



SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

CMPT 125 - Introduction to Computing Science and Programming II - Fall 2021

Lab 4. Binary Encoding
October 6

- Office hours:
 - Sepid: Tuesdays 10:00AM-11:00AM in ASB 9810
 - Kaumil: Wednesdays 11:30AM-12:30PM in ASB 9810
- Tutorials / Labs:
 - Wednesdays 9:30AM - 10:20AM, ASB 9838, Burnaby
 - Wednesdays 10:30AM - 11:20AM, ASB 9838, Burnaby
 - Wednesdays 3:30PM - 4:20PM, ASB 9838, Burnaby
 - Wednesdays 4:30PM - 5:20PM, ASB 9838, Burnaby
- Assignment grading:
 - Make sure to follow instructions carefully, even a single character can result compile error and a zero for your grade.
- Academic Honesty:
 - Do not use something that you can't cite!

- Binary encodings of integers
 - Fixed width encoding
- Non integer arithmetic
 - Scientific Notation
 - Floating point encoding
- Bitwise operations

The values of digits in a number are positional:

Decimal numbers: $582 = 500 + 80 + 2 = 5*10^2 + 8*10^1 + 2*10^0$

Binary numbers: $10110 = 1*2^4 + 0*2^3 + 1*2^2 + 1*2^1 + 0*2^0$

The values of digits in a number are positional:

Decimal numbers: $582 = 500 + 80 + 2 = 5*10^2 + 8*10^1 + 2*10^0$

Binary numbers: $10110 = 1*2^4 + 0*2^3 + 1*2^2 + 1*2^1 + 0*2^0$

Exercises:

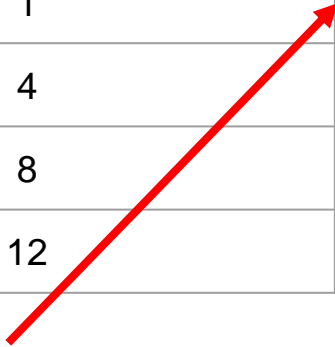
1. Convert 10011011 from binary to decimal.
2. Convert 29 from decimal to binary.
3. Write a program that get an integer in decimal and print its binary form.

Simple data types are usually fixed in width:

	bytes	
int	4	-2,147,483,648 to 2,147,483,647
long long int	8	$-(2^{63})$ to $(2^{63})-1$
char	1	-128 to 127
float	4	
double	8	
long double	12	

Simple data types are usually fixed in width:

	bytes	
int	4	-2,147,483,648 to 2,147,483,647
long long int	8	$-(2^{63})$ to $(2^{63})-1$
char	1	-128 to 127
float	4	
double	8	
long double	12	



One of the digits is for the sign

Two common decimal numbers:

$$\frac{1}{3} = 0.3333333333$$

$$\frac{2}{3} = 0.6666666666$$

Cannot write the decimal with finite number of digits.

So we round them.

A convention to express numbers by their magnitude:

Speed of light = 2.99792458×10^8 m/s

One gigabyte = 1.073741824×10^9 bytes

$\frac{1}{3} = 3.33333333333 \times 10^{-1}$

Same conventions are used for binary

A float is composed of 32 bits:

1 bit for sign (0 – positive, 1 – negative)

23 bits for the significand (significant digits of the number)

1.b₂₂b₂₁...b₀

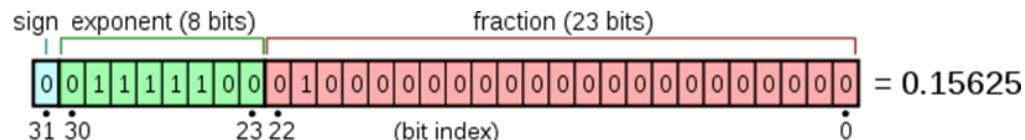
b₂₂ represents the digit of $\frac{1}{2}$

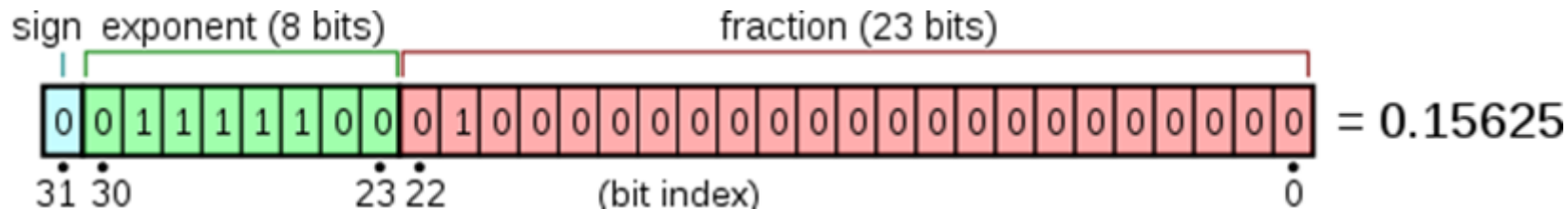
b₂₁ represents the digit of $\frac{1}{4}$...

8 bits for the exponent – ranges from -127 to 128

Range of the representation: $1.b_{22}b_{21}...b_0 \times 2^{(\text{exp}-127)}$

between $\approx 2^{128} \approx 3.40 \times 10^{38}$ and $\approx 2^{-127} \approx 1.17 \times 10^{-38}$





The number is $(-1)^{\text{sign}} \times (1 + \text{fraction}) \times 2^{\text{exp}-127}$

In this example:

$$1 \times (1 + 1/4) \times 2^{124-127}$$

$$= 1.25 \times 2^{-3}$$

$$= 1.25/8 = 0.15625$$

Symbol	Operator
&	bitwise AND
	bitwise inclusive OR
^	bitwise XOR (exclusive OR)
<<	left shift
>>	right shift
~	bitwise NOT (one's complement) (unary)

Exercises:

1. Assign the maximum and the minimum int to a variable using bitwise operations.

1. In the case of int type, what is the output of following equations?
 - a. $(1 \ll 31) - 1$
 - b. $(-1 \ll 3)$
 - c. $(-1 \gg 3)$
 - d. $\sim(-1)$

3. Considering the tradeoff between memory and speed, what is the best way to keep a binary flag for an array with the minimum memory?

Exercises:

1. Assign the maximum and the minimum int to a variable using bitwise operations.

1. In the case of int type, what is the output of following equations?
 - a. $(1 \ll 31) - 1$
 - b. $(-1 \ll 3)$
 - c. $(-1 \gg 3)$
 - d. $\sim(-1)$

3. Considering the tradeoff between memory and speed, what is the best way to keep a binary flag for an array with the minimum memory?

Programming exercises:

Please run the provided codes (`bug`, `enc`, `large_int`, `unsigned_int_wraparound`) and try to run and understand the outputs of each one.