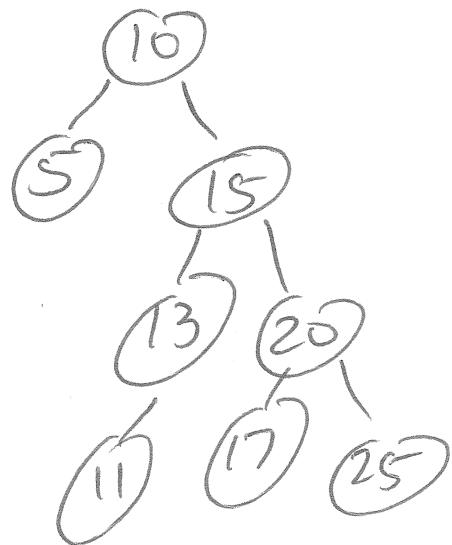


① Attendance ✓

② Final Project Introduction ✓

③ Pick Groups ✓

④ 2-4 Trees

Reg BST

1 item per node

leaf nodes at

* different depths

AVL Tree

↳ leaves can be
diff depths

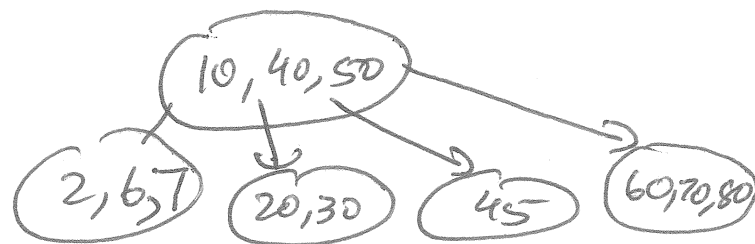
BUT we "generally"

balance allows for $O(\lg n)$
worst case height

2-4 Tree

① Nodes can have in between
2 and 4 children (1 and 3
values)

② All leaf nodes are at
the same level



Insert 7

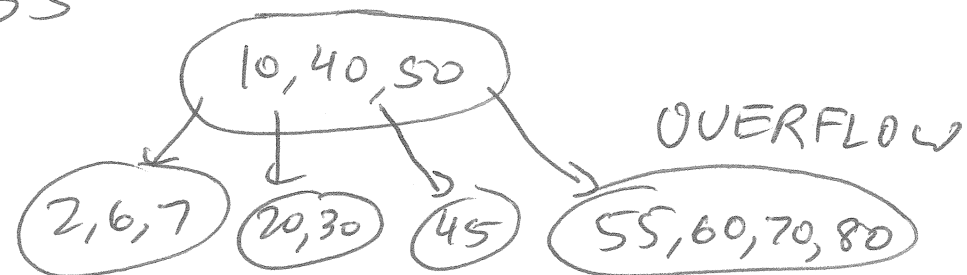
↳ easiest case

Search down to
bottom, add to

appropriate node

if # values ≤ 3 , done

Insert 55



Issue: Node w/ inserted value has > 3 values.

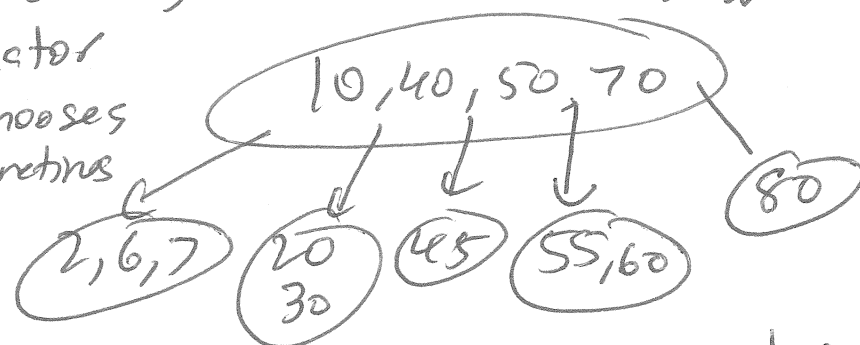
FIX OVERFLOW

Continue
up
tree
as
needed

1) Take 3rd value in node + push to parent.

