CS350: Data Structures

Tree Traversal

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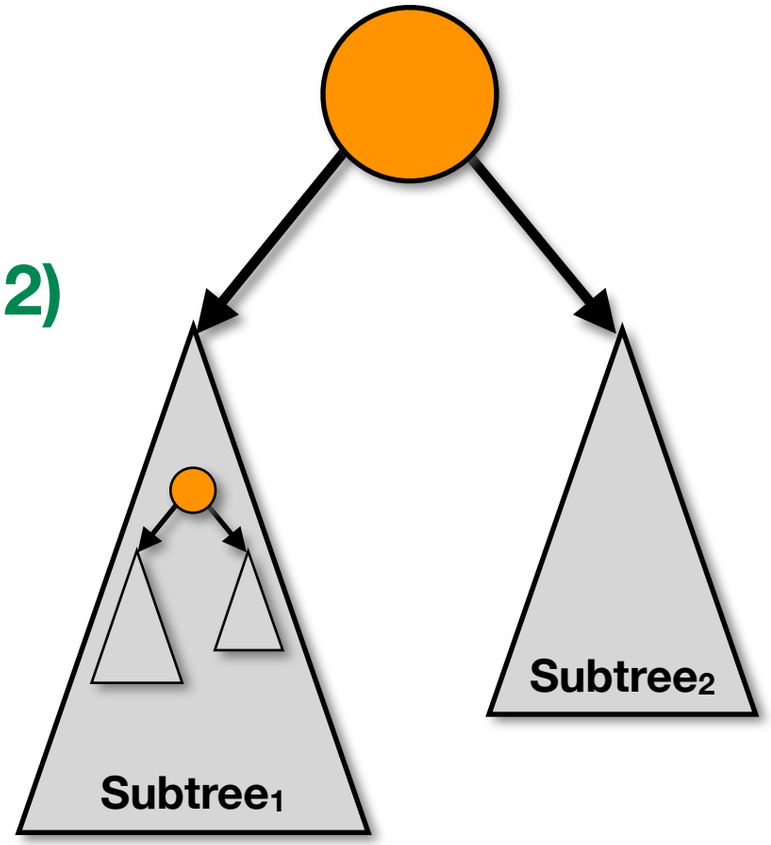
Defining Trees Recursively

- **Trees can easily be defined recursively**

- **Definition of a binary tree (a tree with arity of 2)**
  - A binary tree is either empty (represented by a null pointer), or is made of a single node, where the left and the right pointers each point to a binary tree



Defining Trees Recursively

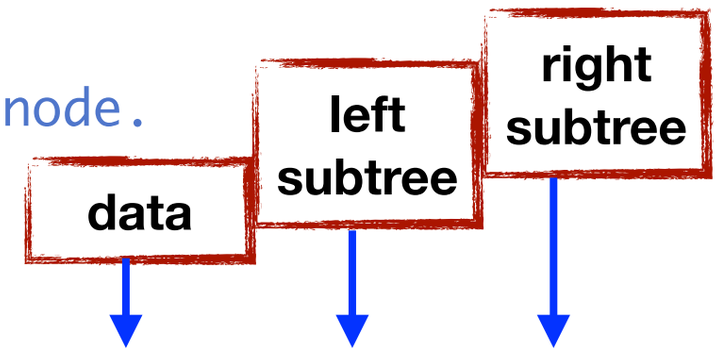
- **More generally, a tree with unspecified arity is defined as**
  - A tree is a collection of nodes (one node is called the root)
  - A collection of nodes can be empty, otherwise a tree consists of a root node (R) and zero or more non-empty subtrees each of whose roots are connected by an edge to the root R

- **Because they are easily defined recursively, it is also easy to traverse them (visit each node) recursively**

Duplicating a Tree

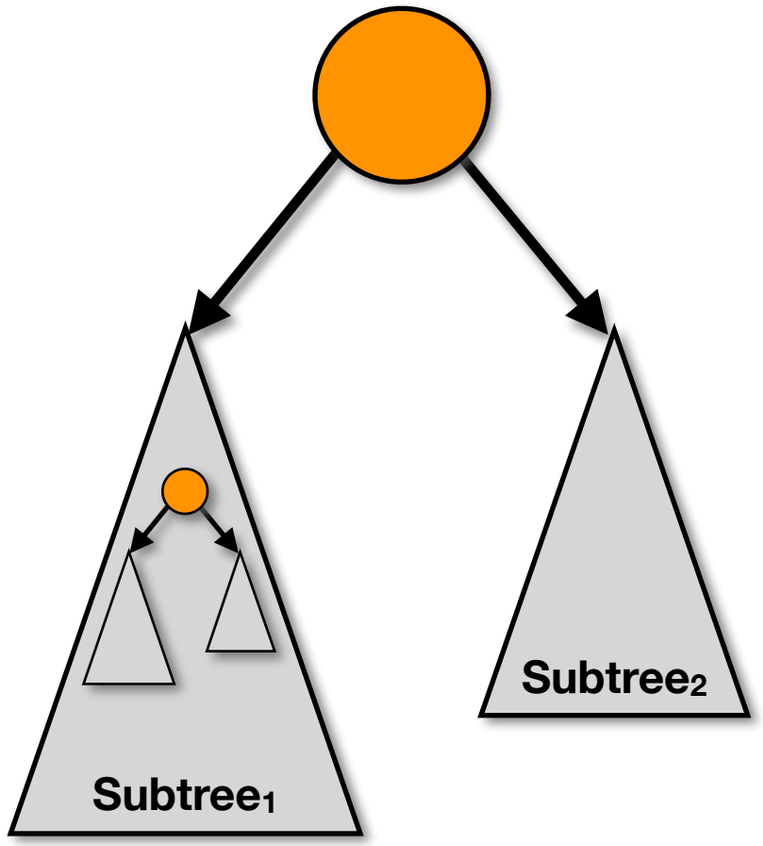
```
/**
 * Return a reference to a node that is the root of a
 * duplicate of the binary tree rooted at the current node.
 */
public BinaryNode<AnyType> duplicate( )
{   // Create the new node for the new tree
    BinaryNode<AnyType> root = new BinaryNode<AnyType>(element, null, null);

    if( left != null )                      // If there's a left subtree
        root.left = left.duplicate( );      // Duplicate and attach
    if( right != null )                     // If there's a right subtree
        root.right = right.duplicate( );    // Duplicate and attach
    return root;                            // Return resulting tree
}
```



