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

V

THEN..Arabic Numerals?

Humans counting!

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

THEN....Tally Marks

THEN ...Roman Numerals

V

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."

.

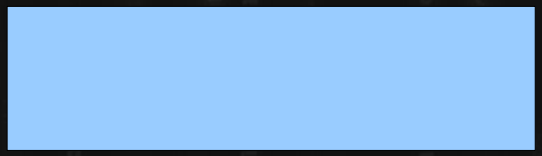
.

```
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)

100x1 + 10x0 + 1x1

(10^2)x1 + (10^1)x0 + (10^0)x1

“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)

10x2 + 1x0

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!

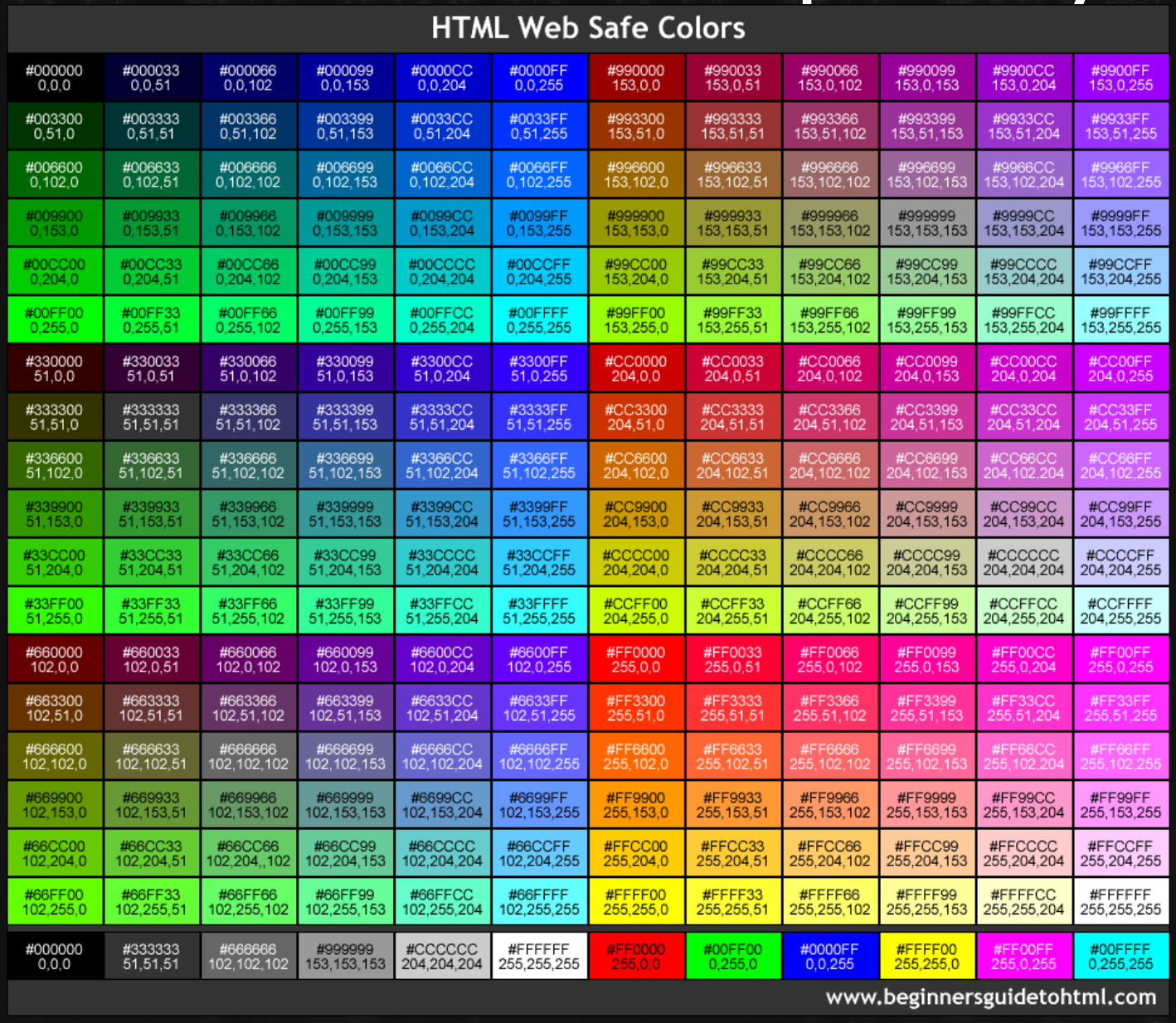
BUT, MAC addresses are like:

ac:d5:b8:c0:e1:03

0-FF?

SAME THING! See, also RGB Colors!

Where this comes up today...



Also, computer “gibberish?”

Like…

0x19C653CB3D30EeEe2F99f9f4B987E3b2288OFFCF

Also, computer “gibberish?”

Like…

0x19C653CB3D30EeEe2F99f9f4B987E3b2288OFFCF

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:

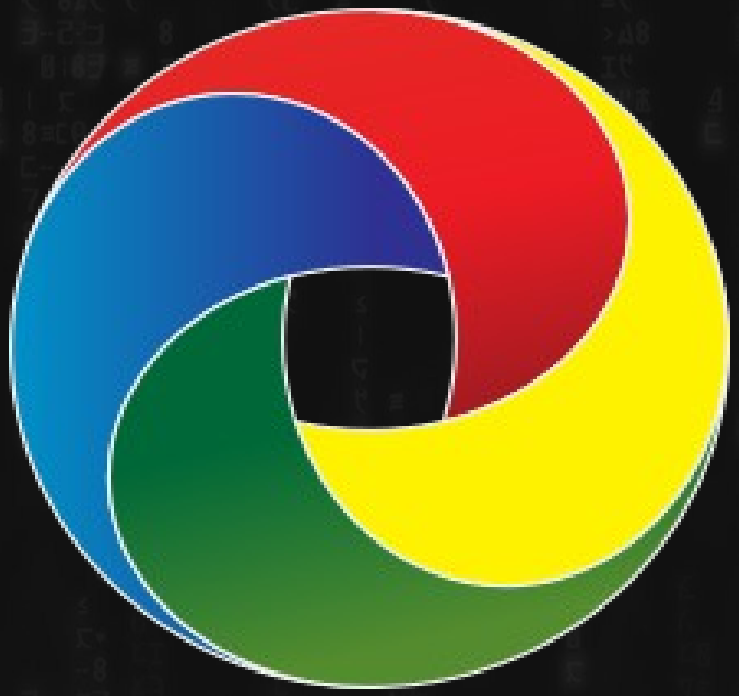
- Basically, two formats:

  Raster and Vector.

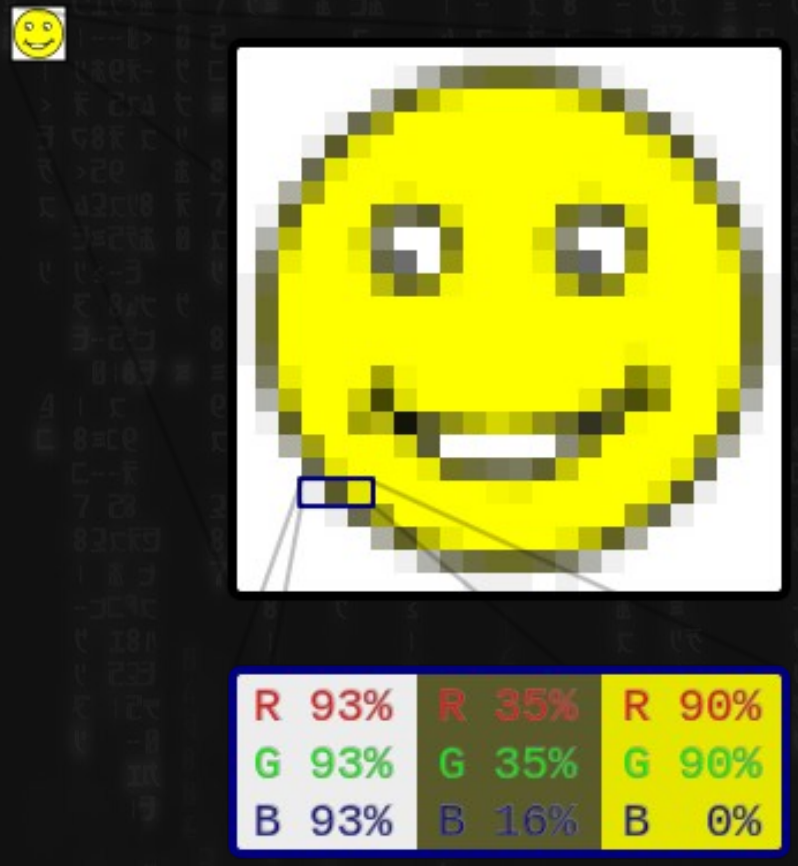
