DataHub: Collaborative Data Science and Dataset Version Management at Scale

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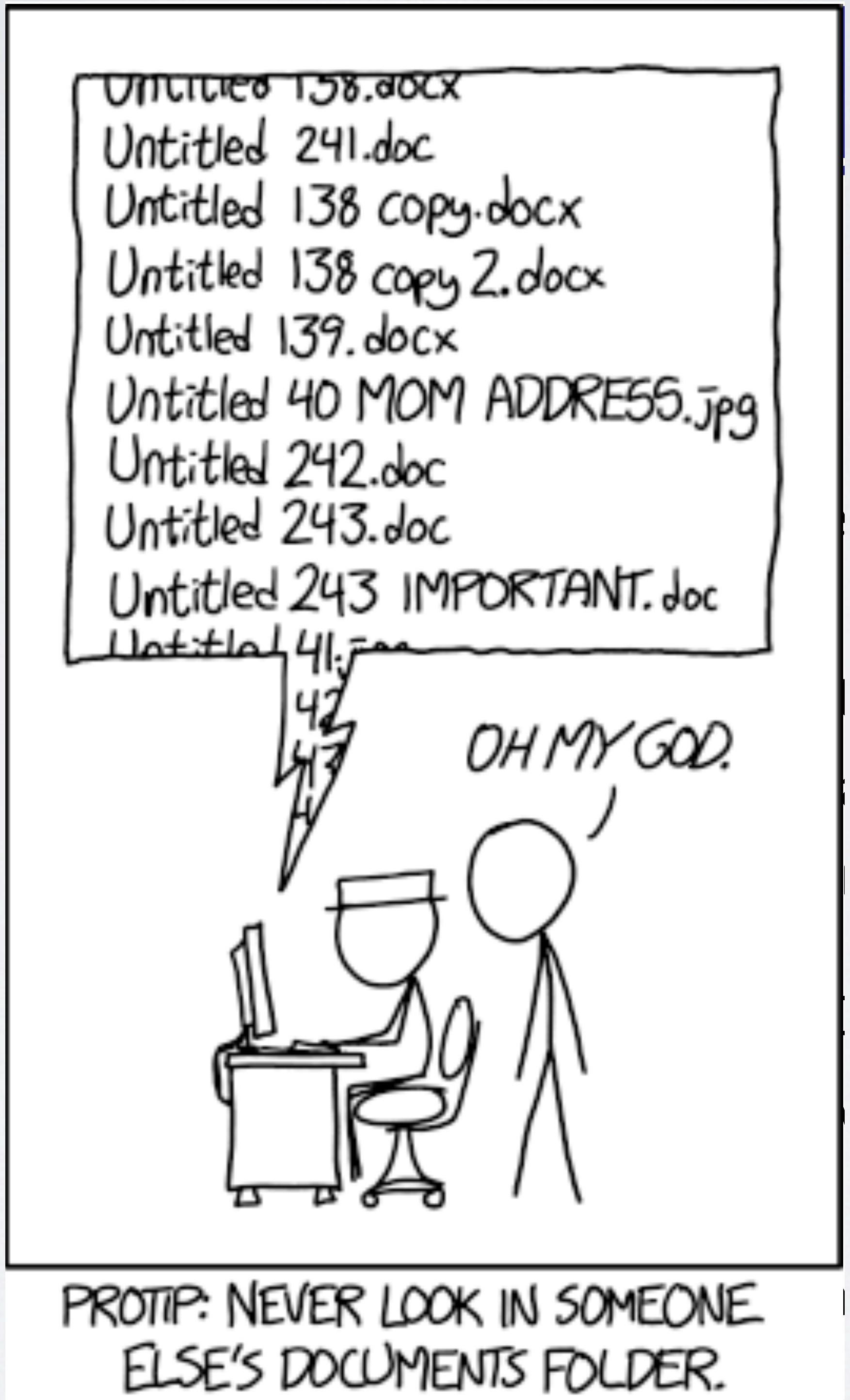
U Illinois

Deep, Dark Secrets of Data Science



Courtesy: XKCD

How bad could taset ma it get?

FINALLY REVEALED

The Investigator Team

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Anant Bhardwaj

A True (Horror) Story of Dataset Management

Before

What did we learn?

Research Scientist

We use about 100TB of data across 20-30 researchers

We spend a **LOT** of money on this.

Everything is organized around shared folders, and everyone has access.

Our dataset management scheme is so simple, it's great!

What did we learn?

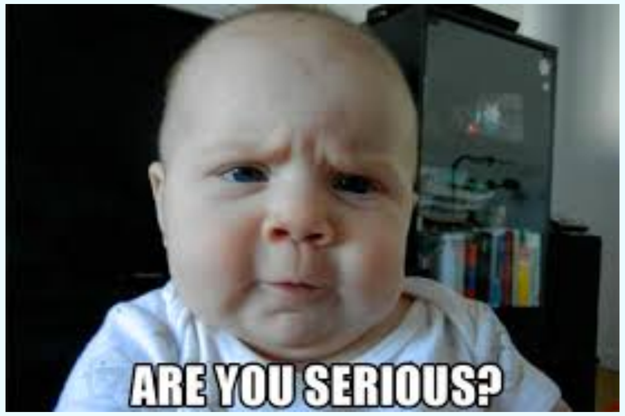
So how do users work on datasets?

They typically make a private copy.

Us

But wouldn't that mean lots of redundant versions and duplication?

