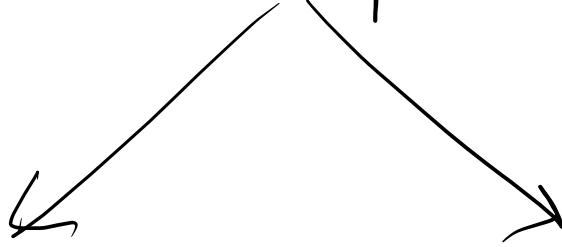


Heaps

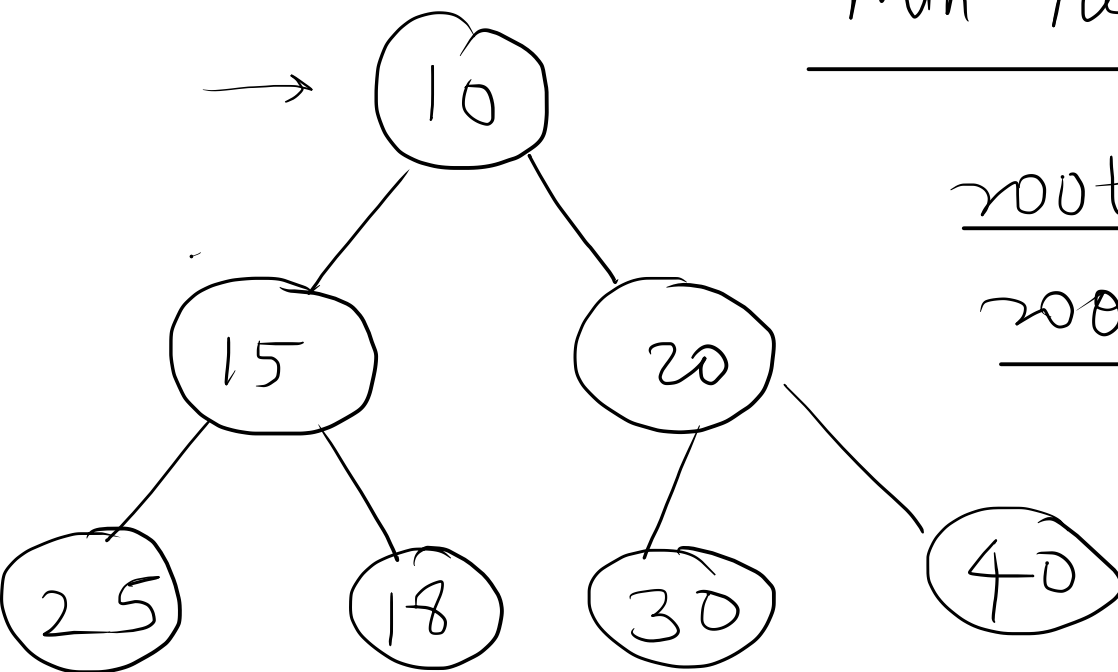
- Complete binary tree
- Satisfies heap property

Heaps



Min Heap

Max Heap



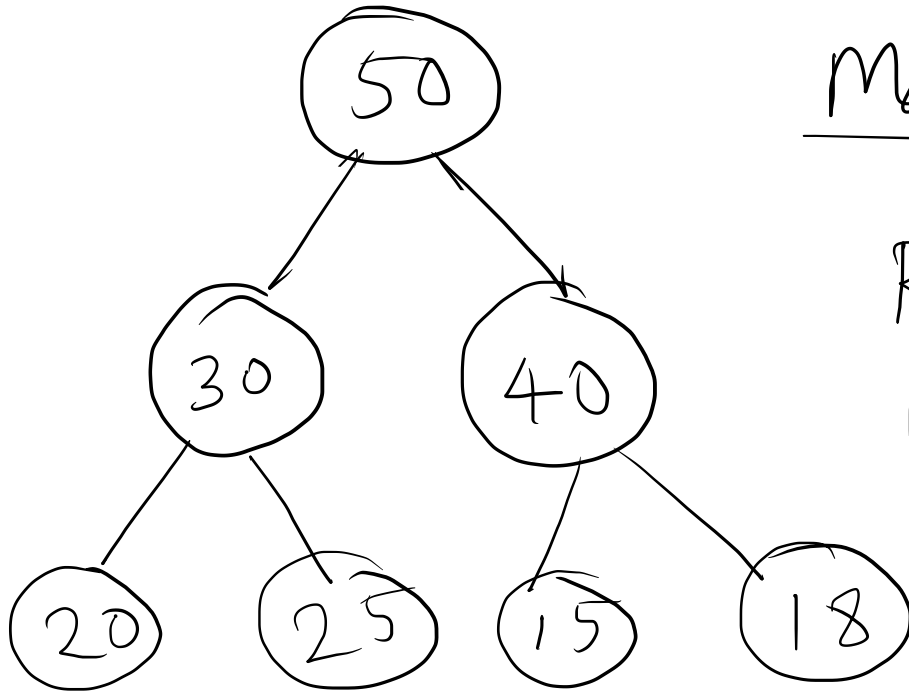
Min Heap

root \leq left

root \leq right

Min Heap:

Minimum \rightarrow root



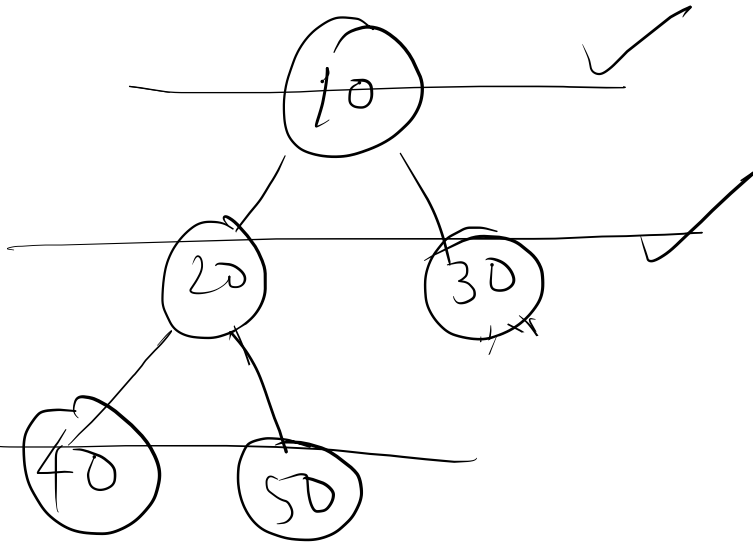
Max Heap

Root \geq left

Root \geq right

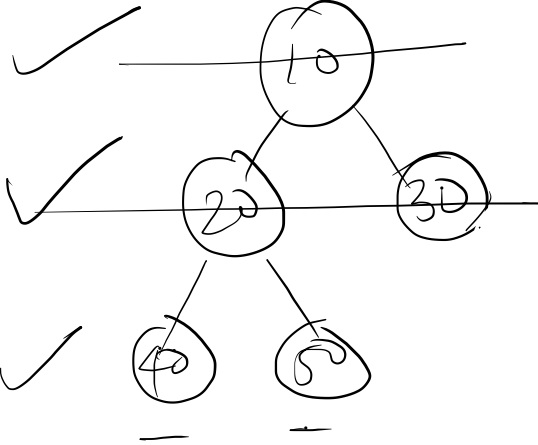
Root of max heap \rightarrow maximum

Array Representation of Heap

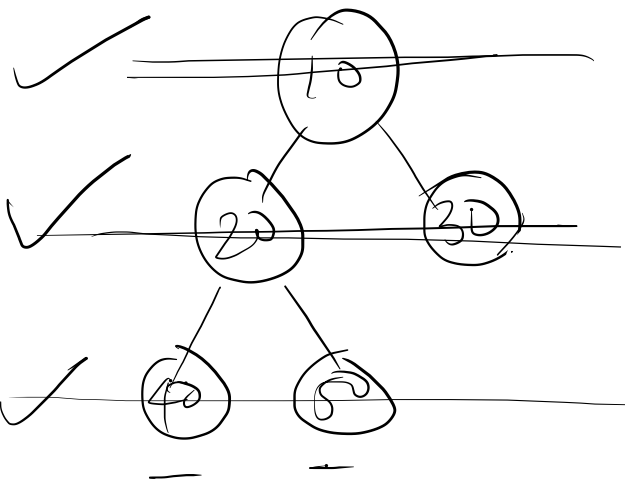


CBT





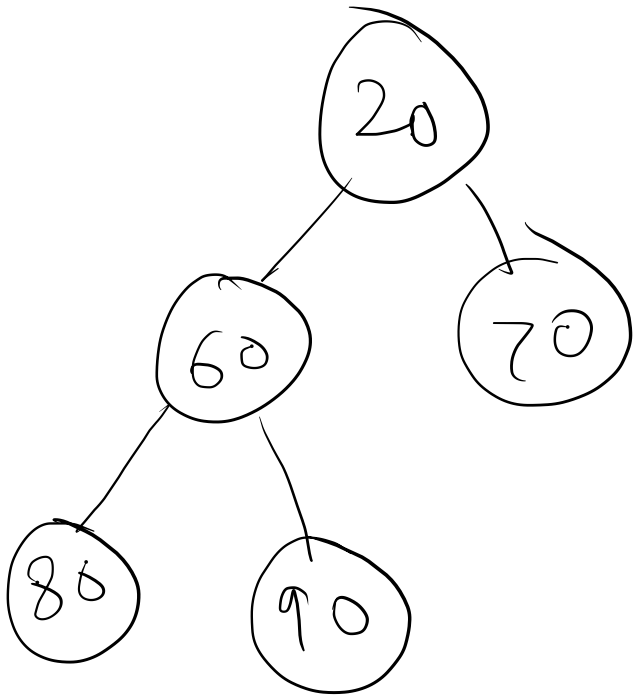
all levels except last are filled
left to right



