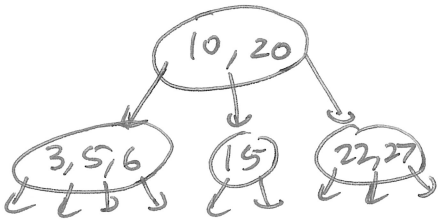
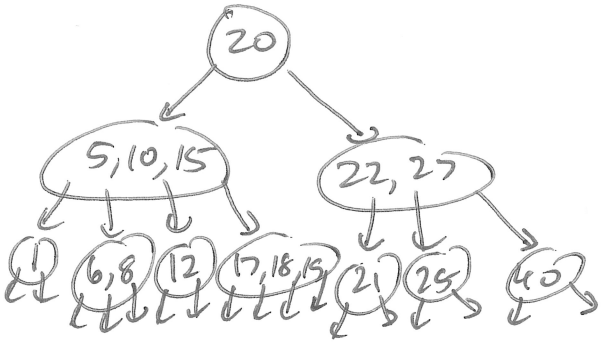
COP 3503 - 1/27/22 2-4 Trees

Requirements

1) each node has in between 2 and 4 children, inclusive, (each node except leaf nodes, store 1 fewer item than children)
2) all leaf nodes are at the same depth.
3) search tree property is maintained





Height: Worst case is complete binary tree

n nodes height $= O(\lg n)$

$n = 2^k - 1$, height $= k - 1$

$n + 1 = 2^k$

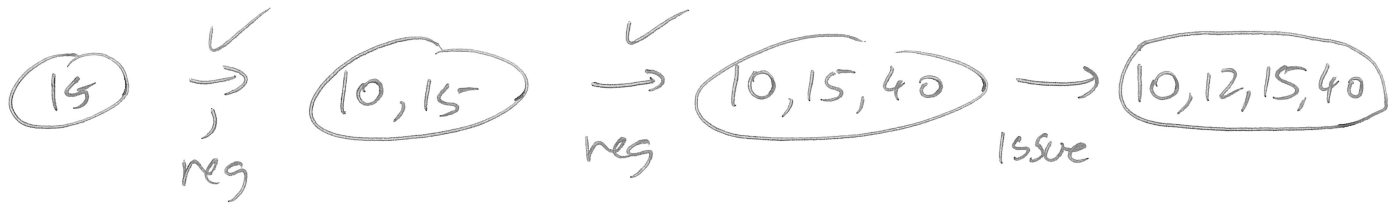
$k = \log_2(n+1)$

Also bound height by $O(\lg n)$ as a lower bound.

(a) Search (Similar to BST search)

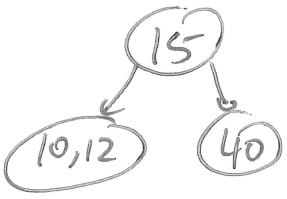
(b) Insert?

Just like AVL tree, if an insert doesn't mess up the rules, we are good!

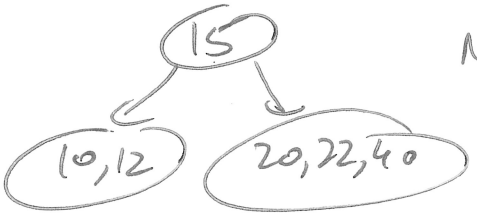


Main issue node goes from storing 3 to 4 items

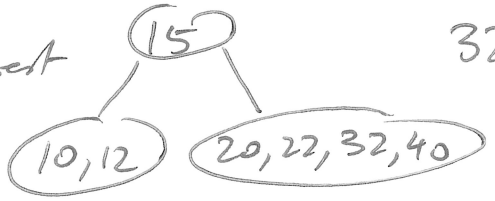
Solution: Split up 3rd value into parent node. If there is no parent, create it.



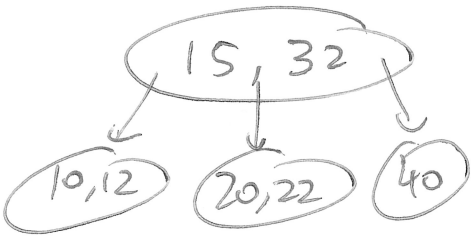
[ALWAYS TAKE INSERTS TO BOTTOM LEVEL!]



