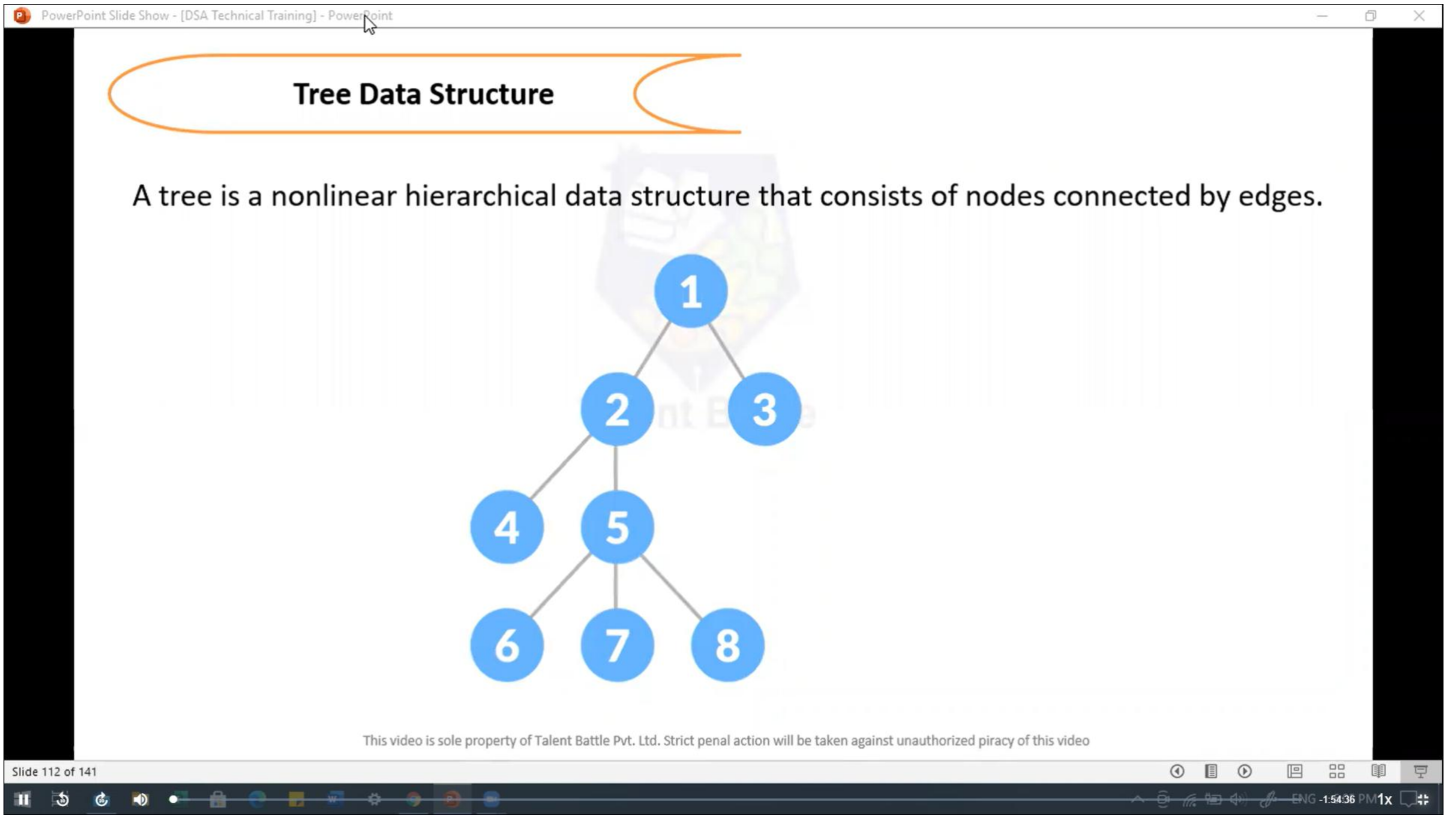
Session-7

Tree Data Structure Part 1



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Tree Data Structure

A tree is a nonlinear hierarchical data structure that consists of nodes connected by edges.

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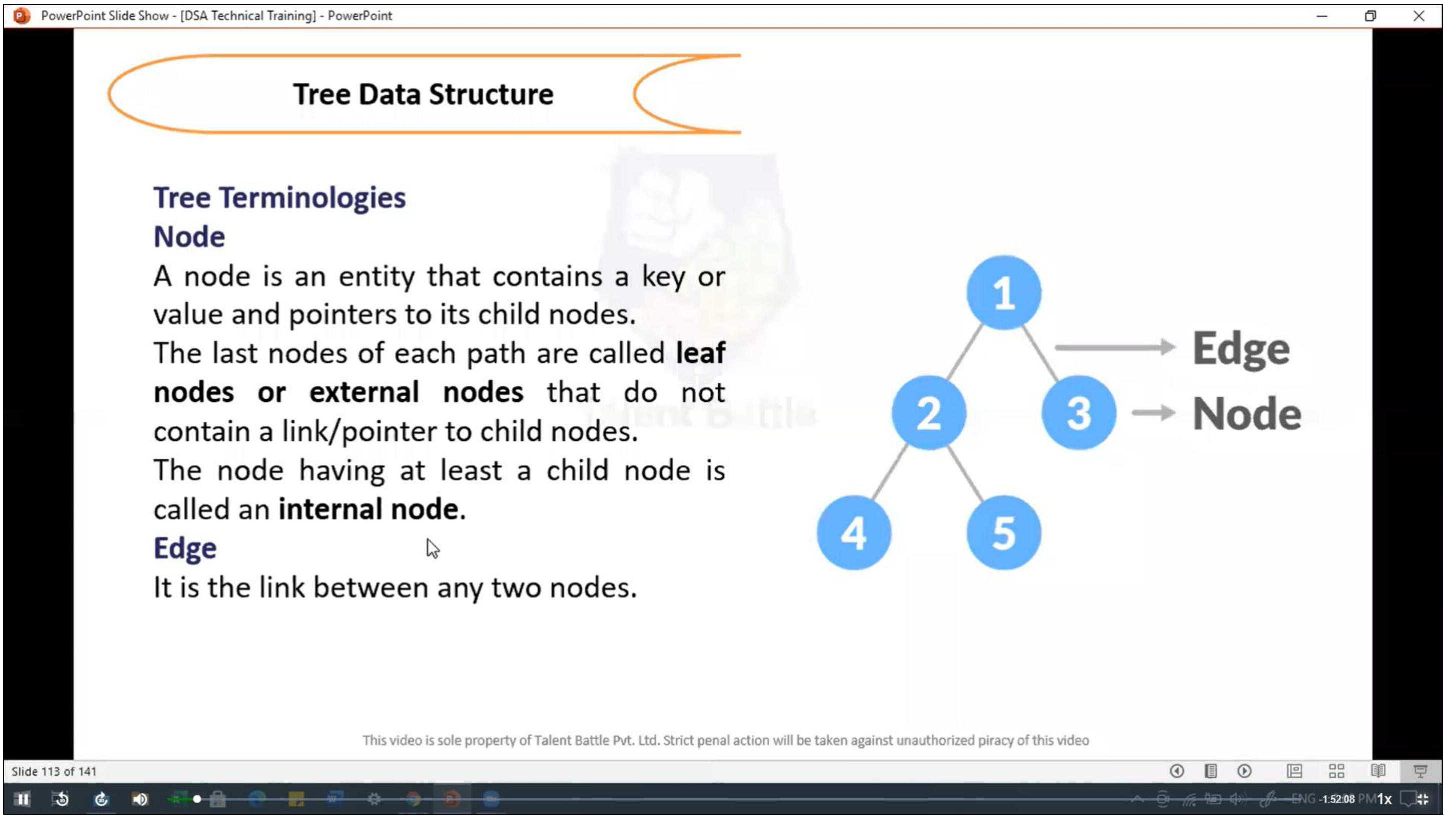

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Tree Data Structure

Tree Terminologies

Node

A node is an entity that contains a key or value and pointers to its child nodes.

The last nodes of each path are called **leaf nodes or external nodes** that do not contain a link/pointer to child nodes.

The node having at least a child node is called an **internal node**.

Edge

It is the link between any two nodes.

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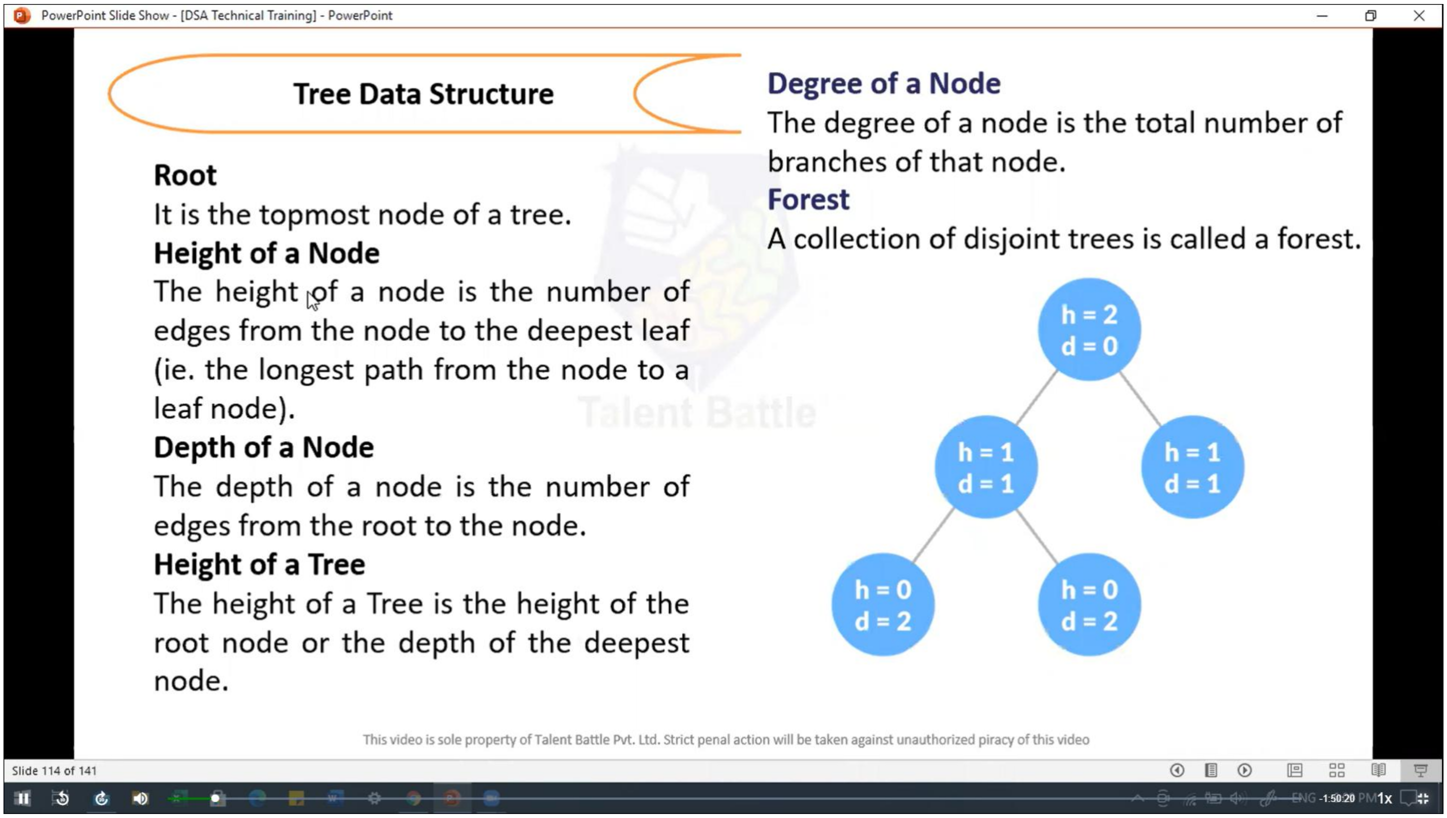

