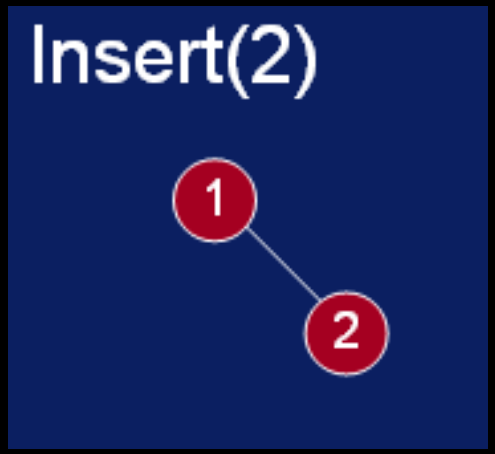
Lecture # 13

AVL Tree Building Example

AVL Tree Building Example



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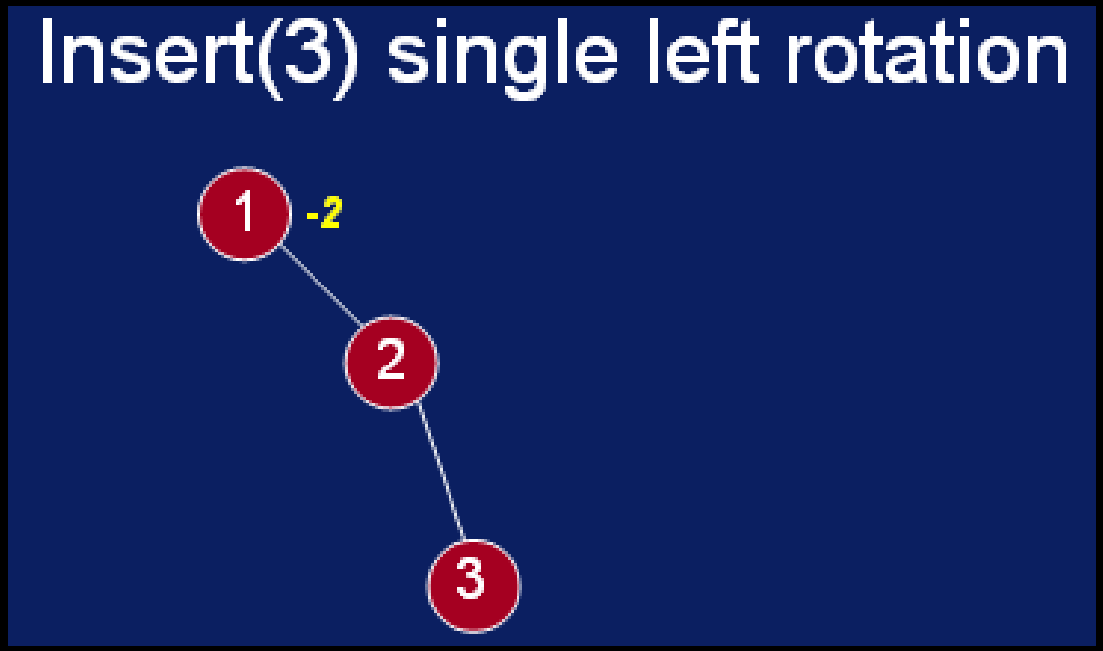

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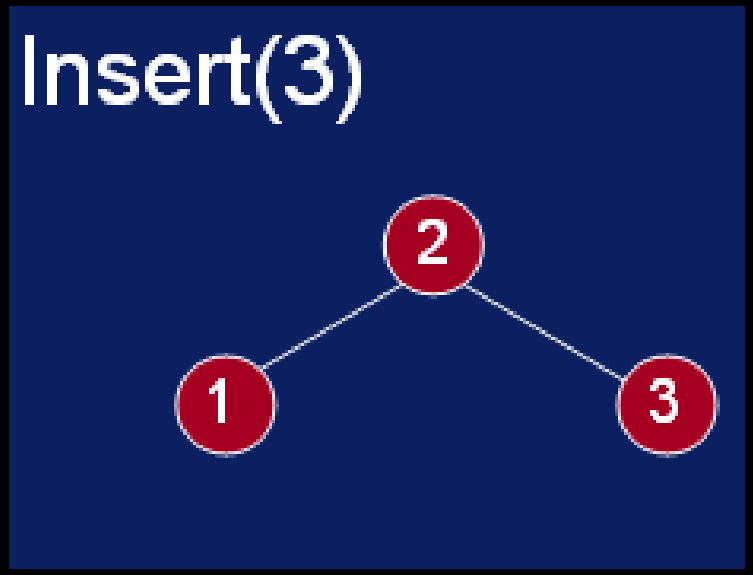

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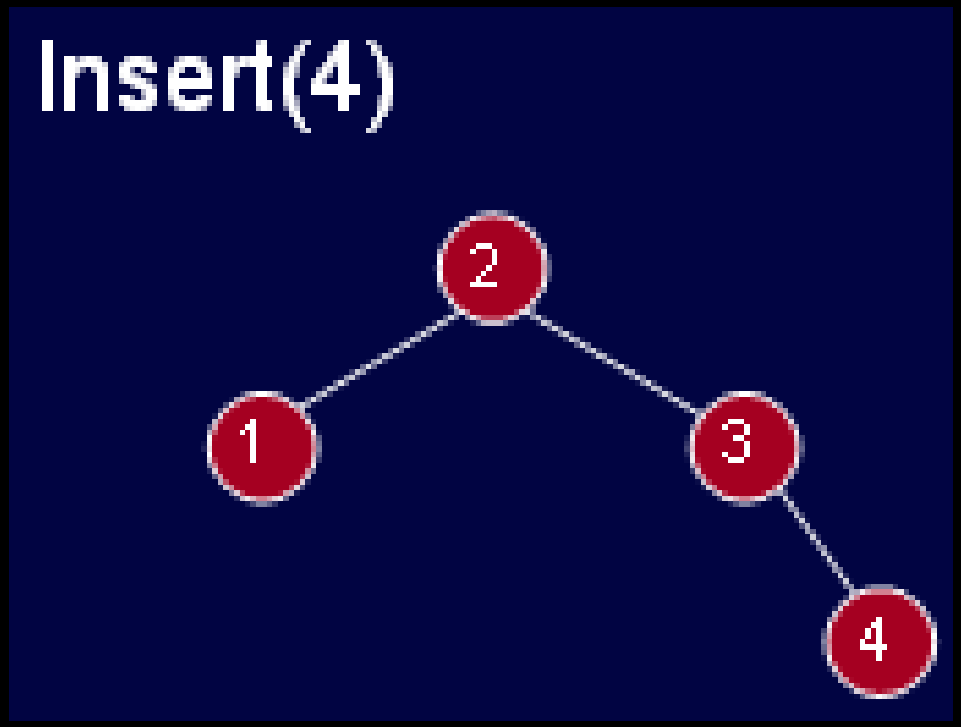

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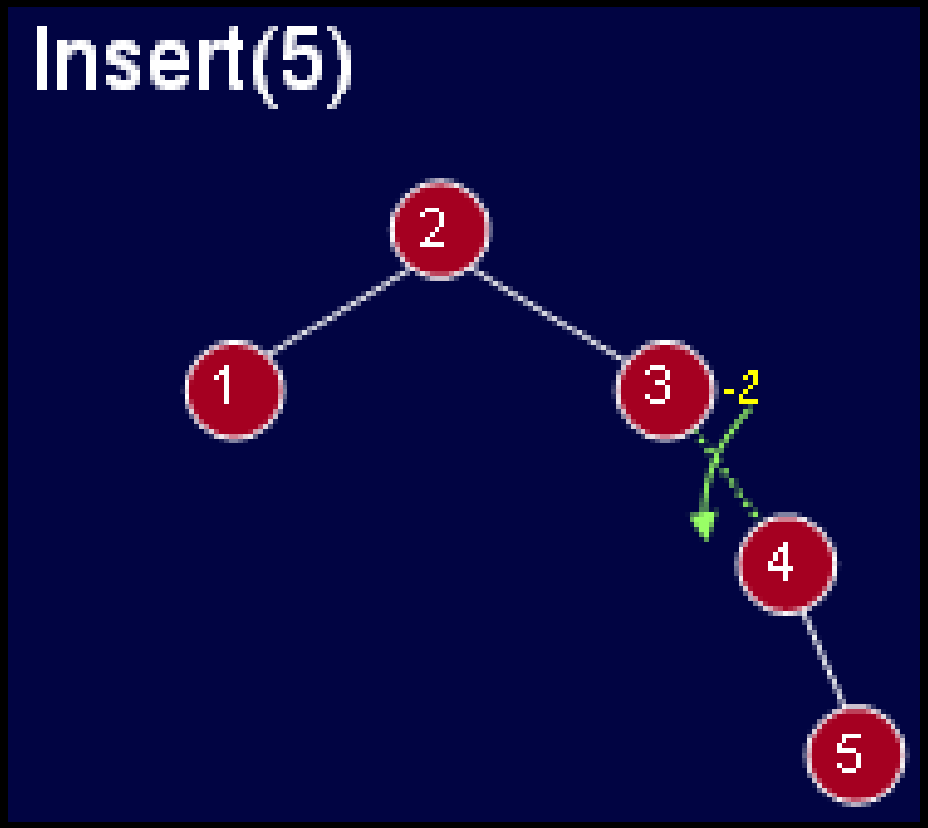

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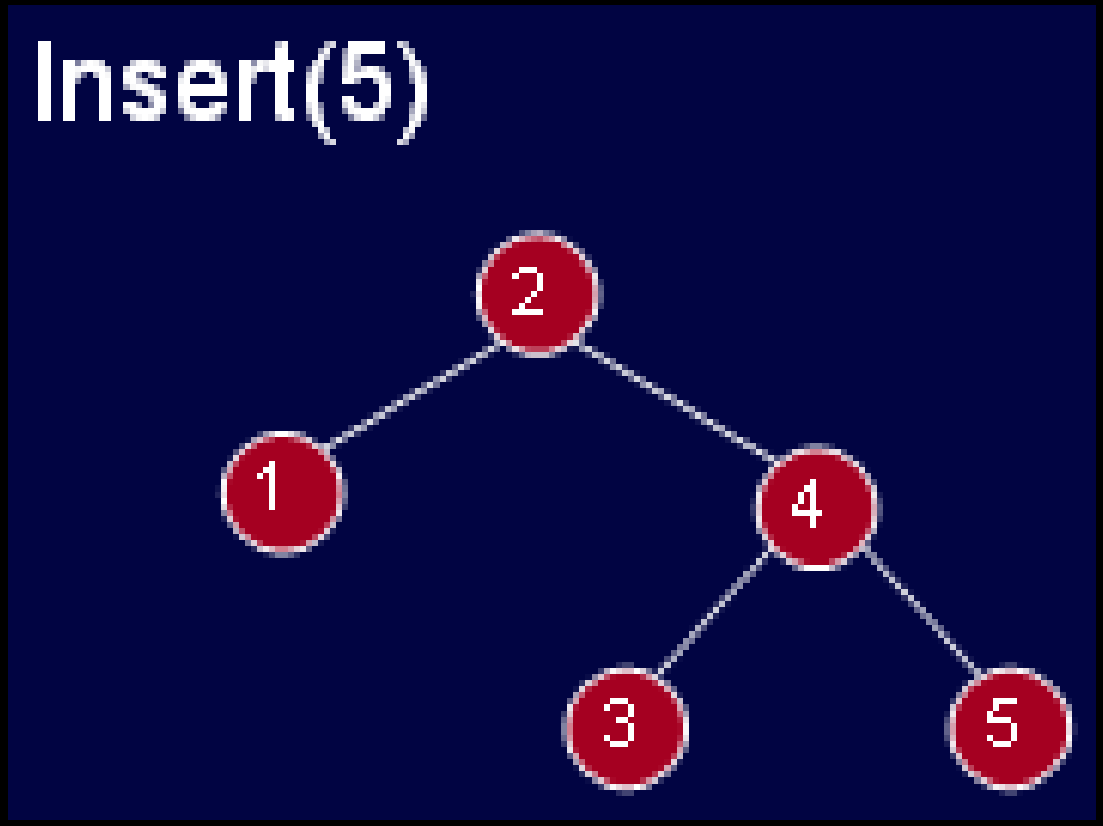

