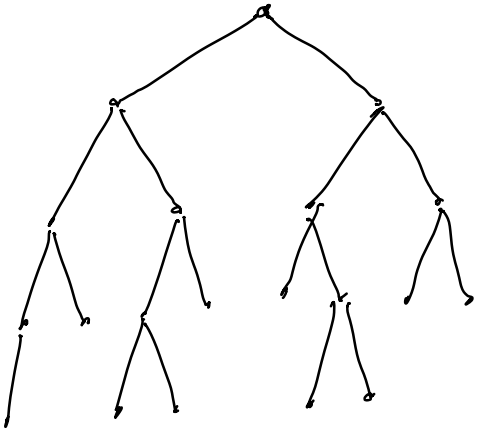
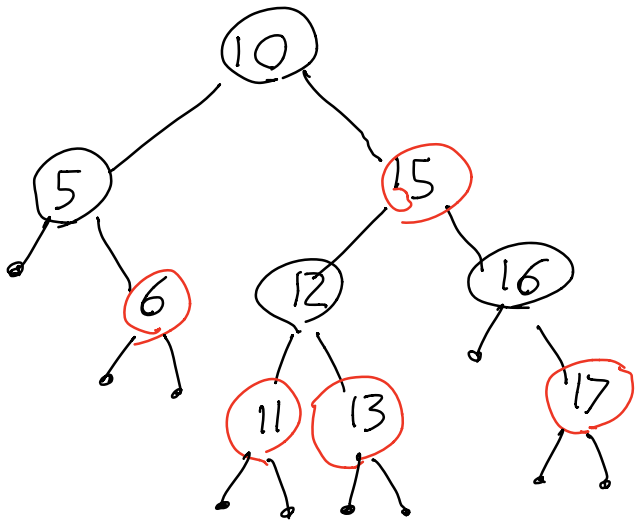
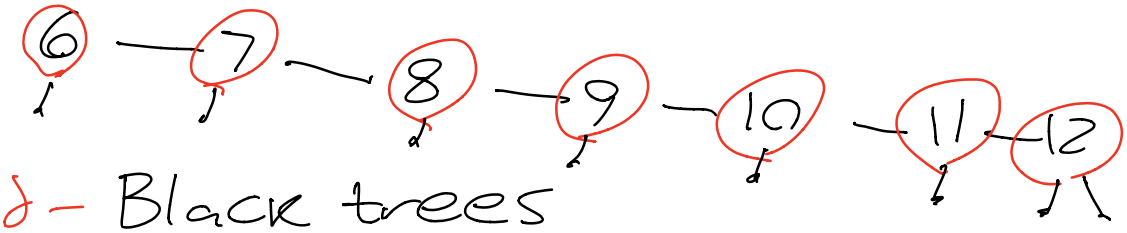
Final Review: Balanced Trees





n nodes

$d \leq \log_2(n) + 1$



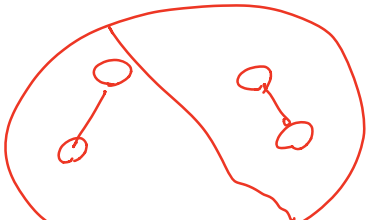
Red-Black trees

Global Invariant:

Every root-leaf path has same # of black nodes.

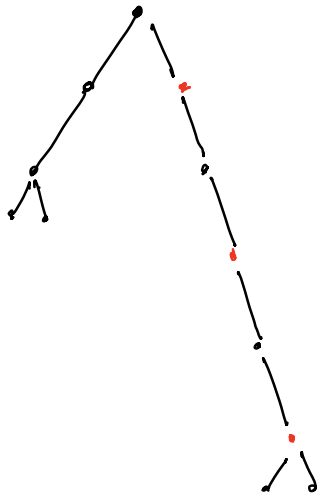
Local Invariant:

No two red nodes can have parent-child relationship. ⇑



n nodes

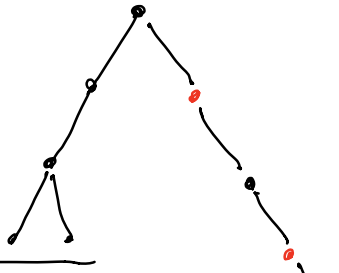
$d \leq 2 \log_2(n)$



4 black nodes
3 red nodes

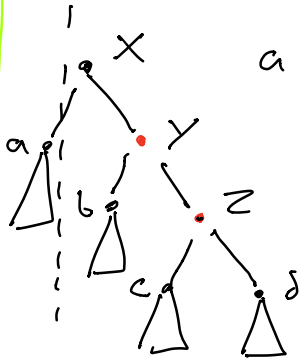
b black nodes
b−1 red nodes

$2b-1$

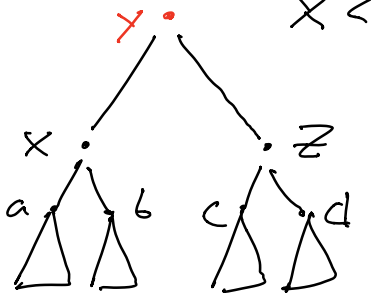


Balance Operation

$a < b < c < d$

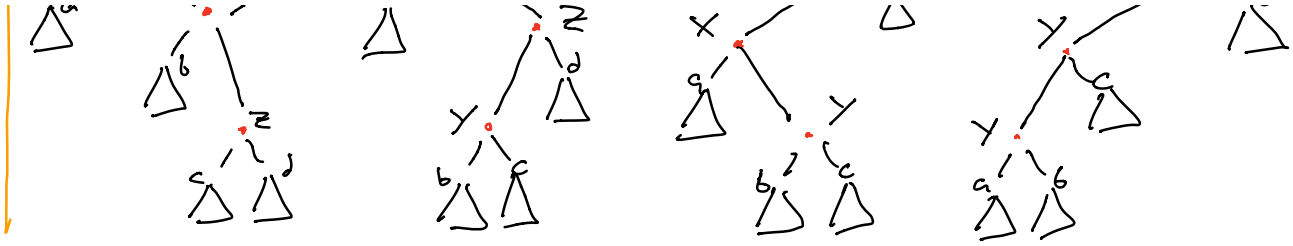


$x < y < z$



$x < y < z$

4 cases



Exercise:

insert 14 into