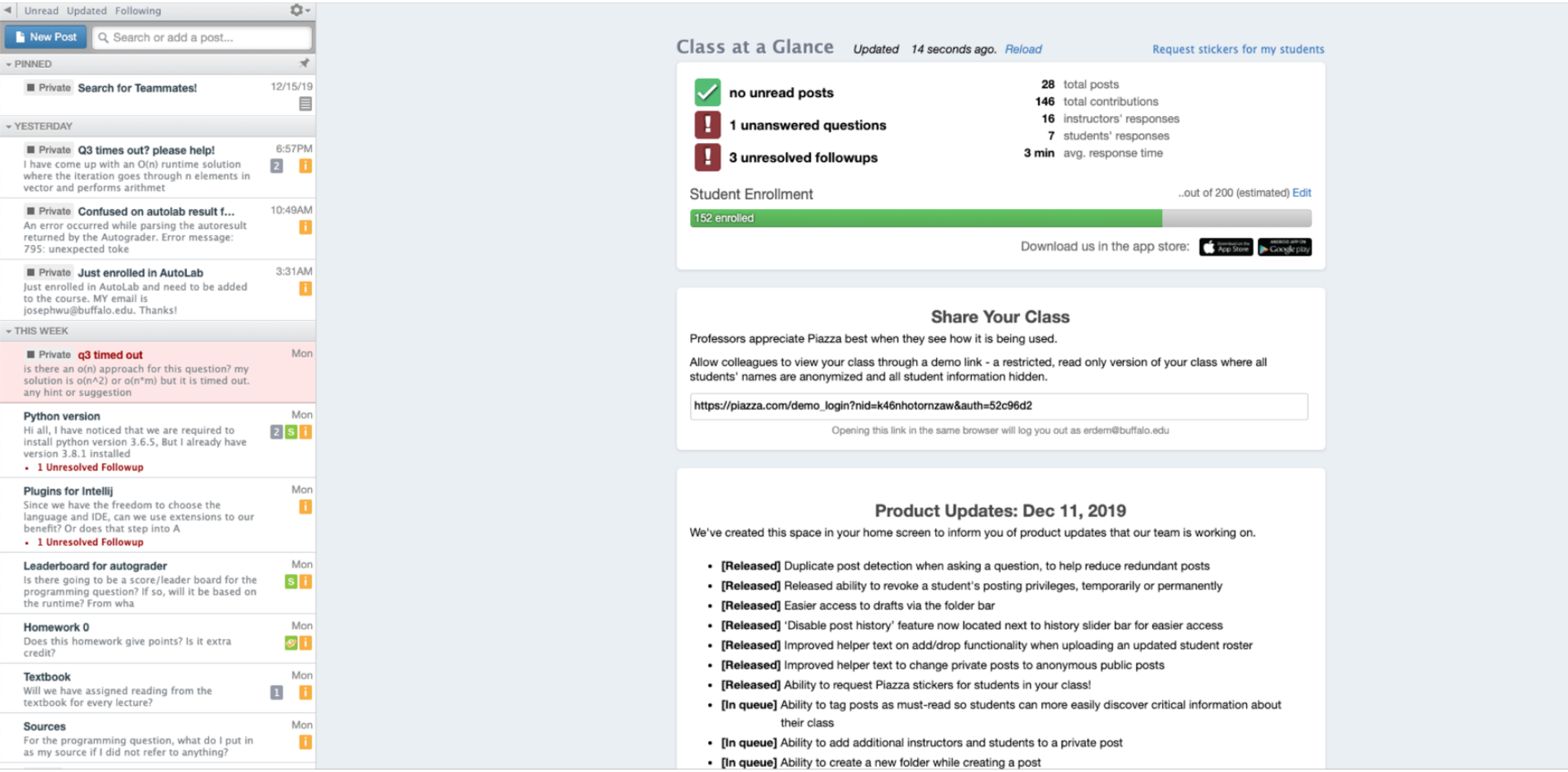
Lecture 2

CSE 331

Jan 29, 2020

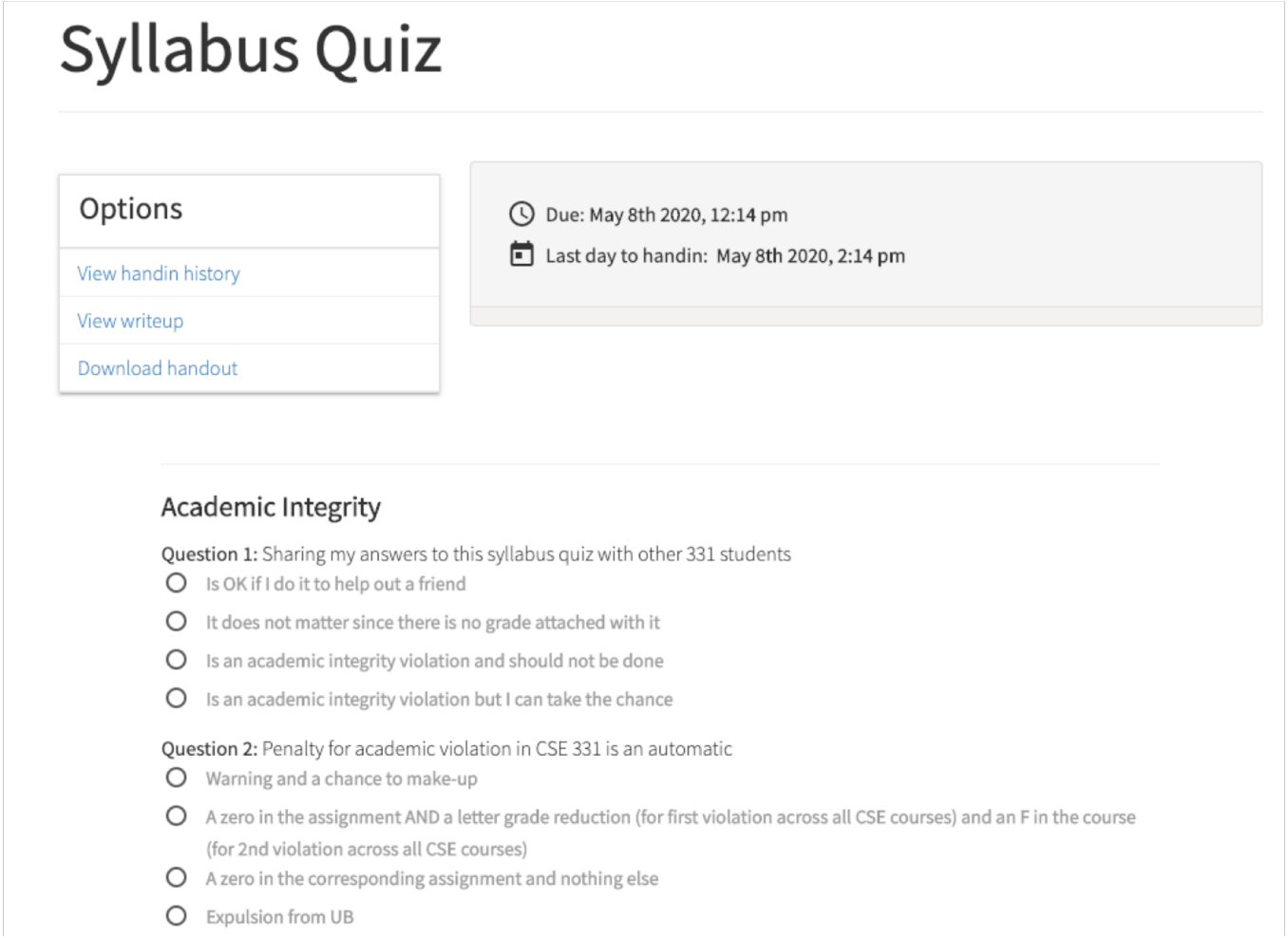
Enroll on Piazza



https://piazza.com/buffalo/spring2020/cse331

Read the syllabus CAREFULLY!

No graded material will be handed back till you pass the syllabus quiz!
Only 70 of you (out of 150) completed!



You can submit the following now

CSE331: Algorithms and Complexity (s20)

Assignments

Homework 0

- Q1 part (a) [Number of perfect matchings]
- Q1 part (b)
- Q3 (Structured Matrix Vector Multiplication)

Quizzes

- Syllabus Quiz

You should be on Autolab now

Allowed Sources

Allowed sources

You can **ONLY** use the following sources for reference once you start working on the homework problems:

1. **the Kleinberg-Tardos textbook,**

> ### Other textbooks are not allowed
> While you can use other textbooks (e.g. those listed in the syllabus) to better understand the lecture material, you **cannot** use them once you start working on the homeworks.

2. **any material linked from this webpage or the CSE 331 piazza page (including any discussion in the Q&A section),**

> ### One-click rule
> When using webpages that are allowed as sources, you **cannot** click on link on that source. (Otherwise within a constant number of clicks one can reach any webpage one wants.)

3. **specific *mathematical* result from a previous course,**
4. **anything discussed in the lectures, recitations and/or office hours** and
5. **any notes that you might have taken during class or recitation.**

> ### Everything else is not allowed
> Note that the above list covers all the allowed sources and **everything else is not allowed.** In particular, *YOU ARE NOT SUPPOSED TO SEARCH FOR SOLUTIONS ON THE*

… even for programming Q

CSE 331 Syllabus Piazza Schedule Homeworks Autolab Mini Project Support Pages Youtube channel

- All discussions and posts on piazza.

Basic programming references

C++ Sources

- cppreference.com (and all pages within the website).

Java Sources

- Oracle Java Documentation (and all pages within the website).

Python Sources

- Python 3.5.2 documentation (and all pages within the website).

