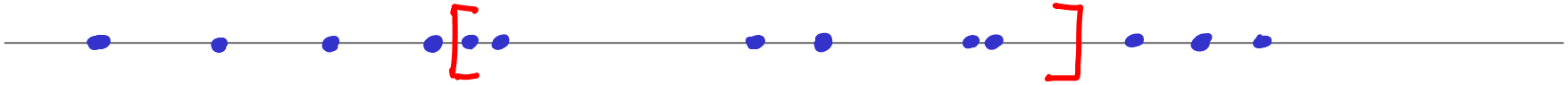
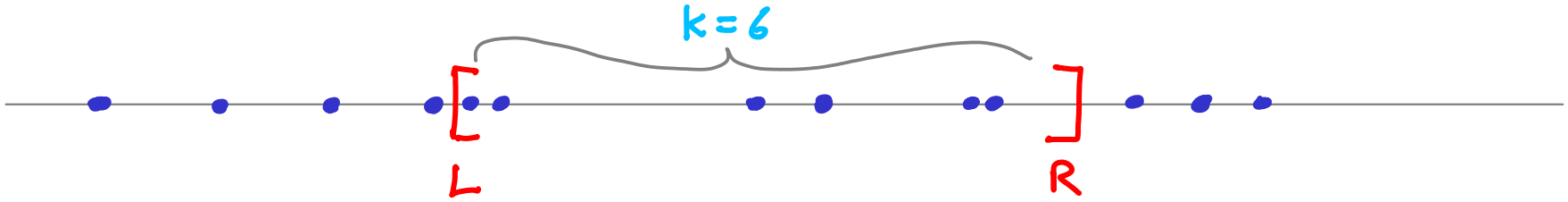
RANGE COUNTING

COUNT (or ENUMERATE) OBJECTS IN A GIVEN RANGE

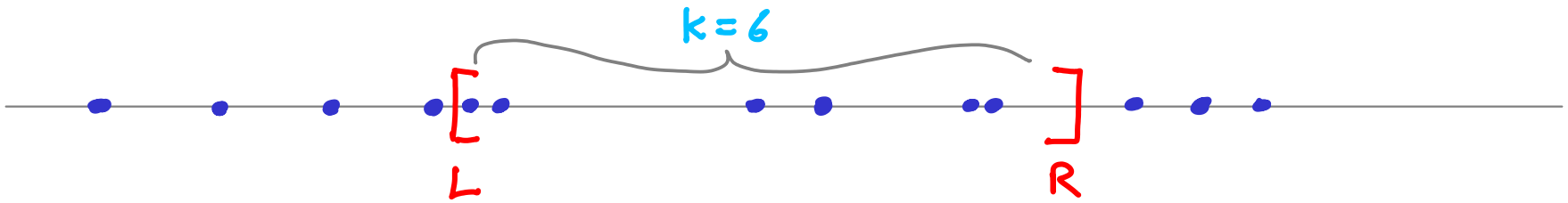
(many times)





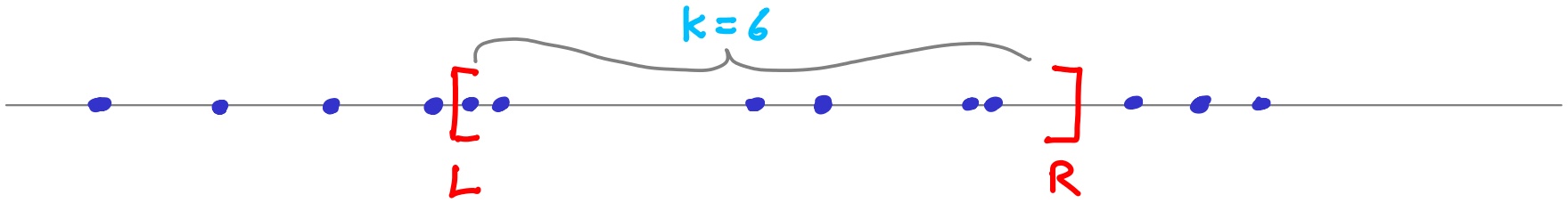
USE ARRAY: $O(\log n)$ to place L, R → to count.

(binary search)



USE ARRAY: $O(\log n)$ to place L,R → to count.

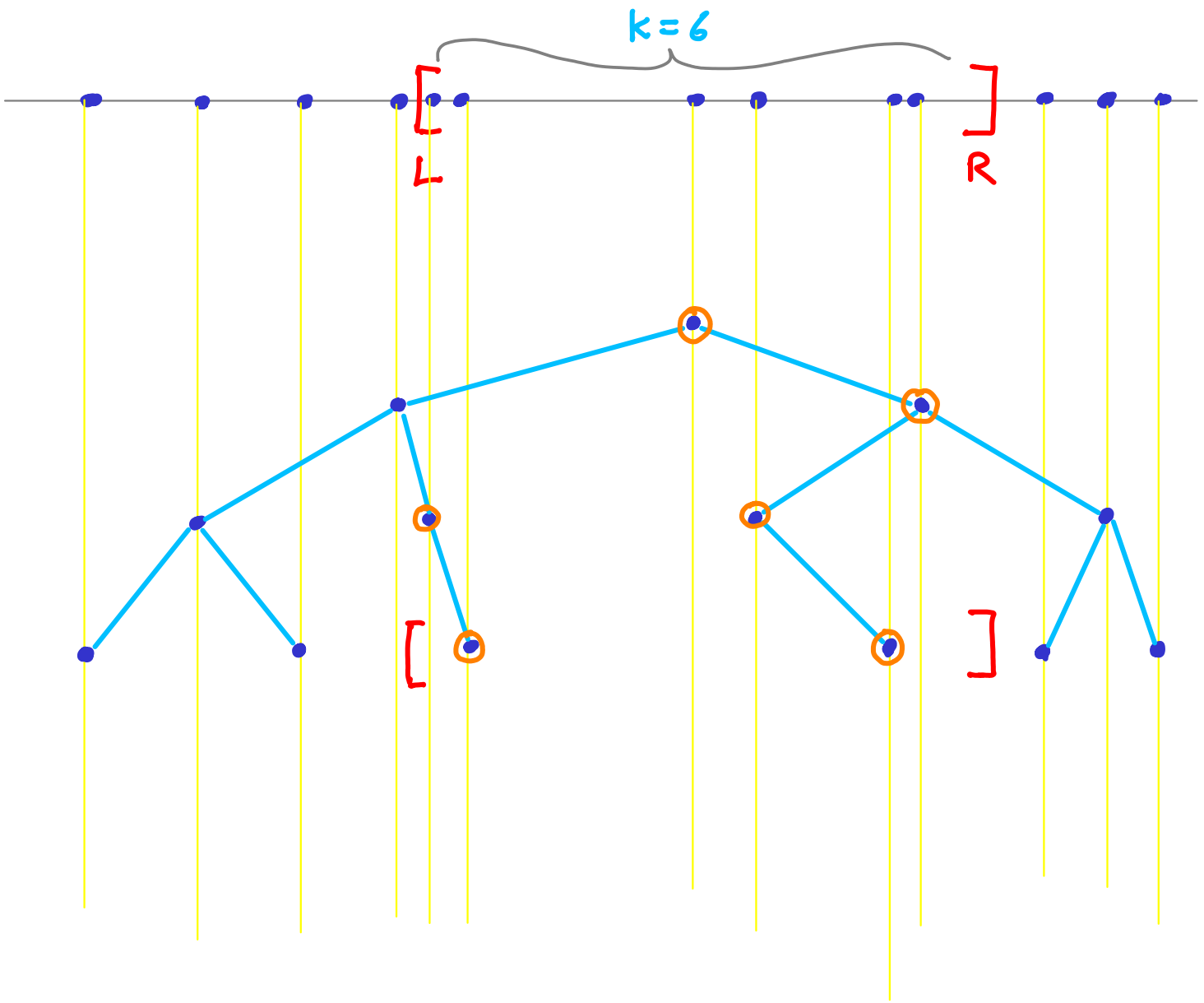
$O(k + \log n)$ to enumerate/report.

