NoSQL Cocktail Hour*

Having Awkward Conversations with Some Popular Modern Non-Relational Data Processing Systems

John Haldeman @ Hackforge – August 2016

* Apologies If I Run Over the Hour

NoSQL Cocktail Hour

For These Systems:

Talk About the following:

1. General Architecture
2. Origins
3. Do “Something” (Use each to answer a question)
4. Security
5. Where it’s used and potential drawbacks
6. Similar Systems

But First – The CAP Theorem

- You can only guarantee two of the following:
  - **C**onsistency (AKA Atomic Consistency): The client can treat the data as a ***single*** up-to-date ***copy***
  - **A**vailability: All clients can access (update) the data at any time
  - **P**artition Tolerance: The system runs well when it's distributed across network partitions

- Modern DBMSs are partitioned systems, so the big tradeoffs are in C and A (note in a non-network partitioned system, you can have both C and A)

- https://www.infoq.com/articles/cap-twelve-years-later-how-the-rules-have-changed:
  - The easiest way to understand CAP is to think of two nodes on opposite sides of a partition:
  - Allowing at least one node to update state will cause the nodes to become inconsistent, thus forfeiting C
  - Likewise, if the choice is to preserve consistency, one side of the partition must act as if it is unavailable, thus forfeiting A
  - Only when nodes communicate is it possible to preserve both consistency and availability, thereby forfeiting P

- It's not black and white and systems can behave differently depending on circumstance (see "Cap-latency connection" side bar of article above)

- This looks like a good resource: http://blog.nahurst.com/visual-guide-to-nosql-systems

General Architecture

Store JSON Documents

Protocol based on a Binary Version of JSON called BSON

No Schemas

Scales Via Sharding (Horizontal Partitioning)

Replica Sets for High Availability

CAP: Values Consistency and Partition Tolerance over Availability


```
{
  "address": {
     "building": "1007",
     "coord": [ -73.856077, 40.848447 ],
     "street": "Morris Park Ave",
     "zipcode": "10462"
  },
  "borough": "Bronx",
  "cuisine": "Bakery",
  "grades": [
     { "date": { "$date": 1393804800000 }, "grade": "A", "score": 2 },
     { "date": { "$date": 1378857600000 }, "grade": "A", "score": 6 },
     { "date": { "$date": 1358985600000 }, "grade": "A", "score": 10 },
     { "date": { "$date": 1322006400000 }, "grade": "A", "score": 9 },
     { "date": { "$date": 1299715200000 }, "grade": "B", "score": 14 }
  ],
  "name": "Morris Park Bake Shop",
  "restaurant_id": "30075445"
}
```


More info at: https://www.mongodb.com/mongodb-architecture

Origins

- 10gen
  - Former DoubleClick employees get together to build a Platform as a Service (PaaS) provider

  - They didn't like the databases available, started building mongoDB

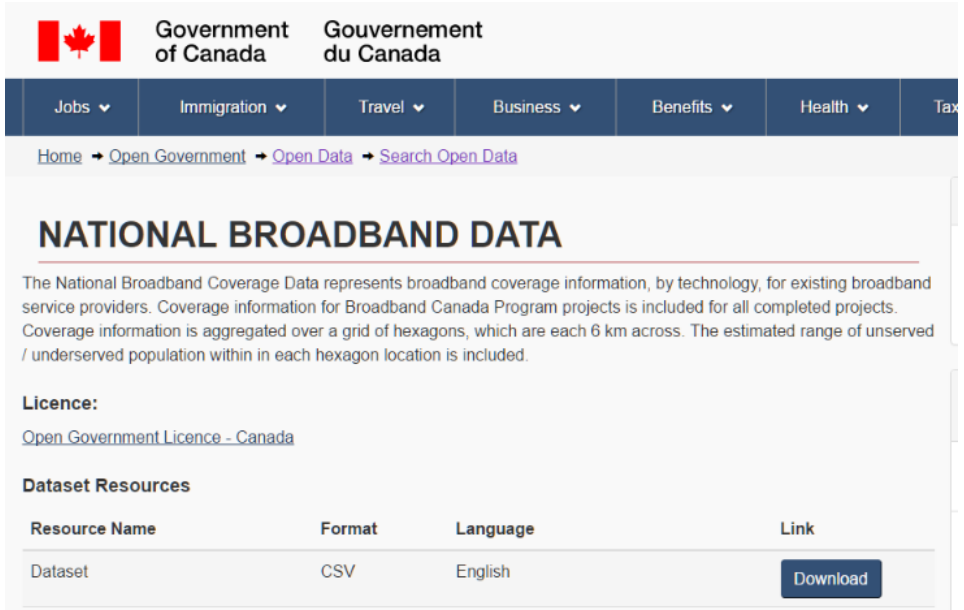
  - 10gen's PaaS business never took off, but mongoDB did well. 10gen eventually became MongoDB, Inc.

Do “Something” With MongoDB

- First we need data. How about this:
  http://open.canada.ca/data/en/dataset/00a331db-121b-445d-b119-35dbbe3eedd9

- National broadband Data (2012 – a little out of date, but good for an example)

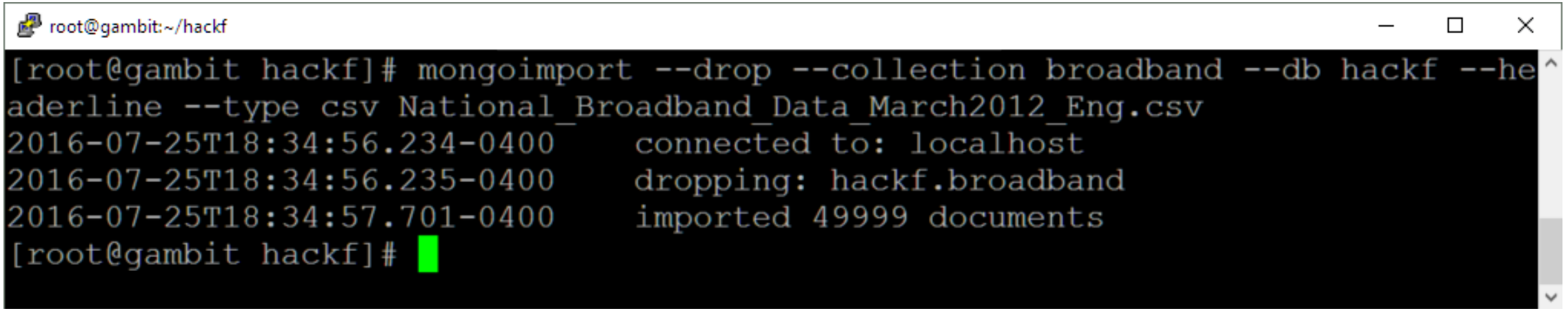
- Let’s see if we can find any places in Windsor/Essex that are unserved/underserved by broadband (< 1.5 Mbps available)



Do “Something” With MongoDB

Import CSV file:

```
mongoimport --drop --collection broadband --db hackf --headerline --type csv National_Broadband_Data_March2012_Eng.csv
```



Do “Something” With MongoDB

What does the data look like. Get first three rows of collection using the MongoDB command line client (mongo):

```
mongo
use hackf
db.broadband.find().limit(3);
```

Do “Something” With MongoDB

- What does the data look like:

root@gambit:~/hackf

```
[root@gambit hackf]# mongo
MongoDB shell version: 3.2.9-rc0
connecting to: test
Server has startup warnings:
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten]
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten] ** WARNING: /sys/kerne
l/mm/transparent_hugepage/enabled is 'always'.
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten] **        We suggest s
etting it to 'never'
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten]
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten] ** WARNING: /sys/kerne
l/mm/transparent_hugepage/defrag is 'always'.
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten] **        We suggest s
etting it to 'never'
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten]
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten] ** WARNING: soft rlimi
ts too low. rlimits set to 4096 processes, 64000 files. Number of processes sh
ould be at least 32000 : 0.5 times number of files.
2016-07-25T18:31:29.677-0400 I CONTROL  [initandlisten]
> use hackf
switched to db hackf
> db.broadband.find().limit(3);
{ "_id" : ObjectId("57969410fc6774f87a34aa5e"), "Hexagon Number" : 40930, "GSA
 Number" : "", "First Nation" : "", "Location Name" : "Aalders Landing, NS @ 4
4.82□N x 64.94□W", "Municipality" : "Annapolis, Subd. D :SC", "Latitude" : 44.
82, "Longitude" : -64.94, "Total Population 2006 Census" : 154, "Unserved / Un
derserved Population in Hexagon" : 0, "Deferral Account" : "F", "DSL Available
" : "F", "Cable Available" : "F", "Wireless Available" : "T" }
{ "_id" : ObjectId("57969410fc6774f87a34aa5f"), "Hexagon Number" : 41100, "GSA
 Number" : "", "First Nation" : "", "Location Name" : "Abercrombie, NS @ 45.6□
N x 62.71□W", "Municipality" : "Pictou, Subd. B :SC", "Latitude" : 45.6, "Long
itude" : -62.71, "Total Population 2006 Census" : 447, "Unserved / Underserved
 Population in Hexagon" : 0, "Deferral Account" : "F", "DSL Available" : "T",
"Cable Available" : "T", "Wireless Available" : "T" }
{ "_id" : ObjectId("57969410fc6774f87a34aa60"), "Hexagon Number" : 40049, "GSA
 Number" : "", "First Nation" : "", "Location Name" : "Abercrombie, NS @ 45.65
□N x 62.71□W", "Municipality" : "Pictou, Subd. B :SC", "Latitude" : 45.65, "Lo
ngitude" : -62.71, "Total Population 2006 Census" : 582, "Unserved / Underserv
ed Population in Hexagon" : 0, "Deferral Account" : "F", "DSL Available" : "T"
, "Cable Available" : "T", "Wireless Available" : "T" }
>
```

Do “Something” With MongoDB

- What does the data look like (pretty)
- Completely flat JSON objects. Fine for our example, but if you are using MongoDB to develop an app, it’s likely to have more structure

