

Chapter 4

Data representations and Numbering systems

COMPUTER NUMBERING SYSTEM

Computers have two basic parts –hardware

-software

Computers hardware parts understand what we use or encode in our computer with numbering system

I.e. what enters must be digitized (0,1)

There are four useful numbering systems in computer science

- A. DECIMAL (BASE 10)
- B. BINARY (BASE 2)
- C. OCTAL (BASE 8)
- D. HEXADECIMAL (BASE 16)

A. DECIMAL (BASE 10) –has the numbers 0,1,2,3,4,5,6,7,8,9

e.g. $(397)_{10}$

B. BINARY (BASE 2) –has only 0, 1

e.g. $(1011)_2$

C. OCTAL (BASE 8) –has the numbers 0, 1,2,3,4,5,6,7

e.g. $(472)_8$

D. HEXADECIMAL (BASE 16)-has the numbers 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

e.g. $(D1A3)_{16}$

Why we use these different numbering systems?

If we only use 0 and 1 for expressing everything in the computer most of the things become bulky thus, we have to use different numbering systems to minimize bulkiness.

TRANSFORM WAYS OF NUMBERING SYSTEM

--FROM BASE 10 TO BASE 2

Method 1

e.g. $(397)_{10} \rightarrow ()_2$

Step 1 Write number 2^n from right to left $n=0, 1, 2, 3, 4, \dots$ up to the number nearest to the given number

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1

Step 2 Find the 2^n numbers which added and give the number you want

$$256+128+8+4+1=397$$

Step 3 Make 1 to the number that we add and 0 to the others number

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1
	1	1	0	0	0	1	1	0	1

$$(397)_{10} \rightarrow (110001101)_2$$

Method 2

Iterated Division

397/2 = 198 Remainder 1
198/2 = 99 Remainder 0
99/2 = 49 Remainder 1
49/2 = 24 Remainder 1
24/2 = 12 Remainder 0
12/2 = 6 Remainder 0
6/2 = 3 Remainder 0
3/2 = 1 Remainder 1
1/2 = 0 Remainder 1



- Read the remainders part from the bottom to the top

Ans: $(397)_{10} \rightarrow (110001101)_2$

--From BASE 2 TO BASE 10

e.g. $(1010)_2 \rightarrow (\quad)_{10}$

Write on top of the bits 2^n $n=0,1,2,3...$ from right to left.

2^3	2^2	2^1	2^0
8	4	2	1
1	0	1	0

Then add the 2^n numbers which bit is 1

$8+2=10$ $(1010)_2 \rightarrow (10)_{10}$

--From BASE 10 TO BASE 8

Method 1

e.g. $(397)_{10} \rightarrow (\quad)_8$

First transform into BASE 2 number

$(397)_{10} \rightarrow (110001101)_2$

Then classify all the bits into 3 bit as one group

4 2 1 4 2 1 4 2 1
 2^2 2^1 2^0 2^2 2^1 2^0 2^2 2^1 2^0
1 1 0, 0 0 1, 1 0 1
 $4+2=6$ $0+0+1=1$ $4+1=5$

Then add the number w/c the bit is 1

$(397)_{10} \rightarrow (615)_8$

Method 2

Iterated Division

397/8 = 49 Remainder 5
49/8 = 6 Remainder 1
6/8 = 0 Remainder 6



- Read the remainders part from the bottom to the top
 $(397)_{10} \rightarrow (615)_8$

--From base 8 to base 10

Method 1

e.g. $(571)_8 \rightarrow ()_{10}$

First transform every figure into binary number with 3 bit

$5 \rightarrow \begin{array}{ccc} 4 & 2 & 1 \\ 2^2 & 2^1 & 2^0 \\ 1 & 0 & 1 \end{array}$
 $7 \rightarrow \begin{array}{ccc} 4 & 2 & 1 \\ 2^2 & 2^1 & 2^0 \\ 1 & 1 & 1 \end{array}$
 $1 \rightarrow \begin{array}{ccc} 4 & 2 & 1 \\ 2^2 & 2^1 & 2^0 \\ 0 & 0 & 1 \end{array}$

$(571)_8 \rightarrow (101111001)_2$

→ Add the numbers which bit is 1

$\begin{array}{cccccccc} 256 & 128 & 64 & 32 & 16 & 8 & 4 & 2 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 \end{array}$

→ $256+64+32+16+8+1$

$(571)_8 \rightarrow (377)_{10}$

Method 2

Iterated Multiplications

$(571)_8 \rightarrow ()_{10}$

$1 \cdot 8^0 = 1$

$7 \cdot 8^1 = 56$

$5 \cdot 8^2 = 320$

$1 + 56 + 320 = 377$

$(571)_8 \rightarrow (377)_{10}$

--From base 10 to base 16

Method 1

$(298)_{10} \rightarrow ()_{16}$

First convert $(298)_{10}$ into base 2

$256+32+8+2=298$

$(298)_{10} \rightarrow (100101010)_2$

→ then classify each 4 bit as a one group

$\begin{array}{cccc} 8 & 4 & 2 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array} \quad \begin{array}{cccc} 8 & 4 & 2 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array} \quad \begin{array}{cccc} 8 & 4 & 2 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array}$
 $\begin{array}{cccc} 0 & 0 & 0 & 1, & 0 & 0 & 1 & 0, & 1 & 0 & 1 & 0 \end{array}$

Assign three bit 0, to fill the last 1 bit
 Then add the number w/c the bit is 1
 $0+0+0+0=1$ $0+0+2+0 = 2$ $8 + 2 = 10 \rightarrow A$
 $(298)_{10} \rightarrow (100101010)_2 \rightarrow (12A)_{16}$

Method 2

Iterated Multiplications

$(298)_{10} \rightarrow ()_{16}$
 $298/16 = 18$ Remainder 10 $\rightarrow A$
 $18/16 = 1$ Remainder 2
 $1/16 = 0$ Remainder 1



- Read the remainders part from the bottom to the top

$(298)_{10} \rightarrow (12A)_{16}$

From base 16 to base 10

Method 1

E.g. $(12A)_{16} \rightarrow ()_{10}$

First transform into base 2 in each 4 bit

$1 \rightarrow 8 \quad 4 \quad 2 \quad 1$

$2^3 \quad 2^2 \quad 2^1 \quad 2^0$

0 0 0 1

* we can erase the last three 0 bits

$2 \rightarrow 8 \quad 4 \quad 2 \quad 1$

$2^3 \quad 2^2 \quad 2^1 \quad 2^0$

0 0 1 0

$A \rightarrow 8 \quad 4 \quad 2 \quad 1$

$2^3 \quad 2^2 \quad 2^1 \quad 2^0$

1 0 1 0

$(12A)_{16} \rightarrow (100101010)_2$

256 128 64 32 16 8 4 2 1

1 0 0 1 0 1 0 1 0

$\rightarrow$ Add the numbers which bit is 1

$256+32+8+2=298$

$(12A)_{16} \rightarrow (298)_{10} \rightarrow (100101010)_2$

Method 2

Iterated Multiplications

$A \cdot 16^0 = 10$ i.e. **A** stands for **10** in decimal numbering system

$2 \cdot 16^1 = 32$

$1 \cdot 16^2 = 256$