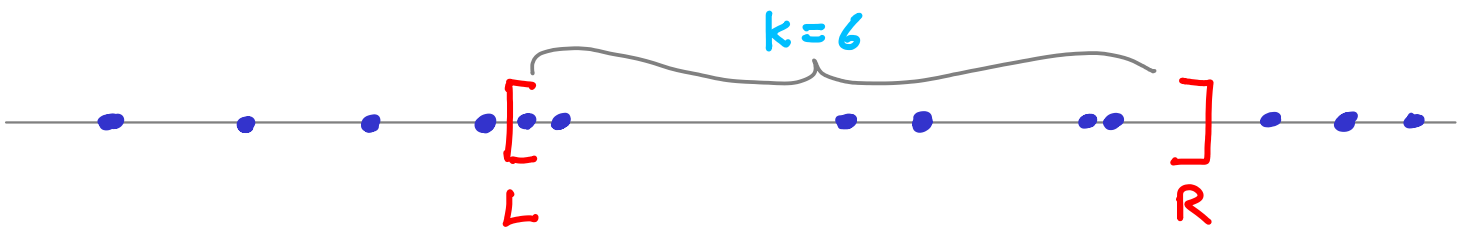


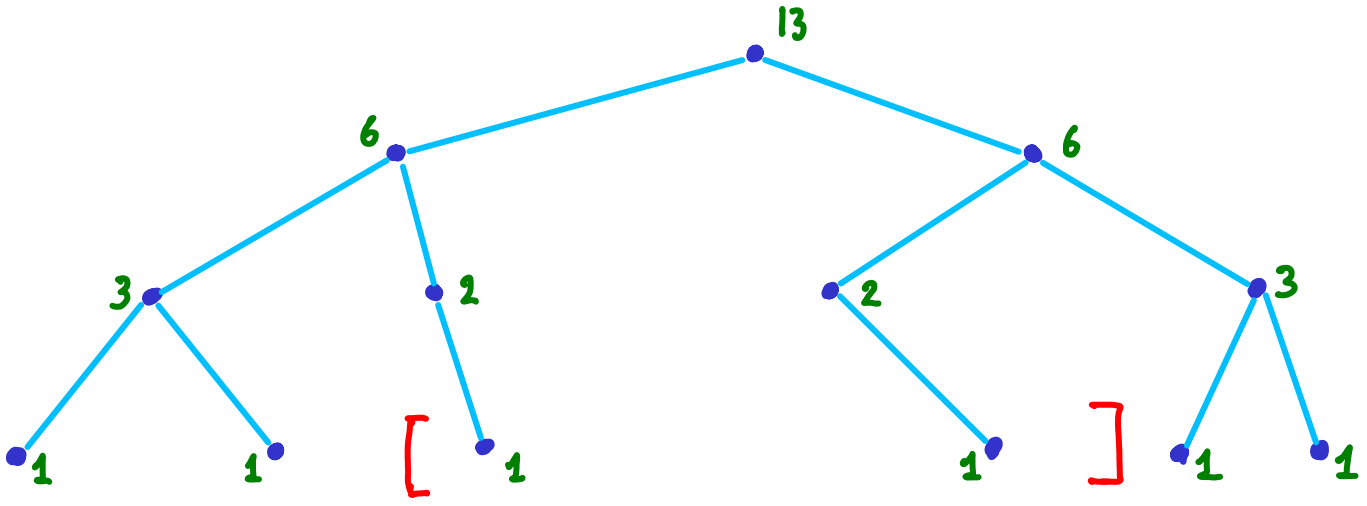
USE ARRAY: $O(\log n)$ to place L,R → to count.

$O(k + \log n)$ to enumerate/report.

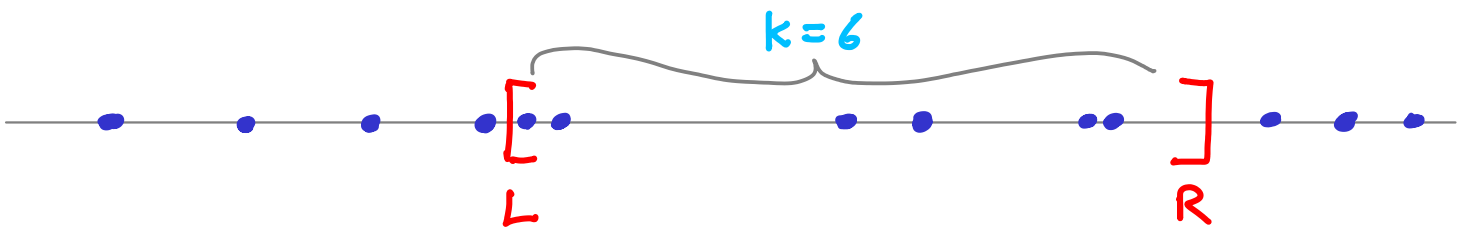
but this is not dynamic [insert/delete data : $O(n)$]


