Tree Data Structure

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A tree data structure is a widely used non-linear data structure in computer science that resembles a tree in nature. It consists of nodes connected by edges. The topmost node is called the root node, and each node can have zero or more child nodes.

Key Terminologies:

1. **Node:** Each element in a tree data structure is called a node. It contains data and references to its child nodes.
2. **Root:** The topmost node of the tree. It is the starting point for traversing the tree.
3. **Parent:** A node from which another node is directly descended.
4. **Child:** A node directly connected to another node when moving away from the root.
5. **Leaf:** A node that has no child nodes.
6. **Edge:** The link between two nodes.
7. **Depth:** The level of a node in the tree. The root node is at level 0, and its children are at level 1, and so on.
8. **Height:** The number of edges on the longest path from the node to a leaf.

Types of Trees:

1. **Binary Tree:** Each node has at most two children – left child and right child.
2. **Binary Search Tree (BST):** A binary tree in which the left child of a node has a value less than the node, and the right child has a value greater than the node.

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3. **Balanced Tree:** A tree in which the height difference between the left and right subtrees of any node is not more than one.

4. **Binary Heap:** A complete binary tree where each node has a value less (or greater) than the values of its children.

Operations on Trees:

1. **Traversal:** Visiting each node in a specific order. Common methods are in-order, pre-order, and post-order traversal.

2. **Search:** Looking for a specific node in the tree.

3. **Insertion:** Adding a new node to the tree.

4. **Deletion:** Removing a node from the tree.

5. **Balancing:** Ensuring the tree remains balanced to maintain efficient operations.

Applications of Trees:

1. **Hierarchical Data:** Representing hierarchical data like file systems, XML, and JSON.

2. **Binary Search Trees:** Used in search operations and implementing associative arrays.

3. **Expression Trees:** Representing expressions in a tree format for easy evaluation.

4. **Decision Trees:** Used in machine learning for classification and regression tasks.

Understanding tree data structures is fundamental in computer science as they provide efficient ways to store and retrieve data in a hierarchical manner.