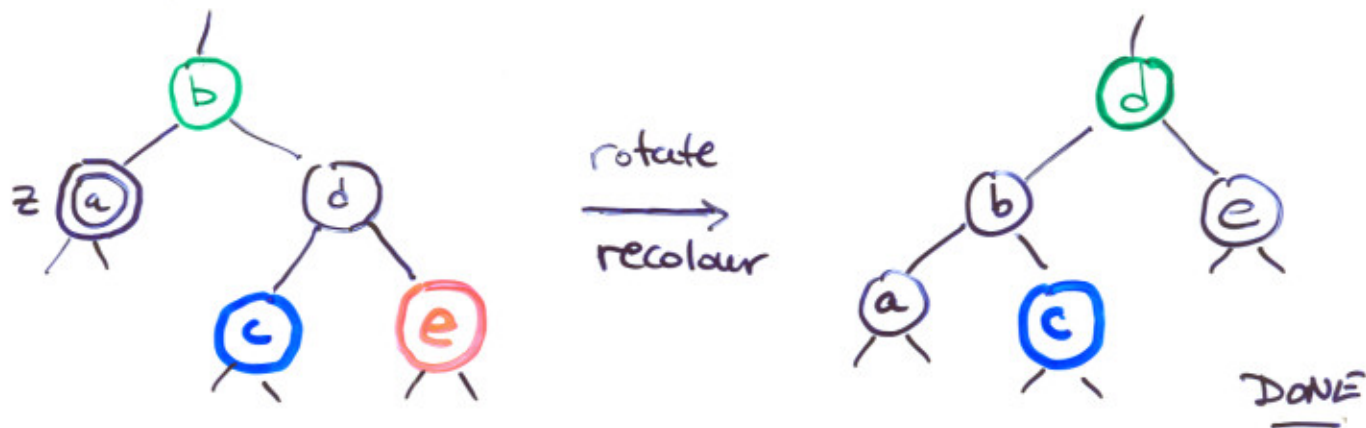


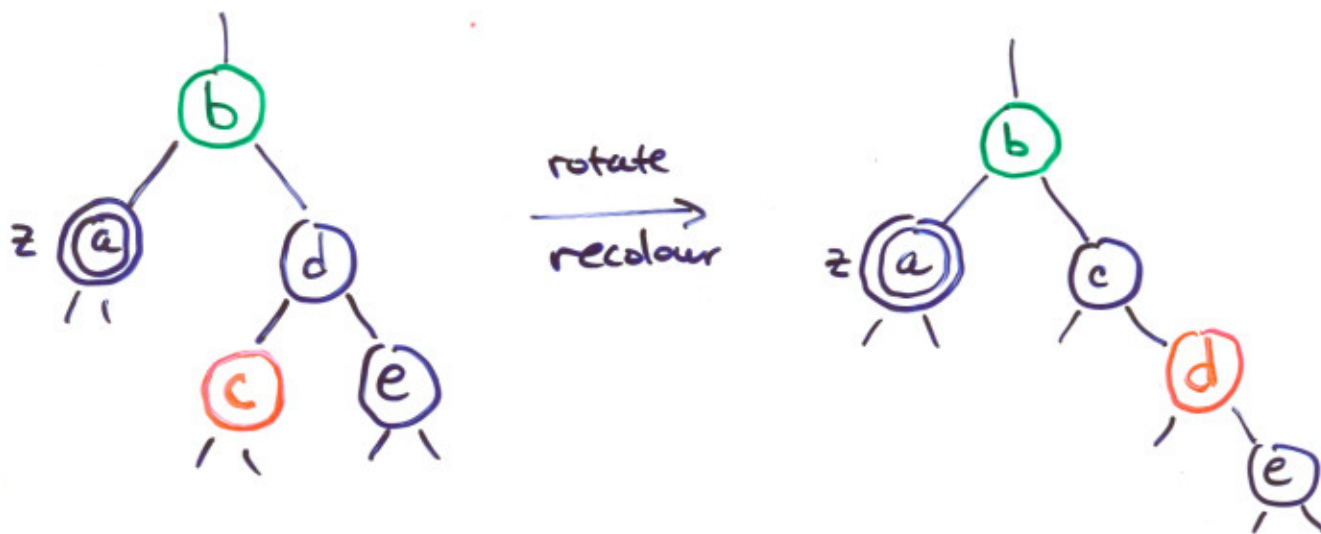
Fixing tree after deletion.

