Using MongoDB and Python for data analysis pipeline

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Proactive Technical Services, MongoDB

Github repo for this talk: http://github.com/braz/pycon2015_talk/


From once off
to real scale
production

What this talk will cover

Pipelines

All about building

Systems

All about tools

Speed

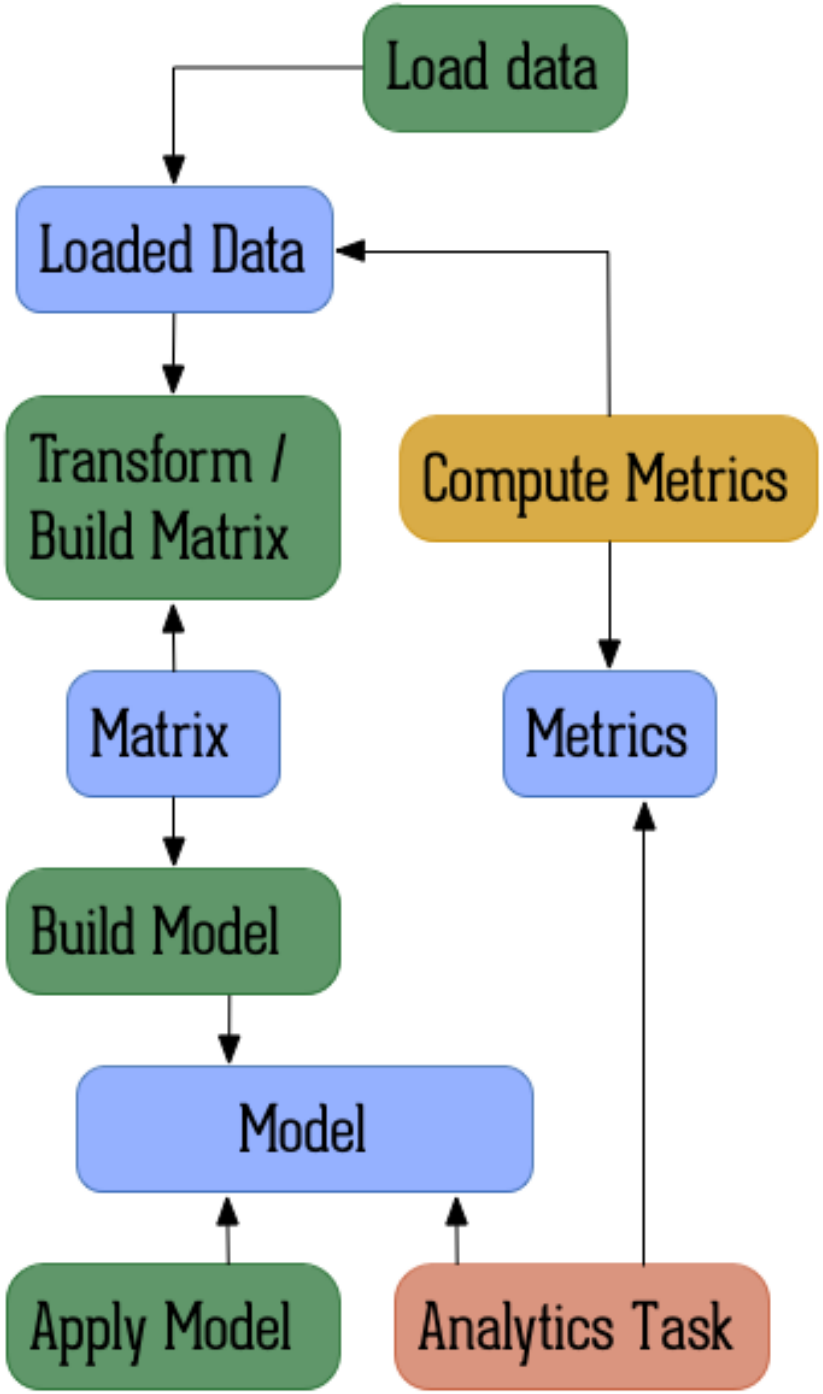
Making it all hum

Challenges for an operational pipeline:

- Combining
- Cleaning / formatting
- Supporting free flow

Reproducibility

Production



An example data pipeline:

- Data
- State
- Operations / Transformation

Averaging a data set

- Python dictionary ~12 million numbers per second
- Python List 110 million numbers per second
- numpy.ndarray 500 million numbers per second

ndarray *or n-dimensional array, provides high-performance c-style arrays uses built-in maths libraries.*

