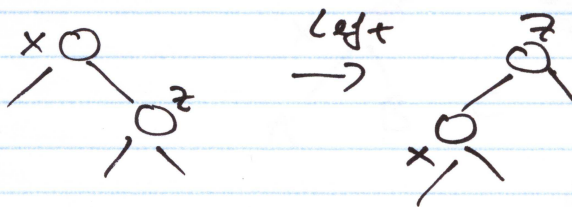


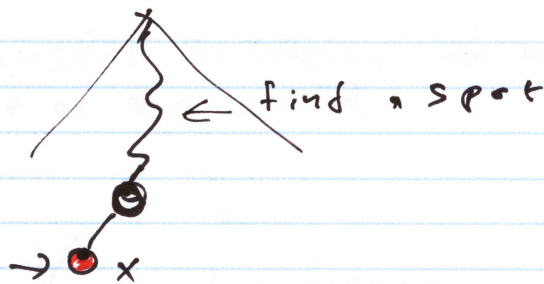
RB Trees:

BST: ~~items~~ in R
 $\forall$ node v : items in L_{SABT} of v
 are smaller or equal to v
 target

- red or black
- root is black
- null nodes (pretend leaves) are black
- no red-red
- each branch has same # of black nodes



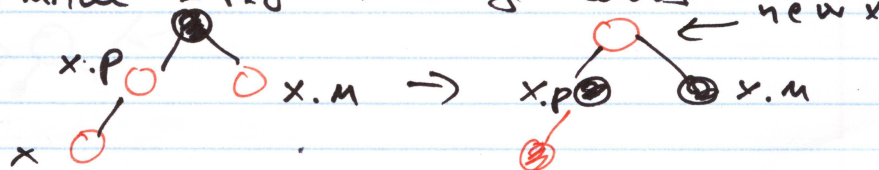
Insertion



- need to fix RR violations

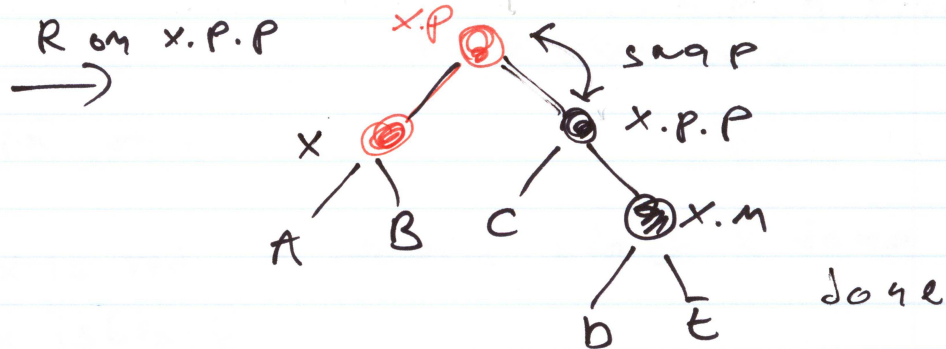
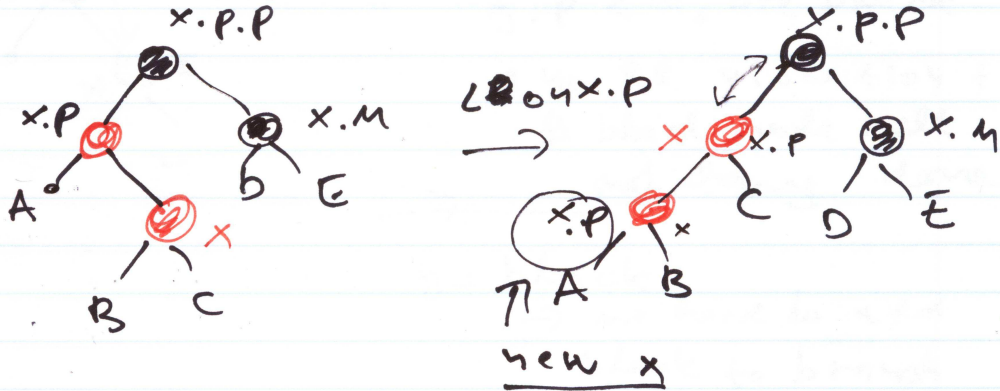
1) $x.p = \text{black}$, done

