Balanced Binaries – AVL Trees

Balanced Binaries – AVL Trees

Height of a tree node:

1. The height of a node with no elements is 0
2. The height of a node with 1 element is 1
3. The height of a node with > 1 element is 1 + the height of its tallest subtree

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AVL tree:

A binary tree in which the difference between the height of the right and left subtrees of the root is never more than one.

Balanced Binaries – AVL Trees

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1. The height of a node with no elements is 0
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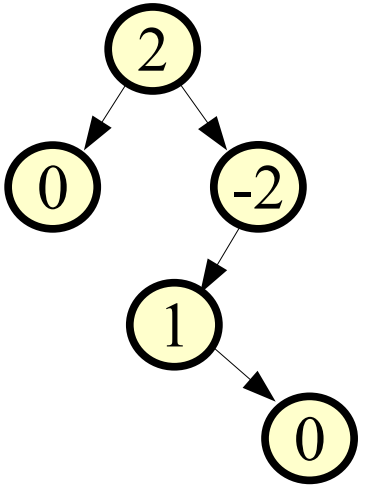
AVL tree:

A binary tree in which the difference between the height of the right and left subtrees of the root is never more than one.

Each node keeps a balance number which is the difference in heights of its two subtrees.

For example,

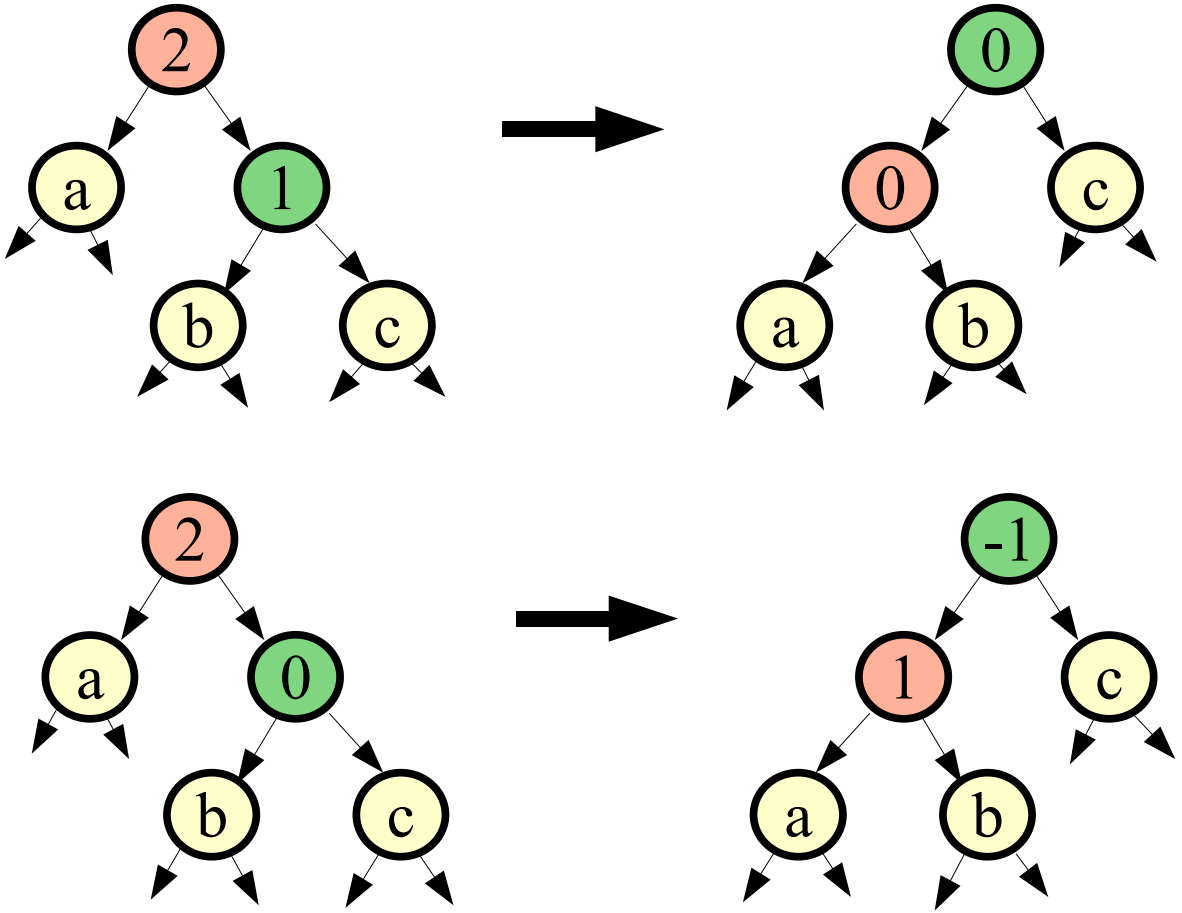


Whenever a balance number is not 0,-1,+1, perform some rotations according to some rules on following pages

Balanced Binaries – AVL Trees

Rules for rotation:

If:

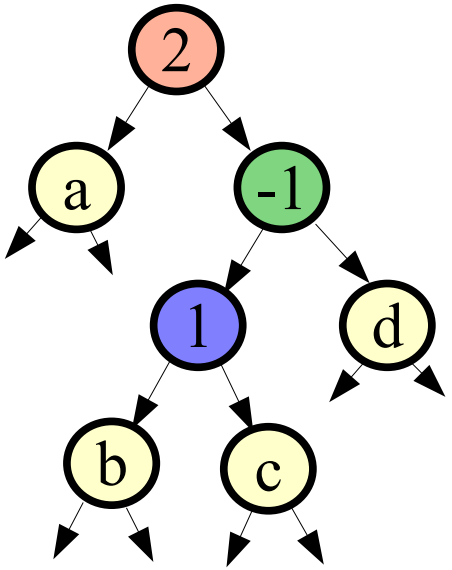


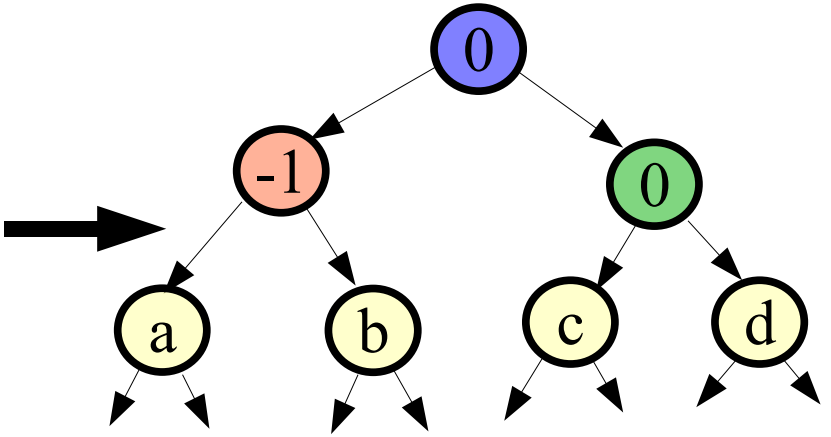
Plus mirror image of these two cases

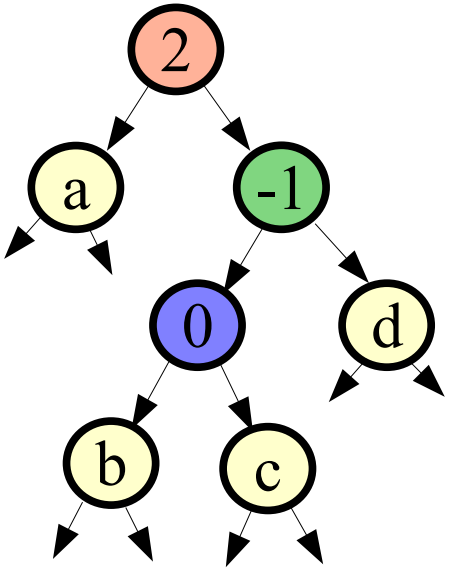
Balanced Binaries – AVL Trees

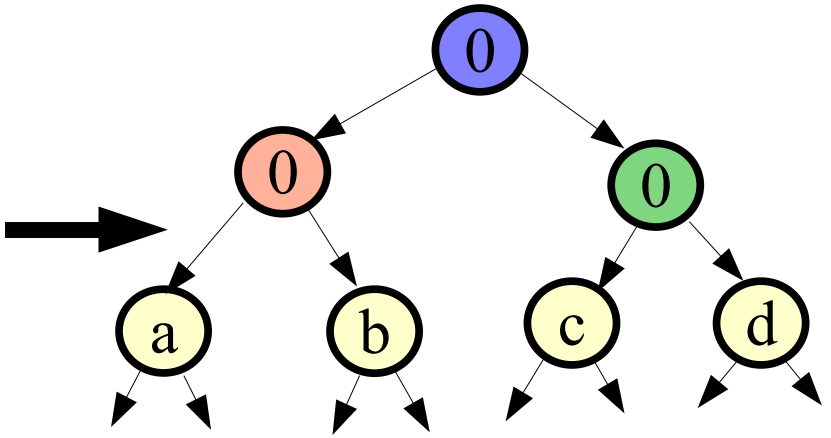
Rules for rotation:

If:





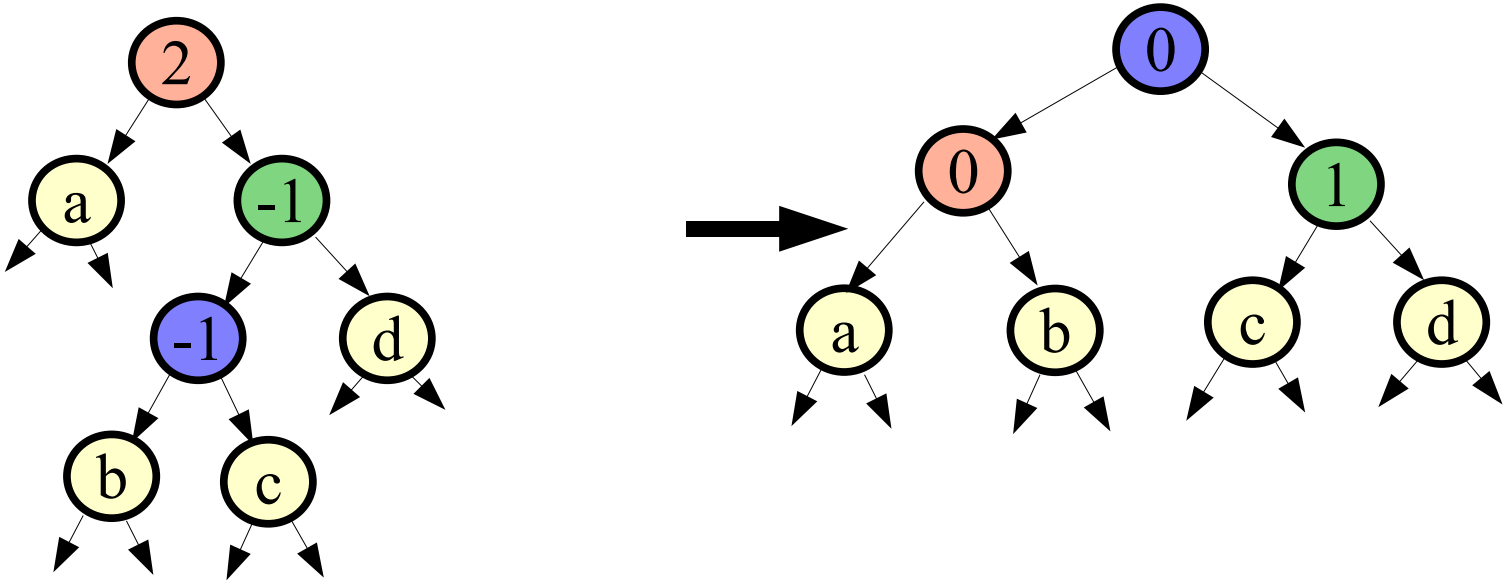




Balanced Binaries – AVL Trees

Rules for rotation:

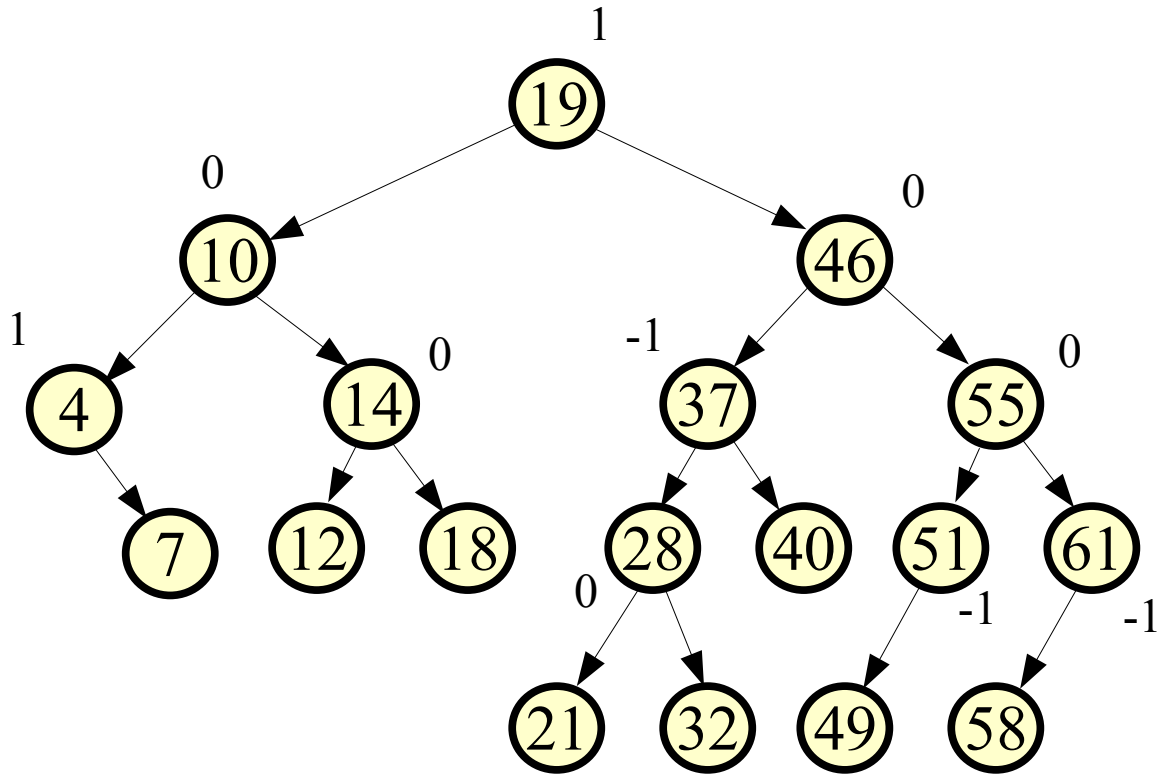
If:



Plus mirror image of these three cases

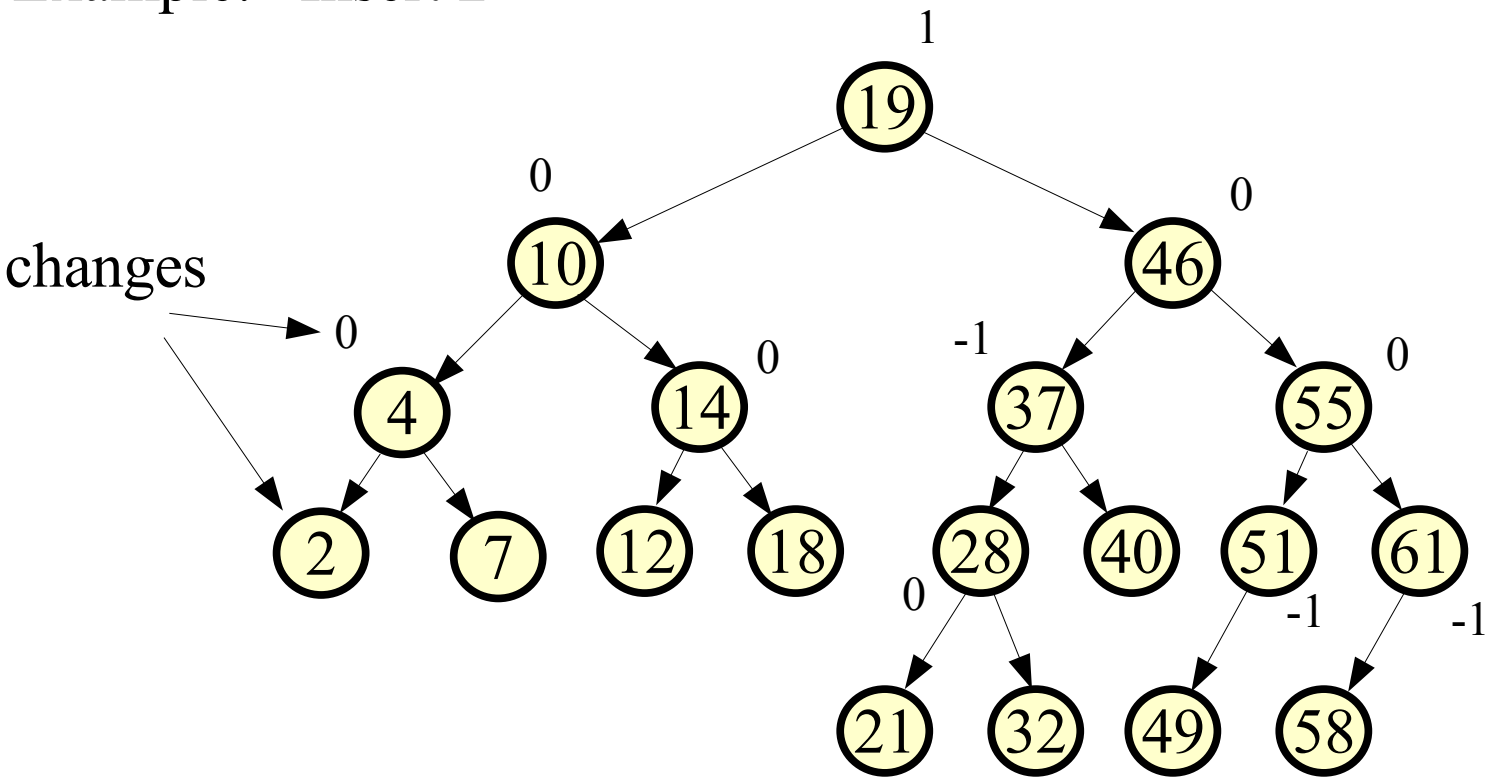
Balanced Binaries – AVL Trees

Example:



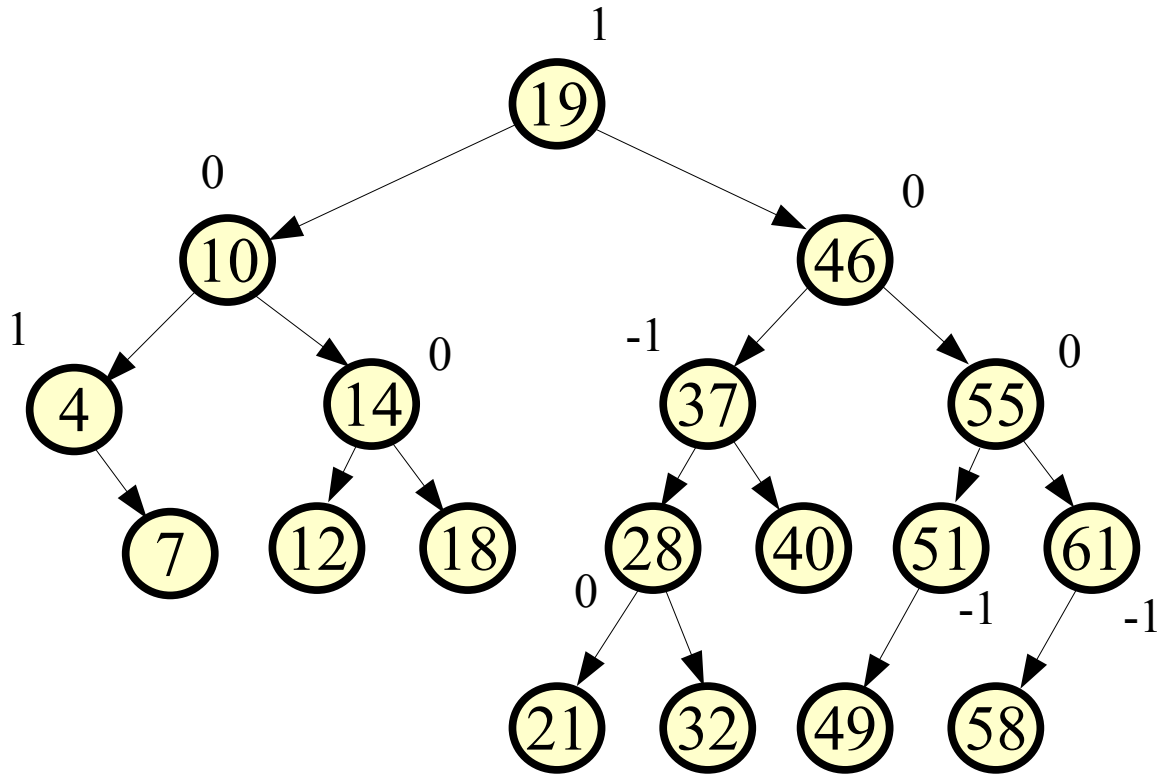
Balanced Binaries – AVL Trees

Example: Insert 2



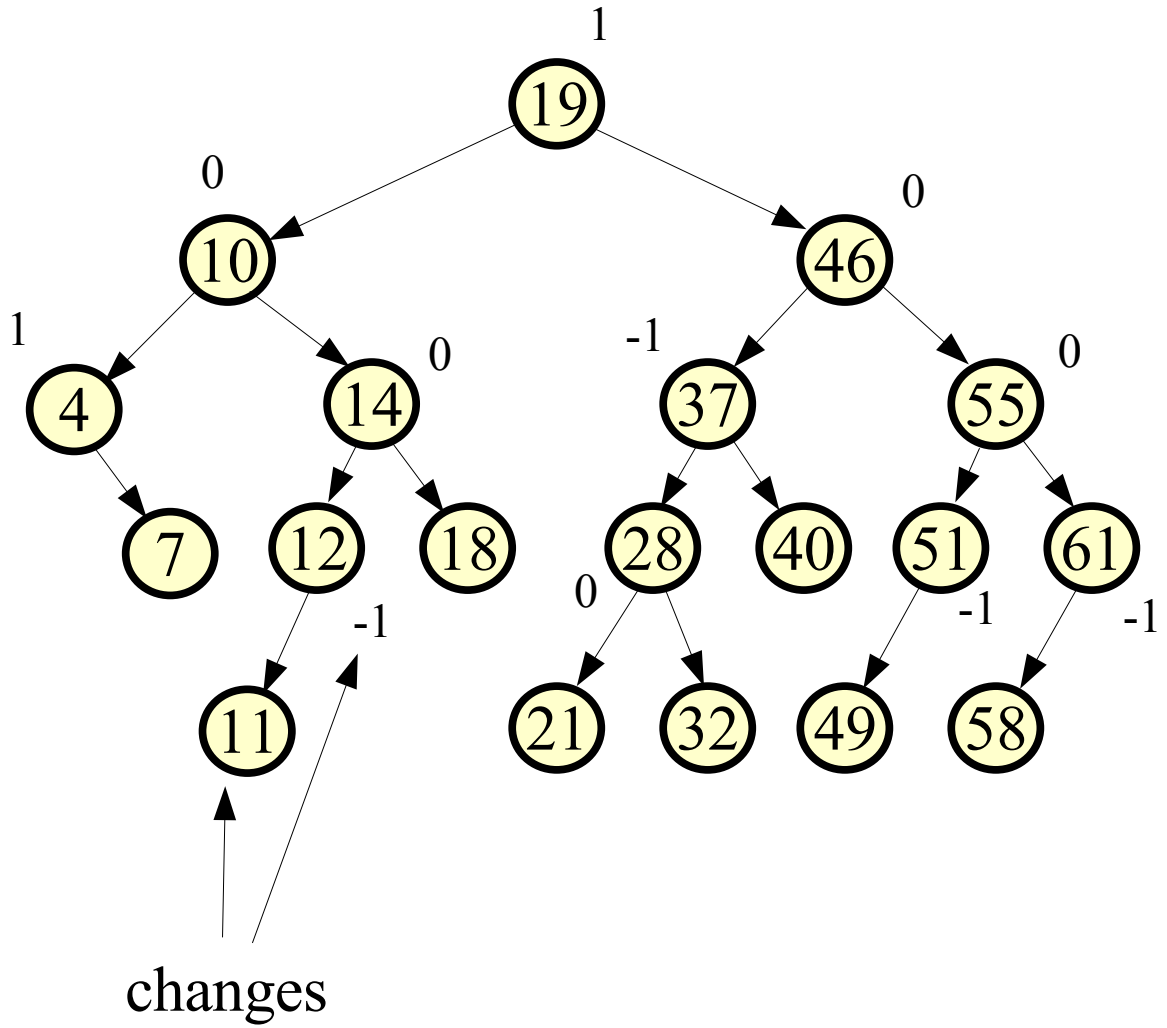
Balanced Binaries – AVL Trees

Example:



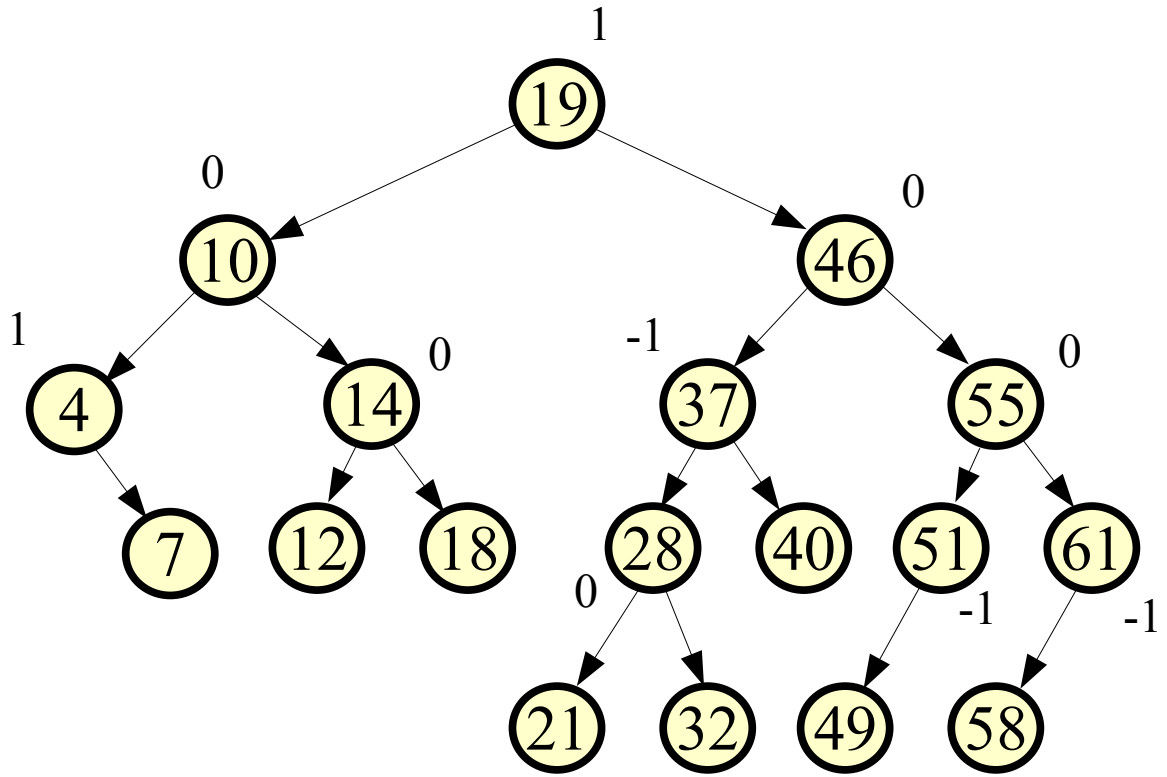
Balanced Binaries – AVL Trees

Example: Insert 11



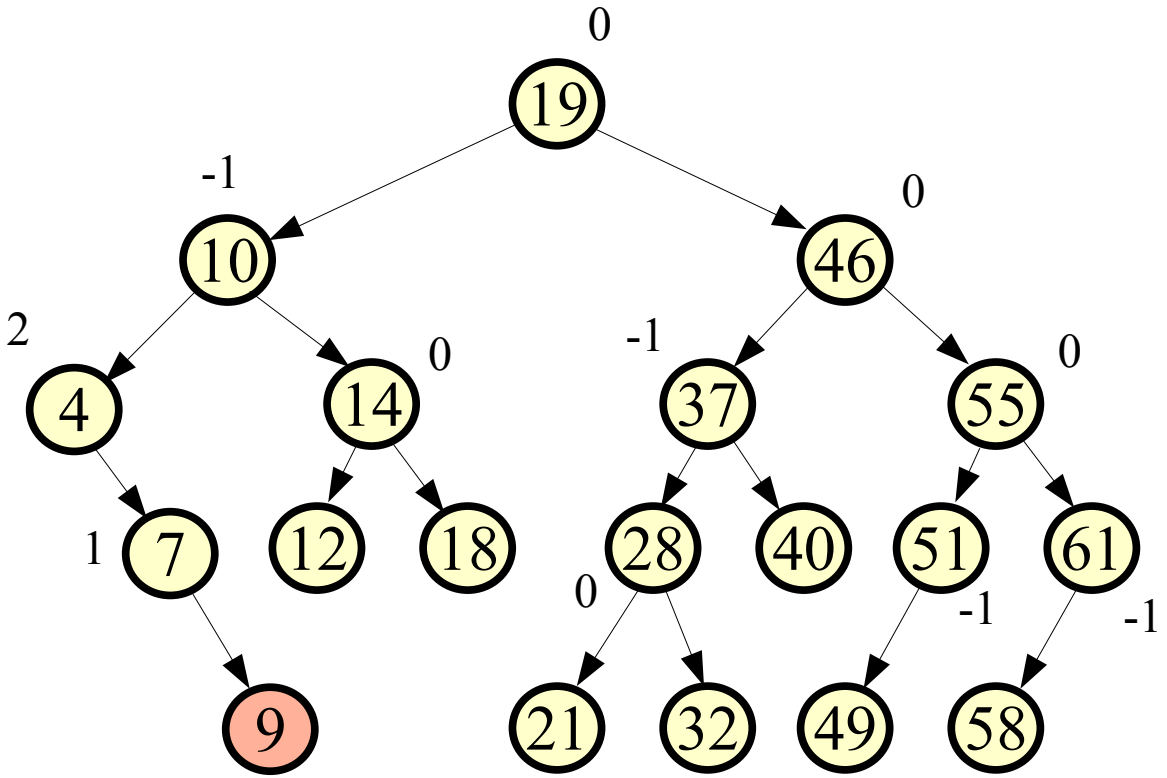
Balanced Binaries – AVL Trees

Example:



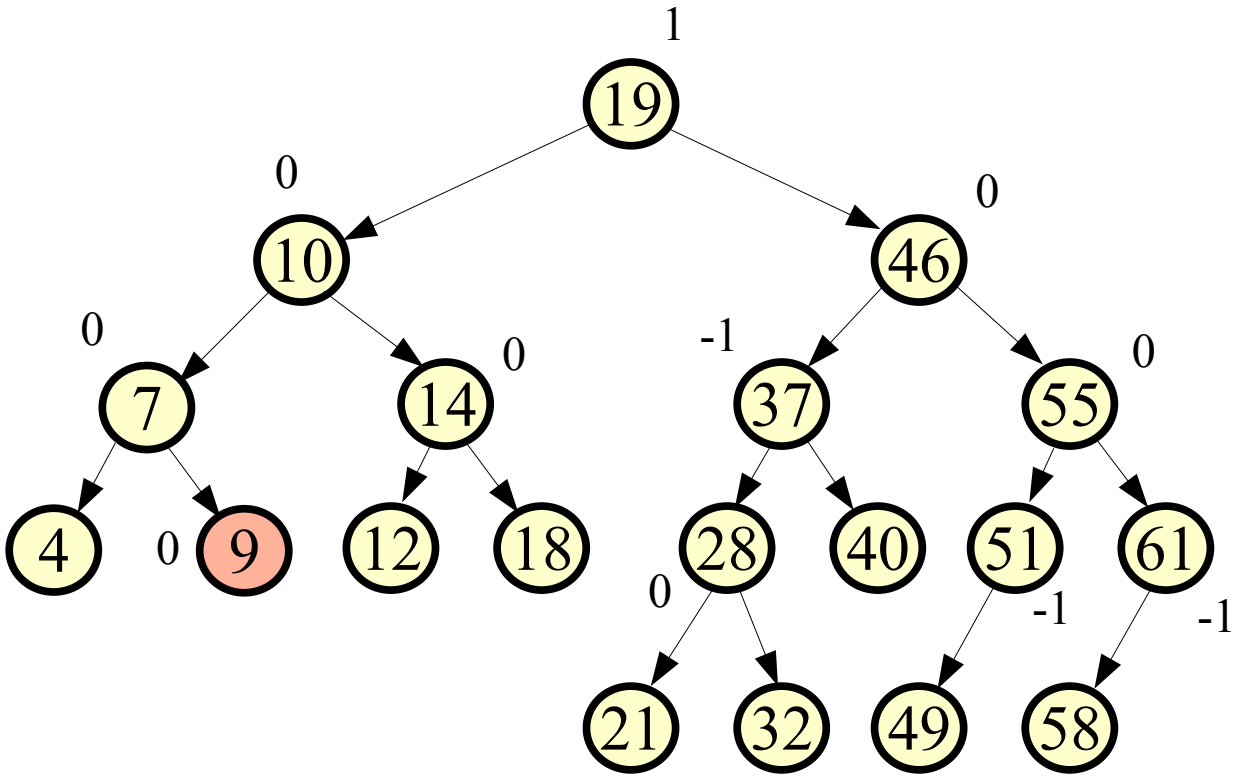
Balanced Binaries – AVL Trees

Example: Insert 9



Balanced Binaries – AVL Trees

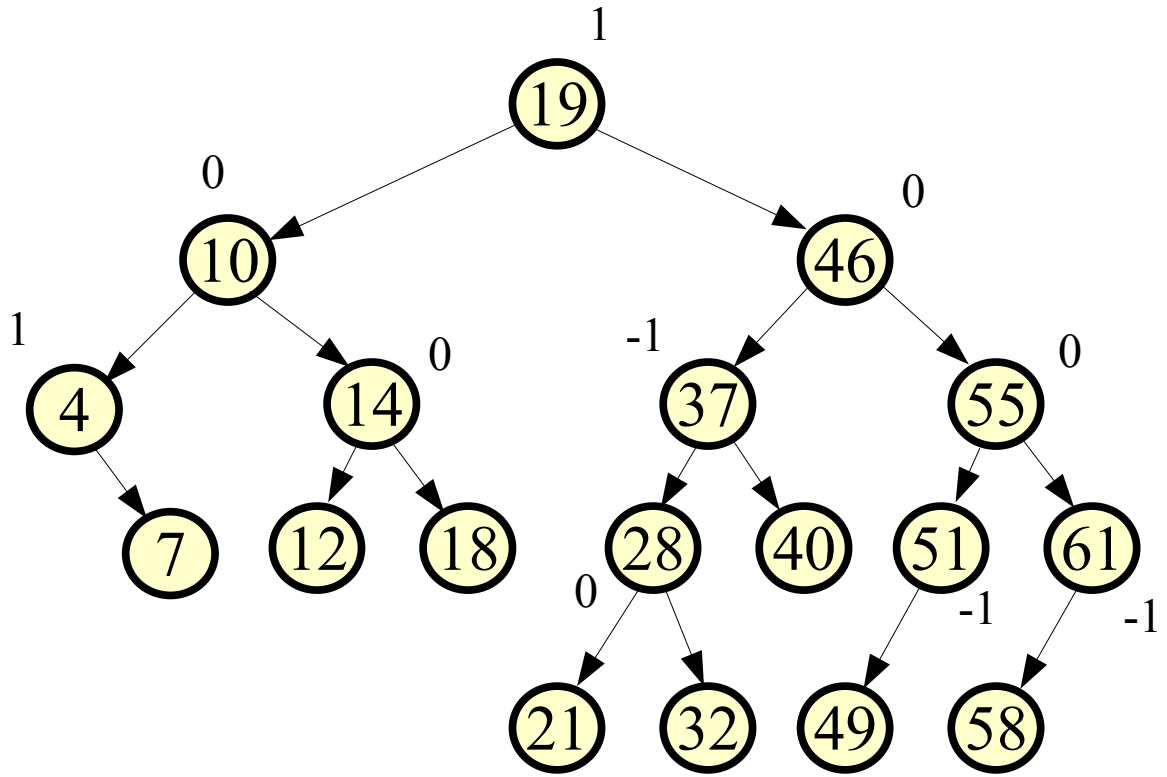
Example: Insert 9



Rotation around 7

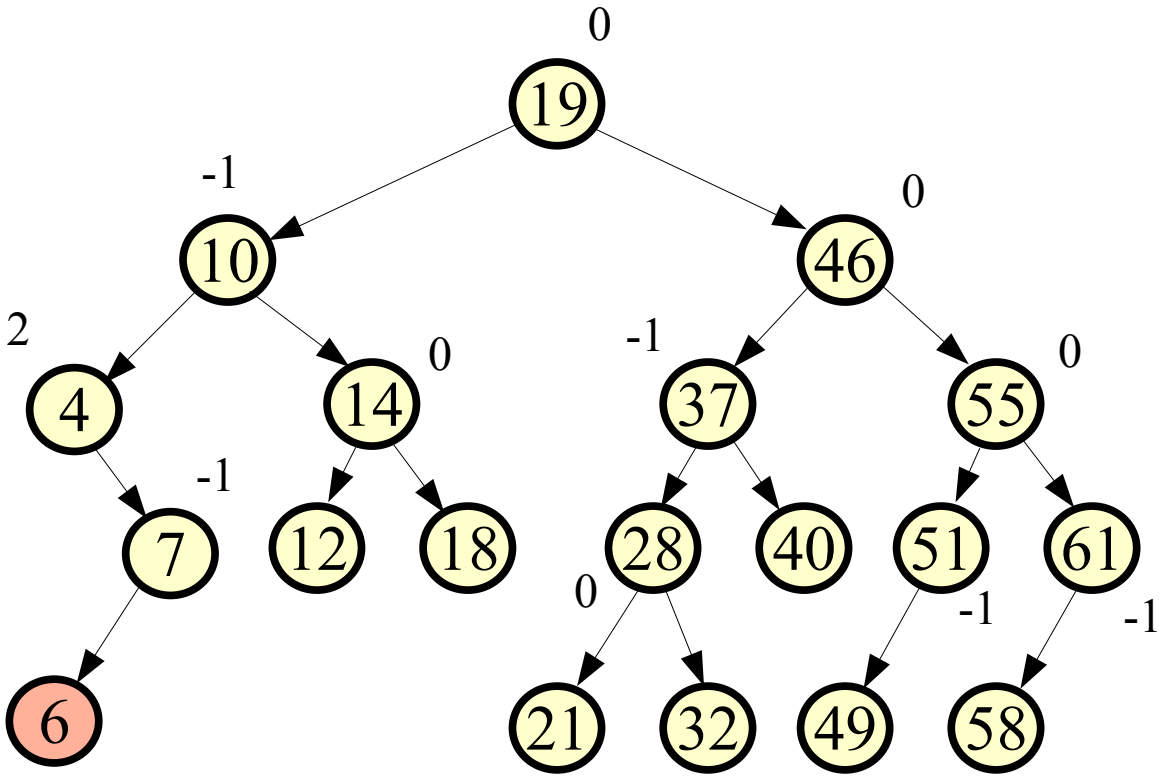
Balanced Binaries – AVL Trees

Example:



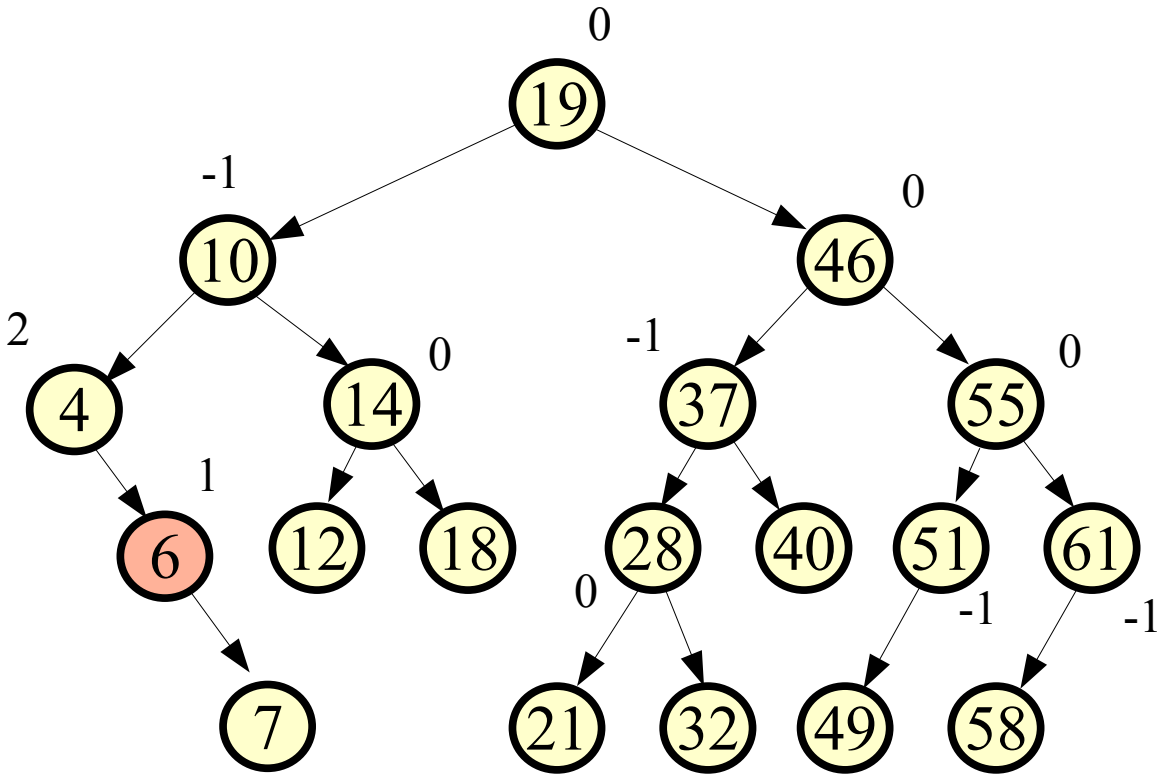
Balanced Binaries – AVL Trees

Example: Insert 6



Balanced Binaries – AVL Trees

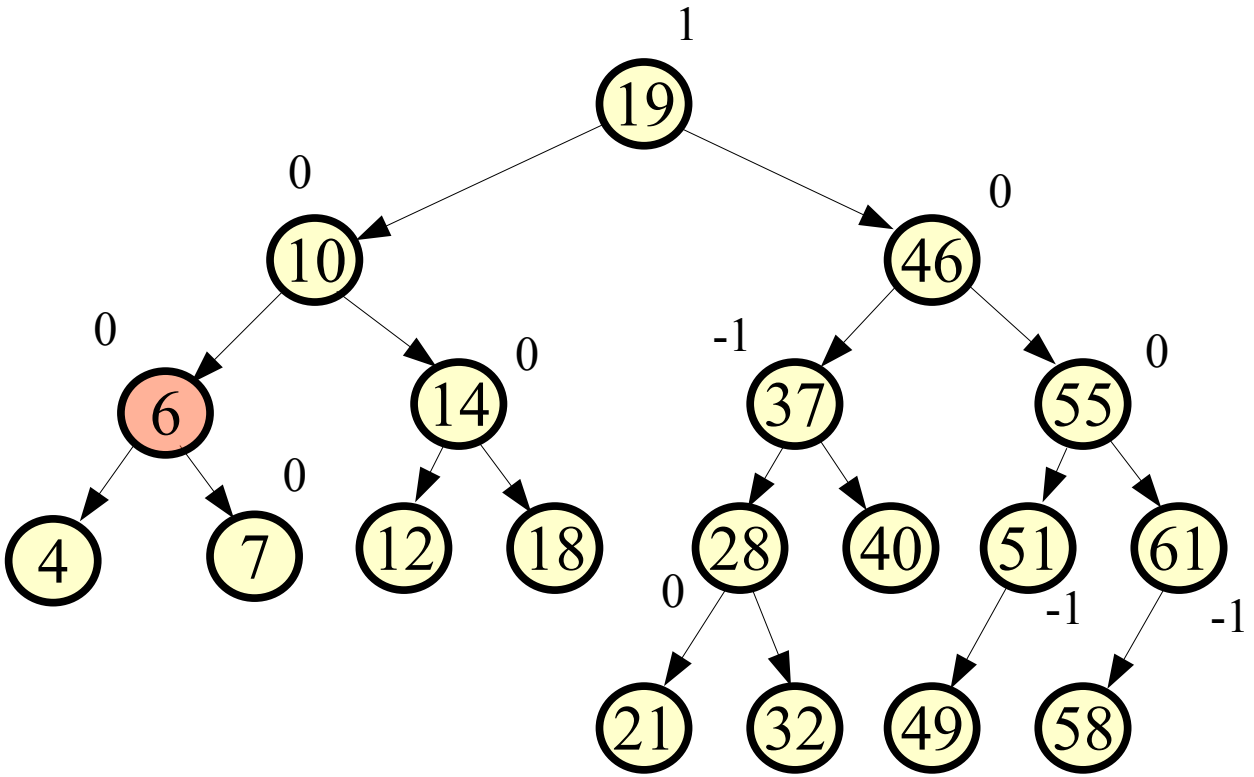
Example: Insert 6



Double rotation

Balanced Binaries – AVL Trees

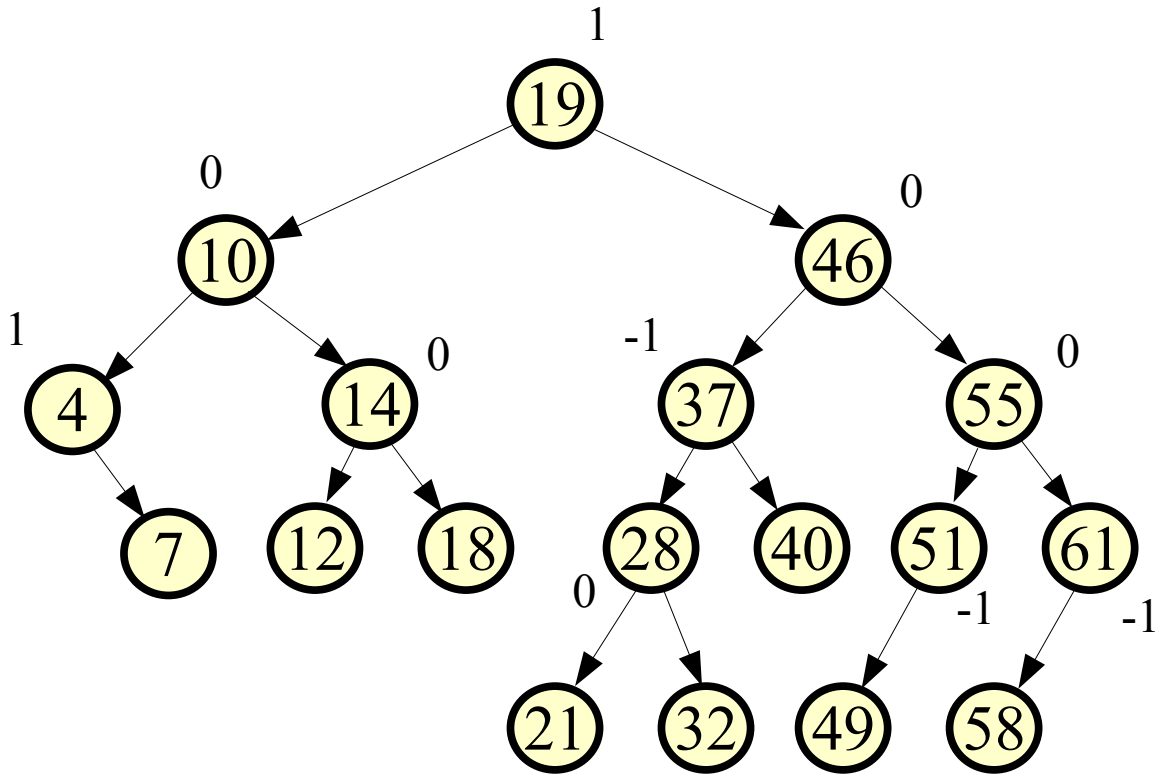
Example: Insert 6



Double rotation

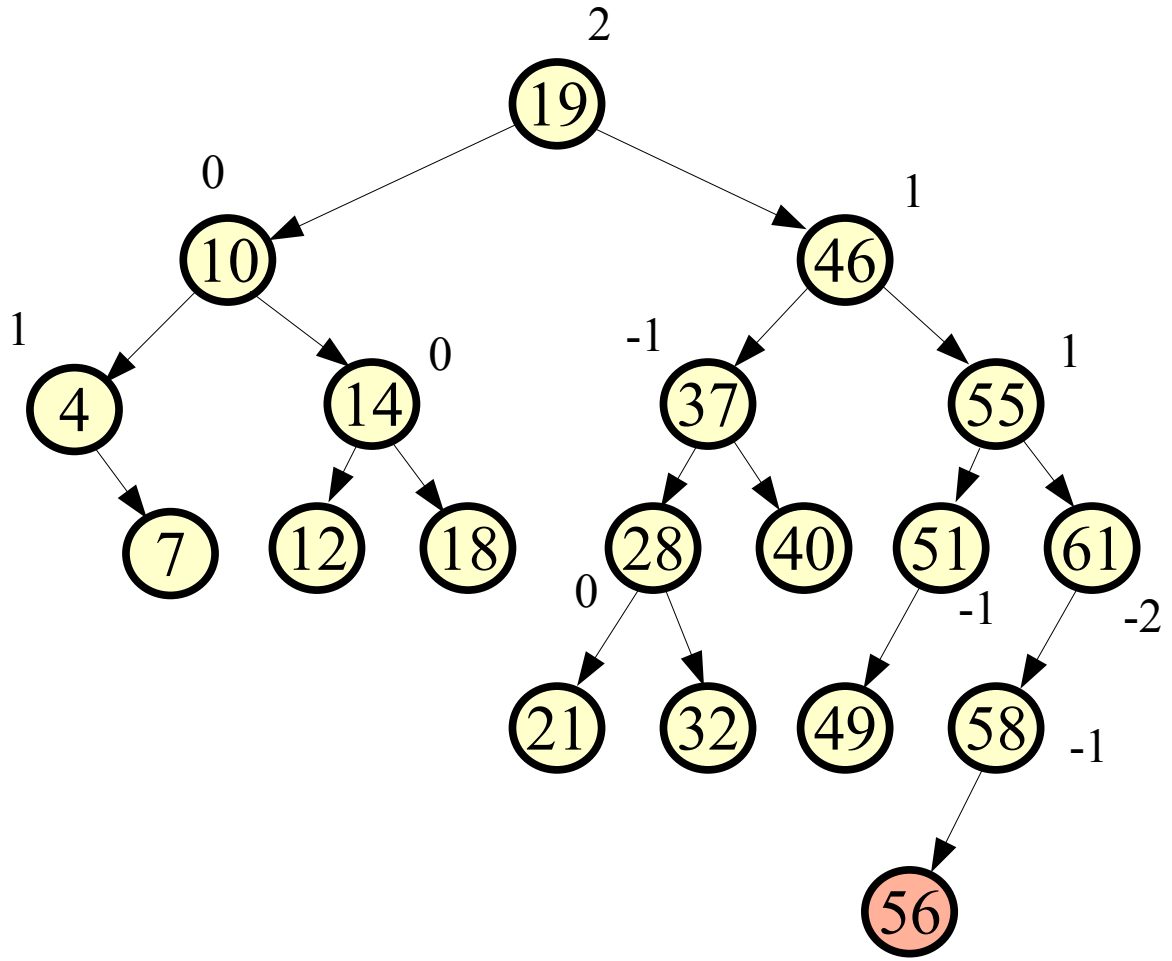
Balanced Binaries – AVL Trees

Example:



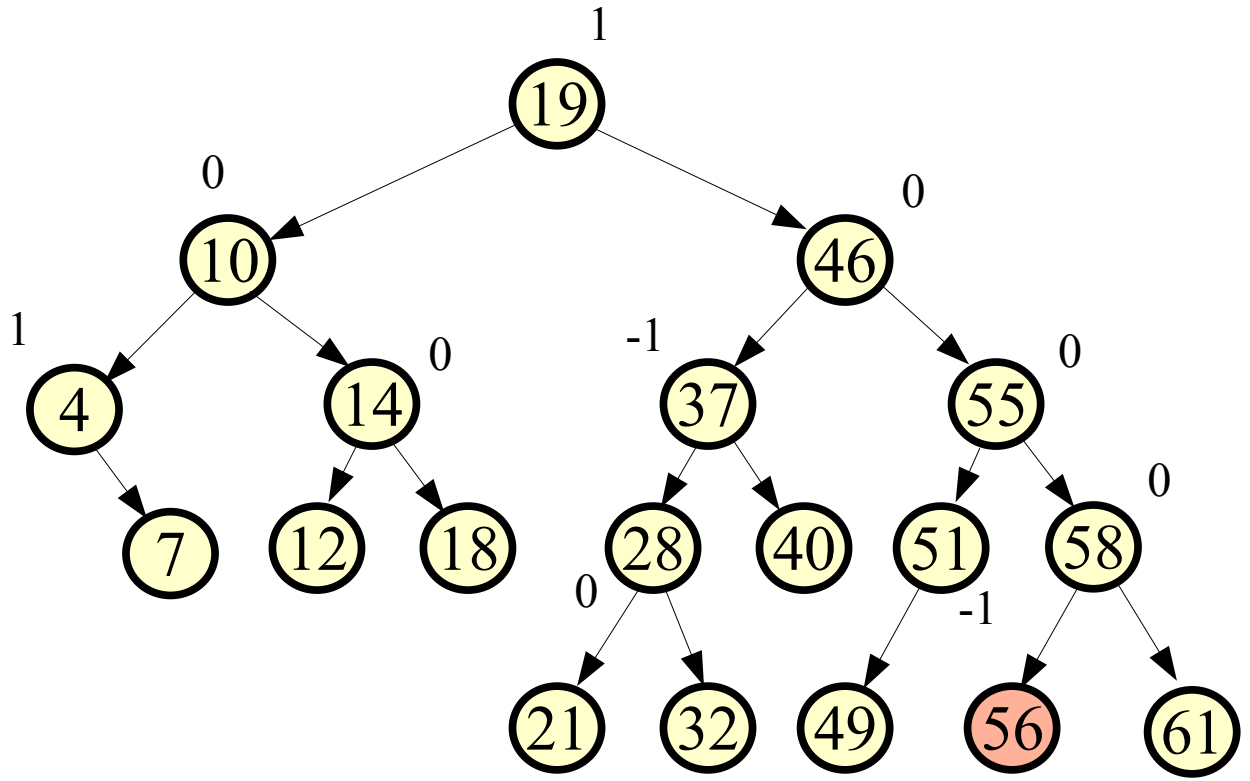
Balanced Binaries – AVL Trees

Example: Insert 56



Balanced Binaries – AVL Trees

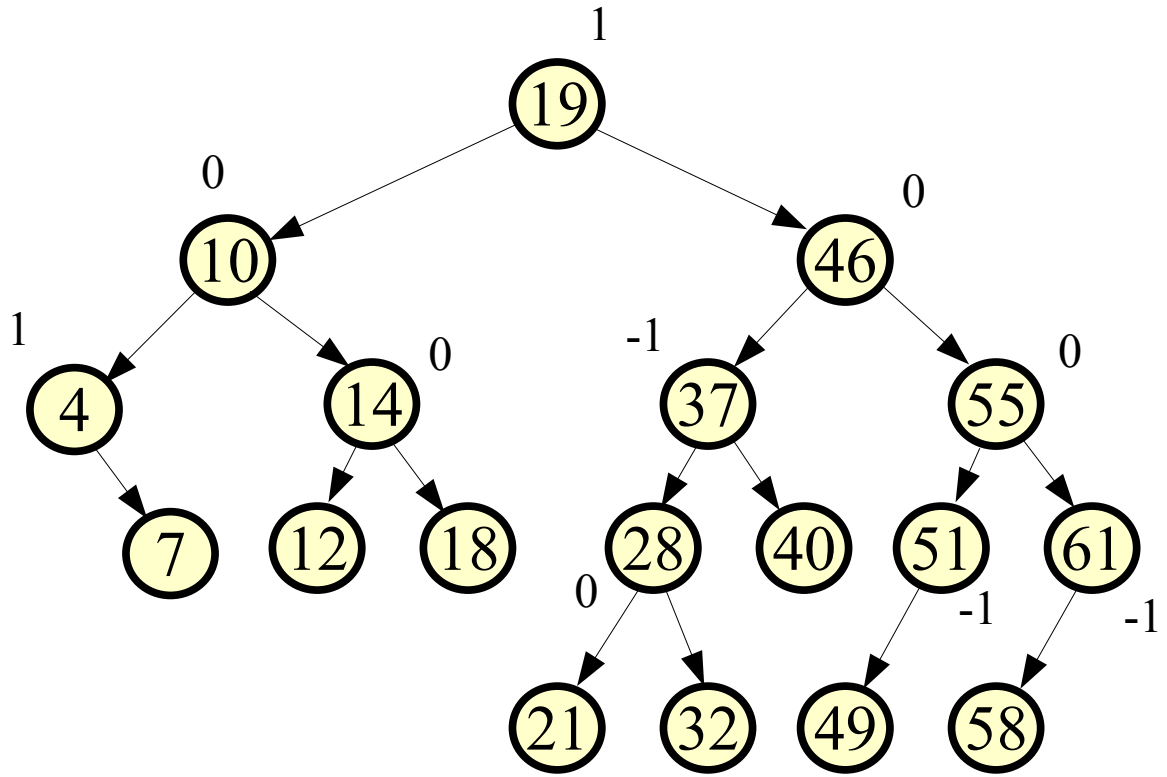
Example: Insert 56



Single rotation around 58

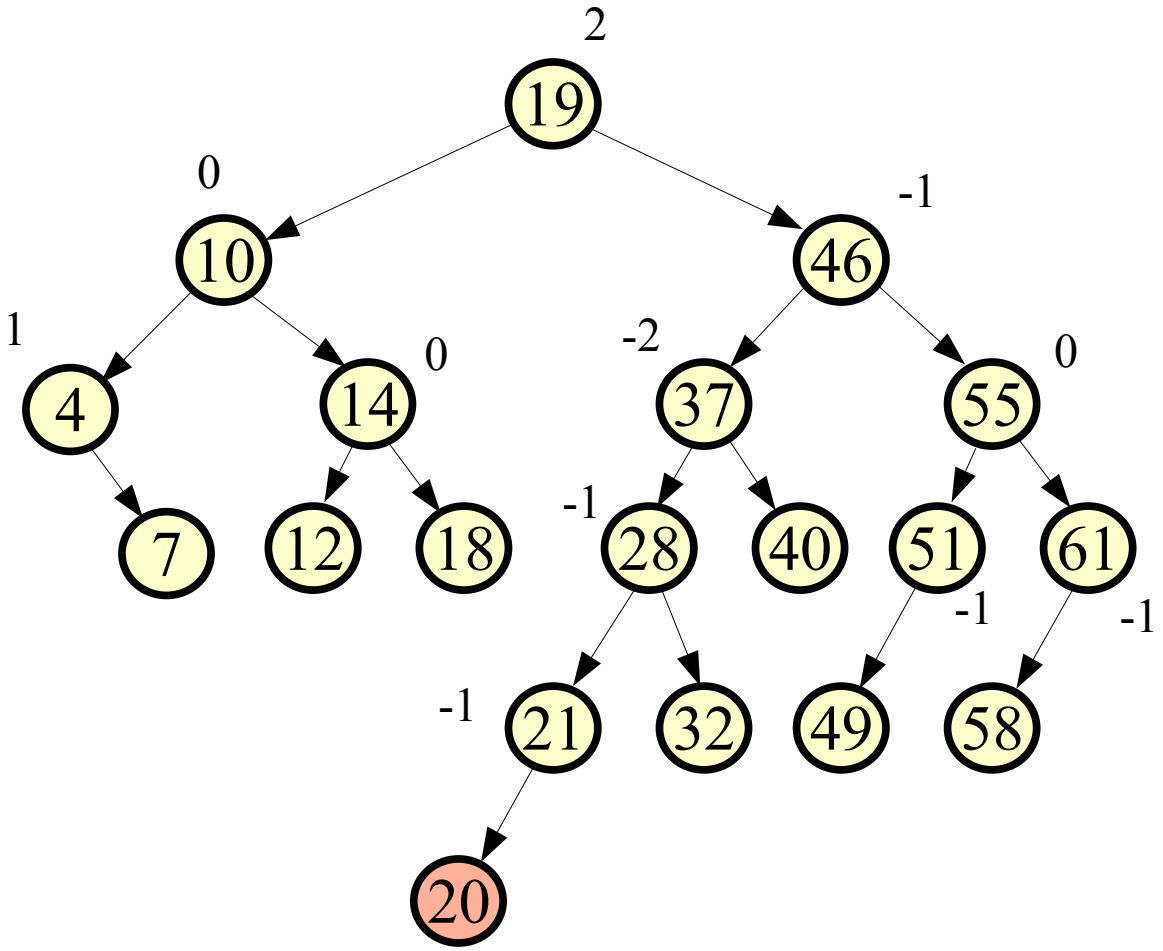
Balanced Binaries – AVL Trees

Example:



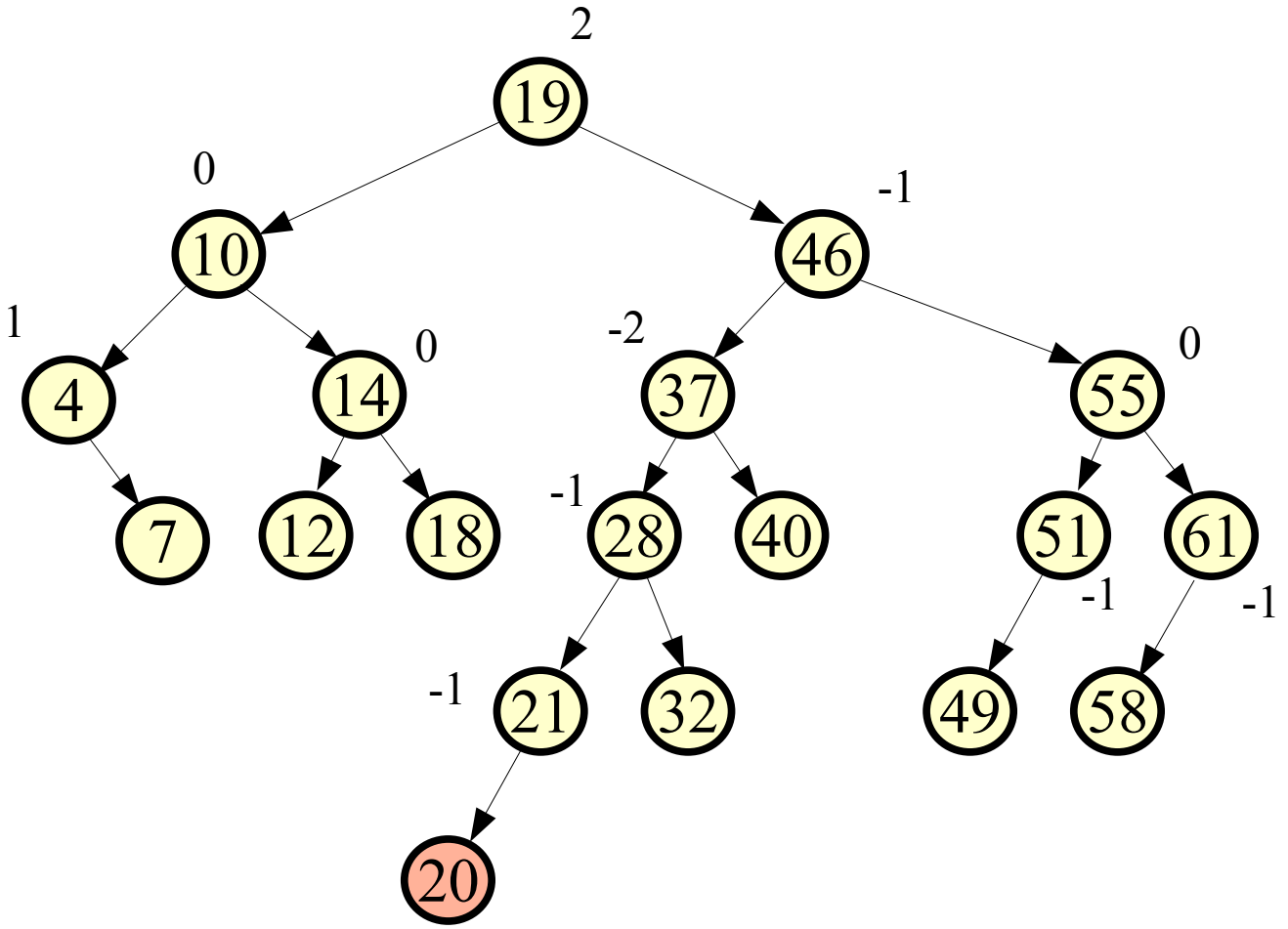
Balanced Binaries – AVL Trees

Example: Insert 20



Balanced Binaries – AVL Trees

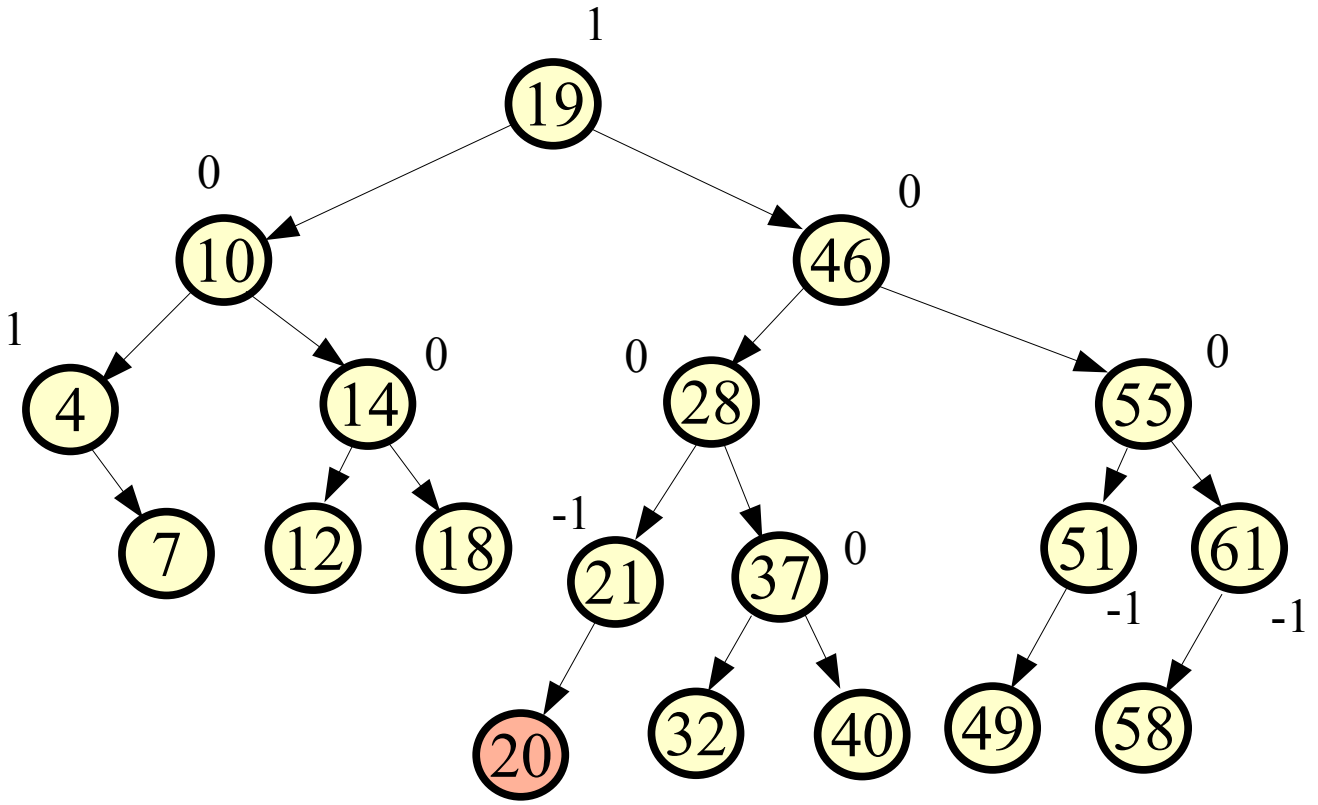
Example: Insert 20



Rotate around 28

Balanced Binaries – AVL Trees

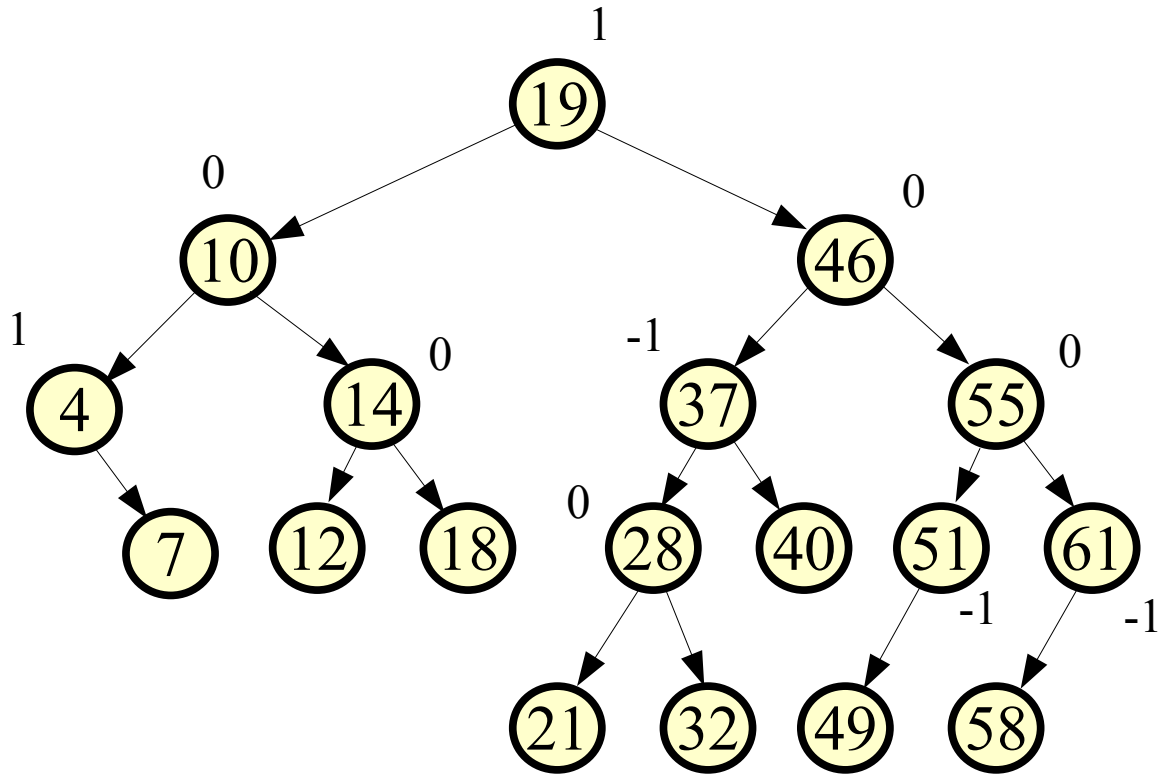
Example: Insert 20



Rotate around 28

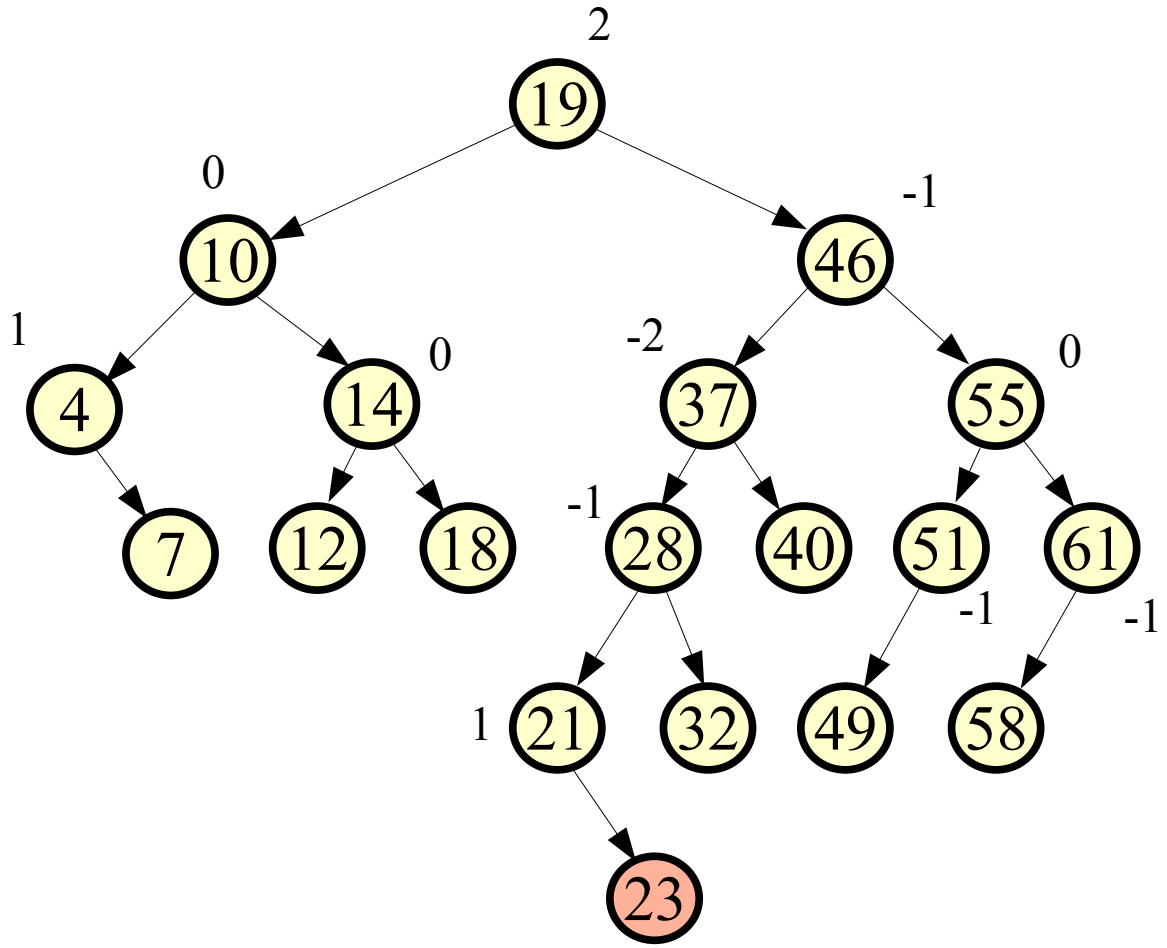
Balanced Binaries – AVL Trees

Example:



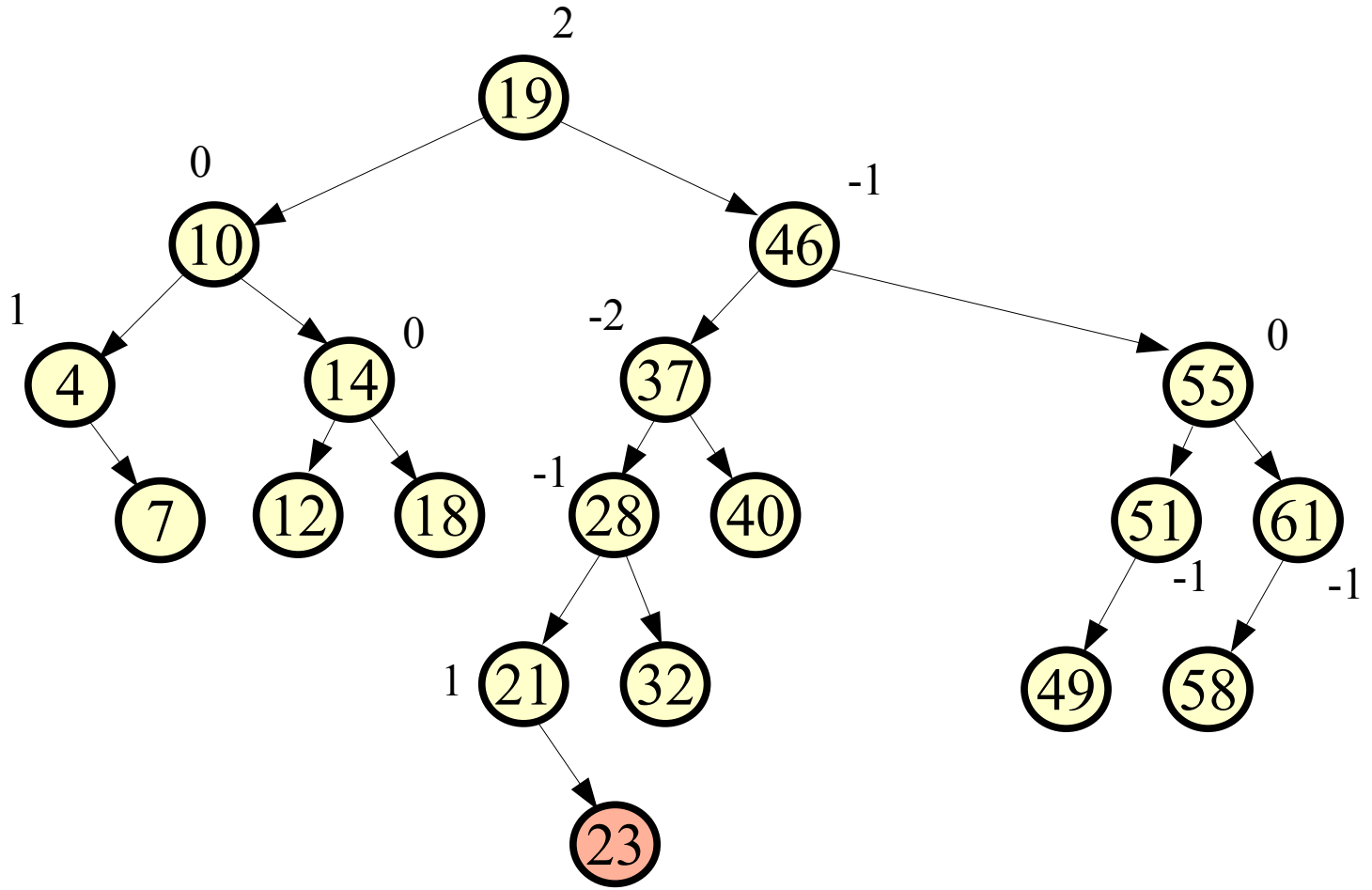
Balanced Binaries – AVL Trees

Example: Insert 23



Balanced Binaries – AVL Trees

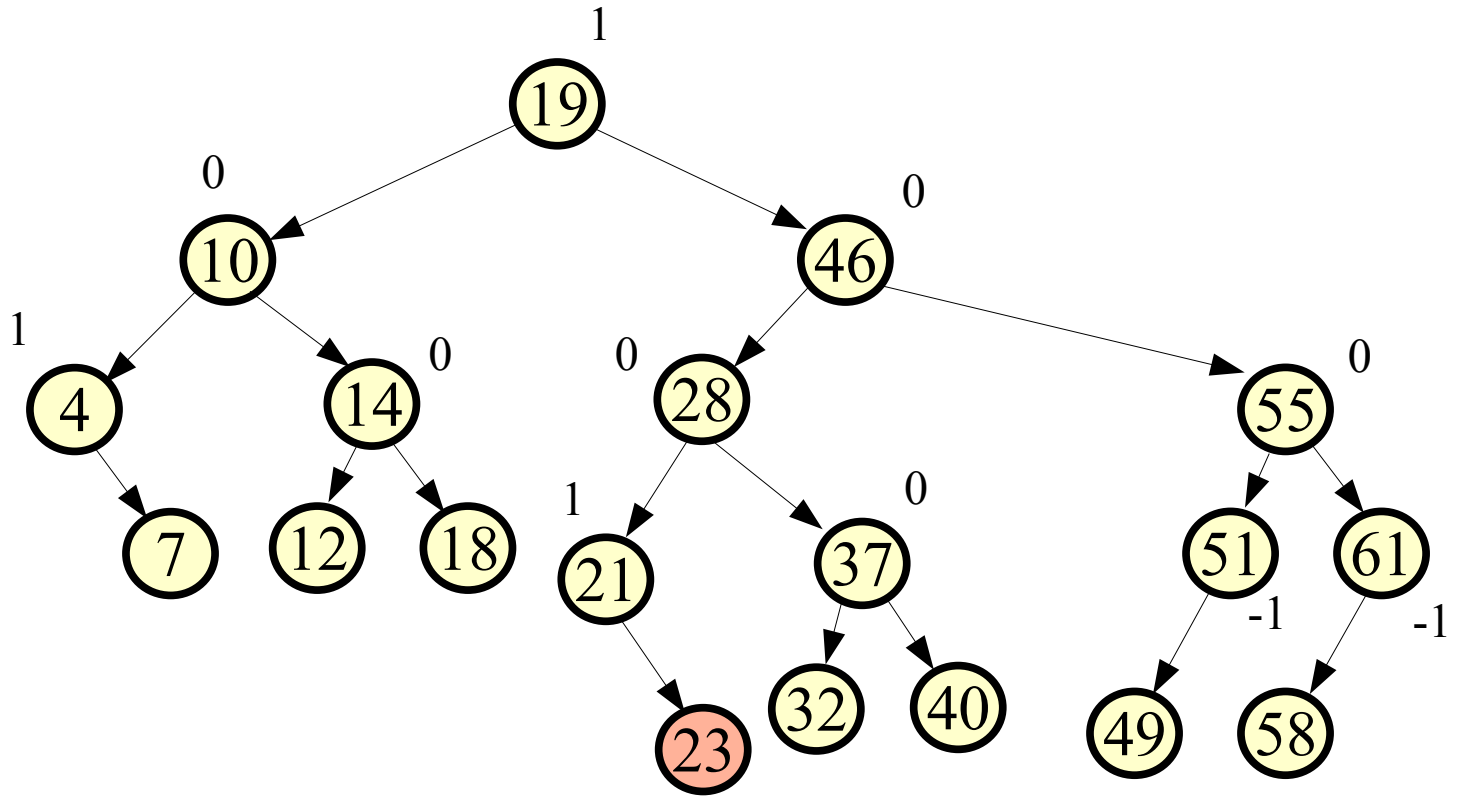
Example: Insert 23



Rotation around 28

Balanced Binaries – AVL Trees

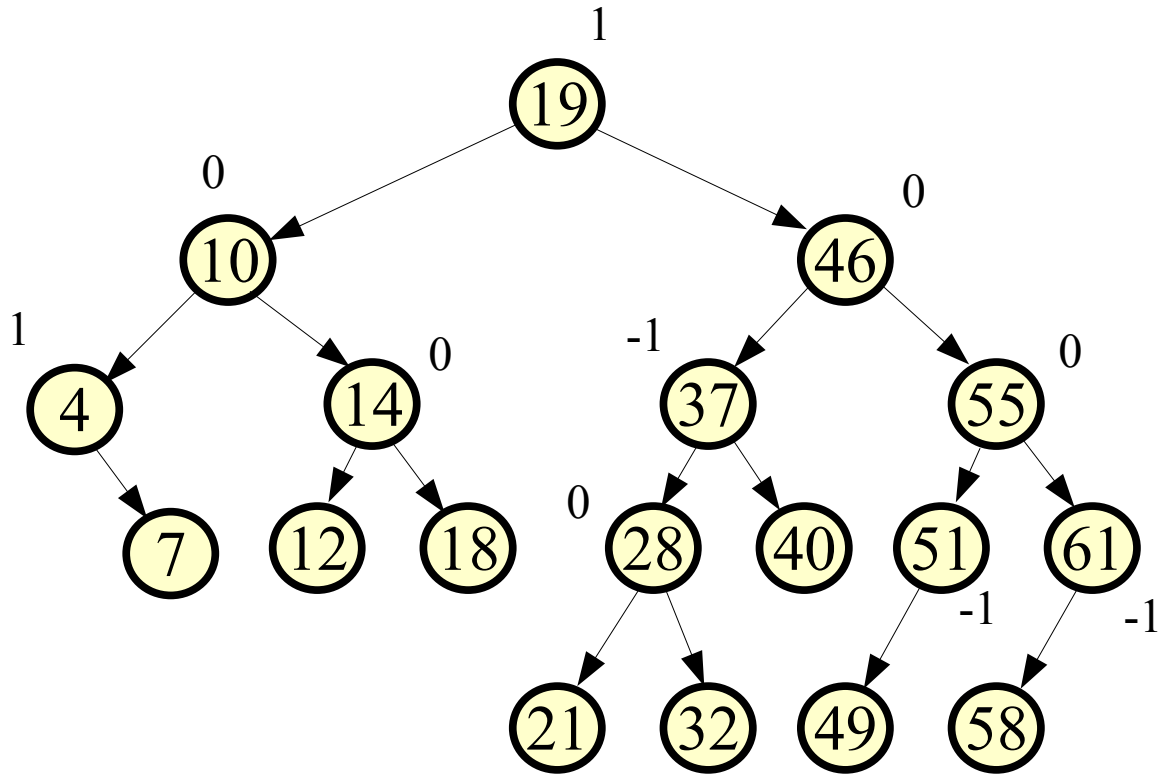
Example: Insert 23



Rotation around 28

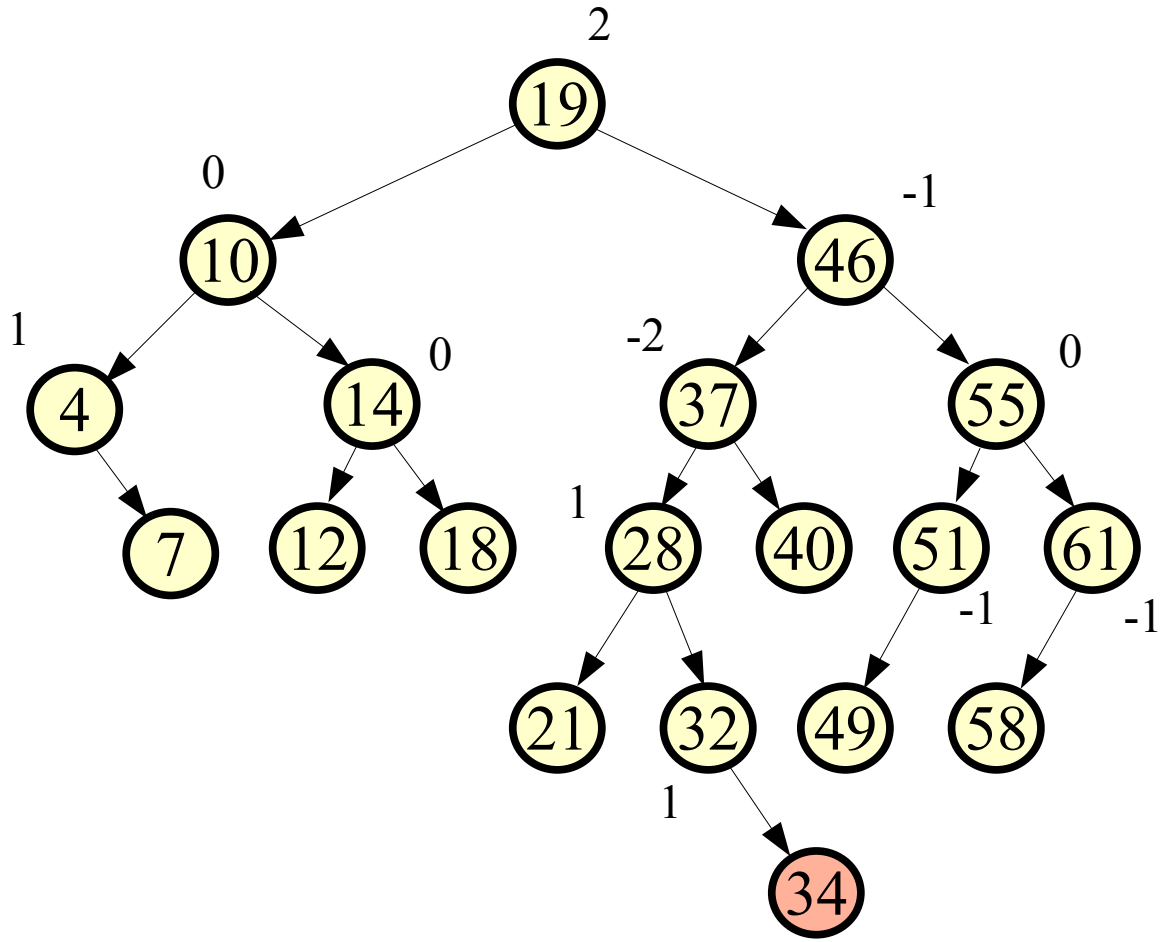
Balanced Binaries – AVL Trees

Example:



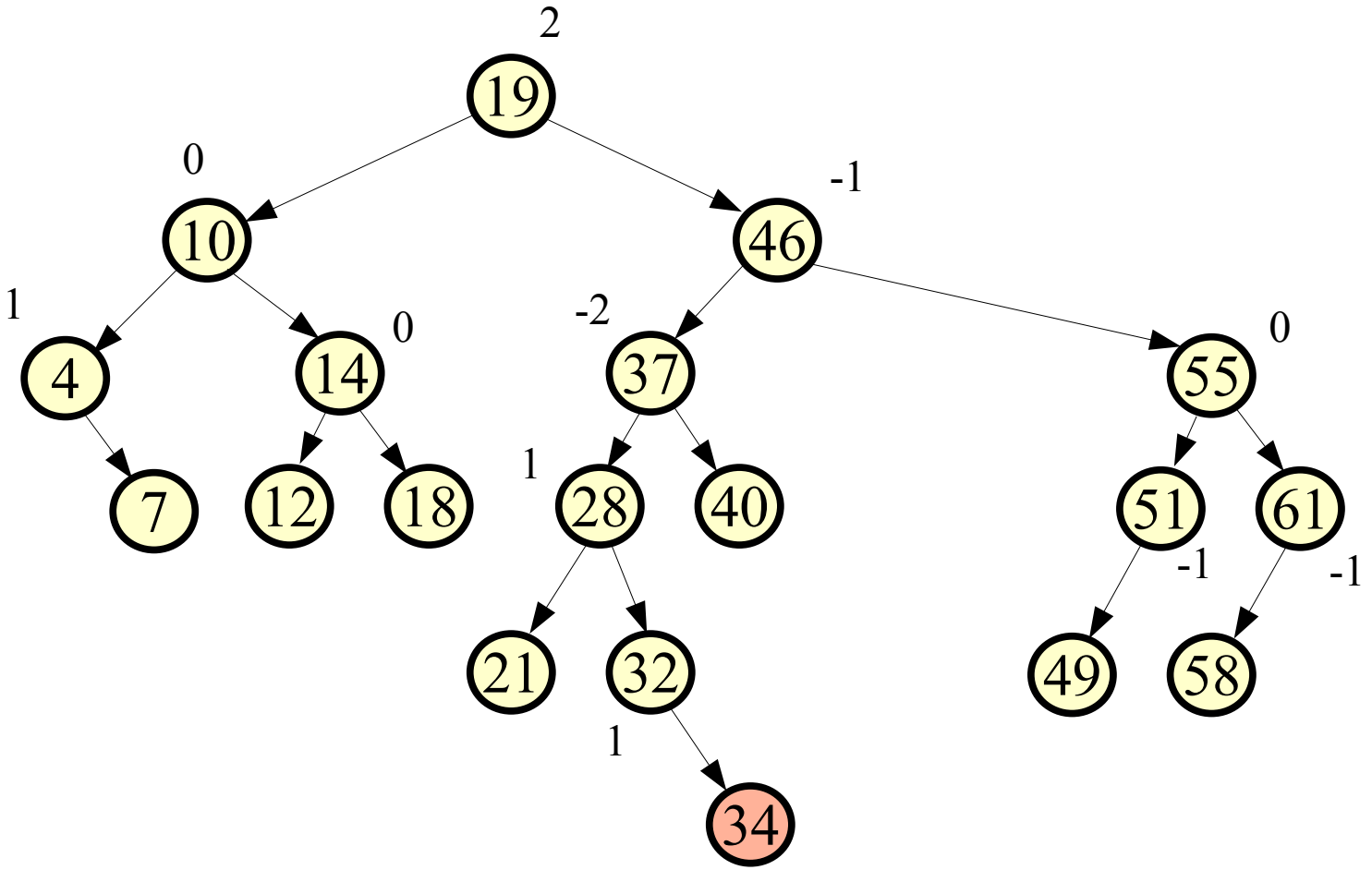
Balanced Binaries – AVL Trees

Example: Insert 34



Balanced Binaries – AVL Trees

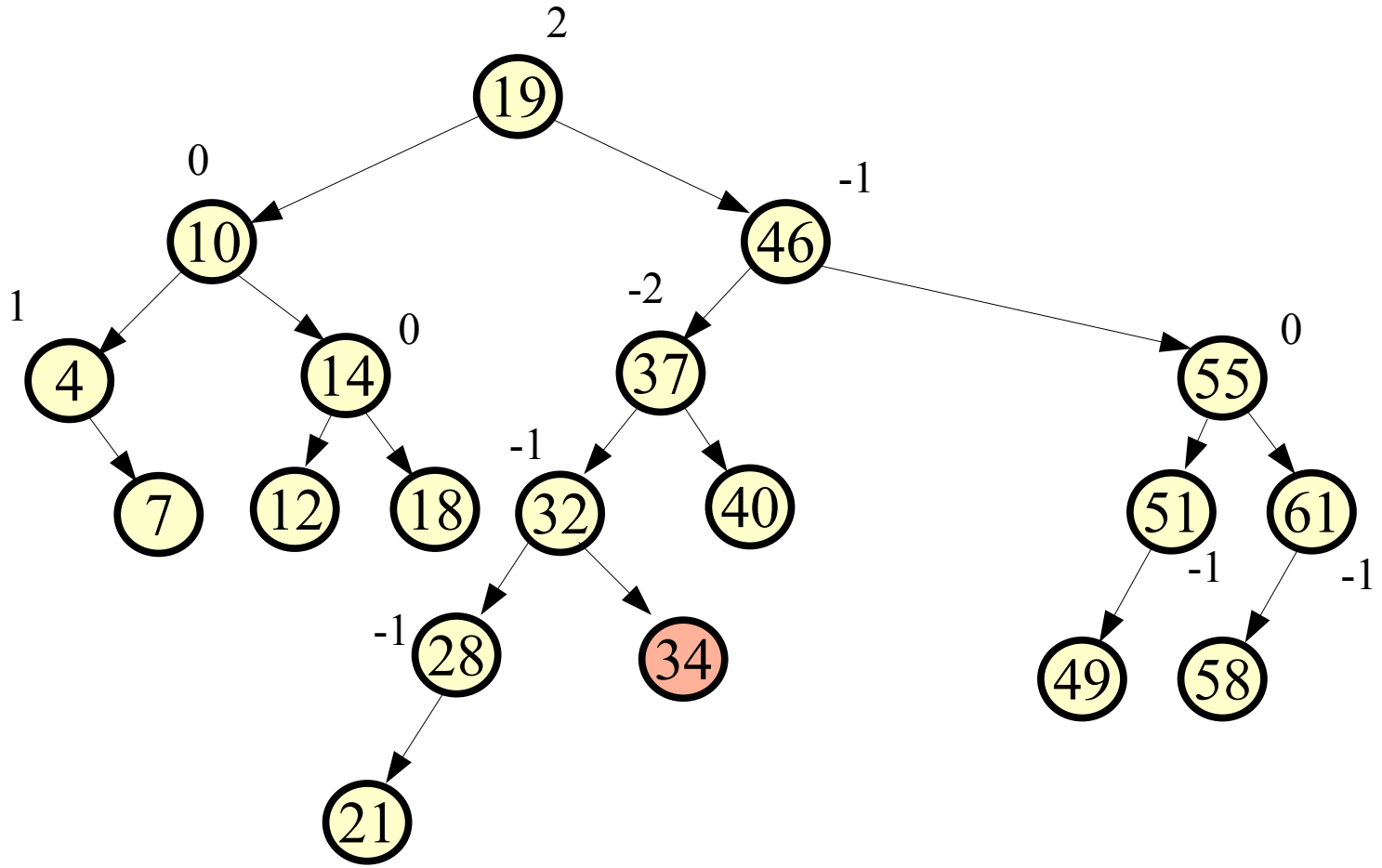
Example: Insert 34



Double rotation around 32

Balanced Binaries – AVL Trees

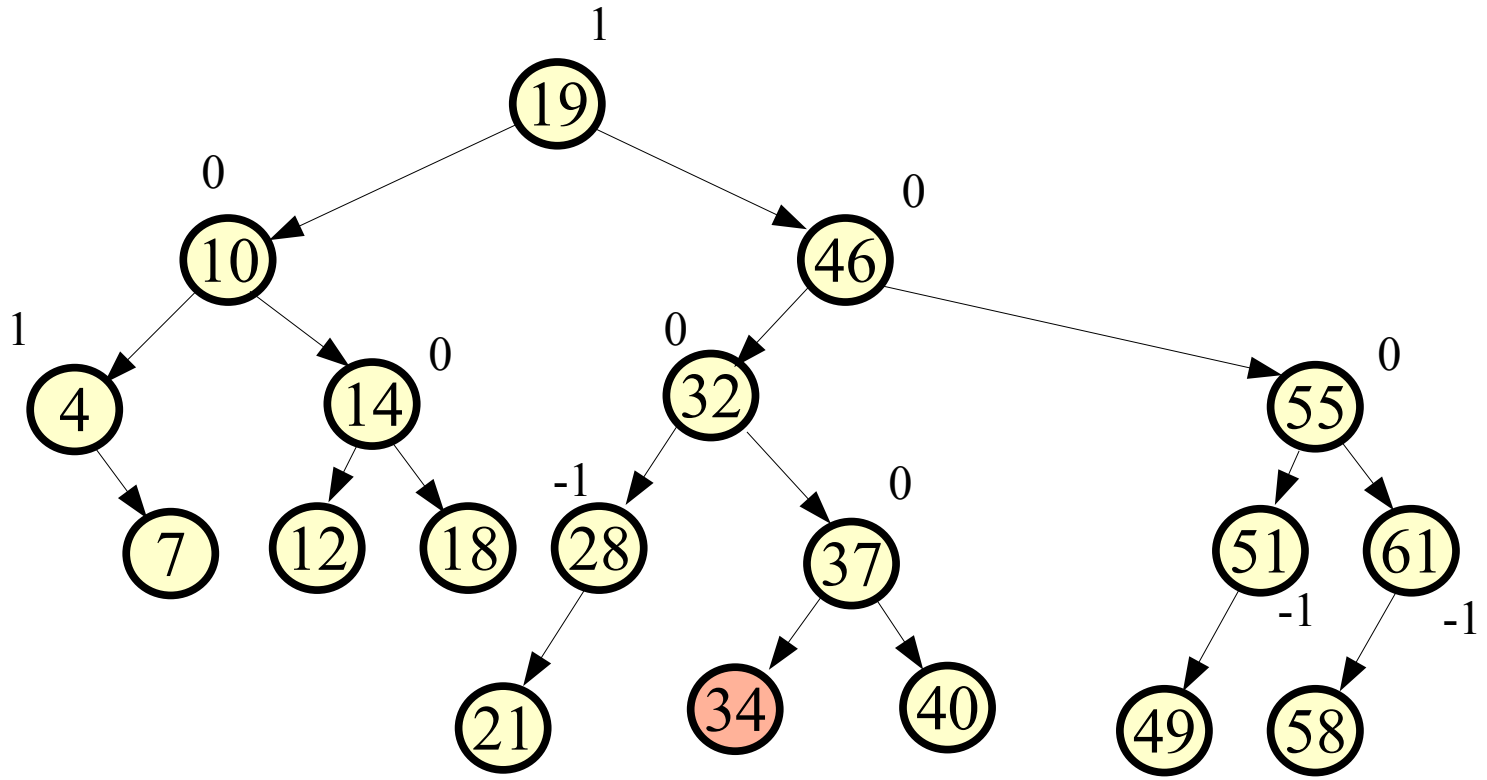
Example: Insert 34



Double rotation around 32

Balanced Binaries – AVL Trees

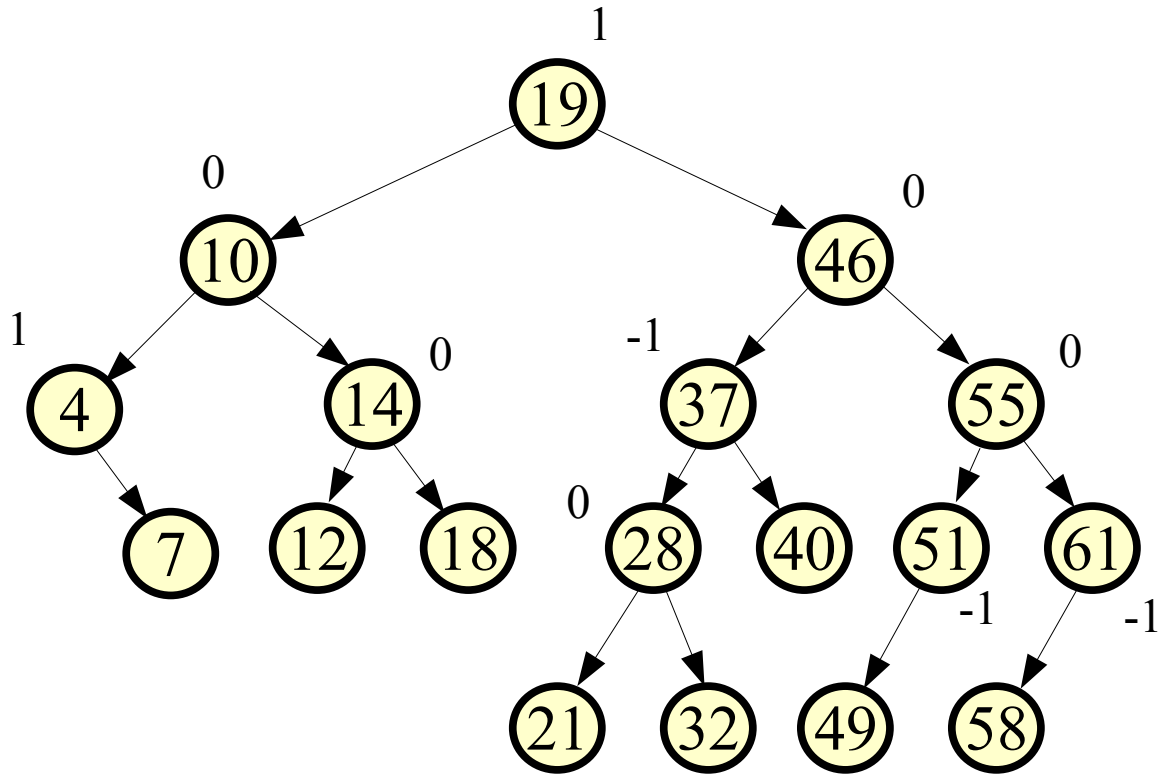
Example: Insert 34



Double rotation around 32

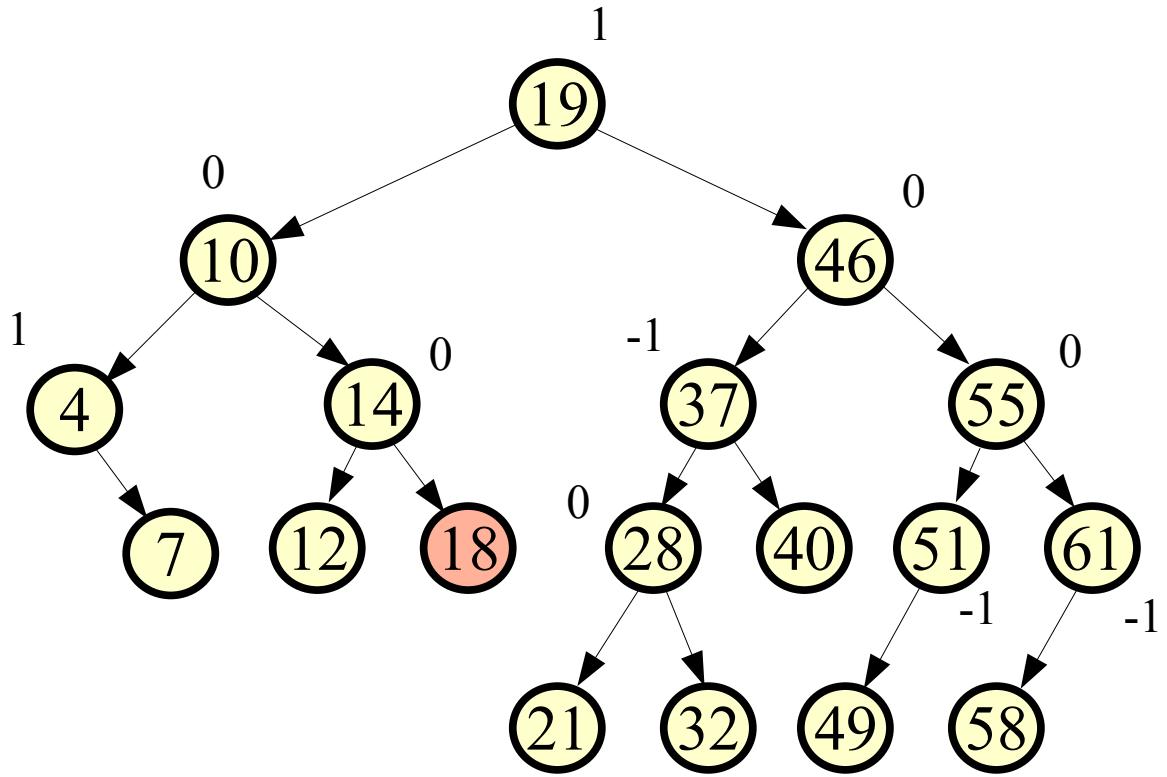
Balanced Binaries – AVL Trees

Example:



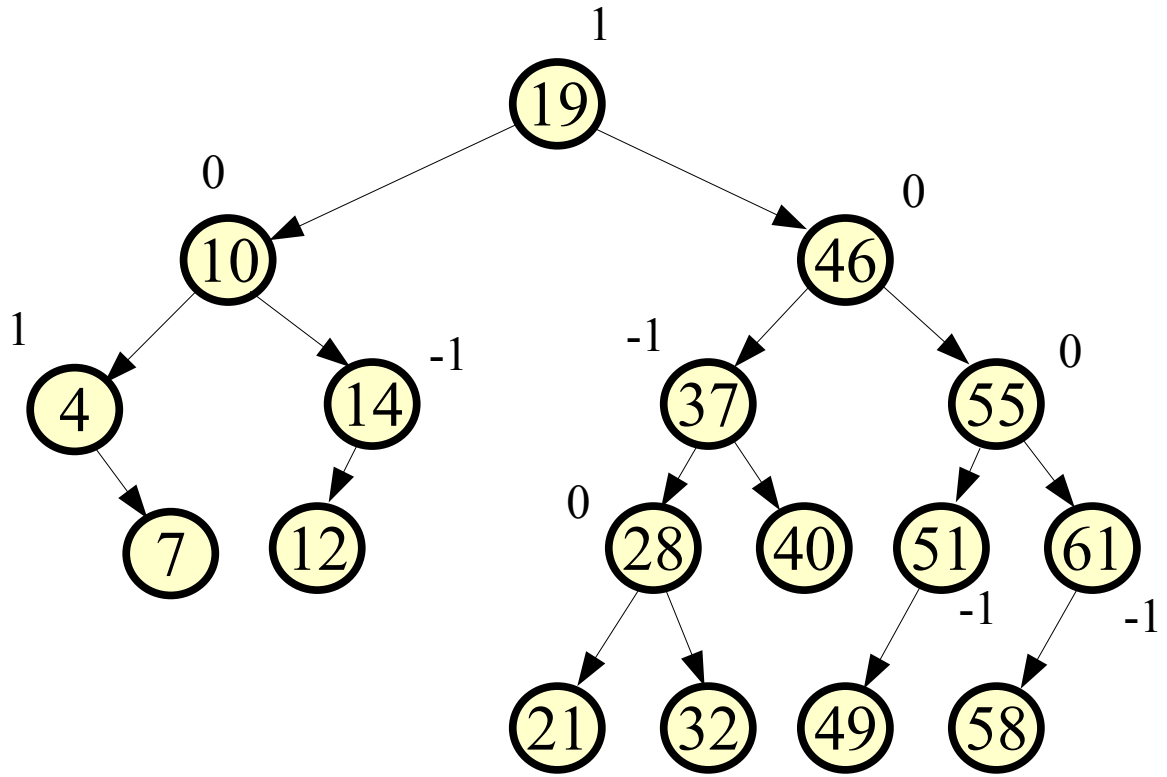
Balanced Binaries – AVL Trees

Example: Delete 18



Balanced Binaries – AVL Trees

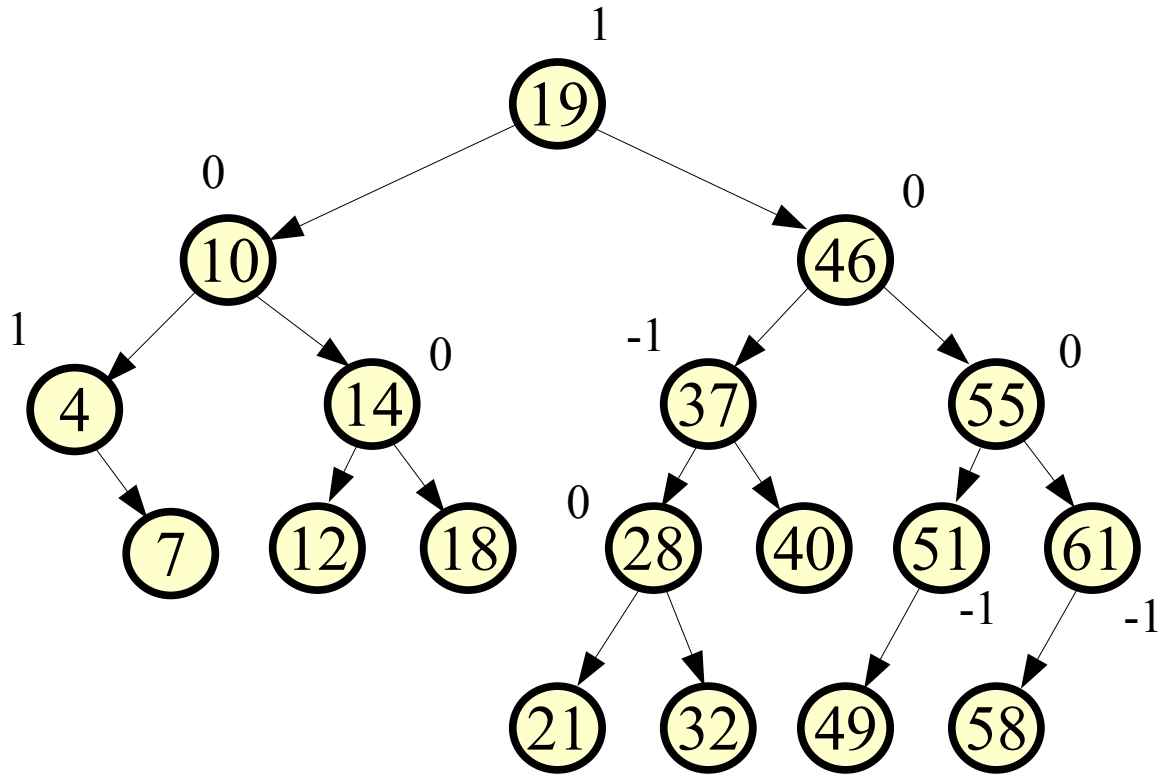
Example: Delete 18



No change

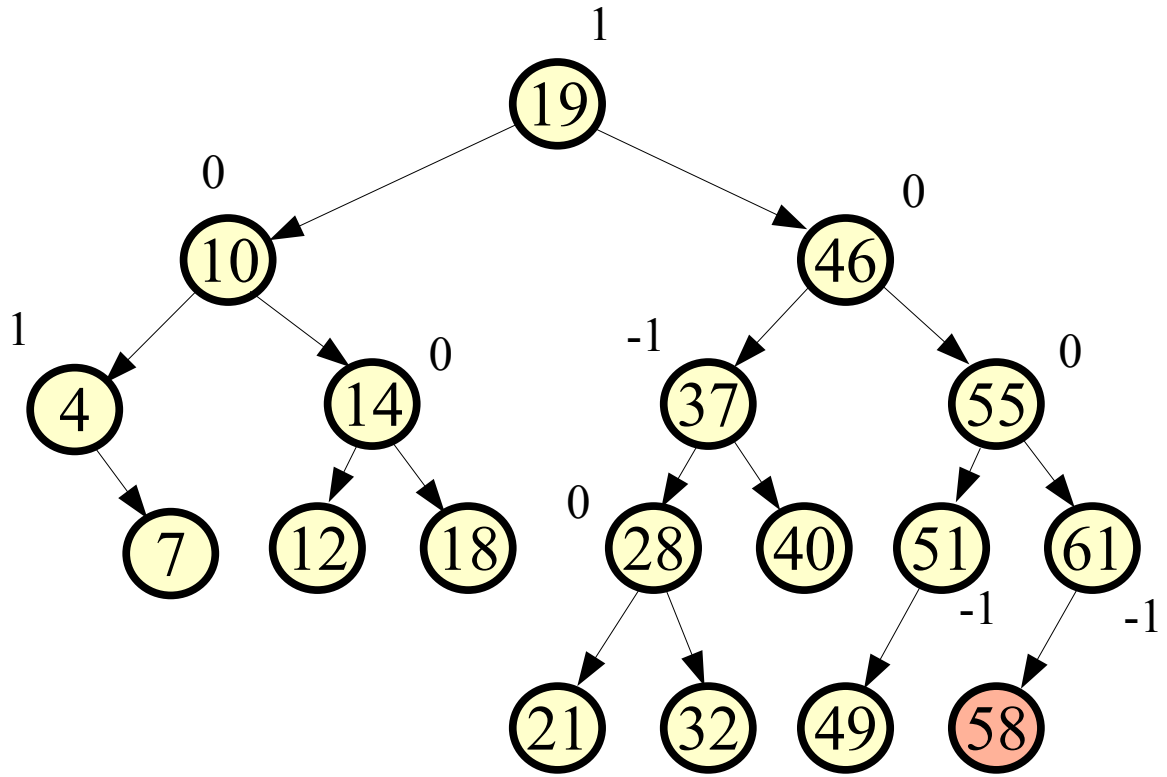
Balanced Binaries – AVL Trees

Example:



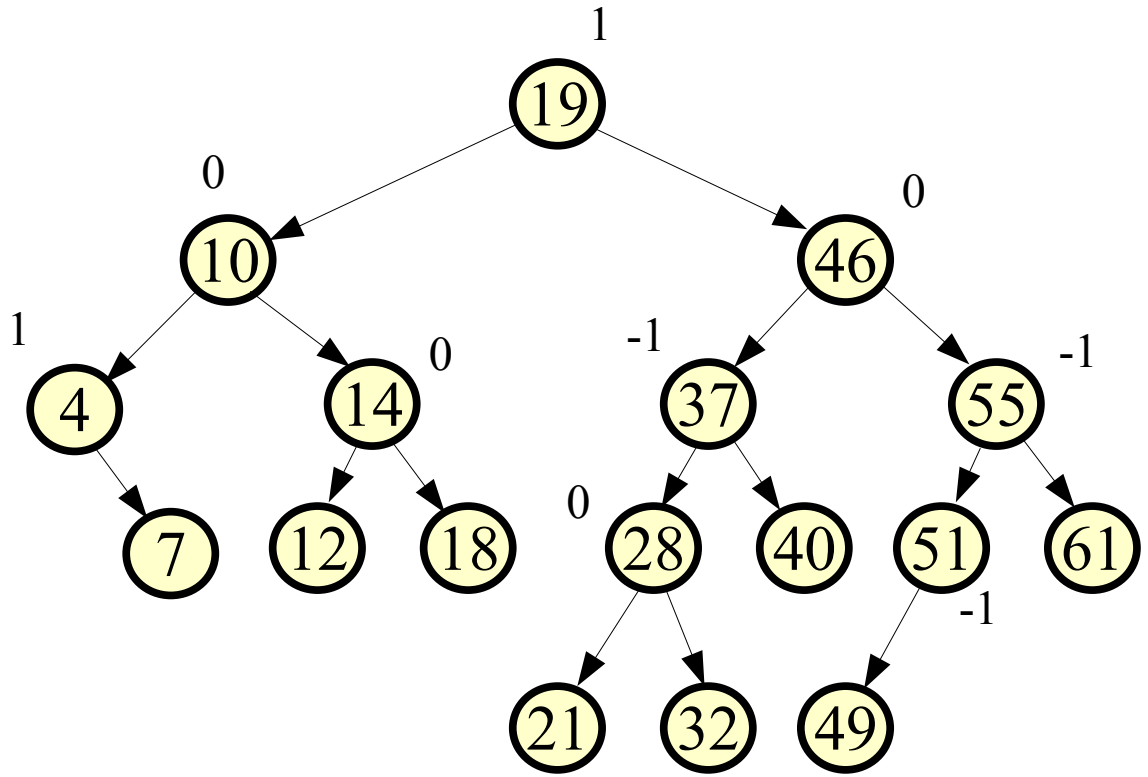
Balanced Binaries – AVL Trees

Example: Delete 58



Balanced Binaries – AVL Trees

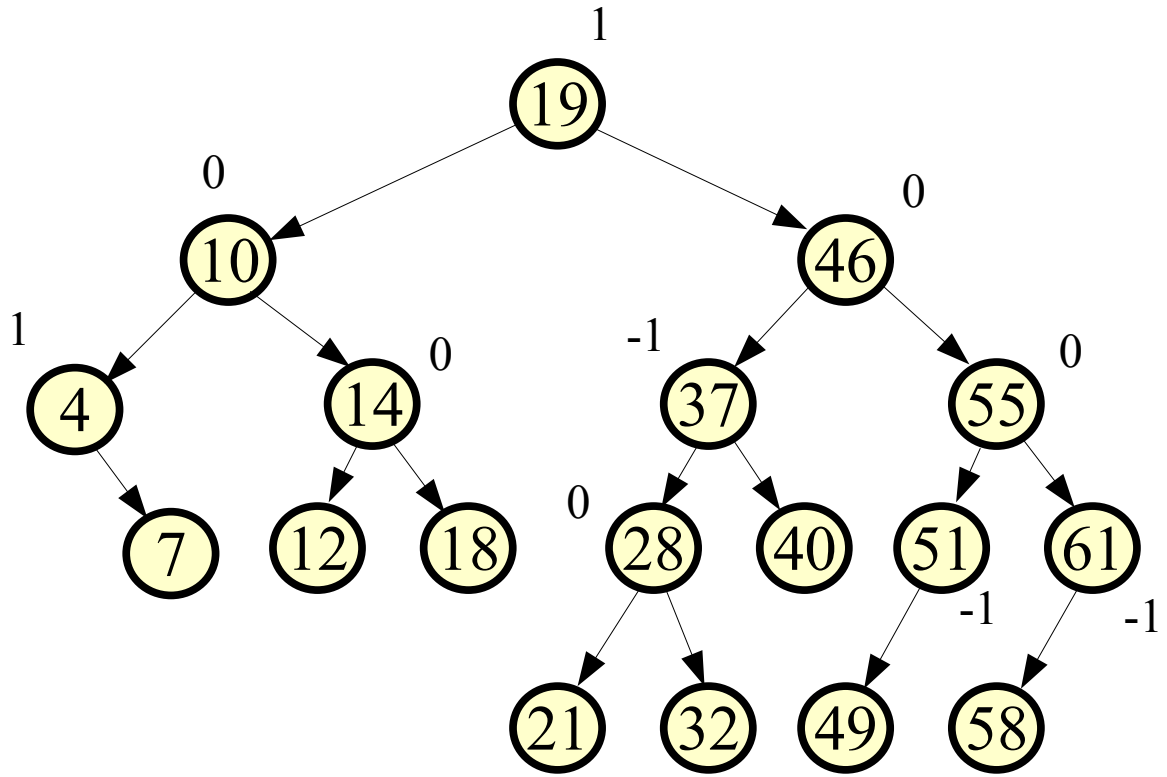
Example: Delete 58



No change

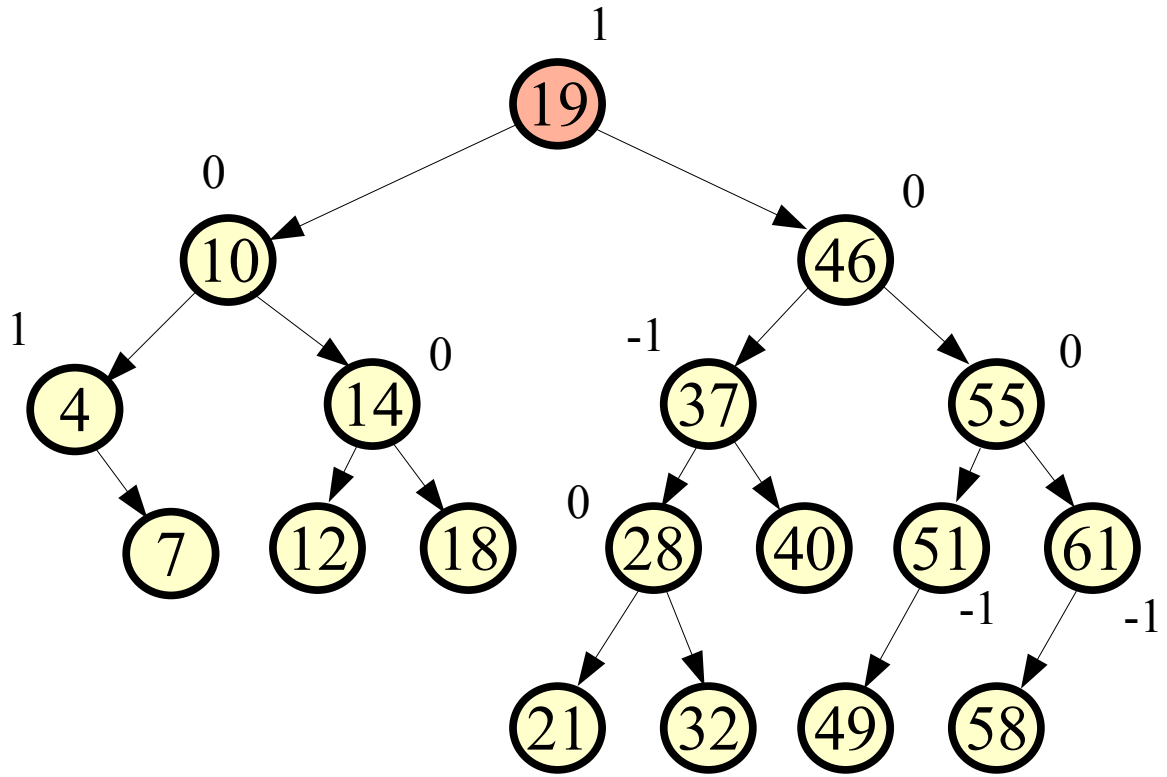
Balanced Binaries – AVL Trees

Example:



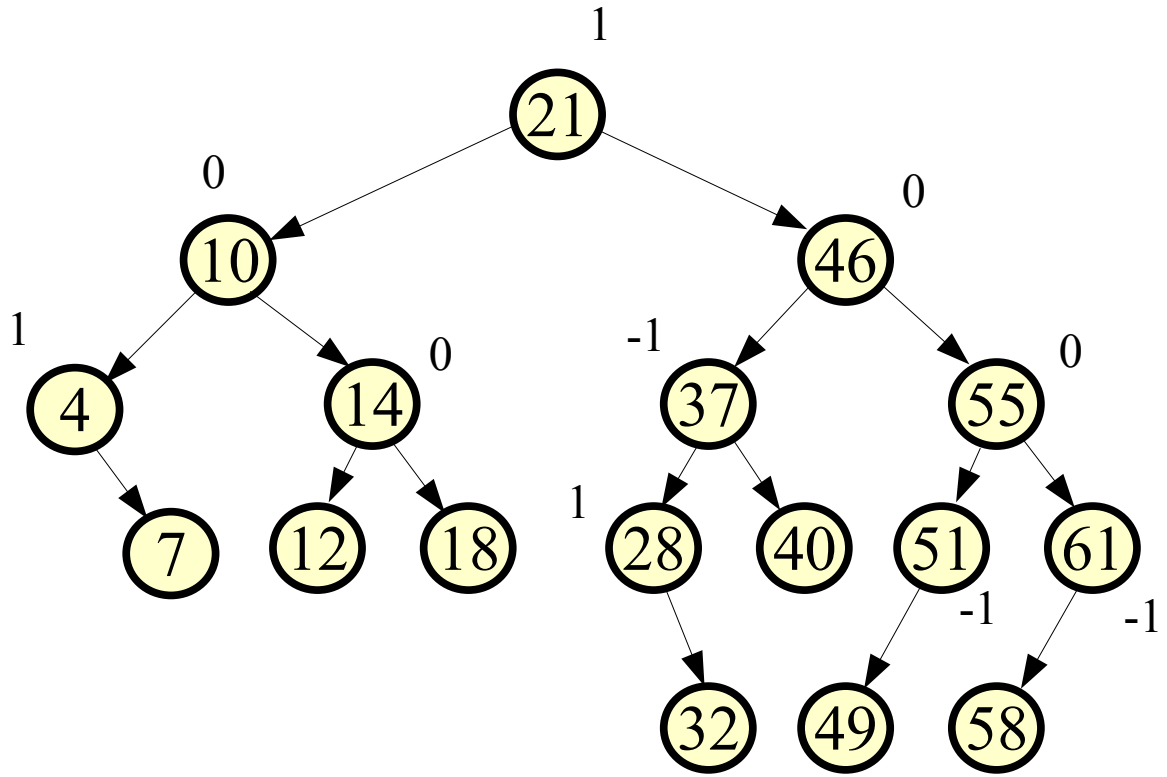
Balanced Binaries – AVL Trees

Example: Delete 19



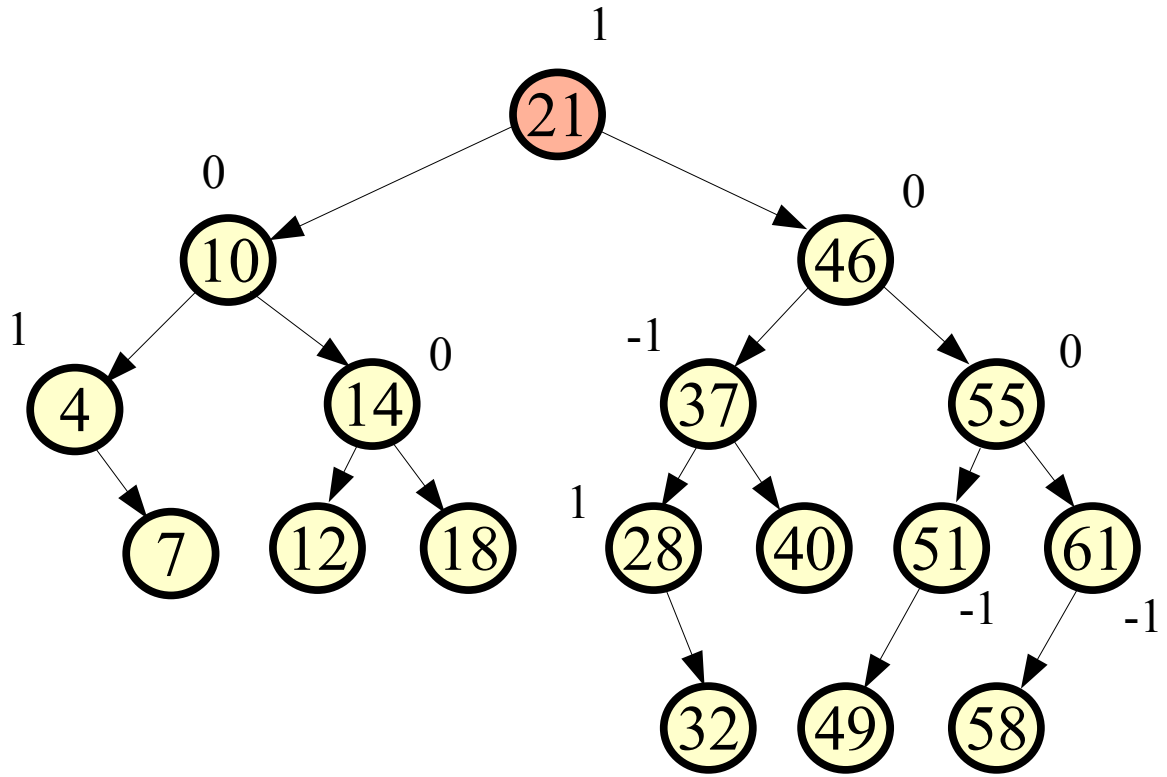
Balanced Binaries – AVL Trees

Example: Delete 19



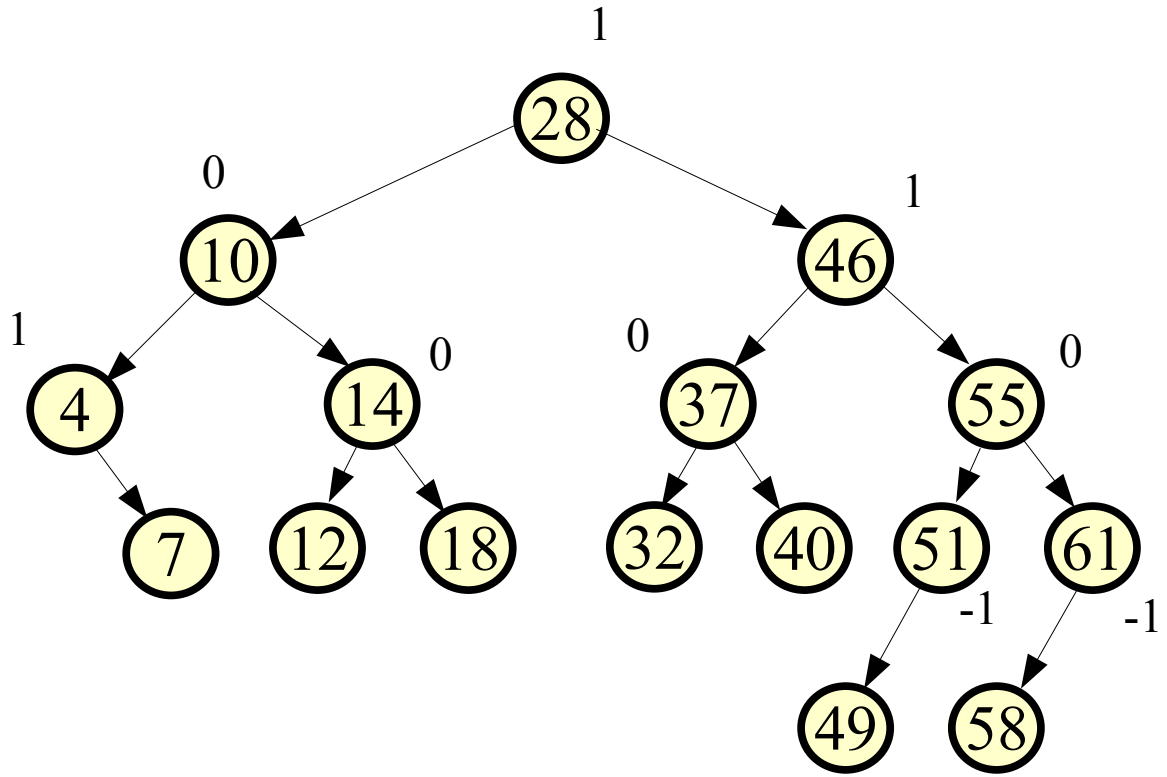
Balanced Binaries – AVL Trees

Example: Delete 21



Balanced Binaries – AVL Trees

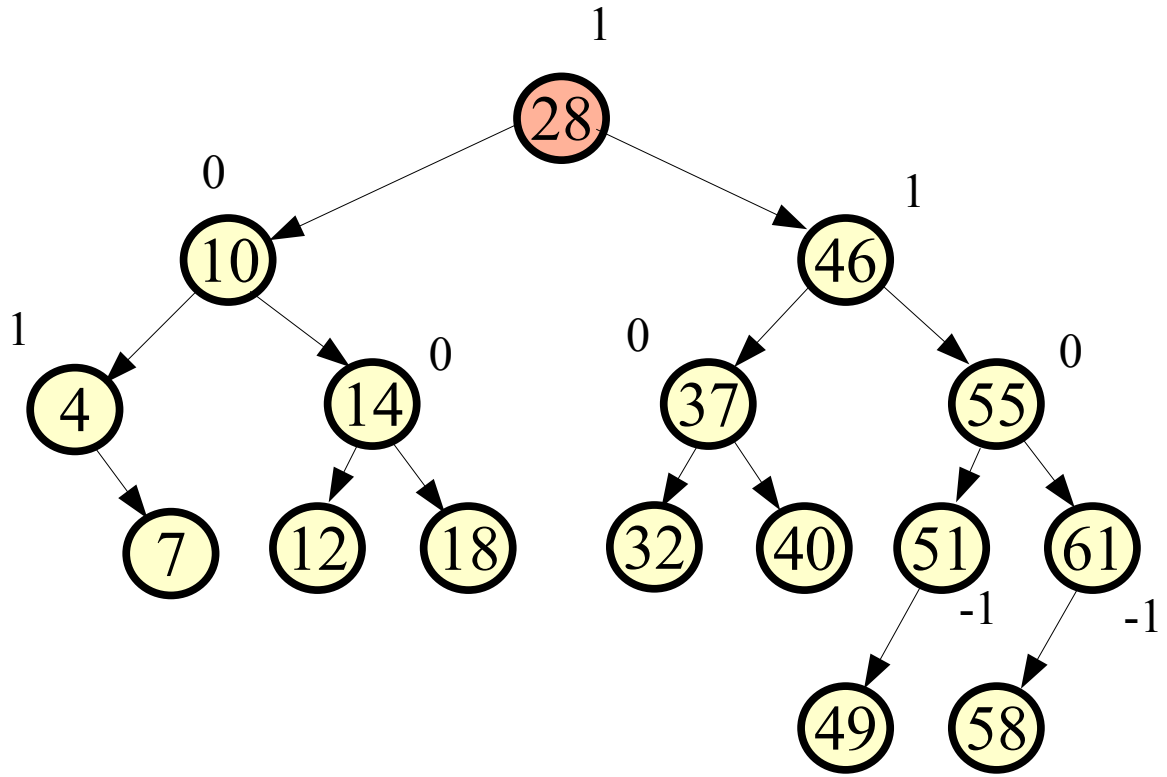
Example: Delete 21



No change

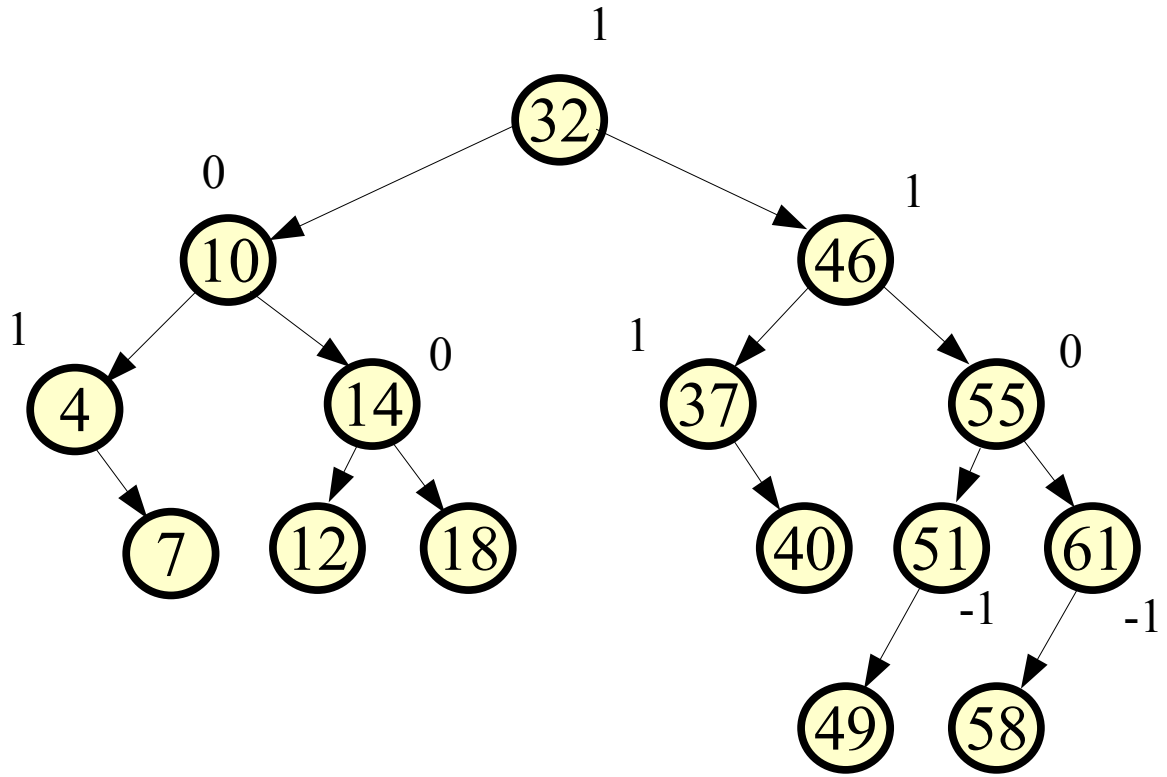
Balanced Binaries – AVL Trees

Example: Delete 28



Balanced Binaries – AVL Trees

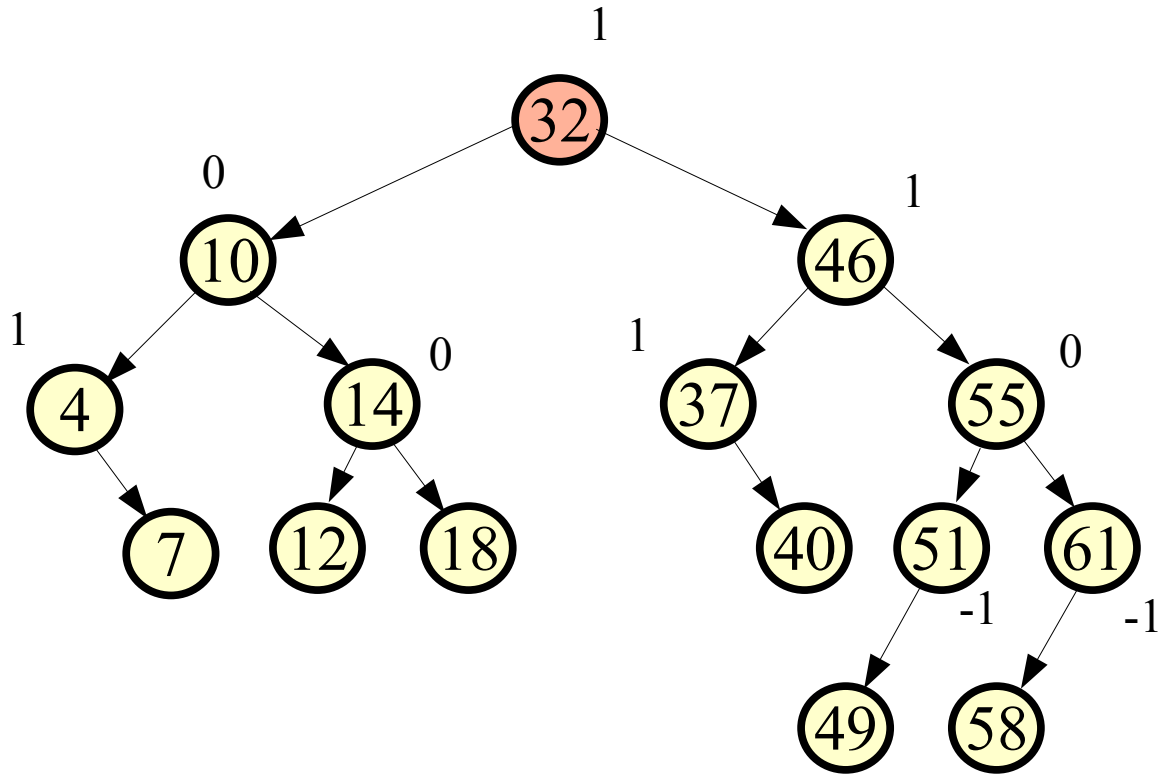
Example: Delete 28



No change

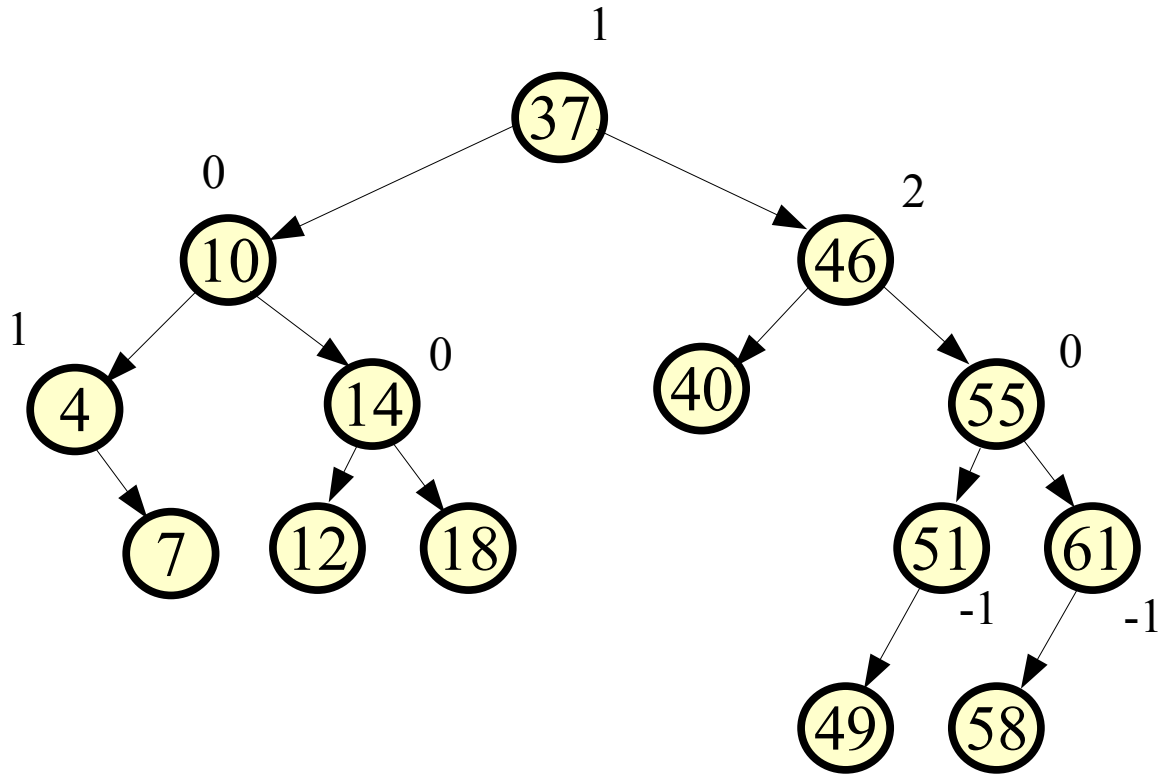
Balanced Binaries – AVL Trees

Example: Delete 32



Balanced Binaries – AVL Trees

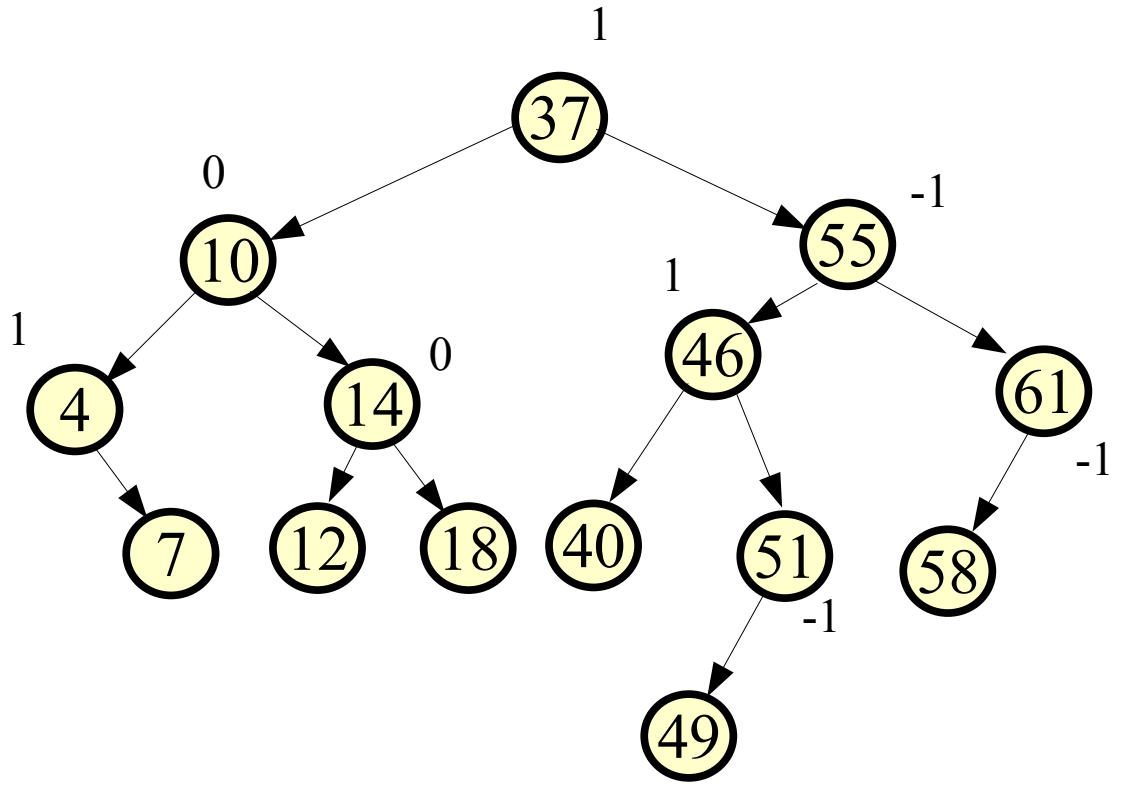
Example: Delete 32



Rotation around 55

Balanced Binaries – AVL Trees

Example: Delete 32



Rotation around 55