  Most of the time you're looking at RASTER, which is basically a grid.
-

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



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 percieve 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…”

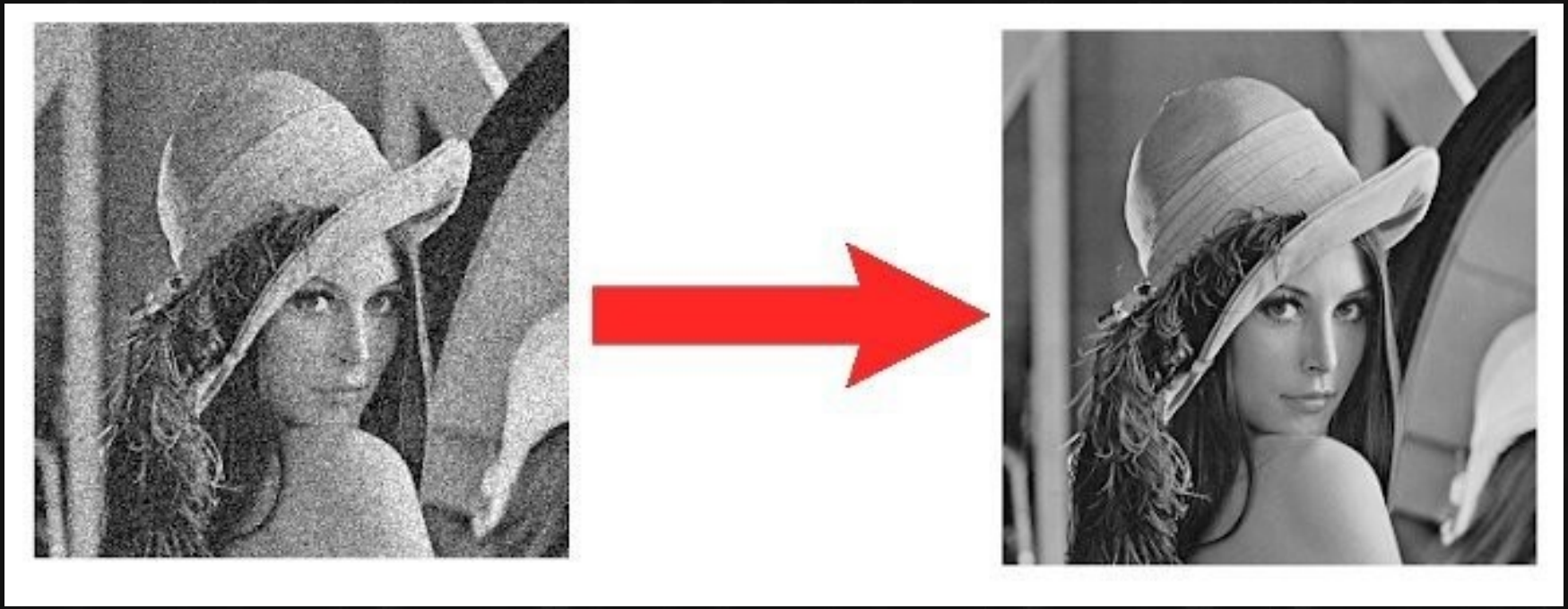
  Okay, so just (x + 1) the darkness every pixel to the left.

  y=x+1

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

  What happens if you compress something lossi-ly 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