Recap

Bit → 1/0

set Bit → 1

unset Bit → 0

$\underline{\ \ }$ $\underline{\ \ }$ $\underline{\ \ }$ $\underline{\ \ }$ $\underline{\ \ }$ $\underline{\ \ }$ $\underline{\ \ }$ ↳ LSB

has highest power of base

[Most significant Bit]
MSB

1 0 0 0 > 0 1 1 1

8 7

which of these will have higher magnitude? → 1st one

8 bit

$$\underbrace{\frac{1}{2^7}\ \frac{0}{2^6}\ \frac{0}{2^5}\ \frac{0}{2^4}\ \frac{0}{2^3}\ \frac{0}{2^2}\ \frac{0}{2^1}\ \frac{0}{2^0}}_{2^7} \quad > \quad \underbrace{\frac{0}{2^7}\ \frac{1}{2^6}\ \frac{1}{2^5}\ \frac{1}{2^4}\ \frac{1}{2^3}\ \frac{1}{2^2}\ \frac{1}{2^1}\ \frac{1}{2^0}}_{2^0+2^1+2^2+\ \cdots\ 2^6}$$

$$\frac{1(2^7-1)}{2-1} = 2^7-1$$

n bit

$$\frac{1}{2^{n-1}}\ \frac{0}{2^{n-2}}\ \frac{0}{2^{n-3}}\ \frac{0}{}\ \cdots\ \frac{0}{2^2}\ \frac{0}{2^1}\ \frac{0}{2^0} \quad > \quad \frac{0}{2^{n-1}}\ \underbrace{\frac{1}{2^{n-2}}\ \frac{1}{2^{n-3}}\ \cdots\ \frac{1}{2^2}\ \frac{1}{2^1}\ \frac{1}{2^0}}$$

2^{n-1}

$$2^0 + 2^1 + 2^2 + 2^3 \ \cdots + 2^{n-2}$$

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

MSB overpowers all the other bits together

Negative no. Representation in Binary

write 8 bit binary no. of 10

0 0 0 0 1 0 1 0

8 bit binary no. of -10

1 0 0 0 1 0 1 0

↳ sign bit [assume]

8 bit Binary of

-3	1	0	0	0	0	0	1	1
-4	1	0	0	0	0	1	0	0
-7	1	0	0	0	0	0	1	1 1

7

lost

6	0	0	0	0	0	1	1	0
-2	1	0	0	0	0	0	1	0
4	1	0	0	0	1	0	0	0
	$\times 2^7$	$\times 2^6$	$\times 2^5$	$\times 2^4$	$\times 2^3$	$\times 2^2$	$\times 2^1$	$\times 2^0$

$2^7 + 2^3 \rightarrow 128 + 8 = 136$

0 0 0 0 0 0 0 0 → 0

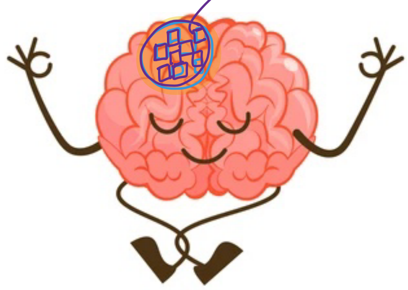
1 0 0 0 0 0 0 0 → -0

How many of u believe that

1 1 1 1

— 7 → -7 ?

Shift + Delete



2's complement

8 bit Binary Representation of 10

0 0 0 0 1 0 1 0

⇓ 1's complement [Invert all Bits]

1 1 1 1 0 1 0 1

⇓ +1 [Add +1 to it]

1 1 1 1 0 1 1 0

-2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

$-128 + 64 + 32 + 16 + 4 + 2 = -10$

8 bit Binary Representation of 3

0 0 0 0 0 0 1 1

⇓

1 1 1 1 1 1 0 0

⇓

1 1 1 1 1 1 0 1

-2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

$-128 + 64 + 32 + 16 + 8 + 4 + 1$

$= -3$

This stores
a magnitude
with signs

For any binary no.,

If MSB bit is set, can no. ever be a +ve no.?