Asymptotic Analysis

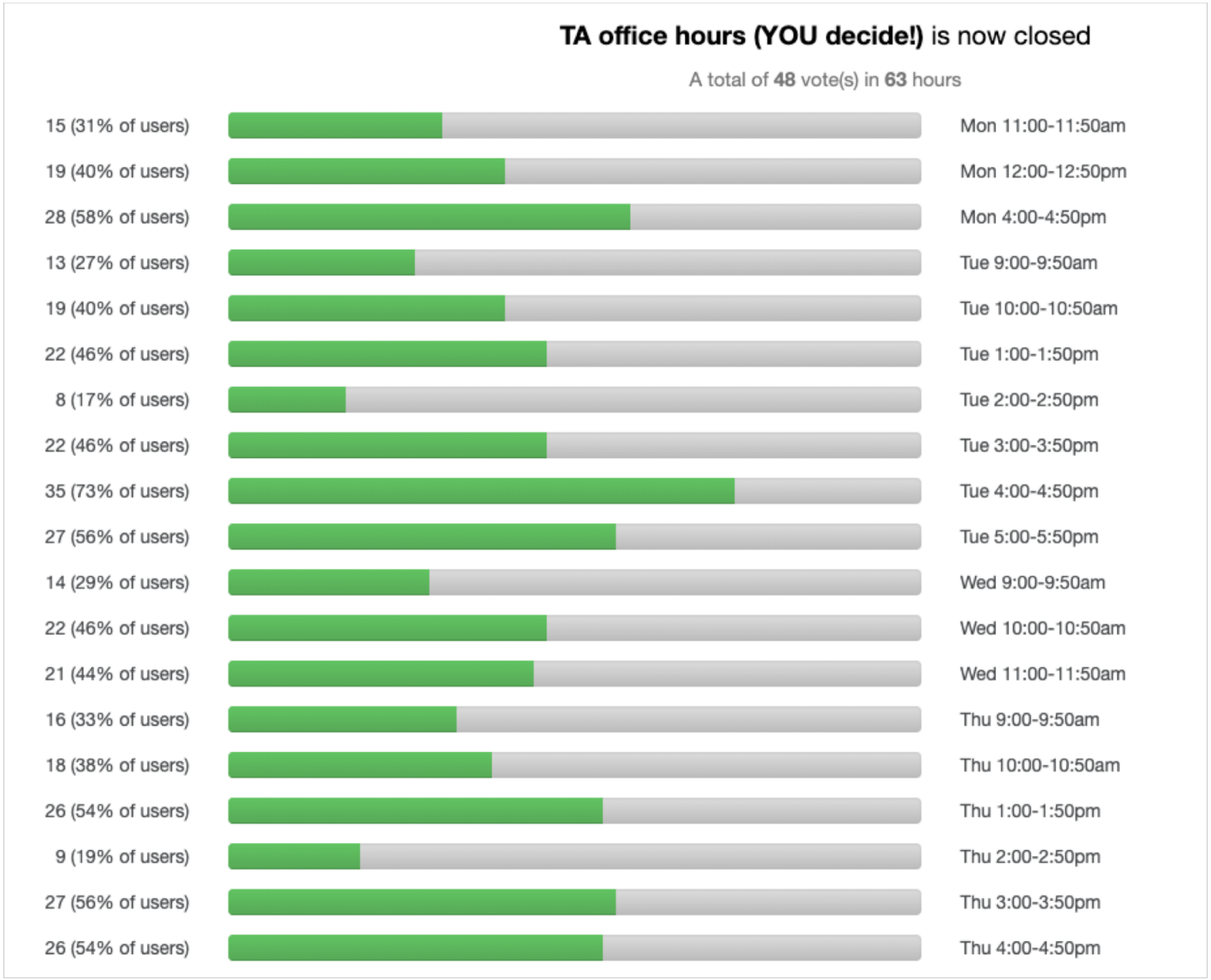
- Big-O cheat sheet.

Wikipedia Pages

Below are some approved Wikipedia pages (in addition to those that are already linked to in other pages in the CSE 331 Fall 2018 web page.

- Gale Shapley algorithm.
- DFS.
- Dijkstra's Algorithm.
- Prim's algorithm

TA Office hours finalized today



My Office hours finalized today

~~Mon 3:00-3:50 and Wed 3:00-3:50~~

Mon 4:00-4:50 and Wed 3:00-3:50

(or by appointment iff you cannot make either)

Why do proofs?

Makes you think logically about problems and solutions

From an engineer who works on Google Maps:

> Proving that the algorithm I am implementing is correct helps me identify corner cases

CSE 331 Support Pages

Why should we do proofs?

We will focus a lot on proofs in CSE 331. In this document I will motivate why doing proofs is good even though you might not do proofs for a living. While doing this, we will also go through examples of how to write algorithm ideas and details as well as proof ideas and details (which you will need to write in your homework solutions).

Some reasons to do proofs

In this section, I will lay out some reasons why I think it is beneficial for you guys to do proofs. The first two are probably more along the lines of "if you do proofs for a living" situation. The rest of the reasons should be valid for all of you. I will try and make the reasons as concrete as possible: in the next section, we will consider algorithms for the specific problem of generating all permutations (recall that we previously had punted on designing an algorithm for this problem).

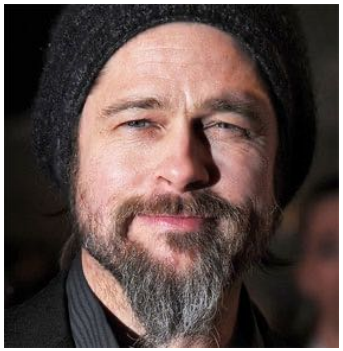
Sometimes you might not have a choice

One of the easiest way to verify an algorithm idea you have is to code up the algorithm and then test it on some (say random) inputs. However, sometimes this might not be a choice. E.g. if you work on Quantum Computing, then you do not have a quantum computer to run your quantum code on! So currently pretty much the only choice you have is to *prove* that your algorithm is indeed correct. For example, one of the crowning achievements of quantum computing is Shor's algorithm to computes the factors of large numbers efficiently on a quantum computer (that recall does not exist yet!). (You might also want to read Scott Aaronson's high level description of Shor's algorithm.) The reason why factoring large numbers is important is that if one can solve this problem efficiently then one can break the RSA cryptosystem. RSA is used everywhere (e.g. when you use your credit card online, RSA is used to make the transaction secure), so this is a big deal.

https://cse.buffalo.edu/~erdem/cse331/support/proofs/index.html

A more subtle incorrect “proof”

Brad Pitt had a beard



waleg.com

Every goat has a beard

animaldiversity.org

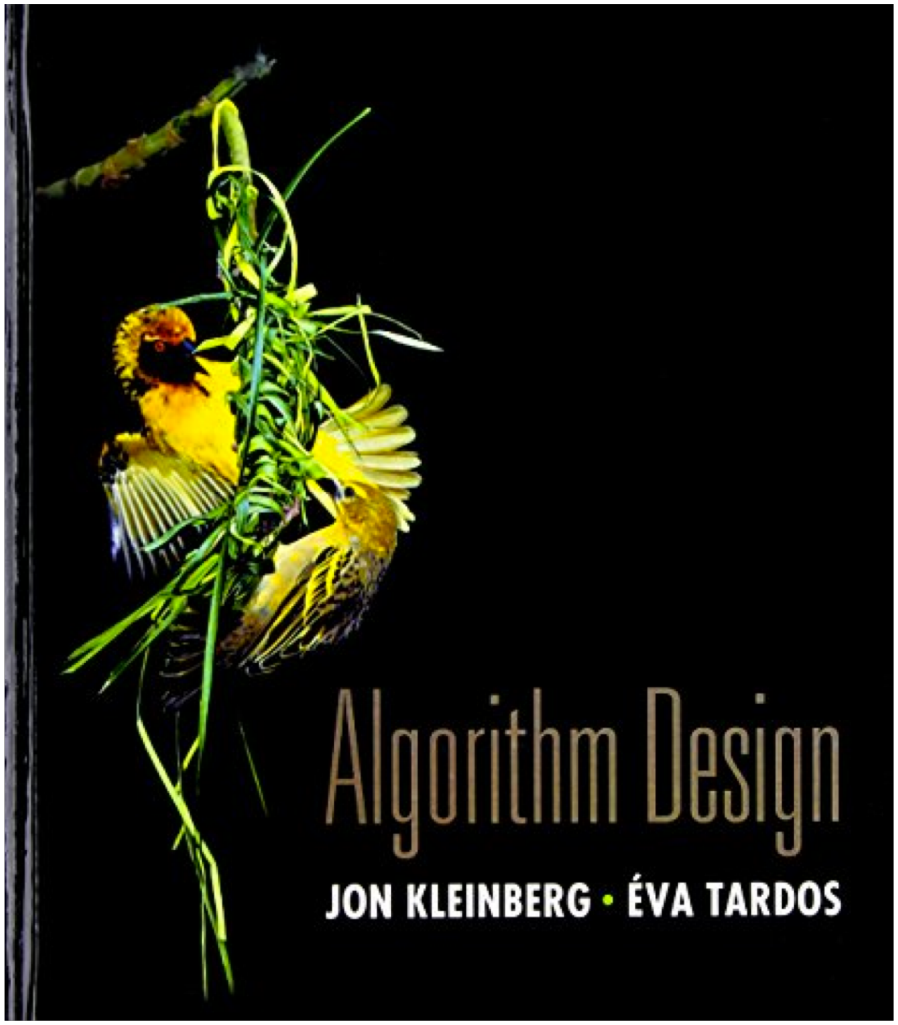
Hence, Brad Pitt is a goat.

More chances to recover

Lowest three HW scores will be dropped

If you do better on the final exam than the mid-term exam then only final exam score will count

Follow the Textbook



CSE 331 Syllabus Piazza Schedule Homeworks Autolab Mini Project Support Pages Sample Exams

CSE 331 Support Page

This page contains certain webpages that students taking CSE 331 might find useful.

The material is roughly divided into two parts: one on (primarily mathematical) background material and one of common mistakes that students generally make.

Disclaimer

Please note that this material is intended as a support material. It is not meant as a replacement for actually having taken background courses like CSE 116, 191 or 250 nor is this meant to be exhaustive. I'll try my best to make these as comprehensive as possible but that might take some time.

Background material

CSE 331 will need a fair bit of math: most of which you must have seen earlier. However, if you have not used those material for a bit then you might be a bit rusty. The pages linked below are some notes that I wrote up that might help you refresh the material that you might have seen in CSE 116, 191 or 250. Also some of the pages are meant to motivate why we do some things a certain way in CSE 331. Finally sometimes (but not often!) we will use material that might not have been covered in previous courses and we did not have much time to cover in class: these pages will fill in those gaps.

Common Mistakes

Here we collect some common mistakes that students make in CSE 331 material (and sometimes more than once). The hope is to list these common pitfalls so that you can avoid them!