Yes. That's why our storage is 100TB.



1: Massive redundancy in stored datasets

What did we learn?

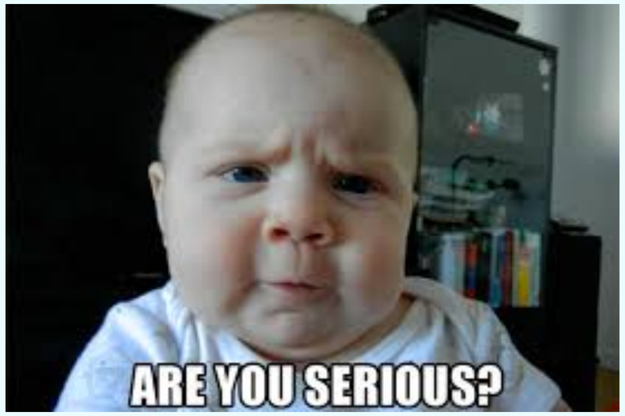
Do you have datasets being analyzed by multiple users simultaneously?

Sure, but we have no way of knowing or resolving modifications

Us

But wouldn't that mean you cannot combine work across users

True. The users will need to discuss.



II: True collaboration is near impossible!

What did we learn?

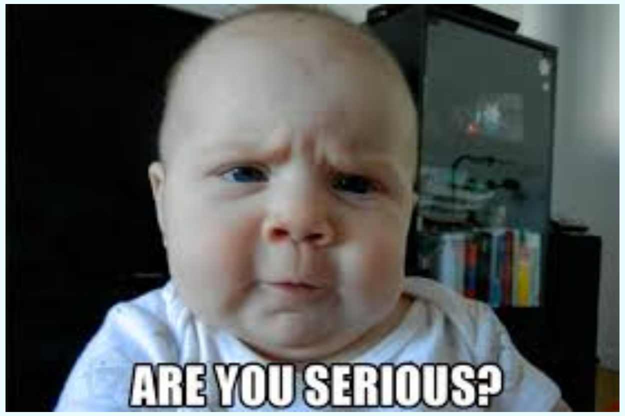
Do you get rid of redundant datasets, given that you have space issues?

All the time!

What if the user had left, and if the dataset is crucial for reproducibility?

Us

We cross our fingers!



III: Unknown dependencies between datasets

What did we learn?

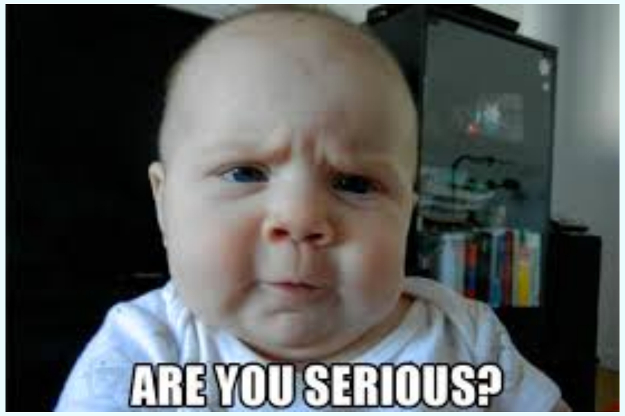
Is there any way users can search for specific dataset versions of interest?

Not really. They talk to me.

What if you leave?

Us

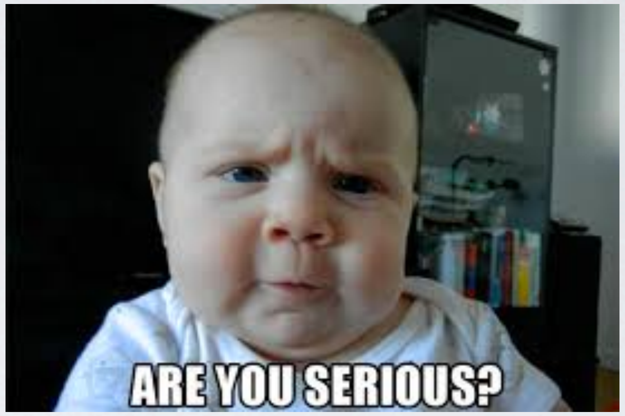
Let's pray for the group's sake that that doesn't happen!



IV: No organization or management of dataset versions.

What did we learn?

The four



1. *Massive redundancy in stored datasets*
2. *Truly collaborative data science is impossible*
3. *Unknown dependencies between dataset versions*
4. *No efficient organization or management of datasets*

Happens all the time…

Every collaborative data science project ends up in dataset version management hell

Surely, there must be a better way?

1. *Massive redundancy in stored datasets*
2. *Truly collaborative data science is impossible*
3. *Unknown dependencies between dataset versions*
4. *No efficient organization or management of datasets*

Have we seen this before?

Analogous to management of source code before source code version control!

How about:
DataHub: a "GitHub for data"

Solving the "AYS" problems

1.	*Massive redundancy in stored datasets*	Compact storage
2.	*Truly collaborative data science is impossible*	"Branching" allowed
3.	*Unknown dependencies between versions*	Explicit and implicit
4.	*No efficient organization or management*	Rich retrieval methods

What about alternatives?

