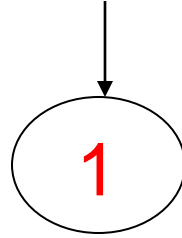


Red Black Trees

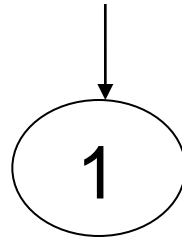
Insertion Example

Example of Inserting Sorted Numbers

▶ 1 2 3 4 5 6 7 8 9 10

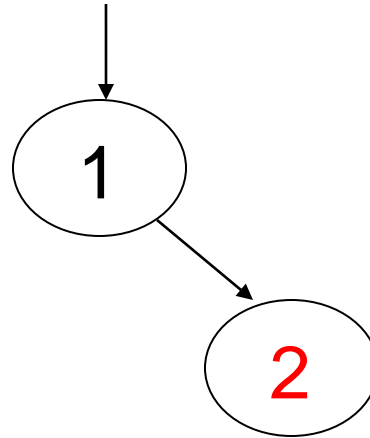


Insert 1. A leaf so red. Realize it is root so recolor to black.



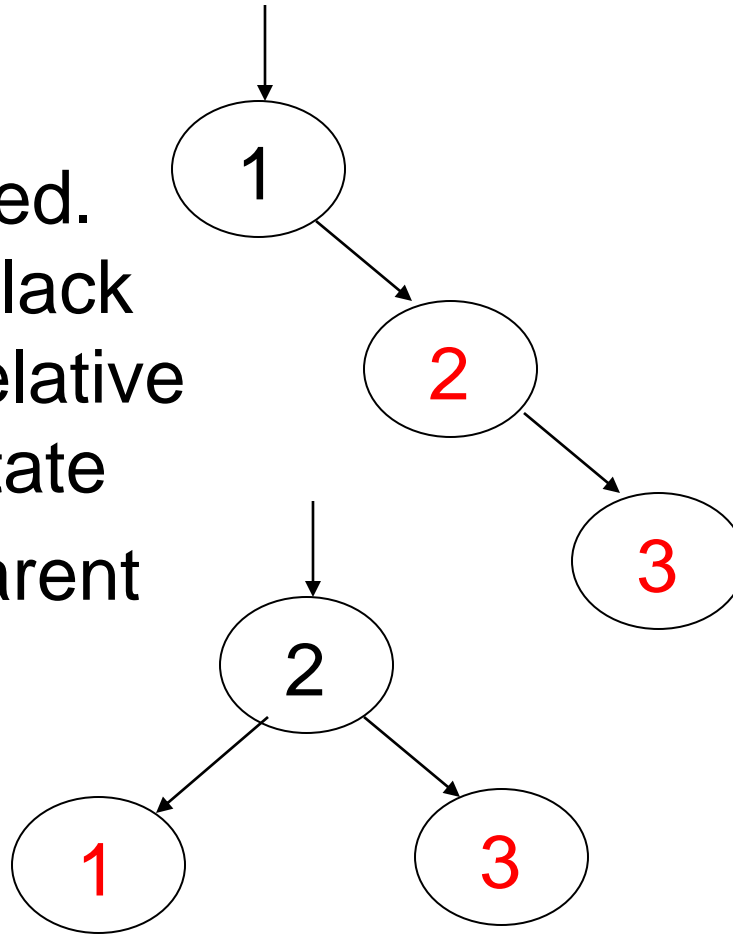
Insert 2

make 2 red. Parent
is black so done.



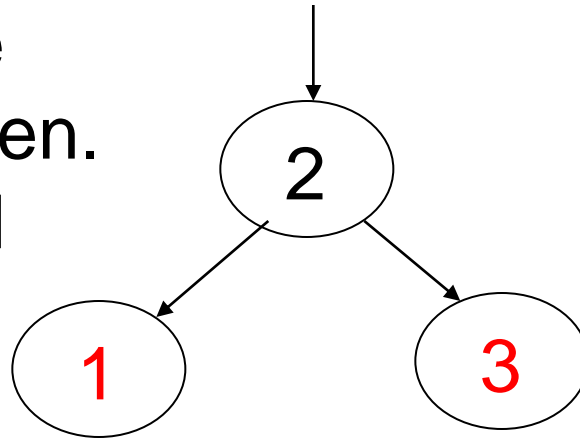
Insert 3

Insert 3. Parent is red.
Parent's sibling is black
(null) 3 is outside relative
to grandparent. Rotate
parent and grandparent

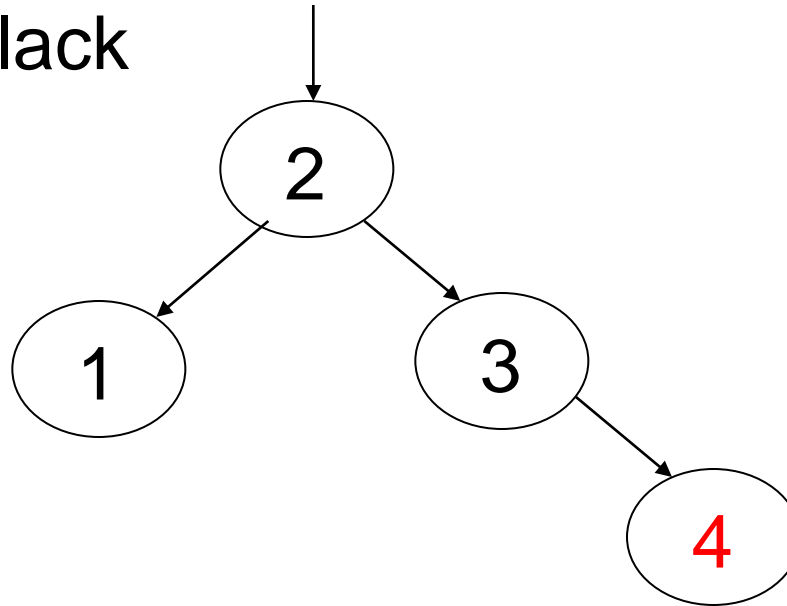


Insert 4

On way down see
2 with 2 red children.
Recolor 2 red and
children black.
Realize 2 is root
so color back to black

