



Take a Selfie: Selbstbezüglichkeit in der Digitalisierung von Allem

Christoph Kirsch

Arbeitsgruppe Computational Systems
Fachbereich Computerwissenschaften
Universität Salzburg



Do you own a smart phone?

How about a tablet? Maybe a laptop?

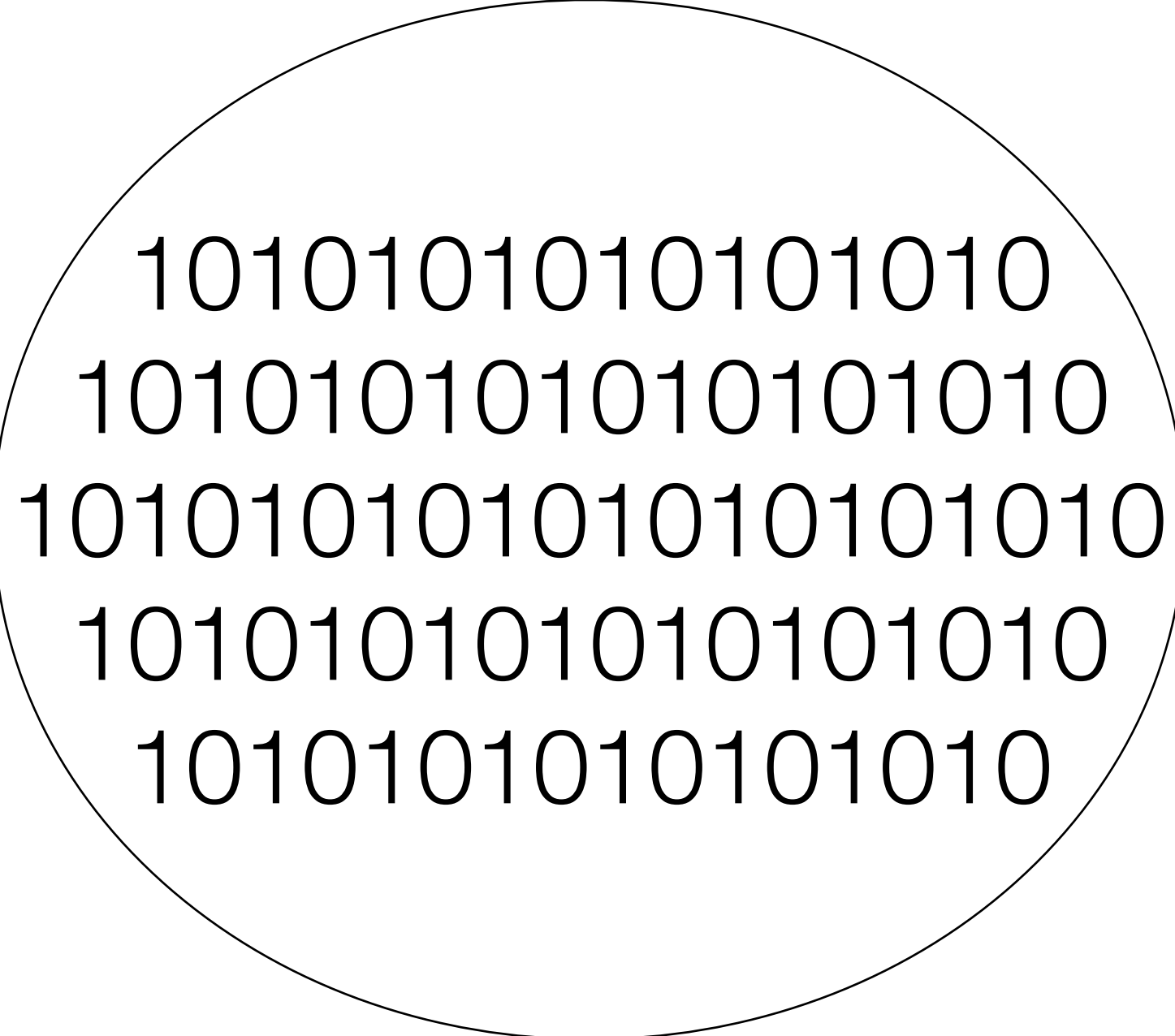
Sorry, but I can't solve your problems!

Really!

But I can tell you a story.

The Automation of Everything

The Phone in Your Pocket: Bits and Bytes



1010101010101010
1010101010101010
10101010101010101010
1010101010101010
1010101010101010

Examples

- Numbers
- Characters
- Music
- Images
- Movies
- ...
- **Software**









What is a Bit?

