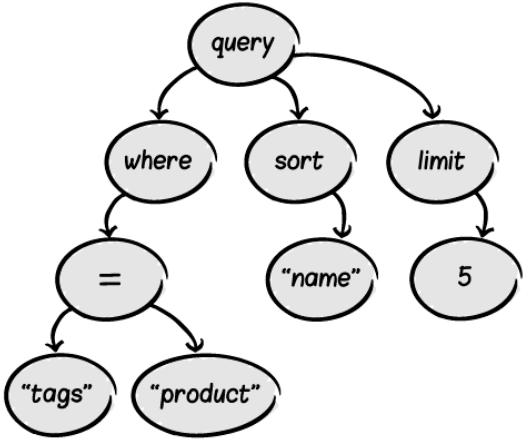
AVL Ağacı



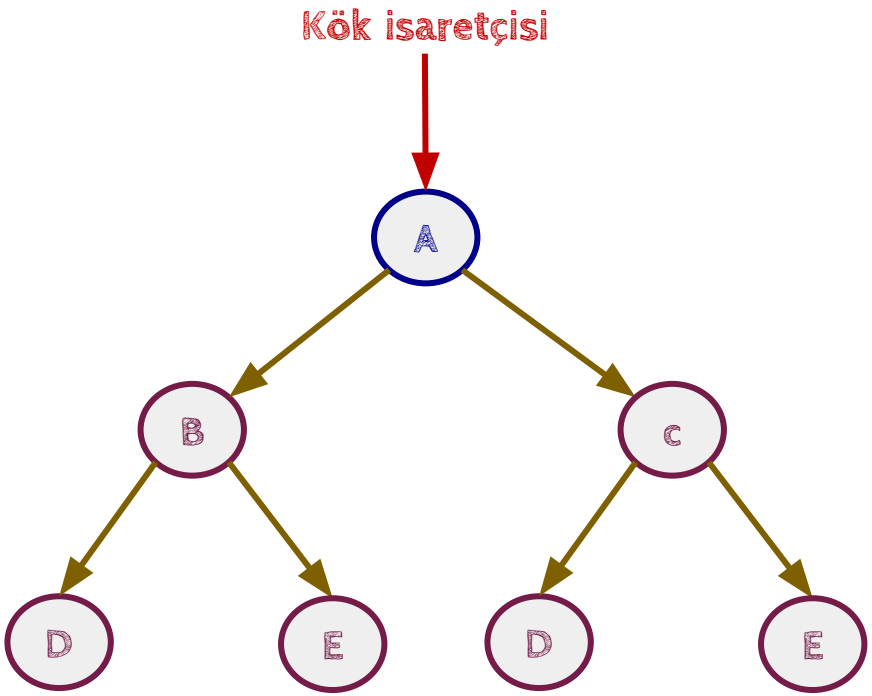
Suhap SAHIN
Onur GÖK

AVL (Adel'son-Vel'skiĭ) Landis Agacı

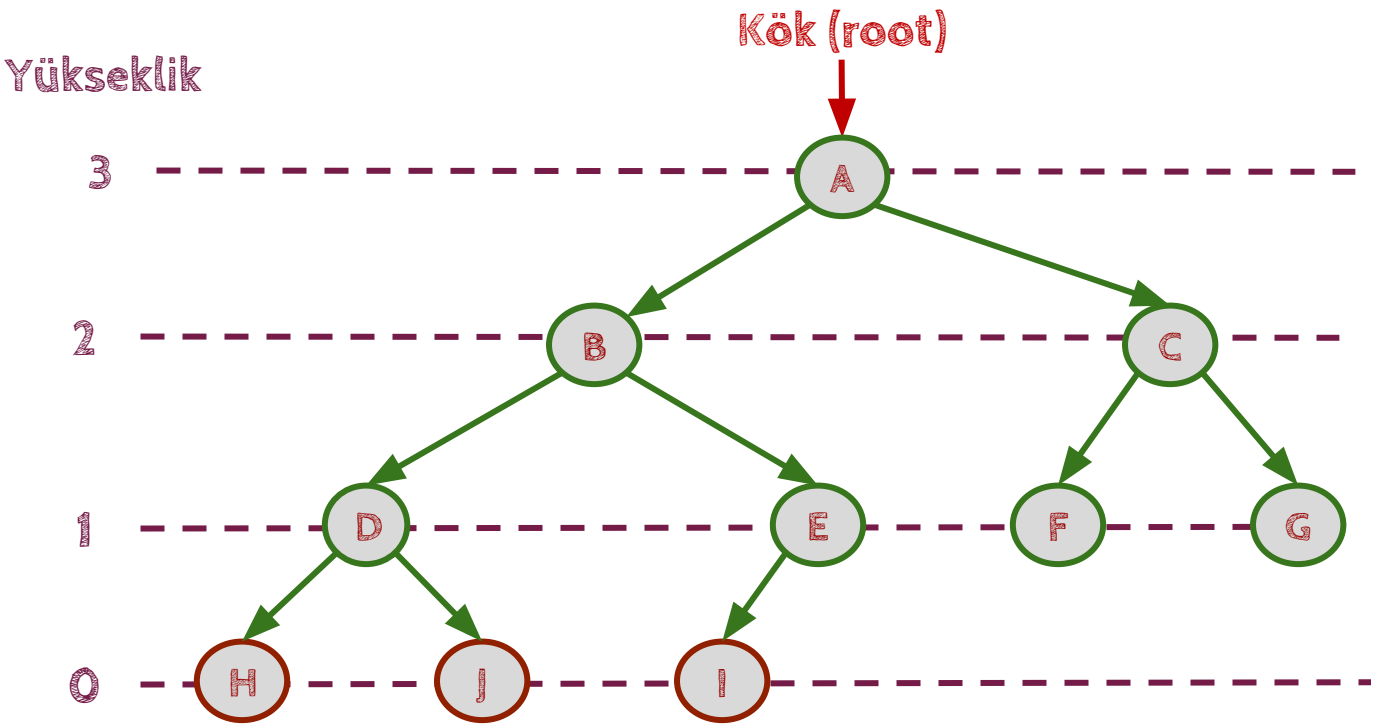
AVL Agacı:

Dengeli ikili agaç

Denge Faktörü



Agaç Veri Modeli

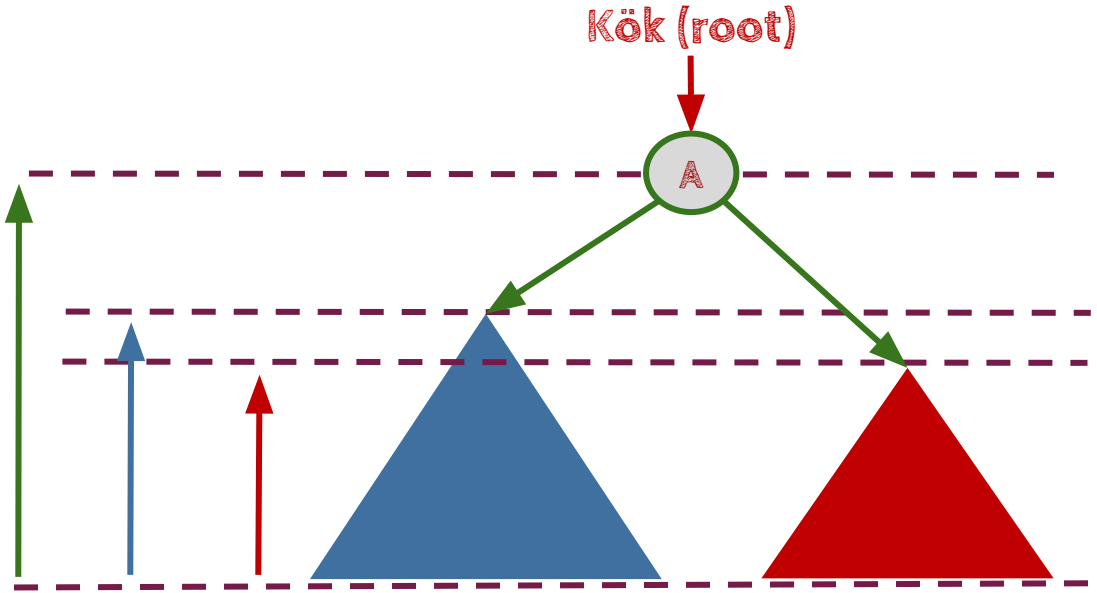


AVL (Adel'son-Vel'skiĭ) Landis Agacı

AVL Agacı:

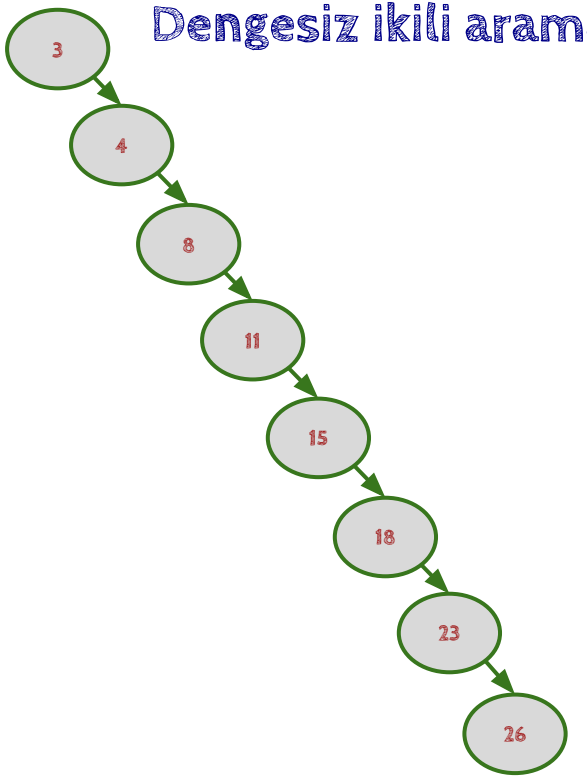
Dengeli ikili agaç

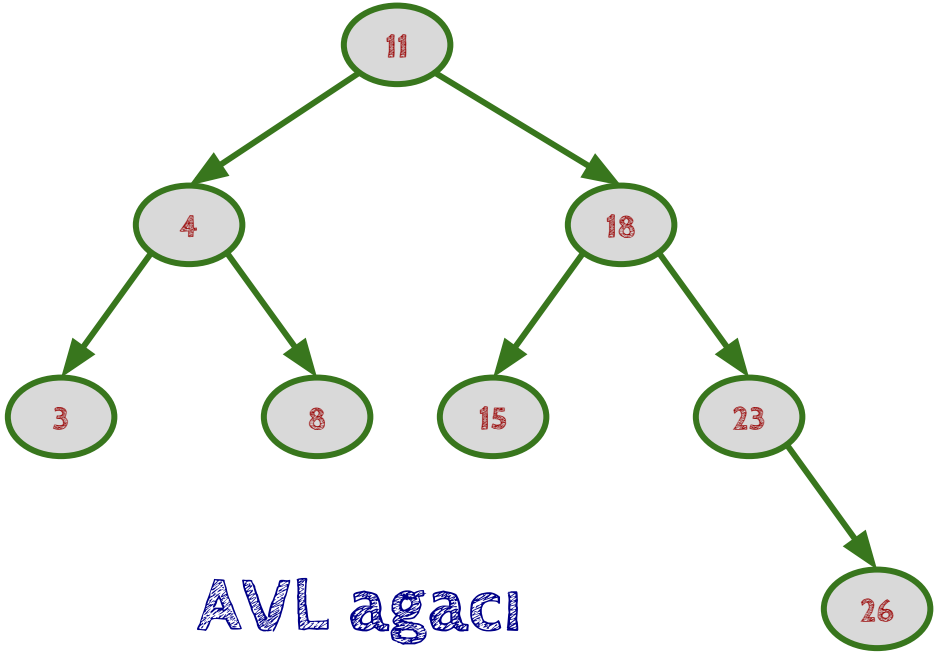
Denge Faktörü



AVL (Adel'son-Vel'skiĭ) Landis Agacı

Dengesiz ikili arama agacı



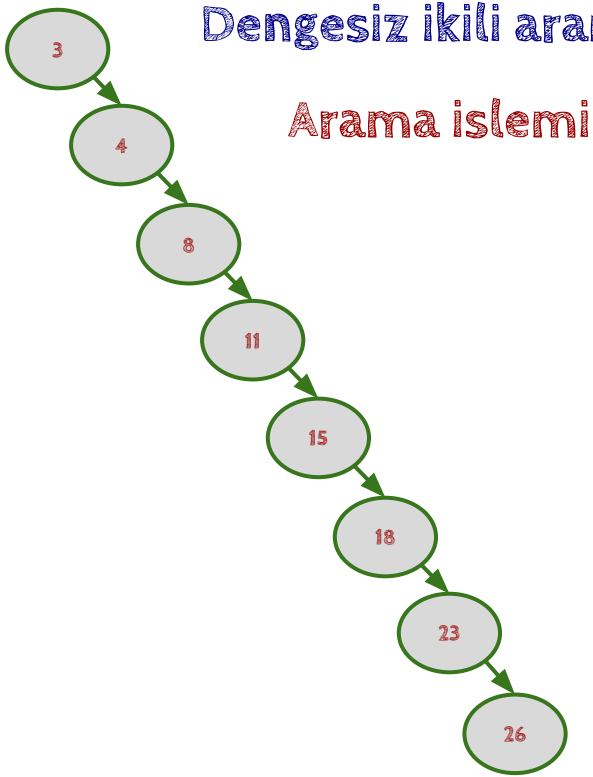


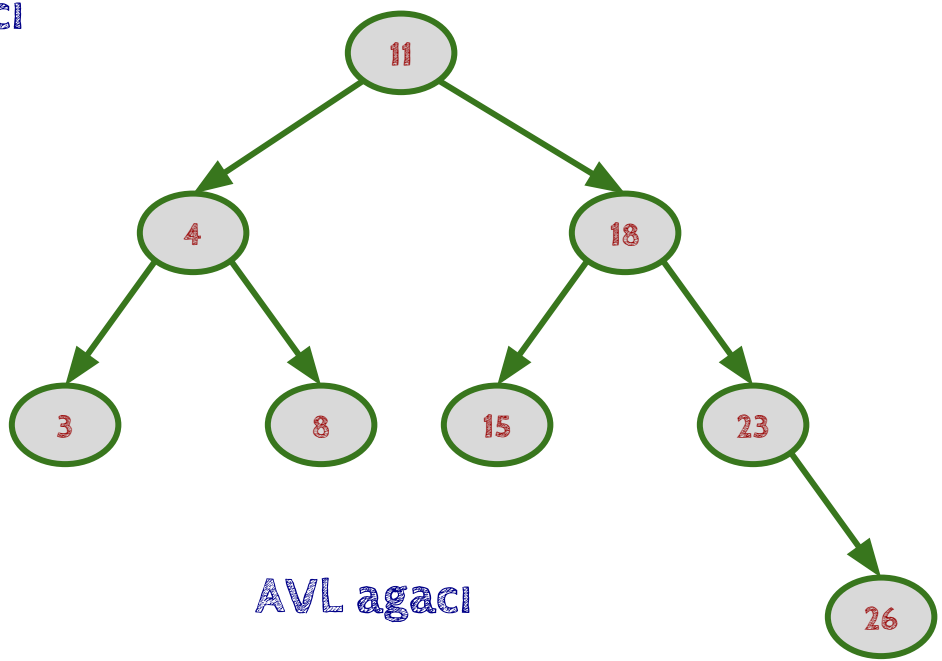
AVL agacı

AVL (Adel'son-Vel'skiĭ) Landis Agacı

Dengesiz ikili arama agacı

Arama islemi O(n)