Other Resources

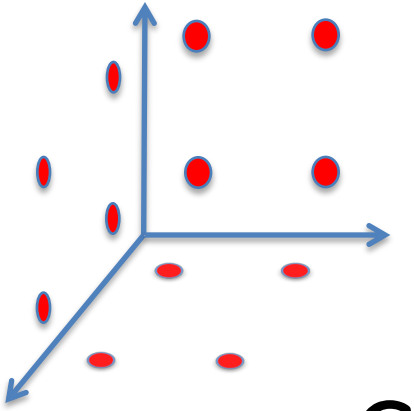
Below we collect other 331 related material that do not neatly fall into the two left category:

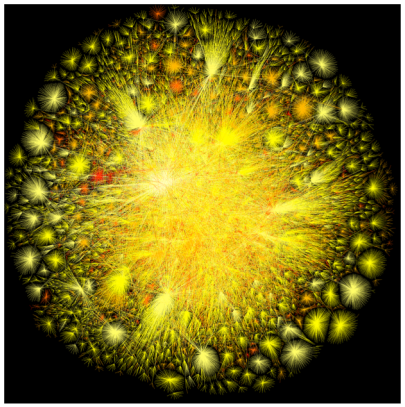
- Visualizing Algorithms.
- Algorithms via Examples.

https://cse.buffalo.edu/~erdem/cse331/support/index.html

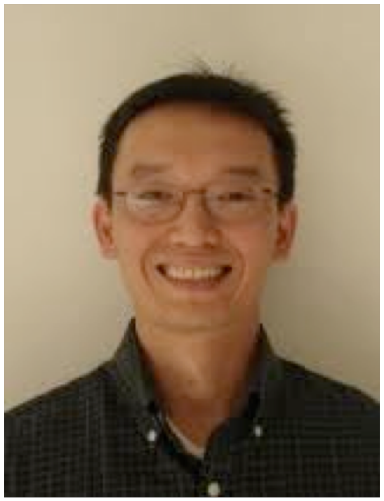
Questions/Comments?

Why should I care ?





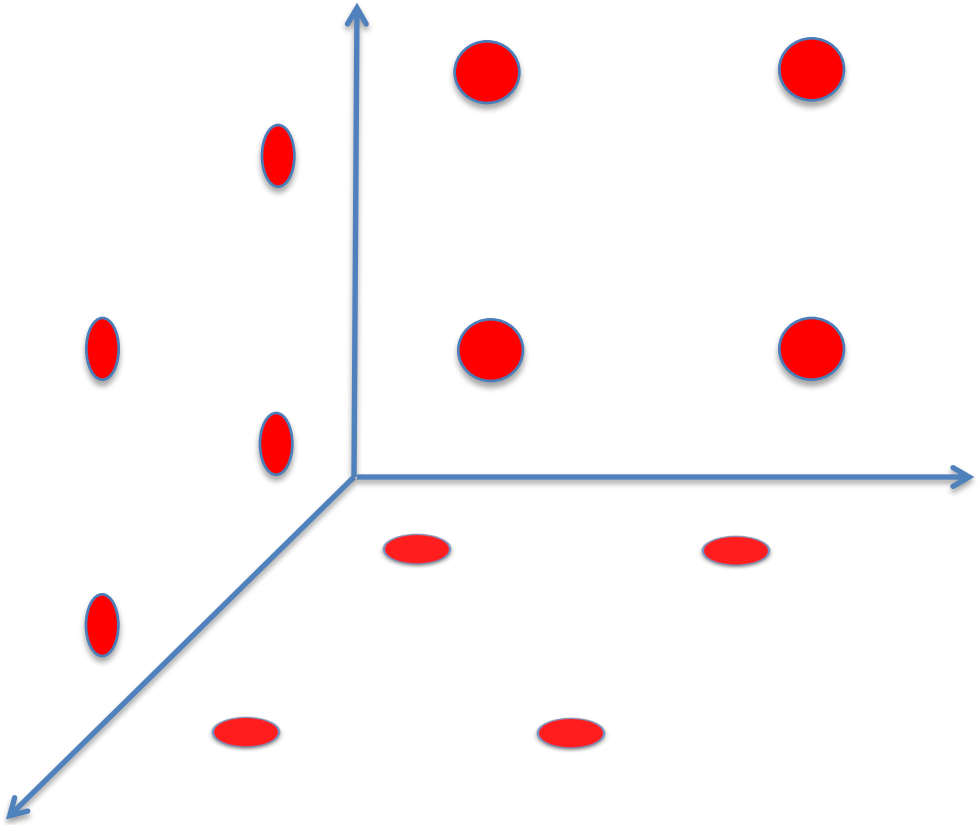
Combining Shadows to Understanding the network



LogicBlox

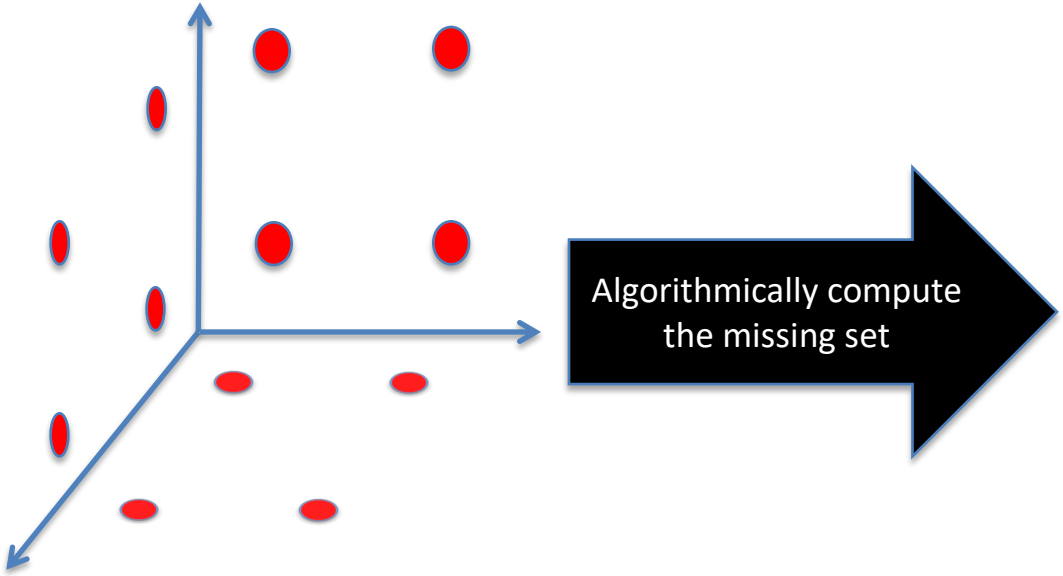
Stanford University

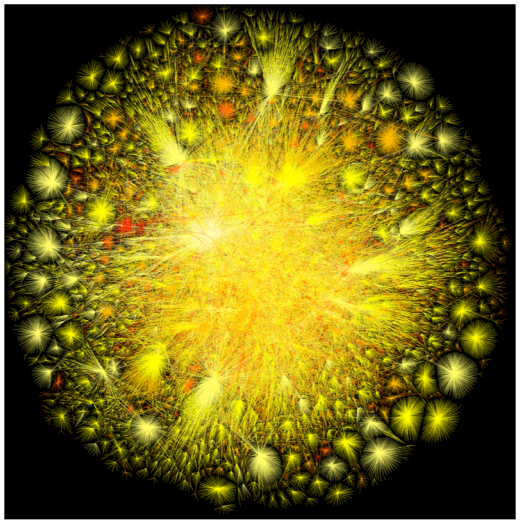
The key technical problem

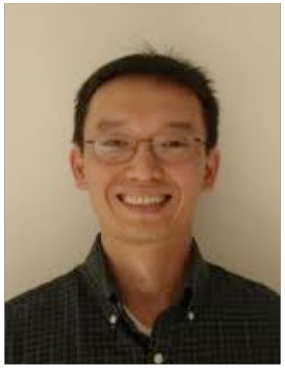


Given the three projections, what is the largest size of the original set of points?

Conquering Shadows to Conquering the Internet







The proof is in the performance

EMPTYHEADED

10x faster

ORACLE

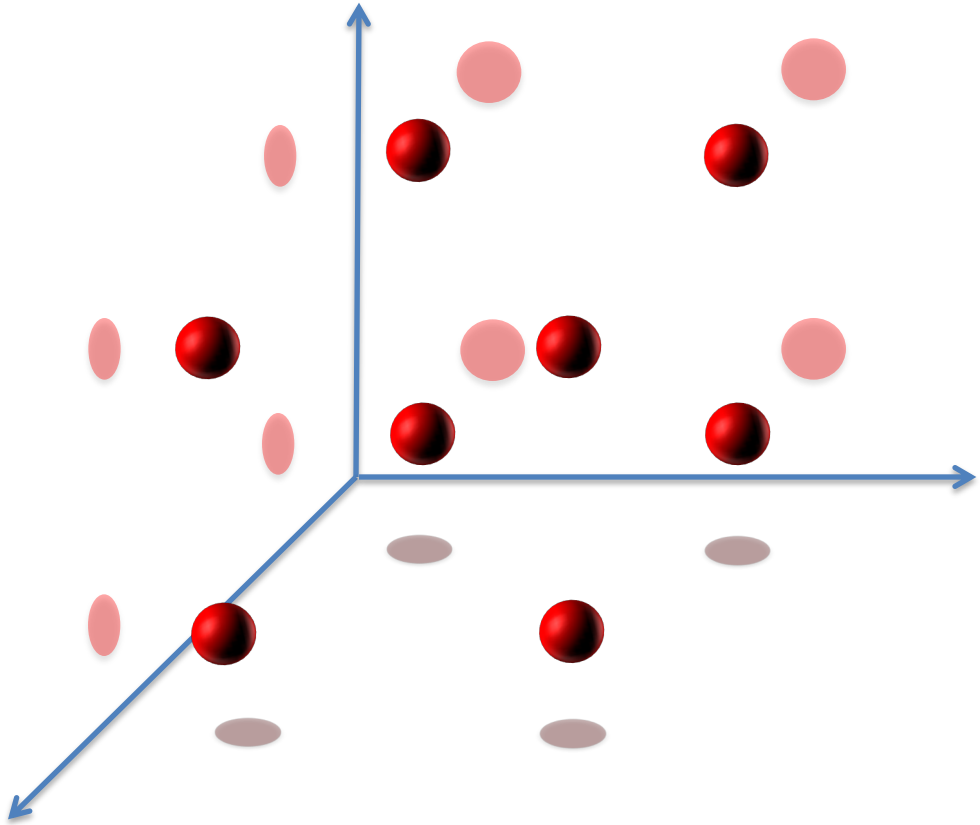
Dato GraphLab

LogicBlox

SNAP

Better algorithm with little hacking will beat a worse algorithm with tons of hacking

The key technical problem



Highly trivial: $4^3 = 64$

Still trivial: $4^2 = 16$

Correct answer: $4^{1.5} = 8$

From someone who got a Google job

“You can let your algorithms class know that the phone interviews are essentially like **a difficult algorithms test**.