k=6
L
R

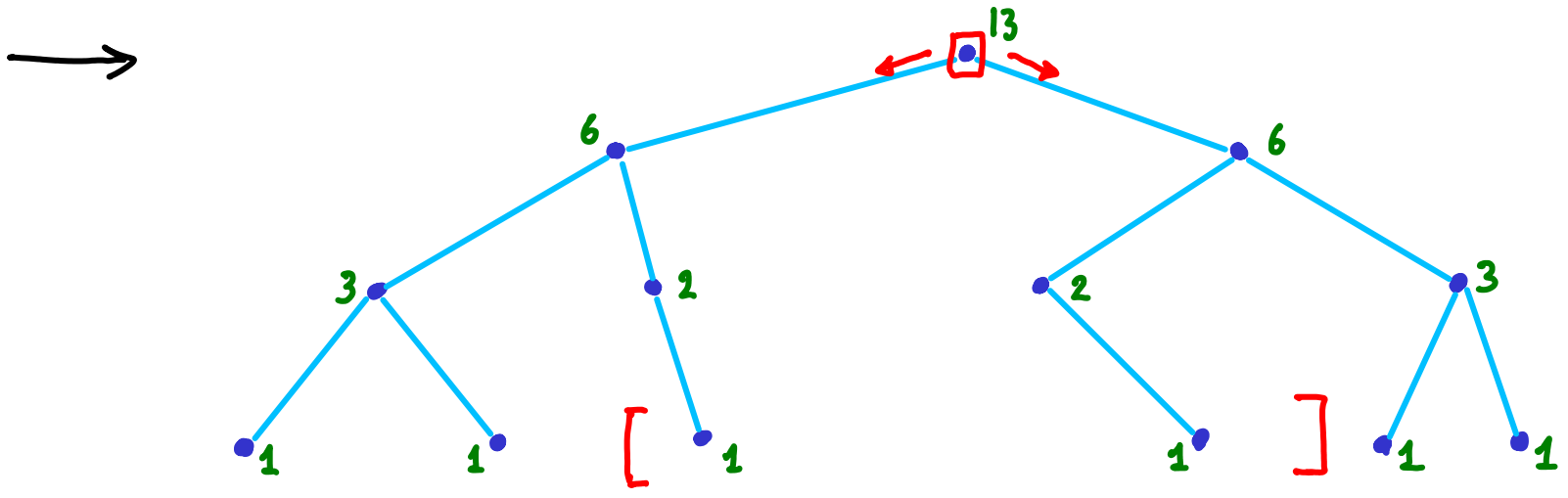


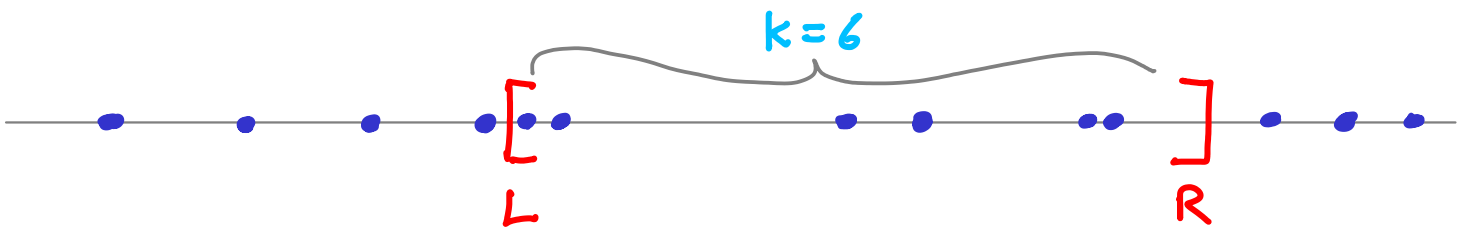


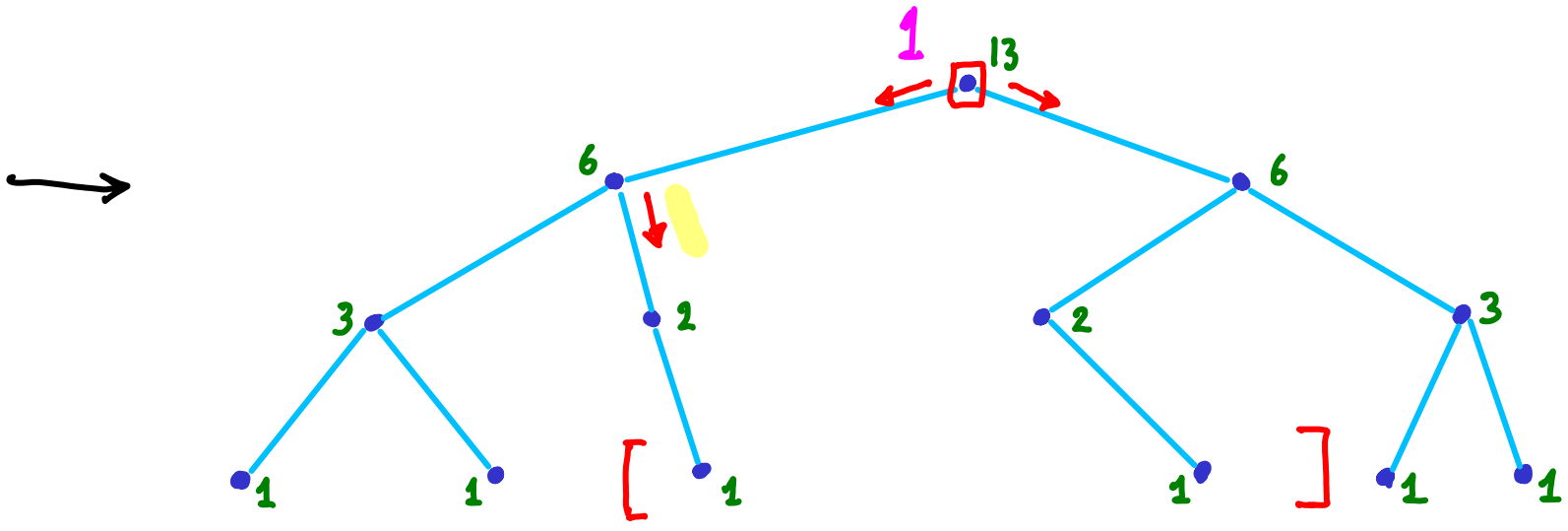
store size of each subtree


k = 6
L
R

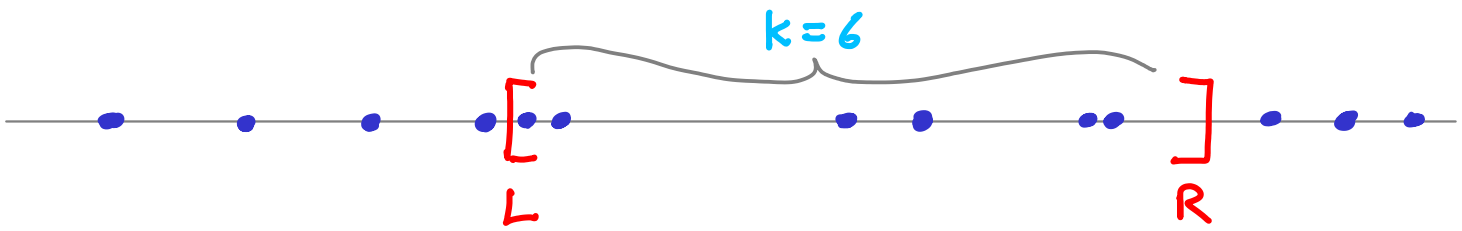

count 1

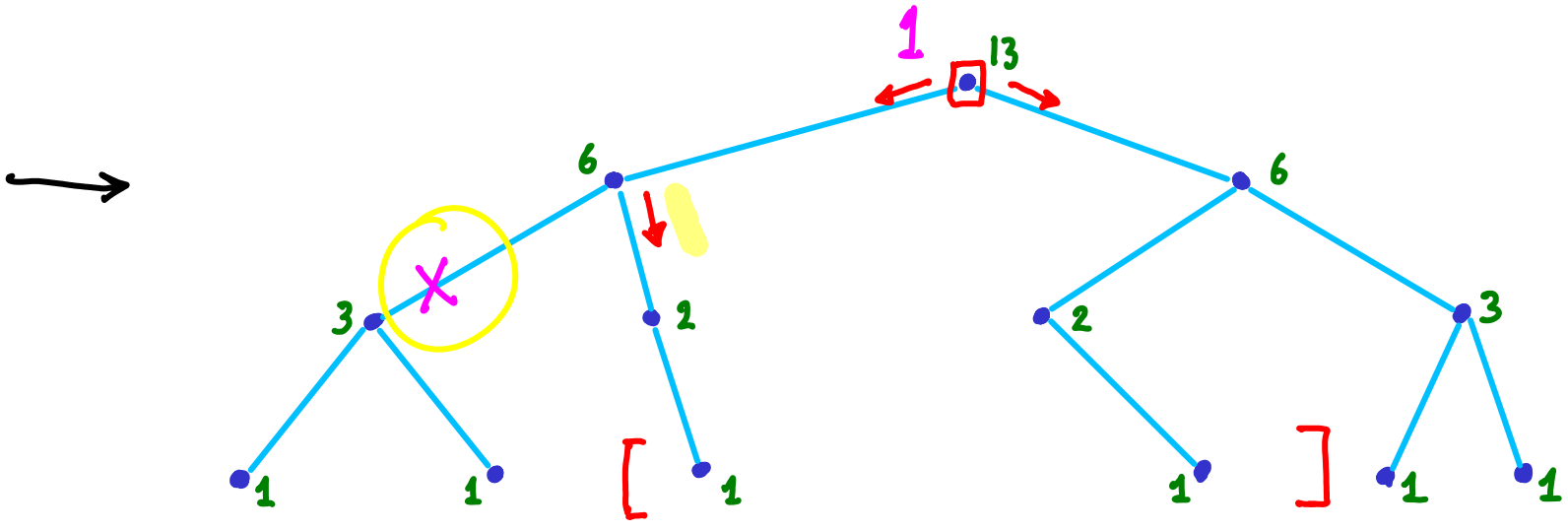