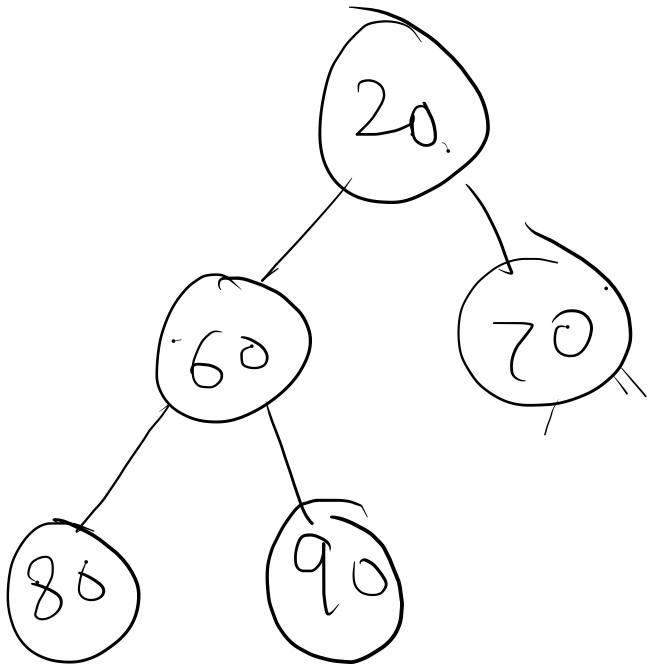
Array representation

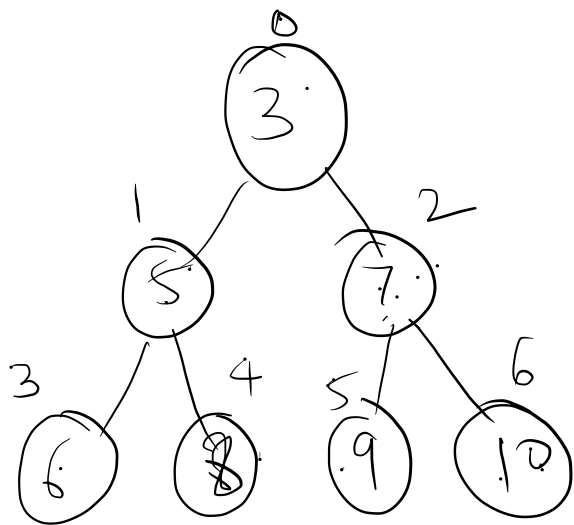
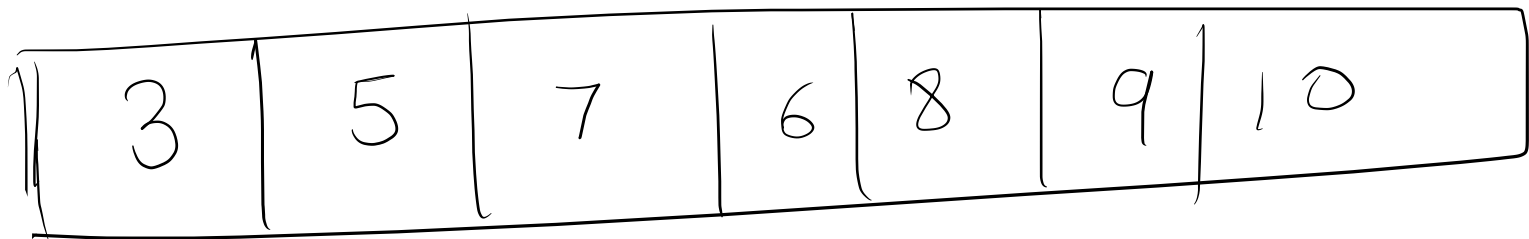
10	20	30	40	50
----	----	----	----	----

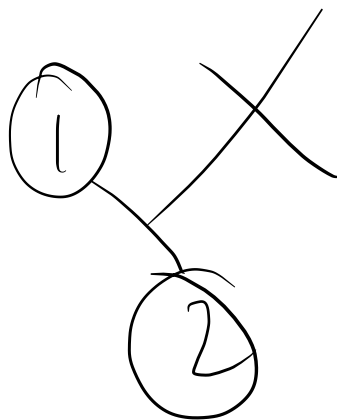
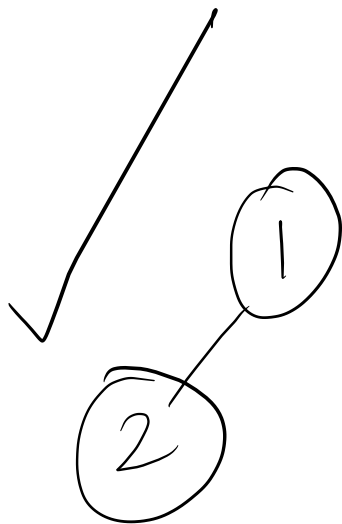
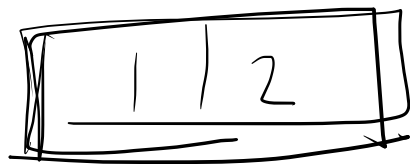
20	60	70	80	90
----	----	----	----	----



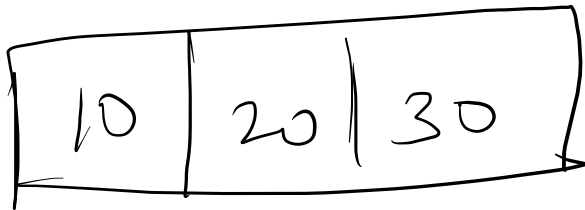
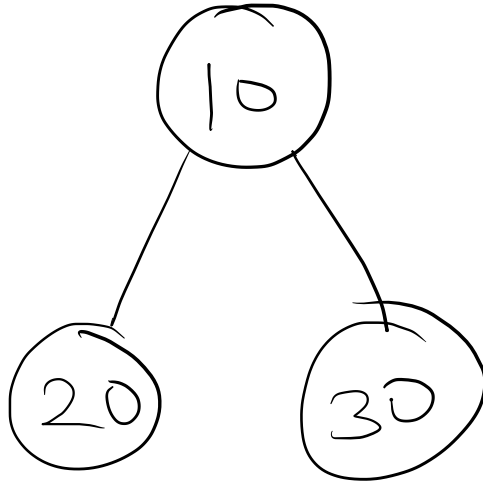
20	60	70	80	90
----	----	----	----	----



