Welcome to CS88

David E. Culler

CS8 – Computational Structures in Data Science

http://inst.eecs.berkeley.edu/~cs88

Lecture 1

August 27, 2018

Welcome

- **We are all here to learn:**

  `Knowledge(end) – Knowledge(start)`

CS88 Team

S88 Team - uGSIs

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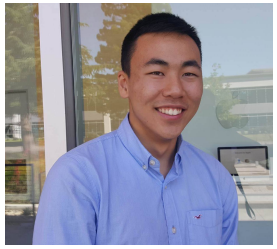
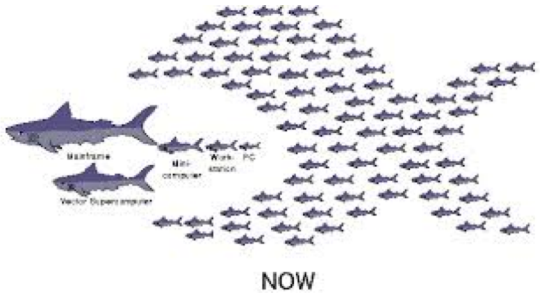
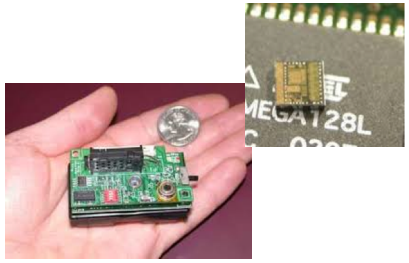


John Yang
john.yang20@berkeley.edu

CS88 Team - me

- David Culler (culler@berkeley.edu)
  - Hearst Field Annex / 465 Soda Hall (amplab)
  - http://www.cs.berkeley.edu/~culler
  - Office hours: Mon 3-4 + TBD
- Build things
  - Cray Time Sharing System
  - OS386, OS286
  - Active Messages
  - Massive High Performance Clusters
  - TinyOS / Berkeley Motes, …
  - LoCal, BOSS, …



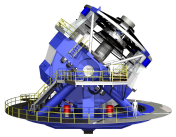


Goals today

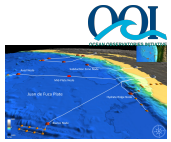
- Introduce you to
  - The field
  - The course
  - The Team
- Answer your questions
- Big Ideas
  - Algorithm
  - Data type
  - Representation

Data Science

Nearly every field of discovery is transitioning from "data poor" to "data rich"


Astronomy: LSST


Physics: LHC

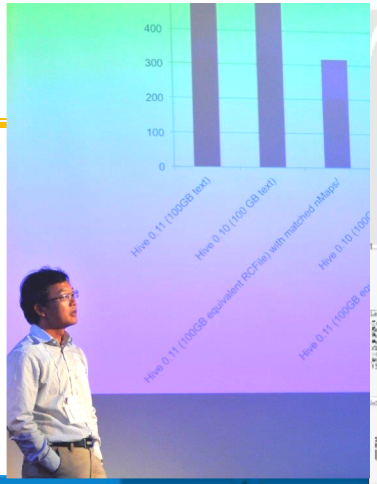

Oceanography: OOI

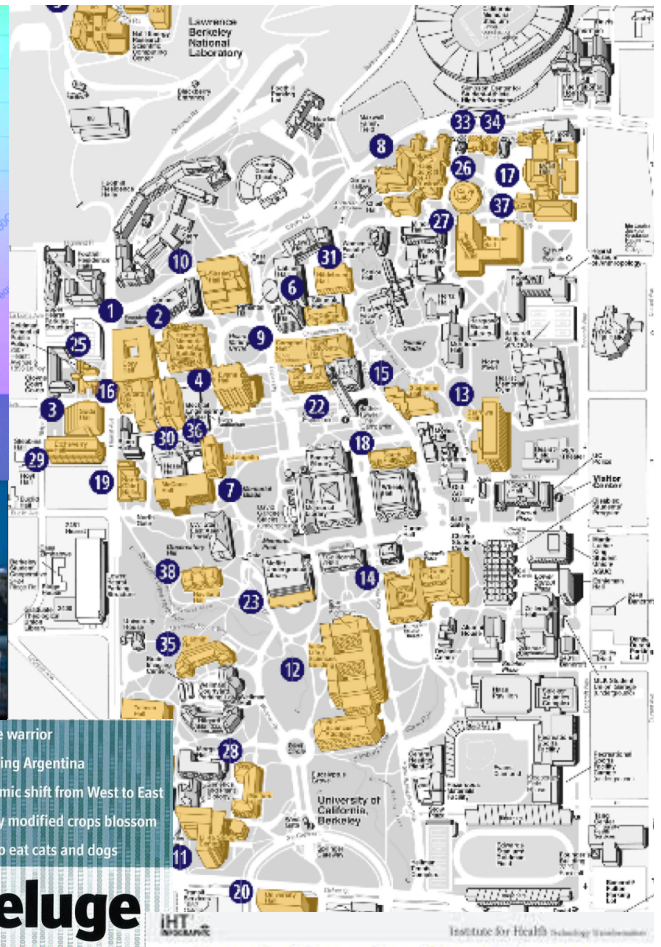

Sociology: The Web


Biology: Sequencing


Economics: POS terminals


Neuro





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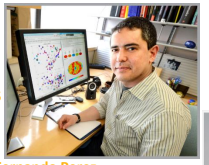
Data Science growing organically everywhere

WIRED Spark: Open Source Superstar Rewrites Future of Big Data
BY CADE METZ 06.19.13 6:30 AM


AMP Lab
Ion Stoica, CS
Michael Franklin, CS


Fernando Perez,
Brain Imaging Center
iPython tools and community


Reconstructing the movies in your mind
Bin Yu, Statistics
Jack Gallant, Neuroscience


Richard Allen
Earth& Plan. Science
Geospatial Lab

The New York Times
Incomes Flat in Recovery but Not for the 1%
Feb 15, 2013
Emmanuel Saez, Economics

KBase
PREDICTIVE BIOLOGY
DOE Systems Biology Knowledgebase

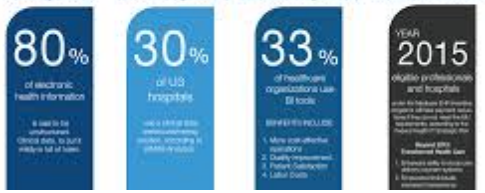
Adam Arkin,
Bioengineering


Charles Marshall
Rosie Gillespie
Integrative Biology
Digitized Museum

The Economist
Obama the warrior
Misgoverning Argentina
The economic shift from West to East
Genetically modified crops blossom
The right to eat cats and dogs

