Module 7
PySpark + ELK + Kafka
Distributed Computing and Streaming Analytics

Conceptual slides inspired by Sebastian Thrun's https://www.udacity.com/learn/machinelearning

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Data

Data


I LOVE IT WHEN
YOU CALL ME BIG
DATA

What is big data?

Big data generally refers to data sets which are too large to process using conventional applications.

Volume: The actual amount of data

Volume: The actual amount of data

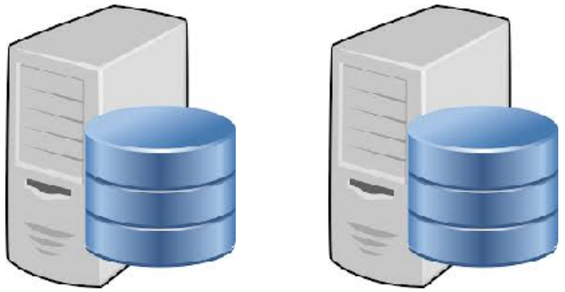
Velocity: The speed at which the data is generated

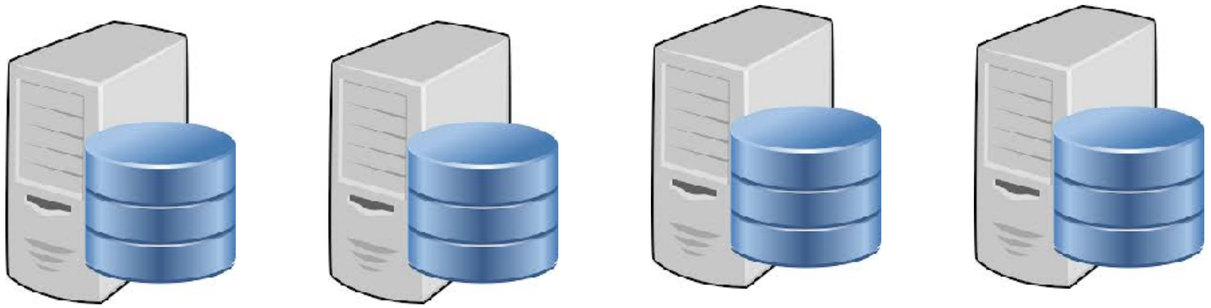
Volume: The actual amount of data

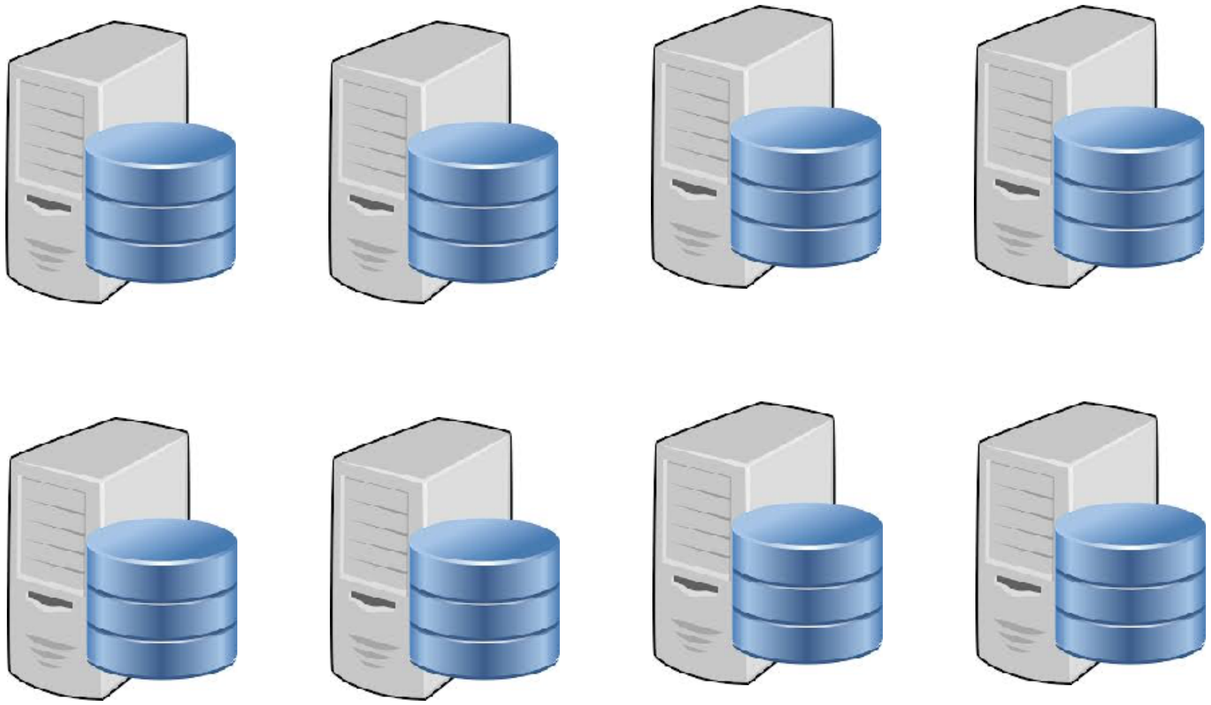
Velocity: The speed at which the data is generated

