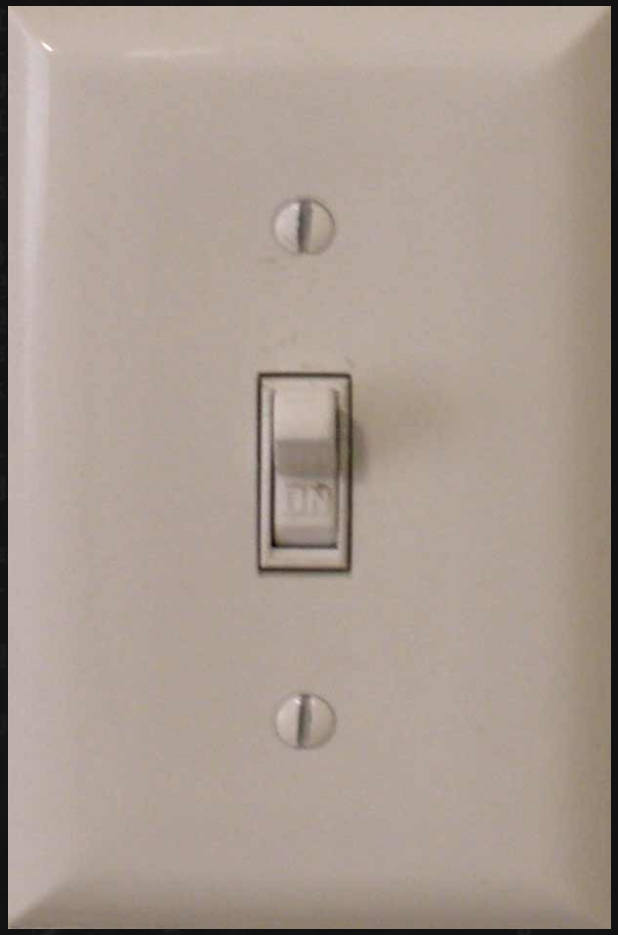
LIS-3353

Fundamentals

Simplest computer I can think of...



If the British went out by Water, we would shew two Lanthorns in the North Church Steeple; and if by Land, one, as a Signal.

(Paul Revere)

izquotes.com

BINARY system. TWO possible choices

Binary System

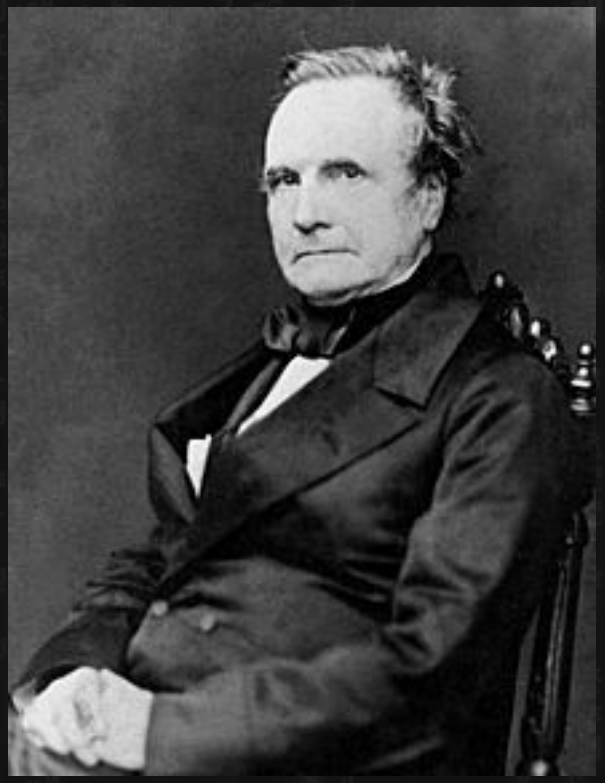
0 and 1

HUGE CONCEPT #1

All computers do is "numbers"

