Welcome ☺

Agenda : Bit Manipulation 2

2 problems
-ve numbers
1/2 problems.

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num : $(0\,0\,0\,0\,1\,0\,0)_2 = 2^2 = 4 \rightarrow 1<<2$

$(0\,0\,1\,0\,0\,0\,0)_2 = 2^4 = 16 \rightarrow 1<<4$

(6 5 4 3 2 1 0)

Power of Left Shift

N = 45 → (5 4 3 2 1 0) → 1 0 1 1 0 1

45	1	0	1	1	0	1	
OR (1<<2)	0	0	0	1	0	0	
	1	0	1	1	0	1	→ 45

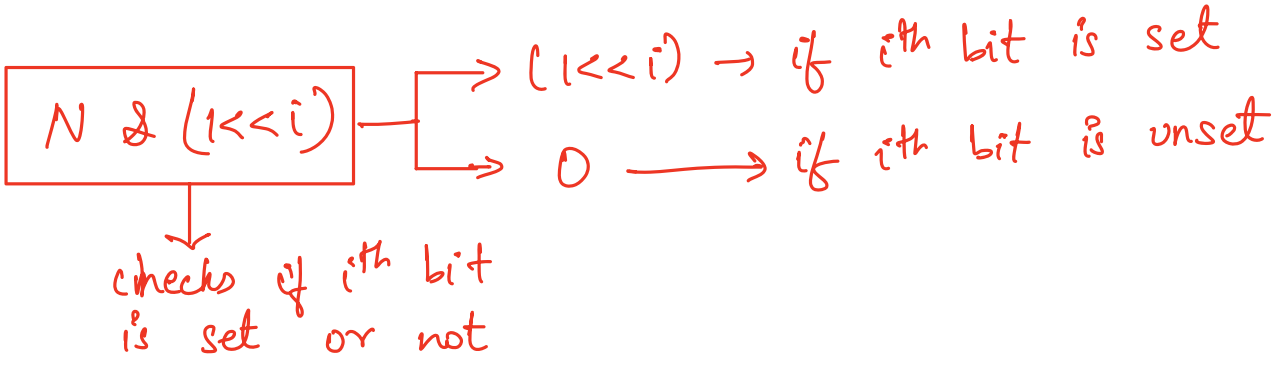
45	1	0	1	1	0	1	→ 45
OR 1<<4	0	1	0	0	0	0	→ 16
	1	1	1	1	0	1	→ 61

N | 1<<i
- N → if i^{th} bit is set
- N + (1<<i) → if i^{th} bit is unset

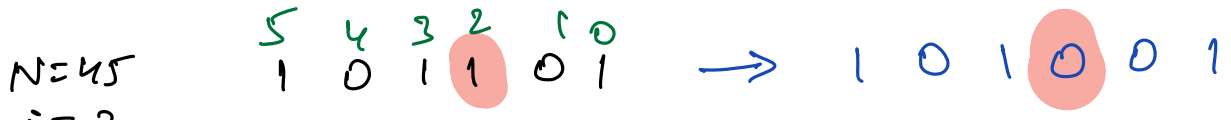
45	1	0	1	1	0	1	
XOR (1<<2)	0	0	0	1	0	0	
	1	0	1	0	0	1	→ 41

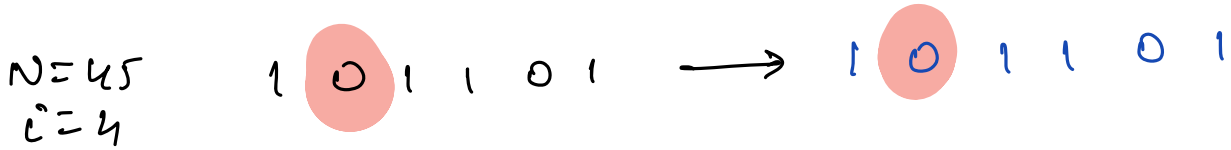
45	1	0	1	1	0	1	→ 45
XOR 1<<4	0	1	0	0	0	0	→ 16
	1	1	1	1	0	1	→ 61

N ^ (1<<i) → Flip i^{th} bit



Q1 Unset i^{th} bit of a number if it is set else no change.