Lots of data structures, specifying the algorithm, analyzing the run time and space requirements... And all on the phone and **you're supposed to talk through your thought process**.”

Coding jobs will be done by AI

stack**sort**

In a recent xkcd's alt text, Randall Munroe suggested **stacksort**, a sort that searches StackOverflow for sorting functions and runs them until it returns the correct answer. So, I made it. If you like running arbitrary code in your browser, try it out.

Like (or hate) it? Comment on HackerNews

stackoverflow_sort(
Try a list of numbers, a string, a list of words or json.

[8,6,7,5,3,0,9]

);

Sort

var output =
Output from the function.

;

output console

Coding jobs will be done by AI

MIT News
ON CAMPUS AND AROUND THE WORLD

Browse or Search

FULL SCREEN

Researchers have developed a flexible way of combining deep learning and symbolic reasoning to teach computers to write short computer programs. Here, Armando Solar-Lezama (left), a professor at CSAIL, speaks with graduate student Maxwell Nye.

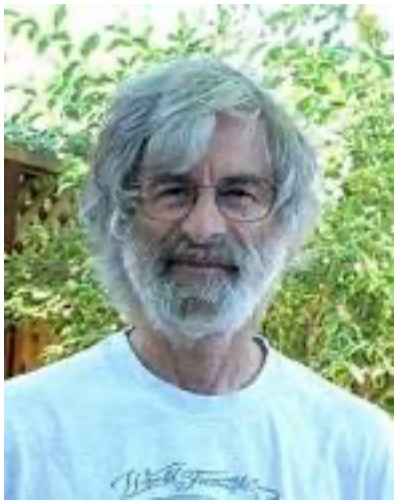
Photo: Kim Martineau

Toward artificial intelligence that learns to write code

Researchers combine deep learning and symbolic reasoning for a more flexible way

So am I doomed?

There will still be room for high level *algorithmic* thinking!



European Association for Theoretical Computer Science

HOME ABOUT SEARCH CURRENT ARCHIVES

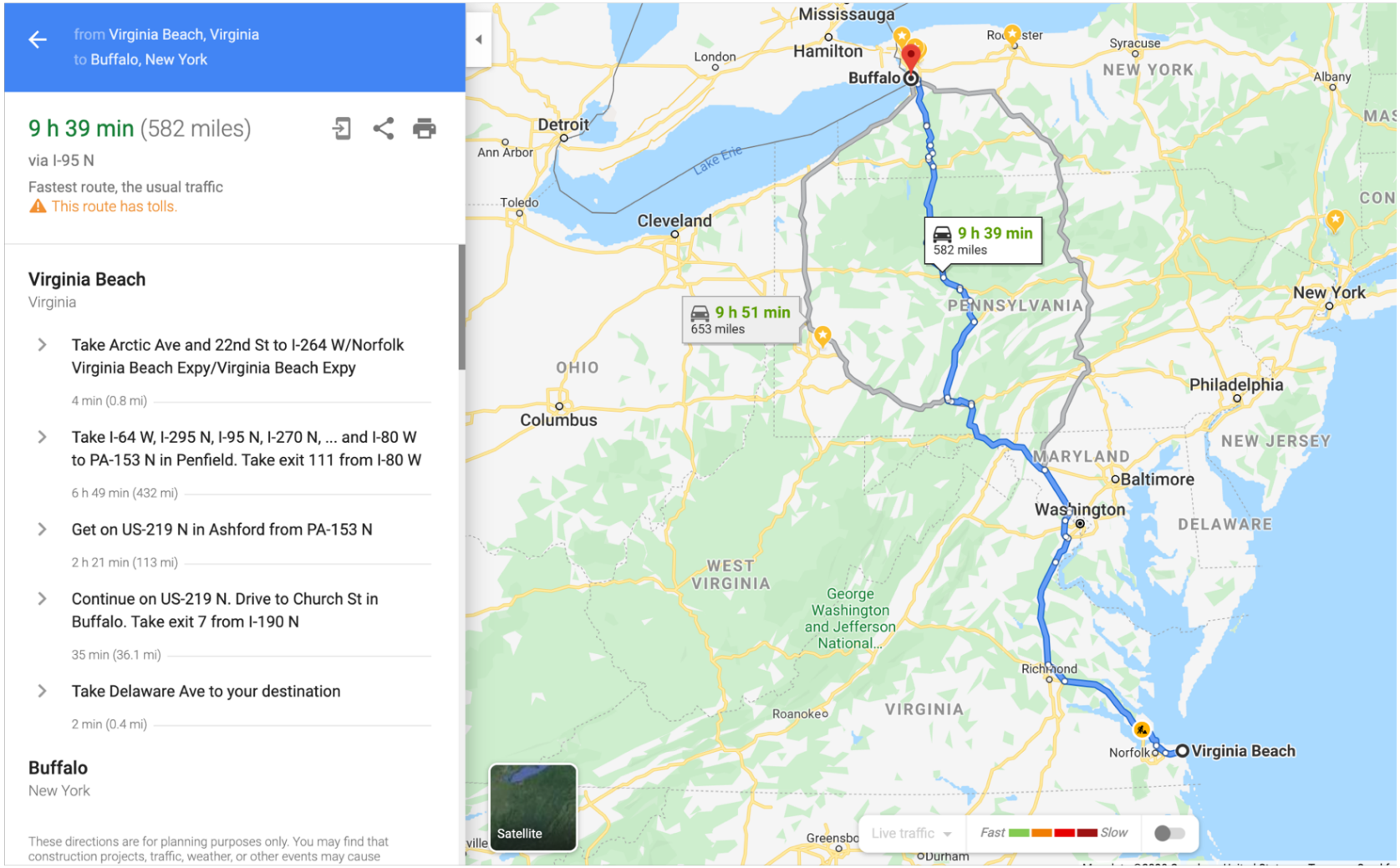
Home > No 125: June 2018 > **Lamport**

If You're Not Writing a Program, Don't Use a Programming Language

Leslie Lamport, Distributed Computing & Education Column by Juraj Hromkovic, Stefan Schmid

Today, programming is generally equated with coding. It's hard to convince students who want to write code that they should learn to think mathematically, above the code level, about what they're doing. Perhaps the following observation will give them pause. ***It's quite likely that during their lifetime, machine learning will completely change the nature of programming. The programming languages they are now using will seem as quaint as Cobol, and the coding skills they are learning will be of little use. But mathematics will remain the queen of science, and the ability to think mathematically will always be useful.***

Why care about algorithms?



Driving directions

Why care about algorithms?

‹ Any Department
‹ Electronics
‹ Camera & Photo
Video
Body Mounted Cameras
Camcorder Accessories
Camcorder Bundles
Camcorder Lenses
Camcorders
Camera Supports & Stabilizers
Lighting
Professional Video Accessories
Professional Video Cameras
Quadcopters & Accessories
Sports & Action Video Cameras
Video Studio

ZARBEE'S NATURALS
Effective and drug-free melatonin promotes a peaceful sleep*

Best Sellers in Camcorders

#1

Video Camera Camcorder Digital YouTube Vlogging Camera Recorder kicteck Full HD 1080P...
★★★★½ 1,601
$63.99 ✓prime

#2

Video Camera Camcorder with Microphone YouTube Camera Recorder 2.7K Ultra HD 20FPS...
★★★★½ 119
$75.99 ✓prime

#3

GoPro Hero5 Session (Renewed)
★★★★☆ 241
$139.99 ✓prime

#4

Canon Video 1960C002 Canon VIXIA HF R800 Camcorder (Black)
★★★★½ 428

#5

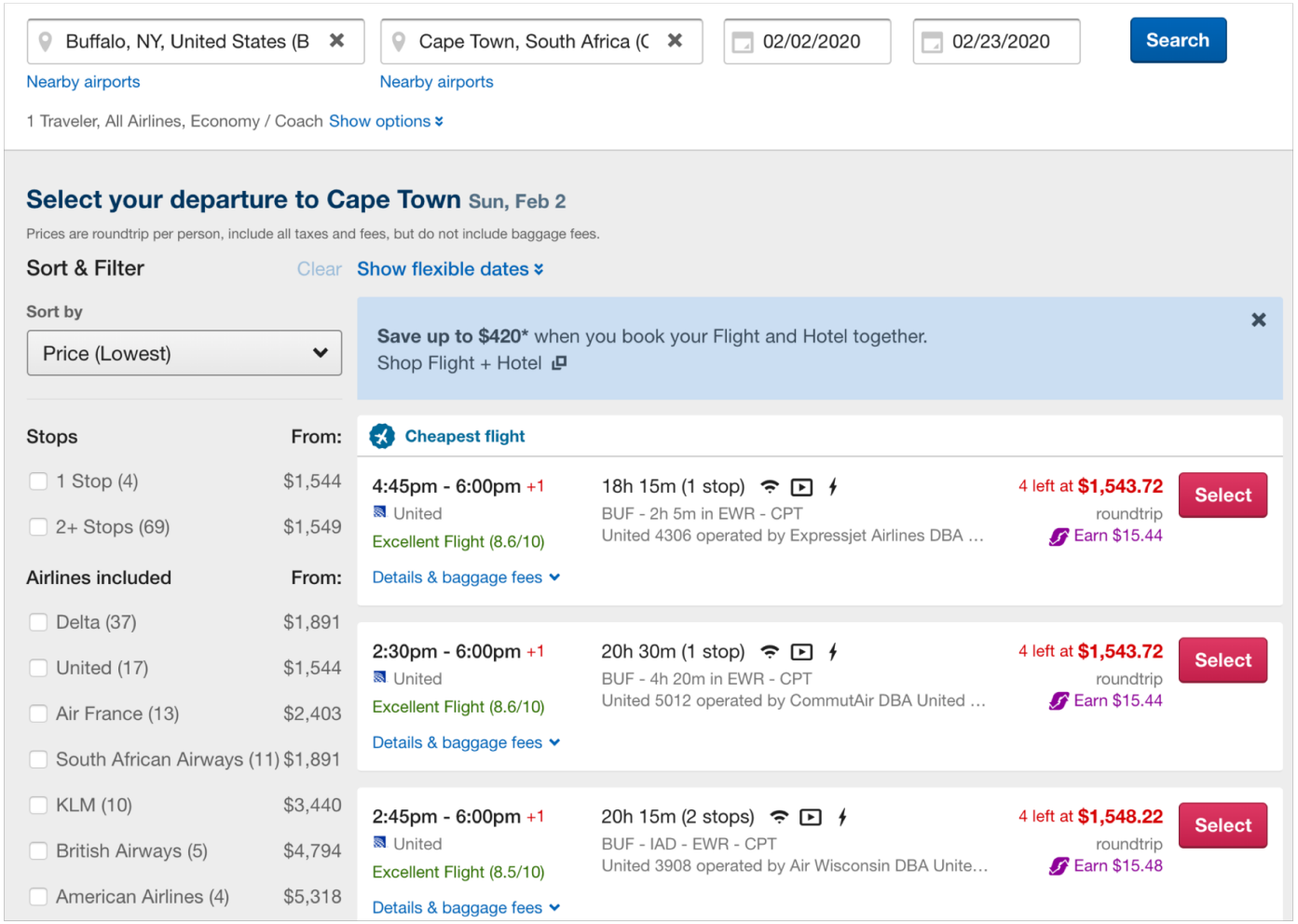
Video Camera Camcorder Full HD 1080P 30FPS 24.0 MP IR Night Vision Vlogging Camera...
★★★★½ 197

