ECE 220

Lecture x0017 - 11/19
Trees, traversal, and BSTs intro

Recap

Recap

- Last week

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- Last week
  - OOP Concepts

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  - OOP Concepts
  - Constructors, destructors, etc.

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    - Constructors, destructors, etc.
    - Inheritance, polymorphism, etc.

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  - OOP Concepts
    - Constructors, destructors, etc.
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    - Containers: lists vs. vectors

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  - OOP Concepts
    - Constructors, destructors, etc.
    - Inheritance, polymorphism, etc.
- Templates
  - Template functions
  - Template classes
  - Template library
    - Containers: lists vs. vectors
    - Iterators

Recap

- Scan QR Code

New concept - trees

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- Recall linked lists

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  - Singly linked lists

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  - Think family trees or organizational charts

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- Trees - are *nonlinear* & hierarchical
  - Think family trees or organizational charts
  - Basic unit ~ node in DLL

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- Recall linked lists
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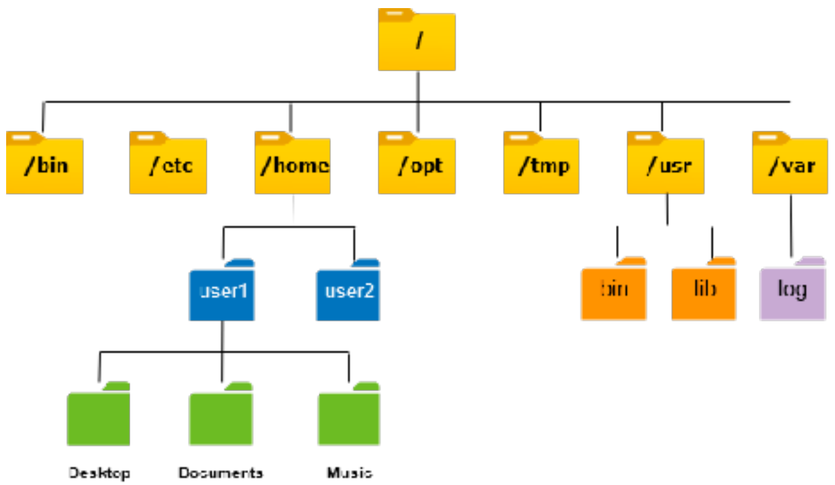
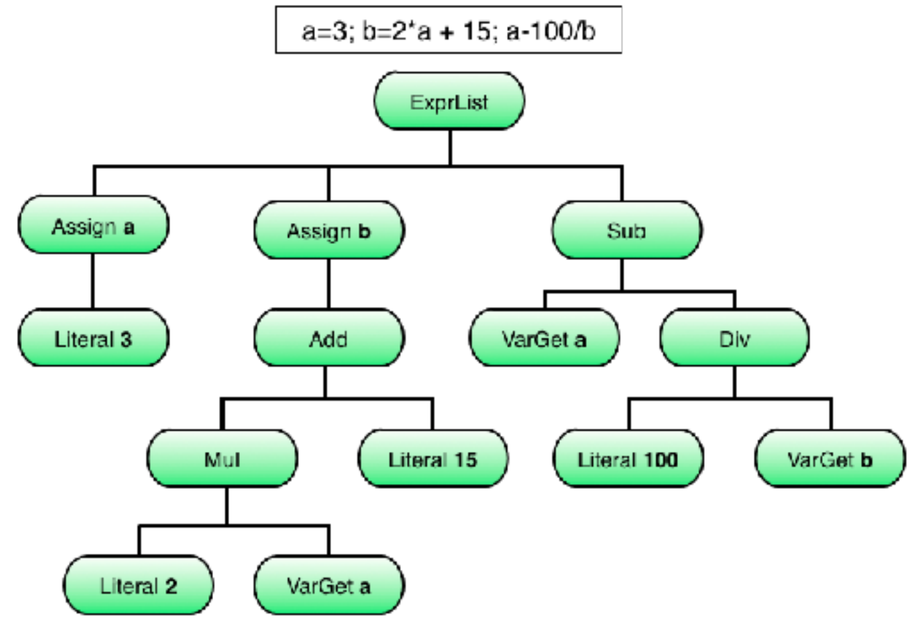
- Trees - are *nonlinear* & hierarchical
  - Think family trees or organizational charts
  - Basic unit ~ node in DLL
- Difference - functions.

Why trees?



QuadTree: https://en.wikipedia.org/wiki/Quadtree

Filesystems, computer graphics, programming languages, taxonomic classifictaion, etc.



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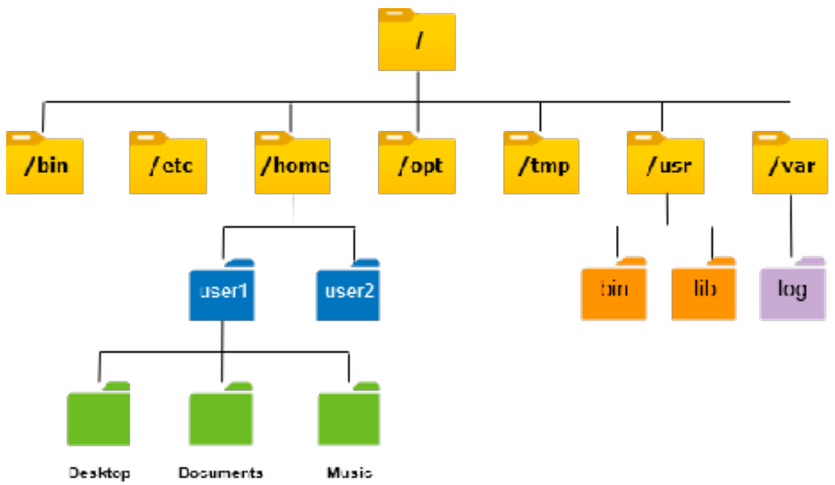

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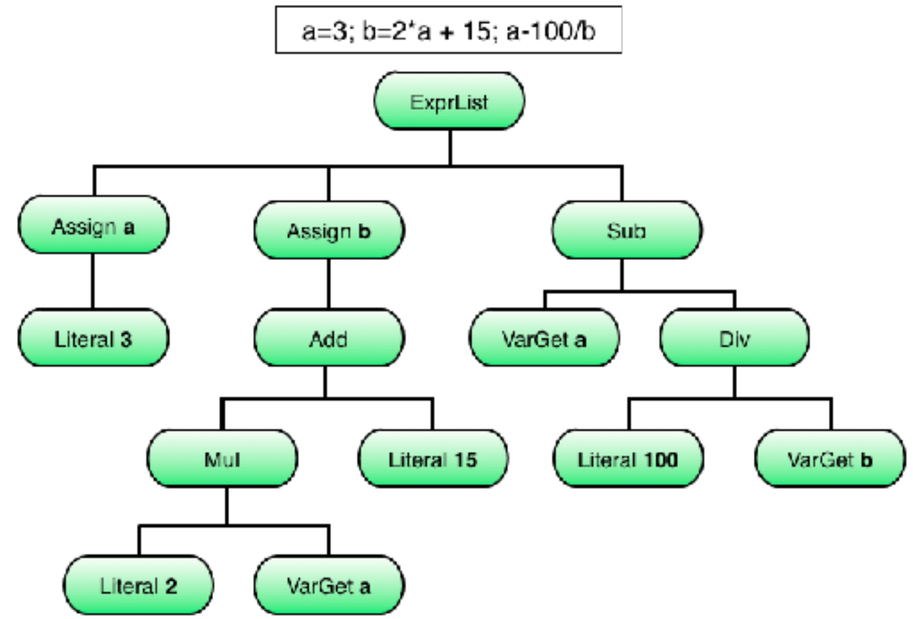
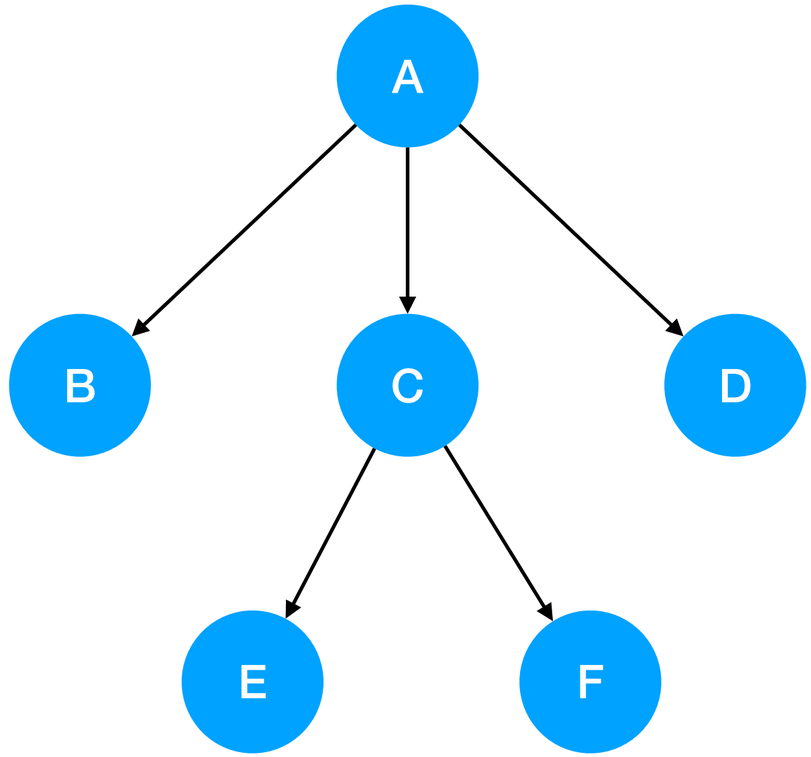
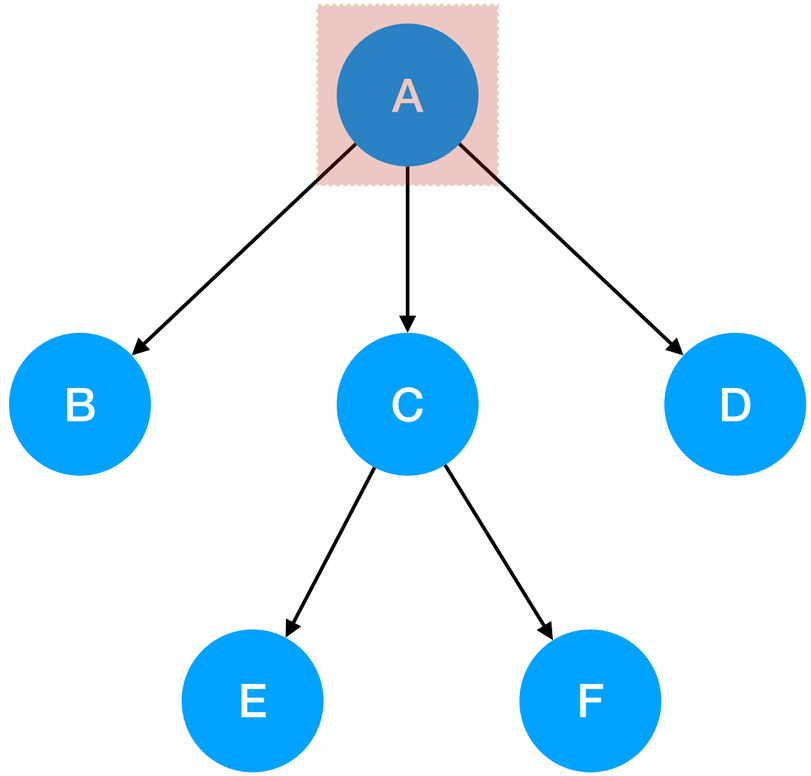


Concepts related to trees



Concepts related to trees

- Root
  - Top most node, no parent.