13
6
6
3
2
2
3
1
1
1
1
1
1
1



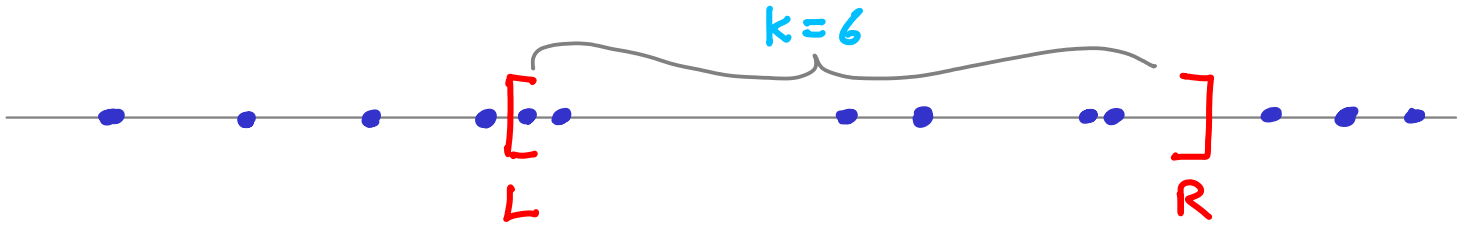


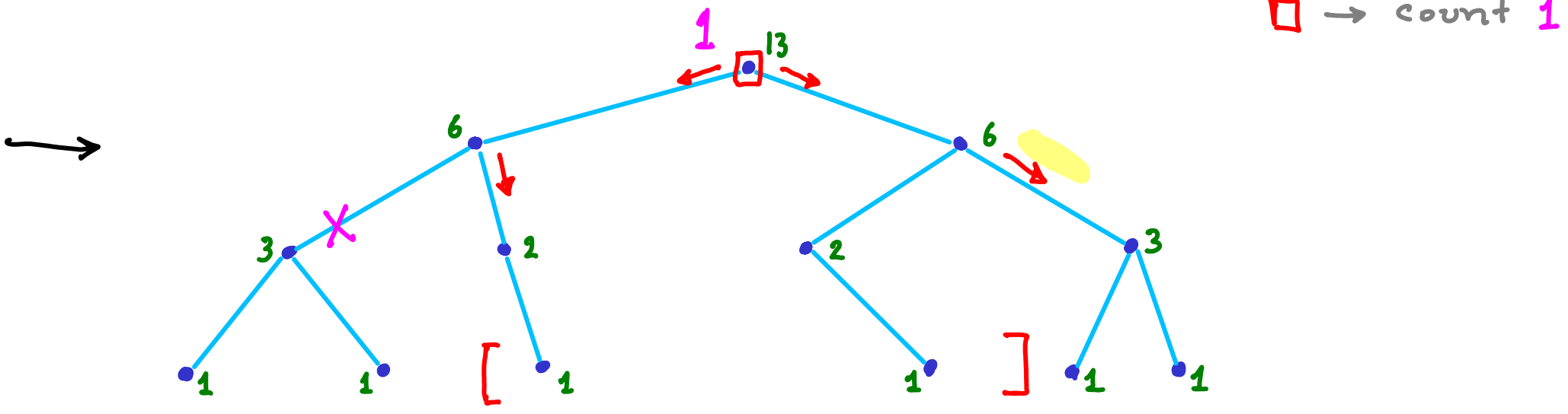
□ → count 1



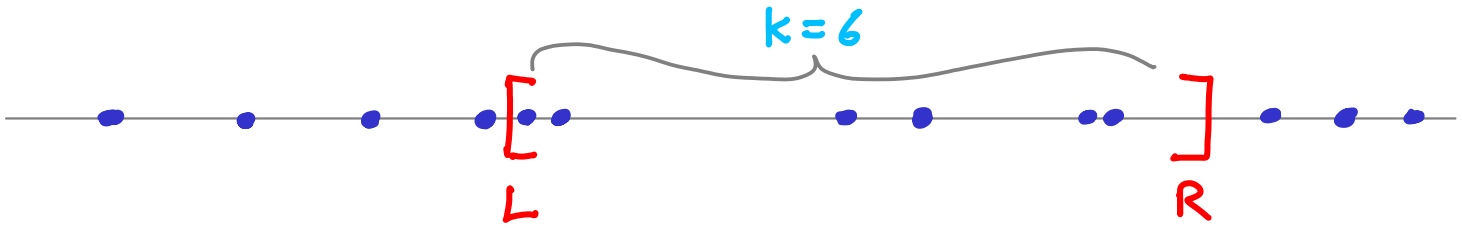


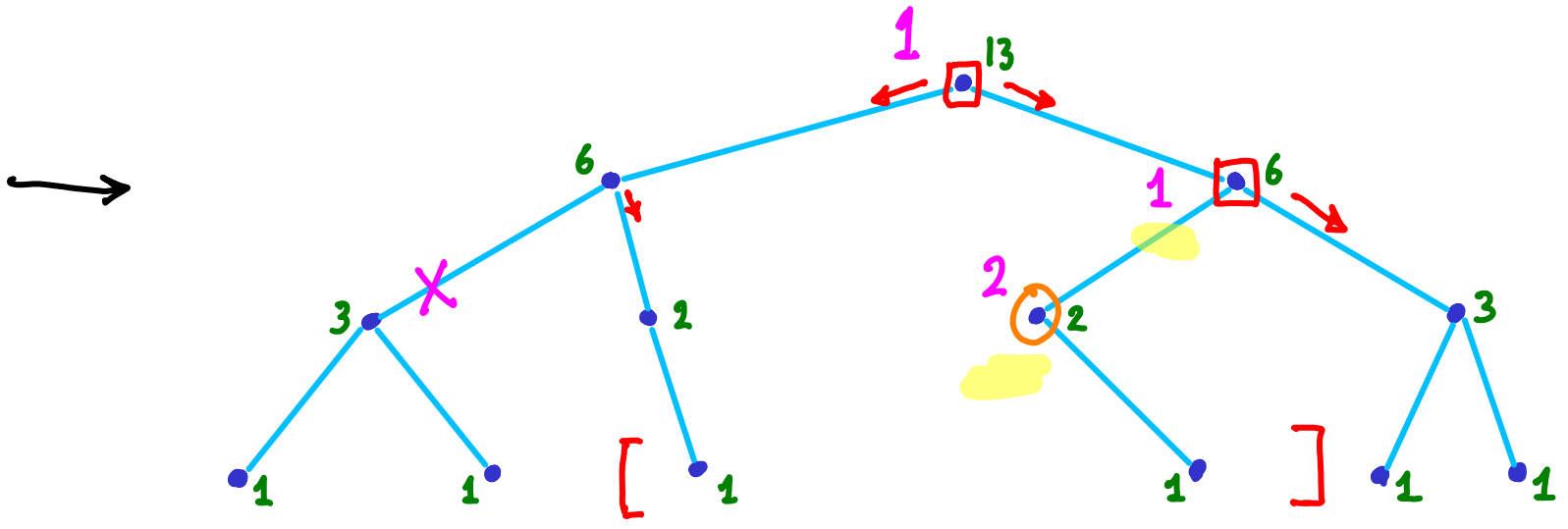
□ → count 1





