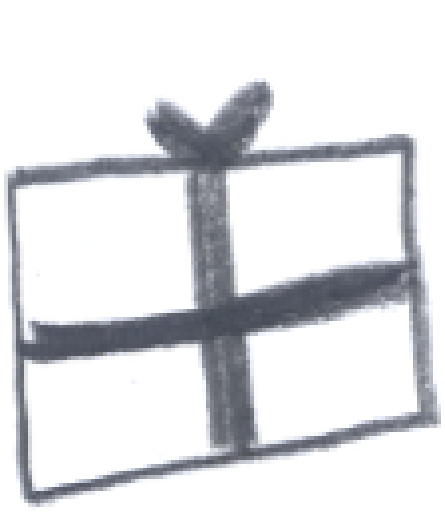
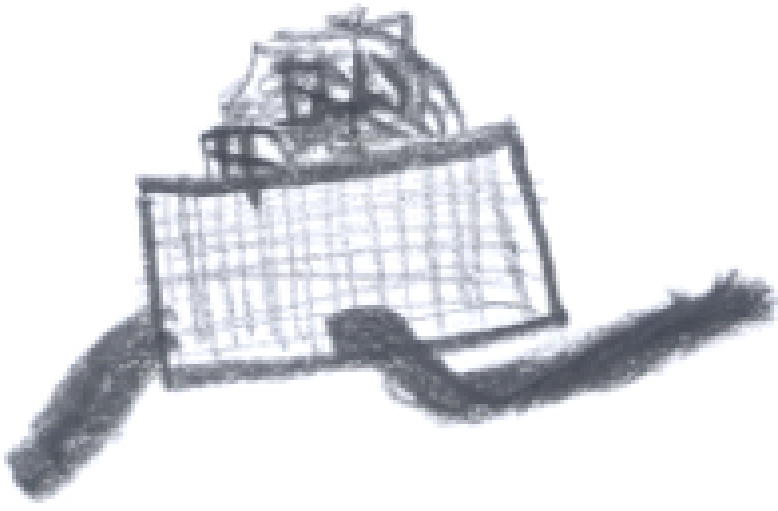
Finding Change in the CouchDB

Dr. James E. Marca

January 13, 2013

Big Data





We've always had big data!

- We've been handling big data for years in transportation
- What's wrong with sticking to the old tools?

Old Way:

- PostgreSQL
- Simple queries
- Canned aggregates

“Is the current reading of volume and occupancy from some detector more or less than what should be expected?”

But we had a new server and a terabyte drive...

...and all the raw data for a year...

...Ready to query dynamically...

...In PostgreSQL

"What is the expected volume
for any 5 minute period
over the prior 365 days
for any loop detector"

My database broke

- The index was too big to fit in RAM
- Extensive disk swapping
- Super-duper slow!

Alternatives for Big Data: NoSQL

- Google (Big Table)
- Amazon (Dynamo)