Pseudocode.

```
if( checkBit(N, i) )
    N^(1<<i)
else
    no change.
```

`N & (1<<i) == 1<<i` **OR** `N|(1<<i) == N`

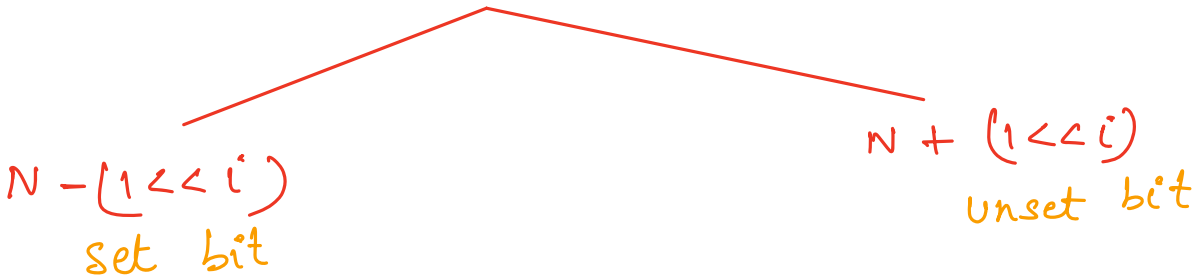
Q Check if i^{th} bit is set

Ans

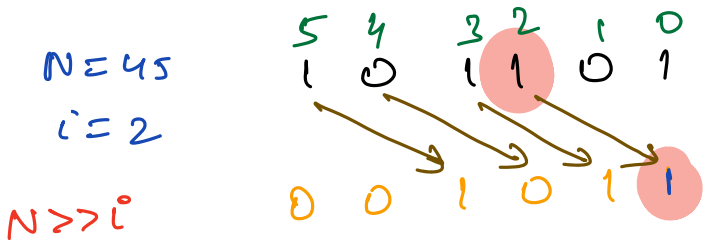
1) $N \& (1<<i) == 1<<i$

2) $N \mid (1<<i) == N$

3) $N \wedge (1<<i) < N$



$N \& 1$
- 1 → if 0^{th} bit is set → odd number
- 0 → if 0^{th} bit is unset → even number



4) $(N>>i) \& 1 == 1$

Q3 Count number of set bits in N

N = 45 → 1 0 1 1 0 1 → 4

Brute force -

int → 32 bits

long → 64 bits

```
ans = 0
for( i -> 0 to 31) 63
{
|    if( checkBit(N, i))
|            ans += 1
}
return ans;
```

32 iterations.

N=10:

	1	0	1	0
N>>1	0	1	0	1
N>>2	0	0	1	0
N>>3	0	0	0	1
N>>4	0	0	0	0
N>>5	0	0	0	0
N>>6	0	0	0	0

```
ans = 0
while (N>0)
{  if( (N & 1) == 1)
|          ans += 1
|  N = N >> 1
}
return ans;
```

→

```
ans = 0
while (N>0)
{
|  ans += (N & 1)
|  N = N >> 1
}
return ans;
```

T.C → $O(\log_2 N)$

N >> 1 = N/2

S.C → O(1)

Negative Numbers

$(-45)_{10} \rightarrow (?)_2$

Most significant Bit (MSB)

Int
32 bits

$2^{31} \quad 2^{30} + 2^{29} + \ldots + 2^0$

$$\frac{2^0(2^{31}-1)}{2-1} = 2^{31}-1$$

$$2^{31} > 2^{31}-1$$

→ MSB will decide the sign of bit (+ve or -ve)

MSB → 0 → +ve
MSB → 1 → -ve

MSB ↑ Signed bit

8 bit system
N = 45

MSB

0 0 1 0 1 1 0 1

1) flip all bits 1 1 0 1 0 0 1 0 → 1's complement

2) add 1 + 0 0 0 0 0 0 0 1

1 1 0 1 0 0 1 1 → 2's complement

$2^7\ 2^6\ 2^4\ 2^1\ 2^0$ → 128 + 64 + 16 + 2 + 1 = 211

$(-2^7)\ 2^6\ 2^4\ 2^1\ 2^0$ → −128 + 64 + 16 + 2 + 1 = −45

Quiz $(-3)_{10} \rightarrow (\ ?\ )_2$

		0	0	0	0	0	0	1	1
Step ①		1	1	1	1	1	1	0	0
Step ②	+	0	0	0	0	0	0	0	1
		1	1	1	1	1	1	0	1

Quiz $(-10)_{10} \rightarrow (\ ?\ )_2$

		0	0	0	0	1	0	1	0
Step ①		1	1	1	1	0	1	0	1
Step ②	+	0	0	0	0	0	0	0	1
		1	1	1	1	0	1	1	0

