Decimal Number System

Digits $\Rightarrow$ $\underbrace{\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}}_{\text{Symbols}}$

Total no. of unique symbols in any number system = Base = 10

$342 = 300 + 40 + 2 = 3\times10^2 + 4\times10^1 + 2\times10^0$

$2563 = 2000 + 500 + 60 + 3 = 2\times10^3 + 5\times10^2 + 6\times10^1 + 3\times10^0$

Octal No. System = $\{0, 1, 2, 3, 4, 5, 6, 7\}$

(Base = 8)

$(1067)_8 = 1\times8^3 + 0\times8^2 + 6\times8^1 + 7\times8^0$

=

Hexadecimal No. System.

(16 Base)

$\{0 - 9, A, B, C, D, E, F\}$

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732 logs of wood.

↓ Bundles of 10

73 bundles & 2 logs

↓ Packet of 10 bundles

7 packets & $\cancel{3}$ 4 bundles & 2 logs.

$$\begin{array}{r} 2 \\ +\ 9 \\ \hline 11 \end{array} \quad (\underline{10} + 1)$$

Binary Number System

Base = 2

Unique Symbols = Bits = {0, 1}

$$\begin{array}{cccc} 3 & 2 & 1 & 0 \end{array}$$
$$(1\ 0\ 1\ 1)_2 = 1\times 2^3 + 0\times 2^2 + 1\times 2^1 + 1\times 2^0$$
$$\begin{array}{cccc} \uparrow & \uparrow & \uparrow & \uparrow \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array}$$

$$= 8 + 0 + 2 + 1$$
$$= 11$$

Binary to Decimal Conversion

1) $\overset{4}{1}\overset{3}{0}\overset{2}{1}\overset{1}{0}\overset{0}{1}$: $(10101)_2 = 1\times 2^4 + 0\times 2^3 + 1\times 2^2 + 0\times 2^1 + 1\times 2^0$

$$= 16 + 0 + 4 + 0 + 1$$

$$= 21$$

Q

$$\overset{6\,5\,4\,3\,2\,1\,0}{(1011010)_2} = 1\times2^6 + 1\times2^4 + 1\times2^3 + 1\times2^1$$

$$= 64 + 16 + 8 + 2$$

$$= \underline{\underline{90}}$$

Decimal to Binary Conversion

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

$$= (10100)_2$$

$$20 - 2^4 = 4 - 2^2 = 0$$

$$(10100)_2$$

Q Binary representation of $\underline{\underline{45}}$

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

$(101101)_2$

Addition of Decimal Numbers

$8/10 = 0$ $\quad 12/10 \quad$ $\frac{11}{10} \Rightarrow$ Carry $= \frac{\text{Result}}{\text{Base}}$

1	1	
3	6	8
4	5	3
8	12	11
$8 \% 10 = \underline{8}$	$12 \% 10 = \underline{2}$	$11 \% 10 = \underline{\underline{1}}$

$11 \% 10 \Rightarrow$ Answer $=$ Result % Base.

Addition of Binary Numbers (Base = 2)

$1/2 \quad 2/2 \quad 2/2 \quad 2/2 \quad 1/2 \quad 2/2$

0	1	1	1	0	1	
	0	1	0	1	0	1
	0	0	1	1	0	1
	1	2	2	2	1	2
	$1 \% 2$	$2 \% 2$	$2 \% 2$	$2 \% 2$	$1 \% 2$	$2 \% 2$
	1	0	0	0	1	0

$$\begin{array}{r} 21 \\ 13 \\ \hline 34 \end{array}$$

Quiz

```
  0 0 1 1 0
  1 0 1 1 0
  0 0 1 1 1
  ---------
  1 1 3 2 1
  ↓ ↓ ↓ ↓ ↓
( 1 1 1 0 1 )
```

Transistors ⇒ Measure the amount of voltage

↓ $\{0, 1, 2, 3, 4\}$

⇓

(Decay in transistor over time)

Bitwise Operators.

AND (&), OR (|), XOR (^), NOT (~).

Bit

0 → False / Unset

1 → True / Set

1) NOT (~/!)

$\sim 0 = 1$
$\sim 1 = 0$

Bits A & B

A	B	AND (&)	OR (|)	XOR(^)
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	0

2) AND (&)

Result of & operator is 1 (True) when all the bits are 1

0 & 0 & 1 & 0 & 1 & 1 = 0

1 & 1 & 1 & 1 & 1 = 1

3) OR (|)

OR is True when any one bit is True

4) XOR (^) ⇒ Exclusive OR

a^b is True only when exactly one bit is True.

