

# LIS-3353

Everything is a number  
aka “Binary”

aka “I get to bring back this thing that a lot of people hate because cryptocurrency is a thing these days”

# Binary System

0 and 1

# How many light switches..

..would it take to store “what season is it?”

# A minimum of 2:

Winter	OFF-OFF	00
Fall	OFF-ON	01
Spring	ON-OFF	10
Summer	ON-ON	11

# Binary System

0 and 1

Humans counting things !!!!

# Humans counting!

In the beginning, there was...probably just a buncha lines, right?

THEN....Tally Marks

THEN ...Roman Numerals

THEN..Arabic Numerals



# Humans counting!

In the beginning, there was...probably just a buncha lines, right?



THEN....Tally Marks



THEN ...Roman Numerals



THEN..Arabic Numerals?



# Humans counting!

In the beginning, there was...probably just a buncha lines, right?



THEN...Tally Marks



THEN ...Roman Numerals



THEN..Arabic Numerals

uh... 5.

# Humans counting!

THEN...

Arabic Numerals

and (this is huge)

“Place Value”

# Humans counting!

THEN...

Arabic Numerals

and (this is huge)

“Place Value”

05.00

Let's get weird:

# Let's get weird:

5

V

5.0

2 + 3

# Let's get weird:

5

V

5.0

2 + 3

cinco

"five"

"dedos en su mano"

"number of fingers on one hand for the majority of people."

.

.

101 (wtf)



# Place Value

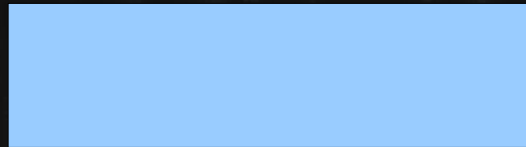
Arabic numerals include ZERO.

This is important for two related reasons:

ONE: Sometimes you want to talk about nothing.

TWO: This enables place value. That is, 10 unique symbols, but both SYMBOL and its LOCATION are important: (would you take the following salary?)

5





# Place Value

And now, you can do magic amazing ridiculous things in your head.

5436

v

5438

101 (Dalmatians)

(100s) (10s) (1s)

$$100 \times 1 + 10 \times 0 + 1 \times 1$$

$$(10^2) \times 1 + (10^1) \times 0 + (10^0) \times 1$$

“101”

(fingers)

(4s) (2s) (1s)

$$4x1 + 2x0 + 1x1$$

$$(2^2)x1 + (2^1)x0 + (2^0)x1$$

decimal (base 10) v. binary (base 2)

0 1 2 3 4 5 6 7 8 9 10 11

0 1 10 11 100 101 110 111 1000 1001 1010 1011

# Let's get even weirder...

So, decimal is good because “people,

Binary is good because computers.

What about both?

(e.g, something “**binary-like**”  
but also “**compact and easy to read?**”



# Let's get even weirder...

We need a power of 2 that's close to 10.

Could do 8, but why not go with 16?'

We just need 6 more familiar symbols...

hexadecimal.

(6 + 10)

decimal (base 10) v. binary (base 2) v. hexadecimal (base 16)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	1	10	11	100	101	110	111	1000	1001	1010	1011	1100	1101	1110	1111	10000	10001	10010
0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	10	11	12



# Quick Binary Review and some bad jokes

How many fingers and toes do you have?

In Base Ten(10) or Decimal?

20

(Twenty)

$$10 \times 2 + 1 \times 0$$

# Quick Binary Review and some bad jokes

How many fingers and toes do you have?

In Base Two (2) or Binary?

10100

- 16x1 8x0 4x1 2x0 1x0

# Quick Binary Review and some bad jokes

How many fingers and toes do you have?

In Base Sixteen (16) or Hexadecimal?

14

$$16 \times 1 + 1 \times 4$$

# Place Value

Decimal	4-bit 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
16	0001 0000	10 (1+0)
17	0001 0001	11 (1+1)

# The jokes...

“There are 10 kinds of people, those who understand binary, and those who don't.”

If you want to get technical, ALL bases are Base 10.