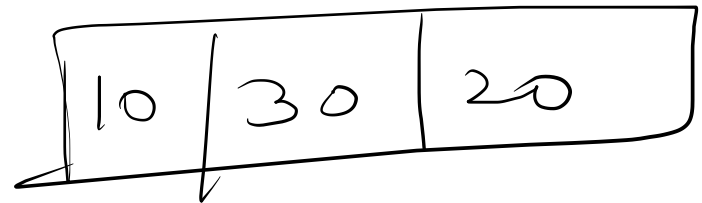
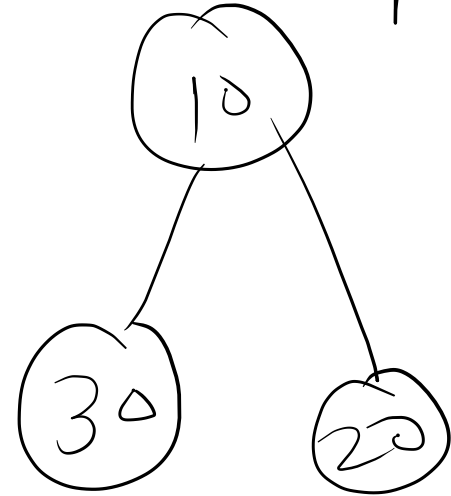


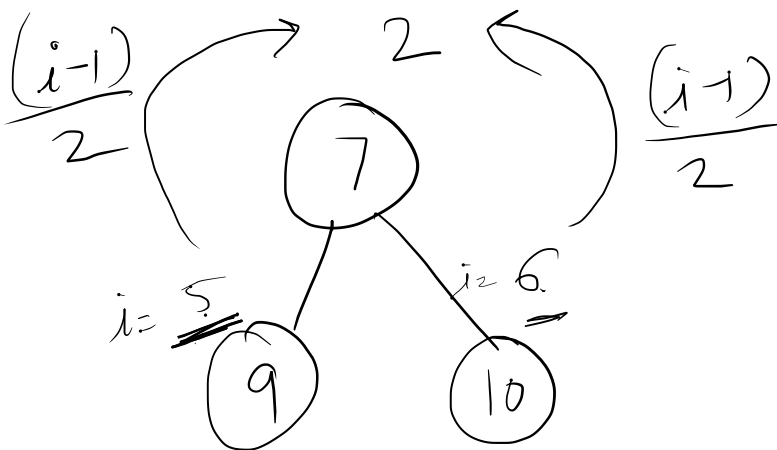
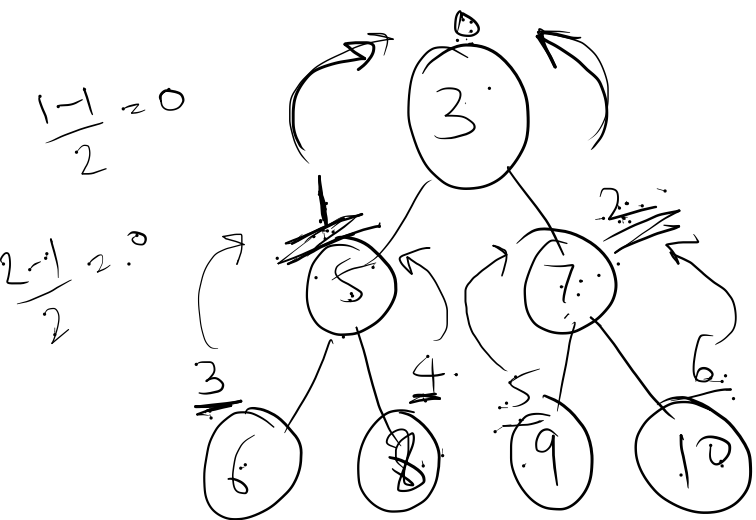
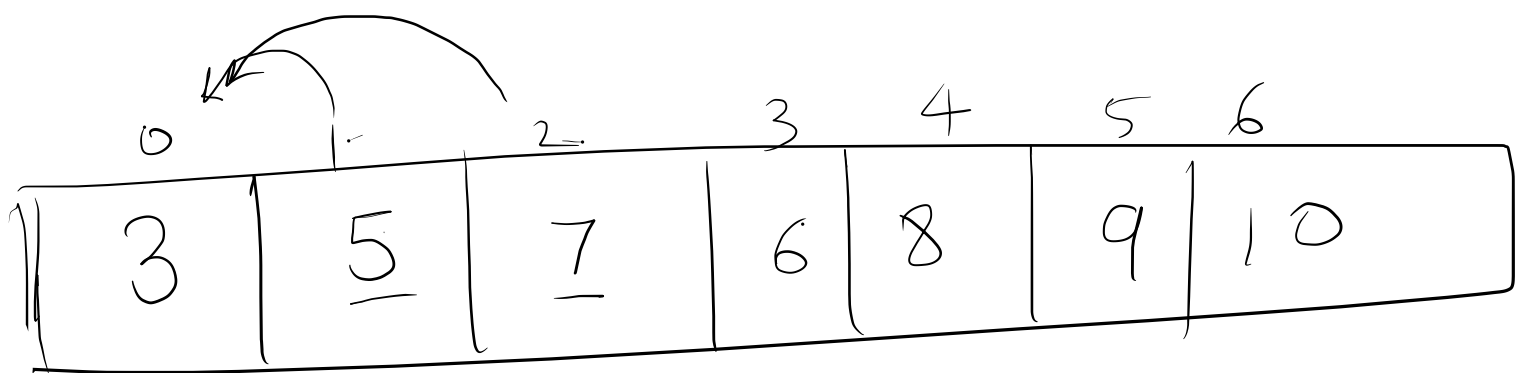