Examples

1) 5 & 6 = 4

		2	1	0
5	→	1	0	1
& 6	→	1	1	0
4	⇐	1	0	0

```
int x = 5;
int y = 6;

print (x & y);
```

2) 20 & 45 = 4

	5	4	3	2	1	0
20 ⇒	0	1	0	1	0	0
45 ⇒	1	0	1	1	0	1
	0	0	0	1	0	0

3) 20 | 45 = 61

	5	4	3	2	1	0
20 ⇒	0	1	0	1	0	0
OR 45 ⇒	1	0	1	1	0	1
	1	1	1	1	0	1

$(111101)_2 = 61$

4) 20^45

	5	4	3	2	1	0
20 ⇒	0	1	0	1	0	0
XOR 45 ⇒	1	0	1	1	0	1
	1	1	1	0	0	1

$(111001)_2 = 57$

Binary Representation of -ve no.

Integers = 32 bits

2^{31}	2^{30}	2^{29}	2^{28}	......	2^{3}	2^{2}	2^{1}	2^{0}
31	30	29	28	......	3	2	1	0

```
int x = 5;
int x = - 5;
```

NOTE: for simplicity lets assume integers have 5 bits.

4	3	2	1	0

4 ↑ Most Significant Bit ⇓ Sign Bit

0 ↑ Least Significant Bit

Sign Bit $\begin{cases} 0 \rightarrow \text{+ve no.} \\ 1 \rightarrow \text{-ve no.} \end{cases}$