Data Transformations

C Zero Mean
S One SD
T √ log INV

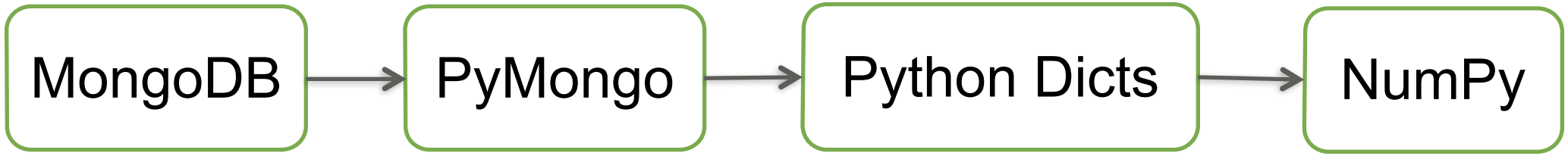
} 1 - Predictors - M {

SS M-Dim Sphere
PCA
PLS

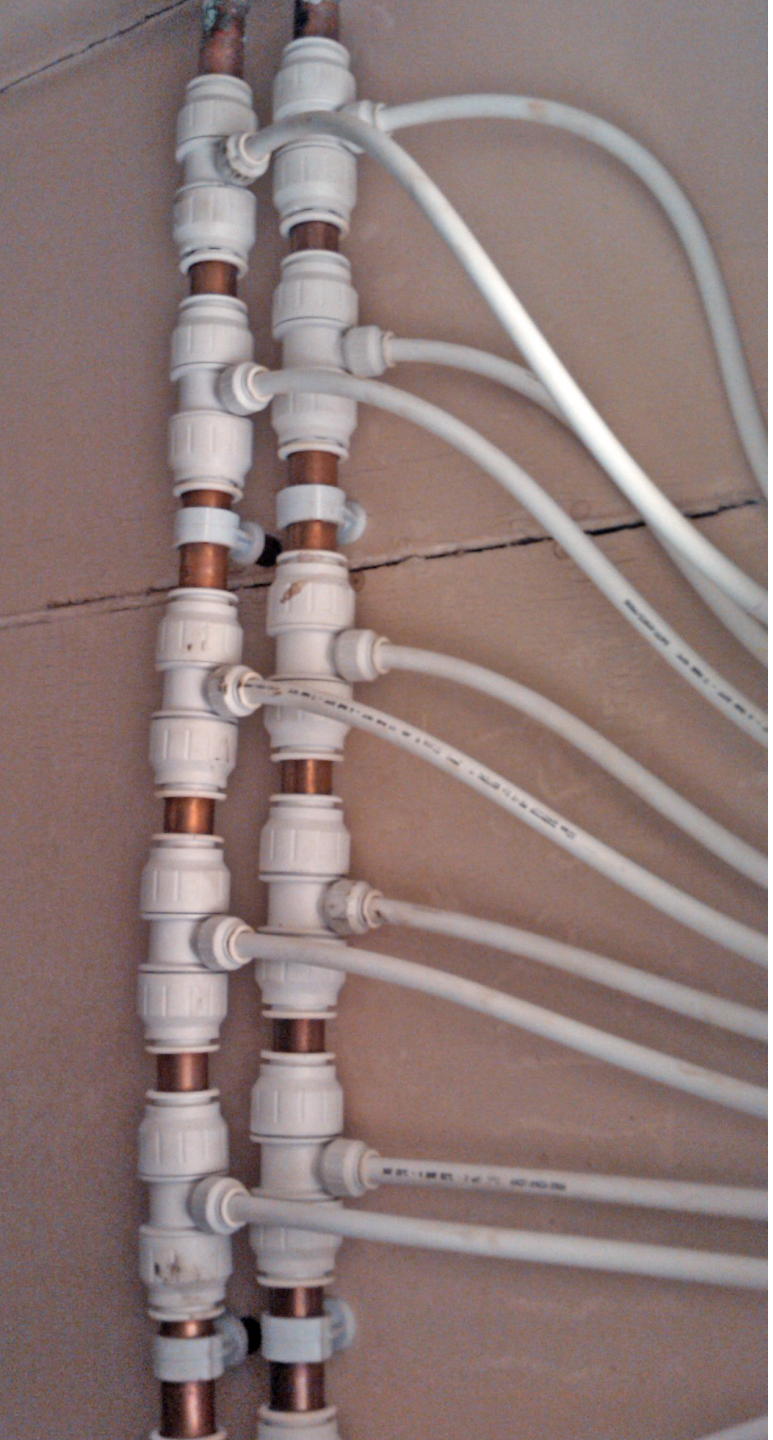
Correlation, Dummy Variables, Filtering

Workflows to / from MongoDB

PyMongo Workflow: ~150,000 documents per second



Monary Workflow: 1,700,000 documents per second



An example of connecting the pipes

- Monary
- MongoDB
- Python
- Airflow

Firstly dive into MongoDB's Aggregation & Monary

Data set and Aggregation

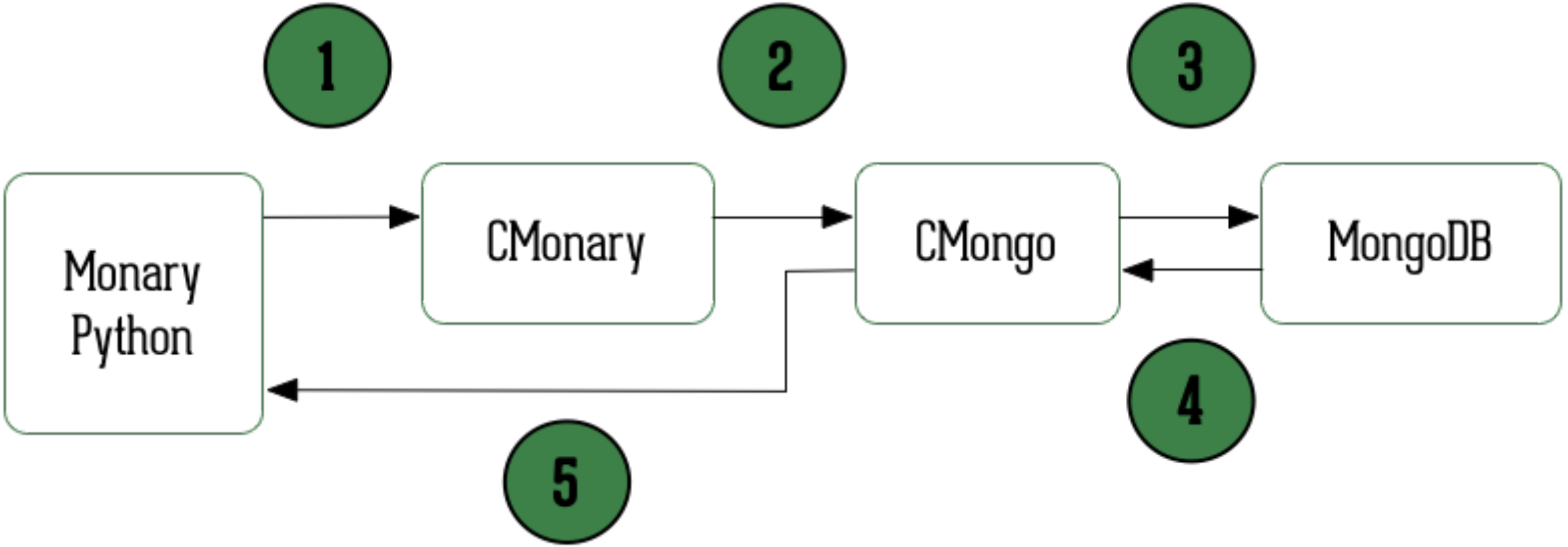
```
zips> db.data.findOne()
{ "_id" : "01001",
   "city" : "AGAWAM",
   "loc" : [
      -72.622739, 42.070206
   ],
   "pop" : 15338,
   "state" : "MA"
}
```

- ID
- City name
- Lat/Long
- Population
- State

```
pipeline = [{"$group" :
{"_id" : "$state",
"totPop" : {"$sum" :
"$pop"}}}]
```

1. Group documents by state
2. Sum the population value for each invidiual city to give a state population total

Monary Query



Monary Query

```
>>> from monary import Monary
>>> m = Monary()
>>> pipeline = [{"$group" : {"_id" :
"$state", "totPop" : {"$sum" : “$pop"}}}]
>>> states, population =
m.aggregate("zips","data", pipeline,
["_id","totpop"], ["string:2", "int64"])
```

Monary Query

```
>>> from monary import Monary
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>>> states, population =
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```

Database

Monary Query

```
>>> from monary import Monary
>>> m = Monary()
>>> pipeline = [{"$group" : {"_id" :
"$state", "totPop" : {"$sum" : “$pop"}}}]
>>> states, population =
m.aggregate("zips","data", pipeline,
["_id","totpop"], ["string:2", "int64"])
```

Field Name

Monary Query