Min Heap ✓



Min Heap ✓





$$\text{parent} = \frac{(i-1)}{2}$$

$$i = 5$$

$$\text{parent} = \frac{5-1}{2} = 2$$

$$i = 6$$

$$\text{parent} : \frac{6-1}{2} = 2$$

$$i = 3.$$

$$\text{parent} = \frac{(i-1)}{2} = 1$$

$$i = 4$$

$$\text{parent} = \frac{(i-1)}{2} = 1$$

$$\underline{\text{Left child} = 2i + 1}$$

$$\underline{\text{Right child} = 2i + 2}$$

$$\underline{i = 1}$$

$$L.C = 2 \times 1 + 1 = 3$$

$$R.C = 2 \times 1 + 2 = 4$$

$$i = 2$$

$$L.C = 2 \times 2 + 1 = 5$$

$$R.C = 2 \times 2 + 2 = 6$$

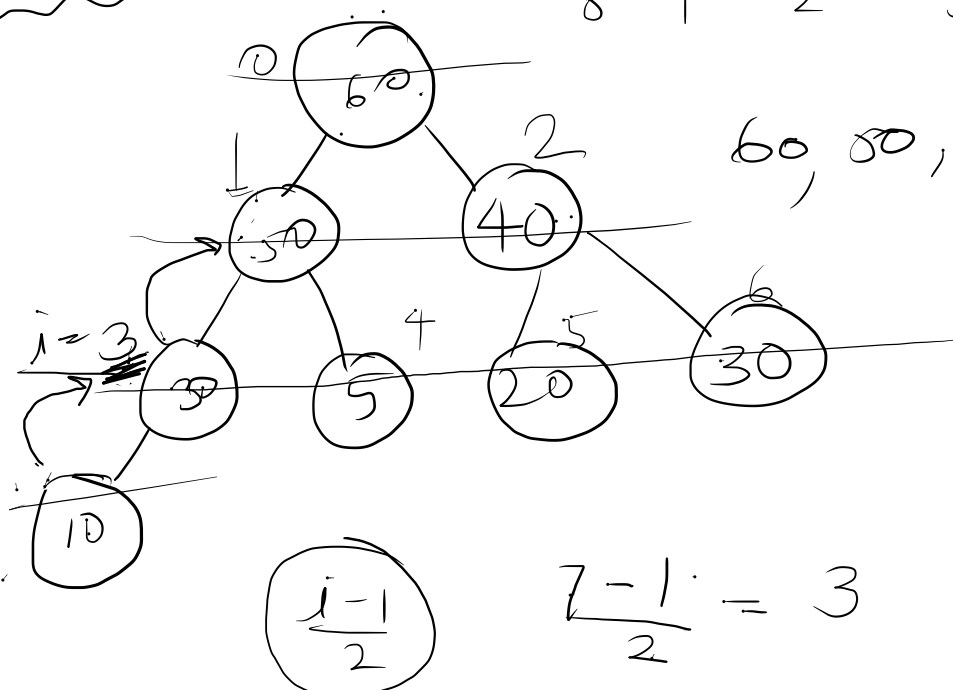
Insertion in Heap \rightarrow Max Heap

Insert = 60

X

50	30	40	10	5	20	30	60
0	1	2	3	4	5	6	7
							(n-1)