Variety: Data arrives in many different forms

http://internetlivestats.com/one-second/








Cloud Computing

MapReduce

http://research.google.com/archive/mapreduce.html

MapReduce in Python

```
import sys

for line in sys.stdin:
    line = line.strip()
    keys = line.split()
    for key in keys:
        value = 1
        print( "%s\t%d" % (key, value) )
```

MapReduce in Python

```
away--you  1
may  1
do1
practically  1
ANYTHING 1
with 1
public 1
domain 1
eBooks.  1
Redistribution 1
is1
subject  1
```

MapReduce in Python

```
import sys

last_key = None
running_total = 0

for input_line in sys.stdin:
   input_line = input_line.strip()
   this_key, value = input_line.split("\t", 1)
   value = int(value)

   if last_key == this_key:
       running_total += value
   else:
       if last_key:
           print( "%s\t%d" % (last_key, running_total) )
       running_total = value
       last_key = this_key

if last_key == this_key:
   print( "%s\t%d" % (last_key, running_total) )
```

MapReduce in Python

```
cat sherlock.txt | ./map.py | sort | ./reduce.py
```

```
available  1
avenue 1
avenue.  1
average  3
averse 5
aversion 2
avert  3
averted  1
avoid  3
avoided  2
…
```

Map Reduce is Hard...Really Hard

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YAHOO!


```
input_lines = LOAD '/tmp/my-copy-of-all-pages-on-internet' AS
(line:chararray);

-- Extract words from each line and put them into a pig bag
-- datatype, then flatten the bag to get one word on each row
words = FOREACH input_lines GENERATE FLATTEN(TOKENIZE(line))
AS word;

 -- filter out any words that are just white spaces
 filtered_words = FILTER words BY word MATCHES '\\w+';

 -- create a group for each word
 word_groups = GROUP filtered_words BY word;

 -- count the entries in each group
 word_count = FOREACH word_groups GENERATE
COUNT(filtered_words) AS count, group AS word;

 -- order the records by count
 ordered_word_count = ORDER word_count BY count DESC;
 STORE ordered_word_count INTO '/tmp/number-of-words-on-
internet';
```

https://en.wikipedia.org/wiki/Pig_(programming_tool)


HIVE


```
SELECT word, count(1) as count
FROM
(
 SELECT explode(split(sentence, ' ‘)) AS word
 FROM texttable
)tempTable
GROUP BY word
```