Range

min no. $1\ 0\ 0\ 0\ 0\ 0\ 0\ 0$ (bits 7 6 5 4 3 2 1 0) $\rightarrow -128$

(-2^7)

max no. $0\ 1\ 1\ 1\ 1\ 1\ 1\ 1 \rightarrow 127$

$2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$

Range of integers

min $\rightarrow$ $1\ 0\ 0\ 0 \ldots 0 \rightarrow -2^{31} = -2147483648 \simeq -2 \times 10^9$

max $\rightarrow$ $0\ 1\ 1\ 1 \ldots 1 \rightarrow 2^{31} - 1 = 2147483647 \simeq 2 \times 10^9$

Range of long

min → $-2^{63} \simeq -9 \times 10^{18}$

max → $2^{63}-1 \simeq 9 \times 10^{18}$

Q Calculate sum of all elements for a given integer array

~~int~~ long sum = 0

for (i = 0 → N-1)

Sum += A[i]

return sum ;

Constraints

$1 \le N \le 10^5$

$1 \le A[i] \le 10^6$

worst case

$[10^6, 10^6, 10^6 \text{ --- } 10^6]$ (105)

Sum = $10^6 * 10^5 = 10^{11}$

∴ overflow

Constraints → TLE / overflow

Q for two given integers a & b. Return a * b

$0 \le a \le 2 * 10^9$

$0 \le b \le 2 * 10^9$

max = 4×10^{18}

① int ans = a * b ✗

return ans

② long ans = a * b ✗

return ans

overflow at multiplication.

③ long ans = long(a*b) ✗

return ans

overflow at multiplication before typecasting.

④ long ans = long(a) * b ✓

return ans

long * int = long

Without typecasting

long ans = a

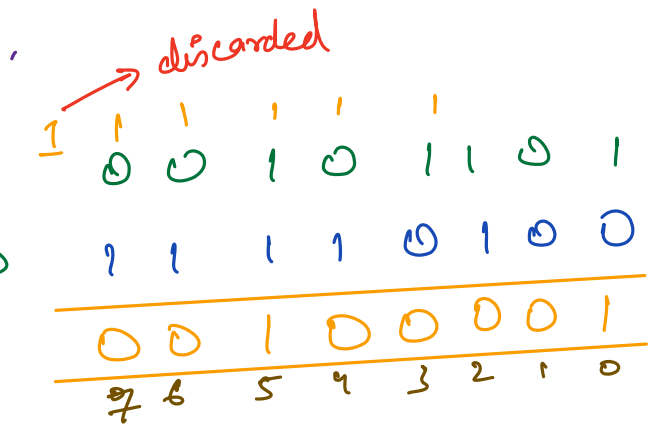
ans *= b

return ans

Subtract Binary Numbers.

45 − 12

⇒ 45 + (−12)



45 − 12 = 33

$2^5 + 2^0 = 32 + 1 = 33$

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doubt session

Q Majority element.

S.C -> O(1)

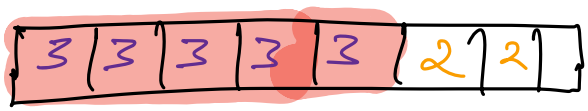
Google Meta

Find majority element.

