



Worst case: $O(n)$

average case: $O(\log n)$

high probability

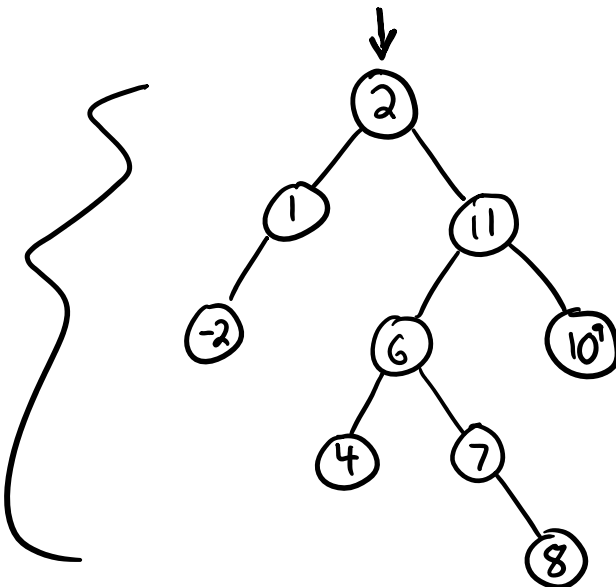
2 11 6 7 8 1 4 -2 10^9

Random Binary Search Tree

$\boxed{\text{Depth}}$

Worst Case: $O(n)$

Best Case: $O(\log n)$

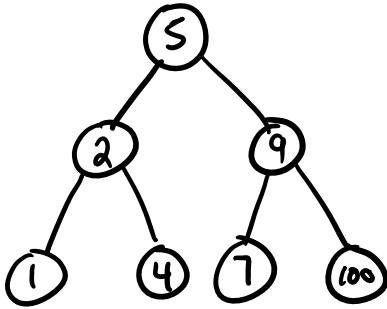
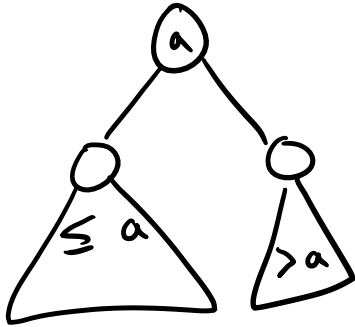


1 3 8 9 10

Cartesian Tree

$x =$ BST value
 $y =$ heap value

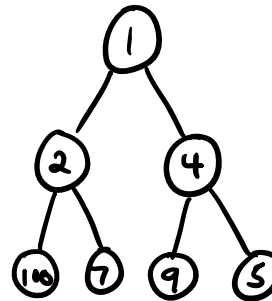
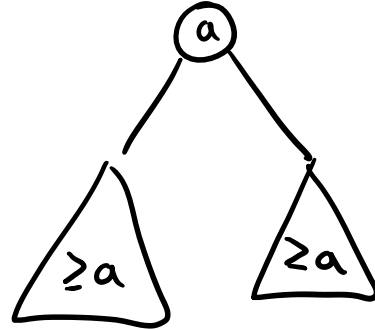
BST property



(1, 8)

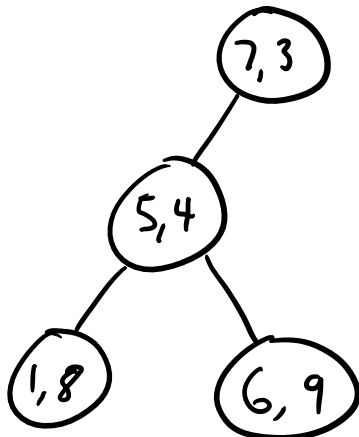
(7, 3)

heap



(5, 4)

(6, 9)