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Tree Data Structure

Root

It is the topmost node of a tree.

Height of a Node

The height of a node is the number of edges from the node to the deepest leaf (ie. the longest path from the node to a leaf node).

Depth of a Node

The depth of a node is the number of edges from the root to the node.

Height of a Tree

The height of a Tree is the height of the root node or the depth of the deepest node.

Degree of a Node

The degree of a node is the total number of branches of that node.

Forest

A collection of disjoint trees is called a forest.

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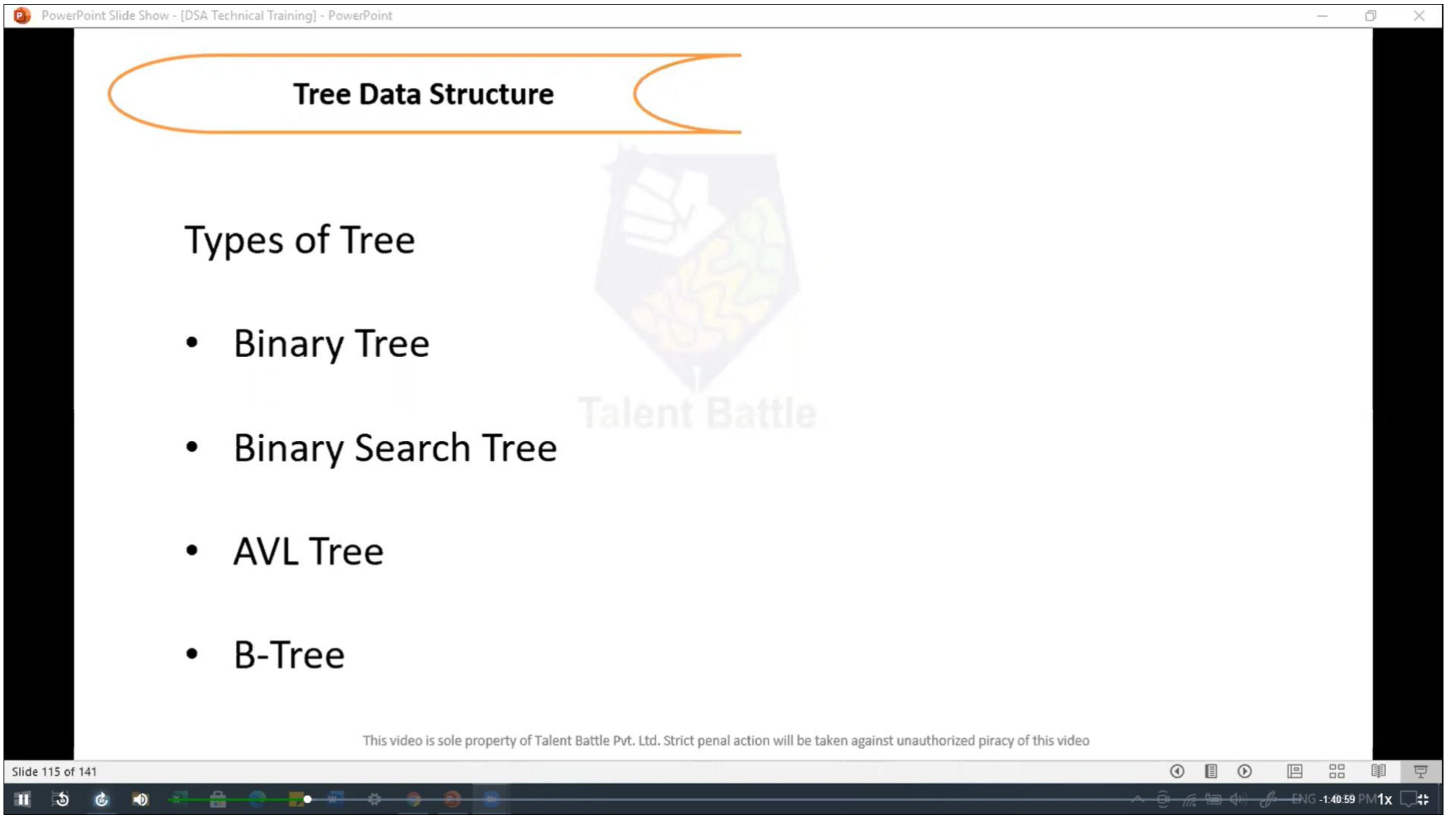

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Tree Data Structure

Types of Tree

- Binary Tree
- Binary Search Tree
- AVL Tree
- B-Tree

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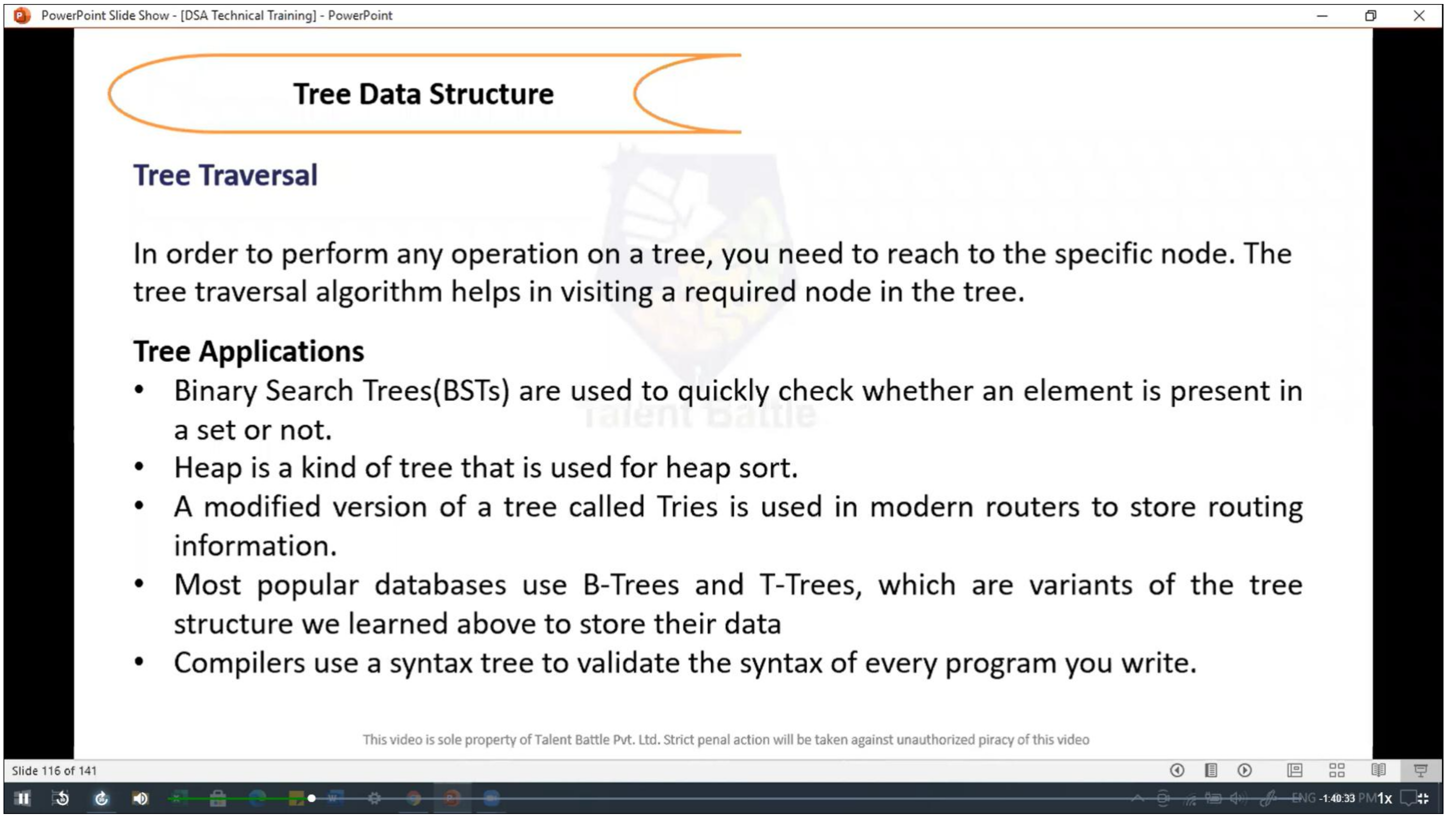
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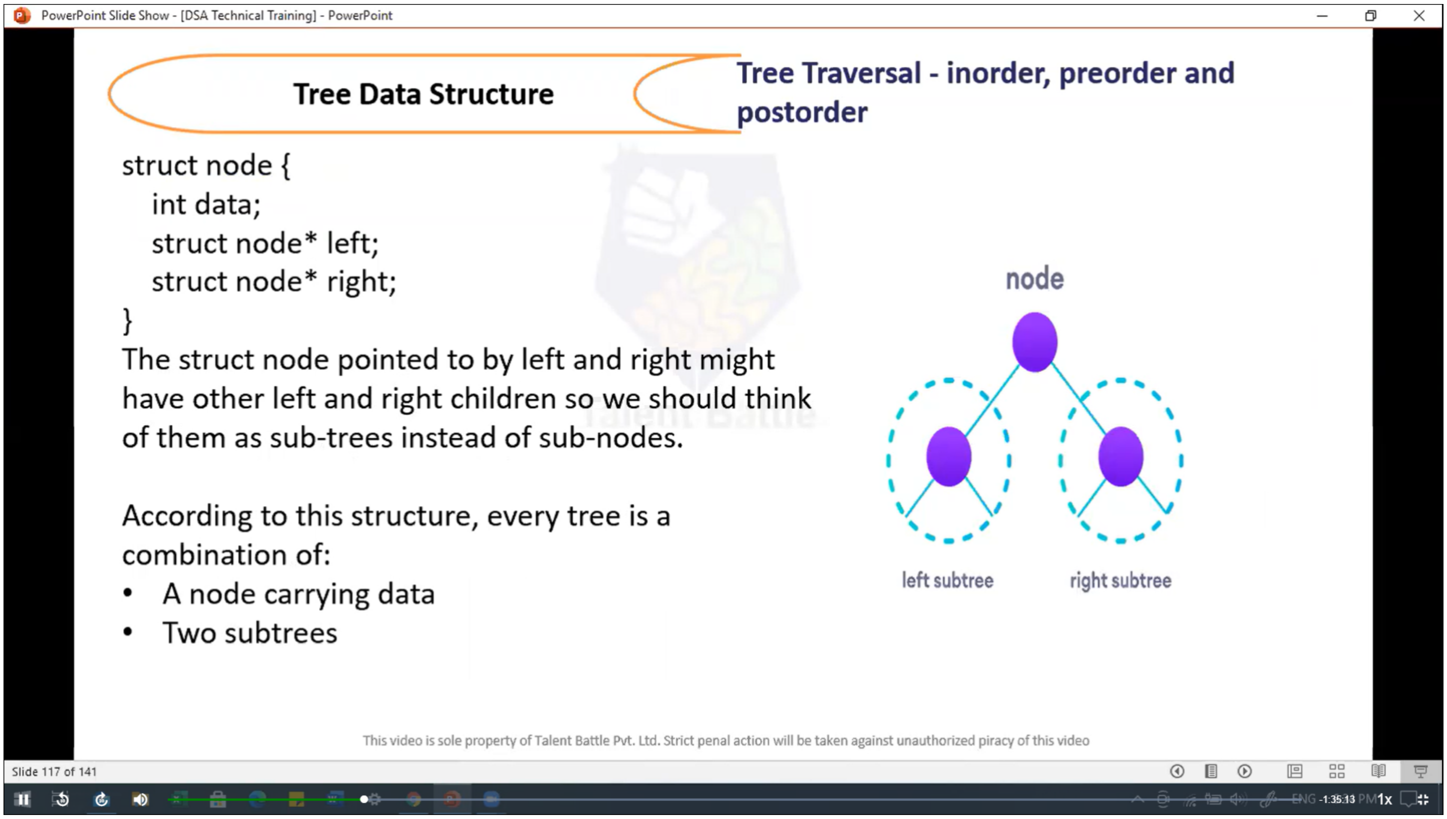
Tree Data Structure

