

W4111
Introduction to Databases
Fall 2015

Computer Science Department
Columbia University

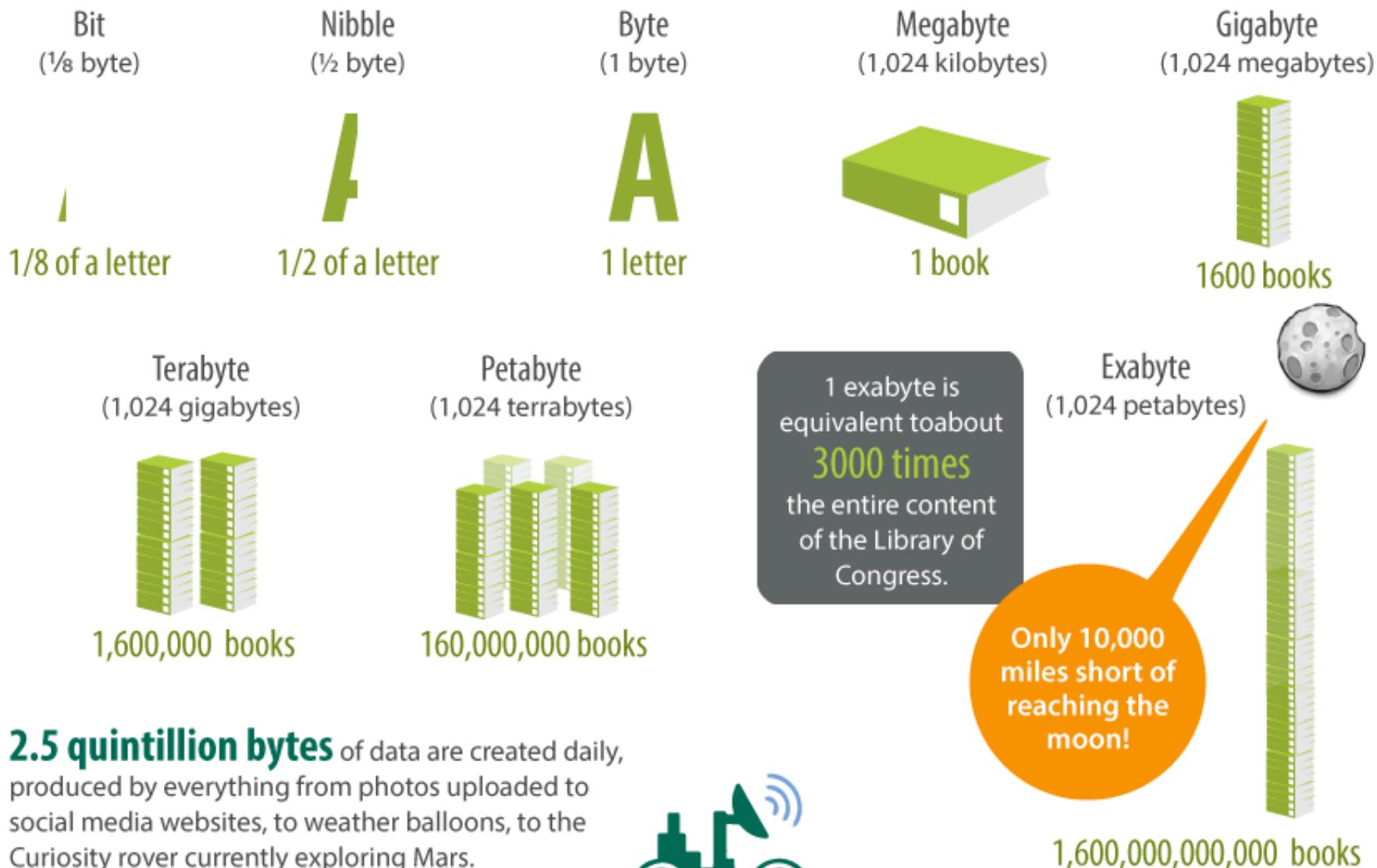
Data

Data
is for serious business

Data
is at the center of most things.

Data
is at the center of *everything*

Data Sizes



2.5 quintillion bytes of data are created daily, produced by everything from photos uploaded to social media websites, to weather balloons, to the Curiosity rover currently exploring Mars.

Bigger Than Big Data

► THE PAST

Digital storage grew annually by **23%** between 1986 and 2007.

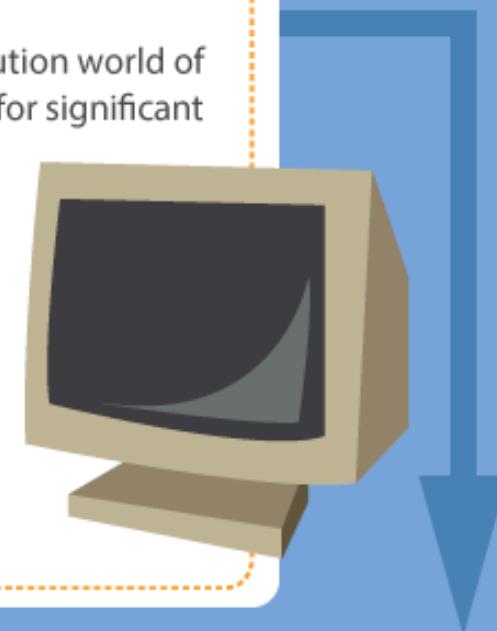
Most data was stored on **videotapes** such as VHS cassettes in the pre-digital revolution world of the late 1980s. Vinyl LP records, audio cassette tapes, and photography accounted for significant portions as well.

Paper-based storage represented **33%** of all data storage on its own in 1986.

25% of all data stored in the world in 2000 was stored digitally.

2002 is the first year that digital storage capacity overtook analog capacity.

94% of all data was stored in digital format by 2007.



► PRESENT

Today, more than **2.5 exabytes** (2.5 billion gigabytes) of data is generated every single day. This is expected to continue growing at a significant rate with mobile devices accounting for much of this data.

Some experts have estimated that **90%** of all of the data the world today was produced within the last two years.

How did we get here?

Data was Manual

67

June 11¹⁹²⁵

Geo. A. Kelly
June 16 Mrs. Chas. Long Jr
June 16 Nellora Wright
June 16 Charity A. Jones
" " Mr. M. A. Carpenter

July 10 James Ostrom trip I 251
July 10 A. W. Gemung
July 10 Millicent Gemung
Waet Kulin

July 11 Mrs. Rawe & Daughter
" " Mrs. Ralph Pease
" " Mrs. A. H. Favours

" " Mrs. J. A. Miller
" " Mrs. J. G. Morris
" " Mrs. C. D. Atta

Mary S. Koayapam
Mrs. Madeline Hoffman
Mrs. Ray Young
Mrs. Alice Whitney
Mrs. Otto St. Adra
Mrs. Anna P. Patricia

Phoenix, Arizona.
Phoenix Arizona
Phoenix Arizona
Prescott - Arizona.
Say Graniusco

