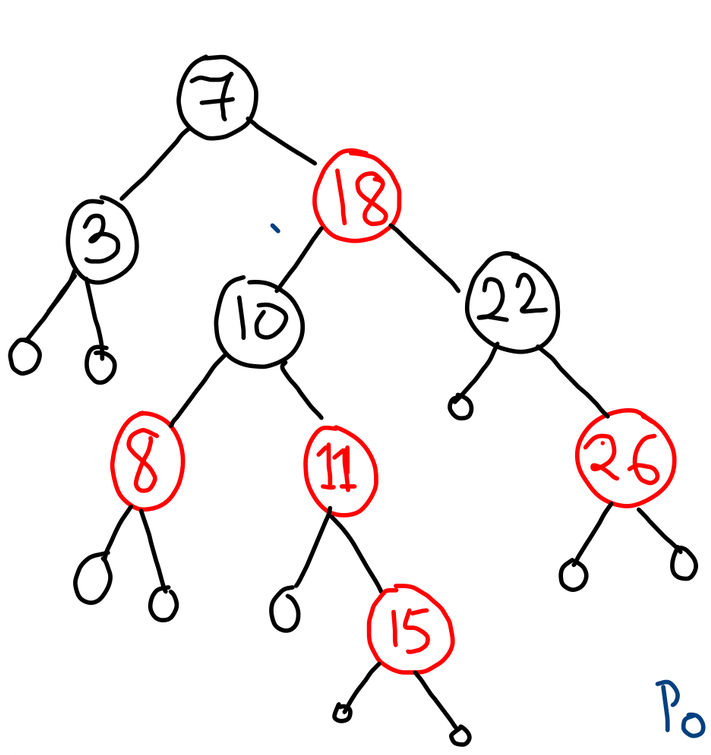
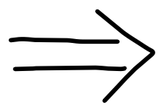
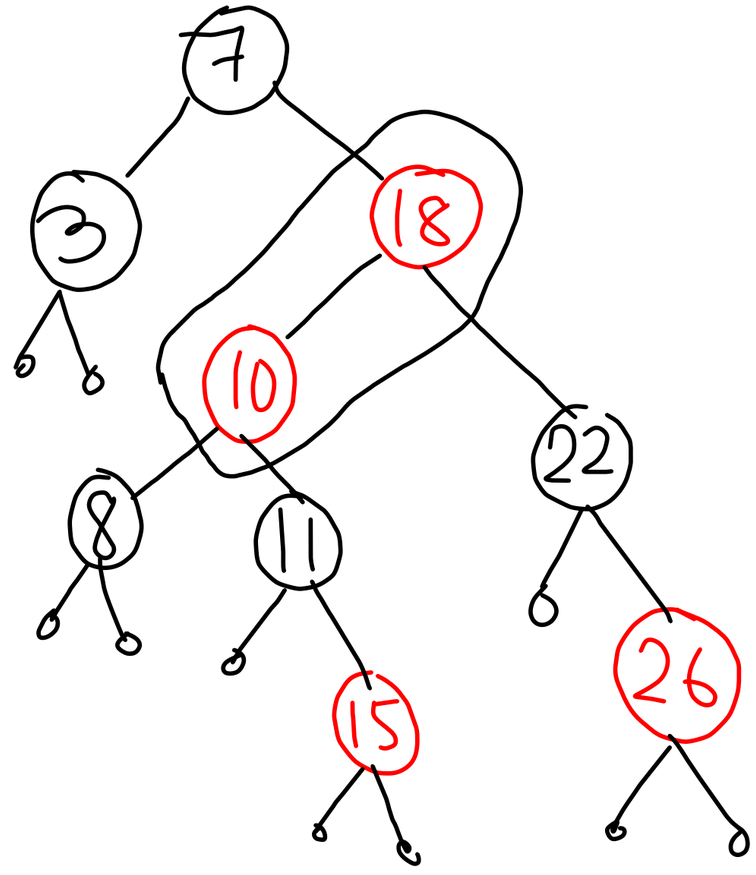
# RED BLACK TREE : INSERTION




Insert "15"






Possible Choices

- Recolor "15" to Black → Blackheight not satisfied
- Recolor "11"
- Recolor "8" & "11"