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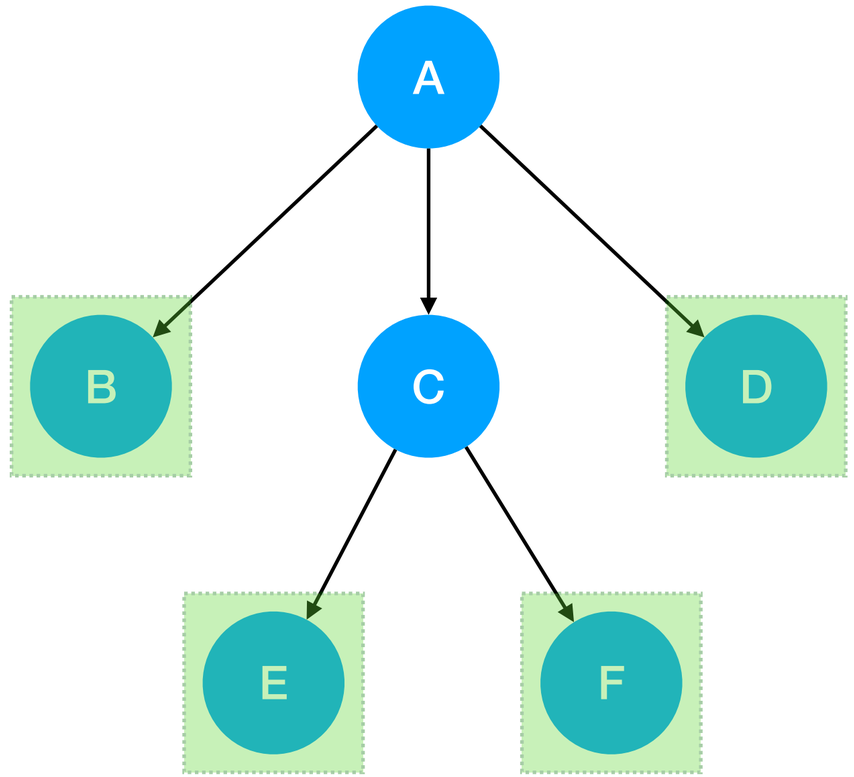
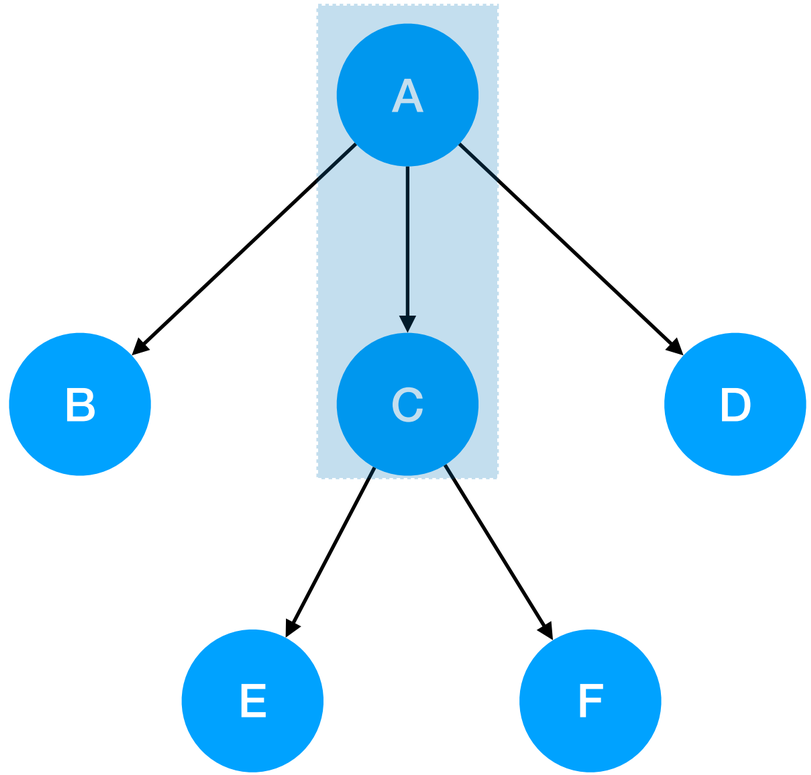


Concepts related to trees

- Root
  - Top most node, no parent.
- Leaf
  - Outermost nodes, no children
- Inner node(s)
  - Has atleast one child



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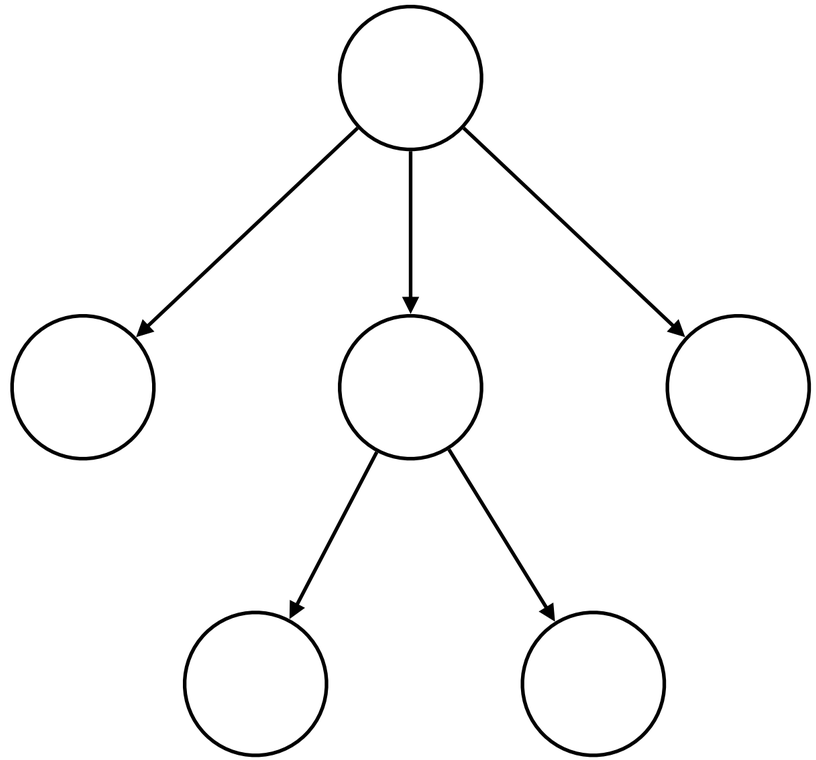
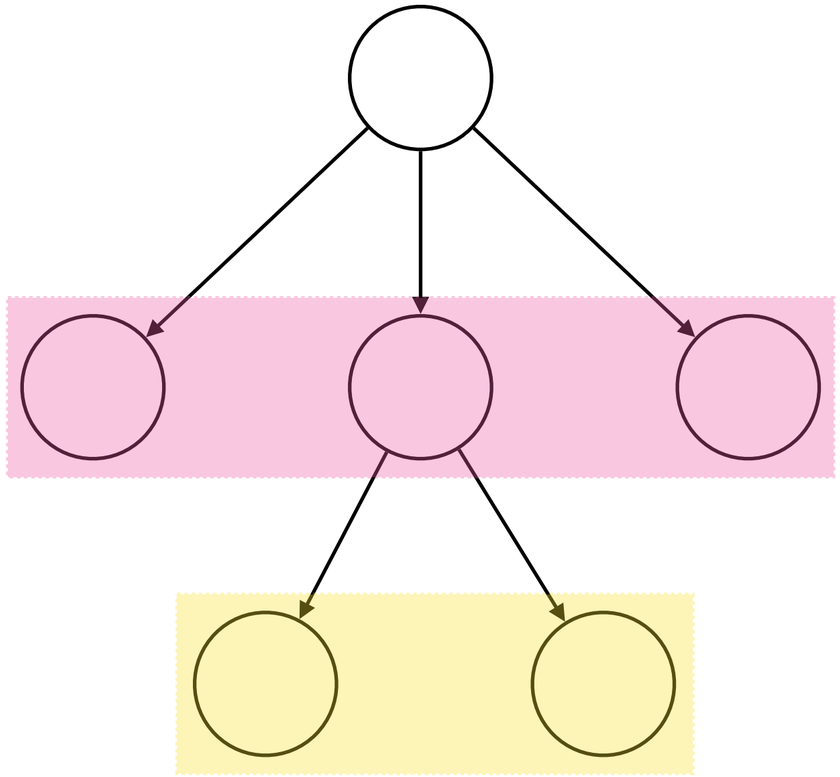


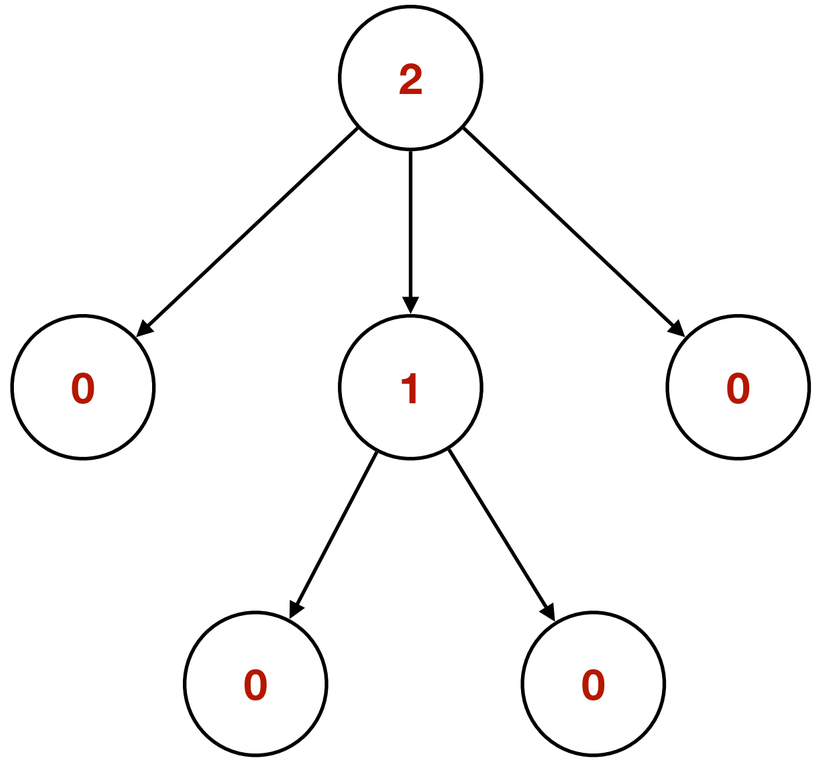
Concepts related to trees

- Siblings



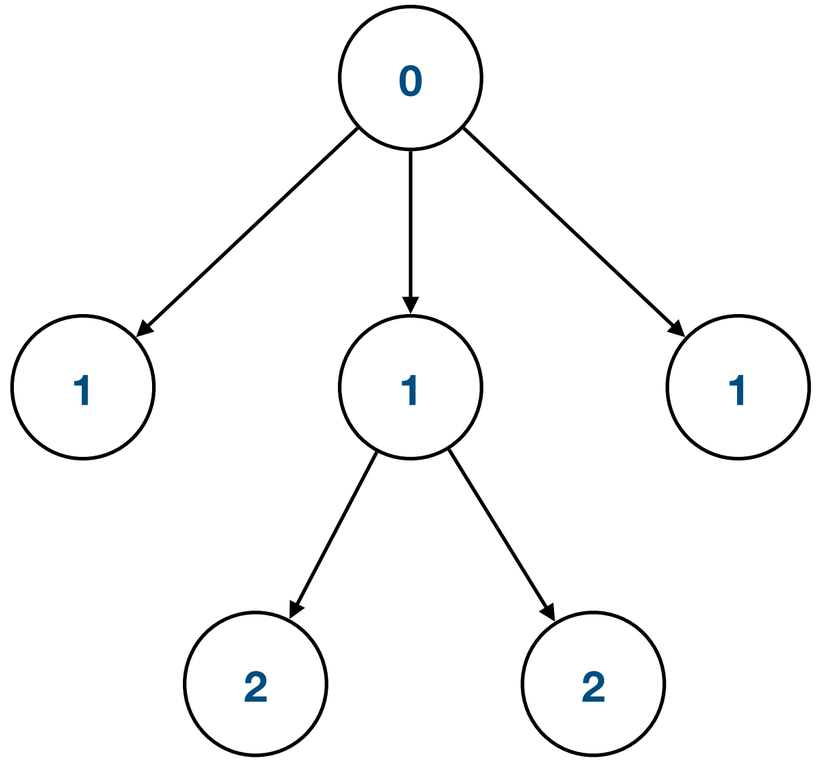
Concepts related to trees

- Siblings
- Height (of a node)
  - Length of *longest* path from given node to a leaf



