CS 488/588: Cloud & Cluster Data Management

Freeway Data in MongoDB

Portland State University, Fall 2020

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DATA

The Freeway Dataset, our MongoDB Data Model,
and our ETL Process

Freeway Dataset

- Relational data in .csv files
- Full of empty NULL values
- Querying in this format would require many joins
- Large freeway_loopdata file

detectorid	starttime	volume	speed	occupancy	status	dqflags
1345	9/15/2011 0:00:00	0		0	0	0
1345	9/15/2011 0:00:20				0	0
1345	9/15/2011 0:00:40	0		0	0	0
1345	9/15/2011 0:01:00	0		0	0	0
1345	9/15/2011 0:01:20	0		0	0	0
1345	9/15/2011 0:01:40	1	47	0	3	0
1345	9/15/2011 0:02:00	0		0	0	0
1345	9/15/2011 0:02:20	0		0	0	0

Table	A <->	Collection
Rows	of <->	Documents
Primary Key	identified by a <->	_id:ObjectId()
Columns	and contains <->	Fields

```
{
    _id: ObjectId(123),
    field: "value"
}
{
    _id: ObjectId(124),
    field: "value"
}
```

A NoSQL, distributed, document-oriented database that uses collections of JSON-type documents which support embedded fields for the storage of related data.

MongoDB

OUR DATA MODEL

Detector Collection:


```
{
        _id: ObjectId("5fad9e5bfb3c57497c725fa5")
        detectorid:1345
        highway: {
                highwayid:3
                shortdirection:"N"
                direction:"NORTH"
                highwayname:"I-205"
        }
        milepost:14.32
        locationtext:"Sunnyside NB"
        detectorclass:1
        lanenumber:1
        station: {
                stationid:1045
                upstream:0
                downstream:1046
                stationclass:1
                numberlanes:4
                latlon:"45.43324,-122.565775"
                length:0.94
        }
}
```


Freeway Loop Data Collection:


```
{
        _id: ObjectId("5fad9f01fb3c57497c725faf")
        detectorid:1345
        starttime:"2011-09-15 00:02:40-07"
        volume:1
        speed:66
}
```

EXTRACT TRANSFORM LOAD

```bash
#!/bin/bash
FNAME=freeway_loopdata.csv
HEADER=$(head -1 $FNAME)
split -b 300m $FNAME sections
n=1
for f in sections*
do
    if [ $n -gt 1 ]; then
        echo $HEADER > part${n}.csv
    fi
    cat $f >> part${n}.csv
    rm $f
    ((n++))
done
```

- The raw freeway_loopdata.csv was too large to load into our database
- We used this split.sh script to section it into workable files
- We cleaned each file of NULL/0 values.
- This allowed us to load all data

- The detectors, stations, and highways were in separate .csv files
- We wrote a Python script to format the data into a detector collection fitting our data model.
- This was saved to a JSON file and loaded to our database

```python
import csv
import json
import pandas as pd

# read in csv files into dataframes
df_de = pd.read_csv ("data/freeway_detectors.csv")
df_st = pd.read_csv ("data/freeway_stations.csv")
df_hw = pd.read_csv ("data/highways.csv")


#Save detector list to json file
with open("detectors.json", "w") as detectors_file:
    json.dump(detectors, detectors_file, indent=4)
```

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Queries

How we answered the freeway dataset questions

Connecting with Python

```python
from pymongo import MongoClient
from pprint import pprint
import getpass as gp
pw = gp.getpass()
username = "DJs"
password = pw
dbname = "djs-freeway"
uri = "mongodb+srv://" + username + ":" + password + \
    "@ccdm-project.f4c6t.mongodb.net/" + dbname + "?retryWrites=true&w=majority"
#client = MongoClient()
#client = MongoClient(uri)
#db = client.test
try:
    client = MongoClient(uri)
    db = client.test
    print("Connected Successfully!!!")
except:
    print("Could not connect to db :( ")


mydb = client[dbname]

de_collection = mydb["freeway_detectors"]
lp_collection = mydb["freeway_loopdata"]

```

Freeway Dataset Questions

Q1

Count low speeds and high speeds: Find the number of speeds < 5 mph and > 80 mph in the data set.

Q2

Volume: Find the total volume for the station Foster NB for Sept 15, 2011.

Q3

Single-Day Station Travel Times: Find travel time for station Foster NB for 5-minute intervals for Sept 15, 2011. Report travel time in seconds.

Q4

Peak Period Travel Times: Find the average travel time for 7-9AM and 4-6PM on September 22, 2011 for the I-205 NB freeway. Report travel time in minutes.

Q5

Route Finding: Find a route from Johnson Creek to Columbia Blvd on I-205 NB using the upstream and downstream fields.

Q6

Update: Change the milepost of the Foster NB station to 22.6.

