

LIS-3353

From Numbers to Thinking:
The Concepts, Illustrated

HUGE CONCEPT #1

All computers do is “numbers”

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

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

Consider this

5

Humans counting!

Humans counting!

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

THEN....Tally Marks

THEN ...Roman Numerals

THEN..Arabic Numerals

Humans counting!

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THEN ...Roman Numerals



THEN..Arabic Numerals?

Humans counting!

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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

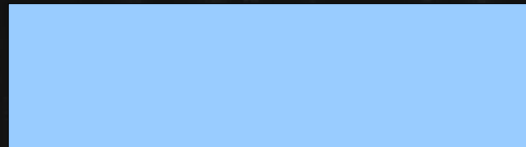
Arabic numerals include ZERO.

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



101 (Dalmatians)

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

100x1 + **10x0** + **1x1**

(10²)x1 + **(10¹)x0** + **(10⁰)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	...						

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.

Is Binary Enough?

(exponential growth and the legend of Paal Paysam)

Is Binary Enough?

(exponential growth and the legend of Paal Paysam)

							128
256	512	1,024	2,048	4,096	8,192	16,384	32,868
64K	128K	256K	512K	1M	2M	4M	8M
16M	32M	64M	128M	256M	512M	1G	2G
4G	8G	16G	32G	64G	128G	256G	512G

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

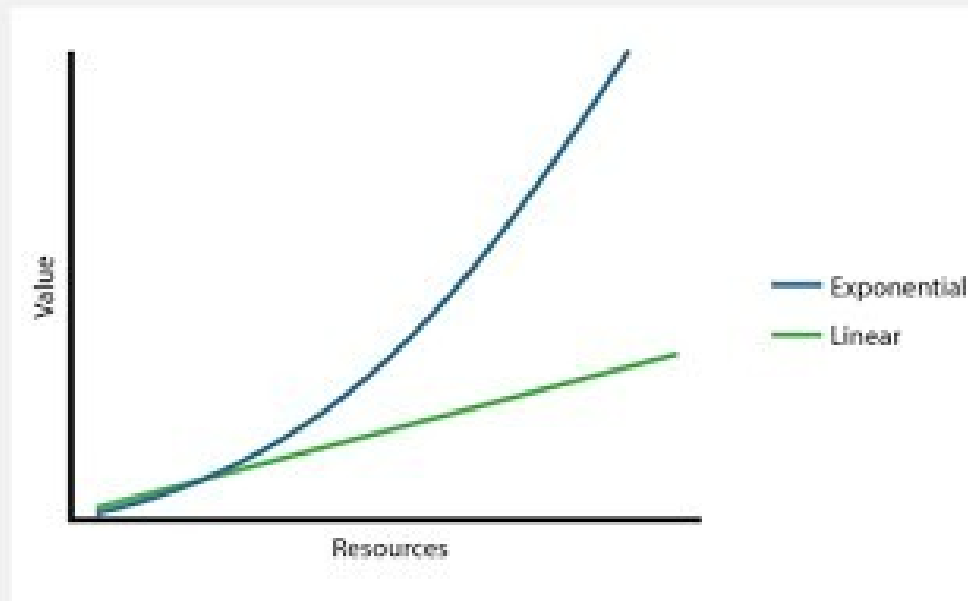
2) The “shape” of computer numbers.

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...

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

LIS-3353

From Instructions to AI

HUGE 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
```

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.)