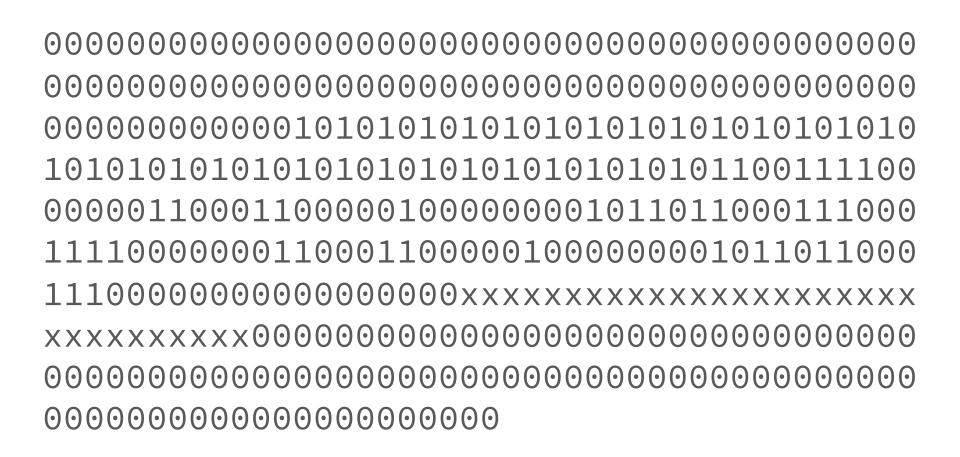
# mjqqt

# Caesar Cipher

- A simple way to encode a "message"
- CC-5 [  $D(x) = (x n) \mod 26$ , where n = 5 ]

plain	А	В	С	D	E	F	G	Н	I	J	K	L	М	N	O	Р	Q	R	S	Т	U	V	W	X	Y	Z
cipher	f	g	h	I	j	k	I	m	n	0	р	q	r	s	t	u	٧	w	X	у	z	а	b	С	d	е

m	j	q	q	t

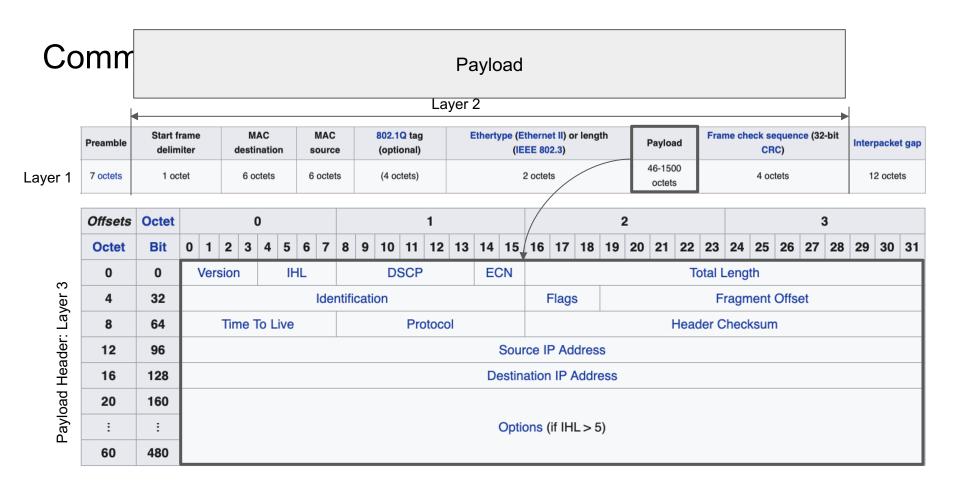


# Introduction to Encodings

- Today's Plan
  - Communication and Bits
  - Discussions on Functions and Mappings
  - Binary Strings and Fields: IPv4 and MIPS Instructions
  - Fixed-length Binary Encodings
    - 3 bits: Octal Encoding
    - 4 bits: Hexadecimal Encoding
    - 5 bits: MIPS Register Encoding
    - 6 bits: Base64 Encoding, MIPS Operations and Functions Encoding
    - 8 bits: ASCII (text) encoding
  - Variable Length Instructions: UTF-8

# Recall: OSI and TCP/IP

Layer	Name	Example Protocol	Naming	Transported	Hardware Device	
7	Application	http	url	data		
6	Presentation					Lloot lovere
5	Session					Host layers
4	Transport	TCP/IP	socket	segment		
3	Network / Internet	IPv4 IPv6	IP	packet	router	
2	Data Link / Link	Ethernet	MAC	frame	switch	Media layers
1	Physical	802.11g	Interface	symbols	hub, bridge	



## Decoding the Message (chunk the bits into fields)

- Inter-Packet Gap, Preamble, and Start of Frame:

  - 10101010 10101010 10101010 10101010 10101010 10101010 10101010
  - 0 10101011
- Mac Address: 3c:06:30:40:2d:8e
  - 0011 1100 : 0000 0110 : 0011 0000 : 0100 0000 : 0010 1101 : 1000 1110 ○ 0011 1100 : 0000 0110 : 0011 0000 : 0100 0000 : 0010 1101 : 1000 1110
- Length: 0000 0000 0000 0000
- Payload:
- Inter-Packet Gap

