

# DATA STRUCTURES AND ALGORITHMS

Tree Data Structure

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2

## Content

- Introduction to Tree Data Structure
- Terminologies of trees.
- Binary Trees and their properties
  - Complete Binary Tree
  - Extended Binary Tree
  - Binary Search Tree

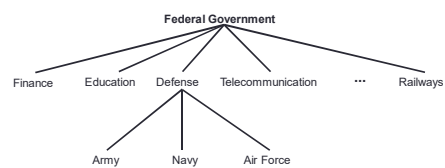
3

## Tree Data Structure

- There are two types of data
  - Elementary Data:
    - Cannot be further divided into sub-parts
  - Group Data
    - Can be divided into sub-parts
    - It is also known as hierarchical data
- Hierarchical Data:
  - Data that has ancestor-descendant, superior-subordinate, whole-part or similar relationship among its elements.
  - The discussed data structures like Arrays, Stack, Queue, Linked List are not suitable for this type of data
  - A Tree is an ideal data structure for representing such kind of data.

4

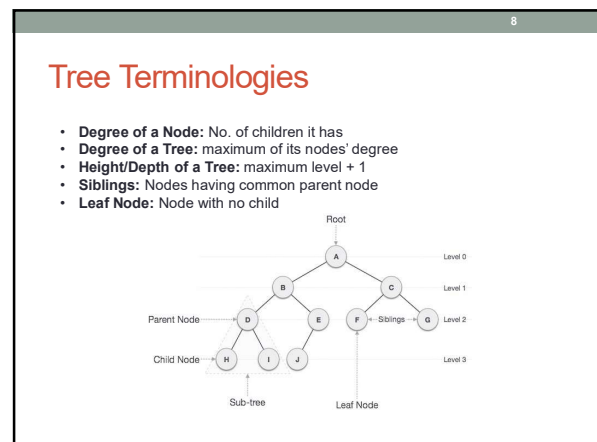
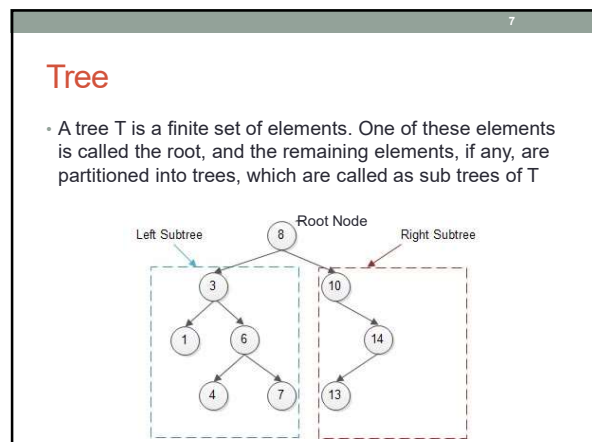
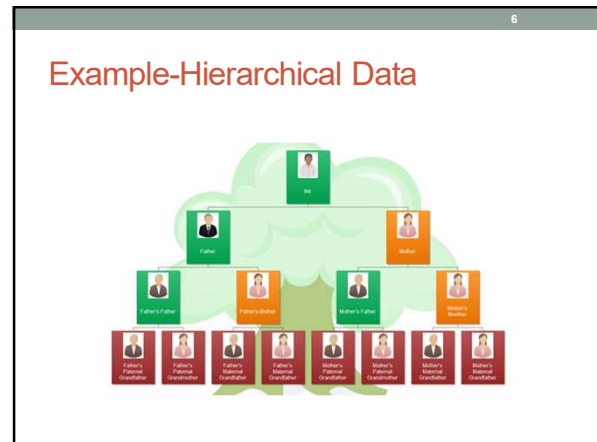
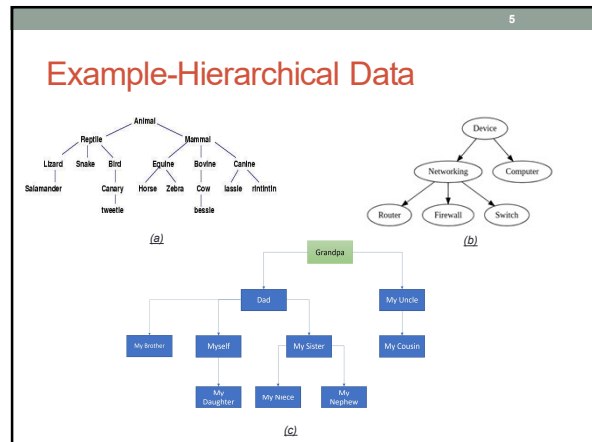
## Example-Hierarchical Data