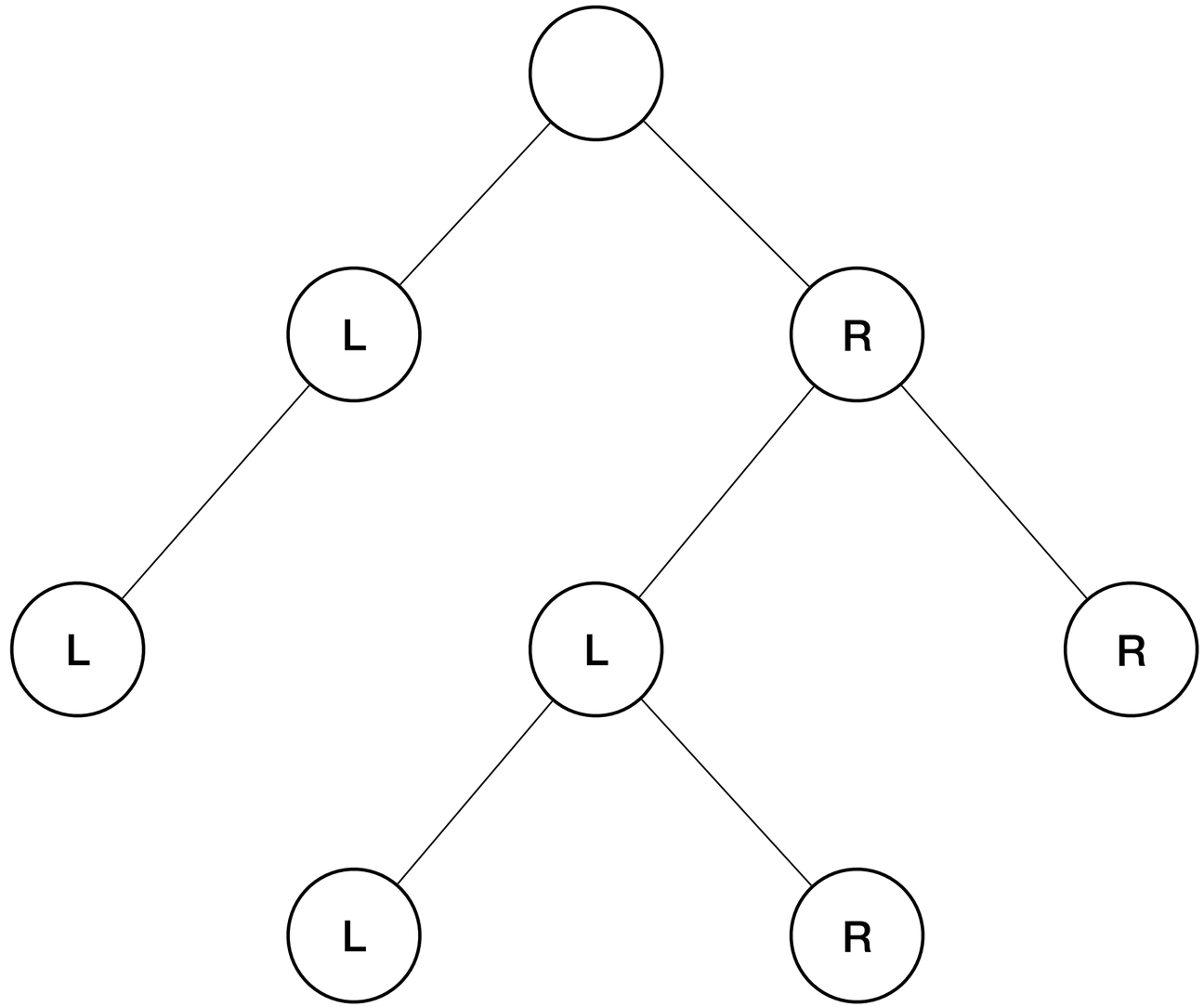
Concepts related to trees

- Siblings
- Height (of a node)
  - Length of *longest* path from given node to a leaf
- Depth (of a node)
  - Length of path from root to given node



Binary trees

- Trees where every node has *at most* two children.



Binary trees

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typedef struct person node;
struct person{
  char *name;
  node *next;
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}node;
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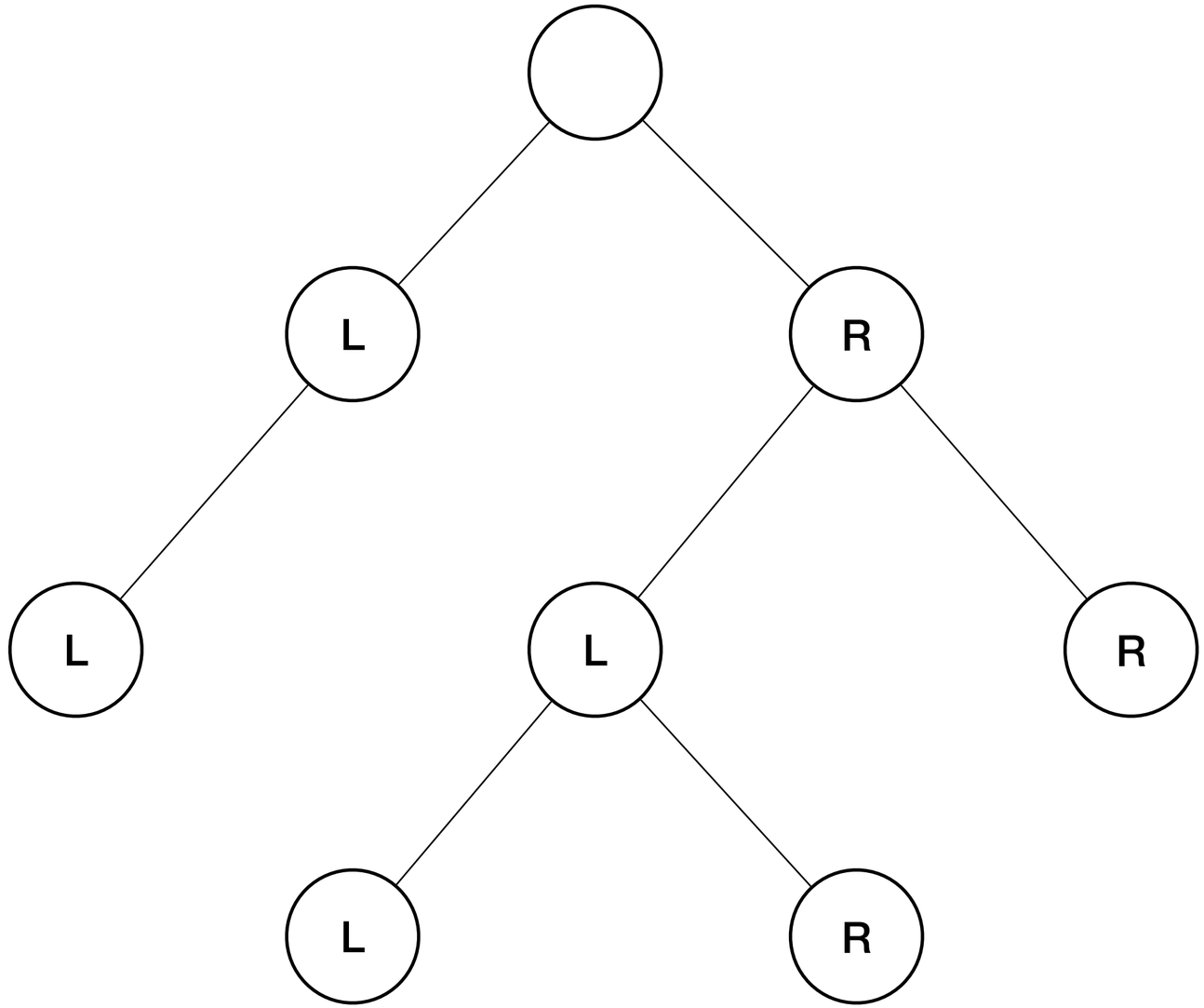

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- Trees where every node has *at most* two children.

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typedef struct person node;
struct person{
   char *name;
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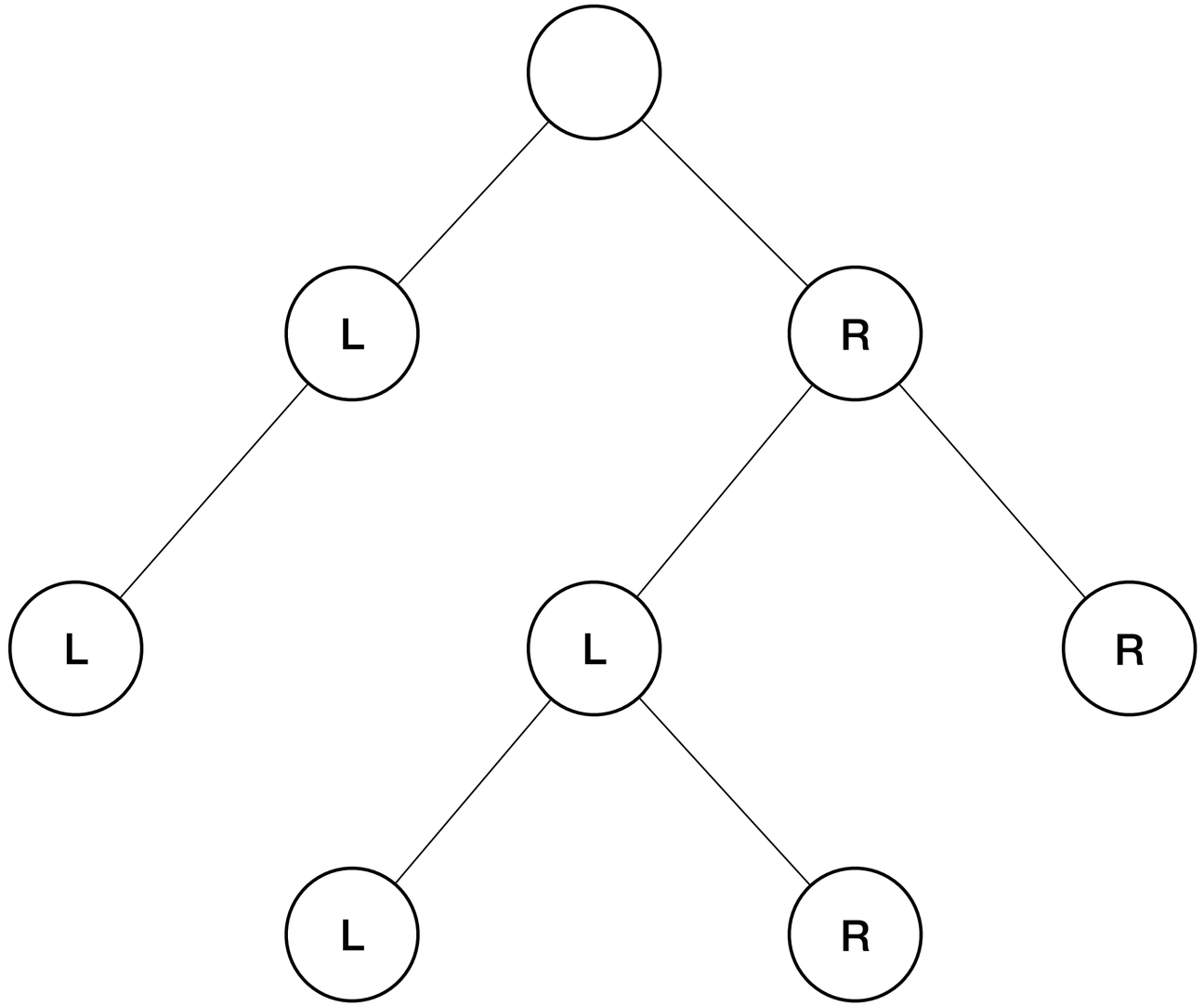
}node;
```