```
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"$state", "totPop" : {"$sum" : “$pop"}}}]
>>> states, population =
m.aggregate("zips","data", pipeline,
["_id","totpop"], ["string:2", "int64"])
```

Return type

Aggregation Result

[u'WA: 4866692', u'HI: 1108229', u'CA: 29754890', u'OR: 2842321', u'NM: 1515069', u'UT: 1722850', u'OK: 3145585', u'LA: 4217595', u'NE: 1578139', u'TX: 16984601', u'MO: 5110648', u'MT: 798948', u'ND: 638272', u'AK: 544698', u'SD: 695397', u'DC: 606900', u'MN: 4372982', u'ID: 1006749', u'KY: 3675484', u'WI: 4891769', u'TN: 4876457', u'AZ: 3665228', u'CO: 3293755', u'KS: 2475285', u'MS: 2573216', u'FL: 12686644', u'IA: 2776420', u'NC: 6628637', u'VA: 6181479', u'IN: 5544136', u'ME: 1226648', u'WV: 1793146', u'MD: 4781379', u'GA: 6478216', u'NH: 1109252', u'NV: 1201833', u'DE: 666168', u'AL: 4040587', u'CT: 3287116', u'SC: 3486703', u'RI: 1003218', u'PA: 11881643', u'VT: 562758', u'MA: 6016425', u'WY: 453528', u'MI: 9295297', u'OH: 10846517', u'AR: 2350725', u'IL: 11427576', u'NJ: 7730188', u'NY: 17990402']

Aggregation Result

```
[u'WA: 4866692', u'HI: 1108229', u'CA: 29754890', u'OR: 2842321', u'NM:
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7730188', u'NY: 17990402']
```
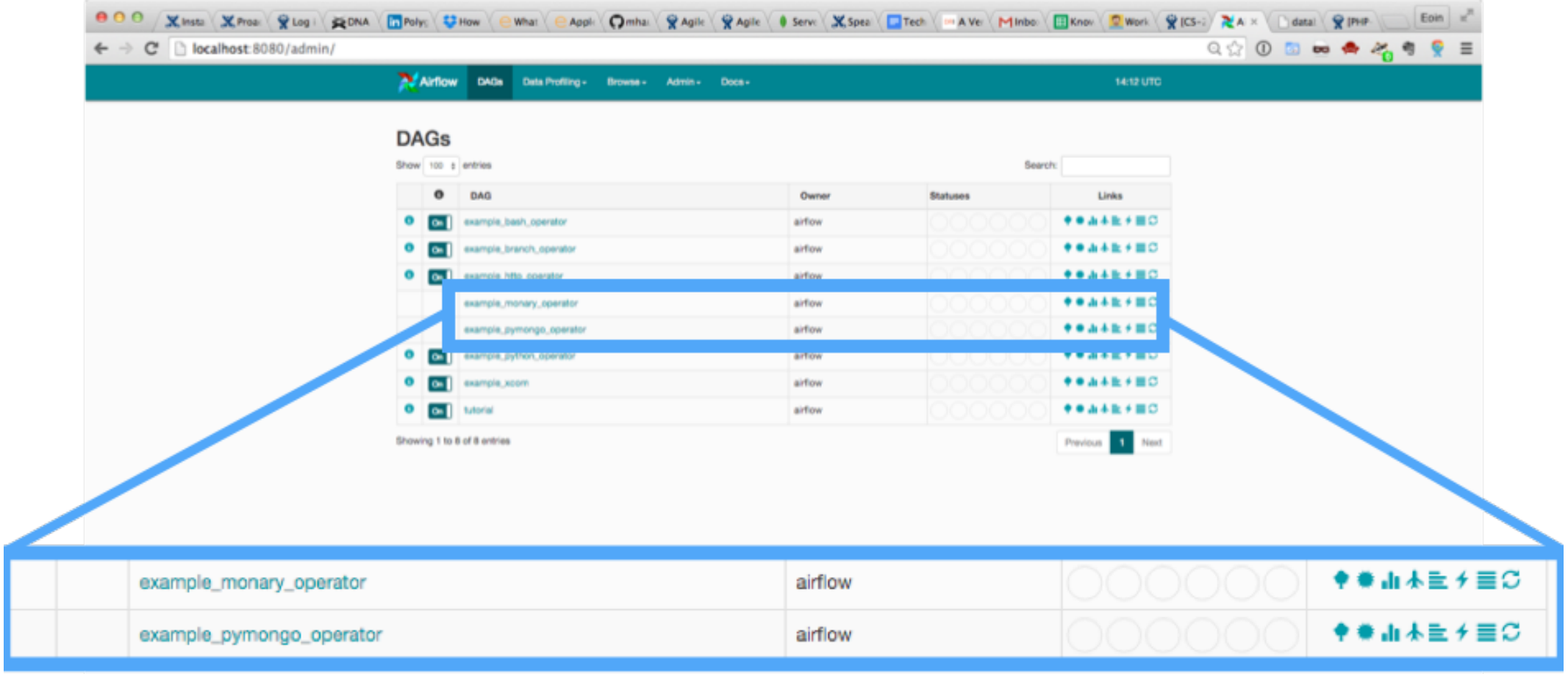


NumPy
Monary
Scikit - learn
mongoDB.
FOR GIANT IDEAS
Python
Cron
Airflow
Luigi
Pandas
Matlibplot
PyTables

Fitting your pipelines together

- Schedule/Repeatable
- Monitoring
- Checkpoints
- Dependencies

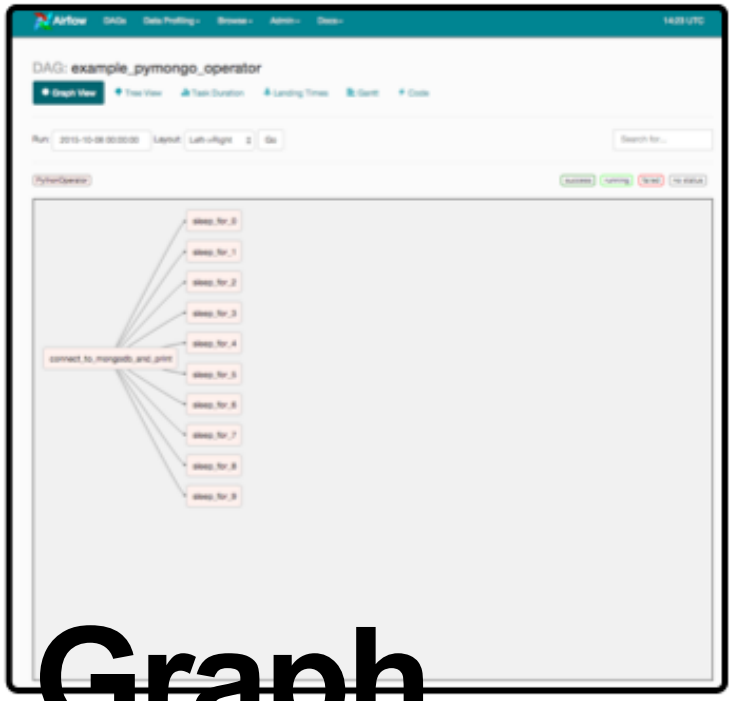
What have these companies done to improve their workflows for data pipelines ?

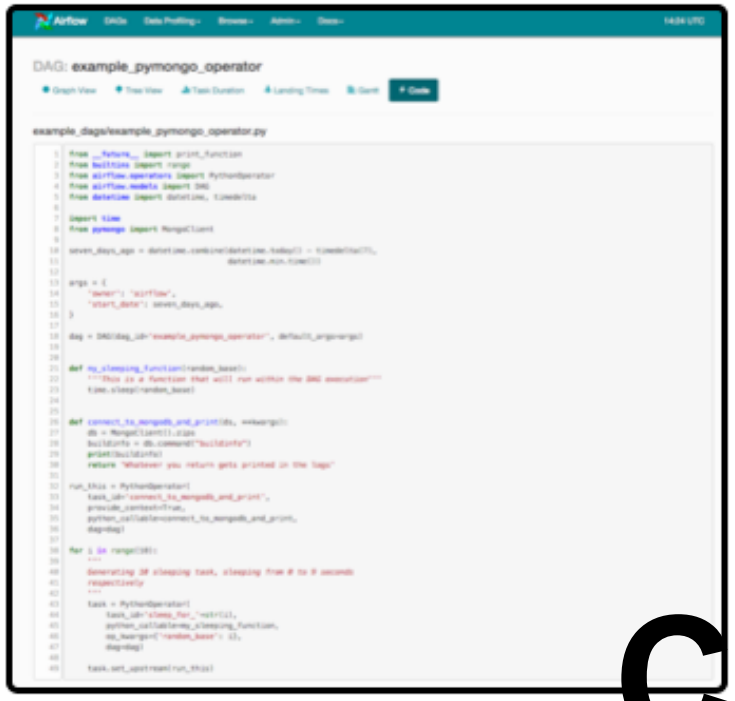


Two Python/MongoDB Examples

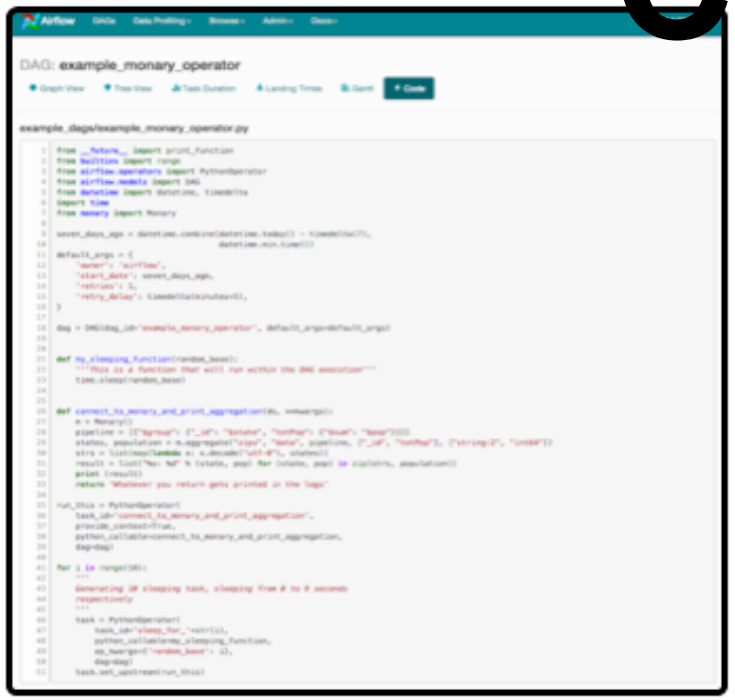
airbnb

Visual


DAG: example_pymongo_operator
connect_to_mongodb_and_print


DAG: example_pymongo_operator
example_dags/example_pymongo_operator.py


DAG: example_monary_operator
connect_to_monary_and_print_aggregation


DAG: example_monary_operator
example_dags/example_monary_operator.py

Code

example_monary_operator.py