Exponential growth =  
Wide range of possibilities

Exponential REDUCTION =  
“Easy to specify things”



# The “shape” of computer numbers

e.g. – 128, 256, 1024, etc.

(why hard drive sizes are “wrong”)



# Where this comes up today...

IP addresses – e.g.

MAC addresses e.g.

(are more similar than you thought)

# Where this comes up today...

IP addresses:

127.0.0.1

192.168.0.1

146.201.195.214

(what's the range here? Ever seen 80.234.553.92?)

# Where this comes up today...

0-255!

BUT, MAC addresses are like:

ac:d5:b8:c0:e1:03

0-FF?

**SAME THING!** See, also RGB Colors!

# Where this comes up today...

HTML Web Safe Colors											
#000000 0,0,0	#000033 0,0,51	#000066 0,0,102	#000099 0,0,153	#0000CC 0,0,204	#0000FF 0,0,255	#990000 153,0,0	#990033 153,0,51	#990066 153,0,102	#990099 153,0,153	#9900CC 153,0,204	#9900FF 153,0,255
#003300 0,51,0	#003333 0,51,51	#003366 0,51,102	#003399 0,51,153	#0033CC 0,51,204	#0033FF 0,51,255	#993300 153,51,0	#993333 153,51,51	#993366 153,51,102	#993399 153,51,153	#9933CC 153,51,204	#9933FF 153,51,255
#006600 0,102,0	#006633 0,102,51	#006666 0,102,102	#006699 0,102,153	#0066CC 0,102,204	#0066FF 0,102,255	#996600 153,102,0	#996633 153,102,51	#996666 153,102,102	#996699 153,102,153	#9966CC 153,102,204	#9966FF 153,102,255
#009900 0,153,0	#009933 0,153,51	#009966 0,153,102	#009999 0,153,153	#0099CC 0,153,204	#0099FF 0,153,255	#999900 153,153,0	#999933 153,153,51	#999966 153,153,102	#999999 153,153,153	#9999CC 153,153,204	#9999FF 153,153,255
#00CC00 0,204,0	#00CC33 0,204,51	#00CC66 0,204,102	#00CC99 0,204,153	#00CCCC 0,204,204	#00CCFF 0,204,255	#99CC00 153,204,0	#99CC33 153,204,51	#99CC66 153,204,102	#99CC99 153,204,153	#99CCCC 153,204,204	#99CCFF 153,204,255
#00FF00 0,255,0	#00FF33 0,255,51	#00FF66 0,255,102	#00FF99 0,255,153	#00FFCC 0,255,204	#00FFFF 0,255,255	#99FF00 153,255,0	#99FF33 153,255,51	#99FF66 153,255,102	#99FF99 153,255,153	#99FFCC 153,255,204	#99FFFF 153,255,255
#330000 51,0,0	#330033 51,0,51	#330066 51,0,102	#330099 51,0,153	#3300CC 51,0,204	#3300FF 51,0,255	#CC0000 204,0,0	#CC0033 204,0,51	#CC0066 204,0,102	#CC0099 204,0,153	#CC00CC 204,0,204	#CC00FF 204,0,255
#333300 51,51,0	#333333 51,51,51	#333366 51,51,102	#333399 51,51,153	#3333CC 51,51,204	#3333FF 51,51,255	#CC3300 204,51,0	#CC3333 204,51,51	#CC3366 204,51,102	#CC3399 204,51,153	#CC33CC 204,51,204	#CC33FF 204,51,255
#336600 51,102,0	#336633 51,102,51	#336666 51,102,102	#336699 51,102,153	#3366CC 51,102,204	#3366FF 51,102,255	#CC6600 204,102,0	#CC6633 204,102,51	#CC6666 204,102,102	#CC6699 204,102,153	#CC66CC 204,102,204	#CC66FF 204,102,255
