BCN1043

COMPUTER ARCHITECTURE & ORGANIZATION

By
Dr. Mritha Ramalingam

Faculty of Computer Systems & Software Engineering
mritha@ump.edu.my

http://ocw.ump.edu.my/

AUTHORS

- **Dr. Mohd Nizam Mohmad Kahar** (mnizam@ump.edu.my)
- **Jamaludin Sallim** (jamal@ump.edu.my)
- **Dr. Syafiq Fauzi Kamarulzaman** (syafiq29@ump.edu.my)
- **Dr. Mritha Ramalingam** (mritha@ump.edu.my)

Faculty of Computer Systems & Software Engineering

Chapter 2

Machine Level Representation of data

- Bits, bytes, and words
- Numeric data representation and number bases
- Fixed- and floating-point systems
- Signed and twos-complement representations

Learning outcomes

- Able to perform operation on numbering system : binary, decimal and hexadecimal
- Able to perform operation on sign magnitude, 1's complement and 2's complement representation.

Chapter 2

Machine Level Representation of data

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Bits, Bytes and Words

Bits - A computer's world is a binary world and communication of instruction and data by the devices that process them is always in binary (bit 0 or bit 1)

Bytes

- A collection of 8 bits
- used represent a character such as a letter, number, or typographic symbol ("Q","4","&")
- ASCII Encoding

EXAMPLE:

1 BIT EXAMPLE: 0

1 BYTE = 8 BITS

Bits, Bytes and Words

Word

- 2 bytes form a word
- to represent the bigger number or characters.
- Unicode encoding

EXAMPLE: 00001111

1 WORD = 2 BYTES = 16 BITS

EXAMPLE: 11110000 00001111

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Machine Level Representation of data

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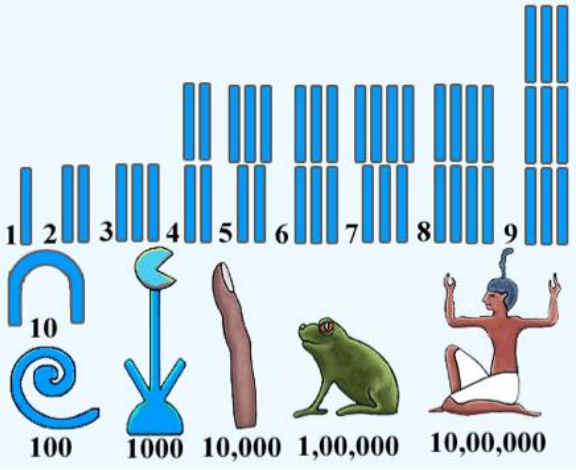
Numeric data representation and number bases

Number data representation



Source: http://static.wixstatic.com

	I = 1	V = 5	X = 10	L = 50	C = 100	D = 500	M = 1000		
I 1	XI 11	XXI 21	XXXI 31	XLI 41	LI 51	LXI 61	LXXI 71	LXXXI 81	XCI 91	CI 101
II 2	XII 12	XXII 22	XXXII 32	XLII 42	LII 52	LXII 62	LXXII 72	LXXXII 82	XCII 92	CCXII 212
III 3	XIII 13	XXIII 23	XXXIII 33	XLIII 43	LIII 53	LXIII 63	LXXIII 73	LXXXIII 83	XCIII 93	CCCLIII 353
IV 4	XIV 14	XXIV 24	XXXIV 34	XLIV 44	LIV 54	LXIV 64	LXXIV 74	LXXXIV 84	XCIV 94	CDIV 404
V 5	XV 15	XXV 25	XXXV 35	XLV 45	LV 55	LXV 65	LXXV 75	LXXXV 85	XCV 95	DLV 555
VI 6	XVI 16	XXVI 26	XXXVI 36	XLVI 46	LVI 56	LXVI 66	LXXVI 76	LXXXVI 86	XCVI 96	DCCCXLVI 846
VII 7	XVII 17	XXVII 27	XXXVII 37	XLVII 47	LVII 57	LXVII 67	LXXVII 77	LXXXVII 87	XCVII 97	CMXXVII 927
VIII 8	XVIII 18	XXVIII 28	XXXVIII 38	XLVIII 48	LVIII 58	LXVIII 68	LXXVIII 78	LXXXVIII 88	XCVIII 98	MVIII 1008
IX 9	XIX 19	XXIX 29	XXXIX 39	XLIX 49	LIX 59	LXIX 69	LXXIX 79	LXXXIX 89	XCIX 99	MCMXCIX 1999
X 10	XX 20	XXX 30	XL 40	L 50	LX 60	LXX 70	LXXX 80	XC 90	C 100	MMCDXX 2420

Source: https://nicholasacademy.com/

Egyptian

Roman

Numeric data representation and number bases

- Fundamental to understand how computers work is understanding the number system that computer use to store data and communicate with each other
- Number system has been used to understand computer

Numeric data representation and number bases

Number bases

- Base 10 (decimal)
  - E.g.: 3945_{10} / 3945D
- Base 2 (binary)
  - E.g.: 10101011_2 / 10101011B
- Base 16 (hexadecimal)
  - E.g.: $0A3E_{16}$ / 0A3EH
- Base 8 (octal)
  - E.g.: 17_8