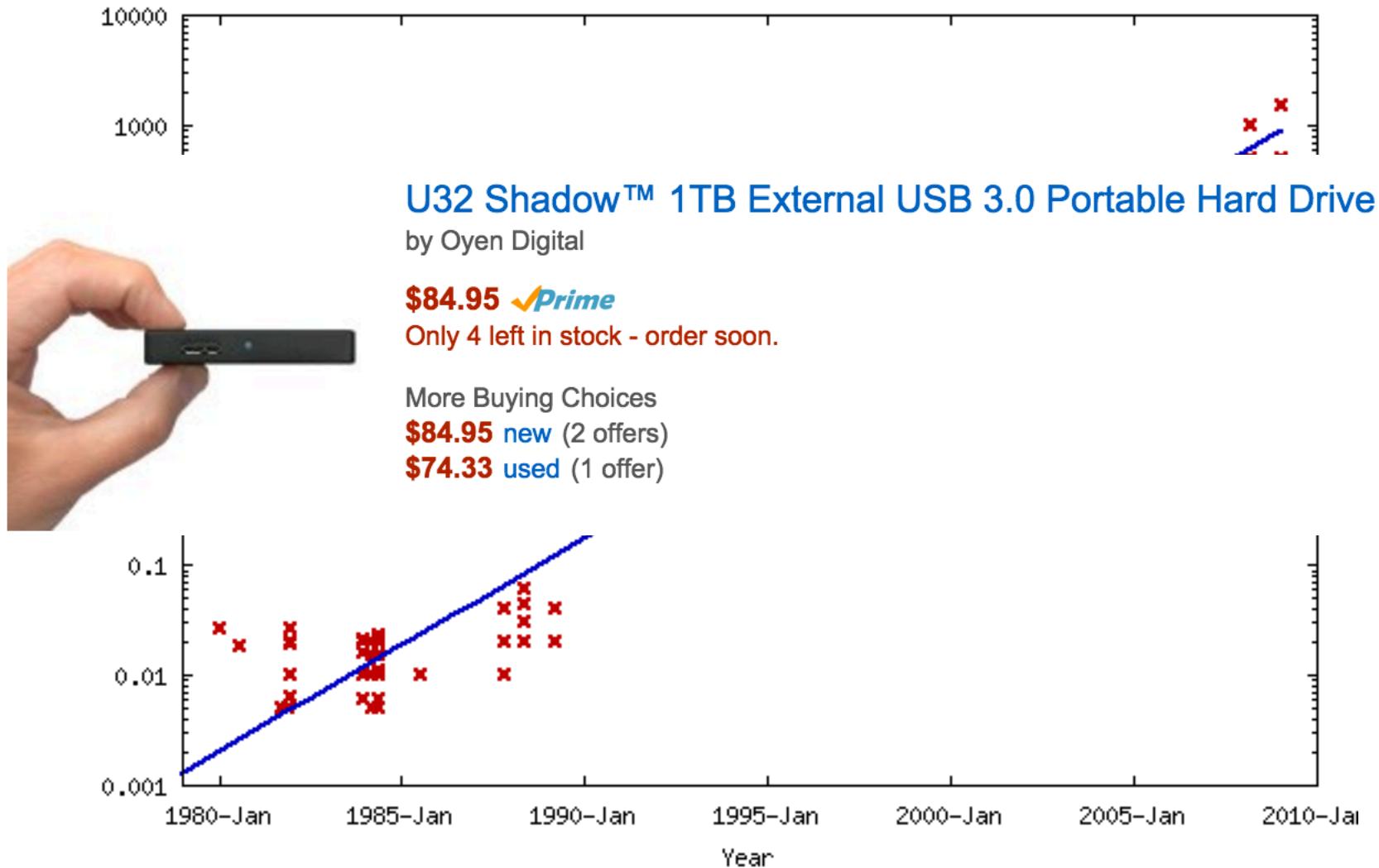
Prescott -
8. Mt Vernon St. Prescott
Dixey Arizona
Dixey, Arizona
Ph. 719 - N.Y. Calif.
Say Graniusco
Prescott
"

Arizona
"

Data was *Expensive*



Data is Cheap



Data is Automated

Physical devices



Data is Automated

Physical devices

Software logs

Data is *Ubiquitous*

Physical devices

Software logs

Phones



Data is *Ubiquitous*

Physical devices

Software logs

Phones

GPS/Cars



Data is *Everywhere*

Physical devices

Software logs

Phones

GPS/Cars

Internet of *Things*



All this data, what are we doing with it?

What are we doing with data?

Health



What are we doing with data?

Health



What are we doing with data?

Health

Investigative Journalism



The image shows the cover of a report titled "Surgeon Scorecard" by ProPublica. The cover is black with white text. At the top left is the ProPublica logo. To its right, separated by a vertical line, is the word "Patient Safety". Below this, the title "Surgeon Scorecard" is written in large, bold, white serif capital letters. Underneath the title, the authors are listed as "by Sisi Wei, Olga Pierce and Marshall Allen, ProPublica, Updated July 15, 2015". A descriptive paragraph at the bottom explains the report's purpose: "Guided by experts, ProPublica calculated death and complication rates for surgeons performing one of eight elective procedures in Medicare, carefully adjusting for differences in patient health, age and hospital quality. Use this database to know more about a surgeon before your operation."

What are we doing?

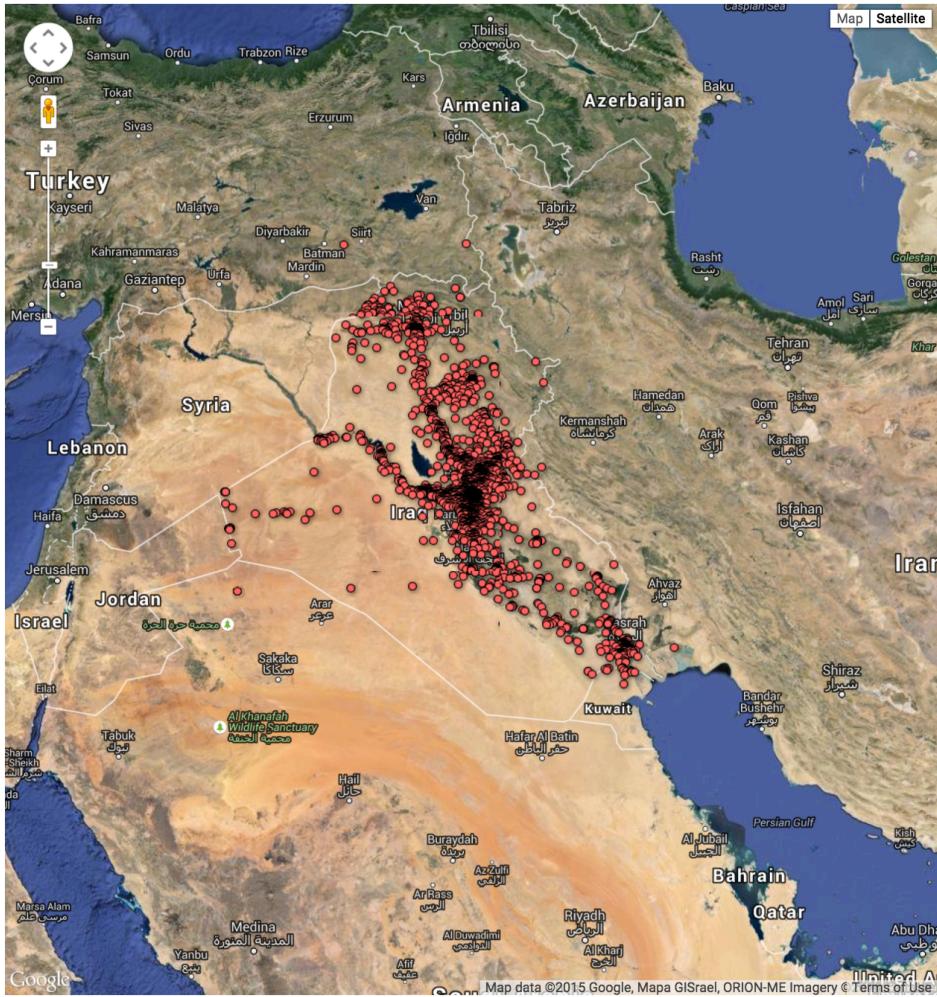
Health Investigative Journalism

Wikileaks Iraq war logs: every death mapped

The Wikileaks Iraq war logs provide us with a unique picture of every death in Iraq. These are those events mapped using Google Fusion tables

- [Download the data from the Datablog](#)

[Share](#) 737
[Tweet](#) 283
[+1](#) 33
[in Share](#) 0



What are we doing with data?

Health

Investigative Journalism

Recommendations



What are we doing with data?

Health

Innovative Technologies

Forbes / Tech

2 FREE Issues of Forbes

FEB 16, 2012 @ 11:02 AM

2,814,982 VIEWS



How Target Figured Out A Teen Girl Was Pregnant Before Her Father Did



Kashmir Hill, FORBES STAFF

Welcome to *The Not-So Private Parts* where technology & privacy collide

[FOLLOW ON FORBES \(2079\)](#)



Opinions expressed by Forbes Contributors are their own.

