
WELCOME
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[Data structures]

[17/10/2024]

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In this Course

1. Complexity
2. Recursion
3. Arrays
4. Linked Lists
5. Stacks / Queues
6. Trees

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Big-O notation

Big-O notation describes the complexity of your code using algebraic terms. It describes the limiting behavior of our algorithm when the argument tends to infinity.

What is the complexity of loops?

Loops running constant time: O(1)
Loops running n times: O(n)
Loops running multiple of n: O(n)
Nested loop: O(n2)

We only care for dominant terms

```
for (int i=1; i<=c; i=i+1) {
            some O(1) expression
}

for (int i=1; i<=n; i=i+c) {
            some O(1) expression
}
for (int i=1; i<=n*c; i=i+1) {
            some O(1) expression
}
for (int i=1; i<=n; i=i+1) {
      for (int j=1; j<=n; j=i+1) {
            some O(1) expression
      }
}
```

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Recursion

The process in which a function calls itself directly or indirectly is called recursion and the corresponding function is called a recursive function.

- Performing the same operations multiple times with different inputs.
- In every step, we try smaller inputs to make the problem smaller.
- Base condition is needed to stop the recursion otherwise infinite loop will occur.

```
int factorial(int n)
{
    if (n == 0)
        return 1;
    else
        return n * factorial(n-1);
}
```

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Space complexity

Space complexity refers to the total amount of memory space used by an algorithm/program, including the space of input values for execution

What is the space complexity of factorial?

- n integer input parameter
- Factorial is recursive

Recursive solution: O(n), Iterative solution: O(1)

```
int factorial(int n)
{
   if (n == 0)
      return 1;
   else
      return n * factorial(n-1);
}
```

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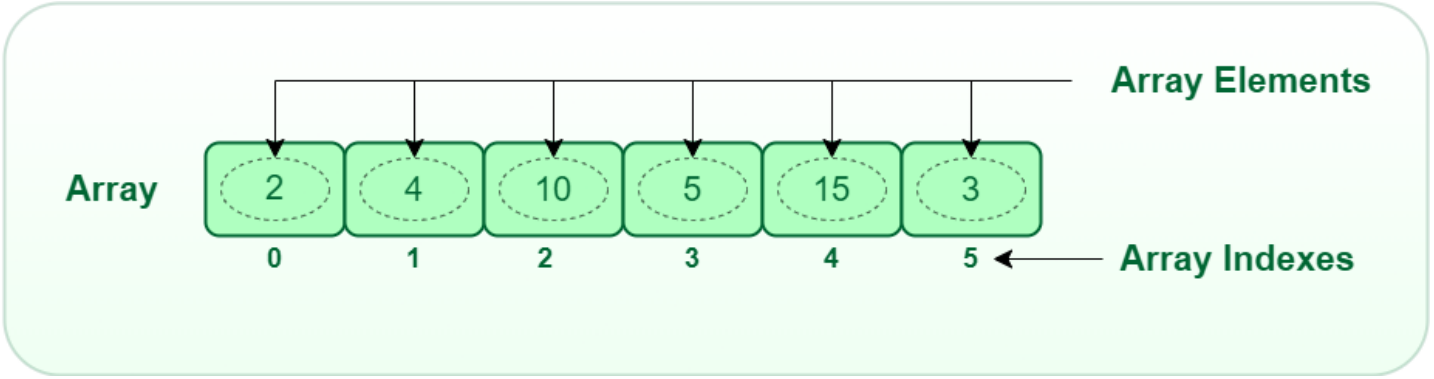
Merge Overlapping Intervals

Given a set of time intervals in any order, our task is to merge all overlapping intervals into one and output the result which should have only mutually exclusive intervals.

Input: Intervals = {{1,3},{2,4},{6,8},{9,10}}
Output: {{1, 4}, {6, 8}, {9, 10}}
Explanation: Given intervals: [1,3],[2,4],[6,8],[9,10], we have only two overlapping intervals here,[1,3] and [2,4]. Therefore, we will merge these two and return [1,4],[6,8], [9,10].
Input: Intervals = {{6,8},{1,9},{2,4},{4,7}}
Output: {{1, 9}}

Arrays/Lists

An array is a collection of items of same data type stored at contiguous memory locations. Each element is accessed through its index.



The array is fixed size. For expanding if we change the size we can't be sure that we get the next memory location to us for free. The shrinking will not work because the array, when declared, gets memory statically allocated, and thus compiler is the only one that can destroy it.
Lists are like dynamically sized arrays. Their size can change dynamically on runtime.

