CS61c Summer 2014 Discussion 6 – Floating Point and Performance

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1 Floating Point Numbers (IEEE Standard 754)

	Sign(S)	Exponent (E)	Fraction (F)
Single Precision	1 bit	8 bits	23 bits
Double Precision	1 bit	11 bits	52 bits

$$Floating\ Point\ value = (-1)^S \times (1+F) \times 2^{E-bias}$$

- **Special values**

±Zero	E = 0, F = 0	**±Infinity**	E = 255, F = 0
NaN	E = 255, F ≠ 0	**Denormalized numbers**	E = 0, F ≠ 0

1.1 Exercises

1. Convert the following decimal numbers into binary : 1.0, 2.5, 0.125, 0.6666...
   $1.0 = 2^0 = 1.0_2$
   $2.5 = 2^1 + 2^{-1} = 10.1_2$
   $0.125 = 2^{-3} = 0.001_2$
   $0.0666... = 2^{-1} + 2^{-3} + 2^5 + ... = 0.10101010..._2$

2. Convert the following numbers into hex using single precision floating point : 2.0, -9.5, 15.333..., $+\infty$.
   $2.0 = (-1)^0 \times (1+0) \times 2^{128-127} = 0x40000000$
   $-9.5 = -0b1001.1 = -0b1.0011 * 2^3 = -(1)^1 \times (1 + 2^{-3} + 2^{-4}) \times 2^{130-127} = 0xC1180000$
   $15.333 = 0b01111.01010101... = 1.111010101... * 2^3 = 0b01000001011101010101010101010101 = 0x41755555$
   $+\infty = 0x7F800000$

3. Convert the following numbers from hex into decimal using single precision floating point: 0x0, 0xff9abcde, 0x41040000, 0xC0B40000
   $0x0 = 0$
   $0xff9abcde = NaN$
   $0x41040000 = 8.25$
   $0xC0B40000 = -5.625$

2 Performance

To measure CPU performance, we use CPU Time which only considers processor time.

- CPU Time = Instructions × CPI × Clock Cycle Time.

2.1 Exercises

1. Suppose that you were developing a software that contains the following mix of instructions, which processor is the best choice?

Operation	Frequency	A's CPI	B's CPI	C's CPI
ALU	30%	1	1	1
Store	30%	3	5	3
Load	20%	2	3	4
Branch	20%	3	2	2

   Average CPI:
   A = $0.3 * 1 + 0.3 * 3 + 0.2 * 2 + 0.2 * 3 = 2.2$
   B = 2.8
   C = 2.4
   A wins

2. You then find out that the processors have different clock speeds. A is a 1 Ghz processor, B is a 1.5 Ghz processor, and C is a 750 Mhz processor. Which one is the best choice?
   1/freq = seconds / cycle
   cycle/inst(CPI) * seconds/cycle = seconds/inst
   seconds/cycle: A = 1ns, B = 0.66ns, C = 1.33ns
   seconds/inst: A = 2.2ns, B = 1.86ns, C = 3.2ns
   B wins

3. You contact the manufactures about each processor and found out that they have different instruction sets, so then running your software takes a different number of instructions on each. You find out that A averages 1000 instructions, B averages 800 instructions and C averages 1200 instructions. Which one is the best now?
   instructions/program * seconds/instruction = seconds/program (CPU Time)
   seconds/program: A = 2.2μs, B = 1.493μs, c = 3.84μs.
   B wins