Many issues with directly using GitHub or SC-VC:

- Cannot handle large datasets or large # of versions
- Querying and retrieval functionality is primitive
- Datasets have regular repeating structure

Many issues with temporal databases: similar issues, plus one major one:

- Only supports a linear chain of versions

The Vision for DataHub

The
ONE·STOP
OPEN
Play here
UNDER 25?
PUSH
This store closes Saturday 5th June
It will re-open as a Tesco Express later this year
HALF PRICE
open every
wines

for collaborative data science and dataset version management

satisfying all your dataset book-keeping needs.

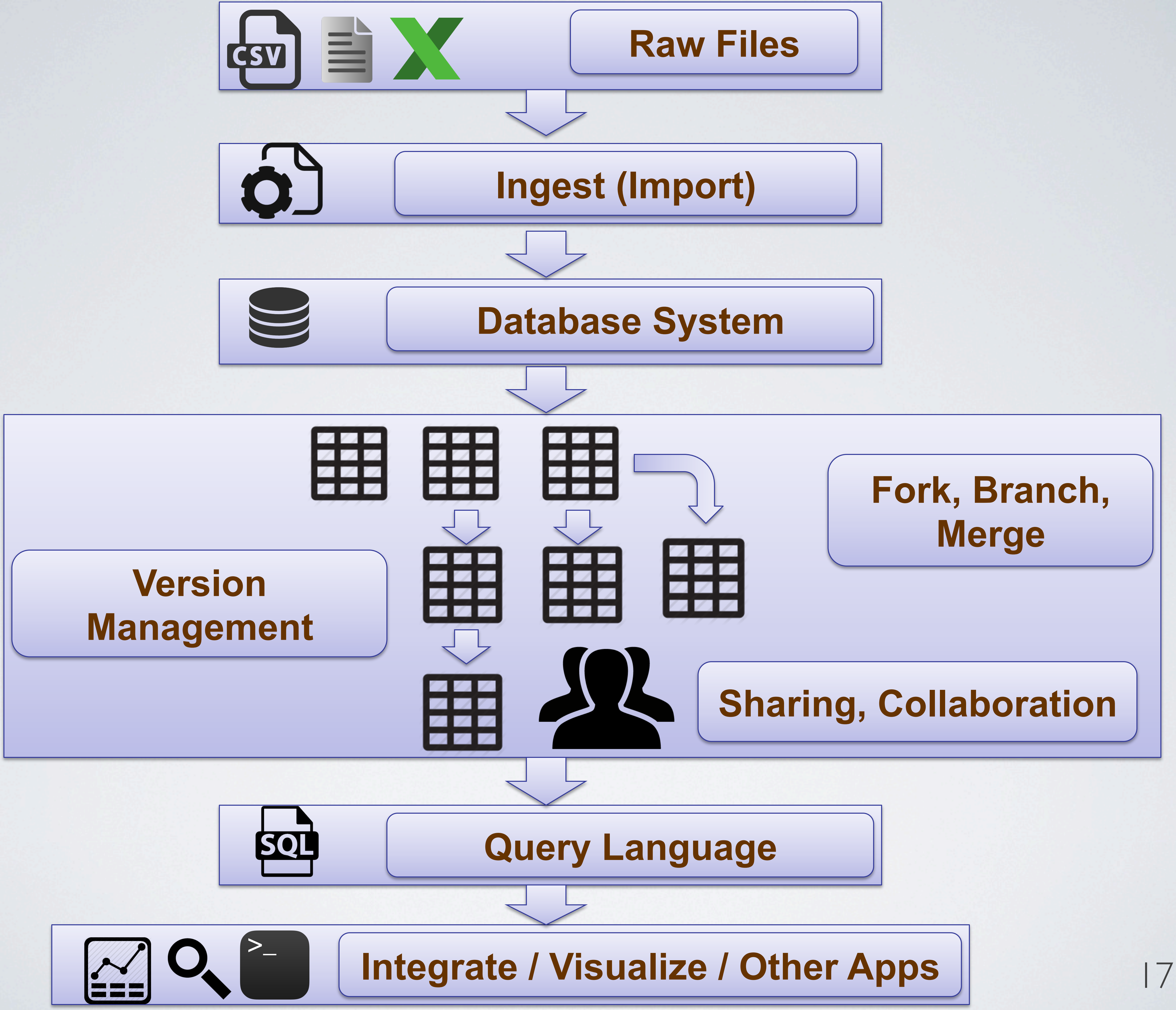
The Vision for DataHub

Basics:

- *Efficient maintenance and management of dataset versions*

DataHub will also have:

- *A rich query language encompassing data and versions*
- *In-built essential data science functionality such as ingestion, and integration, plus API hooks to external apps (MATLAB, R, …)*



Raw Files

Ingest (Import)