Determining the Size of a Tree

- **The size of a tree can be defined as:**
  - `LeftSubtree.size( ) + RightSubtree.size( ) + 1`
    - Determine the size of each subtree, add them together, add 1 additional node to represent the root node



Determining the Size of a Tree (Cont.)

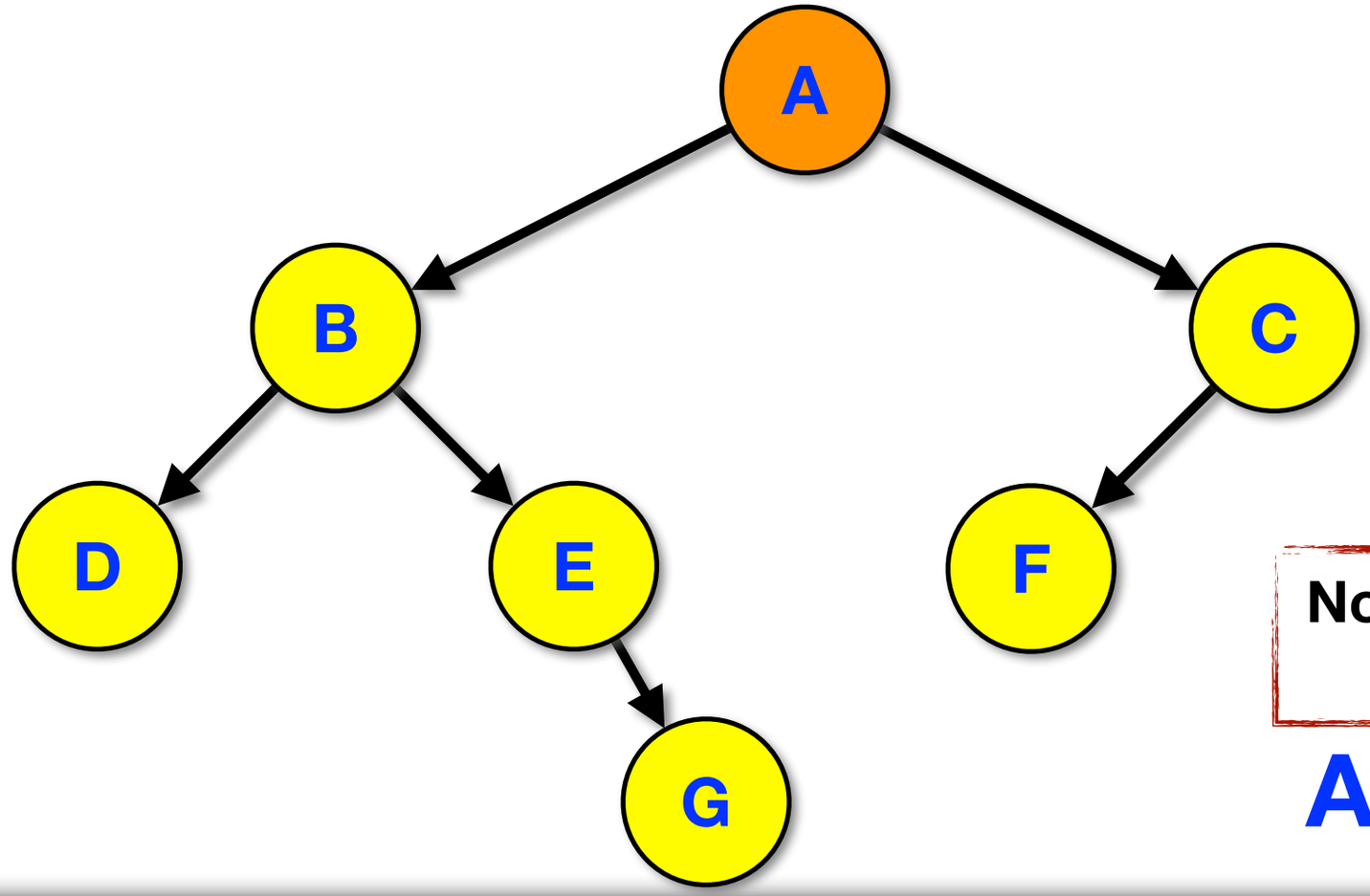
```
/**
 * Return the size of the binary tree rooted at t.
 */
public static int size( BinaryNode<AnyType> t )
{
    if( t == null )
        return 0;
    else
        return 1 + size( t.left ) + size( t.right );
}
```

