Lecture 02

Path to Lecture Folder: \\sandata\Xeon\Fall 2018\Bismillah Jan

Data Representation and Number System

Computers Process Data

- Computers are used to process all types of information in a broad spectrum fields. For example
  - **Numeric data** consisting of Integers and real numbers are used in programs calculating payroll. We typically perform **arithmetic operations** on numeric data.
  - **Strings** of **alphabets** and numbers (**Alphanumeric Data**) are processed in customer record keeping systems.

Computers Process Data

- Multimedia content including **images**, **sound** and **text** are frequently used in a large collection of application areas.

- **Signals** representing various types of information like **temperature**, **pressure**, **presence or absence of objects** etc. are processed by computers in Robotics, IoT, monitoring and control applications.

- …

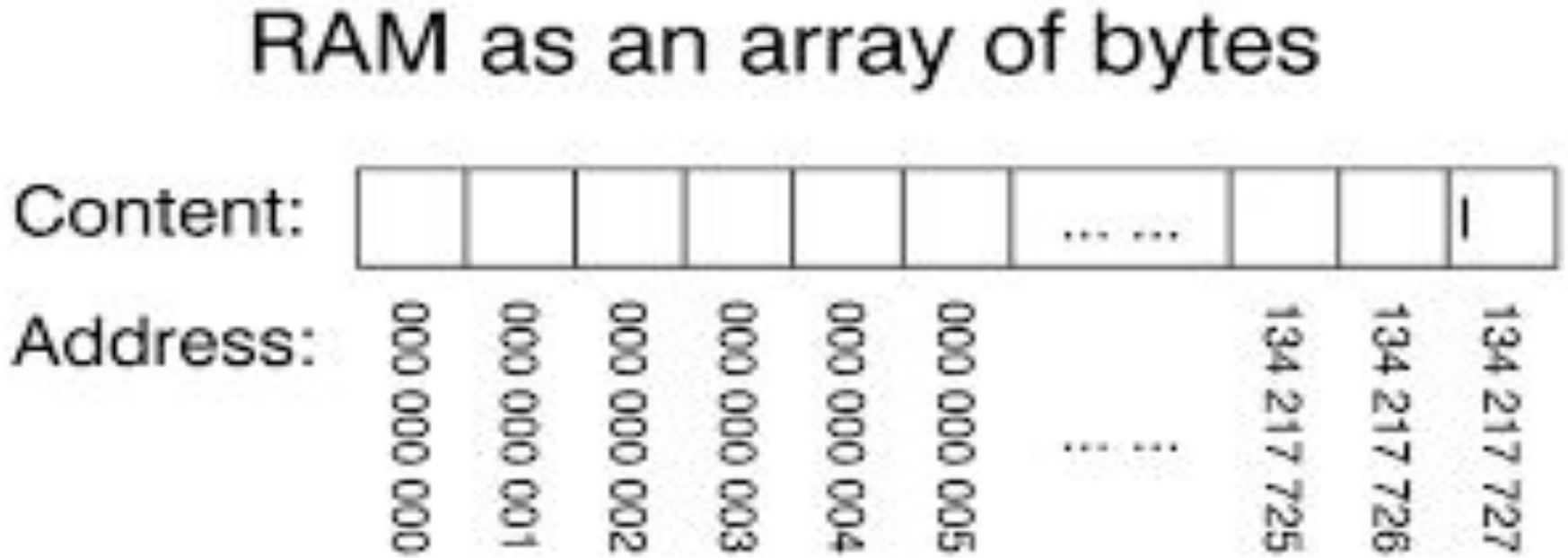
Computer store data in memory

- Digital computers have been made such that all data and instructions(program) for processing must be stored in computers memory before processing.

- **TODAY WE ARE GOING TO LEARN HOW VARIOUS TYPES OF DATA/INFORMATION IS REPRESENTED IN A MODERN COMPUTER'S MEMORY AND SOME IDEA OF HOW THE PROCESSING IS DONE.**

WHAT IS Random Access MEMORY(RAM)?

- A computer scientists view memory as a sequence of **Bytes** with each byte having a unique **address**.
  - Byte is enough **space** to store a alphabet/character.



What is inside a Byte?

- Byte is enough **space** to store a alphabet/character.