Violation: z is double-black

Case 1 z's sibling is black,
z's far nephew red.

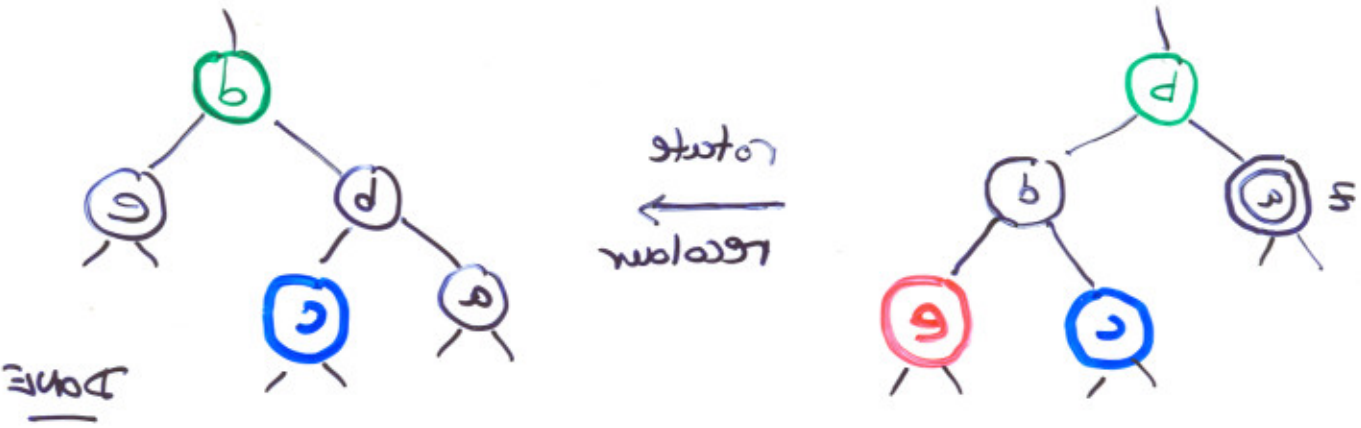


Case 2 z's sibling black
z's close nephew is red, far nephew black

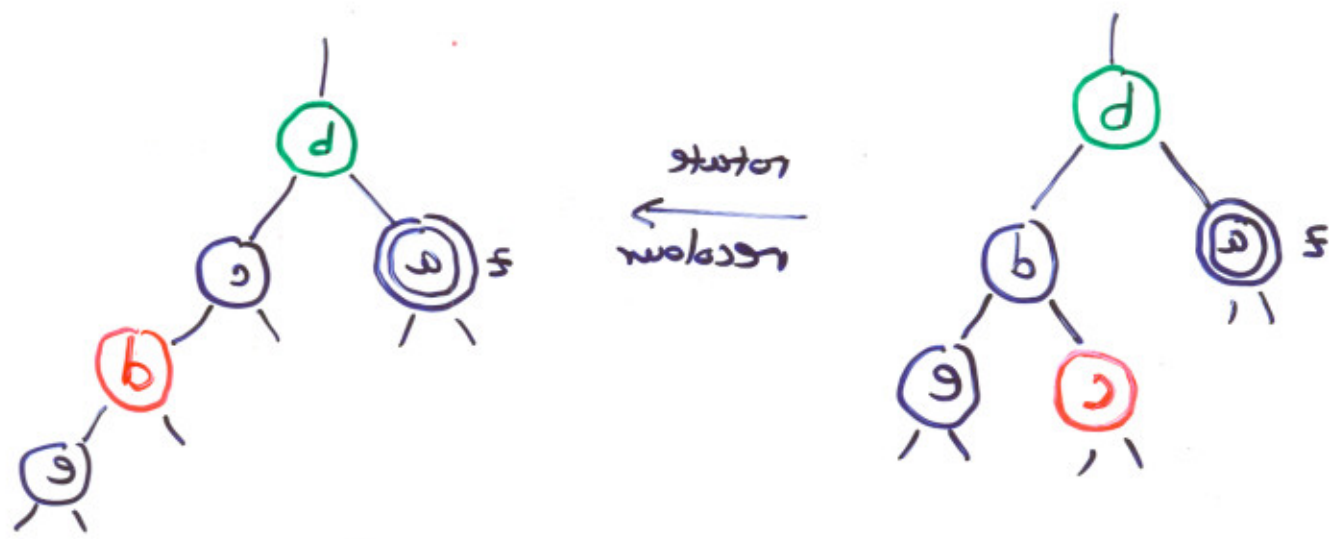


Fixing tree after deletion.
 Violation: Δ is double-black

Case I
 Δ 's for nephew red.
 Δ 's zipping is black.

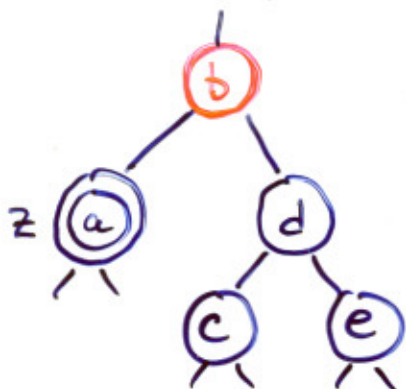


Case 2
 Δ 's close nephew is red, for nephew black
