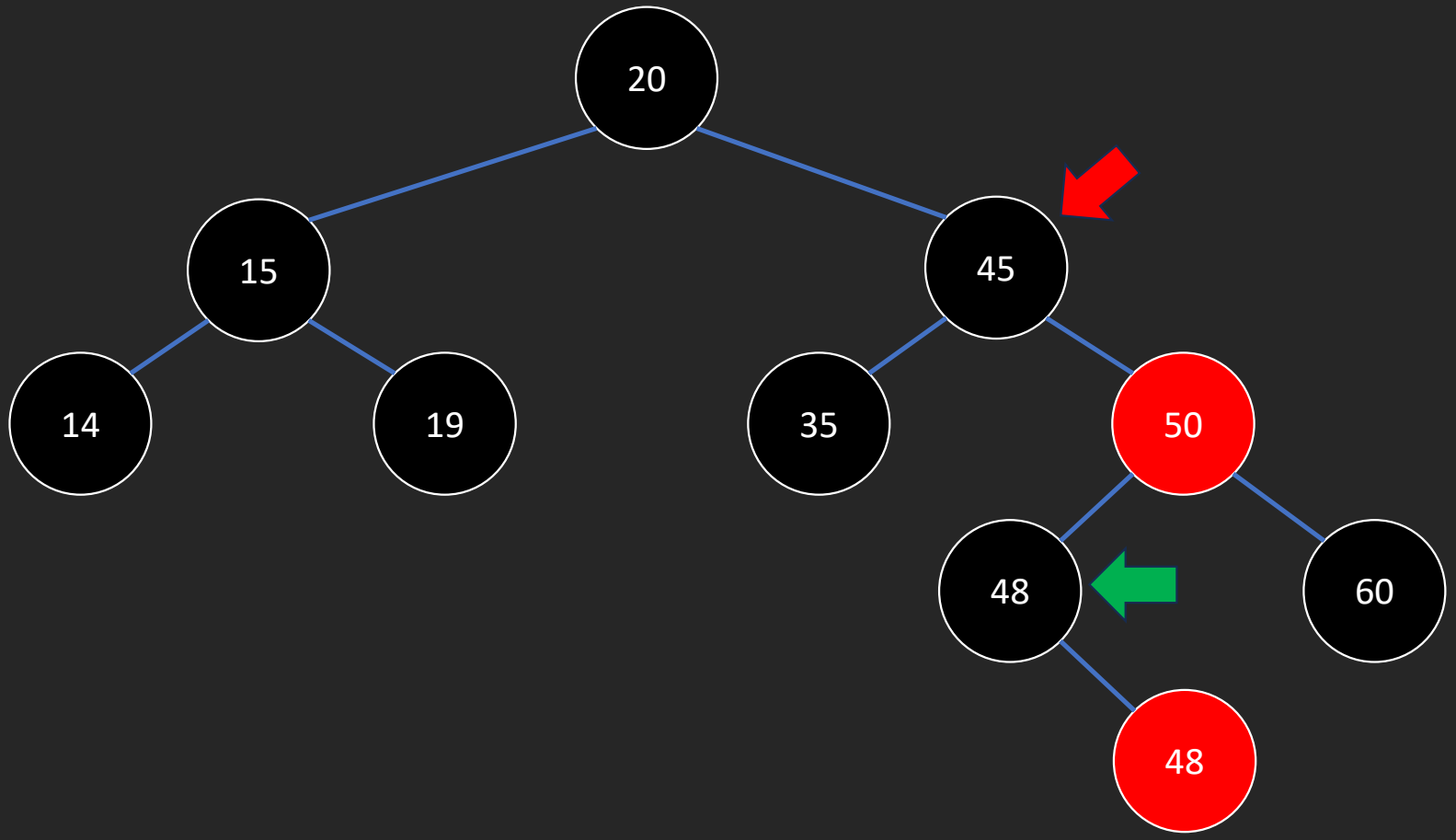

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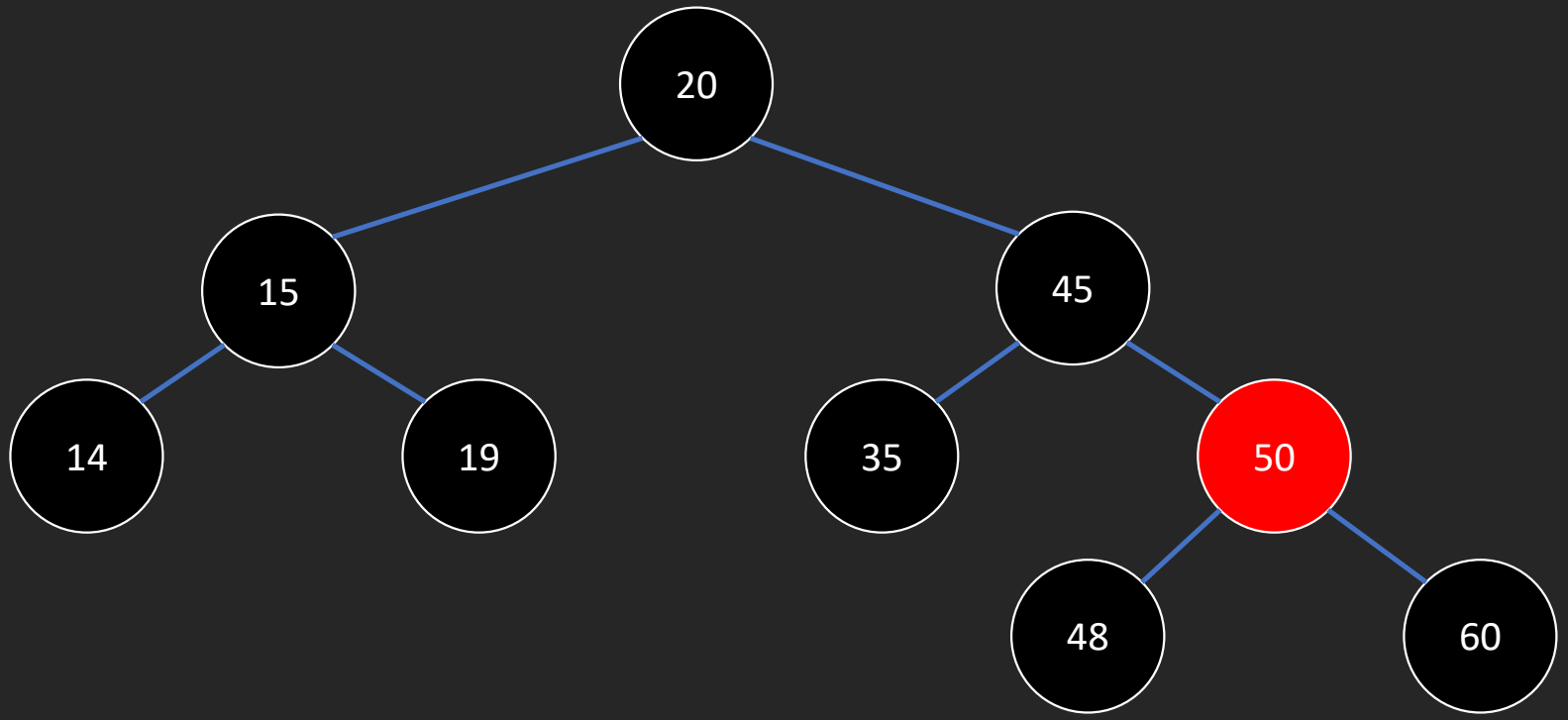

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What if RB Properties are not maintained? We need to Fix. In the next lesson.

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