Tree Traversal

- **A tree traversal is a systematic method of visiting each node in a tree**
- **Different tree traversal algorithms visit nodes of a tree in different orders**
- **Tree traversal algorithms**
  - **Preorder** traversal
  - **Postorder** traversal
  - **Inorder** traversal
  - **Level-order** traversal

Preorder Traversal

- **In preorder traversal, a node is processed and then its children are processed recursively**
  - The `duplicate` method is an example of a preorder traversal -- the root is created first, then the subtrees are duplicated



Nodes are visited in the following order:

A B D E G C F

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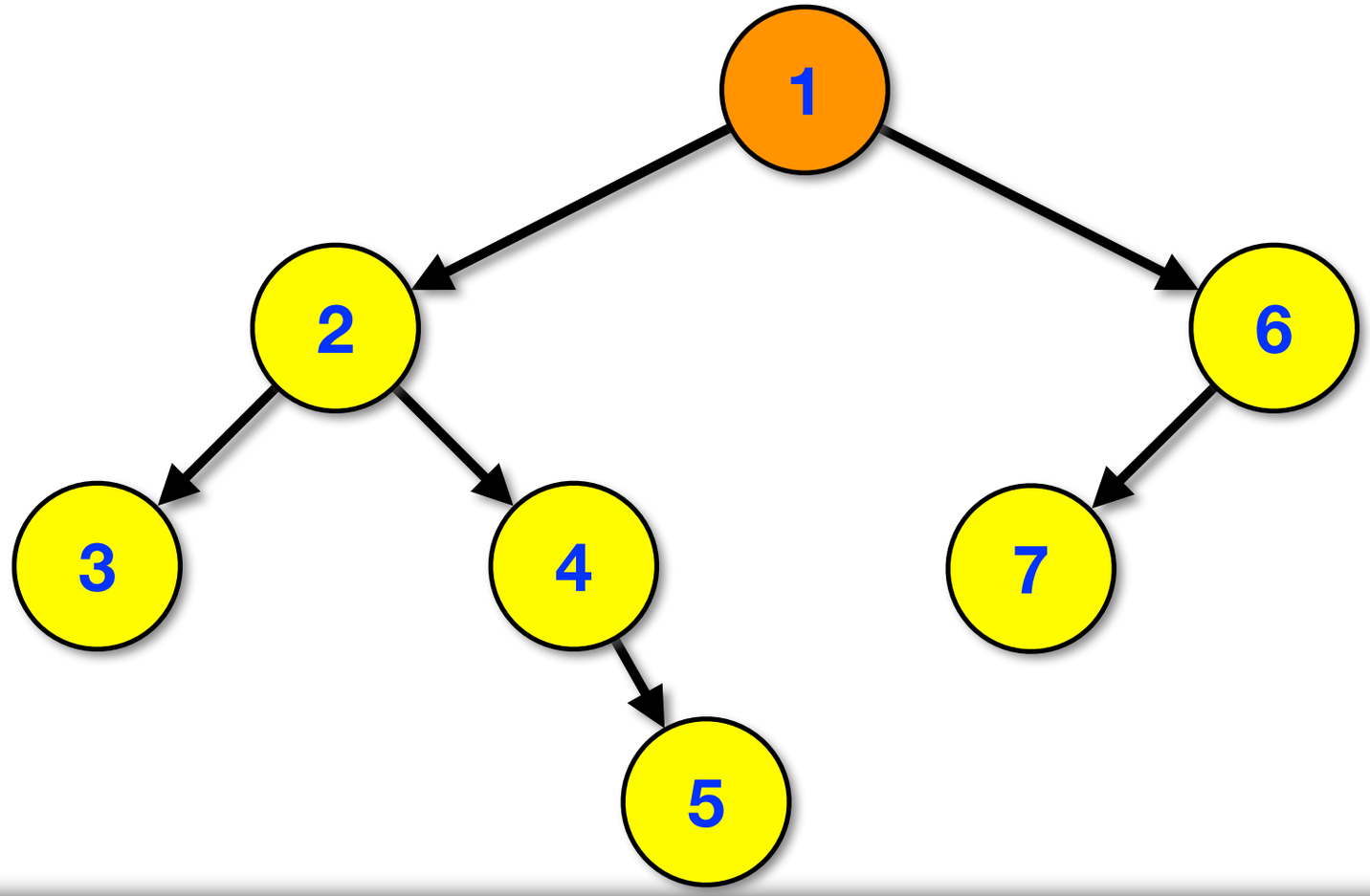