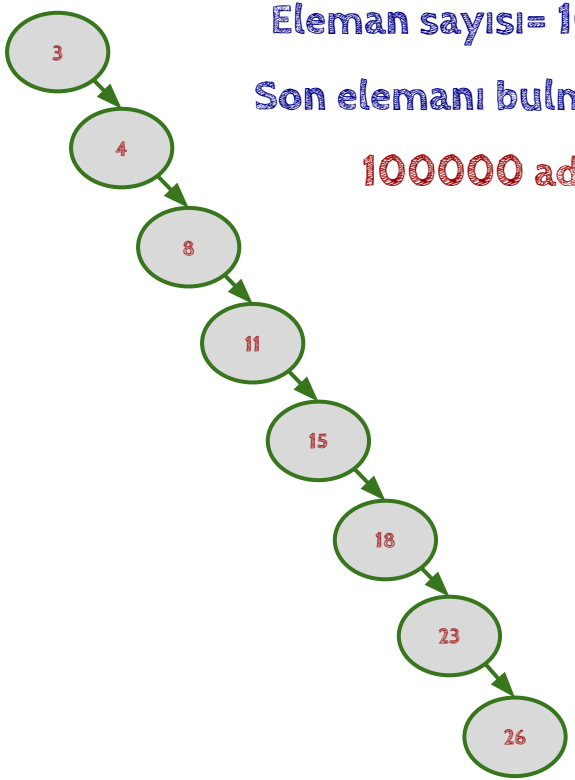




AVL agacı

Arama islemi $O(\log_2 n)$

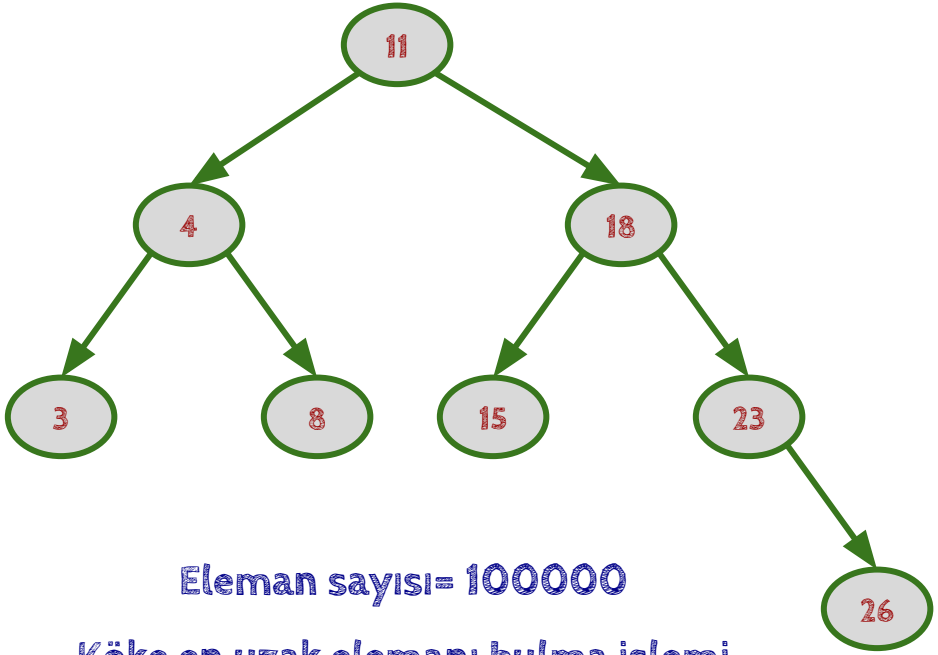
AVL (Adel'son-Vel'skiĭ) Landis Agacı



Eleman sayısı= 100000

Son elemanı bulma islemi

100000 adım



Eleman sayısı= 100000

Köke en uzak elemanı bulma islemi

$\log_2(100000) = 17$ adım

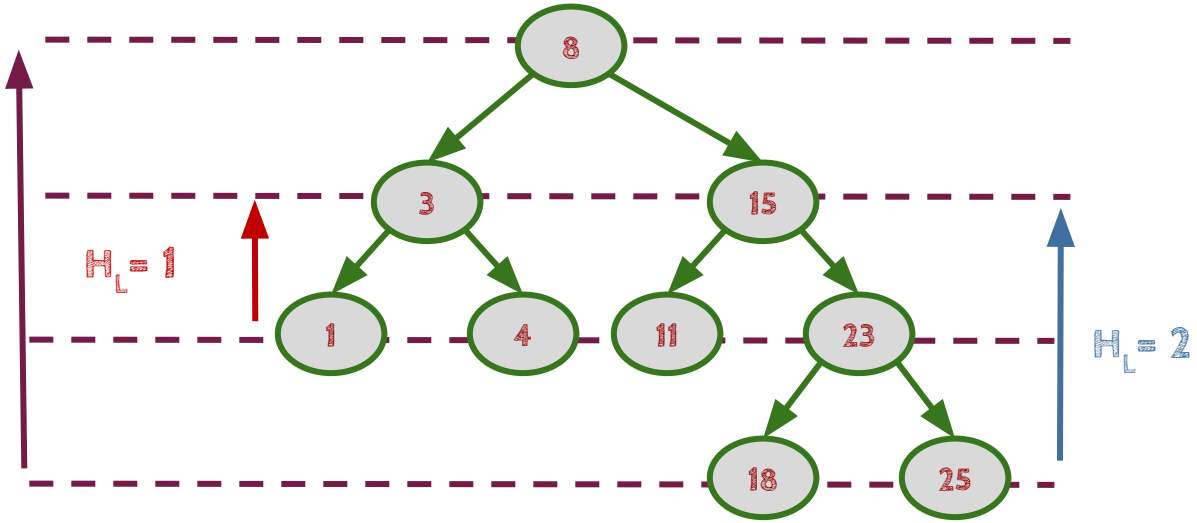
AVL Denge Faktörü

H_L : Sol alt agacın yüksekligi

H_R : Sag alt agacın yüksekligi

denge faktörü = H_L - H_R

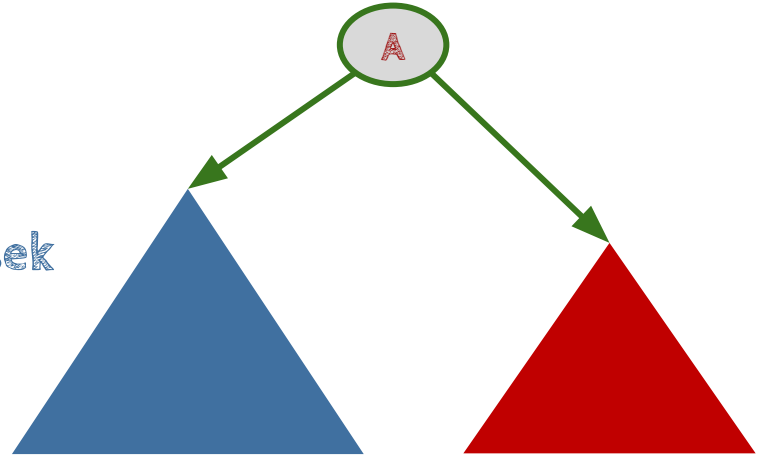
denge faktörü = 1 - 2 = -1



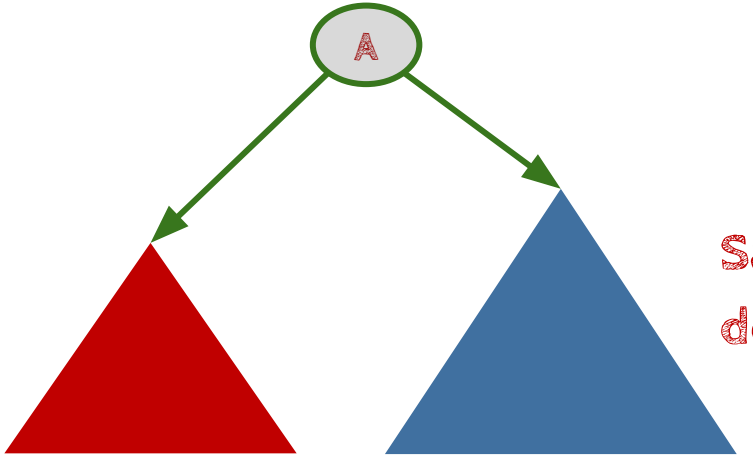
AVL Denge Faktörü

Sol agaç daha yüksek

denge faktörü = +1



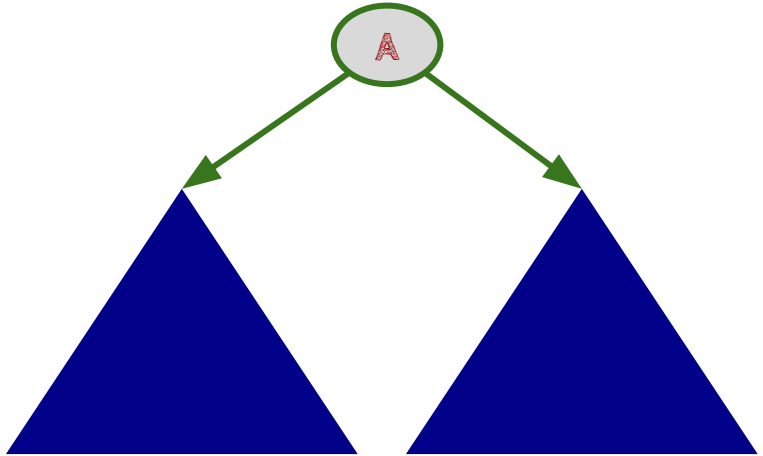
AVL Denge Faktörü



Sag agaç daha yüksek

denge faktörü = -1

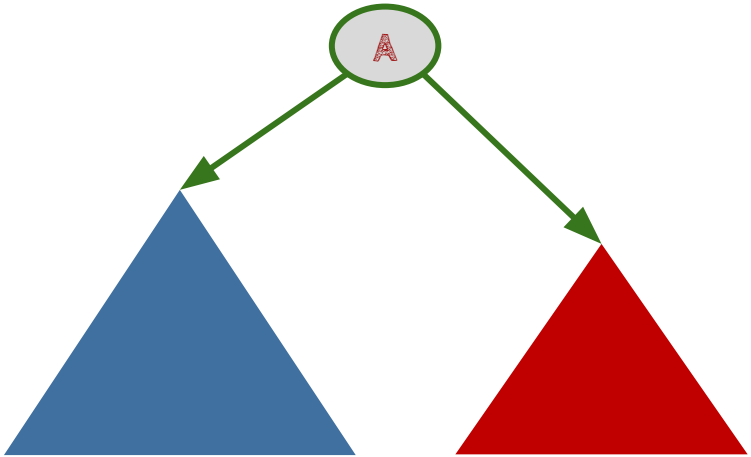
AVL Denge Faktörü



iki taraf esit yükseklikteyse denge faktörü = 0

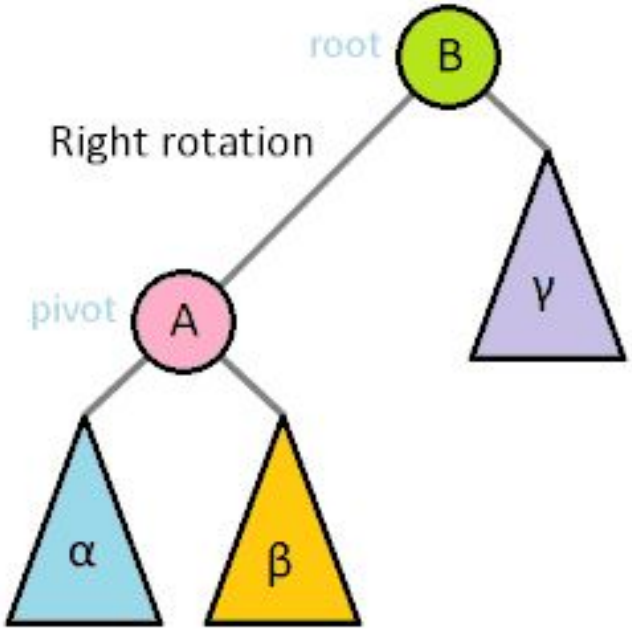
AVL Denge Faktörü

Ekleme veya silme esnasında, herhangi bir dügümün denge faktörü -2 veya +2 olursa dengeleme islemi yapılır



AVL Denge Faktörü

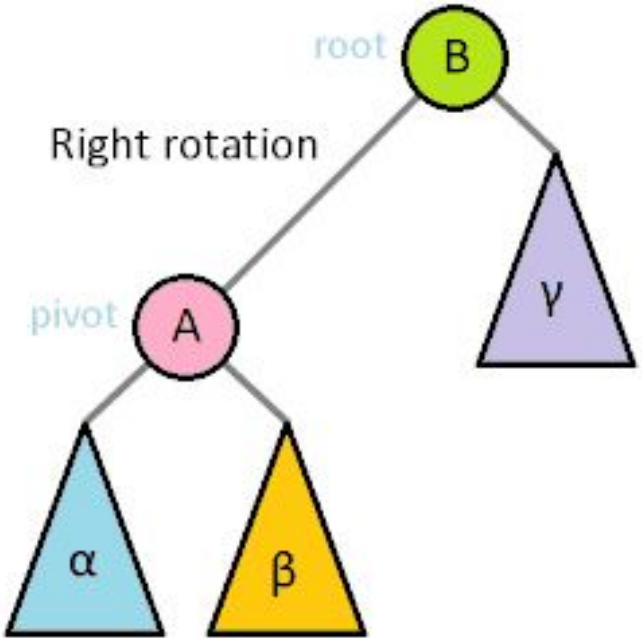
AVL agacı bazı dügümlerin saga veya sola döndürülmesiyle dengeli hale getirilebilir.



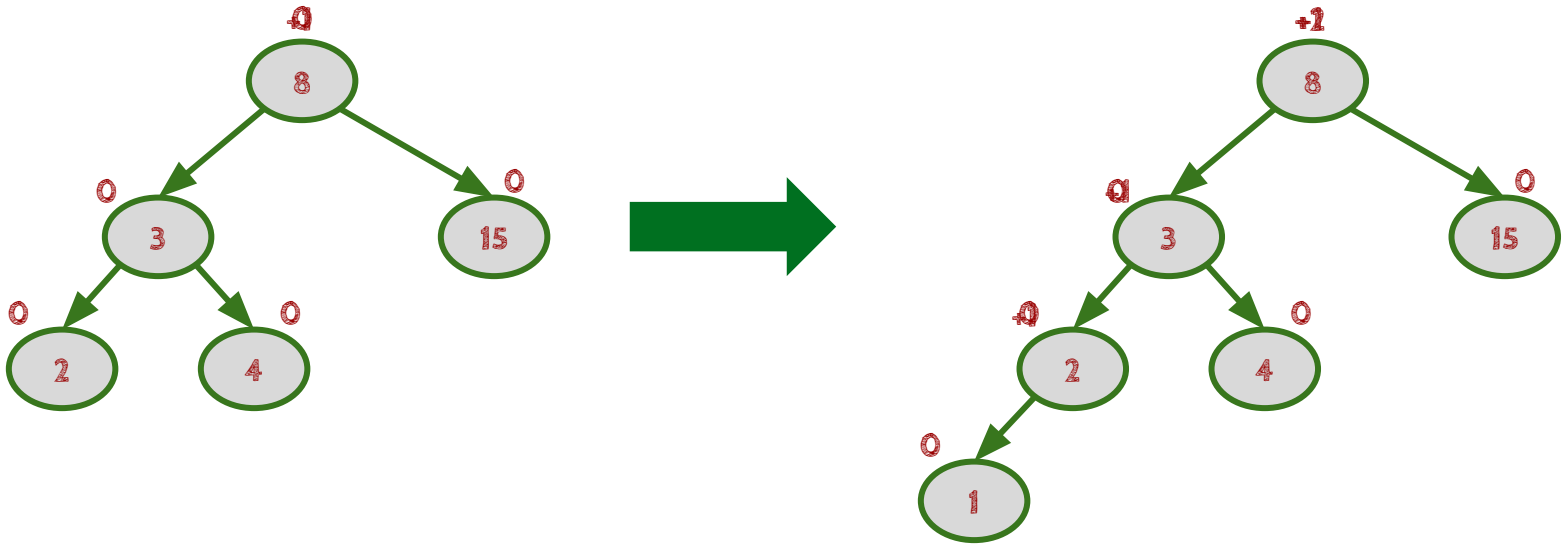
AVL Denge Faktörü

Dengesiz agacı dengeleme isleminde dört durum vardır:

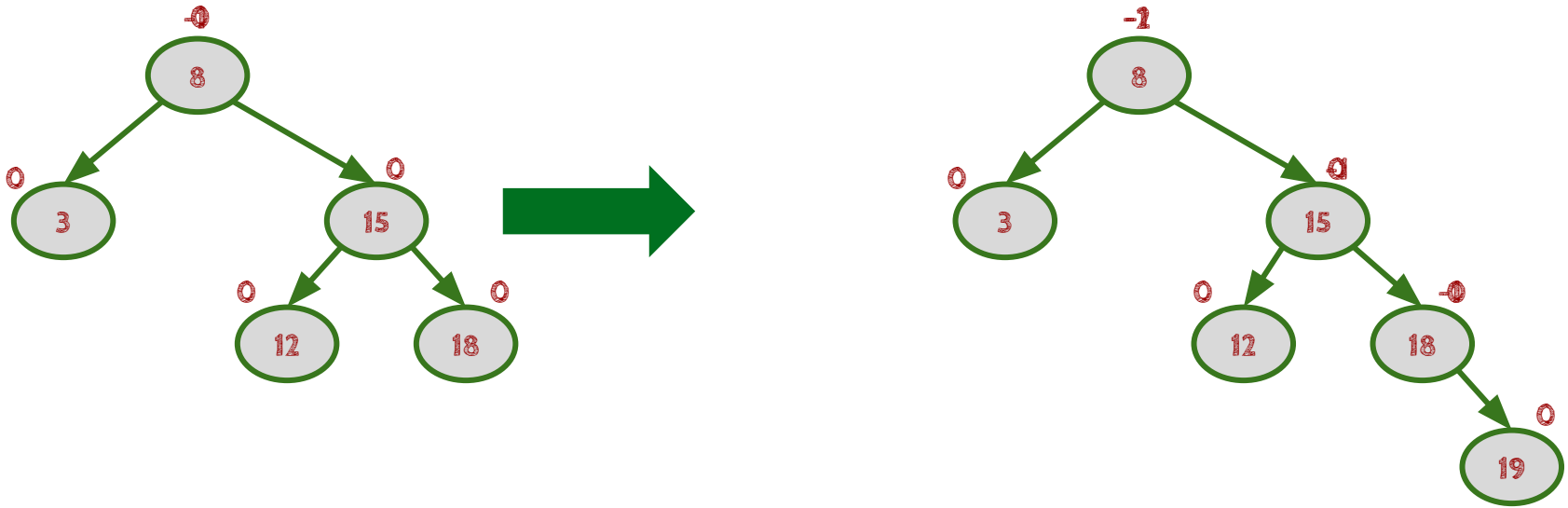
- solun solu
- sagın sagı
- solun sagı
- sagın solu



