Department of
Computer Engineering

Data Structure & Algorithms

Balanced Binary Tree

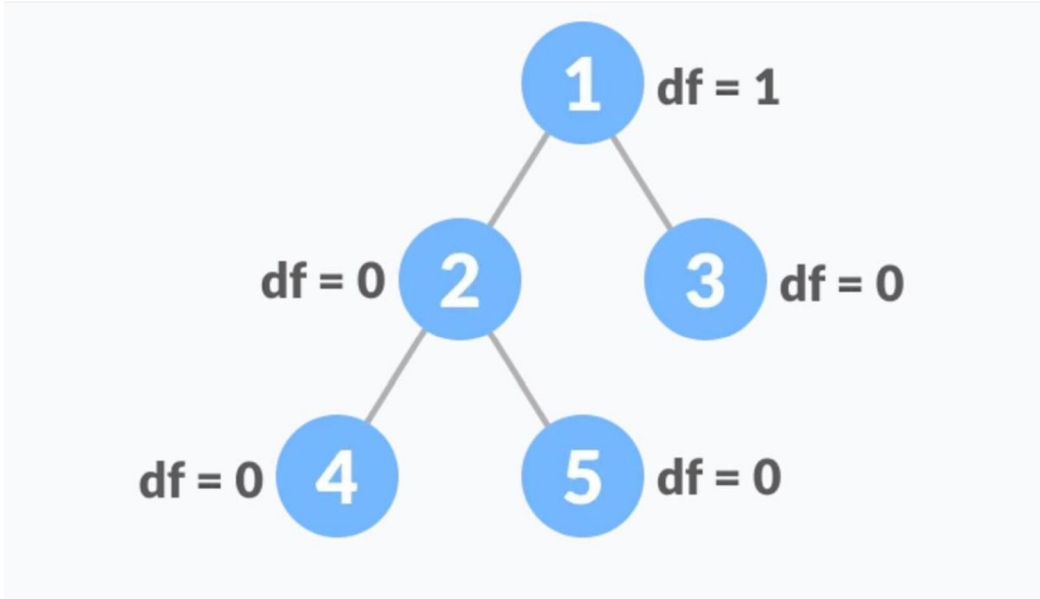
Definition

- A **balanced binary tree** is a binary tree in which the difference between the height of the left subtree and right subtree of each node is not more than 1.

- A balanced binary tree is also known as a *height balanced tree*.

- In a balanced binary tree, the tree height is **O(logN)**, where N is the number of nodes.

Example

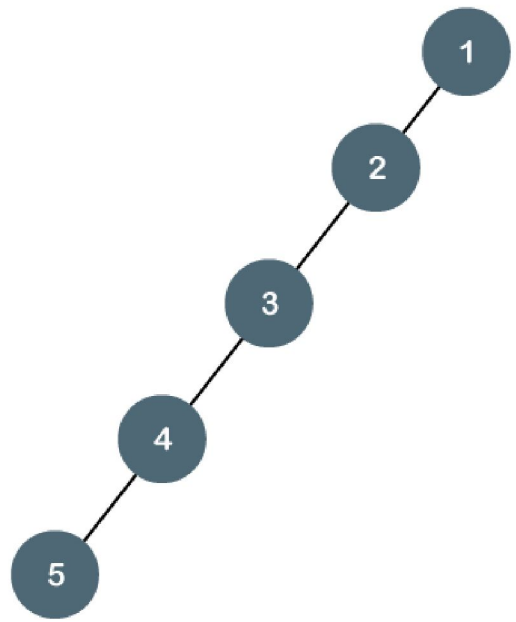


Balanced Binary Tree with depth at each level

df = depth = |height of left child - height of right child|

Example

An example of a *non-balanced* binary tree is a **degenerate tree** where every parent node has only one child node:



Why is it important that a binary tree be balanced?

- We have seen that the efficiency of many important operations on trees is related to the Height of the tree - for example searching, inserting, and deleting in a BST are all O(Height).
- In general, the relation between Height (H) and the number of nodes (N) in a tree can vary from H = N (degenerate tree) to H = log(N) (balanced binary tree).
- **For efficiency's sake, we would like to guarantee that H equals to O(logN).**

Self-balancing binary search tree

- **Self-Balancing Binary Search Trees** are *height-balanced* binary search trees that automatically keeps height as small as possible when insertion and deletion operations are performed on tree. The height is typically maintained in order of Log n so that all operations take O(Log n) time on average.

- A **red-black** tree is a kind of self-balancing binary search tree.