#339900 51,153,0	#339933 51,153,51	#339966 51,153,102	#339999 51,153,153	#3399CC 51,153,204	#3399FF 51,153,255	#CC9900 204,153,0	#CC9933 204,153,51	#CC9966 204,153,102	#CC9999 204,153,153	#CC99CC 204,153,204	#CC99FF 204,153,255
#33CC00 51,204,0	#33CC33 51,204,51	#33CC66 51,204,102	#33CC99 51,204,153	#33CCCC 51,204,204	#33CCFF 51,204,255	#CCCC00 204,204,0	#CCCC33 204,204,51	#CCCC66 204,204,102	#CCCC99 204,204,153	#CCCCCC 204,204,204	#CCCCFF 204,204,255
#33FF00 51,255,0	#33FF33 51,255,51	#33FF66 51,255,102	#33FF99 51,255,153	#33FFCC 51,255,204	#33FFFF 51,255,255	#CCFF00 204,255,0	#CCFF33 204,255,51	#CCFF66 204,255,102	#CCFF99 204,255,153	#CCFFCC 204,255,204	#CCFFFF 204,255,255
#660000 102,0,0	#660033 102,0,51	#660066 102,0,102	#660099 102,0,153	#6600CC 102,0,204	#6600FF 102,0,255	#FF0000 255,0,0	#FF0033 255,0,51	#FF0066 255,0,102	#FF0099 255,0,153	#FF00CC 255,0,204	#FF00FF 255,0,255
#663300 102,51,0	#663333 102,51,51	#663366 102,51,102	#663399 102,51,153	#6633CC 102,51,204	#6633FF 102,51,255	#FF3300 255,51,0	#FF3333 255,51,51	#FF3366 255,51,102	#FF3399 255,51,153	#FF33CC 255,51,204	#FF33FF 255,51,255
#666600 102,102,0	#666633 102,102,51	#666666 102,102,102	#666699 102,102,153	#6666CC 102,102,204	#6666FF 102,102,255	#FF6600 255,102,0	#FF6633 255,102,51	#FF6666 255,102,102	#FF6699 255,102,153	#FF66CC 255,102,204	#FF66FF 255,102,255
#669900 102,153,0	#669933 102,153,51	#669966 102,153,102	#669999 102,153,153	#6699CC 102,153,204	#6699FF 102,153,255	#FF9900 255,153,0	#FF9933 255,153,51	#FF9966 255,153,102	#FF9999 255,153,153	#FF99CC 255,153,204	#FF99FF 255,153,255
#66CC00 102,204,0	#66CC33 102,204,51	#66CC66 102,204,102	#66CC99 102,204,153	#66CCCC 102,204,204	#66CCFF 102,204,255	#FFCC00 255,204,0	#FFCC33 255,204,51	#FFCC66 255,204,102	#FFCC99 255,204,153	#FFCCCC 255,204,204	#FFCCFF 255,204,255
#66FF00 102,255,0	#66FF33 102,255,51	#66FF66 102,255,102	#66FF99 102,255,153	#66FFCC 102,255,204	#66FFFF 102,255,255	#FFFF00 255,255,0	#FFFF33 255,255,51	#FFFF66 255,255,102	#FFFF99 255,255,153	#FFFFCC 255,255,204	#FFFFFF 255,255,255
#000000 0,0,0	#333333 51,51,51	#666666 102,102,102	#999999 153,153,153	#CCCCCC 204,204,204	#FFFFFF 255,255,255	#FF0000 255,0,0	#00FF00 0,255,0	#0000FF 0,0,255	#FFFF00 255,255,0	#FF00FF 255,0,255	#00FFFF 0,255,255

Also, computer “gibberish?”

Like...

**Ox19C653CB3D30EeEe2F99f9f4B987E3b2288OFFCF**



# Also, computer “gibberish?”

## Like...

**Ox19C653CB3D30EeEe2F99f9f4B987E3b22880FFCF**

Public address for cryptocurrency; here, ethereum.

**Also, simply a big ol' base 16 number**

Is this real? Maybe send it some money and find out :)

(NEXT WEEK, how are you **not** able to steal my money now that you have this?)



Computers don't do “magic”

Not even A.I.

They just take data and mess  
around with it.

e.g our “Magic Genie..