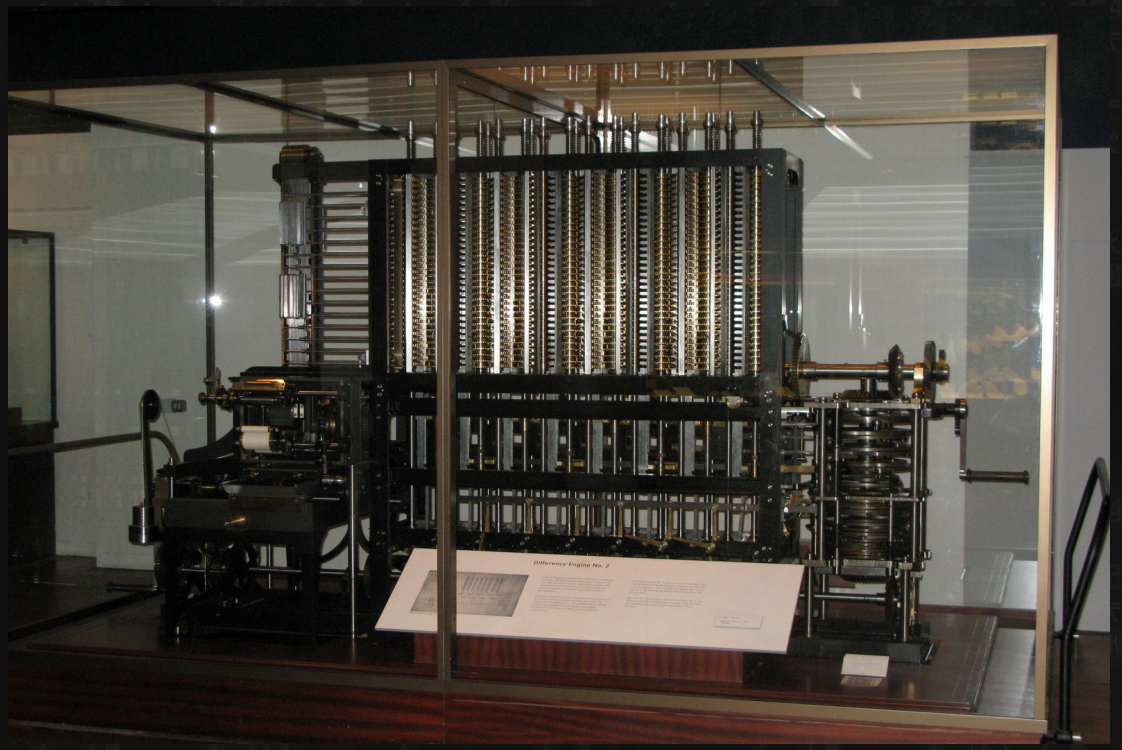
- you put numbers into them
- it messes with the numbers
- it gives you some numbers back

Charles Babbage



“The whole of arithmetic now appeared within the grasp of mechanism.”

The Difference Engine



..which is this

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."

.