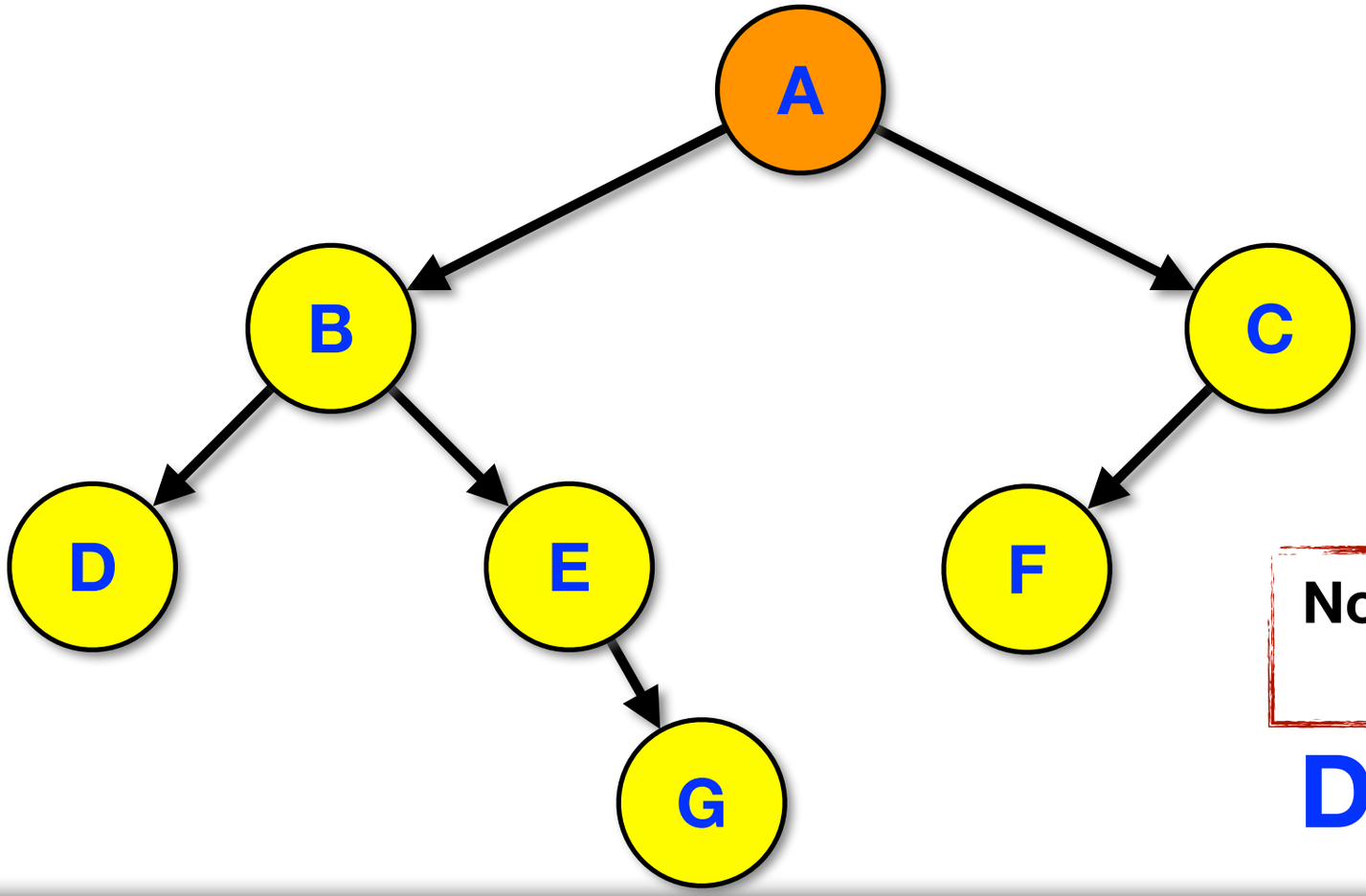


Preorder Traversal

```
// Print tree rooted at current node using preorder traversal.
public void printPreOrder( )
{
    System.out.println( element );  // Process Node
    if( left != null )
        left.printPreOrder( );      // Process Left Subtree
    if( right != null )
        right.printPreOrder( );     // Process Right Subtree
}
```

Postorder Traversal

- **In postorder traversal, a node is processed after both children are processed recursively**
  - The `size` method is an example of a postorder traversal -- the size of subtrees are determined to find the size of the current tree