The data deluge
AND HOW TO HANDLE IT: A 14-PAGE SPECIAL REPORT

Analytics in Healthcare
Analytics: The Nervous System of IT-Enabled Healthcare



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A National Challenge

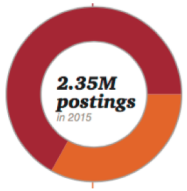
Report | McKinsey Global Institute

Big data: The next frontier for innovation, competition, and productivity

May 2011 | by James Manyika, Michael Chui, Brad Brown, Jacques Bughin, Richard Dobbs, Charles Roxburgh, Angela Hung Byers

pwc.com/us/dsa-skills

Increasingly US jobs require data science and analytics skills. Can we meet the demand? The current shortage of skills in the national job pool demonstrates that business-as-usual strategies won't satisfy the growing need. If we are to unlock the promise and potential of data and all the technologies that depend on it, employers and educators will have to transform.



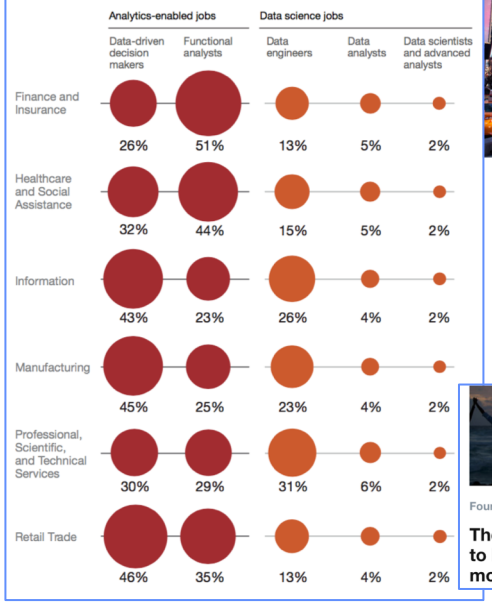
Investing in America's data science and analytics talent

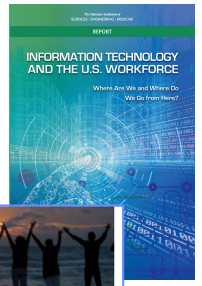
The case for action

April 2017

BHEF

Of 2.35 million job postings in the US.



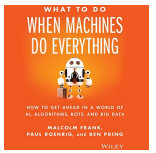


Fourth Industrial Revolution

The fourth sector is a chance to build a new economic model for the benefit of all

By 2021, **69% of employers expect** candidates with DSA skills to get preference for jobs in their organizations.
Only **23% of college** and university leaders say their graduates will have those skills.