Database System

Version Management

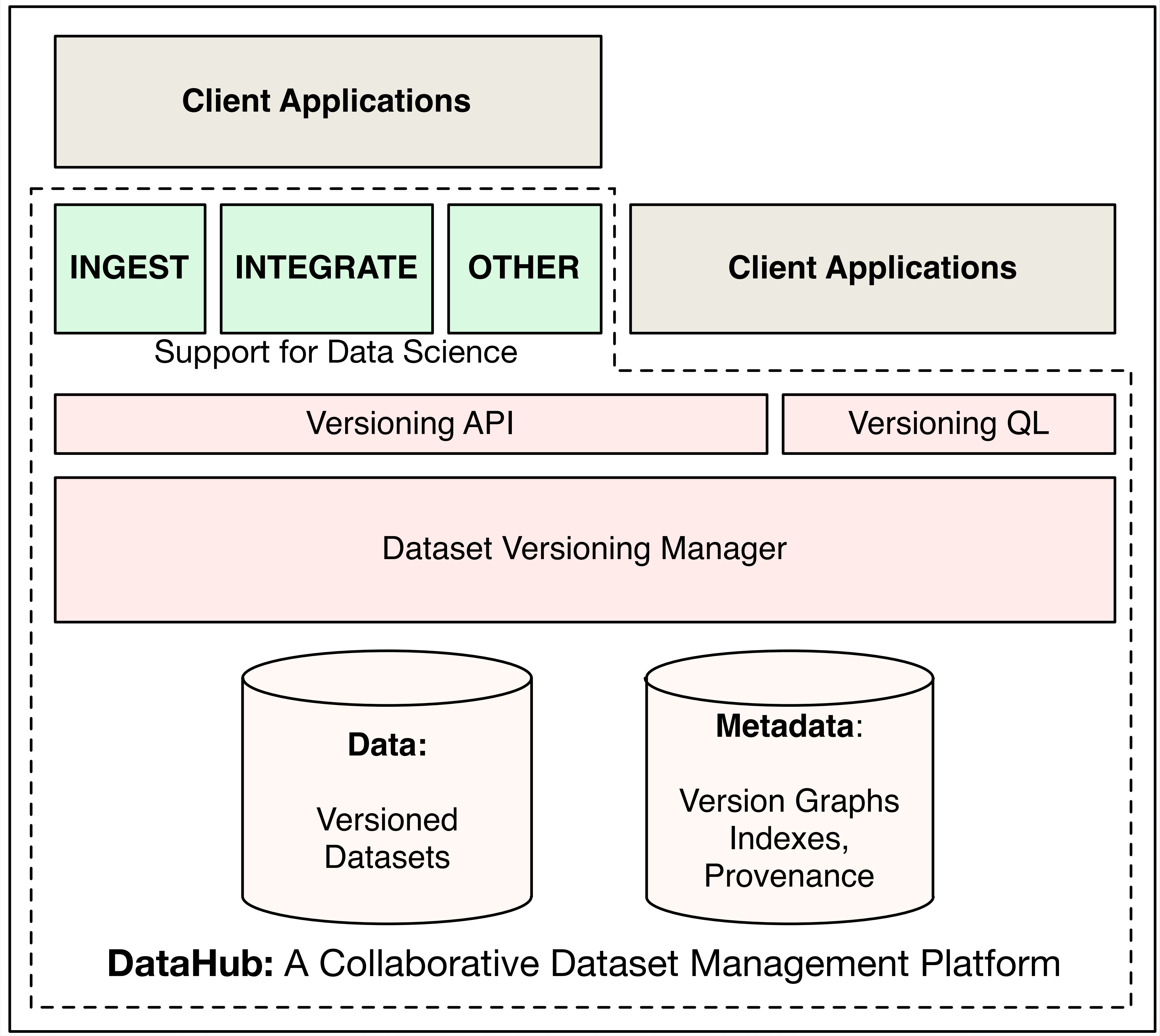
Fork, Branch, Merge

Sharing, Collaboration

Query Language

Integrate / Visualize / Other Apps

DataHub Architecture



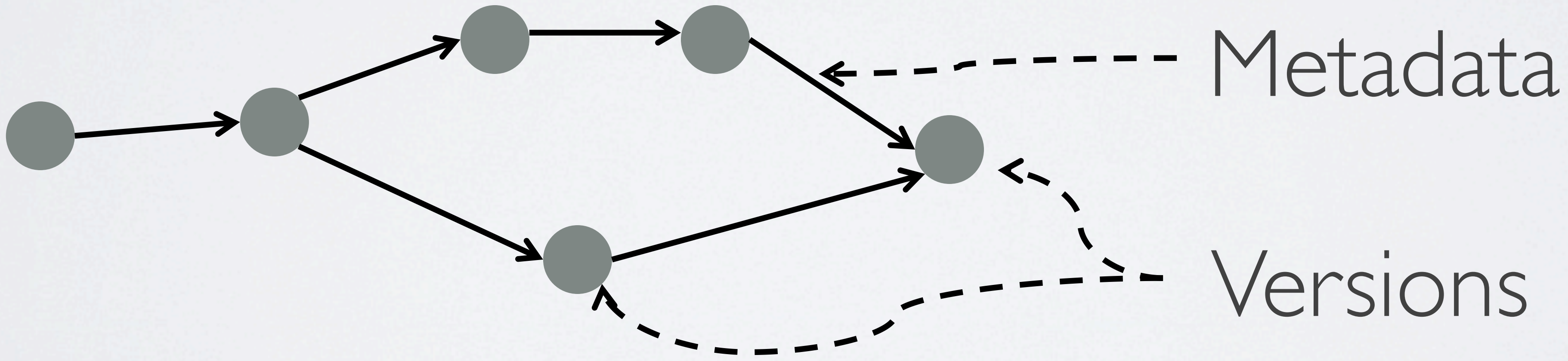
Data Model and Basic API

Flexible "Schema-later" Data Model

Groups of records with different schemas in same table

Key	Value
Sam	(Berkeley, 2003, Hellerstein)
Amol	(Berkeley, 2004, Hellerstein)
Aaron	(UCSB, 2014, El Abbadi and Agrawal)

Key	School	Year	Advisor
Sam	Berkeley	2003	Hellerstein
Amol	Berkeley	2004	Hellerstein
Aaron	UCSB	2014	El Abbadi and Agrawal