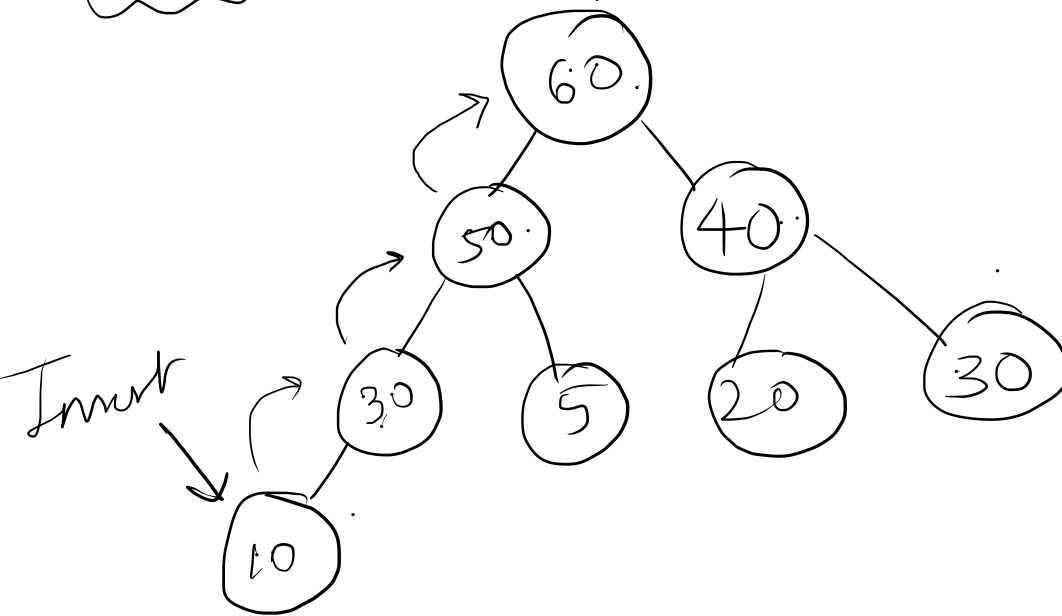
60, 30, 40, 30, 5, 20, 30, 10

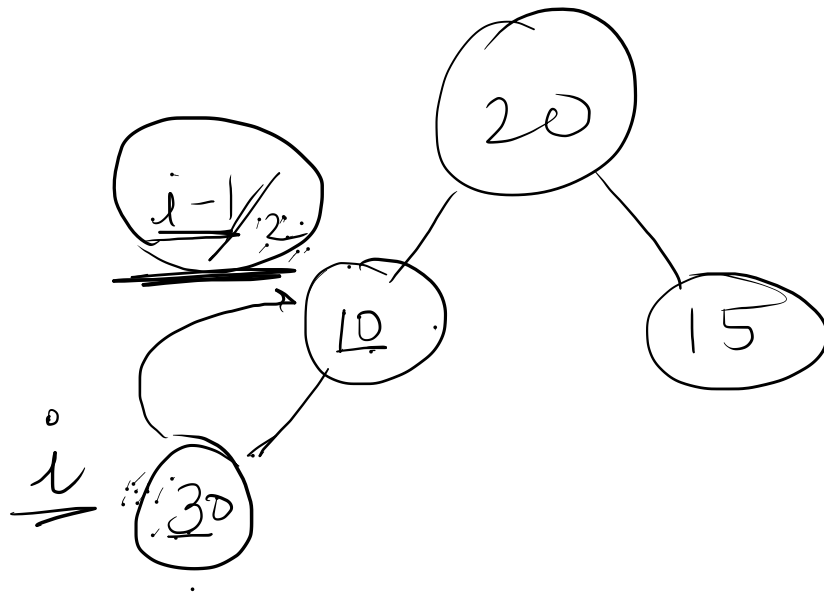


Insertion in Heap

50	30	40	10	5	20	30
----	----	----	----	---	----	----

Insert = 60

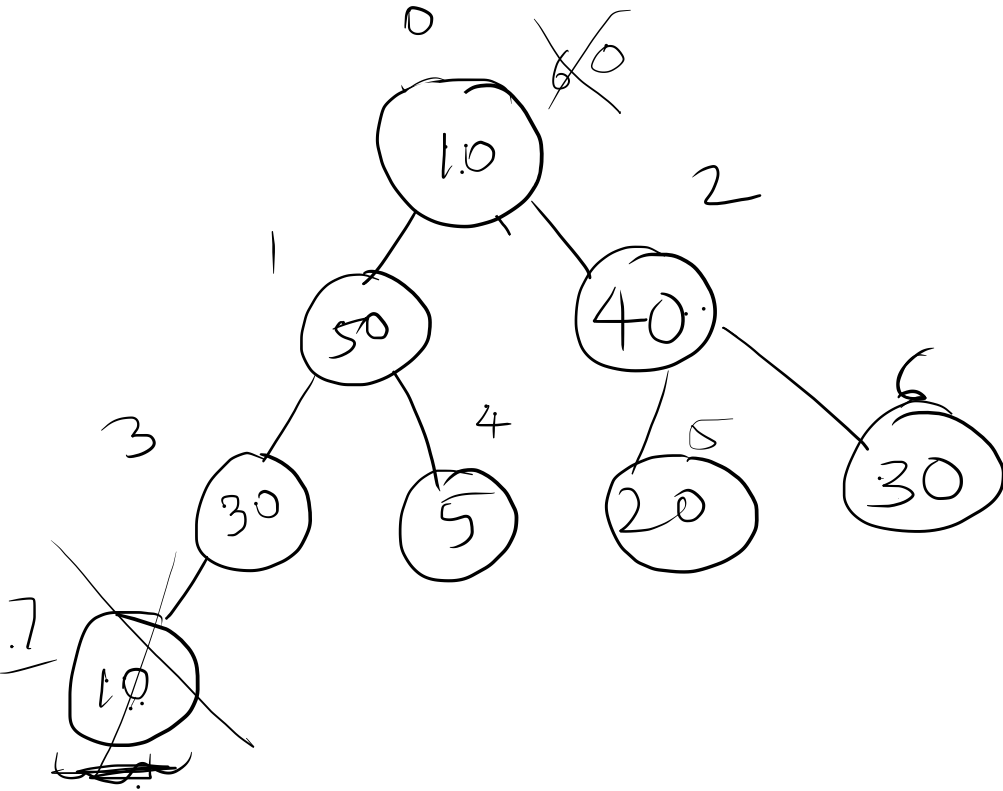




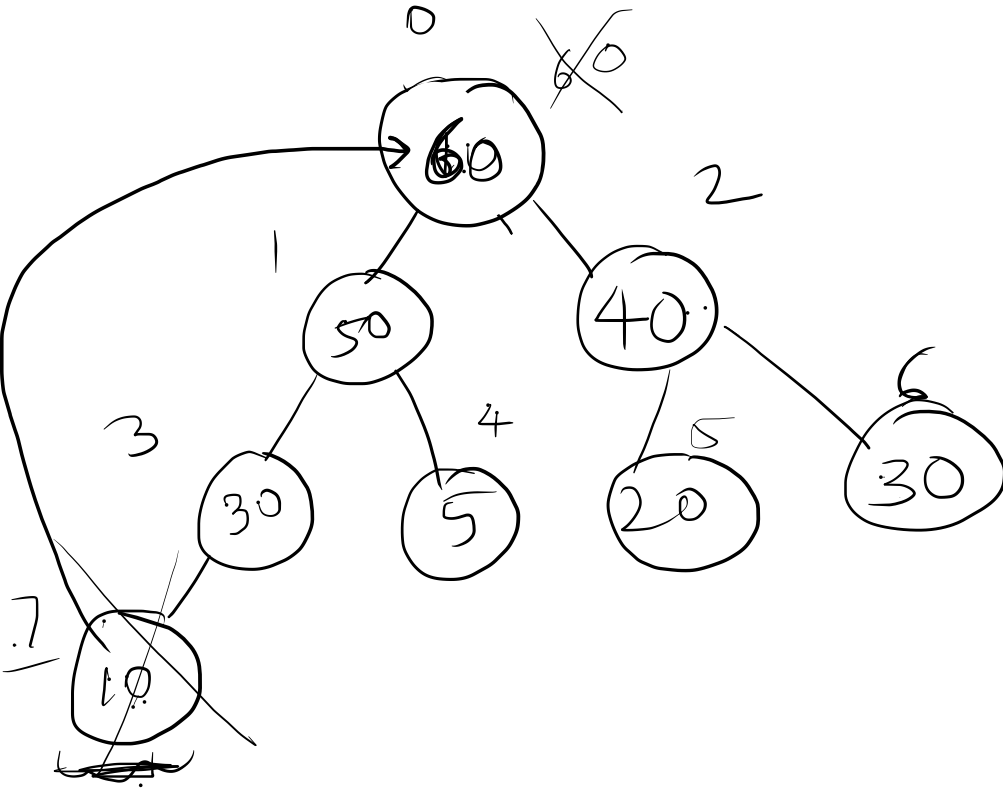
Insert 30

$10 < 30$, swap

Deletion in Heap

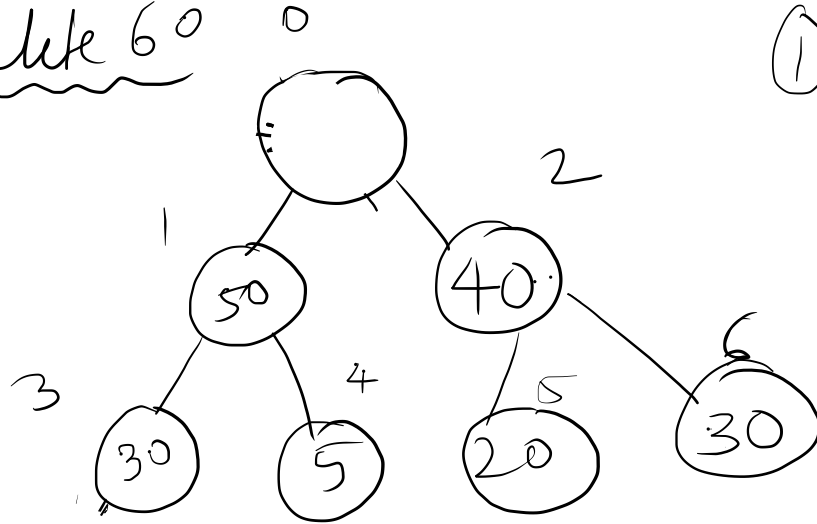


Deletion in Heap