2) Split other 3 values into 2 nodes
"left" one storing 2 value, "right"
one storing 1. OVERFLOW

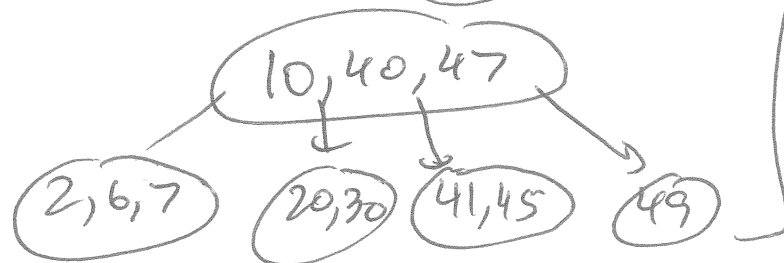
Online simulator
sometimes chooses
3rd value, sometimes
2nd value!



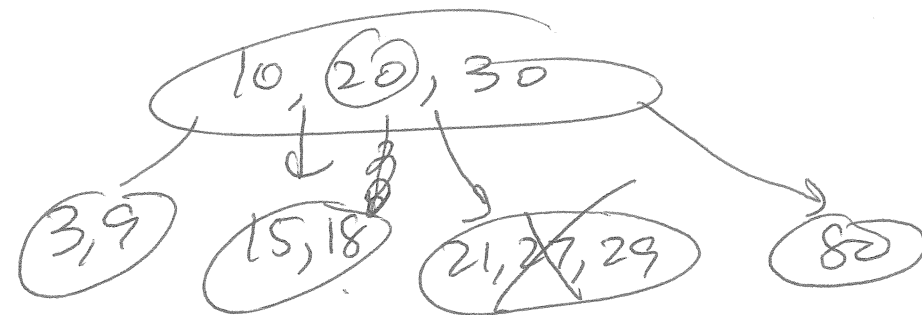
Insert 41



Rest SAME



Delete



Delete 27

Case 1: Value in leaf node w/ > 1 item

Case 2: Value in leaf node it's only one

- Example 80 (from below)
- Adjacent siblings has > 1 value
- No adjacent sibling has > 1 value

Case 3: Value not in leaf node

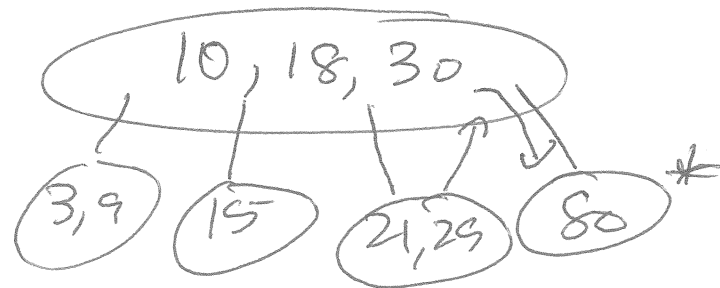
Example: Delete 20

→ Don't delete physical location

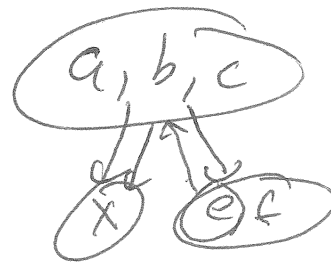
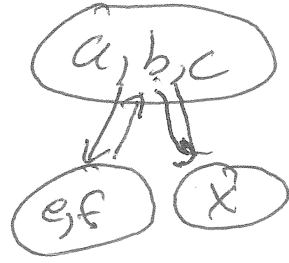
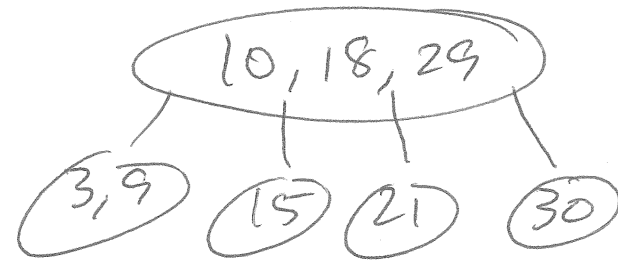
→ replace w/ predecessor or successor