		Sign ↓				
	1	0				
10 :		0	1	0	1	0
− 10 :		1	1	0	1	0
	X	0	0	1	0	0

0 : 0 0 0 0 0

-0 = 0 : 1 0 0 0 0

2 representation of 0

2's Complement Representation

10 : 0 1 0 1 0

Invert all bits

1 0 1 0 1

Add 1

0 0 0 0 1

1 0 1 1 0

Binary representation of -10

1 1 1 1

10 : 0 1 0 1 0

-10 : 1 0 1 1 0

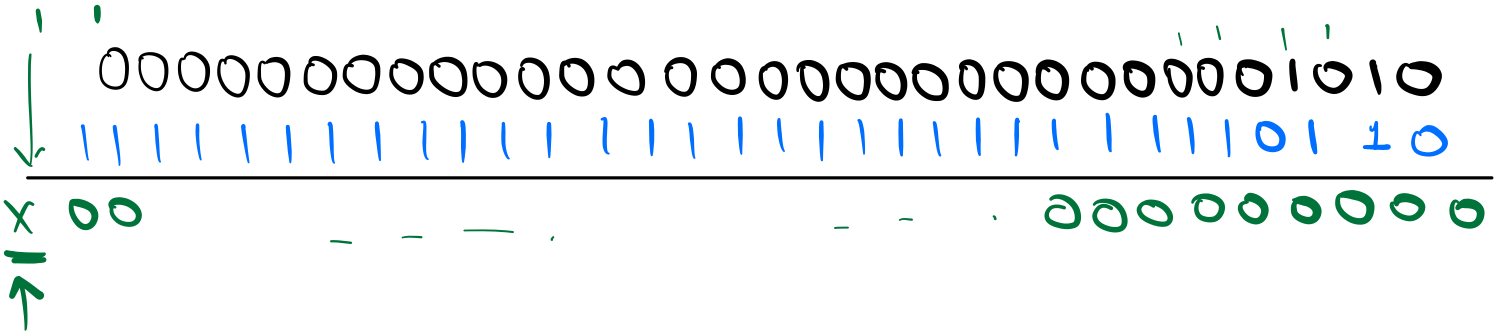
$\times$ 0 0 0 0 0

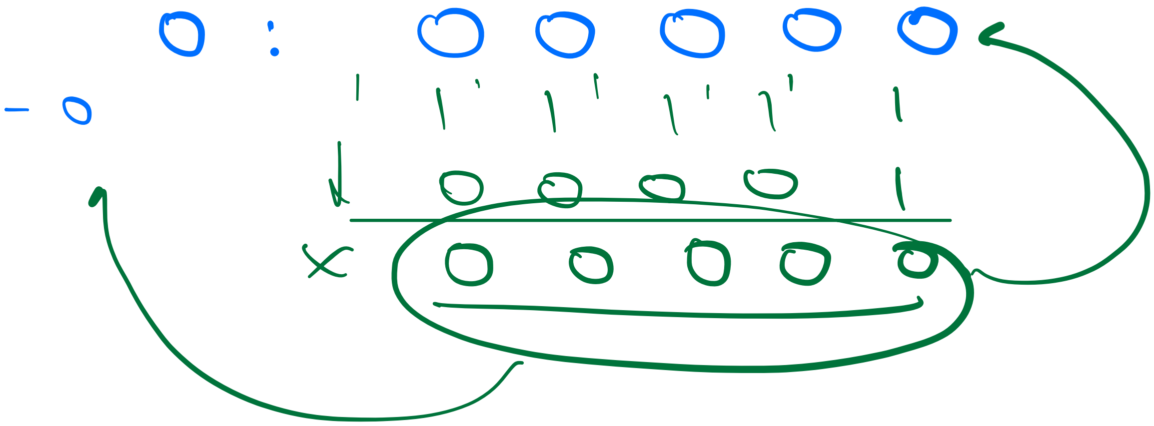
10: 00000000000000000000000000001010

11111111111111111111111111110101

0001

-10: 11111111111111111111111111110110





Range of Data Types

-2^4	2^3	2^2	2^1	2^0
4	3	2	1	0

4 Bits will contribute to value

Sign Bit

→ +ve → 0

→ −ve → 1

	4	3	2	1	0
10 :	0	1	0	1	0
	-2^4	2^3	2^2	2^1	2^0

$$= \cancel{0\times(-2^4)} + \overset{8}{1\times 2^3} + \cancel{0\times 2^2} + \overset{2}{1\times 2^1} + \cancel{0\times 2^0} = 10$$

$$-10: \quad \overset{4}{\underset{-2^4}{1}} \quad \overset{3}{\underset{2^3}{0}} \quad \overset{2}{\underset{2^2}{1}} \quad \overset{1}{\underset{2^1}{1}} \quad \overset{0}{\underset{2^0}{0}} = 1\times(-2^4) + 0\times 2^3 + 1\times 2^2 + 1\times 2^1 + 0\times 2^0$$

$$= -16 + 4 + 2 = -10$$

32 Bit System

-2^{31}	2^{30}	2^{29}	2^{28}	......	2^3	2^2	2^1	2^0
31	30	29	28	......	3	2	1	0

31 → Sign Bit

No. of Bits	Unsigned	Signed.
2 ↓ $2^2 = 4$	$\_\_ \; \_\_$ $2^1 \quad 2^0$ Max $= (11)_2 = 3$ Min $= (00)_2 = 0$ $[0, 3]$	$\_\_ \; \_\_$ $-2^1 \quad 2^0$ Max $= (01)_2 = 1$ Min $= (10)_2 = -2$ $[-2, 1]$
8 ↓ 2^8	$2^7 \; . . . . \; 2^1 \; 2^0$ Max $= 11111111 = 2^8 - 1$ Min $= 00000000 = 0$	$-2^7 \; 2^6 \; 2^5 \; . . . . . . \; 2^1 \; 2^0$ Max $= 01111111 = 2^7 - 1$ Min $= 10000000 = -2^7$

	$[0, 2^8-1]$	$[-2^7, 2^7-1]$
N Bit no. ↓ 2^N	__ __ __ .... __ __ 2^{N-1} ... 2^1 2^0 Max = 11111...11 = 2^N-1 Min = 000000...0 = 0 $[0, 2^N-1]$	↓ __ __ __ .... __ __ -2^{N-1} 2^{N-2} ..... 2^1 2^0 Max : 01111....11 = $2^{(N-1)}-1$ Min : 10000...0 = -2^{N-1} $[-2^{N-1}, 2^{(N-1)}-1]$

$$2^{N-2}+2^{N-3}+2^{N-4} \ldots\ldots\ldots +2^2+2^1+2^0$$

$$\left(2^{(N-1)}-1\right)$$

Integer $(N=32) \Rightarrow 2^{32}$

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

s e

$$(2^{31}-1)-(-2^{31})+1$$

$$2\times 2^{31} \cancel{-1} \cancel{+1}$$

$$= 2^{32}$$

friday at 9:00PM

9:05 → 10:30

↓

1hr 25min

H.W: String Class function