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Multidimensional Arrays

A multidimensional array is an array of arrays. Arrays can have any number of dimensions.

	COLUMN 0	COLUMN 1	COLUMN 2
ROW 0	1	4	2
ROW 1	3	6	8

To access an element, we must specify the number of both row and column .Traversing a 2D array requires a nested loop.

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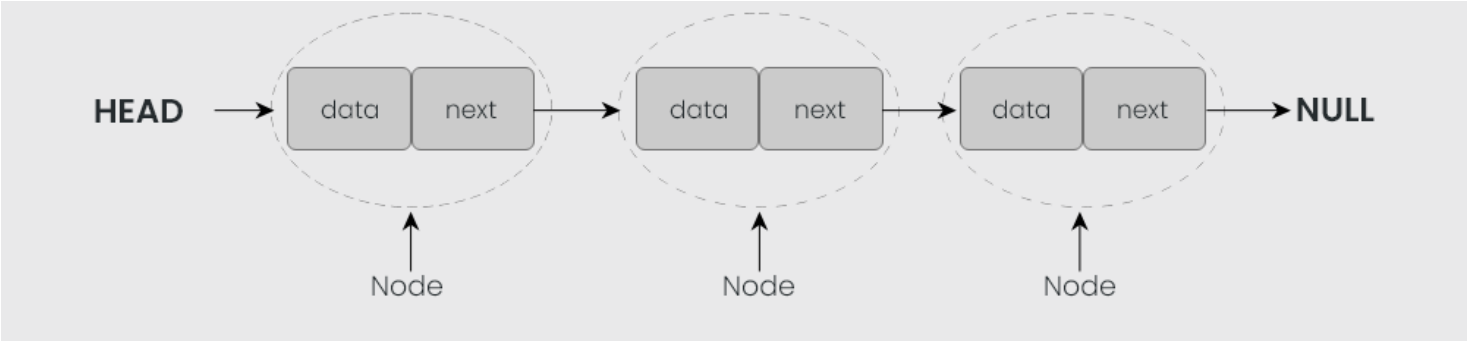
Linked Lists

A linked list is a linear data structure, in which the elements are not stored at contiguous memory locations. The elements in a linked list are linked using pointers



Basic Operations:

- Push
- Delete
- Print

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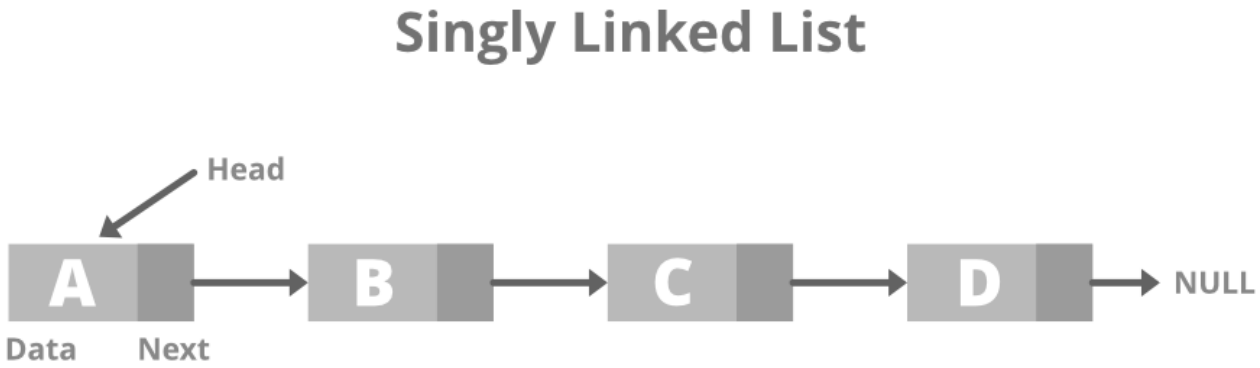
Singly Linked Lists

It is the simplest type of linked list in which every node contains some data and a pointer to the next node of the same data type.



