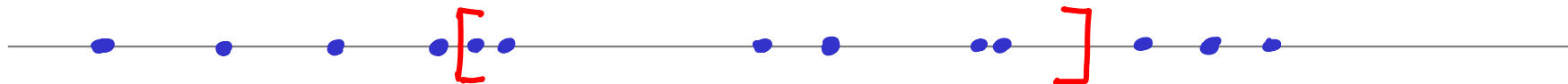
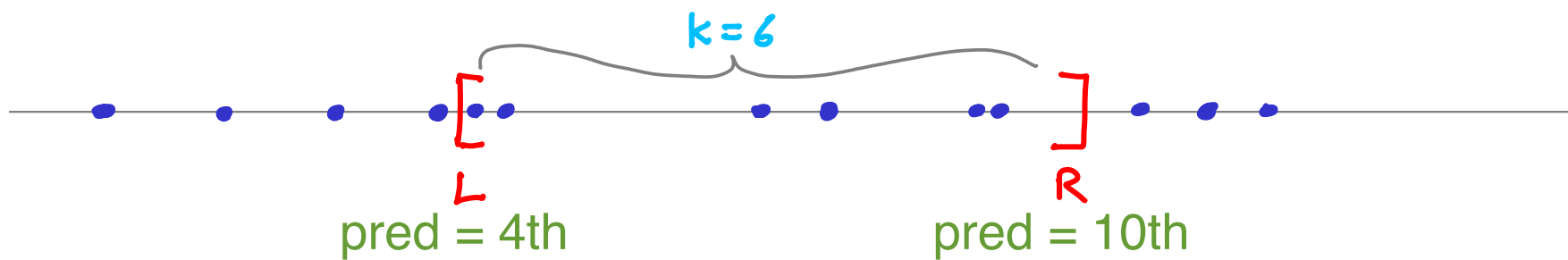


# RANGE COUNTING

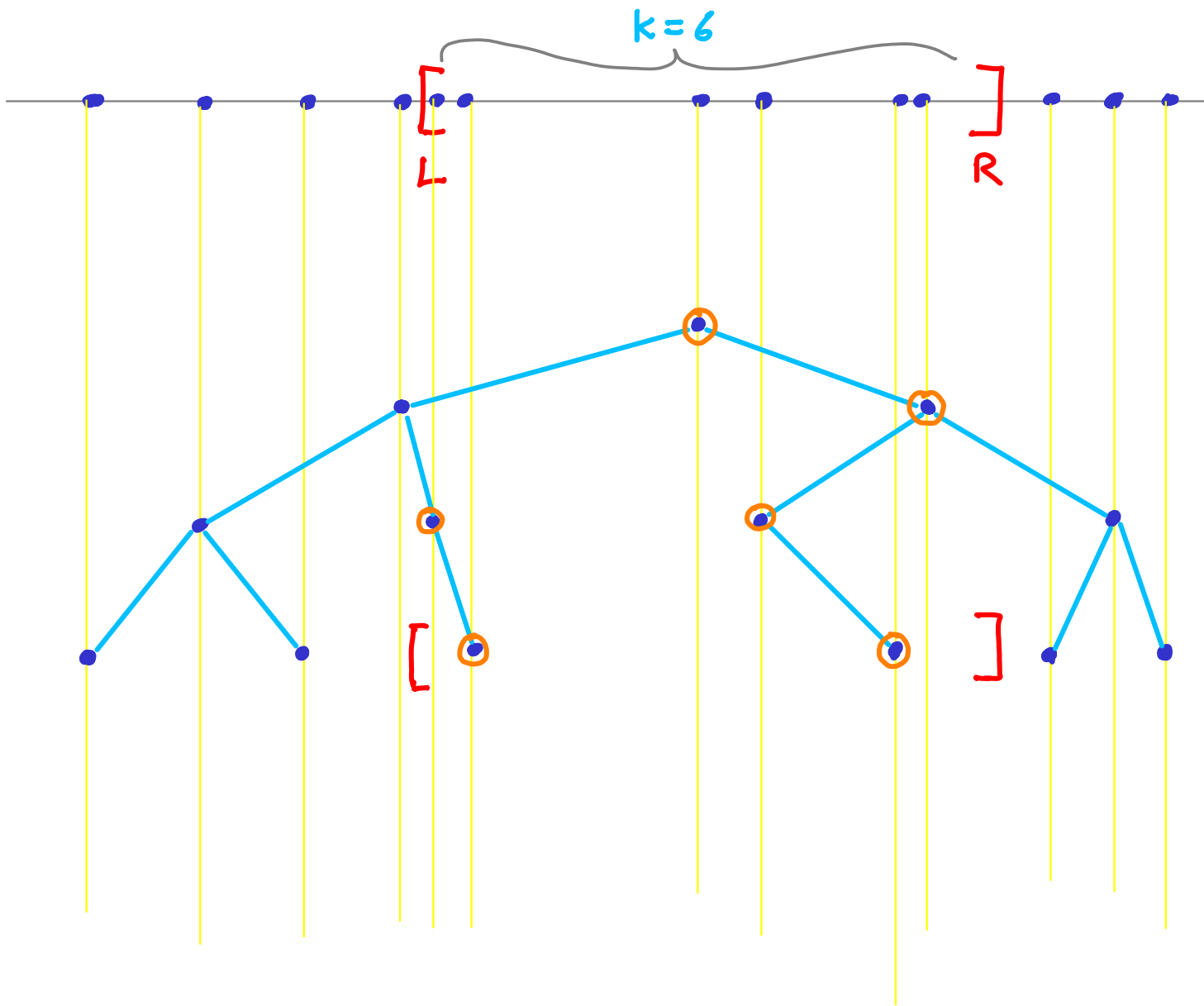
COUNT (or ENUMERATE) OBJECTS IN A GIVEN RANGE  
(many times)