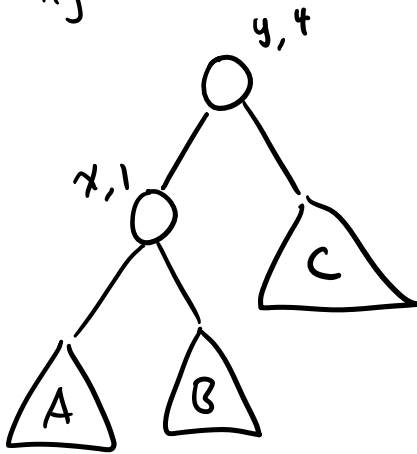


Treap:

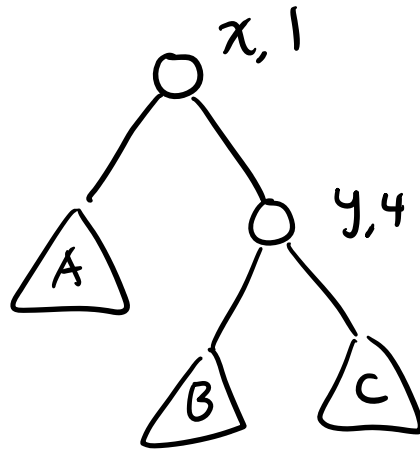
x = key
 y = randomized } build Cartesian Tree