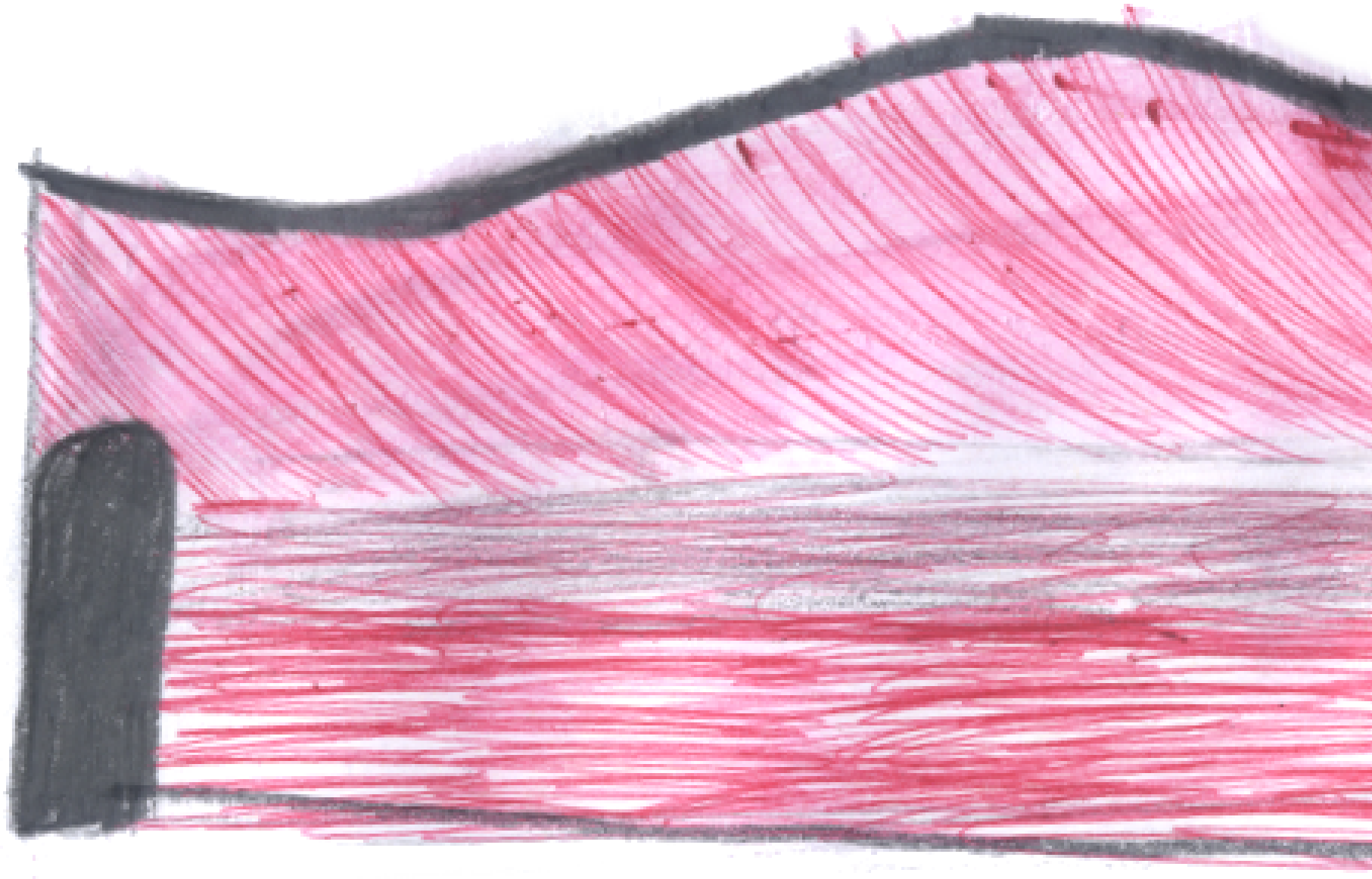
Options we considered

- flat files
- CouchDB
- TokyoTyrant
- Cassandra
- Hadoop

Options available now

- Hadoop
- MongoDB
- Riak
- CouchDB
- BigCouch
- Couchbase
- Cassandra
- Voldemort
- RethinkDB
- Datalog
- and more all the time...

Why do I think CouchDB is good for transportation data?