Tree Traversal

In order to perform any operation on a tree, you need to reach to the specific node. The tree traversal algorithm helps in visiting a required node in the tree.

Tree Applications

- Binary Search Trees(BSTs) are used to quickly check whether an element is present in a set or not.
- Heap is a kind of tree that is used for heap sort.
- A modified version of a tree called Tries is used in modern routers to store routing information.
- Most popular databases use B-Trees and T-Trees, which are variants of the tree structure we learned above to store their data
- Compilers use a syntax tree to validate the syntax of every program you write.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node
left subtree
right subtree

Tree Data Structure

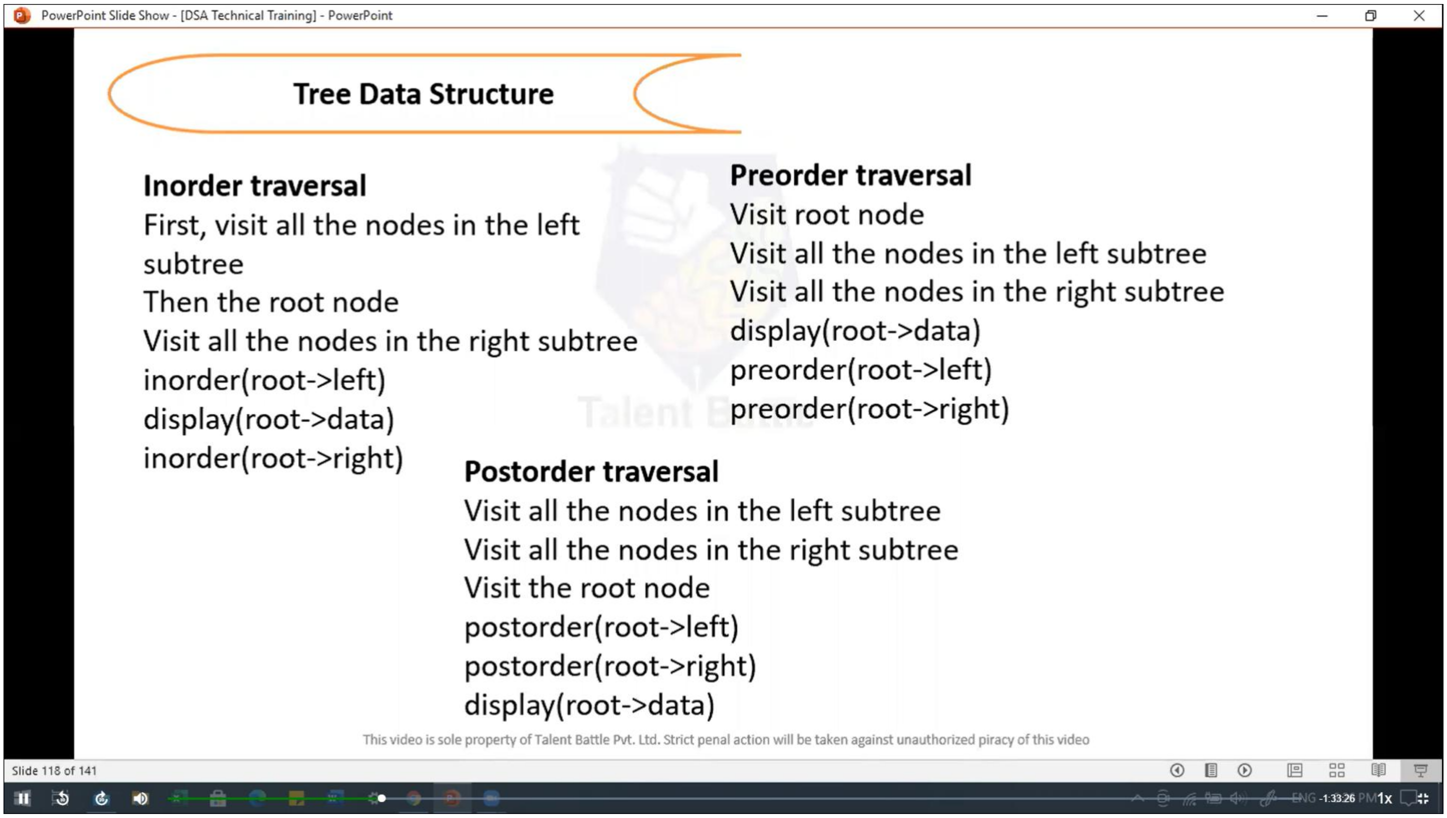
Tree Traversal - inorder, preorder and postorder

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

The struct node pointed to by left and right might have other left and right children so we should think of them as sub-trees instead of sub-nodes.

According to this structure, every tree is a combination of:

- A node carrying data
- Two subtrees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Tree Data Structure

Inorder traversal

First, visit all the nodes in the left subtree

Then the root node

Visit all the nodes in the right subtree

```
inorder(root->left)
display(root->data)
inorder(root->right)
```

Preorder traversal

Visit root node

Visit all the nodes in the left subtree

Visit all the nodes in the right subtree

```
display(root->data)
preorder(root->left)
preorder(root->right)
```

