

Balanced Search Trees

Chapter 19

Balanced Search Trees

- Height of binary search tree
 - Sensitive to order of additions and removals
- Various search trees can retain balance
 - Despite additions and removals

Balanced Search Trees

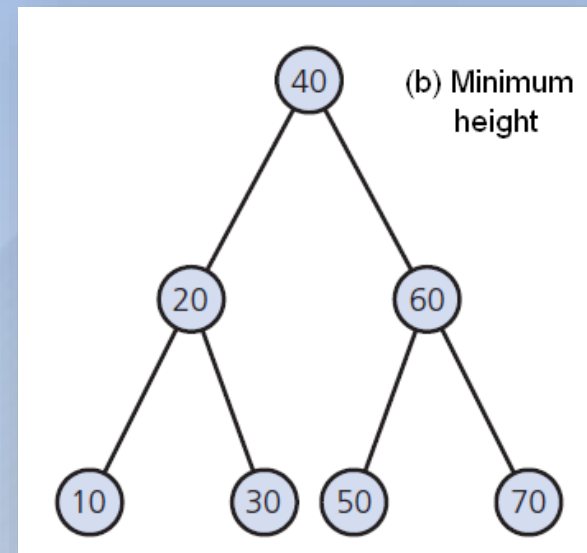
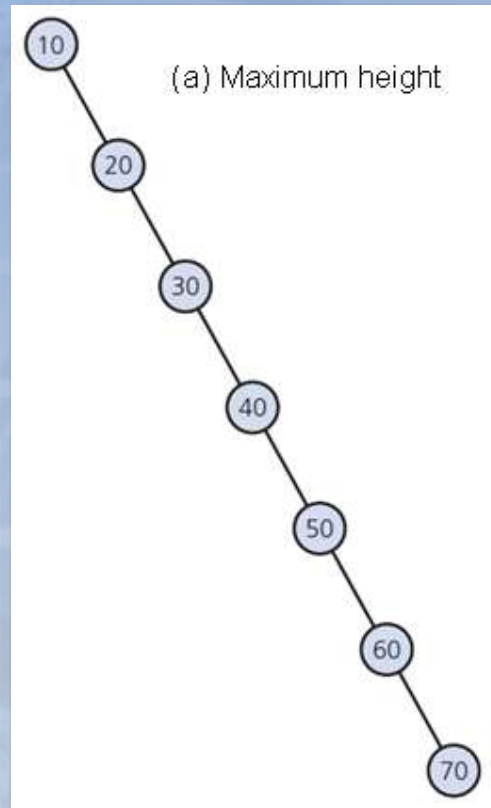


FIGURE 19-1 The tallest and shortest binary search trees containing the same data

AVL Trees

- An AVL tree
 - A balanced binary search tree
- Maintains its height close to the minimum
- Rotations restore the balance

AVL Trees

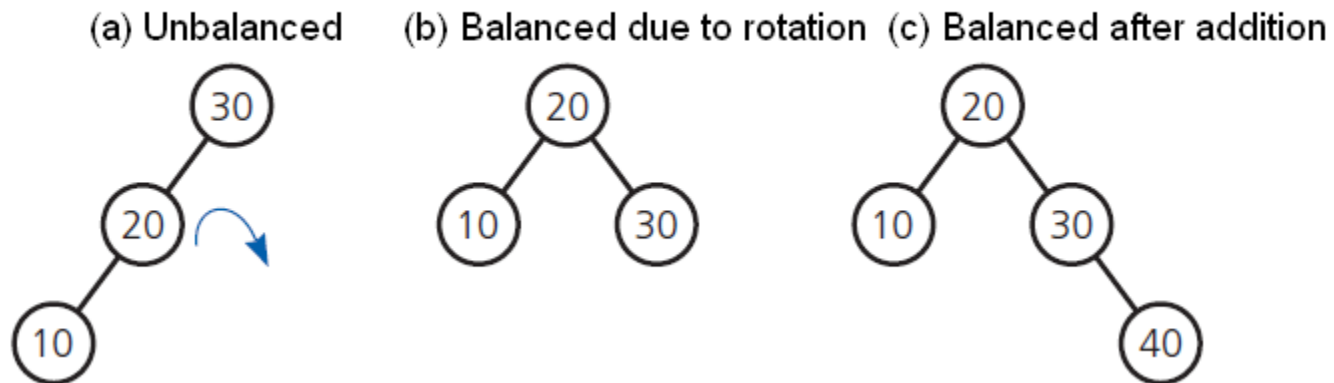
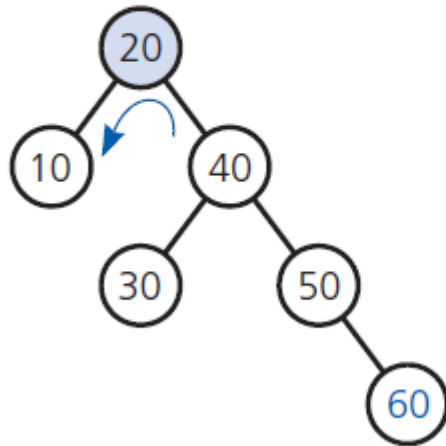