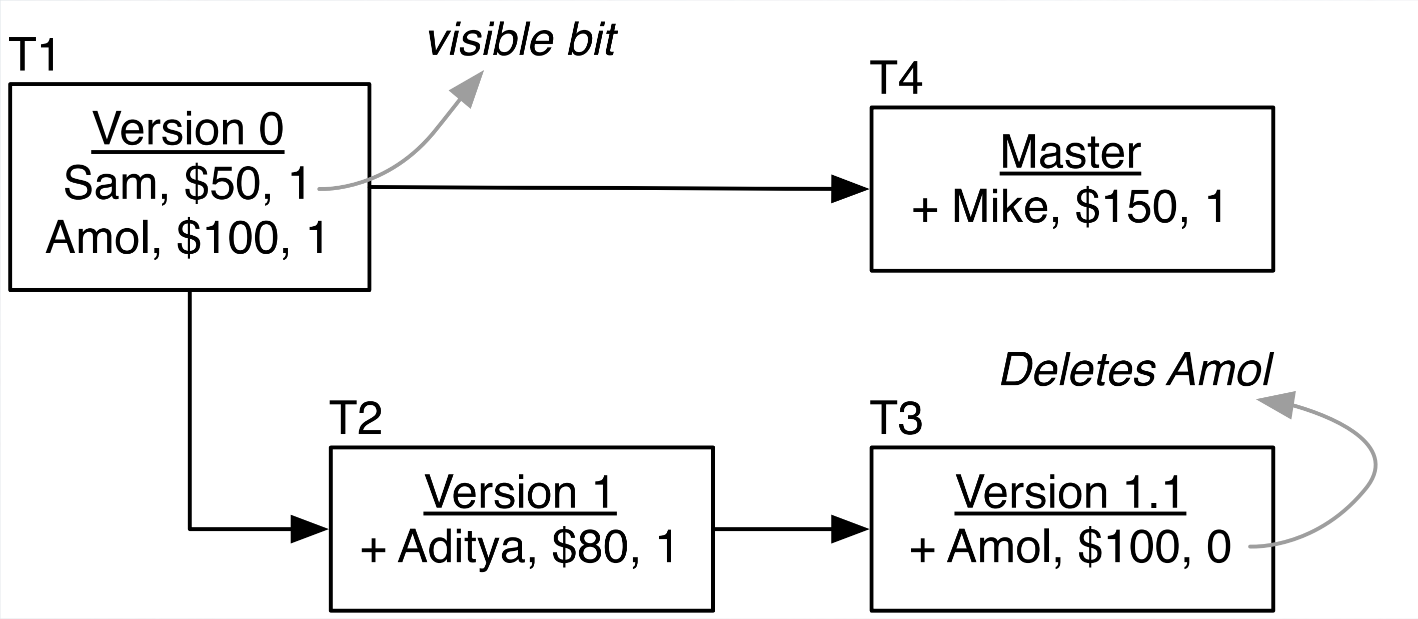
Standard git commands: branch, commit, fork, merge, rollback, checkout

Storing and Retrieving Versions

Simplest Strawman Approach:

Store: For every version, store "delta" from previous DAG version

Retrieve: Start from version pointer, walk up to root



The Good:

- Somewhat Compact

The Bad:

- Inefficient to construct versions

  Walk up entire chains
- Inefficient to look up all versions that contain a tuple

Q: Why store delta from the previous version?

Q: Why not materialize some versions completely?

Q: What kind of indexes should we use?

Branching and Merging

More questions than answers!

- *Q: How do we allow users operate on servers and/or their local machines without missing updates?*

- *Q: What if the datasets are large? Can users work on samples?*

- *Q: How do we detect conflicts and allow users to merge conflicting branches with as little effort as possible?*

Rich Query Language

Can combine versions and data!

