Q ⇒ Given a list of integers and q queries,

In each query you will have 2 type

Type 1 → x y $a[x] = y$

Type 2 → x y $\text{Sum}\underline{[x \ldots y]}$

Range Queries

1) Type 1 query → $a[x] = y$ → $O(1)$

Type 2 query → $[X \quad Y]$ → $O(n)$

iterate

$x \to 0$

$y \to n-1$

$SC \to O(1)$

2) $f(x, y) = \text{prefix}(y) - \text{prefix}(x-1)$

Sum of elements from x to y

→ $a[x] = y$

Type 1 → $O(n)$

↳ Type 2 → $O(1)$

$SC \to O(1)$

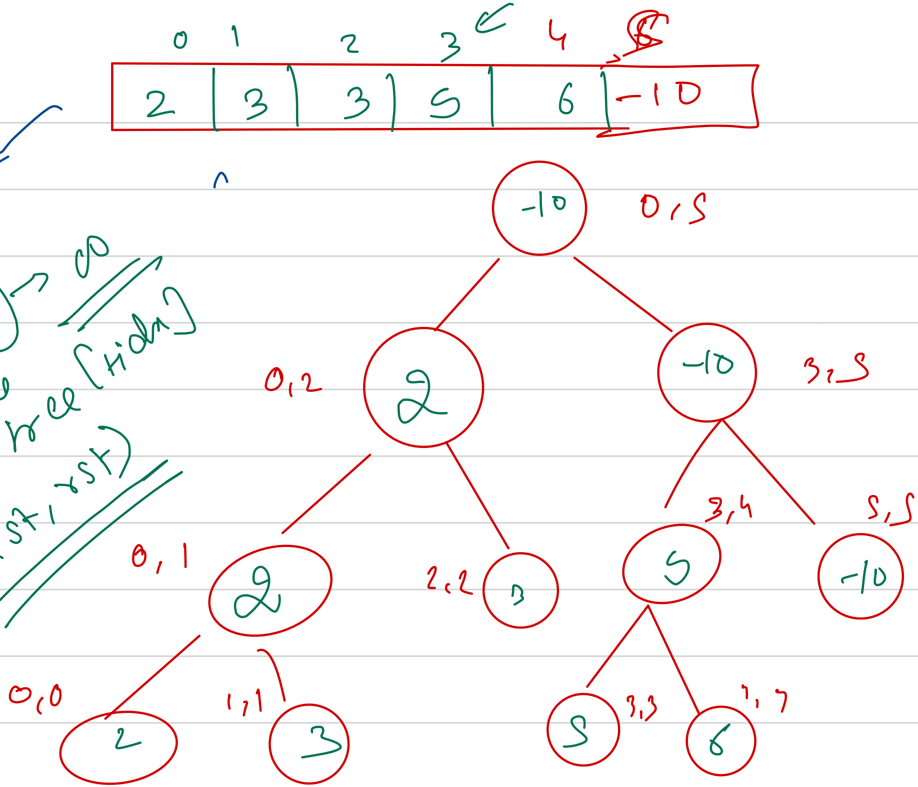
Segment Trees → We represent segment trees as a hierarchy based DS, but implement it linearly.

Demo

complete outside } → ∞

cap inside tree (tidx)

partial min (lst, rst)



→ 9

a(x)=y

Type 1 → x y

Type 2 → x y

min (x.. y)

0,3

0,4

3 → 5

TC → update → O(h)

query → O(h)

Example of Segment trees

Each node denotes some segment.

1) if the range denoted by the node is completely inside the range denoted by query, then this whole node is useful. Return node value.

2) if the range denoted by the node is completely outside the range denoted by query, then this whole node is not useful. Return 0.