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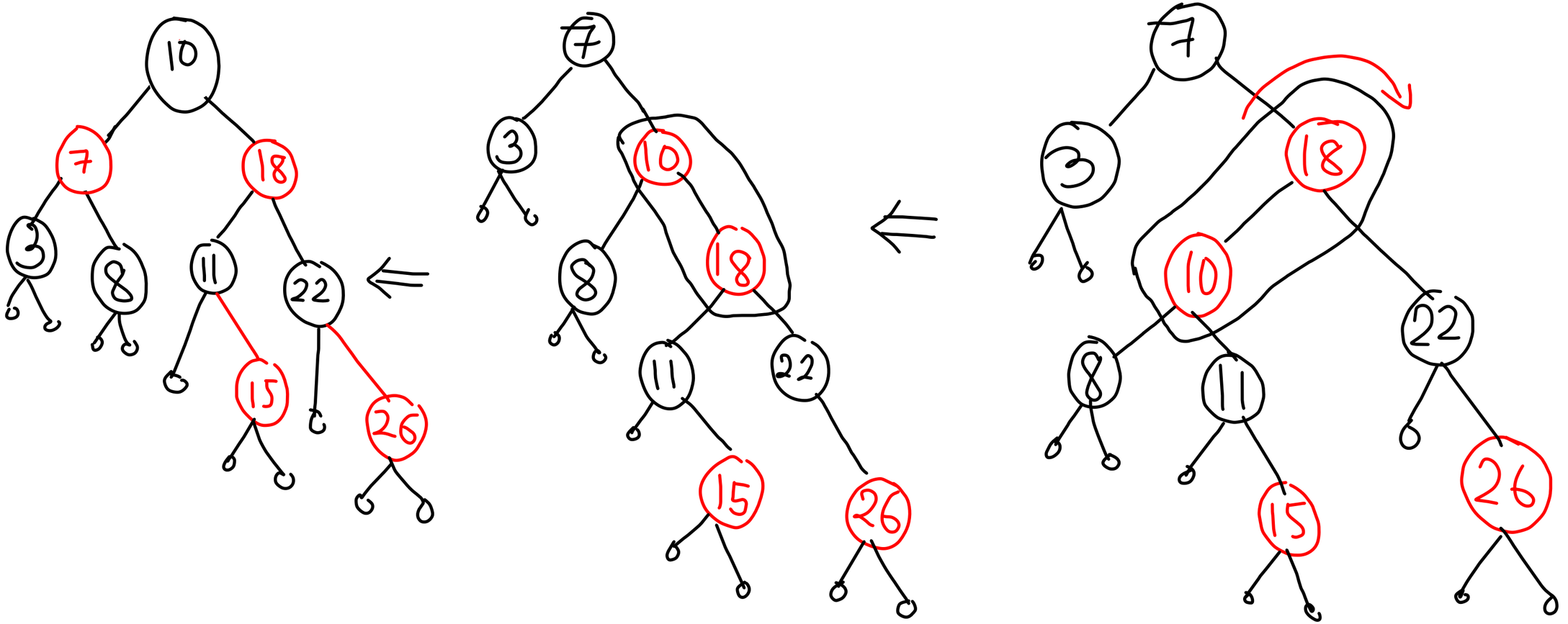
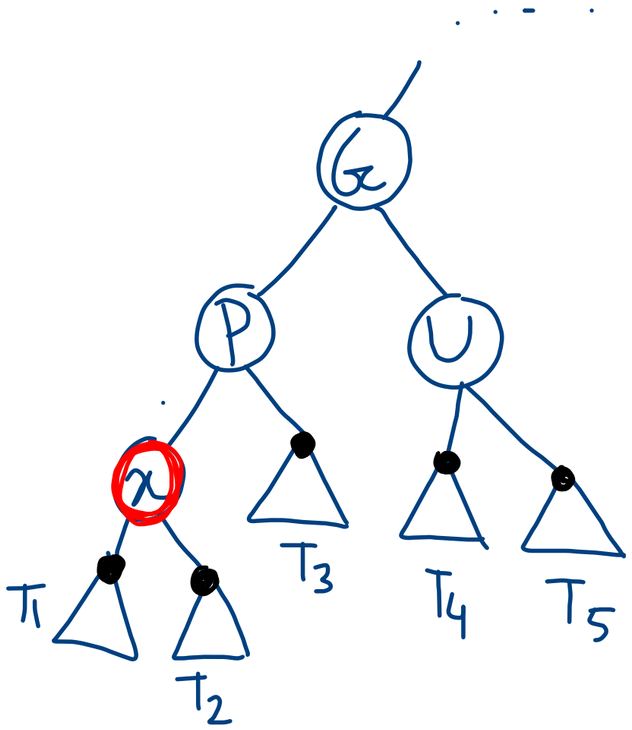