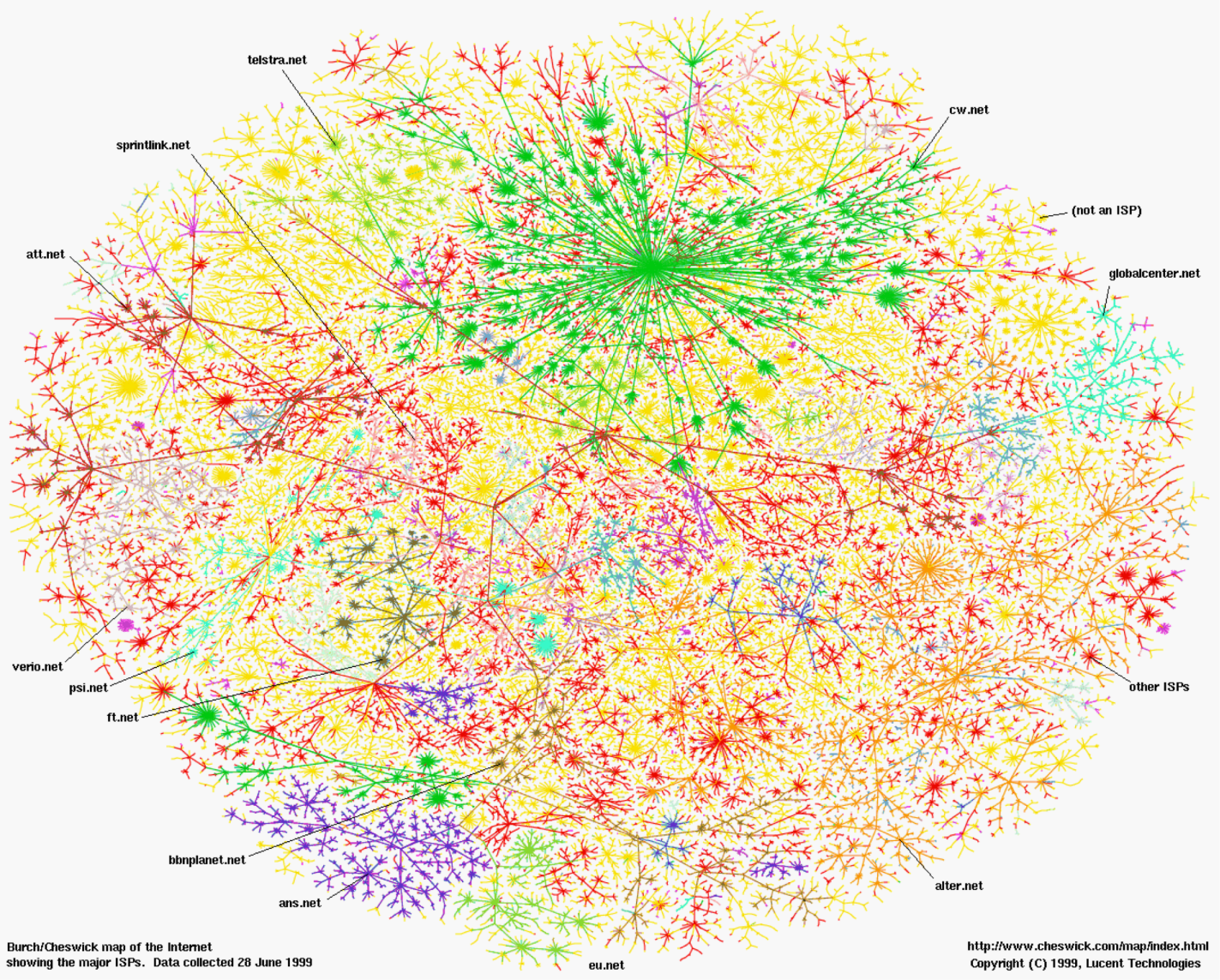
Augmenting Human Intelligence



WORLD ECONOMIC FORUM

The Fourth Industrial Revolution: what it means, how to respond

Greatest Artifact of Human Civilization …



The Global Village

% of world's population

4.2 B

ARPANet

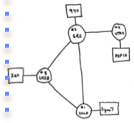
Internet

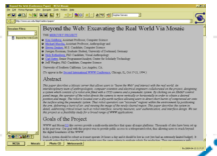
WWW

2.0 B 1/26/11

RFC 675 TCP/IP

HTTP 0.9





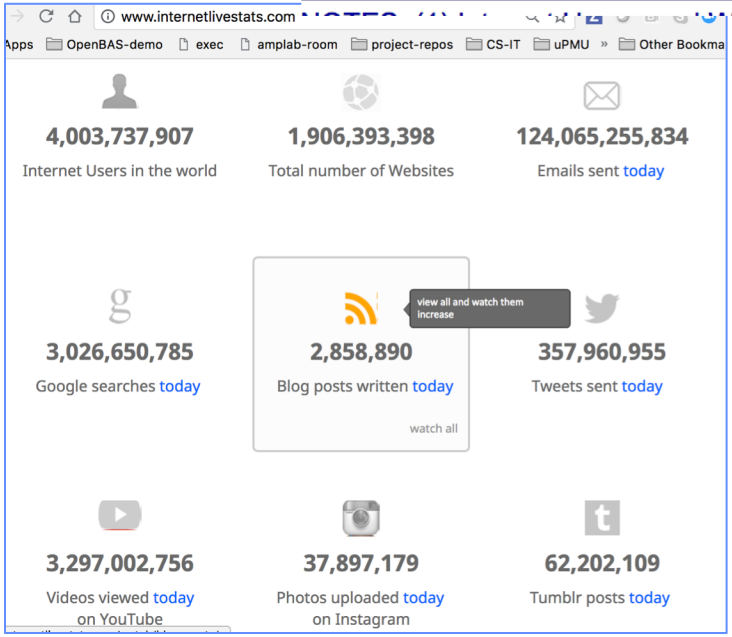
45
40
35
30
25
20
15
10
5

1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

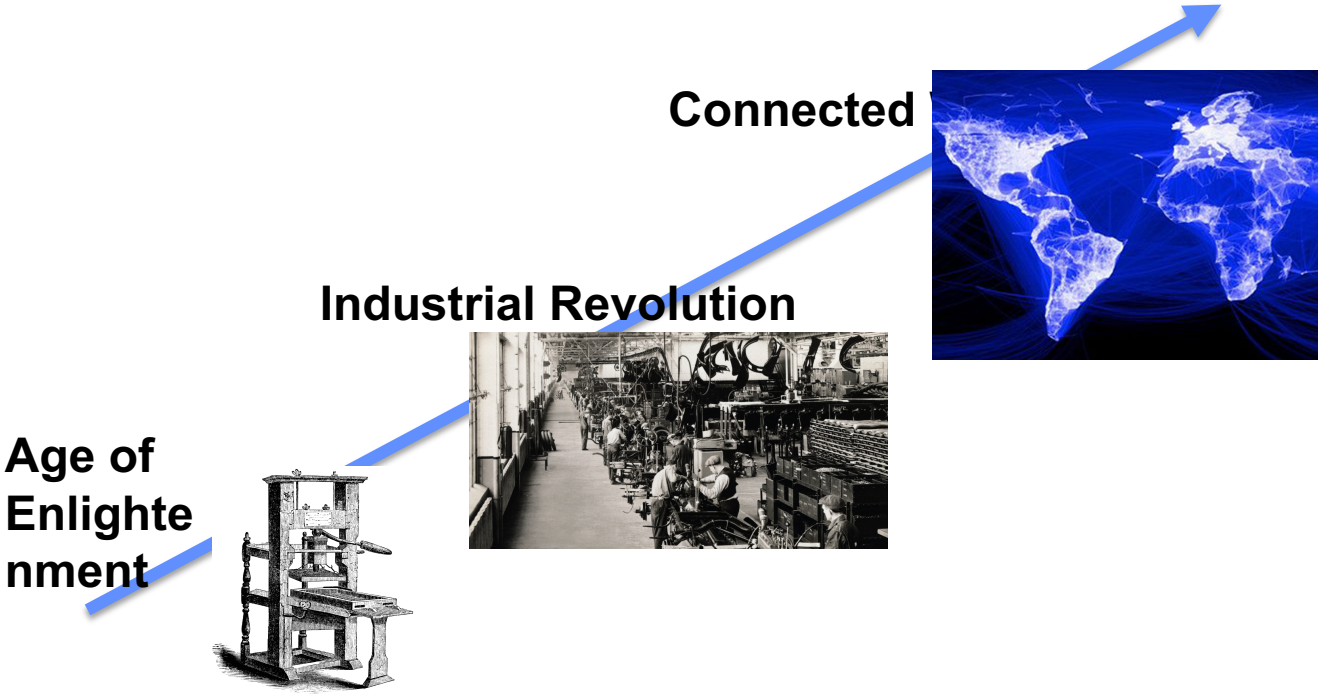
1969 1974 1990 2018

WORLD INTERNET USAGE AND POPULATION STATISTICS
DEC 31, 2017 - Update

World Regions	Population (2018 Est.)	Population % of World	Internet Users 31 Dec 2017	Penetration Rate (% Pop.)	Growth 2000-2018
Africa	1,287,914,329	16.9 %	453,329,534	35.2 %	9,941 %
Asia	4,207,588,157	55.1 %	2,023,630,194	48.1 %	1,670 %
Europe	827,650,849	10.8 %	704,833,752	85.2 %	570 %
Latin America / Caribbean	652,047,996	8.5 %	437,001,277	67.0 %	2,318 %
Middle East	254,438,981	3.3 %	164,037,259	64.5 %	4,893 %
North America	363,844,662	4.8 %	345,660,847	95.0 %	219 %
Oceania / Australia	41,273,454	0.6 %	28,439,277	68.9 %	273 %
WORLD TOTAL	7,634,758,428	100.0 %	4,156,932,140	54.4 %	1,052 %