- We view a byte consisting of eight **bi-state circuits/switches**
- **Each circuit/switch** can either be in the **ON** state or **OFF** state or it hold either **positive charge** or **negative charge**.

- A byte consists of 8 such switches/circuits and each one of these switches is known as a **Bit.**

What can be represented using a Bit

- Single Bit can be used to represent two different quantities
  - ON means TRUE and OFF means FALSE
  - ON means number 79 and OFF means number -23
  - ON means 23.5 and OFF means 39.25
  - ON means **RED COLOR** and OFF means **BLUE COLOR**
  - …
- Most commonly ON means 1 and OFF means **0 and** therefore **Bit** is also known as **Bi**nary Digi**t (Bit)**

Memory Measuring Units
(As viewed by computer scientists)

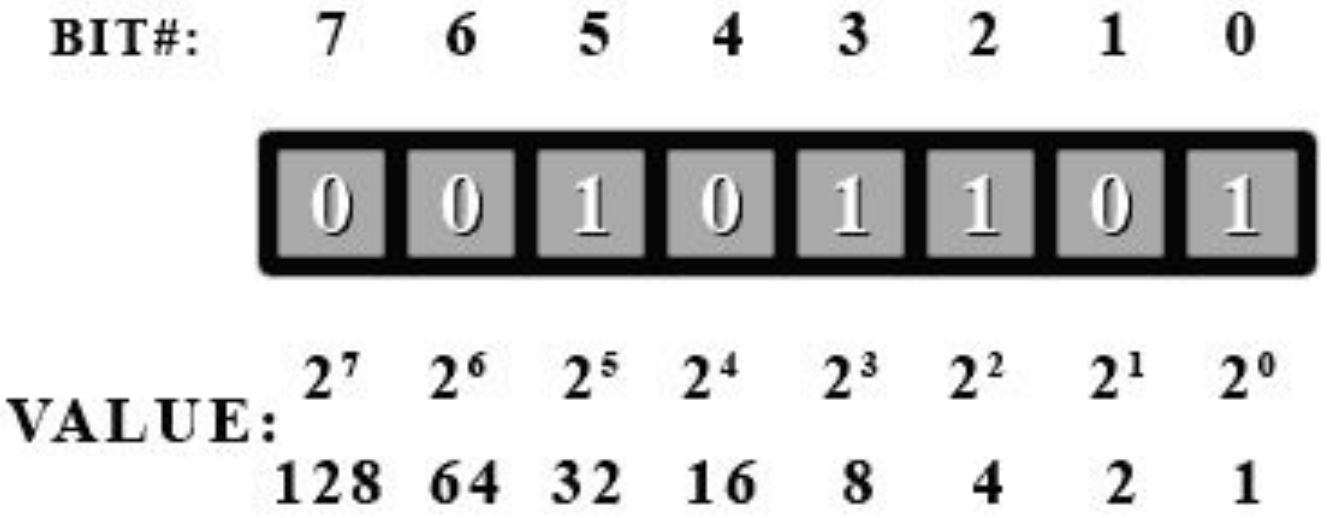
UNIT	ABBREVIATION	STORAGE
Bit	B	Binary Digit, Single 1 or 0
Nibble	-	4 bits
Byte/Octet	B	8 bits
Kilobyte	KB	1024 bytes
Megabyte	MB	1024 KB
Gigabyte	GB	1024 MB
Terabyte	TB	1024 GB
Petabyte	PB	1024 TB
Exabyte	EB	1024 PB
Zettabyte	ZB	1024 EB
Yottabyte	YB	1024 ZB

