



CS 225

Data Structures

February 7 – Trees Theory and Traversal

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How many NULLs?

Theorem: If there are n data items in our representation of a binary tree, then there are _____ NULL pointers.



How many NULLs?

Base Cases:

$n = 0$:

$n = 1$:

$n = 2$:



How many NULLs?

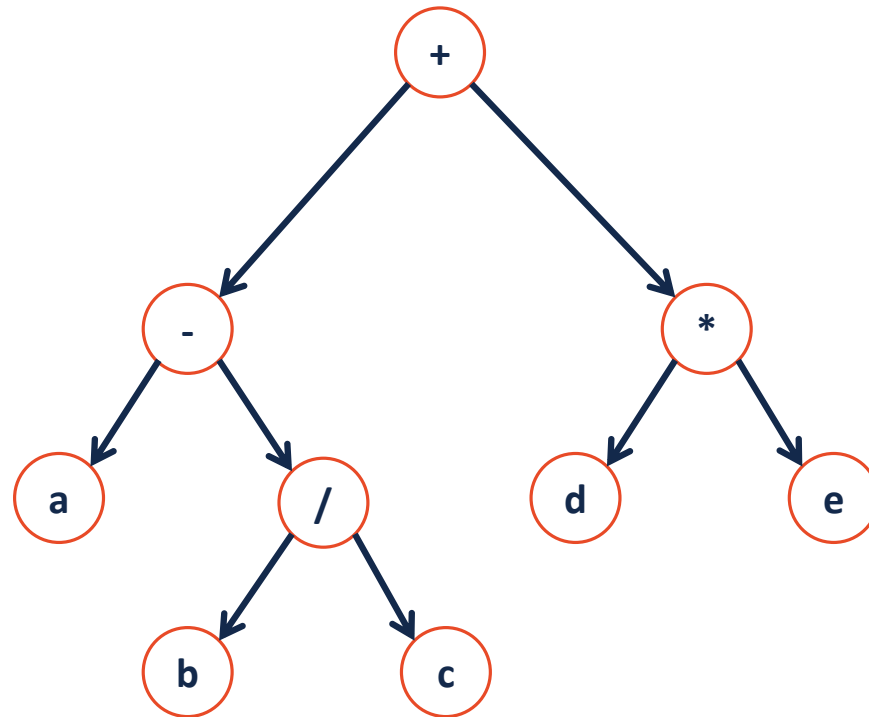
Induction Hypothesis:



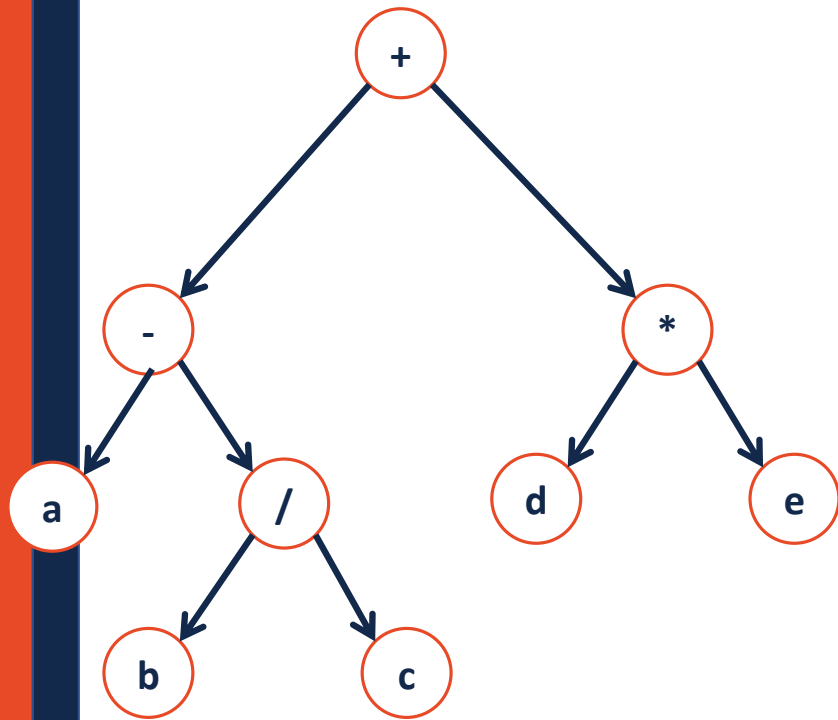
How many NULLs?