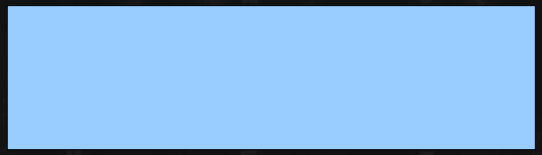
.

```
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?)



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.”

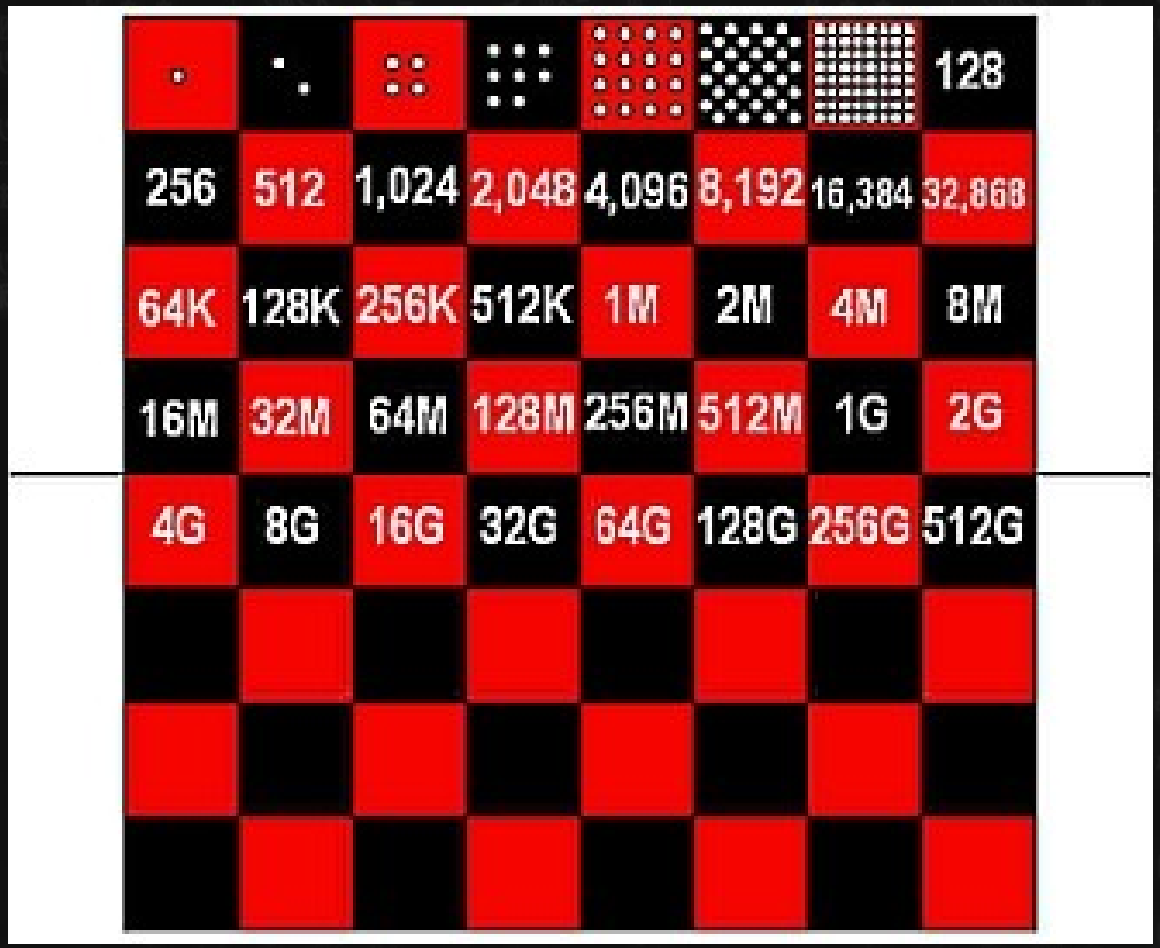
If you want to get technical, ALL bases are Base 10.

Is Binary Enough?

(exponential growth and the legend of Paal Paysam)

Is Binary Enough?

(exponential growth and the legend of Paal Paysam)



2^{1}	=	2	2^{11}	=	2,048	2^{21}	=	2,097,152
2^{2}	=	4	**2^{12}**	**=**	**4,096**	2^{22}	=	4,194,304
2^{3}	=	8	2^{13}	=	8,192	2^{23}	=	8,388,608
2^{4}	**=**	16	2^{14}	=	16,384	**2^{24}**	**=**	**16,777,216**
2^{5}	=	32	2^{15}	=	32,768	2^{25}	=	33,554,432