Numeric data representation and number bases

Number Systems

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

ASCII

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	Null	32	20	Space	64	40	@	96	60	`
1	01	Start of heading	33	21	!	65	41	A	97	61	a
2	02	Start of text	34	22	"	66	42	B	98	62	b
3	03	End of text	35	23	#	67	43	C	99	63	c
4	04	End of transmit	36	24	$	68	44	D	100	64	d
5	05	Enquiry	37	25	%	69	45	E	101	65	e
6	06	Acknowledge	38	26	&	70	46	F	102	66	f
7	07	Audible bell	39	27	'	71	47	G	103	67	g
8	08	Backspace	40	28	(	72	48	H	104	68	h
9	09	Horizontal tab	41	29	)	73	49	I	105	69	i
10	0A	Line feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage return	45	2D	-	77	4D	M	109	6D	m
14	0E	Shift out	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	47	2F	/	79	4F	O	111	6F	o
16	10	Data link escape	48	30	0	80	50	P	112	70	p
17	11	Device control 1	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	50	32	2	82	52	R	114	72	r
19	13	Device control 3	51	33	3	83	53	S	115	73	s
20	14	Device control 4	52	34	4	84	54	T	116	74	t
21	15	Neg. acknowledge	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	54	36	6	86	56	V	118	76	v
23	17	End trans. block	55	37	7	87	57	W	119	77	w
24	18	Cancel	56	38	8	88	58	X	120	78	x
25	19	End of medium	57	39	9	89	59	Y	121	79	y
26	1A	Substitution	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	63	3F	?	95	5F	_	127	7F	□

Source: http://docplayer.hu

Decimal system - Base or Radix 10

- Used everyday
- E.g. 4728
  - Four Thousands, Seven hundreds,

    Two tens and 8
  - $4728 = (4 \times \mathbf{1000}) + (7 \times \mathbf{100}) + (2 \times \mathbf{10}) + 8$
  - Each digit is multiplied by 10 raised by the power of digit position
  - $4728 = (4 \times \mathbf{10^3}) + (7 \times \mathbf{10^2}) + (2 \times \mathbf{10^1}) + (8 \times \mathbf{10^0})$

Decimal system - Base or Radix 10

Common powers of 10

Power	Preface	Symbol	Value
10^{-12}	pico	p	.000000000001
10^{-9}	nano	n	.000000001
10^{-6}	micro	μ	.000001
10^{-3}	milli	m	.001
10^{3}	kilo	k	1000
10^{6}	mega	M	1000000
10^{9}	giga	G	1000000000
10^{12}	tera	T	1000000000000

Binary system - Base or Radix 2

- Only Two Digits
- 1 and 0
- Represent Base 2
- Each digit is multiplied by 2 raised by the power of digit position
- $100_2 = (1 \times 2^2) + (0 \times 2^1) + (0 \times 2^0)$

  $= 4_{10}$
- $101011B = (1 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$

  $= 43D$

Binary system - Base or Radix 2

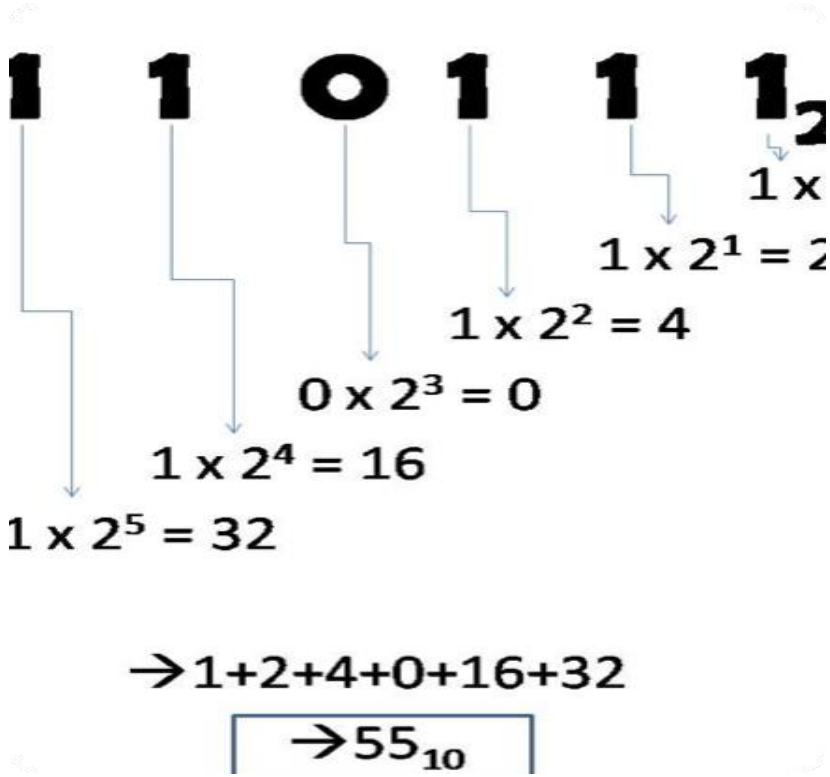
Common powers of 2

Power	Preface	Symbol	Value
2^{10}	kilo	k	1024
2^{20}	mega	M	1048576
2^{30}	Giga	G	1073741824

Binary system - Base or Radix 2

- Binary is very difficult to human to read all the digits and to understand [with lot of digits]
- Human being are comfortable to decimal number system
- However… Conversion between binary and decimal occurs

Binary system - Base or Radix 2



Hexadecimal system - Base or Radix 16

- In most computers, binary data occupy some multiple of 4 bits, and hence some multiple of a single hexadecimal digit
- Binary digits are grouped into sets of four
- Each possible combination of four binary digits is given a symbol - 16 hexadecimal digits
- Each digit is multiplied by 16 raised by the power of digit position

Hexadecimal system - Base or Radix 16

Example

$2C_{16} = (2 \times 16^1) + (C \times 16^0)$

$= (2 \times 16^1) + (12 \times 16^0)$

$= 44_{10}$

Binary	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Chapter 2
Machine Level Representation of data

Chapter 2 will continue!