Consider an arbitrary tree T containing n data elements:

Access All the Nodes - Traversals

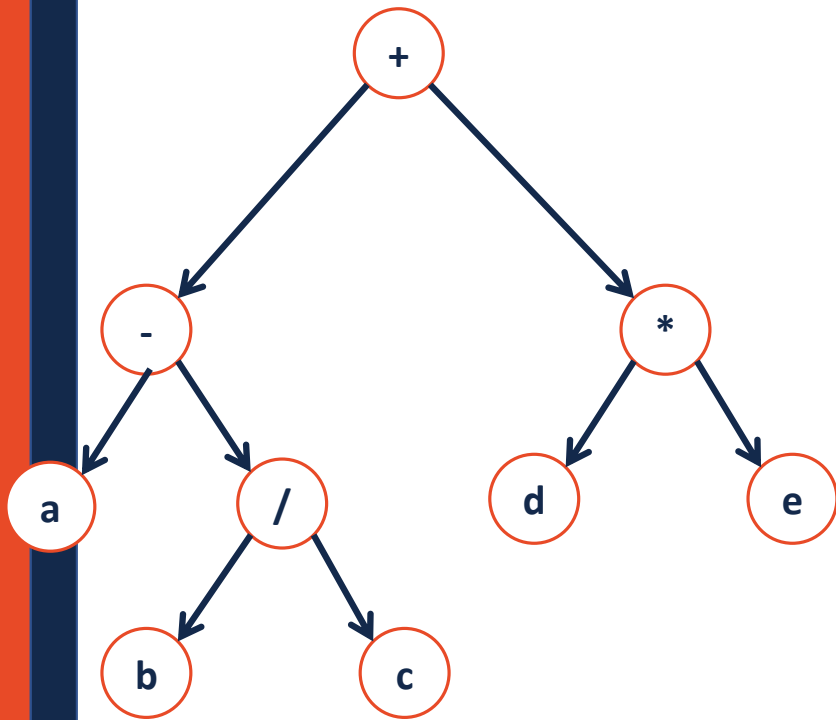


Traversals



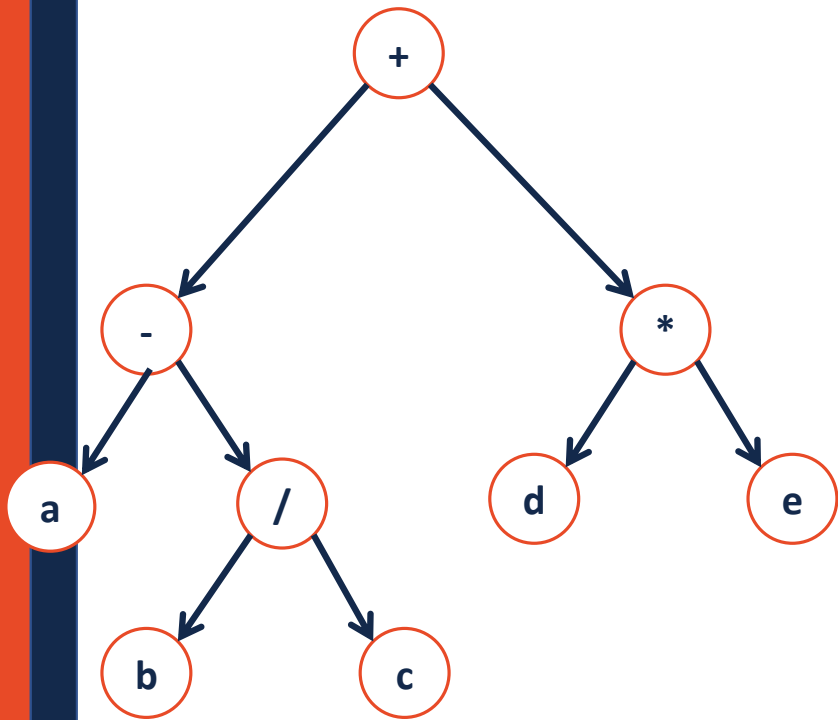
```
49 template<class T>
50 void BinaryTree<T>::__Order(TreeNode * cur)
51 {
52
53
54
55
56
57
58 }
```