Era of Transformation



A Connected World of Data

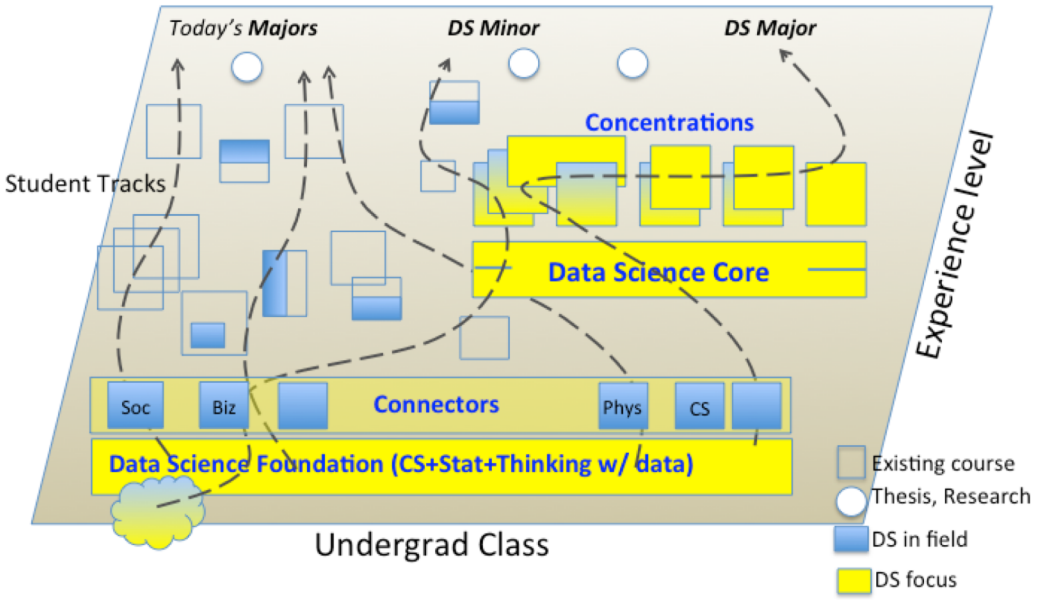
- The world's knowledge at our finger tips
- *Digitialization* of life, industry and society
- Intimately connected to billions of us, globally
- Explosion of observational instruments
  - Genomics, Microscopy, Astronomical, …
- Vast Computational power to do analytics
- Synthetic design exploration thru simulation
- Machine reading of everything
- Statistical machine learning algorithms to "discover" structure

What if I could … ?

- See the world's digital footprints?
- Read everything that's ever been written?
- Take it all in and dive down anywhere as far as the science can take me?
- Learn the physical/chemical/biological /sociological/neurological… models from the data?
- Explore billions of designs and pick the one I want?
- … ?

Data 8 – Foundations of Data Science

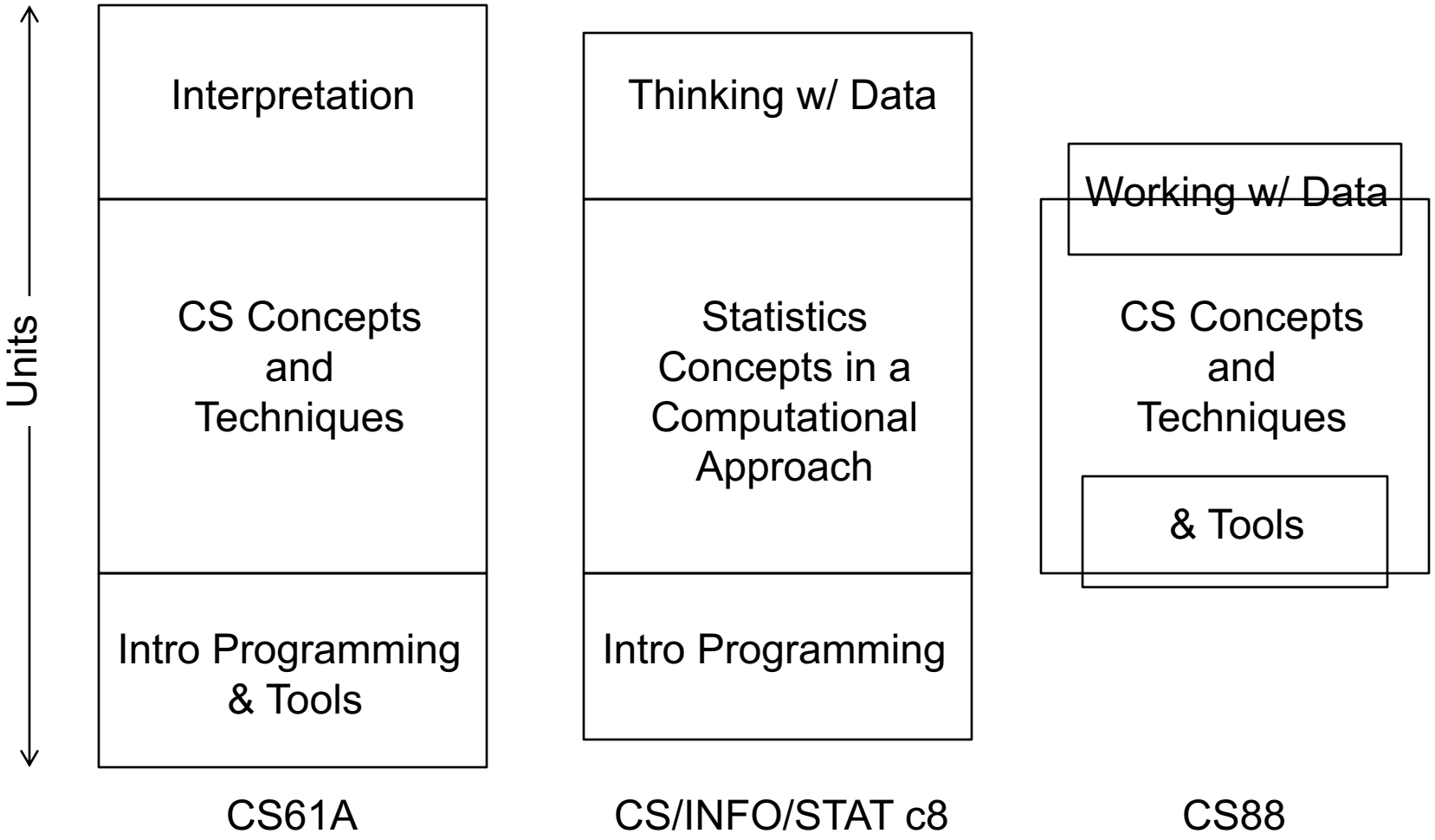
- **Computational Thinking + Inferential Thinking in the context of working with real world data**
- **Introduce you to several computational concepts in a simple data-centered setting**
  - **Authoring computational documents**
  - **Tables**
  - **Within Python3 and "SciPy"**