FIGURE 19-2 An unbalanced binary search tree

AVL Trees

(a) The addition of 60 to an AVL tree destroys its balance



(b) A single left rotation restores the tree's balance

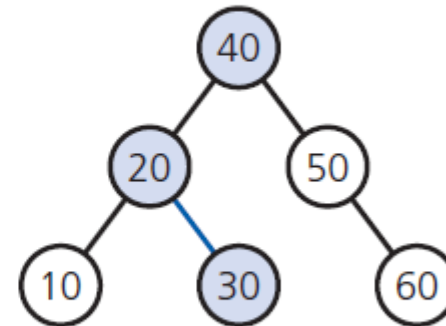
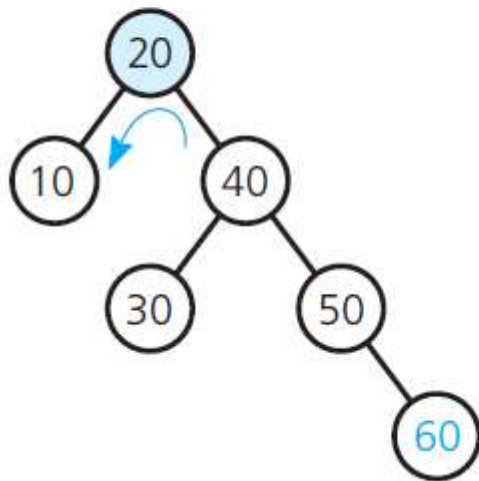


FIGURE 19-3 Correcting an imbalance in an AVL tree due to an addition by using a single rotation to the left

AVL Trees

(a) The addition of 60 to an AVL tree destroys its balance



(b) A single left rotation restores the tree's balance

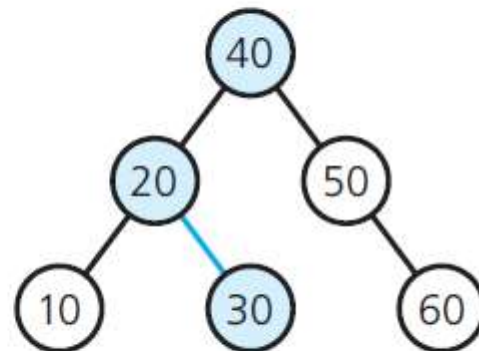


FIGURE 19-3 Correcting an imbalance in an AVL tree due to an addition by using a single rotation to the left

AVL Trees

(c) The general case for a single left rotation in an AVL tree whose height decreases