```
typedef struct node treeNode;
struct node{
   int data;
   treeNode *left;
   treeNode *right;
};
```



Traversing trees

Traversing trees

- You can traverse trees in three ways

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- You can traverse trees in three ways
  - Pre-order
  - Root, Left, Right

For each node, read the data of the **node**, then visit the **left** subtree and then the **right** subtree.

Traversing trees

- You can traverse trees in three ways
  - Pre-order
    - Root, Left, Right
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For each node, read the data of the **node**, then visit the **left** subtree and then the **right** subtree.

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Traversing trees

- You can traverse trees in three ways
  - Pre-order
    - Root, Left, Right
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    - Left, Root, Right
  - Post-order
    - Left, Right, Root

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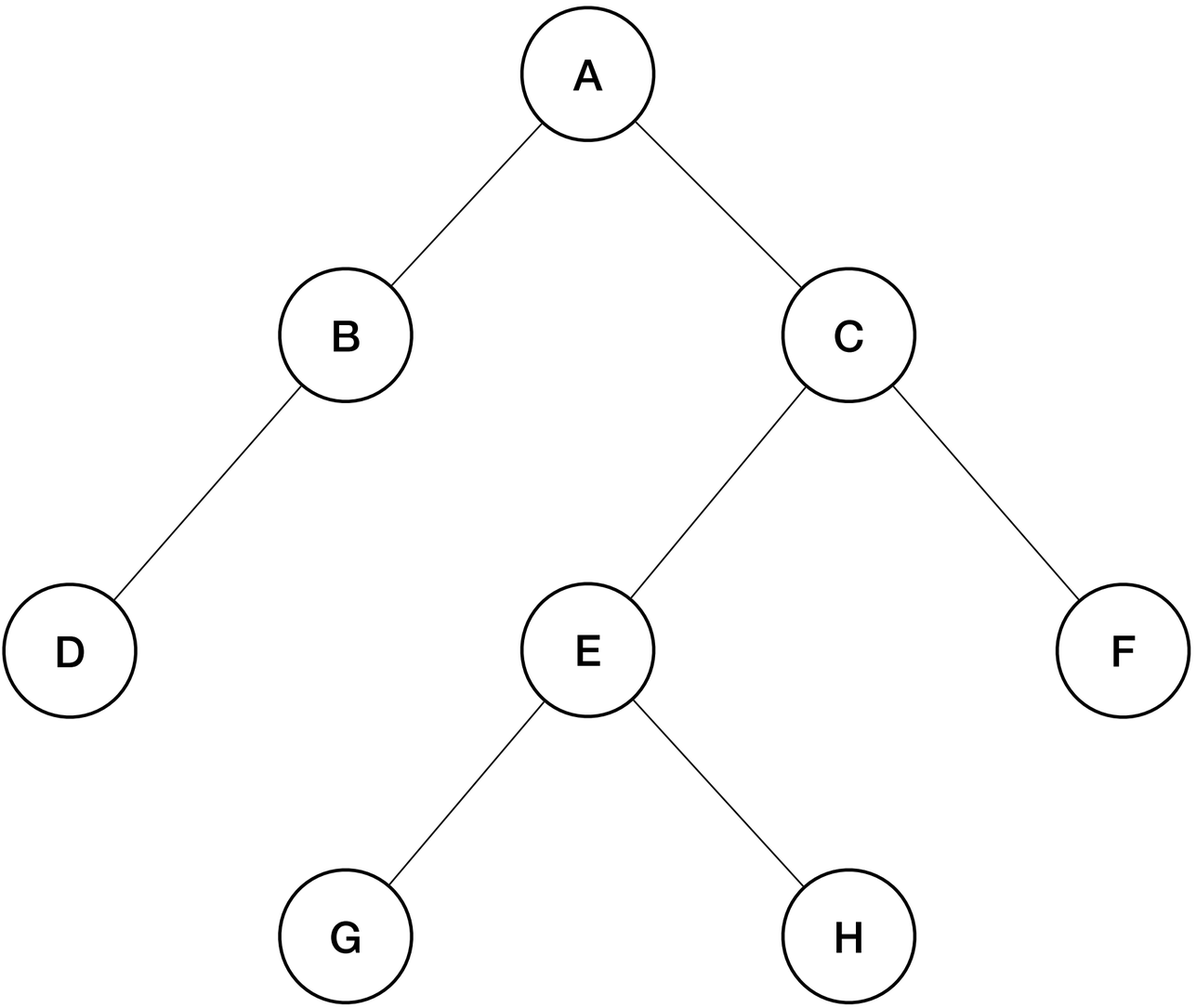

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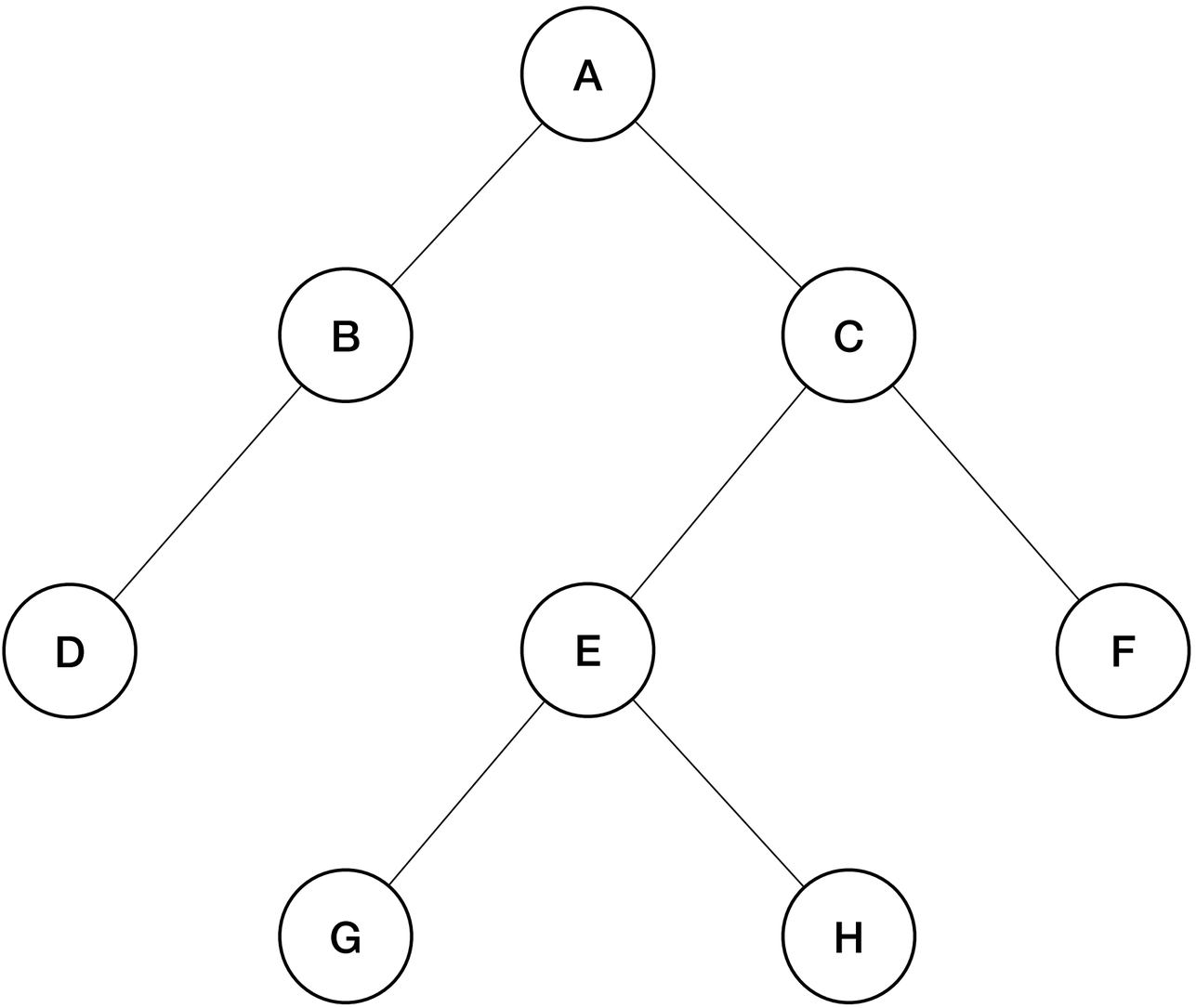

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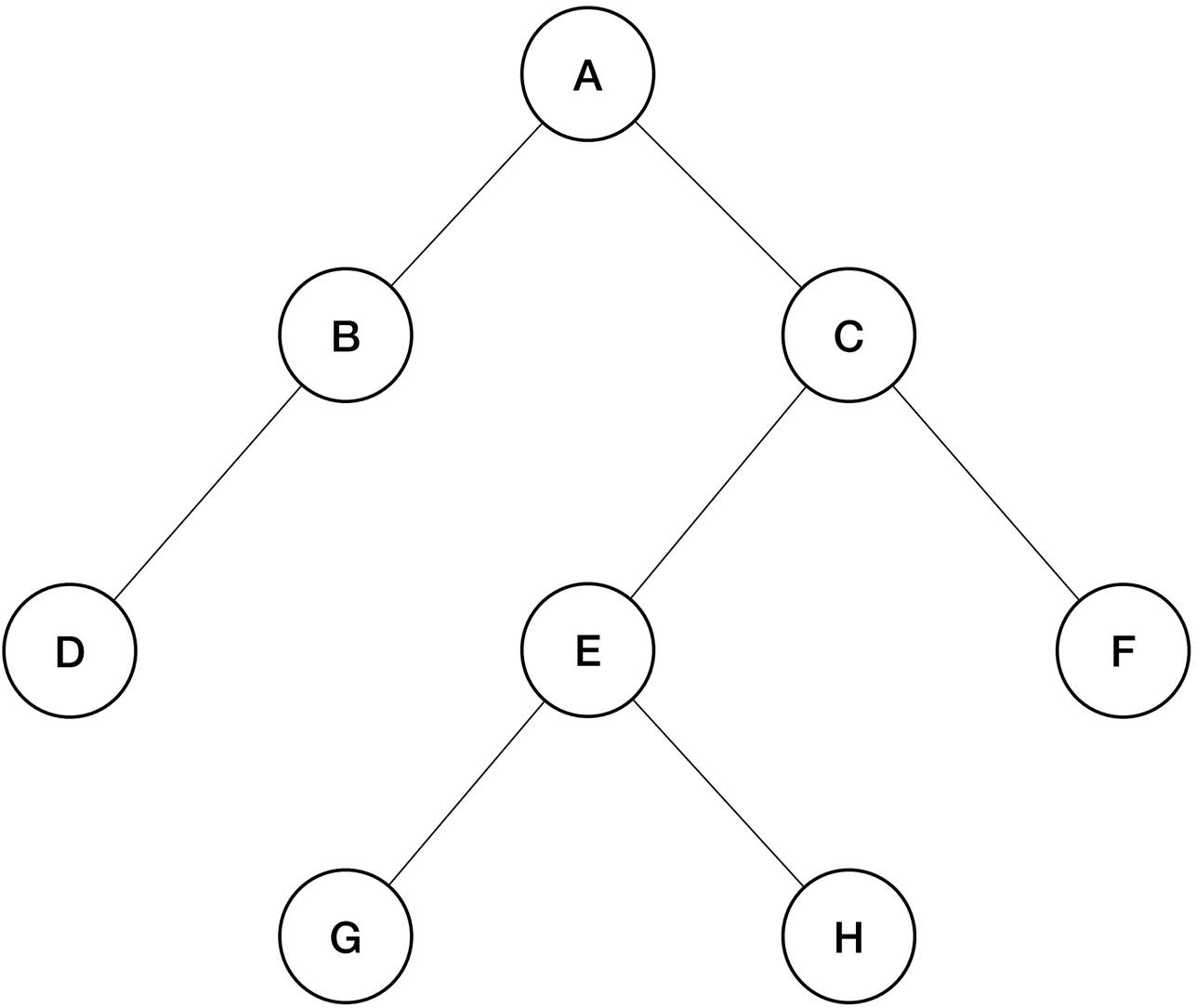

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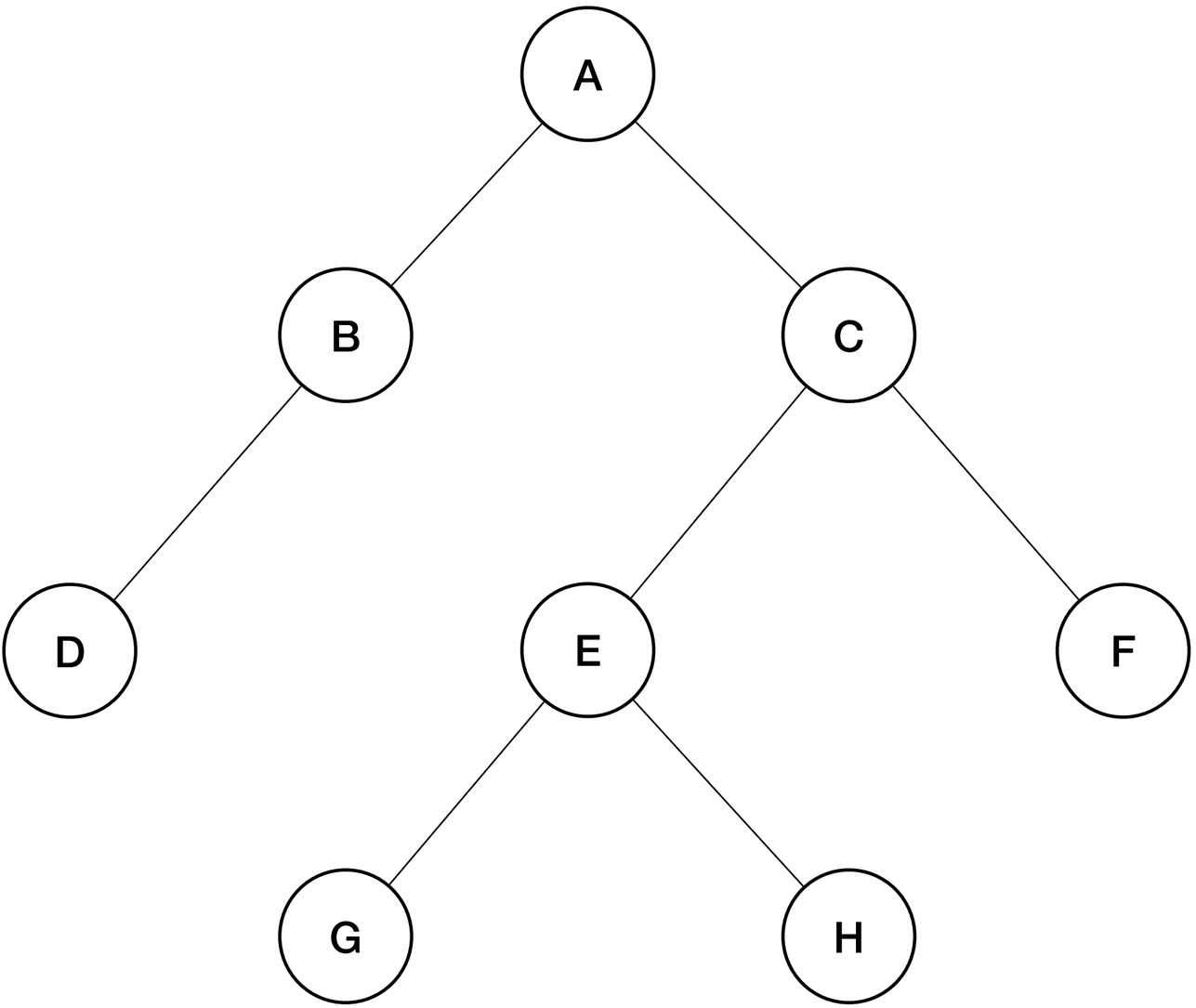

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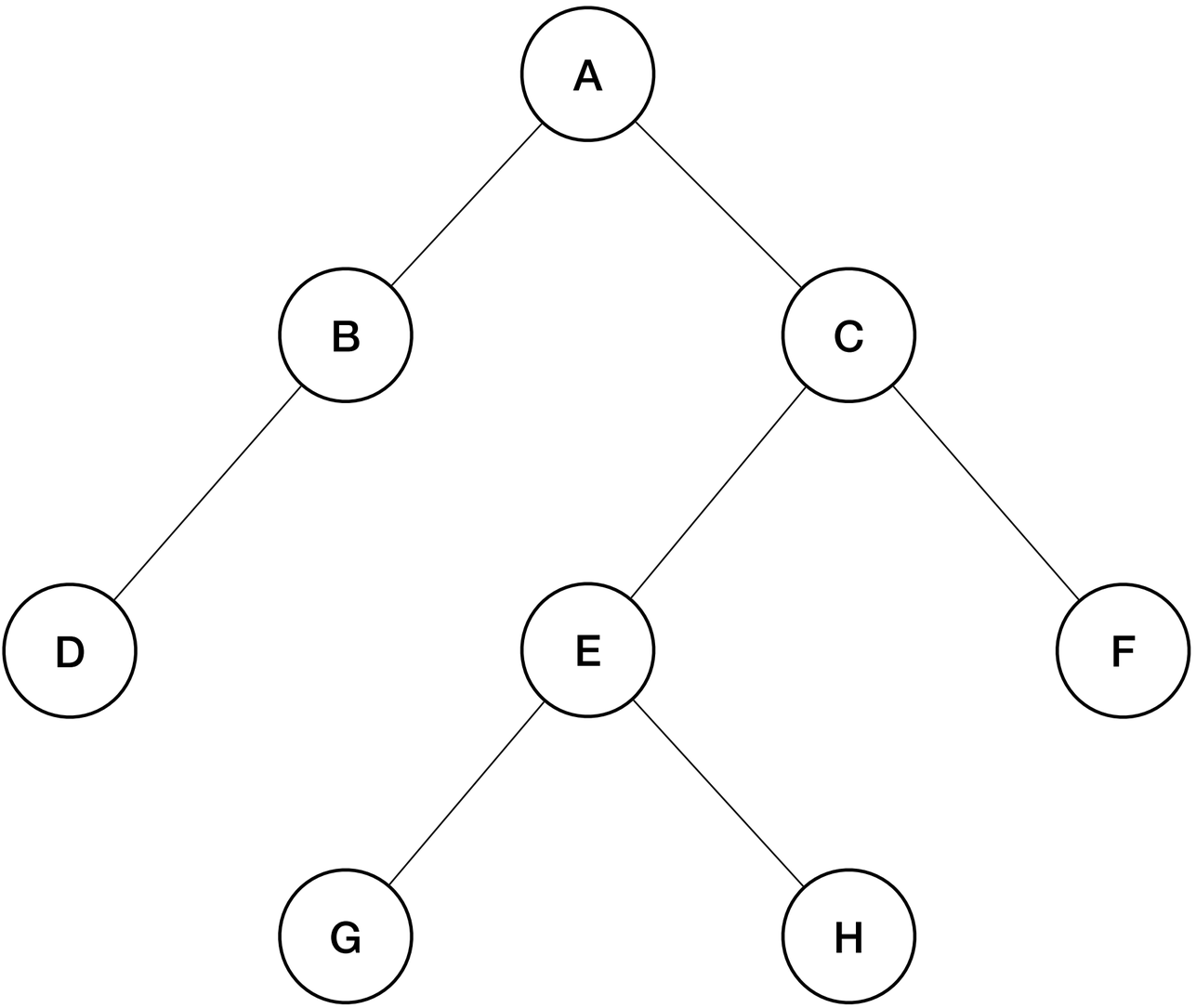

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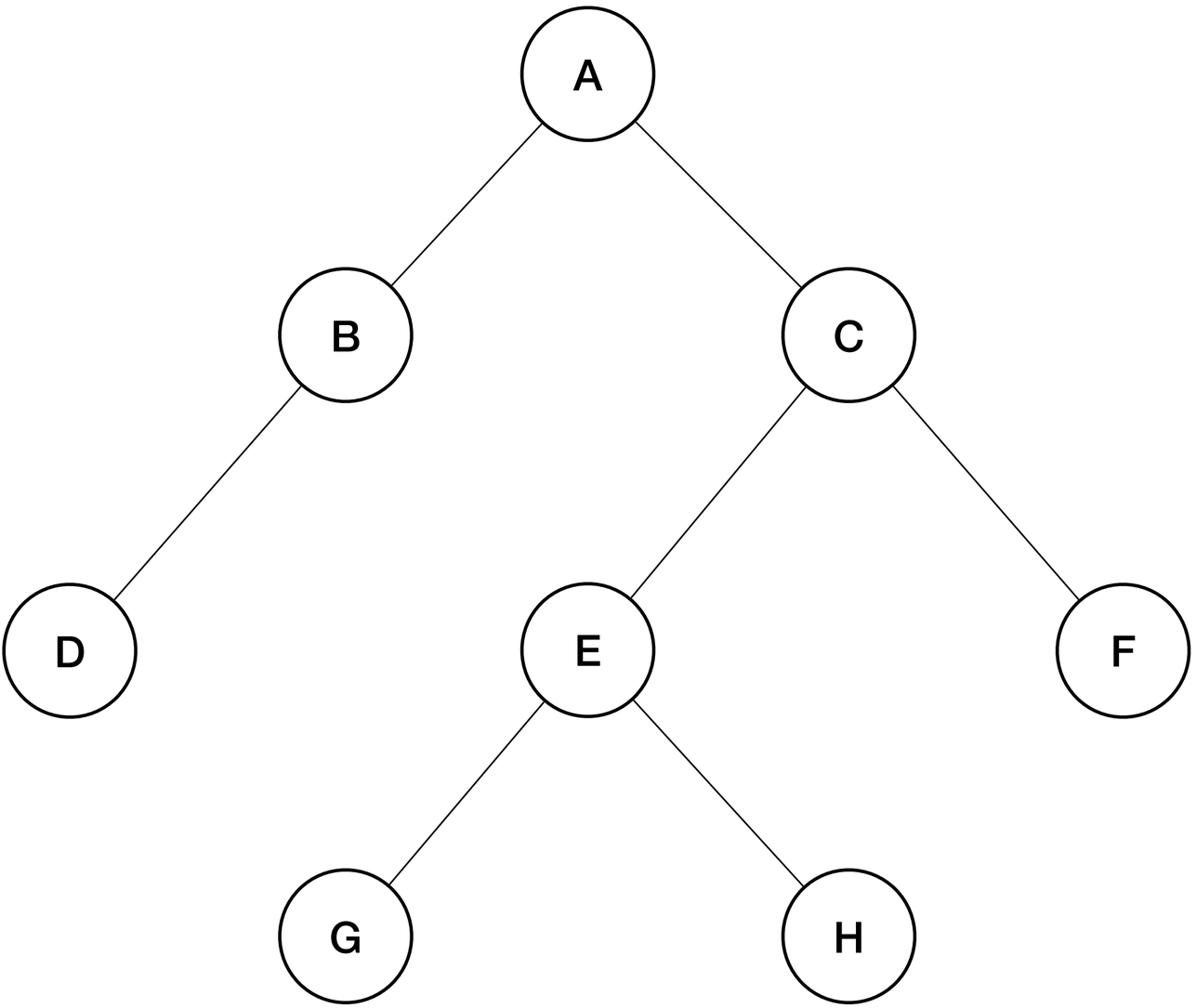

