

Bit Manipulation - II



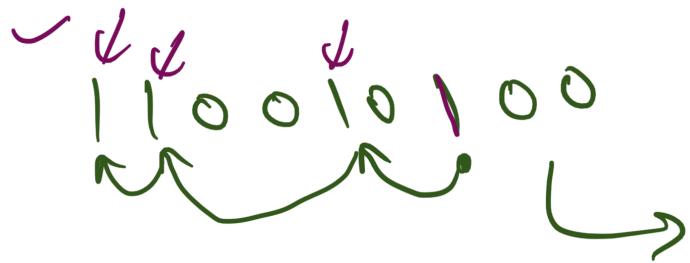
110010100 → $(\text{deg } n)$ → 0000000001111111
 MSB LSB

$n \geq (n-1)$
 Least significant set
 bit turns 0

$$\begin{array}{r}
 & 1101 \\
 & \times 1100 \\
 \hline
 & 1100
 \end{array}$$

\downarrow_{12}

$$\begin{array}{r}
 12 \rightarrow 1100 \\
 11 \rightarrow 1011 \\
 \hline
 1000
 \end{array}$$

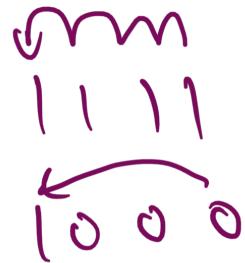
 110010
110001

62 61

111110
111101

11111000
11110111

11110000

 1111
1000

Find the only non-repeating element in an array where every other element repeats twice.

Using $O(N^2)$ $arr = \{ 2, 3, 1, 4, 1, 2, 3, 4 \}$ $\rightarrow O(N^2)$

Using Hashset.

2
X 3

$\rightarrow O(N)$
Space $\rightarrow O(N)$

XOR property

①

$$a \wedge a = 0$$

$$S \wedge S = 0$$

$$\begin{array}{r} 101 \\ \wedge 101 \\ \hline 000 \end{array} \rightarrow 0$$

$$\begin{array}{r} 101 \\ \wedge 000 \\ \hline 101 \end{array} \rightarrow 5$$

②

$$a \wedge 0 = a$$

$$a[] = [2, 1, 4, 1, 2, 3, 4]$$

$$\begin{aligned} res &= \boxed{0 \wedge 2} = \underline{\underline{2}} \wedge \underline{\underline{1}} \wedge \underline{\underline{4}} \wedge \underline{\underline{1}} \wedge \underline{\underline{2}} \\ &= \cancel{X} \wedge \cancel{4} \wedge \cancel{3} \wedge \cancel{X} \\ &= \cancel{4} \wedge \cancel{3} \wedge \cancel{X} \\ &= \underline{\underline{3}} \end{aligned}$$

$$\begin{array}{r} 001 \\ 100 \\ \hline 101 \end{array} \rightarrow 5$$

$$\begin{array}{r} 10 \\ \wedge 01 \\ \hline 11 \\ \wedge 100 \\ \hline 111 \\ \wedge 010 \\ \hline 10 \end{array}$$

Find the two non-repeating elements in an array where every other element repeats twice.

↙ int arr = {2, 4, 1, 2, 3, 7, 4, 1}

↓
0 1 1

1 1 1
—
1 0 0
2
Least significant set bit

res = 0 \oplus 2 \oplus 4 \oplus 1 \oplus 2 \oplus 3 \oplus 7 \oplus 4 \oplus 1
 $\underline{\quad}$
res = 3 \oplus 7 = 4