Representation using Tree Data Structure

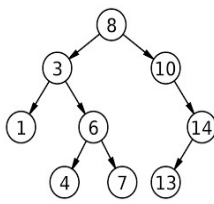
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Representation using Array Data Structure

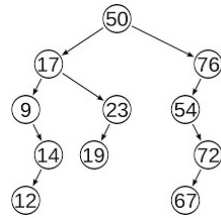


## Binary Trees:

- A binary tree is a tree in which each node either has 0, 1 or 2 children



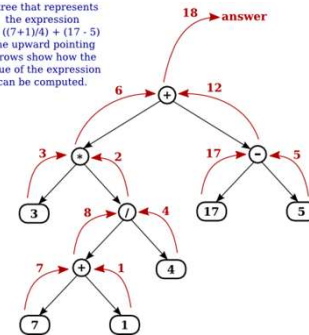
Example 1: Binary Tree



Example 2: Binary Tree

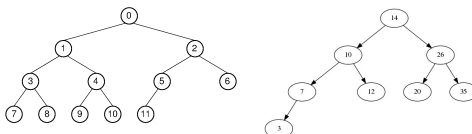
## Binary Trees for Mathematical Expressions

A tree that represents the expression  $3 * ((7 + 1) / 4) + (17 - 5)$ . The upward pointing arrows show how the value of the expression can be computed.

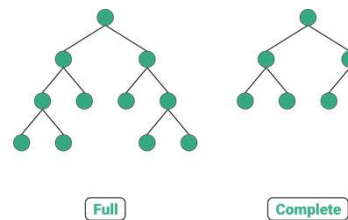


## Complete Binary Tree

- A binary tree  $T$  is said to be complete if all its level, except the last, have maximum number of possible nodes, and all the nodes at the last level appear as far as left as possible i.e. if at the last level, a node have only one child it will be the left one



## Binary Tree vs. Complete Binary Tree



Full

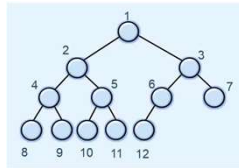
Complete

13

## Complete Binary Tree

- If we numbered nodes of a complete binary tree from top-to-bottom and left-to-right, level by level then we can find the children and parent of any node numbered  $K$  in the complete binary tree.

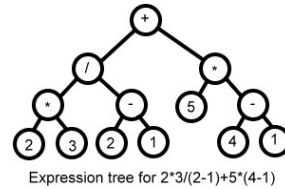
- **Left Child:**  $2K$
- **Right Child:**  $2K + 1$
- **Parent:**  $\lfloor K/2 \rfloor$
- **Height ( $H_n$ )=Depth( $D_n$ )= $\lceil \log_2 n + 1 \rceil$**
- $= \lceil \log_2(12) + 1 \rceil = \lceil 3.58 + 1 \rceil = 4$



14

## Extended Binary Tree

- A binary tree  $T$  is said to be an extended binary tree if each node has either 0 or 2 children,
- In such tree, nodes with two children are known as internal nodes and nodes with 0 children are known as external nodes.



15

## Binary search Tree (BST)

- A Binary search tree is a tree that satisfies the following properties
  - Every element has the key (content) and no other node has the same key i.e. keys are unique
  - The keys, if any, in the left sub tree of the root are small than the key in the root node
  - The keys, if any, in the right sub tree of the root are larger than the key in the root node
  - The left and right sub tree of root are also binary search trees

16

## Binary search Tree (BST) - Examples