Traversals



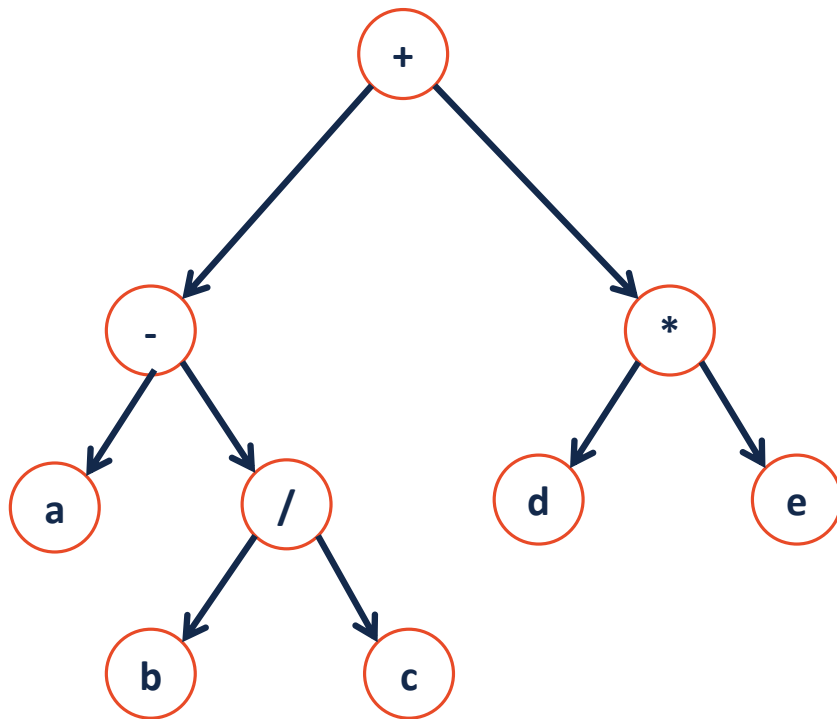
```
49 template<class T>
50 void BinaryTree<T>::__Order(TreeNode * cur) {
51     if (cur != NULL) {
52         _____;
53         __Order(cur->left);
54         _____;
55         __Order(cur->right);
56         _____;
57     }
58 }
```