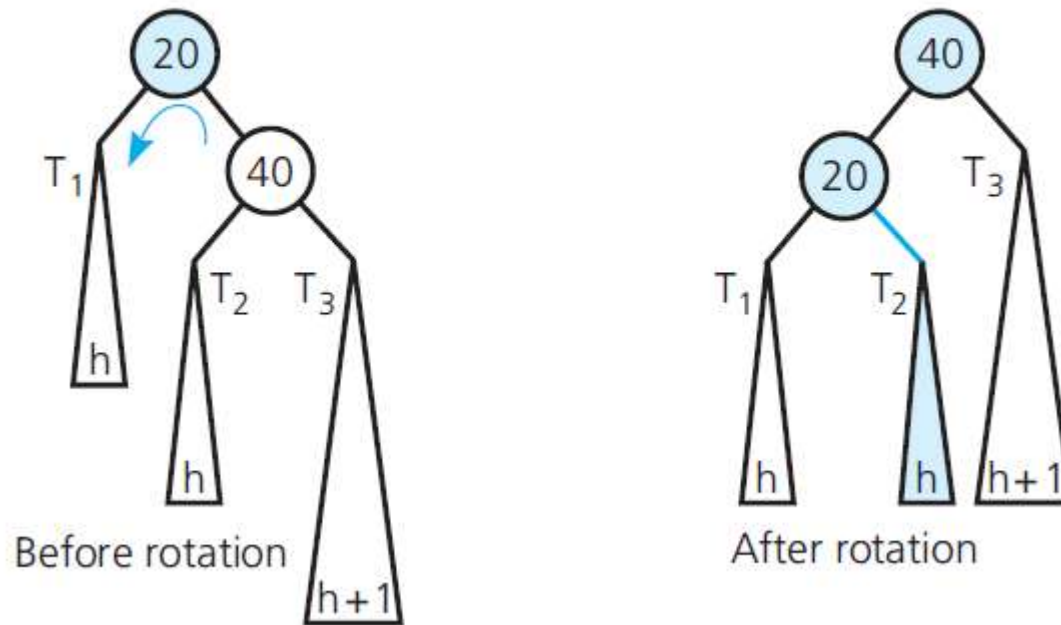
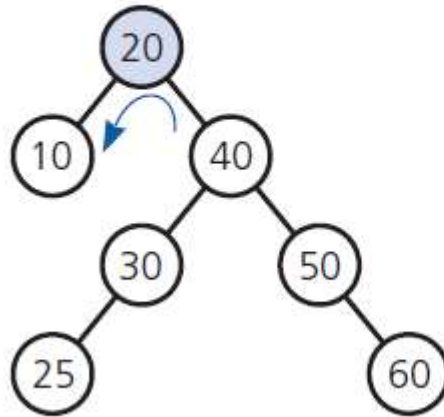


FIGURE 19-3 Correcting an imbalance in an AVL tree due to an addition by using a single rotation to the left

AVL Trees

(a) Unbalanced



(b) After a single left rotation that restores the tree's balance

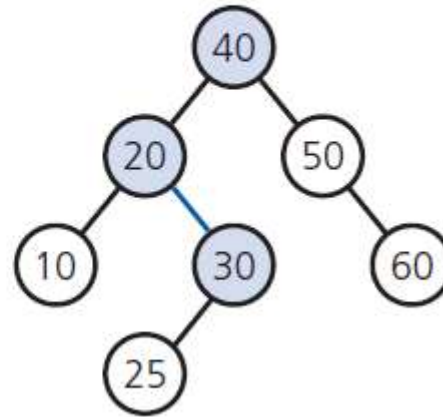
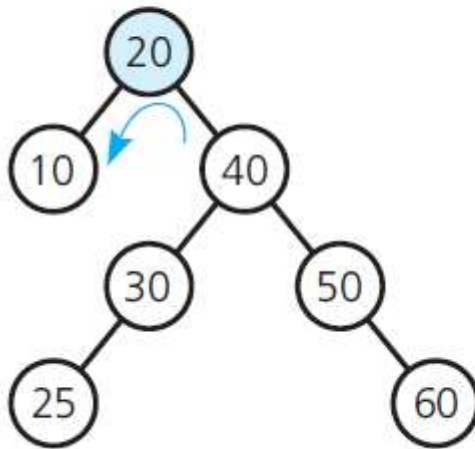


FIGURE 19-4 A single rotation to the left that does not affect the height of an AVL tree

