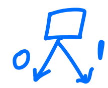
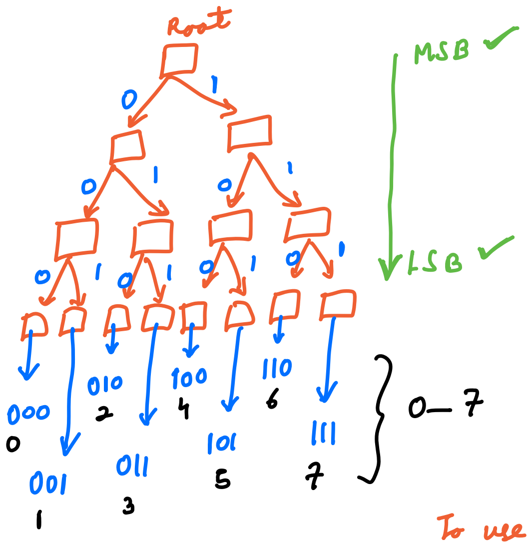
Trie of Bits

↳ 0/1



class node {
  //data
  node children []; //node zero;
  //node one;
  node () {
  children = new node [2];
  // data
  }
}



Height = 4	0 – 15
5	0 – 31 ✓
32	$0 - (2^{32} - 1)$

To use all numbers from 0 to $(2^k - 1)$, trie of height k is used. ✓

$\boxed{\text{Trie of Bits is a binary tree}}$

Q→ Find max value of A[i] ^ A[j] ∀ pairs (i, j).

A	B	A^B
0	0	0
0	1	1
1	0	1
1	1	0

Eg→ A = [9, 8, 10, 7]

Brute → ∀ pairs (i, j) find A[i] ^ A[j] & take max value. $TC = O(N^2)$ ✓

9 ^ 8 = 1001 ^ 1000 = 0001 = 1
9 ^ 10 = 1001 ^ 1010 = 0011 = 3
9 ^ 7 = 1001 ^ 0111 = 1110 = 14
8 ^ 10 = 2
8 ^ 7 = 15 ✓
10 ^ 7 = 1010 ^ 0111 = 1101 = 13

Ans = 15

15 = 1111
7 → 1111 ^ 0111 = 1000 = 8 ✓
11 → 1111 ^ 1011 = 0100 = 4
13 → 1111 ^ 1101 = 0010 = 2
14 → 1111 ^ 1110 = 0001 = 1

15 = 1111   7 = 0111 ✓
8 = 1000
1111 ^ 1000 = 0111 = 7

Making more significant bits = 1 can be a better choice to get higher result. ✓

$$A = [\overset{0}{5}, \overset{1}{10}, \overset{2}{15}, \overset{3}{20}, \overset{4}{25}, \overset{5}{30}]$$

Height = 5 (0 — 31)

$\forall i$ find j which give max $\underline{A[i] \wedge A[j]}$ ✓

$\boxed{i > j}$

	16	8	4	2	1
5 =	0	0	1	0	1
10 =	0	1	0	1	0
15 =	0	1	1	1	1
20 =	1	0	1	0	0
25 =	1	1	0	0	1
30 =	1	1	1	1	0

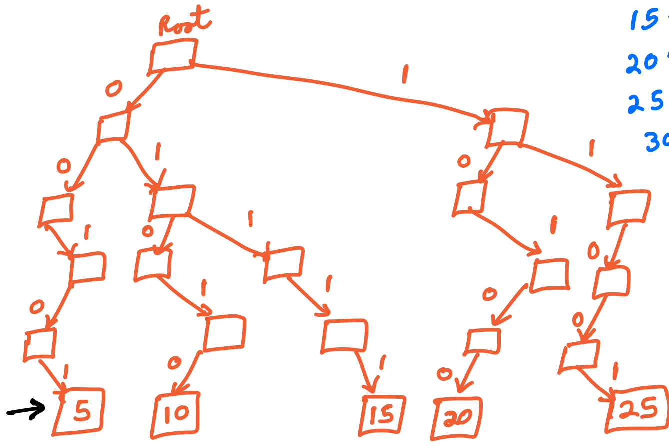
$10 \wedge 5 = 01111 = 15$

$15 \wedge 5 = 01010 = 10$

$20 \wedge 10 = 11110 = 30$

$25 \wedge 5 = 11100 = 28$

$30 \wedge 5 = 11011 = 27$



1) Query

2) Insert

Ans = ~~15~~ 30 ✓

$TC = O(H * N)$ ✓
↓
5

$SC < \underline{O(H * N)}$

Q→ Find max XOR subarray of an array?