```
from __future__ import print_function
from builtins import range
from airflow.operators import PythonOperator
from airflow.models import DAG
from datetime import datetime, timedelta
import time
from monary import Monary

seven_days_ago = datetime.combine(datetime.today() - timedelta(7),
                                  datetime.min.time())
default_args = {
    'owner': 'airflow',
    'start_date': seven_days_ago,
    'retries': 1,
    'retry_delay': timedelta(minutes=5),
}

dag = DAG(dag_id='example_monary_operator', default_args=default_args)

def my_sleeping_function(random_base):
    '''This is a function that will run within the DAG execution'''
    time.sleep(random_base)
```

example_monary_operator.py

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from __future__ import print_function
from builtins import range
from airflow.operators import PythonOperator
from airflow.models import DAG
from datetime import datetime, timedelta
import time
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```

IMPORTS

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SETTINGS

example_monary_operator.py

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DAG & Functions

example_monary_operator.py

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from builtins import range
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from airflow.models import DAG
from datetime import datetime, timedelta
import time
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```

example_monary_operator.py

```
def connect_to_monary_and_print_aggregation(ds, **kwargs):
    m = Monary()
    pipeline = [{"$group": {"_id": "$state", "totPop": {"$sum":
"$pop"}}}]
    states, population = m.aggregate("zips", "data", pipeline, ["_id",
"totPop"], ["string:2", "int64"])
    strs = list(map(lambda x: x.decode("utf-8"), states))
    result = list("%s: %d" % (state, pop) for (state, pop) in
zip(strs, population))
    print (result)
    return 'Whatever you return gets printed in the logs'

run_this = PythonOperator(
    task_id='connect_to_monary_and_print_aggregation',
    provide_context=True,
    python_callable=connect_to_monary_and_print_aggregation,
    dag=dag)
```

example_monary_operator.py

AGGREGATION

```
def connect_to_monary_and_print_aggregation(ds, **kwargs):
    m = Monary()
    pipeline = [{"$group": {"_id": "$state", "totPop": {"$sum":
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```

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DAG SETUP

```
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example_monary_operator.py

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    python_callable=connect_to_monary_and_print_aggregation,
    dag=dag)
```

example_monary_operator.py

```
for i in range(10):
    '''
    Generating 10 sleeping tasks, sleeping from 0 to 9
seconds
    respectively
    '''
    task = PythonOperator(
        task_id='sleep_for_'+str(i),
        python_callable=my_sleeping_function,
        op_kwargs={'random_base': i},
        dag=dag)
    task.set_upstream(run_this)
```

example_monary_operator.py

LOOP

```
for i in range(10):
    '''
    Generating 10 sleeping tasks, sleeping from 0 to 9
seconds
    respectively
    '''
    task = PythonOperator(
        task_id='sleep_for_'+str(i),
        python_callable=my_sleeping_function,
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    task.set_upstream(run_this)
```

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```

DAG SETUP

example_monary_operator.py

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        python_callable=my_sleeping_function,
        op_kwargs={'random_base': i},
        dag=dag)
    task.set_upstream(run_this)
```

example_monary_operator.py

