Bit, Byte, Binary encoding of integers

> Tags: bit, byte, binary,

Binary Digit(bit)

- The ***bit*** is a basic unit of information in computing and digital communications
- Can be 1 or 0 (on/off)

How big is it?
-**One bit is the information that is gained when the result of an event with 2 equally probable outcomes become known.**
Example: flipping a coin.

Bit Strings

- For larger values a sequence of bits (bit strings) can be used

  1)*For 2 bits we can store 4 different values*:
  (0,0)(1,0)(0,1)(1,1) or 2^2

  2)*For 3 bits we can store 8 different values*:
  2^3

Byte

- Data capacity is amount of info that can be encoded by computing system
- Commonly used units are **Bytes** (1 byte = 8 bits)
- a byte can store 256 patters (2^8)

Binary Representation

*First of all, let's look at the Positional numbering system:
Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 | *Note that: because there are 10 digits we are going to use 10 as our Base*

1231 = 1 x 10^3 + 2 x 10^2 + 3 x 10^1 + 1 x 10^0

*Now let's take a look at Base-2 positional numbering system****(Binary System):***
Digits: 0, 1 | *Because we have 2 numbers, we are going to use 2 as our base*

1101 = 2^3 x 1 + 2^2 x 1 +2^1 x 0 + 2^0 x 1 = 8 + 4 + 2 + 1 = **15**

As you can see, while the traditional positional numbering system used Base 10, the Binary System used a Base 2 model.

Hexadecimal Representation

- Base-16 positional numbering system.
  Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

1101_2 = 2^3 x 1 + 2^2 x 1 + 2^1 x 0 + 2^0 x 1 = 13_{10} = D_{16}

4 bits can be represented by one Hexadecimal Digit

Binary encoding of integers

1234 in decimal
Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
1234 / 10 = 123 | **4**
123 / 10 = 12 | **3**
12 / 10 = 1 | **2**
1 / 10 = 0 | **1**

From Decimal to Binary

123 in binary
Digits: 0, 1
123 / 2 = 61 | 1
61 / 2 = 30 | 1
30 / 2 = 15 | 0
15 / 2 = 7 | 1
7 / 2 = 3 | 1
3 / 2 = 1 | 1
1 / 2 = 0 | 1
The answer is 1111011

Additional Notes

Shortcuts to convert from binary to hexadecimal

Our binary number:1011010001_2

- Group 4 digit-blocks starting from LSD and if needed fill non-significant zeros before MSD.

Example: Convert 001011010001 to Hexadecimal

1. Group it to 4 digit blocks 0010 1101 0001_2
2. Apply the LSD and MSD rules 10 1101 0001
3. $10_2 = 2_{16}$
4. $1101_2 = 13_2 = D_{16}$
5. $0001_2 = 1_{16}$
   And Done, The answer is $2D1_{16}$

Shortcuts to convert from hexadecimal to binary

- Convert each hex digit to binary and concatenate 4 bit-blocks together in the original order.

Example: Convert $4AF_{16}$ to binary

1. 4 = 0100_2
2. A = 1010_2
3. F = 1111_2
4. Remove the 0's in the beginning and put it in the original order: 100 1010 1111_2

And there we go!, the answer is 10010101111_2

Arithmetic Operations

Addition

- Addition is done very similar to decimal:
  0 + 0 = **0**
  0 + 1 = **1**
  1 + 0 = **1**
  1 + 1 =1**0**
- Let's add two binary numbers:

0010 0110 = 38
0011 1011 = 59