Insert(x)

Case 1: P is black → Don't do anything.

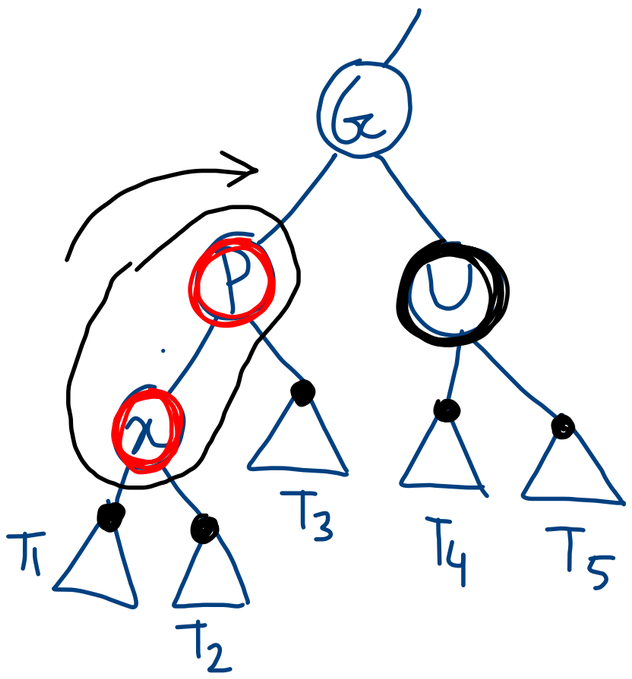
Case 2: P is red

Subcase 2.a (U is red)

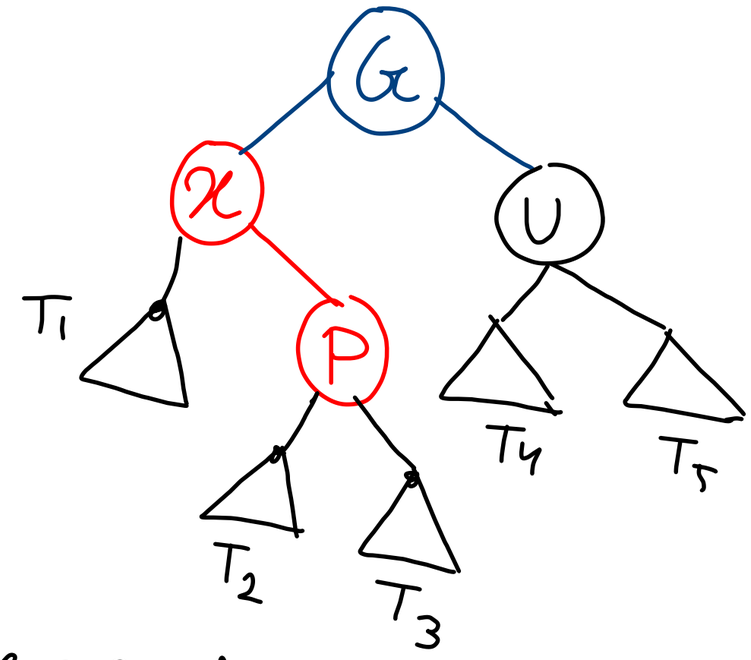
- Recolor both P & U to black
- Recolor G to red (to maintain black-height)
- Recursive use the algo on G.