Eg→ $A = [\overset{0}{1}, \overset{1}{4}, \overset{2}{3}]$

[1] ⟶ 1

[1, 4] → 1 ^ 4 → 5

[1, 4, 3] → 1 ^ 4 ^ 3 → 6

[4] ⟶ 4

[4, 3] → 4 ^ 3 → 7 ✓ (Ans)

[3] ⟶ 3

Bruteforce → $O(N^2)$

∀ subarray find XOR & get max value.

$TC = O(N^3) \to \underline{O(N^2)}$

start	# ends
0	5 (0, 1, 2, 3, 4)
1	4 (1, 2, 3, 4)
2	3 (2, 3, 4)
3	2 (3, 4)
4	1 (4)

$5 + 4 + 3 + 2 + 1 = \underline{15}$

$\underline{\Sigma N}$

1) $\boxed{x \wedge x = 0}$
↓
$\boxed{x \wedge y \wedge x = y}$

2) $\underbrace{x \wedge y} \wedge z$
↓
$(x \wedge y) \wedge (z) = x \wedge (y \wedge z)$

$\boxed{a \wedge b \wedge c} \wedge d = ((a \wedge b) \wedge c) \wedge d$
↓
$x \longrightarrow x \wedge d$

Prefix = [1, (1^4), (1^4, 3)]

$= \underbrace{[1, 5, 6]}$

$P = [\overset{0}{0}, \overset{1}{1}, \overset{2}{5}, \overset{3}{6}]$ ✓

Prefix XOR

$A[i] \wedge A[i+1] \wedge A[i+2] \text{ --- } \wedge A[j] = X$

$x \wedge y \wedge y = x$

$X = A[i] \wedge A[i+1] + \_ \_ \wedge A[j] \nearrow x$ } $P[j]$

$\wedge A[0] \wedge A[1] \wedge A[2] \text{ --- } \wedge A[i-1] \to y$ } $\wedge$

$\wedge A[0] \wedge A[1] \wedge A[2] \text{ - - } \wedge A[i-1] \nearrow y$ } $P[i-1]$

$\boxed{P[i] = P[0] \wedge P[1] \wedge P[2] \text{ - - } \wedge P[i]}$

$\boxed{X = P[j] \wedge P[i-1]}$ ← $TC = O(H * N)$

$i > 0$

Find the max XOR pair in Prefix XOR array. ✓

$SC = O(H * N)$ ✓

0 1 2

$A = [1 \ 4 \ 3]$ $K=3$

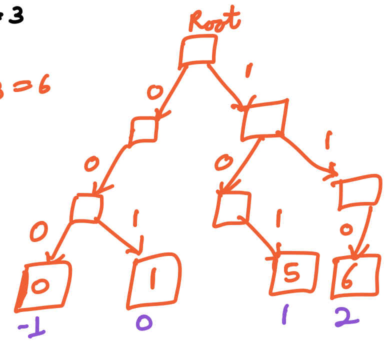
$p = 0 \wedge 1 = 1 \wedge 4 = 5 \wedge 3 = 6$