-NO

We learnt that MSB overpowers rest of the nos.
Even if all the bits are set

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

agnitude is greater than all other
magnitudes combined

$$-2^3 \times 1 + 2^2 \times 1 + 2^1 \times 1 + 2^0 \times 1$$

$$-8 + 4 + 2 + 1$$

$$-8 + 7 = -1$$

Will MSB always negative ?

→ Yes, until you specify [eg. unsigned integer]

In all nos. having MSB as ve-, for a positive no. MSB bit will always be 0.

4 Bit

Can we store 10 in 4 bits ?

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

$\underbrace{2^2 \quad 2^1 \quad 2^0}_{7}$

max no. → 7

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

min no. → -8

# bits	min	max
2	$\underset{-2^1}{1}\ \underset{2^0}{0} \rightarrow -2$	$\underset{-2^1}{0}\ \underset{2^0}{1} \rightarrow 1$
3	$\underset{-2^2}{1}\ \underset{2^1}{0}\ \underset{2^0}{0} \rightarrow -4$	$\underset{-2^2}{0}\ \underset{2^1}{1}\ \underset{2^0}{1} \rightarrow 3$
4	$\underset{-2^3}{1}\ 0\ 0\ 0 \rightarrow -8$	$\underset{-2^3}{0}\ \underset{2^2}{1}\ \underset{2^1}{1}\ \underset{2^0}{1} \rightarrow 4+2+1 = 7$
N	$\underset{-2^{N-1}}{1}\ 0\ 0\ 0 \ldots \underset{2^2}{0}\ \underset{2^1}{0}\ \underset{2^0}{0}$ -2^{N-1}	$\underset{-2^{N-1}}{0}\ 1\ 1 \ldots \underset{2^2}{1}\ \underset{2^1}{1}\ \underset{2^0}{1}$ $2^{N-1}-1$

$\{-2^{N-1},\ 2^{N-1}-1\}$

1 Byte $\rightarrow$ 8 bits $\Rightarrow \{-2^7,\ 2^7-1\} \rightarrow \{-128,\ 127\}$

short int

2 bytes $\rightarrow$ 16 bits $\Rightarrow \{-2^{15},\ 2^{15}-1\} \rightarrow \{-32768,\ 32767\}$

int

4 bytes $\rightarrow$ 32 bits $\Rightarrow \{-2^{31},\ 2^{31}-1\} \approx \{-2\times10^9,\ 2\times10^9\}$

$\{-2,147,483,648 \quad 2,147,483,647\}$

INT_MIN INT_MAX

long 8 bytes $\rightarrow$ 64 bits $\Rightarrow \{-2^{63},\ 2^{63}-1\} \approx \{-8\times10^{18},\ 8\times10^{18}\}$