2^{6}	=	64	**2^{16}**	**=**	**65,536**	2^{26}	=	67,108,864
2^{7}	=	128	2^{17}	=	131,072	2^{27}	=	134,217,728
2^{8}	**=**	256	2^{18}	=	262,144	**2^{28}**	**=**	**268,435,456**
2^{9}	=	512	2^{19}	=	524,288	2^{29}	=	536,870,912
2^{10}	=	1,024	**2^{20}**	**=**	**1,048,576**	2^{30}	=	1,073,741,824

Why is this important?

Why is this important?

1) Exponential Growth

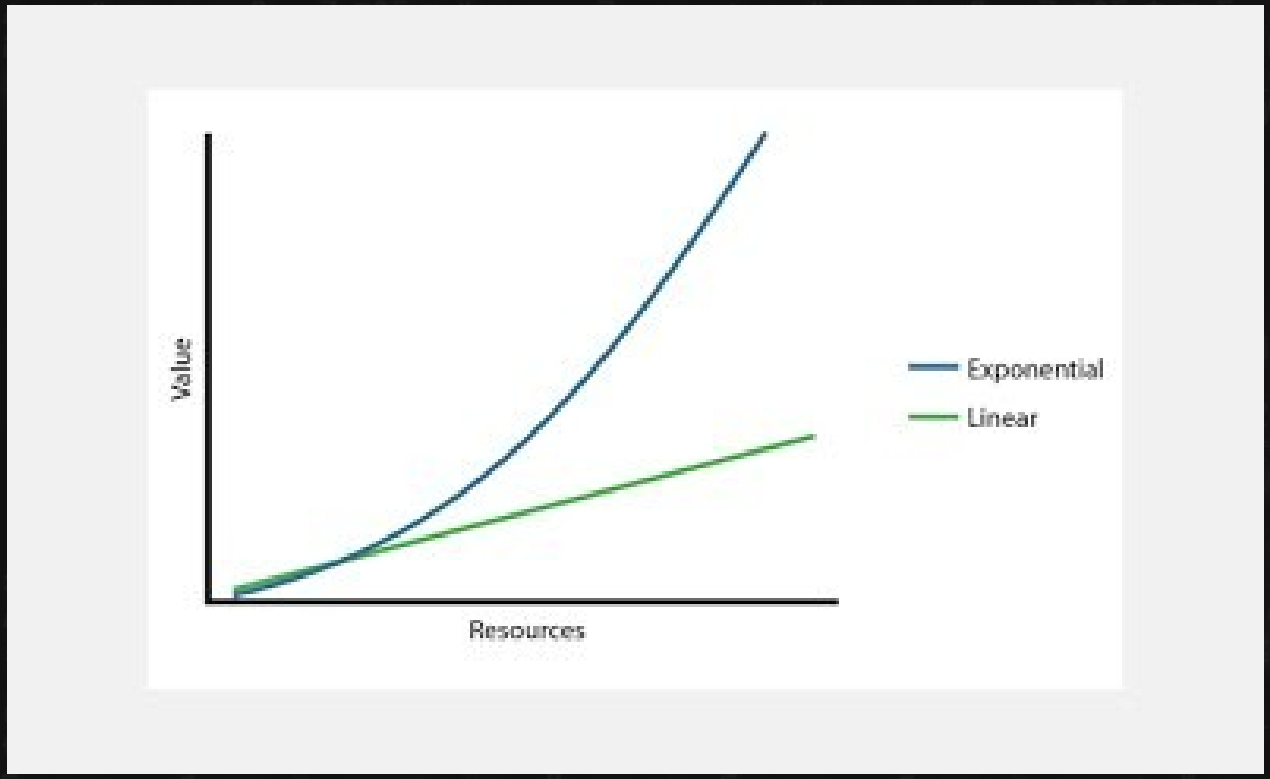
2) The “shape” of computer numbers.

Exponential growth =
Wide range of possibilities

Exponential REDUCTION =
“Easy to specify things”

Why is this important?

1) Exponential Growth (and reduction)
e.g. perception of volume