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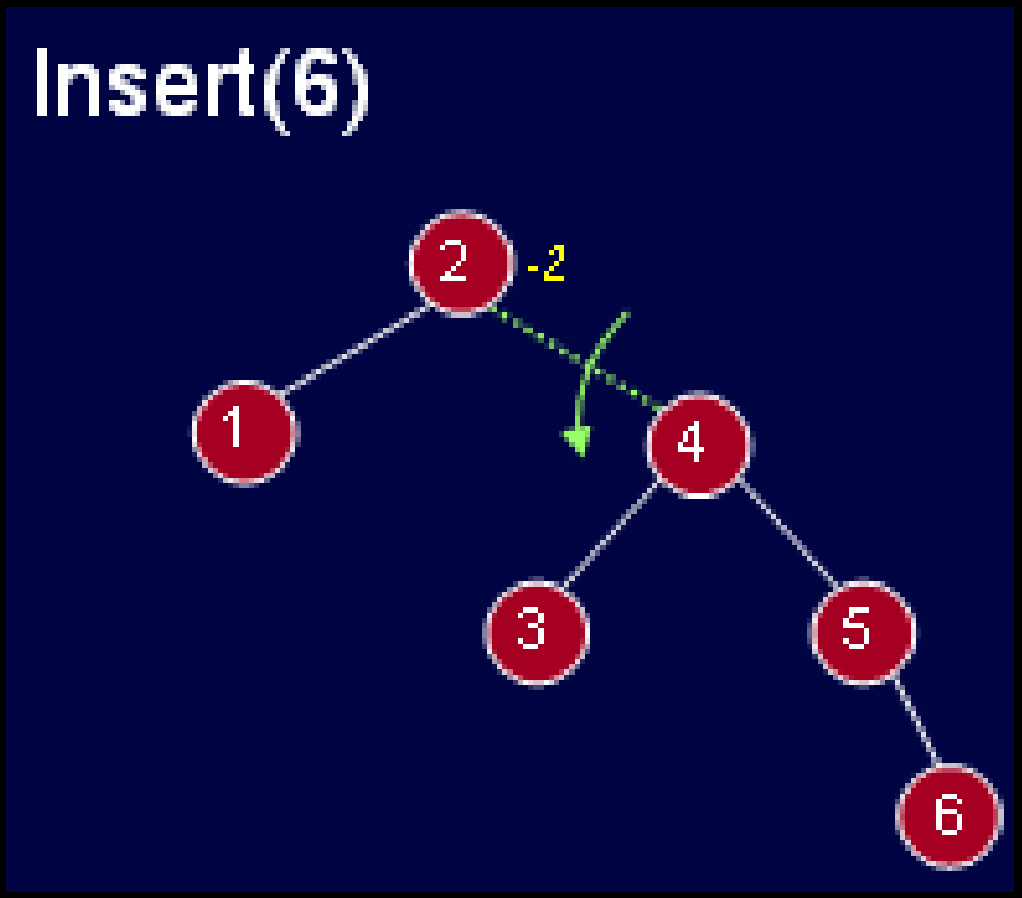

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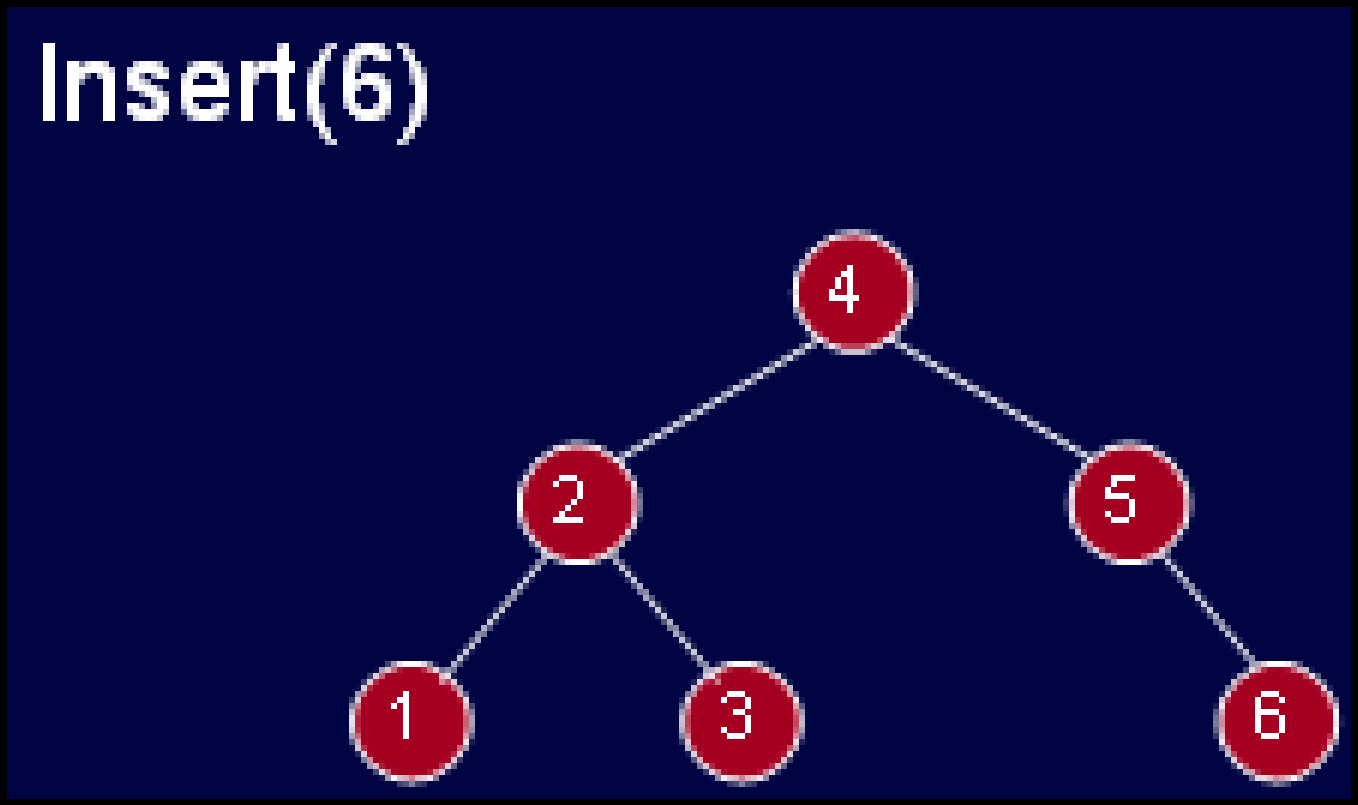

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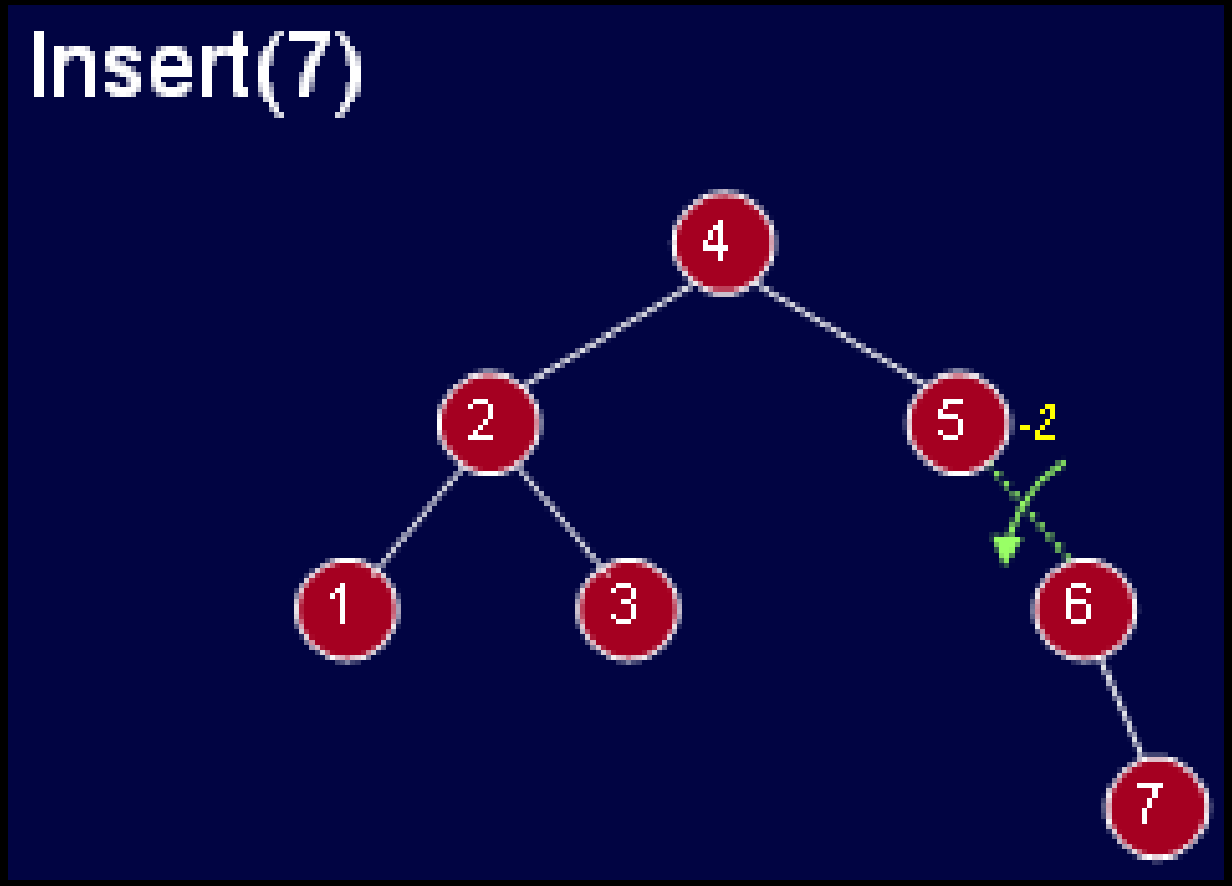

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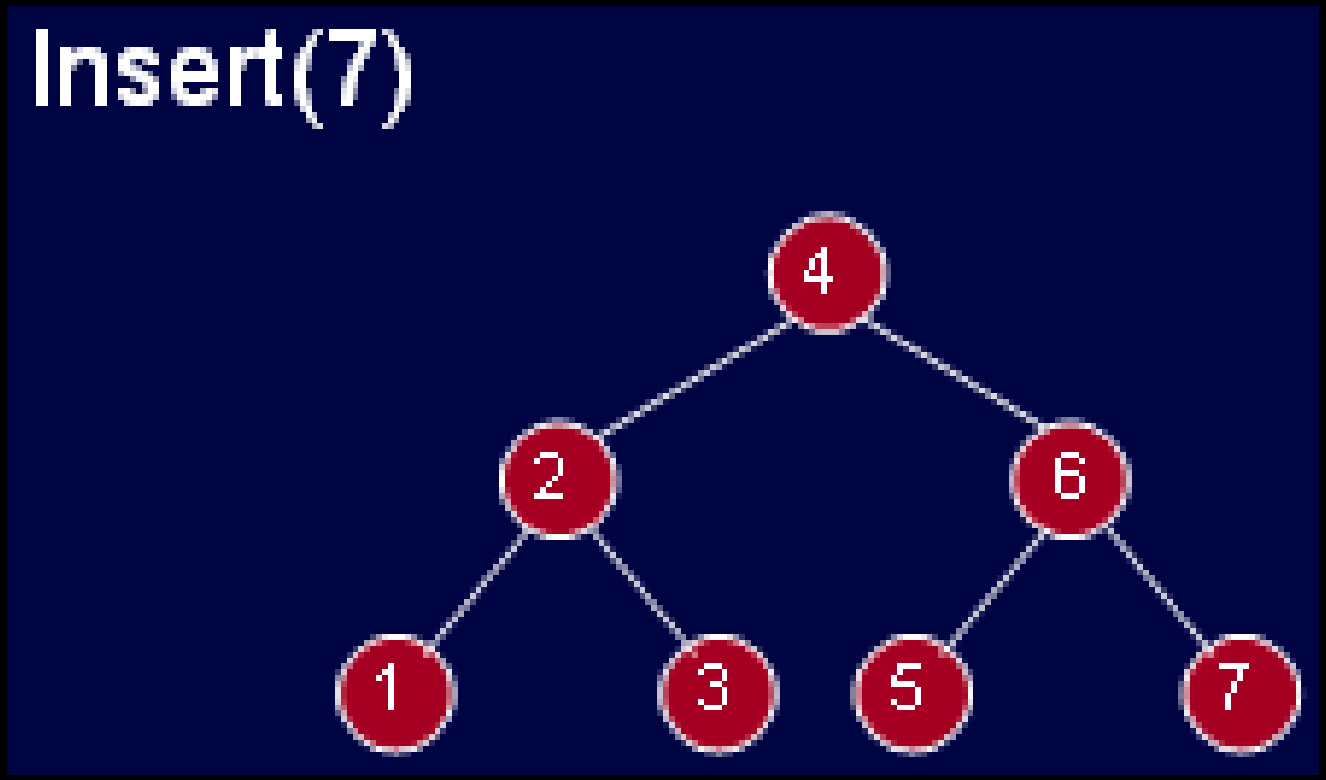