#6

Video Camera Camcorder Vlogging Camera for Youtube Full HD 2.7K 30FPS 30 MP IR Night...
★★★★½ 214

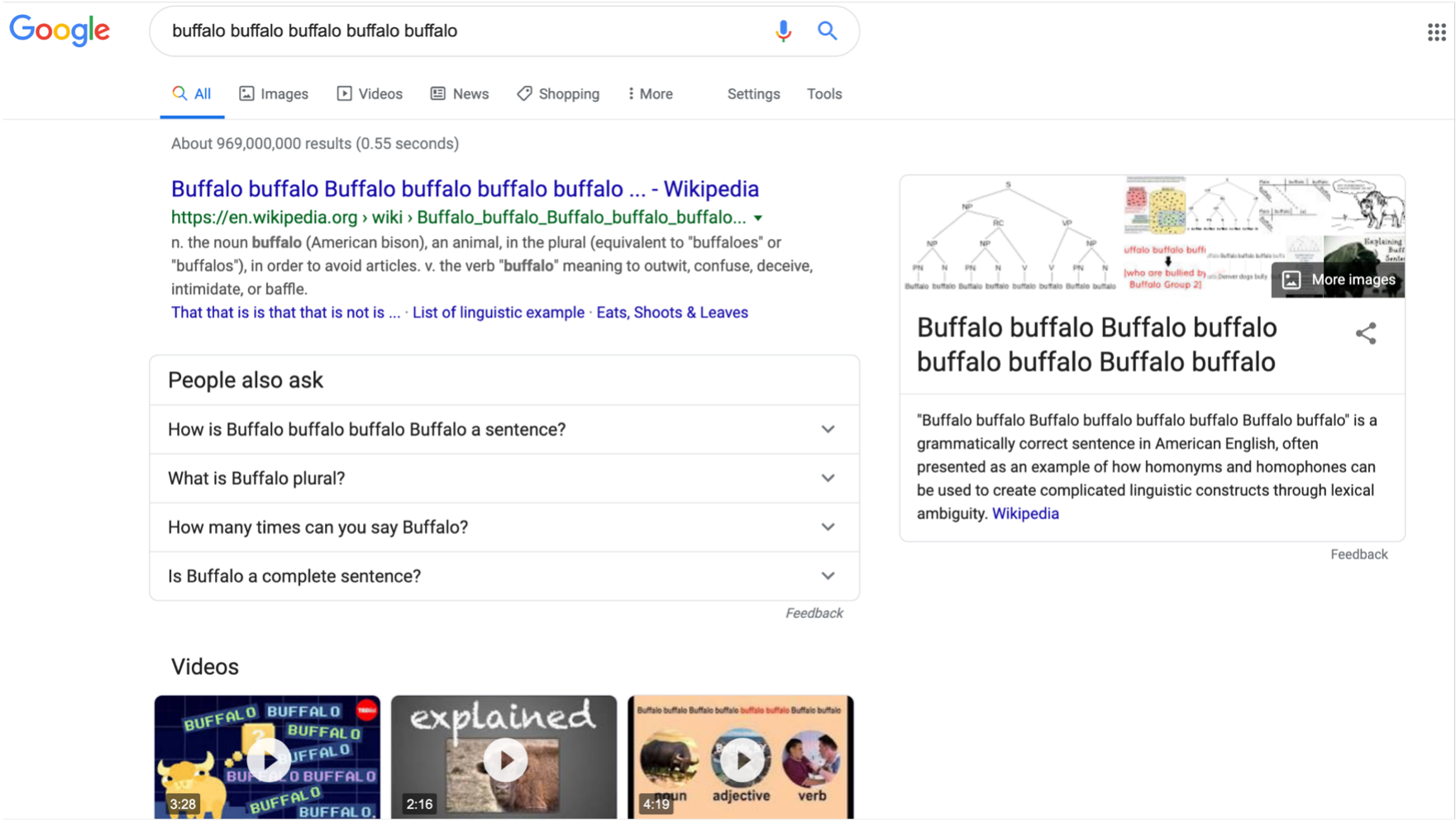
Computing Bestsellers on the fly

Why care about algorithms?



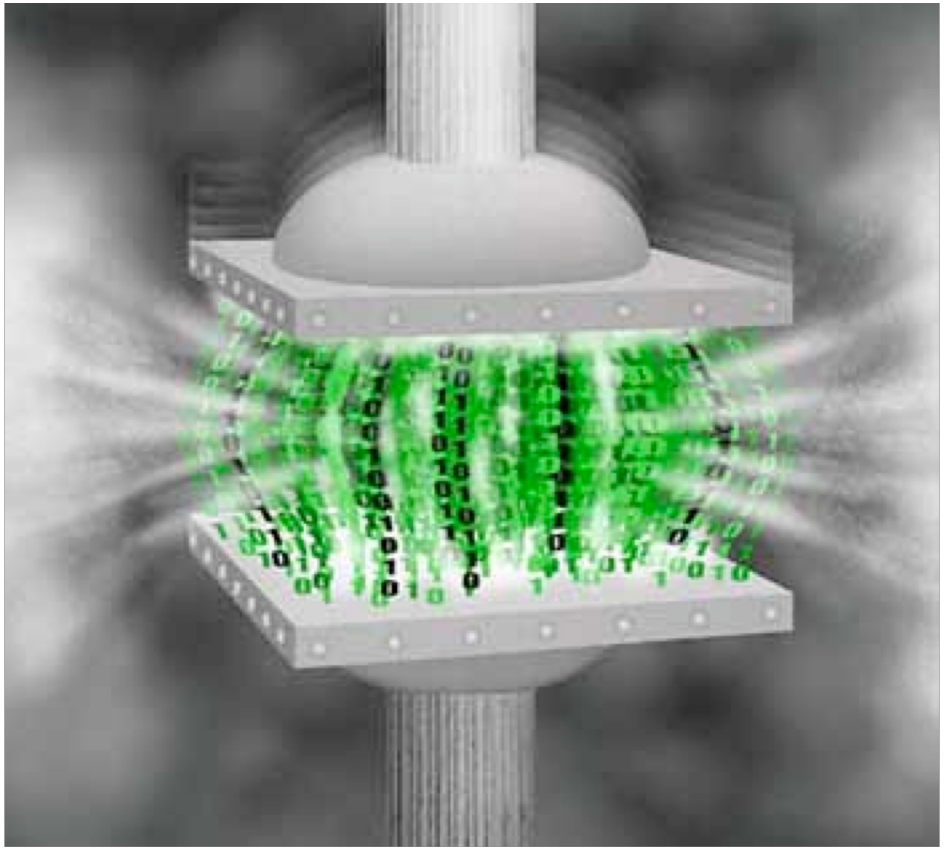
Booking cheapest air tickets

Why care about algorithms?



Google searches

Why care about algorithms?



http://www.di.ens.fr/~cherniav/teaching.html

Data compression

(And I could) go on…

Find out for yourself

Mini project: Video on ethical impacts of algorithm. Groups of size = 3

CSE 331 Mini Project

Spring 2020

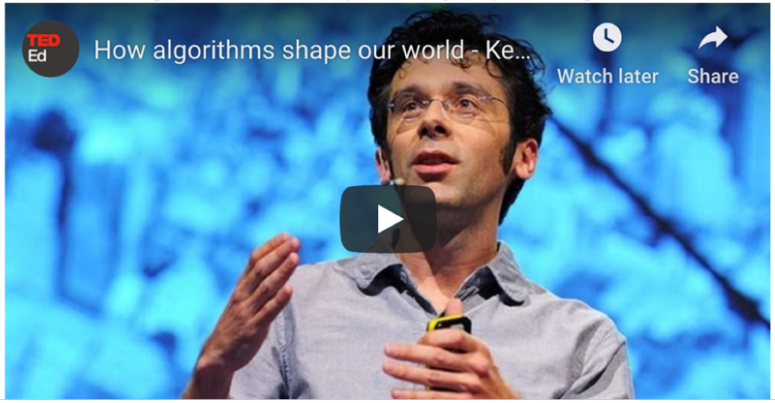
Details and motivations for the mini project.

Motivation

CSE 331 is primarily concerned with the technical aspects of algorithms: how to design them and then how to analyze their correctness and runtime. However, algorithms are pervasive in our world and is common place in many aspects of society. The main aim of the mini-project is to have you explore in some depth social implications of algorithms.

Just to give two examples for such implications:

- Algorithms are pervasive in financial transactions and these algorithms have consequences beyond just trading:



Questions/Comments?

Let the fun begin!

Who is Algorithm named after?