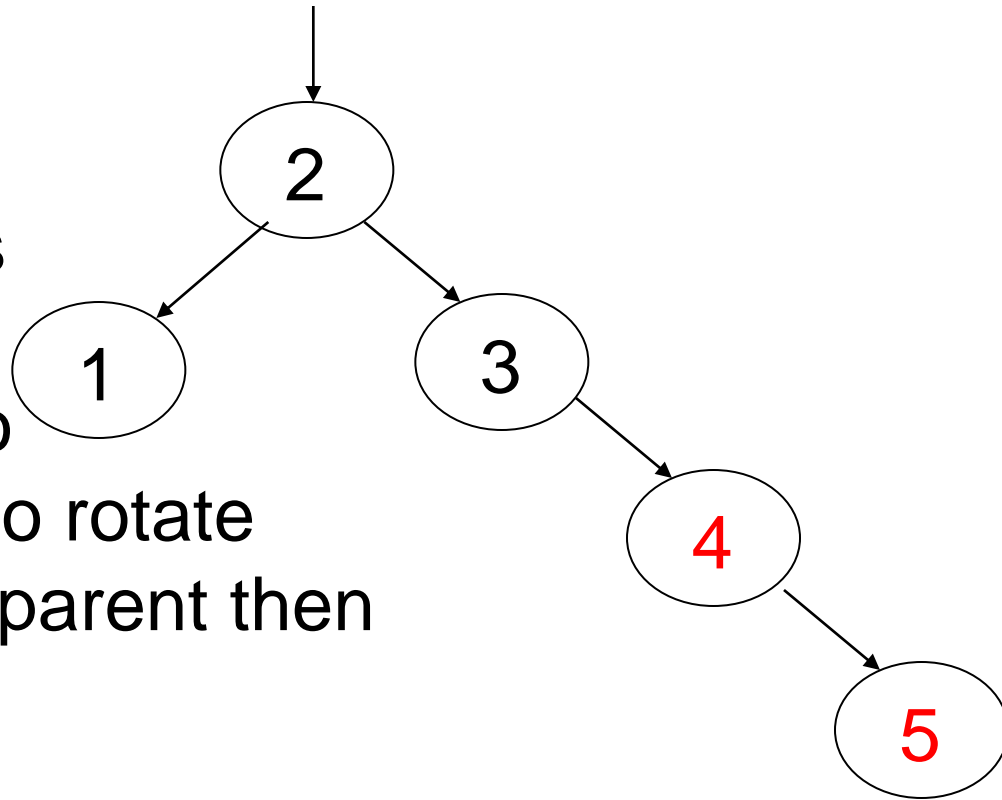


When adding 4
parent is black
so done.

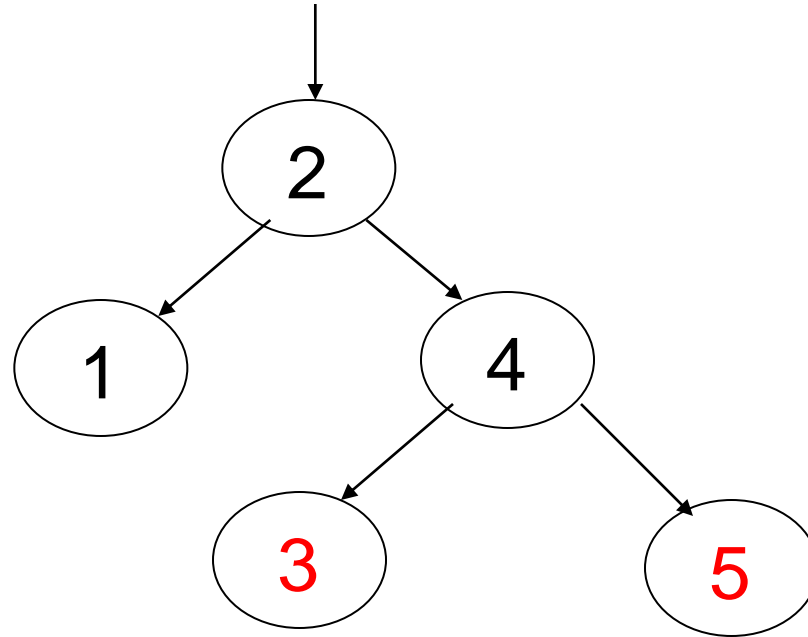


Insert 5

5's parent is red.
Parent's sibling is
black (null). 5 is
outside relative to
grandparent (3) so rotate
parent and grandparent then
recolor