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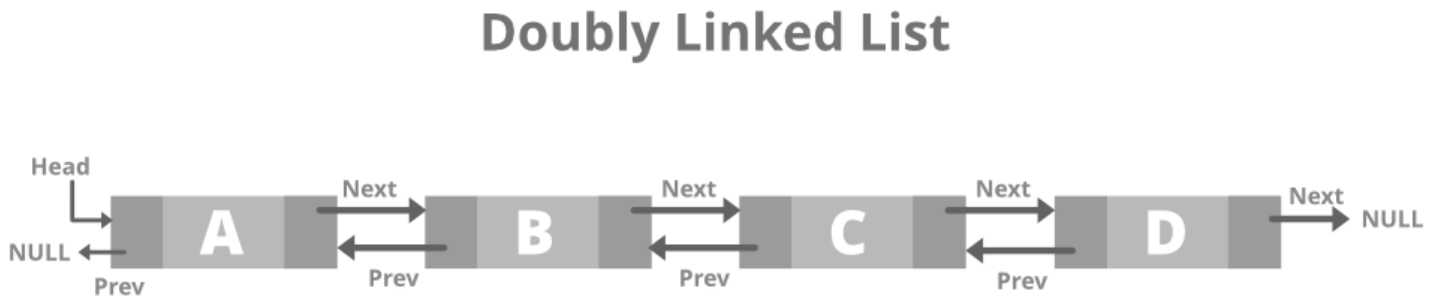
Doubly Linked Lists

A doubly linked list or a two-way linked list is a more complex type of linked list that contains a pointer to the next as well as the previous node in sequence.



Time complexity: O(N)
Space complexity: O(N)

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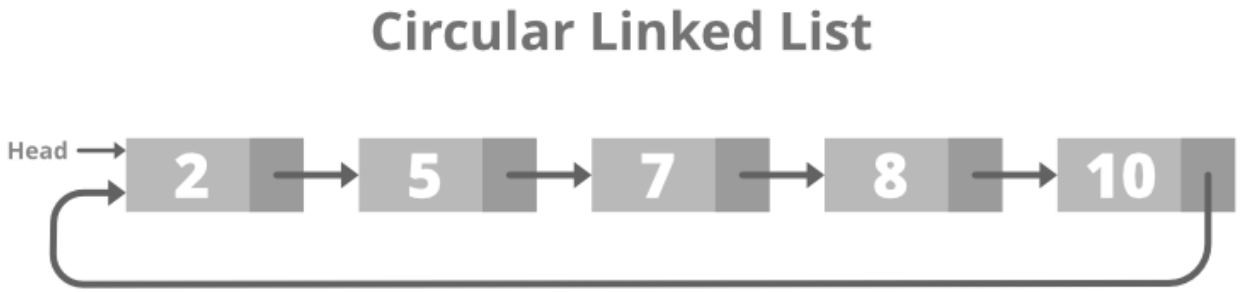
Circular Linked Lists

A circular linked list is that in which the last node contains the pointer to the first node of the list.



Time complexity: O(N)
Space complexity: O(N)

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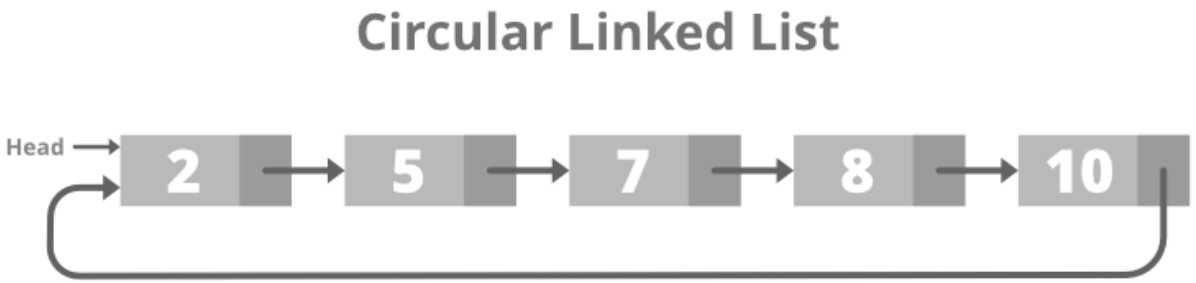
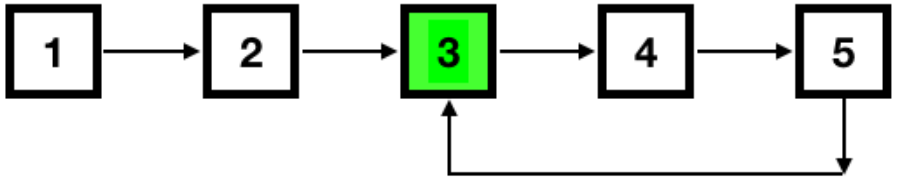
Circular Linked Lists quiz

Can you describe an algorithm to check if a linked list has a circle?