Subcase 2.b (U is black)

- LL Config → 1 Rotation
- LR config → 2 Rotations
- RL - → 2 Rotations
- RR Confi → 1 Rotation



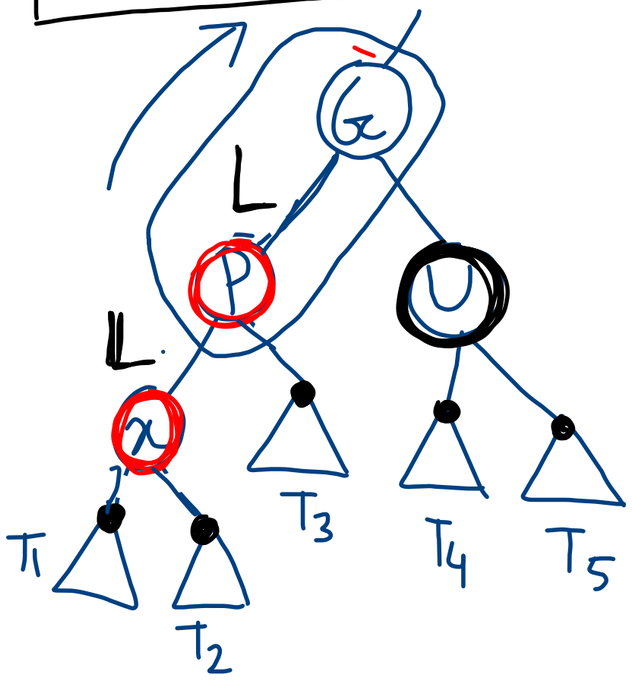

# P is Red, U is black




Insert(x)

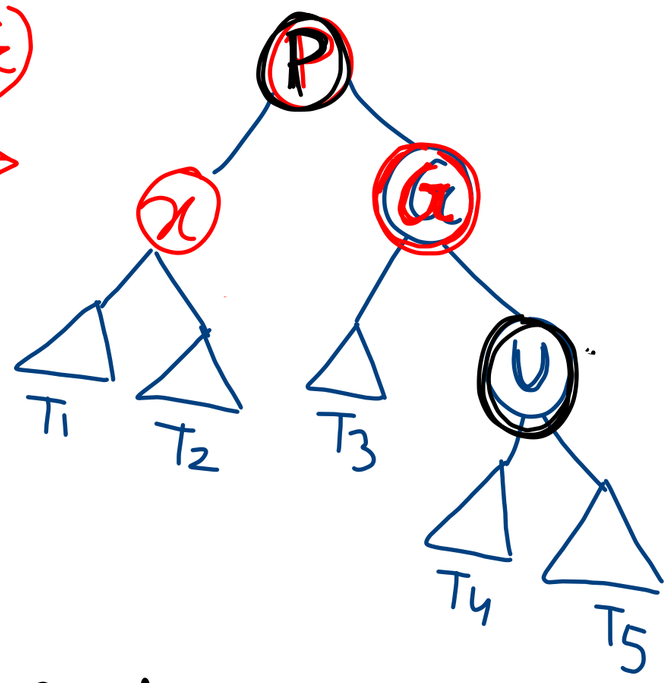
May not be a good option due to black-height.

LL Structure




RightRotate(G)
SwapColors(P & G)