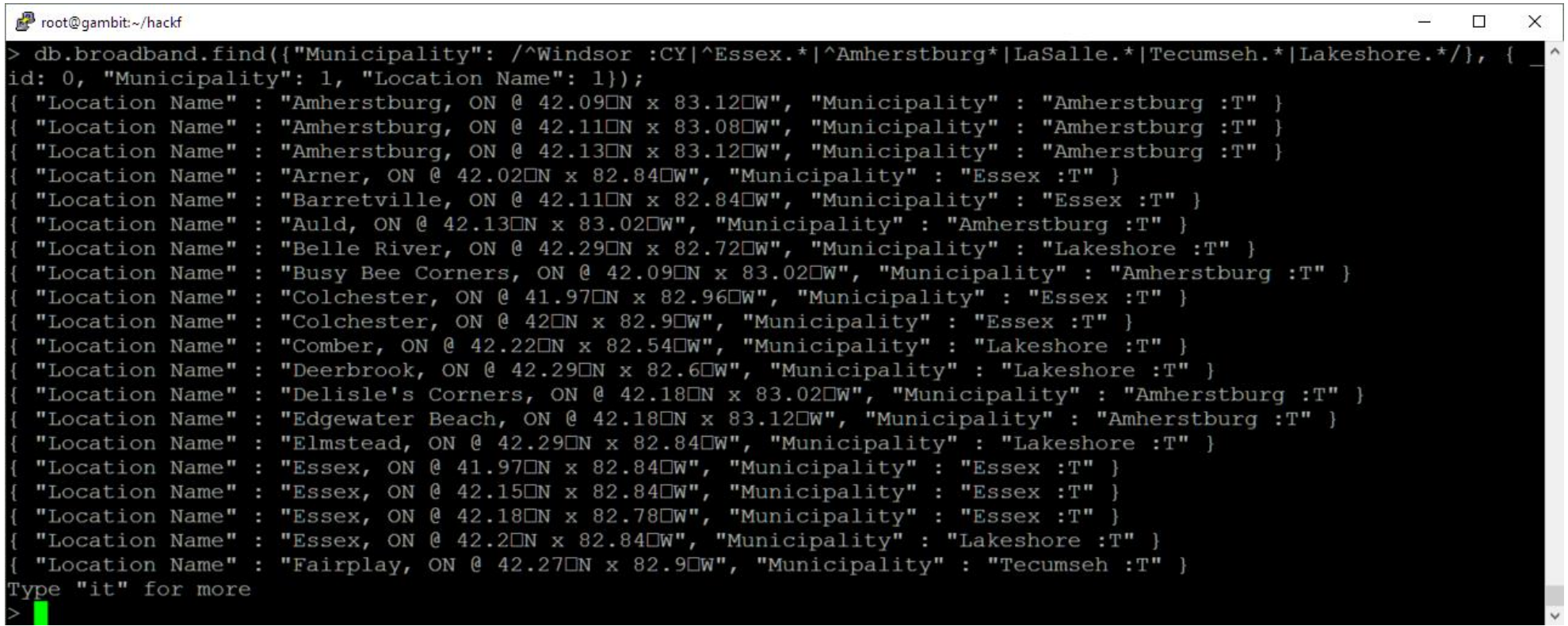
root@gambit:~/hackf

```
> db.broadband.find().limit(3).pretty();
{
        "_id" : ObjectId("57969410fc6774f87a34aa5e"),
        "Hexagon Number" : 40930,
        "GSA Number" : "",
        "First Nation" : "",
        "Location Name" : "Aalders Landing, NS @ 44.82□N x 64.94□W",
        "Municipality" : "Annapolis, Subd. D :SC",
        "Latitude" : 44.82,
        "Longitude" : -64.94,
        "Total Population 2006 Census" : 154,
        "Unserved / Underserved Population in Hexagon" : 0,
        "Deferral Account" : "F",
        "DSL Available" : "F",
        "Cable Available" : "F",
        "Wireless Available" : "T"
}
{
        "_id" : ObjectId("57969410fc6774f87a34aa5f"),
        "Hexagon Number" : 41100,
```

Do “Something” With MongoDB

Get Windsor-Essex Municipalities with a regex:

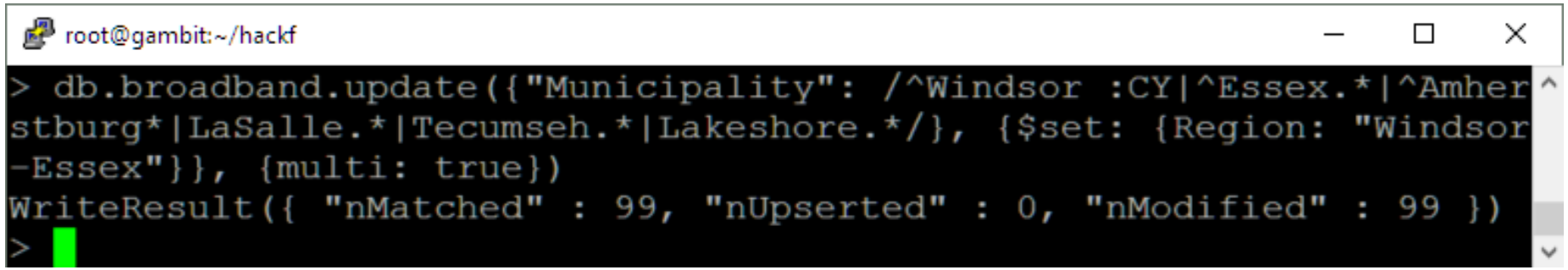
```
db.broadband.find({
        "Municipality":/^Windsor:CY|^Essex.*|^Amherstburg.*^|LaSalle.*|^Tecumseh.*|^Lakeshore.*/
}
,{
        _id : 0,  "Municipality" : 1, "Location Name" : 1
});
```



Do “Something” With MongoDB

Update Those Documents with a New Field “Region”:

```
db.broadband.update({
{"Municipality":/^Windsor:CY|^Essex.*|^Amherstburg.*|^LaSalle.*|^Tecumseh.*|^Lakeshore.*/},
{$set: {"Region" : "Windsor-Essex"}},
{multi : true});
```



Notice the lack of schema modifications – We just write to a field that never existed before and it only exists for those records updated

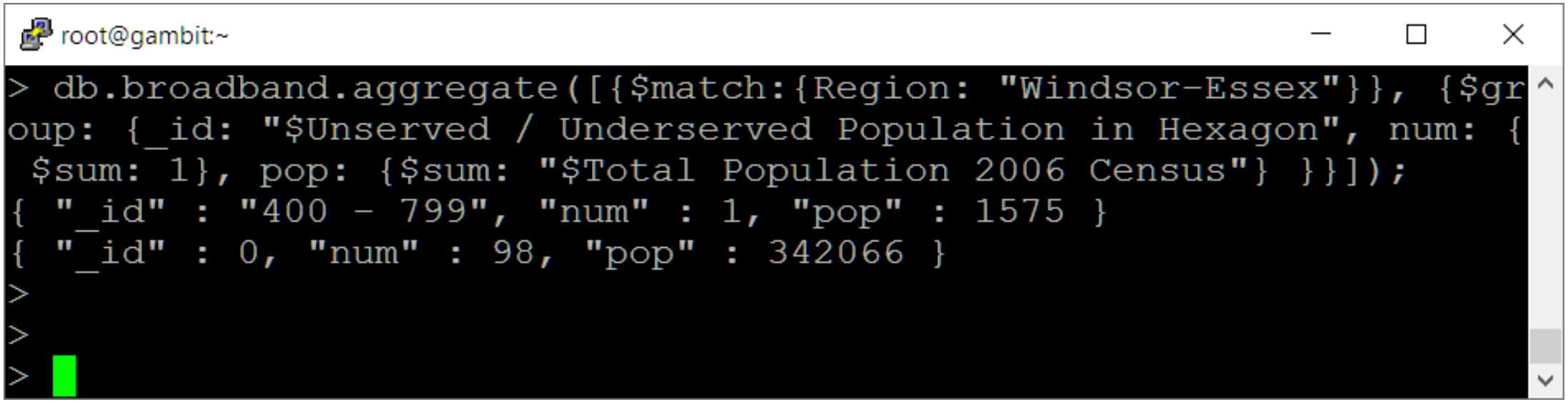
Do “Something” With MongoDB

MongoDB Aggregation Pipelines. Get the categories of under served areas and calculate some stats:

```
db.broadband.aggregate(
        [
                $match: {Region: "Windsor-Essex"} },
                {$group:
                        {  id: "$Unserved / Underserved Population in Hexagon",
                         num: { $sum: 1},
                         pop: {$sum: "$Total Population 2006 Census"}
                        }
                }
        ]
);
```

Do “Something” With MongoDB

MongoDB Aggregation Pipelines. Get the categories of under served areas and calculate some stats:



Do “Something” With MongoDB

Add in a $push to get the region names in each category:

```
db.broadband.aggregate(
        [
                $match: {Region: "Windsor-Essex"}},
                {$group:
                        {_id: "$Unserved / Underserved Population in Hexagon",
                        num: { $sum: 1},
                        pop: {$sum: "$Total Population 2006 Census"},
                        areas: {$push: {Municipality: "$Municipality", Location: "$Location Name" }
                        }
                }
        ]
);
```

Do “Something” With MongoDB

Add in a $push to get the region names in each category:

```
root@gambit:~
> db.broadband.aggregate([{$match:{Region: "Windsor-Essex"}}, {$gr
oup: {_id: "$Unserved / Underserved Population in Hexagon", num: {
 $sum: 1}, pop: {$sum: "$Total Population 2006 Census"}, areas: {$
push: {Municipality: "$Municipality", Location: "$Location Name" }
}}}]).pretty();
{
        "_id" : "400 - 799",
        "num" : 1,
        "pop" : 1575,
        "areas" : [
                {
                        "Municipality" : "Lakeshore :T",
                        "Location" : "Stoney Point/Pointe-aux-Roch
es, ON @ 42.31□N x 82.54□W"
                }
        ]
}
{
        "_id" : 0,
        "num" : 98,
        "pop" : 342066,
        "areas" : [
                {
                        "Municipality" : "Amherstburg :T",
                        "Location" : "Amherstburg, ON @ 42.09□N x
83.12□W"
                },
                {
```

Security

Feature	Notes
Authentication	None (default), Native, x.509, LDAP(“enterprise”), Kerberos (“enterprise”)
Authorization (access controls)	Administrative, database and collection level privileges available to assign to roles. More difficult to limit access to documents and elements within a collection. User admins can be separated from DB admins, which can be separated from users.
Encryption – Client/Server Communication	TLS/SSL Supported
Encryption – Data on Disk	Wired Tiger (newer storage engine) allows for native encryption with external management of keys in a KMIP provider
Auditing	Built in Facility Available

https://docs.mongodb.com/manual/core/security-user-defined-roles/

Where it's used

Good List: https://www.mongodb.com/who-uses-mongodb

When I first encountered it was primarily e-commerce use cases:

Now becoming common in corporate/government use cases too:

This a great "all-rounder" that's easy for program for and query after the fact.