Storage units (www.byte-notes.com

Bits within Bytes and Place Value

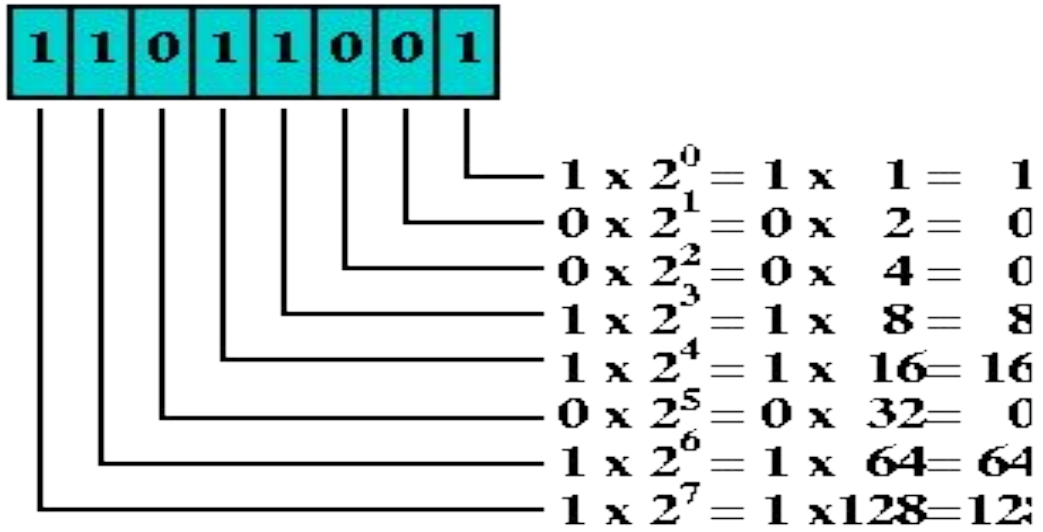
- Bits within a byte have Place and a Place Value with least significant bit at place 0 and most significant bit at place 7.

- Bit at place ***i*** has place value 2^i



Bytes as Numbers

- We can view each byte as a binary number. For Example the following Binary number represents the quantity two hundred and seventeen



$$1 + 8 + 16 + 64 + 128 = 217$$

- Can you see the similarity between Binary and Decimal numbers?

Exercise # 1

Note: Write exercises on a separate page, you have to submit it at the end of lecture

- What Quantities are Represented by the following 8-bit binary numbers.

Bit#	7	6	5	4	3	2	1	0
a.	0	1	1	1	0	1	0	1
b.	1	0	1	1	1	0	1	1
c.	0	1	0	0	0	1	0	0
d.	1	0	1	0	0	0	0	0
e.	0	0	0	0	1	1	1	1

Exercise # 2

- If a Byte is assumed to represent a number, as described earlier, then what is the range (minimum and maximum values) of numbers that can be stored in a 8-bit Byte?

Representing a Decimal Number in Binary

- Let us solve the reverse problem of representing a number within a byte using the idea of place value.

Bit#	7	6	5	4	3	2	1	0
value	128	64	32	16	8	4	2	1
8 =	0	0	0	0	1	0	0	0
128 =	1	0	0	0	0	0	0	0
64=	0	1	0	0	0	0	0	0
96 = 64 + 32	0	1	1	0	0	0	0	0
250=128+64+32+16+8+2	1	1	1	1	1	0	1	0

Exercise # 3

- Represent each of the following quantities as 8-bit binary number.

Bit#	7	6	5	4	3	2	1	0
value	128	64	32	16	8	4	2	1
27								
139								
164								
196								
259								

How can we represent a character?

- IDEA.
  - Assign numeric codes to characters and represent each character in a Byte using it's numeric code.
  - Can we assign numeric codes of our choice to each character?. What might be a problem with this approach?

How can we represent a character?

- IDEA
  - Create a Standard coding scheme so that information can be easily shared between devices from different vendors.
- Standard Codes
  - ASCII
  - Unicode
  - Unicode Transformation Format(UTF) UTF-8, UTF-16
  - ANSI Character Set
  - …

ASCII Character Encoding

Letter | Number | Punctuation | Symbol | Other | undefined

ASCII (1977/1986)