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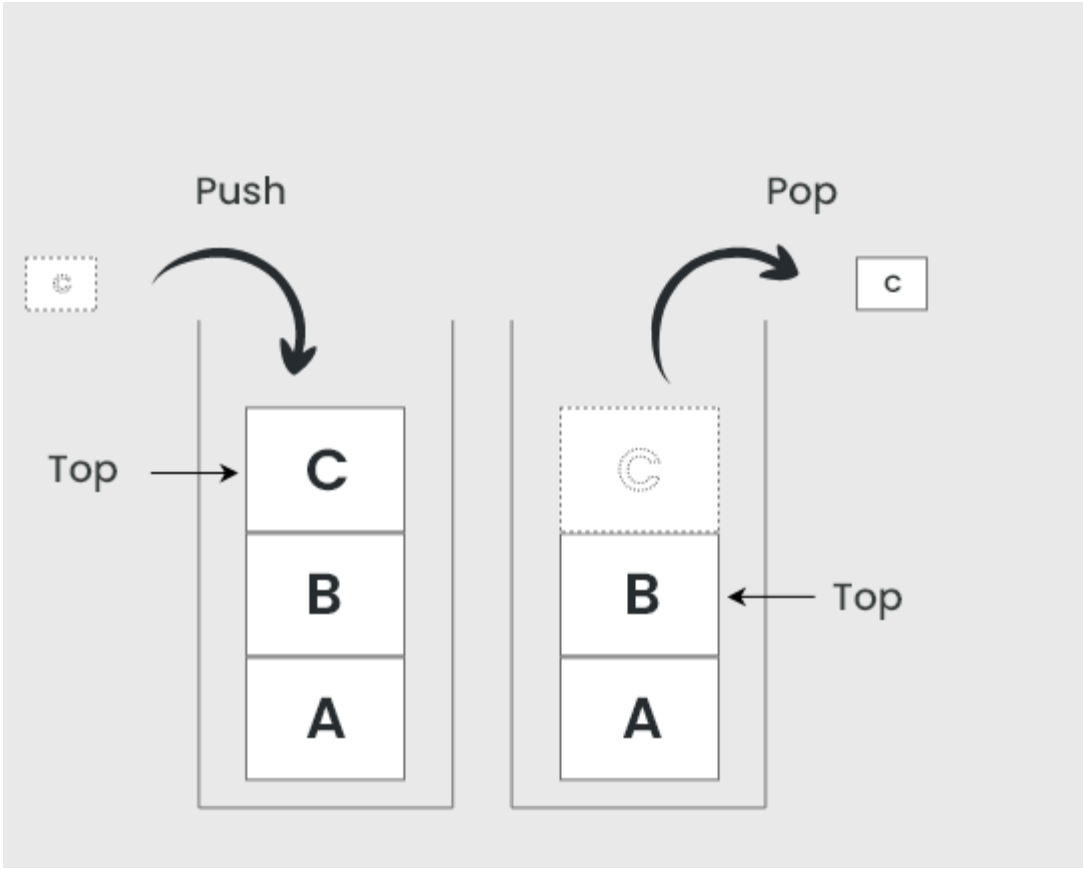
Stacks

Stack is a linear data structure that follows a particular order in which the operations are performed. The order is LIFO(Last In First Out) meaning that the element that is inserted last, comes out first.