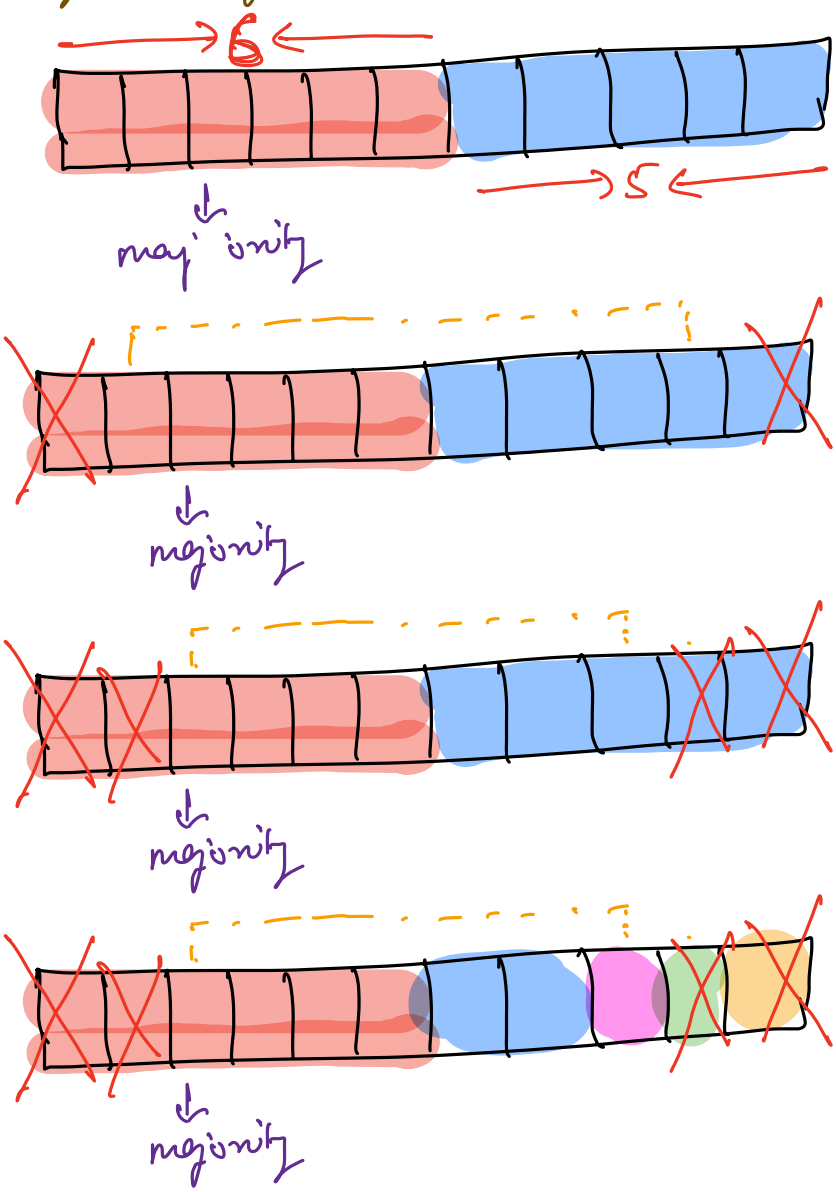
An element which appears more than floor(N/2)

A: 1 6 1 1 2 1 Ans = 1

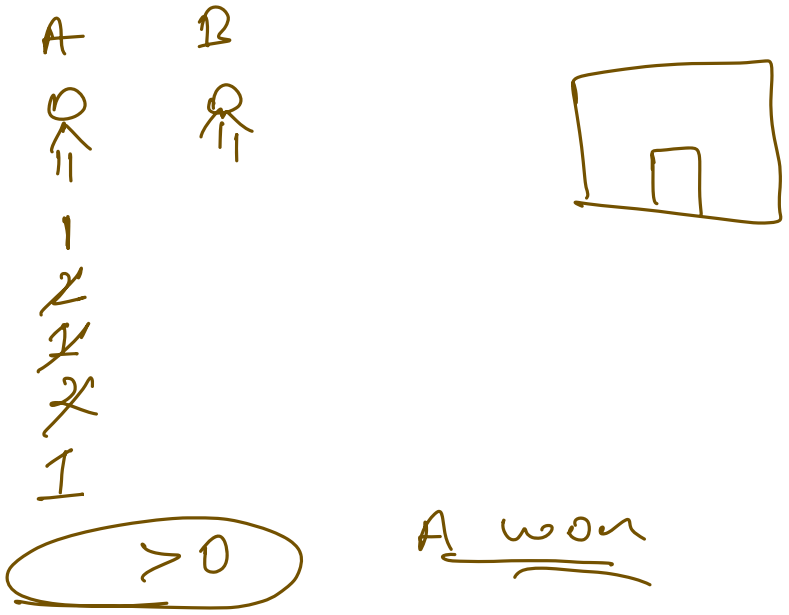
A: 3 4 3 6 1 3 2 5 3 3 3 Ans = 3



① only 1 majority element



(1) If we remove two distinct elements, majority will remain the same.



eg: 3 4 3 6 1 3 2 5 3 3 3

M.E : 3 | ME 1 | ME 2 | ME 3

count ~~1~~ ~~0~~ ~~1~~ 0 | count ~~1~~ 0 | count ~~1~~ 0 | count ~~1~~ ~~2~~ 3

Q $N/2 \longrightarrow N/3$

Q No. of Triplet.

$i < j < k$

$A[i] < A[j] < A[k]$

①

	0	1	2	3	4	5	6
A :	4	1	2	6	9	7	2

left (i) 6 right (k)

4, 1, 2 — 9, 7

$3 * 2 = 6$ triplet.

index 3 will be middle element in 6 triplet.

T.C → $O(N^2)$