

0-9
(Base 10)

Decimal No. System (0, 1, 2, 3, 4, 5, 6, 7, 8, 9)

$$342 \rightarrow 300 + 40 + 2 \rightarrow 3 \times 10^2 + 4 \times 10^1 + 2 \times 10^0$$

$$2563 \rightarrow 2000 + 500 + 60 + 30 \rightarrow 2 \times 10^3 + 5 \times 10^2 + 6 \times 10^1 + 3 \times 10^0$$

0-1
(Base 2)

Binary No. System

$$110 \rightarrow 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 \rightarrow 6$$

$$1011 \rightarrow 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \rightarrow 11$$

....	2^5	2^4	2^3	2^2	2^1	2^0
....	0	0	0	0	0	1
....	0	0	0	0	1	0
	0	0	0	0	1	1
	0	0	0	1	0	0
	0	0	0	1	0	1
	0	0	0	1	1	0
	0	1	0	0	0	1
	1	1	1	0	1	1

Binary to Decimal



$$\begin{array}{r} (1 \ 0 \ 1 \ 1 \ 0)_2 \\ \begin{array}{l} \rightarrow 0 \times 2^0 = 0 \\ \rightarrow 1 \times 2^1 = 2 \\ \rightarrow 1 \times 2^2 = 4 \\ \rightarrow 0 \times 2^3 = 0 \\ \rightarrow 1 \times 2^4 = 16 \end{array} \\ \hline 22 \end{array}$$

Ternary Number System (0-2)

$$\begin{array}{r} (1 \ 0 \ 2)_3 \\ \rightarrow 1 \times 3^2 + 0 \times 3^1 + 2 \times 3^0 \\ \downarrow \\ 9 + 0 + 2 = \underline{\underline{11}} \end{array}$$

Octal Number System (0-7)

$$\begin{array}{r} (125)_8 \rightarrow 1 \times 8^2 + 2 \times 8^1 + 5 \times 8^0 \\ 64 + 16 + 5 \\ \underline{\underline{85}} \end{array}$$

Ternary to decimal

$$(02101)_3 \rightarrow \underline{64}$$

$3^4 \quad 3^3 \quad 3^2 \quad 3^1 \quad 3^0$

$$1000001 \quad \checkmark$$

$$6854 \quad \times$$

$$2576 \quad \checkmark$$

$$7460 \quad \checkmark$$

Decimal to Binary

$$(20)_{10} \rightarrow (?)_2$$

2	20	-	0
2	10	-	0
2	5	-	1
2	2	-	0
2	1	-	1
	0		

$$(10100)_2$$

$2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$

$$2^4 + 2^2 = 16 + 4 = \underline{20}$$

Binary of 25 \rightarrow

2	25	-	1
2	12	-	0
2	6	-	0
2	3	-	1
2	1	-	1
	0		

$(11001)_2$

Binary of 37 :

2	37	-	1
2	18	-	0
2	9	-	1
2	4	-	0
2	2	-	0
2	1	-	1
	0		

$(100101)_2$

Add two decimal nos.

$$\begin{array}{r} 11 \\ 368 \\ + 453 \\ \hline 821 \end{array}$$

$$\begin{array}{r} 4578 \\ + 9234 \\ \hline 13812 \end{array}$$

Addition in Binary

$$\begin{array}{r} \textcircled{1} \textcircled{1} \textcircled{1} \\ \downarrow 101 \\ \downarrow 011 \\ \hline 1000 \end{array}$$

$$\begin{array}{r} 111 \\ \downarrow 101 \rightarrow 5 \\ \downarrow 111 \rightarrow 7 \\ \hline 1100 \quad \underline{12} \end{array}$$

QUIZ:

$$\begin{array}{r} 11 \\ a = 10011 \\ b = 01001 \\ \hline 11100 \end{array}$$

Bitwise Operators

: ✓ AND ($\&$)
✓ OR ($|$)
✓ NOT ($!$ / \sim)
✓ XOR (\wedge)
✓ Left shift (\ll)
✓ Right shift (\gg)

