DESIGN AND ANALYSIS OF ALGORITHMS

Surabhi Narayan
Department of Computer Science & Engineering

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B Trees

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B Tree

- Self-balancing search tree
- Each node can contain more than one key
- Can have more than two children.
- All data records (or record keys) are stored at the leaves, in increasing order of the keys each parental node contains $n - 1$ ordered keys.

It is also known as a height-balanced m-way tree.

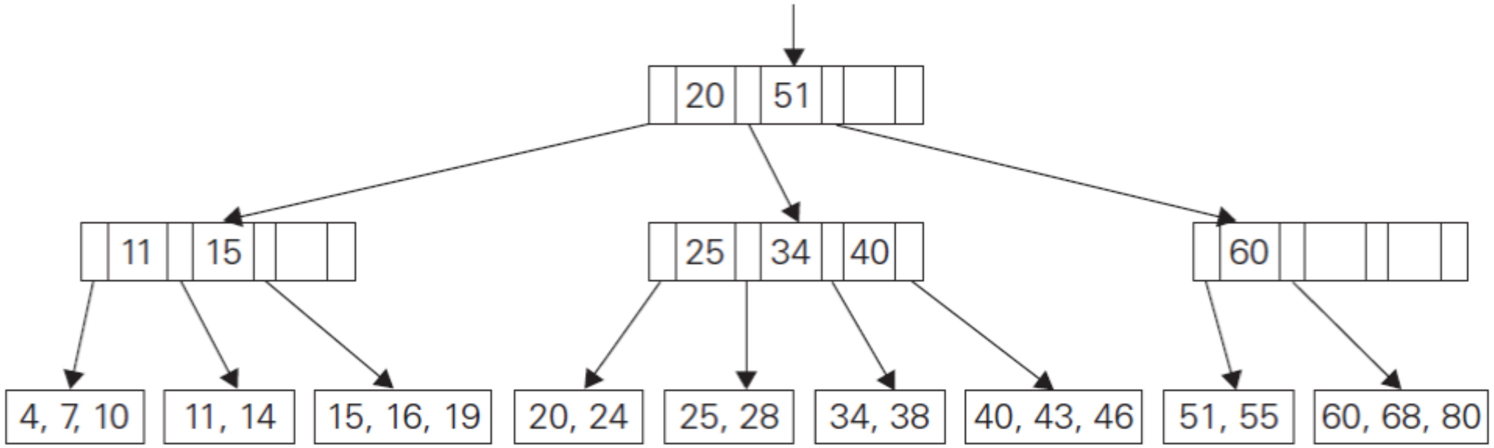

FIGURE 7.8 Example of a B-tree of order 4.

Structural properties:

- All leaves are at the same level.
- For each node x, the keys are stored in increasing order.
- If n is the order of the tree, each internal node can contain at most n - 1 keys along with a pointer to each child.
- Each node except root can have at most n children and at least n/2 children.
- All leaves have the same depth (i.e. height-h of the tree).
- The root has at least 2 children and contains a minimum of 1 key.
- If $n \geq 1$, then for any n-key B-tree of height h and minimum degree $t \geq 2$, $h \geq \log_t (n+1)/2$
- B-Tree grows and shrinks from the root which is unlike Binary Search Tree. Binary Search Trees grow downward and also shrink from downward.
- Like other balanced Binary Search Trees, time complexity to search, insert and delete is O(log n).

Operations on a B Tree:

- Searching
- Insertion
- Deletion

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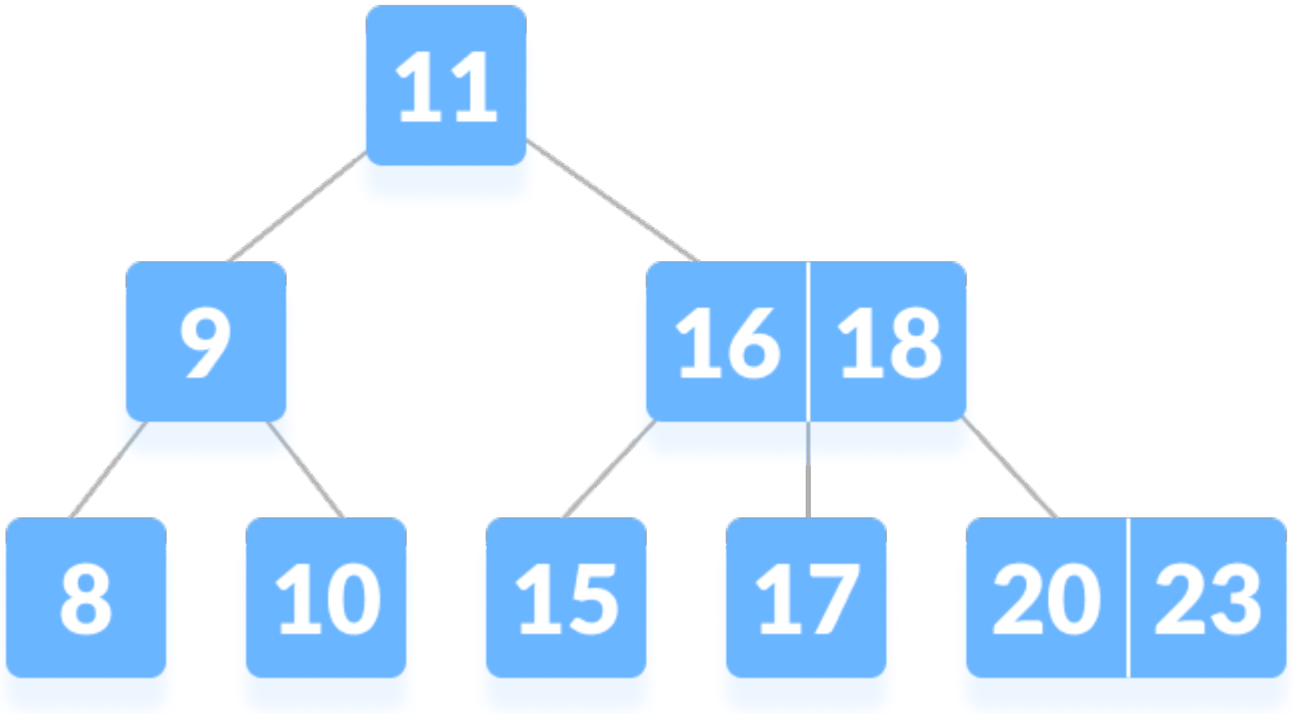
Search

1. Starting from the root node, compare k with the first key of the node.
2. If k = the first key of the node, return the node and the index
3. If k.leaf = true, return NULL, i.e. not found
4. If k < the first key of the root node, search the left child of this key recursively.
5. If there is more than one key in the current node and k > the first key compare k with the next key in the node.
6. If k < next key search the left child of this key (ie. k lies in between the first and the second keys). Else, search the right child of the key
7. Repeat steps 1 to 4 until the leaf is reached.