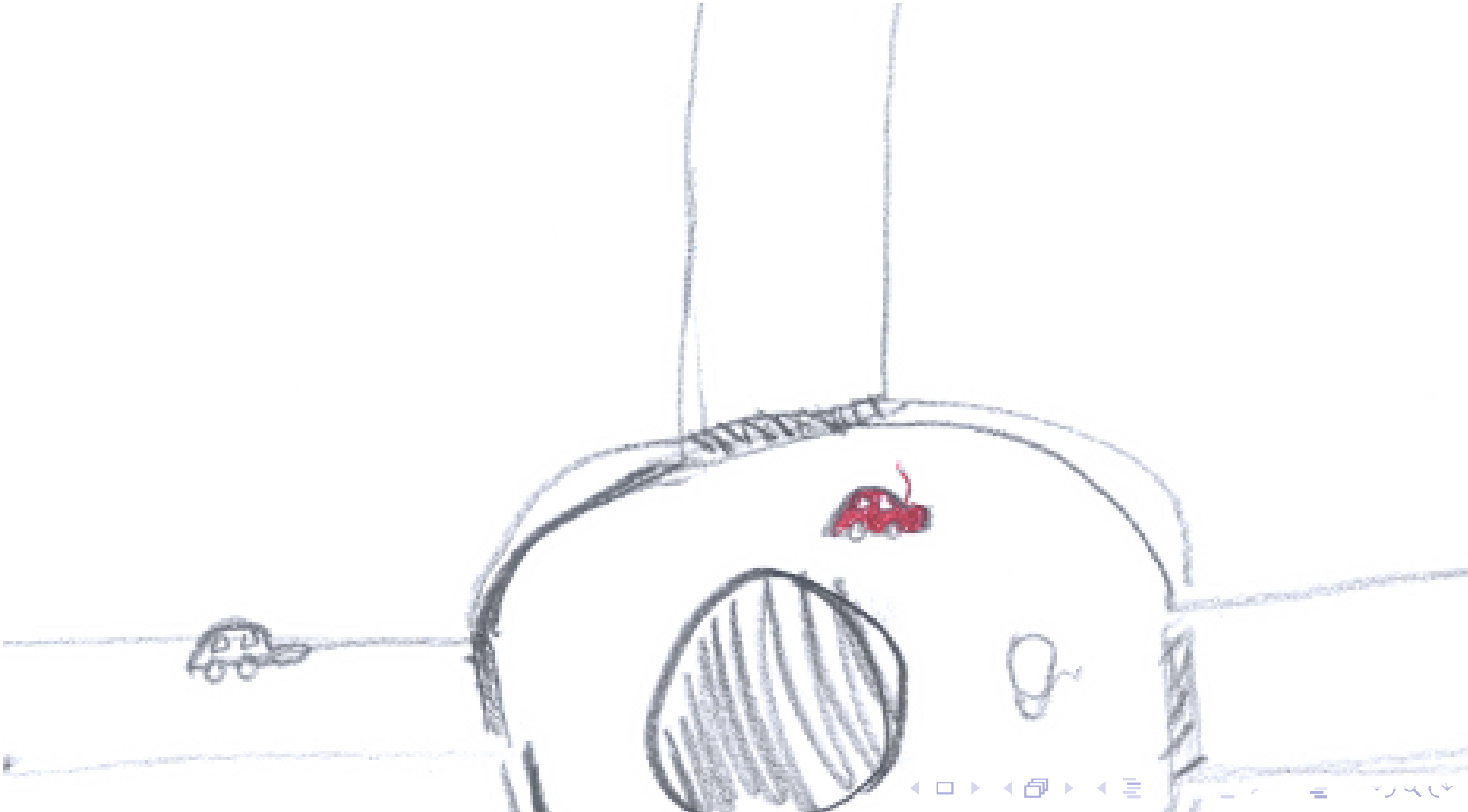


What is transportation data?