0 and 1

What is State?

- 1 bit = 2 states: 0, 1
- 2 bits = 4 states: 00, 01, 10, 11
- 3 bits = 8 states: 000, 001, 010, 011, 100, 101, 110, 111
- 4 bits = 16 states: 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111
- 5 bits = 32 states: ...
- 6 bits = 64 states: ...
- 7 bits = 128 states: ...
- 8 bits = 256 states: ...

State Explosion

N bits = 2^N states

The Phone in Your Pocket!

1 GB = ~8 billion bits!

~ $2^{80000000000}$ states

~ 2^{267} particles
(in the known universe)

The Phone in Your Pocket!

1 GHz = ~1 billion states per second!

~ 2^{30} states per second

31,536,000 = ~ 2^{25} seconds per year

~ 2^{55} states per year

The Phone in Your Pocket!

$\sim 2^{267}$ particles / $\sim 2^{55}$ states

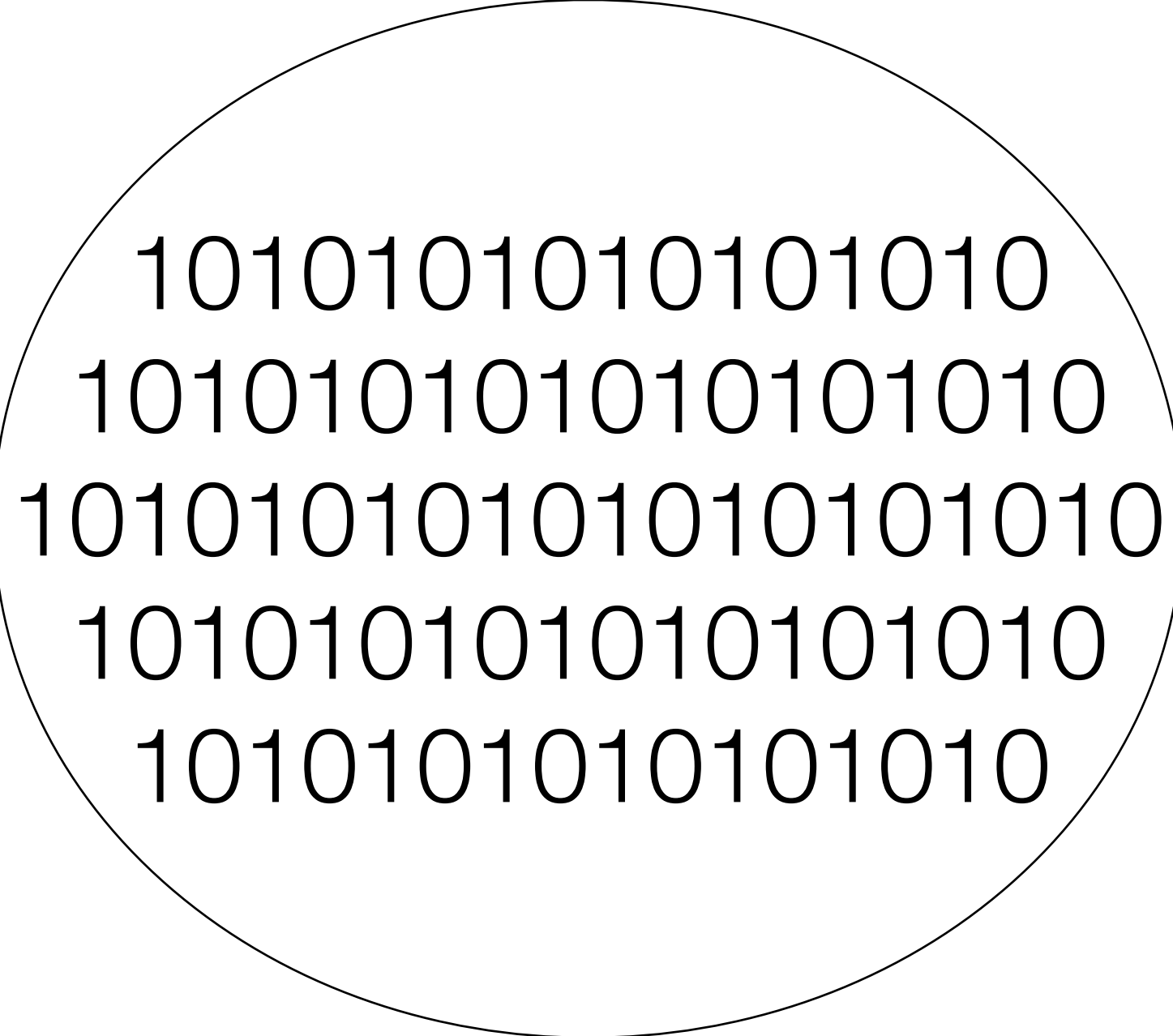
$\sim 2^{212}$ years

$\sim 6582018229284824168619876730229402019930943462534319453394436096$ years

6 vigintillion years

www.wolframalpha.com

Unlimited Innovation in Your Pocket!