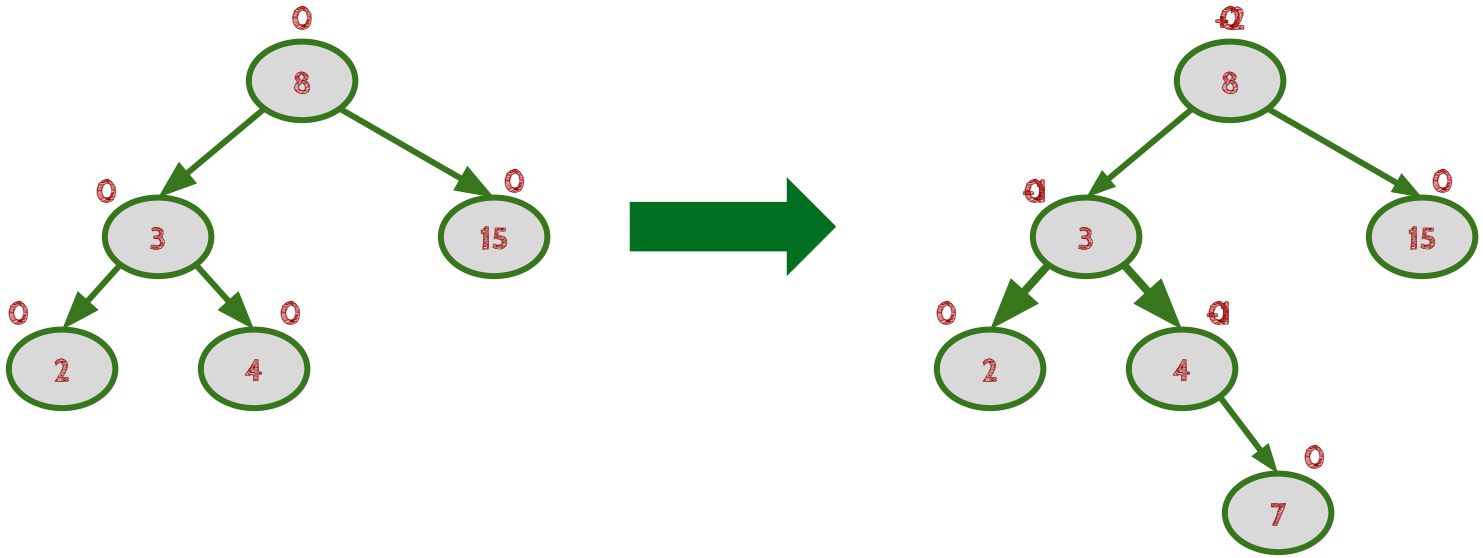
Dengeleme islemi : solun solu



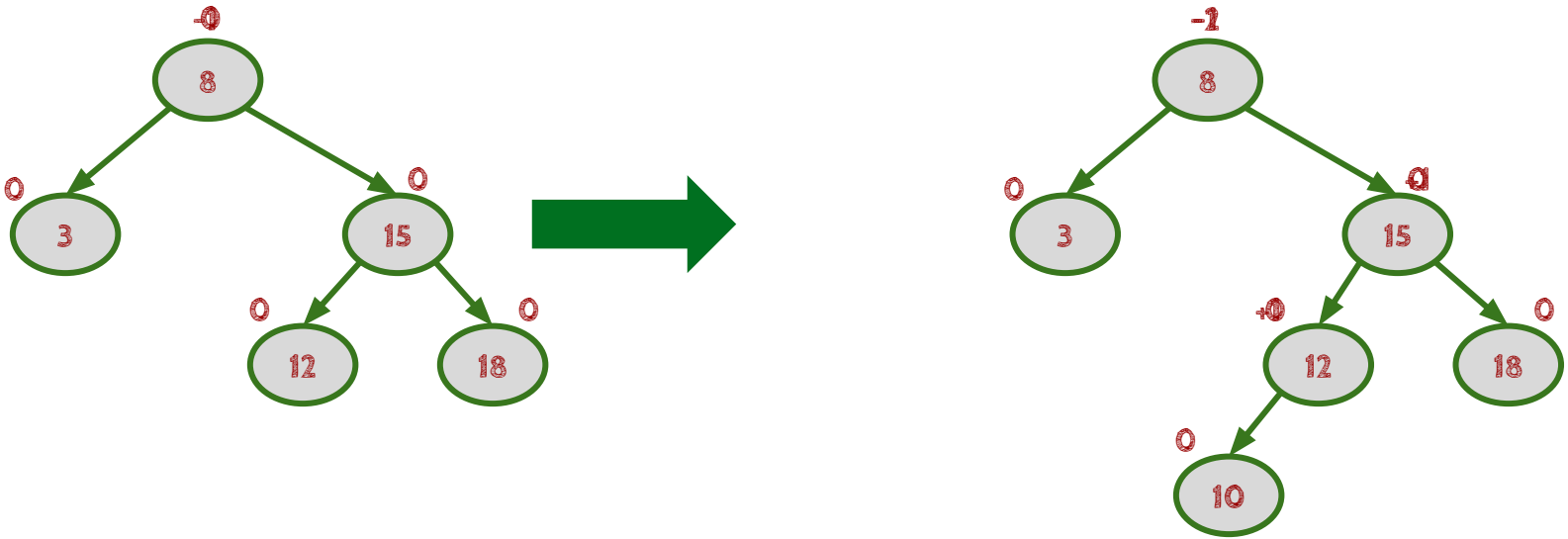
Dengeleme islemi : sağın sağı



Dengeleme islemi : solun sagı

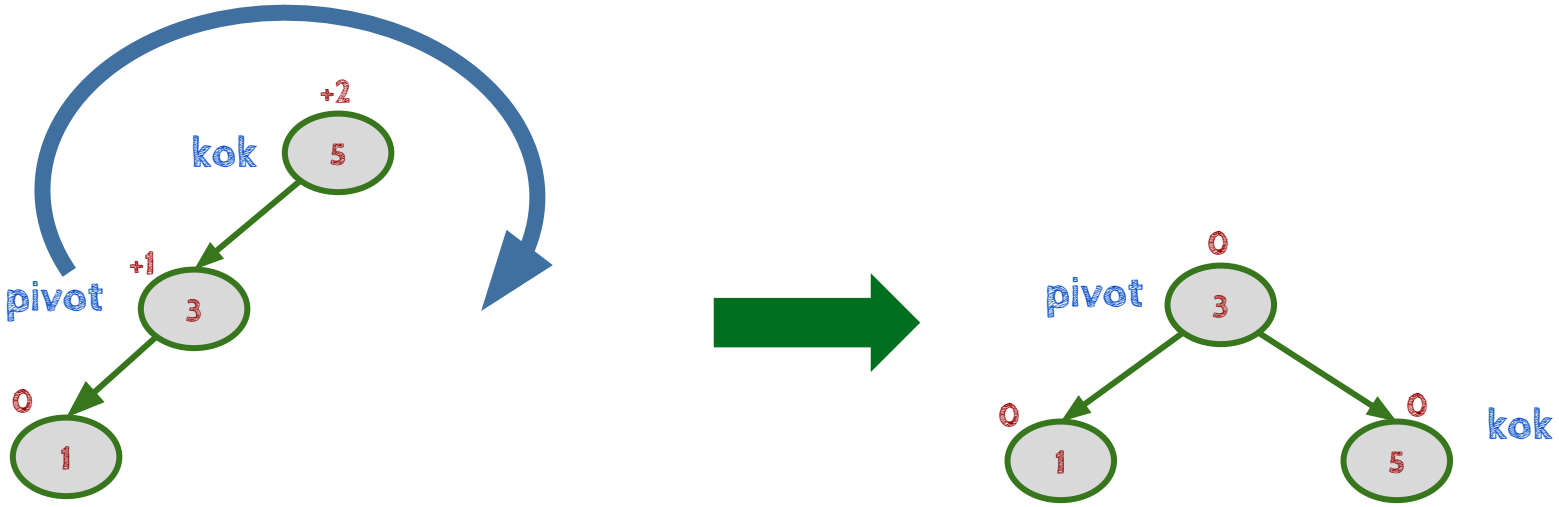


Dengeleme islemi : sagın solu

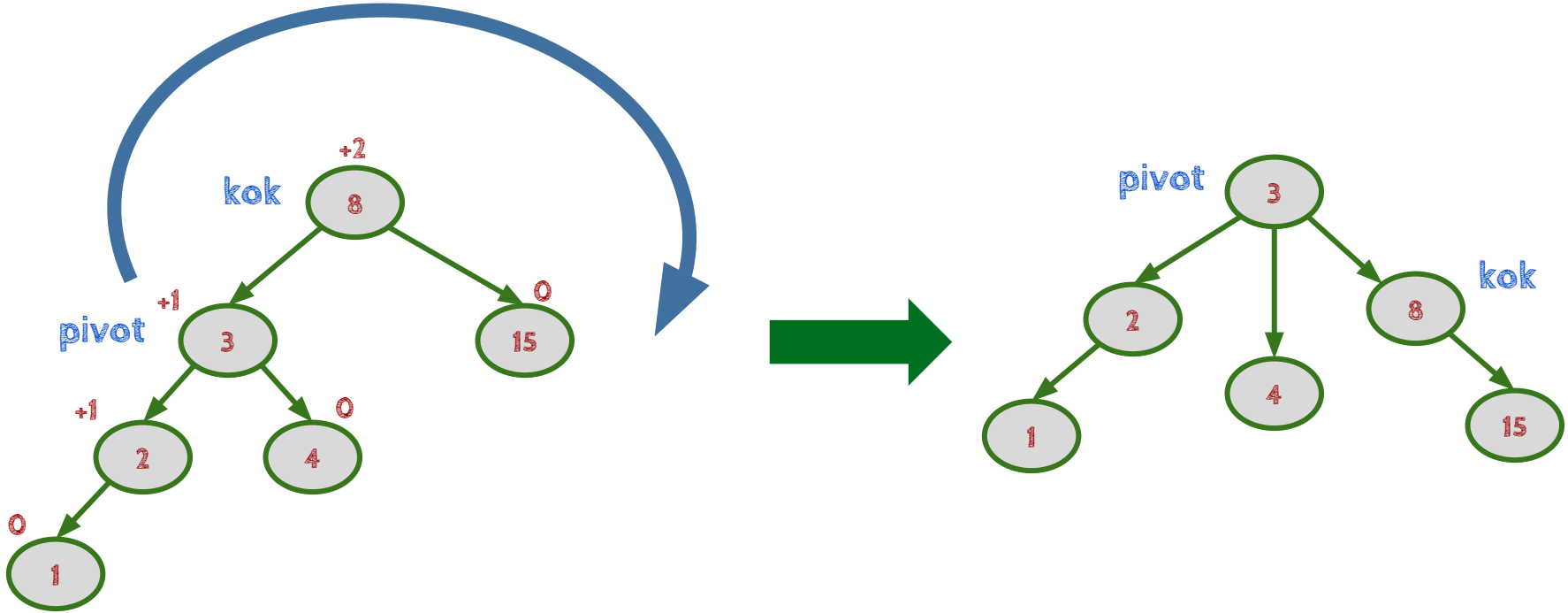


Döndürme : solun solu

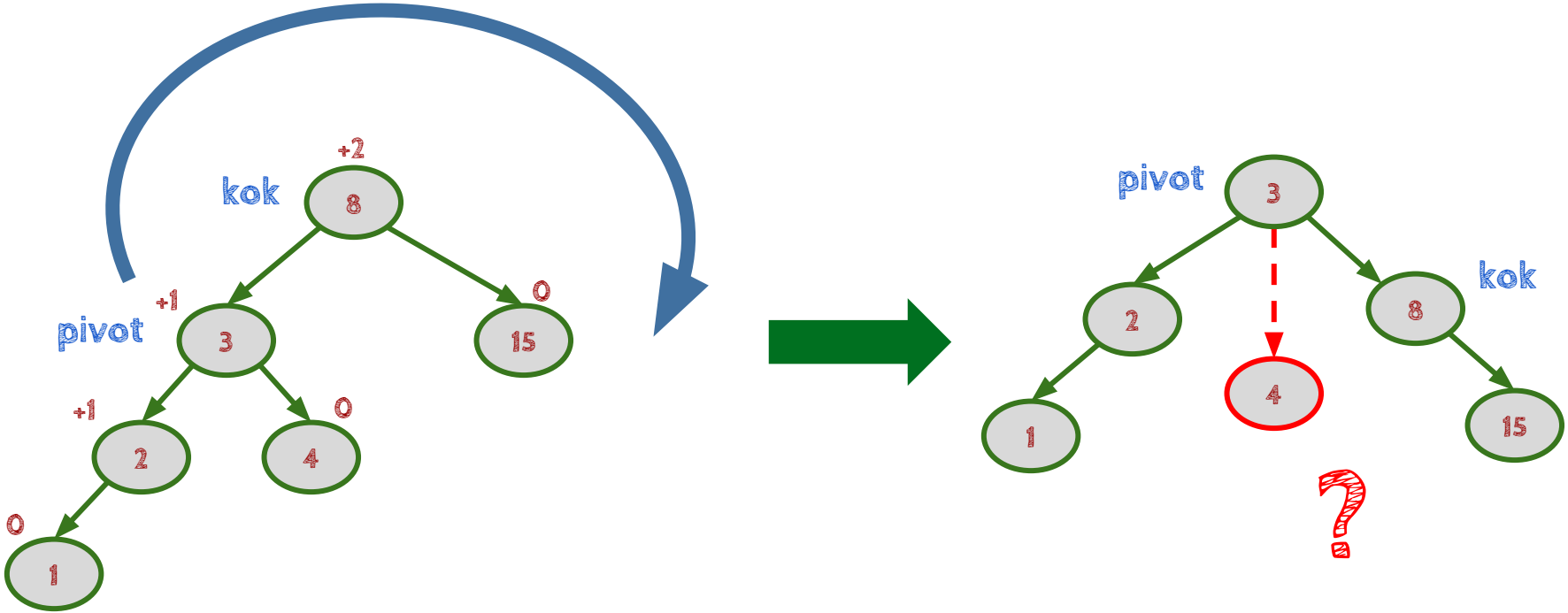
saga döndürme



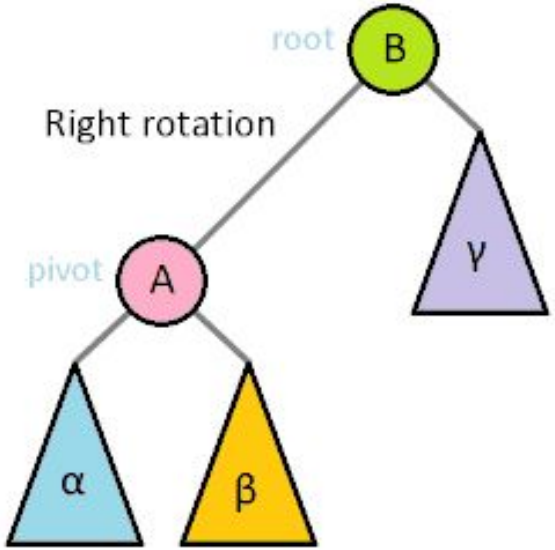
Döndürme : solun solu

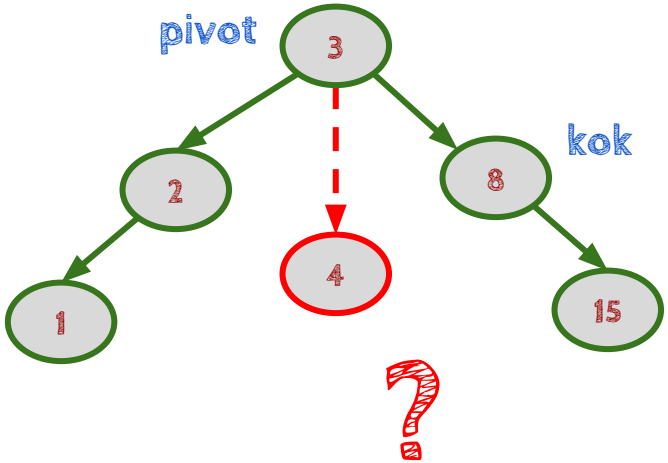


Dengeleme : solun solu