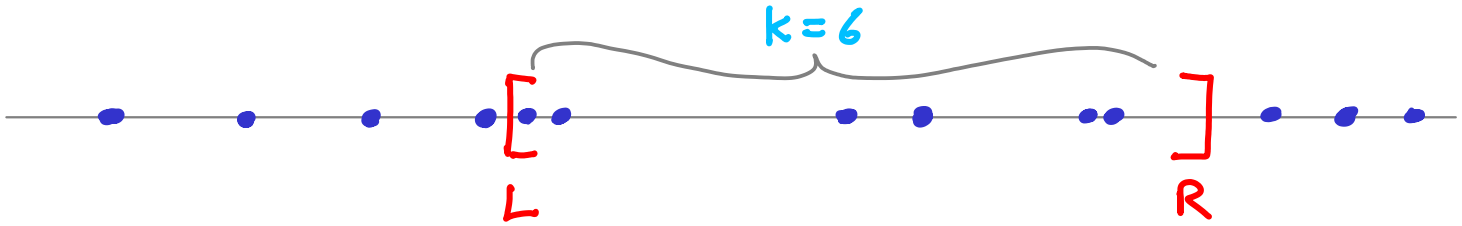
□ → count 1

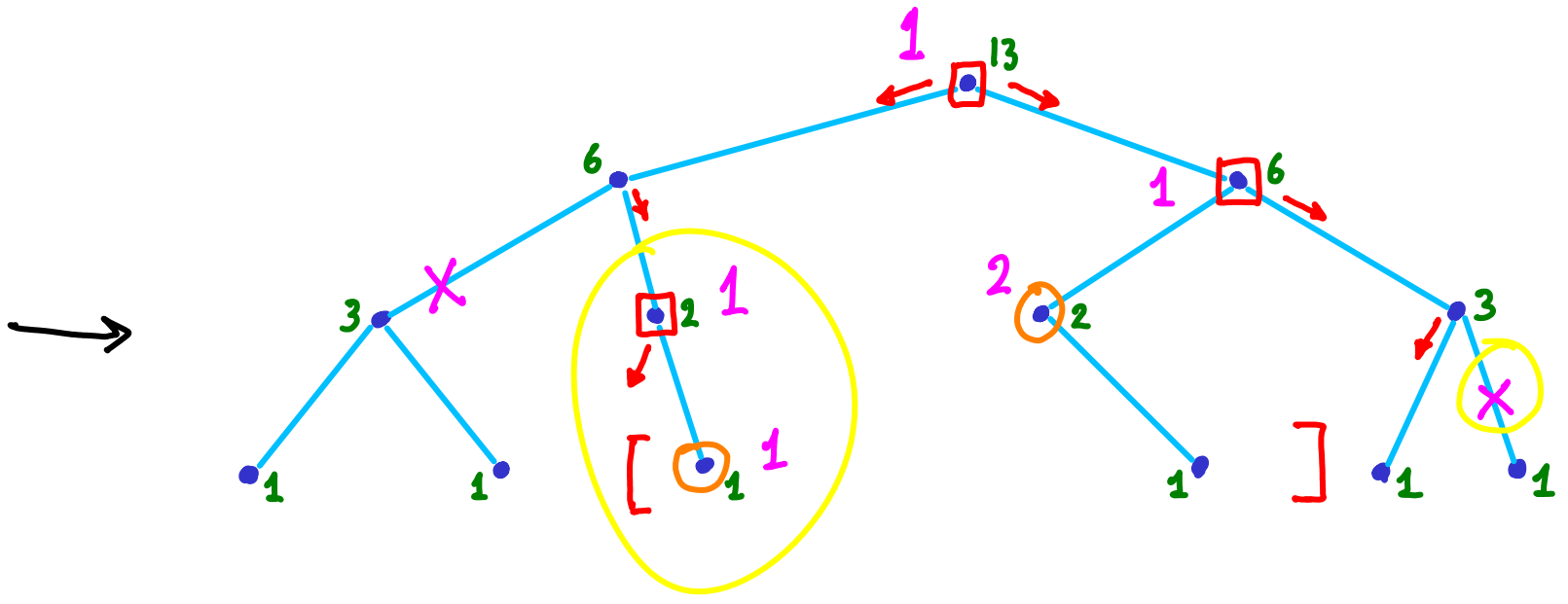




□ → count 1

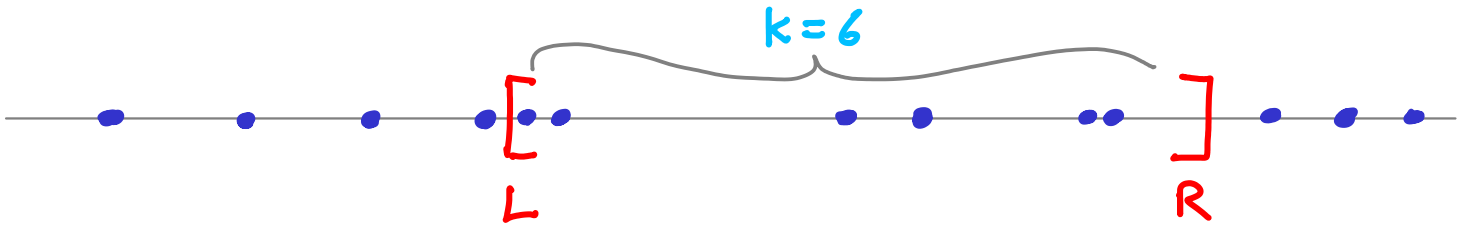
○ → count subtree

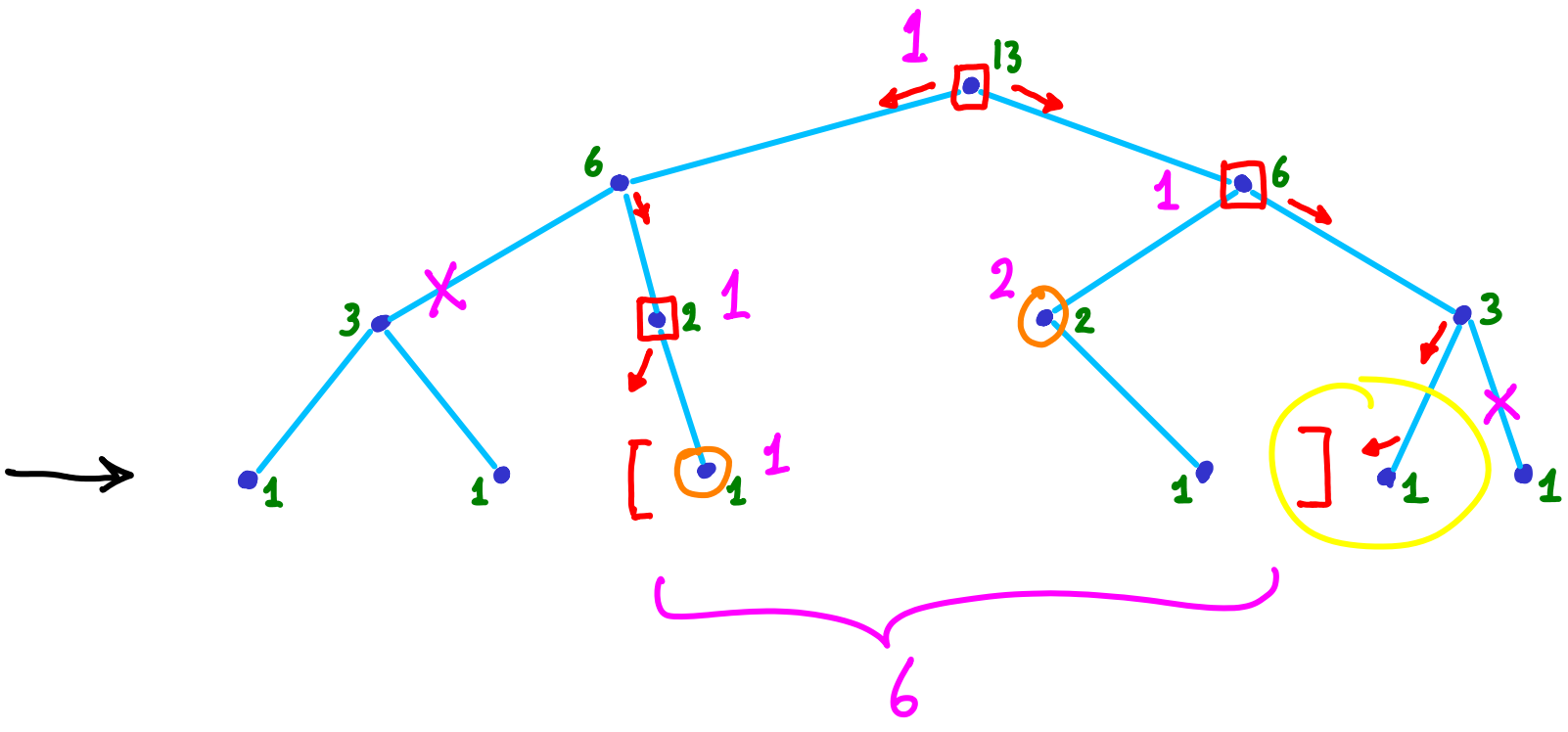




□ → count 1

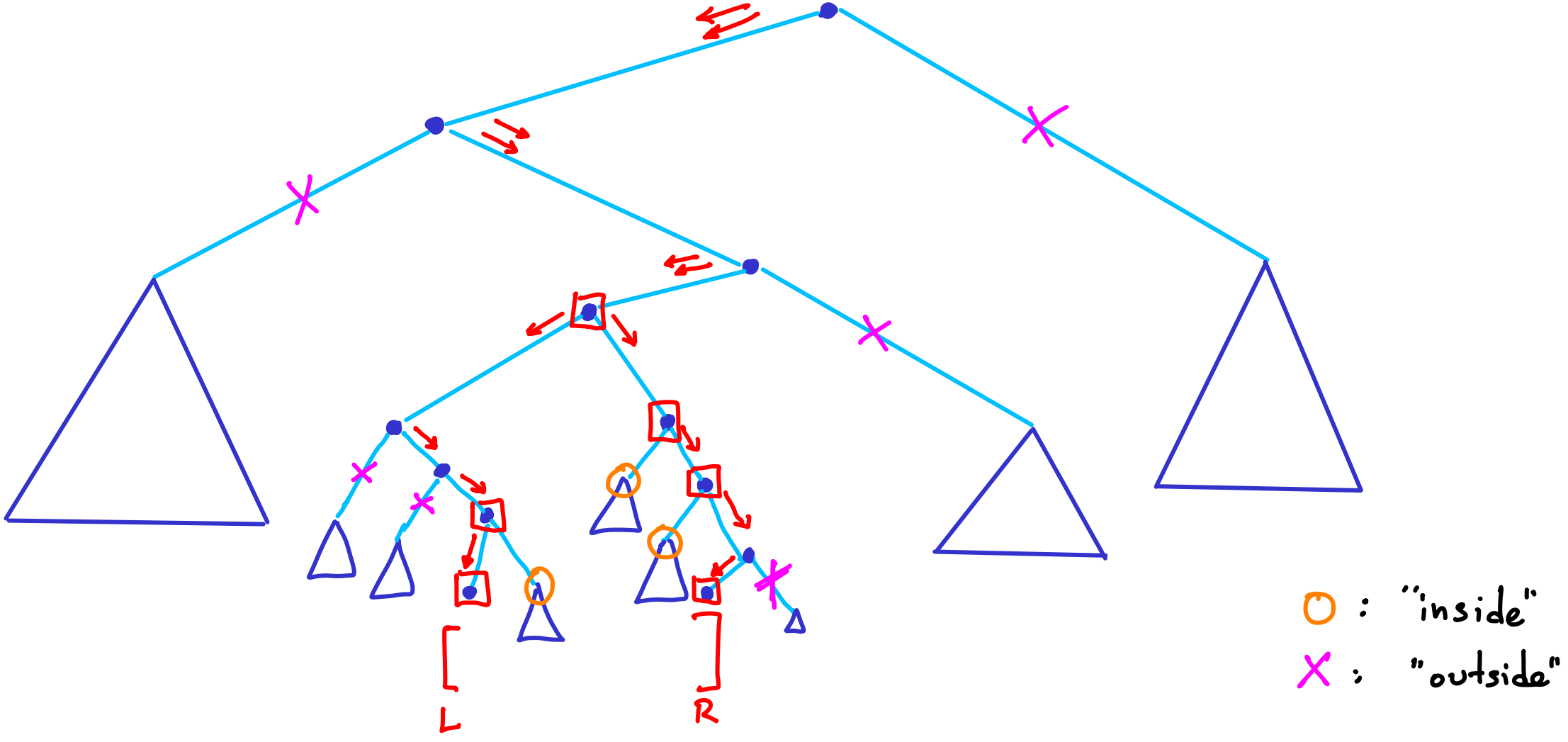