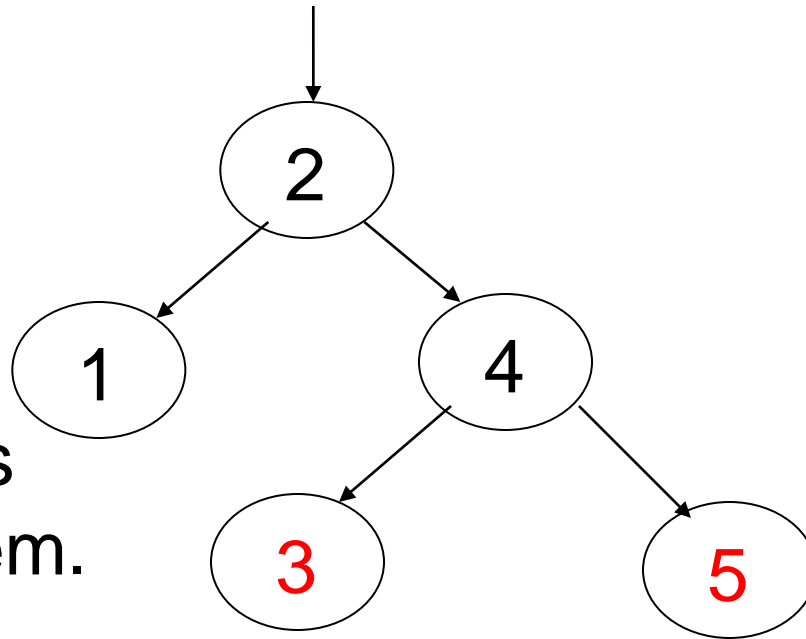


Finish insert of 5



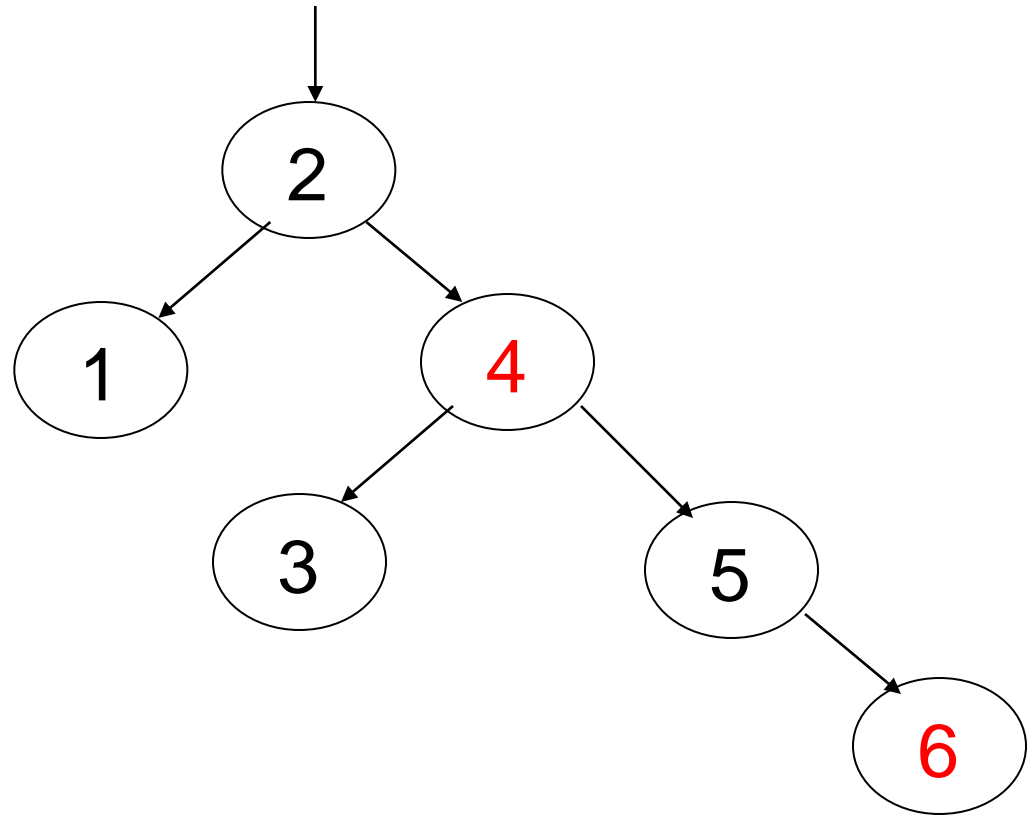
Insert 6

On way down see
4 with 2 red
children. Make
4 red and children
black. 4's parent is
black so no problem.