- largely observations and measurements
- write once
- read raw data for short term applications
- process raw data into summary stats

Example: Loop Detectors

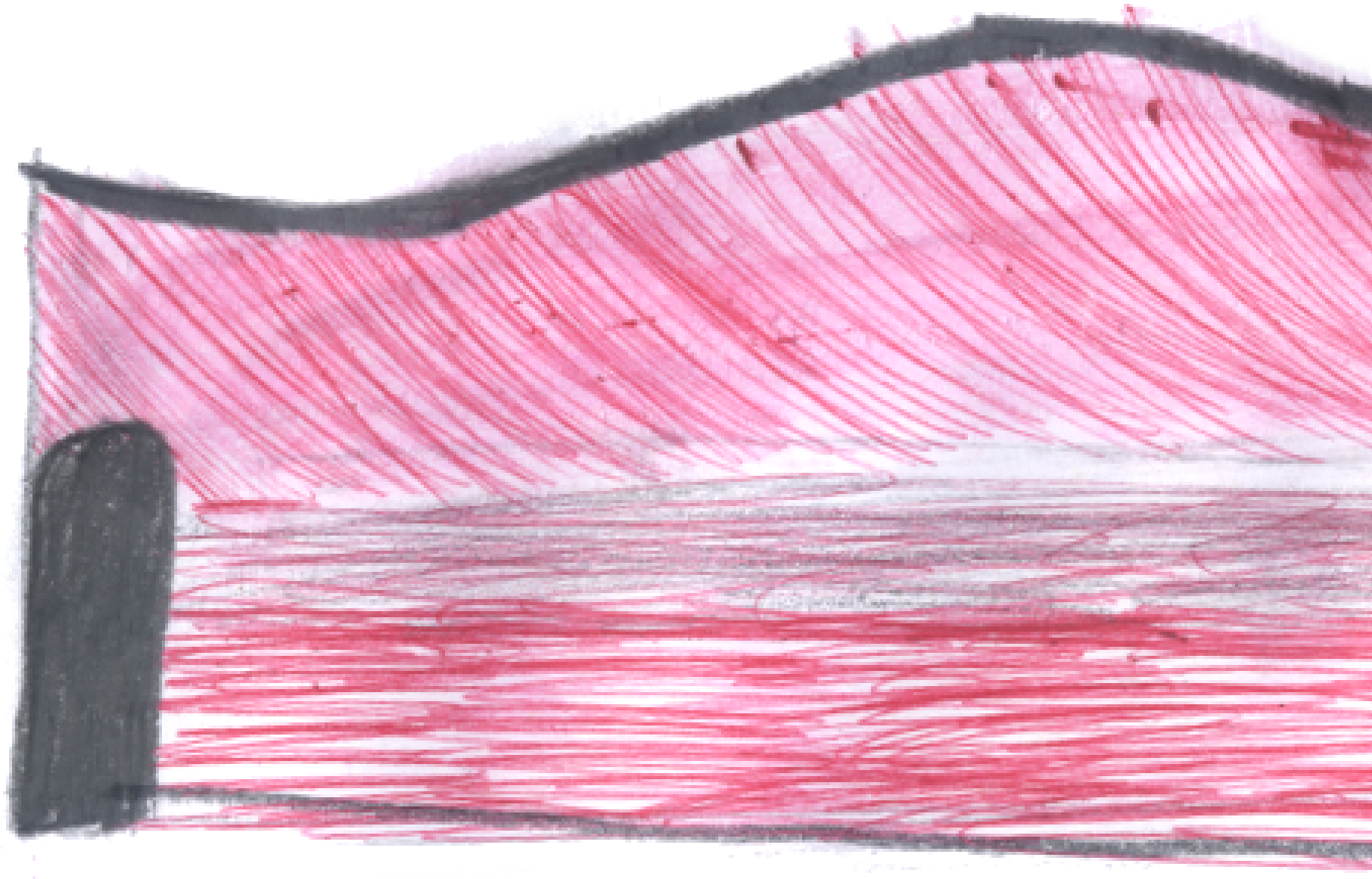
- 30s volume, occupancy
- some misses and noise
- run-once cleanup procedures



Example: Personal GPS and activity stream

- second by second GPS
- slowly growing sets of:
  - routes,
  - destinations,
  - time windows
- small set of repeated queries:
  - Optimize likely activities?
  - Does traffic affect my usual pattern?
  - etc

Why do I think CouchDB is good for transportation data?