The “shape” of computer numbers

e.g. – 128, 256, 1024, etc.

(why hard drive sizes are “wrong”)

Also, computer gibberish?

Like bitcoin addresses?
(3kKno34bvEl...?) –
base 64 numbers

Or Blue screens of death?
(923E0BC902...)
base 16 numbers.

Where this comes up today...

IP addresses -

MAC addresses

(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

Where this comes up today...

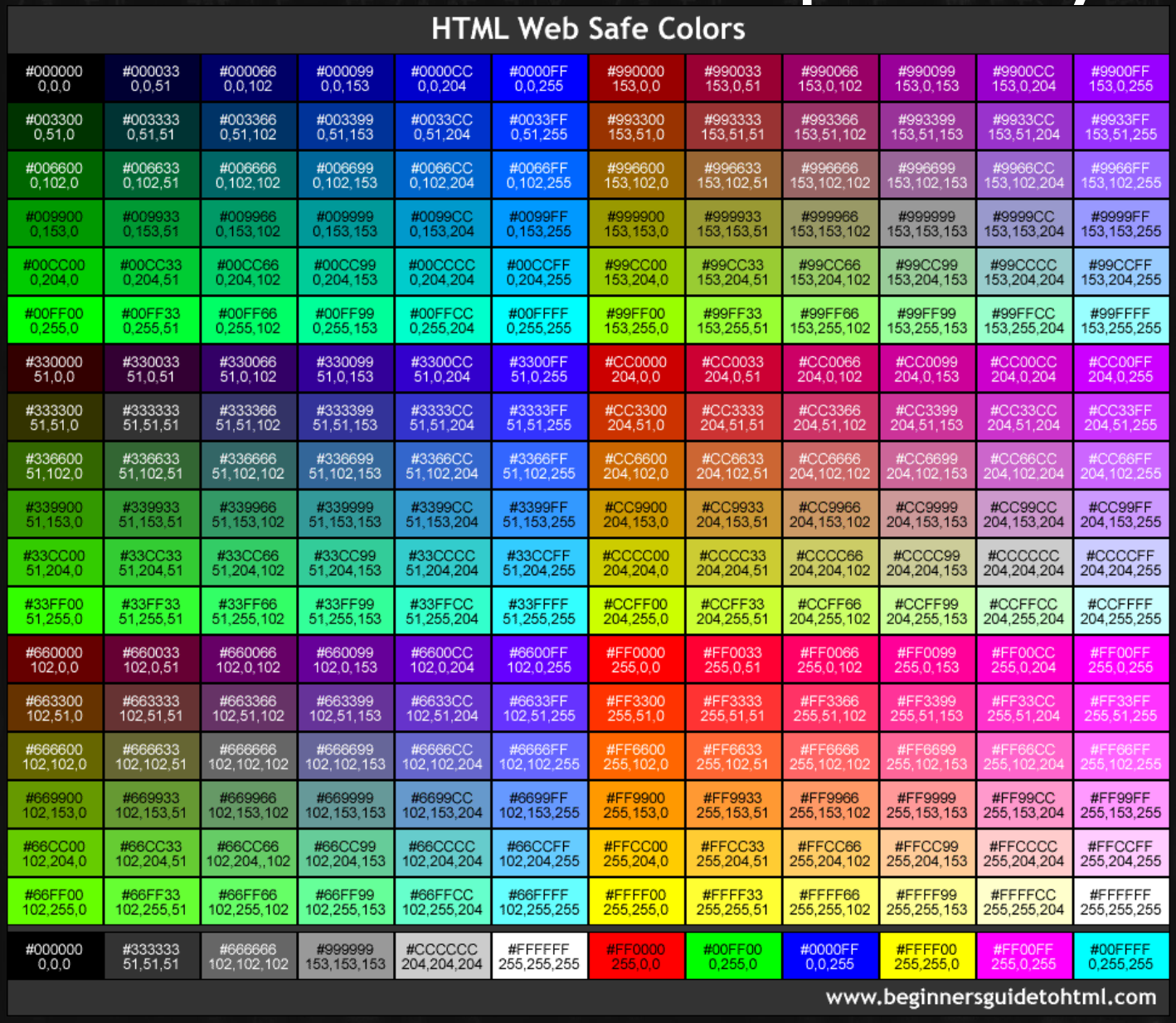
0-255!

BUT, MAC addresses are like:
ac:d5:b8:c0:e1:03

0-FF?

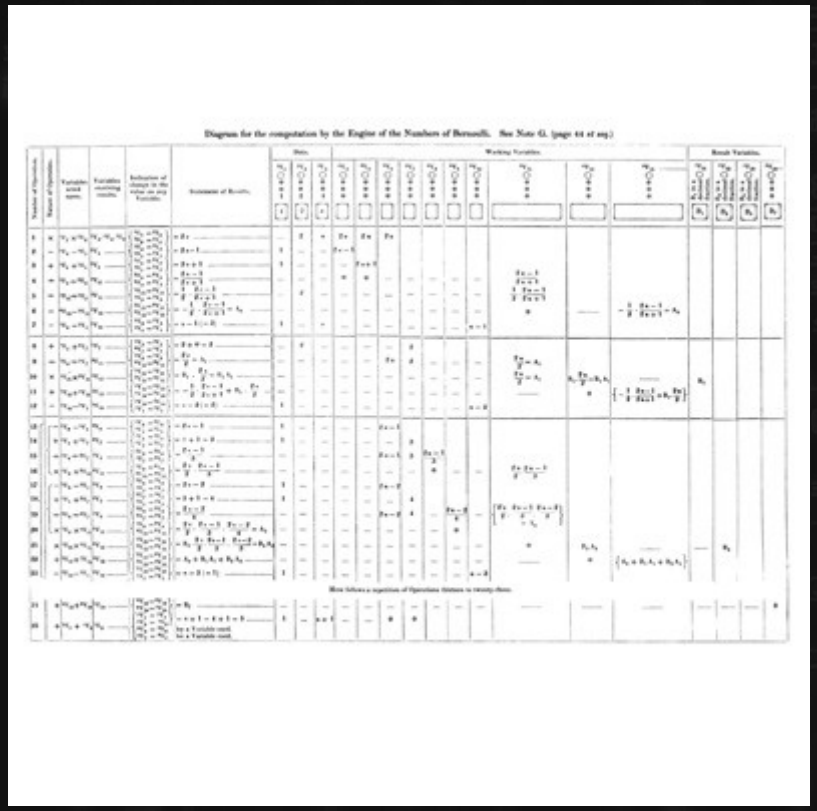
SAME THING! See, also RGB Colors!

Where this comes up today...



Ada Lovelace

The first “program?”