Some things it might not be good at

A lot of semi-religious debate over “why my database choice is better than yours”:

- Historical issues with concurrency control (locking) but those may have been resolved with recent storage engine updates
- Some feel it may be too memory intensive compared to alternatives like Cassandra – and fails to scale when memory runs out

But the biggest things come from architecture:

- Joins across multiple collections are pretty awkward (although significantly easier in V3.2) – this is a document database after all, not an object-relational database
- Atomicity and transaction control can be problematic - especially when you compare it against many relational DBMSs
- Feature richness may come at the cost of performance (when compared to databases like redis for transactional workloads)

Similar Systems

CouchDB: A document database as well, storing JSON documents. Big differences:

1) Accessed via REST+HTTP instead of with BSON clients
2) Complex querying limited to map-reduce (which is also available in MongoDB). There is no aggregation pipelining
3) Started by Damien Katz – who used to develop for Notes/Domino, which is also a document datastore (Document datastores have been around for a long while)

4) Katz stopped working on CouchDB to work on Couchbase. CouchDB != Couchbase, but MongoDB, CouchDB, and CouchBase are all JSON Document datastores

General Architecture

redis is a key-value store

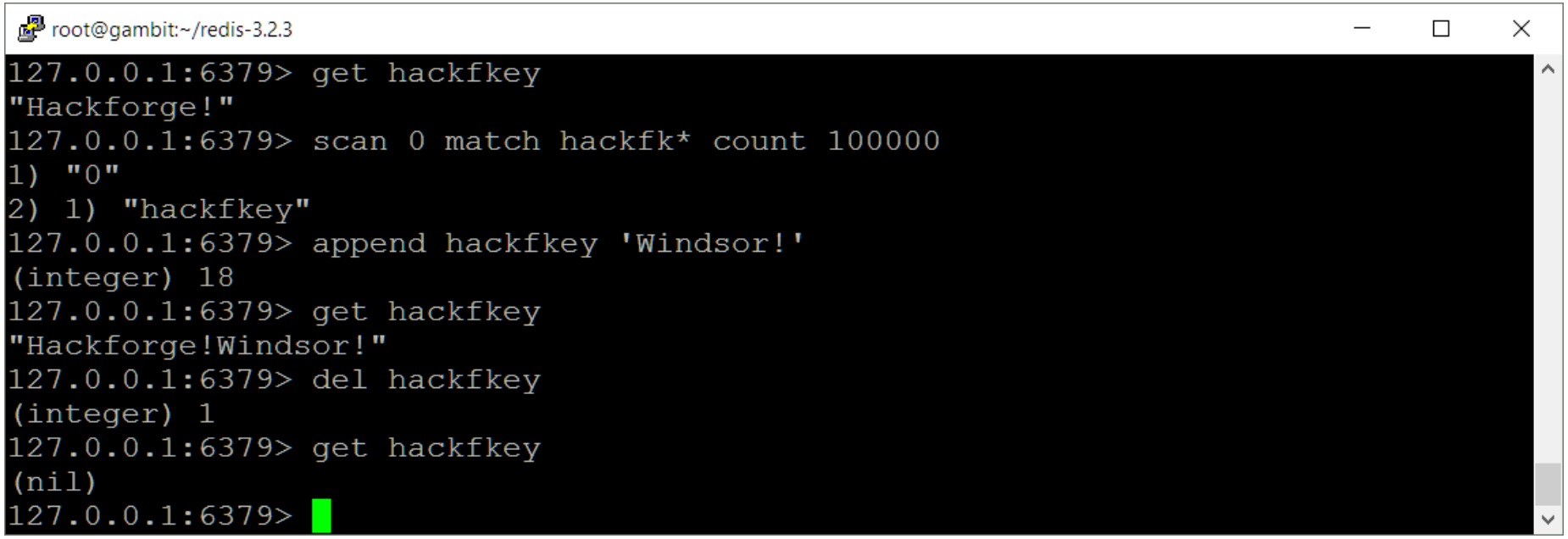
In memory, with varying degrees of persistence available – Can provide zero persistence and is sometimes used as a pure cache layer

CAP: Values Consistency and Partition Tolerance over availability

Protocol (interestingly human readable instead of binary) and storage format is redis specific

No Schemas

Sharding is available (partitioning the keyspace) and master/slave replication capabilities for HA



Data Structures

In addition to String Values, the following data structures are available:

- Hash Tables
- Ordered Lists (like arrays)
- Sets (unique unordered lists)
- Ordered Sets (unique lists ordered by score)
- Publisher/Subscriber channels
- Geospatial Data

Redis…

The only DBMS I know of that reference algorithmic time complexity in the documentation for each command…

So, yes, they are very concerned about performance over pretty much everything else

redis Commands Clients Documentation Community Download Support License

ZRANGE key start stop [WITHSCORES]

Available since 1.2.0.

Time complexity: O(log(N)+M) with N being the number of elements in the sorted set and M the number of elements returned.

Returns the specified range of elements in the sorted set stored at `key`. The elements are considered to be ordered from the lowest to the highest score. Lexicographical order is used for elements with equal score.

See ZREVRANGE when you need the elements ordered from highest to lowest score (and descending lexicographical order for elements with equal score).

Both `start` and `stop` are zero-based indexes, where `0` is the first element, `1` is the next element and so on. They can also be negative numbers indicating offsets from the end of the sorted set, with `-1` being the last element of the sorted set, `-2` the penultimate element and so on.

`start` and `stop` are **inclusive ranges**, so for example `ZRANGE myzset 0 1`

Related commands

- ZADD
- ZCARD
- ZCOUNT
- ZINCRBY
- ZINTERSTORE
- ZLEXCOUNT
- **ZRANGE**
- ZRANGEBYLEX
- ZRANGEBYSCORE
- ZRANK
- ZREM
- ZREMRANGEBYLEX
- ZREMRANGEBYRANK
- ZREMRANGEBYSCORE
- ZREVRANGE

Origins

- Salvatore Sanfilippo started the database after he had trouble storing and displaying real time web traffic data in MySQL (high write loads – read last N records)
- It was his hobby. He went to VMWare and worked on it awhile at VMWare
- That’s pretty much it. The guy still heads up development for it and works at Redis Labs

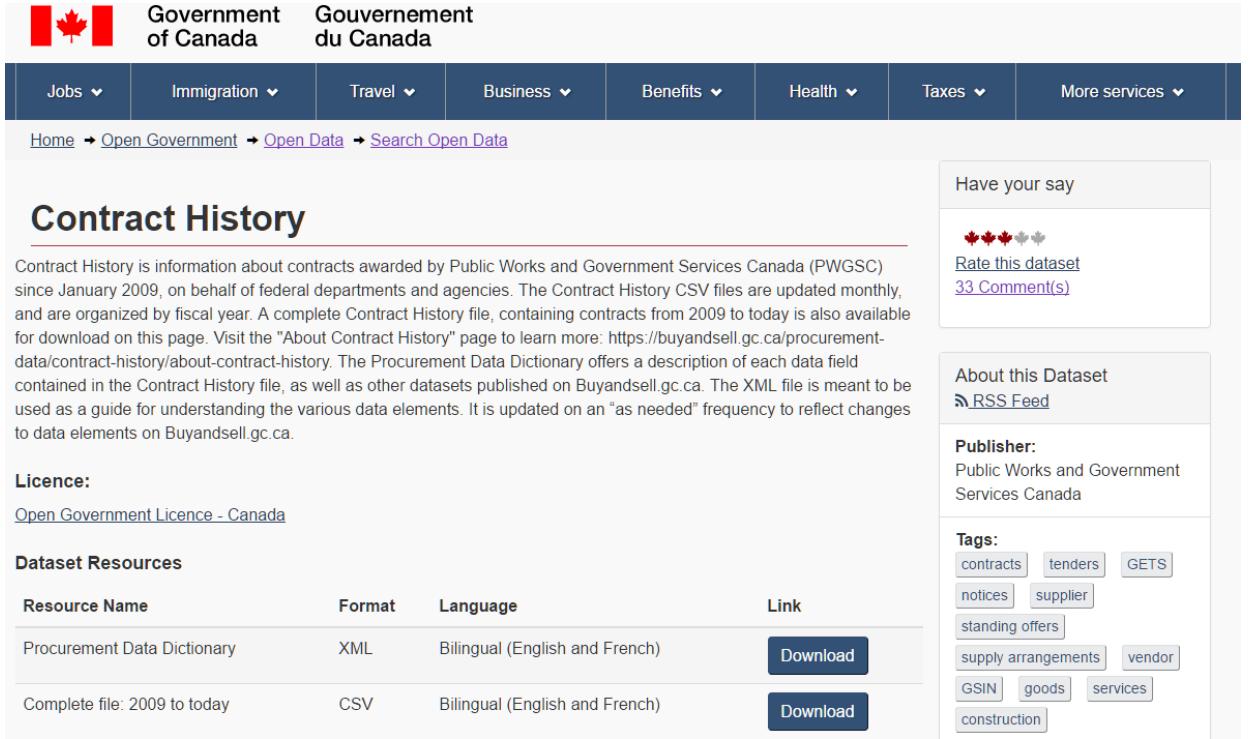
Do “Something” With Redis

- First we need data. How about this:

  http://open.canada.ca/data/en/dataset/53753f06-8b28-42d7-89f7-04cd014323b0

- Contracts awarded by Public Works and Government Services Canada since January 2009

- Let’s see what companies were awarded the most in government contracts



Do “Something” With Redis

- So, we need to add up all the awarded contract values and associate them with companies (acting as the keys)

- Use a sorted set (scored unique members):
  - Contract Values are the Score
  - Companies Awarded the Contracts are the members of the Set
  - Go through the big list and increment the scores by the contract values for each contract

Do “Something” With Redis

- In Redis:
  - For Each Contract:
    - ZINCRBY suppliers <contract_value> <supplier_name>
  - Okay, so we just need to run through the CSV file and run that command…
  - Recommendations for bulk command execution in redis:
    - http://redis.io/topics/mass-insert
    - *sigh* we have to write some code that generates a file that includes the statements formatted as the underlying redis protocol and pipe that file in (ie: redis has no real bulk load utility)

Do “Something” With Redis

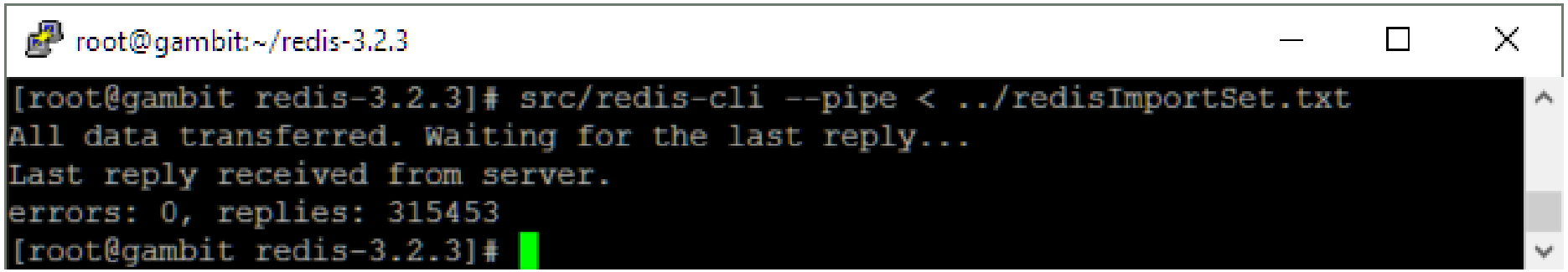
- After the script:

- I omitted the code – it’s not that interesting

```
*4
$7
ZINCRBY
$10
suppliers2
$5
61964
$19
ABCO INDUSTRIES LTD
*4
$7
ZINCRBY
$10
suppliers2
$5
25000
$30
BEST WESTERN PLUS ABERCORN INN
```

Do “Something” With Redis

- Pipe in the Generated File:



- This is like running the file through netcat (nc) but it happens to count the responses at the same time

Do “Something” With Redis

- Query the Data – Largest 20 scores: **ZREVRANGE suppliers2 1 20 WITHSCORES**

root@gambit:~/redis-3.2.3

```
127.0.0.1:6379> ZREVRANGE suppliers2 1 20 WITHSCORES
 1) "GENERAL DYNAMICS LAND SYSTEMS - CANADA"
 2) "5330230307"
 3) "GROUPE SIGNATURE SUR LE SAINT-LAURENT"
 4) "4572961052"
 5) "HALIFAX SHIPYARD"
 6) "2976037482"
 7) "COMMISSIONAIRES"
 8) "2257418353"
 9) "GENERAL DYNAMICS ORDNANCE AND TACTICAL SYSTEMS - CANADA INC"
10) "1530425571"
11) "IMPERIAL OIL"
12) "1160561790"
13) "PCL CONSTRUCTORS CANADA INC"
14) "1130049142"
15) "BELL CANADA"
16) "951964515"
17) "MACK DEFENSE, LLC"
18) "836564376"
19) "GLAXOSMITHKLINE INC"
20) "824345297"
21) "TEXTRON SYSTEMS CANADA, INC"
22) "819002940"
23) "VANCOUVER SHIPYARDS CO LTD"
24) "676165933"
25) "BELL HELICOPTER TEXTRON CANADA LTD"
26) "659146472"
27) "BAE SYSTEMS BOFORS AB"
28) "638225158"
29) "IBM CANADA LTD/IBM CANADA LIMITEE"
30) "630961762"
31) "PROJET RESOLVE INC/PROJECT RESOLVE INC"
32) "620865000"
33) "MERCK CANADA INC"
34) "579594188"
35) "LOGISTIK UNICORP INC"
```

Security

Feature	Notes
Authentication	None! (Well… you can password protect with 1 password general access in case your firewalls fail or are misconfigured)
Authorization (access controls)	Zero!
Encryption – Client/Server Communication	Nada! (Well… you can put in an SSL proxy, but that has nothing to do with Redis)
Encryption – Data on Disk	Nope! (Well… you could do it with a separate system, but that has nothing to do with Redis)
Auditing	Zilch!

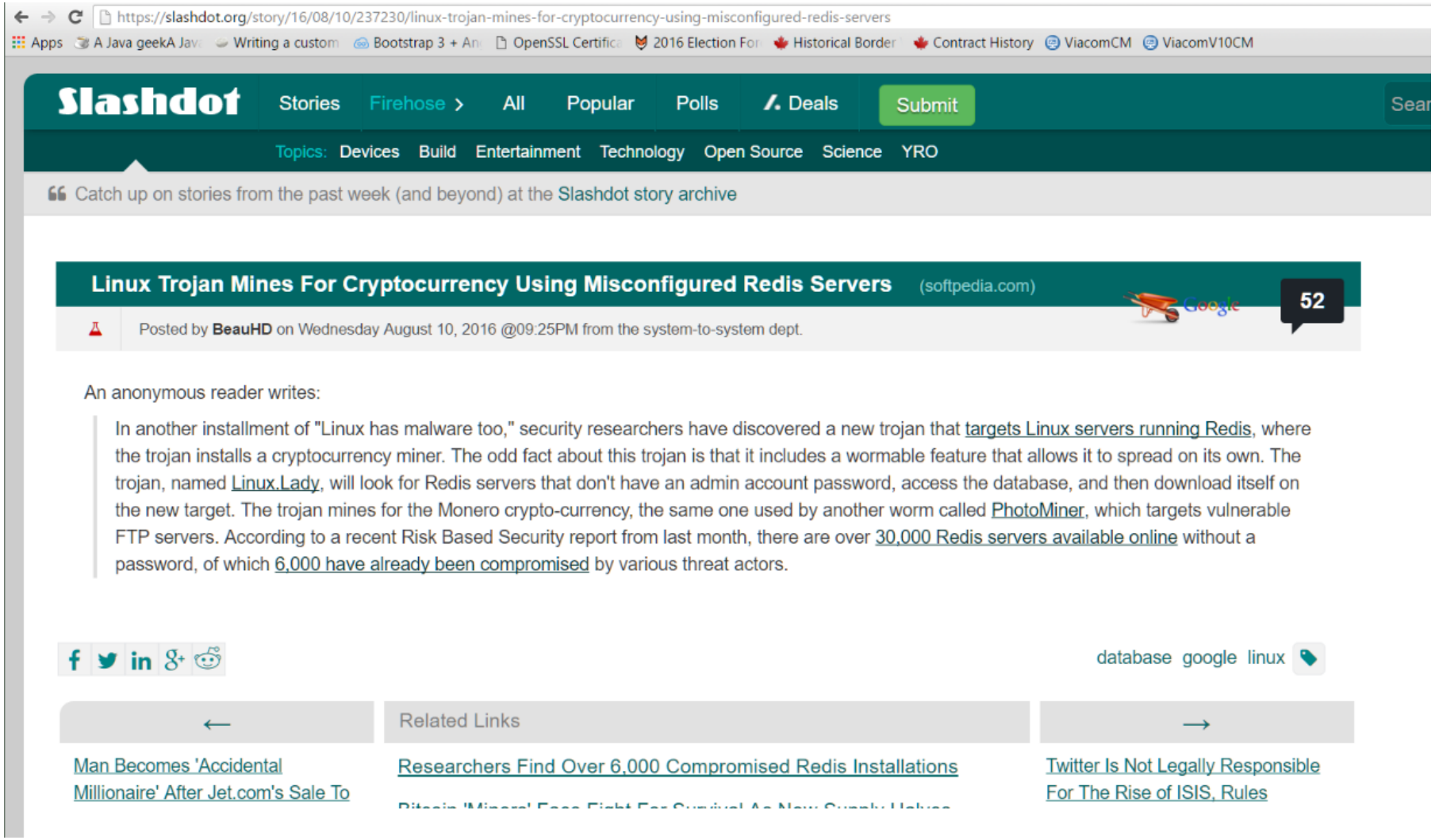
http://redis.io/topics/security

"Redis is designed to be accessed by trusted clients inside trusted environments. This means that usually it is not a good idea to expose the Redis instance directly to the internet or, in general, to an environment where untrusted clients can directly access the Redis TCP port or UNIX socket. […] in general, untrusted access to Redis should always be mediated by a layer implementing ACL"

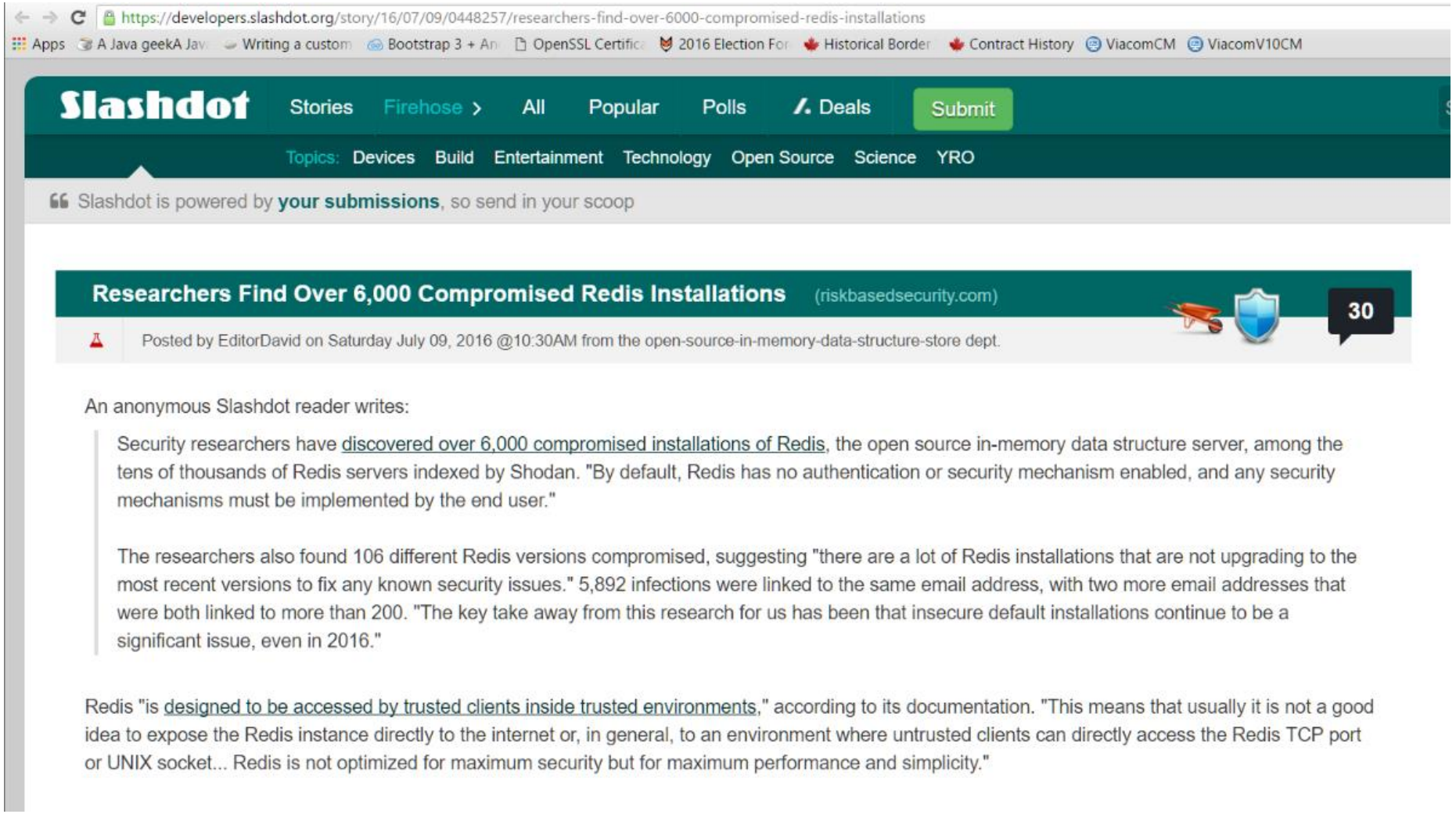
Here's a question – Should you always trust your administrators? Maybe a pre-requisite for Redis is also jump servers and PIM?