 Δ 's zipping black

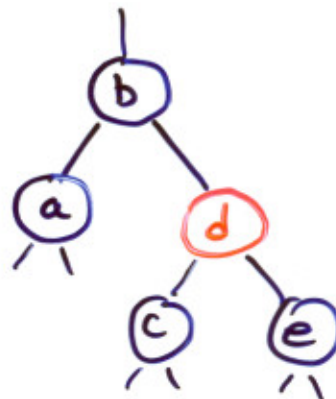


Fixing deletion (continued)

Case III z's sibling and nephews are black
z's parent red

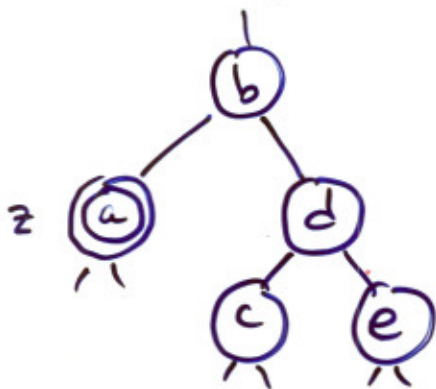


recolour
→

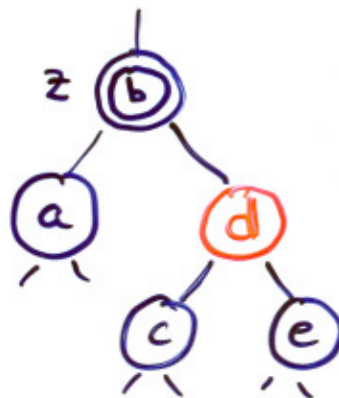


DONE!

Case IV z's sibling and nephews are black
z's parent black



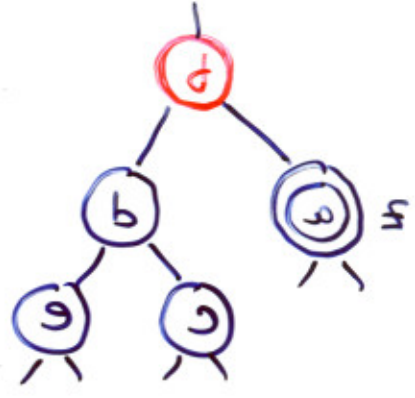
recolour
→



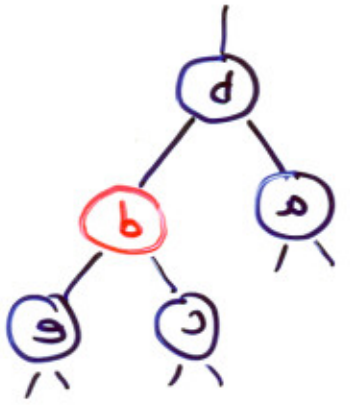
Now violation
is higher up.