0 1 0
1 0 0

2nd position bit

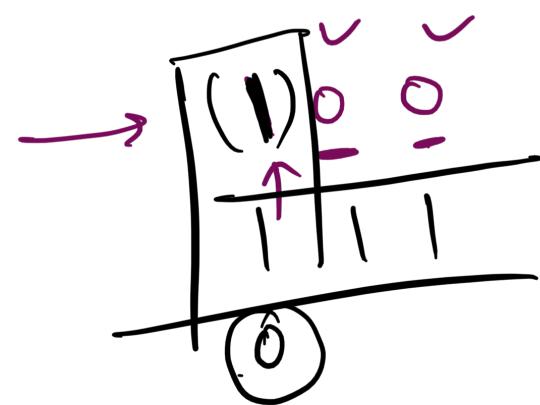
0
2, 1, 2,
3, 1

1
4, 7, 4

$$a \wedge b = 100$$

XOR
0 1 0
0 0 1
0 1 0
0 1 1
0 0 1

X 0 0
X 1 0 0



7
3 \wedge 7 \wedge 7
3

int a[] = {2, 4, 1, 2, 3, 7, 4, 1}

2nd → 0

	1	0	0
2	0	1	0
1	0	0	1
2	0	1	0
3	0	1	1
^	1	0	0

111 → 7

1	0	0
1	1	1
0	1	1

011 → 3

3 \wedge 7 \wedge 7 → 3

mask =

1	0	0	
2	0	1	0
0			

 |

1	0	0	
2	1	0	0
1			

$$a \wedge b = \overbrace{\begin{array}{cccc} 1 & 1 & 1 & 0 \end{array}}^{\downarrow} \rightarrow \begin{array}{cccc} 1 & 1 & 0 & 0 \end{array}$$

$$\begin{array}{r} 1110 \\ 0010 \\ \hline 0010 \end{array} \quad \begin{array}{c} \sim \\ 0001 \end{array} \quad \begin{array}{c} \sim \\ 1101 \end{array} \quad \begin{array}{c} \sim \\ 10010 \end{array}$$

$$1010 \rightarrow 0010$$

$$0110$$

$$\overbrace{\begin{array}{cccc} 1 & 0 & 1 & 0 \end{array}}^{\text{mask}}$$

$$\boxed{n \geq n(n-1)}$$

$$\boxed{n \geq (n-1)}$$

$$q \rightarrow 1001$$

$$\sim q \rightarrow 0110$$

Swap two bits in a given Integer.

7 6 5 4 3 2 1 0
1 0 1 0 1 1 0 1
↑ ↓ ↑

i, j
(n, i, s)

1 0 0 0 1 1 1 1

(n >> i) > 1
↓

(n >> j) > 1

i = 0
j = 1

1 << 1 = 0 0 0 1 0
1 << 5 = 1 0 0 0 0 0
—————
1 0 0 0 1 0

$\text{xor} = \text{ith} \cap \text{jth}$
 i
 j
 ith
 jth

$$\begin{array}{r}
 \downarrow \quad \downarrow \\
 10101101 \\
 \wedge 00100010 \\
 \hline
 10000111
 \end{array}$$

mask
 j

$$(1 << i) | (1 << j)$$

$i = 1$
 $n >> 1$
 1010110
 $\swarrow 1$
 $\searrow 0$
 $n >> s$

$i \text{ pos} \rightarrow 0$
 $j \text{ pos} \rightarrow 1$

$$\begin{array}{r}
 \swarrow 1 \\
 \searrow 1 \\
 \hline
 1
 \end{array}$$

A

$$\begin{array}{r} 10 \rightarrow 1010 \\ \downarrow \quad \downarrow \\ 12 \quad 1100 \end{array}$$

a, b

$\left| \begin{array}{l} a = a \wedge b \\ b = a \wedge b \\ , a = a \wedge b \end{array} \right.$

✓ Reverse the bits of an 32 bit unsigned integer.