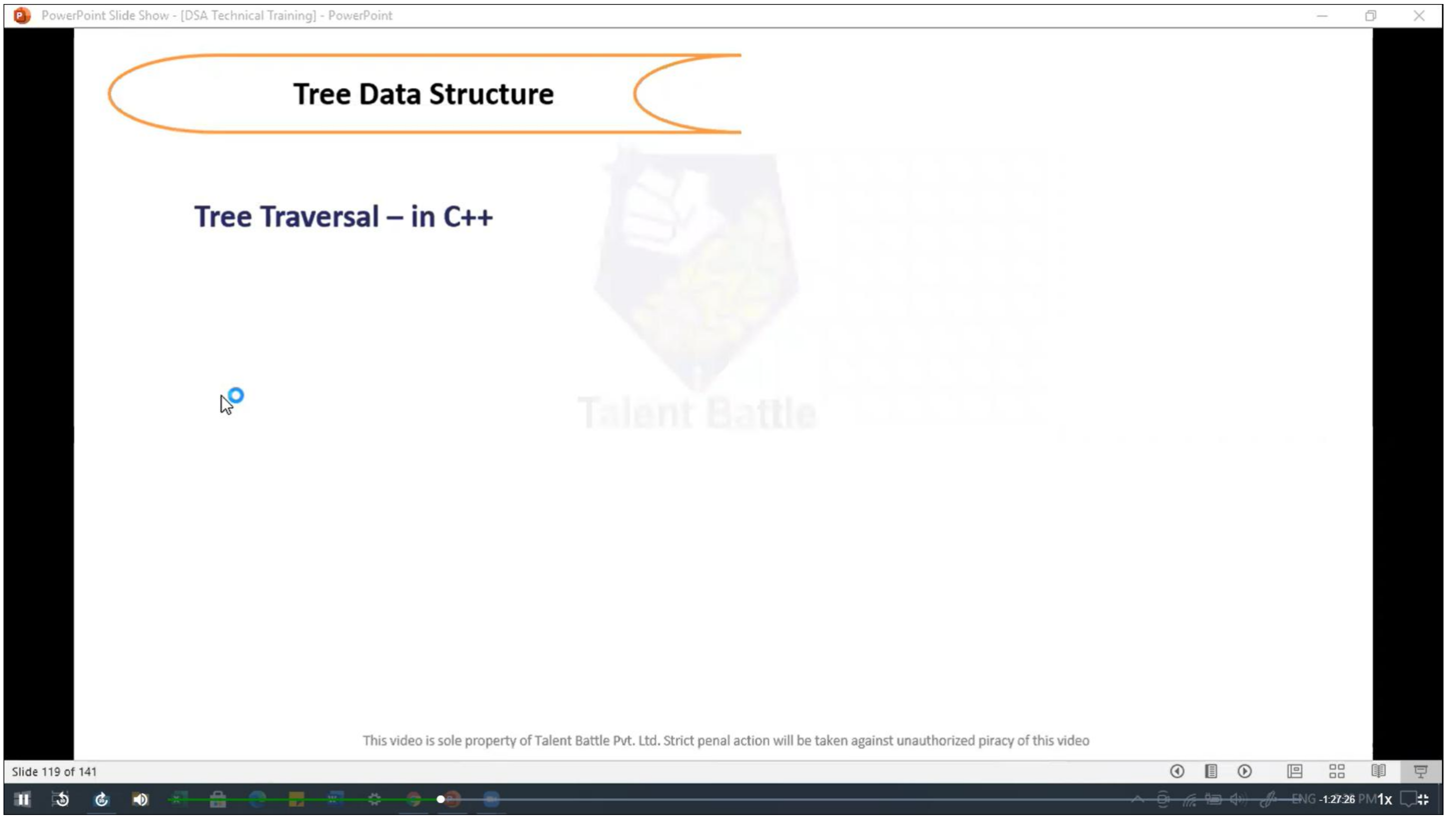
Postorder traversal

Visit all the nodes in the left subtree

Visit all the nodes in the right subtree

Visit the root node

```
postorder(root->left)
postorder(root->right)
display(root->data)
```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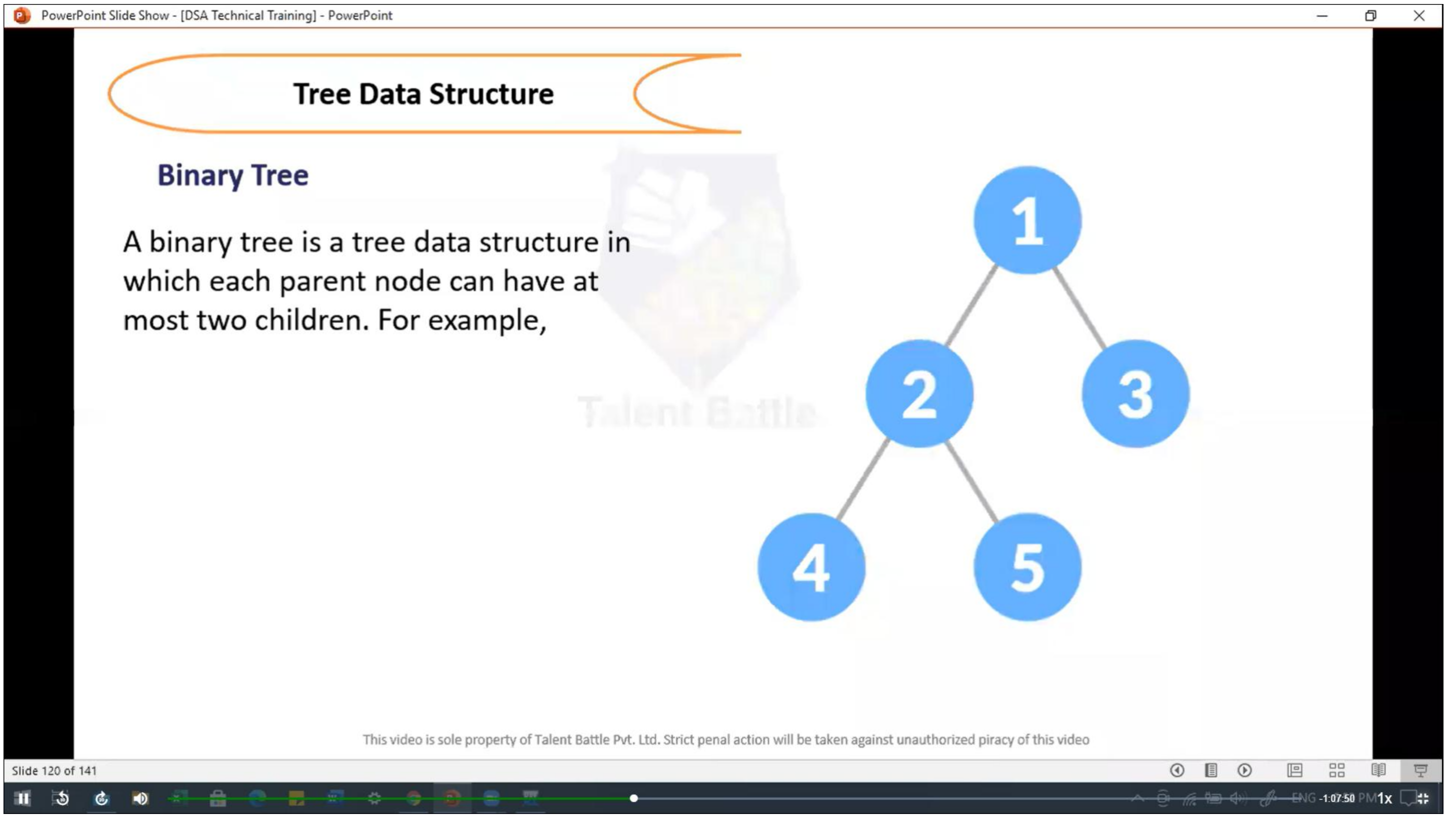
Tree Data Structure

Tree Traversal – in C++



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Tree Data Structure

Binary Tree

A binary tree is a tree data structure in which each parent node can have at most two children. For example,

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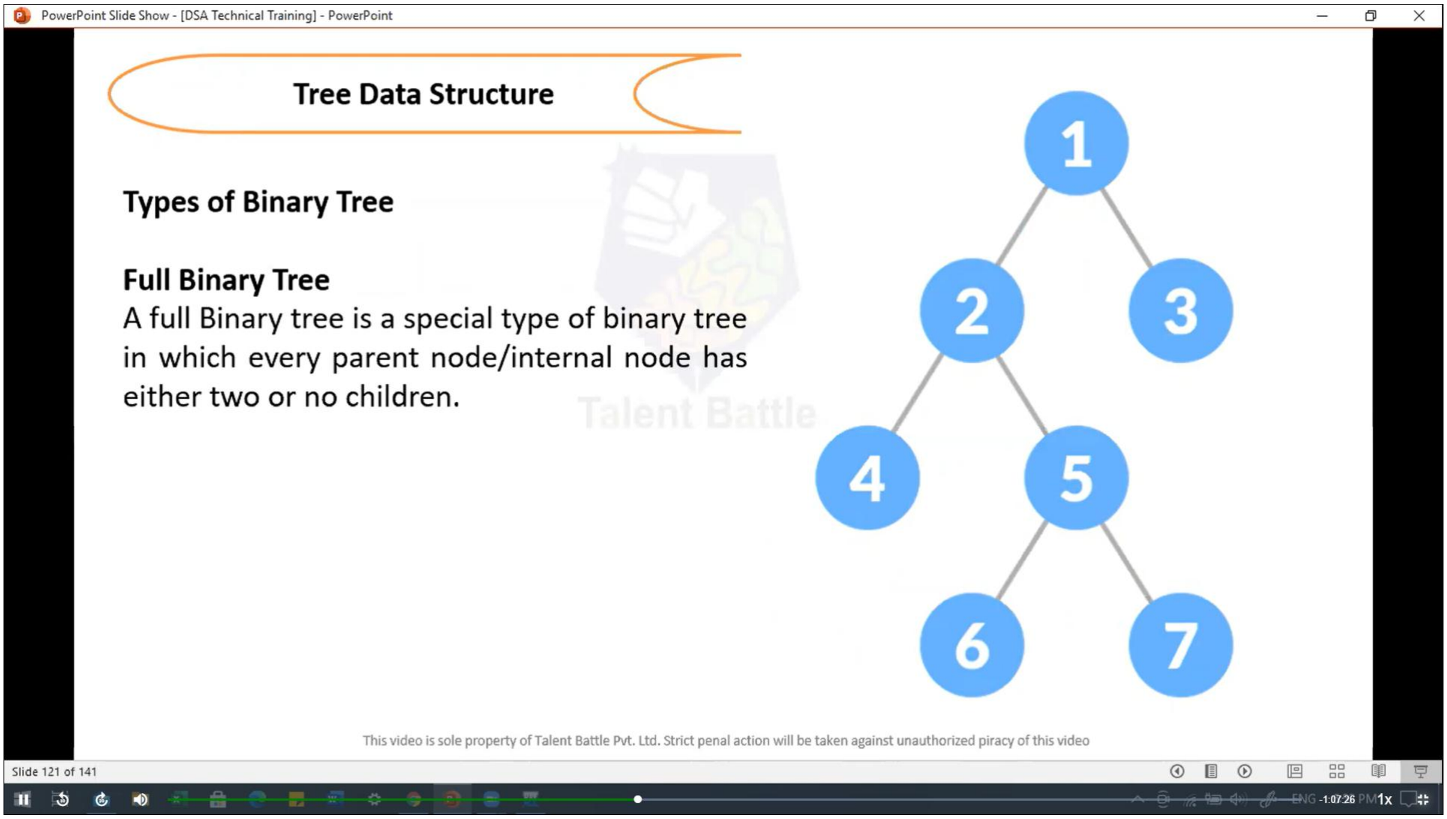

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Tree Data Structure

Types of Binary Tree

Full Binary Tree
A full Binary tree is a special type of binary tree in which every parent node/internal node has either two or no children.