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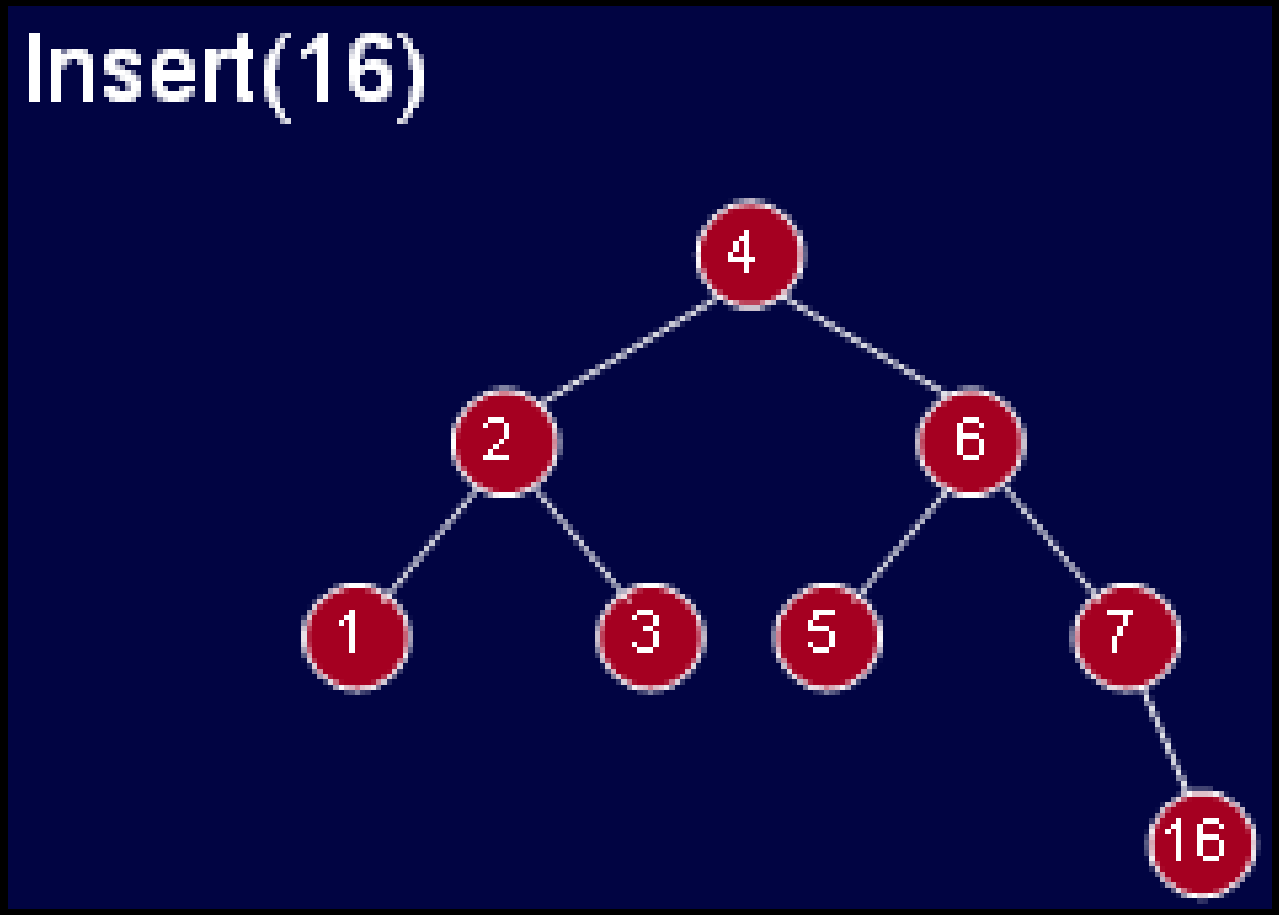

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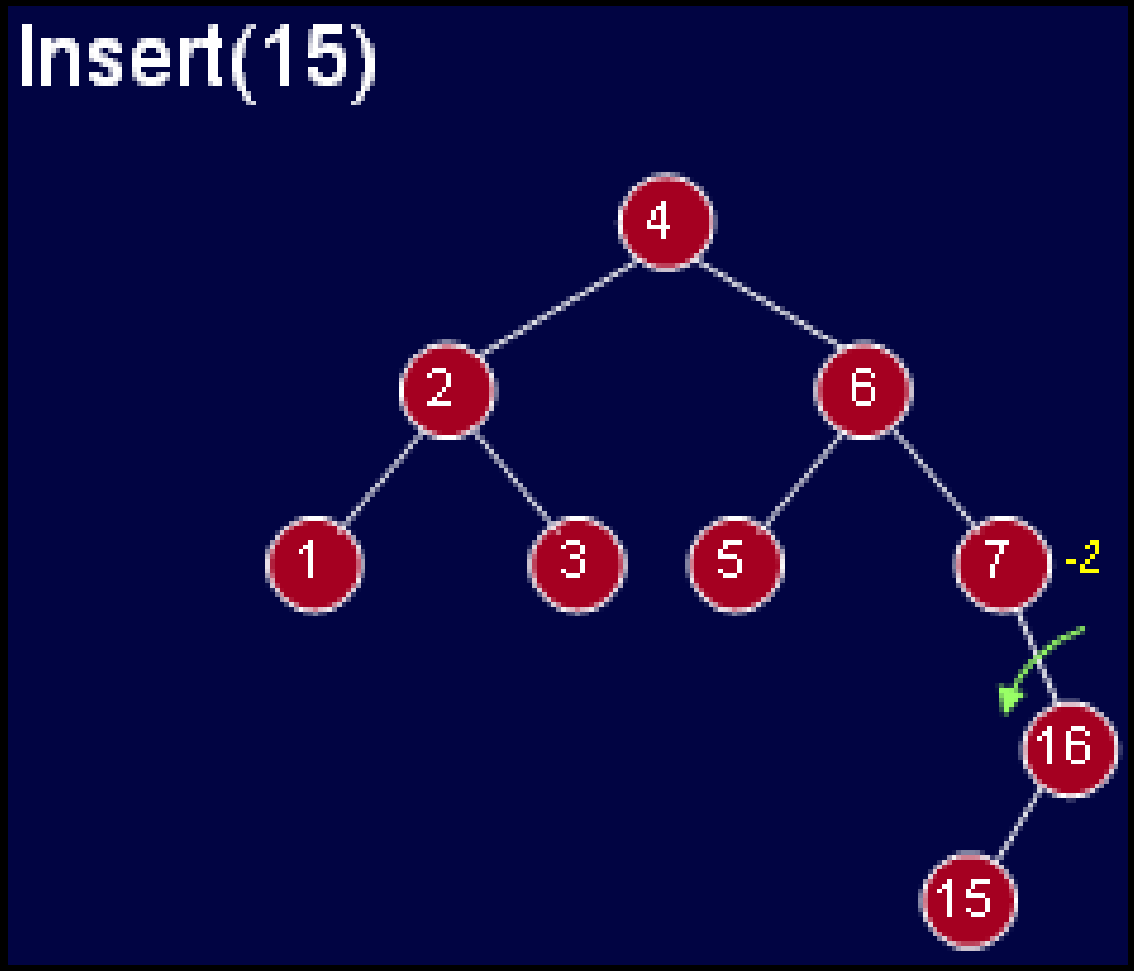

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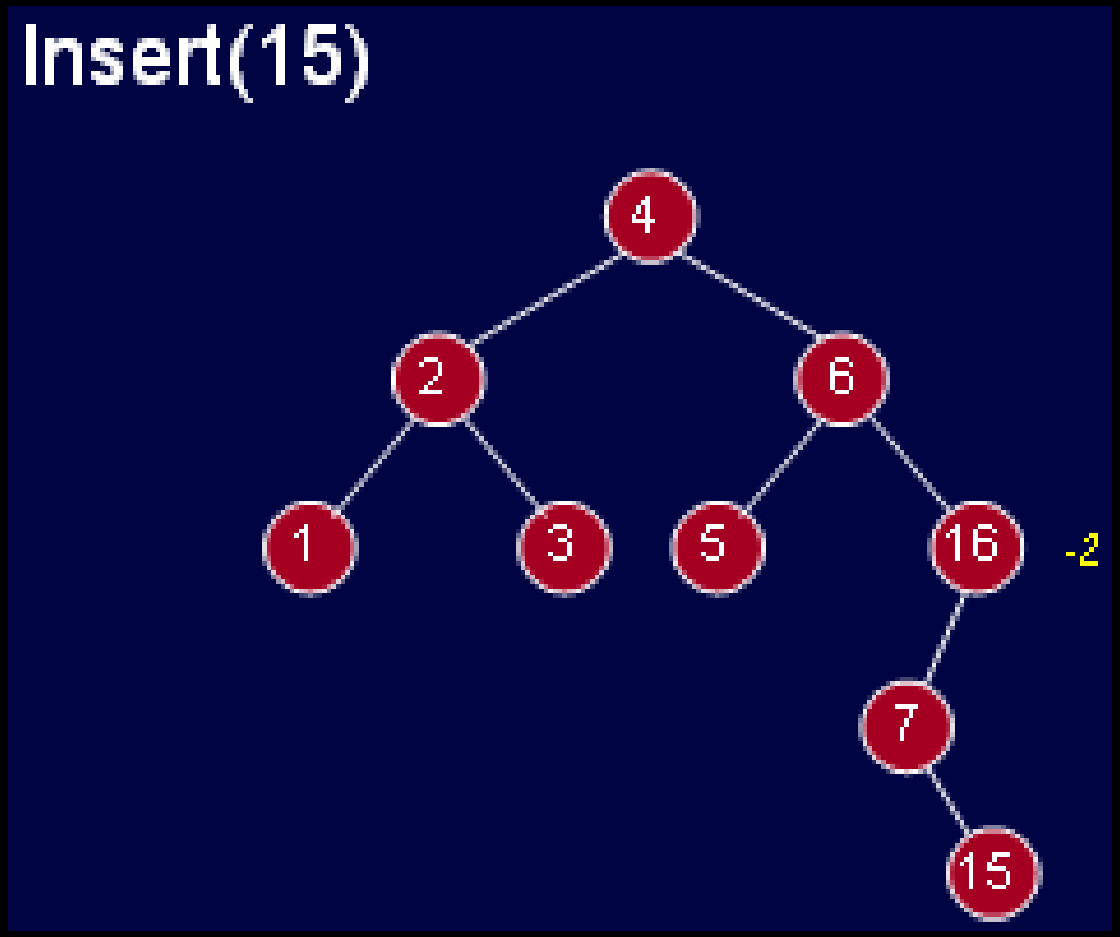


Cases for Rotation

- Single rotation does not seem to restore the balance.
- The problem is the node 15 is in an inner subtree that is too deep.
- Let us revisit the rotations.

Cases for Rotation

- Let us call the node that must be rebalanced Ň.
- Since any node has at most two children, and a height imbalance requires that Ň's two subtrees differ by two (or –2), the violation will occur in four cases:

Cases for Rotation

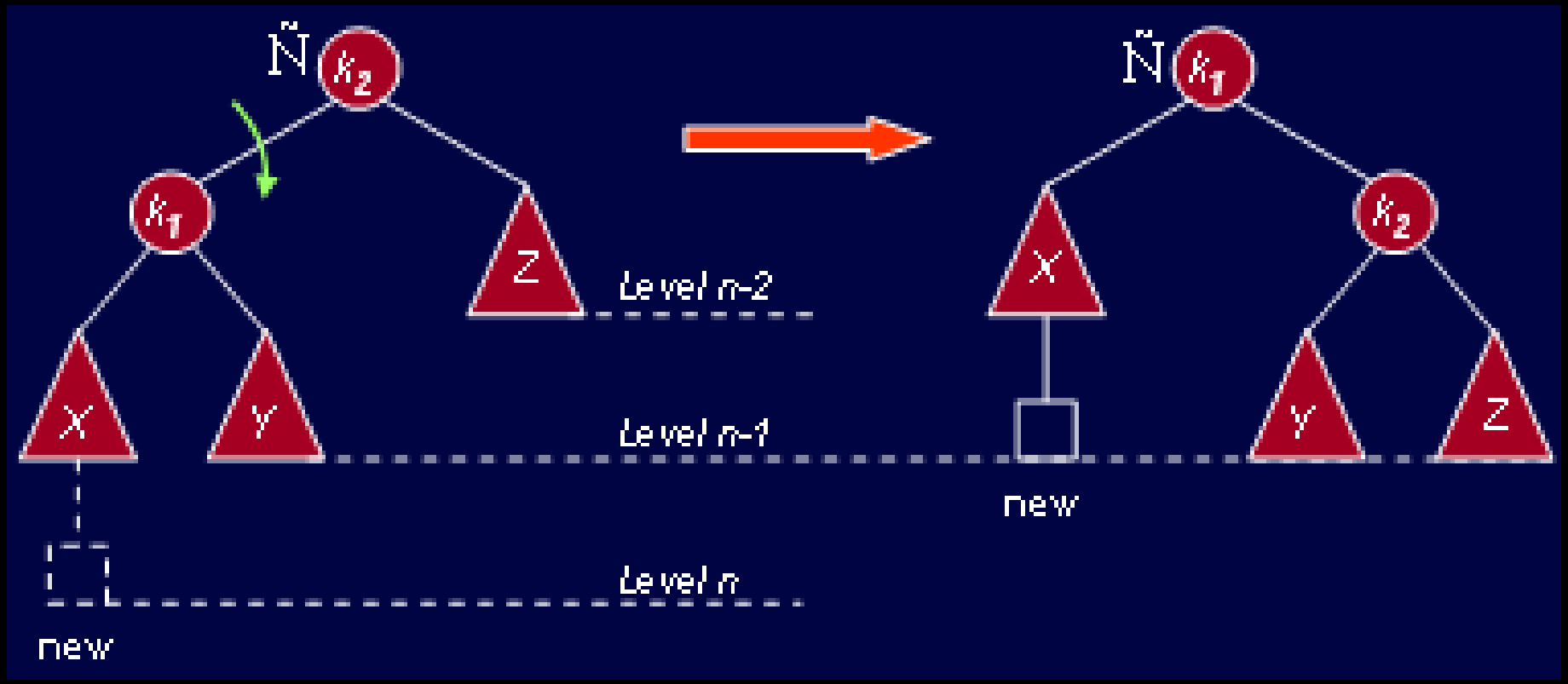
- An insertion into left subtree of the left child of Ň.
- An insertion into right subtree of the left child of Ň.
- An insertion into left subtree of the right child of Ň.
- An insertion into right subtree of the right child of Ň.

Cases for Rotation

- The insertion occurs on the "outside" (i.e., left-left or right-right) in cases 1 and 4
- Single rotation can fix the balance in cases 1 and 4.
- Insertion occurs on the "inside" in cases 2 and 3 which single rotation cannot fix.