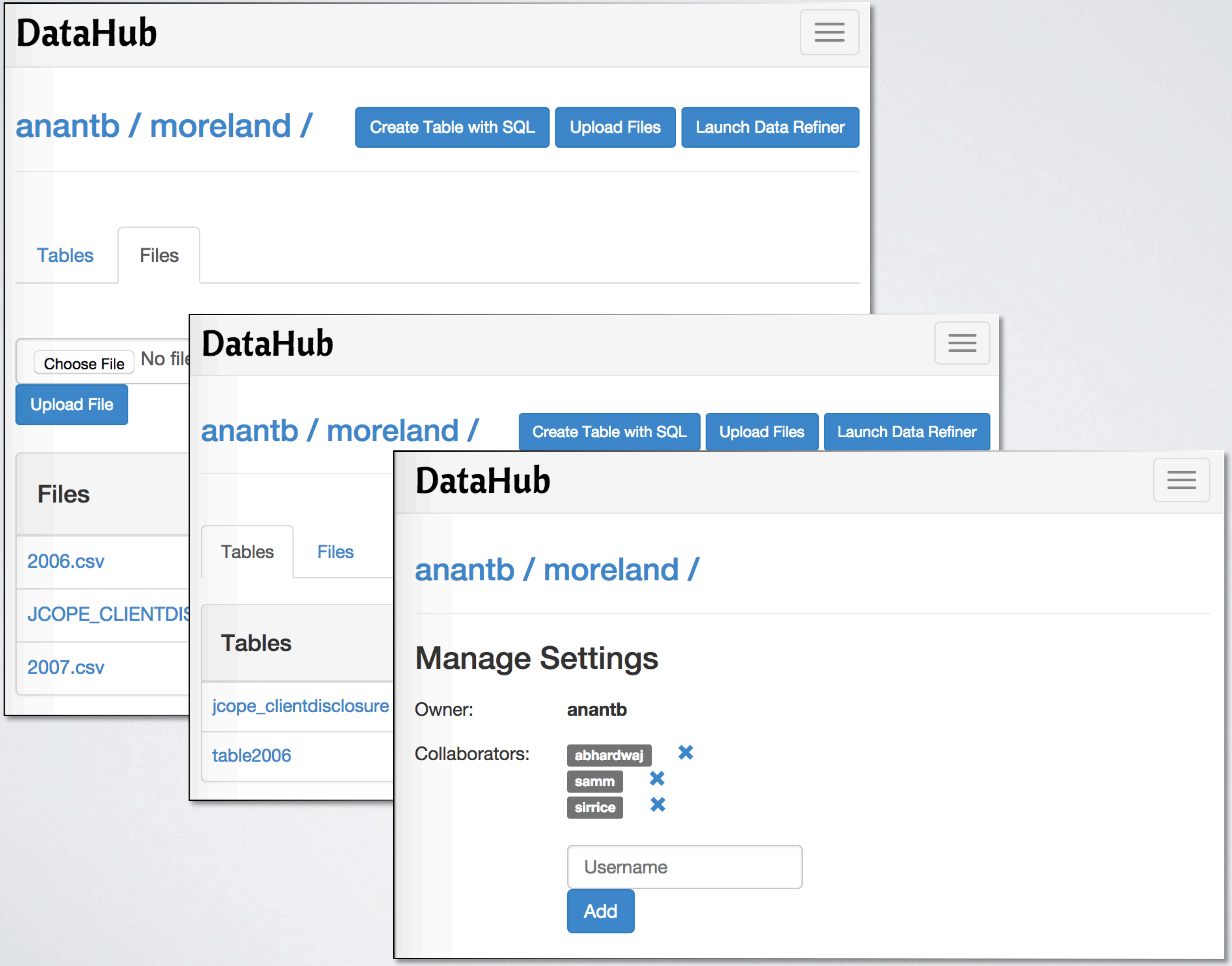
```
SELECT * FROM R[V1], R[V4] WHERE R[V1].ID = R[V4].ID

SELECT VNUM FROM VERSIONS(R) WHERE EXISTS
(SELECT * FROM R[VNUM]  WHERE   E=‘AARON’)
```

Still a work in progress!

Other examples: F

- All versions th are vastly different in size from a given version.
- The first version where a certain tuple was introduced
- All tuples that were introduced in a given version and subsequently deleted

