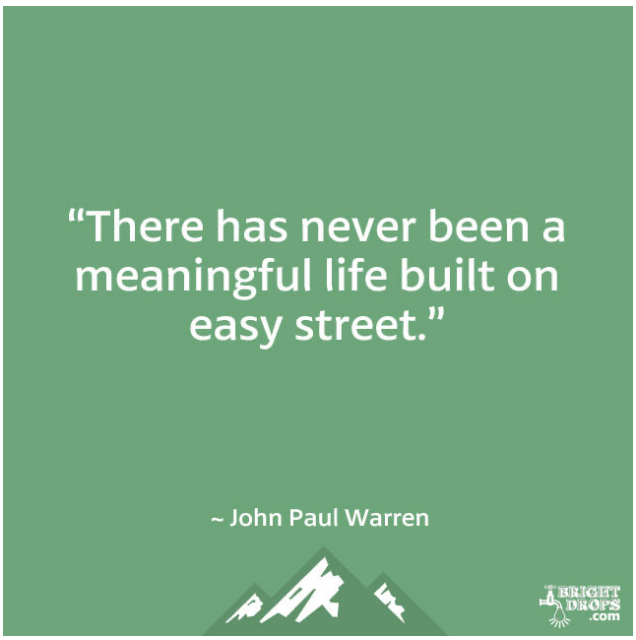
Bit Manipulation 1

Good Evening :)



Content for Today :-

→ Basics of bit Manipulation

- → Number system & conversions
- → Addition of two binary numbers
- → Bitwise operators
- → Basic Properties of bitwise operators

Number system → It is the way of writing to express the numbers.

Decimal no. system

Base → 10

Digits → 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

$[7\ 3\ 2]_{10}$ = 700 + 30 + 2

$= 7\times10^2 + 3\times10^1 + 2\times10^0$

10^0

10^1

10^2

→ 732 {digit * base value}

3 2 1 0

$[2\ 4\ 6\ 3]_{10}$ = $2*10^3 + 4*10^2 + 6*10^1 + 3*10^0$

= 2000 + 400 + 60 + 3

= 2463

10^0

10^1

10^2

10^3

Counting 0 1 2 3 4 5 6 7 8 9

10 11 12 13 14 15 16 17 18 19

20 21 22 . . .

99

100 101 102 . . .

02 Binary no. system

Base - 2

Bits → 0 & 1

$[0110]_2$ (3 2 1 0)

$= 0*2^3 + 1*2^2 + 1*2^1 + 0*2^0$

$= 4 + 2 = 6$ {bits * base value}

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

Counting

0 (0) 1 (1)

10 (2) 11 (3)

100 (4) 101 (5) 110 (6) 111 (7)

1000 (8) . . .

Binary to Decimal

$[1\ 0\ 0\ 0]_2 \longrightarrow [8]_{10}$

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

$= 1*2^3 + 0*2^2 + 0*2^1 + 0*2^0$

$= 8 + 0 + 0 + 0$

$= 8$

Quiz $[1\ 0\ 1\ 1\ 0\ 1\ 0]_2$ $2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

$= 64 + 16 + 8 + 2$

$= [90]_{10}$

Quiz $[1\ 0\ 1\ 0\ 0]_2$ $2^4\ 2^3\ 2^2\ 2^1\ 2^0$

$= 2^4 + 2^2$

$= 16 + 4 = [20]_{10}$

Idea → Extract the last digit one by one & multiply them with their respective base values & you add them to a variable

n = no. in binary

```
int btod (int n)
{
    ans = 0 , mul = 1
    while (n > 0)
    {
        int r = n % 10 ;
        n = n / 10 ;
        ans = ans + r * mul
        mul = mul * 2 ;
    }
    3
}
3
```

// r = n % 2
n = n / 2

verify this

TC : O(no. of digits)

SC : O(1)

TC : $O(\log_{10} n)$

SC : O(1)

$n \to \frac{n}{2} \to \frac{n}{4} \to \frac{n}{8} \dots 1 \Rightarrow O(\log_2 n)$

$n \to \frac{n}{3} \to \frac{n}{9} \to \frac{n}{27} \dots 1 \Rightarrow O(\log_3 n)$

$n \to \frac{n}{10} \to \frac{n}{100} \to \frac{n}{1000} \dots 1 \Rightarrow O(\log_{10} n)$