From “Difference Engine” to “Analytical Engine”...which...

'might act upon other things besides number... the Engine might compose elaborate and scientific pieces of music of any degree of complexity or extent'.

HUGE CONCEPT #1

All computers do is "numbers"

- you put numbers into them
- it messes with the numbers
- it gives you some numbers back

(but, you can store anything in numbers)

What about “words?”

Let's say, we want to say, “Hi.”

ASCII (technically not what we use today, but hey...)

ASCII Code: Character to Binary

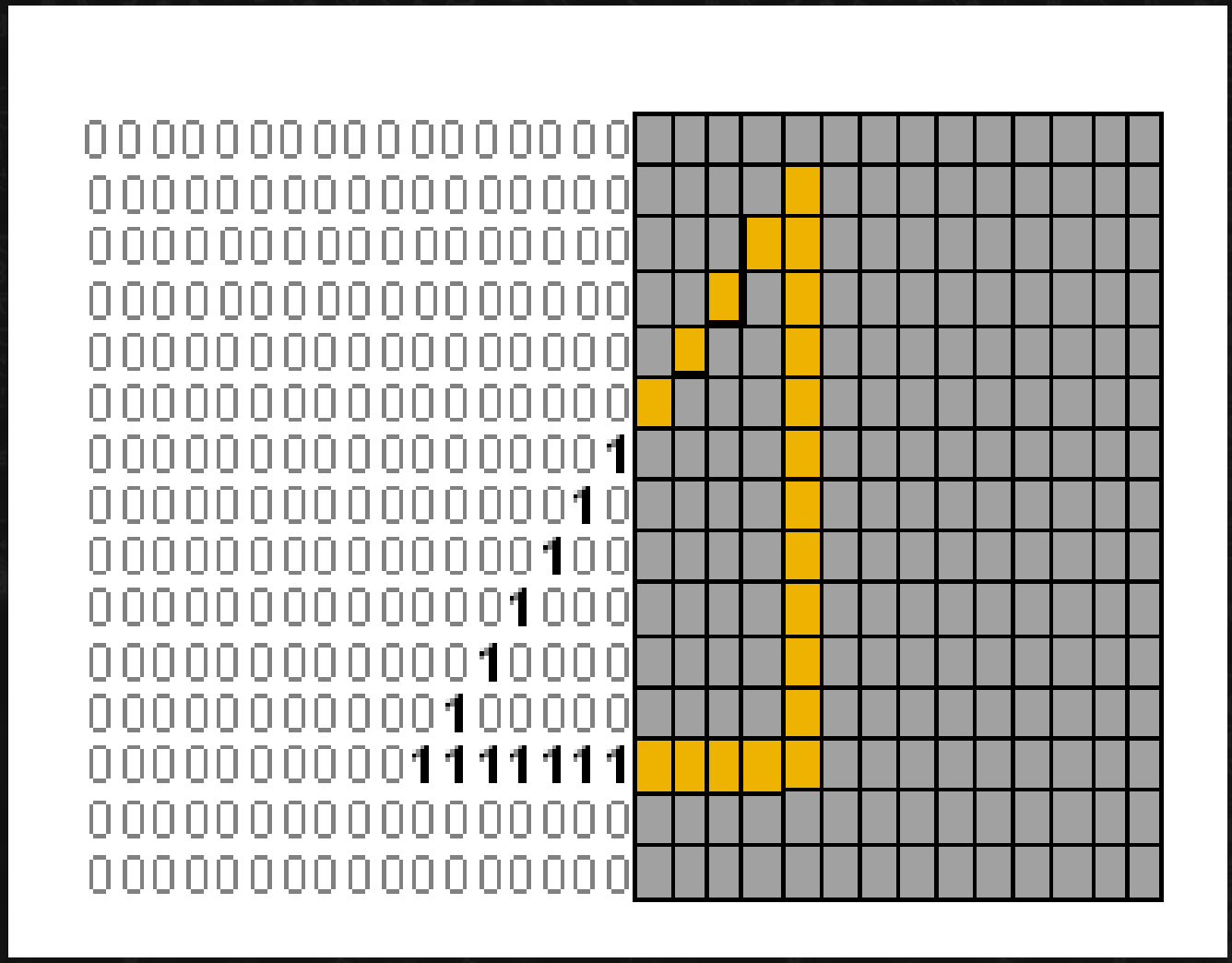
0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	I	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