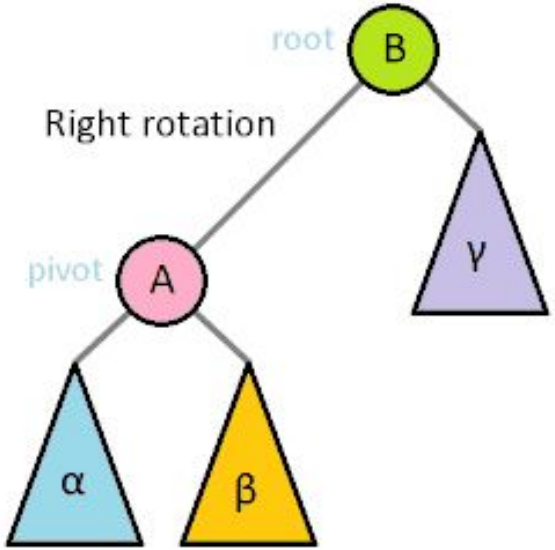


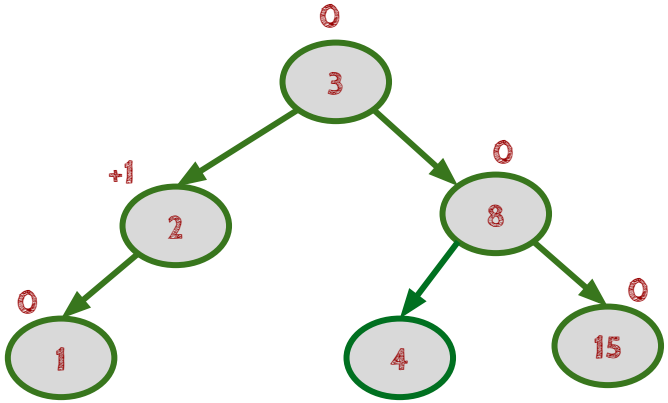
Dengeleme : solun solu





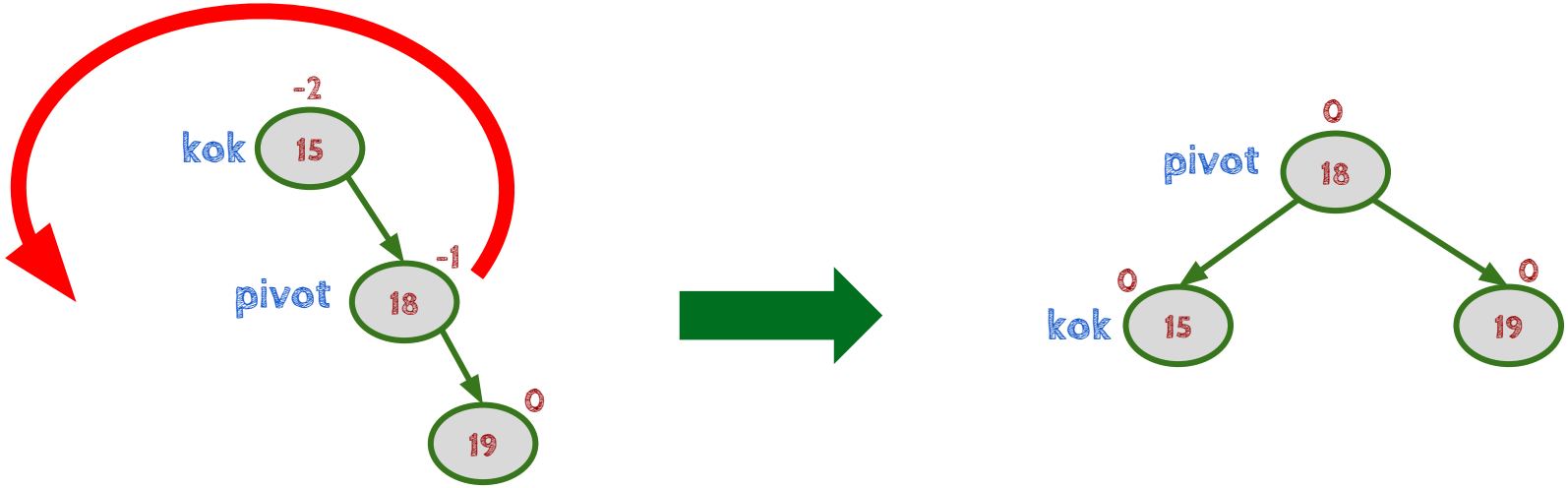
Dengeleme : solun solu



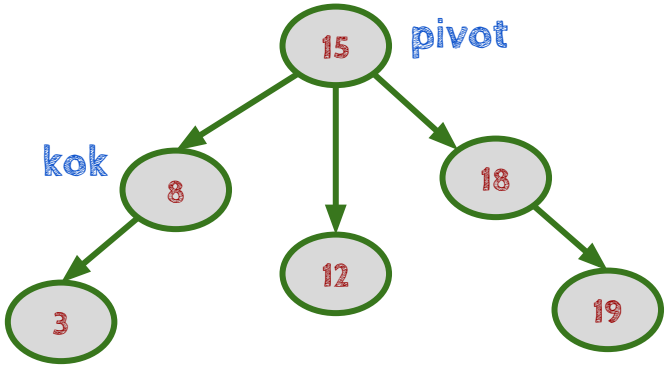


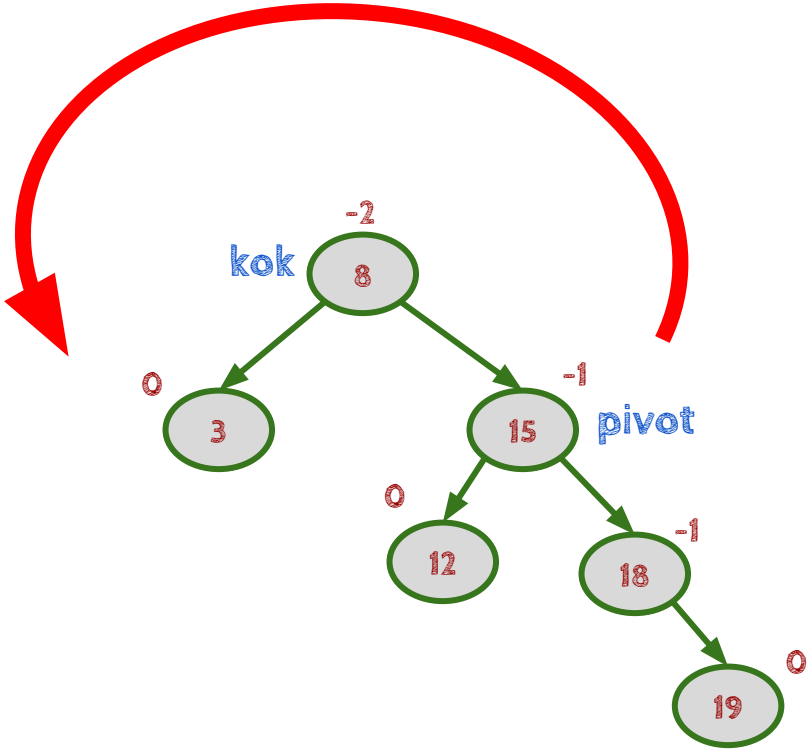
Döndürme : sağın sağı

sola döndürme



Döndürme : sağın sağı





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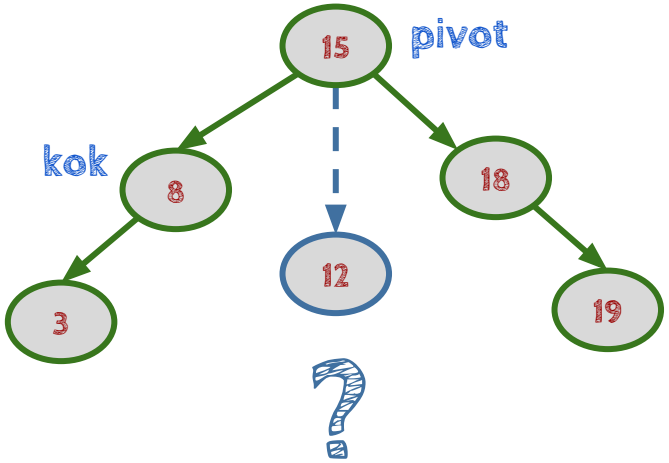
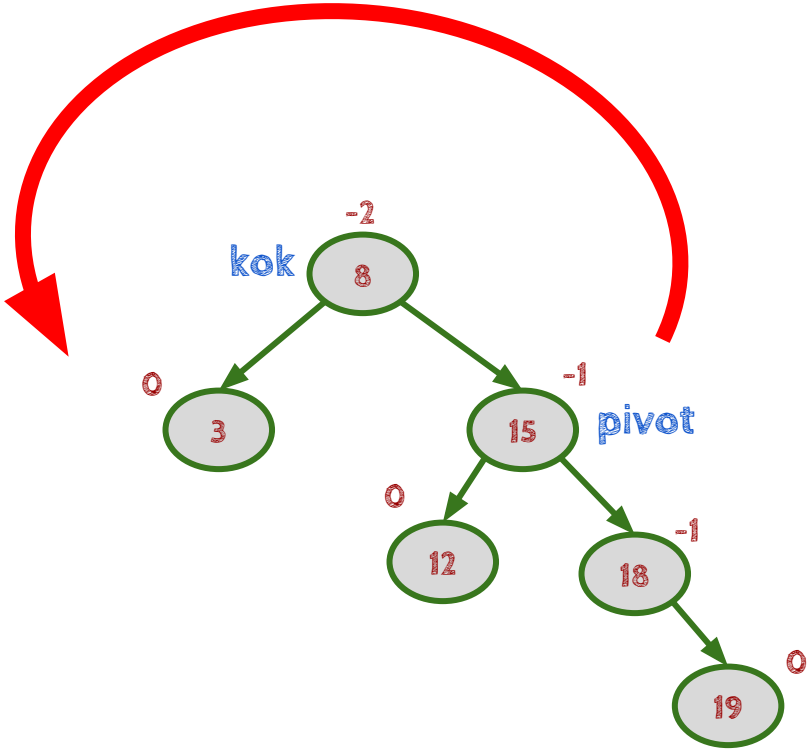
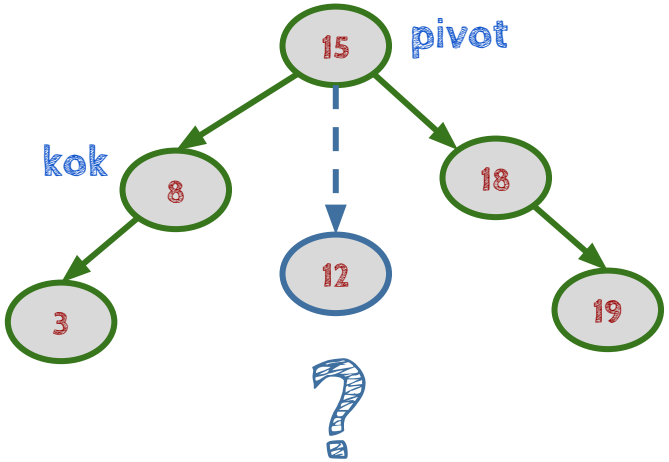
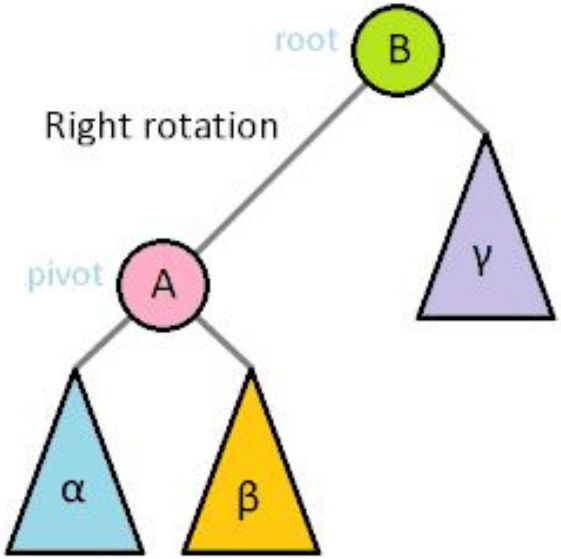


