1) Storing Negative Nos.

2) TLE

3) Importance of Constraints

Bit → 1/0

set → 1

unset → 0

$\underline{\ }\ 2^7\quad \underline{\ }\ 2^6\quad \underline{\ }\ 2^5\quad \underline{\ }\ 2^4\quad \underline{\ }\ 2^3\quad \underline{\ }\ 2^2\quad \underline{\ }\ 2^1\quad \underline{\ }\ 2^0$ → LSB

MSB [Most significant Bit]

$\underbrace{1\ 0\ 0\ 0}_{8} > \underbrace{0\ 1\ 1\ 1}_{7}$

8 bit

$\underset{2^7}{1}\ \underset{2^6}{0}\ \underset{2^5}{0}\ \underset{2^4}{0}\ \underset{2^3}{0}\ \underset{2^2}{0}\ \underset{2^1}{0}\ \underset{2^0}{0} > \underbrace{\underset{2^7}{0}\ \underset{2^6}{1}\ \underset{2^5}{1}\ \underset{2^4}{1}\ \underset{2^3}{1}\ \underset{2^2}{1}\ \underset{2^1}{1}\ \underset{2^0}{1}}$

$2^{n-1}\quad 2^{n-2}$

$2^7 + 0 + 0 + 0 + 0 + 0 + 0 + 0$

$= 2^7$

$\underbrace{2^6 \ldots + 2^2 + 2^1 + 2^0}$

$2^0 + 2^1 + 2^2 + \ldots 2^6$

$\frac{a(r^n - 1)}{r-1}$ $\quad r = 2$, $a = 1$

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

N Bits

$$\underbrace{\frac{1}{2^{n-1}}\ \frac{0}{}\ \frac{0}{}\ \frac{0}{}\ \cdots\ \frac{0}{2^2}\ \frac{0}{2^1}\ \frac{0}{2^0}}_{2^{n-1}}$$

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

$$1\times 2^{n-2} \cdots + 1\times2^1 + 1\times2^0$$

$$\Downarrow$$

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

magnitude of MSB overpowers the rest of the bits taken together.

8 bit binary representation of 10

0 0 0 0 1 0 1 0

$-10 =$ 1 0 0 0 1 0 1 0

↳ sign bit [assume]

1

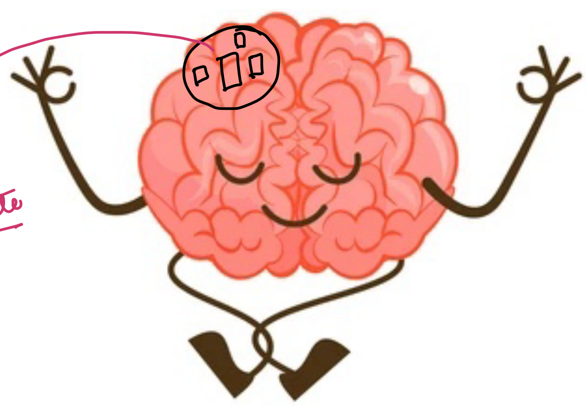
-3	1	0	0	0	0	0	1	1
-4	1	0	0	0	0	1	0	0
-7	~~1~~	0	0	0	0	0	1	1	1

					1	1		
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

0 0 0 0 0 0 0 0 → 0

1 0 0 0 0 0 0 0 → ? -0

Shift + Delete



2's complement → way of finding negative equivalent of binary nos.

1. Find 1's complement of the Binary no. [Toggle the bits]
2. Add 1 to it

$\underline{\underline{10}}$

0 0 0 0 1 0 1 0

1 1 1 1 0 1 0 1 — 1's complement

(carry: 1)

+ 1 — add 1

1 1 1 1 0 1 1 0 → -10

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

$-128 + 64 + 32 + 16 + 0 + 4 + 2$ → -10

$\underline{\underline{3}}$

0 0 0 0 0 0 1 1

↓

1 1 1 1 1 1 0 0

+ 1

1 1 1 1 1 1 0 1 → -3

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

$-128 + 64 + 32 + 16 + 8 + 4 + 1$ → -3

$\frac{1}{-2^7}$ $\underbrace{\_\ \_\ \_\ \_\ \_\ \_\ \_}$

$$\frac{\boxed{1}}{-2^3}\ \frac{1}{2^2}\ \frac{1}{2^1}\ \frac{1}{2^0}$$

$$-8+4+2+1 \rightarrow -1$$

If MSB is set, no. can't be positive.

unsigned $\rightarrow$ MSB is not negative.