Abū ʿAbd Allāh Muhammad ibn Mūsā al-Khwārizmī

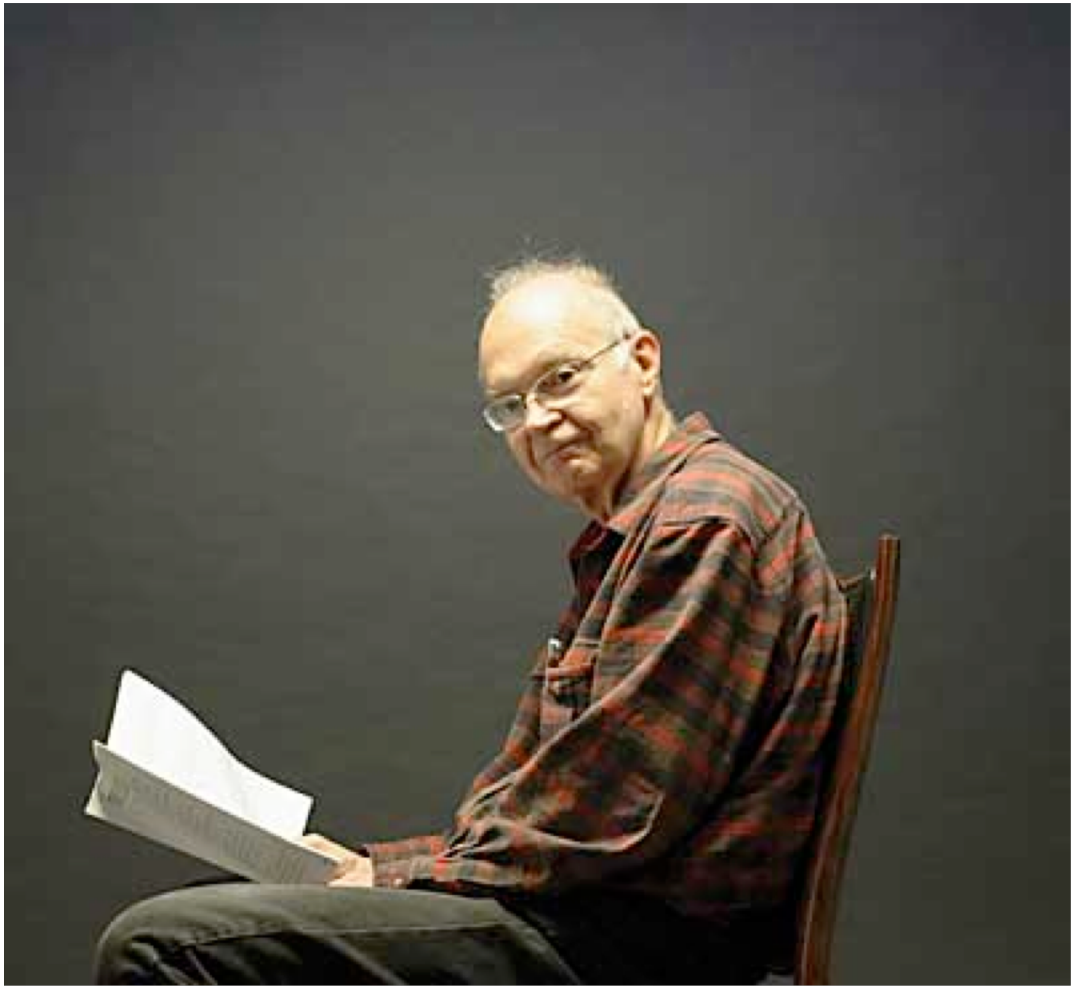
9th century Persian astronomer/mathematician

825 AD: “On Calculation with Arabic Numerals”

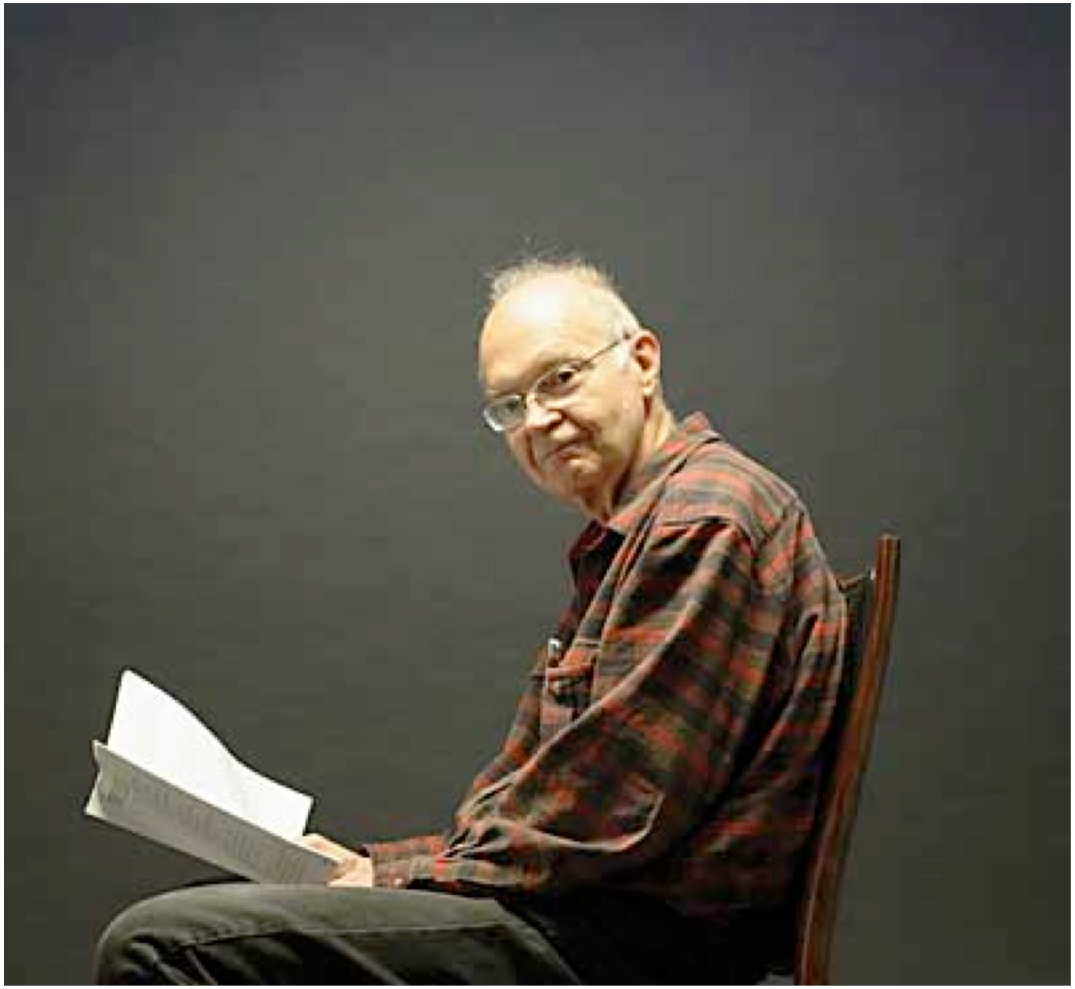
Latin translation 12th century

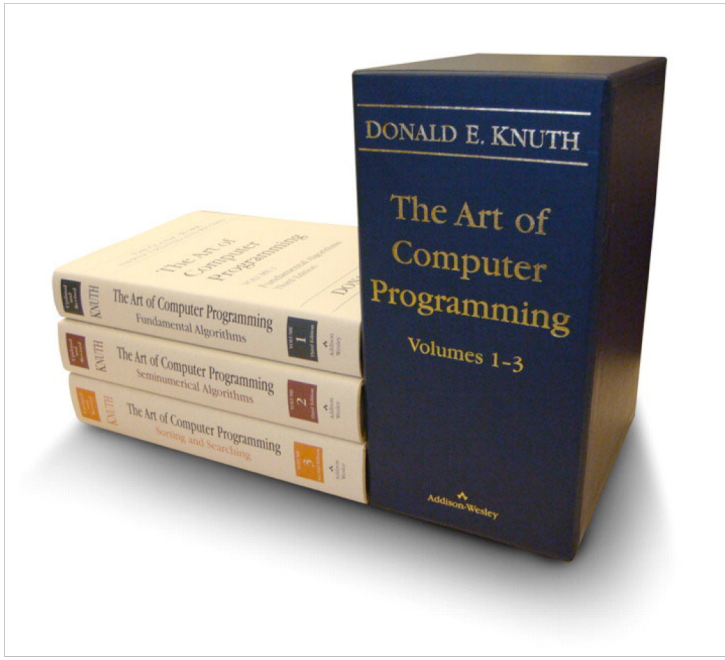
“Algorithmi de numero Indorum”

What are Algorithms?

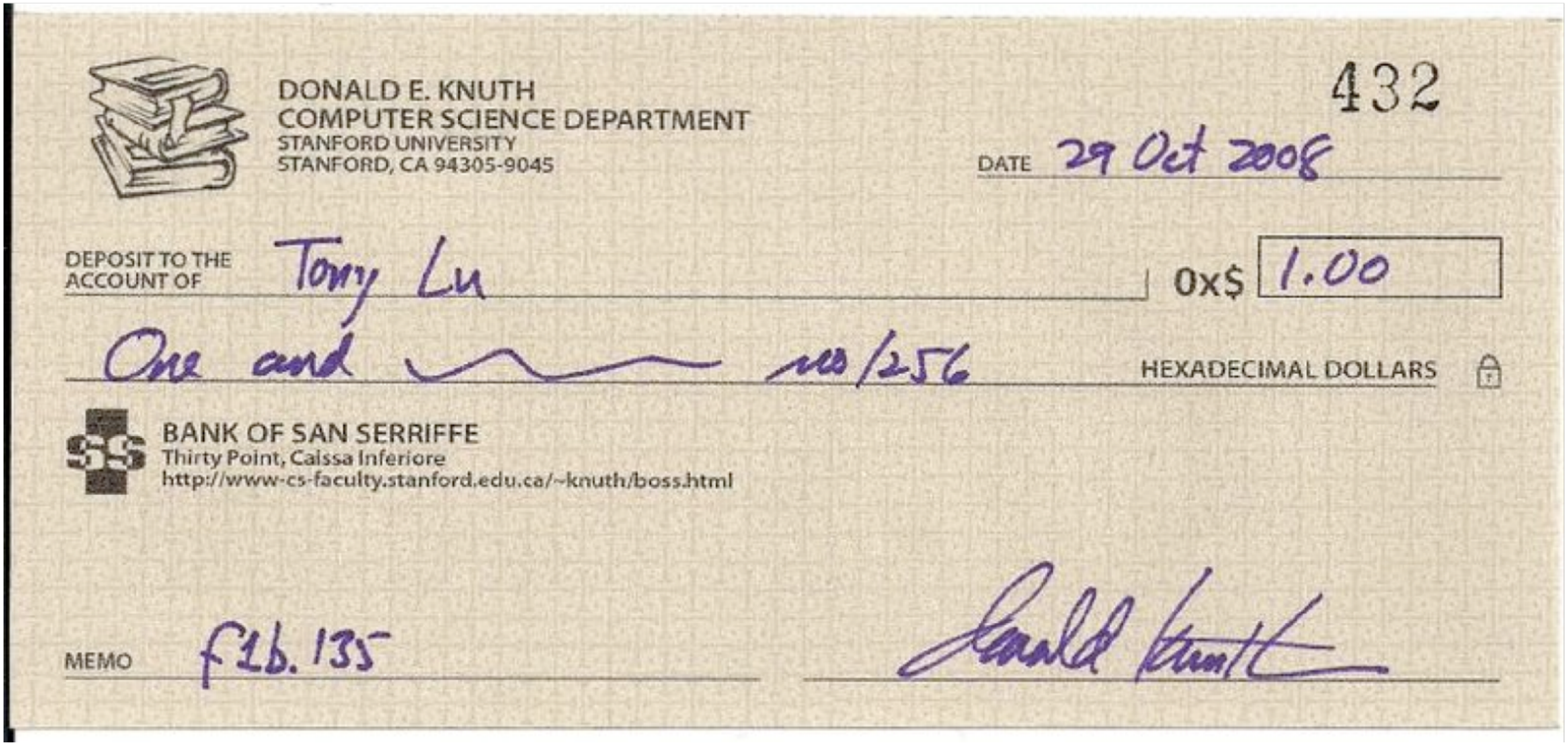


Don Knuth




DONALD E. KNUTH
The Art of Computer Programming
Volumes 1-3
The Art of Computer Programming
Fundamental Algorithms
The Art of Computer Programming
Seminumerical Algorithms
The Art of Computer Programming
Sorting and Searching
Addison-Wesley

