# DATA STRUCTURES & ALGORITHMS

Trees : M ways

Instructor: Engr. Laraib Siddiqui

# M-Way Search Tree

It can have more than two children.

M is called the *degree* of the tree.

Requirement????

*Favors retrieval and manipulation of data stored in external memory.*

*Goal???*

*Minimizes the accesses while retrieving a key from a file.*

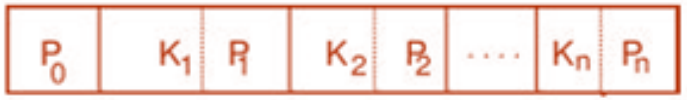
# M-Way Search Tree

It can have m pointers and m-1 keys in one node.

Properties:

- Each node has 0 .. m subtrees
- A node with k < m subtrees, contains k-1 keys.
- The key values of the first subtree are all less than the key value.
- The data entries are ordered.

Representation:

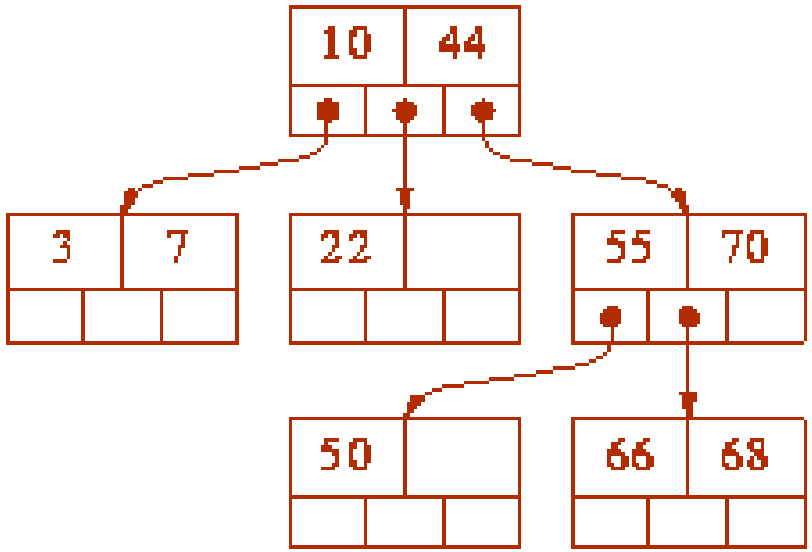



Where,

P are pointers to the subtree.