Tree Balancing

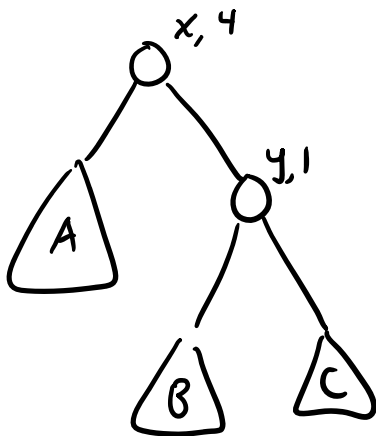
Right rotate



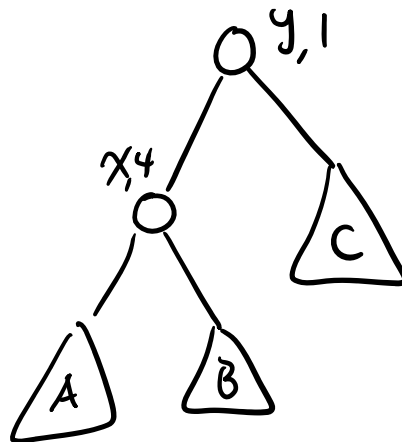
\Rightarrow



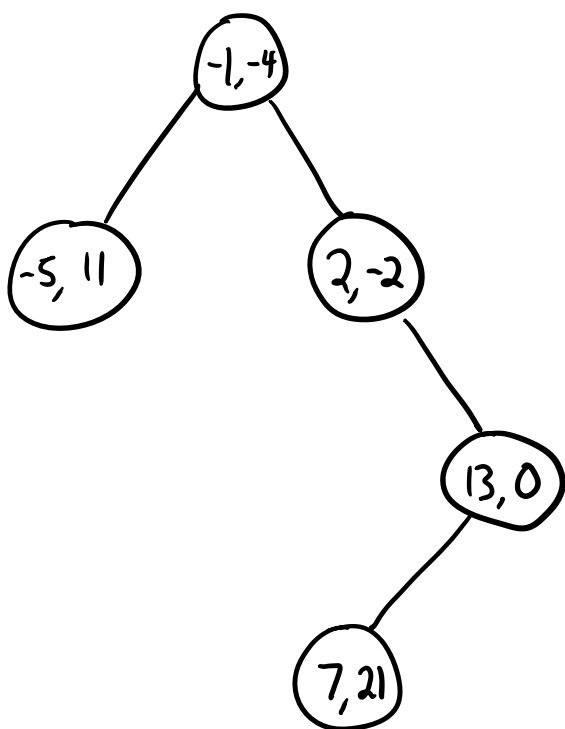
Left rotate



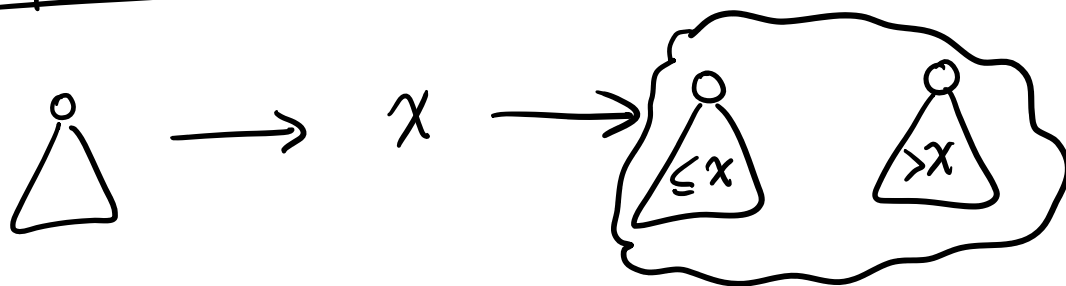
\Rightarrow



-5	-1	2	7	13
11	-4	-2	21	0

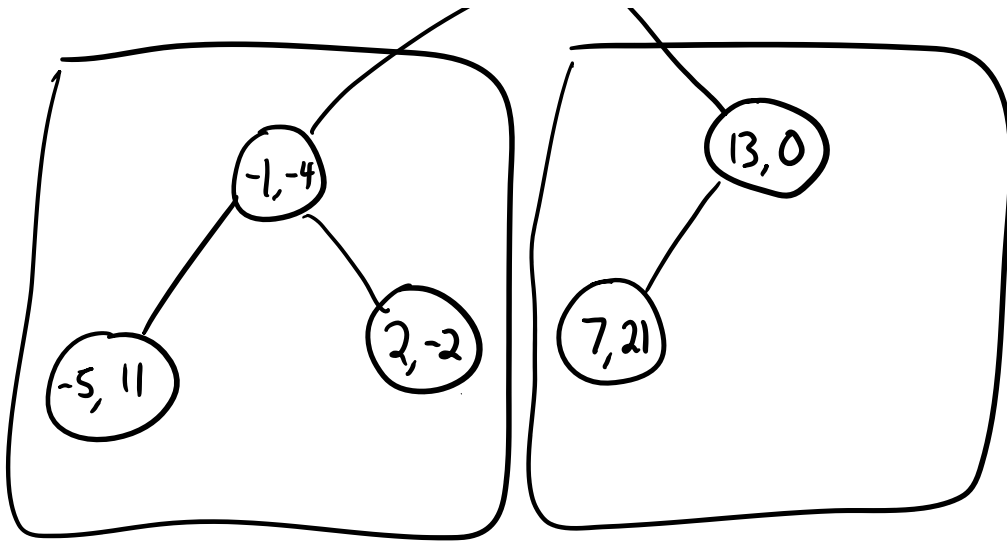


Split tree in half $O(\log n)$



$(3, -\infty)$



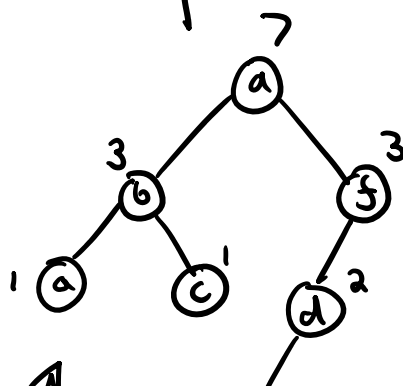


a z b c a d b a a b c a b b b

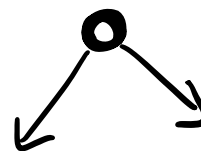
- insert a character into string
 - delete a character from string
 - move pieces around
- } $O(\log n)$