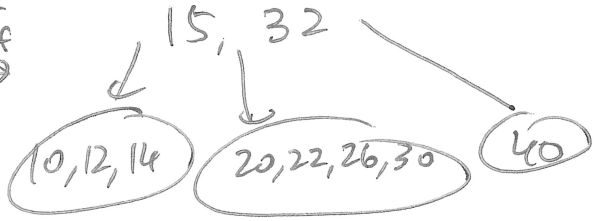
Now insert 32



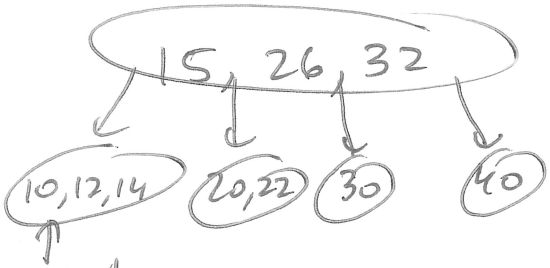
32 jumps to parent

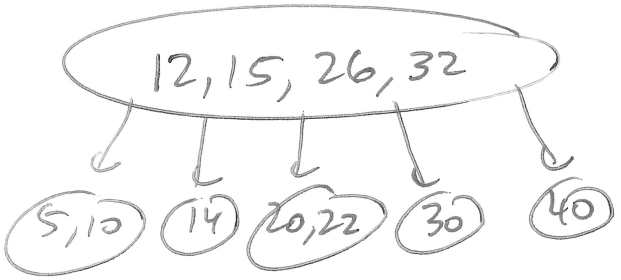


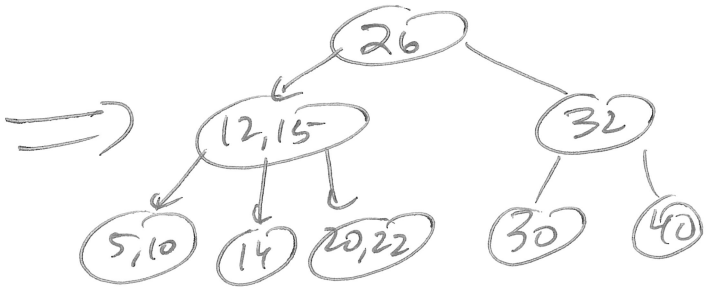
insert stuff



26 is moving up

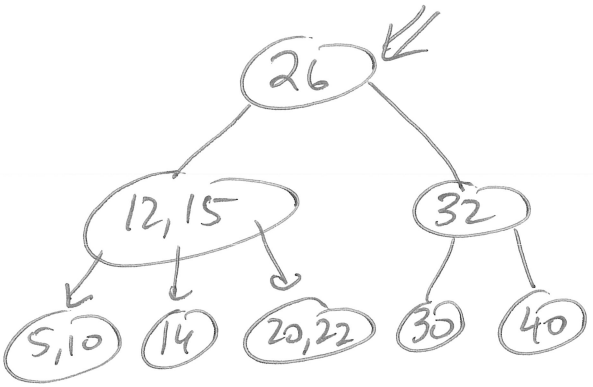




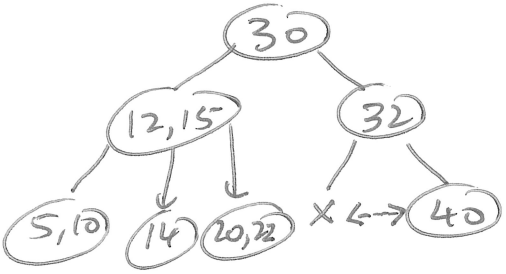


Delete

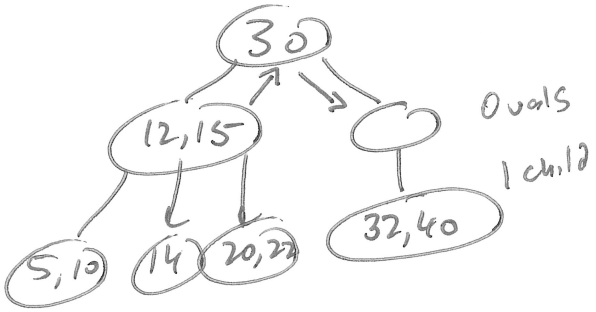
Start w/ same tree



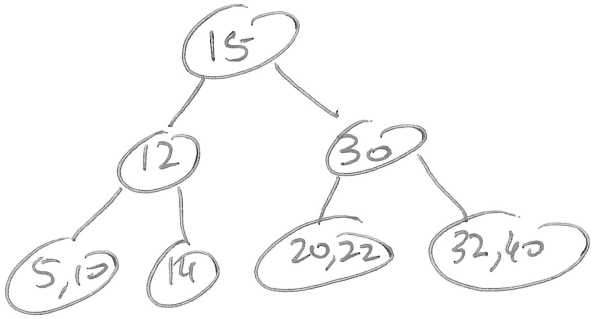
① If trying to delete any node NOT on bottom level, swap with the nearest neighbor on the bottom row (eg: 26 and 30



② once we ID'ed location on bottom row to delete, see if a sibling has > 1 value, adjacent. TRANSFER OPERATION