Irony: Salvatore Sanfilippo, the guy who started Redis used to be a security reasearcher

Exposed Redis Services with no Authentication



Exposed Redis Services with no Authentication

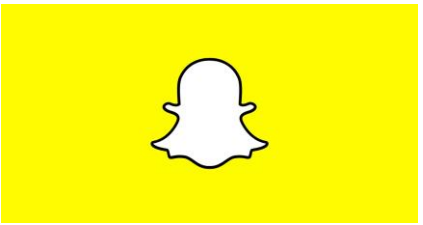


Where it's used

Good List: http://redis.io/topics/whos-using-redis

Mainly "Web Scale" kinds of use cases

craigslist



Potential Drawbacks

- It is clearly built for performance above all else, so certain functions suffer:
  - Security
  - Utilities
  - Extended functions

- Not exactly user friendly
  - Bulk importing data required code and knowing the protocol
  - Something simple like scanning through keys implemented with performance over usability in mind

- Might not be appropriate for analytics (but analytic systems are often not appropriate for transactions – choose it for the right use cases)

Similar Systems

- Memcached is often cited as an alternative for pure caching use cases (key-object store in memory)

- Apache Ignite is an in-memory key-value store, but relies on an external database (nosql/relational) for persistence

- Apache Cassandra (coming up next) is a hybrid key-value/column-oriented data store, so the behavior is somewhat analogous but feels very different

General Architecture

- Cassandra is a hybrid key-value/tabular data store
- Instead of master/slaves, replication occurs across the cluster instead of having dedicated slaves
- Nodes are organized in a ring
- CAP: Cassandra values availability and partition tolerance (it can be configured to be more consistent at the cost of increased latency (ie: availability) – but you can't get row locking)

- Something that takes some getting used to: In Cassandra, you build all your tables with data retrieval as the primary concern – multiple tables/copies of data for each kind of SELECT you plan to do is common

- You interact with Cassandra using a SQL flavored language called CQL

More Info: https://wiki.apache.org/cassandra/ArchitectureOverview

Origins

- Cassandra comes from Facebook – Created to power inbox search features

facebook

- One of the lead developers came from Amazon where he helped author Amazon DyanamoDB (key-value store, ring architecture, other things)

amazon DynamoDB

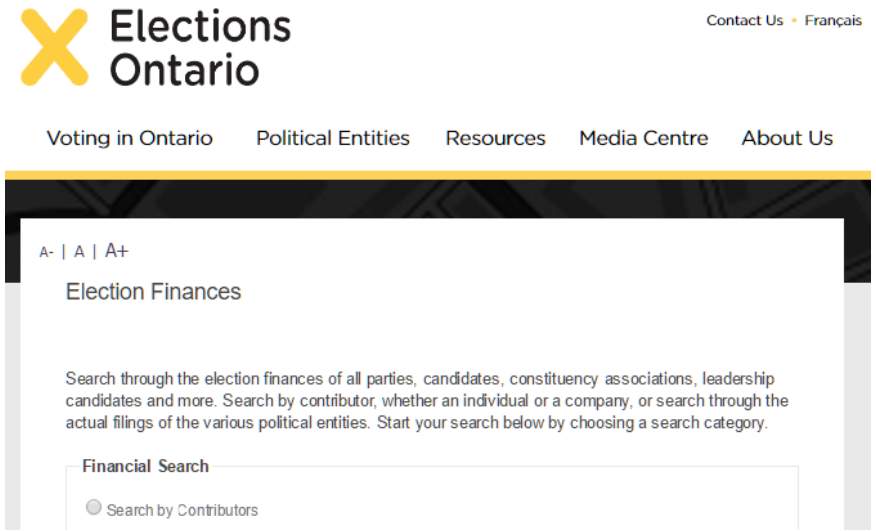
- Also took some inspiration from Google's BigTable Paper (column families, SSTables , other things)

Google

- "Cassandra" probably chosen on purpose – cursed Oracle in Greek Mythology who can see the future, but who's curse is no one believes her

Do “Something” With Cassandra

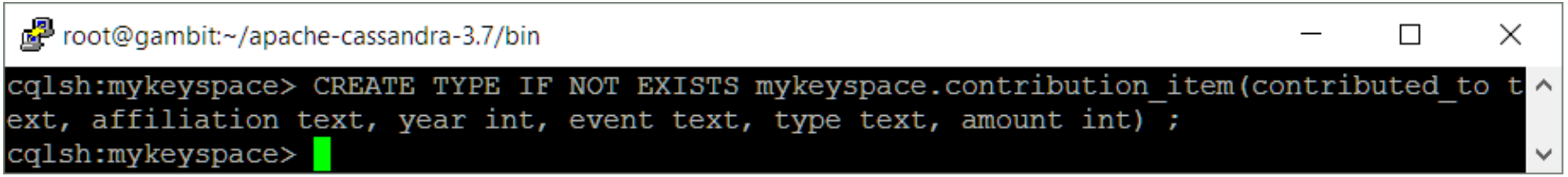
- Elections Ontario keeps a database of Ontario political contributions people can query
  - https://www3.elections.on.ca/internetapp/efsearch.aspx



- Question: Across all “events” (leadership races, individual contributions, yearly contributions, general election contributions), who were the largest contributors to each party - 2014 + 2015

Do “Something” With Cassandra

- In Cassandra, while you define tables, ***they are not relational***. Things you can’t do:
  - Joins (instead denormalize and use collections)
  - No GROUP BY statements (but very basic aggregations are recently supported)
  - Sorting has to be defined during data storage – more on that later
- Create a User Defined Type (UDT) for individual contribution details – we’ll use these in a collection



Do “Something” With Cassandra

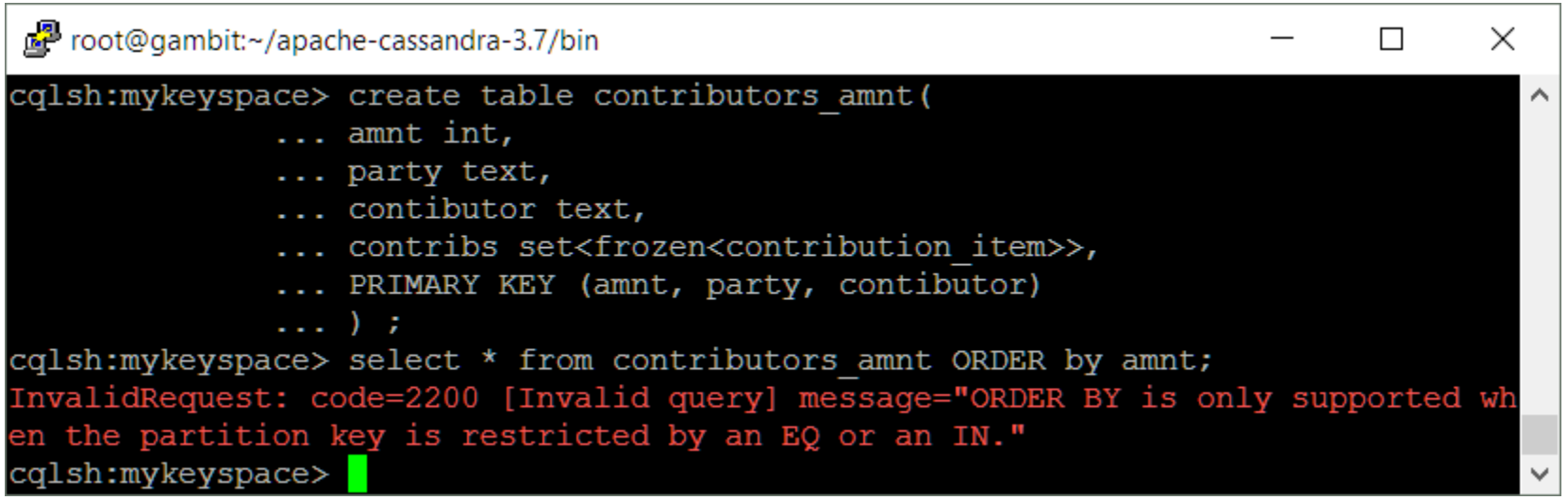
- Create the table (attempt 1). I think to myself “keys are normally sorted and partitioning based on amount contributed would create a pretty good distribution across nodes:

```
create table contributors(
        amnt int,
        party text,
        contibutor text,
        contribs set<frozen<contribution_item>>,
        PRIMARY KEY (amnt, party, contibutor)
)
```

- The first column in the primary key is the partition key

Do “Something” With Cassandra

- No Dice – Cassandra does not want to retrieve all the data from a bunch of nodes and sort them (makes sense actually):



- So, I can sort, but I have to include the partition key in the query

Do “Something” With Cassandra

- Second Attempt: Create the table and define the clustering to force sorting on storage of the data around amnt:

PuTTY (inactive)

```
cqlsh:mykeyspace> create table contributors(
             ... party text,
             ... amnt int,
             ... contibutor text,
             ... contribs set<frozen<contribution_item>>,
             ... PRIMARY KEY (party, amnt, contibutor)
             ... ) WITH CLUSTERING ORDER BY(amnt DESC);
```

- Partitioning on party. Not perfect distribution either but at least I only have to read one partition per query (which is something Cassandra encourages)

Do “Something” With Cassandra

- I have a table now, so take the Election Ontario Flat Files:

C:\Users\john.haldeman\Desktop\ONPolicalContributions.txt - Notepad++

File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

ONPolicalContributions.txt

```
1  Name,Contributed To,Political Affiliation,Year,Event,Type,Amount
2  1003694 ONTARIO INC (CAREPARTNERS) ,Ontario Liberal Party,LIB,2014,2014 Annual Period,Individual,1910
3  1026517 ONTARIO LTD ,Ontario Liberal Party,LIB,2014,2014 Annual Period,Individual,690
4  1035587 ONTARIO INC ,Progressive Conservative Party of Ontario,PCP,2014,2014 Annual Period,Individual,950
5  1037416 ONTARIO INC ,Ontario Liberal Party,LIB,2014,2014 Annual Period,Individual,468
6  1039591 ONTARIO LTD O/A D & D ENTERPRISES ,Progressive Conservative Party of Ontario,PCP,2014,2014 Annual Period,Inc
7  1043 BLOOR INC ,Progressive Conservative Party of Ontario,PCP,2014,2014 Annual Period,Individual,379.52
```

Do “Something” With Cassandra

- Unflatten them to create collections and sum the contributions (I left out of code for this one):