```
$ airflow backfill example_monary_operator -s 2015-01-01 -e 2015-01-02
2015-10-08 15:08:09,532 INFO - Filling up the DagBag from /Users/braz/airflow/dags
2015-10-08 15:08:09,532 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_bash_operator.py
2015-10-08 15:08:09,533 INFO - Loaded DAG <DAG: example_bash_operator>
2015-10-08 15:08:09,533 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_branch_operator.py
2015-10-08 15:08:09,534 INFO - Loaded DAG <DAG: example_branch_operator>
2015-10-08 15:08:09,534 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_http_operator.py
2015-10-08 15:08:09,535 INFO - Loaded DAG <DAG: example_http_operator>
2015-10-08 15:08:09,535 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_monary_operator.py
2015-10-08 15:08:09,719 INFO - Loaded DAG <DAG: example_monary_operator>
2015-10-08 15:08:09,719 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_pymongo_operator.py
2015-10-08 15:08:09,738 INFO - Loaded DAG <DAG: example_pymongo_operator>
2015-10-08 15:08:09,738 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_python_operator.py
2015-10-08 15:08:09,739 INFO - Loaded DAG <DAG: example_python_operator>
2015-10-08 15:08:09,739 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/example_xcom.py
2015-10-08 15:08:09,739 INFO - Loaded DAG <DAG: example_xcom>
2015-10-08 15:08:09,739 INFO - Importing /usr/local/lib/python2.7/site-packages/airflow/example_dags/tutorial.py
2015-10-08 15:08:09,740 INFO - Loaded DAG <DAG: tutorial>
2015-10-08 15:08:09,819 INFO - Adding to queue: airflow run example_monary_operator connect_to_monary_and_print_aggregation 2015-01-02T00:00:00 --local -sd DAGS_FOLDER/example_dags/
example_monary_operator.py -s 2015-01-01T00:00:00
2015-10-08 15:08:09,865 INFO - Adding to queue: airflow run example_monary_operator connect_to_monary_and_print_aggregation 2015-01-01T00:00:00 --local -sd DAGS_FOLDER/example_dags/
example_monary_operator.py -s 2015-01-01T00:00:00
2015-10-08 15:08:14,765 INFO - [backfill progress] waiting: 22 | succeeded: 0 | kicked_off: 2 | failed: 0 | skipped: 0
2015-10-08 15:08:19,765 INFO - commandairflow run example_monary_operator connect_to_monary_and_print_aggregation 2015-01-02T00:00:00 --local -sd DAGS_FOLDER/example_dags/
example_monary_operator.py -s 2015-01-01T00:00:00
Logging into: /Users/braz/airflow/logs/example_monary_operator/connect_to_monary_and_print_aggregation/2015-01-02T00:00:00
[u'WA: 4866692', u'HI: 1108229', u'CA: 29754890', u'OR: 3243234', u'NM: 1515069', u'UT: 1722850', u'OK: 3145585', u'LA: 4217595', u'NE: 1578130', u'TX: 16984601', u'MO: 5110648', u'MT: 798548', u'ND: 638272',
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```
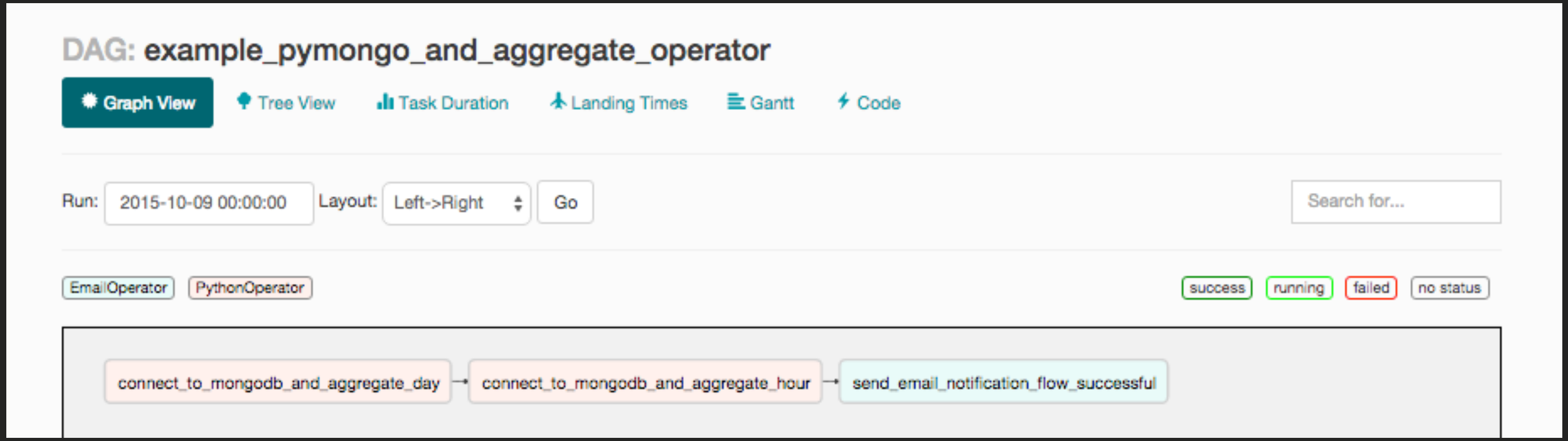

Building your pipeline




```
 pipeline = [{"$project":{'page': '$PAGE', 'time': { 'y':
{'$year':'$DATE'} , 'm':{'$month':'$DATE'}, 'day':
{'$dayOfMonth':'$DATE'}}}}, {'$group':{'_id':
{'p':'$page','y':'$time.y','m':'$time.m','d':'$time.day'}, 'daily':
{'$sum':1}}},{'$out': tmp_created_collection_per_day_name}]
```

Building your pipeline

```
mongoexport -d test -c page_per_day_hits_tmp --type=csv -
f=_id,daily -o page_per_day_hits_tmp.csv

_id.d,_id.m,_id.y,_id.p,daily
3,2,2014,cart.do,115
4,2,2014,cart.do,681
5,2,2014,cart.do,638
6,2,2014,cart.do,610
....
3,2,2014,cart/error.do,2
4,2,2014,cart/error.do,14
5,2,2014,cart/error.do,23
```

Building your pipeline

CONVERSION

```
mongoexport -d test -c page_per_day_hits_tmp --type=csv -
f=_id,daily -o page_per_day_hits_tmp.csv
```

```
_id.d,_id.m,_id.y,_id.p,daily
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```

Building your pipeline

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CSV FILE CONTENTS

Building your pipeline

```
mongoexport -d test -c page_per_day_hits_tmp --type=csv -
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3,2,2014,cart.do,115
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6,2,2014,cart.do,610
....
3,2,2014,cart/error.do,2
4,2,2014,cart/error.do,14
5,2,2014,cart/error.do,23
```
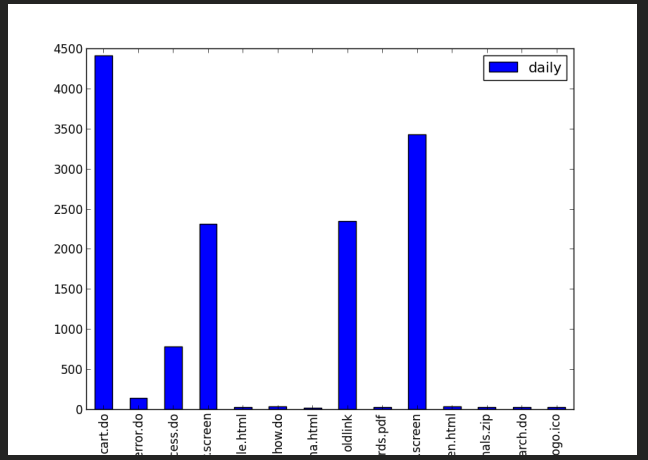

Visualising the results