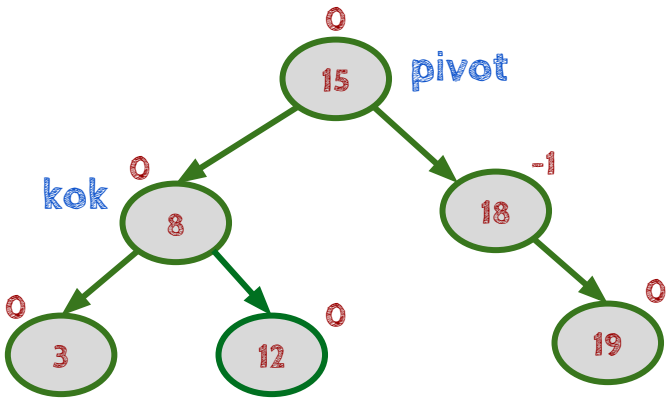


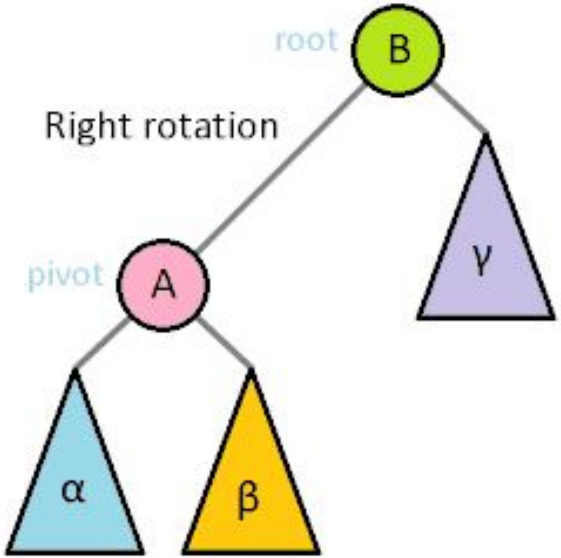
Dengeleme : sağın sağı





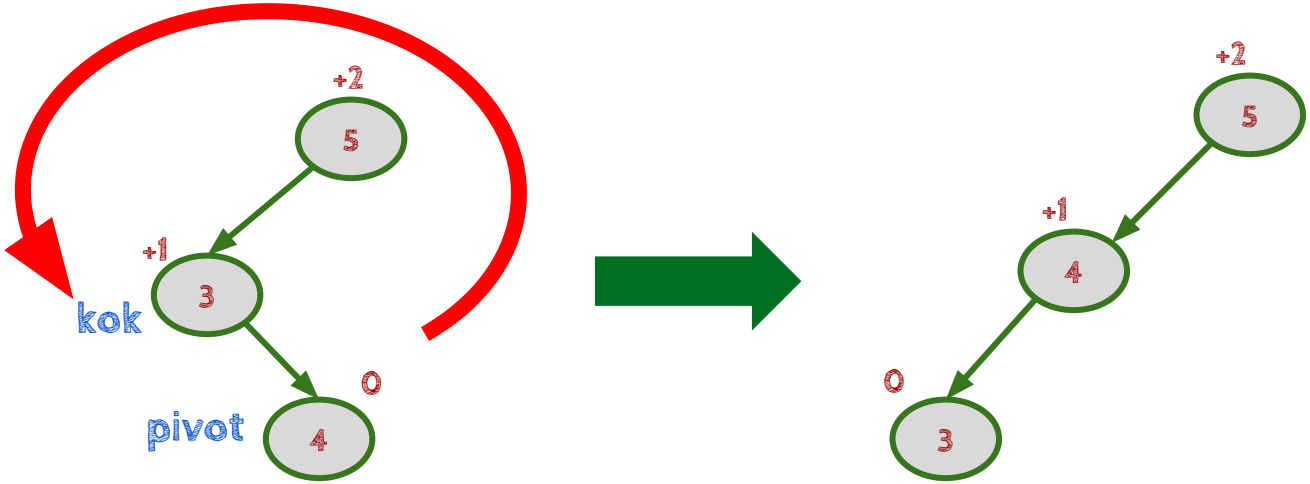
Dengeleme : sağın sağı





Döndürme : solun sağı

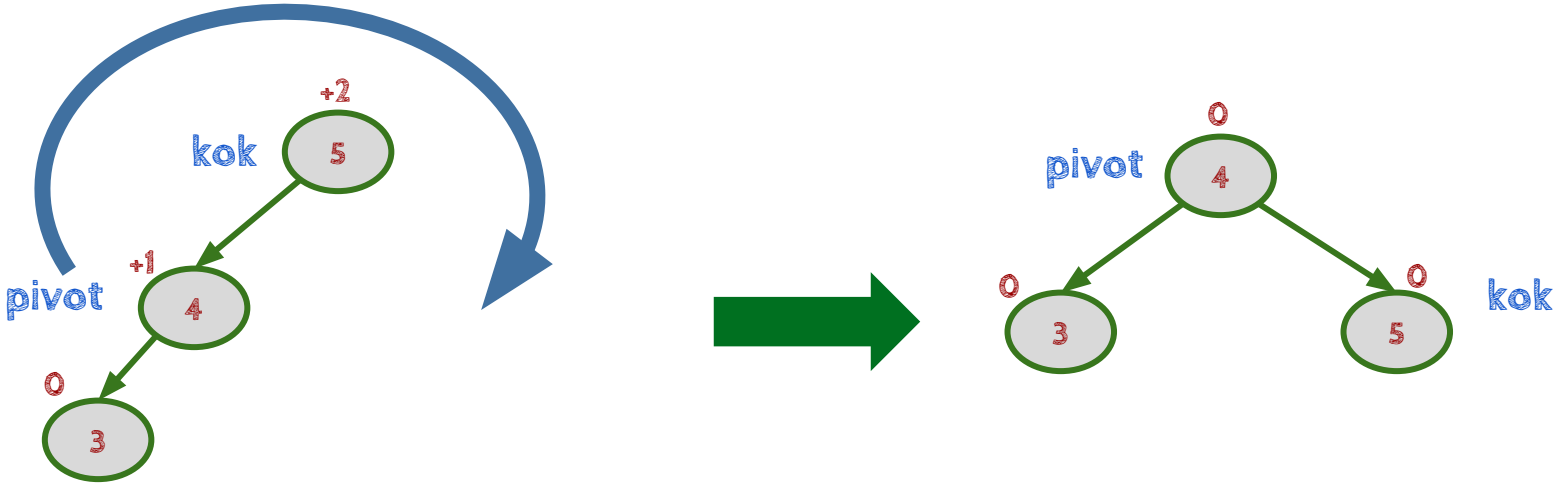
1. Adım: sola döndürme



Döndürme : solun sağı

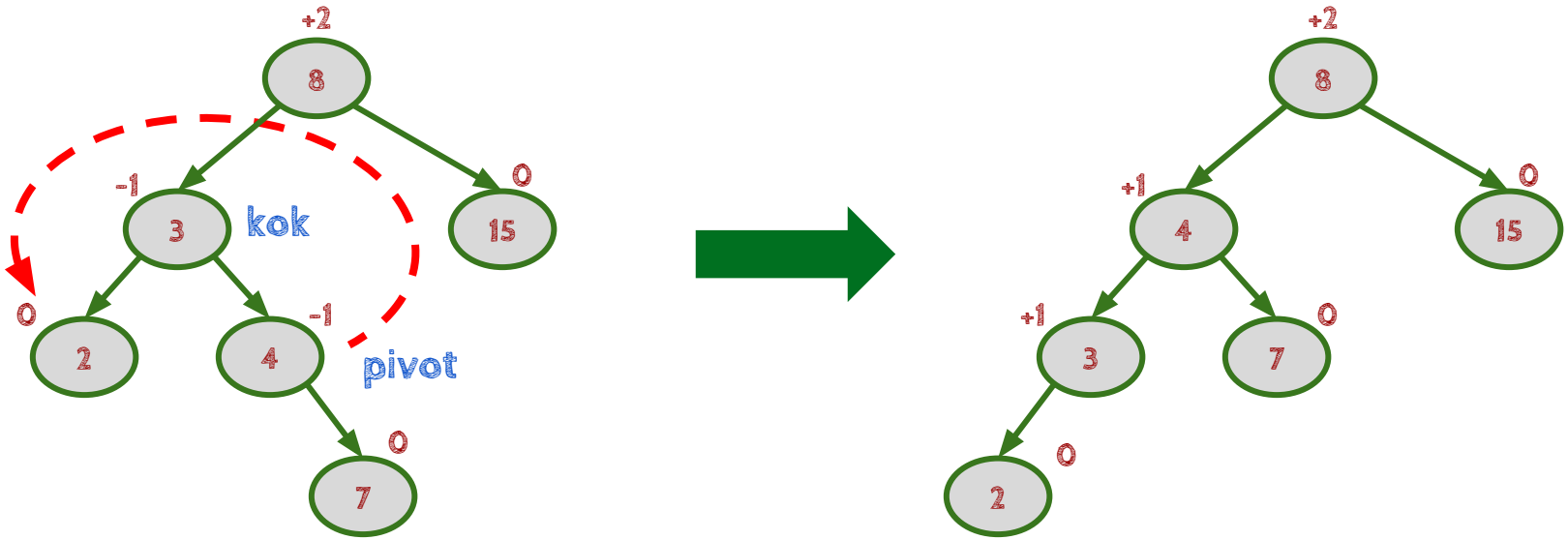
2. Adım: solun solu problemi

saga döndürme



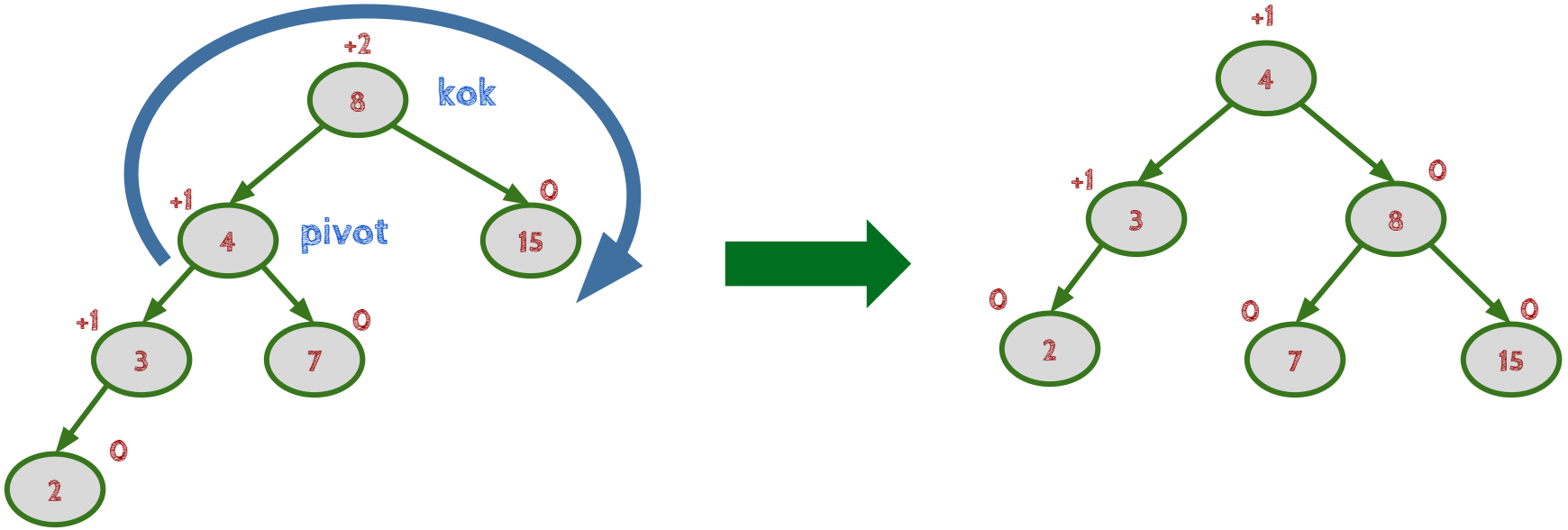
Dengeleme : solun sağı

1. Adım: sola döndürme



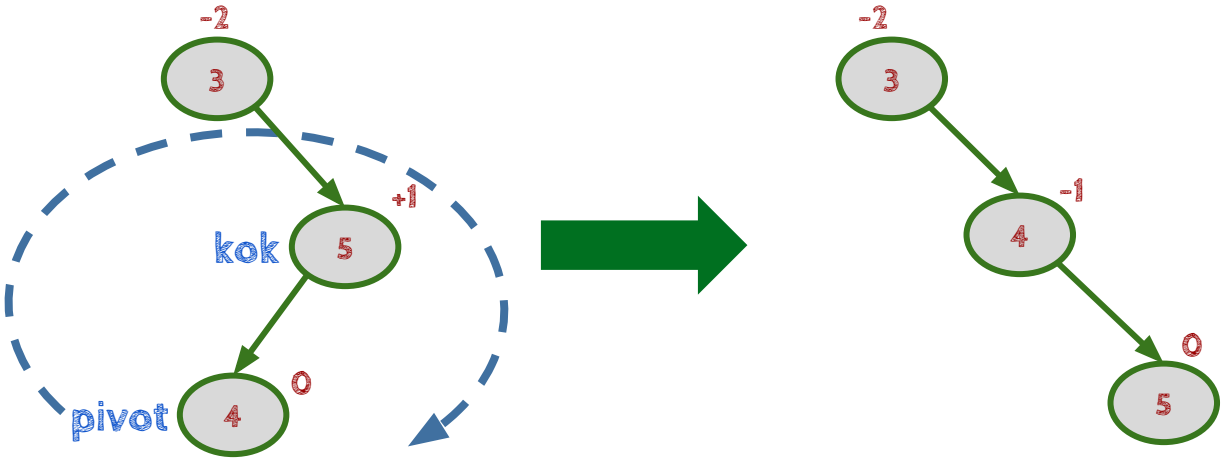
Dengeleme : solun sağı

2. Adım: sağa döndürme



Döndürme : sağın solu

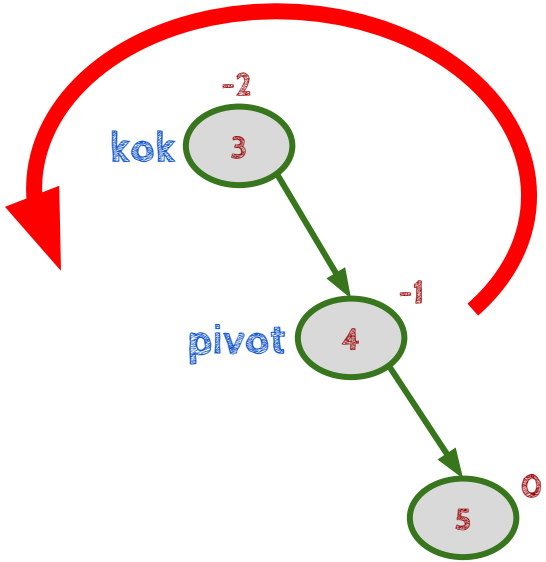
1. Adım: saga döndürme

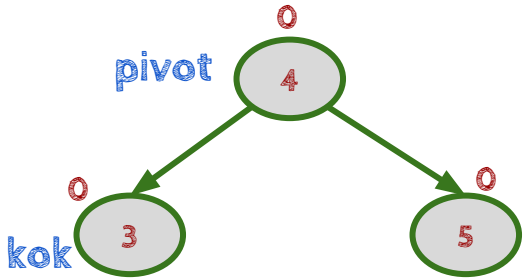


Döndürme : sağın solu

2. Adım: sağın sağı problemi

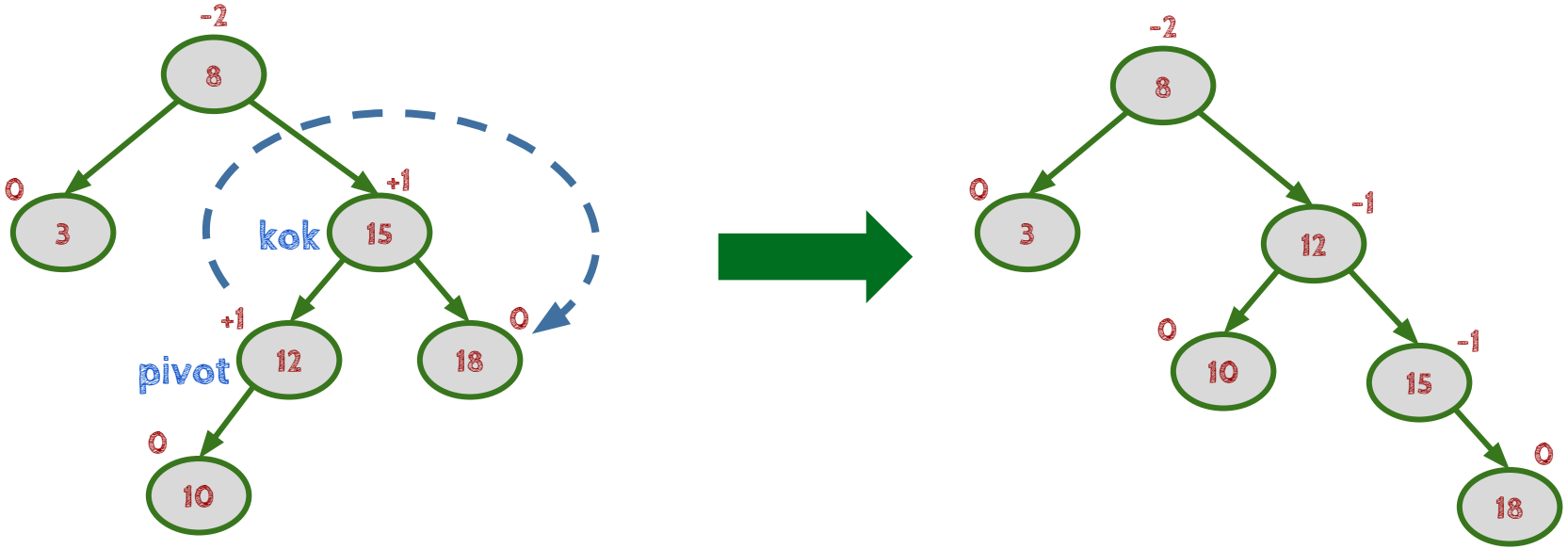
sola döndürme





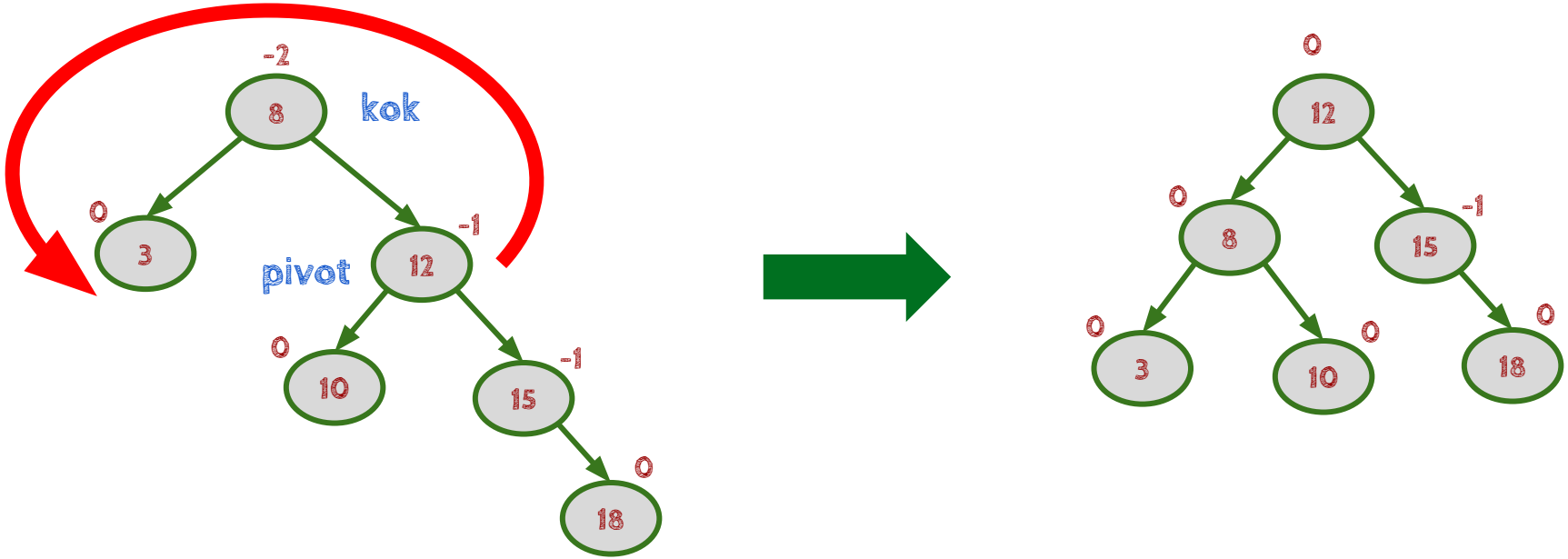
Döndürme : sağın solu

1. Adım: sağa döndürme

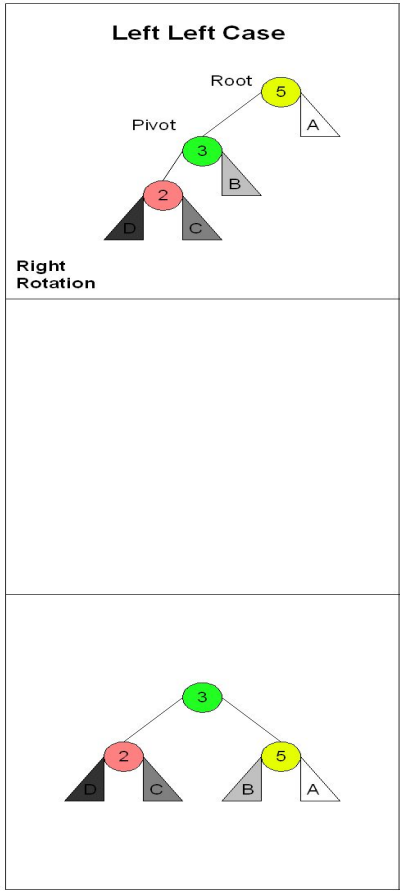


Döndürme : sağın solu

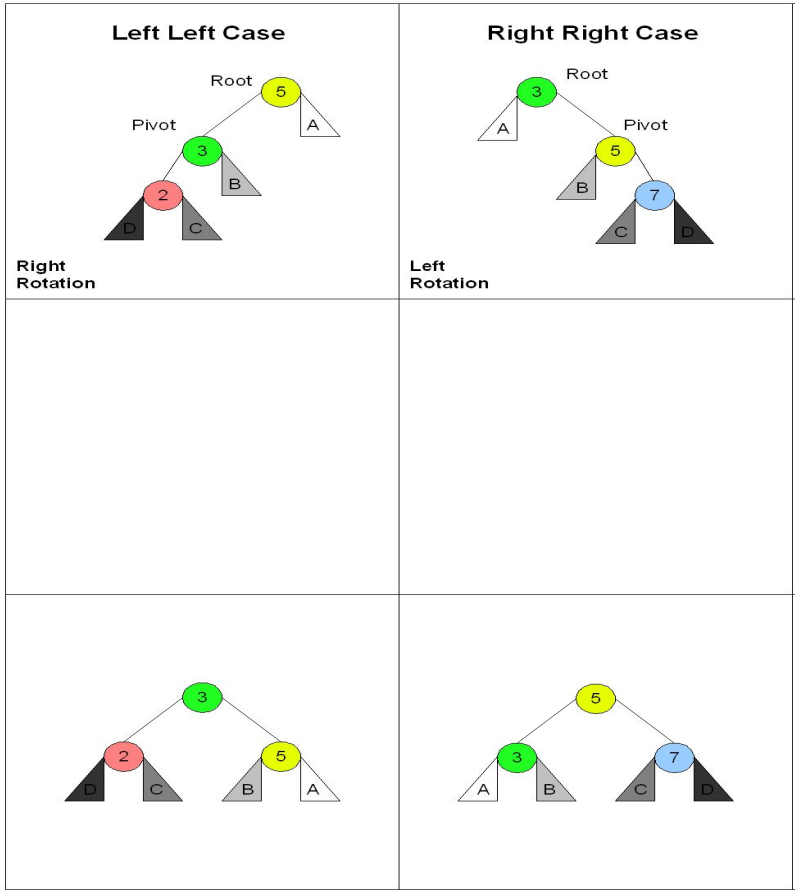
2. Adım: sola döndürme



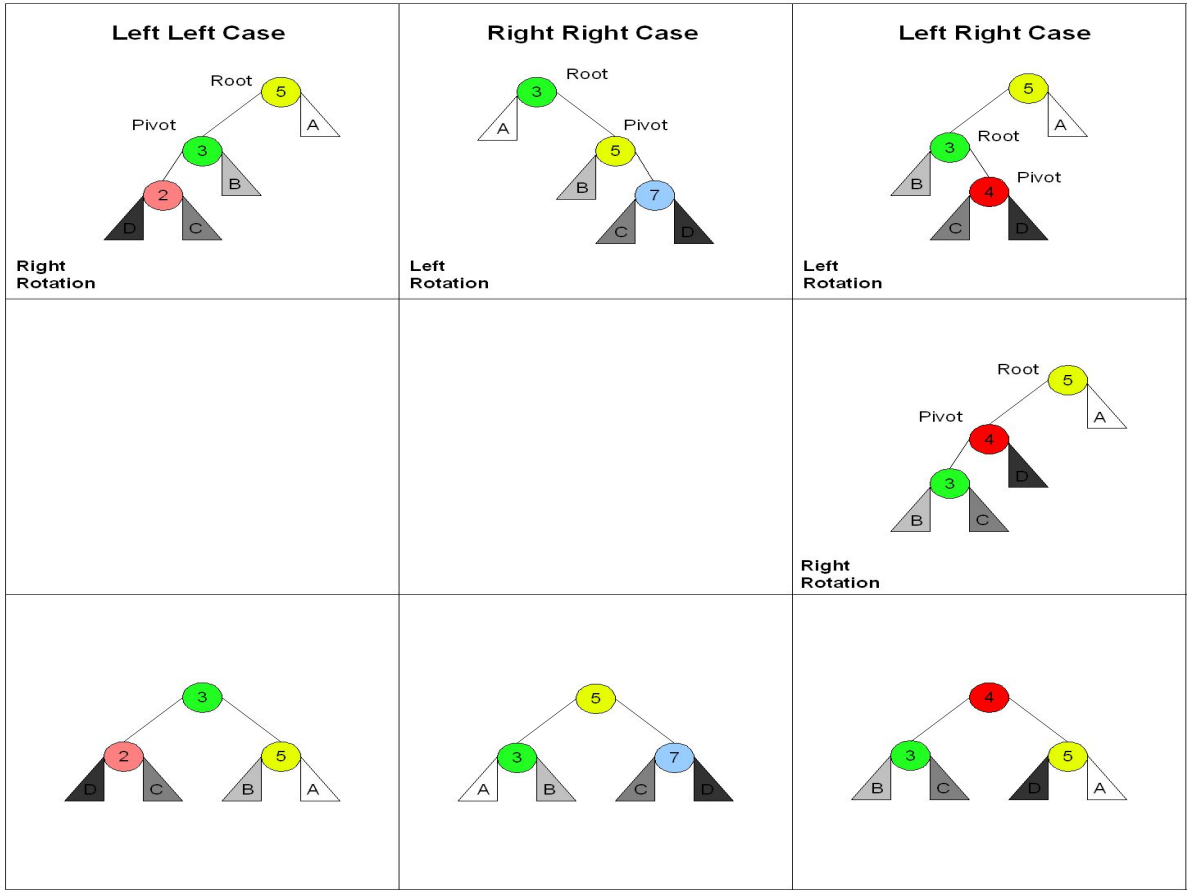
AVL Agacı Döndürme



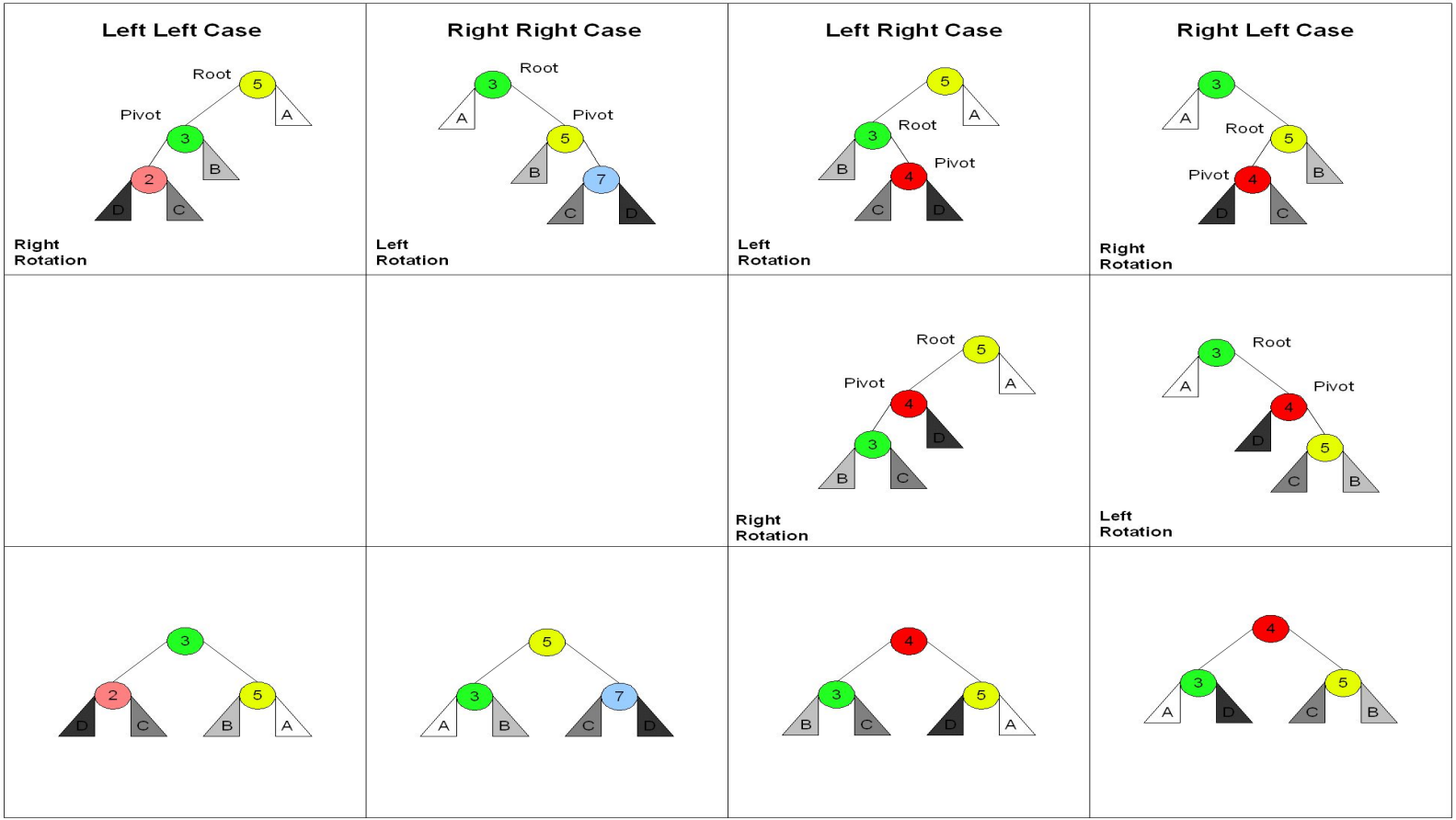
AVL Ağacı Döndürme



AVL Ağacı Döndürme



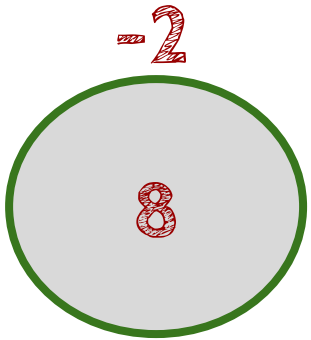
AVL Ağacı Döndürme



AVL Ağacı Gerçeklestirim

```
#include<stdio.h>
#include<stdlib.h>

// AVL ağacı için düğüm
struct Node
{
        int key;
        struct Node *left;
        struct Node *right;
        int height;
};
```



AVL Agacı Gerçeklestirim

```
// Ağaca ait yüksekliği dönen fonksiyon
int height(struct Node *N)
{
        if (N == NULL)
                return 0;
        return N->height;
}

int max(int a, int b)
{
        return (a > b)? a : b;
}
```

AVL Agacı Gerçeklestirim

```
/* Ağaca yeni düğüm ekleme */
struct Node* newNode(int key)
{
        struct Node* node = (struct Node*)malloc(sizeof(struct Node));
        node->key   = key;
        node->left   = NULL;
        node->right  = NULL;
        node->height = 1;  // Yeni düğüm ilk olarak yaprakta eklenir