FULL BIO

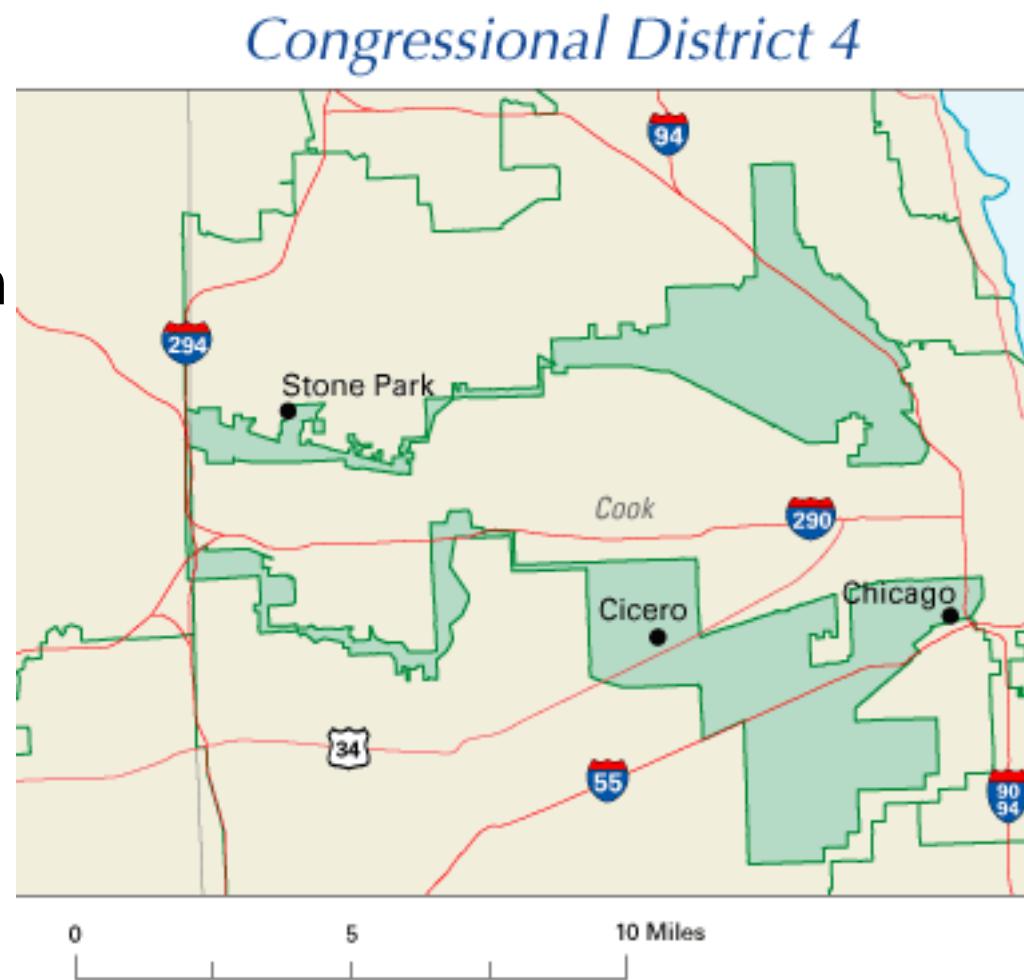
What are we doing with data?

Health

Investigative Journalism

Recommendations

Politics



What are we doing with data?

Health

Investigative Journalism

Recommendations

Politics

The image shows a screenshot of a TIME magazine article. At the top, there is a dark header with the TIME logo and a 'Subscribe' button. Below the header, the text '2012 ELECTION' is written in blue. The main title of the article is 'Inside the Secret World of the Data Crunchers Who Helped Obama Win'. A subtitle below the main title reads: 'Data-driven decisionmaking played a huge role in creating a second term for the 44th President and will be one of the more closely studied elements of the 2012 cycle'.

The image shows a screenshot of the MAYDAY.US website. At the top, there is a red banner with the text 'MAYDAY.US' in white. To the right of the banner is a 'MENU' button. Below the banner, the text 'WE'RE HERE TO FIGHT' is displayed in large, white, hand-drawn style letters. In the center of the page is a red shield-shaped logo containing a white letter 'M'. Below the logo, the text 'Join the movement' is written in a dark blue font. At the very bottom of the page, there is a navigation bar with links for 'HOME', 'ABOUT', 'POLITICS', 'DEMOCRACY', 'MOVEMENT', 'CONTACT', and 'LOG IN'.

What are we doing with data?

Health

Investigative Journalism

Recommendations

Politics

Surveillance

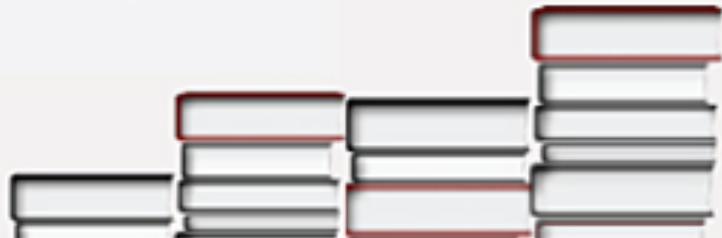
Every day, the NSA intercepts and stores **1.7 billion** emails, phone calls, texts, and other electronic communications.

2



That's equivalent to **138 million books**, every 24 hours.

3



What are we doing with data?

Health

Investigative Journalism

Recommendations

Politics

Surveillance

Identity



30 APR 2012 RESEARCH & IDEAS

India's Ambitious National Identification Program

Comments 30 Email Print Download Share Recommend Share 92

The Unique Identification Authority of India has been charged with implementing a nationwide program to register and assign a unique 12-digit ID to every Indian resident—some 1.2 billion people—by 2020. In a new case, Professor Tarun Khanna and HBS India Research Center Executive Director Anjali Raina discuss the complexities of this massive data management project.

**"YOU ARE BASICALLY DENIED ALMOST EVERYTHING
IF YOU CAN'T PROVE WHO YOU ARE."**

What data?

What data?

Fake data



What data?

Fake data

Biased data

What data?

Fake data

Biased data

Incorrect data

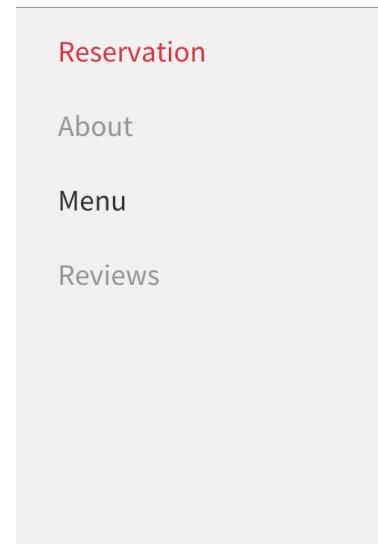
What data?