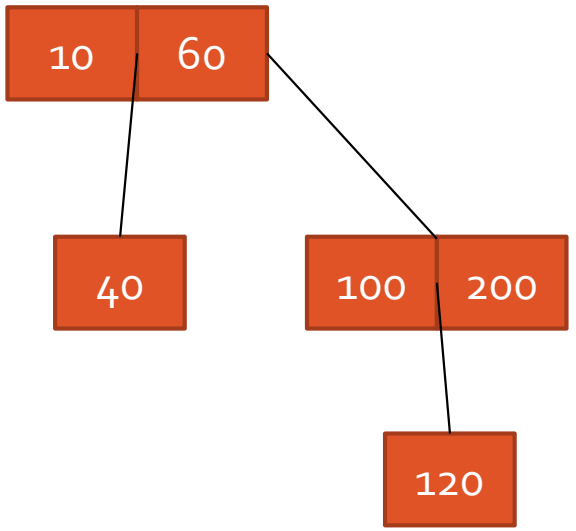
K are key values in the node

# 3-way search tree



# 3-way search tree

Insert 10, 60, 100, 200,40,120

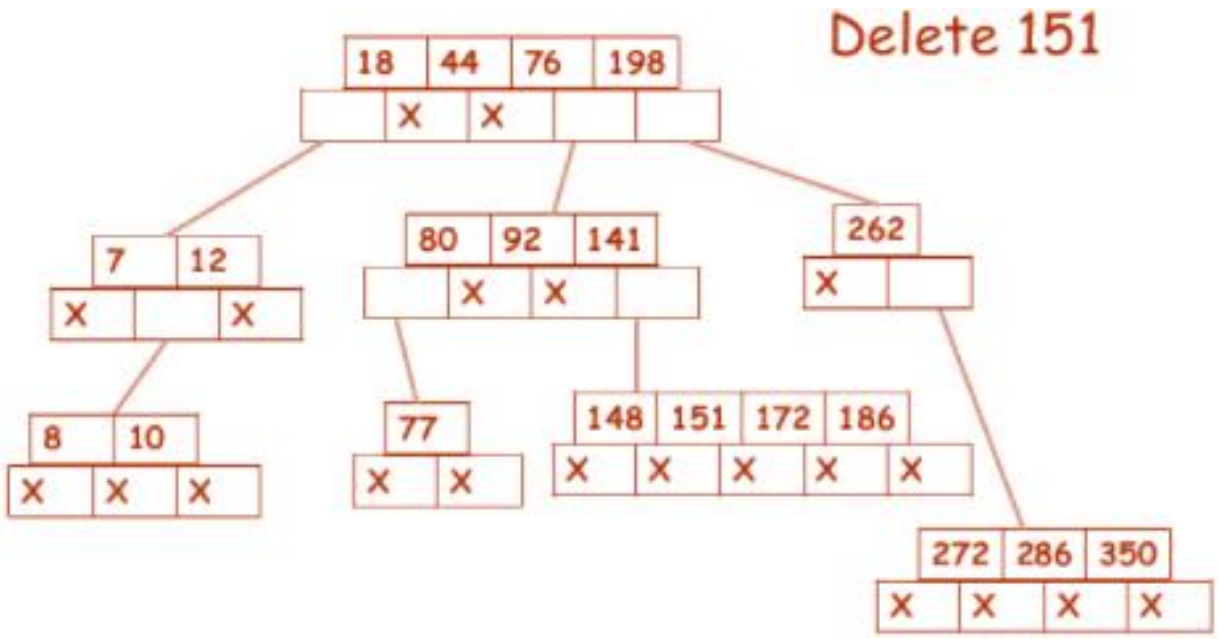


# 4-way search tree

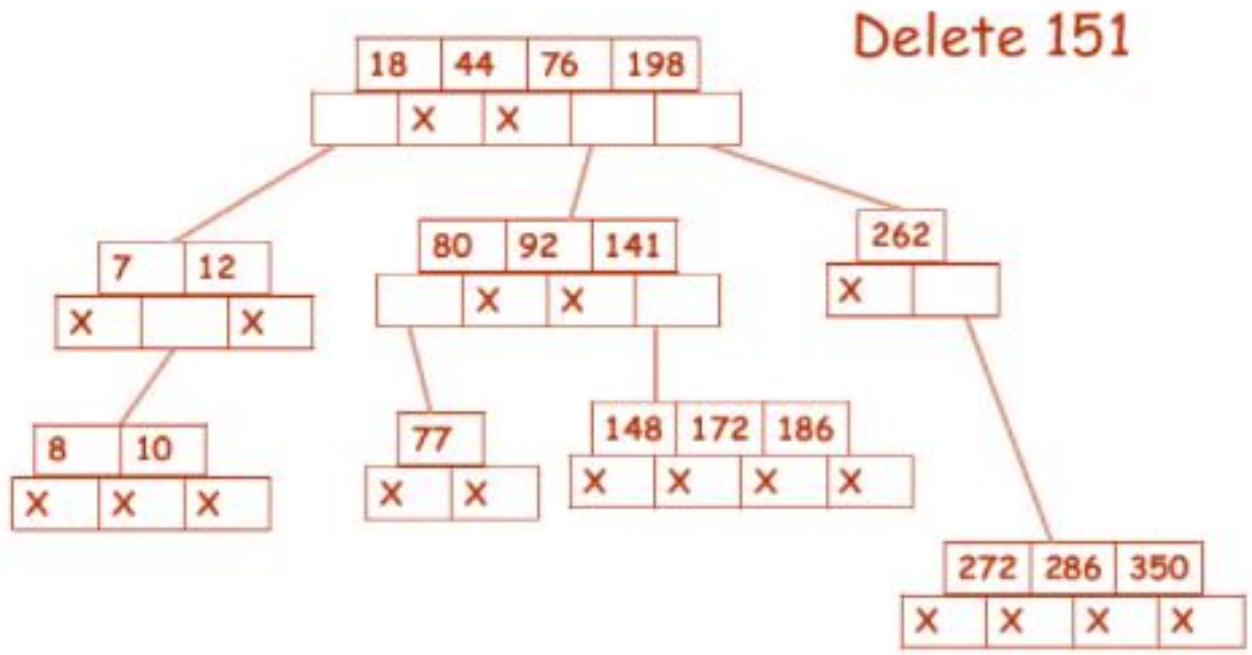
Insert 10, 60, 100, 200,40,120

?

