

# Right Shift Operator ( $\gg$ )

	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$ Discard	
$A = 160$	1	0	1	0	0	0	0	0	$\Rightarrow 160$
$A \gg 1$	0	1	0	1	0	0	0	0	$\Rightarrow 80$
$A \gg 2$	0	0	1	0	1	0	0	0	$\Rightarrow 40$
$A \gg 3$	0	0	0	1	0	1	0	0	$\Rightarrow 20$
									$\vdots$

$$(A \gg n) = A / 2^n$$

## Power of Left Shift

Check 4<sup>th</sup> Bit

$$\begin{array}{r}
 N = \\
 M = \\
 \hline
 (N \& M) = 
 \end{array}
 \begin{array}{cccccc}
 5 & 4 & 3 & 2 & 1 & 0 \\
 1 & 0 & 1 & 1 & 0 & 1 \\
 0 & 1 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0
 \end{array} = 0$$

$$\begin{array}{r}
 N = \\
 M = \\
 \hline
 \end{array}
 \begin{array}{cccccc}
 5 & 4 & 3 & 2 & 1 & 0 \\
 1 & 1 & 1 & 1 & 0 & 1 \\
 0 & 1 & 0 & 0 & 0 & 0 \\
 0 & 1 & 0 & 0 & 0 & 0
 \end{array} \neq 0$$

$(2^i)$   
 $(2^i)$   
 $i$

$2^0 \ 2^1 \ 2^2 \ 2^3 \ 2^4$

$(\log i)$

$$(A \ll i) = A \times 2^i$$

put  $A = 1$

$$(1 \ll i) = 2^i$$

$N \& (1 \ll i)$    
 $\swarrow$   $0 \Rightarrow i^{\text{th}}$  bit is not set   
 $\searrow$   $> 0 \Rightarrow i^{\text{th}}$  bit is set

$N =$    
 $\begin{matrix} & 5 & 4 & 3 & 2 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 \end{matrix}$

Given a no.  $N \Rightarrow$  Set  $i^{\text{th}}$  bit of  $N$ .

$i = 4$	$i = 3$
$\begin{matrix} 5 & 4 & 3 & 2 & 1 & 0 \\ N = & 1 & 0 & 1 & 1 & 0 & 1 \end{matrix}$	$\begin{matrix} 5 & 4 & 3 & 2 & 1 & 0 \\ N = & 1 & 0 & 1 & 1 & 0 & 1 \end{matrix}$
$M = \text{OR } 0 \ 1 \ 0 \ 0 \ 0 \ 0$	$M = \text{OR } 0 \ 0 \ 1 \ 0 \ 0 \ 0$
$\hline 1 \ 1 \ 1 \ 1 \ 0 \ 1$	$\hline 1 \ 0 \ 1 \ 1 \ 0 \ 1$

$\begin{matrix} 1 & \_ & 0 & = & 1 \\ 0 & \_ & 0 & = & 0 \end{matrix}$

$> (\text{OR}) \text{ or } (\text{XOR})$

$\begin{matrix} 1 & \_ & 1 & = & 1 \\ 0 & \_ & 1 & = & 1 \end{matrix}$

$> \text{OR}$

$N = N | (1 \ll i) \Rightarrow$  set  $i^{\text{th}}$  bit of  $N$

```
int a = 4;
a = a + 4;
print(a);  $\Rightarrow 4$ 
a = a + 4;
print(a)  $\Rightarrow 8$ 
```



Given a no.  $N \Rightarrow$  Toggle  $i^{\text{th}}$  bit of  $N$ .  
( $1 \rightarrow 0$ ) or ( $0 \rightarrow 1$ )

$i = 4$

	5	4	3	2	1	0
$N =$	1	0	1	1	0	1
$M = \text{xor}$	0	1	0	0	0	0
	1	1	1	1	0	1

$i = 3$

	5	4	3	2	1	0
$N =$	1	0	1	1	0	1
$M = \text{xor}$	0	0	1	0	0	0
	1	0	0	1	0	1

1	—	0	=	1
0	—	0	=	0

$> (\text{OR})$  or  $(\text{xOR})$

1	—	1	=	0
0	—	1	=	1

$> \text{xOR}$



Given a no.  $N \Rightarrow$  Unset the  $i^{\text{th}}$  bit of the no.  $N$ .

	$i = 4$					
	5	4	3	2	1	0
$N =$	1	0	1	1	0	1
$M =$	0	1	0	0	0	0
	1	0	1	1	0	1

	$i = 3$					
	5	4	3	2	1	0
$N =$	1	0	1	1	0	1
$M =$	0	0	1	0	0	0
	1	0	0	1	0	1

$N$ 
 $\begin{cases} \xrightarrow{i^{th}} 0 \Rightarrow \text{Don't do anything.} \\ \xrightarrow{\quad} 1 \Rightarrow \text{Toggle} \end{cases}$

if  $(N \& (1 \ll i) \neq 0) \wedge // i^{th} \text{ bit is set}$

$N = N \wedge (1 \ll i);$

}

Q Given an integer  $N$ . Count the no. of set bits in  $N$ .

Eg  $N = 12 \Rightarrow 1100 \Rightarrow 2$

bool checkBit ( $N, i$ ) {

if  $((N \& (1 \ll i)) \neq 0) \wedge$

return false;

{ else {

return true;

}

}

```
count = 0;
```

```
for (i=0; i < 32; i++) {  
    if (checkBit(N, i))  
        count++;  
}
```

```
{
```

```
    return count;
```

(N > 1)

N = 1010 ..... 00101011  
0101 ..... 00010101

```
int countBit(N) {
```

```
    count = 0;
```

```
    while (N > 0) {
```

```
        if (N & 1 == 1) {  
            count++;
```

```
        }
```

```
        N = (N >> 1);
```

```
    }
```

```
    return count;
```

```
}
```



Sam has a cat

Every day the cat behaves good, sam

feeds "the" cat.

Day 1  $\Rightarrow$  1 unit of food if cat behaves good  
Day 2  $\Rightarrow$  2 units " " " "  
3  $\Rightarrow$  4 units " " " "  
4  $\Rightarrow$  8  
:  
:

Given the total units of food Sam has given to the cat. Can you find out the no. of days the cat behaved good.

Total food = 79 units

$2^n$  . . . . .  $2^3$   $2^2$   $2^1$   $2^0$   
1 0 1 0 1 1 0 0 0 0 1 0 1

$2^4$   $2^3$   $2^2$   $2^1$   $2^0$   
1 0 1 0 1

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

=

## Binary Representation of Negative No.

Assume 5 bits

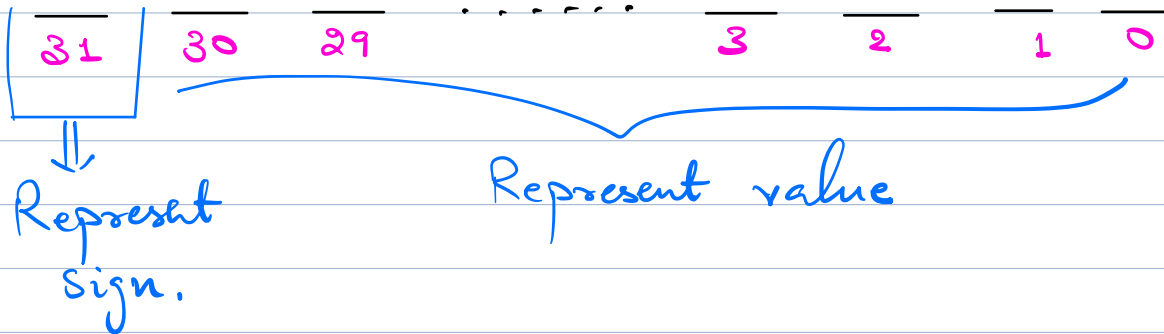
MSB

$2^4$   $2^3$   $2^2$   $2^1$   $2^0$

10  $\rightarrow$  0 1 0 1 0

MSB  $\begin{cases} 0 \Rightarrow +ve \\ 1 \Rightarrow -ve \end{cases}$

MSB  $\Rightarrow$  Sign Bit



int x = 5  
unsigned int x = 5

$10 \rightarrow 01010$   
 Add  $-10 \rightarrow 11010$   
 $0 \rightarrow 00100$  (Not binary repres. of 0)  
 $0 \rightarrow 00000$   
 $-0 = 0 \rightarrow 10000$  (2 different Binary repres. of 0)

2's complement

-10 in Binary

1) Take binary representation of 10

$$10 \rightarrow 01010$$

2) Invert all bits

$$10101$$

3) Add 1 to the result of step 2

$$\begin{array}{r} 10101 \\ 00001 \\ \hline -10 \rightarrow 10110 \end{array}$$

$$\begin{array}{r} -10 \Rightarrow 10110 \\ 10 \Rightarrow 01010 \\ 0 \Rightarrow 00000 \\ \hline \end{array}$$

Sign Bit  $\leftarrow$

$$-10 \Rightarrow \begin{array}{c} 2^4 \\ \hline 1 \end{array} 0 1 1 0$$

$\Downarrow$

$$\begin{aligned} & (-2^4) \times 1 + 2^3 \times 0 + 2^2 \times 1 + 2^1 \times 1 + 2^0 \times 0 \\ &= -16 + 0 + 4 + 2 + 0 \\ &= -10 \end{aligned}$$

$$00101$$



# Range of Data Types

$N$	Signed	Unsigned
2	$\begin{array}{cc} \overline{-2^1} & \overline{2^0} \end{array}$ $\text{Max} \Rightarrow 01 = 1$ $\text{Min} \Rightarrow 10 = -2$ $\text{Range} = [-2, 1]$	$\begin{array}{cc} \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} \Rightarrow 11 = 3$ $\text{Min} \Rightarrow 00 \Rightarrow 0$ $\text{Range} = [0, 3]$
4	$\begin{array}{cccc} \overline{-2^3} & \overline{2^2} & \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} \Rightarrow 0111 = 2^3 - 1 = 7$ $\text{Min} \Rightarrow 1000 \Rightarrow -8$ $\text{Range} = [-8, 7]$ $= [-2^3, 2^3 - 1]$	$\begin{array}{cccc} \overline{2^3} & \overline{2^2} & \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} \Rightarrow 1111 = 2^4 - 1 = 15$ $2^3 + 2^2 + 2^1 + 2^0$ $\text{Min} \Rightarrow 0000 = 0$ $\text{Range} \Rightarrow [0, 15]$ $= [0, 2^4 - 1]$
32	$\begin{array}{ccccccc} \overline{-2^{31}} & \overline{2^{30}} & & & & \overline{2^2} & \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} \Rightarrow 0111\dots11 \Rightarrow 2^{31} - 1$ $\text{Min} = 1000000 \Rightarrow -2^{31}$ $\text{Range} = [-2^{31}, 2^{31} - 1]$	$\begin{array}{ccccccc} \overline{2^{31}} & \overline{2^{30}} & & & & \overline{2^2} & \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} = 11\dots111 = 2^{32} - 1$ $\text{Min} = 0000000 = 0$ $\text{Range} = [0, 2^{32} - 1]$
$N$	$\begin{array}{ccccccc} \overline{-2^{N-1}} & \overline{2^{N-2}} & & & & \overline{2^2} & \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} = 0111\dots111 \Rightarrow 2^{N-1} - 1$	$\begin{array}{ccccccc} \overline{2^{N-1}} & \overline{2^{N-2}} & & & & \overline{2^2} & \overline{2^1} & \overline{2^0} \end{array}$ $\text{Max} = 111111 = 2^N - 1$

$$\text{Min} = 1000\dots00 \Rightarrow -2^{N-1}$$

$$\text{Range} = [-2^{N-1}, 2^{N-1}-1]$$

$$\text{Min} = 0000\dots0 = 0$$

$$\text{Range} = [0, 2^{N-1}]$$

## Importance of Constraints

$$2^{31} \approx 10^9$$

$$\text{int } a = 10^5$$

$$\text{int } b = 10^6$$

$$\text{int } c = (a \times b) \quad \text{ALU (Arithmetic Logic Unit)}$$

???

(10<sup>11</sup> ??)

Overflow.

! How to avoid overflow.

$$1) \text{ long } c = (\text{long})(\underline{a \times b}) \quad \text{X}$$

$$2) \text{ long } c = ((\text{long})a) \times b$$

$$2) \text{ long } c = a \times (\text{long})b$$

$$2) \text{ long } c = (\text{long})a \times (\text{long})b \quad \checkmark$$

Doubt

$$20B, 14R$$

v 2

Same color  $\rightarrow$  Blue  
diff  $\Rightarrow$  Red.

$\frac{2B}{-1} / \frac{2R}{\downarrow +1 \text{ Blue}} \Rightarrow 1 \text{ Blue}$

$1R + 1B \Rightarrow 1 \text{ Red Ball} \Rightarrow -1 \text{ Blue}$