	_0	_1	_2	_3	_4	_5	_6	_7	_8	_9	_A	_B	_C	_D	_E	_F
0_	NUL 0000 0	SOH 0001 1	STX 0002 2	ETX 0003 3	EOT 0004 4	ENQ 0005 5	ACK 0006 6	BEL 0007 7	BS 0008 8	HT 0009 9	LF 000A 10	VT 000B 11	FF 000C 12	CR 000D 13	SO 000E 14	SI 000F 15
1_	DLE 0010 16	DC1 0011 17	DC2 0012 18	DC3 0013 19	DC4 0014 20	NAK 0015 21	SYN 0016 22	ETB 0017 23	CAN 0018 24	EM 0019 25	SUB 001A 26	ESC 001B 27	FS 001C 28	GS 001D 29	RS 001E 30	US 001F 31
2_	SP 0020 32	! 0021 33	" 0022 34	# 0023 35	$ 0024 36	% 0025 37	& 0026 38	' 0027 39	(0028 40	) 0029 41	* 002A 42	+ 002B 43	, 002C 44	- 002D 45	. 002E 46	/ 002F 47
3_	0 0030 48	1 0031 49	2 0032 50	3 0033 51	4 0034 52	5 0035 53	6 0036 54	7 0037 55	8 0038 56	9 0039 57	: 003A 58	; 003B 59	< 003C 60	= 003D 61	> 003E 62	? 003F 63
4_	@ 0040 64	A 0041 65	B 0042 66	C 0043 67	D 0044 68	E 0045 69	F 0046 70	G 0047 71	H 0048 72	I 0049 73	J 004A 74	K 004B 75	L 004C 76	M 004D 77	N 004E 78	O 004F 79
5_	P 0050 80	Q 0051 81	R 0052 82	S 0053 83	T 0054 84	U 0055 85	V 0056 86	W 0057 87	X 0058 88	Y 0059 89	Z 005A 90	[005B 91	\ 005C 92	] 005D 93	^ 005E 94	_ 005F 95
6_	` 0060 96	a 0061 97	b 0062 98	c 0063 99	d 0064 100	e 0065 101	f 0066 102	g 0067 103	h 0068 104	i 0069 105	j 006A 106	k 006B 107	l 006C 108	m 006D 109	n 006E 110	o 006F 111
7_	p 0070 112	q 0071 113	r 0072 114	s 0073 115	t 0074 116	u 0075 117	v 0076 118	w 0077 119	x 0078 120	y 0079 121	z 007A 122	{ 007B 123	| 007C 124	} 007D 125	~ 007E 126	DEL 007F 127

Exercise # 4

- The following 23 values represents a message consisting of 23 characters stored in RAM.

- If the message has been written using 8-Bit Extended ASCII codes then decipher the message

87 104 97 84 32 105 83 32 89 111 117 82 32 76 65 83 116 32 78 65 77 69 63

WhaT iS YouR LASt NAME?

Exercise # 5

- Use ASCII encoding to give answer to the question in the previous Exercise?

Representing Non-Negative(Unsigned) Integer Values

- Idea No 1.
  - Each integer is a sequence of characters and hence we can use character encoding to represent each quantity as a sequence of characters.

Exercise # 5

- Represent the following integer quantities as sequence of bytes encoded using ASCII characters.

20456
196
1024
32
100015

Representing Non-Negative(Unsigned) Integer Values

- Idea No 2.
  - Integer quantities can be represented using the idea of place value using binary number system. That is each bit has a place value and total value stored is sum of all the place values included in the number.

Representing Non-Negative(Unsigned) Integer Values

- Problem
  - A byte has only eight bits and hence we can not represent quantities bigger than 255 in a byte. For processing integer quantities this is an unacceptably low value.

- Solution
  - Use 2 or more bytes to store an integer quantity

Byte 1								Byte 0							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Exercise # 6

- Use 2-Bytes to represent each of the following quantity

20456	= 01001111 11101000
196	
1024	
32	
100015	

- What is the Maximum unsigned integer value that can be represented using 2 Bytes?

Exercise # 7

- Use 4-Bytes to represent each of the following quantity

20456	= 00000000 00000000 01001111 11101000
196	
1024	
32	
100015	

- What is the Maximum unsigned integer value that can be represented using 4 Bytes?

Representing signed Integer Values

- Problem
  - How can we represent Signed (Both negative and positive) numbers?
- Solution
  - FIX ONE OF THE BIT FOR REPRESENTING SIGN (Sign-Magnitude method)
  - Use 2's Complement Representation (Optional)
    - Place value of the most significant bit is considered negative

Exercise

- Represent each of the following quantity in 2-bytes using sign-magnitude method.

65536
196
-65535
-32
100015

How to represent images in RAM?

- Image is a rectangular collection{array} of samples.
- IDEA
  - Let's represent as a **value of color** at each sample point.
- Color at each point can be the amounts of RED, GREEN and BLUE colors to makeup the color.
  - We can represent color at each point as three unsigned numbers and hence we might use three bytes to represent each color value