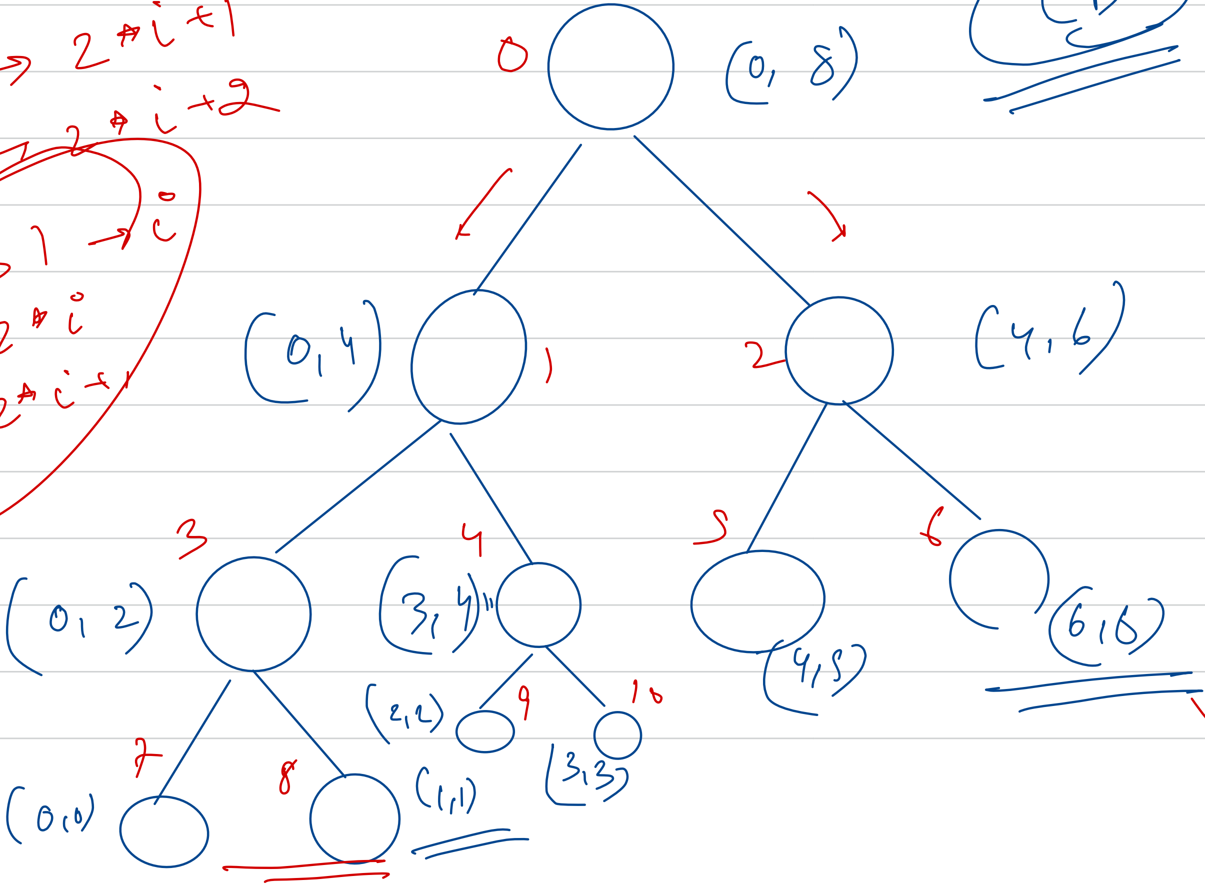
if root → 0

root → i
lst → 2*i+1
rst → 2*i+2

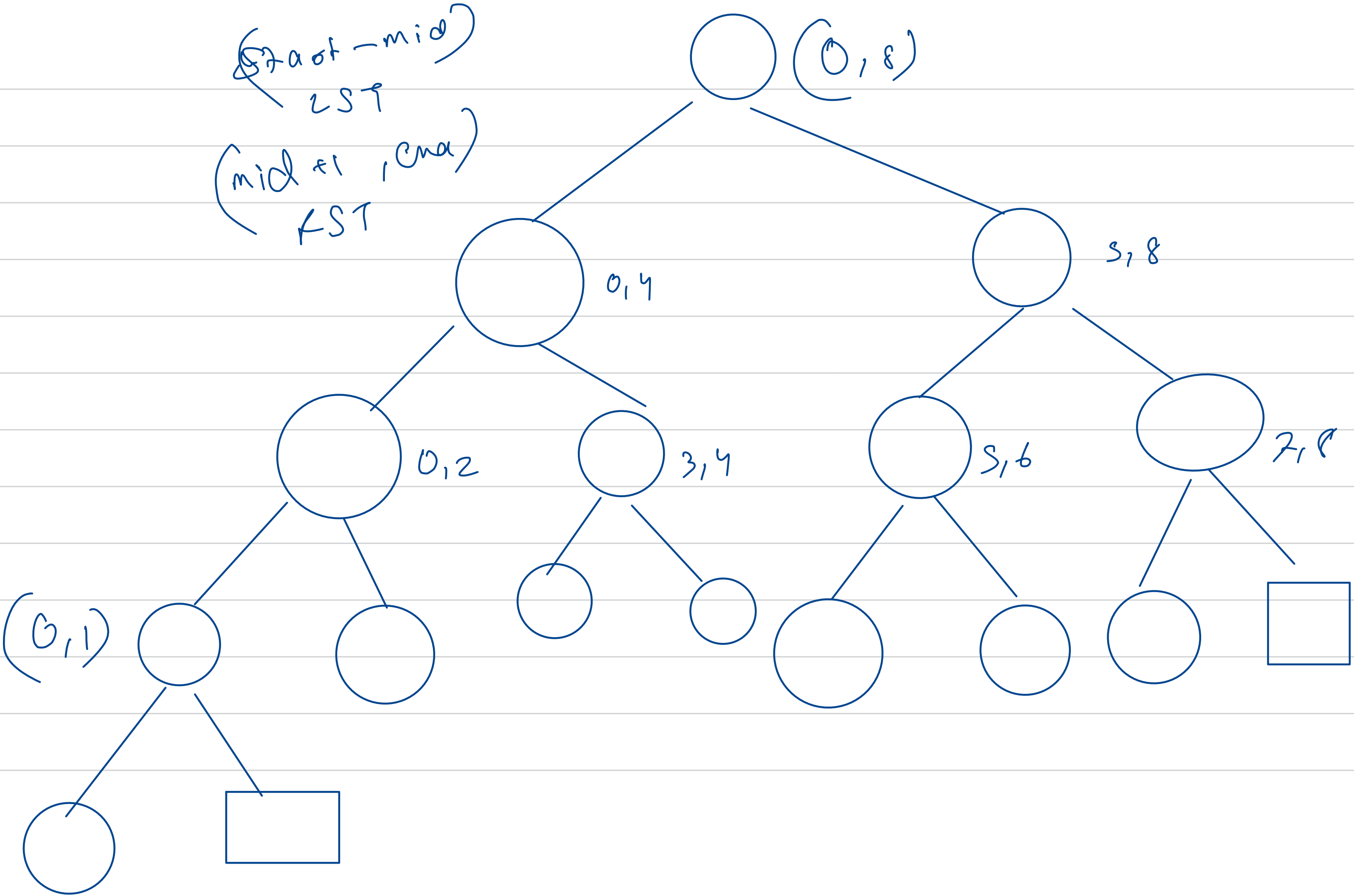
root → 1 → i
lst → 2*i
rst → 2*i+1

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9

CBT



2nd last leaf


(Start - mid)
LST
(mid+1 , end)
RST
(0, 8)
0, 4
5, 8
0, 2
3, 4
5, 6
7, 8
(0, 1)