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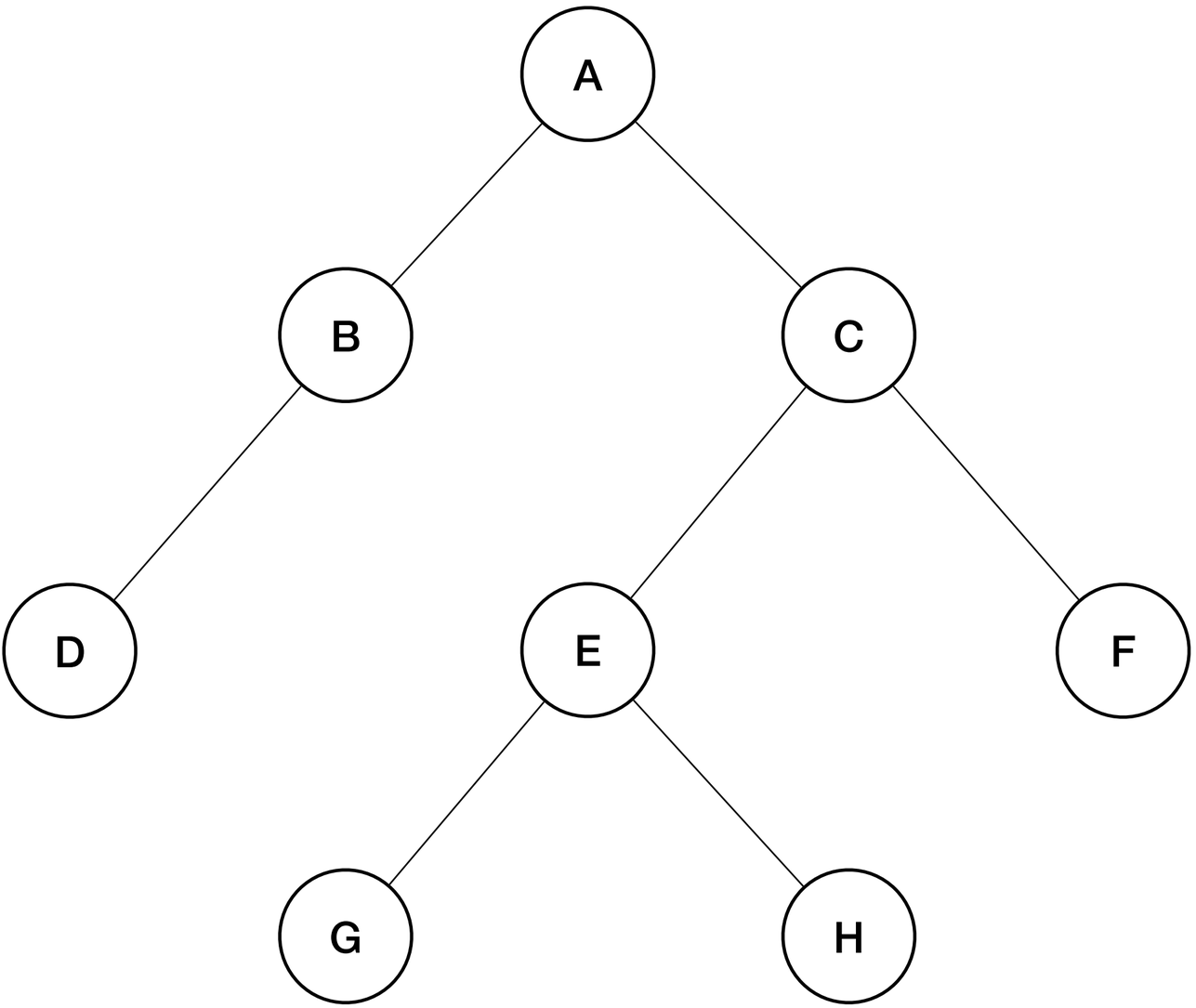

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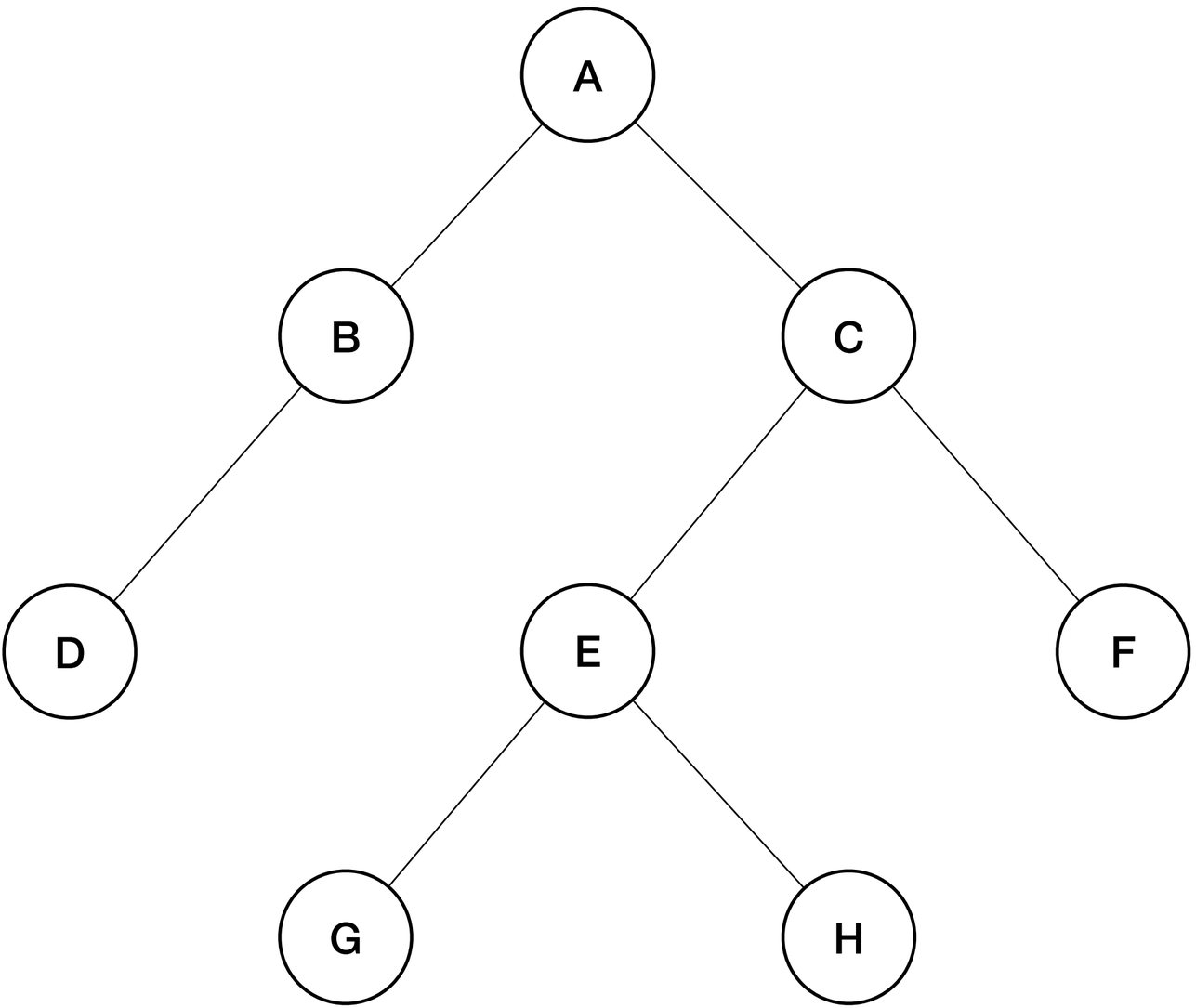

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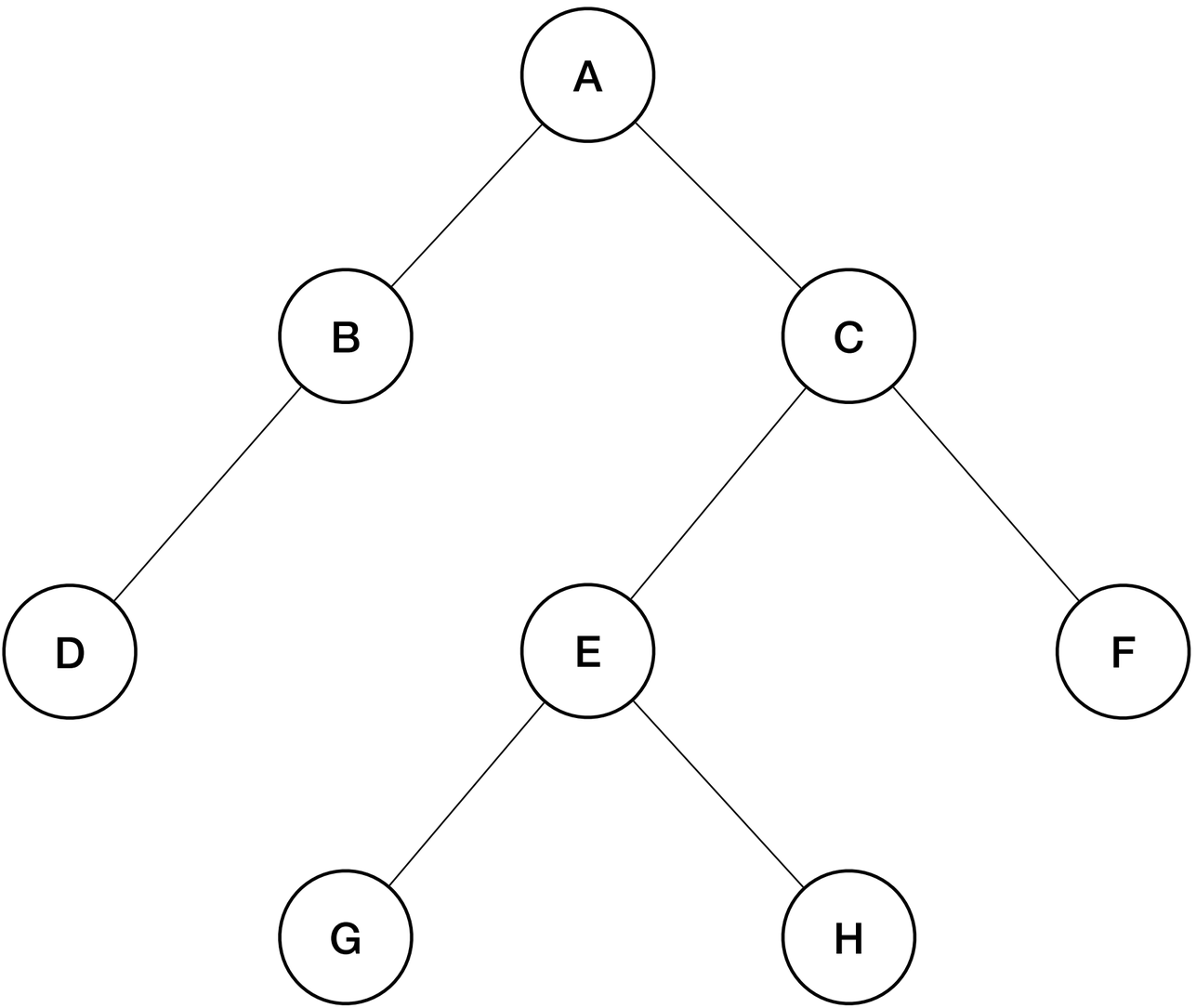
Traversing trees



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  - Traverse through all the children of a node, then visit the grandchildren.

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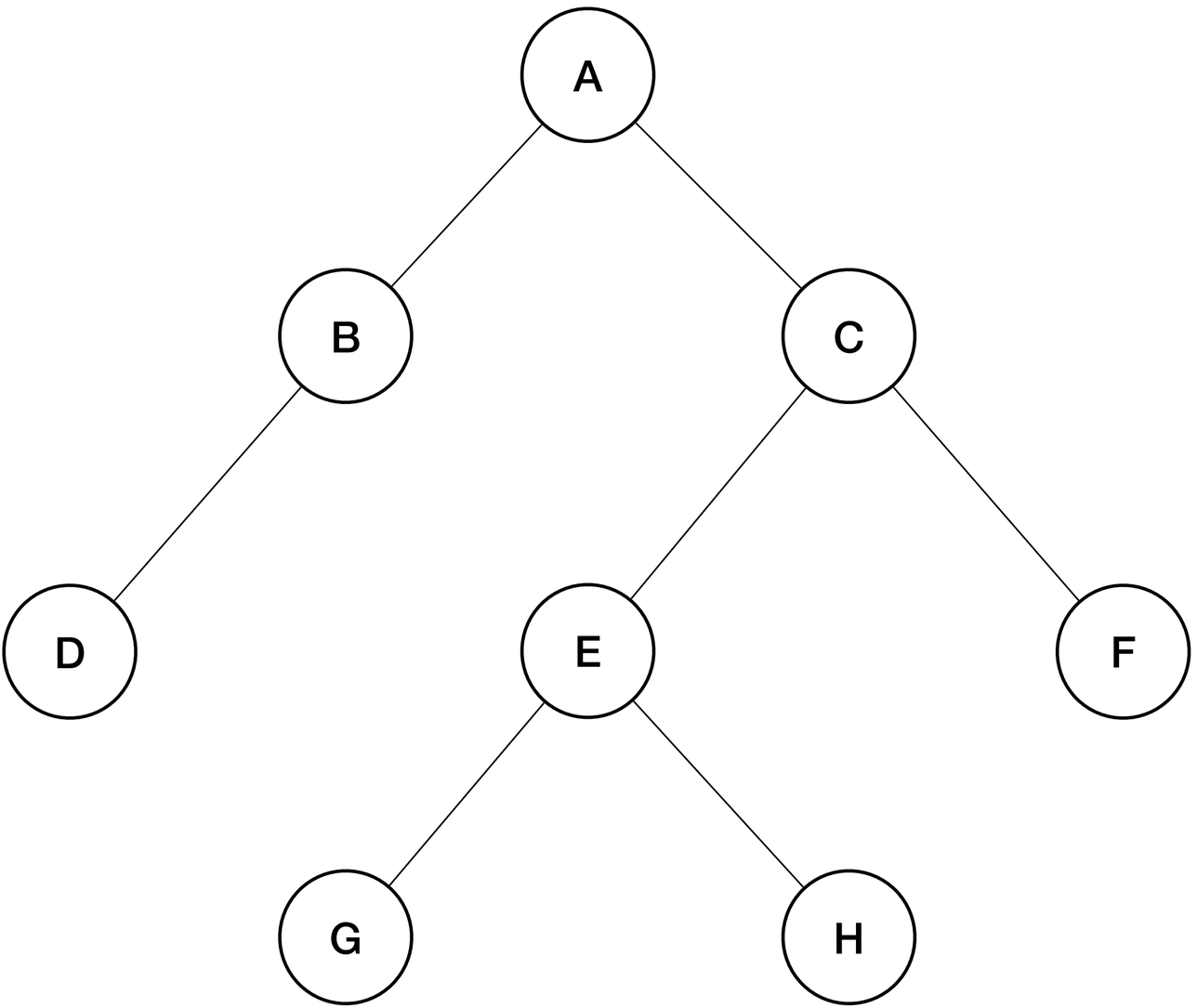

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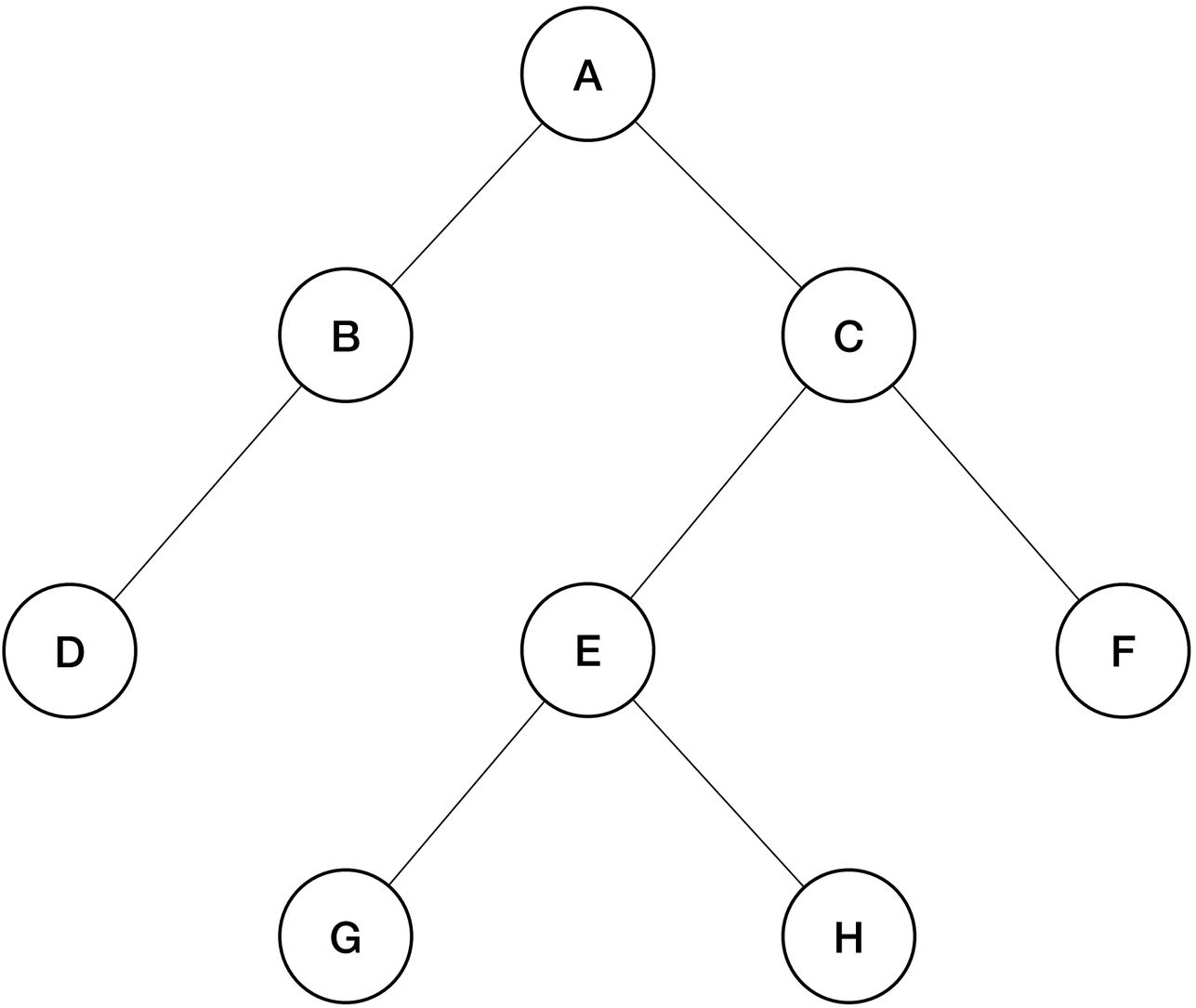

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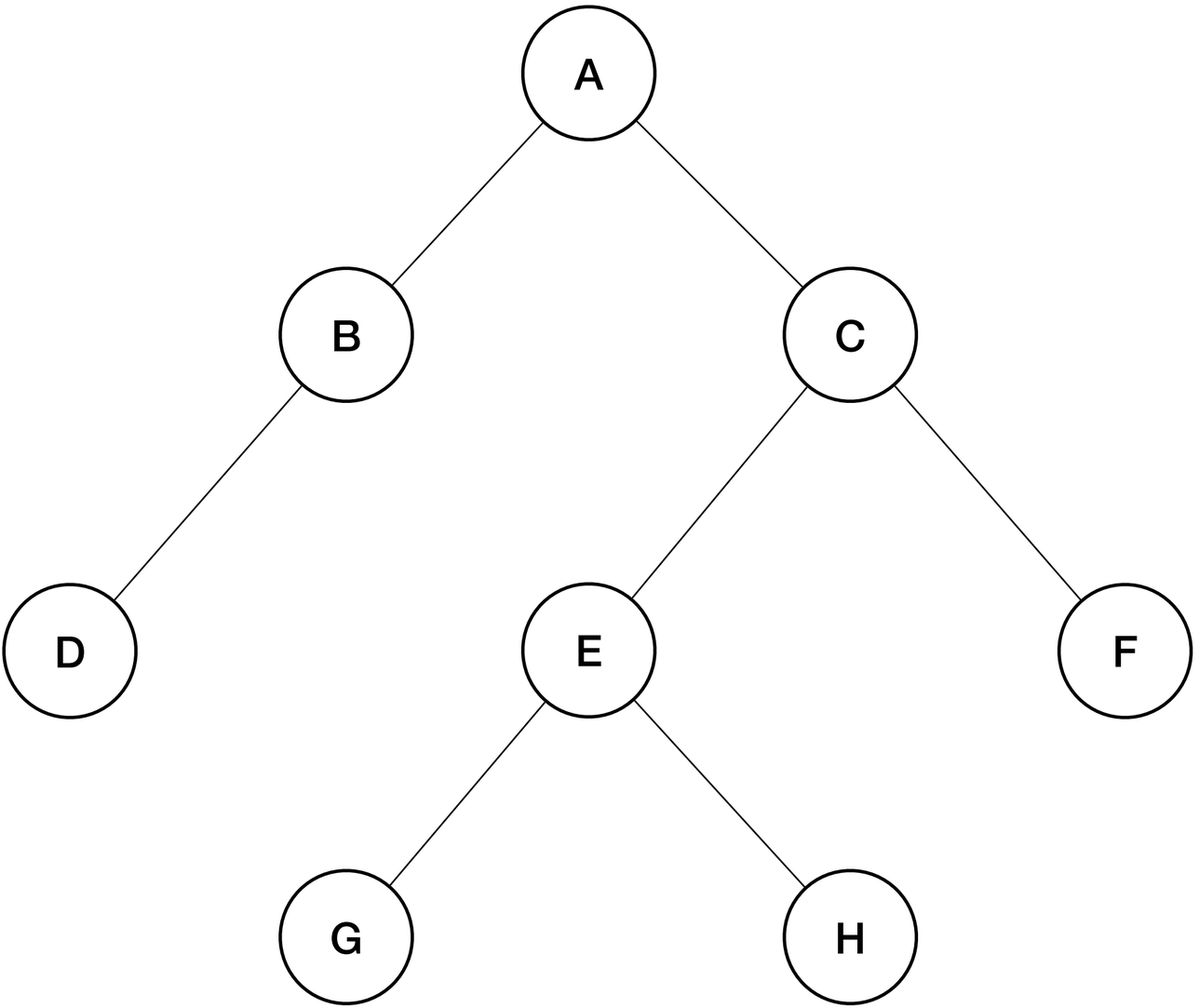
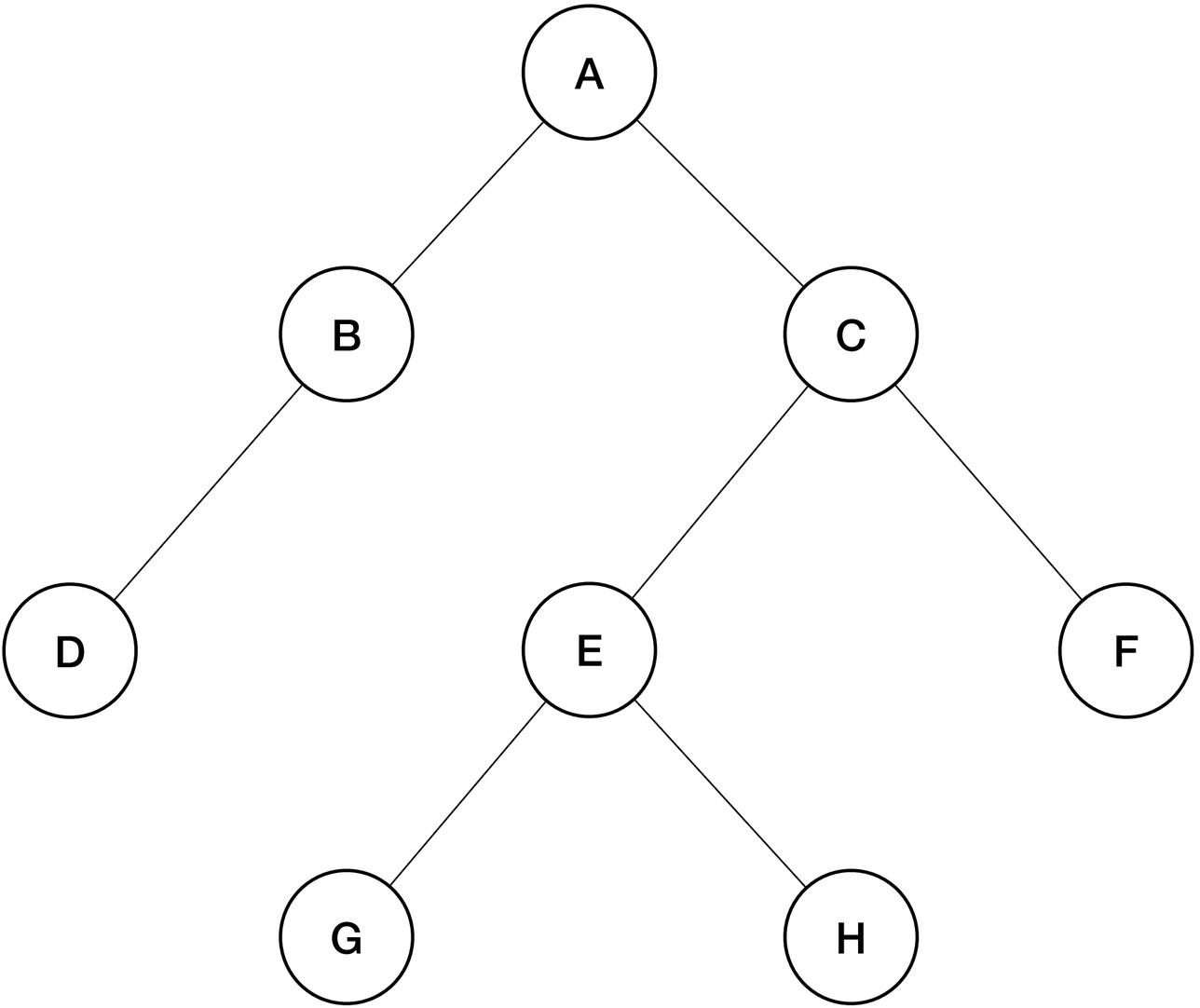