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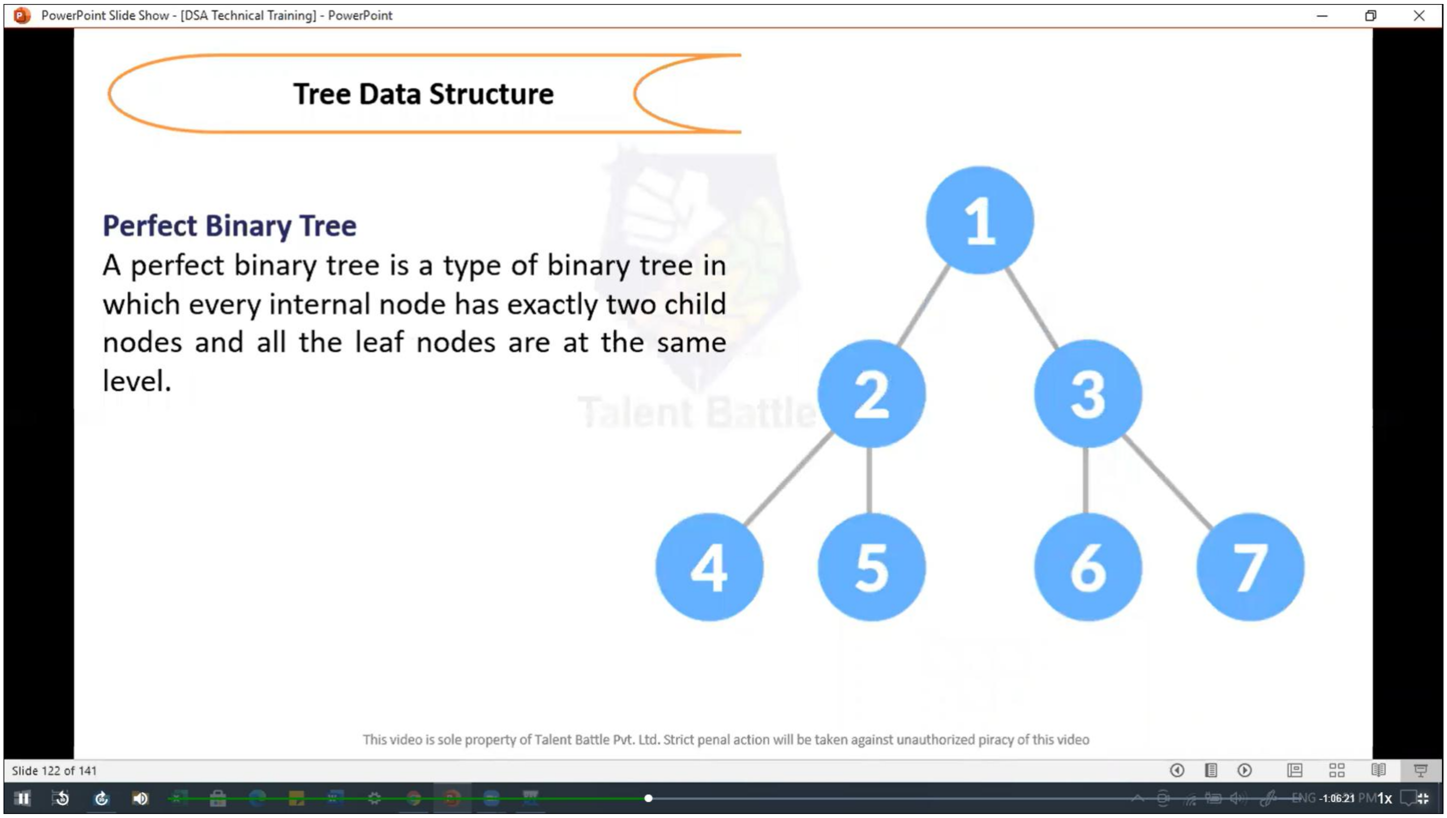

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Tree Data Structure

Perfect Binary Tree

A perfect binary tree is a type of binary tree in which every internal node has exactly two child nodes and all the leaf nodes are at the same level.

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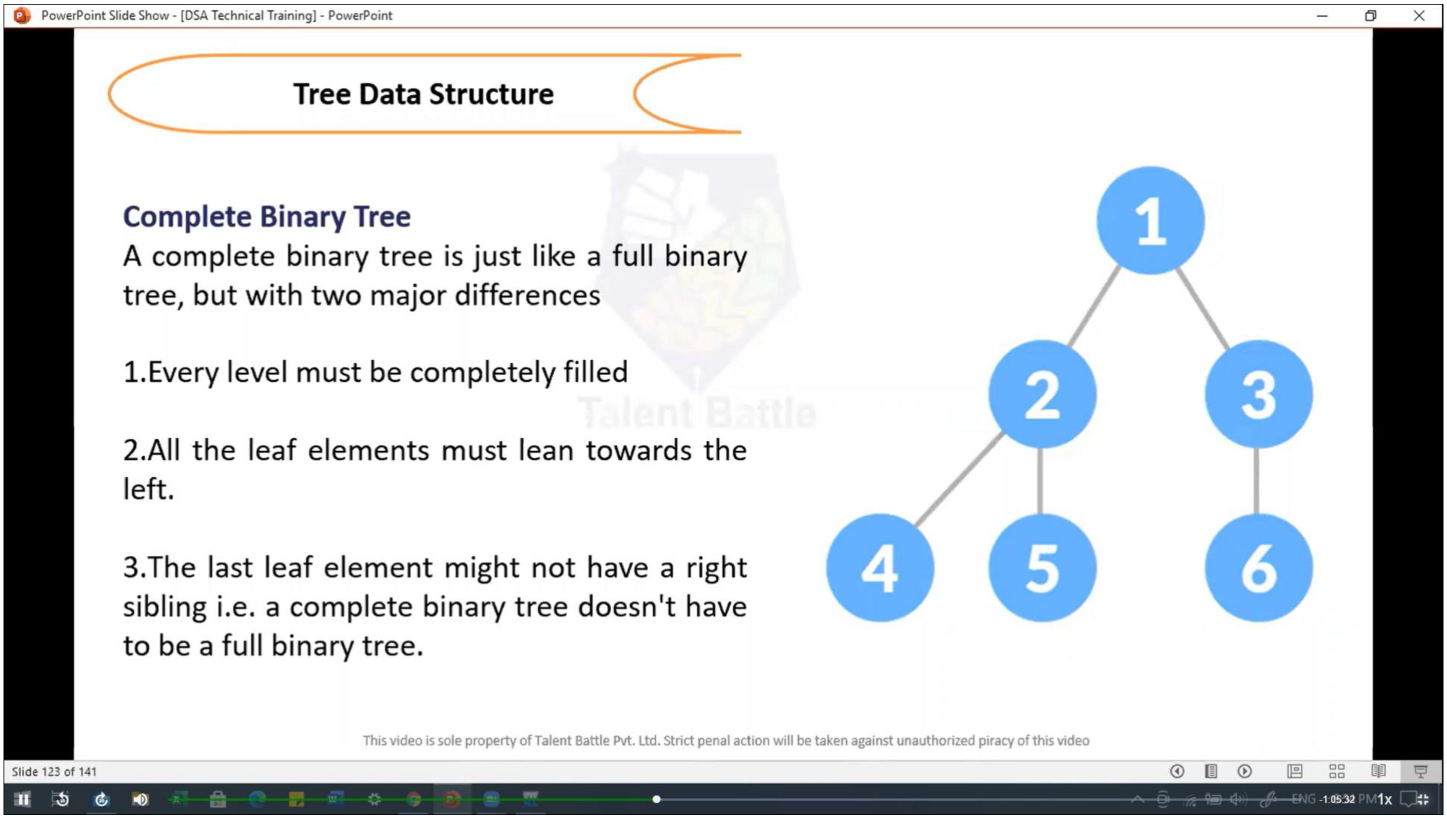

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Tree Data Structure

Complete Binary Tree

A complete binary tree is just like a full binary tree, but with two major differences

1.Every level must be completely filled

2.All the leaf elements must lean towards the left.

3.The last leaf element might not have a right sibling i.e. a complete binary tree doesn't have to be a full binary tree.