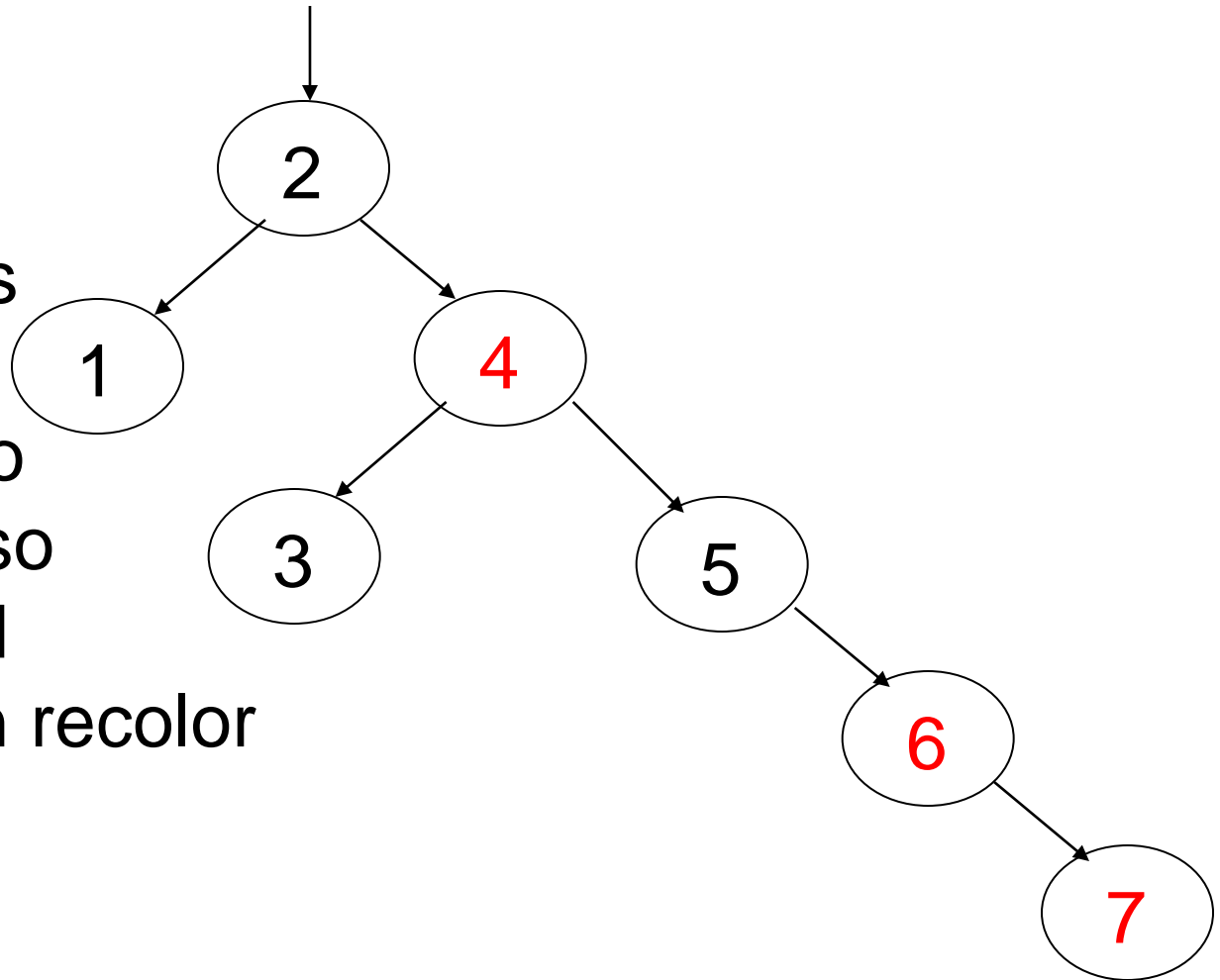
Finishing insert of 6

6's parent is black
so done.

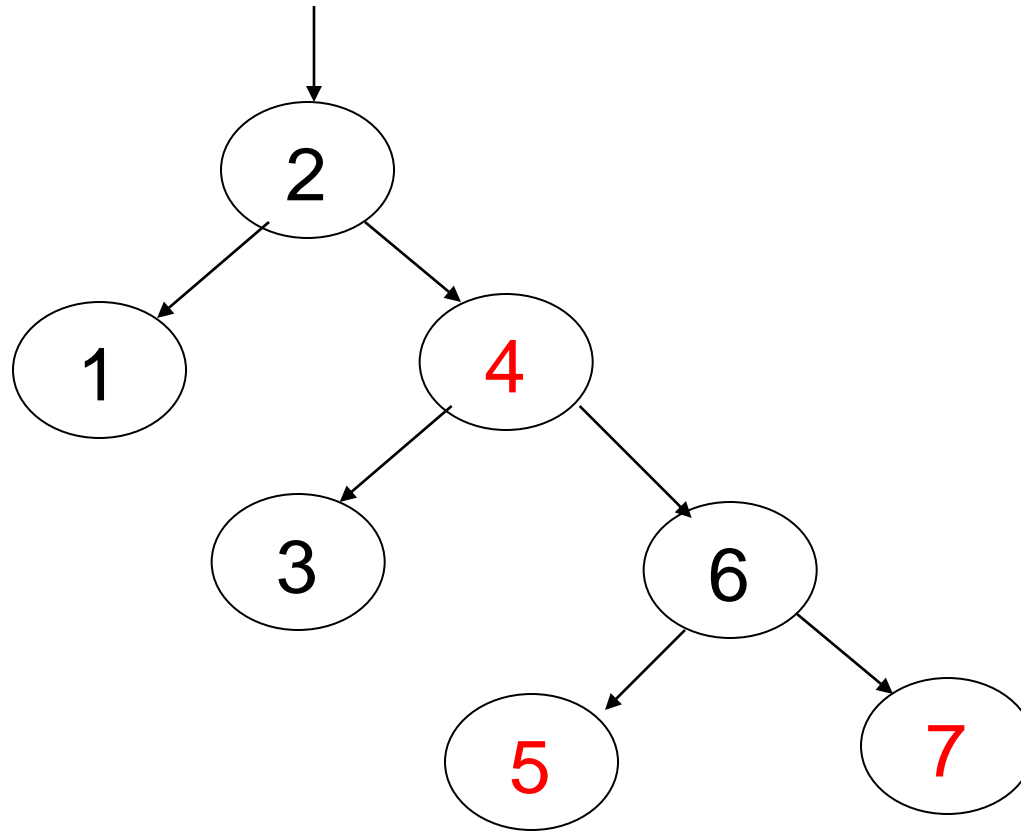


Insert 7

7's parent is red.
Parent's sibling is
black (null). 7 is
outside relative to
grandparent (5) so
rotate parent and
grandparent then recolor