Q1

Count low speeds and high speeds: Find the number of speeds < 5 mph and > 80 mph in the data set.

```
# Query 1: count the number of speeds < 5 mph and > 80 mph
result1 = lp_collection.count_documents(
    {"speed": {"$lt": 5}})
print("Number of speeds < 5:", result1)
result2 = lp_collection.count_documents(
    {"speed": {"$gt": 80}})
print("Number of speeds > 80:", result2)
```

```
Number of speeds < 5: 1269204
Number of speeds > 80: 62203
```

Q6

Update: Change the milepost of the Foster NB station to 22.6.

```
#Query 6 update milepost at "Foster NB" from 18.1 -> 22.6
qry6 = de_collection.update_many({"locationtext": {"$eq":'Foster NB'}}, {"$set": {"milepost": 22.6}})

cursor = de_collection.find({"locationtext": {"$eq": 'Foster NB'}})
for record in cursor:
  print(record)
```

```
{'_id': ObjectId('5fc420ddce0db46a9c85b88d'), 'milepost': 18.1, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88e'), 'milepost': 18.1, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88f'), 'milepost': 18.1, 'locationtext': 'Foster NB'}
Matched:3
Updated:3
{'_id': ObjectId('5fc420ddce0db46a9c85b88d'), 'milepost': 22.6, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88e'), 'milepost': 22.6, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88f'), 'milepost': 22.6, 'locationtext': 'Foster NB'}
```

Clean up freeway loop data for the rest of the queries

```python
# Remove unneeded loopdata after running Q1
# Q2 & 3 only need loopdata from Sept 15
# Q4 only needs loopdata from Sept 22
# Q5 onyl needs detector collection
filter={
    '$nor': [
        {
            'starttime': {
                '$regex': '2011-09-22',
                '$options': 'i'
            }
        }, {
            'starttime': {
                '$regex': '2011-09-15',
                '$options': 'i'
            }
        }
    ]
}

result = lp_collection.delete_many(
  filter=filter
)
print(f"Deleted:{result.deleted_count}")
```

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SELF-CRITIQUE

Challenges we faced and how we would change our approach in the future.

	QUERY PLANS	DATASET	ETL METHODS
DID CHANGE	• First, used MongoDB Compass UI aggregation tool • Switched to using a Python connection script • After running Q1, we truncated freeway_loopdata due to "max space used (512mb) error stopping us from performing operations.	StackOverflow (public dataset) • Exported data from BigQuery to GCS bucket files • Mounted GCS bucket to VM so we could access it like a local file system • AND THEN 1 out of 1000s of files took up all 512MB of space in MongoDB Switched to Freeway Dataset	• At first, we loaded in all four datasets as is, but realized we had to combine some of the datasets. • Edited the data in the freeway_loopdata to contain the only the fields we needed for the queries.
WOULD CHANGE	• Start figuring out queries earlier with smaller freeway_loopdata subset • Start with Python connection script, then use Compass UI as needed for assistance	• Do more research on dataset's size before trying to use it • Find a subset that would work for StackOverflow dataset	• Design data model FIRST • Write script to clean the freeway_loopdata of NULL/0 values • Add another index, other than the default one if possible

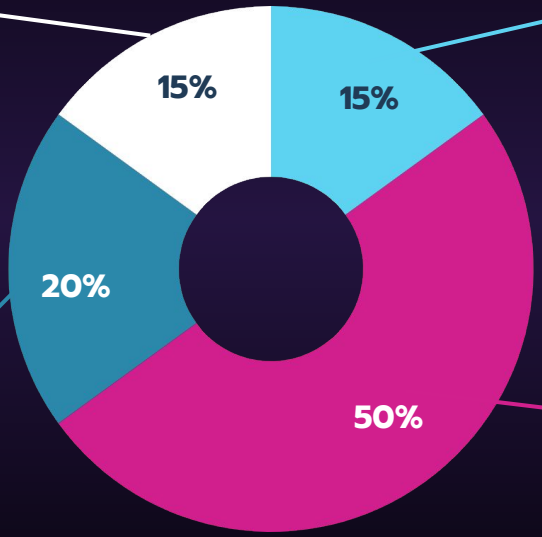
TIME INVESTMENT

ADMIN

- Setting up MongoDB went pretty smoothly on our own boxes and we also set up a VM on GCP. We created a Github for scripts and a shared Google drive for cleaned and transformed data.

ANALYZE

This has the potential to be a bit more than 15% by the time we complete them, but so far we have invested a disproportionate time doing ETL activities.



ARCHITECTURE

We spent a good amount of time thinking about the best data model with the goal of fitting it to the queries we needed to make.

ETL

Choosing a dataset, cleaning and transforming the data, and loading it to our data model took a lot of time.