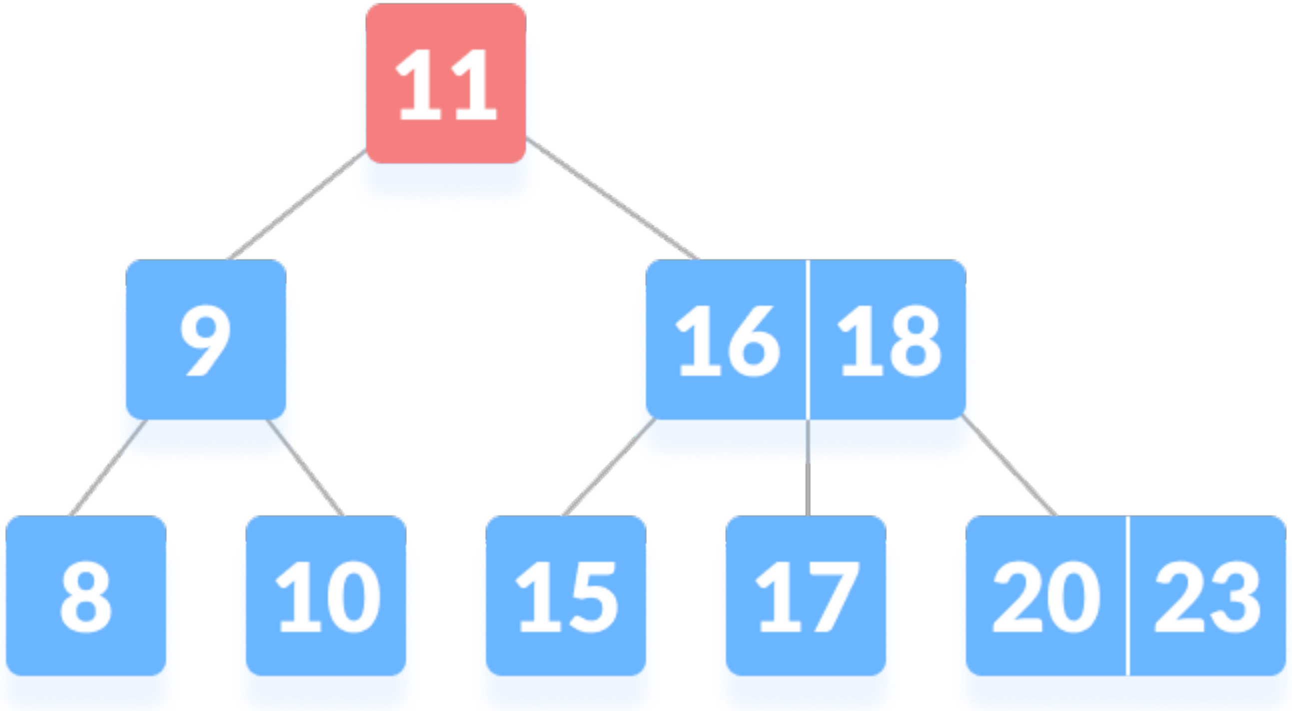
B Tree

Let us search key , k = 17



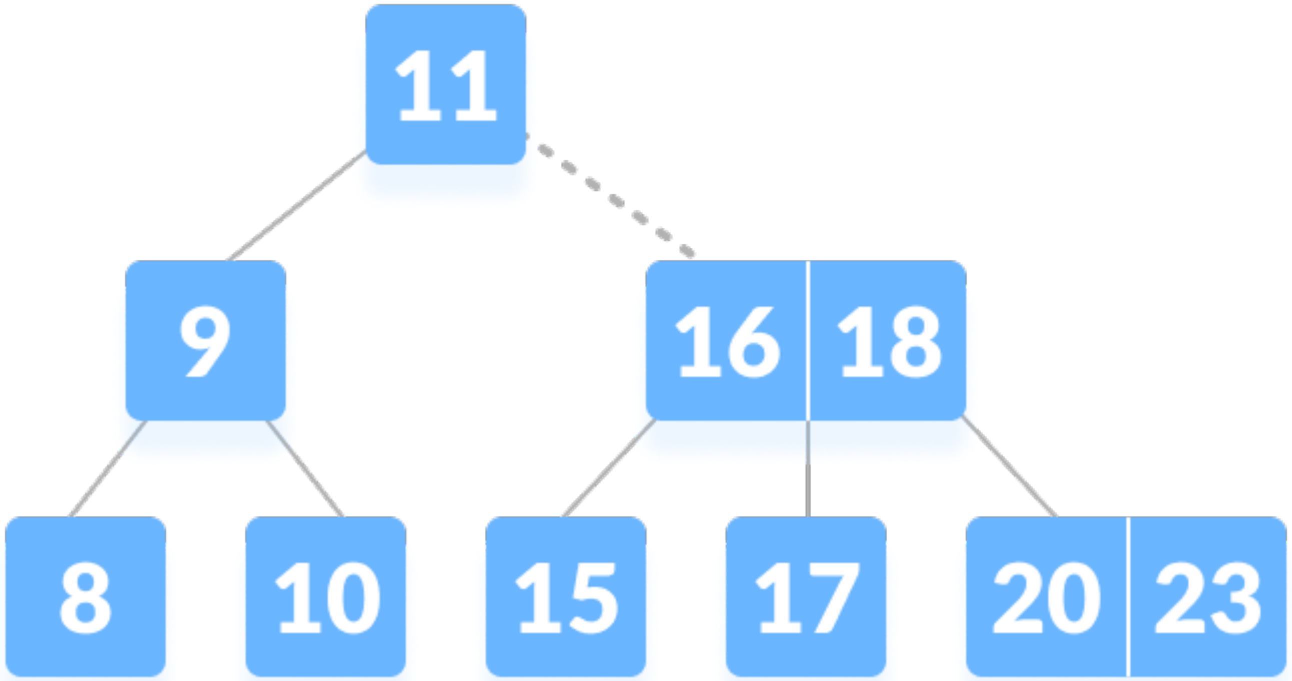
B Tree