# Types of Encodings

- String of bits:
  - Inter-Packet Gap, Preamble, Start of Frame
- Binary:
  - Flags: Reserved, Don't Fragment, More Fragments
- Integer:
  - o Length, Version Number, TTL, etc.
- Index:
  - Protocol Lookup Table

<b>Protocol Number</b>	Protocol Name	Abbreviation
1	Internet Control Message Protocol	ICMP
2	Internet Group Management Protocol	IGMP
6	Transmission Control Protocol	TCP
17	User Datagram Protocol	UDP
41	IPv6 encapsulation	ENCAP
89	Open Shortest Path First	OSPF
132	Stream Control Transmission Protocol	SCTP

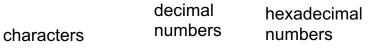
- MAC Address: 3c:06:30:40:2d:8e
  - 0011 1100 : 0000 0100 : 0011 000 : 0100 0000 : 0010 1101 : 1000 1110
  - Hexadecimal -> Binary
- IP Address: www.csun.edu
  - Dotted Decimal Notation: 130.166.238.19
  - 0 1000 0010 . 1010 0110 . 1110 1110 . 0001 0011
  - Decimal -> Binary
- Data: (follows the IPv4 header)
  - o text, images, video, audio, colors, etc.

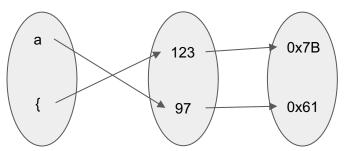
# Mappings and Functions

- Mapping: defines a relationship
- Function: a binary relation between two sets
  - o Encode: input -> output
  - Decode: output -> input
- A table can represent a function

INPUT	OUTPUT 1	OUTPUT 2
5	8	53
2	5	50
4	7	52
9	?	?
h	?	104 ?







## **Encoding Examples:**

Fixe	d Length Lookup Tables:	e.g., 0100 0011	0110 0001 0111 0100
0	Octal (3 bit chunks):	020660564	010 000 110 110 000 101 110 100
0	Binary Coded Decimal (4 bit chunks):	436,174	0100 0011 0110 0001 0111 0100
0	Hexadecimal (4 bit chunks):	0x436174	0100 0011 0110 0001 0111 0100
0	Base64 (6 bit chunks):	Q2F0	010000 110110 000101 110100
0	ASCII (8 bit chunks):	Cat	01000011 01100001 01110100
0	MIPS Instruction (32 bit chunks):	add \$t0,\$t1,\$t2	0000 0001 0100 1011 0100 0000 0010 0000

- Various Lengths: (function used to perform the mapping)
  - o short int (16 bit chunks):

-32,768 ... 32,767

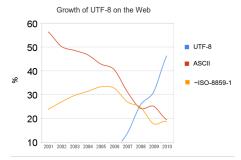
o int (32 bit chunks):

-2,147,483,648 ... 2,147,483,647

long int (64 bit chunks):

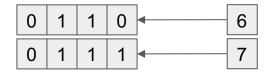
-9,223,372,036,854,775,808 ... 9,223,372,036,854,775,807

- Variable Length:
  - UTF-8
    - Unicode Transformation Format
    - 1 byte to 4 bytes used to encode each character



# **BCD**: Binary Coded Decimal

Encoding of: 6 & 7

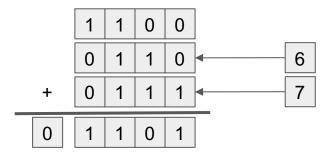


- An encoding for numbers, where precision is required
- Four bits are used to encode each digit
- Addition is performed on each 4-bit chunk (nibble)

N	Code	N	Code
0	0000	8	1000
1	0001	9	1001
2	0010		1010
3	0011		1011
4	0100		1100
5	0101		1101
6	0110		1110
7	0111		1111

#### **BCD**: Addition

Addition performed on the nibble level: 6+7



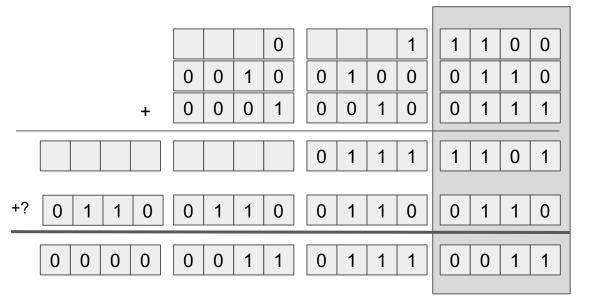
if (overflow or invalid code ) then

	+	•		0	1	1	0	
0	0	0	1	0	0	1	1	

N	Code	N	Code
0	0000	8	▶1000
1	0001	9	1001
2	0010		1010
3	0011		1011
4	0100		1100
5	0101		1101
6	0110		1110
7	0111		1111

jump 6

BCD: Addition Example: 246 + 127= 373



N	Code	N	Code
0	0000	8	1000
1	0001	9	1001
2	0010		1010
3	0011		1011
4	0100		1100
5	0101		1101
6	0110		1110
7	0111		1111

## Instruction Encoding: MIPS

- (6 bits) The <u>op</u>eration to be performed (<u>MIPS Encoding</u>)
  - It also indicates the encoding format to be used!
  - There are three primary formats: R, I, and J.

