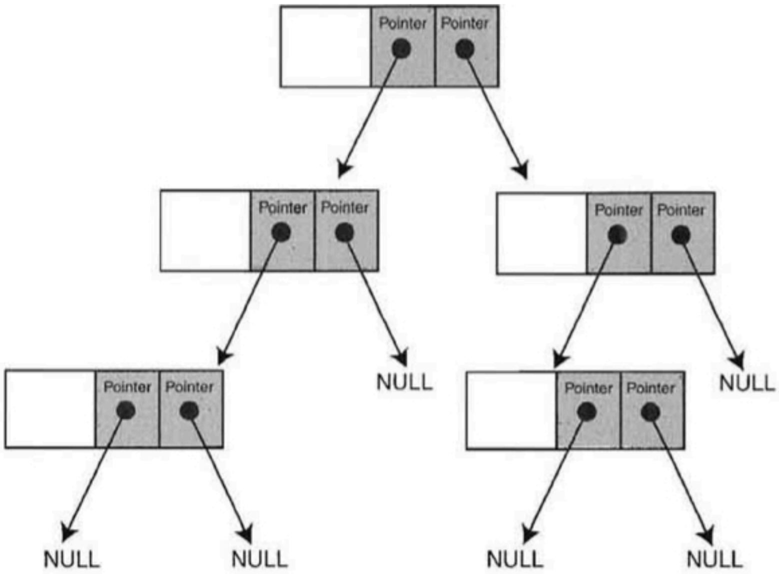
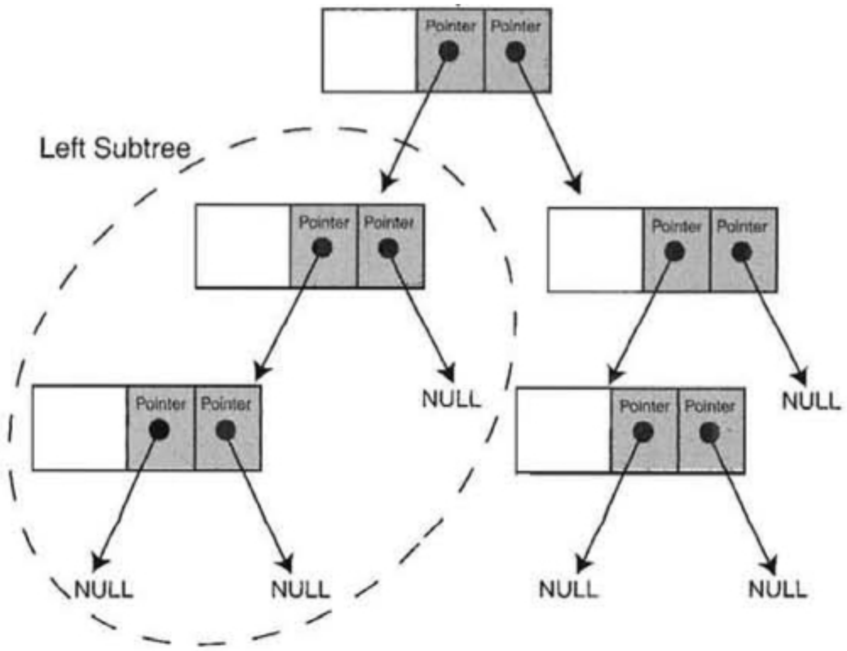
Binary Trees

Trees

- nodes=objects
  - data section
  - linkage info
- parent
- children
  - binary= max 2
  - left/right
- tree root
  - like listhead