Don Knuth Reward Checks

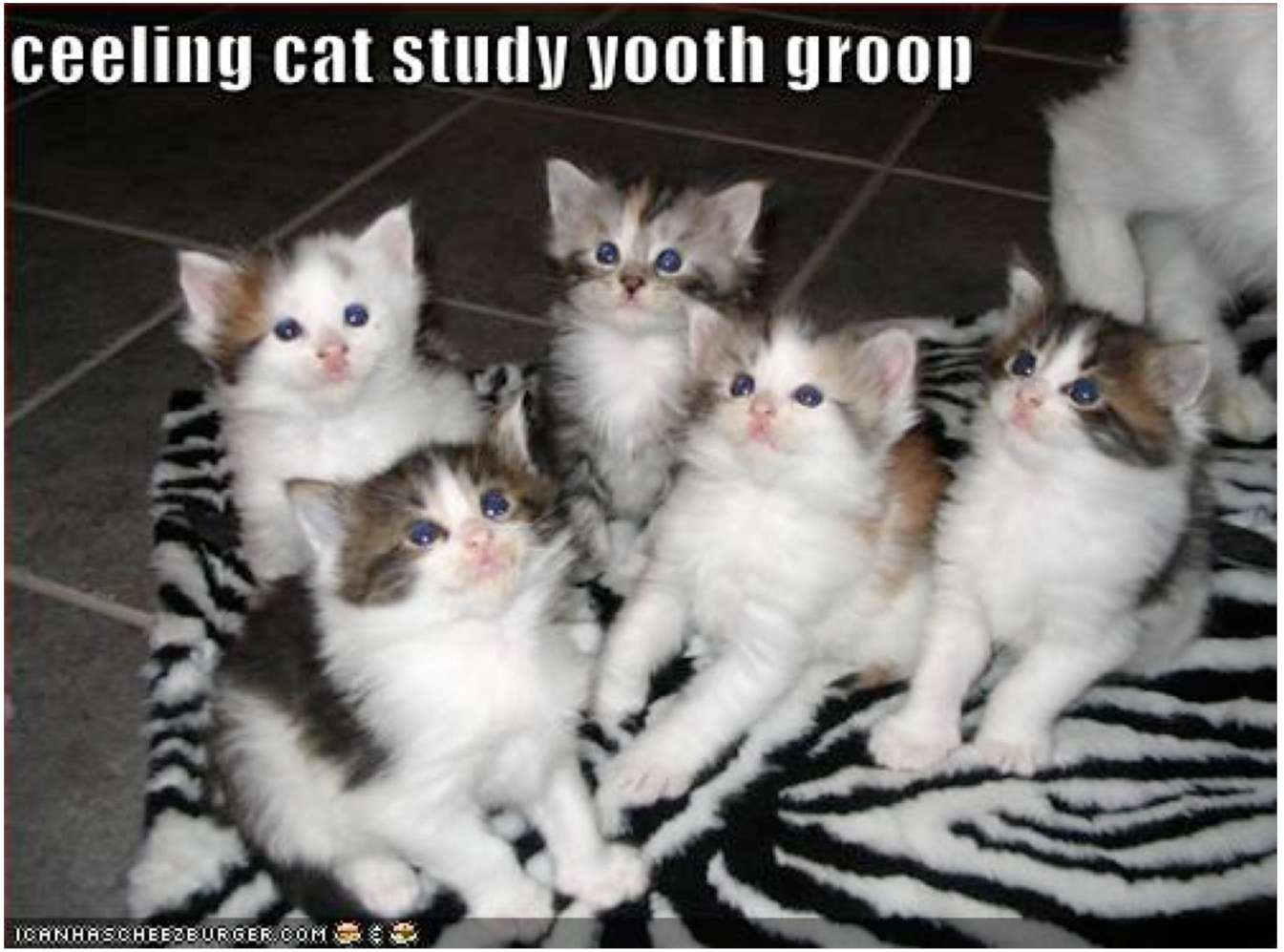


http://www.flickr.com/photos/32184482@N03/3010989157/

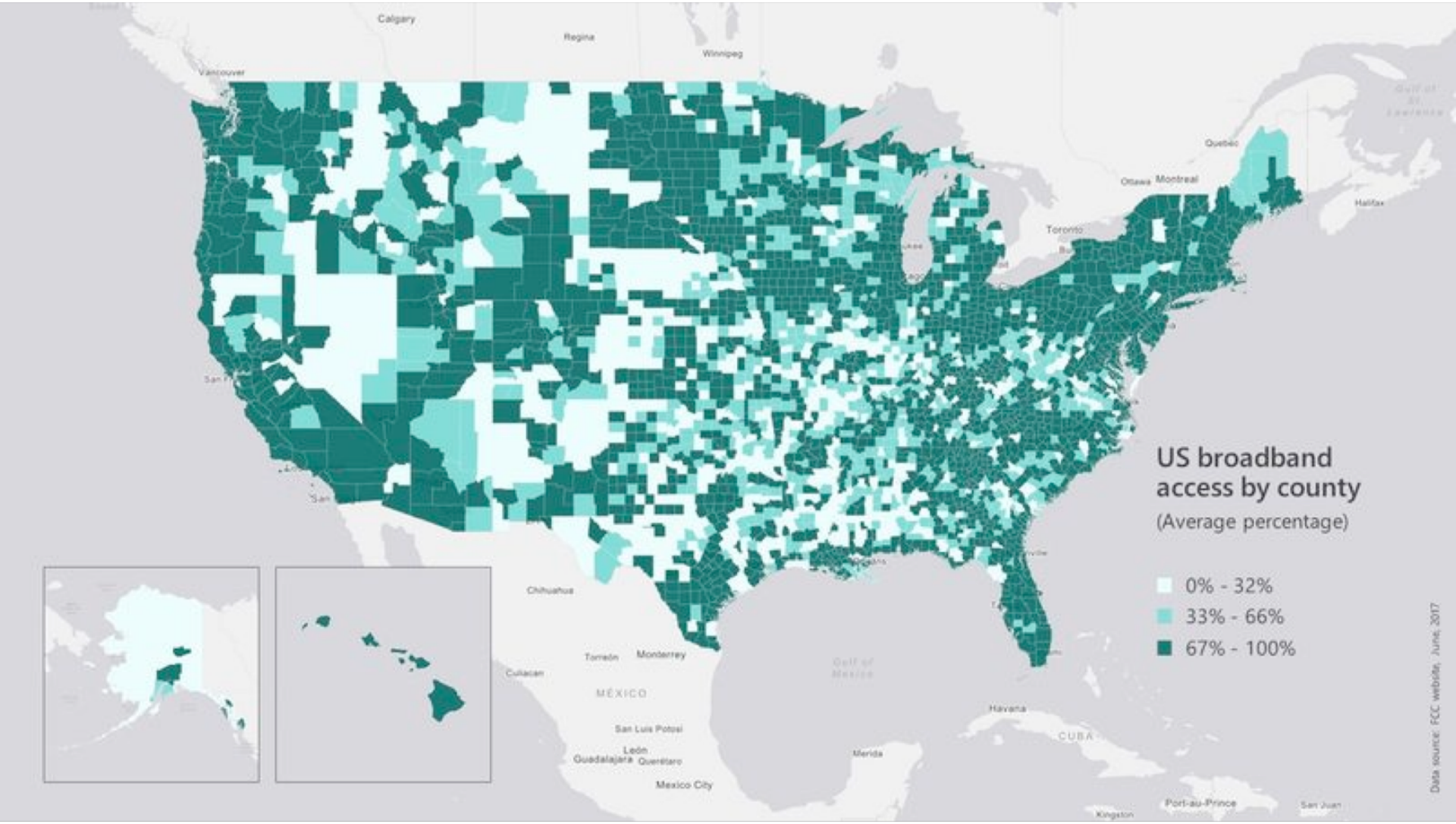
Knuth's Definition

An algorithm is a finite, definitive, effective procedure with some input and some output