# Remember:

- We're presuming that:
    - - the **local** computer is fast
    - and
      - File storage is costly
    - - the network is slow
- => thus, small filesizes are better.

# File Compression (e.g. ZIP)

- Lossless (or “Perfect”) file compression.

To make smaller, so as to be able to store more, or send faster.

But also, to reproduce PERFECTLY.

(it's not magic)

# Consider:

- *“Penelope and Robert Jones Smith went to the car and grabbed the bat and the ball and the chair and the Doritos and Penelope's coat and Robert Jones Smith's favorite suit and the directions to the park. Penelope told Robert Jones Smith that they and the other people were going to have a wonderful and fun and lovely day. Robert Jones Smith told Penelope that he agreed. Also, that her name started with P.”*

# First step:

- Turn all the ands into &.

- &->and
- *Penelope & Robert Jones Smith went to the car & grabbed the bat & the ball & the chair & the Doritos & Penelope's coat & Robert Jones Smith's favorite suit & the directions to the park. Penelope told Robert Jones Smith that they & the other people were going to have a wonderful & fun & lovely day. Robert Jones Smith told Penelope that he agreed. Also, that her name started with P.*



# But this doesn't have to read like English...

- &->and

- #->the

*Penelope & Robert Jones Smith went to # car & grabbed # bat & # ball & # chair & # Doritos & Penelope's coat & Robert Jones Smith's favorite suit & # directions to # park. Penelope told Robert Jones Smith that #y & # o#r people were going to have a wonderful & fun & lovely day. Robert Jones Smith told Penelope that he agreed. Also, that her name started with P.*

# Robert has a long name...

- &->and
- #->the
- RJS->Robert Jones Smith
- *Penelope & RJS went to # car & grabbed # bat & # ball & # chair & # Doritos & Penelope's coat & RJS's favorite suit & # directions to # park. Penelope told RJS that #y & # o#r people were going to have a wonderful & fun & lovely day. RJS told Penelope that he agreed. Also, that her name started with P.*

# Penelope too, but wait...

- “Also, that her name started with P”

→

“Also, that her name started with Penelope”

# So, then...

- &->and
- #->the
- RJS->Robert Jones Smith
- PP->P(unchanged)
- P->Penelope
- 
- P & RJS went to # car & grabbed # bat & # ball & # chair & # Doritos & P's coat & RJS's favorite suit & # directions to # park. P told RJS that #y & # o#r people were going to have a wonderful & fun & lovely day. RJS told P that he agreed. Also, that her name started with PP.

# But what if the next file is?

- P P P P
- 
- →

PP PP PP PP

The file gets BIGGER.

# Pictures on the web:

- Basically, two formats:

Raster and Vector.

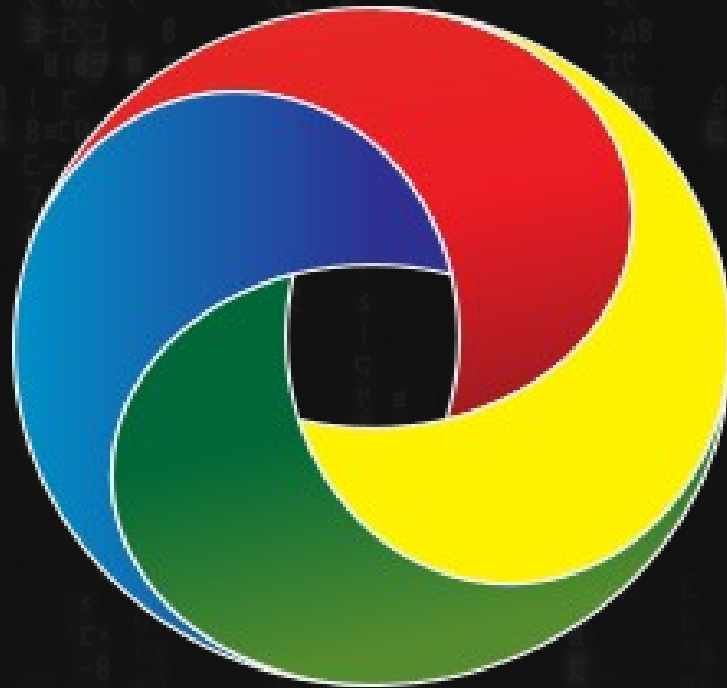
Most of the time you're looking at RASTER, which is basically a grid.