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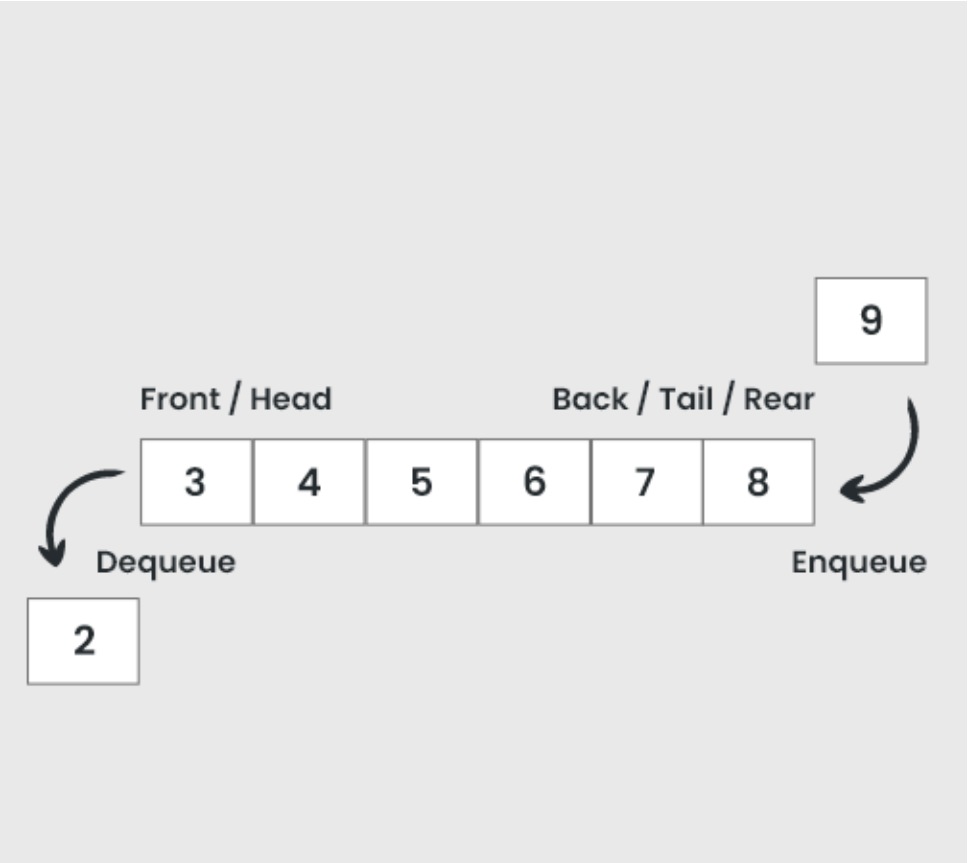
Stacks

Pros	Cons
Easy implementation	Limited capacity
Efficient memory utilization	No random access
Fast access time	Memory management
Helps in function calls	Not suitable for certain applications
Supports backtracking	Stack overflow and underflow
Used in Compiler Design	Recursive function calls limitations

Queues

A Queue is defined as a linear data structure that is open at both ends and the operations are performed in First In First Out (FIFO) order.



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Queues

Pros	Cons
Easy to manipulate large amount of Data	Insertion / deletion at the middle are hard
Insert & delete are fast	Searching takes O(N) time
Useful for multi customer systems	Overhead memory
Can be used to implement other data structures	Synchronization issues

Length of the longest valid substring

Given a string consisting of opening and closing parenthesis, find the length of the longest valid parenthesis substring.

Input : (((()
Output : 2
Explanation : ()

Input:)()())
Output : 4
Explanation: ()()

Input: ()((()))))
Output: 6
Explanation: ()(())