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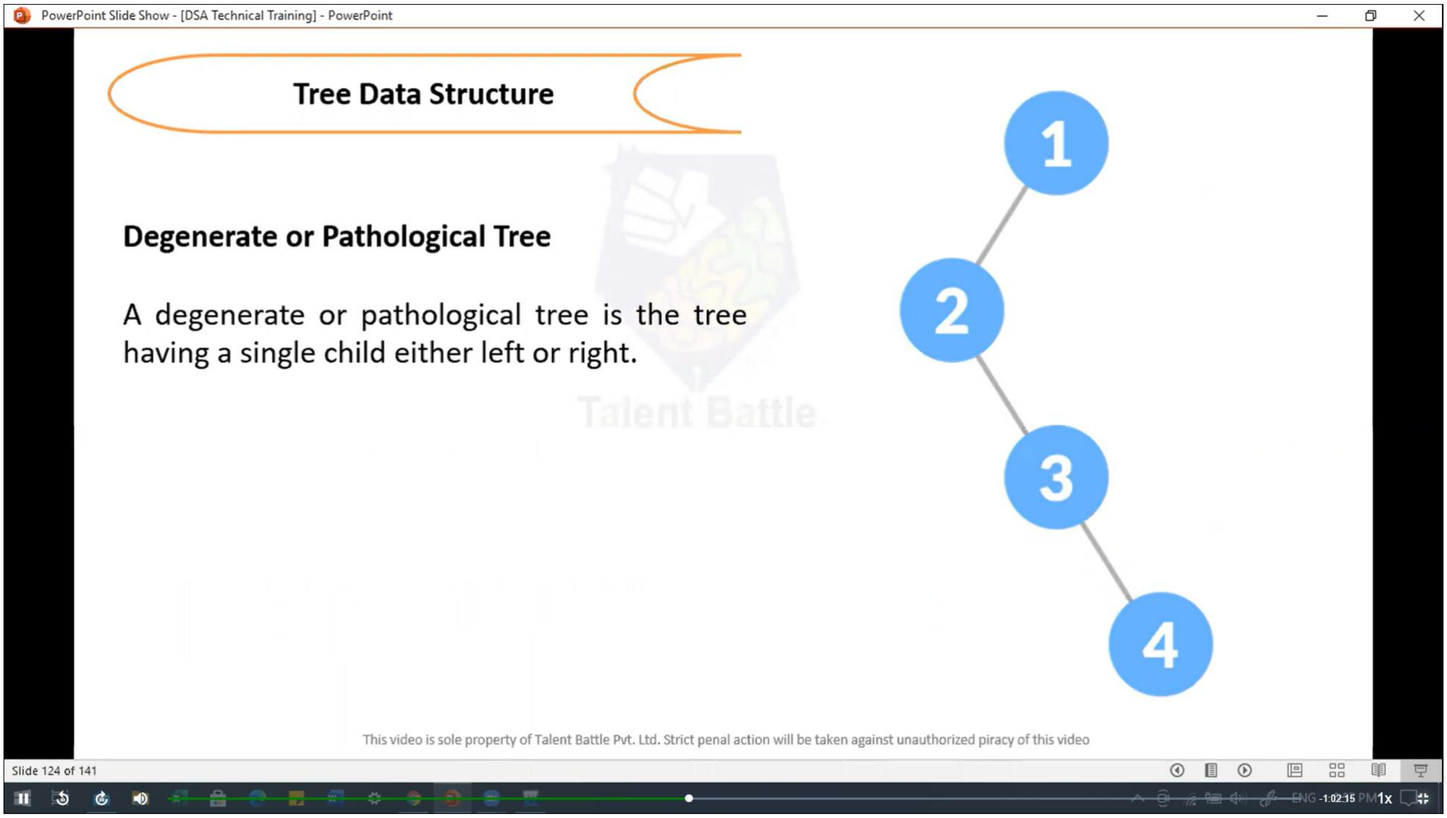
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1
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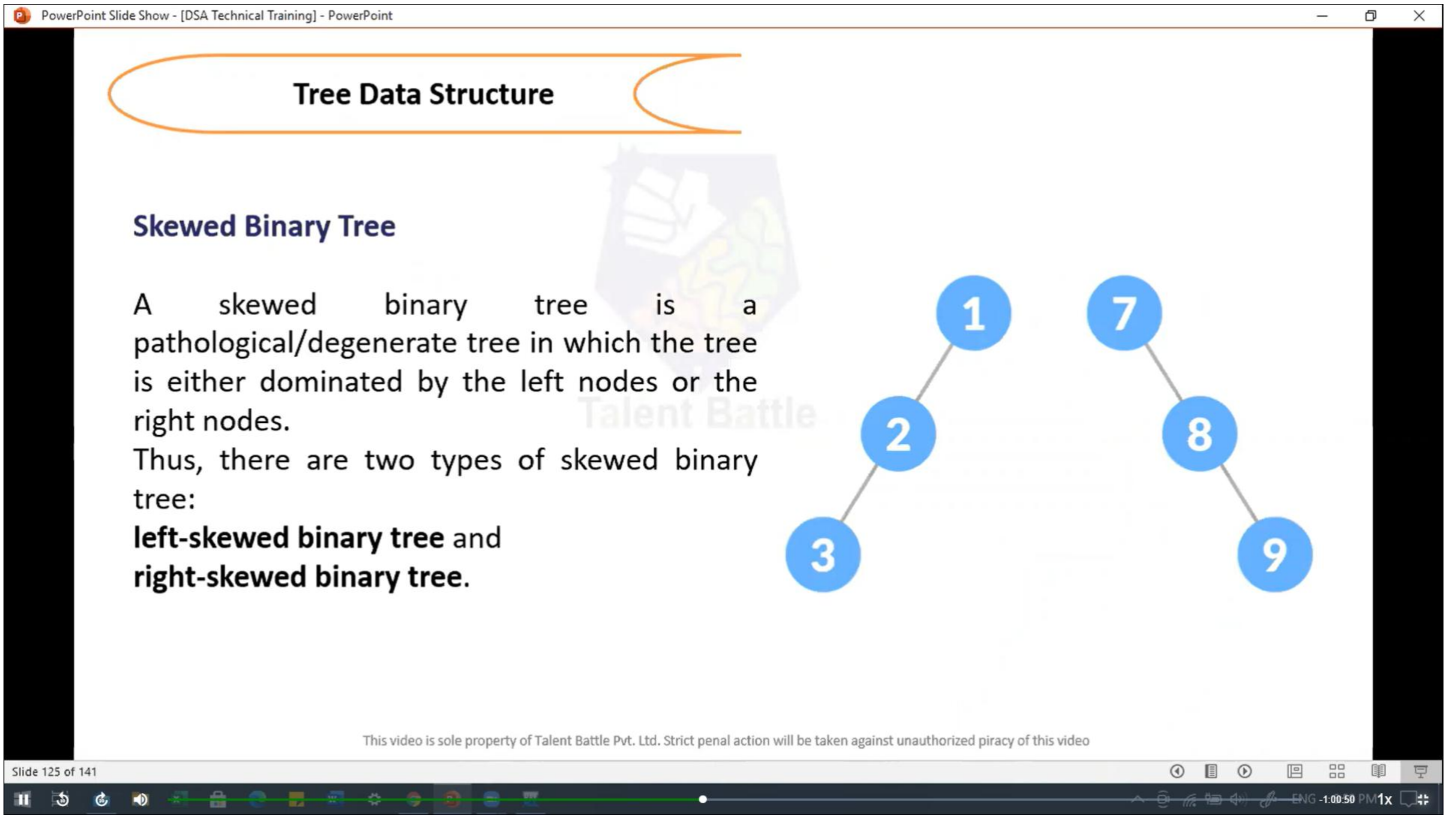
Tree Data Structure

Degenerate or Pathological Tree

A degenerate or pathological tree is the tree having a single child either left or right.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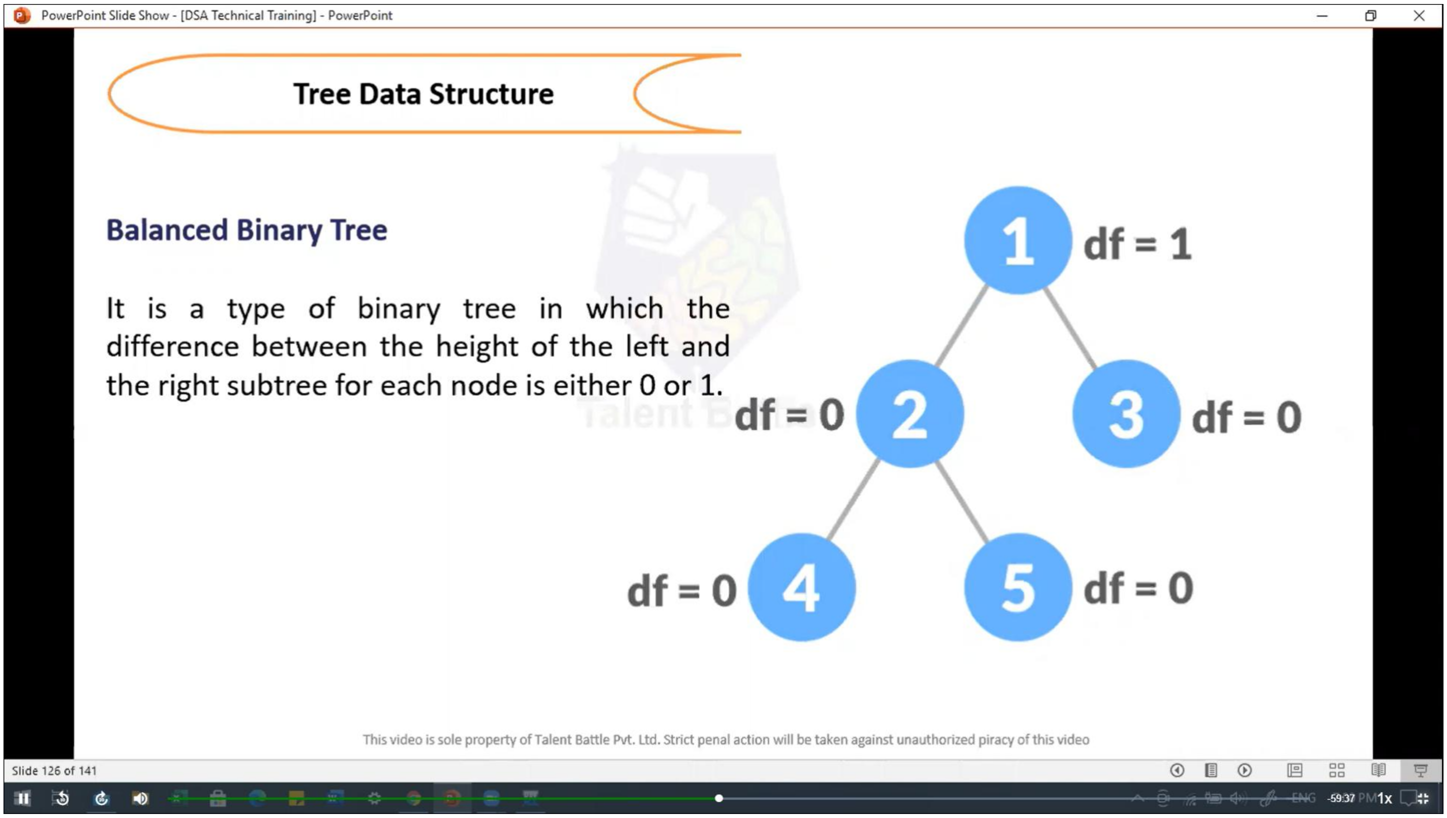
Tree Data Structure

Skewed Binary Tree

A skewed binary tree is a pathological/degenerate tree in which the tree is either dominated by the left nodes or the right nodes.
Thus, there are two types of skewed binary tree:
left-skewed binary tree and
right-skewed binary tree.