        return(node);
}
```

AVL Agacı Gerçeklestirim

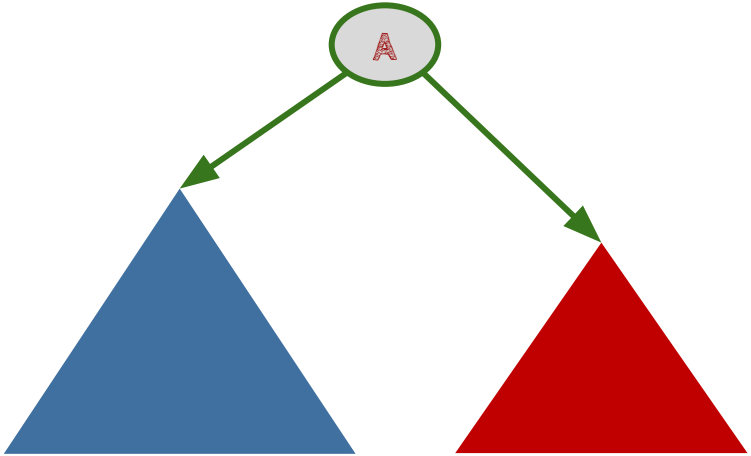
```
/*
 y (sol taraf) veya x (sağ taraf) pivotları ile döndürülecek
 alt ağaçlar T1, T2 ve T3'dür.
              y                                  x
             / \        Sağa  Döndürme          /  \
            x   T3      – – – – – – – >         T1    y
           / \          < - - - - - - -                / \
         T1  T2        Sola Döndürme             T2  T3
*/
struct Node *rightRotate(struct Node *y)
{
        struct Node *x = y->left;
        struct Node *T2 = x->right;
        // Döndürme
        x->right = y;
        y->left = T2;
        // Yükseklikler güncelleniyor
        y->height = max(height(y->left), height(y->right))+1;
        x->height = max(height(x->left), height(x->right))+1;
        // yeni kok
        return x;
}
```

AVL Agacı Gerçeklestirim

```
/*
 y (sol taraf) veya x (sağ taraf) pivotları ile döndürülecek
 alt ağaçlar T1, T2 ve T3'dür.
              y                                  x
             / \        Sağa  Döndürme          /   \
            x   T3      – – – – – – – >         T1     y
           / \          < - - - - - - -                / \
         T1  T2        Sola Döndürme              T2 T3
*/
struct Node *leftRotate(struct Node *x)
{
        struct Node *y = x->right;
        struct Node *T2 = y->left;
        // döndürme
        y->left = x;
        x->right = T2;
        //  Yükseklikler güncelleniyor
        x->height = max(height(x->left), height(x->right))+1;
        y->height = max(height(y->left), height(y->right))+1;
        // yeni kok
        return y;
}
```

AVL Agacı Gerçeklestirim

```
// N. düğüm için denge faktörü
int getBalance(struct Node *N)
{
        if (N == NULL)
                return 0;
        return height(N->left) - height(N->right);
}
```



AVL Agacı Gerçeklestirim

```
struct Node* insert(struct Node* node, int key){
        /* BST ağacına ekleme */
        if (node == NULL)  return(newNode(key));