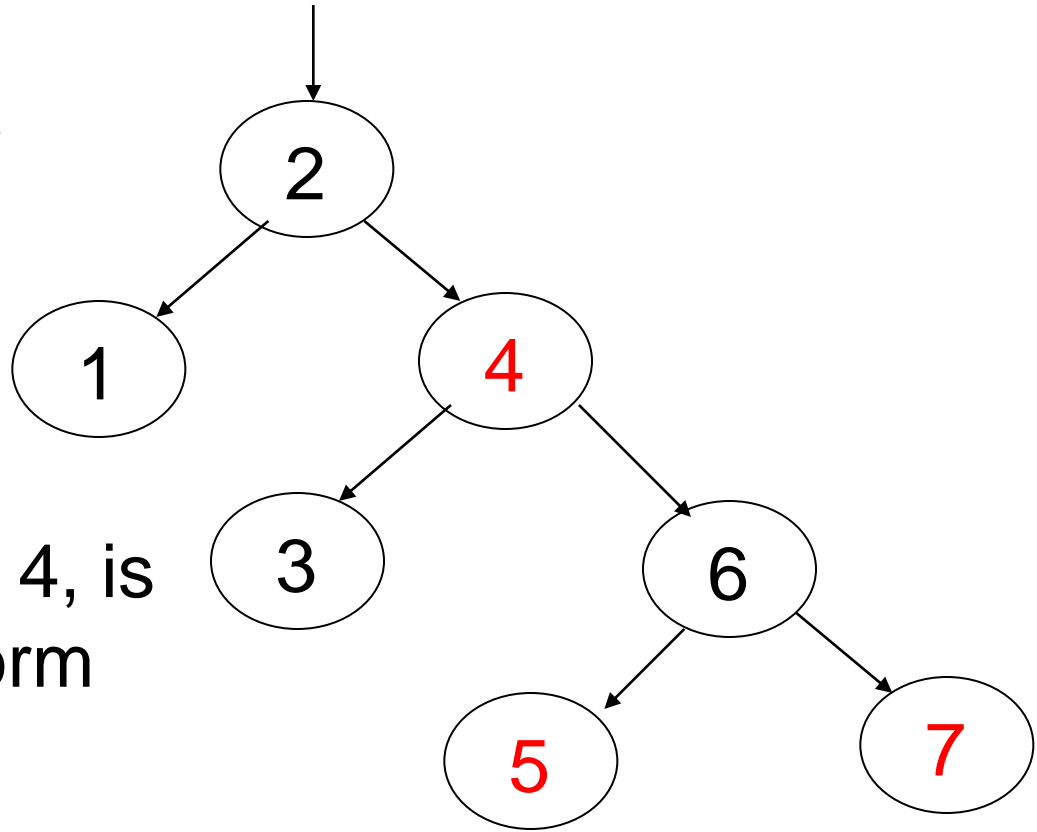


Finish insert of 7



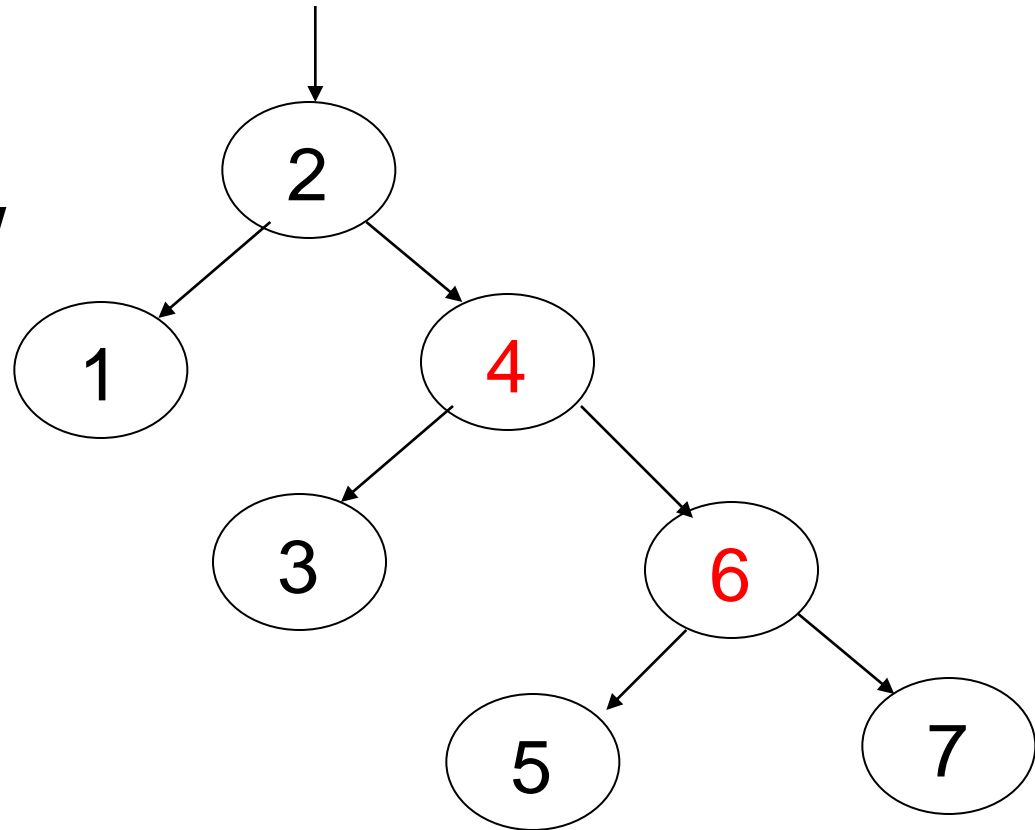
Insert 8

On way down see 6 with 2 red children.
Make 6 red and children black. This creates a problem because 6's parent, 4, is also red. Must perform rotation.