Fake data

Biased data

Incorrect data

Mixed data



SIDES

Fruit Plate	\$7	S
Patatas Bravas, Spicy-Tangy Sauce and Rosemary Aioli	\$9	H

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BLOG

TOOLS

APIS

POLICY

ISSUES

PRESS

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CONTACT

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Follow Us

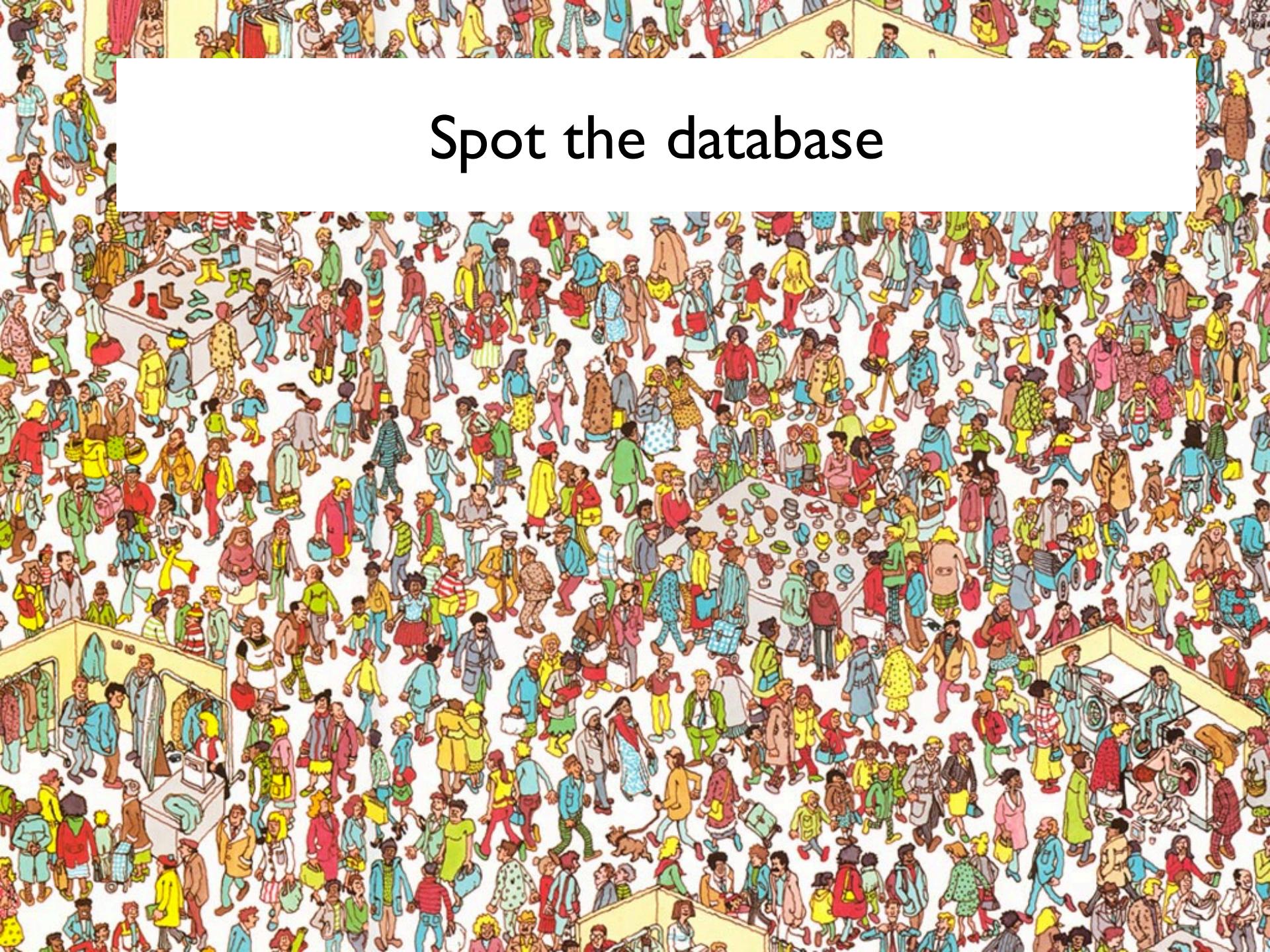


DONATE

JOIN

Making government & politics more accountable & transparent .

Data will be crucial to
how we live
as individuals and as a society



Spot the database







Search Locations



Recent Cities

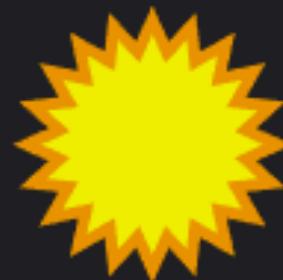
Cambridge, MA

New York, NY

(●) Upper West Side

82 °F

Feels like 82°



82°

69°

10%



75°

71°

68°

71°

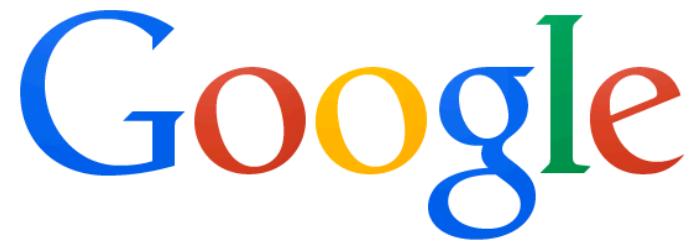
80°

82°

80°

77°

75°



Search Google or type URL



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Search Twitter

**the treeship**

@thetreeship

TWEETS
0FOLLOWING
6FOLLOWERS
3

Who to follow

**Aditya Parameswaran** @adi...
Followed by sirrice and others[Follow](#)**dr electronic max** @emax
Followed by Grace Woo and...[Follow](#)**Find people you know**

Import your contacts from Gmail

Connect other address books

Trends · Change**#GOPDebate**

Five Things To Watch For, While Watching

The GOP Debate

64.7K Tweets about this trend

#Ashes2015

Australia 60 all out: Stats and facts that will leave you bamboozled

122K Tweets about this trend

What's happening?

sirrice retweeted

**IOC MEDIA** @iocmedia · Aug 2

Congratulations to the World Flying Disc Federation (WFDF), which was granted full IOC recognition at the #128IOCSession today!

[Reply](#) [Retweet 519](#) [Star 317](#) [More](#)**Eliran Sapir** @eliransapir · Jul 30[c-span.org/video/?327380-...](#)[Reply](#) [Retweet](#) [Flag](#) [Star](#) [More](#)

sirrice retweeted

**Fred Werner** @SustainableFred · Jul 28

@berkeleyside the sun put on a show over Berkeley BEFORE sunset today

[Reply](#) [Retweet 10](#) [Flag](#) [Star 13](#) [More](#)

Eliran Sapir retweeted

**Apptopia** @Apptopia · Jul 28Thanks @BostInno for naming us a finalist in the #CoolestCompanies! We're cool, like the other side of the pillow. :) [bostinno.streetwise.co/all-series/coo...](#)

2012-01-04 00:01:23,180 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: Receiving
010

2012-01-04 00:01:23,184 INFO org.apache.hadoop.hdfs.server.datanode.DataNode.clienttrace
cliID: DFSClient_-603743753, offset: 0, srvID: DS-292194659-127.0.1.1-50010-13247633001

2012-01-04 00:01:23,185 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: PacketRespo

2012-01-04 00:01:23,291 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: Receiving
10 Is this a Database?

2012-01-04 00:01:23,293 INFO org.apache.hadoop.hdfs.server.datanode.DataNode.clienttrace
cliID: DFSClient_-603743753, offset: 0, srvID: DS-292194659-127.0.1.1-50010-132476330017

2012-01-04 00:01:23,293 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: PacketRespo

2012-01-04 00:01:23,324 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: Receiving
010

2012-01-04 00:01:23,326 INFO org.apache.hadoop.hdfs.server.datanode.DataNode.clienttrace
cliID: DFSClient_-603743753, offset: 0, srvID: DS-292194659-127.0.1.1-50010-1324763300176

2012-01-04 00:01:23,327 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: PacketRespo

2012-01-04 00:01:23,409 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: Receiving
10

2012-01-04 00:01:23,411 INFO org.apache.hadoop.hdfs.server.datanode.DataNode.clienttrace
, cliID: DFSClient_-603743753, offset: 0, srvID: DS-292194659-127.0.1.1-50010-13247633001

2012-01-04 00:01:23,411 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: PacketRespo

2012-01-04 00:01:23,433 INFO org.apache.hadoop.hdfs.server.datanode.DataNode.clienttrace
cliID: DFSClient_-2054881890, offset: 0, srvID: DS-292194659-127.0.1.1-50010-13247633001