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LESSONS LEARNED

MongoDB and Cloud Data Management

OUR TAKEAWAYS

- ETL takes time and planning
- MongoDB is a user-friendly database
- Dataset sizes can be very misleading
- Taking the time to write a script is better than trying to do the task manually
- MongoDB gives you a default index if you don't specify one
- Denormalized data > Normalized data

OUR ADVICE

- Don't try to do ETL without deciding on a data model
- Some of the functions in the manual are deprecated, so check which versions supports the functions you're using.
- DB compass is great as a guide for writing some queries ...
- ... But just default to using a good connection script in a language you know

QUESTIONS?

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APPENDIX

Dataset Size: *Full Freeway Dataset (approximately 660MB)*
Number of Queries : 4

Q1

Count low speeds and high speeds: Find the number of speeds < 5 mph and > 80 mph in the data set.

```
# Query 1: count the number of speeds < 5 mph and > 80 mph
result1 = lp_collection.count_documents(
    {"speed": {"$lt": 5}})
print("Number of speeds < 5:", result1)
result2 = lp_collection.count_documents(
    {"speed": {"$gt": 80}})
print("Number of speeds > 80:", result2)
```

```
Number of speeds < 5: 1269204
Number of speeds > 80: 62203
```

Q2

Volume: Find the total volume for the station Foster NB for Sept 15, 2011.

```
#Query 2 Find the total volume for the station Foster NB for Sept 15, 2011
qry2 = [{'$lookup': {'from': 'freeway_detectors',
            'localField': 'detectorid',
            'foreignField': 'detectorid',
            'as': 'detectors'}},
            {'$match': {'detectors.locationtext': 'Foster NB'}},
            {'$match': {'starttime': {'$regex': '2011-09-15'}}},
            {'$group': {'_id': 'None', 'TotalVolume': {
                '$sum': '$volume'}}}]
cursor = lp_collection.aggregate(qry2)
result = list(cursor)
print("Query 2 results: ",result)
```

```
Query 2 results:  [{'_id': 'None', 'TotalVolume': 49891}]
```

Q3

Single-Day Station Travel Times: Find travel time for station Foster NB for 5-minute intervals for Sept 15, 2011. Report travel time in seconds.

Q4

Peak Period Travel Times: Find the average travel time for 7-9AM and 4-6PM on September 22, 2011 for the I-205 NB freeway. Report travel time in minutes.

Q5

Route Finding: Find a route from Johnson Creek to Columbia Blvd on I-205 NB using the upstream and downstream fields.

```
#Query 5 Find the path from Johnson Creek to I-205 NB at Columbia
i = 0
text = 'Johnson Cr NB'
print(i,":",text)
while text != 'I-205 NB at Columbia':
  qry5 = [ {'$match': {'locationtext': text}},
         {'$lookup': {
            'from': 'freeway_detectors',
            'let': {'down': '$station.downstream',
                'lanenum': '$lanenumber'},
            'pipeline': [{'$match': {'$expr': {
                            '$eq': ['$station.stationid', '$$down']}}},
                            {'$match': {'$expr': {'$eq': ['$lanenumber', '$$lanenum']}}}
            ],
            'as': 'downstation'}},
            {'$limit': 1},
        {'$unwind': {'path': '$downstation'}},
        {'$project': {'downstation.locationtext': 1}}]
  cursor = de_collection.aggregate(qry5)
  result = list(cursor)
  i += 1
  for doc in result:
    text2 = doc["downstation"]
    text = text2["locationtext"]
    print(i,":",text)
```

```
0 : Johnson Cr NB
1 : Foster NB
2 : Powell to I-205 NB
3 : Division NB
4 : I-205 NB at Glisan
5 : I-205 NB at Columbia
```

Q6

Update: Change the milepost of the Foster NB station to 22.6.

```
#Query 6 update milepost at "Foster NB" from 18.1 -> 22.6
qry6 = de_collection.update_many({"locationtext": {"$eq":'Foster NB'}}, {"$set": {"milepost": 22.6}})

cursor = de_collection.find({"locationtext": {"$eq": 'Foster NB'}})
for record in cursor:
  print(record)
```

```
{'_id': ObjectId('5fc420ddce0db46a9c85b88d'), 'milepost': 18.1, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88e'), 'milepost': 18.1, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88f'), 'milepost': 18.1, 'locationtext': 'Foster NB'}
Matched:3
Updated:3
{'_id': ObjectId('5fc420ddce0db46a9c85b88d'), 'milepost': 22.6, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88e'), 'milepost': 22.6, 'locationtext': 'Foster NB'}
{'_id': ObjectId('5fc420ddce0db46a9c85b88f'), 'milepost': 22.6, 'locationtext': 'Foster NB'}
```

Source code available on Github

https://github.com/santitobon9/Cloud-Cluster-Freeway-Project.git