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.

- ...

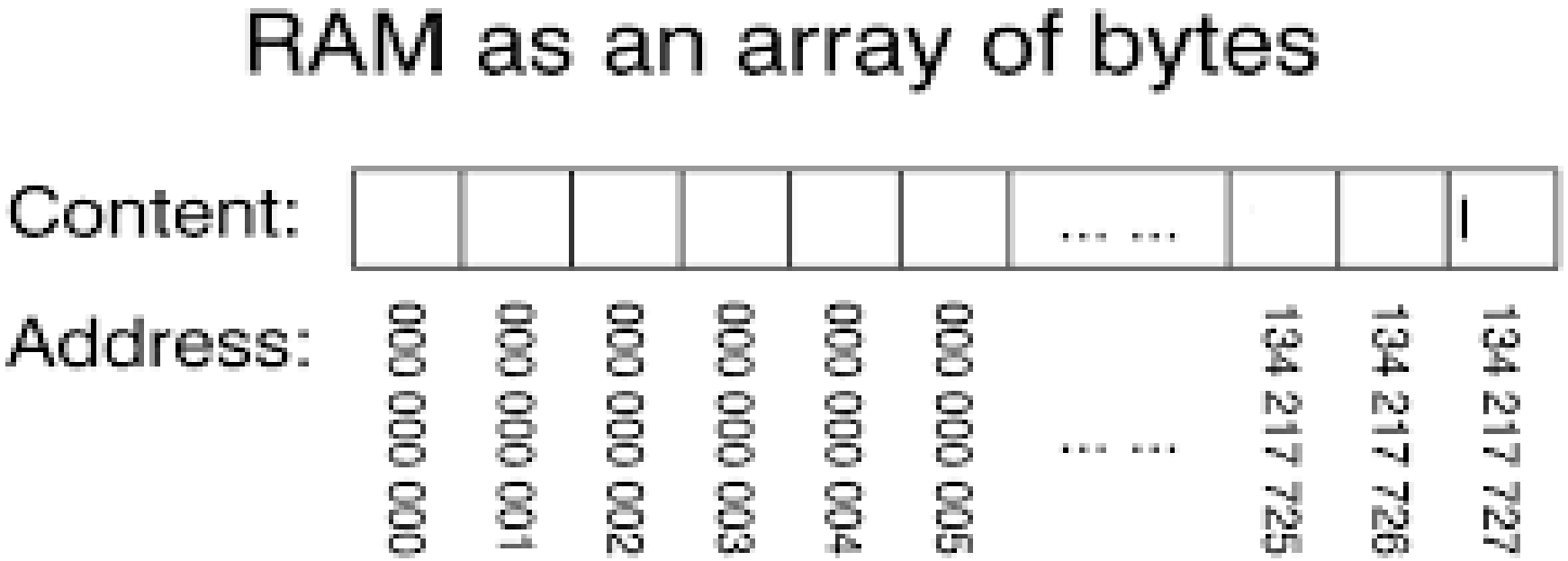
Computer store data in memory

- 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)?

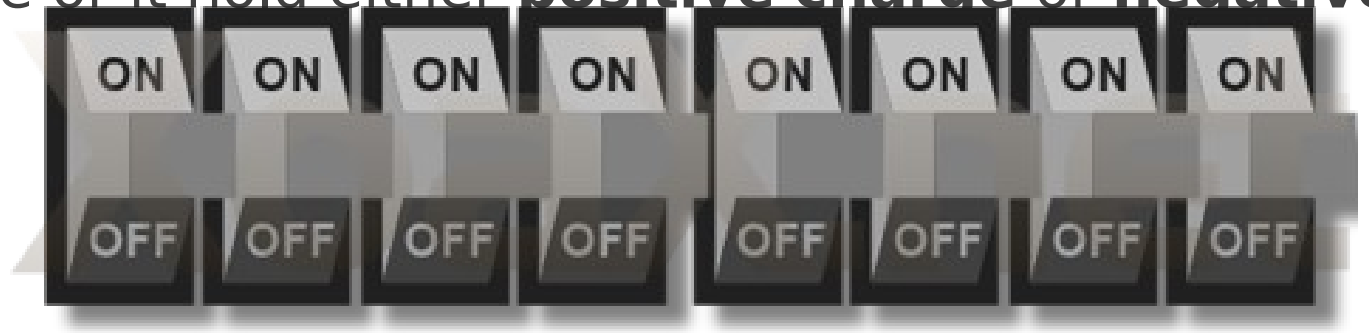
- A computer scientists view memory as a sequence of **Bytes** with each byte having a unique **address**.
  - Byte is enough **space** to store a alphabet/character.