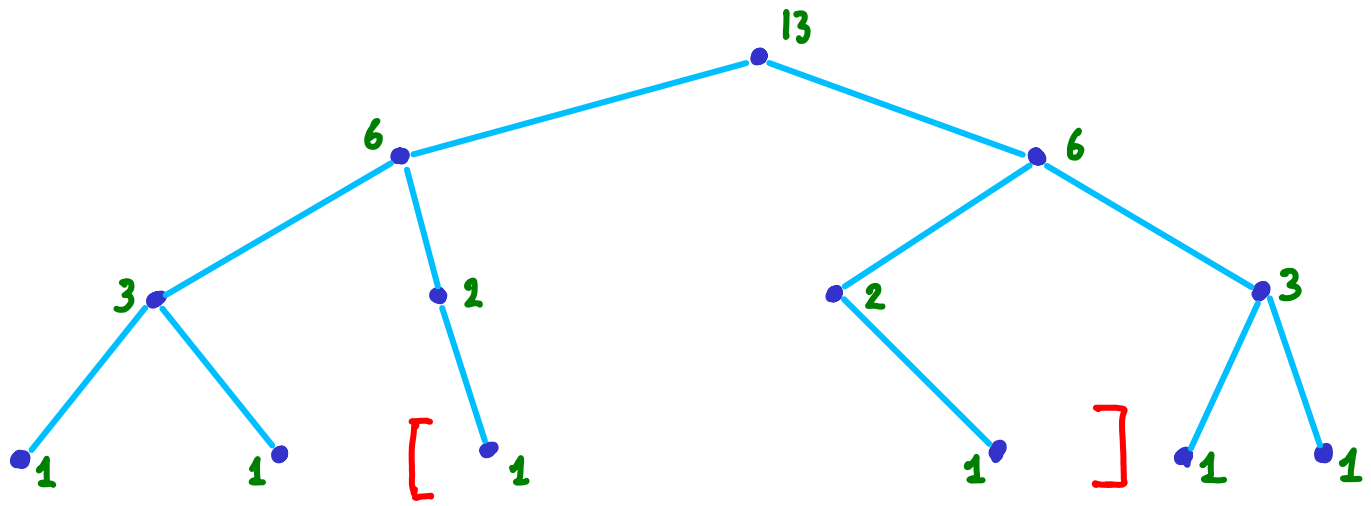
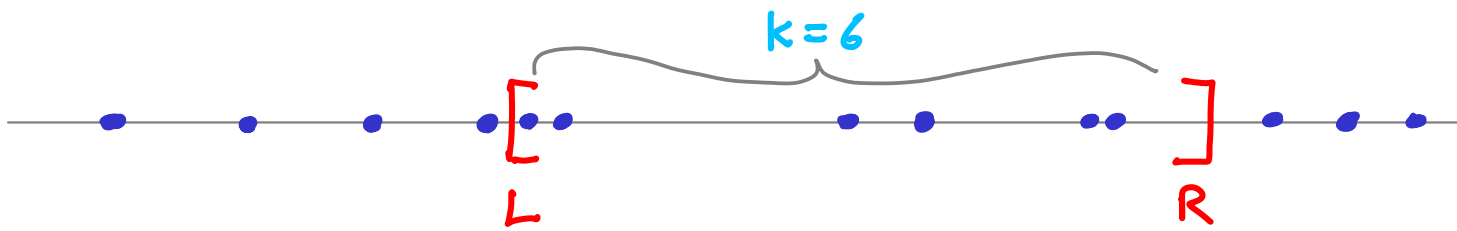