○ → count subtree

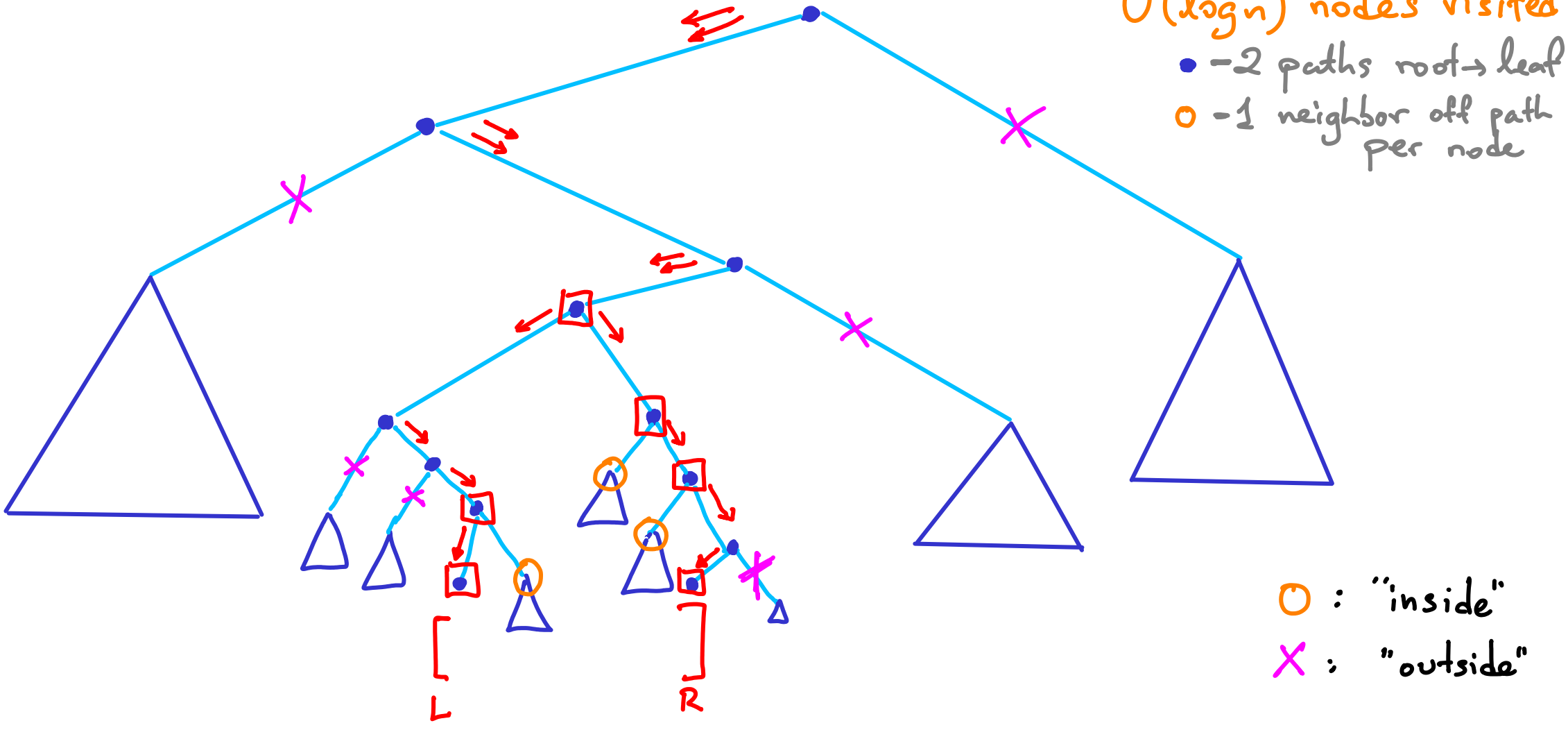




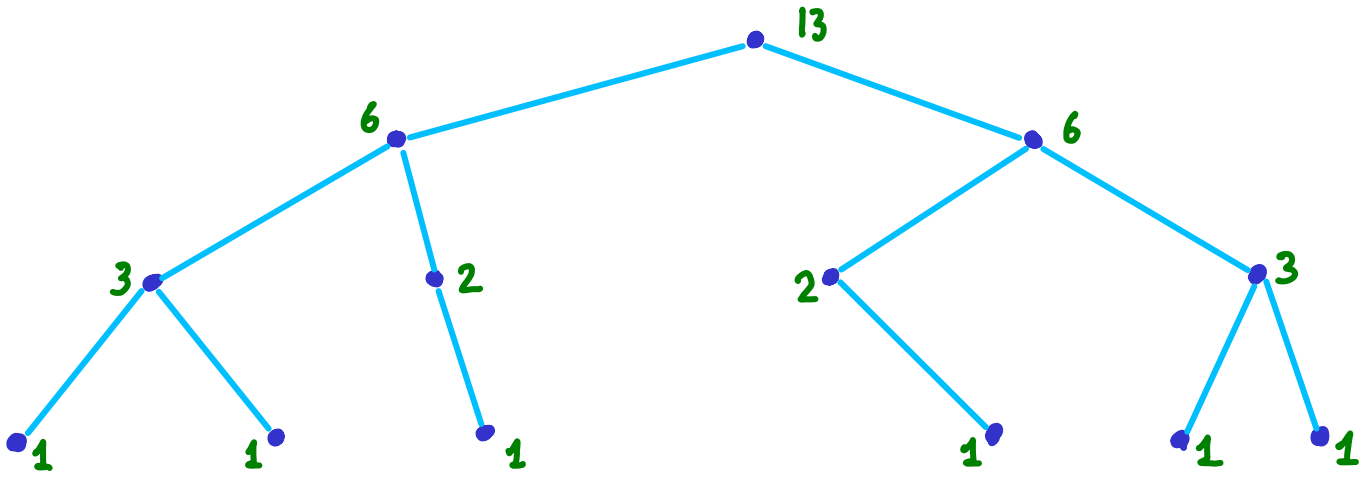
□ → count 1

○ → count subtree

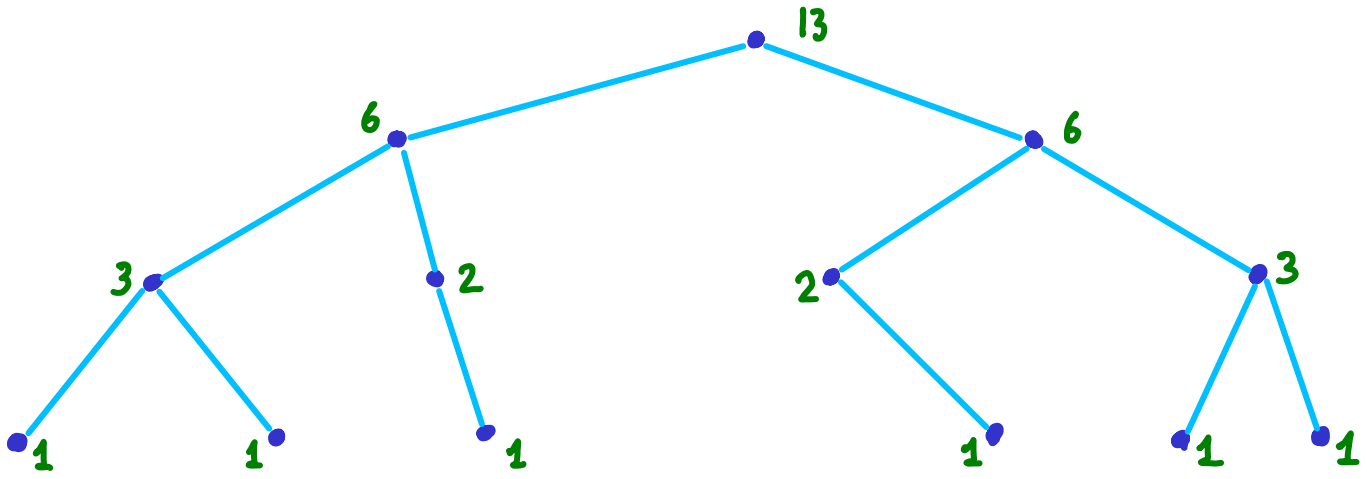

L
R
O : "inside"
X : "outside"


O(log n) nodes visited