H - 01001000
i – 01101001

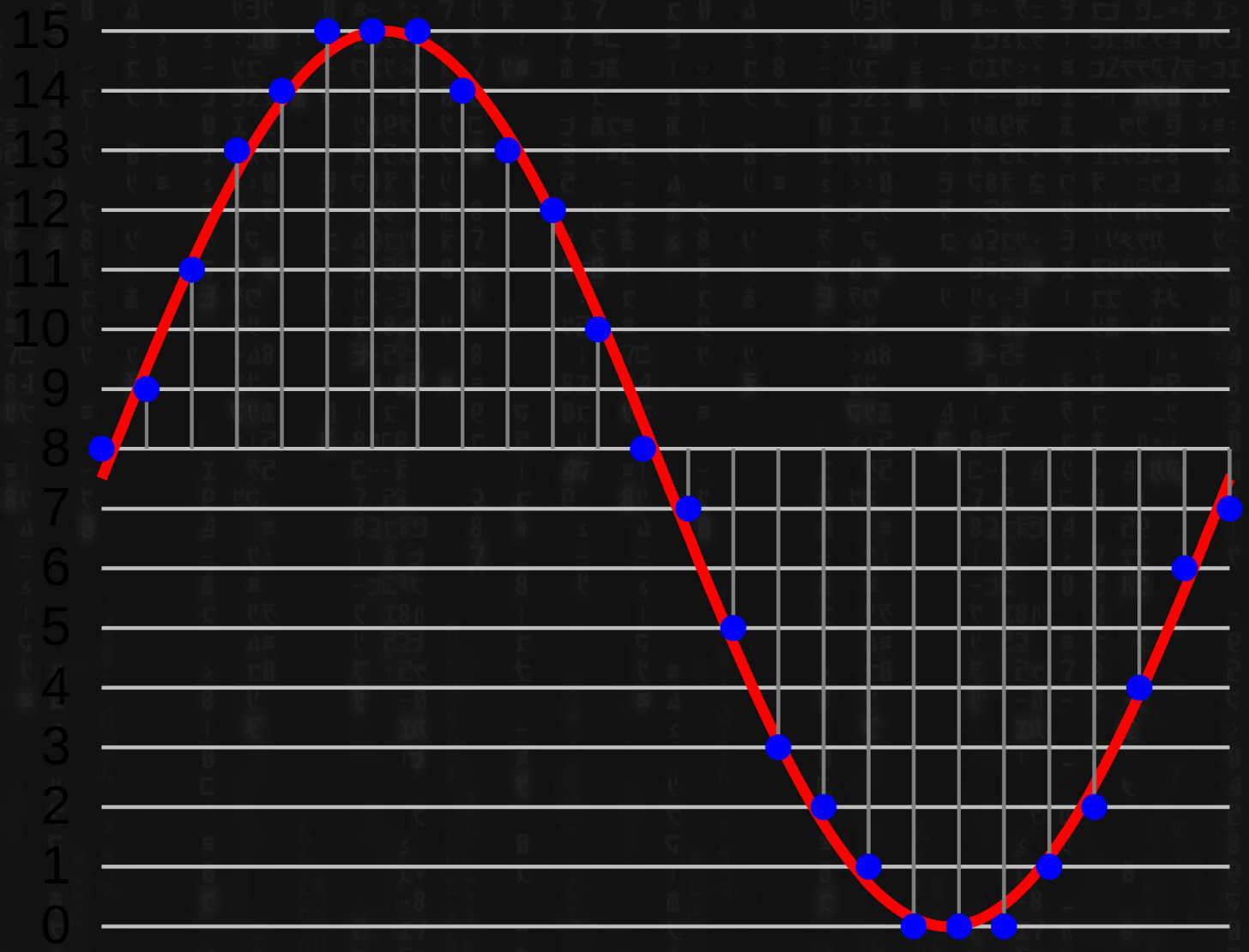
01001000,01101001

(or really, just “72,105”. More on that later….)

Images?



Sound/Music?



- email?
- mp3 file?
- snapchat photo?
- tweet?

ALL NUMBERS.
ALWAYS “CONVERTIBLE”

HUGE CONCEPT #1

All computers do is "numbers"

- you put numbers into them
- it messes with the numbers
- it gives you some numbers back

(but, you can store anything in numbers)

HUGE CONCEPT #1 +
ANYTHING IN NUMBERS

yields

HUGE(R) CONCEPT #2

HUGE(R) CONCEPT #2

All computers do is follow a very precise list of instructions that one or more people wrote.

Understanding Power