Deletion in Heap

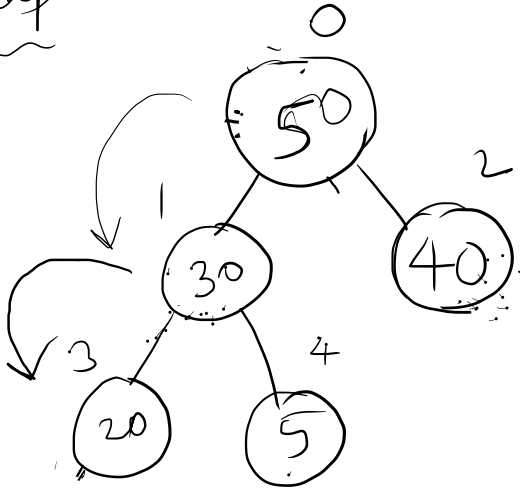
Delete 60



① Replace root with
last element → CBT

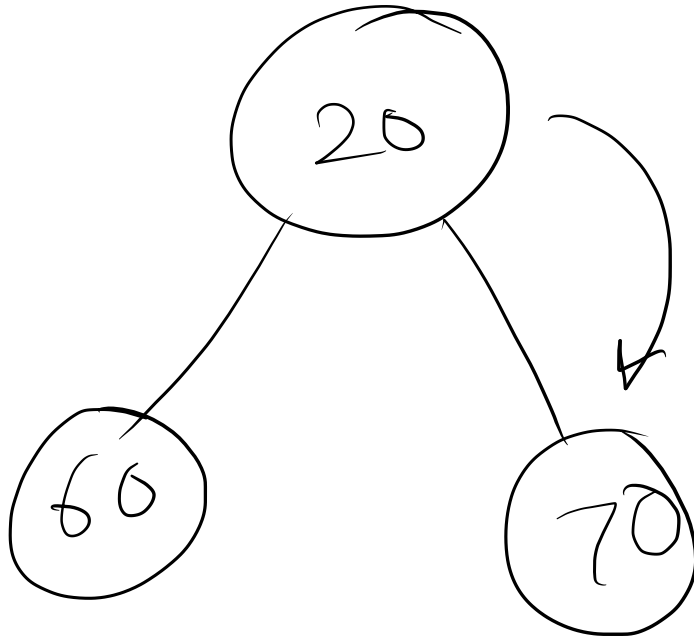
Deletion in Heap

max heap

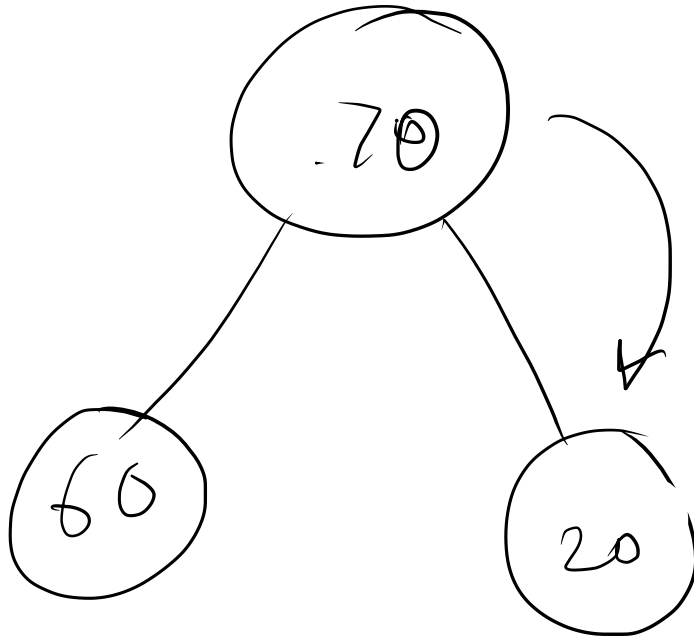


- ① Replace root with last element \rightarrow CBT
- ② adjust by swapping

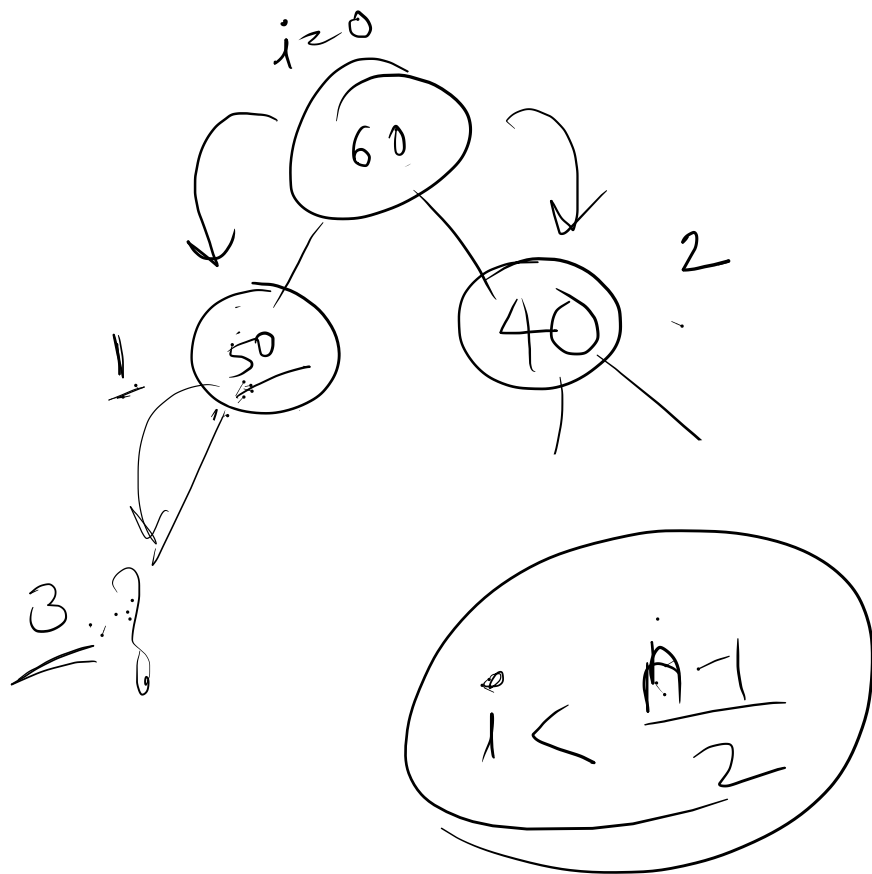
$\max(\text{left}, \text{right})$



swap with max (lfr, right)