K is not found in the root so, compare it with the root key

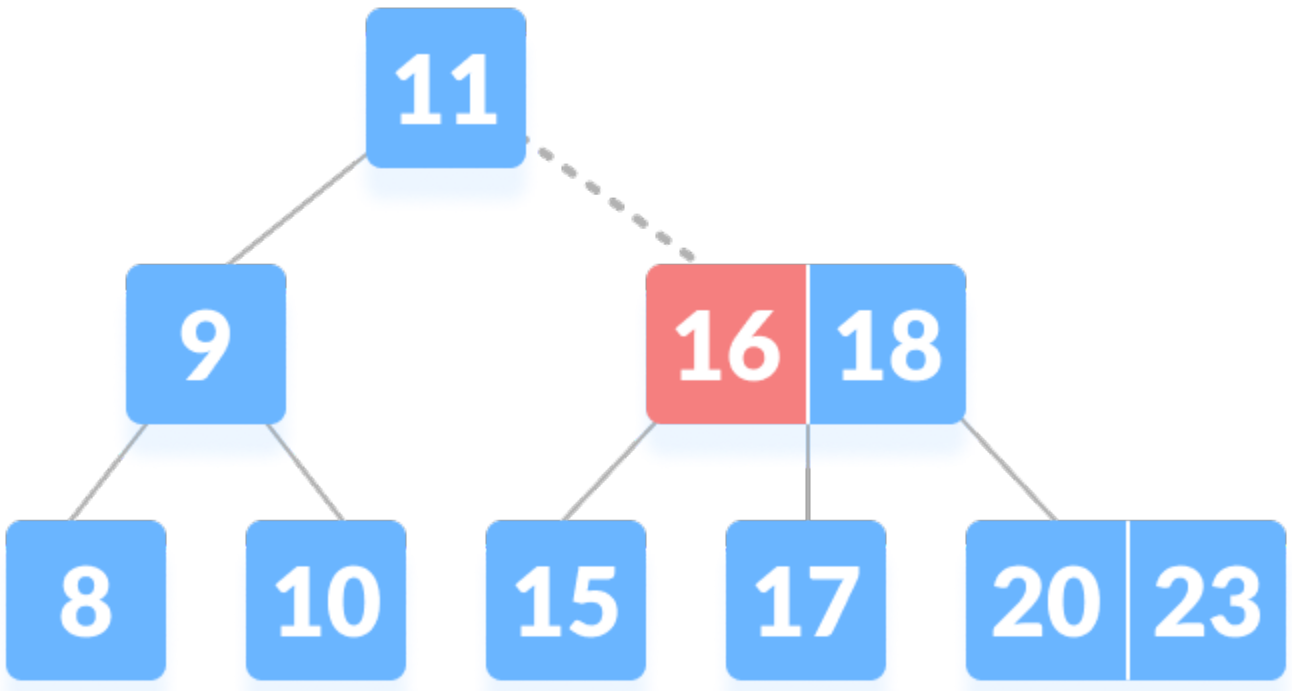


B Tree

Since k > 11 go to the right child of the root node.