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Tree Data Structure

Balanced Binary Tree

It is a type of binary tree in which the difference between the height of the left and the right subtree for each node is either 0 or 1.

1
df = 1
2
df = 0
3
df = 0
4
df = 0
5
df = 0
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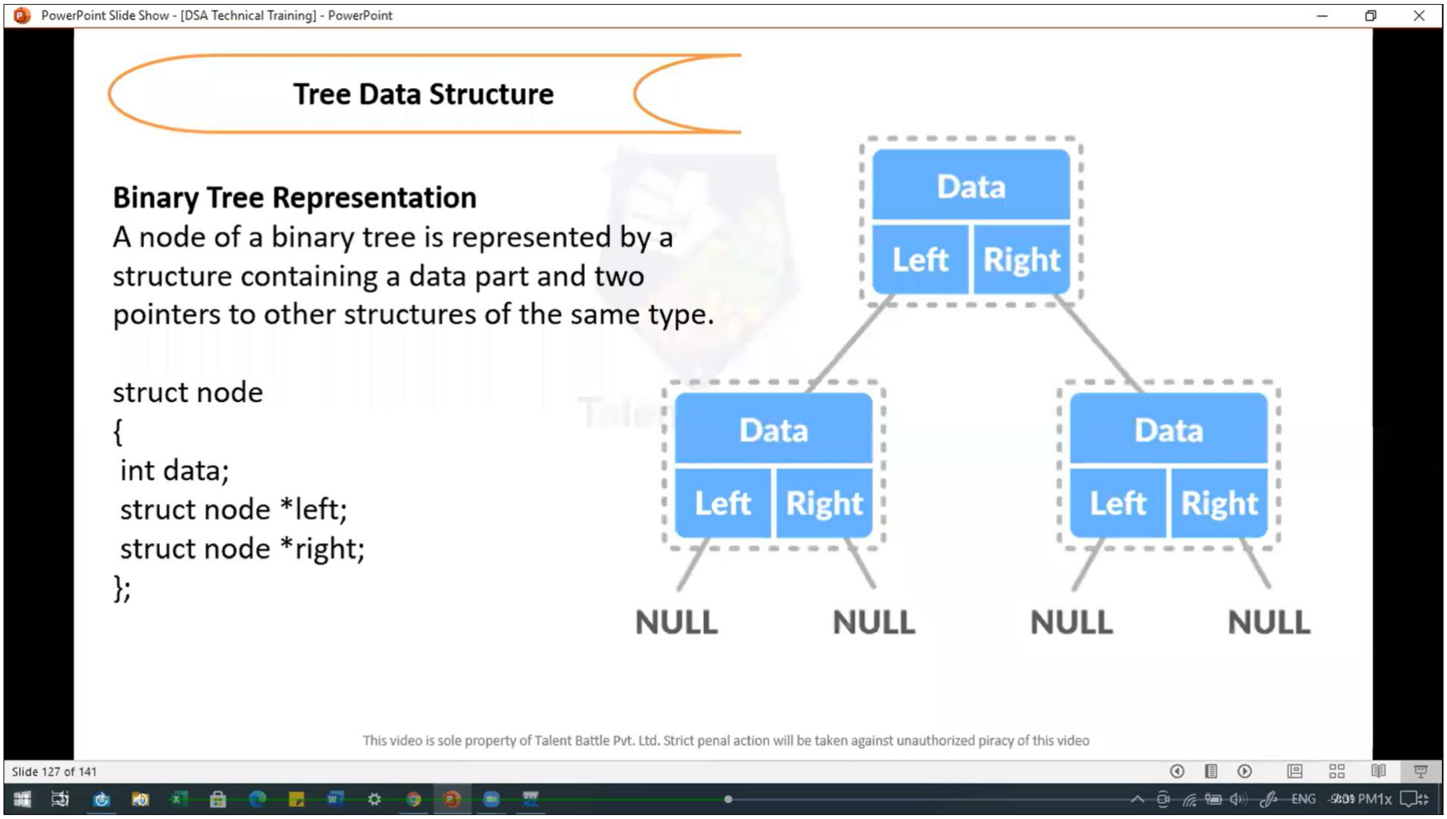

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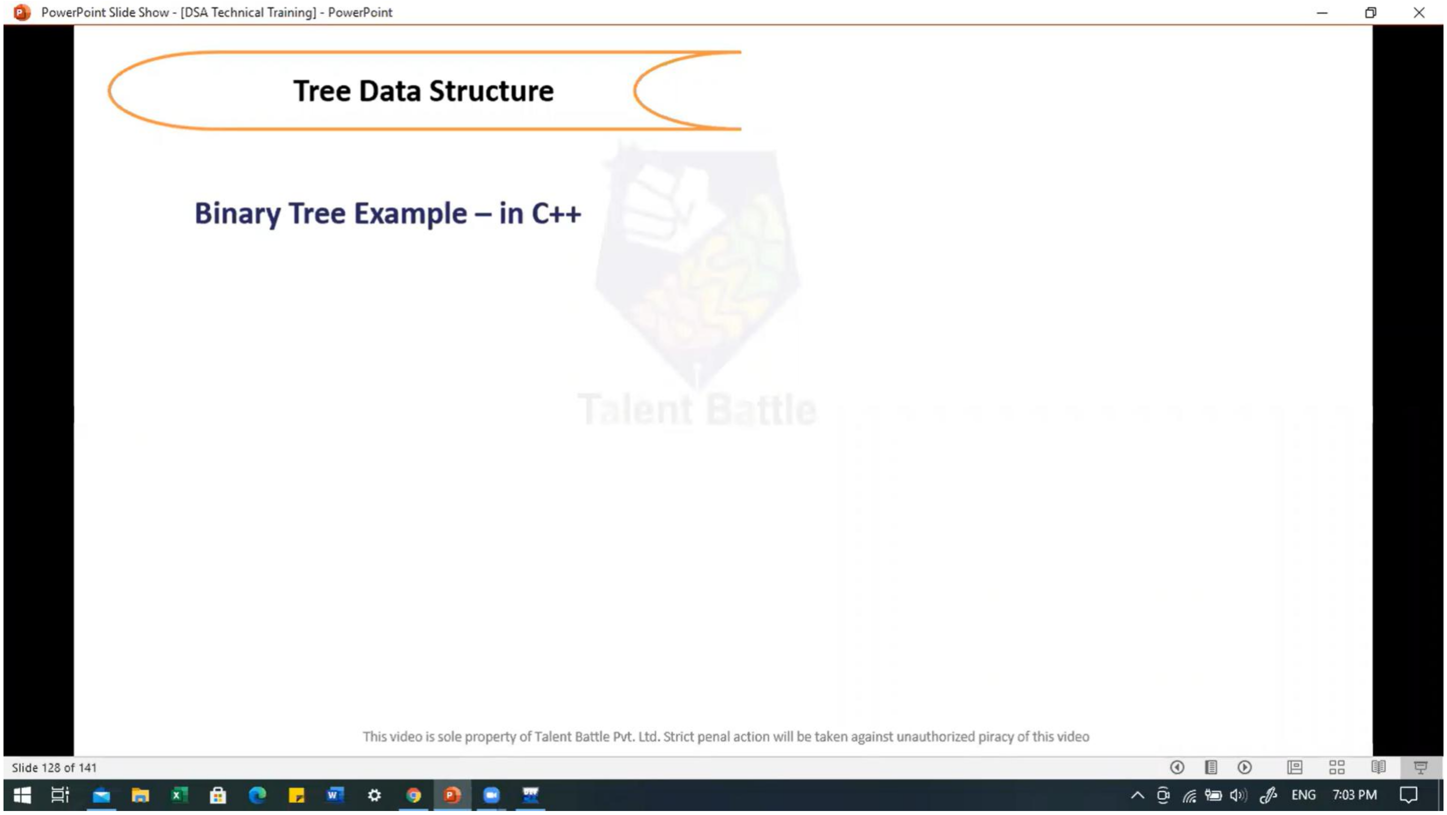
Tree Data Structure

Binary Tree Representation

A node of a binary tree is represented by a structure containing a data part and two pointers to other structures of the same type.

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



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Tree Data Structure

Binary Tree Example – in C++

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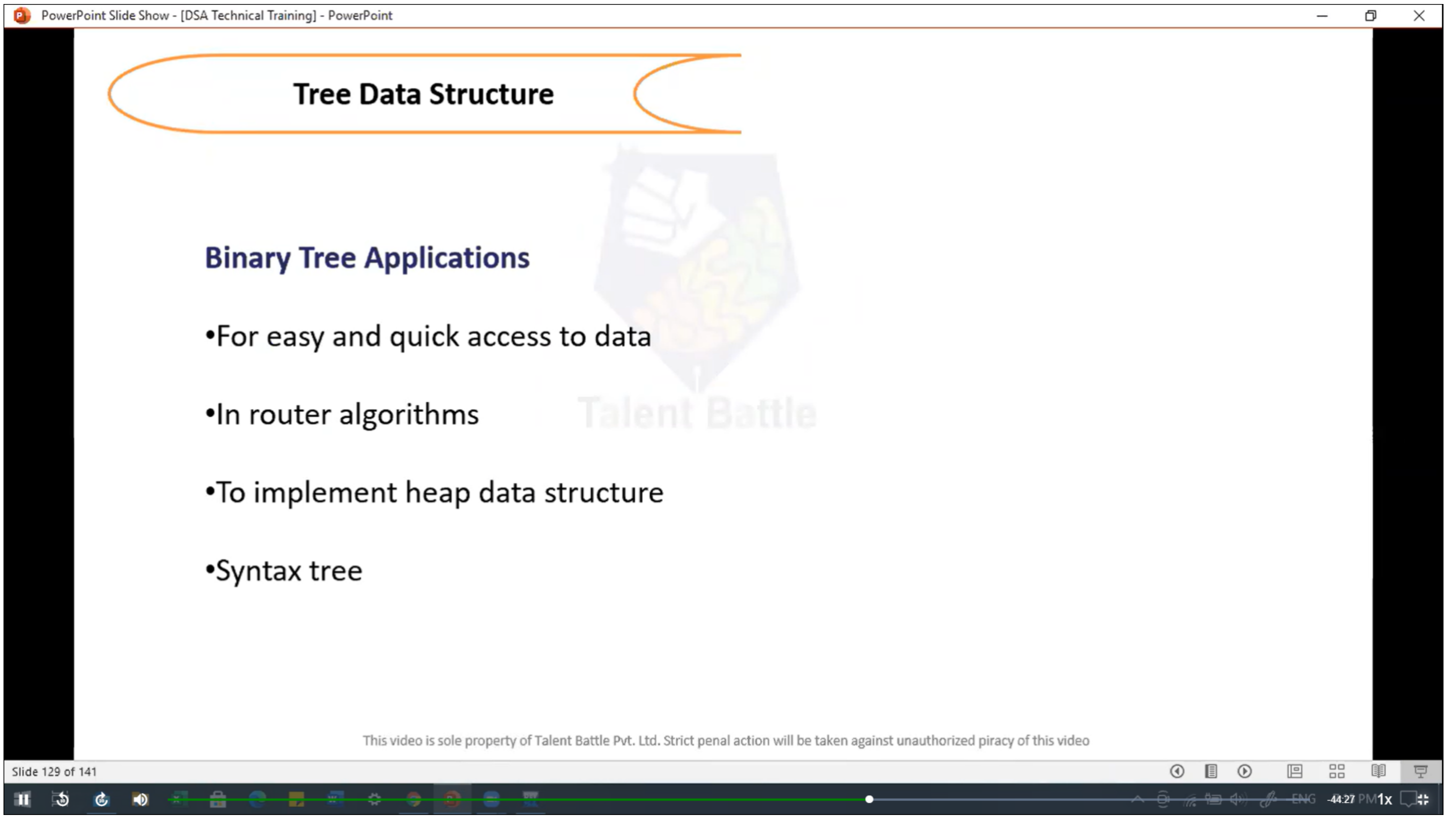