swap with max (lfr, right)

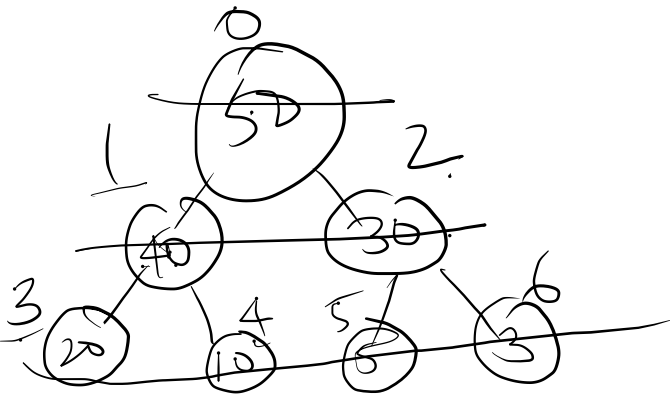


$$\underline{i = 2i + 1}$$

$$\underline{i = 2i + 2}$$

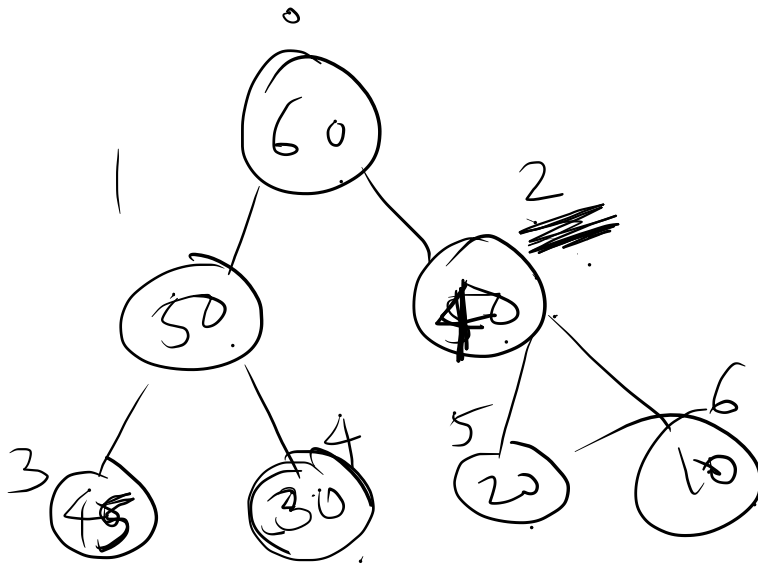
$$\underline{i = \text{maximum}}$$

				X		X		X		X
50	40	30	20	10	5	3				
0	1	2	3	4	5	6				



0	1	2	3	4	5	6
60	50	40	45	30	20	10

$$\frac{7-1}{2} = \underline{\underline{3}}$$



last parent index

$$\underline{\underline{i < 3}}$$