```
In [1]: import pandas as pd
In [2]: import numpy as np
In [3]: import matplotlib.pyplot as plt
In [4]: df1 = pd.read_csv('page_per_day_hits_tmp.csv', names=['day', 'month',
'year', 'page', 'daily'], header=0)
Out[4]:
     day  month  year                page  daily
0      3      2  2014           cart.do    115
1      4      2  2014           cart.do    681
..   ...    ...   ...               ...    ...
103   10      2  2014  stuff/logo.ico        3
[104 rows x 5 columns]

In [5]: grouped = df1.groupby(['page'])
Out[5]: <pandas.core.groupby.DataFrameGroupBy object at 0x10f6b0dd0>

In [6]: grouped.agg({'daily':'sum'}).plot(kind='bar')
Out[6]: <matplotlib.axes.AxesSubplot at 0x10f8f4d10>
```



Scikit-learn churn data

```
['State', 'Account Length', 'Area Code', 'Phone', "Int'l Plan", 'VMail Plan',
'VMail Message', 'Day Mins', 'Day Calls', 'Day Charge', 'Eve Mins', 'Eve
Calls', 'Eve Charge', 'Night Mins', 'Night Calls', 'Night Charge', 'Intl Mins',
'Intl Calls', 'Intl Charge', 'CustServ Calls', 'Churn?']
```

	State	Account Length	Area Code	Phone	Intl Plan	VMail Plan	\
0	KS	128	415	382-4657	no	yes	
1	OH	107	415	371-7191	no	yes	
2	NJ	137	415	358-1921	no	no	
3	OH	84	408	375-9999	yes	no	

	Night Charge	Intl Mins	Intl Calls	Intl Charge	CustServ Calls	Churn?
0	11.01	10.0	3	2.70	1	False.
1	11.45	13.7	3	3.70	1	False.
2	7.32	12.2	5	3.29	0	False.
3	8.86	6.6	7	1.78	2	False.

Scikit-learn churn example

```
from __future__ import division
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import json

from sklearn.cross_validation import KFold
from sklearn.preprocessing import StandardScaler
from sklearn.cross_validation import train_test_split
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier as RF
%matplotlib inline
churn_df = pd.read_csv('churn.csv')
col_names = churn_df.columns.tolist()

print "Column names:"
print col_names

to_show = col_names[:6] + col_names[-6:]
```

Scikit-learn churn example

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from __future__ import division
import pandas as pd
import numpy as np
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IMPORTS

Scikit-learn churn example

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LOAD FILE / EXPLORE DATA

Scikit-learn churn example

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```

Scikit-learn churn example

```
print "\nSample data:"
churn_df[to_show].head(2)
# Isolate target data
churn_result = churn_df['Churn?']
y = np.where(churn_result == 'True.',1,0)
to_drop = ['State','Area Code','Phone','Churn?']
churn_feat_space = churn_df.drop(to_drop,axis=1)
# 'yes'/'no' has to be converted to boolean values
# NumPy converts these from boolean to 1. and 0. later
yes_no_cols = ["Int'l Plan","VMail Plan"]
churn_feat_space[yes_no_cols] = churn_feat_space[yes_no_cols] == 'yes'