($20 \rightarrow \underline{18}$ or $20 \rightarrow \underline{21}$)

→ guaranteed
to be in leaf

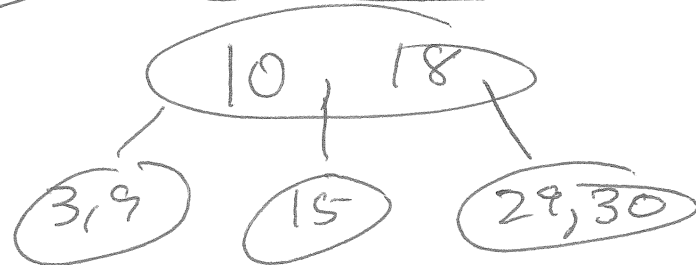
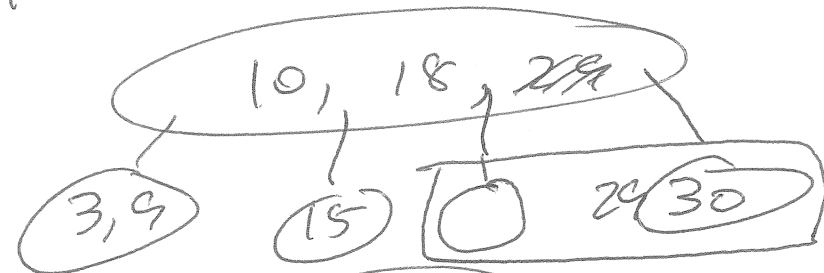


Transfer operation for adjacent sibling
with > 1 value, 29 goes to parent,
value in parent comes down



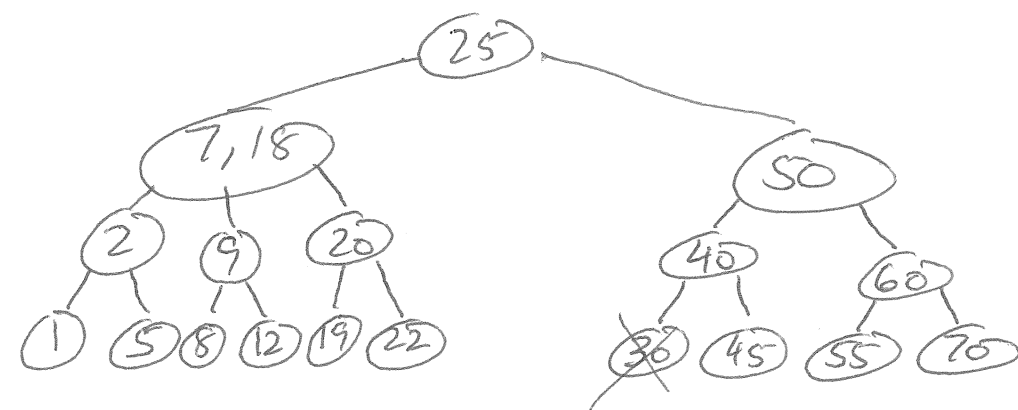
Delete 21
Case where no adjacent
sibling has > 1 value