• - 2 paths root → leaf
o - 1 neighbor off path per node
L
R
o : "inside"
X : "outside"

Can we update subtree sizes when inserting/deleting data?



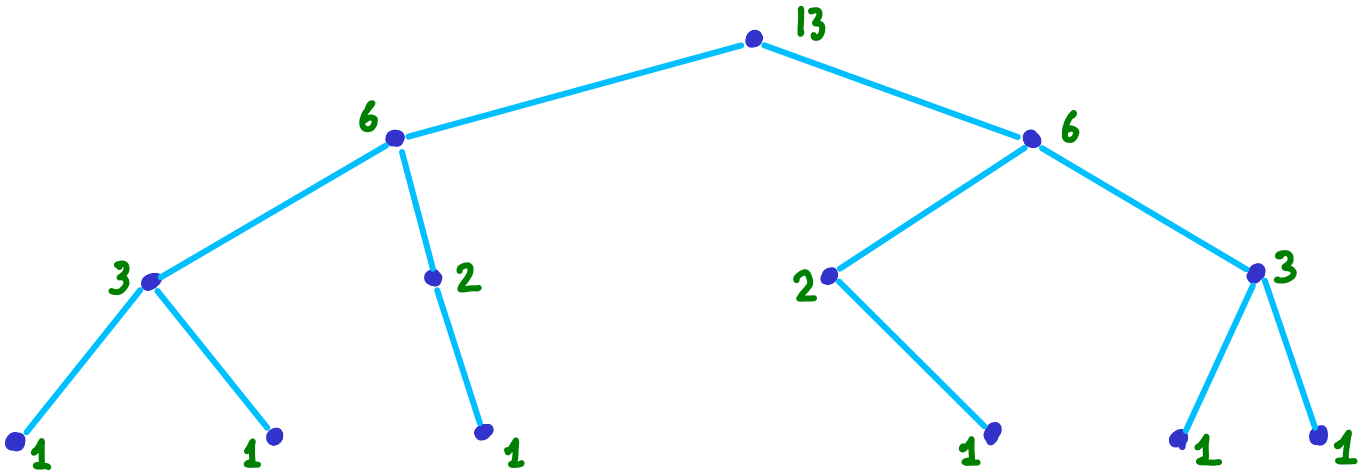
Can we update subtree sizes when inserting/deleting data?