Signed Numbers.

4 Bit

$$\underbrace{\frac{1}{-2^3}\ \frac{0}{2^2}\ \frac{0}{2^1}\ \frac{0}{2^0}}$$

$\Downarrow$

-8

$$\underbrace{0\ 1\ 1\ 1}_{7}$$

-8 to 7

$\frac{1}{2^1}\ \frac{0}{2^0}$ | $\frac{0}{2^1}\ \frac{1}{2^0}$

1

-2 1 -

# no of bits	Min	Max
2	-2	1
3	-4	3
4	-8	7
⋮		
N	$\underbrace{-2^{N-1}}$	$\underbrace{2^{N-1}-1}$

$N=4 \Rightarrow -2^3 \downarrow -8$

$2^3-1 \downarrow 7$

$N=3 \Rightarrow -2^2 \downarrow -4$

$2^2-1 \downarrow 3$

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

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

short int $\rightarrow$ 2 Bytes $\rightarrow$ 16 bits $\Rightarrow \{-2^{15}, 2^{15}-1\}$

$$\Downarrow$$

$\{-32768, 32767\}$

int

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

$\{-2147483648, 2147483647\}$

INT_MIN INT_MAX

long

8 Bytes $\rightarrow$ 64 Bits

$\{-2^{63}, 2^{63}-1\} \rightarrow \{-8\times10^{18}, 8\times10^{18}\}$

Approximation

$$\boxed{2^{10} = 1024 \approx 1000 = 10^3}$$

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

Apply cube on Both sides

$$(2^{10})^3 \approx (10^3)^3$$

$$2^{30} \approx 10^9$$

$$(2^{10})^6 \approx (10^3)^6$$

$$2^{60} \approx 10^{18}$$

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

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

Importance of Constraints

$a, b \rightarrow$ integers

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

$\boxed{\text{int } c = a * b}$ X

$\boxed{\text{long } c = a * b}$ X

$\boxed{\text{long } c = (\text{long})(a * b)}$ X

$\boxed{\text{long } c = ((\text{long})\ a) * b}$ ✓

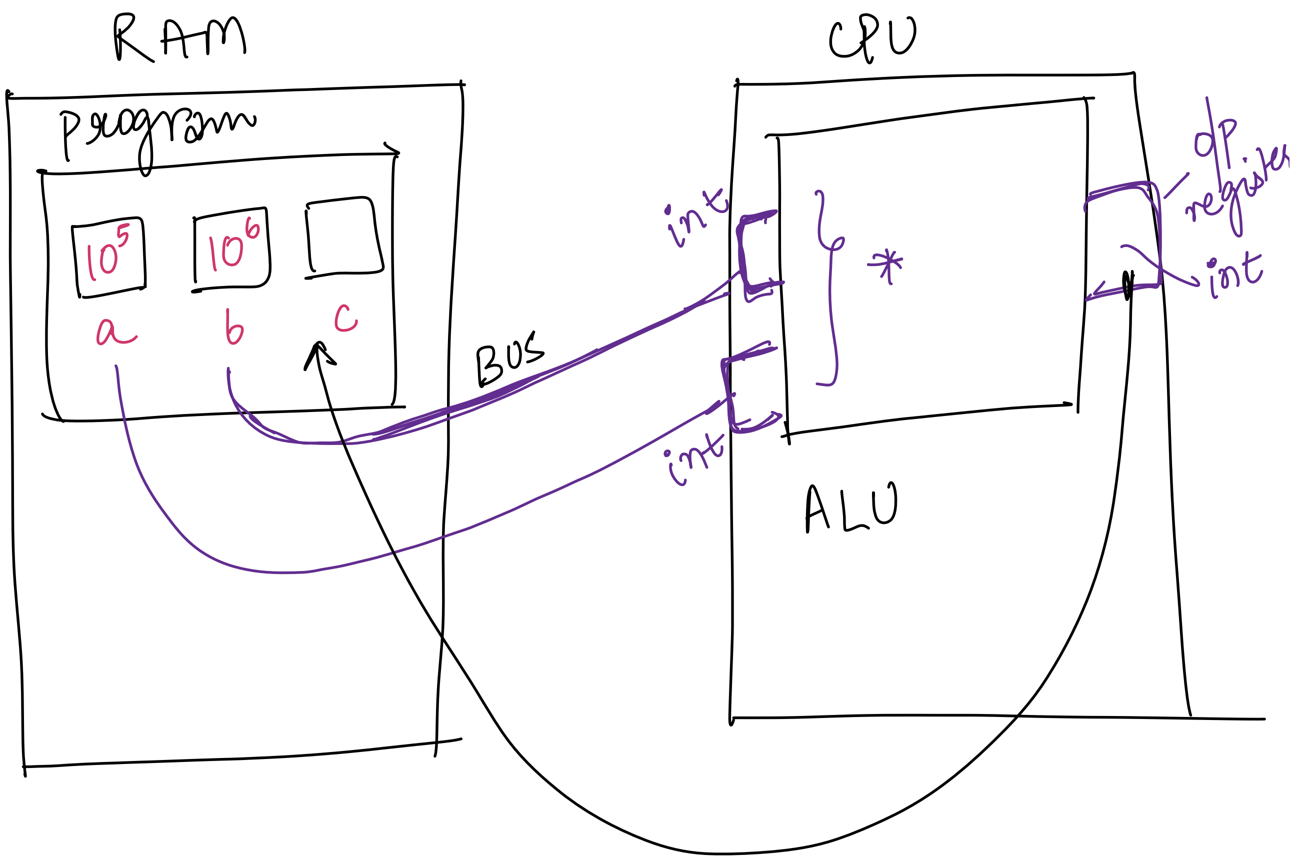
Can we store 10^{11} in an integer?