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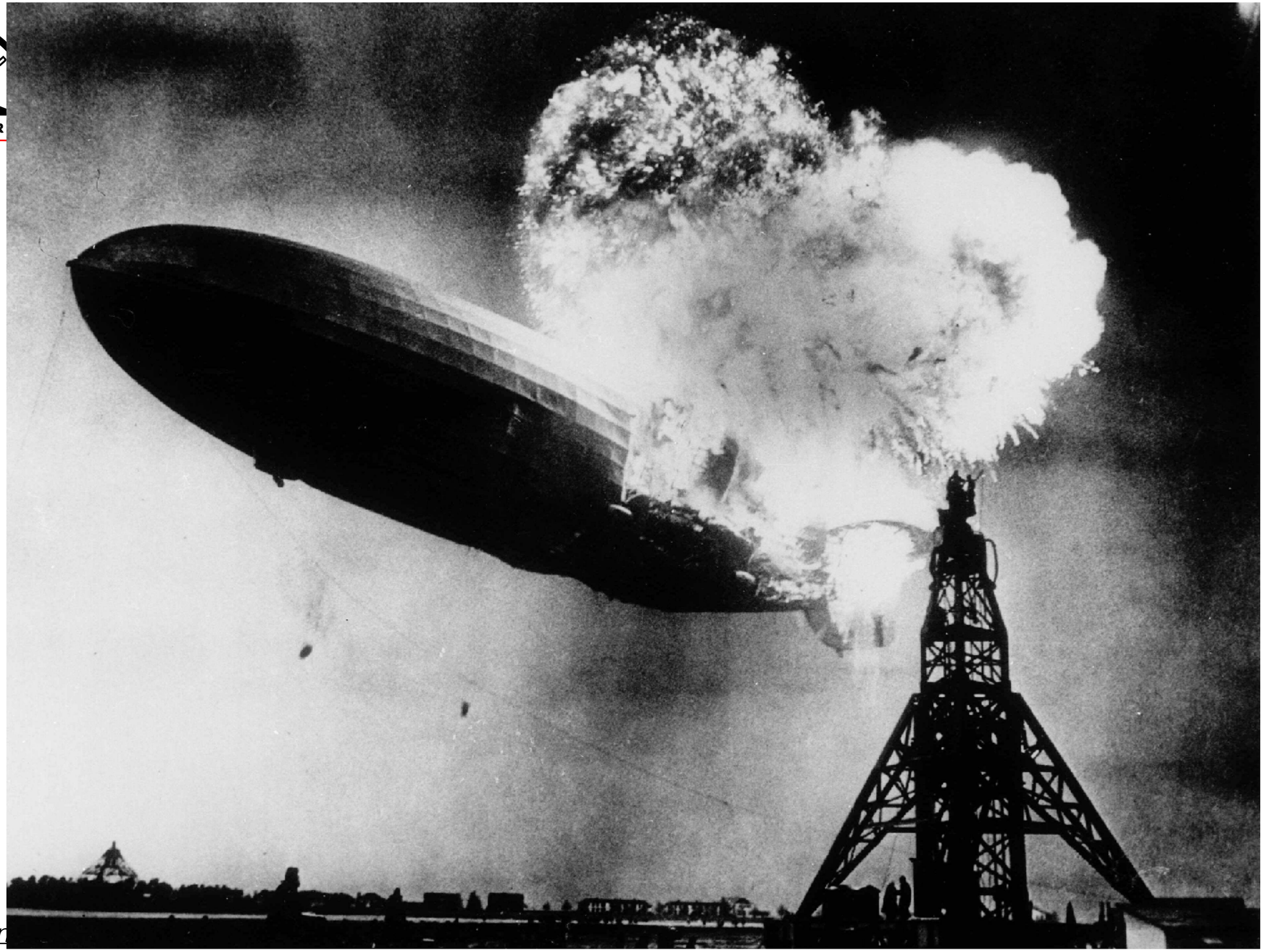
Apache Zeppelin

What is it?