Screenshots



DataHub

anantb / moreland /

No fil

Files

2006.csv

JCOPE_CLIENTDIS

2007.csv

DataHub

anantb / moreland /

Tables

jcope_clientdisclosure

table2006

DataHub

anantb / moreland /

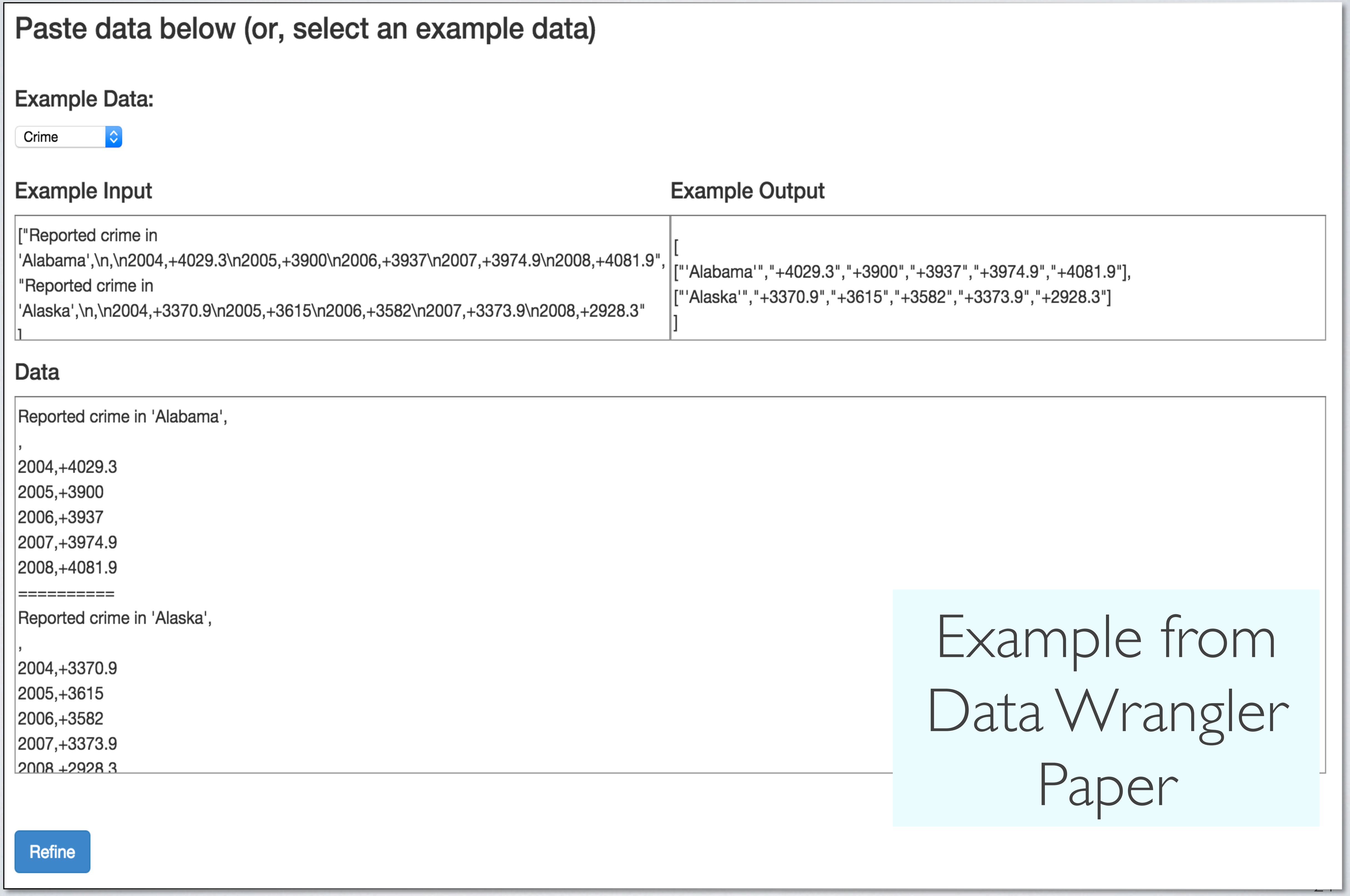
Manage Settings

Owner: anantb

Collaborators: abhardwaj ✖ samm ✖ sirrice ✖

Username

App: Ingest by Example



Paste data below (or, select an example data)

Example Data:

Example Input

```
["Reported crime in
'Alabama',\n,\n2004,+4029.3\n2005,+3900\n2006,+3937\n2007,+3974.9\n2008,+4081.9",
"Reported crime in
'Alaska',\n,\n2004,+3370.9\n2005,+3615\n2006,+3582\n2007,+3373.9\n2008,+2928.3"
]
```

Example Output

```
[
["'Alabama'","+4029.3","+3900","+3937","+3974.9","+4081.9"],
["'Alaska'","+3370.9","+3615","+3582","+3373.9","+2928.3"]
]
```

Data

```
Reported crime in 'Alabama',
,
2004,+4029.3
2005,+3900
2006,+3937
2007,+3974.9
2008,+4081.9
==========
Reported crime in 'Alaska',
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2008,+2928.3
```
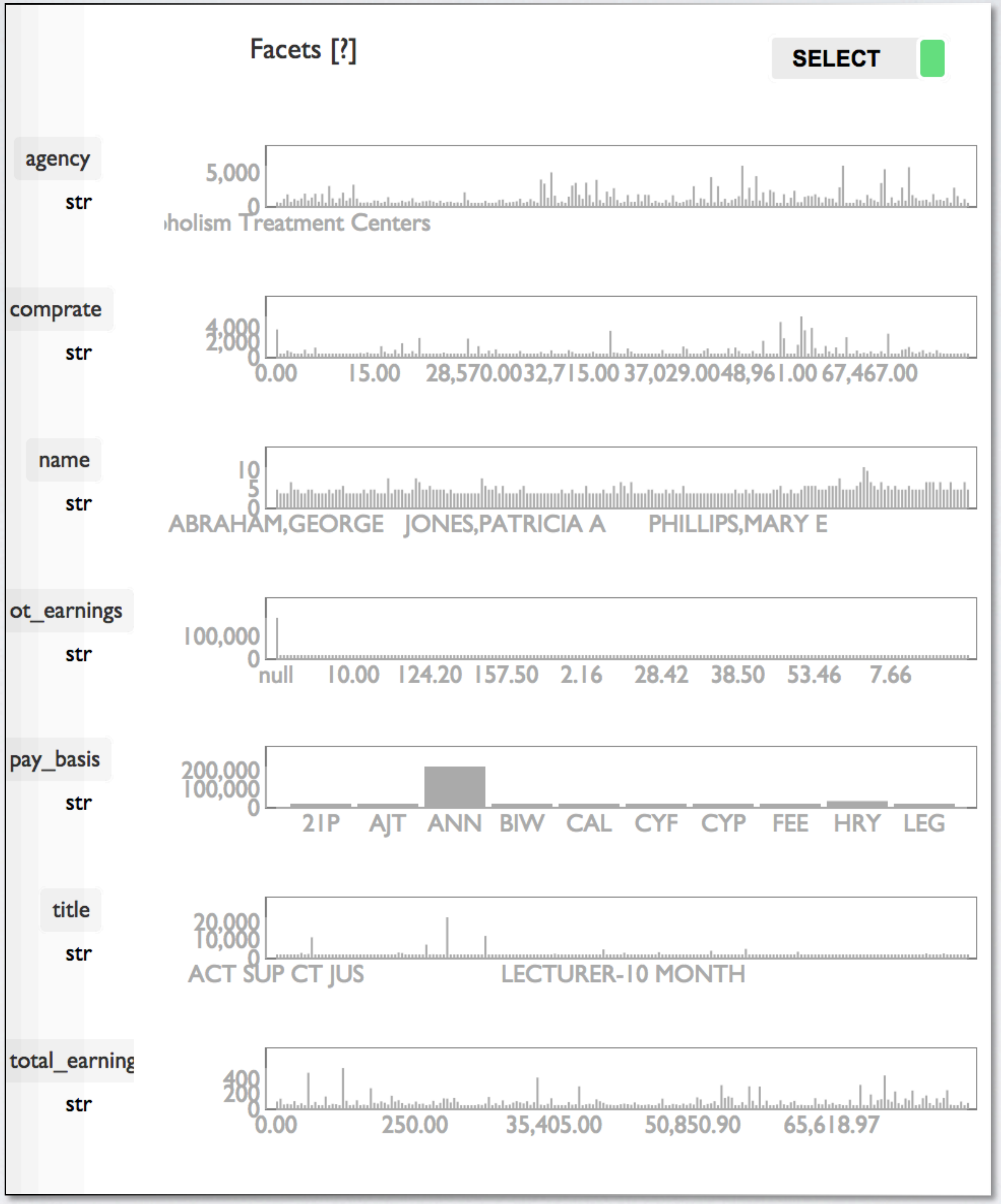