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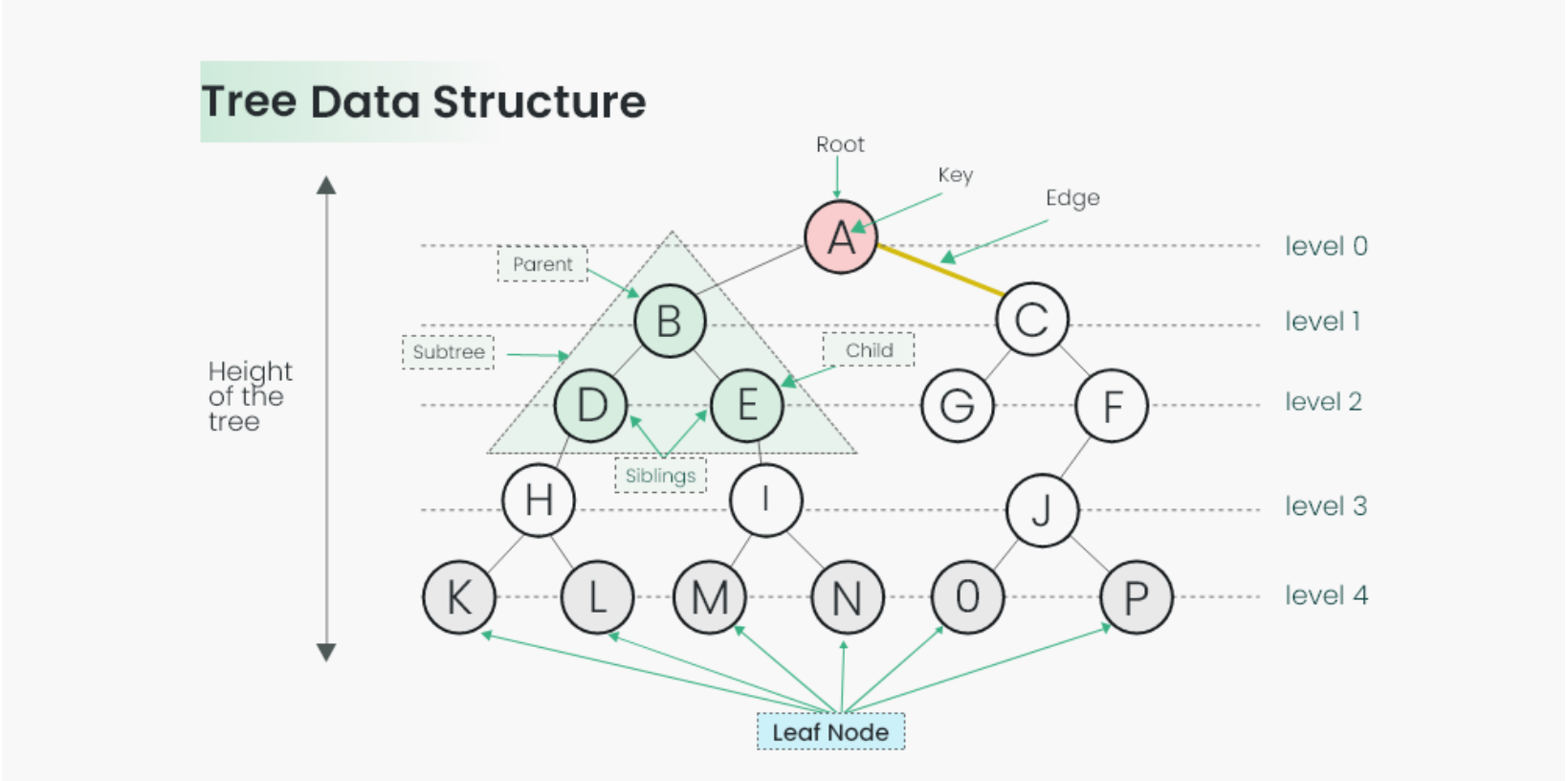
Trees

Tree Data Structure is a hierarchical data structure in which a collection of elements known as nodes are connected to each other via edges such that there exists exactly one path between any two nodes.



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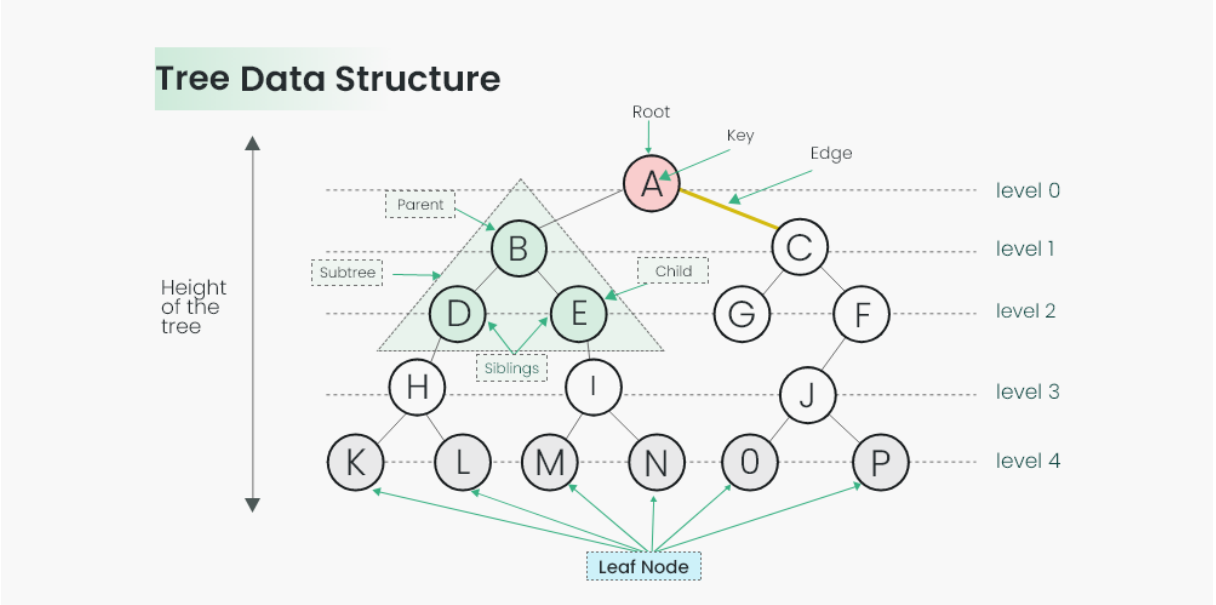
Trees – Basic Operations