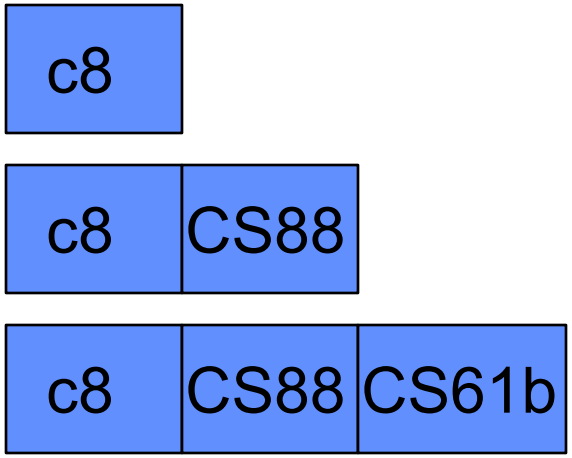
CS88 – Computational Structures in Data Science

- **Deeper understanding of the computing concepts introduced in c8**
  - **Hands-on experience => Foundational Concept**
  - **How would you create what you use in c8 ?**
- **Extend your understanding of the structure of computation**
  - **What is involved in interpreting the code you write ?**
  - **Deeper CS Concepts: Recursion, Objects, Classes, Higher-order Functions, Declarative programming, …**
  - **Managing complexity in creating larger software systems through composition**
- **Create complete (and fun) applications**
- **In a data-centric approach**

How does CS88 relate to CS61A ?



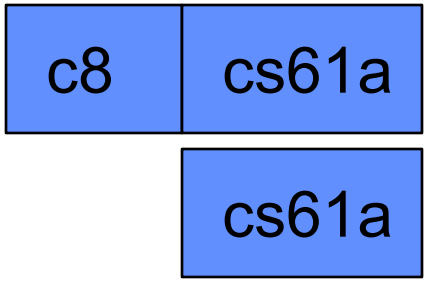
Opportunities for students



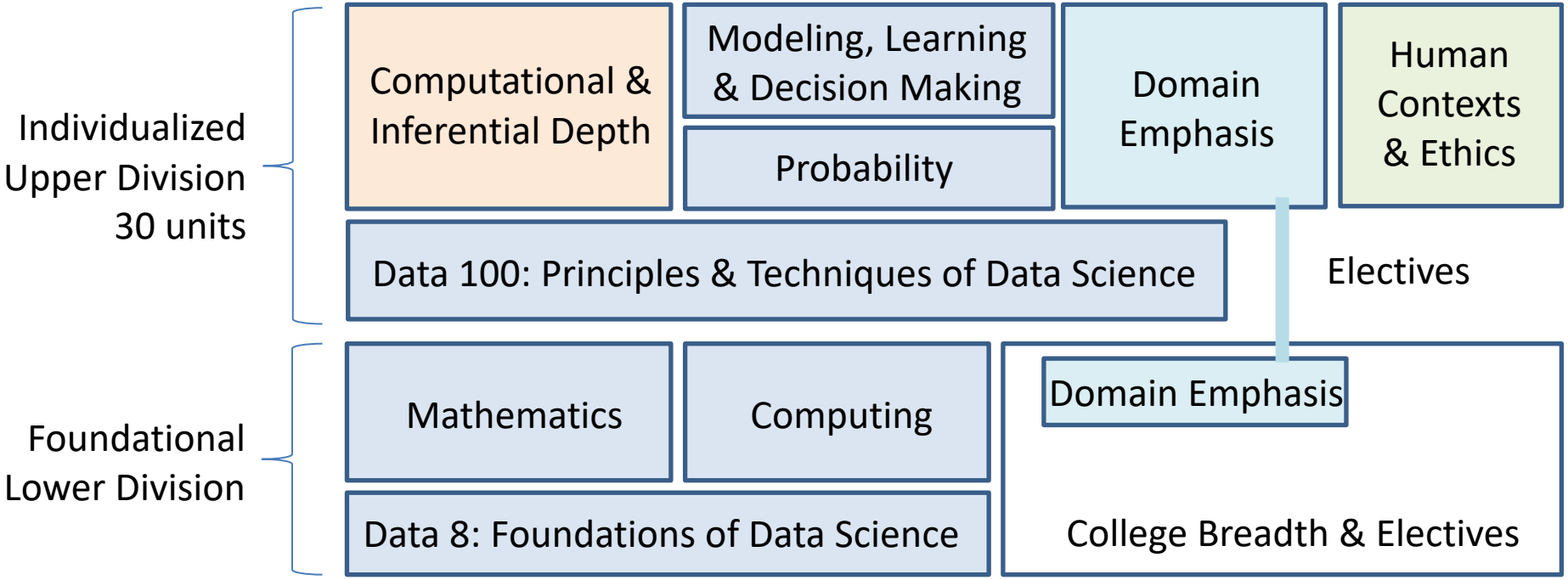
CS minor

***

CS major

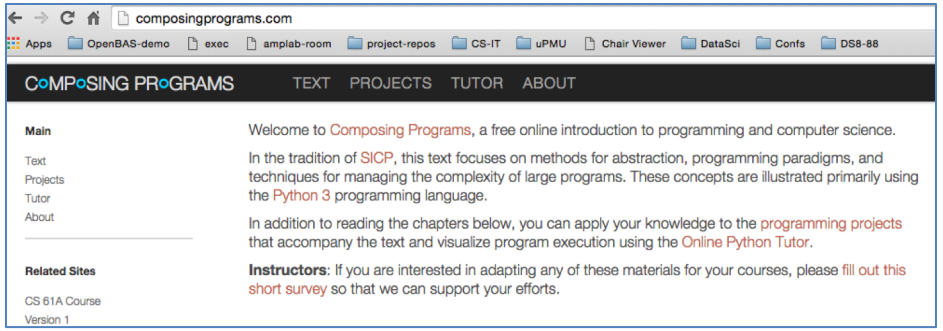


A New Data Science Major soon



Course Structure

- Monday Lecture + Friday Lab/Discussion
- Lecture introduces concepts (quickly)
- Lab provides concrete detail hands-on
- Homework cements your understanding
  - Out Friday, Due Thursday
- Projects (3) put your understanding to work in building complete applications
- Readings: composingprograms.com
  - Same as cs61a



Course Culture

- **Learning**
- **Community**
- **Respect**
- **Collaboration**
- **Peer Instruction**