Fixing deletion (continued)

Case III
5/2 zipping and neighbors are black
5/2 parent red



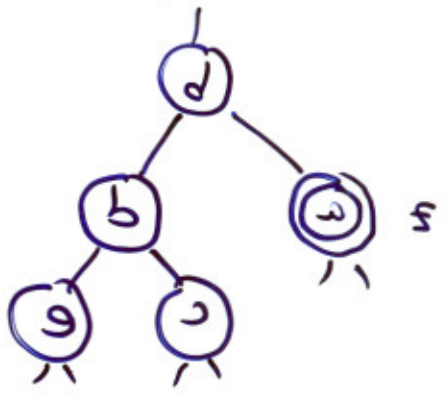
rotation
←



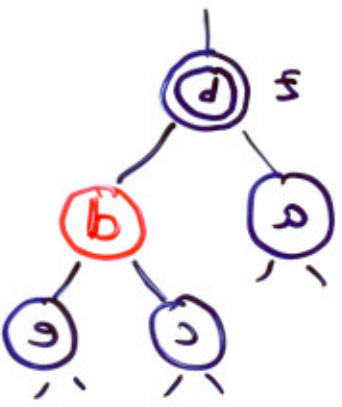
DONE!

Case IV

5/1 zipping and neighbors are black
5/1 parent black



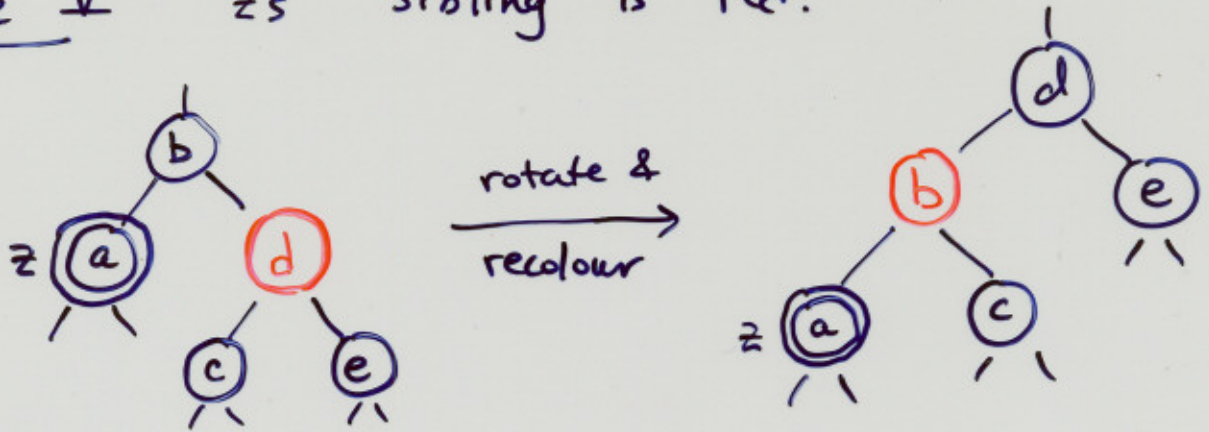
rotation
←



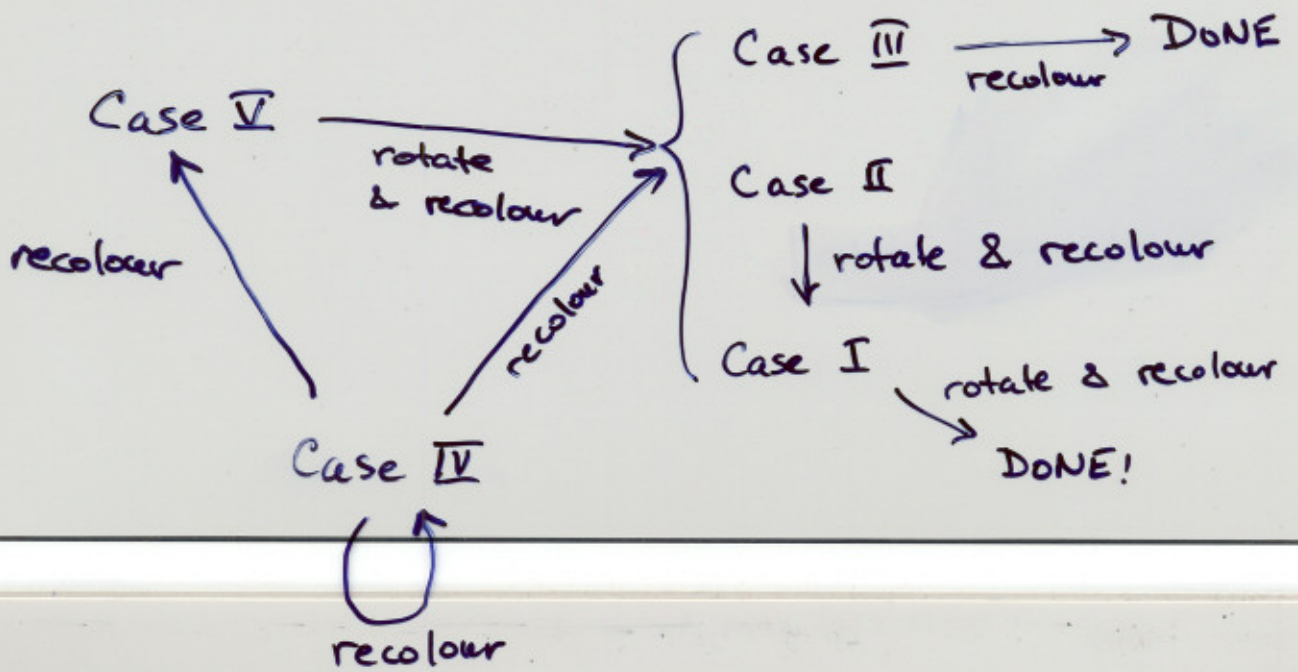