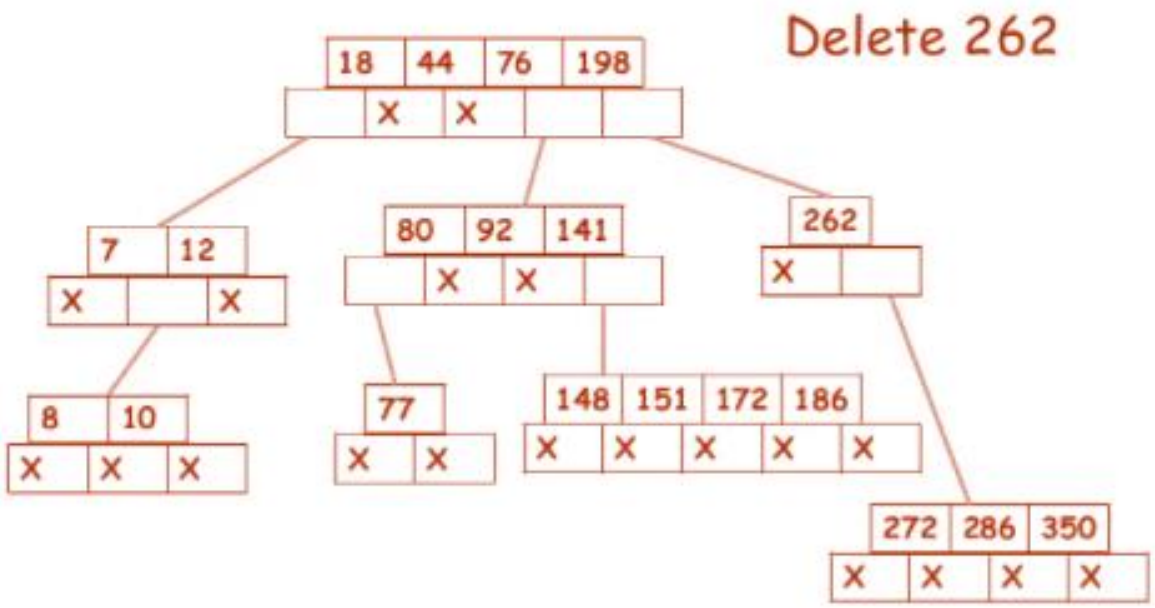
# 5 Way - Deletion



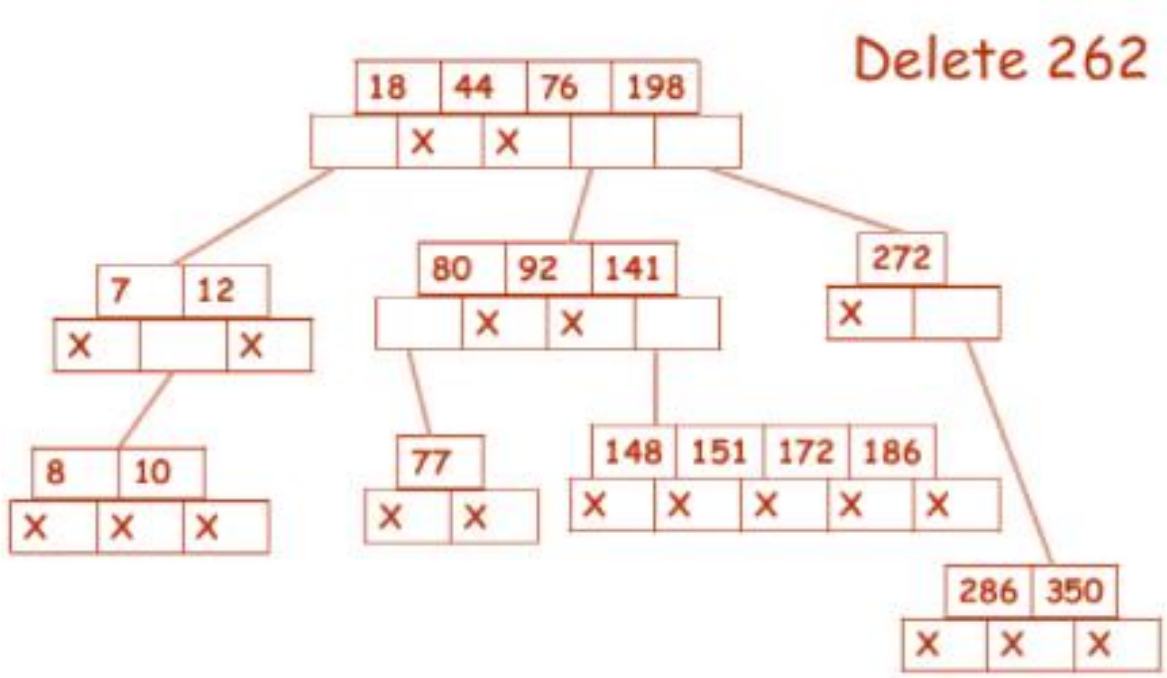
# 5 Way - Deletion



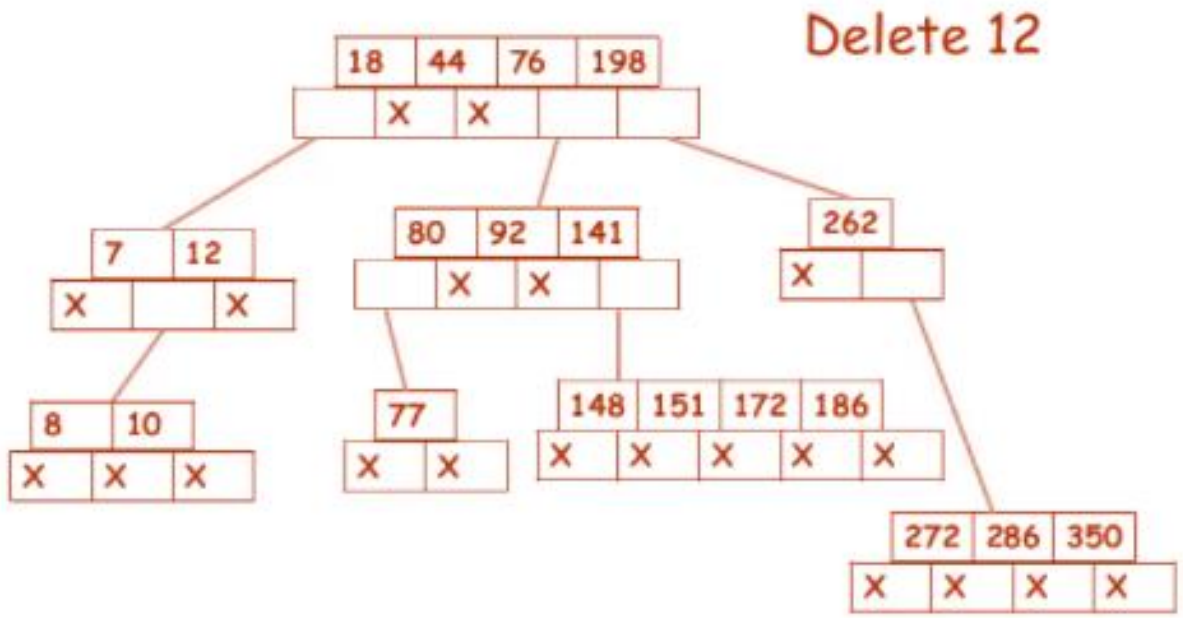
# 5 Way - Deletion



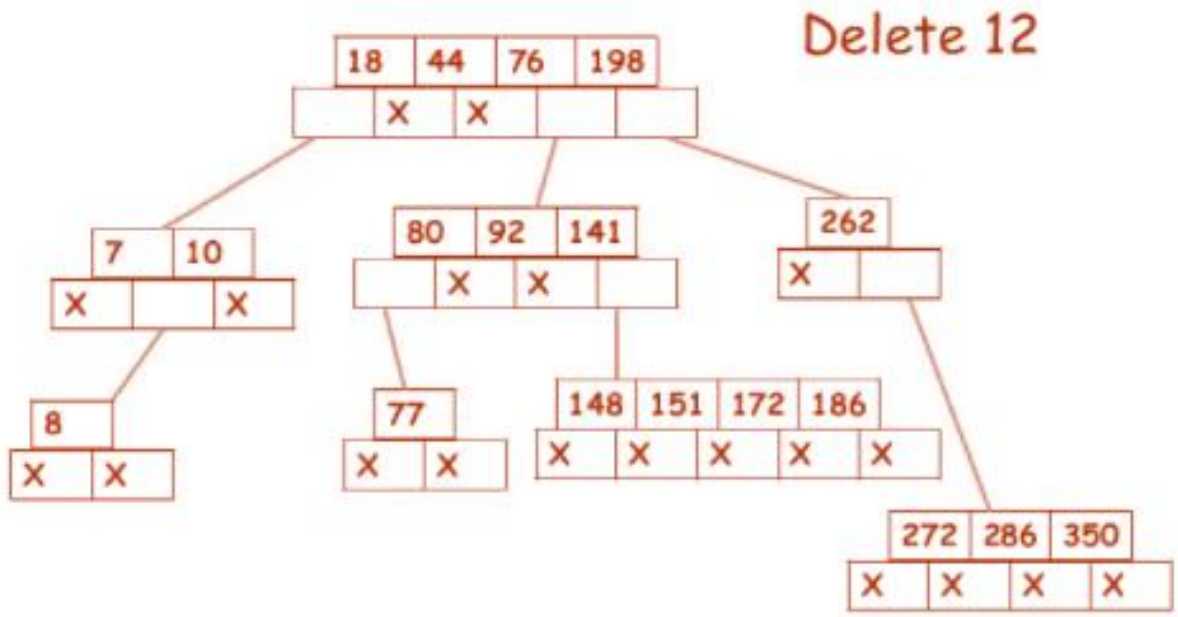
# 5 Way - Deletion



# 5 Way - Deletion



# 5 Way - Deletion

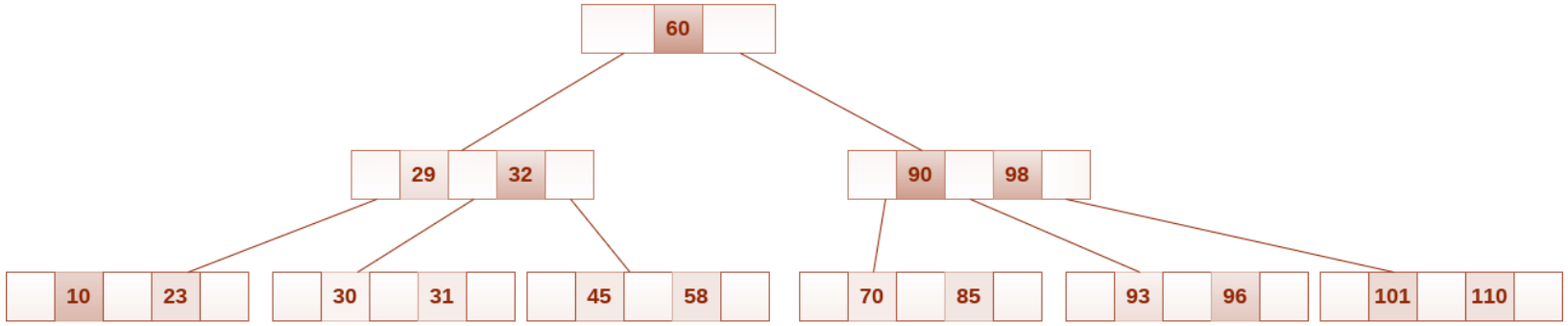