Rope

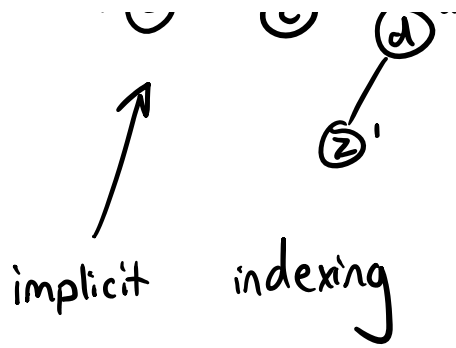
abca³df ← in order traversal



0

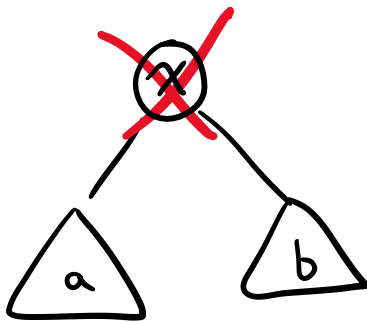


Sum



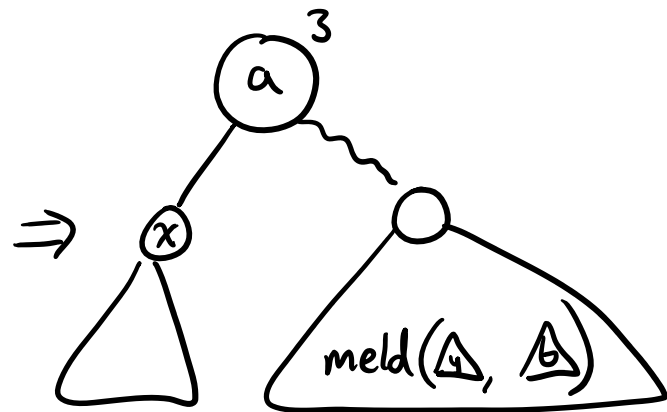
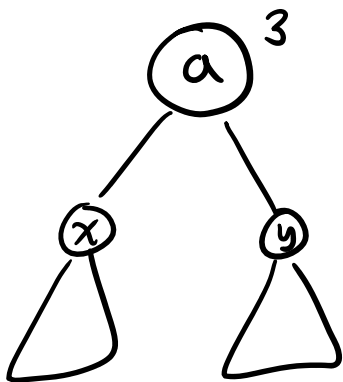
Sum
min
max

Deletion in a treap



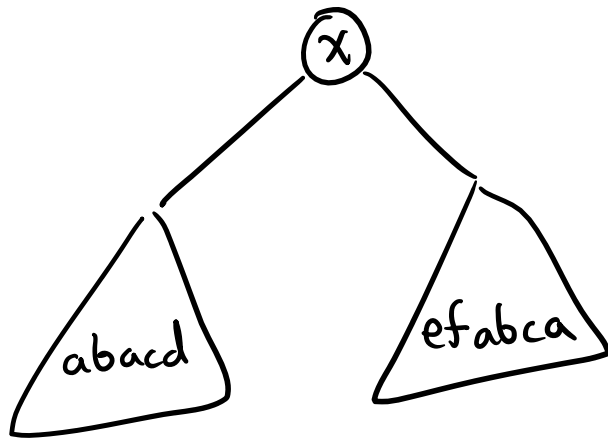
$\rightarrow \text{meld}(\triangle a, \triangle b)$
 $O(\log n)$

Meld



$\text{depth}(a) + \text{depth}(b)$

split
 abacd|efabca



meld (, )

