Computation Organisation (CSE1400) — Summary

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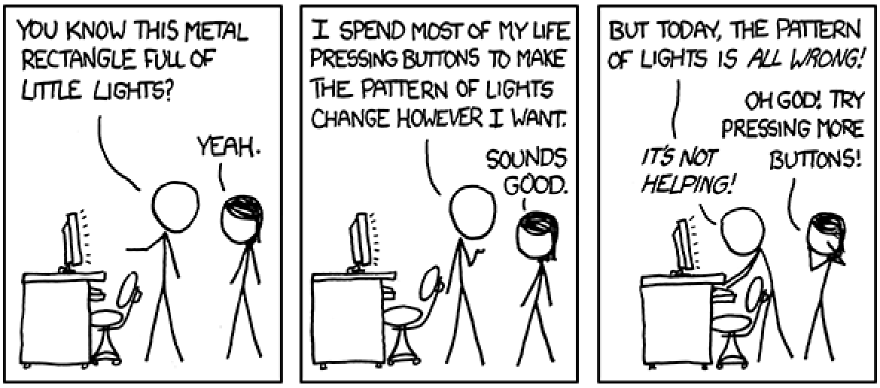

Abstract

This document contains a summary of the Computation Organisation course given in the first year of Computer Science and Engineering. This is *not* a definitive guide, and might contain errors. Please send an email to "dany@atlasdev.nl". This summary is distributed under the MIT license.

Contents

1 Number Representation

By default the standard binary system can only represent unsigned integers. With other number representation systems you can also represent signed numbers and floats. This chapter describes different number systems.

1.1 Sign & Magnitude

Sign & Magnitude is the (for humans) the simplest method of representing numbers. You add one bit at the most significant bit (the 'sign' bit). This bit defines if the rest of the bitstring is positive or negative. A 0 indicates a positive number, a 1 a negative one. Applying direct operations to these numbers does not work, for example $5 + -5$. When you do this with Sign & Magnitude you'll end up with 2. This is obviously not correct. Also you end up with two zero's, 0000 and 1000.

Decimal	Binary	S & M
72	0100 1000	0100 1000
-57	–	1011 1001
8	0000 1000	0000 1000
-8	–	1000 1000
-43.75	–	–

Table 1: Sign & Magnitude

1.2 One's Complement

One's complement is the same as Sign & Magnitude, but when the sign is positive you need to take the complement of the number. It's a lot better for computer to work with, but you still cannot directly do operations to it. If you do attempt to do calculations to it, you will get an offset of 1.

Decimal	Binary	One's Complement
72	0100 1000	0100 1000
-57	–	1100 0110
8	0000 1000	0000 1000
-8	–	1111 0111
-43.75	–	–

Table 2: One's Complement

1.3 Two's Complement

Two's complement is the same as one's complement. The difference is that you'll add 1 to the result when the number is negative. This also makes sure there is only one zero.

Decimal	Binary	Two's Complement
72	0100 1000	0100 1000
-57	–	1100 0111
8	0000 1000	0000 1000
-8	–	1111 1000
-43.75	–	–

Table 3: Two's Complement

1.4 Excess-N

Excess-N is great for really large positive or negative numbers. The N in Excess-N stands for the offset used. For example, if you want to represent 5 you can do $5 + N$. This gives $5 + 3 = 8$ in Excess-3. To get the 5 back you can just substract the N to the number. For example $8 - 3 = 5$.

Decimal	Binary	Excess-128	Excess-57
72	0100 1000	1100 1000	1000 0001
-57	–	0100 0111	0000 0000
8	0000 1000	1000 1000	0100 0001
-8	–	0111 1000	0011 0001
-43.75	–	–	–

Table 4: Excess-N

1.5 IEEE-754

IEEE-754 is an way of representing floats. It has the following parts:

Name	Bits (32-bit)	Bits (64-bit)	Description
Sign	1	1	0 for positive, 1 for negative
Exponent	8	11	Exponent for the Mantissa
Mantissa	23	52	The actual number, encodeds

Table 5: Parts of IEEE-754

To convert a number to IEEE-754 you first have to convert the number to binary. Let's take the number -43.75. We can already see that the sign bit should be 1, as the number is negative. Let's first convert the interger first part, this gives 00101011. Then convert the decimal part seperately and add it. This gives 00101011.1100. Now move the point to the first 1 and remember the places you've moved. This gives 001.010111100, with 5 places moved. The 5 is your exponent, but it needs a bias to deal with negative numbers. With 32-bit the bias is 127, in 64-bit 1023. We are using 32-bit, so apply a bias of 127. This gives an exponent of $exp = 5 + 127 = 132$ or 10000100. For the mantissa part you copy all digits after the dot and right-pad with 0's till 23 bits. This gives you 01011110000000000000000. The complete format IEEE-754 gives 11000010001011110000000000000000

Decimal	Binary	Sign	Exponent	Mantissa
72	0100 1000	0	1000 0101	001 0000 0000 0000 0000 0000
-57	–	1	1000 0100	110 0100 0000 0000 0000 0000
8	0000 1000	0	1000 0010	000 0000 0000 0000 0000 0000
-8	–	1	1000 0010	000 0000 0000 0000 0000 0000
-43.75	–	1	1000 0100	010 1111 0000 0000 0000 0000

Table 6: IEEE-754