Decimal to binary

$[20]_{10} = [10100]_2$

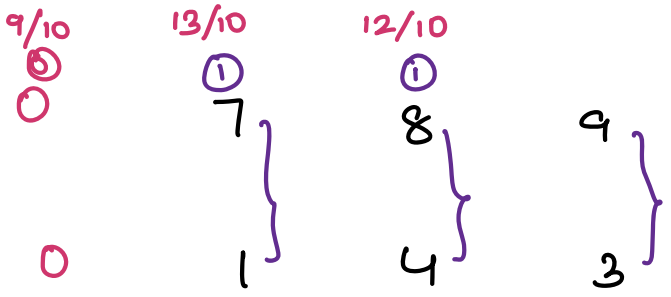
2	20	
2	10	0
2	5	0
2	2	1
2	1	0
	0	1

Quiz → $[45]_{10} \rightarrow [101101]_2$

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

Code → {TODO}

* Addition of Decimal number



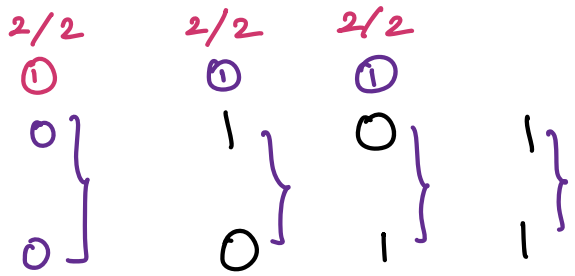
dig = sum % 10

carry = sum / 10

9 % 10 | 13 % 10 | 12 % 10

9 | 3 | 2

* Addition of two binary no.



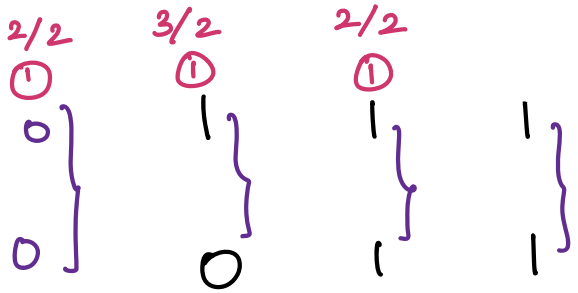
rem = sum % 2

carry = sum / 2

1 % 2 | 2 % 2 | 2 % 2 | 2 % 2

1 | 0 | 0 | 0

02

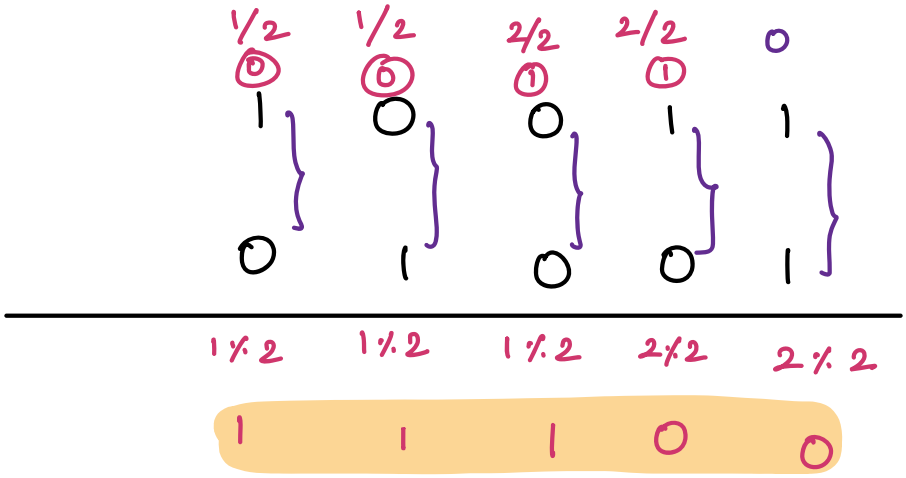


→ sum

1 % 2 | 2 % 2 | 3 % 2 | 2 % 2

1 | 0 | 1 | 0

03.



* 89 & 143 Decimal

sum/2 → sum%2

n_1	n_2	n_1%10 d_1	n_2%10 d_2	carry	d_1+d_2+c sum	sum%10 rem	ans
89	143	9	3	0	12	2	$2*10^0$
8	14	8	4	12/10 → 1	13	3	$3*10^1$
0	1	0	1	13/10	2	2	$2*10^2$
0	0			2/10			232

Code → {TODO}

* Bits

int → 4 bytes → 32 bits

1 byte = 8 bits

int x = 7 ⟶ 111

x = 0 0 0 0 0 0 . . . 0 0 0 0 0 1 1 1

31 30 29 28 . . . 7 6 5 4 3 2 1 0

* **Bitwise operators**

`&` , `|` , `^` , `~` , `<<` , `>>`

AND OR XOR NOT left right

A	B	A&B	A|B	A^B	~A	~B
0	1	0	1	1	1	0
0	0	0	0	0	1	1
1	1	1	1	0	0	0
1	0	0	1	1	0	1

unset bit = 0

set bit = 1

A & B = Both the bits has to be set.