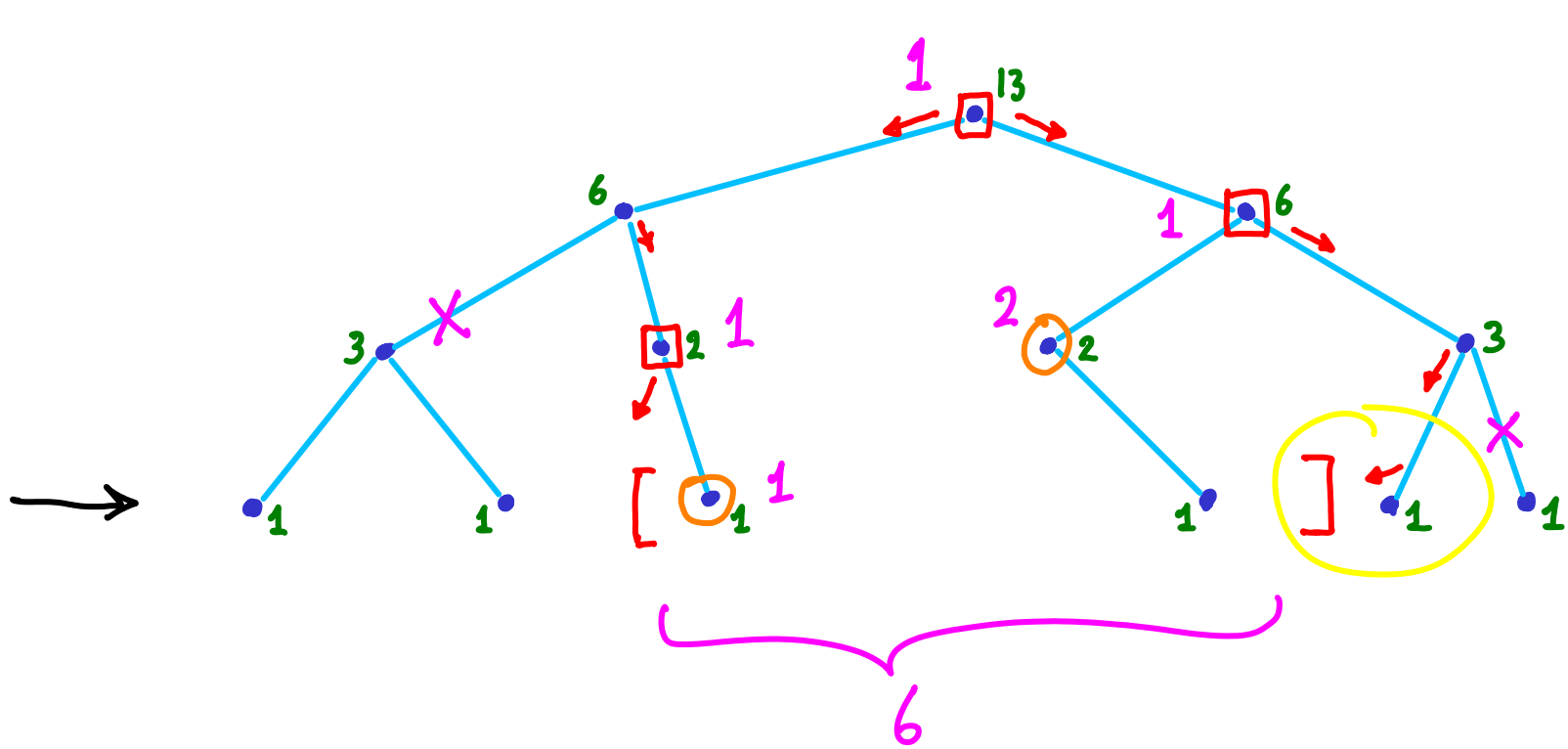
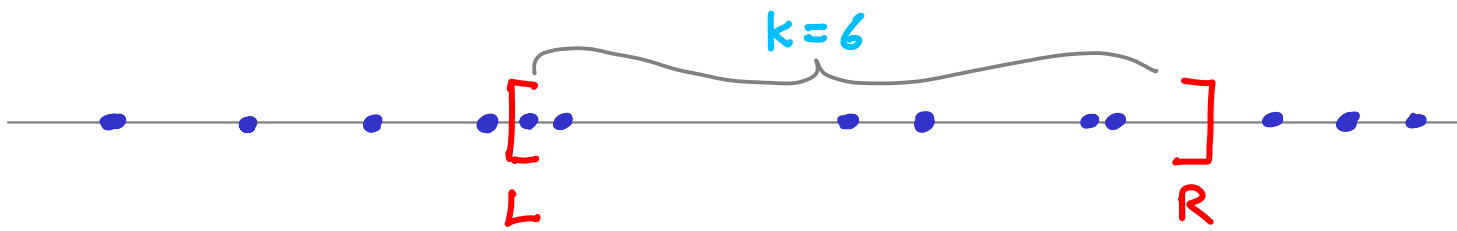
USE ARRAY:  $O(\log n)$  to place  $L, R \rightarrow$  to count. (binary search)  
 $O(k + \log n)$  to enumerate/report.