$101 \wedge 011$

$= 110 = 6$

1) Query

2) Insert



$\leftarrow (i-1) \ +1$

start

$i-j$ → subarray

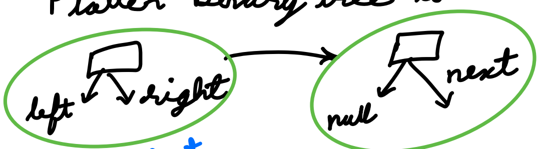
Ans = ~~1~~ ~~5~~ 7

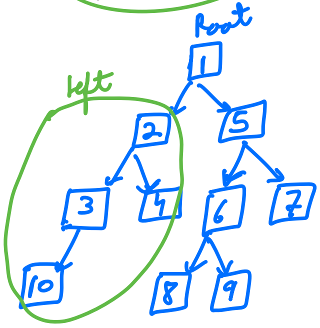
$1 \wedge 0 = 1$

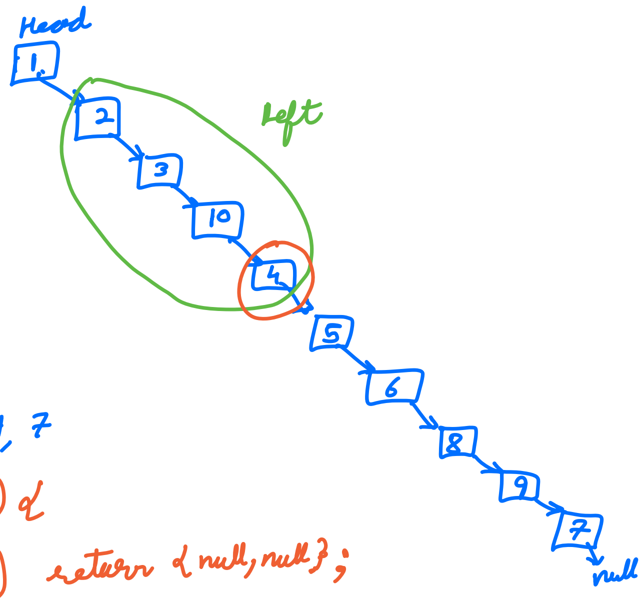
$5 \wedge 0 = 5$

$6 \wedge 1 = 7$

Q→ Flatten Binary tree to LL via preorder traversal. (Epifi)



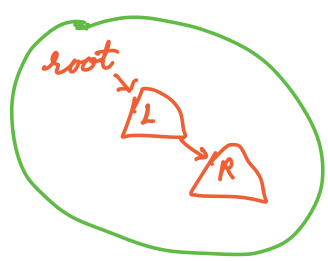


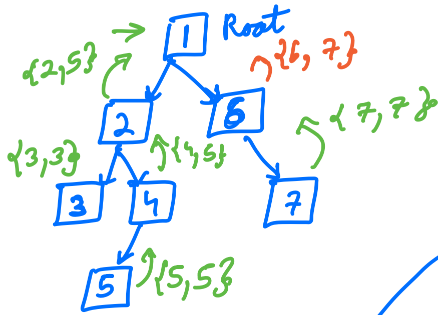


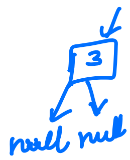
Preorder = 1, 2, 3, 10, 4, 5, 6, 8, 9, 7

H, T → Head, Tail

```
pair<node> flatten(root) {
    if(root == null) return {null, null};
    L = flatten(root.left);
    R = flatten(root.right);
    root.left = null;
    if(L.H != null) {
        root.right = L.H;
        L.T.right = R.H;
    } else { root.right = R.H; }
    return {root, (R.T != null ? R.T : (L.T != null ? L.T : root))};
}
```



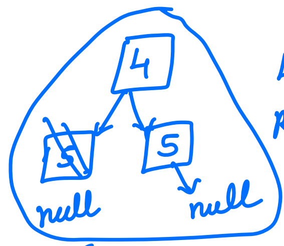




L = null, null

R = null, null

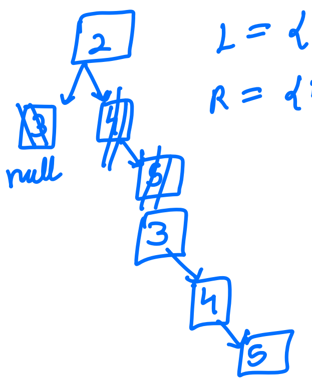
{3, 3}



L = {5, 5}

R = {null, null}

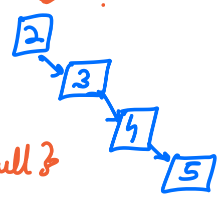
{4, 5}

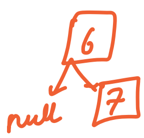


L = {3, 3}

R = {4, 5}

{2, 5}





L = {null, null}

R = {7, 7}

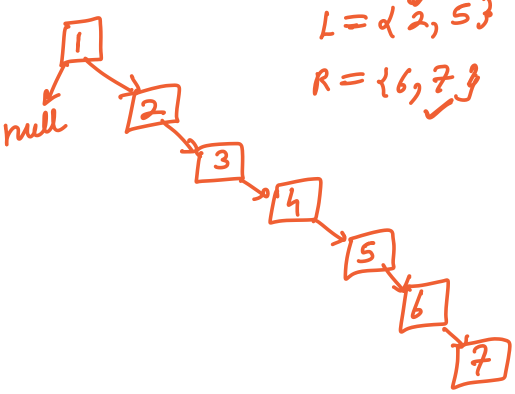
{6, 7}

TC = O(N)

SC = O(H)

L = {2, 5}

R = {6, 7}



{1, 7}

(Ans)