What is CouchDB?

- A document oriented *database*

What is a database?

- store data
- get data
- allow multiple users

Why not just use flat files?

Consider loop detectors

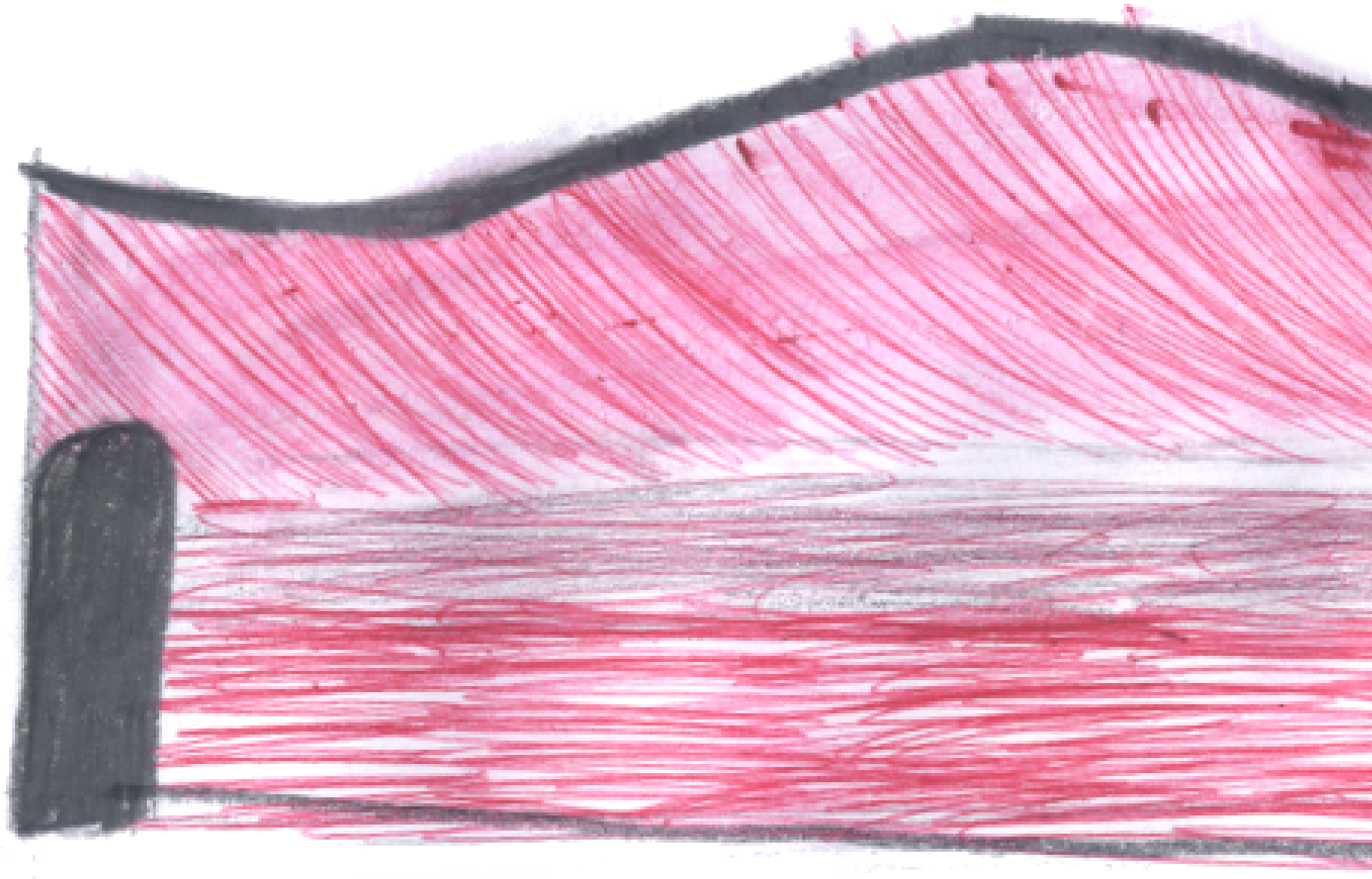
- One file per loop detector per year, or
- One file for all detectors per day (what PeMS does)
- Easy to organize and distribute
- Fine for single user