Repeat
is higher up.
Now violation

Fixing deletion (contd)

Case V z's sibling is red.



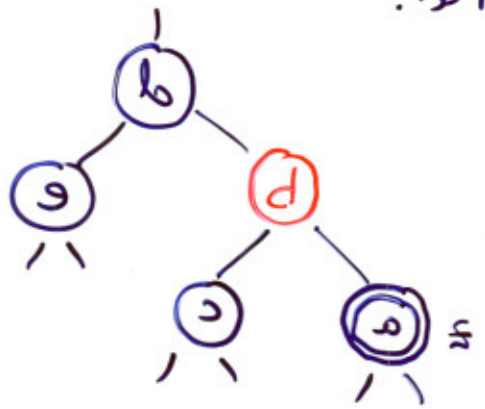
GO TO CASE I, II, III



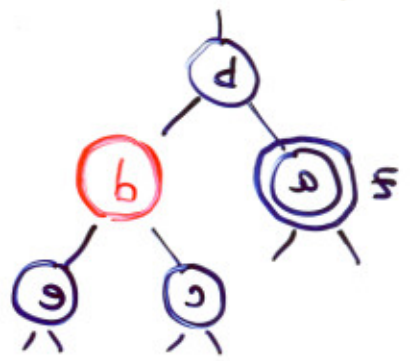
Note: max #
rotations needed
= 3.

Fixing deletion (cont'd)

Case V
is a zipling is req.



rotation & rebalancing



NO TO CASE I, II, III