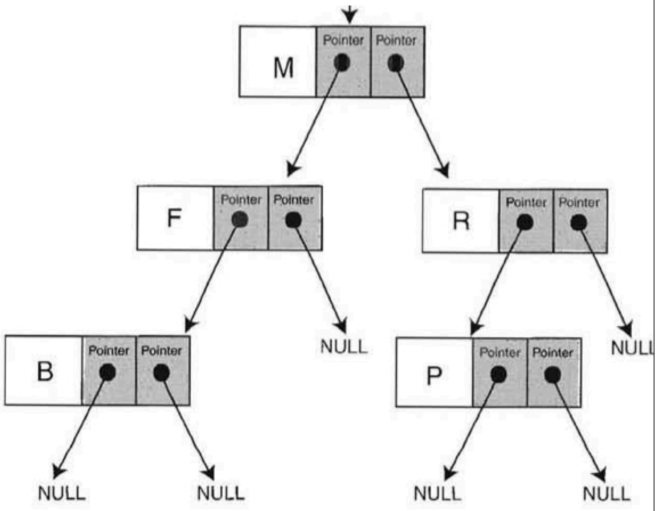


SubTree



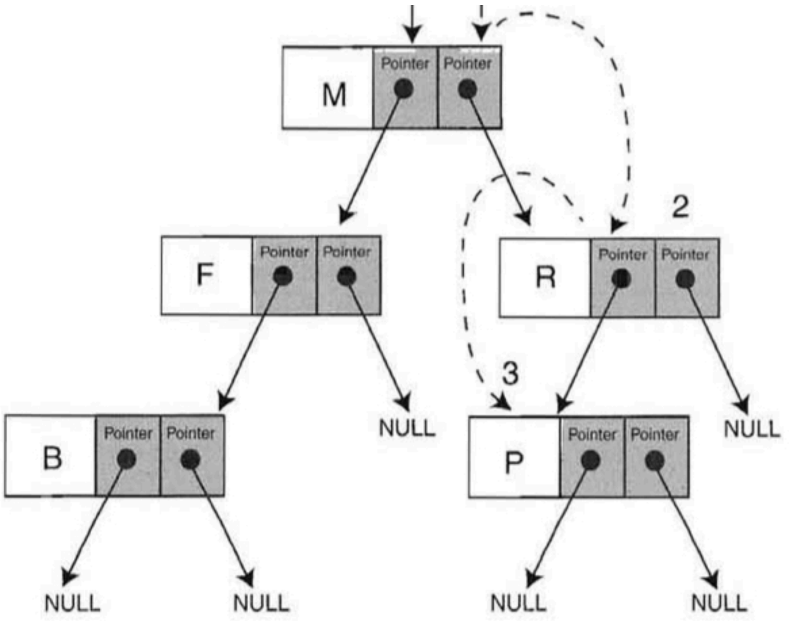
Binary Search Tree

- Fundamental property
- left subtree values <= value value
- right subtree values >= node value



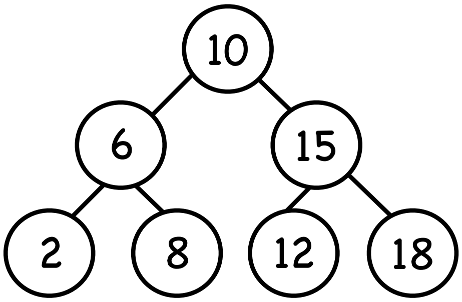
Binary Search : look for value

look for 'P'

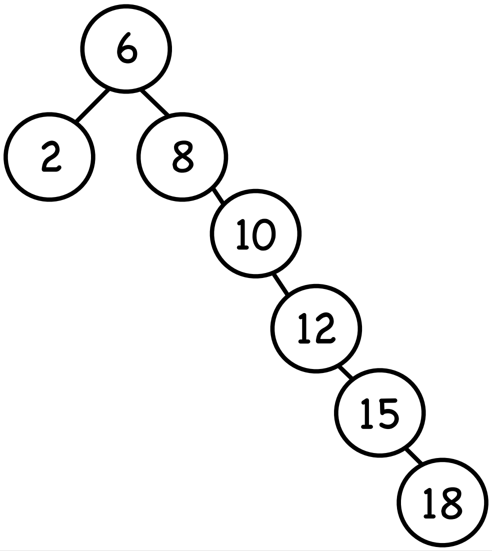


Tree Balance

GOOD



BAD



Tree Operations: create

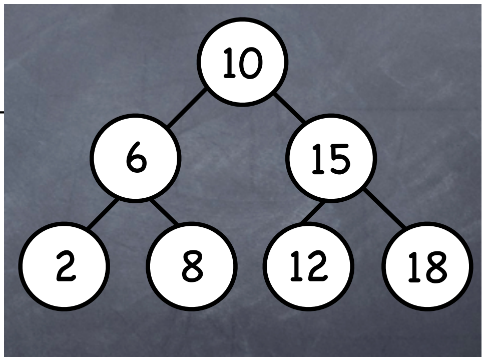
- similar to lists, but different linkage

```
class treenode{
  int value;
  treenode* parent, lchild, rchild;
};
```