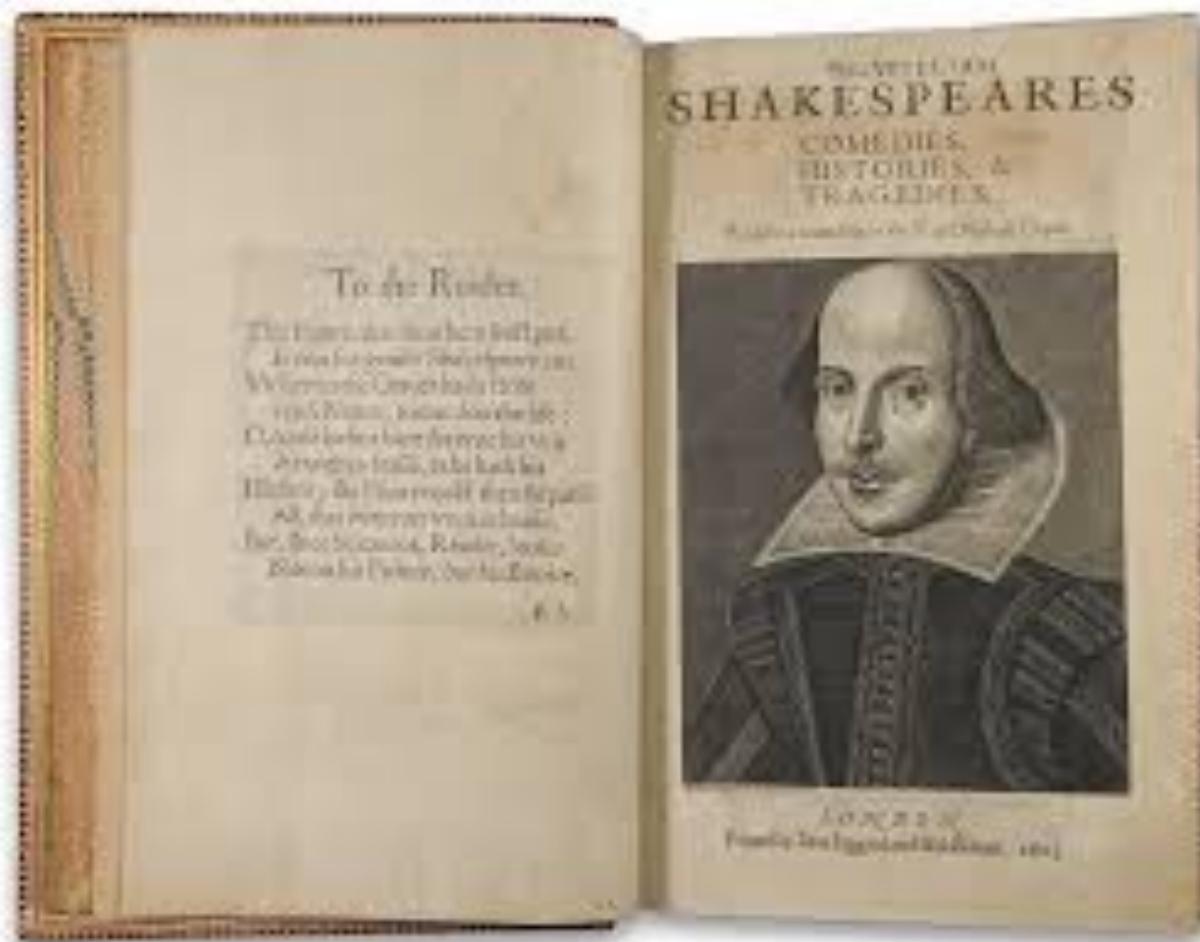
2012-01-04 00:01:23,494 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: Receiving
10

2012-01-04 00:01:23,498 INFO org.apache.hadoop.hdfs.server.datanode.DataNode.clienttrace
, cliID: DFSClient_-2054881890, offset: 0, srvID: DS-292194659-127.0.1.1-50010-13247633001

2012-01-04 00:01:23,498 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: PacketRespo

2012-01-04 00:01:23,523 INFO org.apache.hadoop.hdfs.server.datanode.DataNode: Receiving
010





To Sir: Reader:

This volume has been left you,
As you for some time have been
My constant Companion in Ease
And Pleasure; but as now the life
Of Man is but a short continuall
Progression, and he hath his
Hilights, so these will be your Hilights:
All other enterprizes will be
For these to follow. Reader, look
Upon this Picture, and be well advised.

SHAKESPEARE'S
COMEDIES,
HISTORIES, &
TRAGEDIES.

A Collection of the Best English Drame



London
Printed for T. Egerton and W. Johnson, 1664.

SALES_DATA_TABLES.xlsx - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Developer

C39 Alfa Romeo Mito

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	ID	BRAND	MODEL	YYYYMM	REGION	D_MODEL_ID	D_MONTH_ID	D_REGION_ID	SALES_UNITS	MM/YYYY					
2	1000	Alfa Romeo	Alfa Romeo 147	201202	Netherlands	1000	1001	1000	1	Feb-12					
3	1001	Alfa Romeo	Alfa Romeo 147	201203	Netherlands	1000	1002	1000	1	Mar-12					
4	1002	Alfa Romeo	Alfa Romeo 159	201201	Netherlands	1001	1000	1000	24	Jan-12					
5	1003	Alfa Romeo	Alfa Romeo 159	201202	Netherlands	1001	1001	1000	15	Feb-12					
6	1004	Alfa Romeo	Alfa Romeo 159	201203	Netherlands	1001	1002	1000	14	Mar-12					
7	1005	Alfa Romeo	Alfa Romeo 159	201204	Netherlands	1001	1003	1000	3	Apr-12					
8	1006	Alfa Romeo	Alfa Romeo 159	201205	Netherlands	1001	1004	1000	7	May-12					
9	1007	Alfa Romeo	Alfa Romeo 159	201206	Netherlands	1001	1005	1000	5	Jun-12					
10	1008	Alfa Romeo	Alfa Romeo 159	201207	Netherlands	1001	1006	1000	3	Jul-12					
11	1009	Alfa Romeo	Alfa Romeo 159	201208	Netherlands	1001	1007	1000	2	Aug-12					
12	1010	Alfa Romeo	Alfa Romeo 159	201209	Netherlands	1001	1008	1000	1	Sep-12					
13	1011	Alfa Romeo	Alfa Romeo 159	201210	Netherlands	1001	1009	1000	1	Oct-12					
14	1012	Alfa Romeo	Alfa Romeo 159	201211	Netherlands	1001	1010	1000	1	Nov-12					
15	1013	Alfa Romeo	Alfa Romeo 159	201301	Netherlands	1001	1012	1000	1	Jan-13					
16	1014	Alfa Romeo	Alfa Romeo 159	201302	Netherlands	1001	1013	1000	4	Feb-13					
17	1015	Alfa Romeo	Alfa Romeo Giulietta	201201	Netherlands	1002	1000	1000	278	Jan-12					
18	1016	Alfa Romeo	Alfa Romeo Giulietta	201202	Netherlands	1002	1001	1000	186	Feb-12					
19	1017	Alfa Romeo	Alfa Romeo Giulietta	201203	Netherlands	1002	1002	1000	176	Mar-12					
20	1018	Alfa Romeo	Alfa Romeo Giulietta	201204	Netherlands	1002	1003	1000	132	Apr-12					
21	1019	Alfa Romeo	Alfa Romeo Giulietta	201205	Netherlands	1002	1004	1000	142	May-12					
22	1020	Alfa Romeo	Alfa Romeo Giulietta	201206	Netherlands	1002	1005	1000	174	Jun-12					
23	1021	Alfa Romeo	Alfa Romeo Giulietta	201207	Netherlands	1002	1006	1000	56	Jul-12					
24	1022	Alfa Romeo	Alfa Romeo Giulietta	201208	Netherlands	1002	1007	1000	62	Aug-12					
25	1023	Alfa Romeo	Alfa Romeo Giulietta	201209	Netherlands	1002	1008	1000	71	Sep-12					
26	1024	Alfa Romeo	Alfa Romeo Giulietta	201210	Netherlands	1002	1009	1000	72	Oct-12					
27	1025	Alfa Romeo	Alfa Romeo Giulietta	201211	Netherlands	1002	1010	1000	46	Nov-12					
28	1026	Alfa Romeo	Alfa Romeo Giulietta	201212	Netherlands	1002	1011	1000	47	Dec-12					
29	1027	Alfa Romeo	Alfa Romeo Giulietta	201301	Netherlands	1002	1012	1000	107	Jan-13					

F_SALES D_MODEL D_MONTH D_REGION

Ready

Dewey #	10 Main Classes	Kinds of Books
000-099	General Works	encyclopedias, almanacs, record books, such as Guinness
100-199	Philosophy and Psychology	paranormal phenomena, such as ghosts, ethics, how we think
200-299	Religion	mythology, religions
300-399	Social Science	government, holidays, folklore, fairy tales, education, community
400-499	Language	English and foreign languages, sign language, dictionaries
500-599	Natural Science	math, chemistry, biology, weather, rocks, plants, animals in nature
600-699	Applied Science	inventions, health, drugs, transportation, cooking, pets
700-799	Fine Arts and Recreation	crafts, art, drawing, painting, music, games, TV, movies, sports
800-899	Literature	short stories, poetry, plays, jokes, riddles (fiction could be here)
900-999	History and Geography	countries, flags, historical events, biographies (92 or 920)

What is a Database?

