



# SEGMENT TREE

Build, Query, Update, Lazy

# CONCEPT

- Graphs
- Trees
- Sorry lads, no search trees for today
- Segment Tree

# SO WHAT KIND OF PROBLEMS DOES ST SOLVE?

We have an array  $[1 \dots n]$  we have two kinds of queries

- Find the sum of elements from index  $l$  to  $r$  where  $1 \leq l \leq r \leq n$
- Change the value of a specified element  $a_i$  to a new value  $x$  where  $1 \leq i \leq n$

Find *min/max* in an array with an update query (Range Minimum Query or RMQ)

And many others...



# SEGMENT TREE ILLUSTRATION



# **BUILD FUNCTION**



# QUERY FUNCTION



# UPDATE FUNCTION

# COMPLEXITY

- Build Function  $O(n)$  [There are  $2n - 1$  nodes]
- Update and Query  $O(\log n)$  [Height of the tree is  $\log n$ ]



# PROBLEMS

- <https://www.spoj.com/problems/KGSS/>

# OPEN DISCUSSION: WHAT IF WE NEEDED TO UPDATE A GIVEN RANGE?

- For example: Increase all elements in a range by  $x$

# LAZY PROPAGATION

- Restoring the  $O(\log n)$  complexity for the **query** function
- Skipping unnecessary steps

# PROBLEM ON LAZY PROPAGATION

- <https://www.spoj.com/problems/HORRIBLE/>
- <https://www.spoj.com/problems/LITE>



**THAT'S IT FOR TODAY**