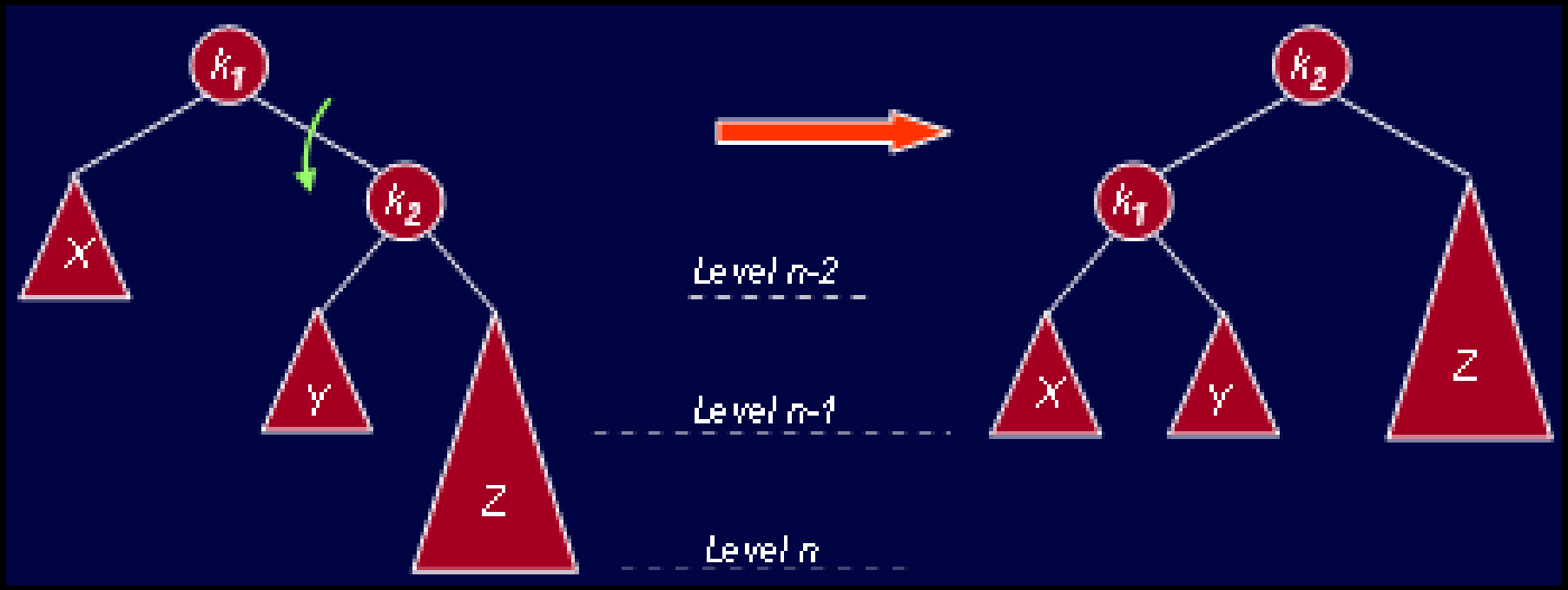
Cases for Rotation

- Single right rotation to fix case 1.



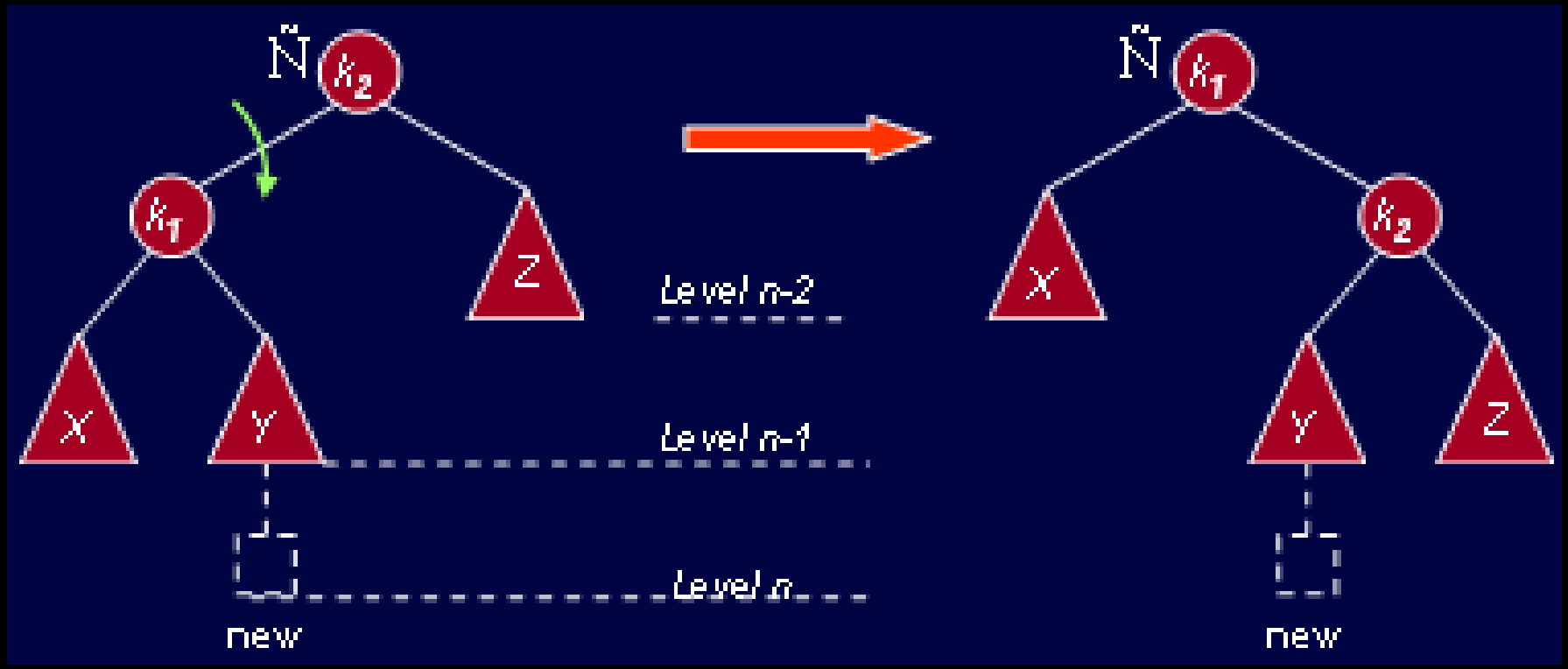
Cases for Rotation

- Single left rotation to fix case 4.

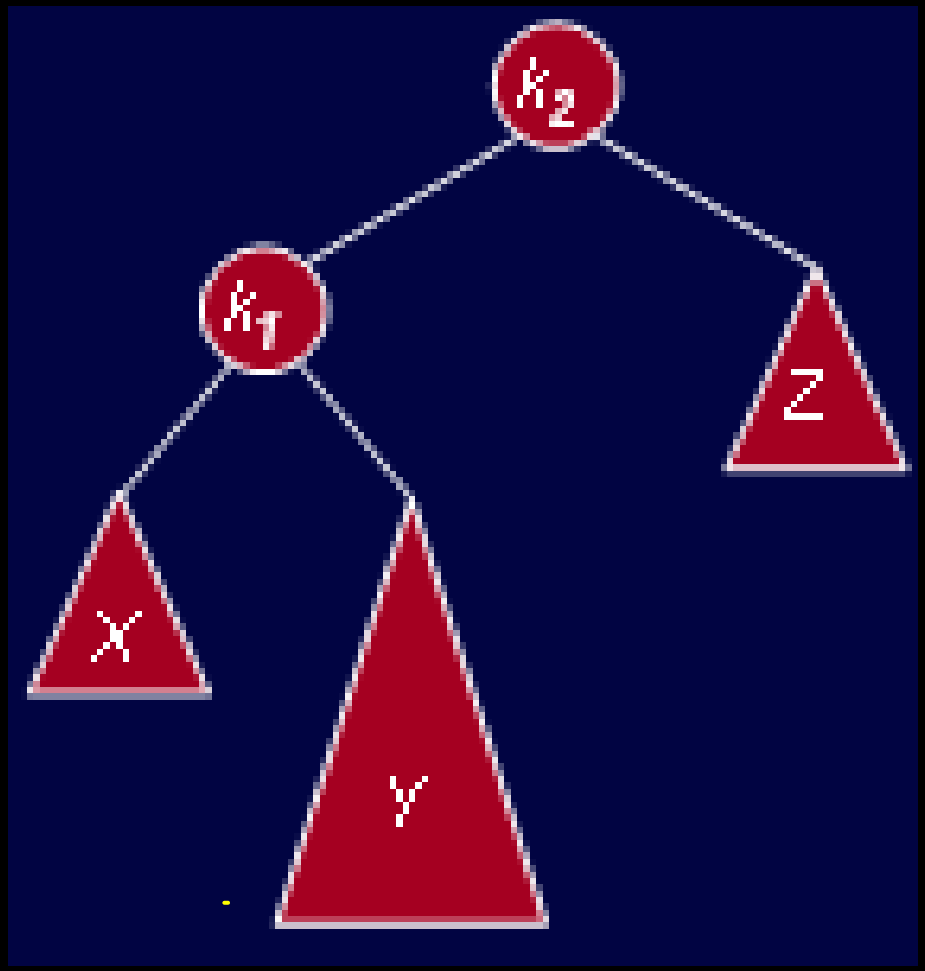


Cases for Rotation

- Single right rotation *fails* to fix case 2.

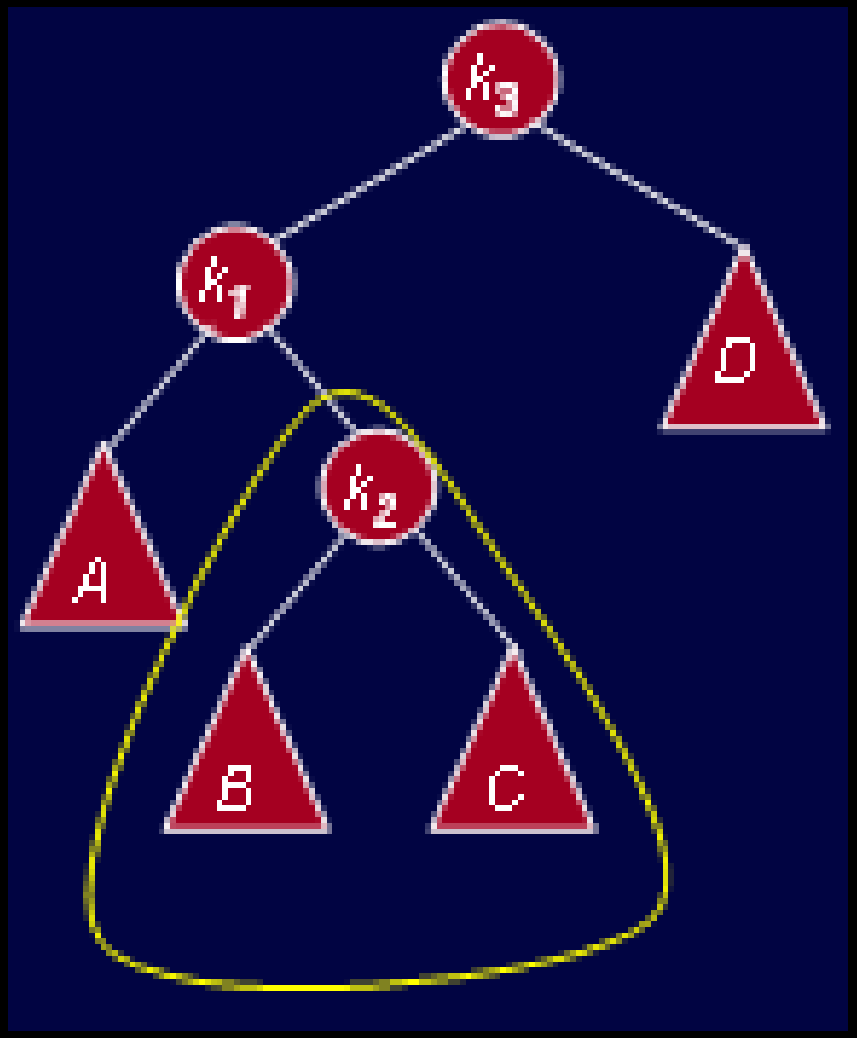


Cases for Rotation



- Y is non-empty because the new node was inserted in Y.
- Thus Y has a root and two subtrees.
- View the entire tree with four subtrees connected with 3 nodes.