Collaboration

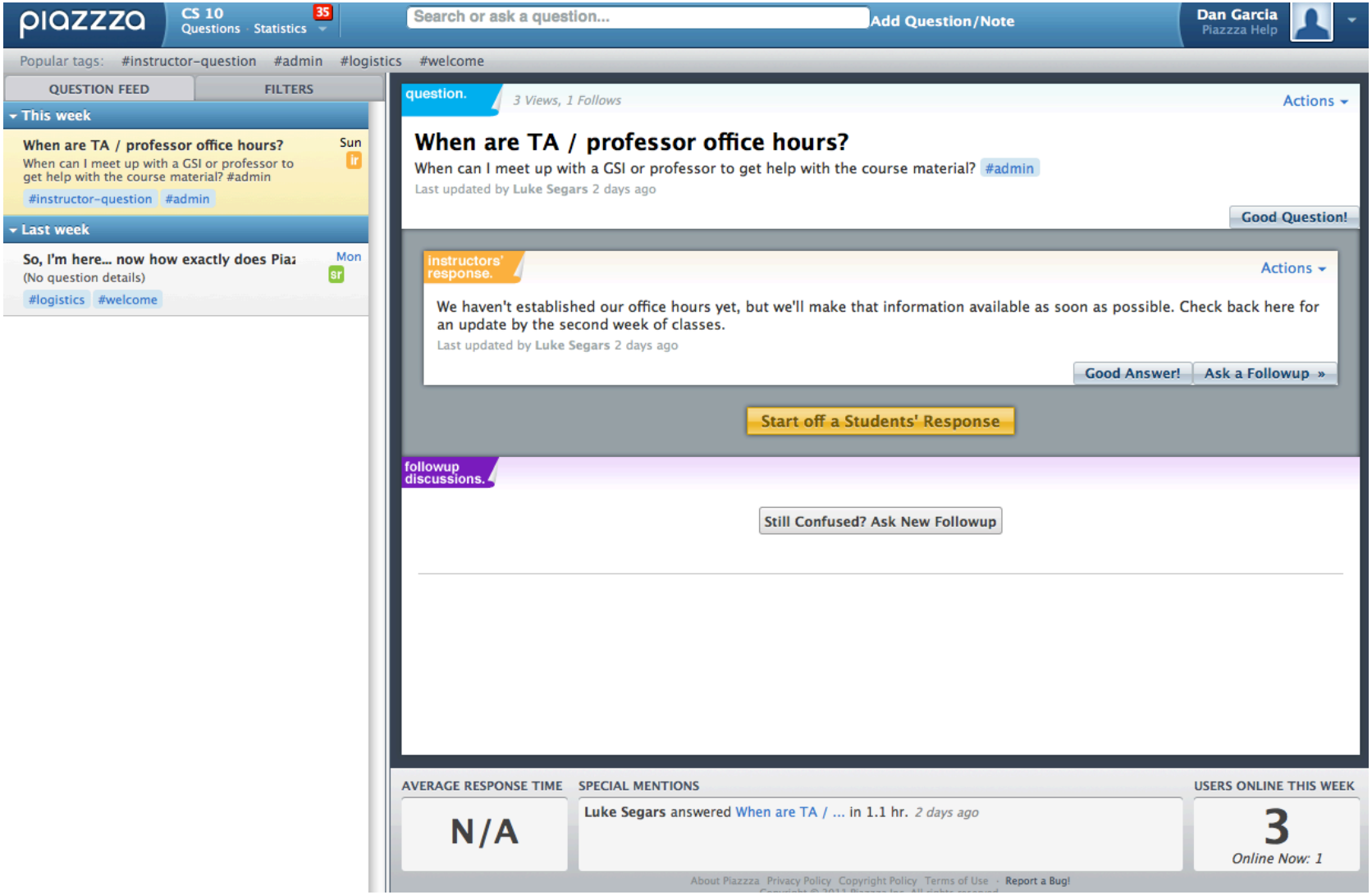
Asking questions is highly encouraged

- Discuss all questions with each other (except exams)
- Submit lab assignments individually (graded on completeness)
  - If you come to lab, you can collaborate liberally
  - If you choose not to come to lab, you must work alone
- Submit homework individually and list collaborators
- Submit projects in pairs; find a partner in your lab

The Limits of collaboration

- Don't share solutions with each other (except project partners)
- Copying solutions will result in failing the course

Piazza for {ask,answer}ing questions



Where will we work?

- datahub.Berkeley.edu
- The computer you carry around
- inst.eecs.Berkeley.edu

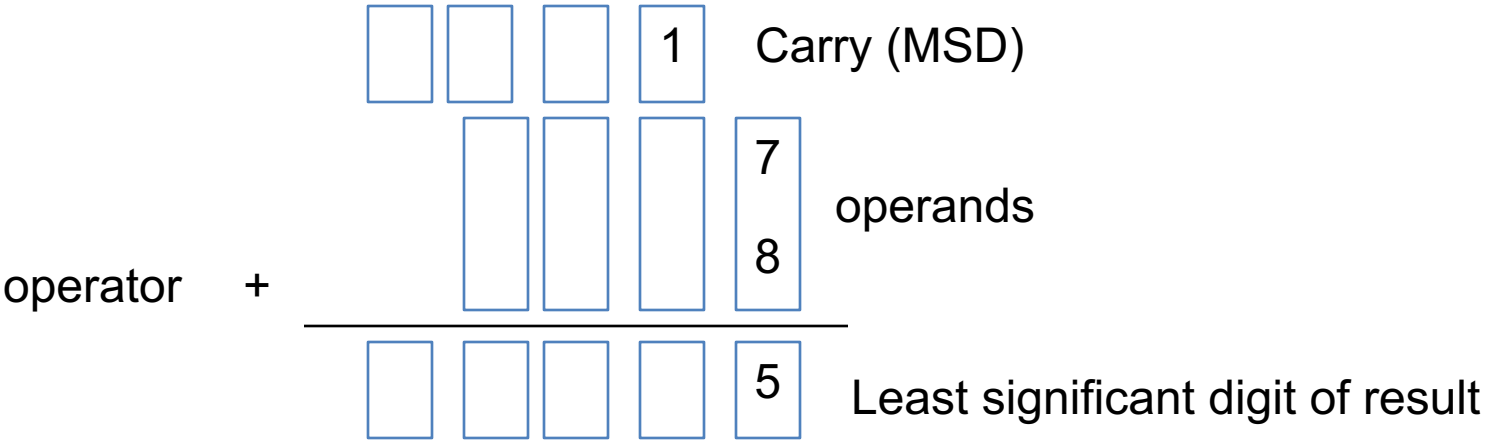
Lab Sections Assignments

- We will collect availability on Wednesday
- Attend any lab section on Friday.
- Assignments effective following Friday.