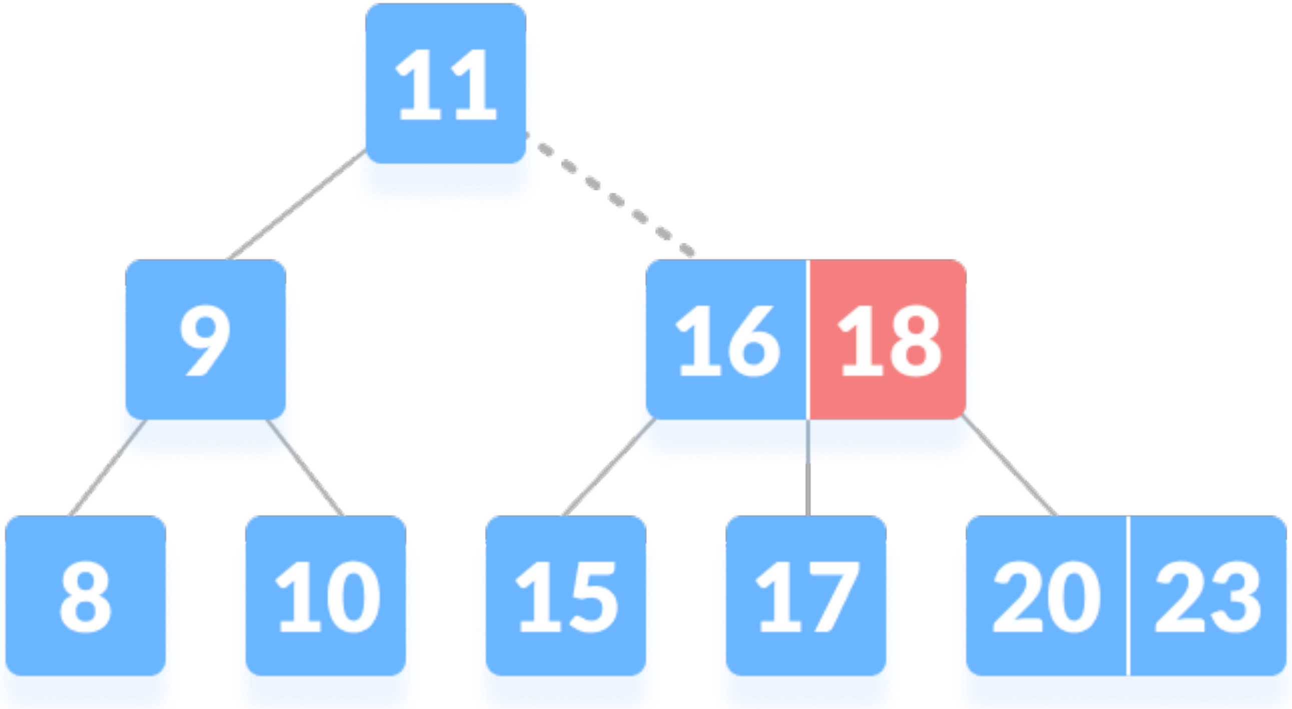


Compare k with 16. Since k > 16, compare k with the next key 18

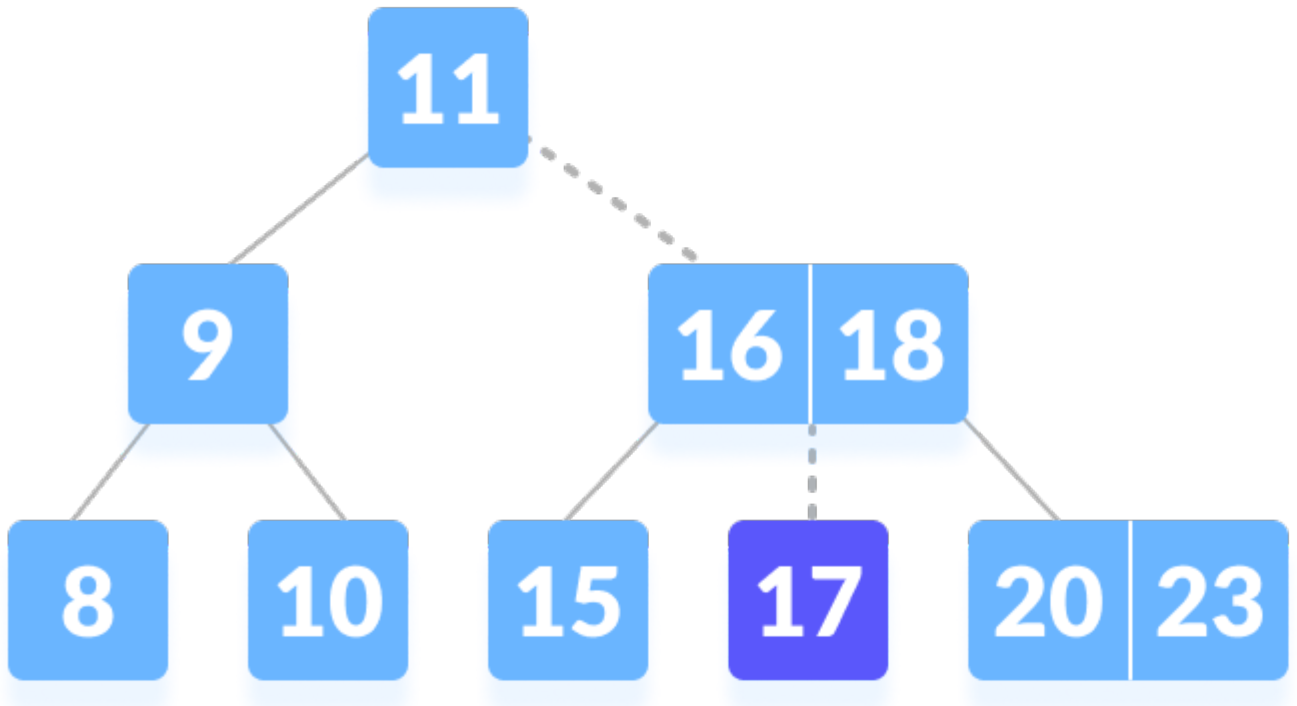


B Tree

Since k < 18, k lies between 16 and 