

University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering

ECE 120: Introduction to Computing

Representations and Bits

Today's Random Topic: History!

MIT students created the Big Screw Award, which is given to “whoever [sic] has screwed over the most students over the past year.”

One professor taught in French to win it.

The rest of my lectures will use this code:

Good luck!

Represent One Type of Information with Another

We often represent one type of information with other patterns, physical quantities, and so forth.

examples

- English letters represented by drawn patterns
- colors represented by variations in radio signal amplitude

The **mapping from one form to another** is called a **representation**.

Follow These Simple Instructions

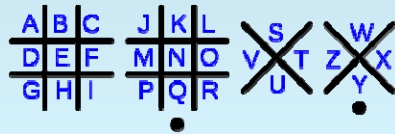
Please do so for the rest of today's lecture.

You thought I was kidding?

Knowing the Representation May Help You



The code above is called a tic-tac-toe code: each letter (information) is represented by a drawing (pattern).



What Do We Need to Make a Representation Useful?

What properties are necessary for a representation to be useful?

Hints:

- Think about the tic-tac-toe code.
- Think about algorithm properties.

First Answer: Representations Must be Well-Defined

All users must **know the translation in advance**.

Our goal is communication, not obfuscation.



Some Mappings May Not be Usable by Computers

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J |
| K | L | M | N | O | P | Q | R | S | T |
| U | V | W | X | Y | Z | | | | |

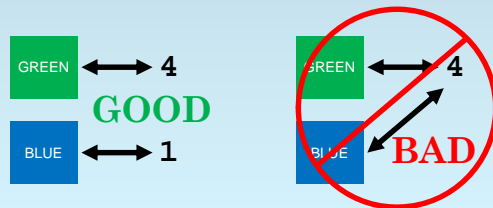
If we use 10 digits to represent 26 letters as shown above, what does “143” mean?

BED? **BOX?** **VYN?**

Computers are dumb—they cannot guess.

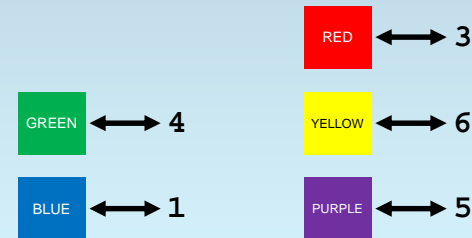
Second Answer: Representations Must be Unambiguous

Each pattern must represent **at most one thing**.



But Some Patterns May Represent Nothing

In the representation below, the digits 0, 2, 7, 8, and 9 represent no color.



Computers are Based on Electrons

In digital systems, electrons are **all we have** to represent information!

What can you ask about electrons?

How many electrons are in a certain place? (related closely to voltage)

So...

- Choose a ground: 0V by definition.
- Pick a higher voltage (called V_{dd}).



Computer Representations are Based on Binary digiT's

Now ask:

At a given physical location, what is the voltage?

Voltage near V_{dd} is a "1."

Voltage near 0V is a "0."

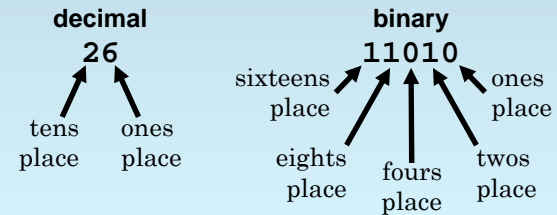
The location thus holds a binary digit, which we call a **bit**.



Physical Locations Enable Place Value

Each bit is somewhere on a computer chip.

So using positional / **place value** is natural.



Represented by What? The Answer is Always “Bits”

Remember:

- Electrons are all we have inside computers.
- No decimal, no hexadecimal, no letters, no real numbers, no colors.
- **ALL computer representations are based on bits.**



A Question for You: How Many Bits do We Need?

How many bits do we need to represent a whole number in the range...

- from **0 to 31**?
 - 32 different integers
 - so **we need 5 bits** ($2^5 = 32$ bit patterns)
- from **0 to 100**?
 - 101 different integers
 - so **we need 7 bits** ($2^7 = 128$ bit patterns)

We Need One Bit Pattern for Each Possible Thing

Trick question: How many bits do we need to represent two books?

- **The Collected Works of Shakespeare**
- **Our textbook by Patt & Patel**
 - 2 different books
 - so **we need only 1 bit!** ($2^1 = 2$ bit patterns)

What matters is the **number of things**, not what those things are.

How Many Bits Do We Need to Represent N Things?

Let's test your understanding (and generalize)!

How many bits do we need to represent...

- a whole number from **1000 to 1100**?
101 different integers, so **7 bits** ($2^7 = 128$)
- one of **199 flavors of ice cream**?
199 different flavors, so **8 bits** ($2^8 = 256$)
- **a living person**?
7-8 billion people, so **33 bits** ($2^{33} > 8$ billion)
- **N things**?
 $\lceil \log_2 N \rceil$ (ceiling / integer at least as large as
log base 2 of **N**)

Today's Not-so-Random Topics

- Layers in a Computer System
- Representations and Bits
- Integer Representations