Cases for Rotation



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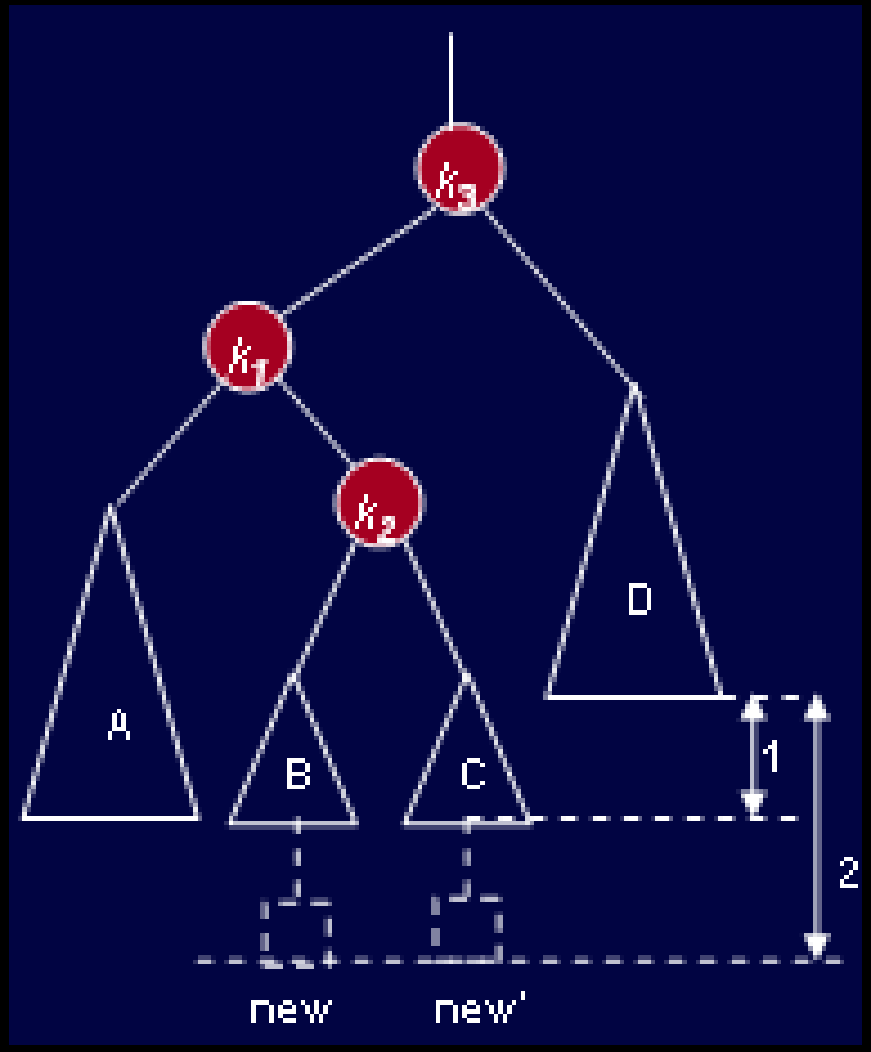
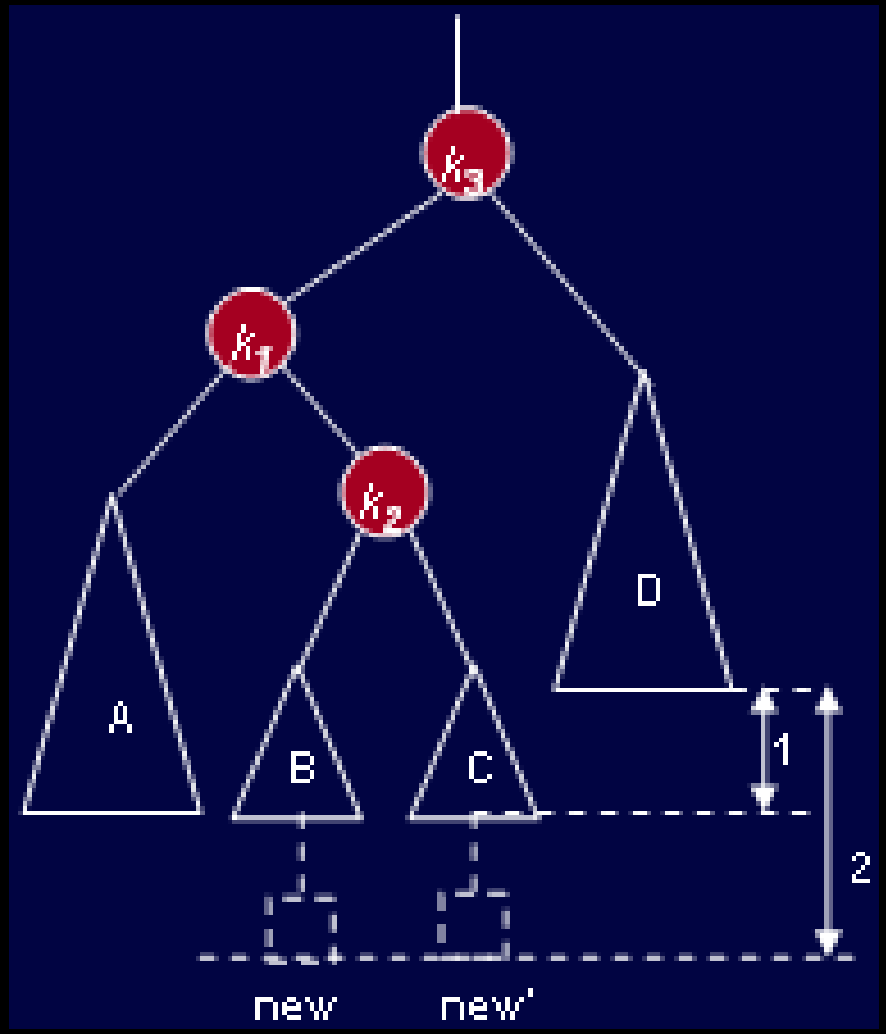
Cases for Rotation



- Exactly one of tree *B* or *C* is two levels deeper than *D*; we are not sure which one.
- Good thing: it does not matter where it is added.
- To rebalance, *k3* cannot be left as the root.

New node inserted at either of the two spots

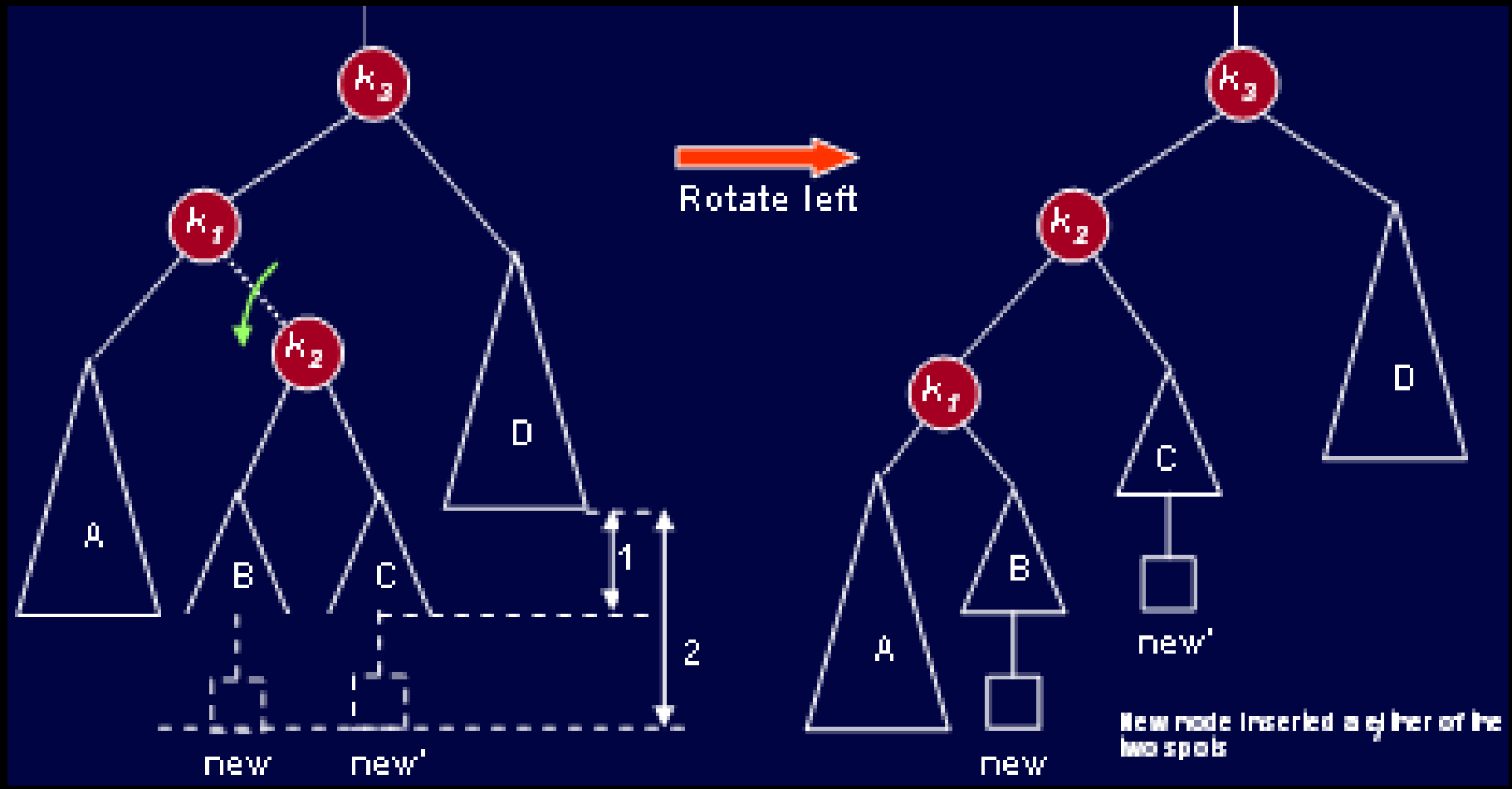
Cases for Rotation



- A rotation between *k3* and *k1* (*k3* was *k2* then) was shown to not work.
- The only alternative is to place *k2* as the new root.
- This forces *k1* to be *k2*'s left child and *k3* to be its right child.

Cases for Rotation

- Left-right *double* rotation to fix case 2.



Cases for Rotation

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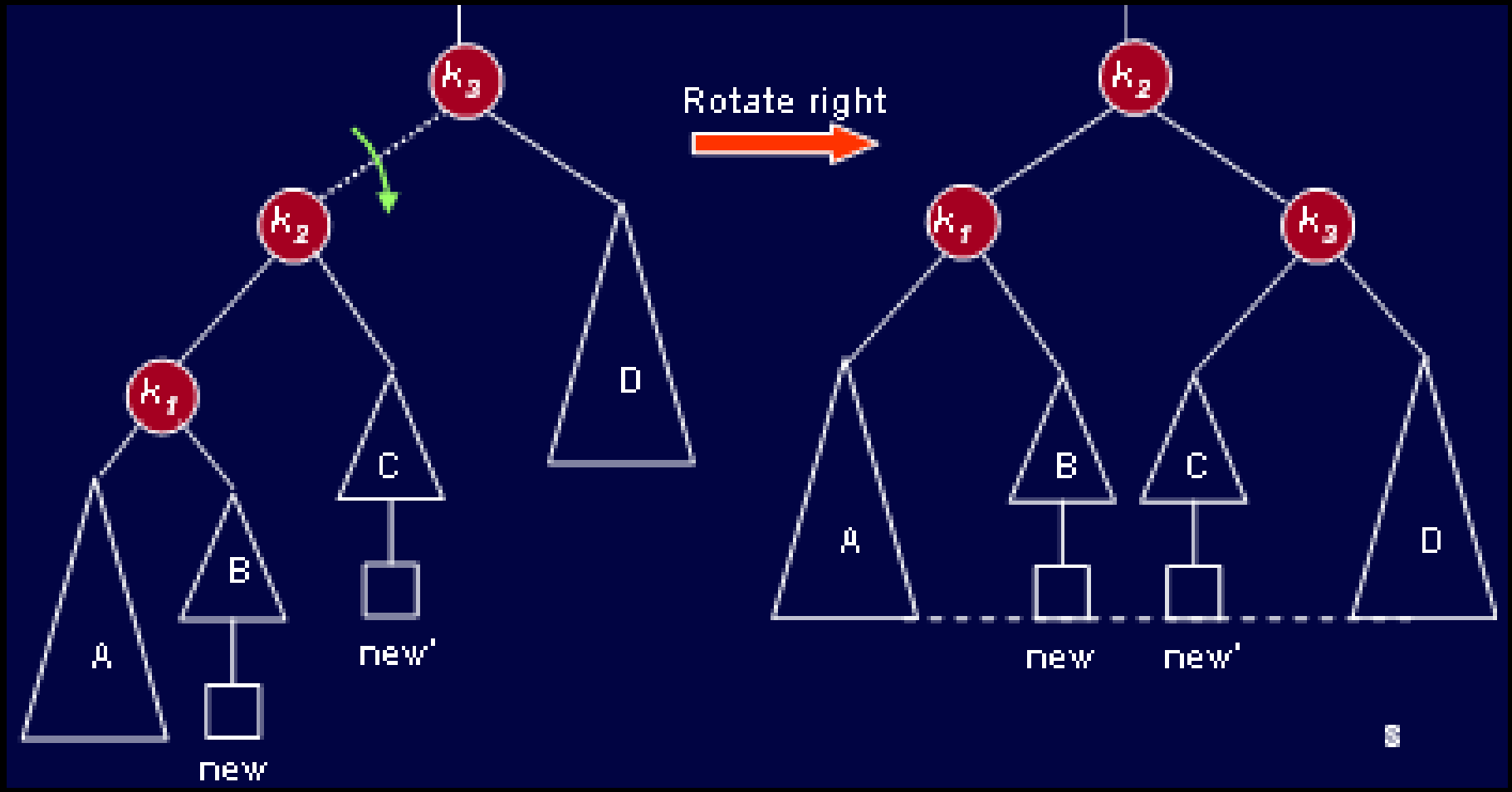
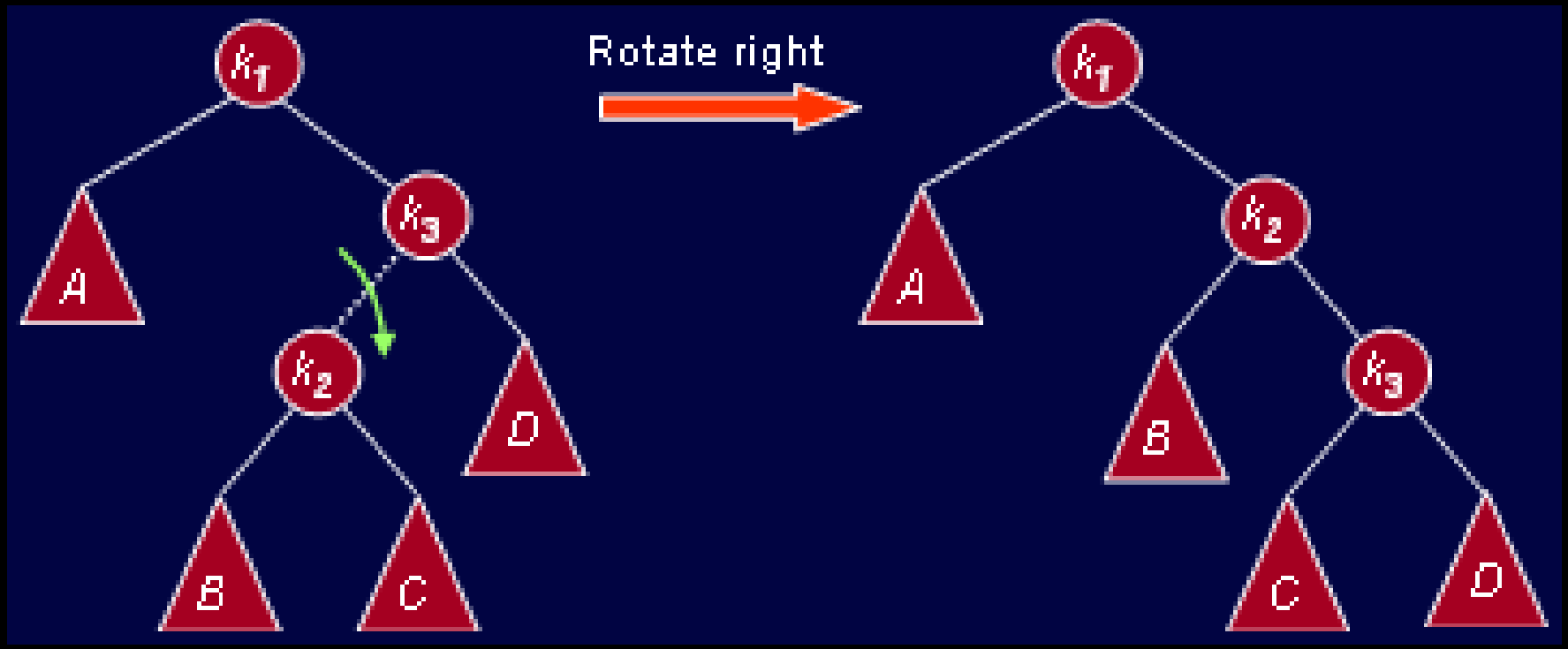