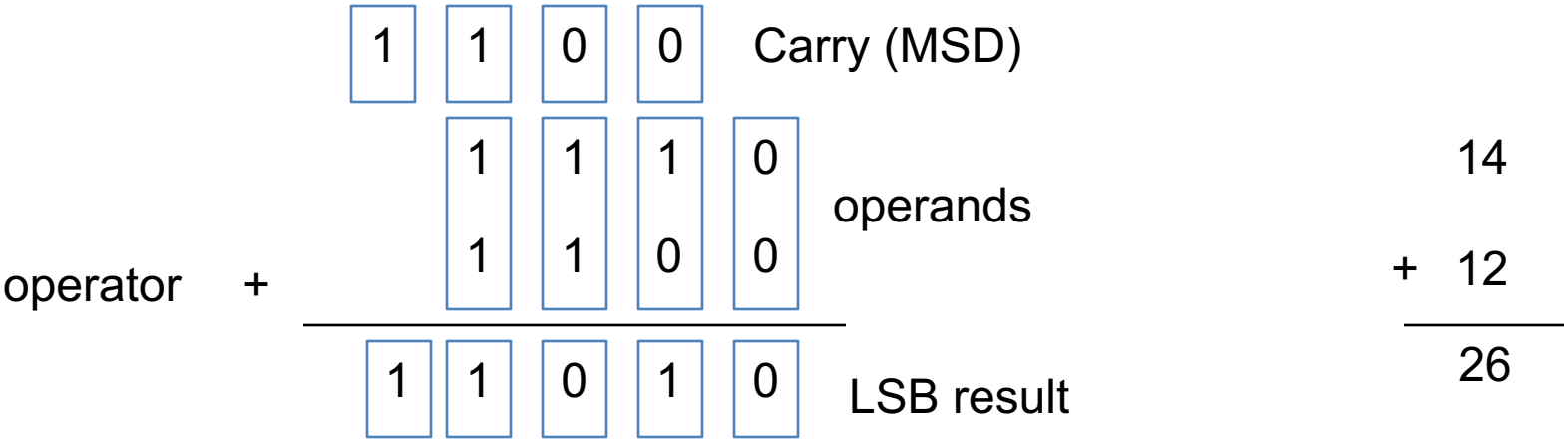
Algorithm

- An algorithm (pronounced AL-go-rith-um) is a procedure or formula for solving a problem.
- In mathematics and computer science, an algorithm is a self-contained step-by-step set of operations to be performed.
- An algorithm is an effective method that can be expressed within a finite amount of space and time and in a well-defined formal language for calculating a function.

Algorithms early in life



Algorithms early in life (in binary)



A Simple Algorithm in Class

- **Count the number of students**

More interesting one, …

- **Betcha people in here share a birthday?**

https://en.wikipedia.org/wiki/List_of_Presidents_of_the_United_States_by_date_of_birth

Presidents?

Abstraction

- **Detail removal**
  - **"The act or process of leaving out of consideration one or more properties of a complex object so as to attend to others."**
- **Generalization**
  - **"The process of formulating general concepts by abstracting common properties of instances"**

Henri Matisse *"Naked Blue IV"*

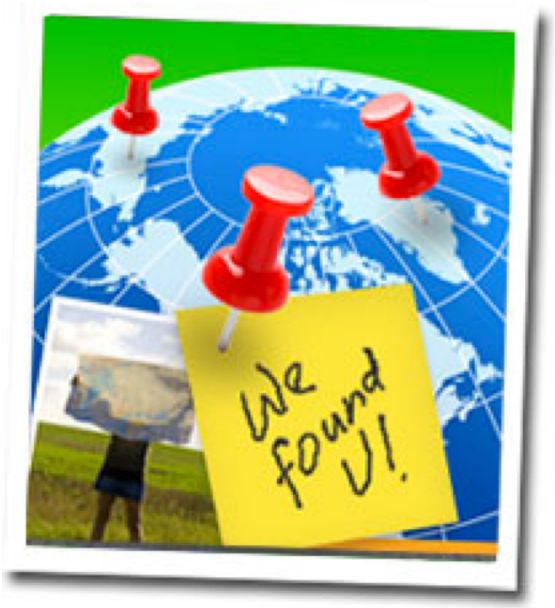
Experiment


Standard Time Zones of the World
WHERE ARE YOU FROM?
CANADA
UNITED STATES
MEXICO
BRAZIL
ARGENTINA
CHILE
PERU
BOLIVIA
PARAGUAY
URUGUAY
COLOMBIA
VENEZUELA
ECUADOR
RUSSIA
CHINA
INDIA
MONGOLIA
KAZAKHSTAN
JAPAN
PHILIPPINES
INDONESIA
AUSTRALIA
NEW ZEALAND
ALGERIA
LIBYA
EGYPT
SUDAN
ETHIOPIA
NIGERIA
ZAIRE
SOUTH AFRICA
SAUDI ARABIA
IRAN
IRAQ
TURKEY
FRANCE
GERMANY
SPAIN
UNITED KINGDOM
SWEDEN
NORWAY
FINLAND
POLAND
UKRAINE
North Atlantic Ocean
South Atlantic Ocean
North Pacific Ocean
South Pacific Ocean
Indian Ocean
Arctic
International Date Line
Coordinated Universal Time (U.T.C.) formerly Greenwich Mean Time
C.A.R. -Central African Republic
F.Y.R.O.M. -The Former Yugoslav Republic of Macedonia

Where are you from?

Possible Answers:

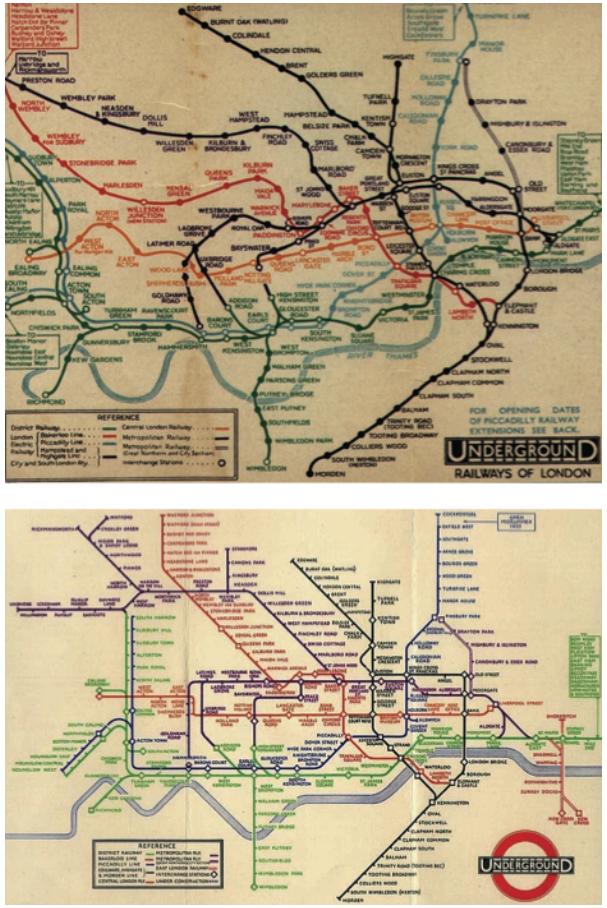
- **China**
- **California**
- **The Bay Area**
- **San Mateo**
- **1947 Center Street, Berkeley, CA**
- **37.8693° N, 122.2696° W**



All correct but different levels of abstraction!