A web based notebook that enables interactive data analytics

Built in integration with

GEODE

PostgreSQL

cassandra

Zeppelin makes exploring data easy

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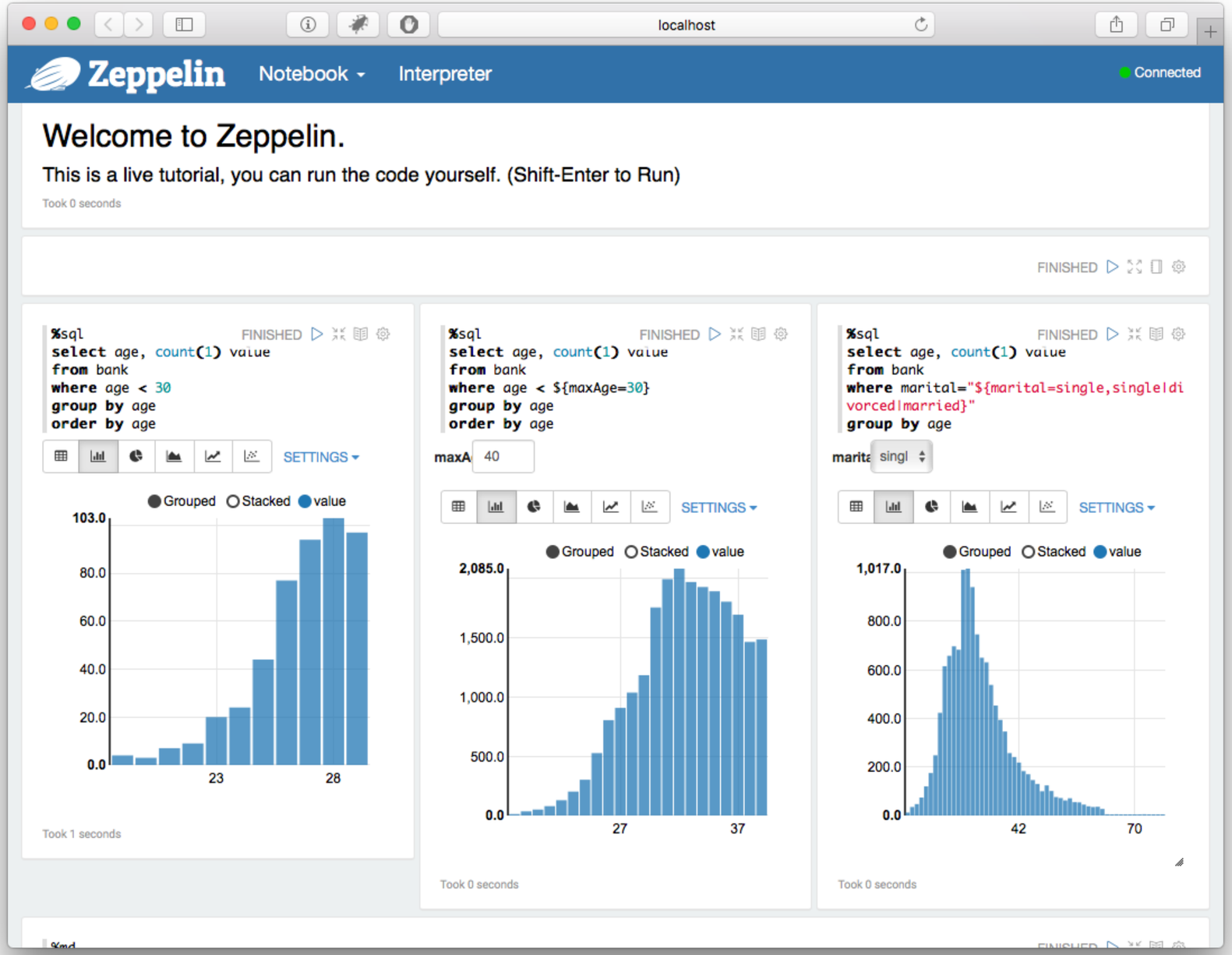
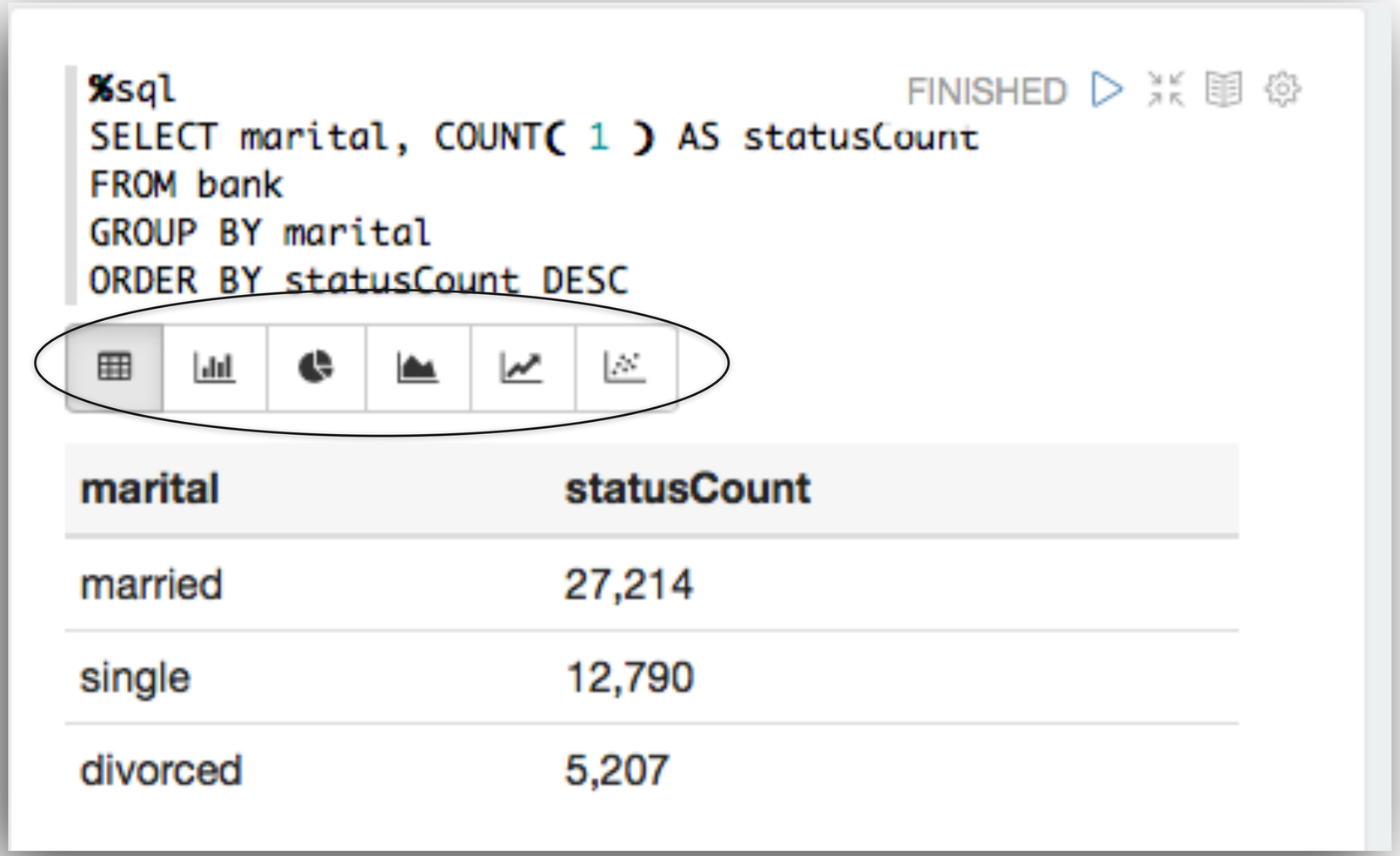
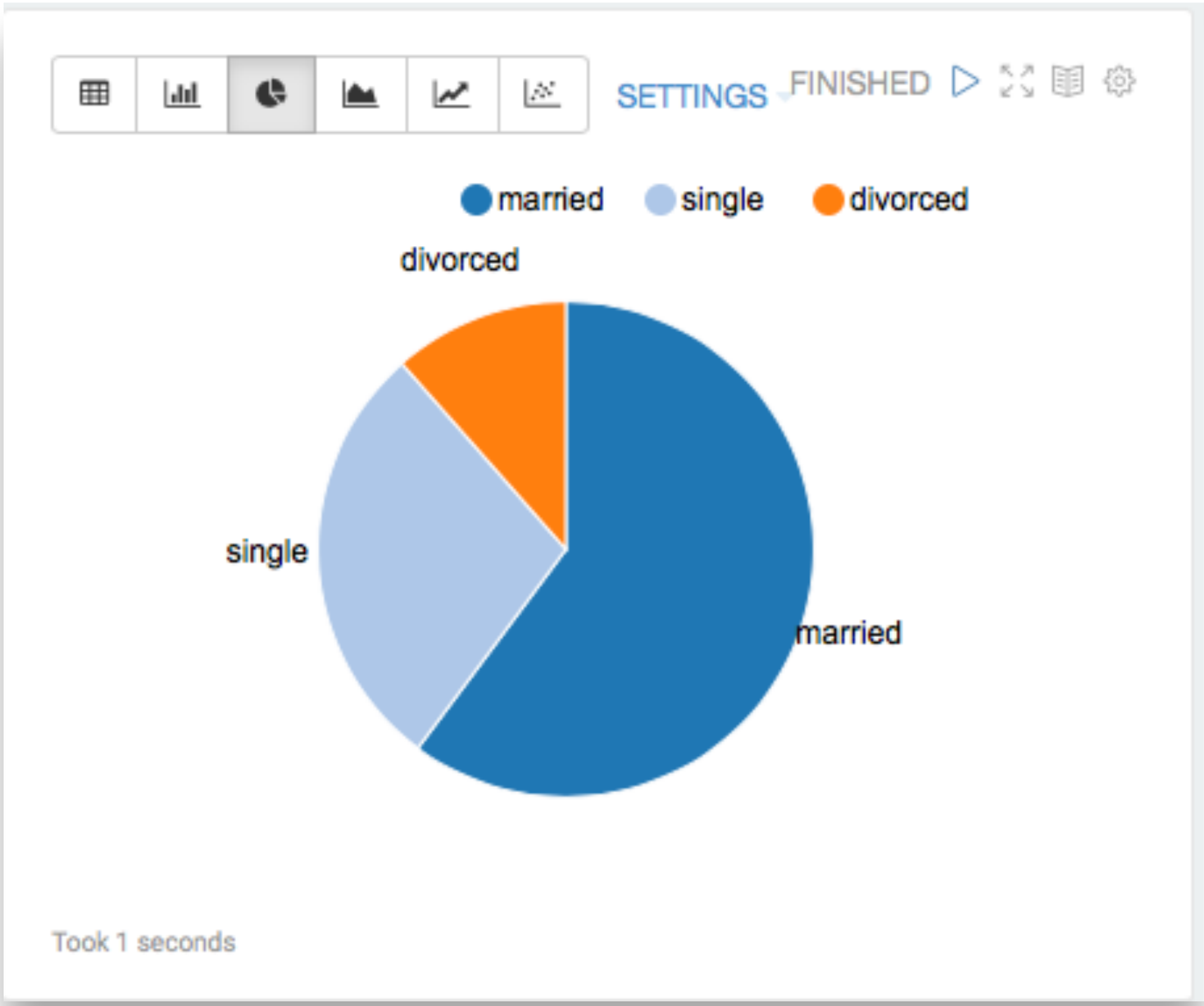