                if (key < node->key)  node->left  = insert(node->left, key);
                else if (key > node->key)  node->right = insert(node->right, key);
                else  return node;
        /* 2. Yükseklikler güncelleniyor */
        node->height = 1 + max(height(node->left), height(node->right));
        /* 3. Yeni ekleme işlemi ile denge hesaplanıyor */
        int balance = getBalance(node);
        // Eklenen düğüm dengesiz ise 4 durum vardır
        // Solun solu
        if (balance > 1 && key < node->left->key)          return rightRotate(node);
        // Sağın sağı
        if (balance < -1 && key > node->right->key)  return leftRotate(node);
        // Solun sağı
        if (balance > 1 && key > node->left->key){
                node->left =  leftRotate(node->left);  return rightRotate(node);
        }
        // Sağın solu
        if (balance < -1 && key < node->right->key) {
                node->right = rightRotate(node->right);   return leftRotate(node);
        }
        return node;
}
```

AVL Agacı Gerçeklestirim

```
// Ağaç içinde dolaşma
void preOrder(struct Node *root)
{
        if(root != NULL){
                printf("%d ", root->key);
                preOrder(root->left);
                preOrder(root->right);
        }
}
```

Köke ugra
Sol alt agacı preorder olarak dolas
Sag alt agacı preorder olarak dolas

AVL Agacı Gerçeklestirim

```
int main()
{
        struct Node *root = NULL;
        root = insert(root, 10);
        root = insert(root, 20);
        root = insert(root, 30);
        root = insert(root, 40);
        root = insert(root, 50);
        root = insert(root, 25);
        /* AVL ağacı
                30
              /   \
            20   40
           /  \    \
         10  25   50
        */
        printf("AVL ağacında Preorder dolaşma:\n");
        preOrder(root);
        return 0;
}
```

Köke ugra
Sol alt agacı preorder olarak dolas
Sag alt agacı preorder olarak dolas

30 20 10 25 40 50

Sorular