Structured data

What is a Database?

Lots of
Structured data

Database Management System (DBMS)

A system to **store, manage** and **access** databases

Database Management System (DBMS)

System to **safely** and **reliably** store **lots** of **persistent** structured data and is **convenient** for **multiple** users to **efficiently** access and modify.

Is a script a DBMS?

Java/Python/etc Script

Data stored in variables (RAM)

Very fast access

Is Excel a DBMS?

Microsoft office security

Visually access/modify/compute over data cells

Click save to store persistently

Is the file system a DBMS?

Manages files that are persistently stored on disk

Open/read/seek/write access to files

Access via file names

Access control via permissions

Is the file system a DBMS?

You and a friend edit the same text file
Save at the same time
What happens?

1. Your changes survive
2. Friend's changes survive
3. Both changes survive
4. No changes survive
5. $\neg \backslash (\psi) \neg$

Is the file system a DBMS?

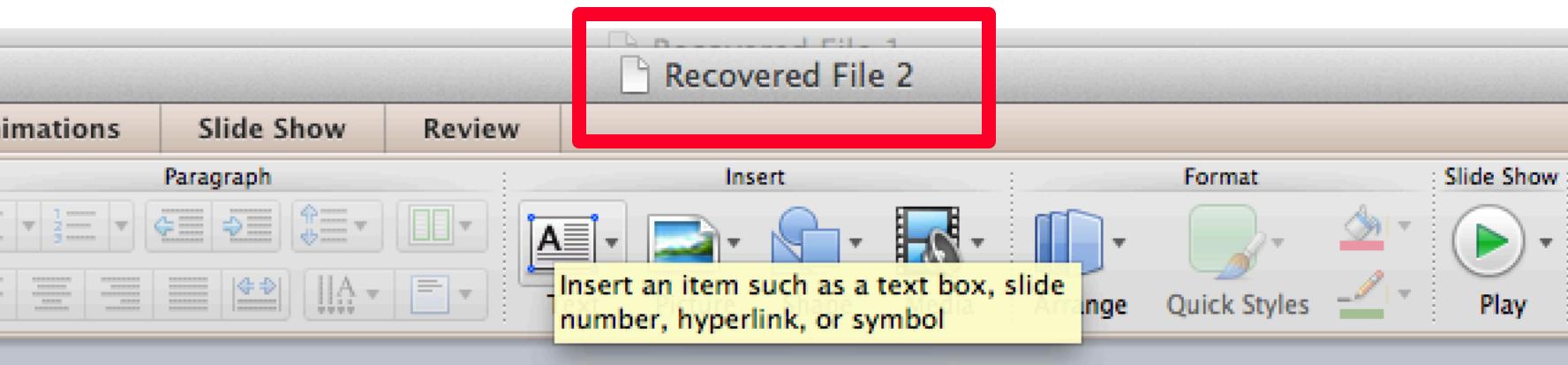
You edit a text file

Computer crashes

What happens?

1. All changes survive
2. No changes survive
3. Changes from last save survive
4. $\neg \backslash(\forall)_/\neg$

Is the file system a DBMS?



COMS W4111
Introduction to Databases

Want Guarantees from DBMS

You want to write a hot new app on a DBMS.
What do you *not* want to worry about?

Failures disk, machine, human, corruption, deity

Lots of users

Ad-hoc data access

Data formats csv? tsv? custom format?

Database Management System (DBMS)

System to **safely** and **reliably** store **lots** of **persistent** structured data and is **convenient** for **multiple** users to **efficiently** access and modify.

Database Management System (DBMS)

Safe	Consistent and correct data after failures
Reliable	99.99+% Uptime
Lots	>>RAM (terabytes)
Persistent	Lives longer than DBMS application
Convenient	Physical Independence. Declarative.
Multiple Users	Concurrent access. Access control.
Efficient	<i>Fast: 100k+ queries / sec</i>

DBMSes in the Wild

Classic Relational

\$\$: Oracle, IBM, Microsoft, Teradata, EMC, etc

Free: MySQL, PostgreSQL

New Relational

In-Memory, Column-store, Streaming

Non-traditional

Search (Google, Bing, Lucene), Scientific, Geographic

NoSQL

Big Data: Hadoop, Spark, etc

Key-value: Mongo, BerkeleyDB, Cassandra, etc

DBMS-as-a-Service

Microsoft Azure, Amazon Redshift/RDS, etc...

Encompasses most of CS

OS	DBMS directly manages hardware
Languages	SQL is a domain specific language
Theory	Algorithms, models, NP-complete
AI/ML	Knowledge Discovery
Logic	Relational Algebra = 1 st order logic

Scalable Computer Science

Good time to learn!

Cloud programmer

Data science

Data engineer

Machine learning engineer



DATA

Data Scientist: The Sexiest Job of the 21st Century

by Thomas H. Davenport and D.J. Patil

FROM THE OCTOBER 2012 ISSUE

2 Key Concepts

Data Independence
Declarative Languages

Serve to insulate application programmers
from the system implementation

Data Independence

External Schema

Describe how users see data

External Schema

Conceptual Schema

Describes logical structure

Conceptual Schema

Physical Schema

Describes files and indexes

Physical Schema

“Data”

Example App: Guuber

Users(**uid int**, name str, age int)

Drivers(**did int**, name str)

Rides(**uid int, did int**, distance float, drive_time float)



Data Independence

UID	Name	Age
0	Eugene	17
1	Luis	20
2	Ken	30

0,Eugene,17
1,Luis,20
2,Ken,30
CSV File

What is the number of adults?

Data Independence

UID	Name	Age
0	Eugene	17
1	Luis	20
2	Ken	30

0,Eugene,17
1,Luis,20
2,Ken,30
CSV File

```
n = 0
for line in csv_file:
    attributes = line.split(",")
    if attributes[2] >= 18:
        n += 1
```

Data Independence

UID	Name	Age
0	Eugene	17
1	Luis	20
2	Ken	30

0,1,2
Eugene,Luis,Ken
17,20,30

CSV File

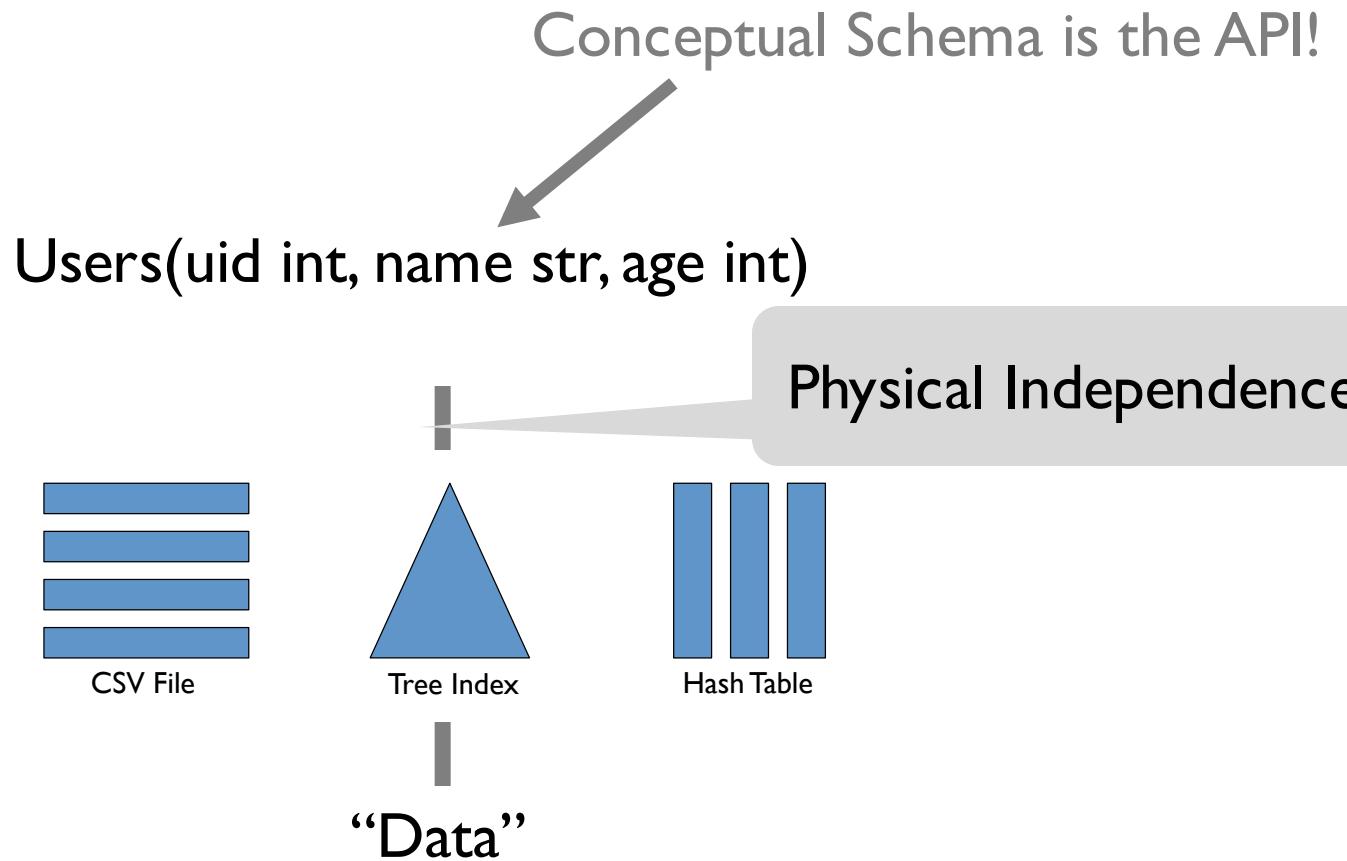
~~n = 0~~

```
For line in csv_file:  
    attributes = line.split(",")  
    if attributes[2] >= 18:  
        n += 1
```

