CS61C Spring 2015 Discussion 9

Floating Point

The IEEE 754 standard defines a binary representation for floating point values using three fields:

- The *sign* determines the sign of the number (0 for positive, 1 for negative)
- The *exponent* is in **biased notation** with a bias of 127
- The *significand* is akin to unsigned, but used to store a fraction instead of an integer.

The below table shows the bit breakdown for the single precision (32-bit) representation:

Sign	Exponent	Significand
1 bit	8 bits	23 bits

There is also a double precision encoding format that uses 64 bits. This behaves the same as the single precision but uses 11 bits for the exponent (and thus a bias of 1023) and 52 bits for the significand.

How a float is interpreted depends on the values in the exponent and significand fields:

For normalized floats:

$$\text{Value} = (-1)^{\text{Sign}} \times 2^{(\text{Exponent} - \text{Bias})} \times 1.\text{significand}_2$$

For denormalized floats:

$$\text{Value} = (-1)^{\text{Sign}} \times 2^{(\text{Exponent} - \text{Bias} + 1)} \times 0.\text{significand}_2$$

Exponent	**Significand**	**Meaning**
0	Anything	Denorm
1-254	Anything	Normal
255	0	Infinity
255	Nonzero	NaN

Exercises

1. How many zeroes can be represented using a float?

   2

2. What is the largest finite positive value that can be stored using a single precision float?

   0x7FFFFFFF 0x7F7FFFFF?

3. What is the smallest positive value that can be stored using a single precision float?

   0x00000001

4. What is the smallest positive normalized value that can be stored using a single precision float?

   0x00800001

5. Convert the following numbers from binary to decimal or from decimal to binary:

0x00000000	8.25	0x00000F00	39.5625	0xFF94BEEF	-∞
			0x411DC000	NaN	FF800000
0	0x04100000		0x421E4000: 2^5, not 8, 9/16, not 7/16		
	0x41				

2^-126 x (2^-12 +2^-13 + 2^-14 + 2^-15)

AMAT

AMAT is the average (expected) time it takes for memory access. It can be calculated using this formula:

$$\text{AMAT} = \text{hit time} + \text{miss rate} \times \text{miss penalty}$$

Miss rates can be given in terms of either local miss rates or global miss rates. The *local miss rate* of a cache is the percentage of accesses into the particular cache that miss at the cache, while the *global miss rate* is the percentage of all accesses that miss at the cache.

<u>Exercises</u>

Suppose your system consists of:

- A L1$ that hits in 2 cycles and has a local miss rate of 20%
- A L2$ that hits in 15 cycles and has a global miss rate of 5%
- Main memory hits in 100 cycles

1. What is the local miss rate of L2$?

   $\boxed{.2\,x = .05,\ x = 25\%}$

2. What is the AMAT of the system?

   2 + .2(15 + .25(100)) = 10

3. Suppose we want to reduce the AMAT of the system to 8 or lower by adding in a L3$. If the L3$ has a local miss rate of 30%, what is the largest hit time that the L3$ can have?

   2 + .2(15 + .25(h + .3(100))) <= 8
   h <= 30

Flynn Taxonomy

1. Explain SISD and give an example if available.

   Single Instruction Single Data is a simple unicore process that matches each instruction to it own data source.

2. Explain SIMD and give an example if available.

   Single instruction multi Data sources allows a single instruction to affect multiple data sources. e.g. when a float instruction pulls data from 4 separate locations

3. Explain MISD and give an example if available.

   Multiple instruction single data source would allow multiple instructions to be processed on the same piece of data. No example given.

4. Explain MIMD and give an example if available.

   Multiple instructions multiple data source allows several instructions to be processed on different data sources in parallel, e.g. multi threaded programs.