FUSION OPERATION

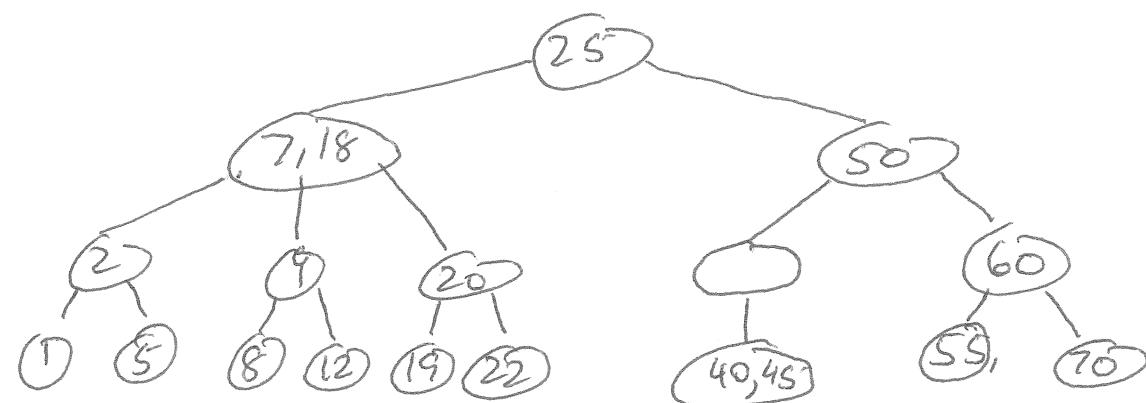


DROP
VALUE
FROM
PARENT INTO
ADJACENT
CHILD +
FUSE THIS
NODE W/
EMPTY
ONE

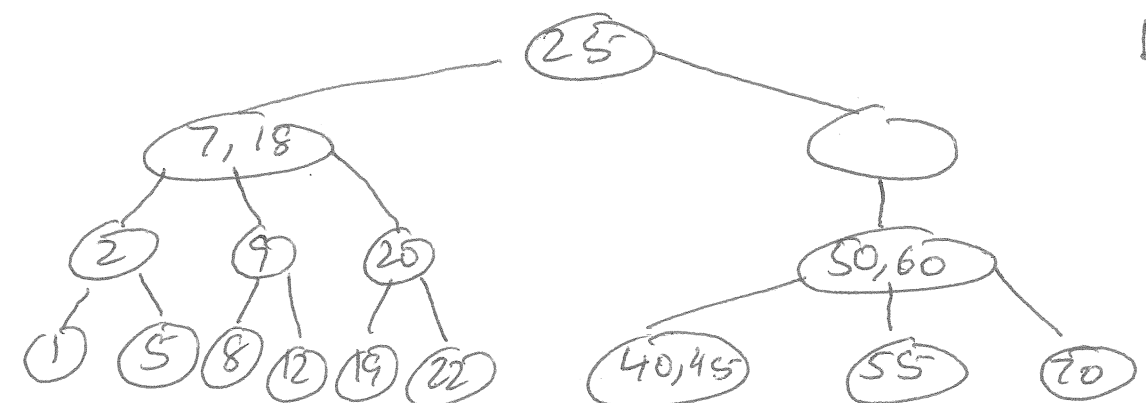
This could cascade to
another fusion operation
above.



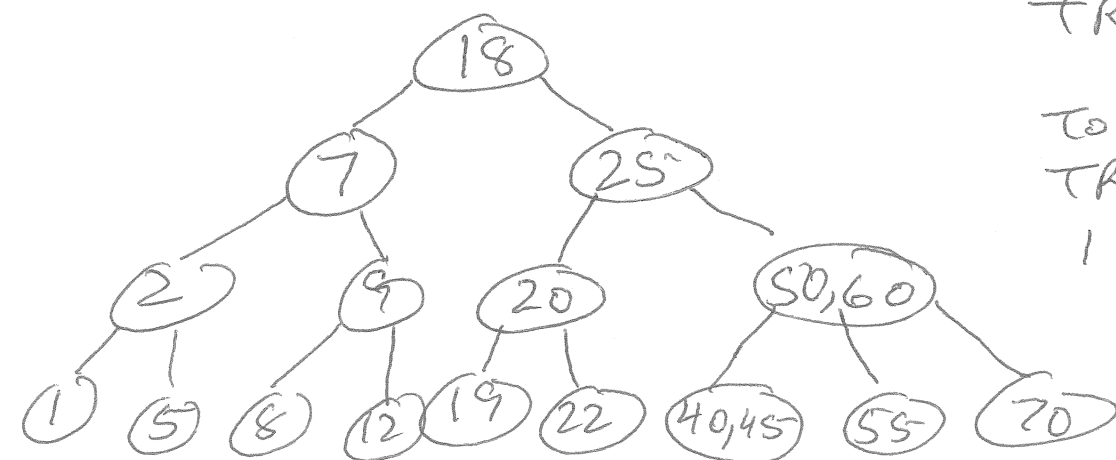
Delete 30



DROP 40
FUSE



DROP 50
FUSE



TRANSFER
25
TO EMPTY,
TRANSFER
18 TO ROOT