A | B = Only one bit has to be set

A ^ B = same same puppy shame

↳ different bits = 1

same bits = 0

A = 20 A = 0 1 0 1 0 0

B = 45 B = 1 0 1 1 0 1

print (A & B) = 0 0 0 1 0 0 ⟶ 4

print (A | B) = 1 1 1 1 0 1 ⟶ 61

print (A ^ B) = 1 1 1 0 0 1 ⟶ 57

* Properties of Bitwise operators

01. A & 1 =

A = 1010

A = 1011

A = 1 0 1 0

& 1 = 0 0 0 1

0 0 0 0

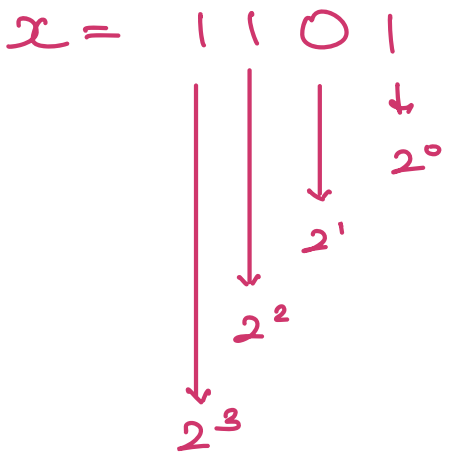
A = 1 0 1 1

& 1 0 0 0 1

0 0 0 1

A & 1 → 0 { A last bit is 0 } ⇒ { A is even }

A & 1 → 1 { A last bit is 1 } ⇒ { A is odd }



$$x = (1*2^3) + (1*2^2) + (0*2^1) + (1*2^0)$$

even + even + even + odd

even + odd = odd

To check for even → if (x % 2 == 0)

Aam zindagi

if (x & 1 == 0)

Mentos zindagi

02. A & 0 = 0

03. A & A = A

04. A | 0 = A

A = 1 0 1

| 0 = 0 0 0

1 0 1

05. $A \mid 1$

- A (A = odd no)
- $A+1$ (A = even no)

$A = 1010$

$1 = 0001$

$1011 \rightarrow A+1$

$A = 1011$

$1 = 0001$

$= 1011 \rightarrow A$

06. $A \mid A = A$

07. $A \wedge 0 = A$

$A = 1010$

$0 = 0000$

$1010 \rightarrow A$

$A = 1011$

$0 = 0000$

$1011 \Rightarrow A$

08 $A \wedge A = 0$ } XOR of two same values = 0

$A = 1011$

$A = 1011$

$0000 = 0$

* **Commutative prop**

A = 1010
& B = 1011
A&B = 1010

B = 1011
& A 1010
B&A = 1010

01. $A \& B = B \& A$

02 $A | B = B | A$

03 $A \hat{} B = B \hat{} A$

04. $A \& B \& C = C \& B \& A = A \& C \& B = B \& C \& A = B \& A \& C$

$(A) \& (B \& C)$
$x \quad y$

$x = A$
$y = B \& C$

$A \& (C \& B)$
$x \quad z$

$x \& z = z \& x$

$C \& B \& A$
$z \quad x$

05 $A | B | C = A | C | B = B | C | A = B | A | C \ldots$

06. $A \hat{} B \hat{} C = B \hat{} C \hat{} A = B \hat{} A \hat{} C = A \hat{} C \hat{} B \ldots$

Quiz $a \hat{} b \hat{} c \hat{} b \hat{} d \hat{} d \hat{} c =$

$a \hat{} b \hat{} b \hat{} c \hat{} c \hat{} d \hat{} d = a \hat{} 0 \hat{} 0 \hat{} 0$

$= a \hat{} 0 = a$

01. Given an arr[N]. All the numbers are duplicates except one. Find that unique no.

arr[] = {6, 9, 3, 6, 9} ⇒ 3

arr[] = {6, 9, 10, 6, 10} ⇒ 9

Ideas

01. Sort the array = {3, 6, 6, 9, 9}

TC: O(nlogn)
SC: O(1)