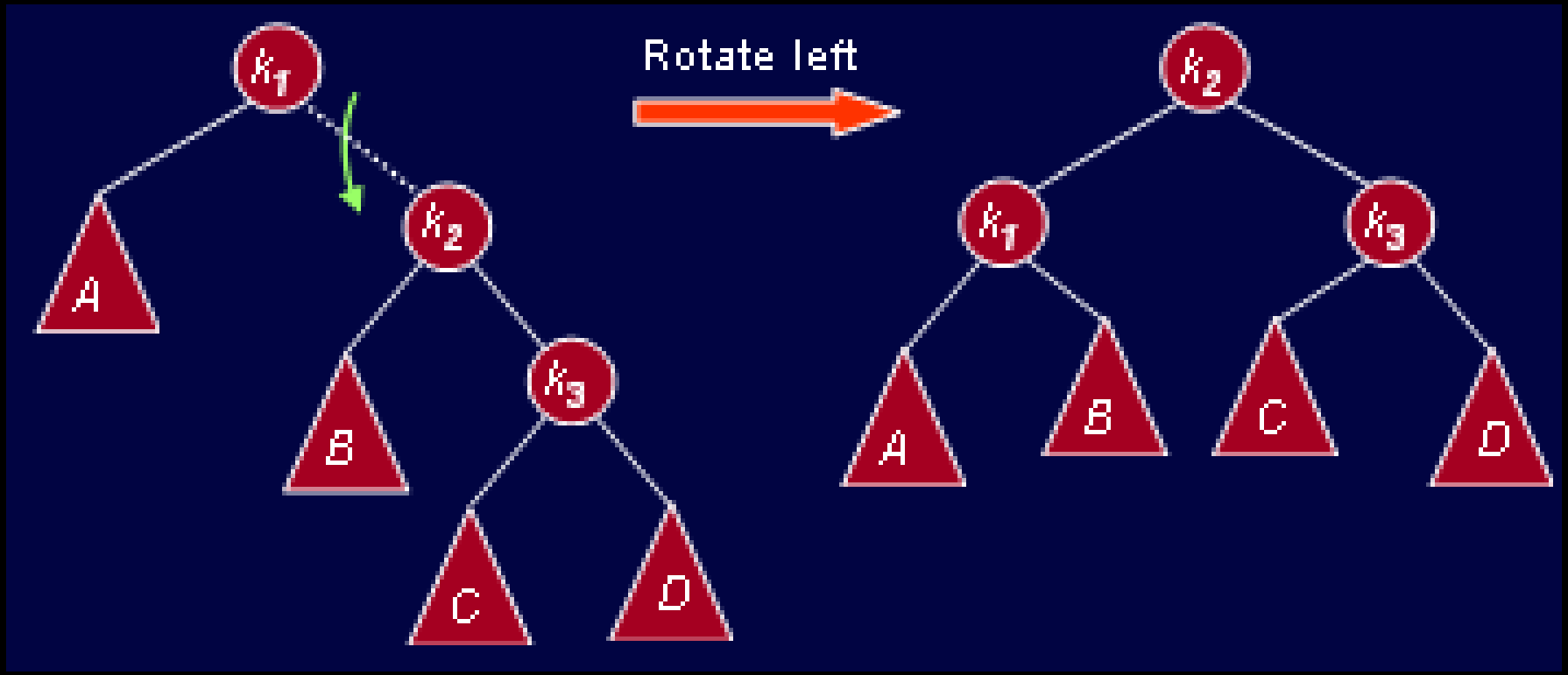
Cases for Rotation

- Right-left *double* rotation to fix case 3 .



Cases for Rotation

- Right-left *double* rotation to fix case 3 .



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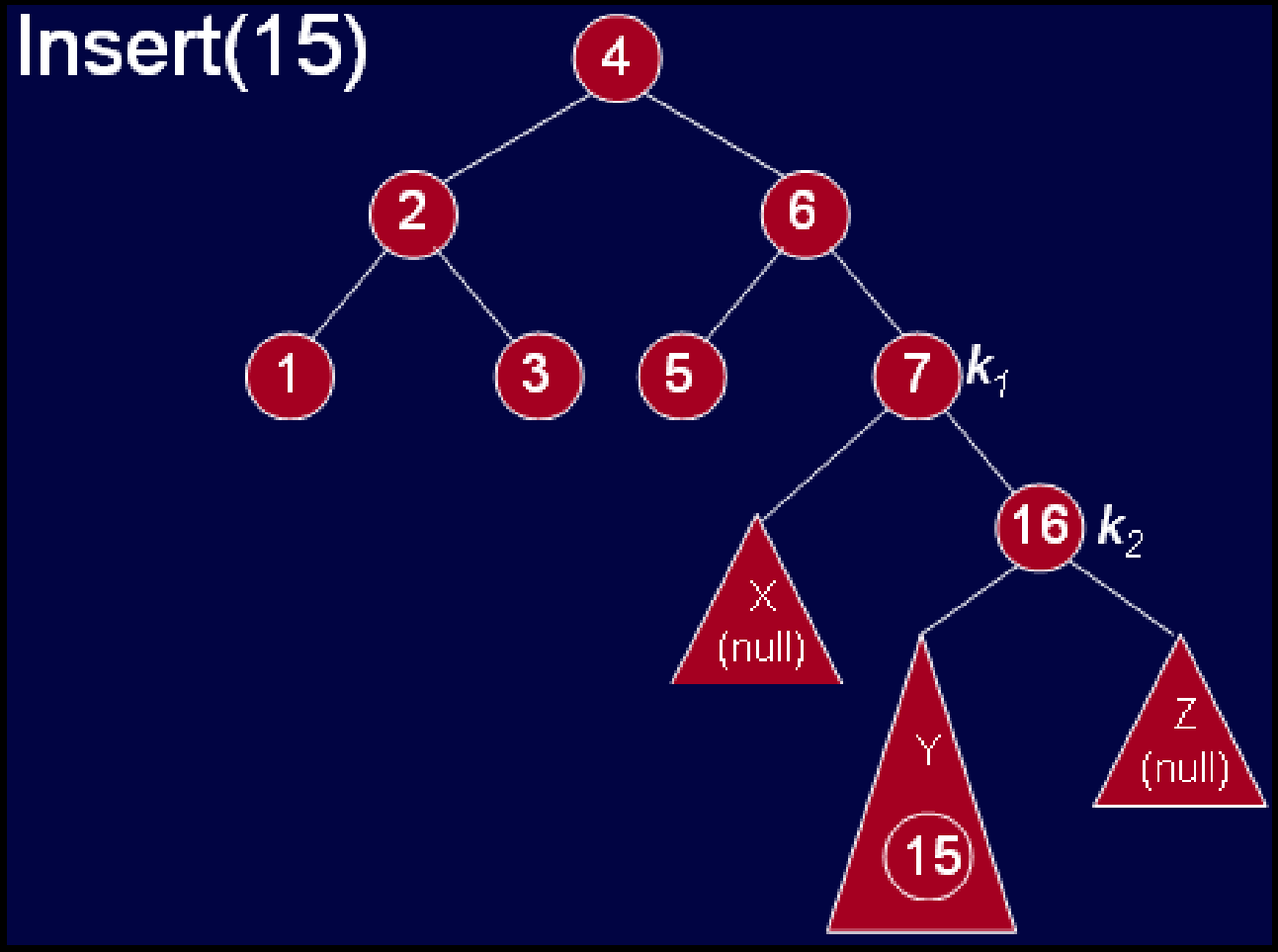

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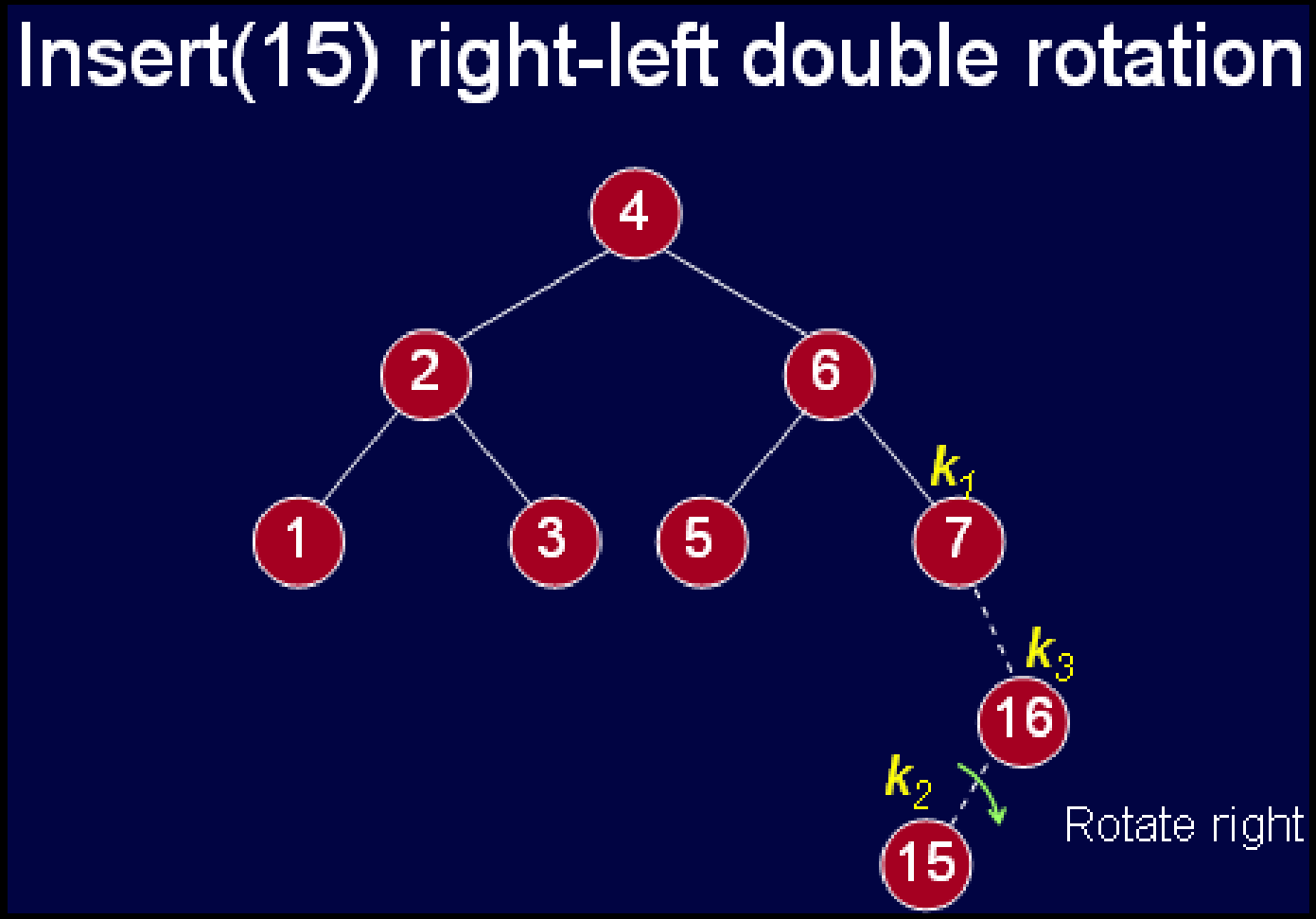