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Tree Data Structure

Binary Tree Applications

- For easy and quick access to data
- In router algorithms
- To implement heap data structure
- Syntax tree

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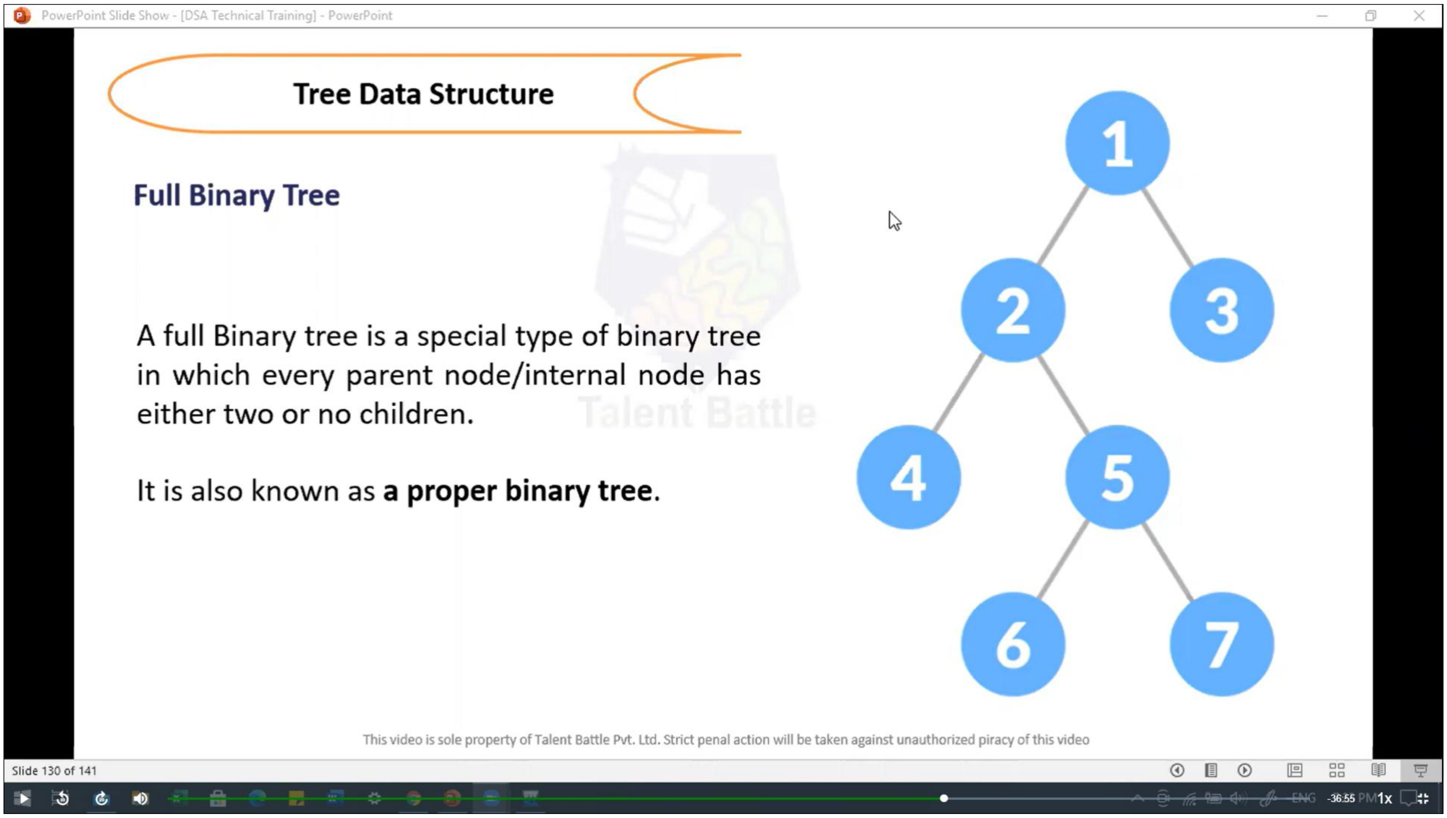
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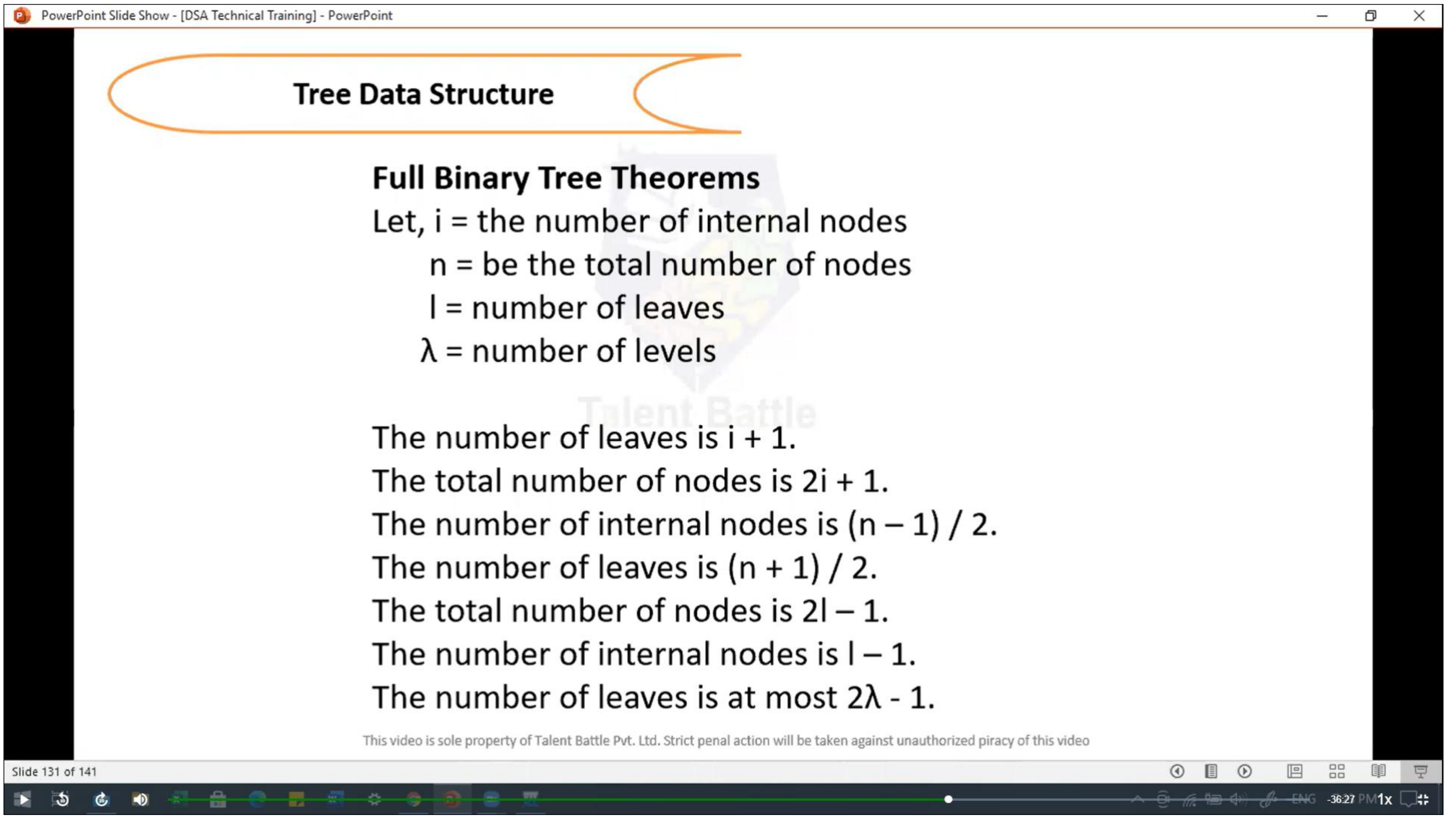
Tree Data Structure

Full Binary Tree

A full Binary tree is a special type of binary tree in which every parent node/internal node has either two or no children.

It is also known as **a proper binary tree**.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Tree Data Structure

Full Binary Tree Theorems

Let, i = the number of internal nodes
n = be the total number of nodes
l = number of leaves
λ = number of levels

The number of leaves is i + 1.
The total number of nodes is 2i + 1.
The number of internal nodes is (n – 1) / 2.
The number of leaves is (n + 1) / 2.
The total number of nodes is 2l – 1.
The number of internal nodes is l – 1.
The number of leaves is at most 2λ - 1.