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D G E B F C A

Postorder Traversal

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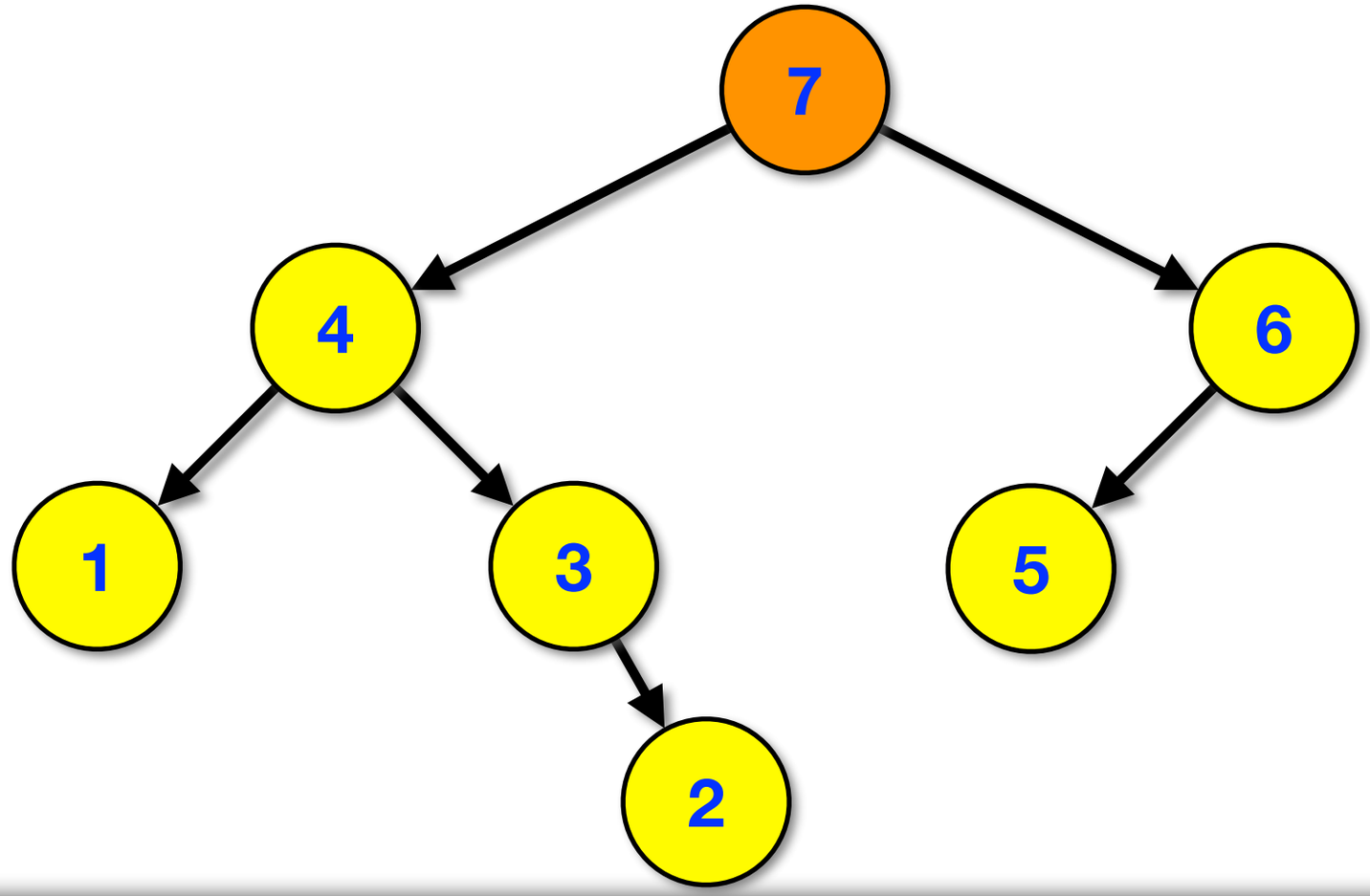
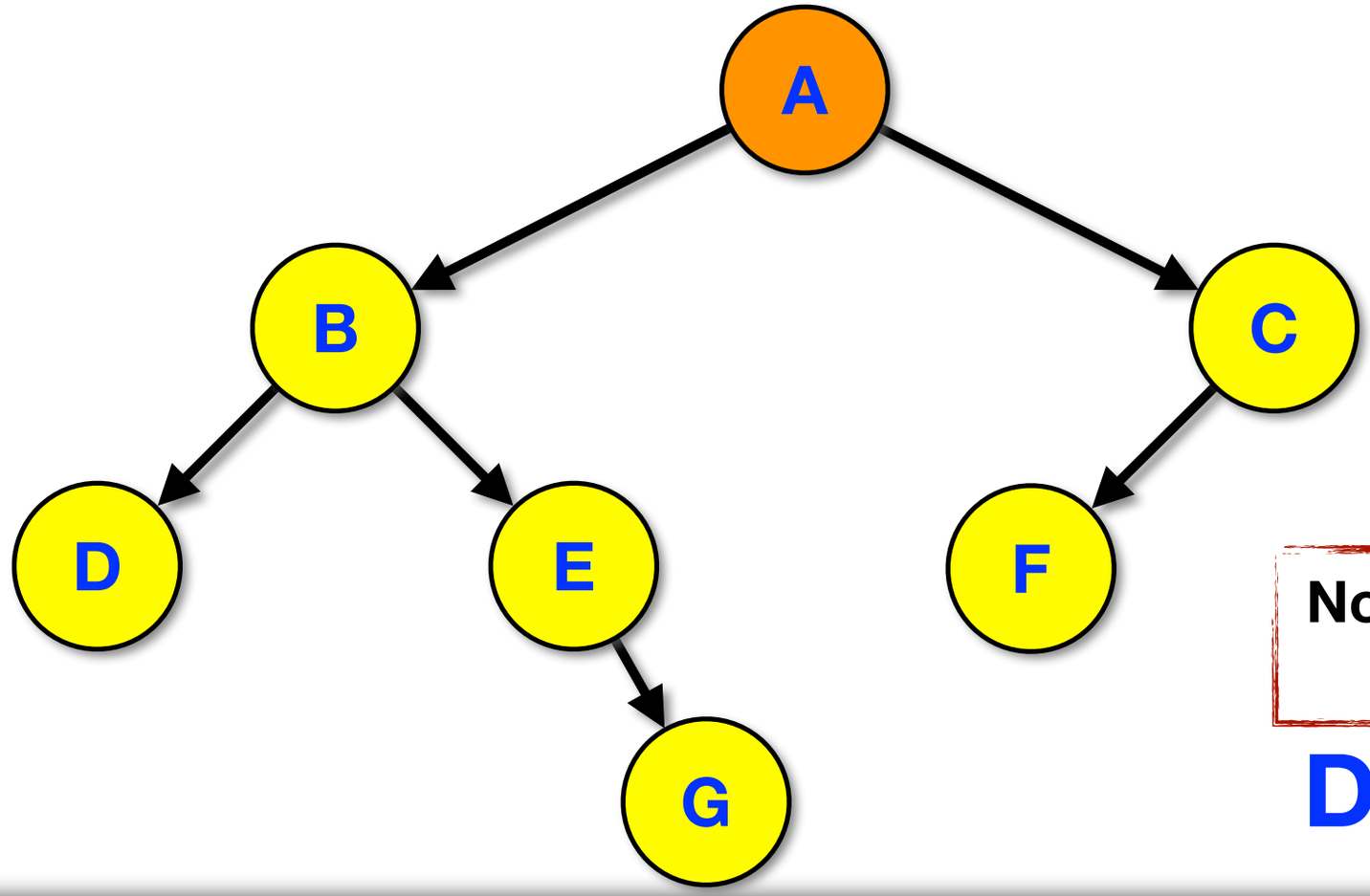