# Pull out features for future use
features = churn_feat_space.columns
X = churn_feat_space.as_matrix().astype(np.float)
scaler = StandardScaler()
X = scaler.fit_transform(X)
print "Feature space holds %d observations and %d features" % X.shape
print "Unique target labels:", np.unique(y)
```

Scikit-learn churn example

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FORMAT DATA FOR USAGE

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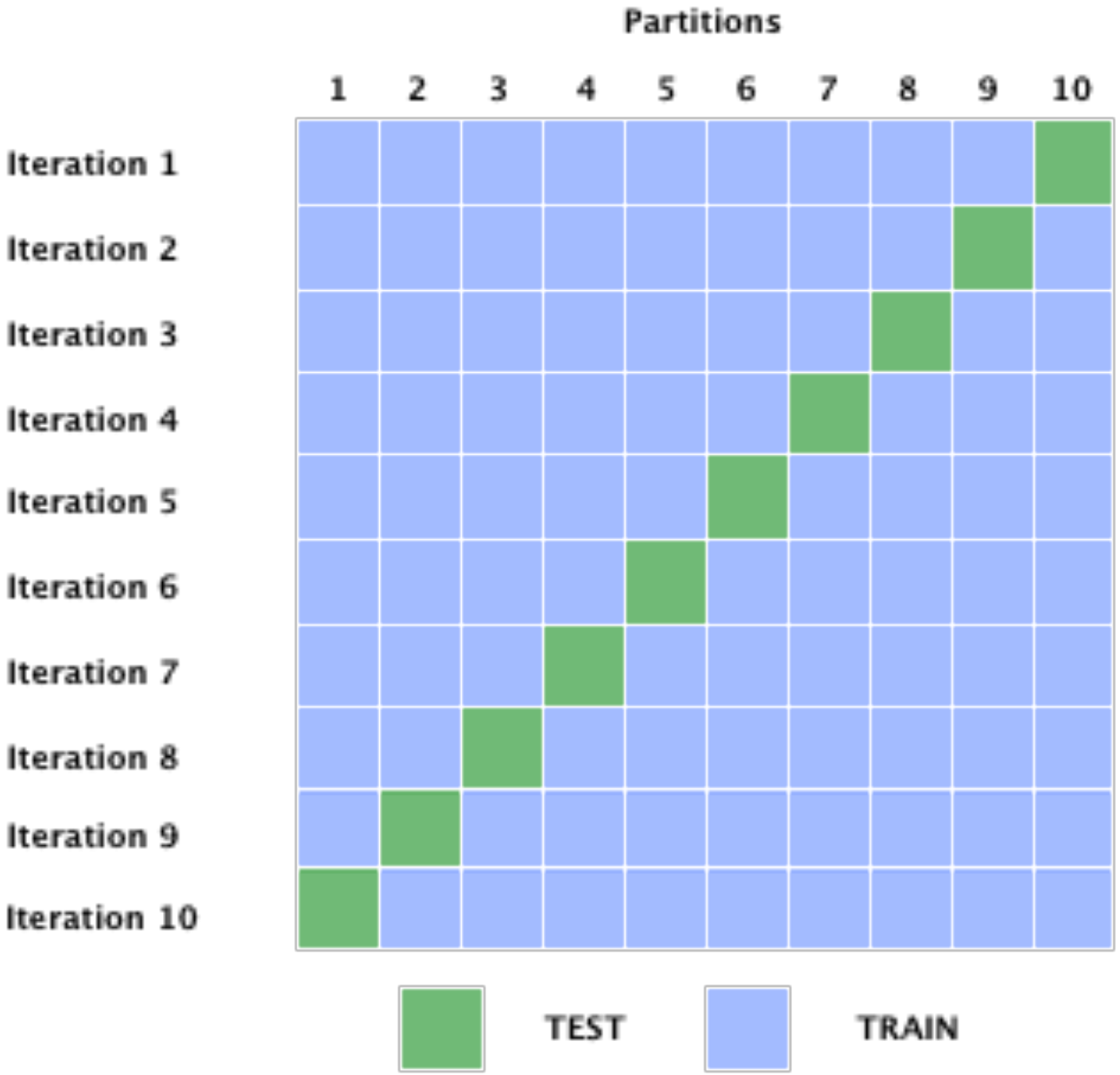
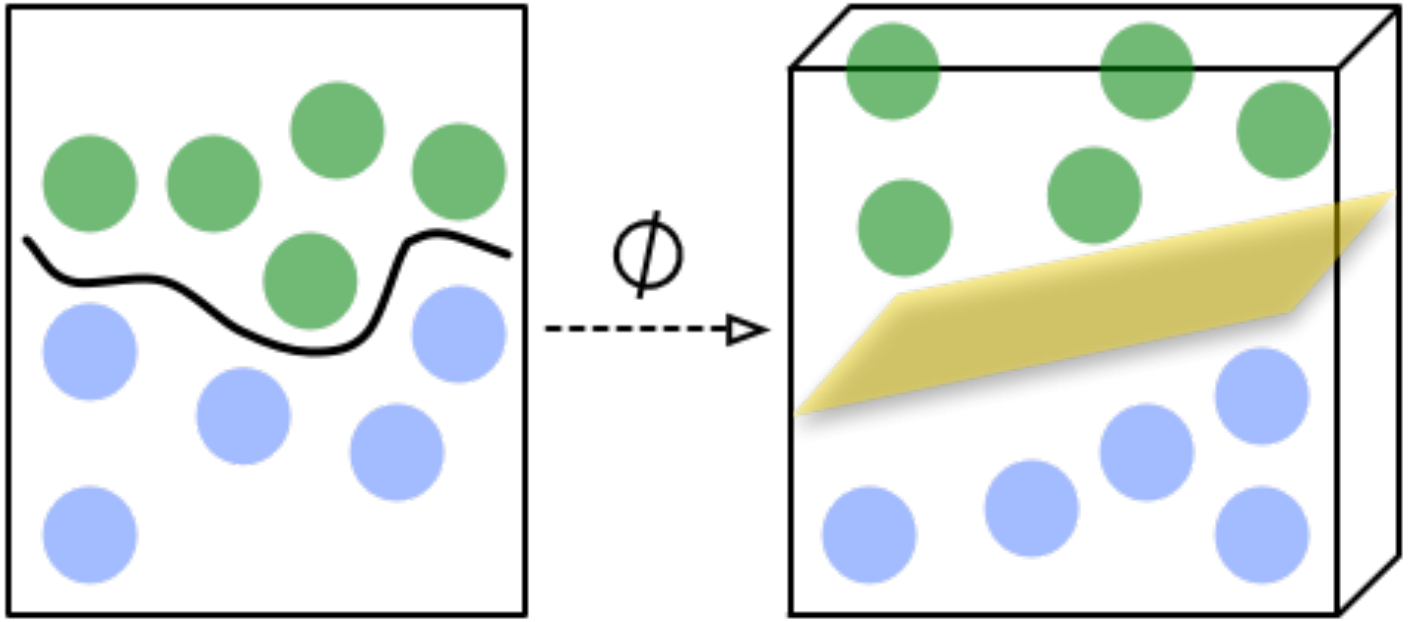


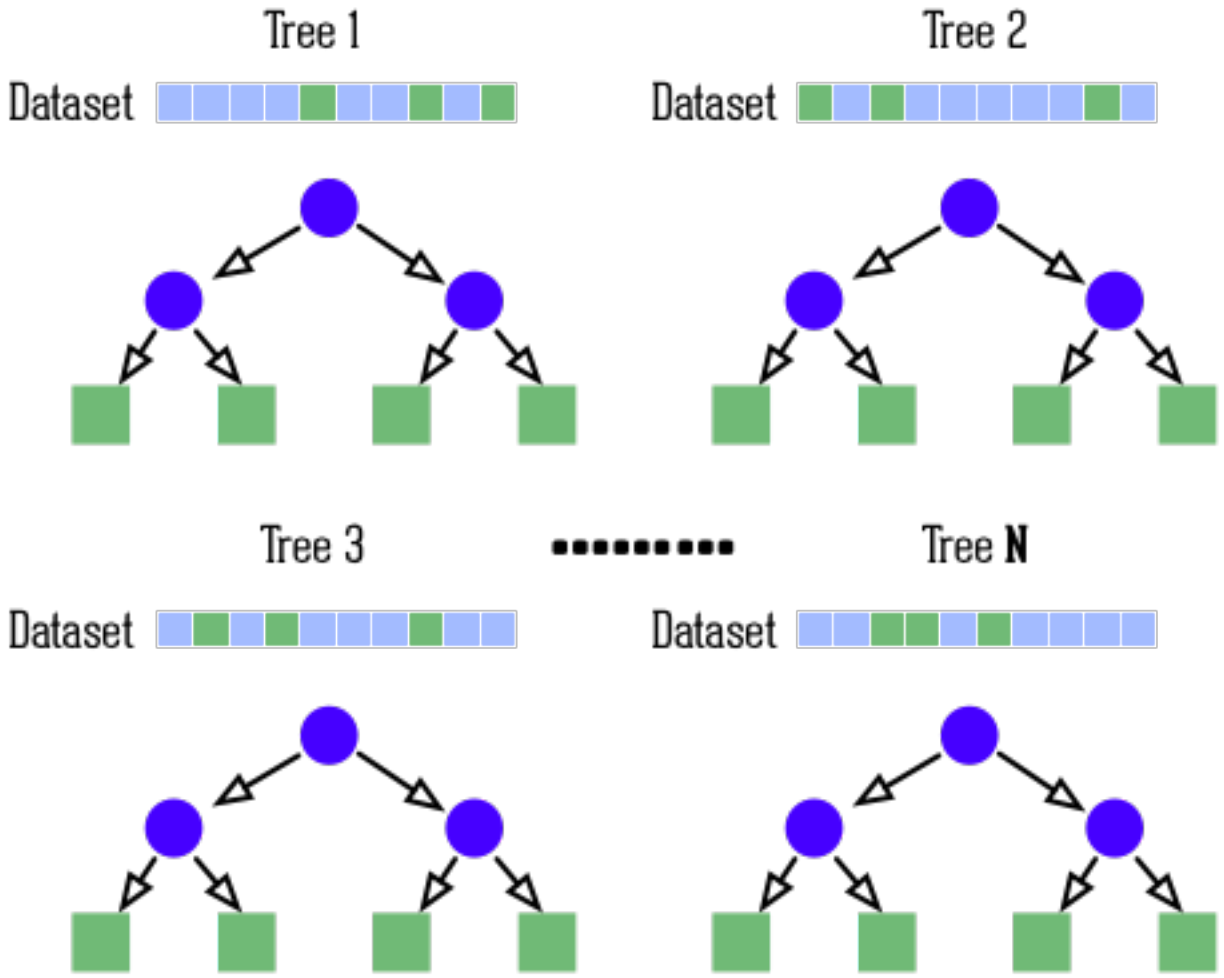
10 Cross Fold

Support Vector Machine



A list of number [a n-dimensional vector] and transform the points into higher dimensions so it is easier to separate them using a [n-1] dimensional hyperplane.

Random Forest



Traverse each tree and at each node in a tree:

i. Select **m** random predictor variables from available set
ii. Use the variable with best split [use objective function]
iii. Move to next node in tree

Scikit-learn churn example