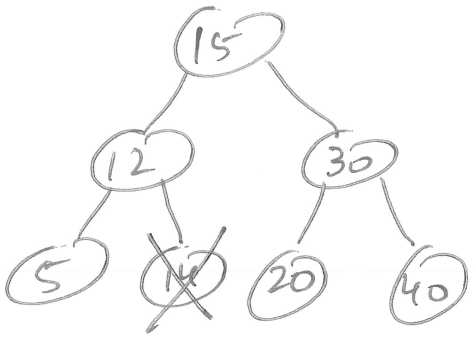
③ If there is nodne, FUSE the node to delete with an adjacent node. THEN TO ACCOUNT FOR FEWER children, drop the appropriate value into the fused node



If we're in case 2, we'll finish delete there.

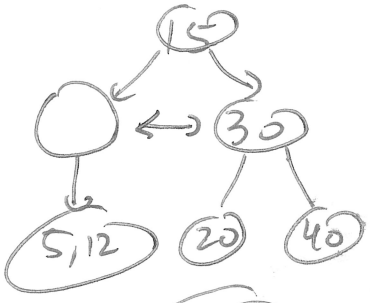
If we're in case 3, we may propagate an error to the previous (higher) level.

Height Reduction Case

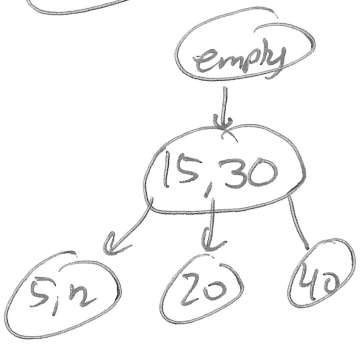


Del 14

⇒

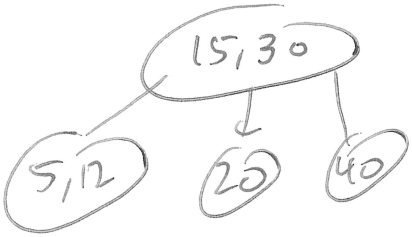


Step 1 fuse 5 + empty then drop 12.

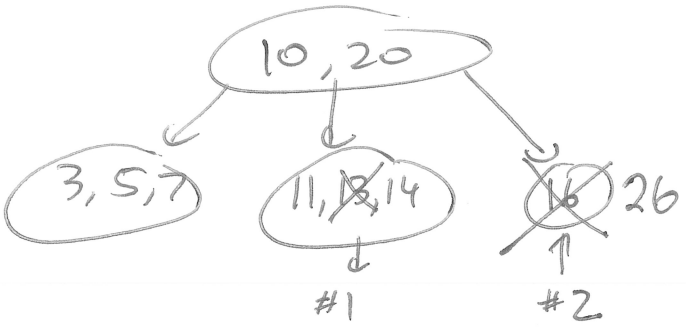


Step 2 fuse 30 + empty then drop 15

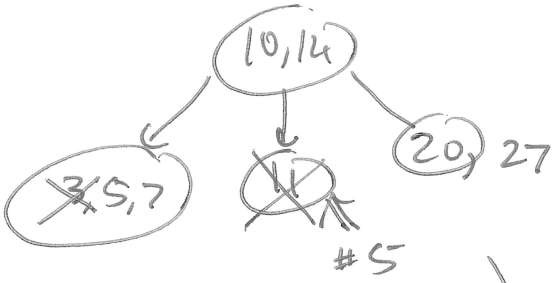
If root is empty, get rid of it, reassign root:



More Delete Cases

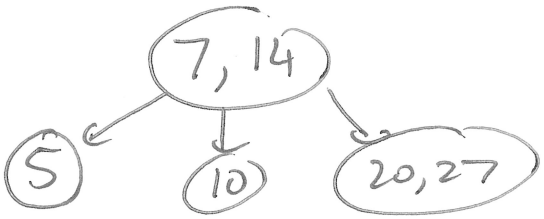


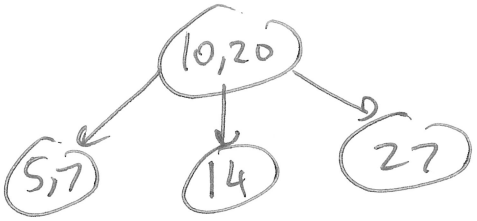
1. Delete 13
2. Delete ~~16~~ 26
3. Delete 3
4. Add 27
5. Delete 11

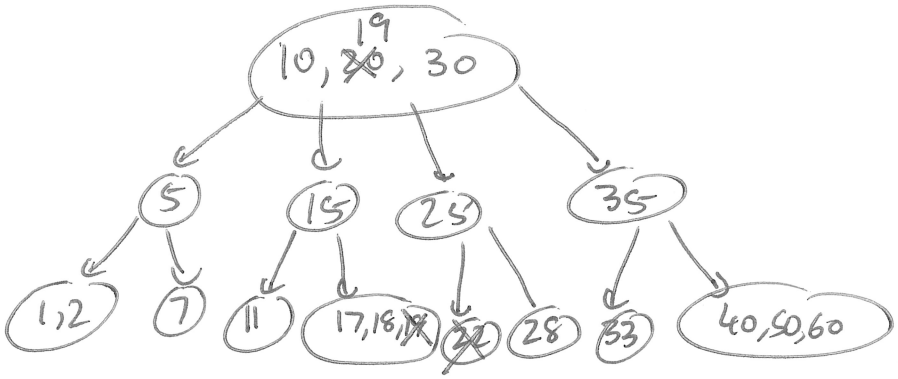


Transfer 7

Transfer 20





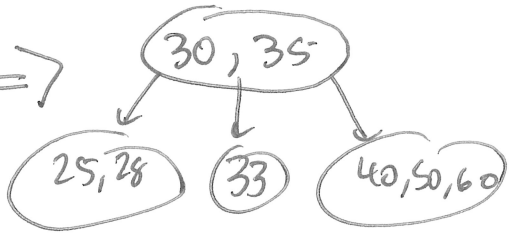


Delete 20

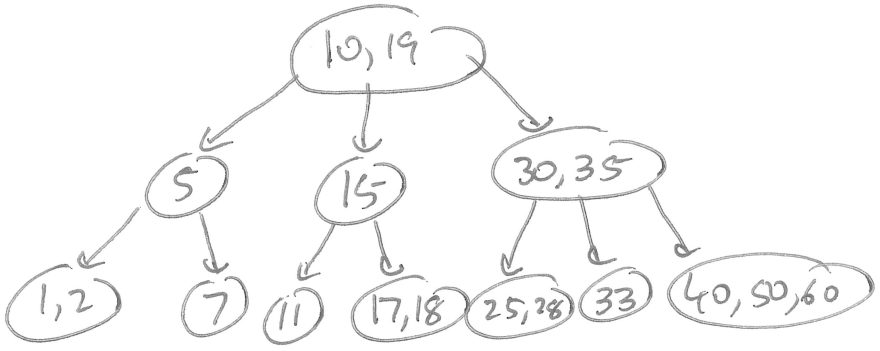
Delete 22

Subpicture :

⇒



no transfer


10, 19
5
15
30, 35
1, 2
7
11
17, 18
25, 28
33
40, 50, 60