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**
- **E**ach **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)

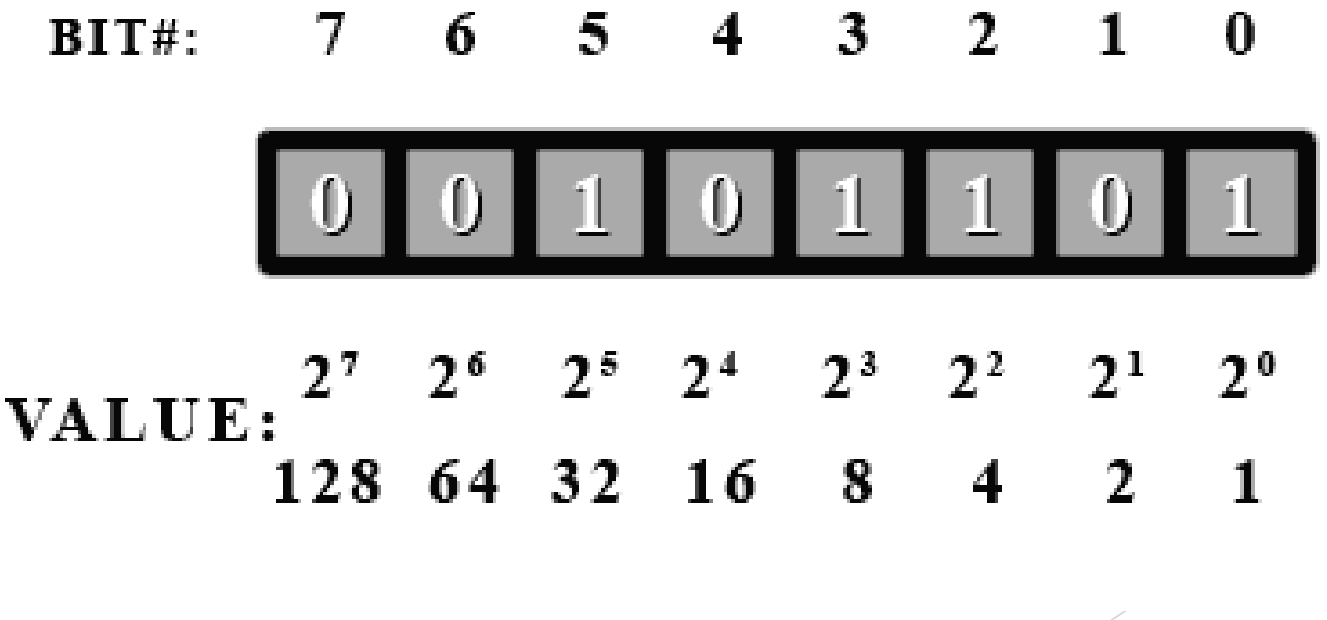
UNIT	ABBREVIATION	STORAGE
Bit	B	Binary Digit, Single 1 or 0
Nibble	-	4 bits
Byte/Octet	B	8 bits
Kilobyte	KB	1024 bytes
Megabyte	MB	1024 KB
Gigabyte	GB	1024 MB
Terabyte	TB	1024 GB
Petabyte	PB	1024 TB
Exabyte	EB	1024 PB
Zettabyte	ZB	1024 EB
Yottabyte	YB	1024 ZB

Storage units (www.byte-notes.com

Bits within Bytes and Place Value

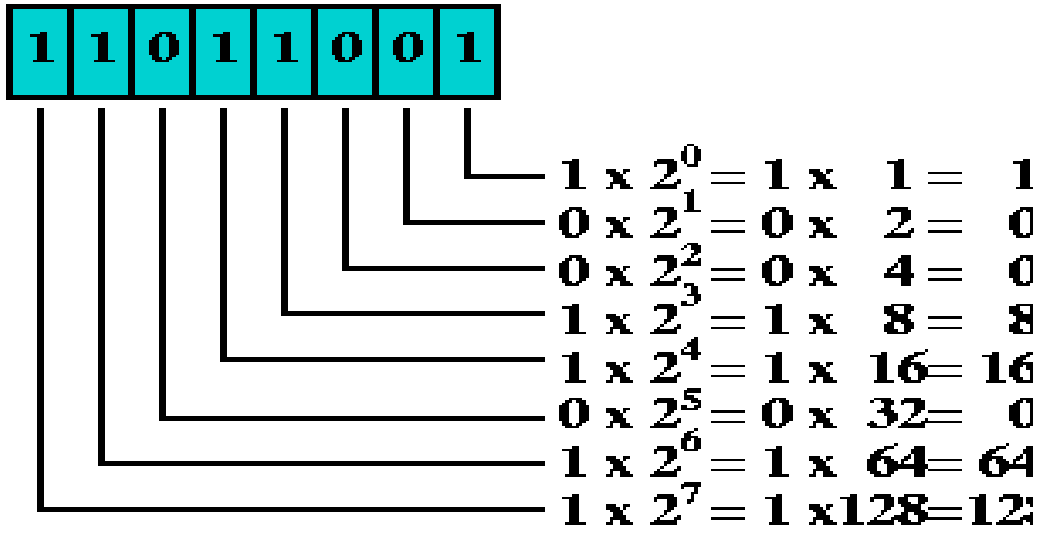
- Bits within a byte have Place and a Place Value with least significant bit at place 0 and most significant bit at place 7.

- 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