Example from Data Wrangler Paper

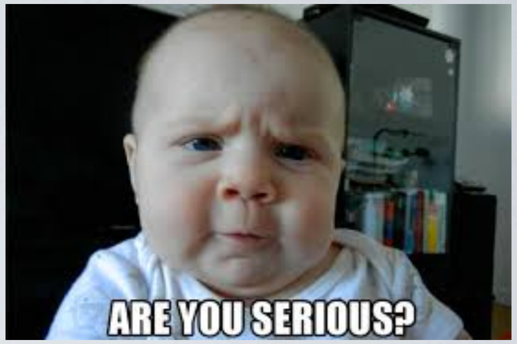
App: Automatic Visualization



Papers in the works..

- Fundamentals:
  - *Blobs:* Exploring the trade-off between storage and recreation/retrieval cost for blob stores
  - *Relational:* Exploring SQL-based versioning implementations and indexing
- Add-on functionality:
  - *Ingest:* Ingest by example
  - *Viz:* Automatically generating query visualizations

To Summarize



- Dataset management as of today is bad, bad, bad
- DataHub is "GitHub for data"; an *essential prerequisite* to collaborative data science
  - Tracking, managing, reasoning about, and retrieving versions
  - Fundamental building block for study of other problems
- DataHub has in-built data science functionality, plus hooks
  - Ingestion: ingest by example
  - Integration: search, and auto-integrate
  - Provenance: explicit and implicit
  - Visualization: manual and automatic

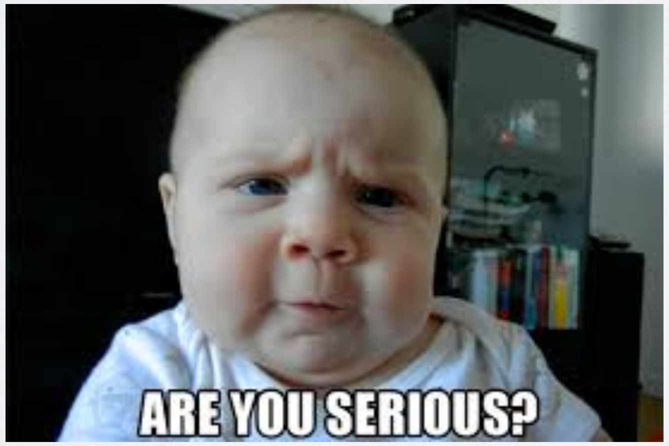
Lots of related work!

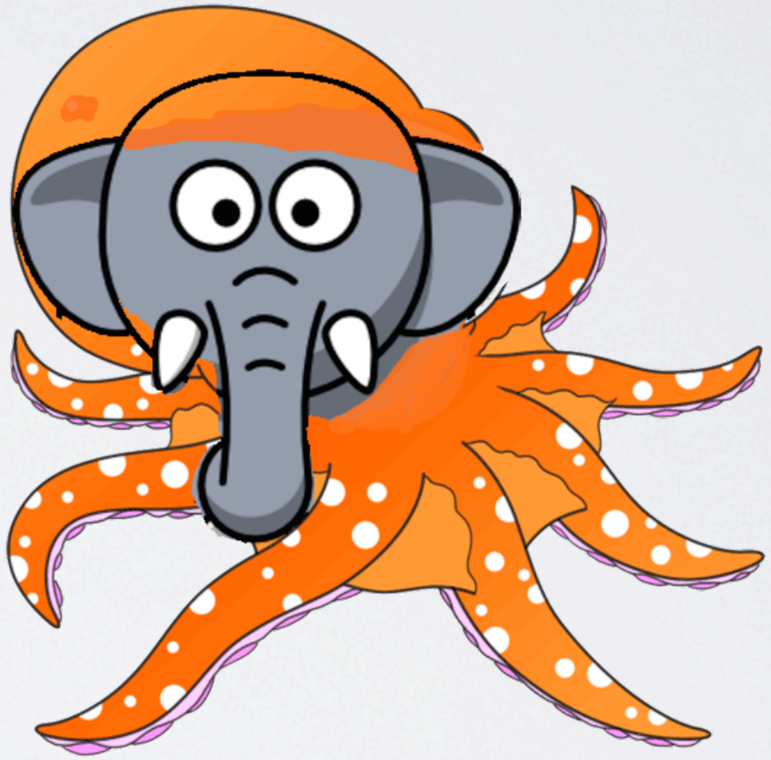
Integrated with versioned storage

To find out more and contribute…

datahub.csail.mit.edu

FINALLY REVEALED





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