NOT
=
 $0 \rightarrow 1$
 $1 \rightarrow 0$

$\sim (1011)_2 \longrightarrow (0100)_2$

A	B	AND	OR	XOR
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	0

$$5: \quad 1 \ 0 \ 1$$

$$6: \quad 1 \ 1 \ 0$$

$$5 \& 6: \quad 1 \ 0 \ 0$$

$$5 | 6: \quad 1 \ 1 \ 1$$

$$5 \wedge 6: \quad 0 \ 1 \ 1$$

$$8 \ 4 \ 2 \ 1$$

$$13: \quad 1 \ 1 \ 0 \ 1$$

$$10: \quad 1 \ 0 \ 1 \ 0$$

$$13 \& 10: \quad 1 \ 0 \ 0 \ 0 \quad \rightarrow 8$$

		32	16	8	4	2	1
A: 20		0	1	0	1	0	0
B: 45		1	0	1	1	0	1
		<hr/>					
A^B		1	1	1	0	0	1
		<hr/>					

$$\Rightarrow 57$$

Even 2^4 2^3 2^2 2^1 2^0
 16 8 4 2 1

10	0	1	0	1	0
16	1	0	0	0	0
8	0	1	0	0	0
2	0	0	0	1	0
6	0	0	1	1	0
18	1	0	0	1	0
22	1	0	1	1	0

odd

16 8 4 2 1

15	0	1	1	1	1
11	0	1	0	1	1
9	0	1	0	0	1
3	0	0	0	1	1
17	1	0	0	0	1
23	1	0	1	1	1
7	0	0	1	1	1

In Binary Rep

Even → oth bit : 0

Odd → oth bit : 1

Properties

(1)

$A \& 1$:

$A = 10 \rightarrow$
 $1 \rightarrow$

0th
 $1 \ 0 \ 1 \ 0$
 $0 \ 0 \ 0 \ 1$
 $\boxed{0 \ 0 \ 0} \ \boxed{}$

$0 \& 1 \rightarrow 0$
 $1 \& 1 \rightarrow 1$

$A \& 1$
 if A is odd $\rightarrow 1$
 if A is even $\rightarrow 0$

This bit can either be 0/1

If 0th bit in A :

1 : 0th bit in ans : 1

0 : " " " " 0

(2)

$A | 1$:

$A = 10 \rightarrow$
 $1 \ 0 \ 1 \ 0$
 $0 \ 0 \ 0 \ 1$

$\boxed{1 \ 0 \ 1} \ \boxed{}$

remains same as A

$\rightarrow 1$ (irrespective of bit in A)

$A | 1$
 A is odd $\rightarrow A$
 A is even $\rightarrow A + 1$

$A : 10 | 1 \rightarrow 11$

$12 | 1 \rightarrow 13$

$6 | 1 \rightarrow 7$

$8 | 1 \rightarrow 9$

if A is odd

$A : 11 | 1 \rightarrow 11$
 $A : 5 | 1 \rightarrow 5$
 $A : 7 | 1 \rightarrow 7$

$\begin{array}{r} 1 \ 0 \ 1 \ 1 \rightarrow 11 \\ 0 \ 0 \ 0 \ 1 \\ \hline 1 \ 0 \ 1 \ 1 \rightarrow 11 \end{array}$
 $\begin{array}{r} 1 \ 0 \ 1 \rightarrow 5 \\ 0 \ 0 \ 1 \\ \hline 1 \ 0 \ 1 \rightarrow 5 \end{array}$
 $\begin{array}{r} 0 \ 1 \ 1 \ 1 \rightarrow 7 \\ 0 \ 0 \ 0 \ 1 \\ \hline 0 \ 1 \ 1 \ 1 \rightarrow 7 \end{array}$

③ $A \wedge 1$

$$\begin{array}{r} A : 10 \longrightarrow 1010 \\ 1 \longrightarrow 0001 \\ \hline \boxed{1011} \end{array}$$

$A \wedge 1$
 \swarrow A is even $\rightarrow A+1$
 \searrow A is odd $\rightarrow A-1$

bits present in A will come

$$1 \wedge 0 \rightarrow 1$$

$$0 \wedge 0 \rightarrow 0$$

$$0 \wedge 1 \rightarrow 1$$

$$1 \wedge 1 \rightarrow 0$$

10 $1010 \rightarrow 1011 = 11$
 6 $0110 \rightarrow 0111 = 7$
 4 $0100 \rightarrow 0101 = 5$
 14 $1110 \rightarrow 1111 = 15$