Detail Removal (in Data Science)

- You'll want to look at only the interesting data, leave out the details, zoom in/out…
- Abstraction is the idea that you focus on the essence, the cleanest way to map the messy real world to one you can build
- Experts are often brought in to know what to remove and what to keep!



The London Underground 1928 Map & the 1933 map by Harry Beck.

The Power of Abstraction, Everywhere!

- **Examples:**
  - **Functions (e.g., sin x)**
  - **Hiring contractors**
  - **Application Programming Interfaces (APIs)**
  - **Technology (e.g., cars)**

- **Amazing things are built when these layer**
  - **And the abstraction layers are getting deeper by the day!**

We only need to worry about the interface, or specification, or contract NOT how (or by whom) it's built

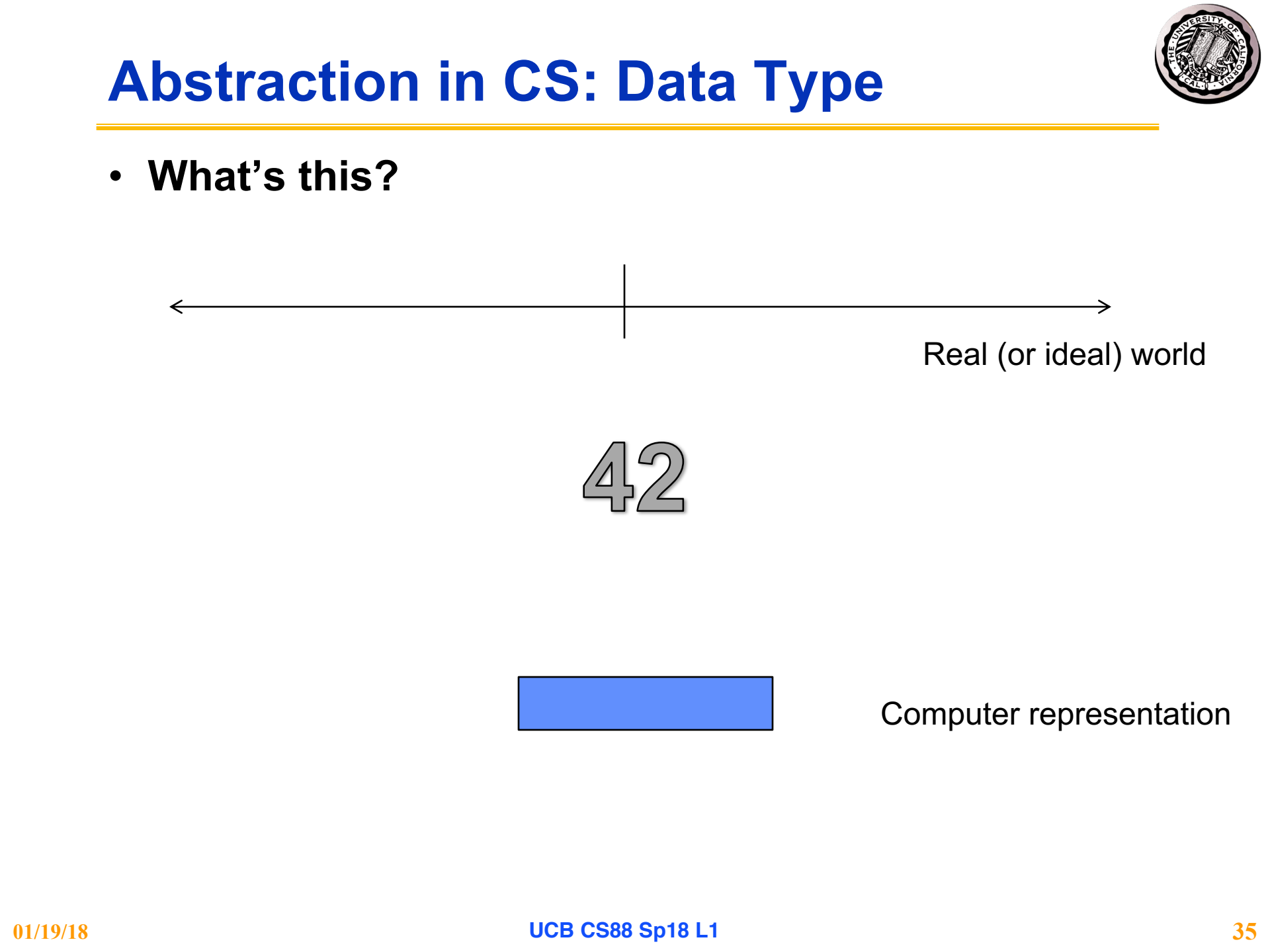
Above the abstraction line

Abstraction Barrier (Interface)
(the interface, or specification, or contract)

Below the abstraction line

This is where / how / when / by whom it is actually built, which is done according to the interface, specification, or contract.

Abstraction in CS: Data Type



- **What's this?**

Real (or ideal) world

42

Computer representation

Data Types and Operations

- Set of elements
  - with some internal representation
  - E.g. Integers, Floats, Booleans, Strings, …
- Set of operations on elements of the type
  - e.g. +, *, -, /, %, //, **
  - ==, <, >, <=, >=
- Properties
  - Commutative, Associative, … , Closure (???)
- Expressions are valid well-defined sets of operations on elements that produce a value of a type

Questions

- What's the difference between '==' and '=' ?

Lab and HW this week

- **Lab will get you to where you have a *program development environment***
  - **Even on your computer**
- **HW will give practice and explain subtleties of types, operators, and expressions**
  - **In a program development environment**

Question of the week

- How many “things” can you represent with **N** bits