Postorder Traversal

```
// Print tree rooted at current node using postorder traversal
public void printPostOrder( )
{
    if( left != null )
        left.printPostOrder( );      // Process Left Subtree
    if( right != null )
        right.printPostOrder( );     // Process Right Subtree
    System.out.println( element );   // Process Node
}
```

Inorder Traversal

- **In inorder traversal, the left child is processed recursively, then the current node is processed, then the right child is recursively processed**

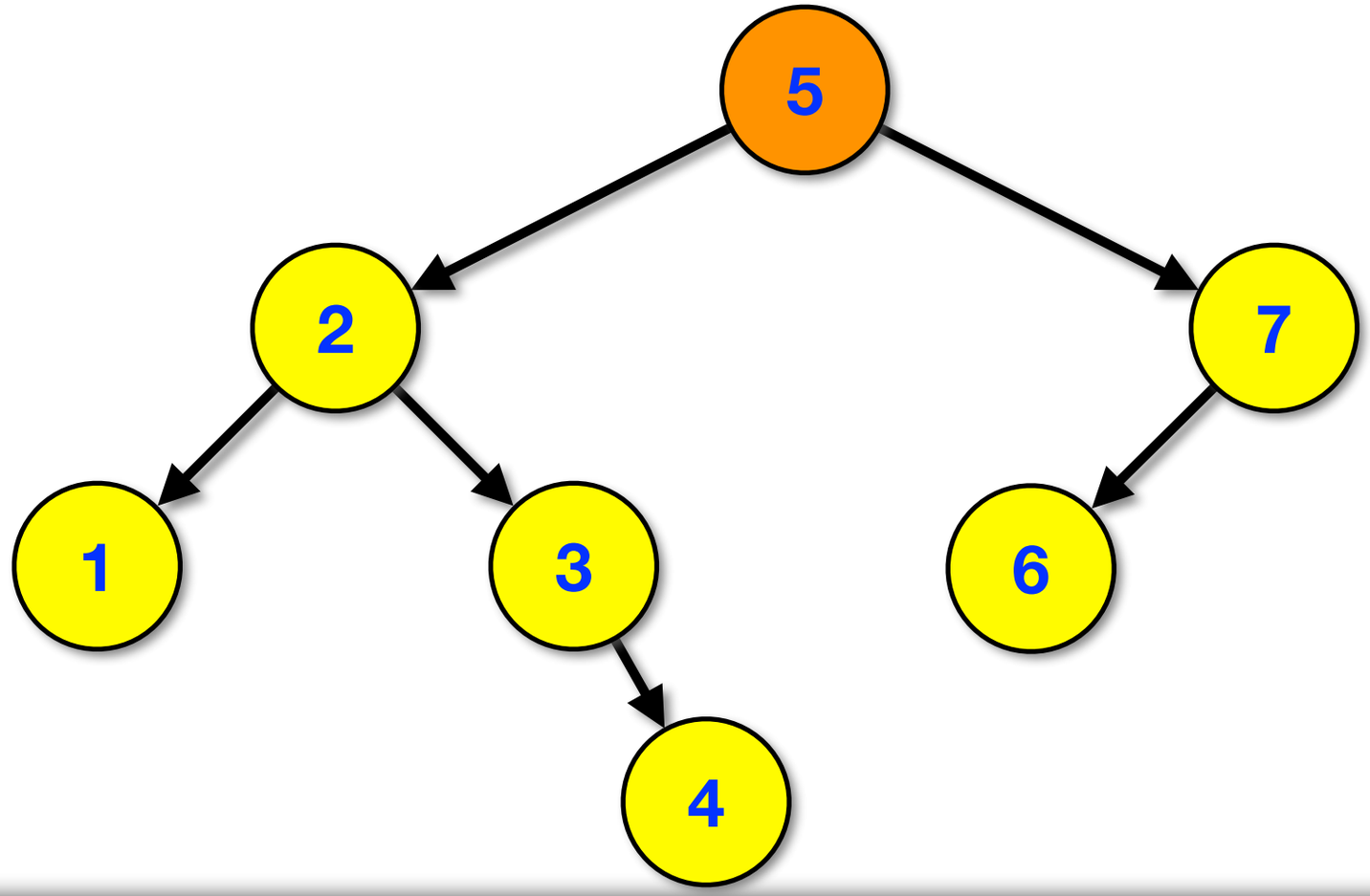


Nodes are visited in the following order:

D B E G A F C

Inorder Traversal

- **In inorder traversal, the left child is processed recursively, then the current node is processed, then the right child is recursively processed**

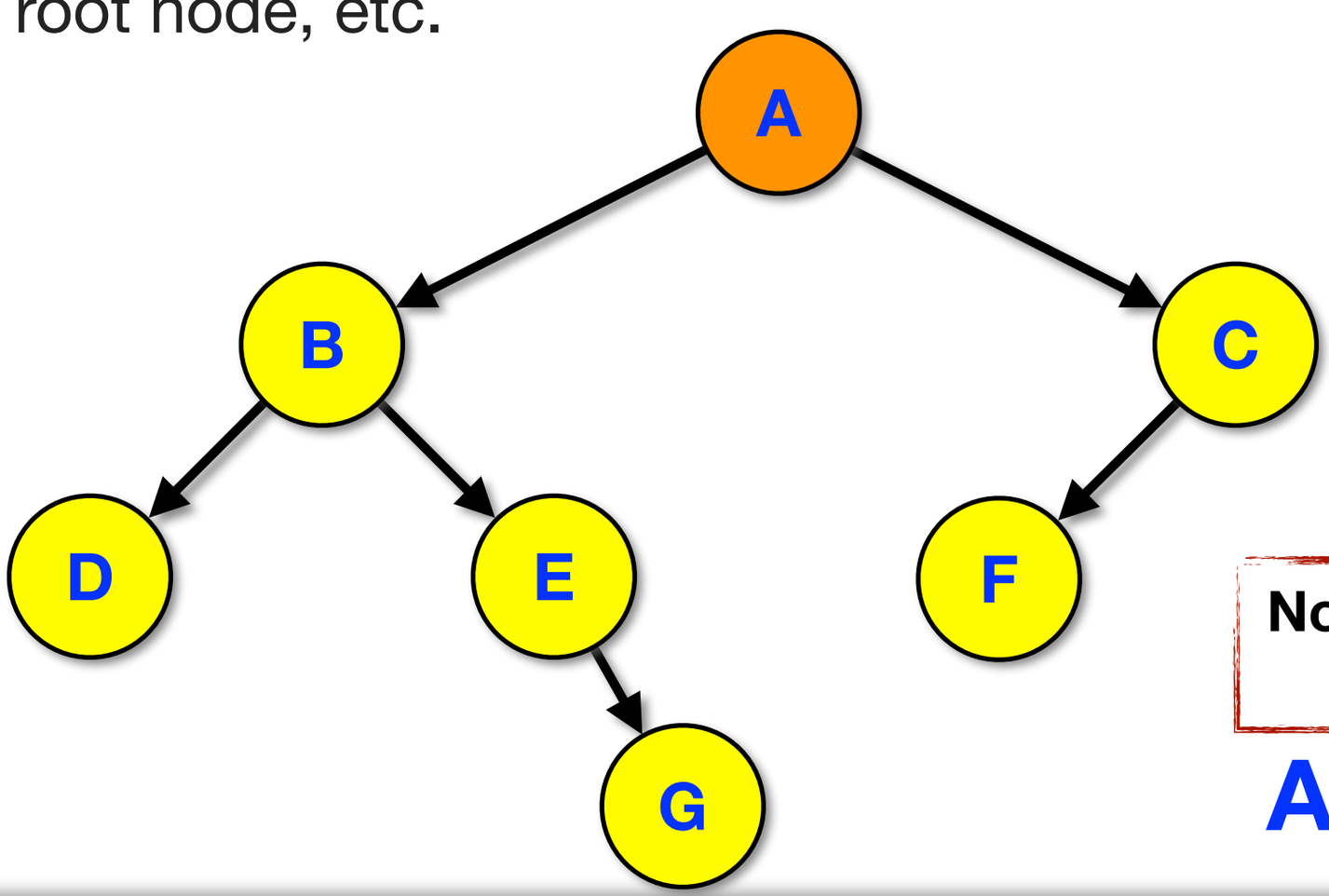


Inorder Traversal

```
// Print tree rooted at current node using inorder traversal
public void printInOrder( )
{
    if( left != null )
        left.printInOrder( );         // Process Left Subtree
    System.out.println( element );    // Process Current Node
    if( right != null )
        right.printInOrder( );        // Process Right Subtree
}
```