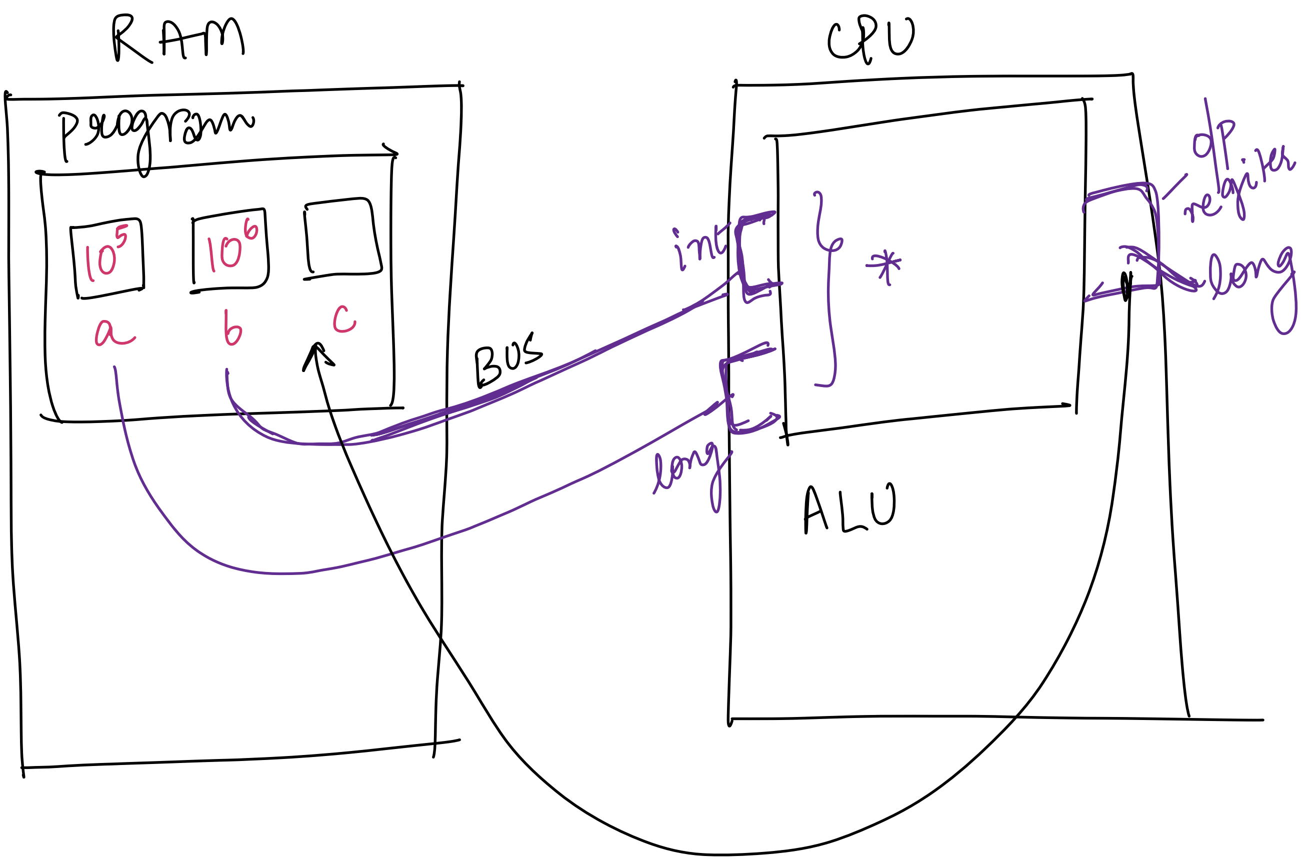
YES

YES

YES

NO


RAM
program
10^5
10^6
a
b
c
BUS
CPU
int
int
*
o/p register
int
ALU


RAM
program
10^5
10^6
a
b
c
BUS
CPU
int
long
*
o/p register
long
ALU

int a, b ;

long c = $\underbrace{a * b}$ * 1L

Q.
N array ele, calc the sum of array elements

```
~~int~~ long sum = 0
for (i = 0 ; i < n ; i++) {
|    sum += arr[i]
}
return sum
```

$arr[N] = \{10^6, 10^6, 10^6 \ldots N\}$

$10^6 \times N$

Ask for constraints!

$\boxed{1 <= N <= 10^5}$

$\boxed{1 <= arr[i] <= 10^6}$

$1 <= sum <= \underbrace{10^6 \times 10^5} \rightarrow 10^{11}$

Why TLE happens?

Hiring challenge of Google

2 questions → Q1 → Observations → logic → code → TLE → Optimization 1 → TLE → Q2

→ Q2

1 GHz → 1 Billion instructions run per second.

In 1 sec → 10^9 instructions

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

#1 (i = 1), #1 (i<=100), #2 (i++ : i=i+1), #1 (print(i))

1 iteration = 4 instructions

100 X 4 = 400 instructions

1 iterations = 10 instructions

Iterations in 10^9 instructions ?

10 instruction = 1 iteration

10^9 instructions = $\frac{1}{10} \times 10^9$ iteration

10^8 iterations

Program

↓

10 instructions → 1 iteration

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

100 instructions $\rightarrow$ 1 iteration

10^9 instructions $\rightarrow$ $\frac{1}{10^2} \times 10^9$

$= 10^7$ iteration

[10^7 to 10^8] iterations

Constraints

$1 <= N <= 10^5$ array size

$1 \le ar[i] \le 10^9$ array value

$O(N^2)$

$N = 10^5$

$N^2 \rightarrow 10^{10}$ X

TLE

$O(N)$

$N = 10^5$ } ✓

constraints

$1 <= N <= 10^3$

$O(N^2)$

$N^2 \rightarrow (10^3)^2 \rightarrow \underbrace{10^6}_{1 \text{ sec}}$