AVL Trees

- An AVT tree is a BST with the additional requirement that:

  For any node in the tree, the height of its left and right subtrees differs by at most 1.

- The height of an empty subtree is -1.

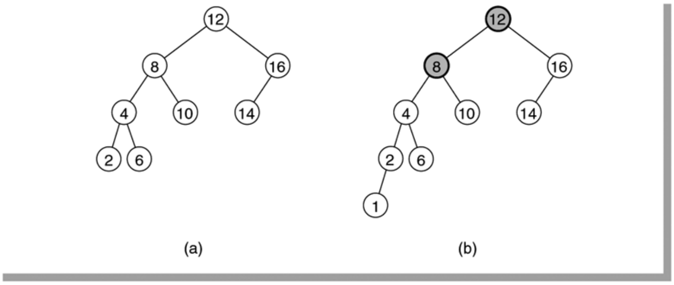


figure 19.21

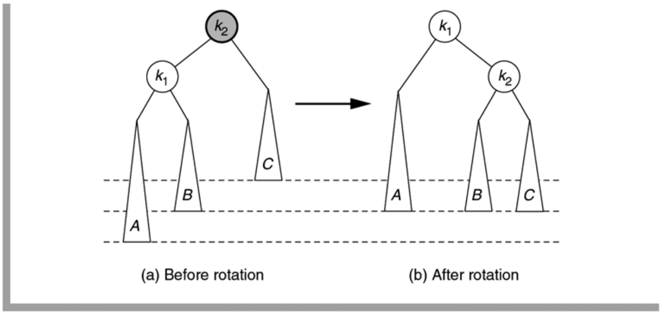
Two binary search trees: (a) an AVL tree; (b) not an AVL tree (unbalanced nodes are darkened)

Four Cases to Consider

- A height imbalance occurs because:
  - An insertion in the left subtree of the left child
  - An insertion in the right subtree of the left child
  - An insertion in the left subtree of the right child
  - An insertion in the right subtree of the right child

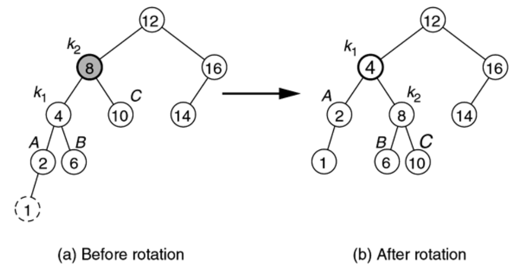
figure 19.23

Single rotation to fix case 1



(a) Before rotation

(b) After rotation

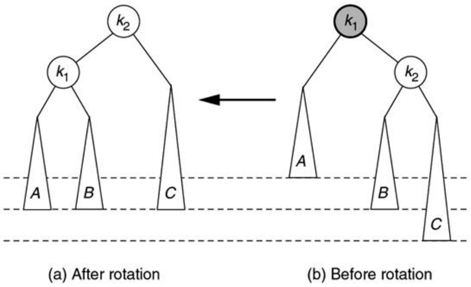


(a) Before rotation

(b) After rotation

figure 19.25

Single rotation fixes an AVL tree after insertion of 1.



(a) After rotation

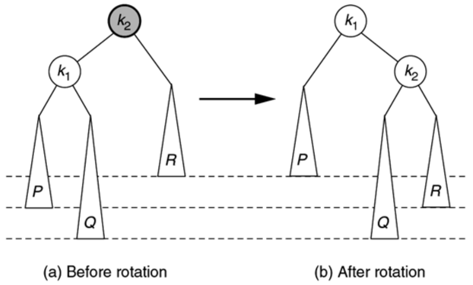
(b) Before rotation

figure 19.26

Symmetric single rotation to fix case 4

figure 19.28

Single rotation does not fix case 2.

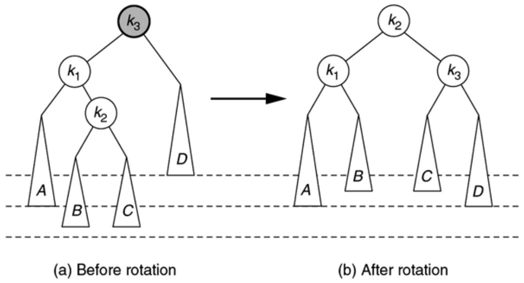


(a) Before rotation

(b) After rotation

figure 19.29

Left–right double rotation to fix case 2



(a) Before rotation

(b) After rotation

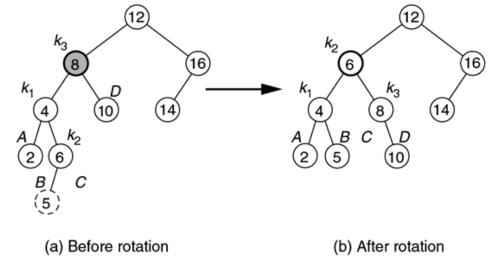


figure 19.30

Double rotation fixes AVL tree after the insertion of 5.

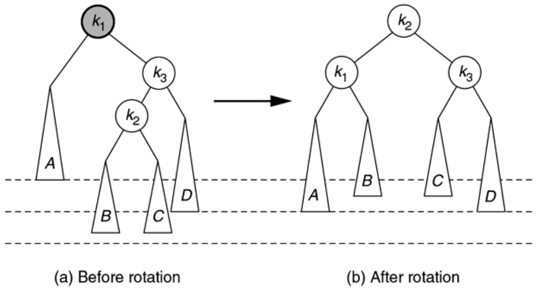


figure 19.31

Right–Left double rotation to fix case 3.