Basic Operations

- Height of tree
- Height/Depth of node
- Level of node
- Search a node
- Find the parent of a node
- Find leafs of node
- Find siblings/children of node
- Tree traversal (Inorder, Preorder, Postorder)



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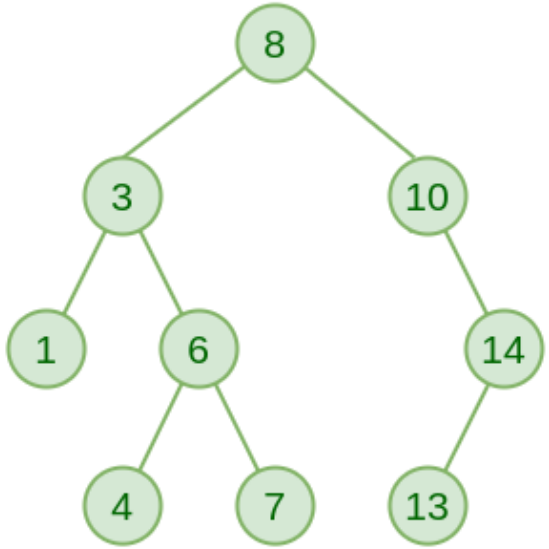
Binary search trees

Binary Tree has the following properties

- The left subtree of a node contains only nodes with keys lesser than the nodes key
- The right subtree of a node contains only nodes with keys greater than the nodes key
- The left and right subtree each must also be a binary search tree.



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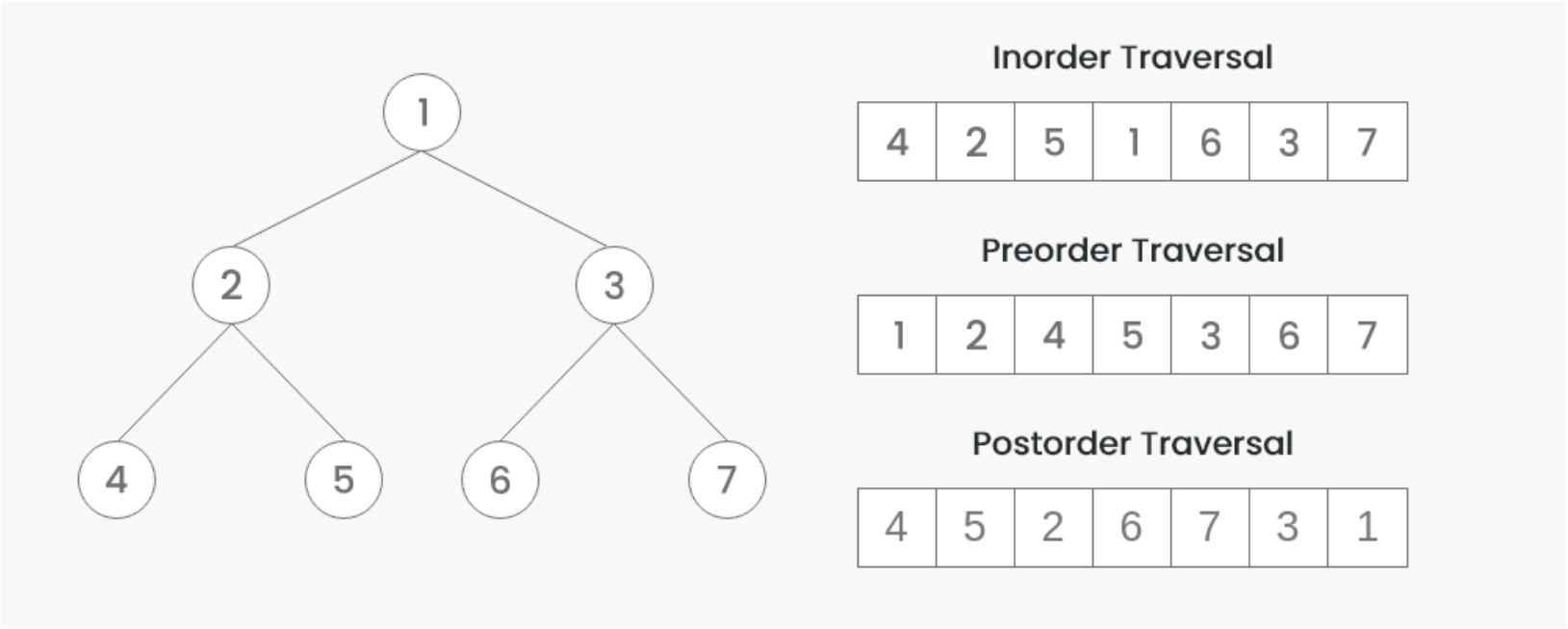
Tree traversal