Remember: Stick with your group

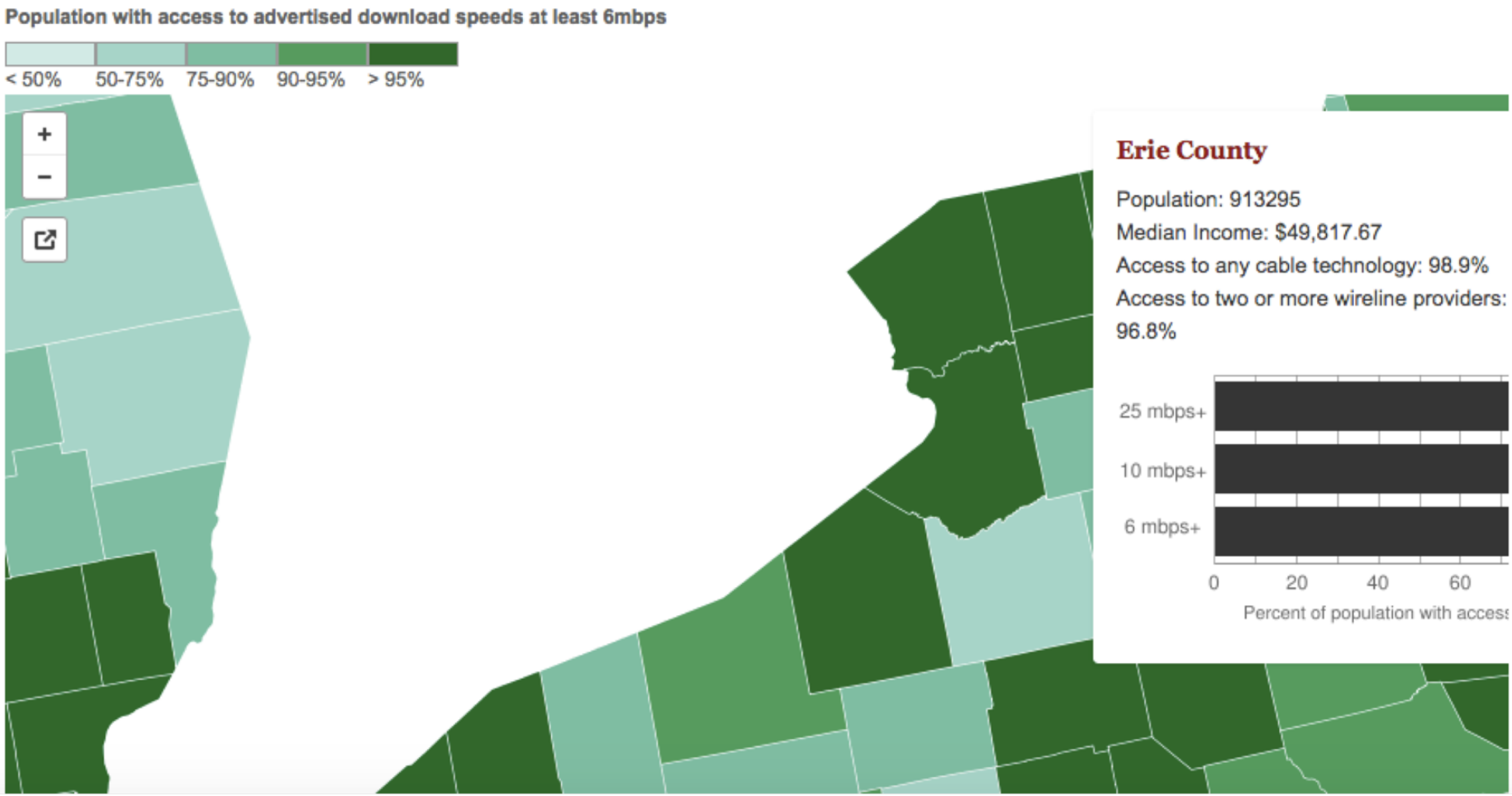


Broadband access



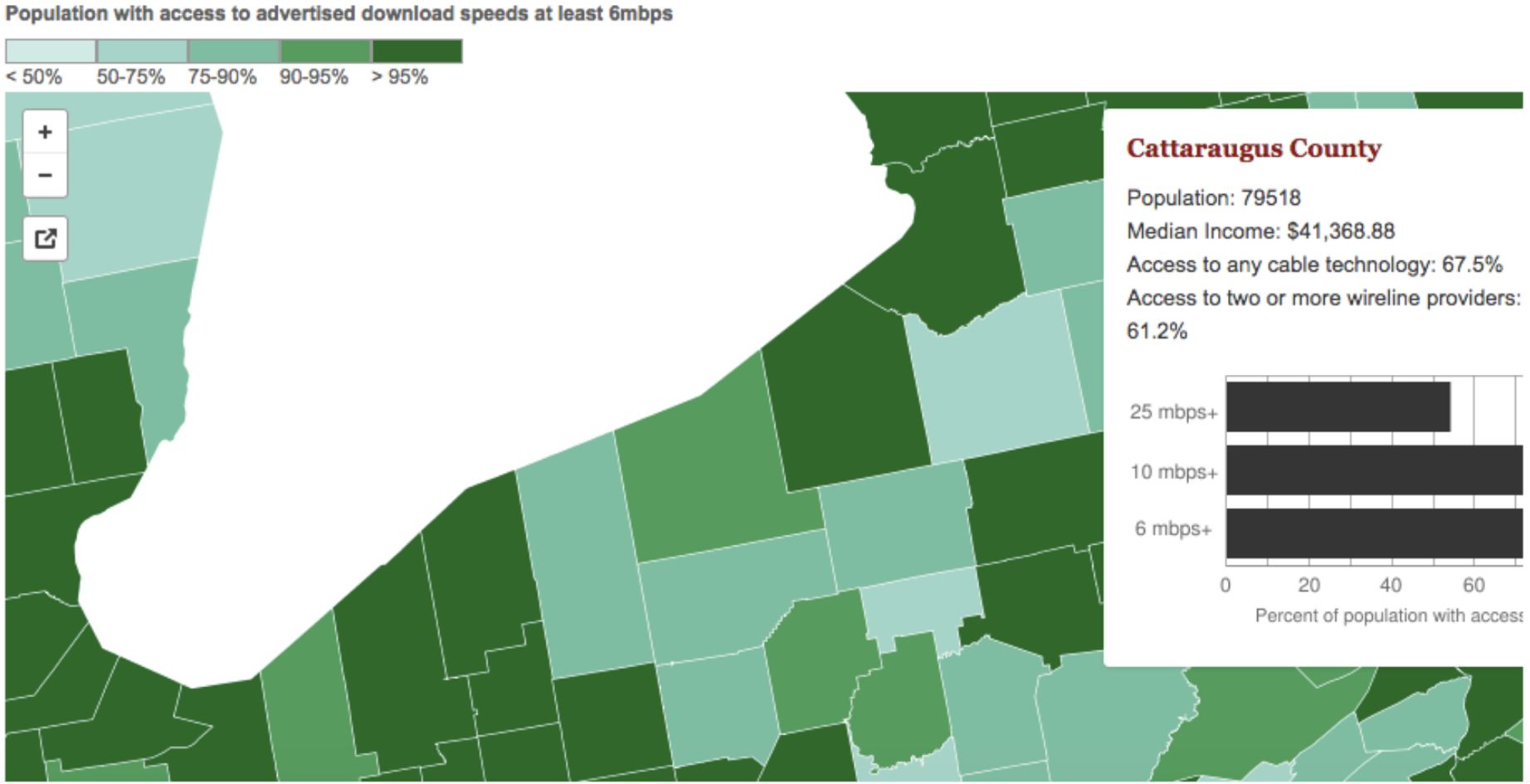
https://assets.bwbx.io/images/users/iqjWHBFdfxIU/iZSjibxE1KJs/v1/800x-1.jpg

Erie county is reasonably good



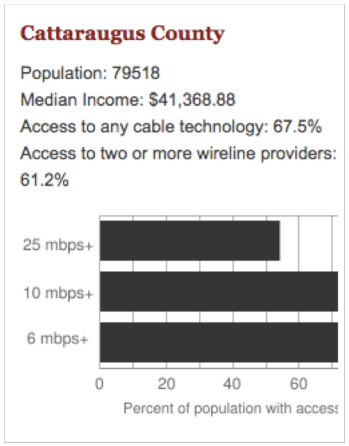
http://www.governing.com/gov-data/broadband-speeds-availability.html

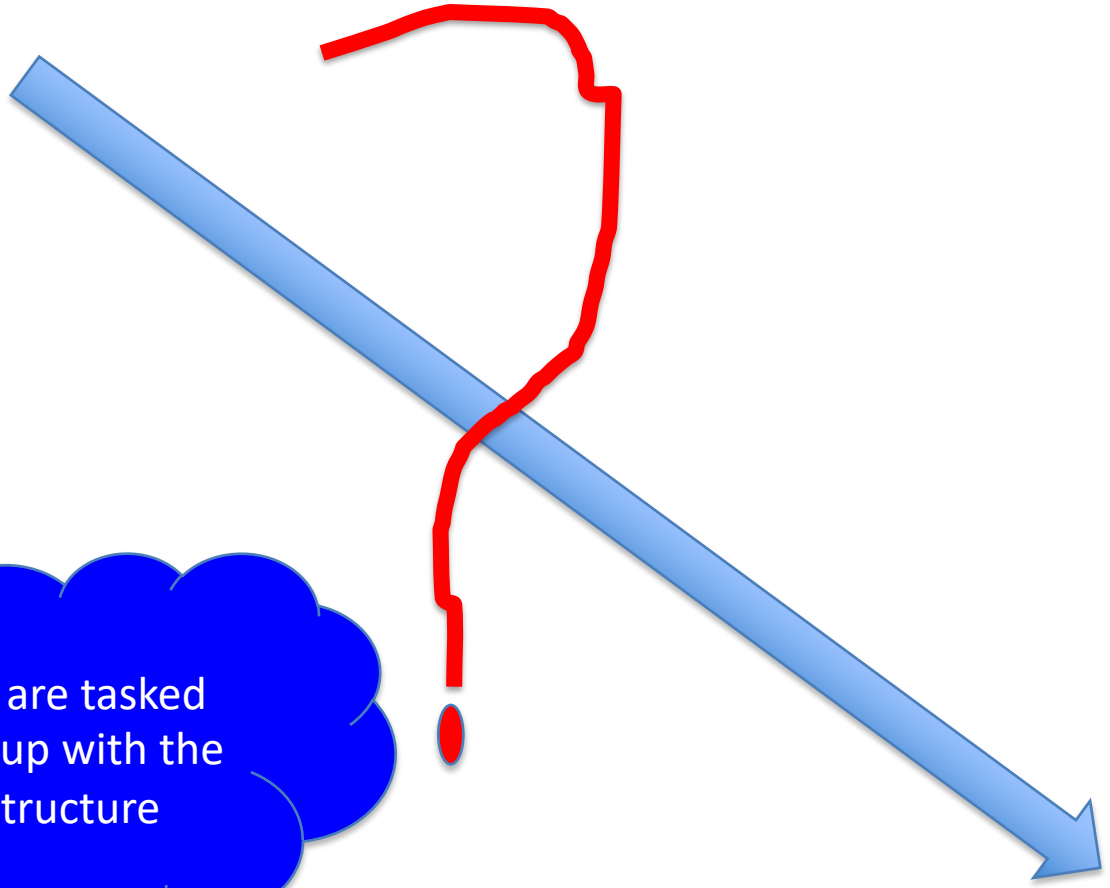
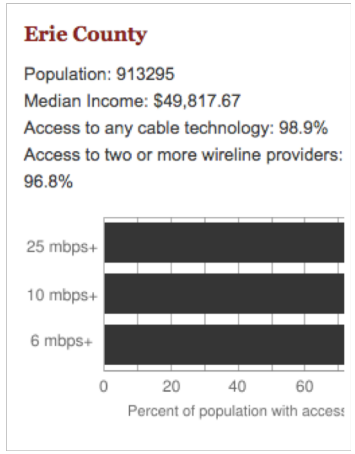
One county over



http://www.governing.com/gov-data/broadband-speeds-availability.html

Make broadband more available





Say you are tasked to come up with the infrastructure