$3 \rightarrow 11$

$\begin{array}{r} 0000000000000011 \\ - \leftarrow \\ \downarrow \\ -3 \end{array}$

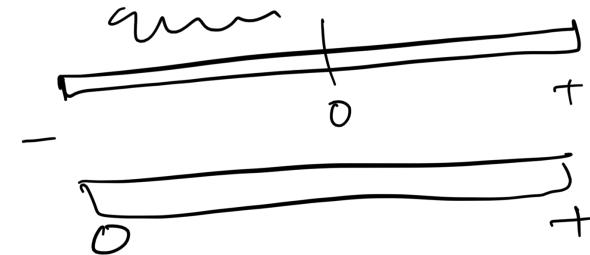
+3 MSB
is for sign

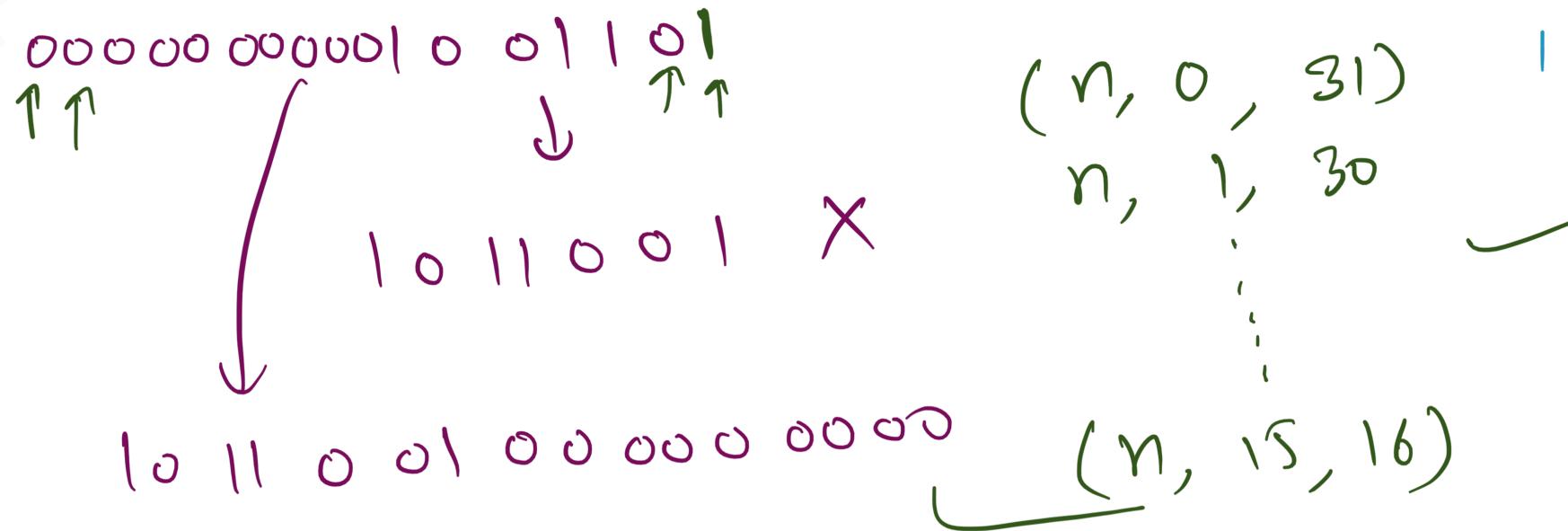
Signed

-2×10^9 to $+2 \times 10^9$

Unsigned

0 to 4×10^9





① swap two bits

for (0 ... 15)

swap(n, i, 31-i)

② $\text{Res} = 0$

100101
- - - - -

3 → 11

zeros e

we
11000000
30 zeros

$2^{30} + 2^{31} =$

✓ 1 << 31
+
0 << 30
+
✓ 1 << 29
+
0 << 28
+
0 << 27
+
✓ 1 << 26
+
⋮

1 0 0 0 0 0
31 zeros



1

$\cancel{2^{31}}$

-

Practice Problems

1. Find the only non-repeating element in an array where every other element repeats thrice.
2. <https://www.interviewbit.com/courses/programming/bit-manipulation/>