= {6, 6, 9, 10, 10}

02. HashMap = freq arr

{ 6 — 2
  9 — 2
  3 — 1 }

TC: O(n)
SC: O(n)

03. XOR of the complete array

```
int oddele (int [] ar)
    int val=0
    for (i=0; i<n; i++)
        val = val ^ ar[i];
    return val;
```

TC: O(n)
SC: O(1)

* arr = {6, 9, 3, 6, 9}

val = 0 0 0 0

^ 6 = 0 1 1 0

---

val = 0 1 1 0

^ 9 = 1 0 0 1

---

val = 1 1 1 1

^ 3 = 0 0 1 1

---

val = 1 1 0 0

^ 6 = 0 1 1 0

---

val = 1 0 1 0

^ 9 = 1 0 0 1

---

val = 0 0 1 1 } 3

6 = 0 1 1 0

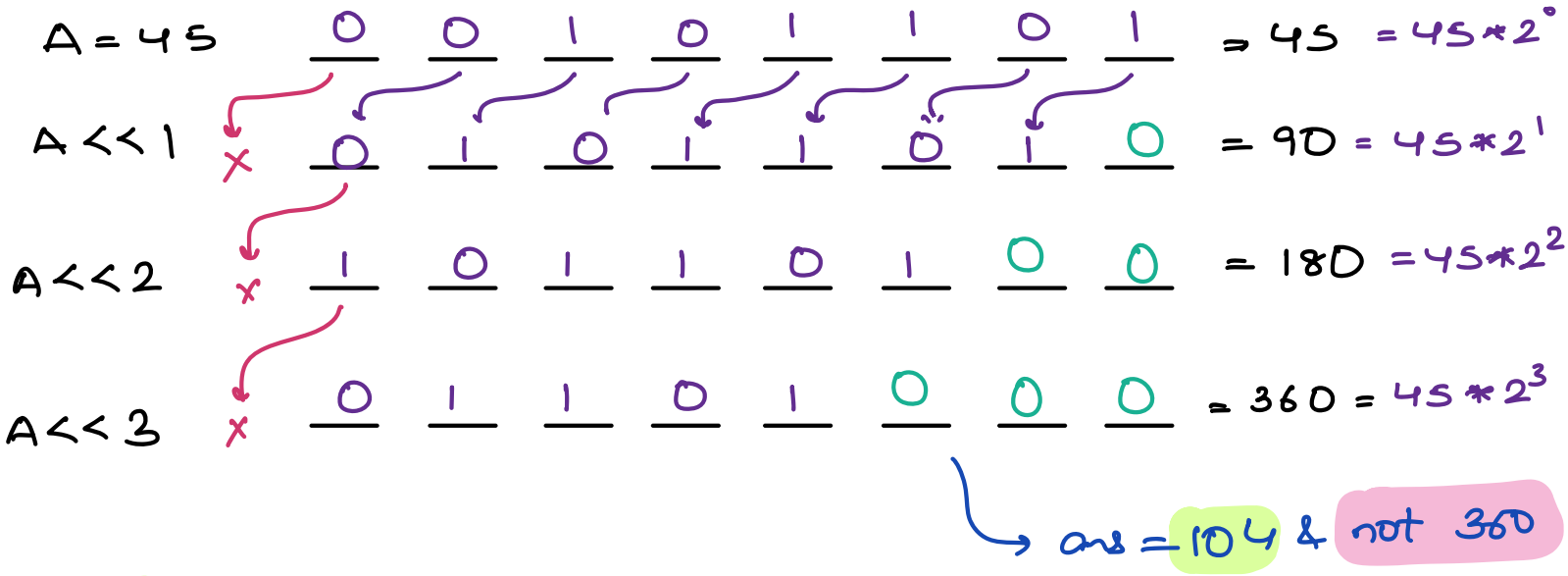
9 = 1 0 0 1

3 = 0 0 1 1

int ⇒ 4 bytes = 32 bits

// Assumption int → 8 bits { Just for explanation }

Left shift operator



overflow

$a << n = a * 2^n$

$1 << n = 2^n$

Max value stored in 8 bits

1 1 1 1 1 1 1 1 = 255

If max space is 255 & you will try to store 360 → overflow

Right shift operator

A = 20 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | = 20 = $20/2^0$

A >> 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | x | = 10 = $20/2^1$

A >> 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | x | = 5 = $20/2^2$

No overflow

$a >> n = \frac{a}{2^n}$