18. Search in the right child of 16 or the left child of 18.



k is found



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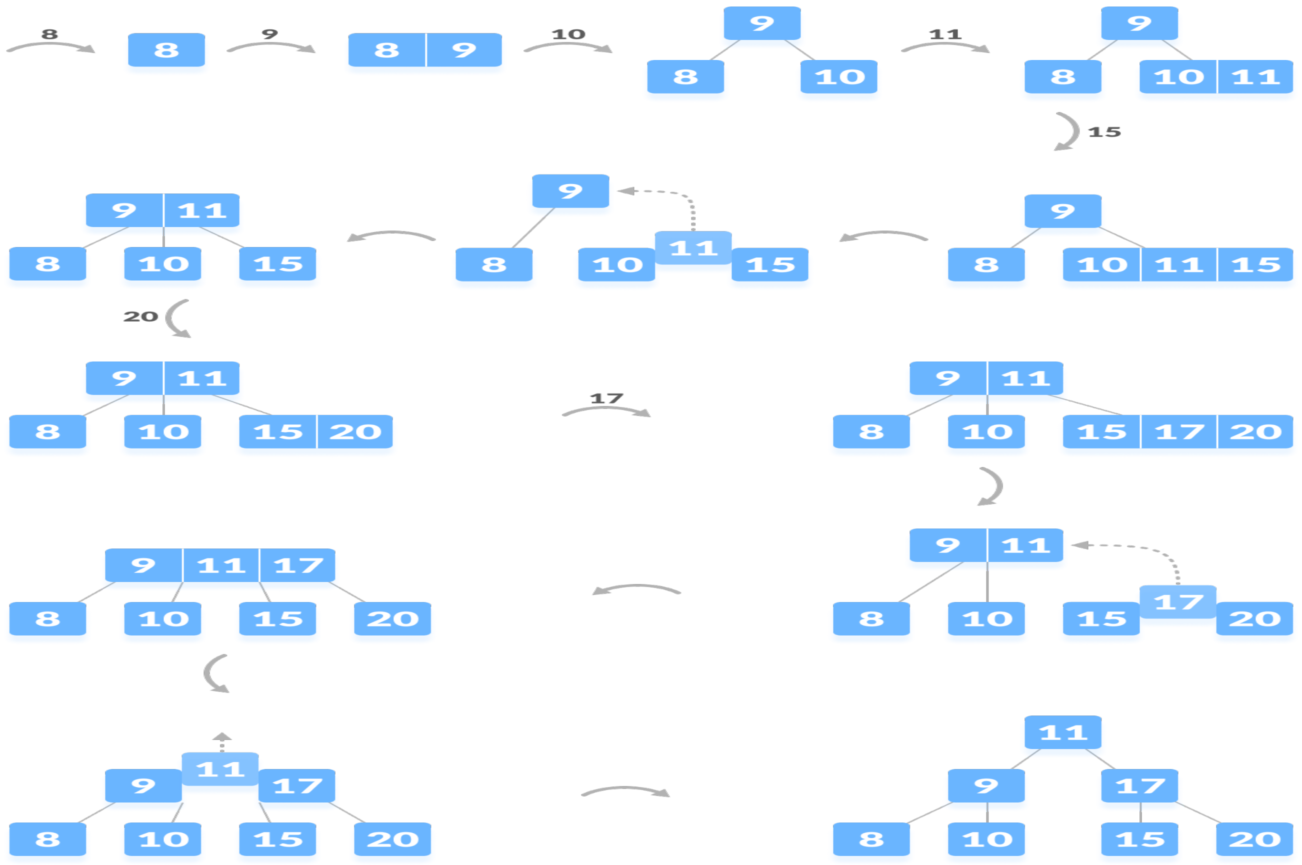
Insertion into a B-tree