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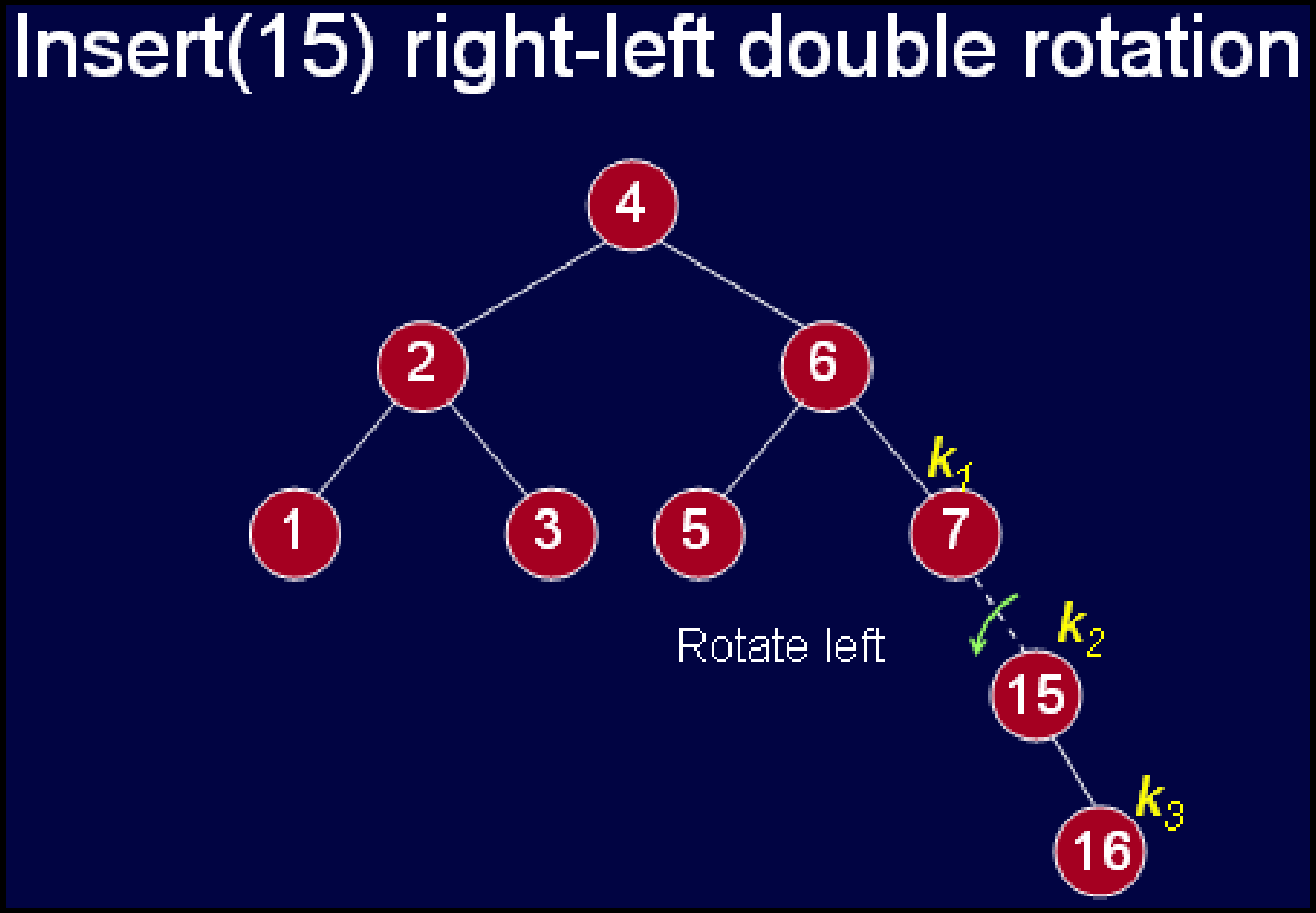

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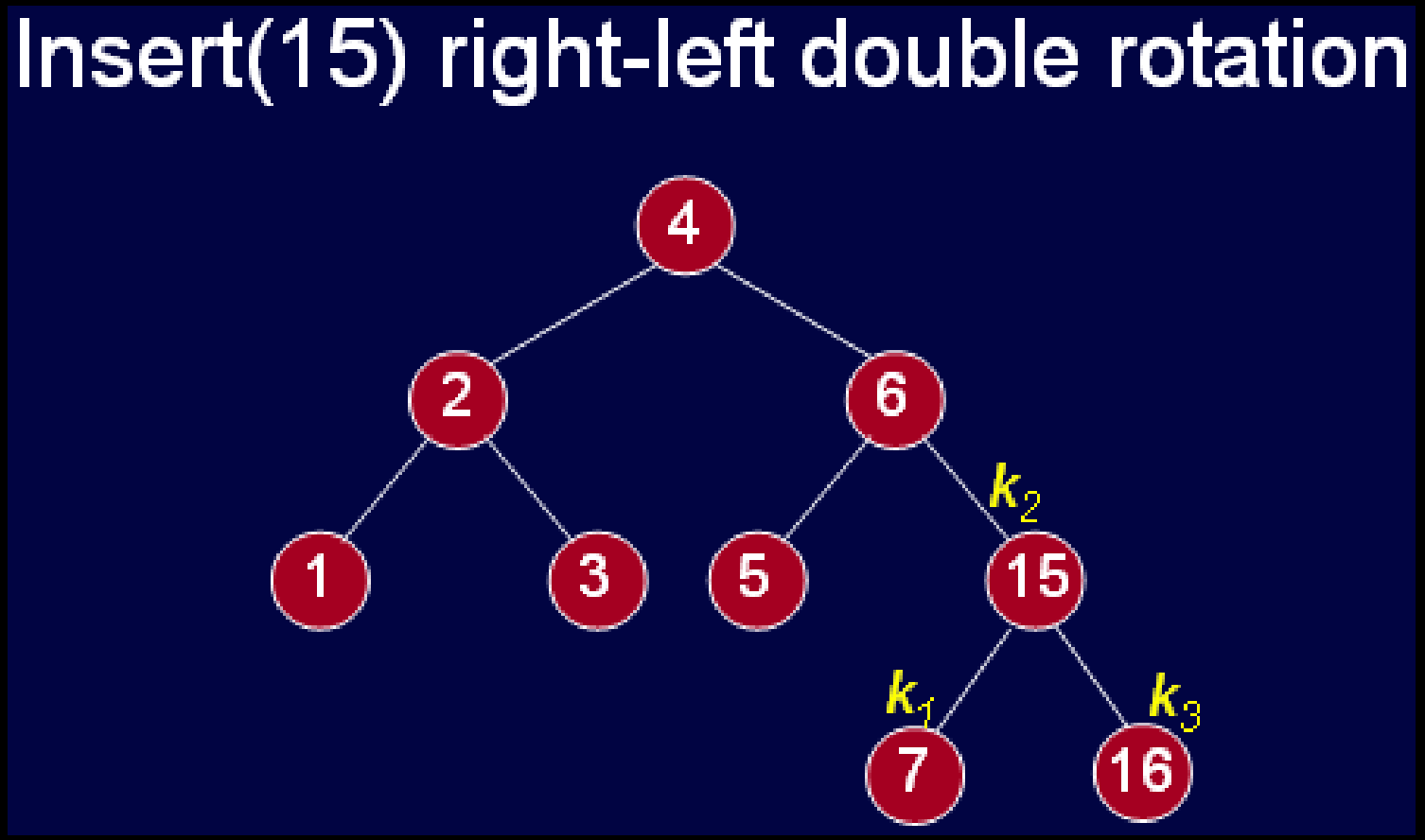

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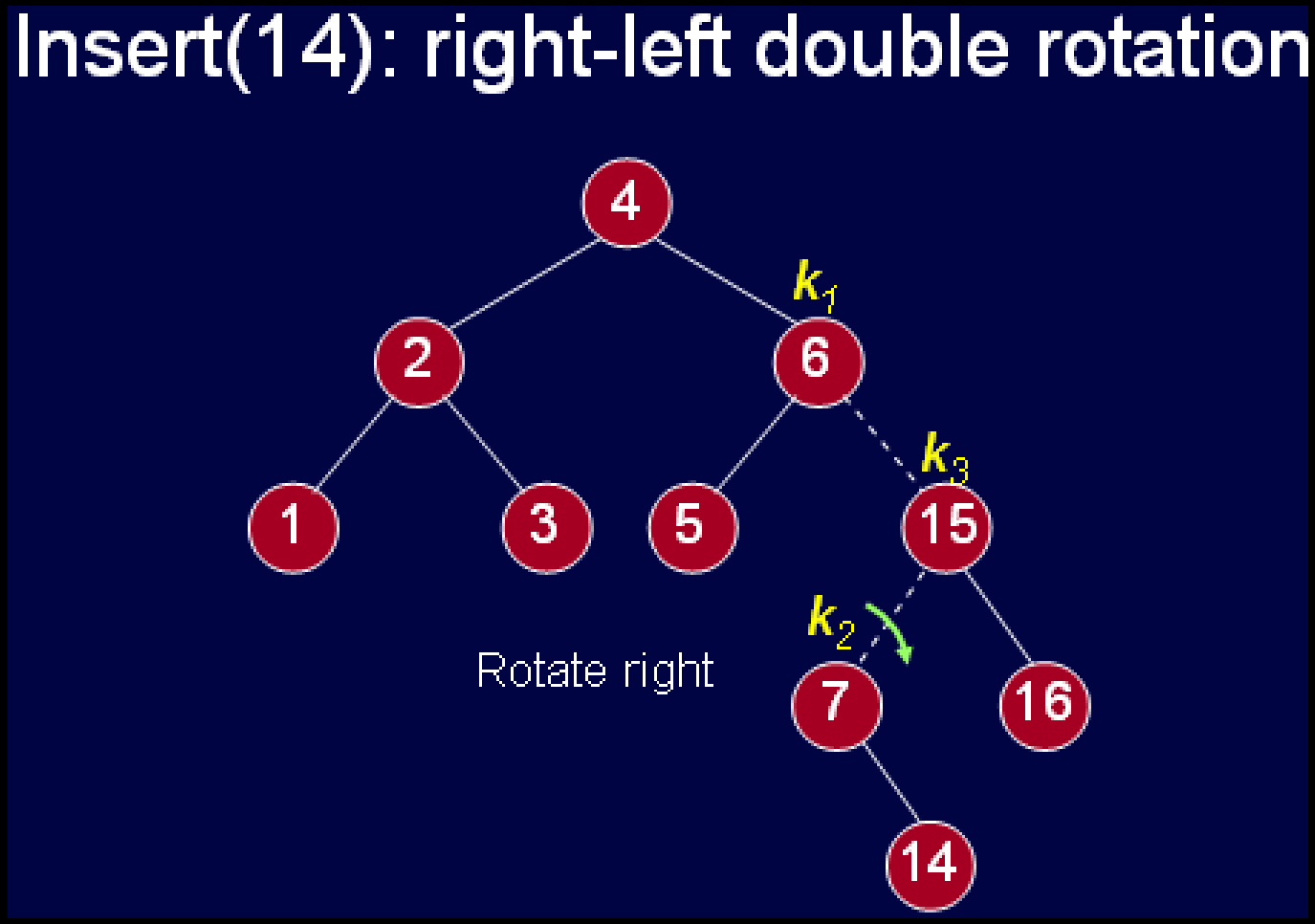