but this is not dynamic [insert/delete data:  $O(n)$ ]





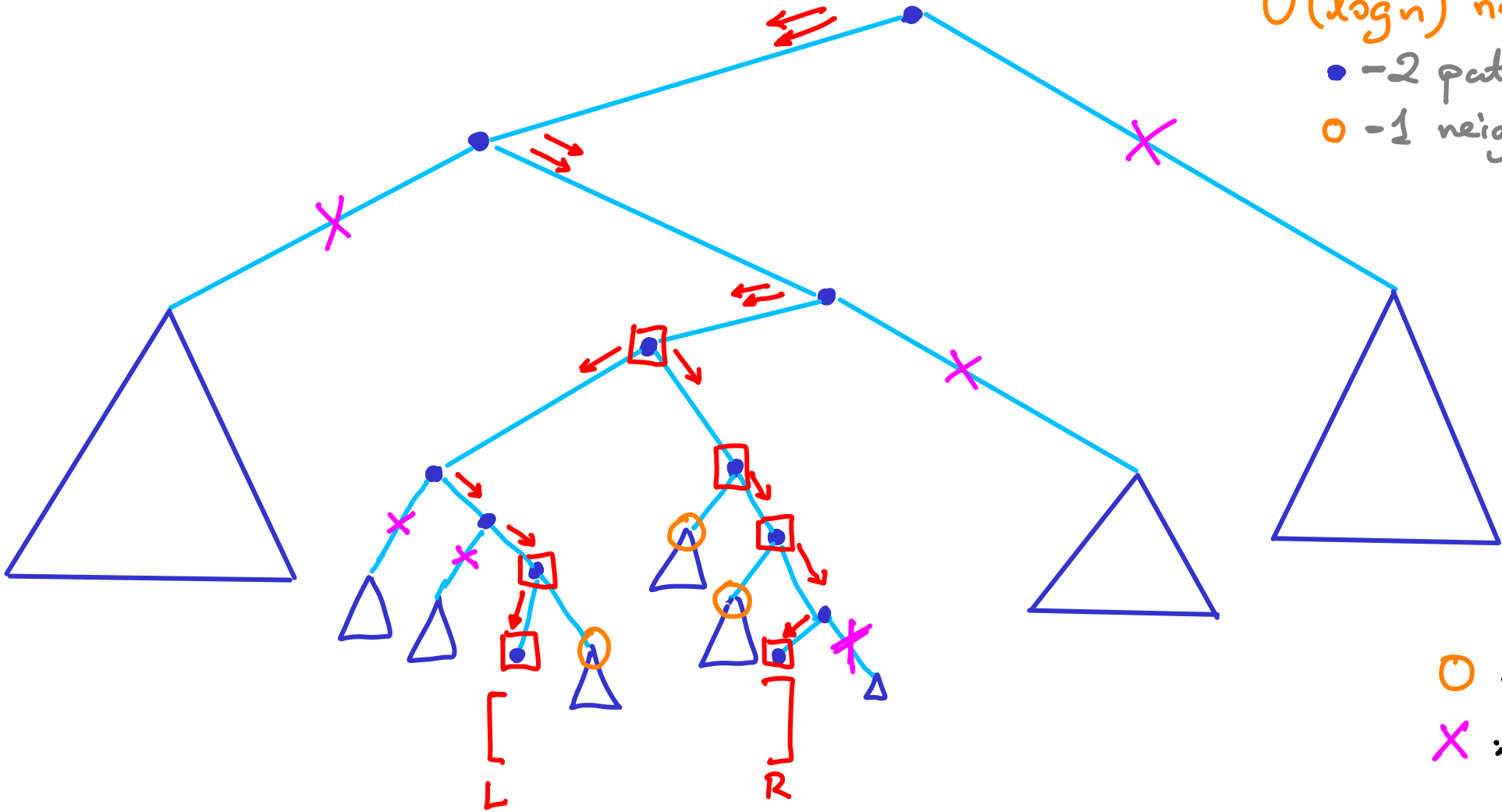
store size of  
each subtree



□ → count 1  
 ○ → count subtree