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1010101010101010

But:

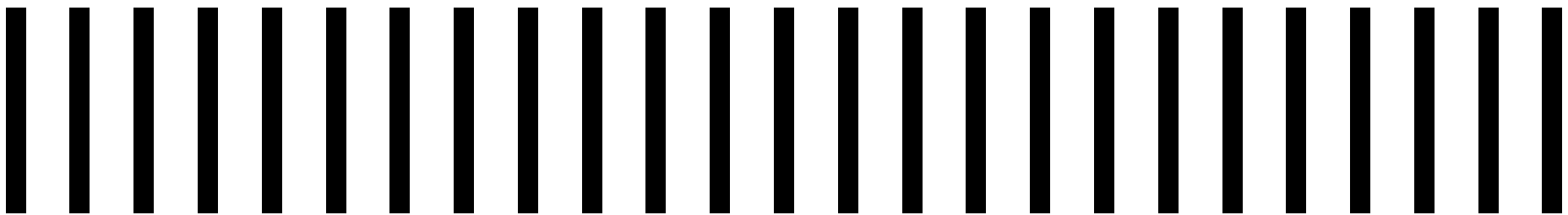
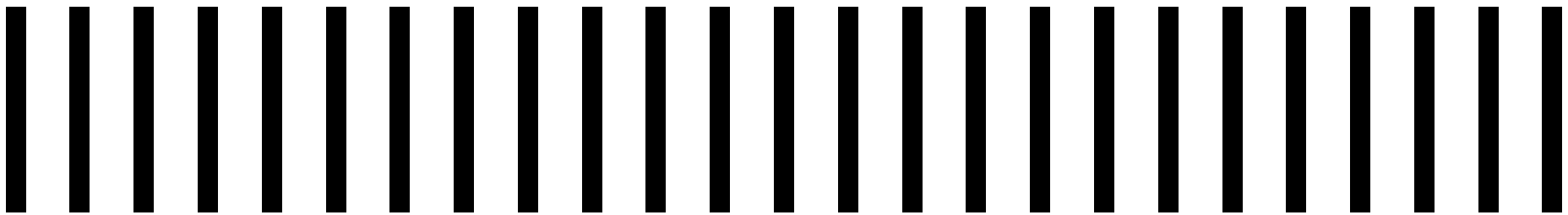
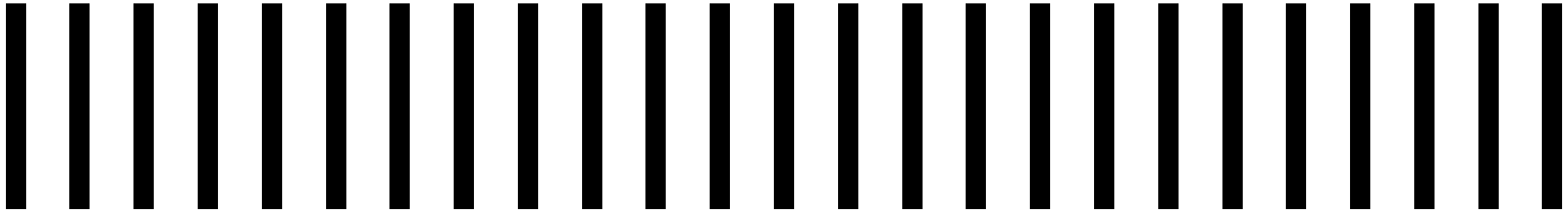
In your phone, there is
no text, **no** music, **no** images, **no** video!

There are **just bits**, lots and lots of bits!

1010101

85

1010101 is the binary encoding of 85



1010101

-43

1010101 is the binary encoding of -43 in twos complement w/ seven bits

1010101

U

The ASCII Standard associates 1010101 with the uppercase letter U

Where does the meaning of
those bits come from?

