Representation of Numbers and Characters

Outline

- Number systems
- Conversion between number systems
- Addition and subtraction
- Integer representation in computer
- Character representation

Number Systems

- Decimal Number System
 - There are ten basic symbols(digits): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
 - The base ten is represented in decimal as 10
 - $3932 = 3 \times 10^3 + 9 \times 10^2 + 3 \times 10^1 + 2 \times 10^0$
- Binary Number System
 - There are two digits: o and 1
 - The base 2 is represented in binary as 10
 - $11010 = 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$
- Hexadecimal Number System
 - There are sixteen digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
 - The base is sixteen is represented in hex by 10
 - $1A = 1 \times 16^1 + 10 \times 16^0$

Converting Binary and Hex to Decimal

• Hex Number,
$$8A2Dh = 8 \times 16^3 + A \times 16^2 + 2 \times 16^1 + D \times 16^0$$

= $8 \times 16^3 + 10 \times 16^2 + 2 \times 16^1 + 13 \times 16^0$
= $35373d$

• Binary Number,
$$1101b = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

= 13d

Converting Decimal to Binary and Hex

• Decimal Number, 11172d

$$11172 = 698 \times 16 + 4$$

$$698 = 43 \times 16 + 10(A)$$

$$43 = 2 \times 16 + 11(B)$$

$$2 = 0 \times 16 + 2$$

$$= 2BA4h$$

• Decimal Number, 95d

$$95 = 47 \times 2 + 1$$

$$47 = 23 \times 2 + 1$$

$$23 = 11 \times 2 + 1$$

$$11 = 5 \times 2 + 1$$

$$5 = 2 \times 2 + 1$$

$$2 = 1 \times 2 + 0$$

$$1 = 0 \times 2 + 1$$

$$= 10111111b$$

Conversion Between Hex and Binary

• Hex Number, 2B3Ch = 0010101100111100b

2	В	3	С
0010	1011	0011	1100

• Binary Number, 1110101010b = 3AAh

0011	1010	1010
3	Α	Α

Addition

Hex Addition

5	В	3	9	h
7	Α	F	4	h
D	6	2	D	h

Binary Addition

1	0	0	1	0	1	1	1	1
			1	1	0	1	1	0
1	0	1	1	0	0	1	0	1

Subtraction

Hex Subtraction

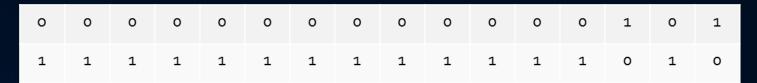
D	2	6	F	h
В	Α	9	4	h
1	7	D	В	h

Binary Subtraction

1	0	0	1
0	1	1	1
0	0	1	0

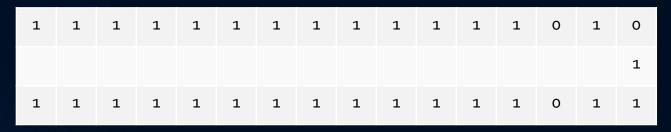
One's Complement Representation

• Representation of 5 and one's complement of 5



Two's Complement Representation

• Representation of 5 and two's complement of 5



- If we add 5 and it's two's complement we will get 10000000000000000
- So the two's complement of a number represents its negative form
- Two's complement of two's complement of 5 is 5

Integer Representations

- Unsigned Integers
 - Represents a magnitude so it is never negative
 - Largest unsigned integer stored in a byte is 11111111b = FFh =255d
 - Biggest unsigned integer stored in a word is 1111111111111111 = FFFFh = 65535d
 - If least significant bit is o then number is even otherwise number is odd
 - Example: Addresses of memory locations, ASCII character codes
- Signed Integers
 - It can either be positive or negative
 - Most significant bit is reserved for sign: o for positive and 1 for negative
 - Negative integers are stored in a computer as two's complement

Decimal Interpretations

- Unsigned Decimal Interpretation
 - Binary to decimal conversion
- Signed Decimal Interpretation
 - If MSB is o then signed decimal is same as unsigned decimal
 - If MSB is 1 take two's complement and convert it to decimal

Decimal Interpretation

- Most significant bit of a positive signed integer is o. So the leading hex digit of a positive signed integer is o-7h. Integers beginning with 8-Fh have 1 in their sign bit so they are negative
- For a word largest positive signed integer is 7FFFh=32767 and smallest negative signed integer is 8000h=-32768
- For a byte largest positive signed integer is 7Fh=127 and smallest negative signed integer is 8oh=--128
- For ooooh-7FFFh and ooh-7Fh, signed decimal=unsigned decimal
- For 8000h-FFFFh, signed decimal = unsigned decimal-65536
- For 8oh-FFh, signed decimal = unsigned decimal-256

Character Representation

- ASCII Code
 - Most popular encoding scheme for characters
 - Uses seven bits to code each character so there are total of 128 ASCII codes
 - Only 95 ASCII codes from 32-126 are considered to be printable
 - Others are used for communication control purposes
- Keyboard
 - Identifies a key by generating an ASCII code when the key is pressed
 - For IBM-PC each key is assigned an unique number called scan code