# B Tree

B Tree is a specialized m-way tree that can be widely used for disk access.

B tree of order m contains all the properties of an M way tree. In addition, it contains the following properties.

- Every node in a B-Tree contains at most m children.
- Every node in a B-Tree except the root node and the leaf node contain at least [m/2] children.
- The root nodes must have at least 2 nodes.
- All leaf nodes must be at the same level.

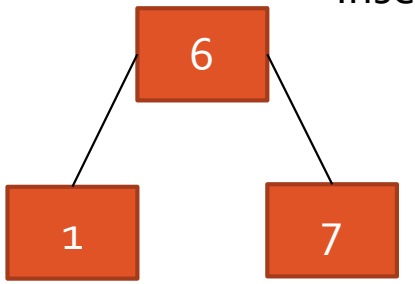


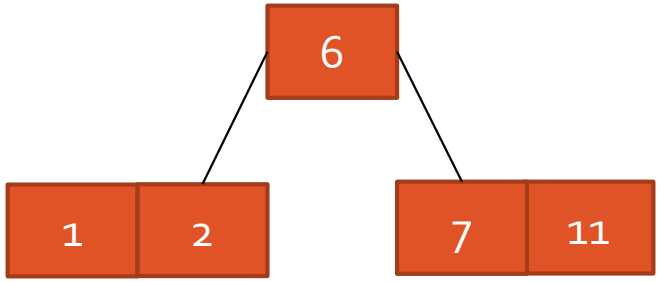
# B tree order 3

Insert 1, 7, 6, 2, 11, 4, 8


Insert 1, 7

Insert 6



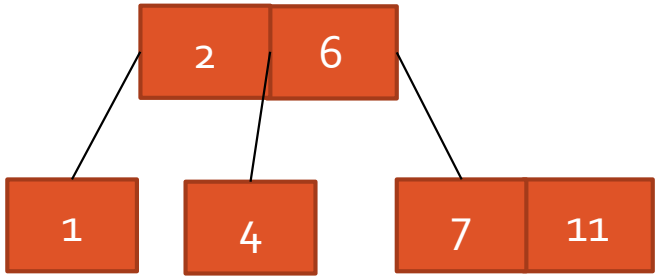




Insert 2, 11

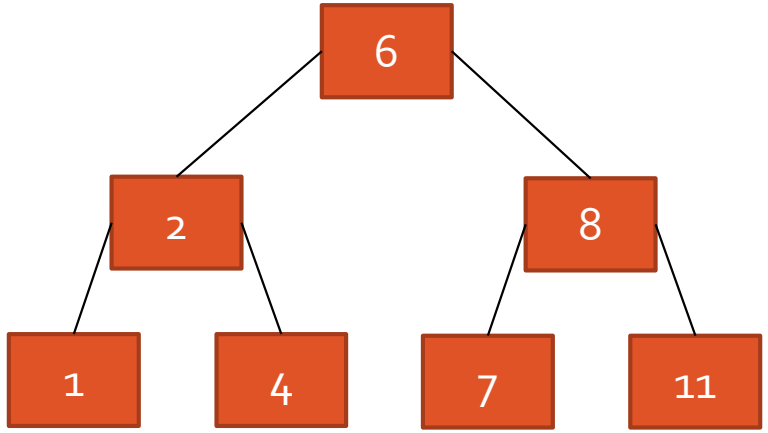
# B Tree- Insertion

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.
   a) Insert the new element in the increasing order of elements.
   b) Split the node into the two nodes at the median.
   c) Push the median element upto its parent node.
   d) If the parent node also contain m-1 number of keys, then split it too by following the same steps.

# Insertion- B tree order 3

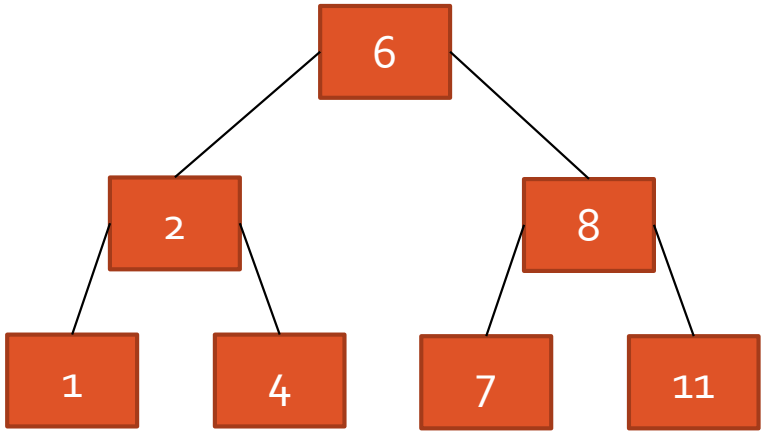



Insert 4




Insert 8

# Insertion- B tree order 3

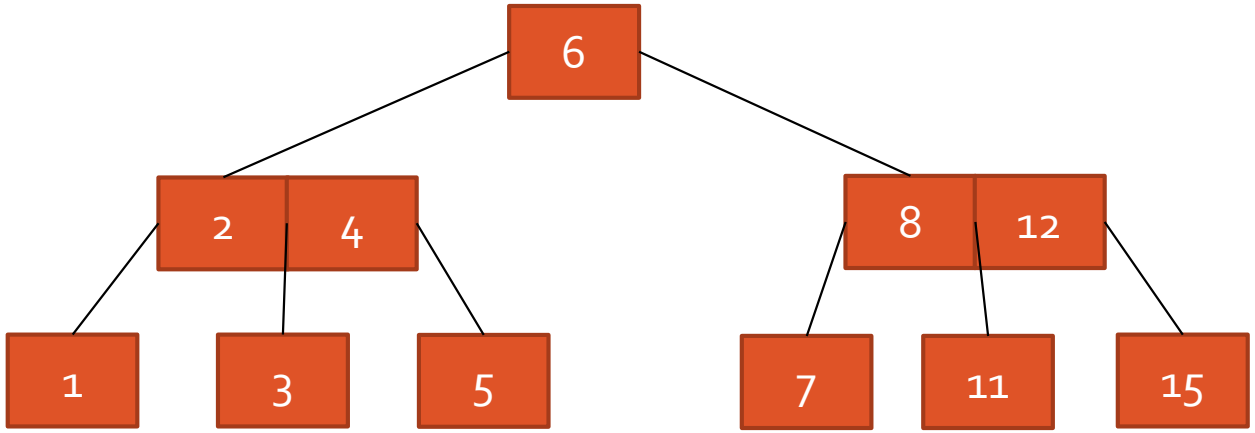



Insert 5, 15, 3, 12 ????

# B tree- Deletion

1. Locate the node.
2. If there are more than [m/2] - 1 keys in the node then delete the desired key from the node.
3. If the  node doesn't contain [m/2] - 1 keys then complete the keys by taking the element from right or left sibling.
   a) If the left sibling contains more than [m/2] - 1 elements then push its largest element up to its parent and move the intervening element down to the node where the key is deleted.
   b) If the right sibling contains more than [m/2] - 1 elements then push its smallest element up to the parent and move intervening element down to the node where the key is deleted.
4. If neither of the sibling contain more than [m/2] - 1 elements then create a new node by joining two leaf nodes and the intervening element of the parent node.
5. If parent is left with less than [m/2] - 1 nodes then, apply the above process on the parent too.