But flat files can lead to trouble

- Bad for multiuser
  - race conditions,
  - version problems,
  - etc
- Difficult to query

"What was the volume and occupancy like last Monday?"

So use a database



The CAP Theorem

Databases are limited by the CAP theorem

- **C**onsistency All database clients see the same data, even with concurrent updates.
- **A**vailability All database clients are able to access some version of the data.
- **P**artition Tolerance The database can be split over multiple servers.

Choose any two

Traditional RDBMS choose C and A

CouchDB chooses A and P

- **A**vailability, **P**artition Tolerance

  "Eventually Consistent"

Consistency isn't that big a deal for traffic data

- This isn't stock trading or e-commerce
- It's okay if:
  - you are 30s behind reading a loop
  - Controller A has slightly more current info than Controller B

A universally consistent view isn't mission critical

Bonus: CouchDB has master-master replication

Replication is:

super awesome

the *change* I was looking for

Replication enables a new data collection architecture

- Put the database at the detector (distributed databases)
- Move data around by using replication

Uses:

- A TMC can still pull-replicate from all detector databases
- A Local or Freeway specific TMC can limit replication to relevant detectors
- A traveler can replicate only the traffic DBs along common routes

All replicating databases will be eventually consistent

Master:Master means all are equally good candidates for replication

Relax

Practical experience

1. Processing, storing raw loop detector data
2. Imputing missing detector data
3. A single stash for storing detector metadata

Processing Raw Loop Detector Data

- Orange County, California (CalTrans District 12)
- about 900 mainline detectors
- Process in R
  - compute 27 different measures per location
  - for 20 minute running time window
  - (vol, occ per lane + 27) per 30s period
  - run models estimating relative risk of accident types
- 280GB of data (three years)
- 590GB of generated views

Database design:

- One CouchDB database per detector
- One document per day

Document per day reasons:

- Based on ~~painful experience~~ informal testing
- One document per year is too big to process
- One document per timestamp would work okay,
- But the web *application* uses daily data
- CouchDB sorts by document id, id is based on timestamp
- HTTP GET:
  /vdsdata/d12/2007/1202248/1202248 2007-01-03 00:00:00

Database per detector per year reasons:

- One big database is possible, but
- Impossible to *split* or *shard* over different machines (now can use BigCouch)
- makes better use of multi-core machines when generating views

Use views to run models and summarize data

- Views are CouchDB's version of map/reduce
- Write JavaScript code for the map function that is run on each document (to apply models, run summaries, etc)
- ProTip© Only use embedded Erlang reduce functions like `_count`,`_sum`, and `_stats`

Difficulty: Need to use another database to collate model output

- Pipe summaries of the per-detector views to a single database for all detectors in the district
- Requires external programming
- Difficult to automate

Application 2: Storing the results of imputation runs

- Similar to prior example
- 400GB of data
- 700GB of generated views
- Databases spread over three machines
- Uses per-district collation databases
- Analysis step used CouchDB to coordinate multiple processes
  - Local “state” database on each machine
  - State databases replicated with each other
  - No overlapping runs were observed

Application 3: Convenient stash for detector metadata

- 20GB of data
- 222MB of generated views
- Uses GeoCouch extensions, stores location of each detector
- Stashes all known metadata about each detector in a single place
- Uses binary attachments to save R analysis output (plots, files)
- Small enough to replicate to my laptop too

Questions?

James E. Marca
UCI ITS
jmarca@translab.its.uci.edu