Data Independence

Conceptual Schema
Describes logical structure

Physical Schema
Describes files and indexes



Data Independence

Users(uid int, name str, age int)

Drivers(did int, name str)

Rides(uid int, did int, distance float, drive_time float)

“Welcome back Mr. Wu”

Data Independence

Users(uid int, **fname str, lname str**, age int)

Drivers(did int, name str)

Rides(uid int, did int, distance float, drive_time float)

“Welcome back Mr. Wu”

Data Independence

Conceptual

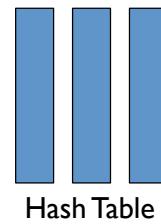
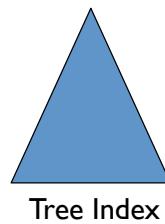
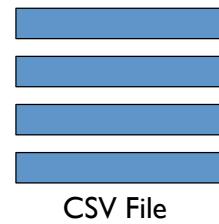
Schema

Describes logical
structure

`Users(uid int, name str, age int)`

Physical Schema

Describes files and
indexes



Physical Independence

“Data”

Data Independence

Conceptual

Schema

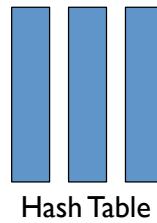
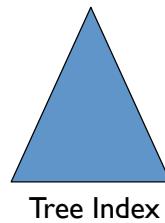
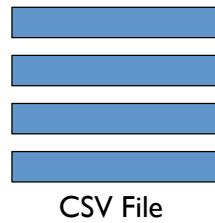
Describes logical
structure

Physical Schema

Describes files and
indexes

Users(uid int, fname str, lname str, age int)

Physical Independence



“Data”

Data Independence

External Schema

Describe how users see data

Conceptual Schema

Describes logical structure

Physical Schema

Describes files and indexes

View 1

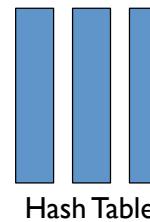
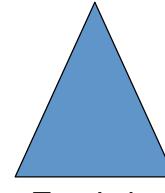
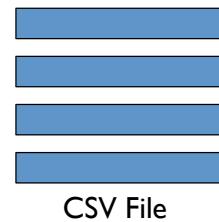
View 2

View 3

Logical Independence

Users(uid int, fname str, lname str, age int)

Physical Independence



“Data”

Data Independence

Physical Independence

Protection from changes in physical structure of data

Logical Independence

Protection from changes in logical structure of data

One of most important properties of a DBMS

Declarative

What you want,

not how to do it.

“Make me a sandwich”

Buy from pb&j store

Make BLT

½ Tuna

Veggie

“Take two slices of wheat bread out of the 2nd shelf, put them next to each other...”

What if on 1st shelf?
Out of wheat bread?
No counter space?

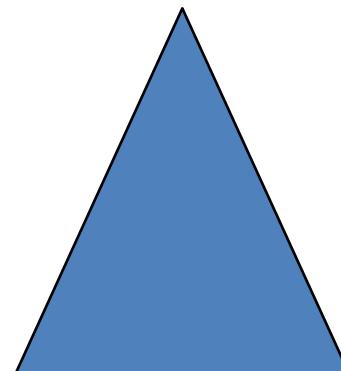
Declarative

“I want all highly rated fast drivers”

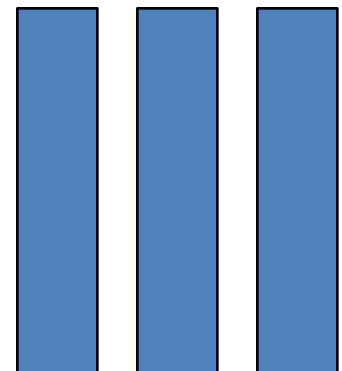
DBMS



CSV File



Tree Index



Hash Table

Declarative

“I want all highly rated fast drivers”

DBMS

Node

Node

Node

Declarative

“I want all highly rated fast drivers”

DBMS

Node

Classic Components in Databases

Concurrency Control

Transactions

Atomicity

Recovery and Logs

Transaction: Execution of a DB Program

Def: *atomic* sequence of DBMS actions

```
Begin;  
<read beth's account>  
<deduct from beth's account>  
<increase eugene's account>  
Commit; (or Abort;)
```

Transaction: Execution of a DB Program

Def: *atomic* sequence of DBMS actions

Each fully executed transaction must leave DB in
consistent state if DB is consistent before transaction

- Users specify simple *integrity constraints* on data, and DBMS enforces the constraints.
- DBMS does not understand semantics of its data
e.g., doesn't know how bank interest is computed
- User's responsibility to ensure transaction (run alone) preserves consistency

Concurrency Control

Concurrently running multiple user programs needed for good performance

Disk accesses are frequent & slow. Keep CPU working on several user programs while waiting.

Concurrency can cause inconsistencies

- e.g., check cleared while account balance being computed.
- *Really* hard to program against

DBMS ensures such problems don't arise

- programmers can pretend to use a single-user system.

Scheduling Concurrent Transactions

Transactions T_1, \dots, T_n are run concurrently
Equivalent to a *serial* ordering (as if no concurrency)

Locks: T_i requests and waits for lock before read/write.

e.g., T_i locks the database, updates, then releases

e.g., T_i locks the table, updates, then releases

e.g., T_i locks rows, updates, then releases

Will talk about how this works later in course.