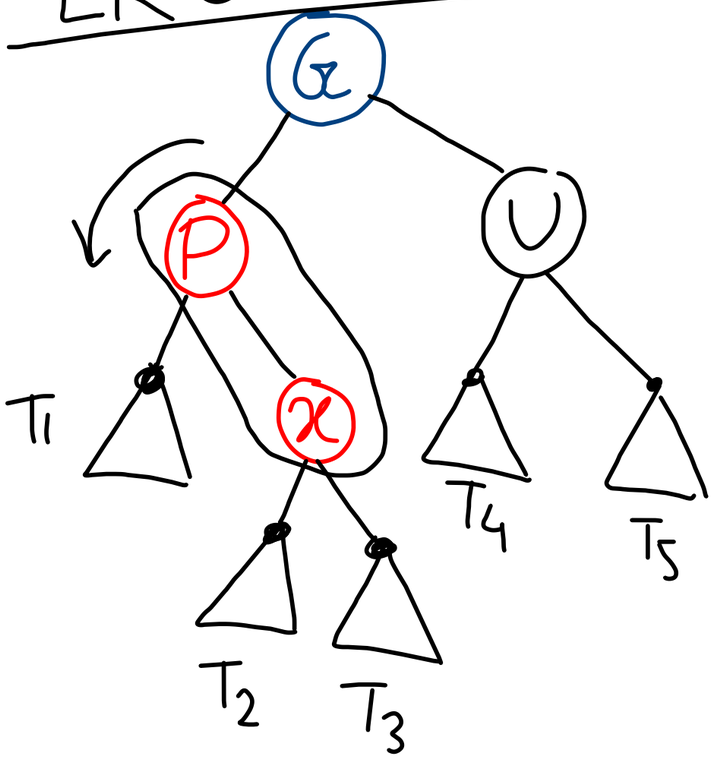
P is Red, U is black



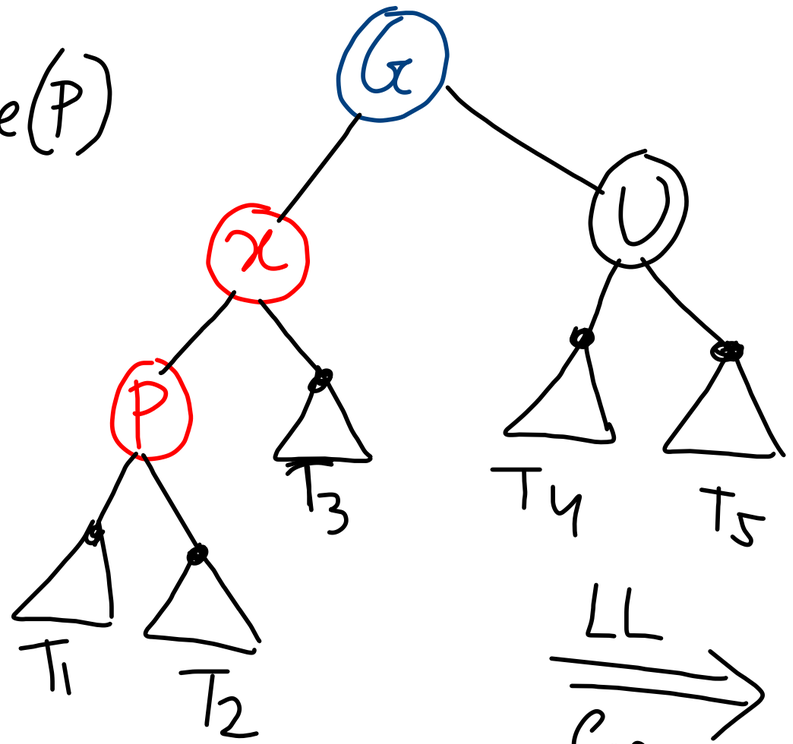

Insert(x)

May not be a good option due to black-height.

## LR configuration




LeftRotate(P)



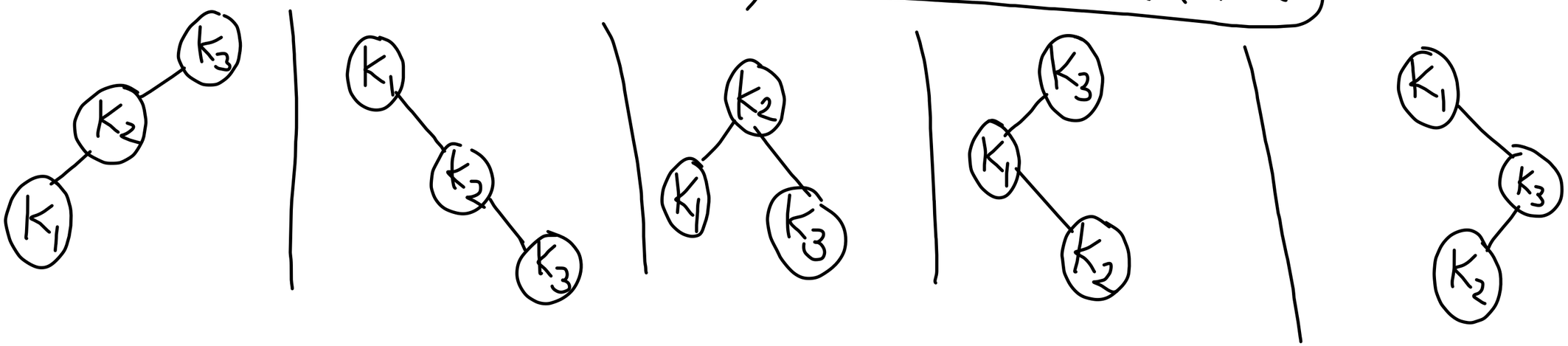

LL Case

- You have a file F containing several words.
- You would like to search for some words (whether $w \in F$?)