```
10 PRINT “John is AWESOME”;
20 GOTO 10
```

Algorithms
aka Telling Machines to Do Stuff

Teaching the robots to escape

1) If there's a door in arms-reach, exit – you're done, else

2) If you can, take one step forward then goto 1), else

3) Rotate to the left until there's not a wall in front of you then goto 1)

(this will get you out of any “regular” empty room)

An almost random bit on recursion

- In computers, it's actually okay to define something with itself.

  PSUEDOCODE!

  Define function=”EscapeFromRoom”{

  1) If there's a door in arms-reach, exit – you're done, else

  2) If you can, take one step forward then EscapeFromRoom, else

  3) Rotate to the left until there's not a wall in front of you then EscapeFromRoom

  }

  (this will get you out of any “regular” empty room)

Go to the store; if they have 2% lactose free chocolate milk, then get me a carton.

Misusing Power

```
go to the store;

if  [[ they have 2% lactose free
chocolate milk]]

then

      get me a carton.
```

The Magic Genie
Recursion, trees, and "crowdsourcing"

{0) Start with "Is it Batman"?}

1) Ask my (yes/no) questions down the tree

2) If win, "yay"

3) If lose, add/replace new last question to one for which my guess was wrong and her guess was right *(optionally, try to be general or"half-y"?)*

- repeat until genius

The Magic Genie
(can be used for evil too...)

- What about instead of

  “Is your person a DC character?”

  you ask real questions about real people?

  (more on this later, but this demonstrates why surveillance is easy and anonymity is hard.)

Phrases you can use to sound smart about computers...

Alan Turing

Not Alan Turing but I'll probably check out the movie too...

“Lots of very simple instructions can add up to complex computations.”

“Turing Machine (Turing Completeness)”

(an infinite tape w/ simple instructions)

"Lots of very simple instructions can add up to complex computations."

"Lambda Calculus"

(mathy way to express the above; this is literally all you have to know)

A.I. ARTIFICIAL INTELLIGENCE!

- up for debate but, history tells a lot; I'd suggest people “move the goalposts” a lot.

“Tests”

- games like Chess

or...

The Turing Test

Simplest expression:

Could a computer (typing/chatting online) fool a human into thinking it was a human?

So then...

AI?