13 : $1101 \rightarrow 1100 = 12$
 7 : $0111 \rightarrow 0110 = 6$
 3 : $0011 \rightarrow 0010 = 2$
 11 : $1011 \rightarrow 1010 = 10$

Some More Properties

$$1) a \oplus a = 0$$

$$2) a \oplus 0 = a$$

$$\left. \begin{array}{l} 3) a \oplus b = b \oplus a \\ a \mid b = b \mid a \\ a \wedge b = b \wedge a \end{array} \right\} \text{Commutative}$$

$$\left. \begin{array}{l} 4) (a \oplus b) \oplus c = (a \oplus c) \oplus b \\ \quad = (b \oplus c) \oplus a \\ (a \mid b) \mid c = (a \mid c) \mid b \\ \quad = (b \mid c) \mid a \\ (a \wedge b) \wedge c = (a \wedge c) \wedge b \\ \quad = (b \wedge c) \wedge a \end{array} \right\} \text{Associative}$$

Inverse of XOR is XOR itself

$$\text{Given } a \oplus b = K ; \quad a \oplus K = b \quad | \quad b \oplus K = a$$

$$a \oplus b = K$$

Do $\wedge b$ on both sides

$$a \wedge b \wedge b = K \wedge b$$

$$a \wedge 0 = K \wedge b$$

$$a = K \wedge b$$

$$a \oplus b = K$$

Do \wedge with a both sides

$$a \wedge a \wedge b = a \wedge K$$

$$0 \wedge b = a \wedge K$$

$$b = a \wedge K$$

Q. Given an array where all elements appear even times except one ele which appear odd times. Identify that ele which appear odd times.

Adobe

MS

Oyo

Amazon

Andocs

2, 8, 3, 1, 2, 2, 3, 2, 8, 1, 1

Ans \rightarrow 1.

Ananth
Shashi

4, 4, 1, 4, 3, 2, 3, 1, 2

Ans \rightarrow 4

(1) \forall every no. get the frequency
if freq is odd \Rightarrow return that ele

TC: $O(N^2)$

SC: $O(1)$

(2) Observations

$$a \wedge a = 0$$

$$a \wedge a \wedge b \rightarrow 0 \wedge b = b$$

$$a \wedge a \wedge a \wedge a \wedge b \rightarrow 0 \wedge b = b$$

$$\cancel{120} \wedge \textcircled{3} \wedge \cancel{5} \wedge \cancel{120} \wedge \cancel{5} \rightarrow \textcircled{3}$$

$$\underline{2 \wedge 1 \wedge 3 \wedge 2 \wedge 1}$$

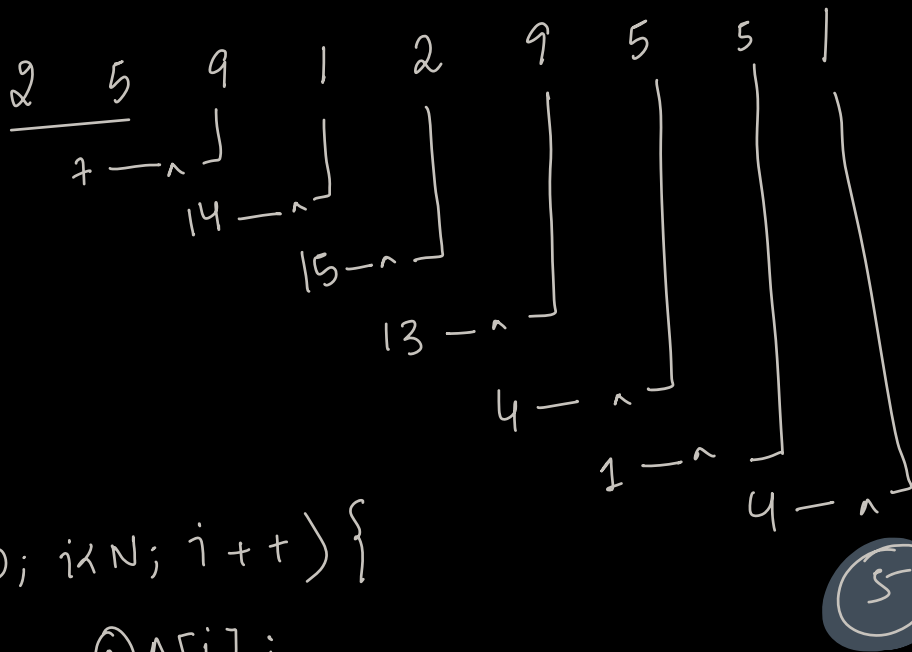
$$\underline{3 \wedge 3 \wedge 2 \wedge 1}$$