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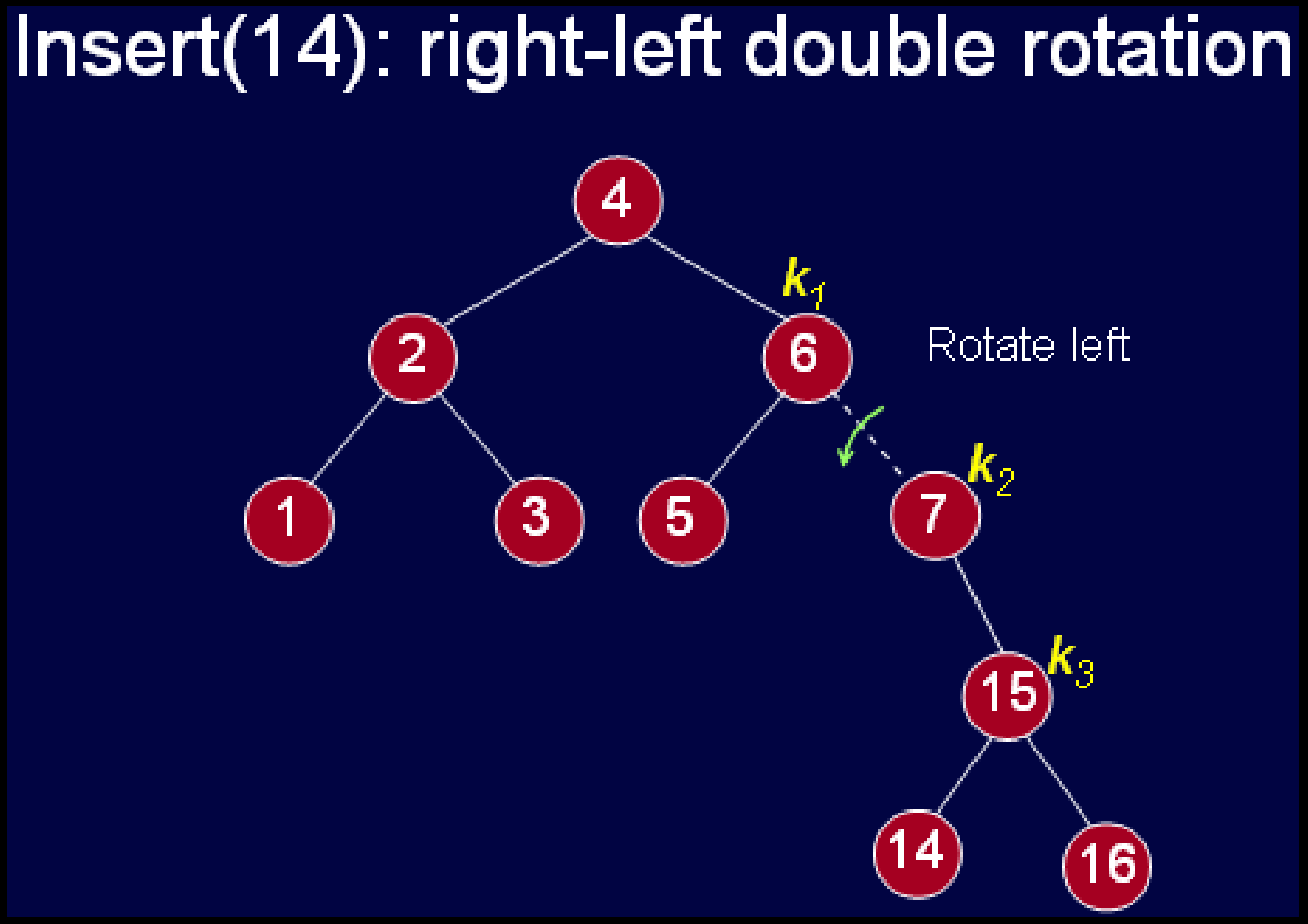

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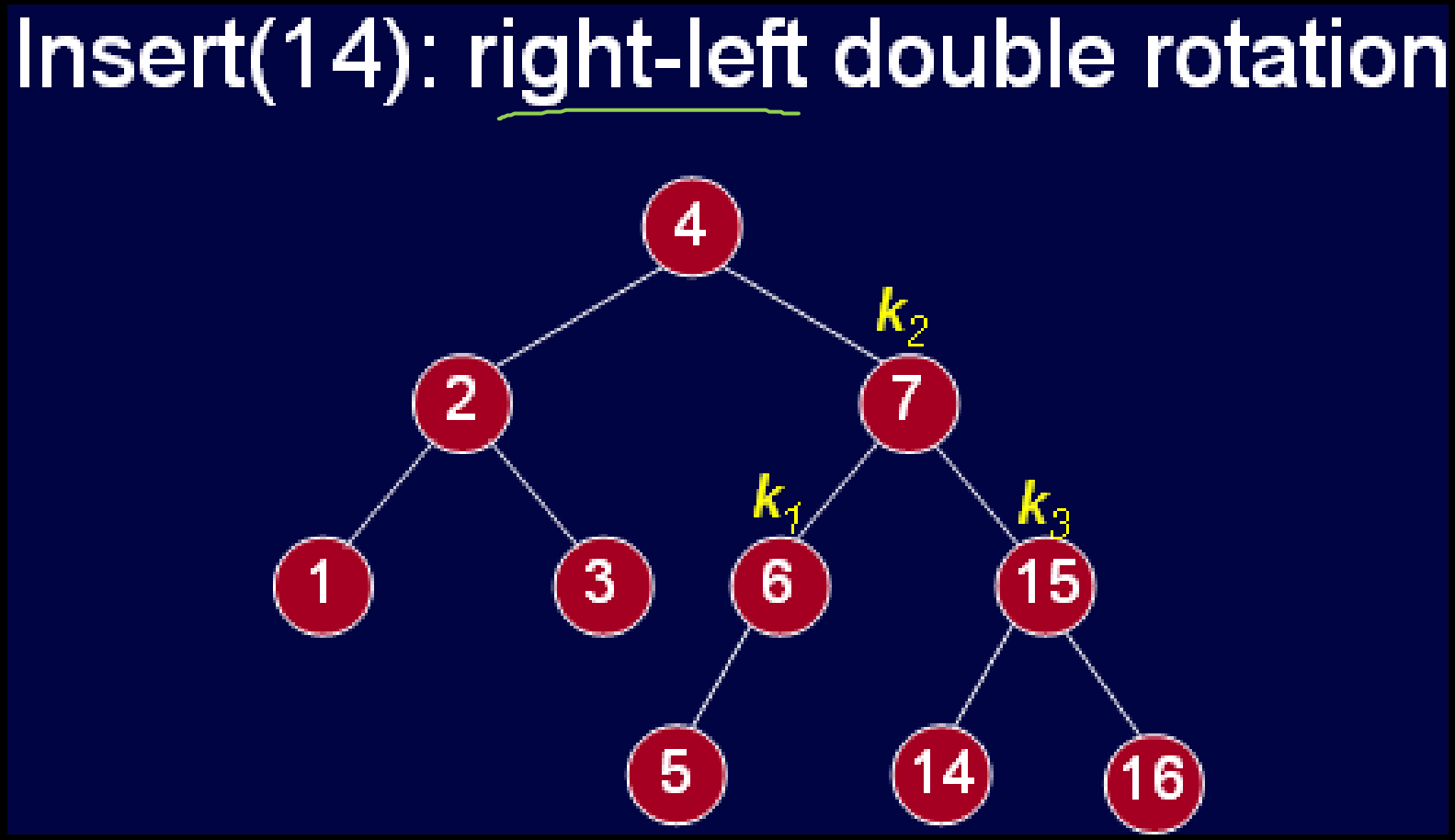

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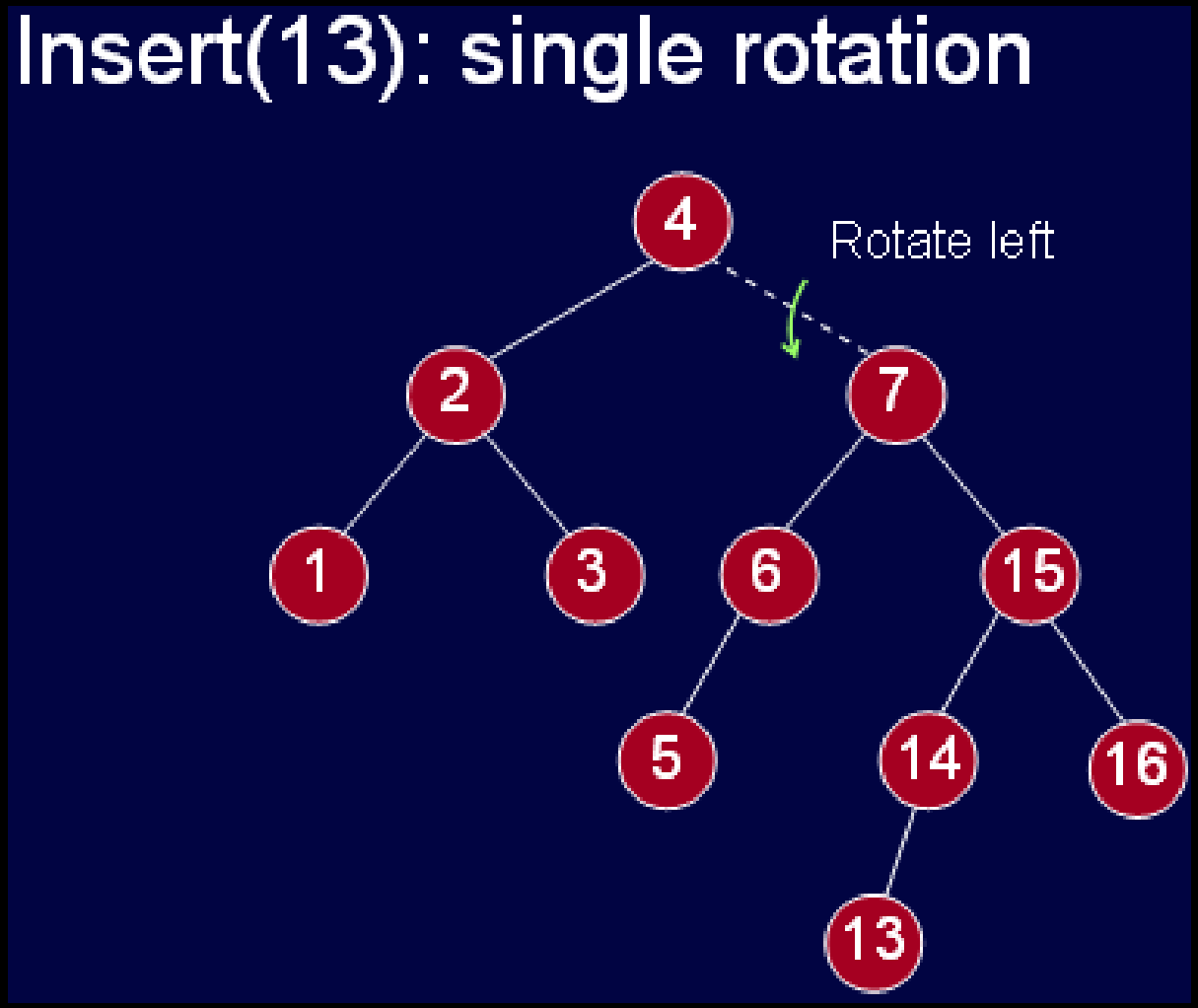

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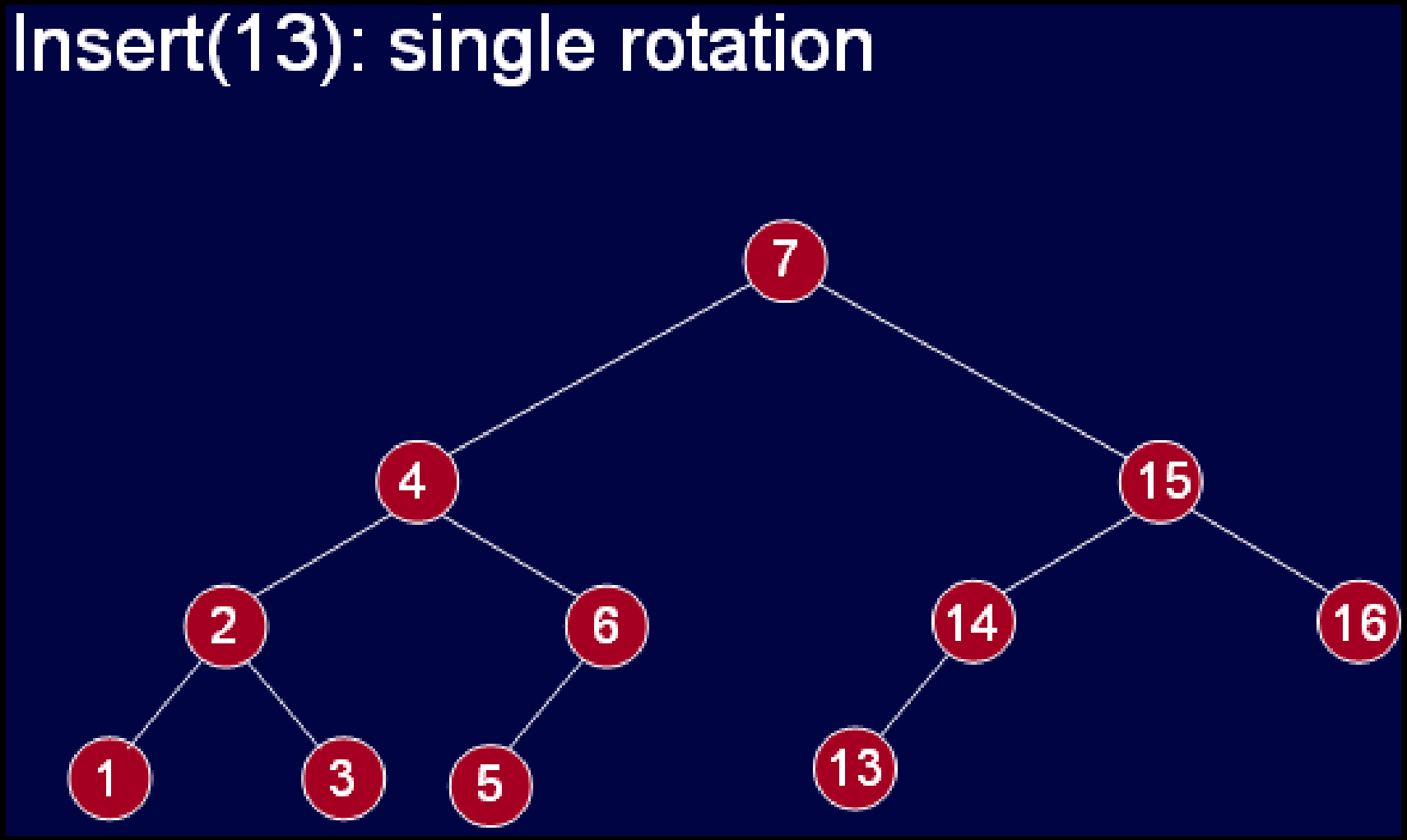

Thanks …