Which Data Structure you should use?

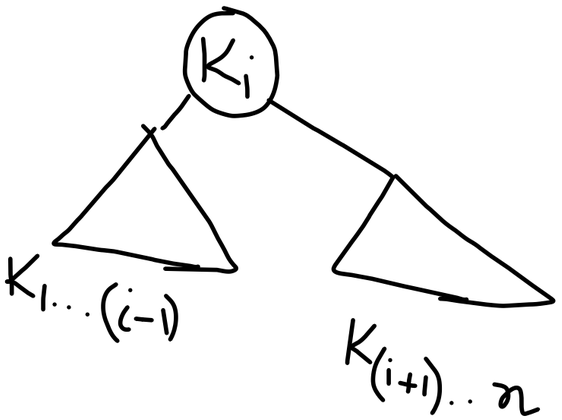
- AVL / RBT (height balanced) — Searching time $O(\log n)$.

$k_1, k_2, k_3$ $(k_1 < k_2 < k_3)$ Binary Search Tree



$n \rightarrow$ nodes $\quad (k_1 < \dots < k_n)$

How many binary Search-trees are there?




$$T(n) = \sum_{i=1}^{n} T(i-1) \cdot T(n-i)$$

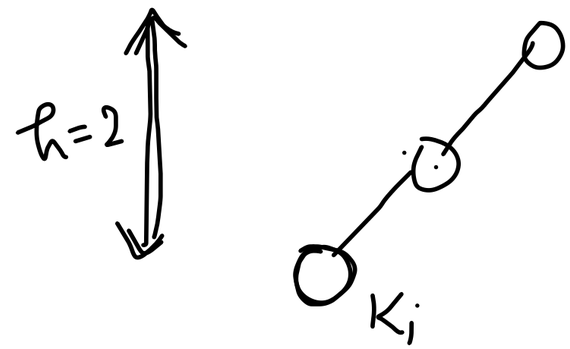
$$= \frac{(2n)!}{(n+1)!\, n!}$$

↳ exponential

$K_1, \ldots, K_n$ $(K_1 < \cdots < K_n)$

$\downarrow$

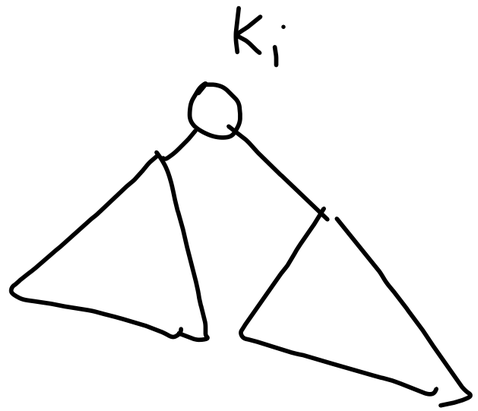
$w_1, \ldots, w_n$ (weights)




(height of $(K_i) + 1$) $\cdot\ w_i$

**Goal:** Minimize $\sum_{i=1}^{n} (\text{height of}(K_i)+1) \cdot w_i$

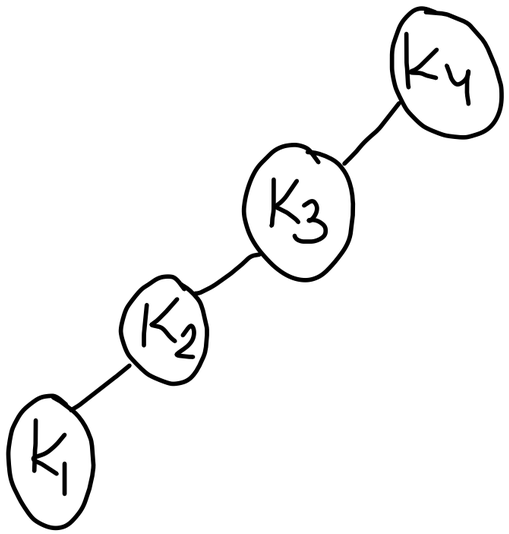
- Exponential – (Trivial)
- Greedy Algo -
  - Put most frequent on top
  - Recursive use the algo.