```
Stack myStack
myStack.push(root)
while(myStack){
     cursor = myStack.pop()
     cursor.print()
     if (cursor->right)
          myStack.push(cursor->right)
     if (cursor->left)
          myStack.push(cursor->left)
}
```

Implementing traversals

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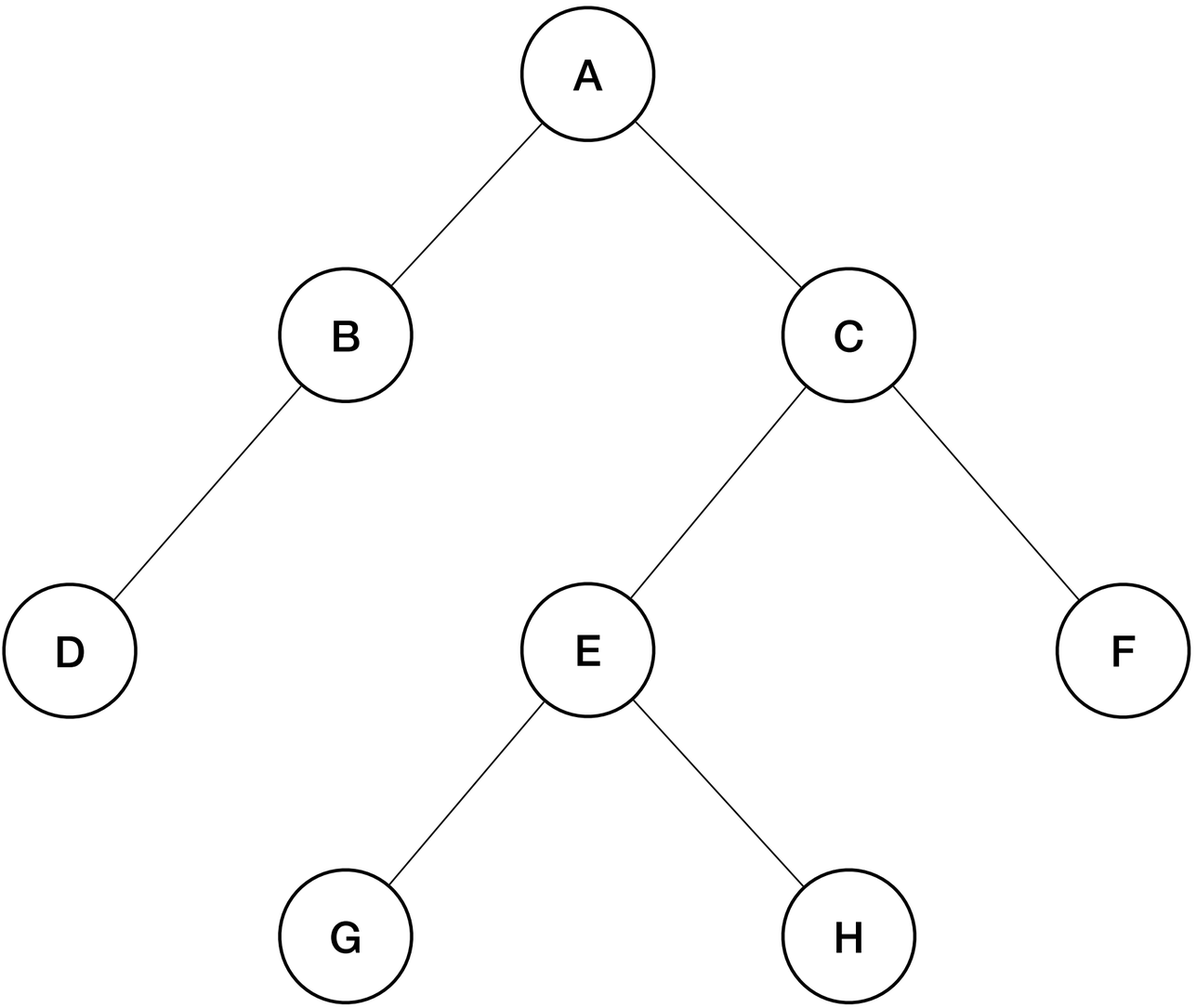
What does this algorithm do?

Implementing traversals



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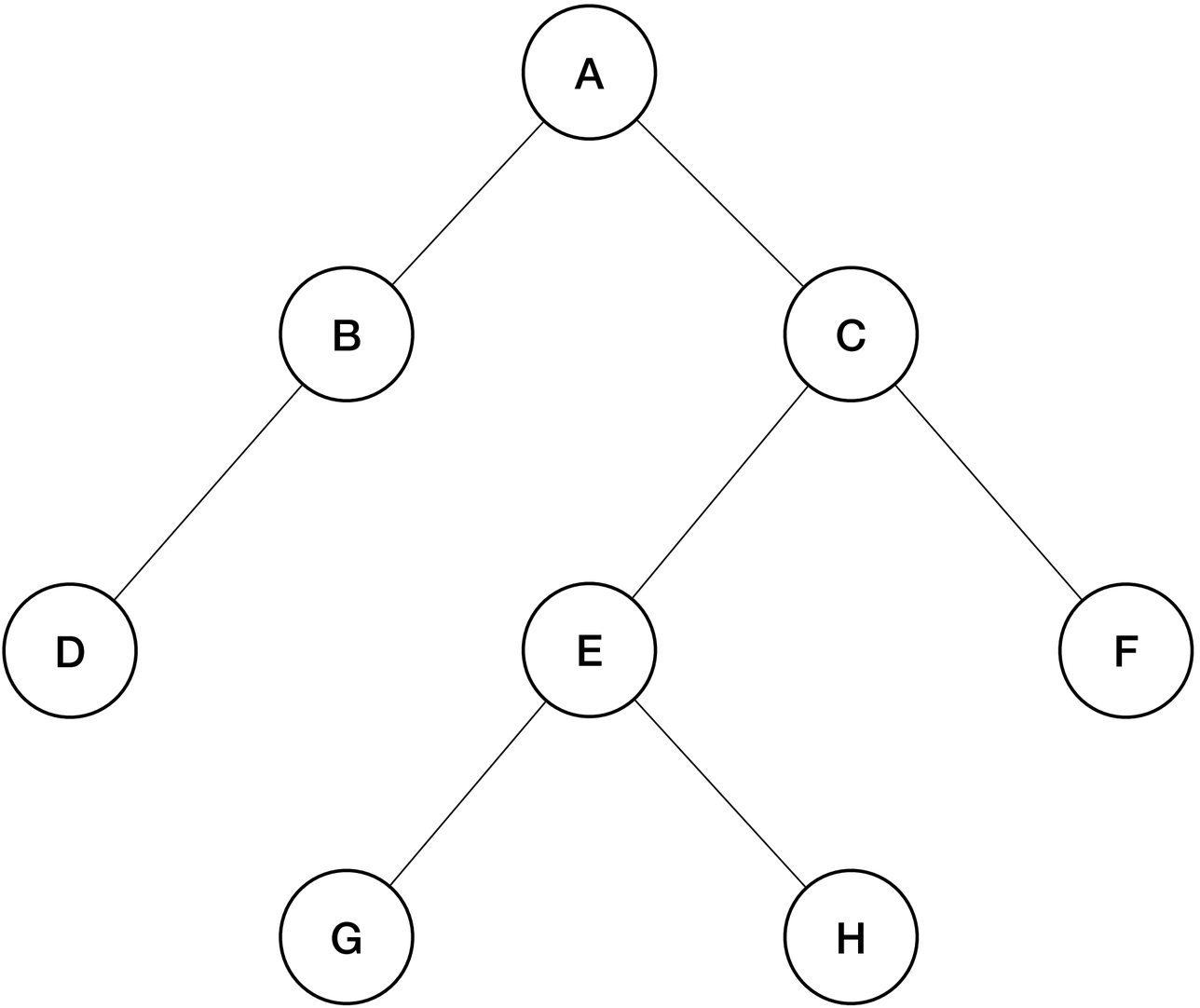
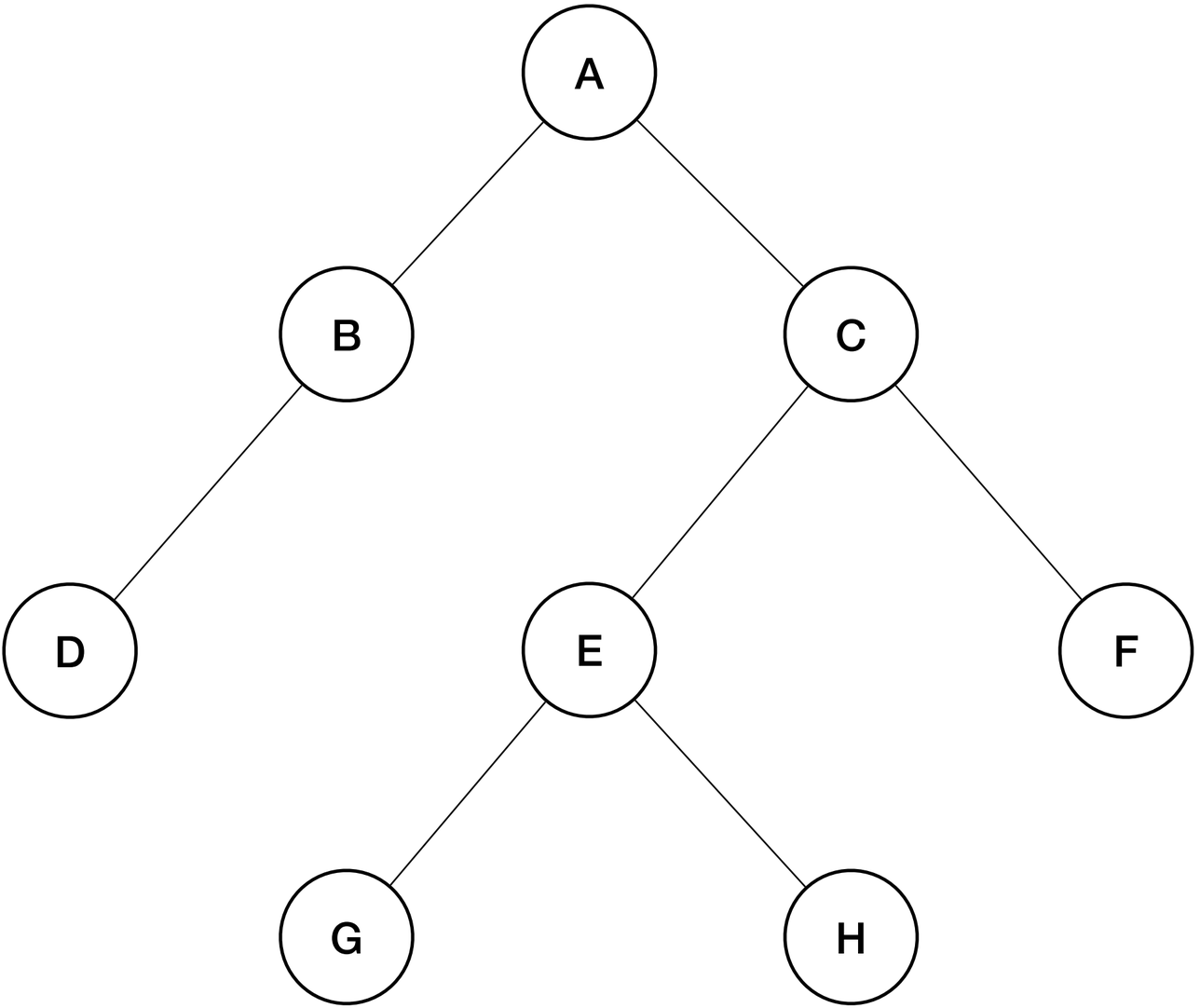