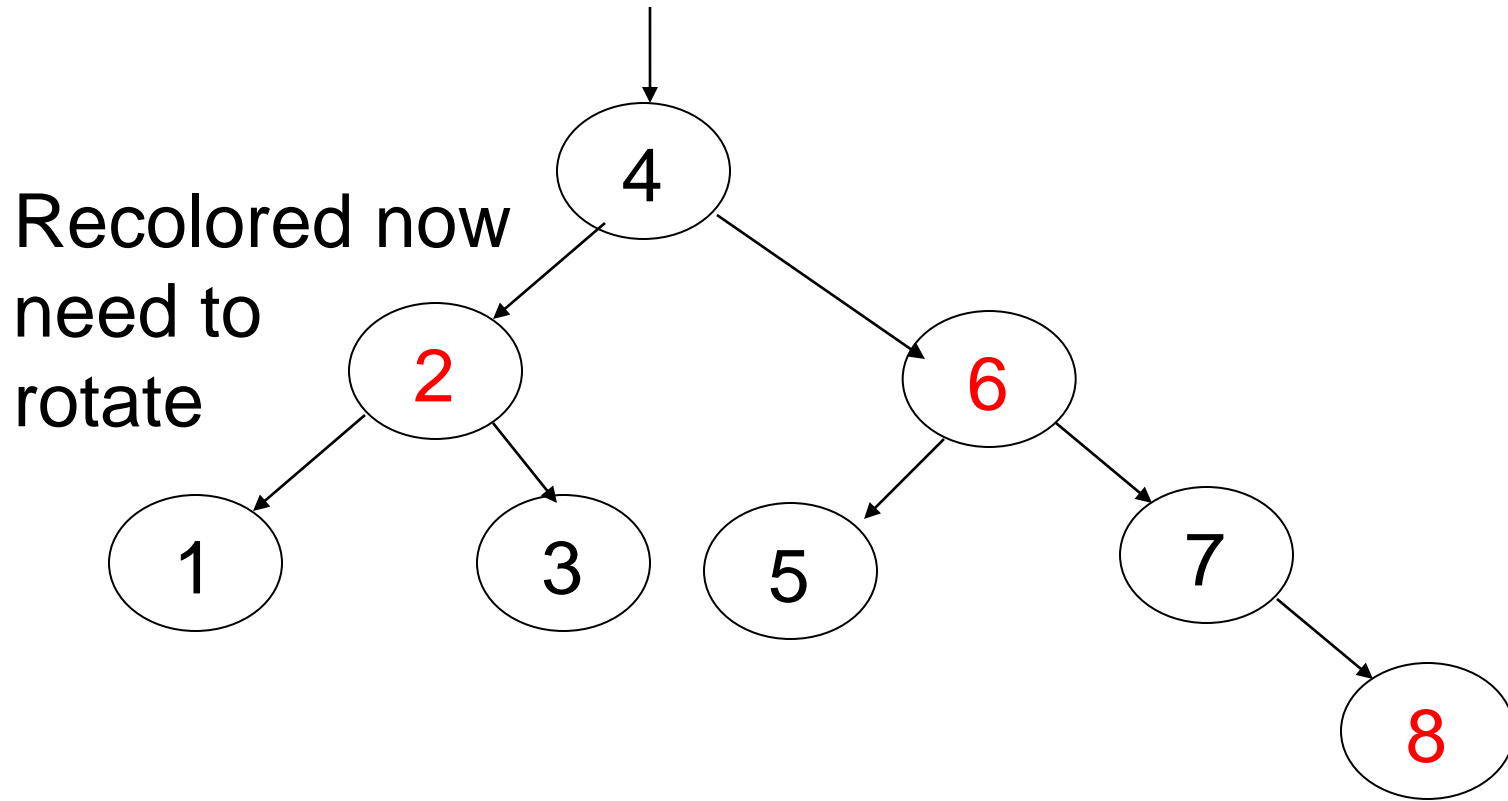


Still Inserting 8

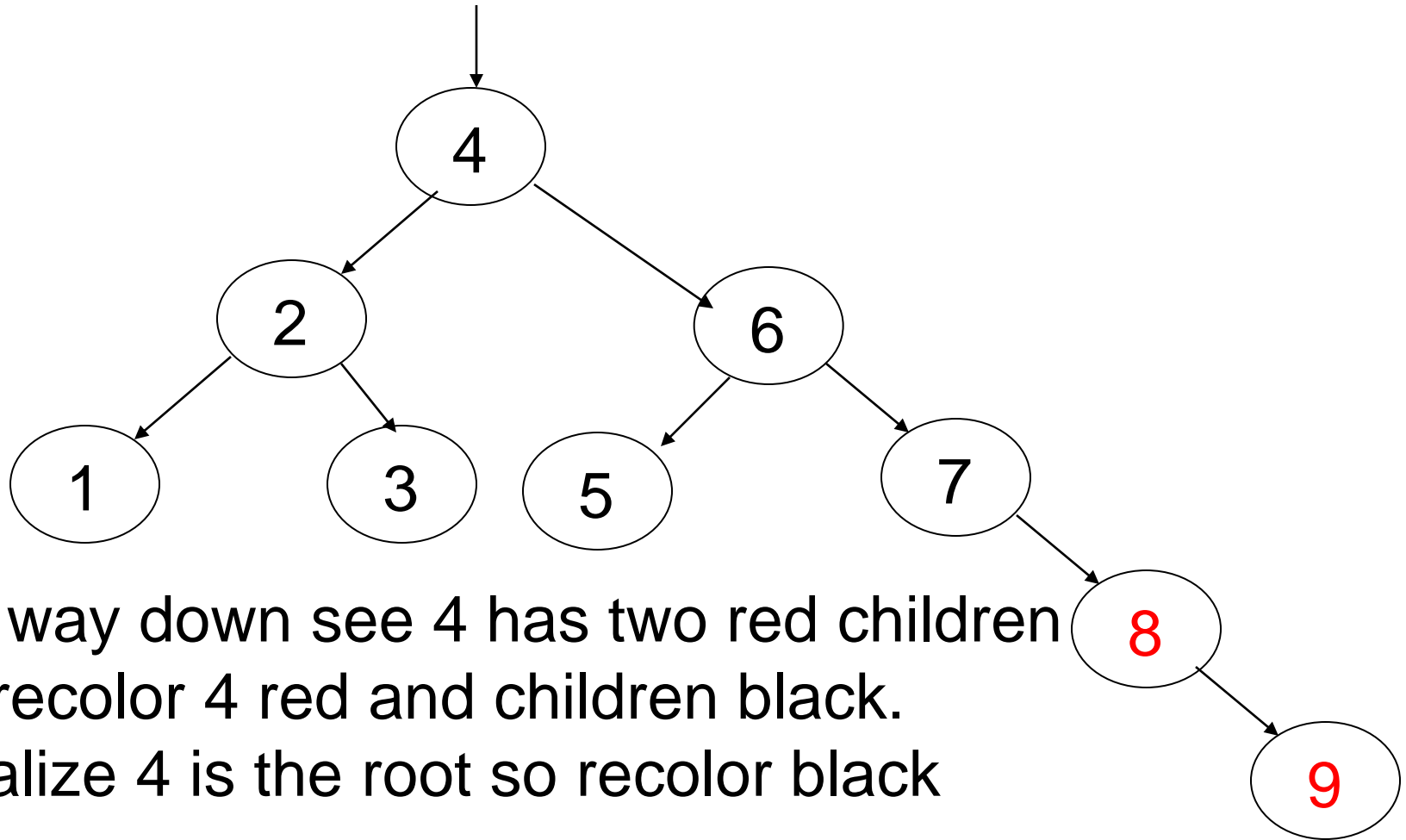
Recolored now
need to
rotate