Atomicity

Def: Xact fully completes, or never happened
even after failures e.g., crashes

Record all actions Xact did during execution in a log

- I. **Write ahead logging:** before making any change, ensure the change is safely recorded in log
2. After failure, read log and undo any incomplete Xacts

The Log

A log record contains enough info to undo actions:

- Transaction id

- T_i writes an object: old and new values

- Log record *must* be safely stored before the changed data

- T_i commits/aborts: store commit/abort action

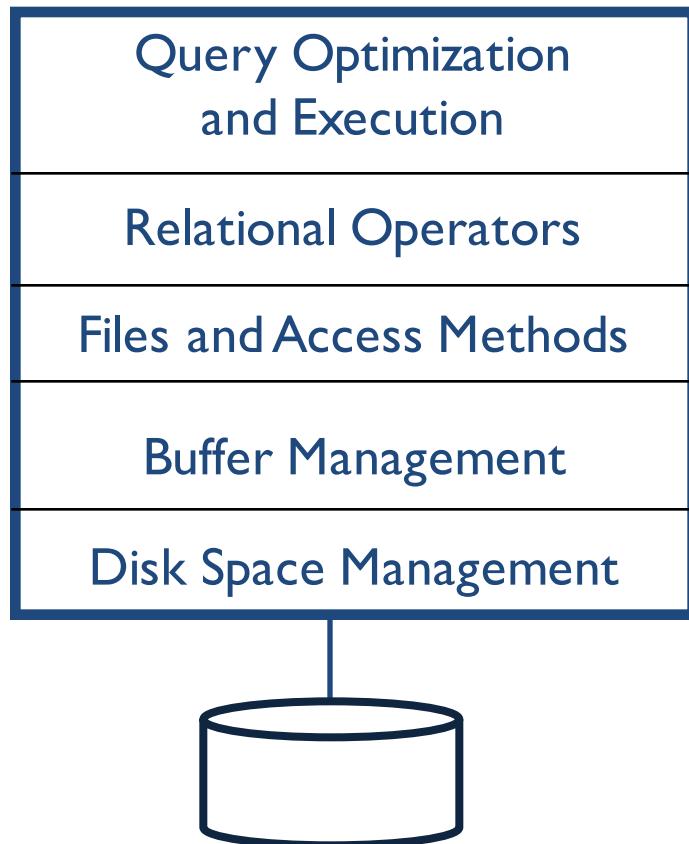
All logging, recovery and concurrency control activities hidden away from user.

Classic Structure of a DBMS

Typical layered architecture
DBMS, not OS, manages
memory and disk

Doesn't show concurrency
control & recovery components

These layers
must consider
concurrency
control and
recovery



Database Courses at Columbia

COMS W4111 - Intro to Databases

Prerequisites: CS3137 or CS3134; fluency in Python

Intro to DBMSes

Data Models Entity-relation, Relational, ...

Relational Algebra

SQL

Applications + SQL cursors, APIs, embedded ...

Normalization

Peek at DBMS internals:

- Storage and indexing

- Query optimization

- Transaction Processing

COMS W4112-Database Sys. Impl.

Storage Methods and Indexing

Query Processing and Optimization for INF Relations,
including external sorting

Materialized Views and Use in Query Optimization

Query Processing and Optimization for ORDBMSs

Transaction Processing and Recovery

Parallel & Distributed DBMSes: Query Proc. and
Optimization

Parallel and Distributed Databases: Transaction Processing

Performance Considerations Beyond I/Os

COMS E6111-Advanced Databases

Prerequisites: CS4111; fluency in Java or Python

Information Retrieval

Web Search

Distributed Information Retrieval and Web Search

Data Mining

Data Warehousing, OLAP, Decision Support

Information Extraction

Scalable Visualization and Interaction

Supporting data analysis

Exploration, explanation and exhibition techniques

Administrivia

Next Up

Set up your environment on the cloud

HW0 is out.

Due by Monday 9/14 10AM sharp.

Must be completed on time to stay in this class

Your Instructor: **Eugene Wu**

B.S. @U.C. Berkeley

Ph.D. @MIT

PostDoc @U.C. Berkeley

Assistant Professor since Fall 2015

Databases, visualization, data analysis
data cleaning, crowdsourcing.

Your Instructor: **Eugene Wu**

Contact

<http://www.cs.columbia.edu/~ewu>

ewu@cs.columbia.edu

7LW1A Schapiro CEPSR

1-212-939-7088

Office hours

Weds 4-5PM

By appointment by email

Class Resources

Class web page

<http://www.cs.columbia.edu/~coms4111>

Discussion board

piazza (linked from courseworks/website)

Announcements from class staff:

CourseWorks → [@columbia.edu email](mailto:@columbia.edu)

Your TAs

Anthony Dubis

Mengqing Wang

Jincheng Li

Sania Arif

All TA office hours in CS TA Room (see class web page)

TA office hours will be posted on class web page

Class Information: Prerequisites

**COMS W3134 - *Data Structures in Java* or
COMS W3137 - *Data Structures and Algorithms***

(equivalent courses taken elsewhere are acceptable as well)

Fluency in Python

**You need permission from the instructor if you don't
have the prerequisites.**

Class Information: Lectures

Mondays and Wednesdays

2:30 - 4 p.m.

833 Mudd

(here)

Grading Information

Midterm: 15% (current est: 10/28)

Final : 40% (last day of class, 12/9)

HW: 15% (4 HWs equally weighed)

Project I: 15%

Project 2: 5%

Median grade: B+ or slightly higher.

Alternative or make-up exams will not be given.

All homework assignments are equally weighted.

Project I has higher weight than Project 2.

Exam Dates

Midterm: 10/28, in class

Final: 12/9 last day of class, in class

If you cannot make the final exam,
do not take this course

Homework

Homeworks usually due at 10AM of due date.

No extensions or exceptions.

Three grace late days for hws throughout the semester.

After using all grace days, 25% grade deduction per late day.

Check full details on web site.

Projects (more details soon)

Two projects.

Teams of two

Run on Microsoft Azure cloud infrastructure

Get CS account if your team doesn't have a computer

Language is Python; w/ a “minimal programming” option.

Project 1

Model and build your own database web application

Explore “traditional” relational database features.

Project 2

TBD

Projects (cont.)

No extensions or exceptions for project submission.

3 grace late days total for project.

After using all grace days, 25% grade deduction per late day.

Check full details on web site.

Collaboration Policy

Read Syllabus on course site for allowed conduct

CS Dept academic honesty policies

<http://www.cs.columbia.edu/education/honesty>

We will not tolerate *any* cheating

Collaboration Policy

Discussing lectures and course material strongly encouraged

Homework and exams are *individual*. No exceptions
Any libraries or code however minor must be disclosed.

Projects are done in teams; no collaboration between teams.

Contact the instructor right away if you have any questions or are falling behind.

Textbook

Raghu Ramakrishnan, Johannes Gehrke: *Database Management Systems*, 3rd edition, McGraw-Hill, 2002

Available from

Bookculture bookstore 536 W. 112th St.

Online retailers

Upperclass-persons

On reserve in Engineering Library

Contests and Rewards

“A+ letter-and-lunch” reward

Students who earn an A+ will get

Personal letter of congratulations from the instructor.

Lunch at Faculty House with instructor and A+ students

Top candidates for cs4111 TA positions in the future.

Project I contest

Four best projects chosen as contest winners.

Winners get:

Option to discuss and demo your project in class.

10% boost in your Project I grade.

On-going Feedback

Please provide feedback throughout the course.

- What is useful or confusing in lecture
- Thoughts about software stack
- Thoughts about assignments

Email me, come to office hours, talk to staff or:

On-going Feedback

Use form on website

The image shows a feedback form titled "Feedback form" with a light gray background. At the top, it says "Please share your comments and suggestions for the course!" Below that, there is a note in red text: "* Required". A section titled "Feedback *" asks the user to "Share what worked or what was confusing/difficult" and contains a large empty text area. Another section titled "Improvements" asks "What change would you suggest to improve things?" and also contains a large empty text area.

Feedback form

Please share your comments and suggestions for the course!

* Required

Feedback *

Share what worked or what was confusing/difficult

Improvements

What change would you suggest to improve things?

Slides borrow material from
Prof. Gravano

Prof. Hellerstein & Franklin@Cal

Prof. Madden & Stonebraker@MIT

(and by transitivity Raghu Ramakrishnan and Johannes Gehrke)

Useful info

<http://www.cs.columbia.edu/~coms4111>

<https://courseworks.columbia.edu/>

MW 2:30-4P, Seeley W. Mudd 833

ewu@cs.columbia.edu

DO HOMEWORK 0!



What's happening?



ewu @sirrice · 18s

. @thisisdhaas @lydiagu is presenting macrotask crowdsourcing at Kings 3 10:45AM today! #vldb15 vldb.org/pvldb/vol8/p16...



Nieman Lab retweeted



Ann Marie Lipinski @AMLwhere · 6m

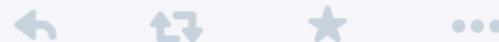
Powerful argument in this ebook for the future of J school by our visiting fellow @webbmedia Important, provocative nieman.harvard.edu/books/how-to-m...



Adam Marcus @marcua · 3m

@sirrice @thisisdhaas @lydiagu dawg you gotta ." that...

10:54 AM - 1 Sep 2015 · Details



Hide conversation



Reply to @marcua @thisisdhaas @lydiagu