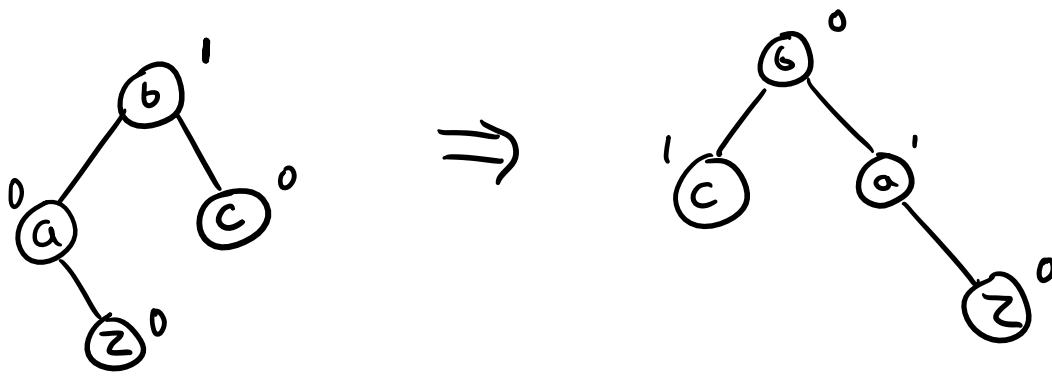
aba arupguha zzz
 ↓
 reverse
 ↓
 aba ahugpura zzz

$O(\log n)$

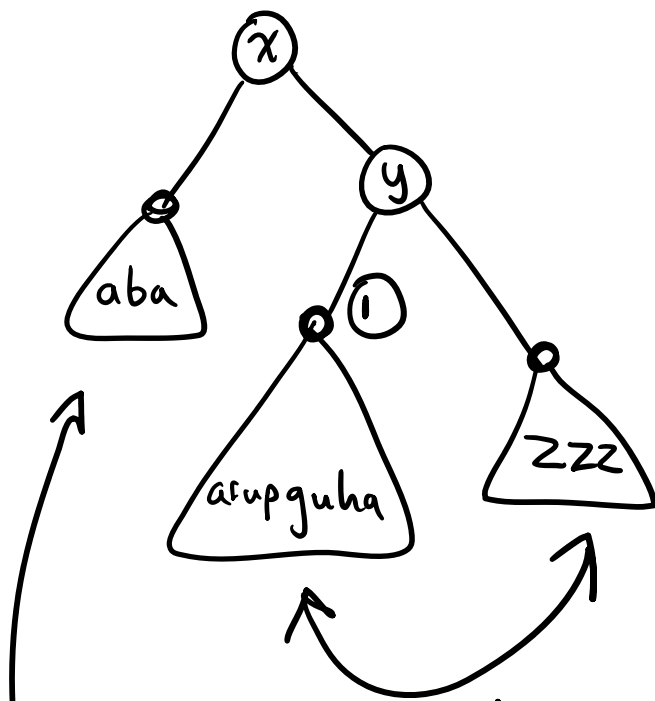
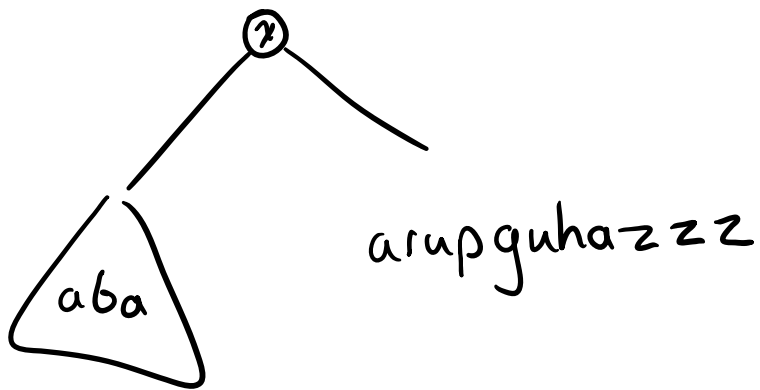
lazy
 propagation

Ⓛ'

ⓐ°



aba | arupguha zzz



A hand-drawn diagram illustrating a process flow. On the left, a large, smooth U-shaped curve is drawn. Below this curve, the word "meld" is written. On the right, a smaller U-shaped curve is drawn. Above this smaller curve, the word "meld" is written. An arrow points from the bottom of the large curve towards the bottom of the smaller curve, indicating a flow or transition between the two stages.

Robotic sort

 10^5

2 3 4 7 11 8

\nearrow \nwarrow

5

operations

2
2
5