AVL Trees

(a) Unbalanced



(b) After a single left rotation that restores the tree's balance

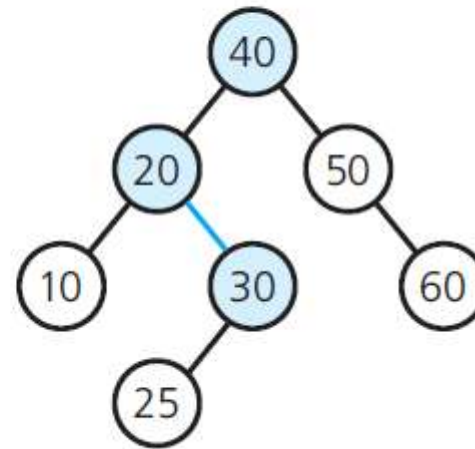


FIGURE 19-4 A single rotation to the left that does not affect the height of an AVL tree

AVL Trees

(c) The general case for a single left rotation in an AVL tree whose height is unchanged

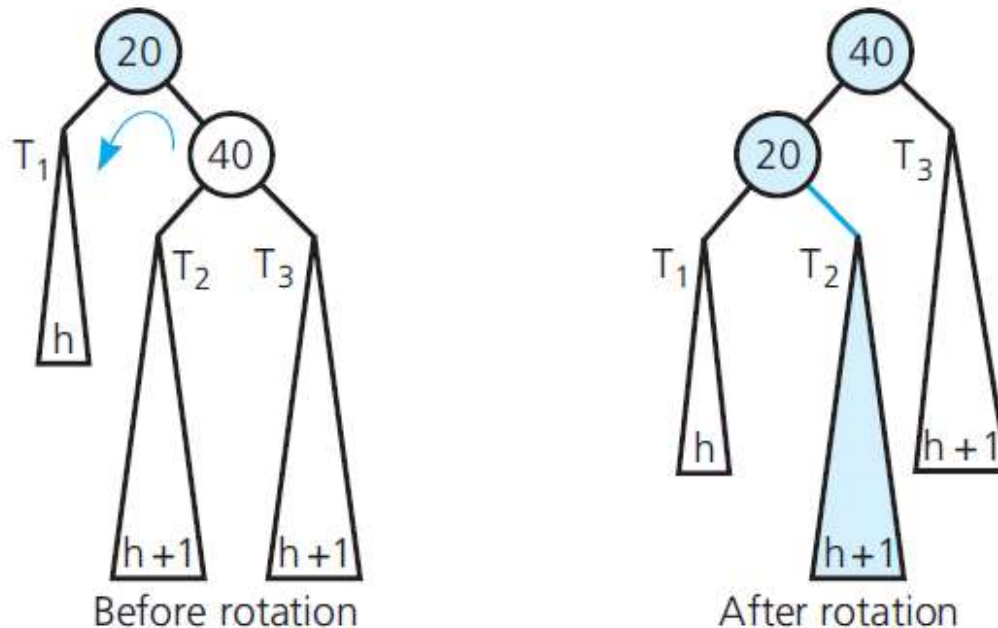
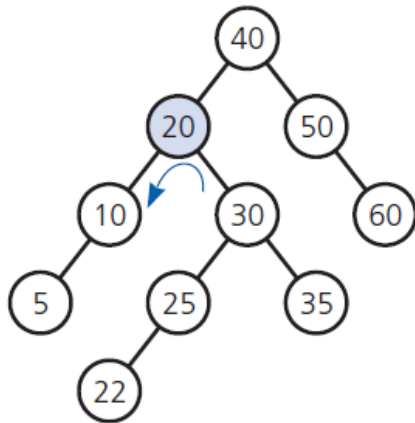