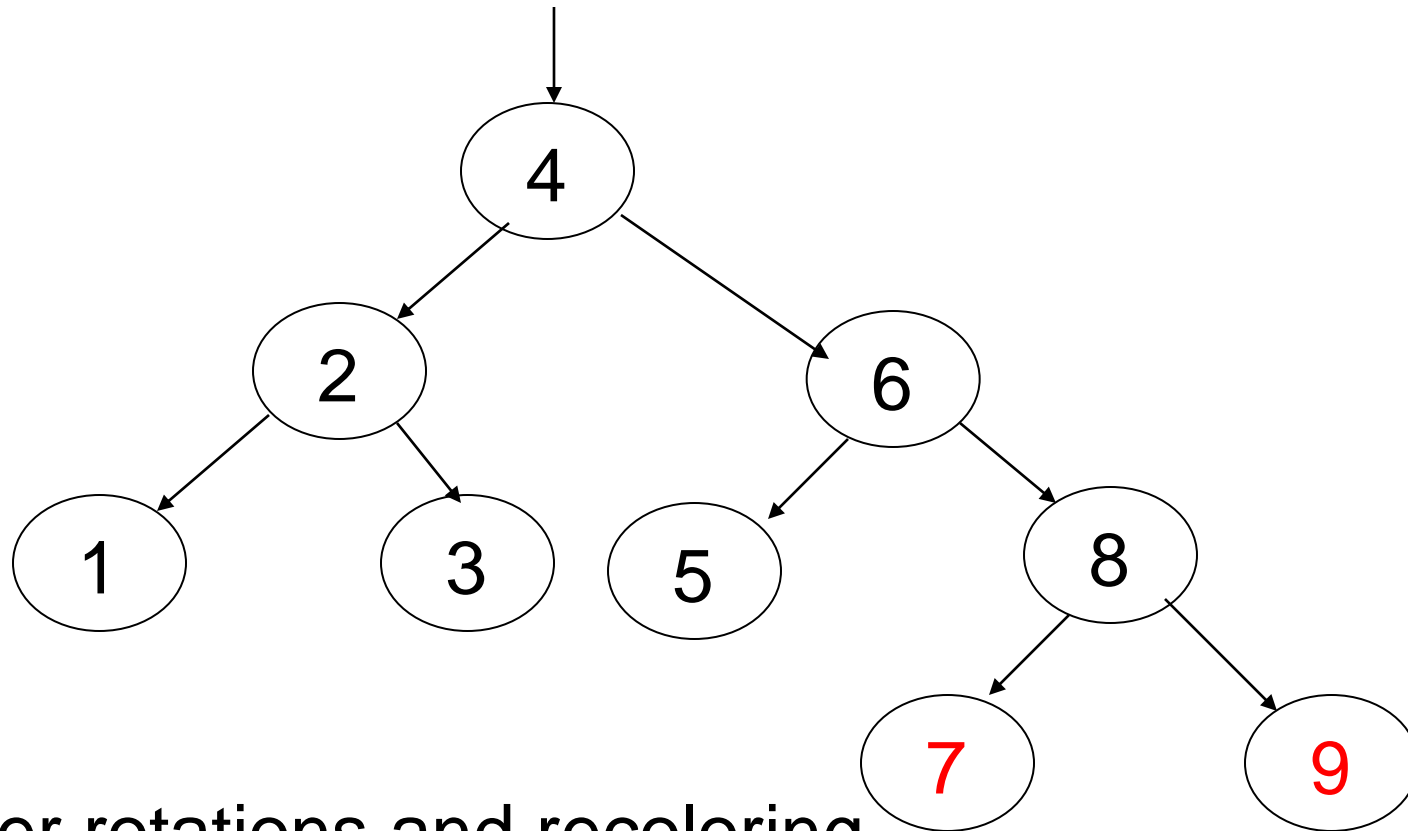
Finish inserting 8



Insert 9

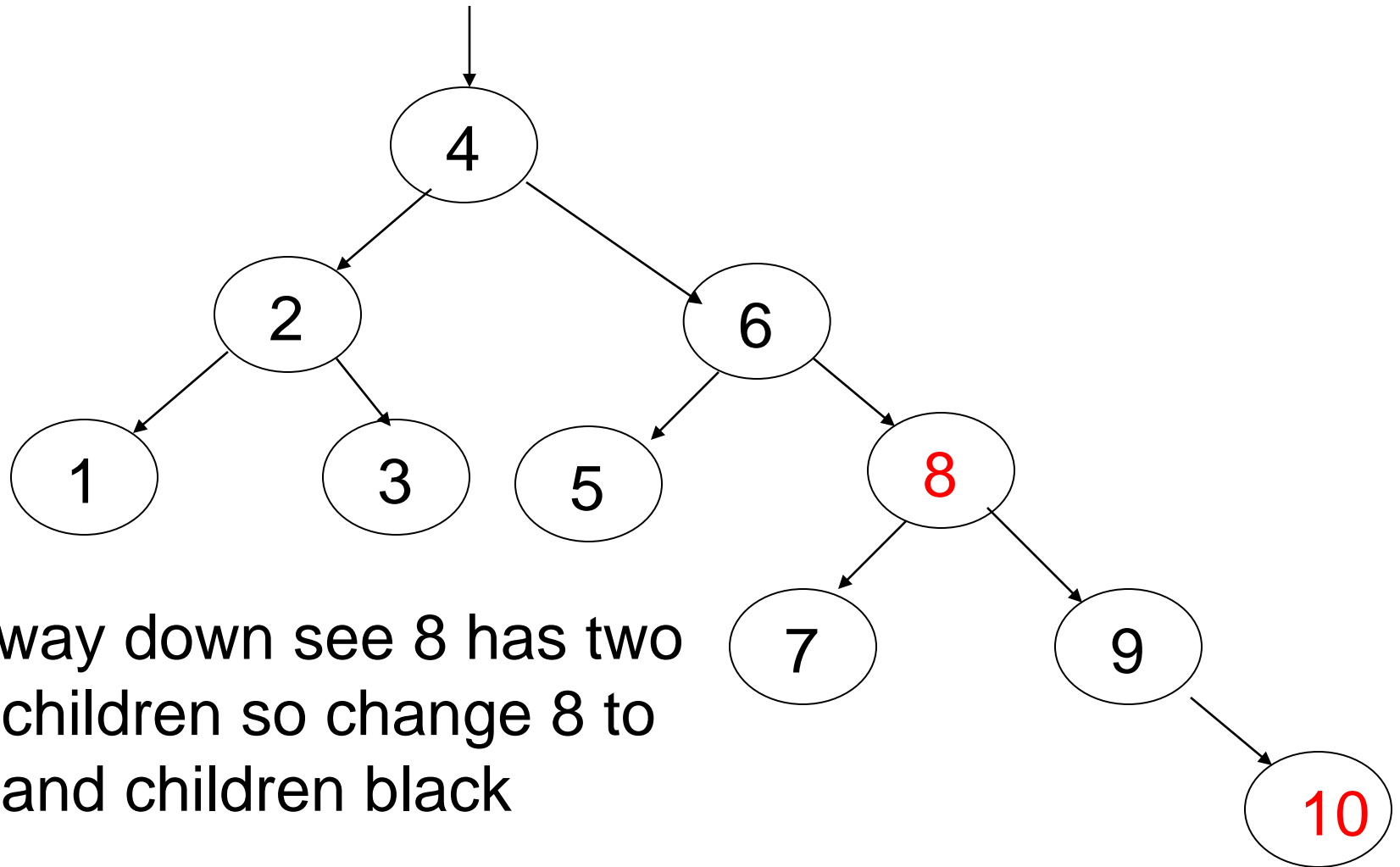


Finish Inserting 9