$K_1, K_2, K_3, K_4$

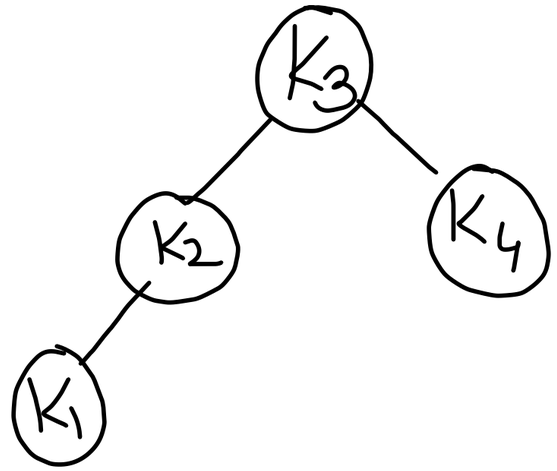
$\downarrow$

1 8 9 10




$10 \cdot 1 + 9 \cdot 2 + 8 \cdot 3 + 1 \cdot 4$

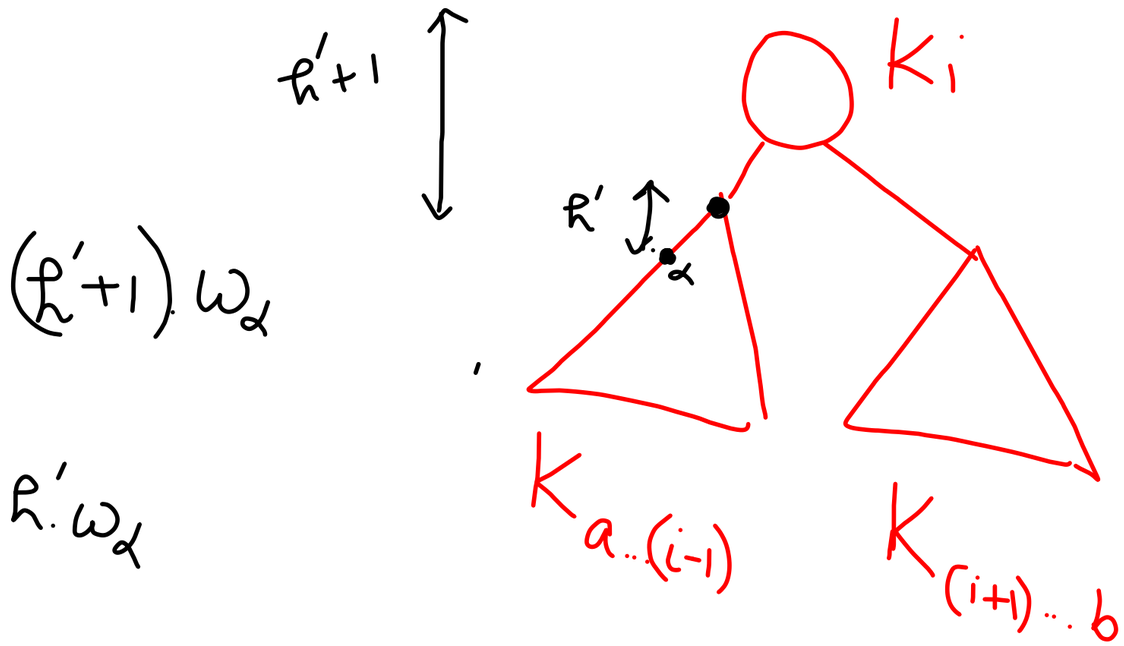
$= 56$




$1 \cdot 3 + 2 \cdot 8 + 1 \cdot 9 + 10 \cdot 2$

$= 48$

# Dynamic Prog




$$e(a,b) = \begin{cases} \omega_i, & \text{if } a=b \\ \min\limits_{a<i<b} \left\{ e(a,i-1) + e(i+1,b) + \sum_{j=a}^{b} \omega_j \right\} \end{cases}$$