Traversals

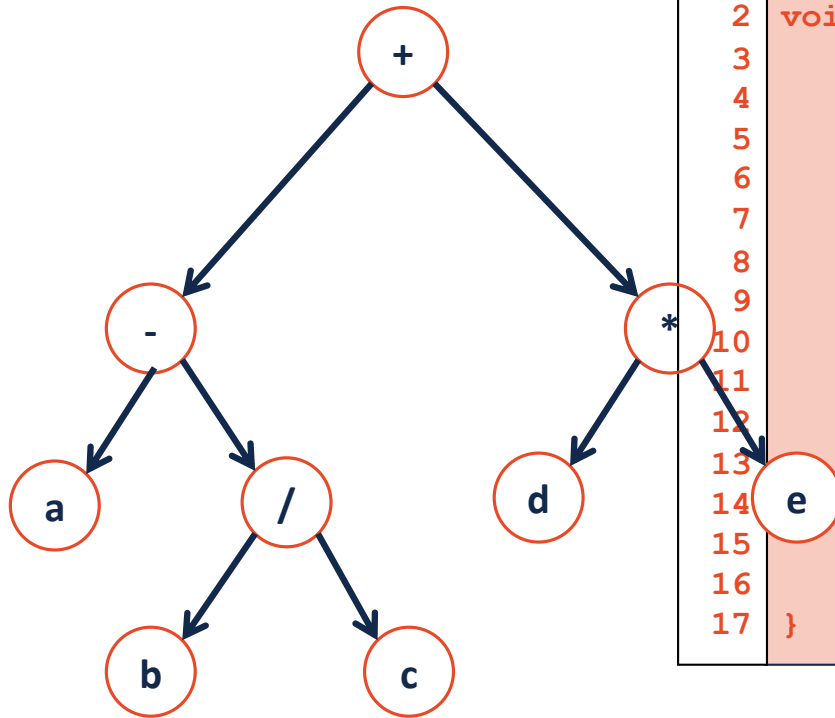


```
49 template<class T>
50 void BinaryTree<T>::__Order(TreeNode * cur) {
51     if (cur != NULL) {
52         _____;
53         __Order(cur->left);
54         _____;
55         __Order(cur->right);
56         _____;
57     }
58 }
```

A Different Type of Traversal



A Different Type of Traversal



```
1  template<class T>
2  void BinaryTree<T>::levelOrder(TreeNode * root) {
3
4
5
6
7
8
9
10
11
12
13
14  e
15
16
17 }
```



Traversal vs. Search

Traversal

Search



Search: Breadth First vs. Depth First

Strategy: Breadth First Search (BFS)

Strategy: Depth First Search (DFS)



Dictionary ADT

Data is often organized into key/value pairs:

UIN → Advising Record

Course Number → Lecture/Lab Schedule

Node → Incident Edges

Flight Number → Arrival Information

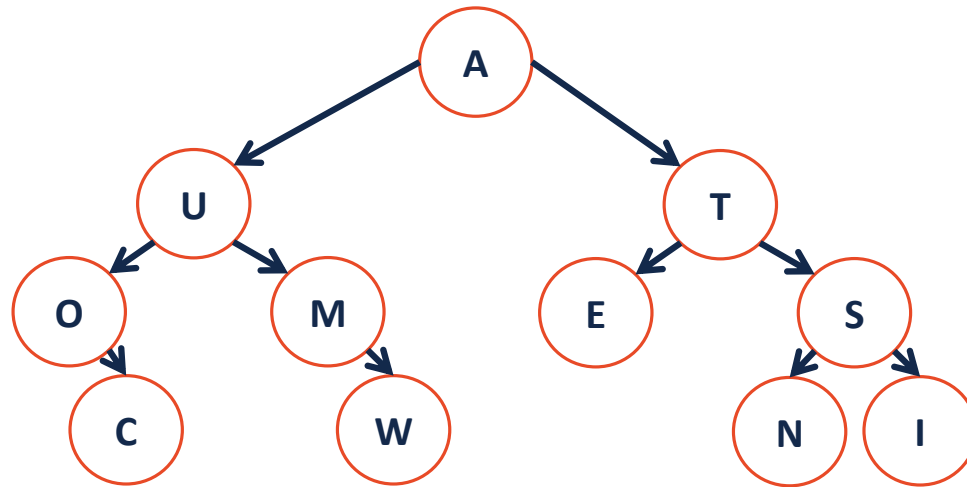
URL → HTML Page

...

Dictionary.h

```
1 #pragma once
2
3
4 class Dictionary {
5     public:
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20     private:
21         // ...
22 };
```

Binary Tree as a Search Structure





Binary Tree as a Search Structure

Binary _____ Tree (BST)

A **BST** is a binary tree **T** such that:

