Binary addition and Subtraction

The Process of addition using binary number is basically identical to that using decimal Notation. Prior to addition and Substraction, let us explain Carry and borrow in binary System.

when a given binary column is filled (contains a 1) and when the digit is to be imple-mented by 1 (added to by 1) Then the Column in question is returned to Zero and a carry is placed in the next higher order column.

For example

```
  cr  cr
  0   1   1  ← (Number)
          1    (add 1)
 ------------
  1   0   0
```

or in more detail

```
      in the 1's column          4   2   1  ← Column
                                              weightage
  with carry of 1     1+1=0,     0   1   1
                                     1
with carry of 1, in the 2's column  -----------
                                 1   0   0
                    cr
                   1+1 = 0
                    cr
  In the 4's column  0+1 = 1
```

For borrow, a binary digit moved from a more Significant column becomes a borrow, and in the new column it carries a weight greater Than before by the base of the system. for example, a 1 in the Third column is to be moved to the Second column

0100 → 0 0 $\dotplus$ 0

This Peculiar notation is Necessary because a 1 moved one column to the right is now weighted twice its previous value.

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M T W T F S S M T W T F S S
1 2 3 4 5 6 7 8 9 10 11
12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29

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Twice 1 is 2, but there is no digit 2 in the binary system. These are then treated as individual digits as illustrated in forth-coming subtraction.

Addition:

Add 1011_2 and 110_2, Concept of Carry is to be used.

In the 1's Column $1+0=1$.
In the 2's Column $1+1=0$, with a Carry of 1
In the 4's Column $1+0+1=1$, with a Carry of 1.
In the 8's Column : $1+1=0$, with a Carry of 1 next higher Column,
but this is last Column of the numbers and therefore, it is written as $1+1=10$, and is read as "Zero and a Carry of 1".

Column weightage

		8	4	2	1
		1	0	1	1
+			1	1	0
	1	0	0	0	1

Subtraction: Subtract 01111_2 from 11011_2.
Concept of borrow is to be used in association with rule that
0 minus 0 equals 0
1 minus 0 equals 1
1 minus 1 equals 0.

As stated earlier 0 minus 1 will require a borrow from next higher-order column which is to be written as $\frac{1}{1}$ on the column demanding a borrow.
Let us depict them in the given problem

	1 (borrow)				
0	0	1 (borrow)			
1	1	0	1	1	$= 27_{10}$ – Minuend
0	1	1	1	1	$= 15_{10}$ – Subtrahend
0	1	1	0	0	$= 12_{10}$ – difference

Another example, Let us subtract 1 from 100_2.

		1	
	1	+	
	+	1	
0	1		
1	0	0	$= 4_{10}$ – minuend
		1	$= 1_{10}$ – Subtrahend
–			
0	1	1	$= 3_{10}$ – difference

Binary multiplication :

The binary multiplication table is

	0	1
0	0	0
1	0	1

The Paper method is illustrated below. Assume multiplicand 1011_2 and multiplier 1010_2. That is

			1	0	1	1	multiplicand
			1	0	1	0	multiplier
			0	0	0	0	
		1	0	1	1		
	0	0	0	0			
1	0	1	1				
1	1	0	1	1	1	0	

In computer, only a fixed number of bit positions are available. Therefore a different method is used which requires use of registers. Register holds these digits. The length of the register is equal to the number of bits it can store. The contents of the register can be shifted to left or right.

(i) If shifted to right by one bit then least significant bit (LSB) is lost. The position occupied by most significant bit (MSB) becomes empty and is filled with Zero.

Contents

1	0	0	1

MSB shifted to left once ⟷ LSB shifted to right once

0	0	1	0

MSB is lost

0	1	0	0

(ii) If shifted to left Then MSB is lost and LSB is filled by a 0.

In order to multiply we need Three registers, a multiplicand register (M) which can store n bits, a multiplier - quotient register (MQ) of n bits to store a multiplier (or The quotient during division) and an accumulator in which Partial Products are added and stored. The accumulator and MQ are joined so that Their contents can be shifted either left or right.

The multiplicand is placed in The M-register. The MQ register is Then shifted one bit to The left. If a 1 is shifted out, M is Then added to The MQ register. If a 0 is shifted out, a 0 is added to The MQ register. The entire Process is repeated as many times as There are Numbers of bits in The multiplier (here four times).

The result appears in MQ register. Process is given below. Assume multiplicand 1011_2 and multiplier 1010_2.

MQ register	1 0 1 0	0 0 0 0
(i) Shift MQ	1 0 1 0 0	0 0 0 0
Add M	~~[illegible]~~	1 0 1 1
Sum in MQ	0 1 0 0	1 0 1 1
(ii) Shift MQ	0 1 0 0 1	0 1 1 0
Add 0		0 0 0 0
Sum in MQ	1 0 0 1	0 1 1 0

							1	1	0	0
(iii) Shift MB	1	0	0	1	0					
Add M							1	0	1	1
Sum in MB		0	0	1	1		0	1	1	1
(IV) Shift in MB	0	0	1	1	0		1	1	1	0
Add 0							0	0	0	0
Sum in MB		0	1	1	0		1	1	1	0

Result

Compare it with paper method.

Binary Division: Computer method and paper method both are separate. Paper method is given below. Assume That dividend is 110110 and divisor is 101 Then

```
          1010      ← Quotient
    101 ) 110110
          101
          ---
           111
           101
           ---
            10  ← Remainder
```

Example 2. Divide 100011 by 111

```
            101
     111 ) 100011
           111
           -----
           00111
             111
           -----
             000
```

Example 3 Divide 1011010 by 110

```
             11101
     110 ) 1011010
           110
           ----
           1010
            110
           ----
            1001
             110
           -----
            00110
              110
              000
```