```
Queue myQueue
myQueue.enqueue(root)
while(myQueue){
    cursor = myQueue.dequeue()
    cursor.print()
    if (cursor->left)
     myQueue.enqueue(cursor->left)
    if (cursor->right)
     myQueue.enqueue(cursor->right)
}
```

Implementing traversals

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What does this algorithm do?

```
typedef struct node{
    int data;
    struct node *left;
    struct node *right;
} node;
```

Practice time

```c
typedef struct node{
    int data;
    struct node *left;
    struct node *right;
} node;
```

Practice time

```c
int main(){
  int arr[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

  node * root = (node *) malloc(sizeof(node));
  root->data = arr[0];
  root->left = NULL;
  root->right=NULL;
  node * cursor = root;

  for (int j=0, i=1; i<11; i=i+2, j++){
    add_left(&cursor, arr[i]);
    add_right(&cursor, arr[i+1]);
    cursor = (j%2==0) ? cursor->right : cursor->left;
  }
  print_preorder(root);
  print_inorder(root);
  print_postorder(root);
  delete_tree(root);
}
```

```c
typedef struct node{
    int data;
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Practice time

- Write functions to:

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Practice time

- Write functions to:
  - Add to the left and right of a node.
- Implement preorder, inorder, and postorder traversals.

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int main(){
  int arr[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

  node * root = (node *) malloc(sizeof(node));
  root->data = arr[0];
  root->left = NULL;
  root->right=NULL;
  node * cursor = root;
  for (int j=0, i=1; i<11; i=i+2, j++){
    add_left(&cursor, arr[i]);
    add_right(&cursor, arr[i+1]);
    cursor = (j%2==0) ? cursor->right : cursor->left;
  }
  print_preorder(root);
  print_inorder(root);
  print_postorder(root);
  delete_tree(root);
}
```

```c
typedef struct node{
    int data;
    struct node *left;
    struct node *right;
} node;
```

Practice time

- Write functions to:
  - Add to the left and right of a node.
  - Implement preorder, inorder, and postorder traversals.
  - Delete a tree.

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Printing a tree

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- Can we print a tree in a human readable way?

Printing a tree

- Can we print a tree in a human readable way?
    - Focus on pre-order traversal

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- Can we print a tree in a human readable way?
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        - Print node, then go left, then go right

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```c
void treeprint(node *cursor, int depth){
  if (cursor == NULL)
    return;
  for (int i = 0; i < depth; i++)
    printf(i == depth - 1 ? "|-" : "  ");
  printf("%d\n", cursor->data);
  treeprint(cursor->left, depth + 1);
  treeprint(cursor->right, depth + 1);
}
```

Printing a tree

- Can we print a tree in a human readable way?
  - Focus on pre-order traversal
    - Print node, then go left, then go right
- Use *depth* to print right amount of indentation

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Let us check if we got previous slide right …