Approximation

$2^{10} = 1024 \simeq 1000 = 10^3$

$2^{10} \simeq 10^3$

Apply cube on BS

$(2^{10})^3 \simeq (10^3)^3 \rightarrow 2^{30} \simeq 10^9$

$(2^{10})^6 \simeq (10^3)^6 \rightarrow 2^{60} \simeq 10^{18}$

multiply 8 on BS

$8 \times 2^{60} \simeq 8 \times 10^{18}$

$2^{63} \simeq 8 \times 10^{18}$

$1 \leq A[i] \leq 10^9$

So that this can fit in integer range

Importance of constraints

int $a = 10^5, \quad b = 10^6$

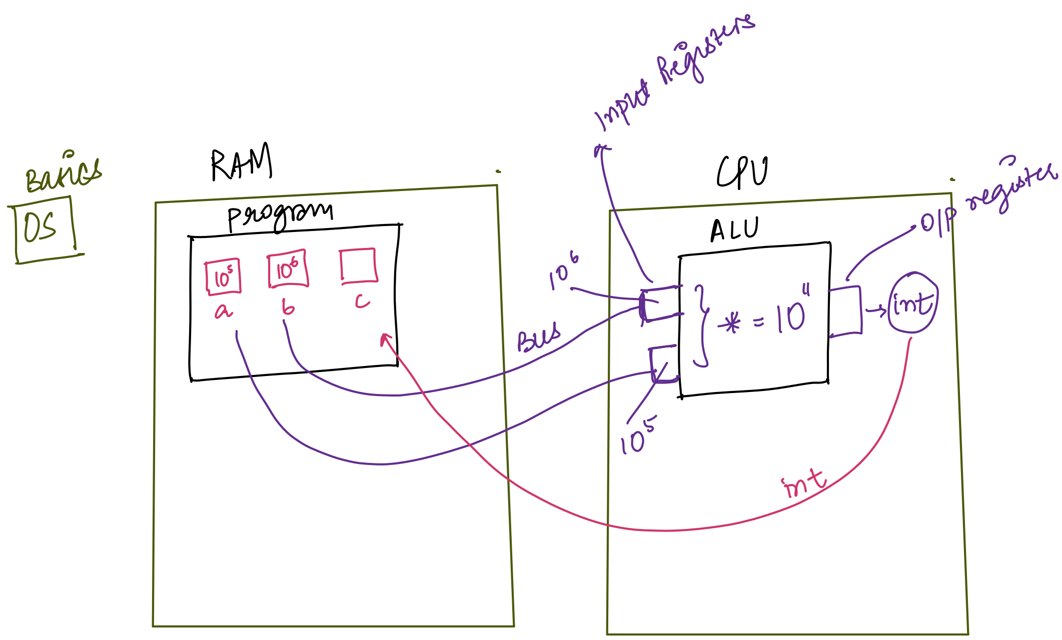
int $c = \underbrace{a \times b}_{\rightarrow 10^{11}}$

Can we store 10^{11} into integer?
— NO
Overflow happens

long $c = \underbrace{a \times b}_{10^{11}}$

long $c = $ long $(a \times b)$

long $c = $ (long)$a \times b$



Que. Given N array ele, calc sum of array elements.

```
long ~~int~~ sum = 0
(i=0 ; i<N ; i++){
    sum = sum + ar[i]
}
return sum
```

Always ask for constraints!

constraints:

$1 <= N <= 10^5$

$1 <= ar[i] <= 10^6$

$\underbrace{1}_{} <= sum <= \underbrace{10^{11}}_{}$

Why TLE occurs

Hiring challenge of Google → Q1 → observations → logic → code → TLE → OS_1 → TLE →
1hr → Q2

Online Editors

Execution time → 1s

In 1 sec ⟶ 10^9 instructions/sec

* Our code can run 10^9 instructions

```
for (i = 1; i <= 100; i++) {
    print (i)
}
```

1, 1, 2, 1

approx 4 instr. per iteration

Total 400 instructions

In our code

1 iteration = 10 instructions $<= 10^8$ iterations

10 inst → 1 iterations

10^9 inst → $\frac{1}{10} \times 10^9 = 10^8$ iterations

10^9 instructions

1 iteration = 100 instructions $<= 10^7$ iterations

100 inst. → 1 iteration

10^9 inst. → $\frac{1}{10^2} \times 10^9 = 10^7$ iterations

At max, we can have approx

→ $[10^7 - 10^8]$ iterations

Constraints

$1 \leq N \leq 10^5$ ← array size

$1 \leq arr[i] \leq 10^9$ ← array value.

Que. ——

$O(N^2)$

→ $N = 10^5 \simeq 10^{10}$ iterations (TLE)

$O(N)$

$N = 10^5 \simeq 10^5$ iterations ✓

Constraints

$1 <= N <= 10^3$

$O(N^2)$ ✓

$N = 10^3 \simeq \underline{\underline{10^6}}$ iterations