C:\Users\john.haldeman\workspace\RedisGen\cassandraImportSet.txt - Notepad++

File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

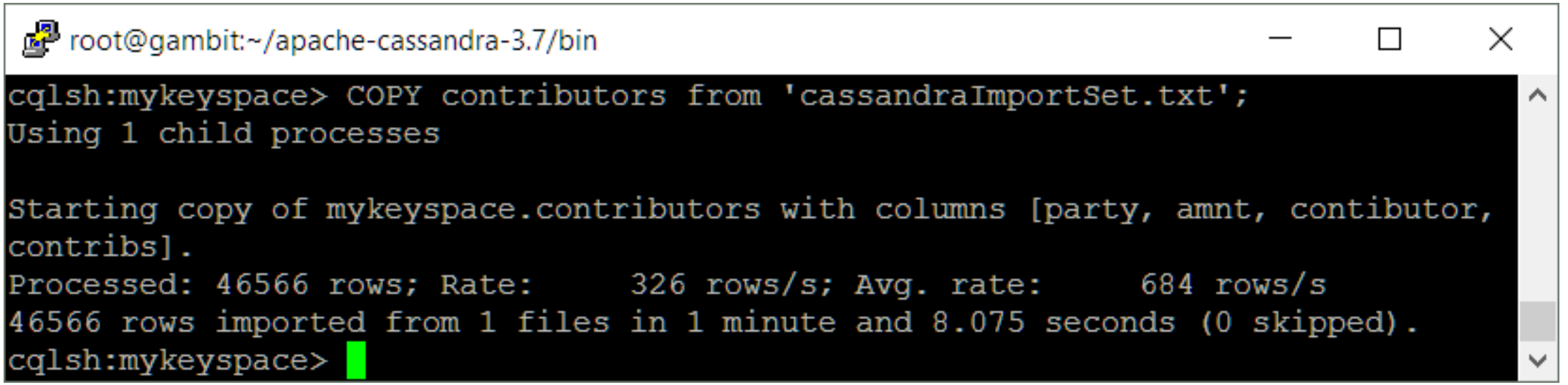
ONPolicalContributions.txt | cassandraImportSet.txt

```
1 "PCP",1000,"GEORGE STEIN LTD","{{contributed_to: 'John Yakabuski', affiliation: 'PCP', year: 2014, event: 'General Election 2014', type: 'Individual', amount: 1000}}"
2 "PCP",210,"886110 ONTARIO LTD","{{contributed_to: 'Patrick Brown', affiliation: 'PCP', year: 2014, event: '2015 Progressive Conservative Party of Ontario Leadership Contes
3 "PCP",140,"SHARPE ANNE","{{contributed_to: 'Progressive Conservative Party of Ontario', affiliation: 'PCP', year: 2015, event: '2015 Annual Period', type: 'Individual', am
4 "LIB",600,"DONSON LYNDA","{{contributed_to: 'Ontario Liberal Party', affiliation: 'LIB', year: 2014, event: '2014 Annual Period', type: 'Individual', amount: 300},{contrib
5 "PCP",300,"MILES MARGARET","{{contributed_to: 'Progressive Conservative Party of Ontario', affiliation: 'PCP', year: 2015, event: '2015 By-Election ED088', type: 'Individu
6 "PCP",200,"MACKIE ALAN","{{contributed_to: 'Progressive Conservative Party of Ontario', affiliation: 'PCP', year: 2014, event: 'General Election 2014', type: 'Individual',
7 "LIB",200,"STEWART JOHN","{{contributed_to: 'Ontario Liberal Party', affiliation: 'LIB', year: 2014, event: 'General Election 2014', type: 'Individual', amount: 200}}"
8 "LIB",350,"MCGRATH JOHN","{{contributed_to: 'Ontario Liberal Party', affiliation: 'LIB', year: 2015, event: '2015 Annual Period', type: 'Individual', amount: 350}}"
```

- Basically I did the GROUP BY outside of Cassandra, but Cassandra experts might be able to do this all in-engine? Maybe with Spark? (more on Spark later)

Do “Something” With Cassandra

- Import the data:



- (For larger data sets, they recommend you compile the data directly into SSTables instead using the Cassandra Java API)

Do “Something” With Cassandra

root@gambit:~/apache-cassandra-3.7/bin

```
cqlsh:mykeyspace> select party, amnt, contibutor from contributors where party='
LIB' LIMIT 20;

 party | amnt  | contibutor
-------+-------+-----------------------------------------------------
   LIB | 60630 |                                        LAZARIDIS MICHAEL
   LIB | 60548 |                              ROGERS COMMUNICATIONS INC
   LIB | 59925 |                         INSURANCE BUREAU OF CANADA IBC
   LIB | 59005 |                                           TONG OPHELIA
   LIB | 57432 |                 CARPENTERS DISTRICT COUNCIL OF ONTARIO
   LIB | 55749 |                                         UNION GAS LTD
   LIB | 54060 |                                          TERANET INC
   LIB | 53630 |                      GREENFIELD SPECIALTY ALCOHOLS INC
   LIB | 52363 |              LIFELABS MEDICAL LABORATORY SERVICES INC
   LIB | 51310 |                              UNIFOR (UNION FOR CANADA)
   LIB | 51240 |                                 SHOPPERS DRUG MART INC
   LIB | 50466 |                                  RENTECH WP CANADA ULC
   LIB | 50372 |              IRON WORKERS DISTRICT COUNCIL OF ONTARIO
   LIB | 49845 |                         SAMSUNG RENEWABLE ENERGY INC
   LIB | 48990 |                       BANK OF NOVA SCOTIA (SCOTIABANK)
   LIB | 48512 |                                           APOTEX INC
   LIB | 47670 |                          ONTARIO COUNCIL OF PAINTERS
   LIB | 47368 |                    ONTARIO HOME BUILDERS ASSOC INC OHBA
   LIB | 46398 | LOC 793 INTERNATIONAL UNION OF OPERATING ENGINEERS
   LIB | 46321 |                      ONTARIO LONG TERM CARE ASSOC OLTCA

(20 rows)
cqlsh:mykeyspace>
```

Do “Something” With Cassandra

root@gambit:~/apache-cassandra-3.7/bin

```
cqlsh:mykeyspace> select party, amnt, contibutor from contributors where party='
NDP' LIMIT 20;

 party | amnt  | contibutor
-------+-------+-----------------------------------------------------------
   NDP | 69825 |                                                DIST 6 USW
   NDP | 66290 |                            AMALGAMATED TRANSIT UNION ONT
   NDP | 64627 |                          LOC 113 AMALGAMATED TRANSIT UNION
   NDP | 57439 |                                                LOC 1 SEIU
   NDP | 54914 |                                                     OPSEU
   NDP | 52661 |                                              LOC 353 IBEW
   NDP | 43955 |                                THE SOCIETY OF ENERGY PROF
   NDP | 41387 |              OECTA ONTARIO ENGLISH CATHOLIC TEACHERS ASSOC
   NDP | 40409 |                             USW POLITICAL ACTION COMMITTEE
   NDP | 37996 |                                              LOC 1998 USW
   NDP | 35627 |                          LOC 46 UA PLUMBING & PIPE FITTING
   NDP | 35345 |                                              BRUCE POWER INC
   NDP | 34580 |                                   CANADIAN LABOUR CONGRESS
   NDP | 34550 |                                              LOC 1000-A UFCW
   NDP | 34322 |                                            UNIFOR THE UNION
   NDP | 32575 |                                   ONTARIO REAL ESTATE ASSOC
   NDP | 31868 |                                              LIFELABS INC
   NDP | 31385 |                          ETFO ELEMENTARY TEACHERS FED OF ONT
   NDP | 31322 |                                              ONTARIO CUPE
   NDP | 30290 | PROVINCIAL BUILDING & CONSTRUCTION TRADES COUNCIL ONTARIO

(20 rows)
cqlsh:mykeyspace>
```

Do “Something” With Cassandra

root@gambit:~/apache-cassandra-3.7/bin

```
cqlsh:mykeyspace> select party, amnt, contibutor from contributors where party='
PCP' LIMIT 20;

 party | amnt   | contibutor
-------+--------+-----------------------------------------------
   PCP | 133250 |                                    MORYTO ADAM
   PCP | 127830 | FEDERATION OF RENTAL HOUSING PROVIDERS OF ONTARIO
   PCP | 110271 |                          INSURANCE BUREAU OF CANADA
   PCP |  74578 |                           ONTARIO REAL ESTATE ASSOC
   PCP |  60230 |                            MILBORNE REAL ESTATE INC
   PCP |  49680 |                              ELEMENT FINANCIAL CORP
   PCP |  47679 |                           MEDIPAC INTERNATIONAL INC
   PCP |  45425 |                                       ROTO-MILL INC
   PCP |  44765 |                              CANADIAN TIRE CORP LTD
   PCP |  44103 |                                 1714486 ONTARIO LTD
   PCP |  43975 |                                         ORLANDO CORP
   PCP |  43250 |                                         JETPORT INC
   PCP |  43250 |                           STRONACH CONSULTING CORP
   PCP |  42389 |                                  BARRICK GOLD CORP
   PCP |  39624 |                                      UNION GAS LTD
   PCP |  39261 |                            MOLSON COORS CANADA INC
   PCP |  38465 |                           ROGERS COMMUNICATIONS INC
   PCP |  37915 |                                       LIFELABS INC
   PCP |  37712 |                                  611428 ONTARIO LTD
   PCP |  35000 |                                         MUNK PETER

(20 rows)
cqlsh:mykeyspace>
```

Do “Something” With Cassandra

root@gambit:~/apache-cassandra-3.7/bin

```
cqlsh:mykeyspace> select party, amnt, contibutor from contributors where party='
GPO' LIMIT 20;

 party | amnt  | contibutor
-------+-------+-----------------------------------
   GPO | 12100 |                        BAGLER DAVE
   GPO |  6985 |                      CRAWFORD CAREN
   GPO |  6905 |                          SMIT BECKY
   GPO |  6310 |                      CLARKE MATTHEW
   GPO |  6284 |                        BROWN TEMARA
   GPO |  6030 |                    NARAYANAN SOLACHI
   GPO |  6000 |                         CANTIN CRAIG
   GPO |  5870 |                       LOHMANN ROGER
   GPO |  5810 |                        FRASER LINDA
   GPO |  5591 |           VETTESE SHAROLYN MATHIEU
   GPO |  5530 |                     KNIGHT GEOFFREY
   GPO |  5450 |                      SCHREINER MIKE
   GPO |  5360 |                        EASTO HAYLEY
   GPO |  5000 |                     ELLIOTT ROBERT S
   GPO |  4630 |                        MANICKAM NARA
   GPO |  4625 |                     ROCHON CLAUDETTE
   GPO |  4535 |                           WATSON AMY
   GPO |  4466 |                            DAYE MARK
   GPO |  4400 |                      HARTWELL GEORGE
   GPO |  4152 | 1912206 ONTARIO INC O/A ELLMAN DESIGN

(20 rows)
cqlsh:mykeyspace>
```

Security

Feature	Notes
Authentication	Native Password Authentication is available. You could extend the authenticator classes to use whatever you like. The Enterprise distributions (eg: Datastax) have authenticators for things like LDAP, Kerberos.
Authorization (access controls)	Native Role Based Authorization is available. You could extend the authorization classes to use whatever you like.
Encryption – Client/Server Communication	Yes: TLS/SSL available
Encryption – Data on Disk	Enterprise Distros (eg: Datastax) have TDE implementations with KMIP integrations. Or you can use something else.
Auditing	None, except if you use an Enterprise distribution (eg: Datastax) or if you use a third party auditing framework (eg: Guardium)

Where It's Used

- Many of the most famous examples chose Cassandra for maximum control and for writing a lot of data quickly (with reads being relatively infrequent)
- More tolerant to amounts of data larger than the available memory (where MongoDB and Redis historically don't do well)

- Instagram migrated from Redis (not from a relational DBMS) to Cassandra for certain functions (the Facebook influence maybe helped?)