Meaning Comes from **Change**

$$\begin{array}{r} 1010101 = 85 \\ + \quad \quad \quad 1 = 1 \\ \hline 1010110 = 86 \end{array}$$

Elementary Arithmetic

Meaning Comes from **Change**

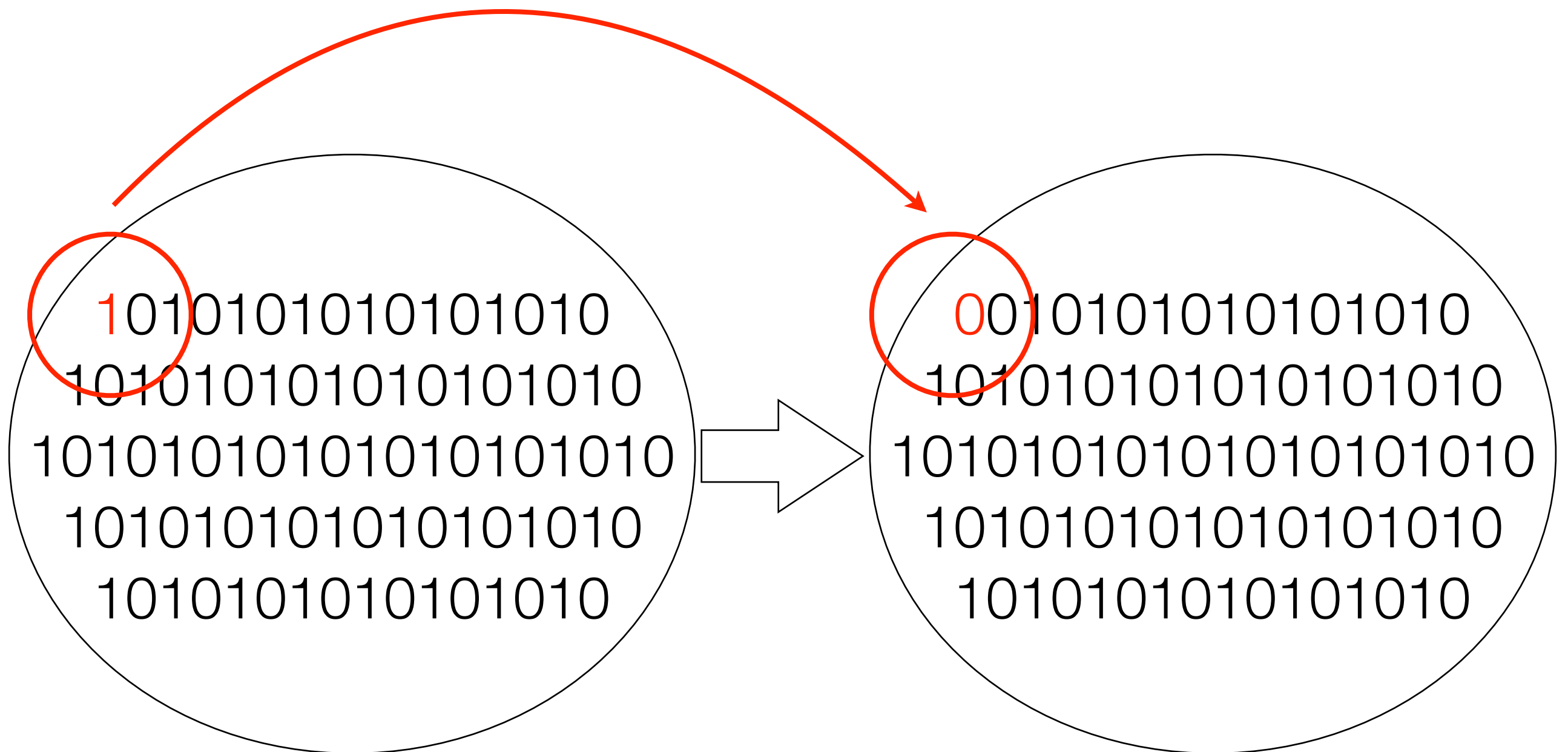
1010101 = U

1**1**10101 = u

Text Manipulation

What Your Phone Does All Day Long

Change from 1 to 0 and from 0 to 1



Software!