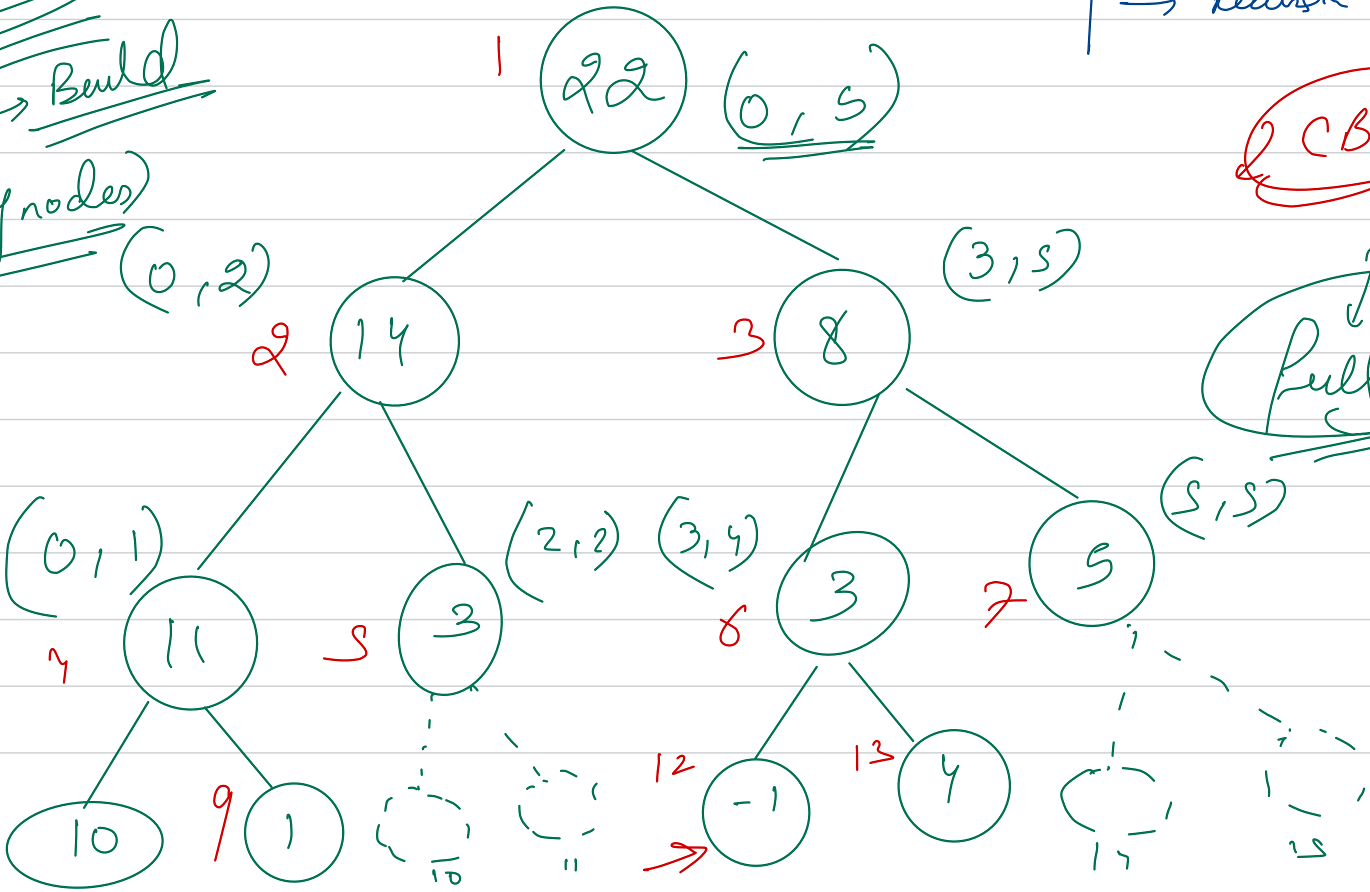
Even length array ←

10	1	3	-1	4	5

→ Self work
→ Base Case
→ Recursion

TC → Build

O(no. of nodes)



CBT

2,2

Full BT

$0 \longrightarrow 1$

$1 \longrightarrow 2$

$2 \longrightarrow 4$

$\vdots$

n^{c_1} $\qquad$ 2^{n}

$\vdots$

$\longrightarrow 2^{l}$

CBT

At the last level → $\boxed{n}$ leaf nodes → Size of arr

internal nodes ??

$O(n)$

Total nodes → $2n$
↳ last level → n
internal → n

In a CBT →

$$\overbrace{\underbrace{2^0 + 2^1 + 2^2 + 2^3 - - - - - - - 2^{h-2}}_{0\text{th lvl} \qquad\qquad 2^{nd}\text{ last level}} + 2^{h-1}}^{\text{last level}} = x$$

$$1 \times \frac{2^{h-1} - 1}{2-1} + 2^{h-1} = x$$

$$2^{h-1} + 2^{h-1} = x + 1 \Rightarrow 2^{h-1} = \frac{(x+1)}{2}$$

Segment → Arrays

2n → Size of the array

→ 3n → 4n

h → perfect BT

Total nodes → S

$2^h - 1 = n$

$2^h = n+1$

$h = \log_2(n+1)$

$S \le 2^h - 1$

$2^{\log n - 2} < n$

$S \le 2^{\log n} - 1$

4n

$\boxed{S < 4 \times n}$

$S < 2^{\log n}$

$S < 2 \times 2^{\log n - 1}$

$S < 2 \times 2 \times 2^{\log n - 2}$

→ $S < 4 \times 2^{\log n - 2}$

Space time
trade off

→ **KGSS** → $\boxed{a_1 \quad a_2 \quad \overset{X}{a_3} \; - - - - \overset{Y}{-} \; a_n}$

$a_1 < a_2 < a_3 < a_n - - - - < a_n$

↳ $\underline{\underline{a_y + a_{y-1}}}$ } → $a_y \to \text{max}$

$a_{y-1} \to 2^{nd}\ \text{max}$

unsorted form → X   Y

↳ max

↳ 2nd max

for each segment → find the max & 2nd max

pair ← <f, s>

f → max

s → 2nd max

root

root → max = max(lst.max, rst.max)

root → 2nd max = min(max(lst.m, RST.2m), max(lst.2m, RST.m))