Introduction

A segment tree is a heap-like data structure that can be used for making update/query operations upon array intervals in logarithmical time. We define the segment trees for the interval [i, j] in the following recursive manner.

- The root node (first node in the array) node will hold the information for the interval [i,j].
- If i < j the left and right children will hold the information for the interval [i, (i + J)/2] and [(i+j)/2 + 1, j].

A segment tree is a cool data structure, primarily used for a range query. It is a height-balanced binary tree with a static structure. The nodes of the segment tree correspond to various intervals and can be augmented with appropriate information pertaining to those intervals.

Need for Segment Trees

Consider the following problem -
Given an array A consisting of n integers. You need to support 2 types of queries.

1. Find the sum of all elements of the array from 1 to i for a given index i.
2. Update the ith element of the array from a[i] to x.

There can be two possible approaches to this problem -

1. Maintain the array A dynamically, so that updates can be done in O(1) but every query of the first type will take O(n) time in the worst case as it will require finding the sum of n elements. So if there are q queries and majority of them are of the first type, then the worst case of this algorithm will be O(nq).
2. Maintain the array B dynamically, where B[i] stores the sum of all elements from A[0] to A[i]. Now each query of the first type can be done in O(1) but every query of the second type will take O(n) time in the worst case as it will require updating all elements of B from i to n. So if there are q queries and the majority of them are of the second type, then the worst case of this algorithm will be O(nq).

We will now discuss how we can use segment trees to support both these type of queries with the total run time of O(qlogn) where q is the number of queries and each query takes O(logn) time.
In short problems where we need to maintain some information with updates, segment trees come to the rescue.