Inserting an element on a B-tree consists of two events: **searching the appropriate node** to insert the element and **splitting the node** if required.Insertion operation always takes place in the bottom-up approach.

Insertion Operation

1.Traverse the B Tree in order to find the appropriate leaf node at which the node can be inserted.
2.If the leaf node contain less than m-1 keys then insert the element in the increasing order.

3. Else, if the leaf node contains m-1 keys, then follow the following steps.
   - Insert the new element in the increasing order of elements.
   - Split the node into the two nodes at the median.
   - Push the median element upto its parent node.
   - If the parent node also contain m-1 number of keys, then split it too by following the same steps.



Insertion Example

Let us understand the insertion operation with the illustrations below.
The elements to be inserted are 8, 9, 10, 11, 15, 16, 17, 18, 20, 23.

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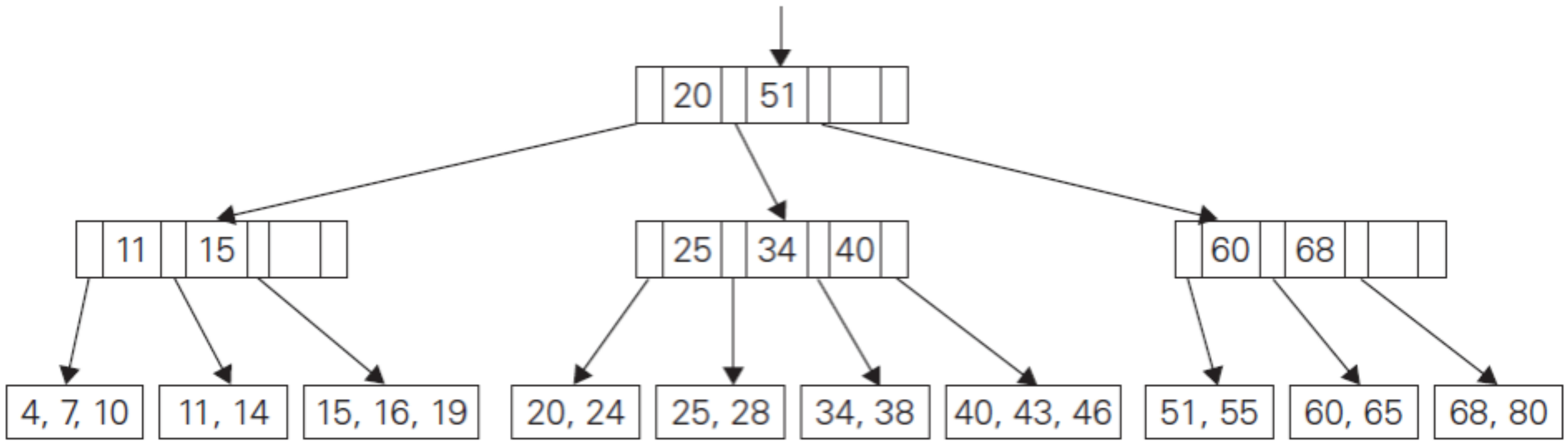

FIGURE 7.9 B-tree obtained after inserting 65 into the B-tree in Figure 7.8.

THANK YOU

Surabhi Narayan
Department of Computer Science &Engineering
surabhinarayan@pes.edu