2) $x.\text{uncle} = \text{red} \Rightarrow \text{change colors}$



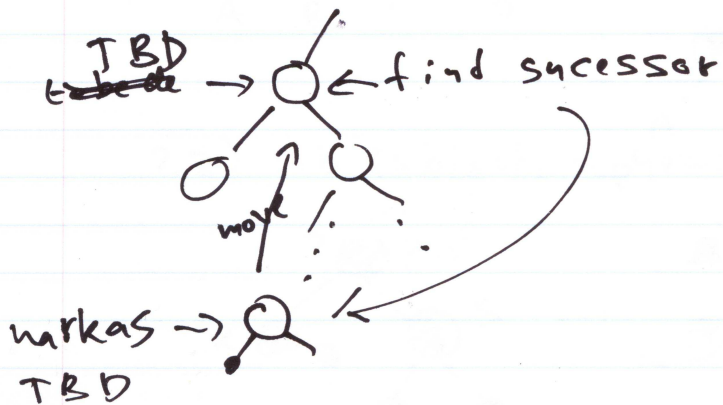
3) $x.mch = \text{black}$

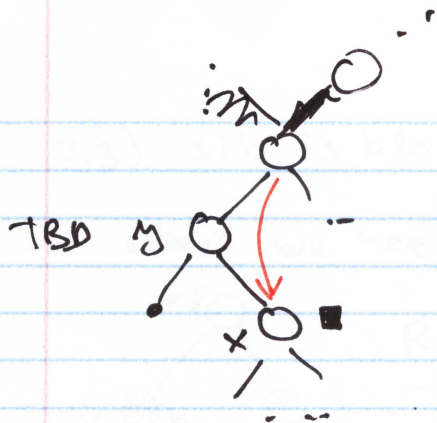
1) make x to be left child



Deletion

- transfer deletion to node with one or no child





if $y = \text{red} \Rightarrow$

$y.p$ & x are black

no RR violation +

black node will

not change done



$y = \text{black}$

$\rightarrow$ we have to add

black to branch

$\dots y.p, y, x, \dots$

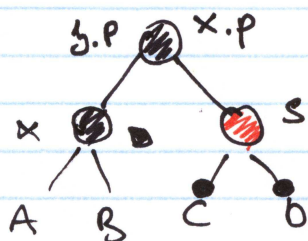
black token to x

Tree fix on x

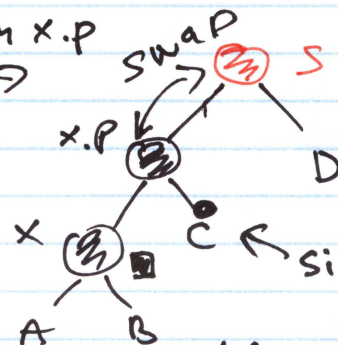
1) x is red $\rightarrow$ color it black & done

2) x is black

2.1) sibling is red

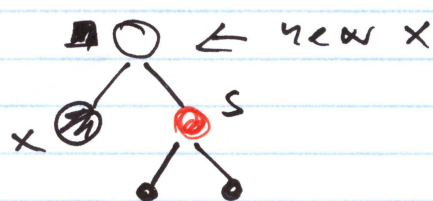
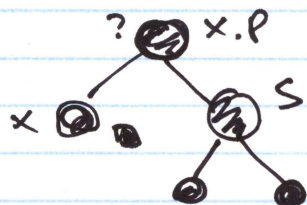


L on $x.p$



sibling is now black

2.2) sib is black, nephews are black



2.3) sib is black, nephew ~~is~~ ^{is not}

case we need far nephew to be ~~black~~ ^{red}