Level-order Traversal

- **In level-order traversal, nodes are processed in the tree from top to bottom, left to right**
  - The first level is the root node, the second level consists of the children of the root node, the third level consists of the grandchildren of the root node, etc.



Nodes are visited in the following order:

A B C D E F G

Level-order Traversal

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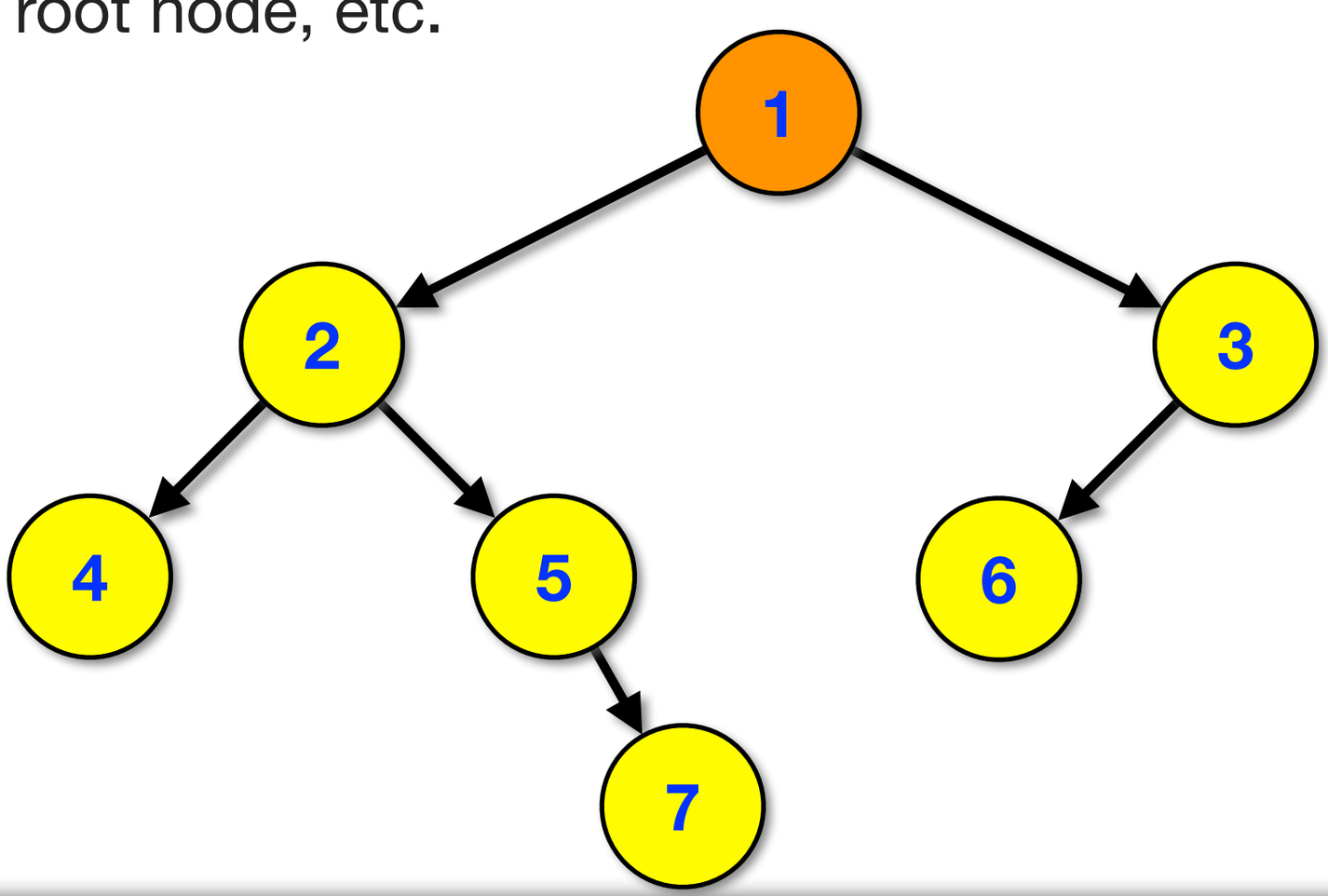

Level-order Traversal

- **A recursive implementation is not well-suited for level-order traversal**
- **A queue can be used to implement level-order traversal instead**

```
q = [instantiate a queue]
q.push(root);

while (!q.isEmpty()) {
    n = q.dequeue();
    visit(n);
    for each child of n {
        q.enqueue(child);
    }
}
```