$$\underline{0 \wedge 2 \wedge 1}$$

$$\underline{2 \wedge 1}$$

$$\textcircled{3}$$

$$\begin{array}{r} 010 \\ 001 \\ \hline 011 \end{array}$$



$$\begin{array}{r} 010 \\ 001 \\ \hline 111 \end{array}$$

```

n = 0
for (i = 0; i < N; i++) {
    n = n ^ A[i];
}
return n
    
```

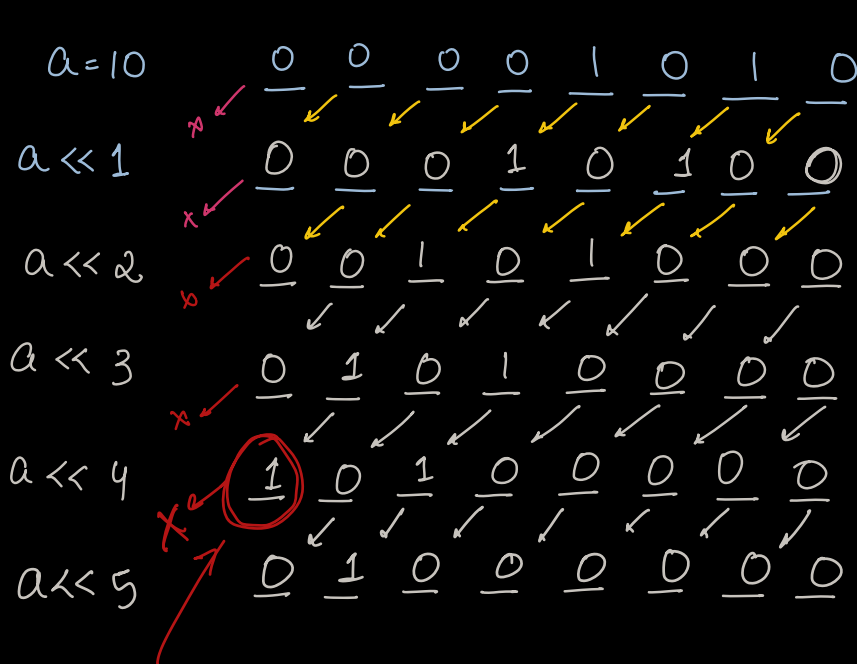
shift
6.

TC: $O(N)$
SC: $O(1)$

Left Shift Operator

literally shifts the bits towards left.

8 bits



10	10×2^0
20	10×2^1
40	10×2^2
80	10×2^3
160	10×2^4

overflow

Not able to store this big no. in the given no. of bits

Expecting a result but not getting it bcz of data loss

$$a \ll n = a * 2^n$$

$$a = 1$$

$$1 \ll n = 1 * 2^n$$

$$1 \ll n = 2^n$$

Right shift \gg
literally bits get shifted towards right

$a = 10$	<u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>1</u> <u>0</u> <u>1</u> <u>0</u>	$\rightarrow 10$	$10/2^0$
$a \gg 1$	<u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>1</u> <u>0</u> <u>1</u>	$\rightarrow 5$	$10/2^1$
$a \gg 2$	<u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>1</u> <u>0</u>	$\rightarrow 2$	$10/2^2$
$a \gg 3$	<u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>1</u>	$\rightarrow 1$	$10/2^3$
$a \gg 4$	<u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u>	$\rightarrow 0$	$10/2^4$
$a \gg 5$	<u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u>		

** No overflow since we are getting expected results

$$a \gg n = a / 2^n$$

$$a = 16$$

$$n = 2$$

$$16 \gg 2 = 16 / 2^2 = \underline{\underline{4}}$$