# Deletion

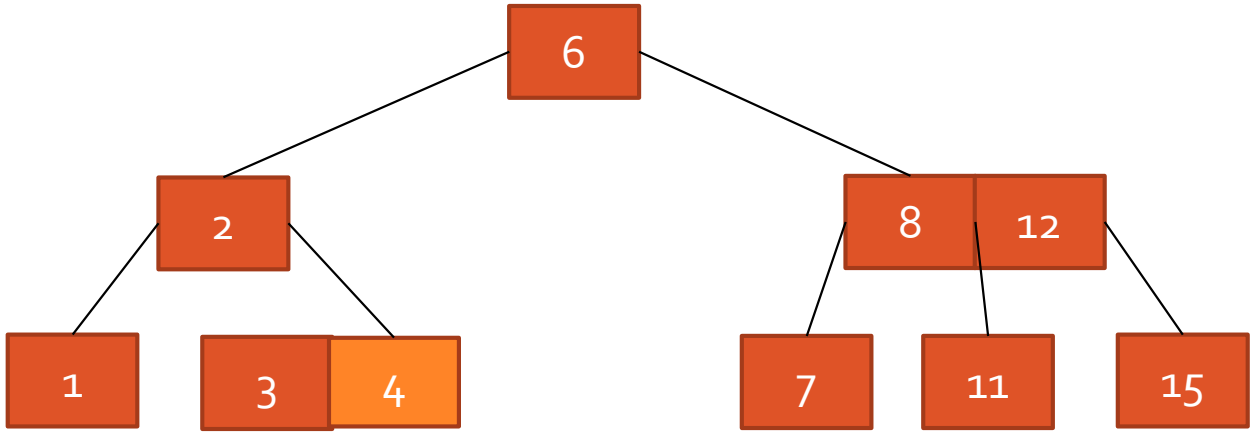



Delete 5

For order 3, min keys can be [m/2] - 1
=> [3/2] - 1
= > 1

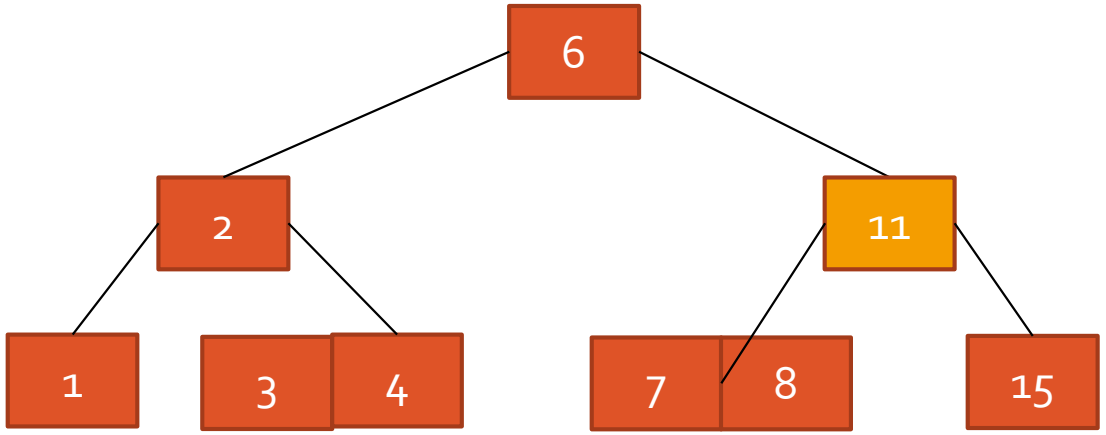
Merge node

# Deletion




Delete 12

# Deletion



# Complexity

| | B Tree |
|---|---|
| Access | O(Log(n)) |
| Search | O(Log(n)) |
| Insertion | O(Log(n)) |
| Deletion | O(Log(n)) |