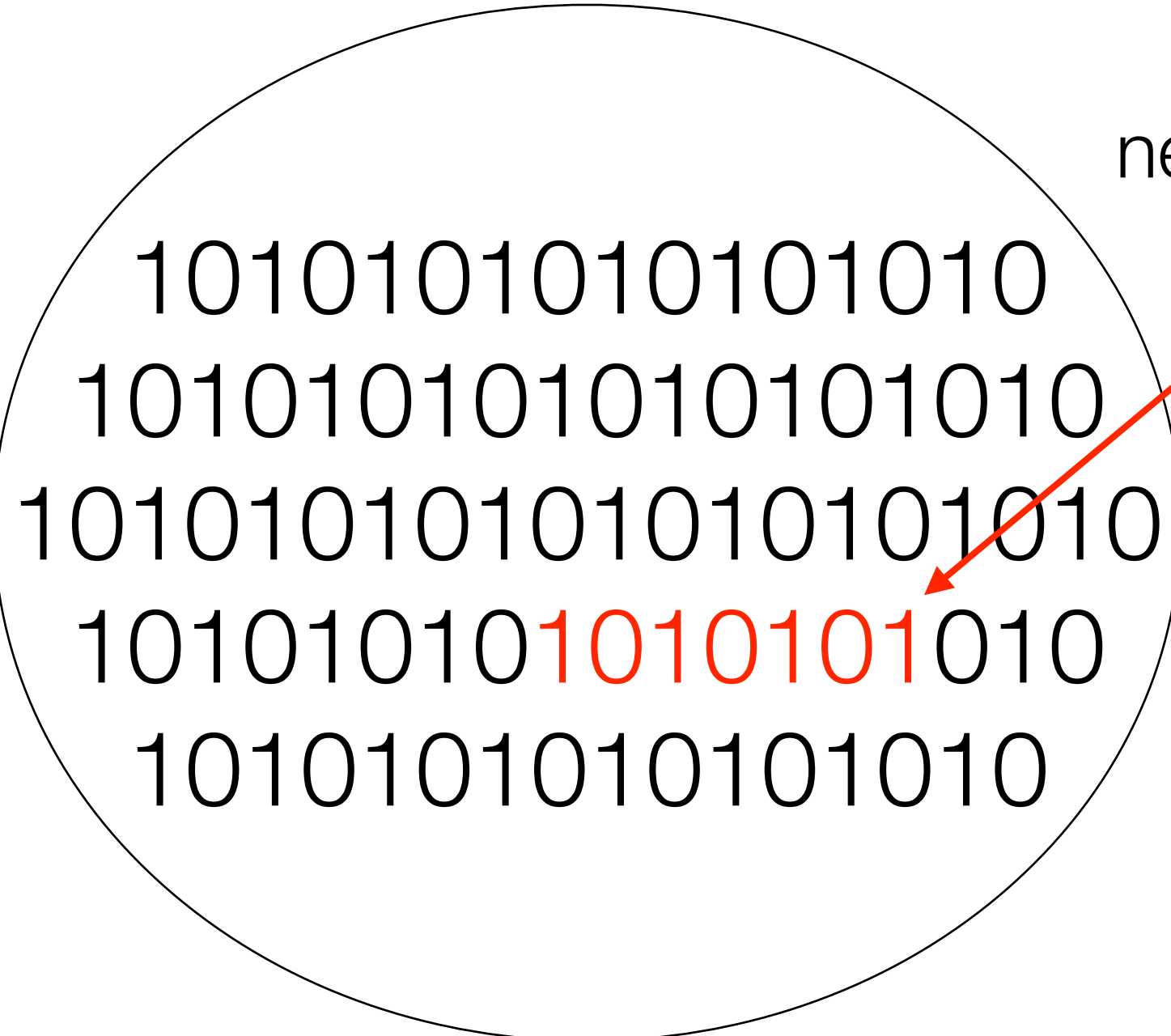
A sequence of instructions
where each instruction tells the machine

1. which **bits to change** and
2. which **instruction is next!**

Each instruction is encoded in, well, bits!

Software or Data?

Data



1010101010101010
1010101010101010
1010101010101010
1010101010101010
1010101010101010

Pointer to
next instruction

Software

Software Written by Humans

```
x = 10;
```

```
while (x > 0) {  
    x = x - 1;  
}
```

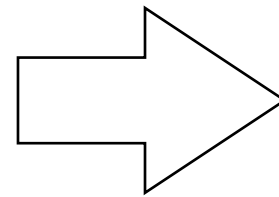
Meaning by Translation

```
x = 10;
```

```
while (x > 0) {  
    x = x - 1;  
}
```

Rheinländisch

Translator

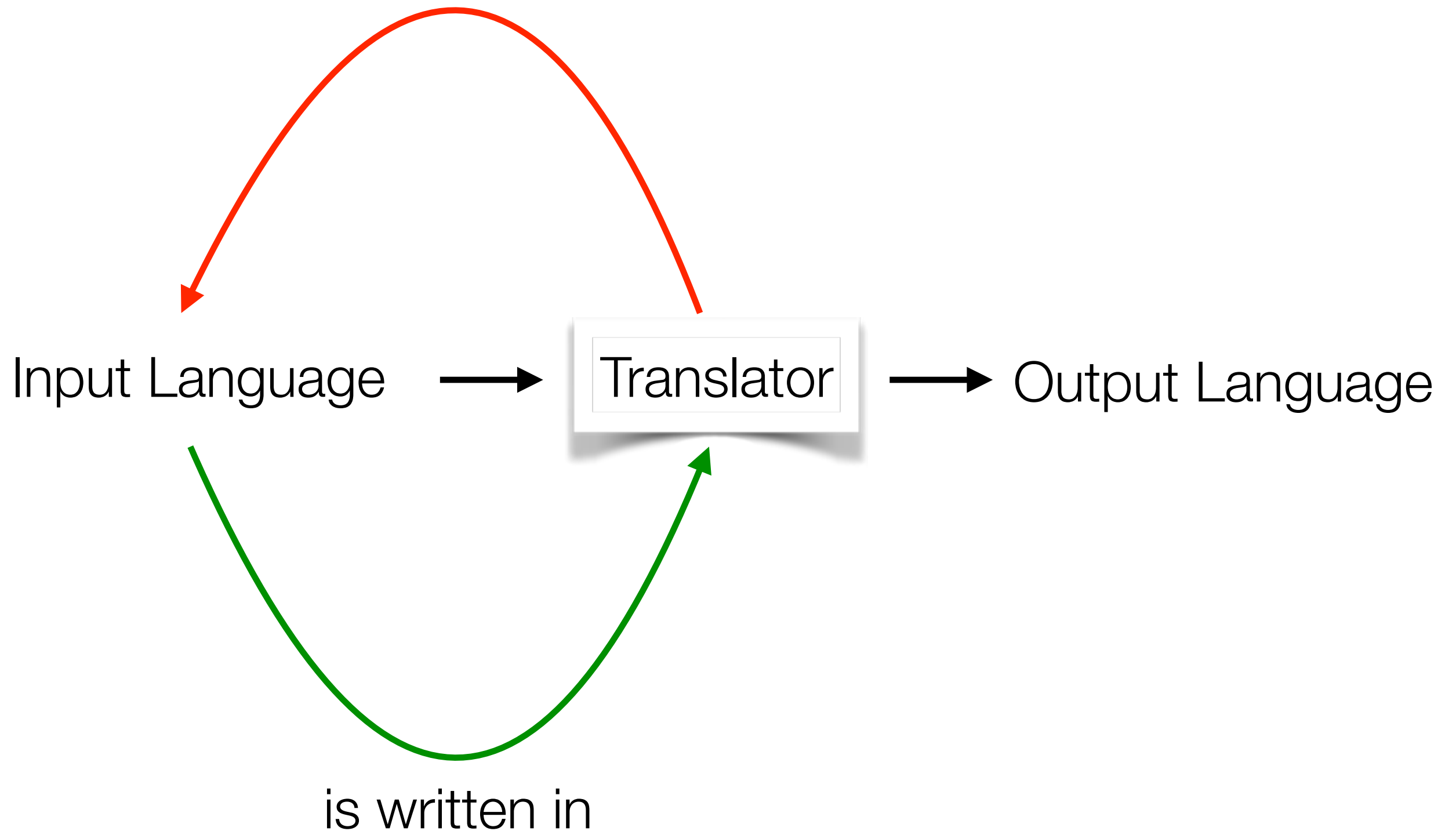


```
101010101010101010  
101010101010101010  
101010101010101010  
101010101010101010  
101010101010101010
```

Wienerisch

Self-Translation

can thus translate itself



An English dictionary defines the meaning of English using English

“This sentence has no meaning.”

-Douglas Hofstadter

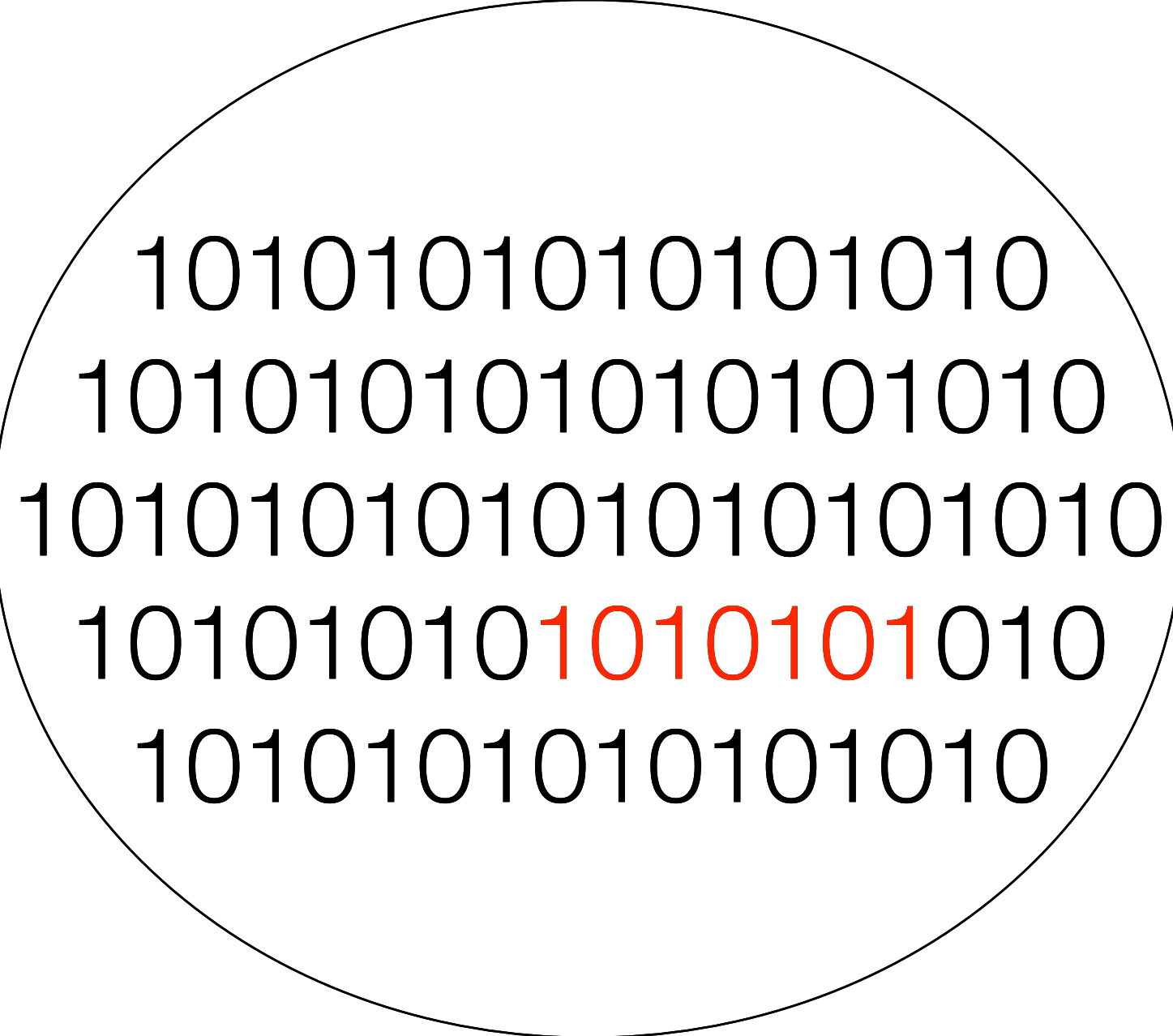
selfie.cs.uni-salzburg.at



Universality of Computing

Anything that can be computed can be computed now, if you have enough time, space, and energy!

Data, Software. It's All Bits!



1010101010101010
1010101010101010
101010101010101010
1010101010101010
1010101010101010

00, 01, 10, 11

0, 1, 2, 3

000, 001, 010, 011, 100, 101, 110, 111

0, 1, 2, 3, 4, 5, 6, 7

Each State of Your Phone is a Natural Number!

34573450344

=

1010101010101010
1010101010101010
1010101010101010
1010101010101010
1010101010101010

Natural Numbers as States of Your Phone

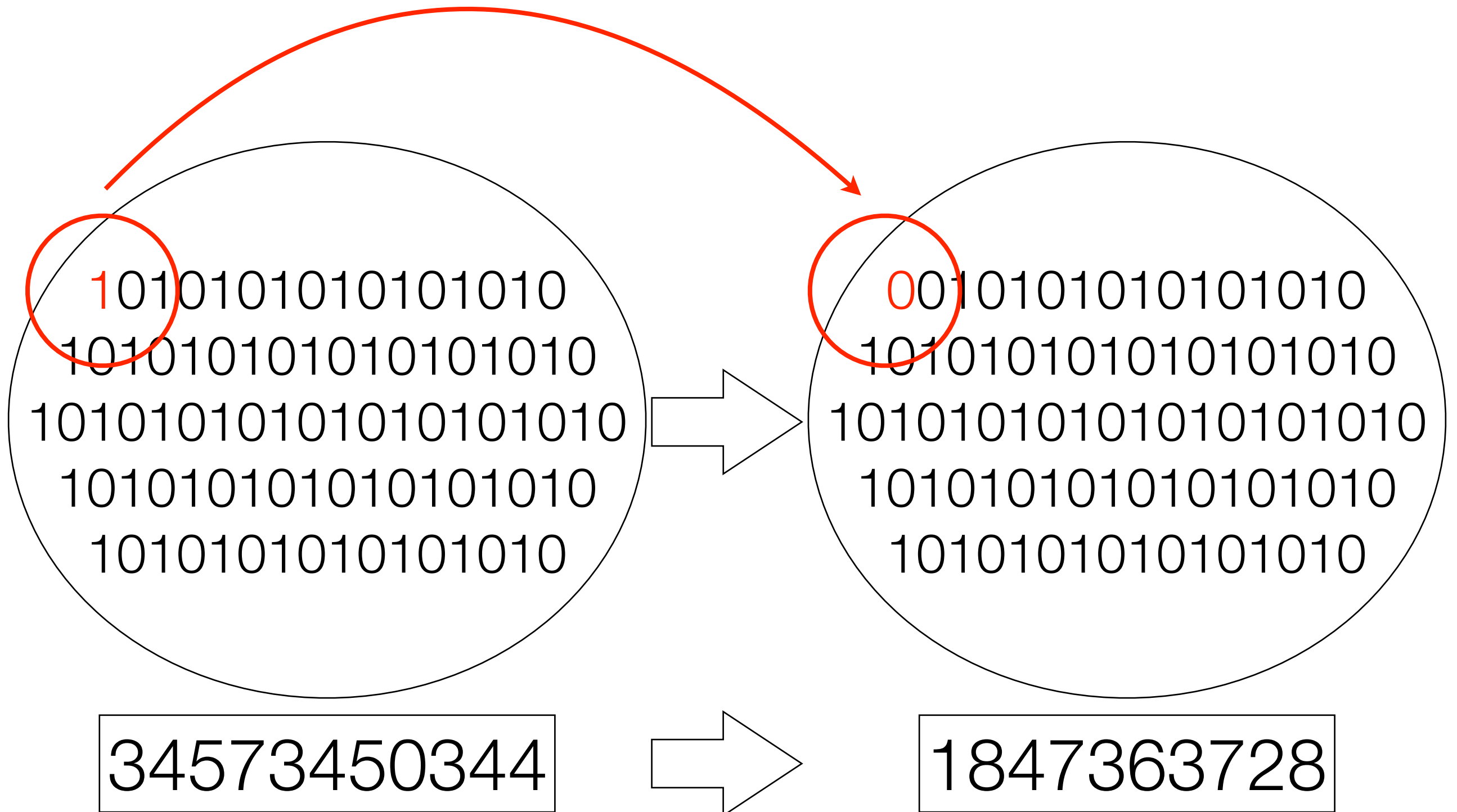
From 0 to $2^{80000000000}$

Gedankenexperiment

From 0 to Infinity!

Computation

Change from 1 to 0 and from 0 to 1



Computation is a Sequence of Natural Numbers



Infinitely Many States. Even More Computation?

States: $N = \{0, 1, 2, \dots\}$

$P(N)$ is the powerset of N , that is, the set of all subsets of N .

Computation: $P(N) = \{\{\}, \{0\}, \{1\}, \{2\}, \{0, 1\}, \{1, 2\}, \{0, 2\}, \{0, 1, 2\}, \dots\}$

“The powerset of a set N is always larger than N , even if N is infinite.”

–Georg Cantor, 1890

There is more computation than states!

This implies that there is computation that cannot be described by any state, that is, by any software!

“Any piece of software can be associated with a unique natural number.”

-Kurt Gödel, 1931

States = Software

Computation = Meaning

There is more meaning than software!

This implies that there is no software that can determine the full meaning of all other software!

There are things that cannot be computed!

But:

We can get arbitrarily close to it!

Encryption

Computer Viruses

Security

Artificial Intelligence

Software Bugs

Self-Driving Cars

Drones

...

“Denn es ist zuletzt doch nur der Geist,
der jede Technik lebendig macht.”

–Johann Wolfgang von Goethe