Inorder:
1)Traverse left subtree
2)Visit the root
3)Traverse right subtree

Preorder:
1) Visit the root
2) Traverse left subtree
3)Traverse right subtree

Postorder:
1)Traverse left subtree
2) Traverse right subtree
3) Visit the root



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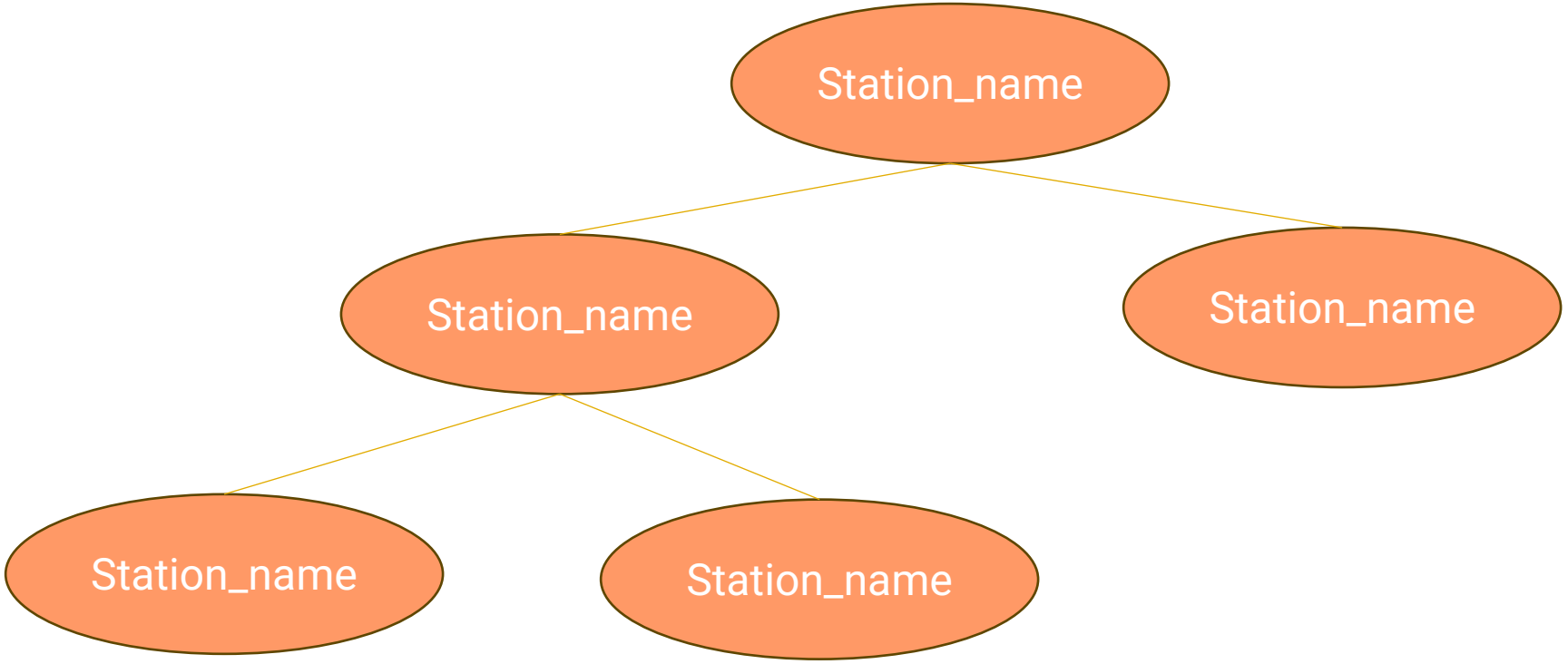
The London subway problem

Given all the London subway stations, design an algorithm that will print the minimum numbers of stations one has to visit to stations containing all the names of English alphabet (pangram)



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Feedback Discussion

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Thank you

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