**B - Tree Datastructure**

∙ Data is stored on the disk in blocks, this data, when brought into main memory (or RAM) is called data structure.

∙ In-case of huge data, searching one record in the disk requires reading the entire disk; this increases time and main memory consumption due to high disk access frequency and data size. ∙ To overcome this, index tables are created that saves the record reference of the records based on the blocks they reside in. This drastically reduces the time and memory consumption. ∙ Since we have huge data, we can create multi-level index tables.

∙ Multi-level index can be designed by using B Tree for keeping the data sorted in a self-balancing fashion.

In search trees like binary search tree, AVL Tree, Red-Black tree, etc., every node contains only one value (key) and a maximum of two children. But there is a special type of search tree called B-Tree in which a node contains more than one value (key) and more than two children. B-Tree was developed in the year 1972 by **Bayer and McCreight** with the name ***Height Balanced m-way Search Tree***. Later it was named as B-Tree.

B-Tree can be defined as follows...

**B-Tree is a self-balanced search tree in which every node contains multiple keys and has more than two children.**

Here, the number of keys in a node and number of children for a node depends on the order of B-Tree. Every B-Tree has an order

.**B-Tree of Order m** has the following properties...

∙ **Property #1** - All **leaf nodes** must be **at same level**.

∙ **Property #2** - All nodes except root must have at

∙ and maximum of **m-1** keys.

∙ **Property #3** - All non leaf nodes except root (i.e. all internal nodes) must have at least **m/2** children.

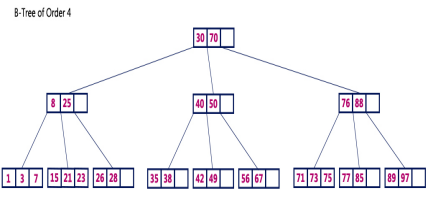
∙ **Property #4** - If the root node is a non leaf node, then it must have **atleast 2** children. ∙ **Property #5** - A non leaf node with **n-1** keys must have **n** number of children.

∙ **Property #6** - All the **key values in a node** must be in **Ascending Order**.

For example, B-Tree of Order 4 contains a maximum of 3 key values in a node and maximum of 4

children for a node.

**Example**

**Operations on a B-Tree**

The following operations are performed on a B-Tree...

**1. Search**

**2. Insertion**

**3. Deletion**

**Search Operation in B-Tree**

The search operation in B-Tree is similar to the search operation in Binary Search Tree. In a Binary search tree, the search process starts from the root node and we make a 2-way decision every time (we go to either left subtree or right subtree). In B-Tree also search process starts from the root node but here we make an n-way decision every time. Where 'n' is the total number of children the node has. In a B

Tree, the search operation is performed with **O(log n)** time complexity. The search operation is performed as follows...

∙ **Step 1 -** Read the search element from the user.

∙ **Step 2 -** Compare the search element with first key value of root node in the tree. ∙ **Step 3 -** If both are matched, then display "Given node is found!!!" and terminate the function∙ **Step 4 -** If both are not matched, then check whether search element is smaller or larger than that key value.

∙ **Step 5 -** If search element is smaller, then continue the search process in left subtree. ∙ **Step 6 -** If search element is larger, then compare the search element with next key value in the same node and repeate steps 3, 4, 5 and 6 until we find the exact match or until the search element is compared with last key value in the leaf node.

∙ **Step 7 -** If the last key value in the leaf node is also not matched then display "Element is not found" and terminate the function.

**Insertion Operation in B-Tree**

In a B-Tree, a new element must be added only at the leaf node. That means, the new keyValue is always attached to the leaf node only. The insertion operation is performed as follows...

∙ **Step 1 -** Check whether tree is Empty.

∙ **Step 2 -** If tree is **Empty**, then create a new node with new key value and insert it into the tree as a root node.

∙ **Step 3 -** If tree is **Not Empty**, then find the suitable leaf node to which the new key value is added using Binary Search Tree logic.

∙ **Step 4 -** If that leaf node has empty position, add the new key value to that leaf node in ascending order of key value within the node.

∙ **Step 5 -** If that leaf node is already full, **split** that leaf node by sending middle value to its parent node. Repeat the same until the sending value is fixed into a node.

∙ **Step 6 -** If the spilting is performed at root node then the middle value becomes new root node for the tree and the height of the tree is increased by one.

**Example**

Construct a **B-Tree of Order 3** by inserting numbers from 1 to 10.