Potential Drawbacks

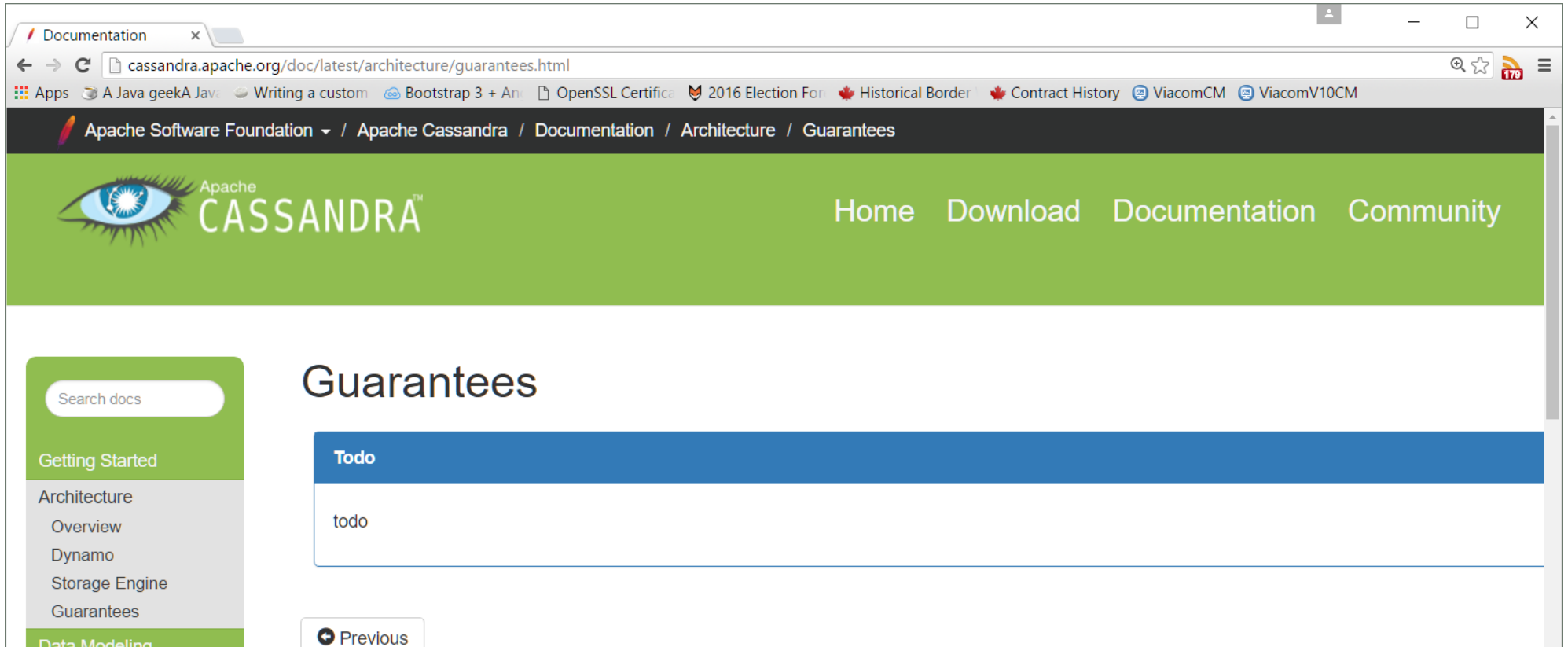
- Cassandra Data Modeling Feels “Unusual”
  - http://www.datastax.com/dev/blog/basic-rules-of-cassandra-data-modeling

  “Try to determine exactly what queries you need to support. […] ***Changes to just one of these query requirements will frequently warrant a data model change for maximum efficiency****. […] To put this another way, each table should pre-build the “answer” to a high-level query that you need to support. If you need different types of answers, you usually need different tables. This is how you optimize for reads.”*

  - It kind of seems like a pain that in order to get another view of the data, you have to rewrite the data into a differently organized table

Potential Drawbacks

- More than some of the other DBMSs explored here, Cassandra does sometimes feel like a moving target (constantly changing). It can be difficult to know if what you are reading was a consideration in the past or is one now
- The official documentation that's supposed to set you straight apparently an evolving work in progress itself:



Similar Systems

- The most similar system in that they both have closely tied origins to Google's BigTable is HBASE:

- HBASE is built on Hadoop which comes next

General Architecture

- HDFS
  - The Hadoop Distributed Filesystem – A single filesystem across many nodes
  - Provides the data for everything that runs on Hadoop
  - Two Major Components:
    - NameNodes: Provide metadata services (but no actual data flows through them). They also orchestrate replication
    - DataNodes: Do the actual storage and data management

- More on HDFS: https://hadoop.apache.org/docs/r2.7.2/hadoop-project-dist/hadoop-hdfs/HdfsDesign.html

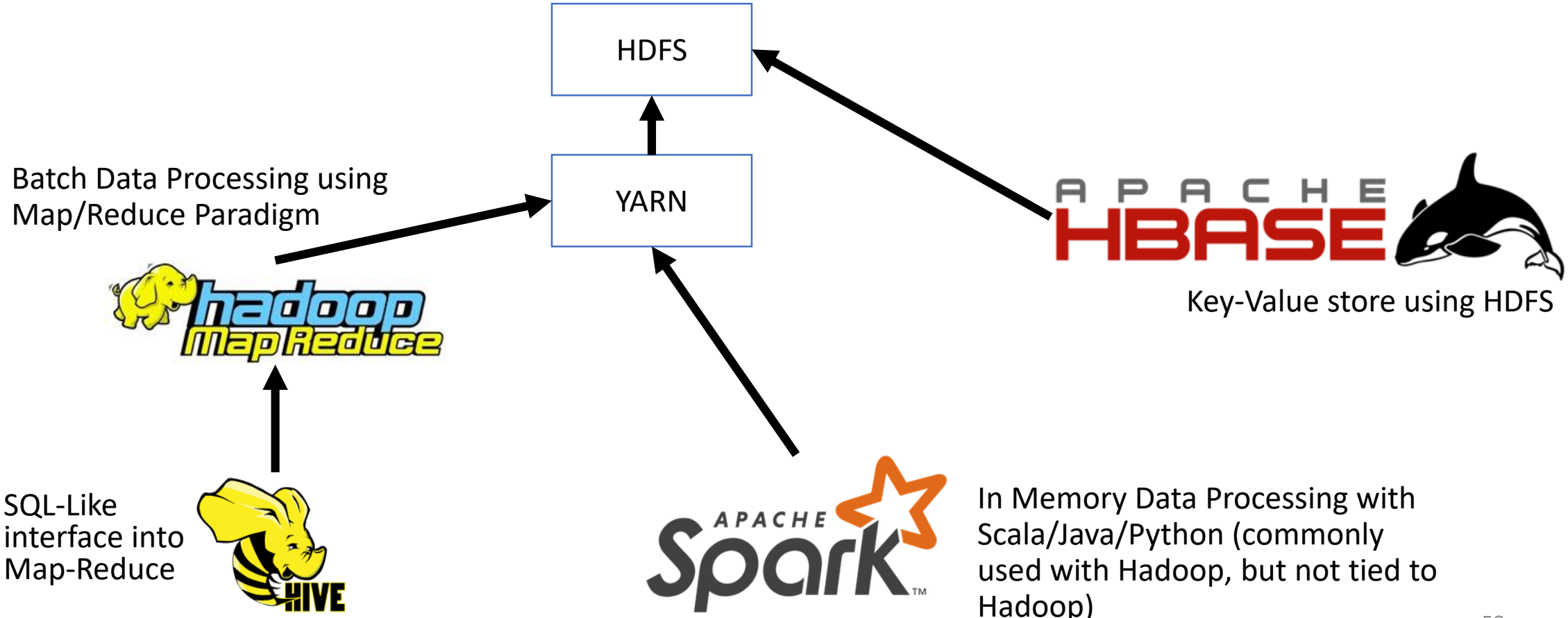
General Architecture

- YARN
  - Yet Another Resource Negotiator
  - Major component is the ResourceManager: Allocates and manages cluster resources (a system scheduler)

- More on YARN: http://hortonworks.com/blog/apache-hadoop-yarn-concepts-and-applications/

General Architecture

- "Stuff" built on top of it (Nowhere near a complete list)

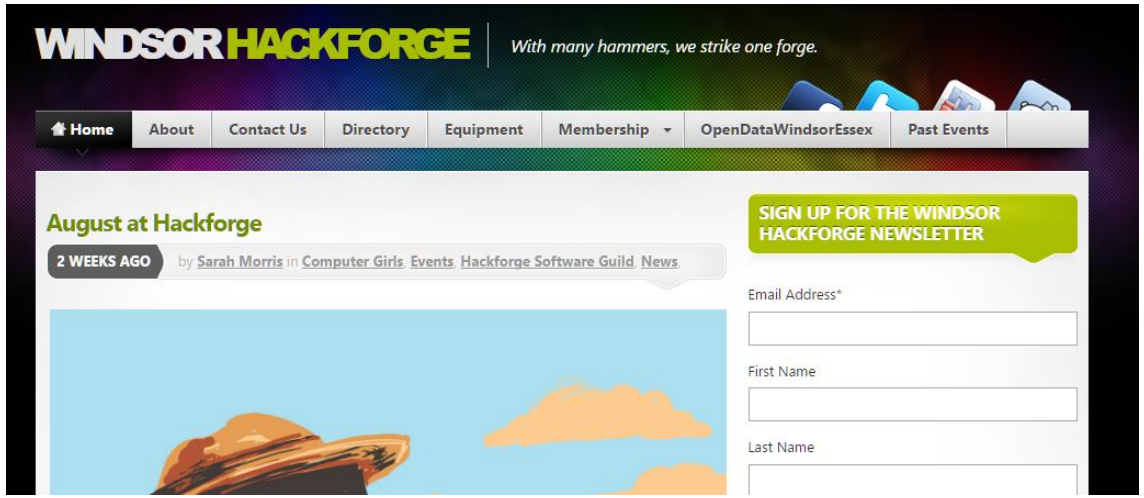


Origins

The Google Filesystem and MapReduce Papers
(http://research.google.com/archive/gfs.html http://research.google.com/archive/mapreduce.html)

Do “Something” With Hadoop

- Hey, websites are data:



- Let’s Analyze Hackforge’s website with Hadoop and Spark using word and link counts – what words appear most often for:
  - http://hackf.org/

