Agenda

Bit Manipulation

Binary [0, 1]

Decimal Number System (10) [0 - 9]

342 : Three hundred forty two : $3 \times 10^2 + 4 \times 10 + 2 \times 10^0$

3 2 1 0
2 5 6 . 3 . : $2 \times 10^3 + 5 \times 10^2 + 6 \times 10^1 + 3 \times 10^0$

10^4 10^3 10^2 10^1 10^0 ⟶ Base value of num ind

4 3 2 1 0

Binary Number System (2) [0, 1]

2^2 2^1 2^0

$(1\ 1\ 0)_2 = 1 \times 2^2 + 1 \times 2^1 = 6$

Q1) $(1\ 0\ 1\ 1\ 0\ 1\ 0)_2$ (6 5 4 3 2 1 0)

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

$0 + 2 + 0 + 8 + 16 + 0 + 64$

$= 90$

Decimal to binary (Repeatedly divide by 2)

Ex 1) 20

		Rem
2	20	
2	10	0
2	5	0
2	2	1
2	1	0
	0	1

$(1\,0\,1\,0\,0)_2$ (4 3 2 1 0)

$2^2 + 2^4 = 20$

Ex 2) 30

		Rem
2	30	
2	15	0
2	7	1
2	3	1
2	1	1
	0	1

$(1\,1\,1\,1\,0)_2$

Q2)

		rem
2	45	
2	22	1
2	11	0
2	5	1
2	2	1
2	1	0
	0	1

$(1\,0\,1\,1\,0\,1)_2$

Additon of decimal numbers

Carry (sum/10)

```
  1  1
  3  6  8
+ 4  5  5
-------
  8  2  3
```

Ans (sum %. 10)

carry : sum / 10 Decimal

ans : sum %. 10

Additon of binary numbers

carry (sum/2)

```
          0
  1  1  1  1/2 1
  0  1  0  1  0  1
+ 0  0  1  1  0  1
-----------------
  1  2  2  2  1  2
-----------------
  1  0  0  0  1  0
```

sum :

Ans :

(sum %. 2)

Q3)

```
    1  1  0
  1  0  1  1  0
  0  0  1  1  1
-------------------
  1  1  1  0  1
-------------------
```

ans : sum % 2

carry : sum / 2

Bitwise operator

1 → set 0 → unset

Truth table

A	B	A&B (AND)	A|B (OR)	A^B (XOR)	~A (NOT)
1	0	0	1	1	0
1	1	1	1	0	0
0	0	0	0	0	1
0	1	0	1	1	1

↓ strict parents ↓ lenient parents

AND → *

OR → +

Not correct

print (5 & 6) ⟶ 4

Bitwise operation

```
5:    1 0 1
6: & 1 1 0
     -------
     1 0 0
     -------
```

XOR → addition without carry

```
  1          (1)        1
+ 0        +  1      + 1
---        ----      ---
  1          0         0
```

20 & 45

```
20 :    0 1 0 1 0 0
45 : & 1 0 1 1 0 1
       -----------
       0 0 0 1 0 0      4
```

92 | 145

Q4) 20 ^ 45

20: 0 1 0 1 0 0

45: 1 0 1 1 0 1

^

$(1\ 1\ 1\ 0\ 0\ 1)_2$

$2^5\ 2^4\ 2^3\ 2^2\ 2^1$

$1 + 0 + 0 + 8 + 16 + 32$

$= 57$

Break (9:54 - 10:10)

1) int [32 bits]

char [8 bits]

$\overline{8}\ (\overline{4}\ \overline{2}\ \overline{1})$

Signed vs Unsigned

Signed	Unsigned
+, -, 0	+, 0
C, C++, Java, python ...	C, C++

unsigned int x = 0, +ve

[by default] int [signd] [in all languages]

signed	unsigned
8 bit	
-2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0	2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0
7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0

signed data types : MSB is negative

↓

Most significant Bit

Negative numbers representation

8 bit :

					1	1		
6	0	0	0	0	0	1	1	0
-6	1	0	0	0	0	1	1	0
	1	0	0	0	1	1	0	0

How to calculate negative

2's compliment

1) Convert no. to binary
2) Invert all bits (0→1) (1→0)
3) Add 1

Convert no. to binary

1) 3:

0	0	0	0	0	0	1	1

[1s compliment]

2)

1	1	1	1	1	1	0	0

3) Add +1

1	1	1	1	1	1	0	0
+ 0	0	0	0	0	0	0	1

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

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

$= -128 + 125$

$= -3$

overflows

(1)	1	1	1	1	1	1	1
	1	1	1	1	1	1	0	1
	0	0	0	0	0	0	1	1
	0	0	0	0	0	0	0	0

Range of datatypes

Min

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

$-2^7 = -128$

Max

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

$2^0 \ldots + 2^7 = 127$

$[-128, 127]$ ✓

32 bit [int]

Min

-2^{31}	2^{30}	2^{29}	2^{28}	....	2^0
1	0	0	0		0

-2^{31}

$[-2^{31}, 2^{31}-1]$

$[-10^9, 10^9]$

Max

-2^{31}	2^{30}	2^{29}	2^{28}	....	2^0
0	1	1	1		1

$2^0 + 2^1 + 2^2 \ldots 2^{30}$

sum of gp

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

$r = 2$

$n = 31$

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

long : 64 bit HW

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

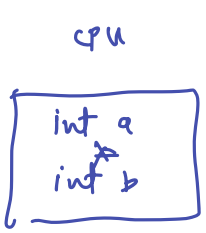
Constraints

$2^{31} = 2 \times 2^{30} = 2 \times (2^{10})^3$
$= 2 \times (10^3)^3$
$= 2 \times 10^9$

int a = 10^5
int b = 10^6

int c = a*b = 10^{11} ∝ Incorrect

long c = a * b ∝ Incorrect



computer (ALU) will assume answer will fit in int

long c = (long) a * b Correct