-

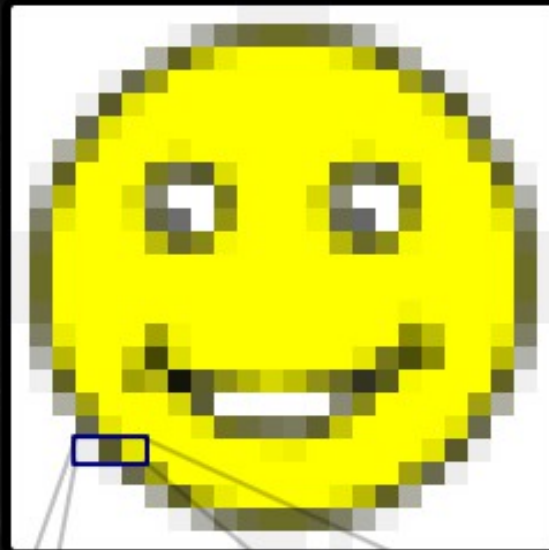


# Vector Graphics

- Use math (specifically, geometry) to tell the computer how to draw the lines and do the colors – then render it somehow



# Lossless (RAW) Raster



R 93%	R 35%	R 90%
G 93%	G 35%	G 90%
B 93%	B 16%	B 0%

# Lossless image compression

- Instead of  
“0,0 = white    0,5 = white
- 0,1 = white    0,6 = white
- 0,2 = white    0,7 = white
- 0,3 = white    0,8 = white
- 0,4 = white    0,9 = white” ...

# Just say..

- 
- 0,0 through 0, 10 = white.

# This also works for audio...

- 1 sec. = silence
- 2 sec. = silence
- 3 sec. = silence....etc

just say

1-10 sec. = silence

..and video

“at 0,0 for 10 seconds = white”



# Lossy Compression

EVEN better, for us humans.

We can't see or hear tiny differences, so this is very good for e.g. pictures/video/sound.

# “Goldilocks and the 3 bears” (with lossy compression)

- 
- 
- Some nosey girl went up in some bears' house, ate their food, fell asleep and freaked out when the bears came back.

# Lossy Compression

EVEN better, for us humans.

We can't see or hear tiny differences, so this is very good for e.g. pictures/video/sound.

# Lossy compression = Good for analogue/multimedia

Tiny filesizes; takes advantage of the limitations in human perception.

We cannot perceive individual pixels (or samples) when surrounded by other meaningful pixels/samples. They blur, frequently in predictable patterns.

- “if 0,0 is white, 0,1 is likely to be white, or light gray”

“if 0,1 is light gray, 0,2 is likely to be slightly darker gray...”

Okay, so just  $(x + 1)$  the darkness every pixel to the left.

$$y=x+1$$

- What happens if you compress something losslessly over and over?

What happens if you compress something lossily over and over?



Can also “fix” images



Okay, AI

First, lets try words.

This is actually not hard...

You could literally just do random words..but that's not great...

Fill in the blank.

Seven \_\_\_\_\_?

Fill in the blank.

Seven \_\_\_\_\_?

Seas?  
Continents?  
Nation Army?

Sure, pick one, sometimes  
randomly.



Fill in the blank.

Four Score and Seven \_\_\_\_\_?

Again, not hard.

The computer just picks the one (or one of the ones) that usually follows **FROM THE DATA IT SEES.**

# Images?

Hey, remember denoising, a few slides ago?

It's just that, BACKWARDS.

1. Turn all (like ALL) the images into pure noise and analyze the patterns associated with the words.

"image of cute kitty"



# Images?

2. Take words, e.g. “womans face,”  
then “denoise” according to what you learned by  
mathematically analyzing