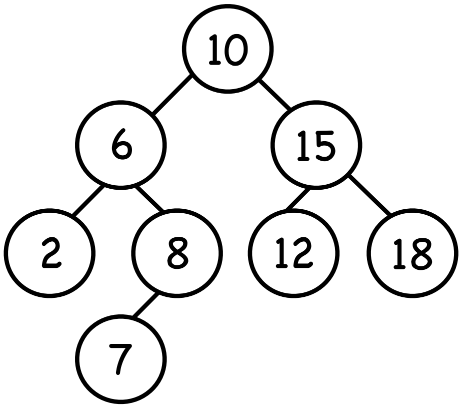
```
treenode* root = new treenode;

root->parent=NULL;

root->lchild = root->rchild=NULL;

root->value = somevalue;
```

Tree Operations:

insert

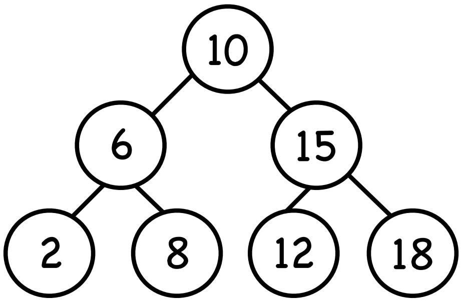


- create new node
- associate value
- insert the node into the tree based on value
  - fundamental property must be preserved
- insert value 7 in example

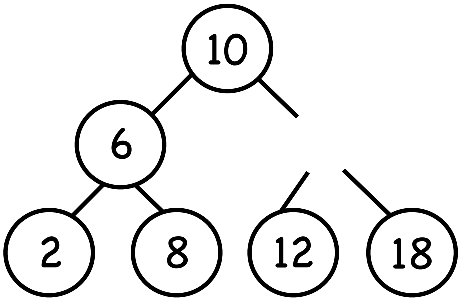


Tree Operations: delete

- delete node content easy



- but linkage has to be handled
  - not so easy



- use successor() / predecessor()
  - to determine what nodes replaces the deleted one
  - and perhaps continue replacements

Predecessor, Successor

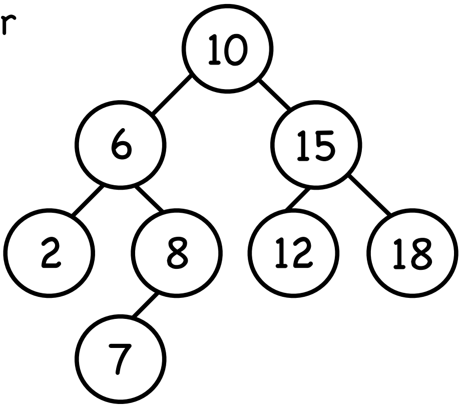
- Predecessor(x) = highest value in the tree smaller or equal to x (but not the same node as x)
- Successor(x) = smallest value in the tree bigger or equal to x (but not the same node as x)

Min, Max

- Min = go deep on the left branch
- Max = go deep on the right branch

Searching the tree

- Binary search Trees very good for searching large amounts of data
- Search for value x
- start at root, repeat
  - compare x with value
  - if found, return
  - if x>value go on the right branch
  - if x<value go on the left branch



Traversing: inorder

recursion order : leftchild, node, rightchild

```
void TraverseInorder (treenode* node){
    if (node==NULL) return;
    TraverseInorder (node->lchild);
    cout<<"  "<<node->value;//process node
    TraverseInorder (node->rchild);
}
```

Traversing : preorder

recursion order : node, leftchild, rightchild

same as DFS

```
void TraversePreOrder (treenode* node){
    if (node==NULL) return;
    cout<<"  "<<node->value;//process node
    TraversePreOrder (node->lchild);
    TraversePreOrder (node->rchild);
}
```

Traversing : postorder

- recursion: leftchild, rightchild, node

```
void TraversePostorder (treenode* node) {
   if (node==NULL) {cout<< "NULL."; return;}
   cout<<"\ngoing left ..."; TraversePostorder (node->lchild);
   cout<<"\ngoing right ..."; TraversePostorder (node->rchild);
   cout<<"  "<<"address="<<node<<"   value="<<node->value;
}
```

Traversing Tree : BFS

- "Breadth First Search"
- nonrecursive : needs a queue
- level by level in the tree (also called "waves"):
  - first the root
  - then all root's children
  - then all the nodes 2-edges away from the root
  - all nodes 3-edges away from the root
  - etc.

Traversing Tree: DFS

- "Depth First Search"
- recursion order : node, leftchild, rightchild
- same as Pre-oder