



Sunbeam Institute of Information Technology
Pune and Karad
PG - DESD

Module – Data Structures

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BST - Types

- **Skewed Binary tree**
 - In binary tree if only left or right links are used, then tree grows in only one direction and such tree is called as skewed binary tree.
 - Left skewed binary tree
 - Right skewed binary tree
 - Tree has maximum height that is same as number of elements
 - Time complexity of searching is $O(n)$. (Like linked list)
- **Balanced BST**
 - If nodes in BST are arranged so that its height is kept as less as possible, is called as balanced BST.
 - Balance Factor = Height of left subtree – Height of right subtree
 - In balanced BST, balance factor of each node is -1, 0 or +1
 - A tree can be balanced by applying series of left or right rotations.
- **AVL Tree**
 - AVL tree is a self balancing binary search tree.
 - Node are balanced on each insert and delete operation.
 - Difference between heights of left and right subtrees can not be more than 1 for all nodes.



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BST - Types

• AVL Tree

- AVL tree is a self balancing binary search tree.
- Node are rebalanced on each insert and delete operation.
- Difference between heights of left and right subtrees can not be more than 1 for all nodes.
- Most of BST operations are done in $O(h)$ i.e. $O(\log n)$ time.
- Need more number of rotations as compared to Red & Black tree.
- Construct an AVL Tree by inserting nodes : 40, 20, 10, 25, 30, 22, 50



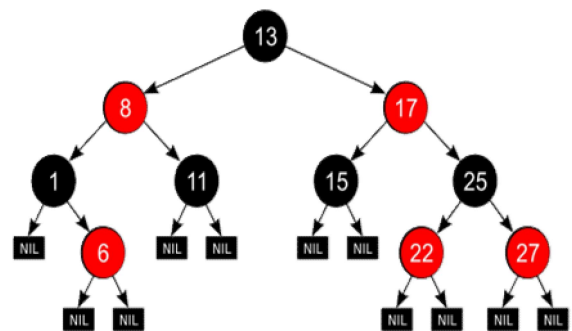
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BST - Types

• Red and Black Tree

- Red and Black tree is a self balancing binary search tree.
- Each node follows some rules:
 - Every node has a color either red or black.
 - Root of tree is always black.
 - Two adjacent cannot be red nodes (Parent color should be different than child).
 - Every path from a node (including root) to any of its descendant NULL node has the equal number of black nodes.
- Most of BST operations are done in $O(h)$ i.e. $O(\log n)$ time.
- For frequent insert/delete, RB tree is preferred over AVL tree.



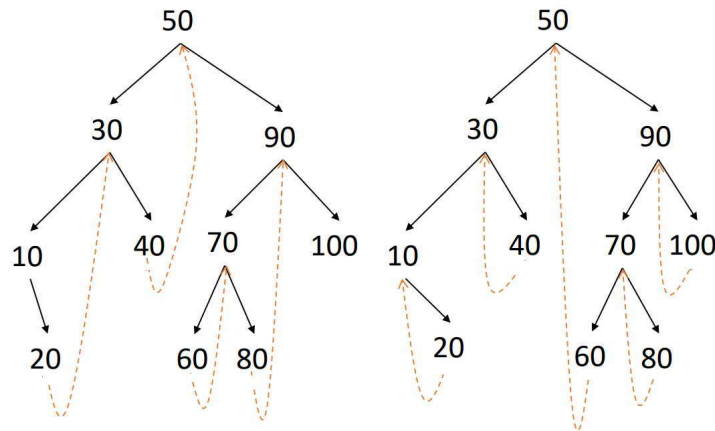
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BST - Types

• Threaded Tree

- Typical BST in-order traversal involves recursion or stack. It slows execution and also need more space.
- Threaded BST keep address of in-order successor or predecessor addresses instead of NULL to speed up in-order traversal (using a loop).
 - Left threaded BST
 - Right threaded BST
 - In-threaded BST



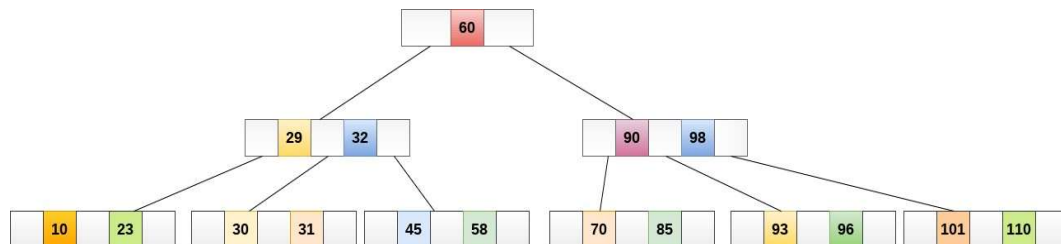
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Tree Types

• B Tree (Tree with degree m/m-way tree)

- A B-Tree of order m can have at most m-1 keys and m children.
- B tree store large number of keys in a single node. This allows storing number of values keeping height minimal.
- Note that in B-Tree all leaf nodes are at same level.
- B-Tree is commonly used for indexing into file systems and databases. It ensures quick data searching and speed up disk access.



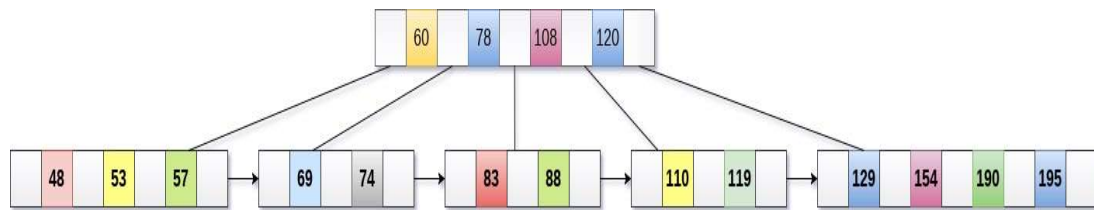
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Tree Types

• B+ Tree

- Extension of B-Tree for efficient insert, delete and search operation.
- Data is stored in leaf nodes only and all leaf nodes are linked together for sequential access.
- Faster searching, simplified deletion (as only from leaf nodes).
- B+ Tree is commonly used for indexing into file systems and databases. It ensures quick data searching and speed up disk access.



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Tree : Types

• Strictly Binary Tree

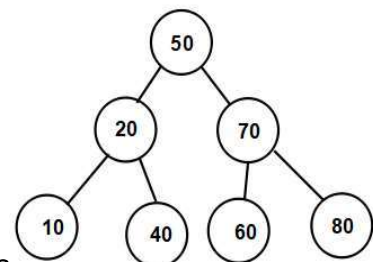
- Binary tree in which each non leaf node has exact two child nodes.

• Full Binary Tree

- Binary tree with its full capacity for the given height.
- In other words, adding one more node will increase height of the tree.
- It is always complete as well as strictly binary tree.
- Number of elements = $2^h - 1$

• Complete Binary Tree

- The binary tree which follows two conditions
 - All leaf nodes are at level h or $h-1$.
 - All leaf nodes at last level (h) are aligned to left as much as possible.



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