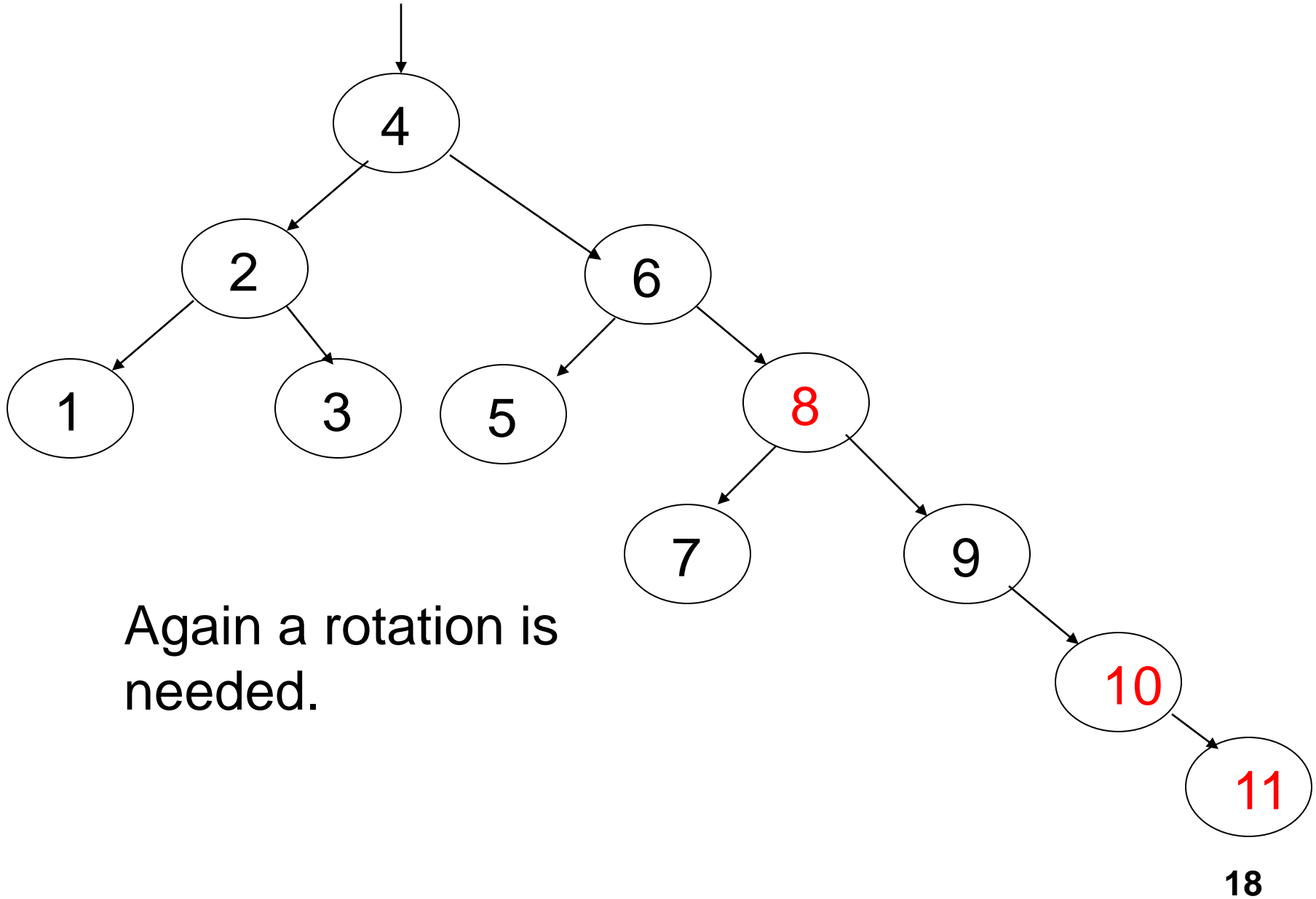


After rotations and recoloring

Insert 10



Insert 11



Finish inserting 11

