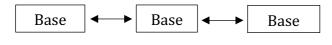
2 Representing Numbers

Bits, Bytes and Words

- Bits refer to single digit, 0 or 1
- Bytes refer to combination of 8 bits
- Words refer to any fixed-width bits (multiples of 8 16, 32, 64...)

Base Conversion



Shortcut to convert base → Always convert to base 2

Example: Convert 243₁₀ to Base 16

→ From Base 10 to Base 2:

Step 1: Convert according to sum of binary

• $243_{10} \rightarrow 1111\ 0011_2$

→ From Base 2 to Base 16:

Step 1: Split the base 2 numbers into blocks of 4 (starts from right)

- 1111 | 0011
- "|" represents splitting

Step 2: Refer relationship between hex and decimal

- 1111 is "F" in HEX
- 0011 is "3" in HEX
- $1111\ 0011_2 \rightarrow F3_{16}$

Comparison of One's and Two's

One's	Two's
Hard to detect overflow	Easy to detect overflow
Two zeros (+0 and -0)	Only one zero (+0)
Need to calculate carry bit and overflow	Ignore carry bit and overflow

One's Complement

- A method to represent binary without +ve & -ve
- Convert binary to One's by swapping the numbers (for -ve decimals)
- Easier to do subtraction by just adding One's (with carry bit and overflow)

+ve	One's	-ve	One's
0	000	-0	111
1	001	-1	110
2	010	-2	101
3	011	-3	100

for 3-bit numbers, maximum is +3, 1st digit in One's is to signify positive or negative

$$3-1 = 3+(-1)$$

$$= 011+(11)$$

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Two's Complement

- Does not have -0
- Convert binary to Two's by swapping numbers and adding 1 (disregard overflows carry bit)

+ve	Two's	-ve	Two's
0	000		
1	001	-1	111
2	010	-2	110
3	011	-3	101
-		-4	100

without carry bit / overflow:

$$3-4 = 3+(-4)$$
 $= 011+100$
 $= 111$

* 111 ≈ -1 (base 10)

With carry bit / overflow:

 $-4-3 = (-4)+(-3)$
 $= 100+101$
 $= 001$
(ignore carry bit)

* 001 ≈ 1 (base (0) so this is false.

 $-4-3 = -7$

Overflow Detection

Scenario	Numbers	Result In	
	(+ve) + (+ve) 3 + 2 = 5	-ve	
Case 1		101 is "-3"	
	By Two's:	But actual answer	
	011 + 010= 101	is 5	
	(-ve) + (-ve) -4 + (-3) = -7	+ve	
Case 2		001 is "1"	
	By Two's: 100 + 101 = 001	But actual answer is -7	

Error Detection Methods

	Parity	Checksums	CRC
Errors	Detect single bit	Detect multiple bits	
Condition	-	Numbers don't cancel each other	-
Method	Set parity bit to even/odd	Agree on a number, X	
Process	1. Set extra bit to 0/1 so that number of "1s" is even/odd	 Sum up the numbers Find the remainder when divided by X Use the remainder to check if the sums are the same again or not 	 Concatenate the numbers Find the remainder when divided by X **same as checksums**