Spring 2019

CSE 112 (Computer Fundamentals

Topic: Addition and Subtraction with Two's Complement

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References

- *Computer Fundamentals by Pradeep K. Sinha, 6th Edition. [Chapter 5]*

- *Fundamentals of Computers by V. Rajaraman and N. Adabala, 6th Edition.*

  [Chapter 6]

Complement of a Number

Number of digits in the number

$$C = B^n - 1 - N$$

- C: Complement of the number
- B: Base of the number
- n: Number of digits in the number
- N: The number

Complement of a Decimal Number

Example

Find the complement of 37_{10}

Solution

Since the number has 2 digits and the value of base is 10,

$$(\text{Base})^n - 1 = 10^2 - 1 = 99$$

$$\text{Now } 99 - 37 = 62$$

Hence, complement of $37_{10} = 62_{10}$

Complement of a Octal Number

Example

Find the complement of 6_8

Solution

Since the number has 1 digit and the value of base is 8,

$(Base)^n - 1 = 8^1 - 1 = 7_{10} = 7_8$

Now $7_8 - 6_8 = 1_8$

Hence, complement of $6_8 = 1_8$

Complement of a Binary Number (1's Complement)

Complement of a binary number can be obtained by transforming all its 0's to 1's and all its 1's to 0's

Example

Complement of 1 0 1 1 0 1 0 is

↓ ↓ ↓ ↓ ↓ ↓ ↓

0 1 0 0 1 0 1

Note: Verify by conventional complement

Complement of a Binary Number (2's Complement)

- In a computer, all numbers are represented in a uniform fashion using a fixed number of bits.
- Thus, for an *n*-bit machine, the range of numbers it can handle is 0 to $2^n - 1$.
- Of the *n* bits of the complement representation, $(n - 1)$ bits represent the magnitude.
- For simplicity, consider a 4-bit machine. Sixteen numbers (0 to 15) can normally be represented using these four bits.

Complement of a Binary Number (2's Complement)…

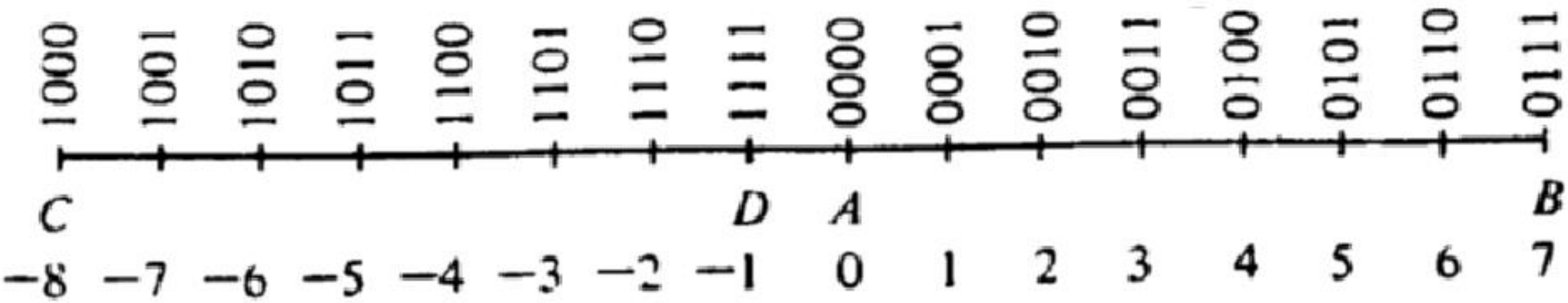

Figure 2.3
The two's complement representation. Note that there are more negative values than positive.

Complement of a Binary Number (2's Complement)…

- There is a simple procedure to obtain the 2's complement of a binary number.
- We first complement each bit of the number (i.e., replace '1' by '0' and '0' by '1').
- Now we add a '1' to the number.
- For example, consider the number 5 whose binary representation is 0101.
- Bit complementation yields 1010. Now adding a '1' to this number gives 1011 which is the 2's complement representation for - 5.

Complement of a Binary Number (2’s Complement)…

- Yet another method of obtaining the 2’s complement of a binary number is to scan the number from right to left and complement all bits appearing after the first appearance of a ‘1’.
- For example the 2’s complement of 0010 is 1110 and that of 0011 is 1101.

Addition/Subtraction of Numbers in 2's Complement Notation

- Represent all negative numbers in 2's complement form.
- Now we have the same procedure for addition and subtraction.
- Subtraction of a number is achieved by adding the 2's complement of the number.
- This is illustrated in the following example where the carry, if any, from the most significant bit, during addition, should be ignored.
- The result has to be interpreted appropriately using the same convention.

Addition/Subtraction of Numbers in 2's Complement Notation…

Example 6.4

Using 2's complement representation, (a) subtract 3 from 5; (b) subtract (-3) from (-5); (c) add (- 5) and (- 2); and (d) add 5 and 4.

SOLUTION;

(a)

5	0101
— 3	1101
	10010

ignore carry

Answer = + 2

(b)

- 5	1011
+ 3	0011
	1110

Answer = - 2

(c)

- 5	1011
- 2	1110
	11001

ignore carry

Answer = - 7

(d)

5	0101
4	0100
	1001

incorrect answer

In the last example we get an incorrect answer because the sum 9 exceeds the range of numbers (0 to 7) we had stipulated in the beginning.

The End