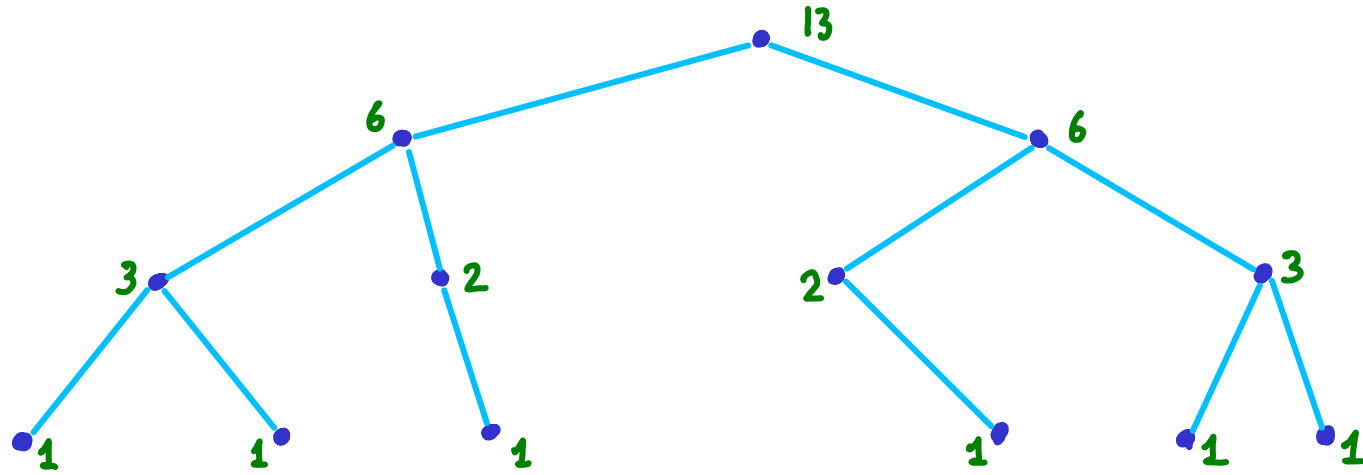
$O(\log n)$  nodes visited

- - 2 paths root  $\rightarrow$  leaf
- - 1 neighbor off path per node



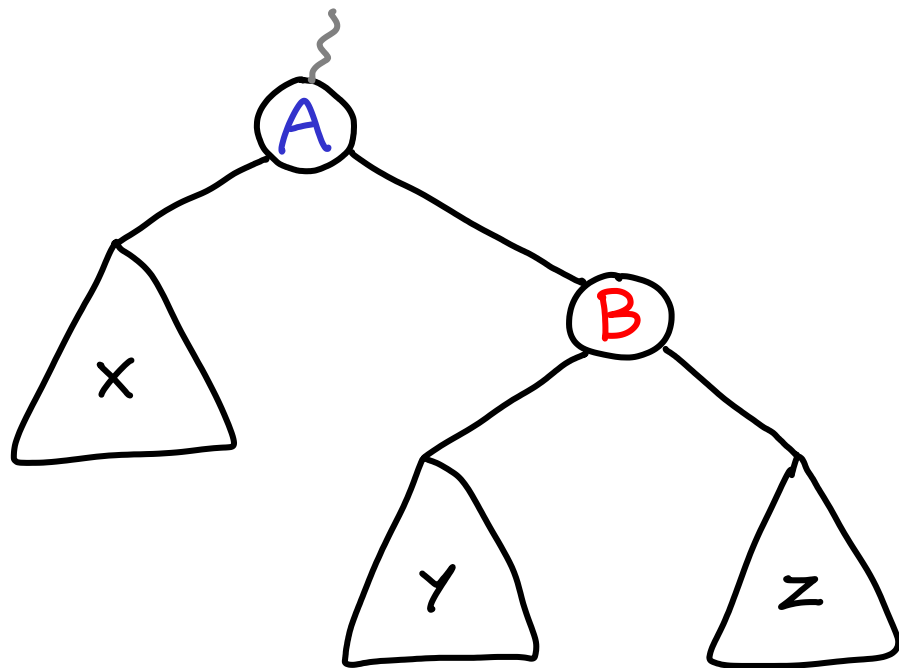
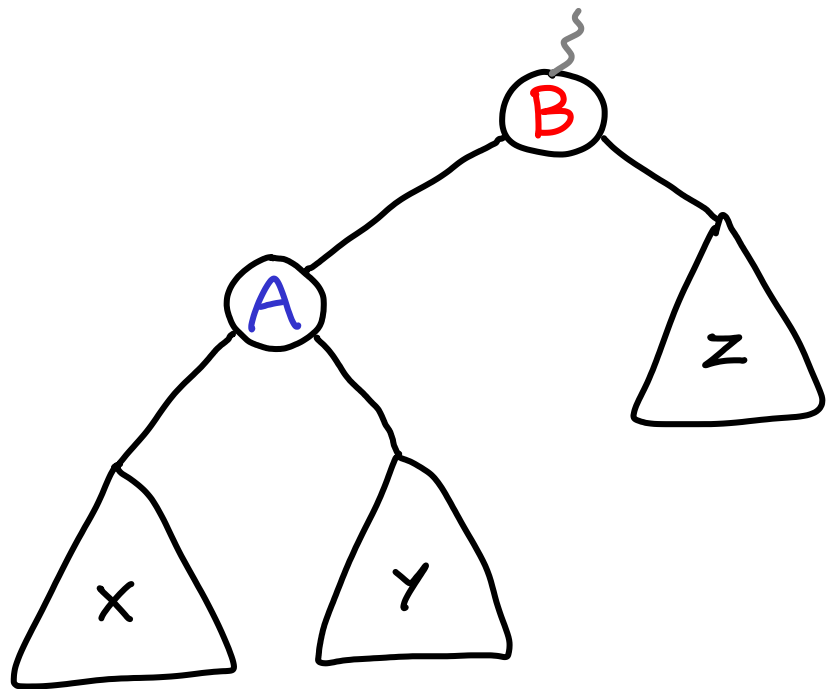
- : "inside"
- × : "outside"

Can we update subtree sizes when inserting/deleting data?



Use a **RB** tree

↳ when are subtree sizes affected? **Rotations**



sizes