Use a RB tree

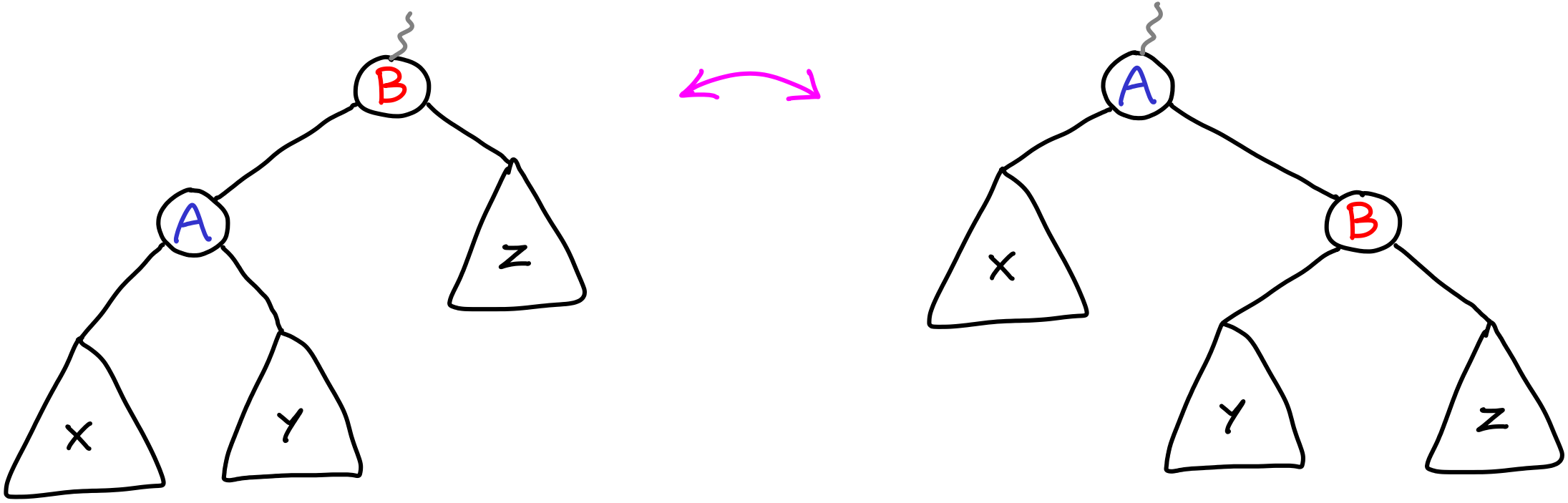
↳ when are subtree sizes affected?

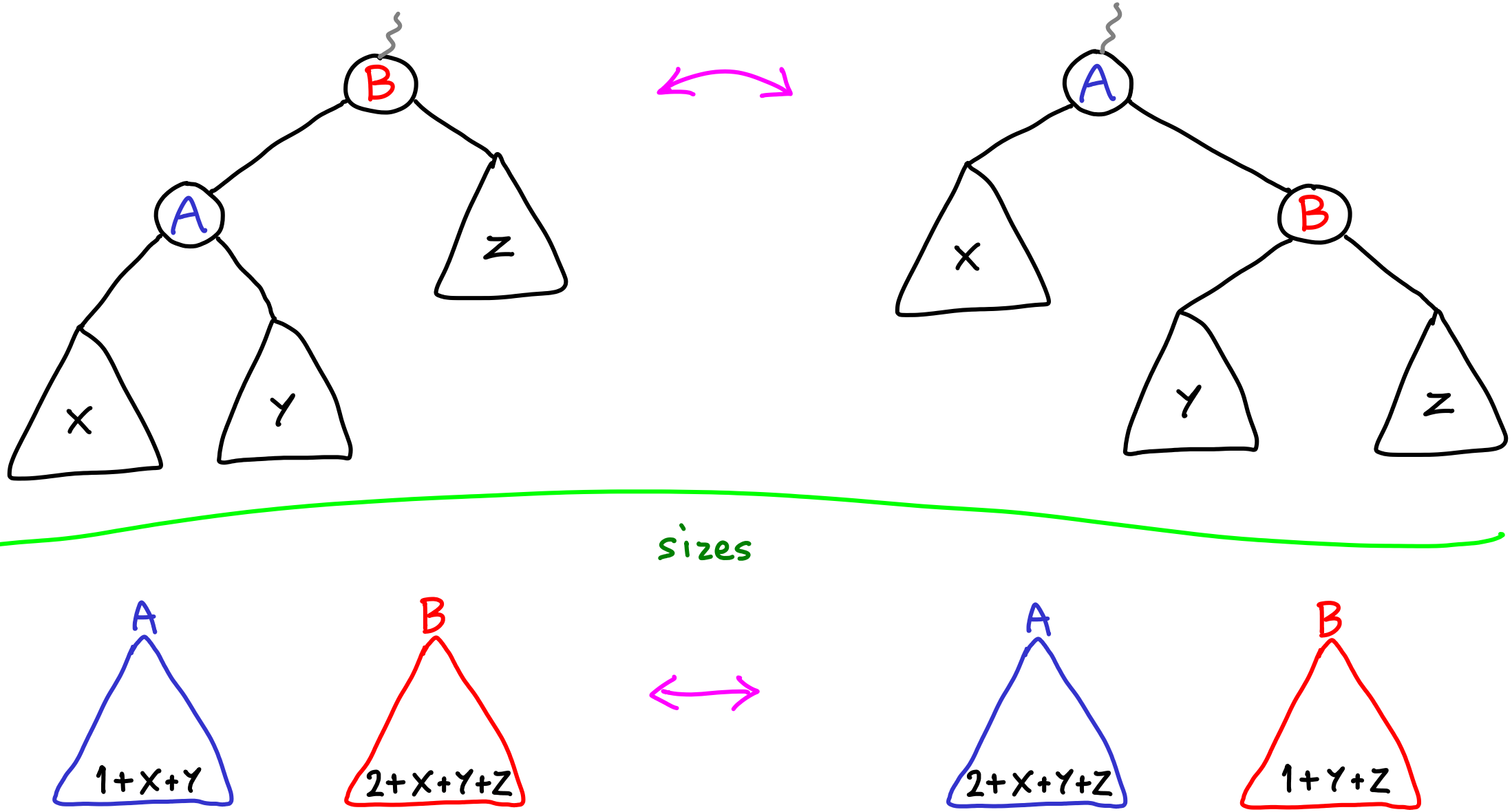
Can we update subtree sizes when inserting/deleting data?



Use a RB tree

↳ when are subtree sizes affected? Rotations


B
A
z
x
y
A
x
B
y
z


B
A
z
x
y
A
x
B
y
z
sizes
A
1+X+Y
B
2+X+Y+Z
A
2+X+Y+Z
B
1+Y+Z