```
from sklearn.svm import SVC
from sklearn.ensemble import
RandomForestClassifier as RF
from sklearn.metrics import
average_precision_score
from sklearn.cross_validation import
KFold

def accuracy(y_true,y_pred):
    # NumPy interpretes True and
False as 1. and 0.
    return np.mean(y_true == y_pred)

def run_cv(X,y,clf_class,**kwargs):
    # Construct a kfolds object
    kf =
KFold(len(y),n_folds=3,shuffle=True)
    y_pred = y.copy()

    # Iterate through folds
    for train_index, test_index in
kf:
        X_train, X_test =
X[train_index], X[test_index]
        y_train = y[train_index]
        clf = clf_class(**kwargs)
        clf.fit(X_train,y_train)
        y_pred[test_index] =
clf.predict(X_test)
    return y_pred

print "Support vector machines:"
print "%.3f" % accuracy(y,
run_cv(X,y,SVC))
print "Random forest:"
print "%.3f" % accuracy(y,
run_cv(X,y,RF))
```

Scikit-learn churn example

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from sklearn.svm import SVC
from sklearn.ensemble import
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```
print "Support vector machines:"
print "%.3f" % accuracy(y,
run_cv(X,y,SVC))
print "Random forest:"
print "%.3f" % accuracy(y,
run_cv(X,y,RF))
```

Cross Fold
K=3

Scikit-learn churn example

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print "%.3f" % accuracy(y,
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```

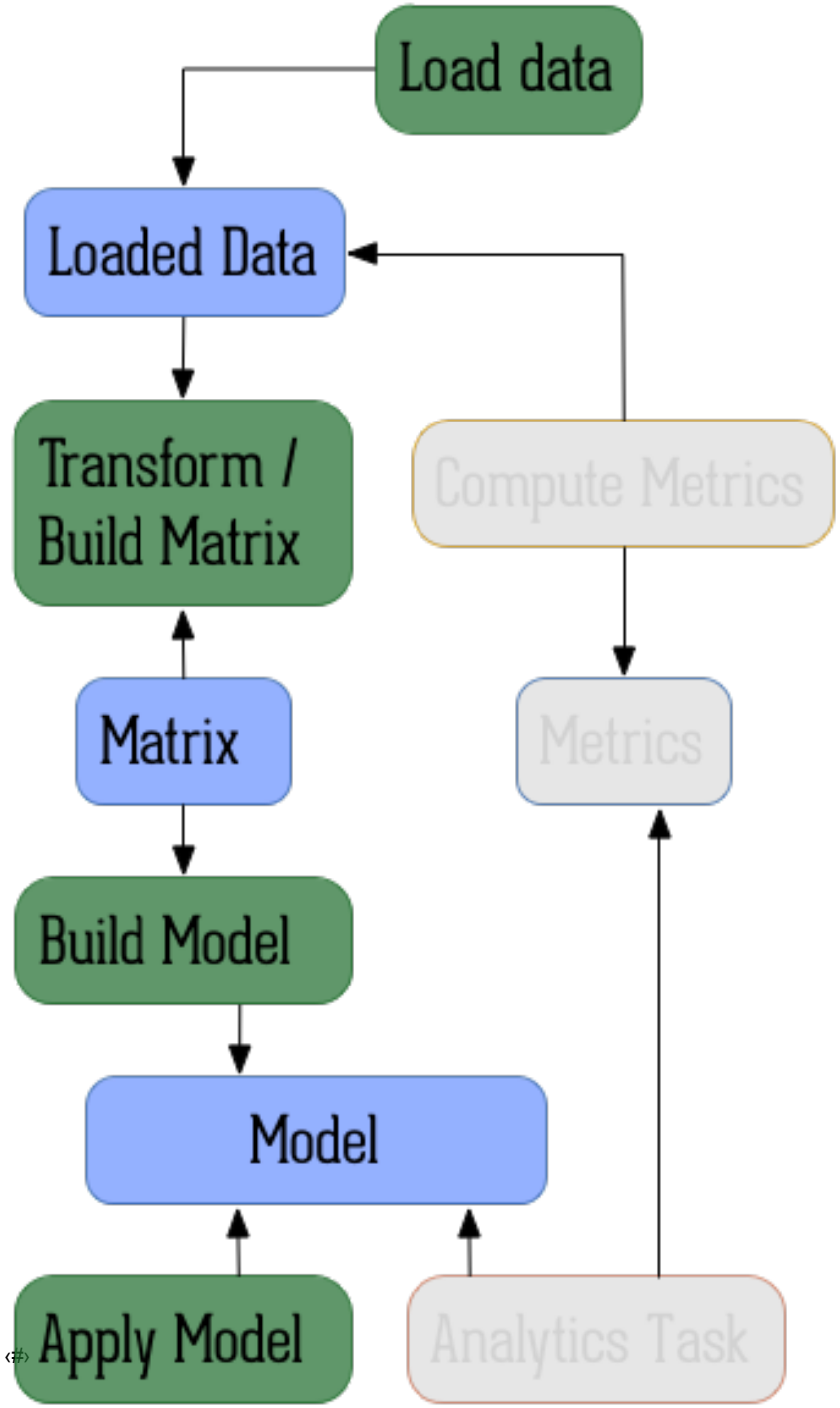

An example data pipeline:

- Data
- State
- Operations / Transformation

Bringing it all together

Systems

Speed

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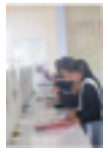

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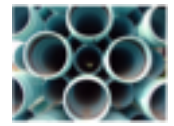

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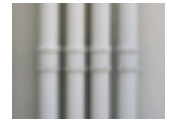

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Thanks!

Questions?

Eoin Brazil
eoin.brazil@mongodb.com