	ซ มแร	5 มเร	5 มเร	5 มเร	5 มเร	ช มเเร	
R	ор	rs	rt	rd	sh	func	
	6 bits	5 bits	5 bits		16 bits		
ı	op	rs	rt	imm			
	6 bits	26 bits					
J	ор	addr					

- Other fields determine
  - o (5 bits) which registers are used (Register Encoding)
    - <u>rs</u>: first source register
    - **rt**: second register
    - rd: destination register
  - o (5 bits) the amount a value is **sh**ifted (range: 0 .. 31)
  - o (6 bits) the mathematical **func**tion to be performed (MIPS Encoding)
  - o (16 bits) the **imm**ediate value (range: -2048 .. 2047)
  - o (26 bits) the <u>address / 4</u>

# Instruction Encoding: MIPS

Three primary instruction encodings include:

<ul><li>R-type</li></ul>	(register)
--------------------------	------------

for instructions using only registers

example: 0x014b4020

for: add \$t0, \$t1, \$t2

I-type (immediate)

for instructions with immediate values:

example: 0x21280005

■ for: addi \$t0, \$t1, 5

- J-type (jump)
  - for instructions that perform unconditional jumps

example: 0x08100000

■ for: j main

uc.	6 bits	5 bits	5 bits	5 bits	5 bits	6 bits
R	op	rs	rt	rd	sh	func

(2# 0000 0001 0100 1011 0100 0000 0010 0000)

$$($t0 = $t1 + $t2)$$

	6 bits	5 bits	5 bits	16 bits
I	ор	rs	rt	imm

(2# 0010 0001 0010 1000 0000 0000 0000 0101)

$$($t0 = $t1 + 5)$$

	6 bits	26 bits		
J	ор	addr		

 $(2\#\ 0000\ 1000\ 0001\ 0000\ 0000\ 0000\ 0000\ 0000)$ 

(goto main # main == 0x00400000)

# An Encoding for the Keyboard

- Look at your keyboard.
  - o a-z, A-Z, 0-9, !@#\$%^&\*()\_+-~`,./<>?;':"[]\{}|
  - don't forget: space, tab, return, and delete key
  - o plus we need other stuff:
  - All total, we we have 128 things to encode (2<sup>n</sup> <= 128, what is the value of n? 7)</li>
- We need to devise an encoding that maps everything to numbers
- How many bits do we need? How many things do we bits in a byte?
- An example of a fixed-width encoding!
- Let's build a table! <u>Keyboard Table</u>
- ASCII, abbreviated from American Standard Code for Information
   Interchange, is a character encoding standard for electronic communication.

# Parity Bit (or Check Bit)

We are only using 7 of the 8 bits, what shall we do with it.

- Algorithm (odd)
  - a. count the number of 1's
  - b. add a 1 to make odd
  - c. transmit
  - d. receive
  - e. count the number of 1's
  - f. if even, ask for the data to be resent

7 hits of data	(accept of 1 bits)	8 bits including parity			
7 bits of data	(count of 1-bits)	even	odd		
0000000	0	0000000 <b>0</b>	00000001		
1010001	3	1010001 <b>1</b>	1010001 <b>0</b>		
1101001	4	1101001 <b>0</b>	1101001 <b>1</b>		
1111111	7	11111111 <b>1</b>	11111110		

#### Checksum:

- \* performs integrity checking at an aggregate level
- \* reliability of networks have greatly improved since way back when!



S: |

# Extended ASCII and UTF-8 (unicode)

- We could use that bit to encode more stuff: 0..255
- But we have even more stuff. Let's use 16 bits to encode: 0..64K
- But now we have doubled what we need to send...
- Enter variable-length encoding.
  - Send only a byte for the most common symbols
  - Use the MSB to indicate a variable length encoding
- UTF-8: encodes >2,000,000 (2^21) values, using a maximum of 4 bytes
- Defines four type of bytes:

ASCII byte: begins with a 0 (1-byte indicator)

Continuation byte: begins with a 10

2-byte Indicator: begins with a 110

3-byte Indicator: begins with a 1110

4-byte Indicator: begins with a 11110

#### Extended ASCII and UTF-8

- The list of <u>UTF-8 characters</u>:
- Layout of the bits:
- Example on how to lay it out:

#### Layout of UTF-8 byte sequences

Number of bytes	First code point	Last code point	Byte 1	Byte 2	Byte 3	Byte 4
1	U+0000	U+007F	0xxxxxxx			
2	U+0080	U+07FF	110xxxxx	10xxxxxx		
3	U+0800	U+FFFF	1110xxxx	10xxxxxx	10xxxxxx	
4	U+10000	<sup>[nb 3]</sup> U+10FFFF	11110xxx	10xxxxxx	10xxxxxx	10xxxxxx