Do “Something” With Hadoop

- Get the data with wget recursive (not in Hadoop yet):

  wget --limit-rate=200k --no-clobber --convert-links --random-wait -r -p -E -e robots=off -U mozilla http://hackf.org/

- Next, convert the site to pure text with a HTML parser. A Lynx dump works for something quick and dirty (not in Hadoop yet):

  lynx -nolist -dump justhtml/_2013_06_01_hackforge-grand-opening_index.html > justtext/_2013_06_01_hackforge-grand-opening_index.txt

  lynx -nolist -dump justhtml/_2013_07_06_forum-is-live_index.html > justtext/_2013_07_06_forum-is-live_index.txt

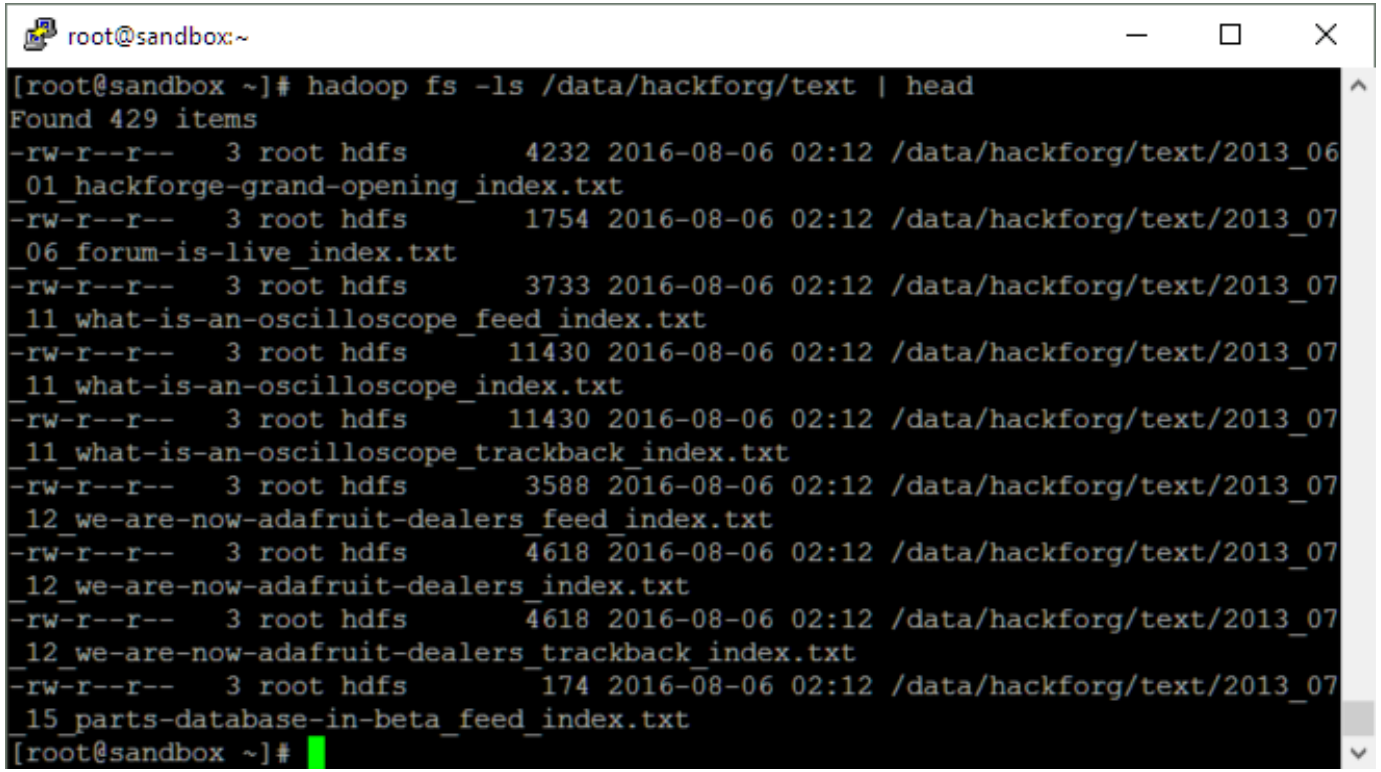
  lynx -nolist -dump justhtml/_2013_07_11_what-is-an-oscilloscope_feed_index.html > justtext/_2013_07_11_what-is-an-oscilloscope_feed_index.txt

  lynx -nolist -dump justhtml/_2013_07_11_what-is-an-oscilloscope_index.html > justtext/_2013_07_11_what-is-an-oscilloscope_index.txt

  ….

Do “Something” With Hadoop

- Copy the data from the local file system to HDFS (Now we are in Hadoop):
  - hadoop fs -copyFromLocal *.txt /data/hackforg/text



Do “Something” With Hadoop

- Use Spark with some Scala to count the words:

Zeppelin Notebook Interpreter Configuration

* Simple Sorted Word Count

```
val textFile = sc.textFile("hdfs:///data/hackforg/text")
val counts = textFile.flatMap(line => line.split(" "))
                 .map(word => (word, 1))
                 .reduceByKey(_ + _)
                 .map(item => item.swap)
                 .sortByKey(false)
counts.saveAsTextFile("hdfs:///data/hackforg/text_out14")
```

```
textFile: org.apache.spark.rdd.RDD[String] = MapPartitionsRDD[1] at textFile at <console>:30
counts: org.apache.spark.rdd.RDD[(Int, String)] = ShuffledRDD[8] at sortByKey at <console>:35
```

Took 102 seconds

Do “Something” With Hadoop

- HDFS shell command to view the results file:

Zeppelin Notebook Interprete

* Simple Sorted Word Count

```
%sh hadoop fs -cat /data/hackforg/text_out14/part*

(205711,)
(7736,the)
(7506,to)
(7492,and)
(5879,*)
(4726,of)
(4429,a)
(4256,for)
(4047,Hackforge)
(3523,+)
(3304,in)
(2992,Windsor)
(2949,is)
(2920,by)
(2753,on)
(2245,2016)
(2173,with)
(2113,/>)
```

Do “Something” With Hadoop

- HDFS shell command to view the results file:

```
* Simple Sorted Word Count
(731,<a)
(708,Sarah)
(695,ago)
(688,our)
(688,Feed)
(669,May)
(658,Ontario)
(657,Morris)
(641,have)
(641,as)
(639,one)
(637,new)
(621,July)
(606,Event)
(599,Trillium)
(599,Open)
(588,us)
(584,August)
(579,women)
(561,Computer)
(557,about)
(540,Data)
```

Do “Something” With Hadoop

- Scala on Spark to look at link counts in HTML:

* Link Count

```
val textFile = sc.textFile("hdfs:///data/hackforg/html")

val counts = textFile.filter(line => line.contains("href"))
                     .flatMap(hrefline => hrefline.split(" "))
                     .filter(word => word.contains("href"))
                     .map(word => word.replace("href=", ""))
                     .map(word => word.split(">")(0))
                     .map(linkWord => (linkWord, 1))
                     .reduceByKey((count1, count2) => (count1 + count2))
                     .map(item => item.swap)
                     .sortByKey(false)


counts.saveAsTextFile("hdfs:///data/hackforg/html_out7")
```

```
textFile: org.apache.spark.rdd.RDD[String] = MapPartitionsRDD[16] at textFile at <console>:30
counts: org.apache.spark.rdd.RDD[(Int, String)] = ShuffledRDD[27] at sortByKey at <console>:40
```

Took 19 seconds

Do “Something” With Hadoop

- Results:

```
%sh hadoop fs -cat /data/hackforg/html_out7/part*

(505,"http://hackf.org/feed/")
(504,"http://hackf.org/")
(483,"http://hackf.org/author/sarah/")
(320,"http://hackf.org/category/events/")
(275,"https://twitter.com/hackforge")
(274,"http://hackf.org/category/news/")
(274,"http://hackf.org/opendatawindsoressex/")
(264,"http://hackf.org/join-us/")
(257,"http://hackf.org/join-us/code-of-conduct/")
(257,"http://hackf.org/join-us/rules/")
(256,"http://hackf.org/member-directory/")
(253,"http://hackf.org/contact-us/")
(253,"http://hackf.org/comments/feed/")
(252,"https://www.facebook.com/Hackforge")
(252,"#page")
(252,'http://hackf.org/wp-content/plugins/mailchimp//css/flick/flick.css?ver=3.9.13')
(252,"http://webchat.freenode.net/?channels=#hackforge")
(252,"http://hackf.org/2016/06/")
(252,"http://hackf.org/2016/02/")
(252,"http://digitalnature.eu/")
(252,"http://wordpress.org/")
(252,"/favicon.ico")
(252,'http://hackf.org/?mcsf_action=main_css&#038;ver=3.9.13')
(252,"http://hackf.org/2015/09/")
(252,'http://hackf.org/wp-content/themes/mystique-child/simple-staff-list-custom.css?ver=3.9.13')
(252,"http://hackf.org/about/")
(252,"http://www.reddit.com/r/hackforge/search?q=hackforge&amp;sort=relevance&amp;restrict_sr=on&amp;t=all")
(252,"http://hackf.org/2016/07/")
```

Security

Feature	Notes
Authentication	Kerberos and Nothing
Authorization (access controls)	At HDFS there are similar access controls to regular filesystems. For the systems on top (HBASE, HIVE, etc.), it varies. Since each system has their own access control mechanisms and structures, it can be a complex task to designed entitlements. There are systems to try help manage the complexity (eg: Apache Ranger)
Encryption – Client/Server Communication	HDFS Transparent encryption handles end to end encryption (at rest and in the communication stream). That being said, that just encrypts the data with the services that interact with HDFS. Most services on top of HDFS (like HBASE, HIVE, Spark, Impala etc.) will have varying support/configurations for communication encryption.
Encryption – Data on Disk	
Auditing	Various native audit logging at the various layers is available

Where It's Used

- Becoming the standard in big data analytics – quite common. Here are some examples outside of web technology:

Potential Drawbacks

- It is a complex technology – a framework for data processing rather than a DBMS with a single interface

- HBASE excepted, most technologies that run on HDFS are primarily for batch processing of OLAP workloads – so use it for the right use cases. There aren't a lot of options for mixed workloads (but when you are dealing with Big Data, there may be no options for mixed workloads anyway)

- Some people struggle to understand the Map-Reduce paradigm, which is the traditional one used on Hadoop

Similar Systems

- There seem to be similar systems for each component in the ecosystem, but it’s difficult to find something that is similar to Hadoop as a whole

NoSQL Cocktail Hour

I'm good at helping you with ***almost*** everything and I am easy to talk to (but arguably postgresql is both those things as well – but I am schema-less)

I am extremely fast as long as I can keep it all in memory

If you have a problem that involves lots of data, there is probably something somewhere in the Hadoop ecosystem that will help you out

I am good at writing things down quickly and telling you things quickly. It just gets awkward if the views you want change often or if you need me to summarize the data