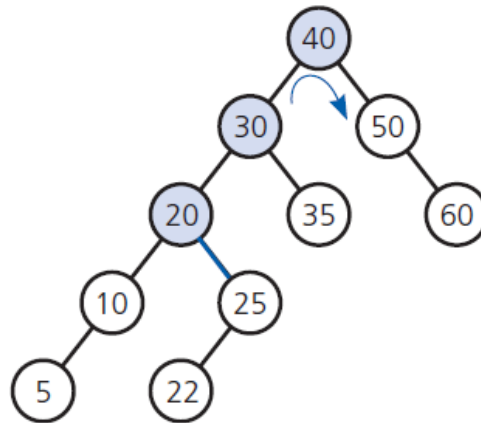
FIGURE 19-4 A single rotation to the left that does not affect the height of an AVL tree

AVL Trees

(a) Before the rotation



(b) After a left rotation



(c) After the right rotation

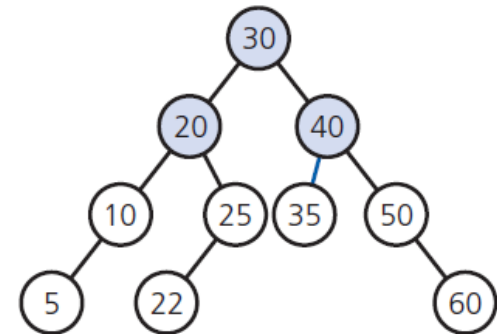


FIGURE 19-5 A double rotation that decreases the height of an AVL tree

AVL Trees

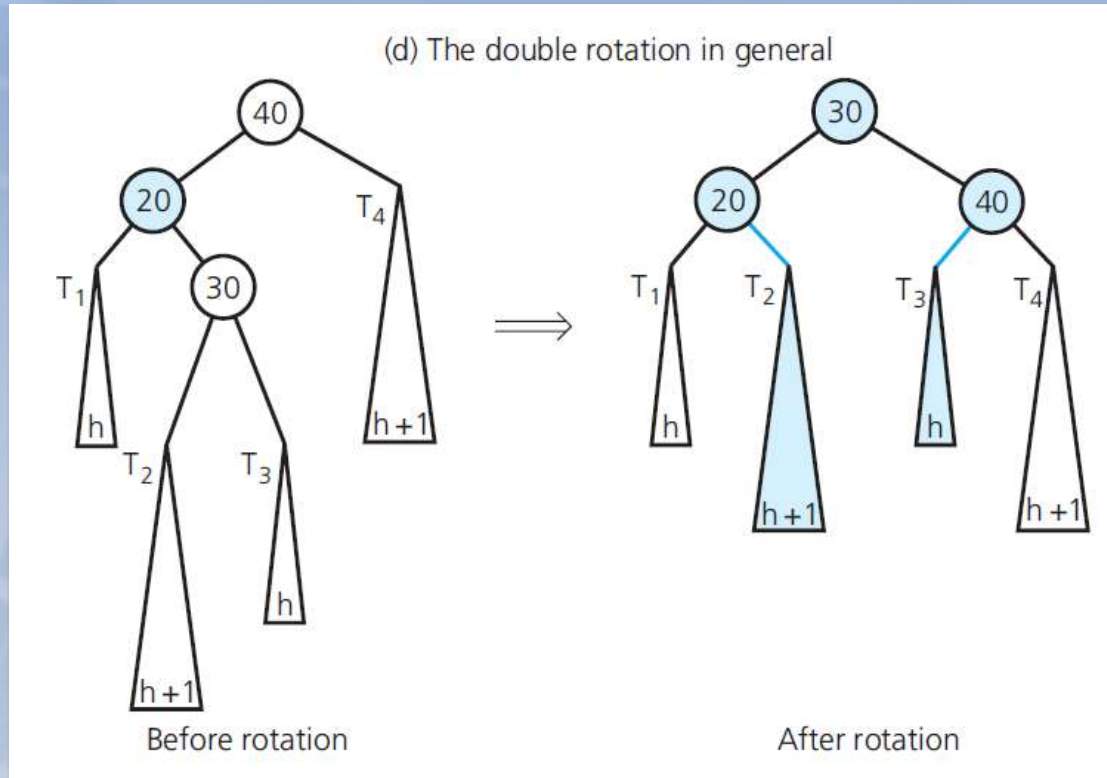


FIGURE 19-5 A double rotation that decreases the height of an AVL tree