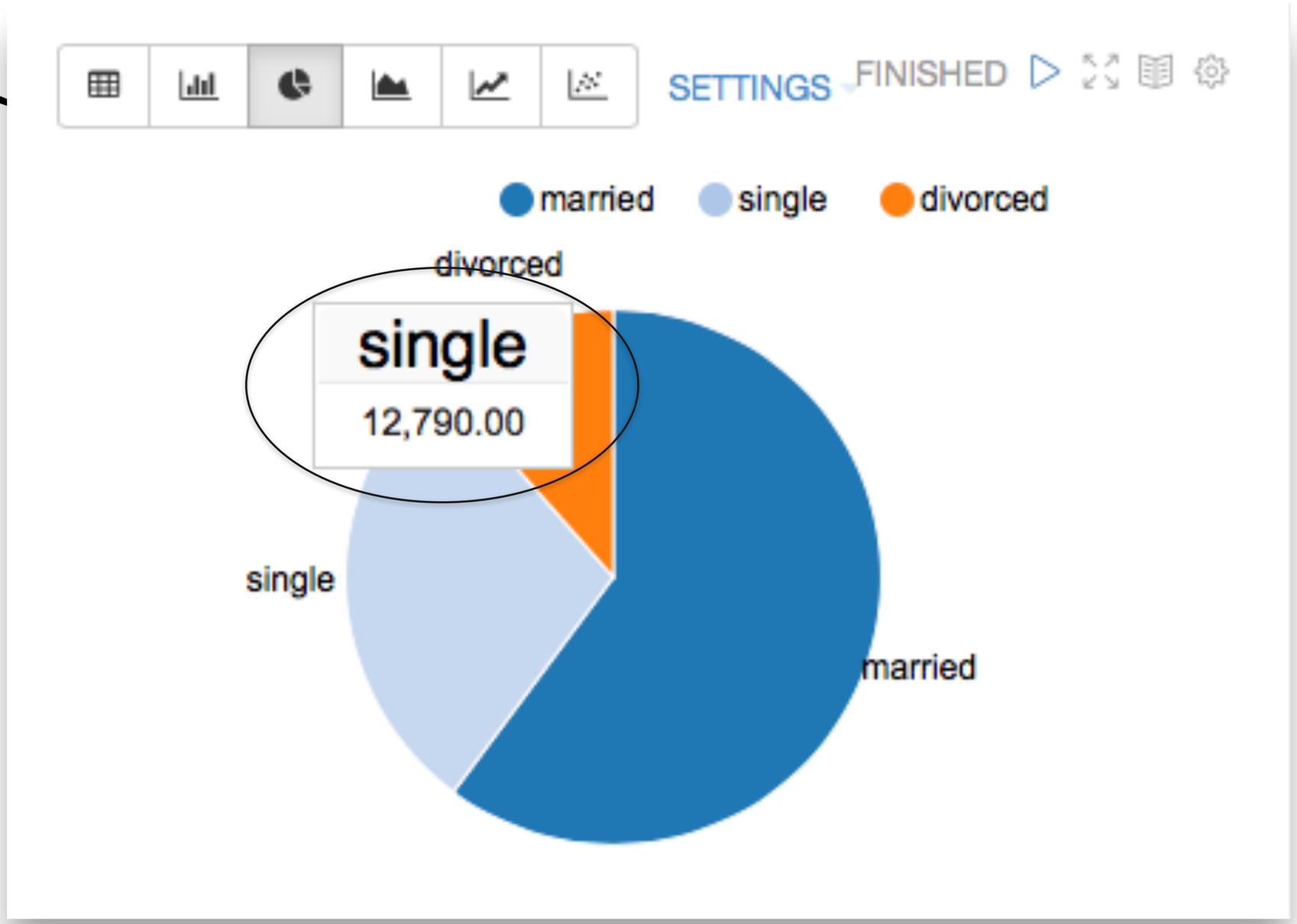
gtkcyber.com

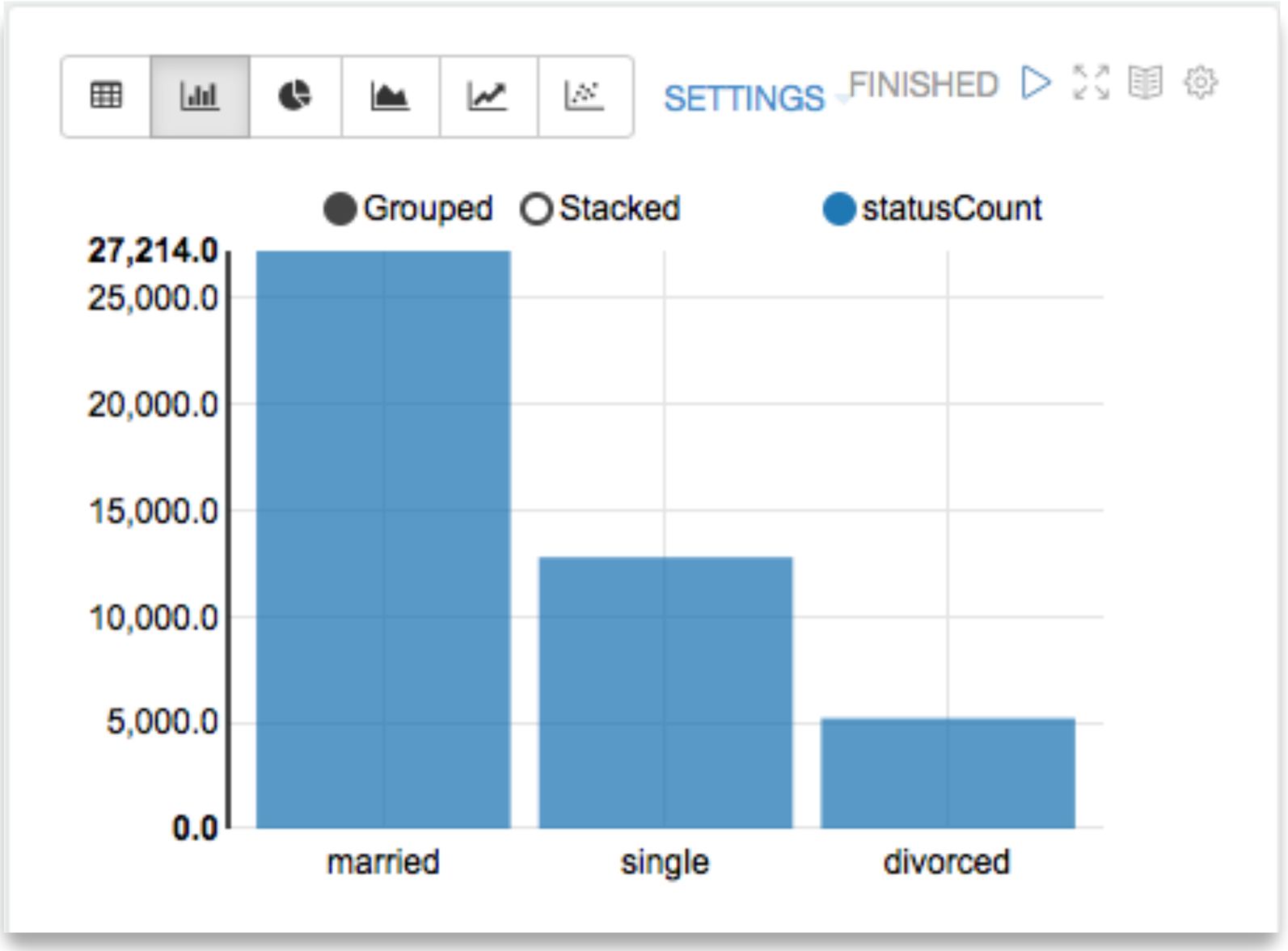

```
val bankText = sc.textFile("/Users/cgivre/Downloads/bank/bank-full.csv")

case class Bank(age:Integer, job:String, marital : String, education : String, ba
Integer)

val bank = bankText.map(s=>s.split(";")).filter(s=>s(0)!="\"age\"").map(
    s=>Bank(s(0).toInt,
            s(1).replaceAll("\"", ""),
            s(2).replaceAll("\"", ""),
            s(3).replaceAll("\"", ""),
            s(5).replaceAll("\"", "").toInt
        )
)

bank.toDF().registerTempTable("bank")
```


```
%sql
SELECT marital, COUNT( 1 ) AS statusCount
FROM bank
GROUP BY marital
ORDER BY statusCount DESC
```

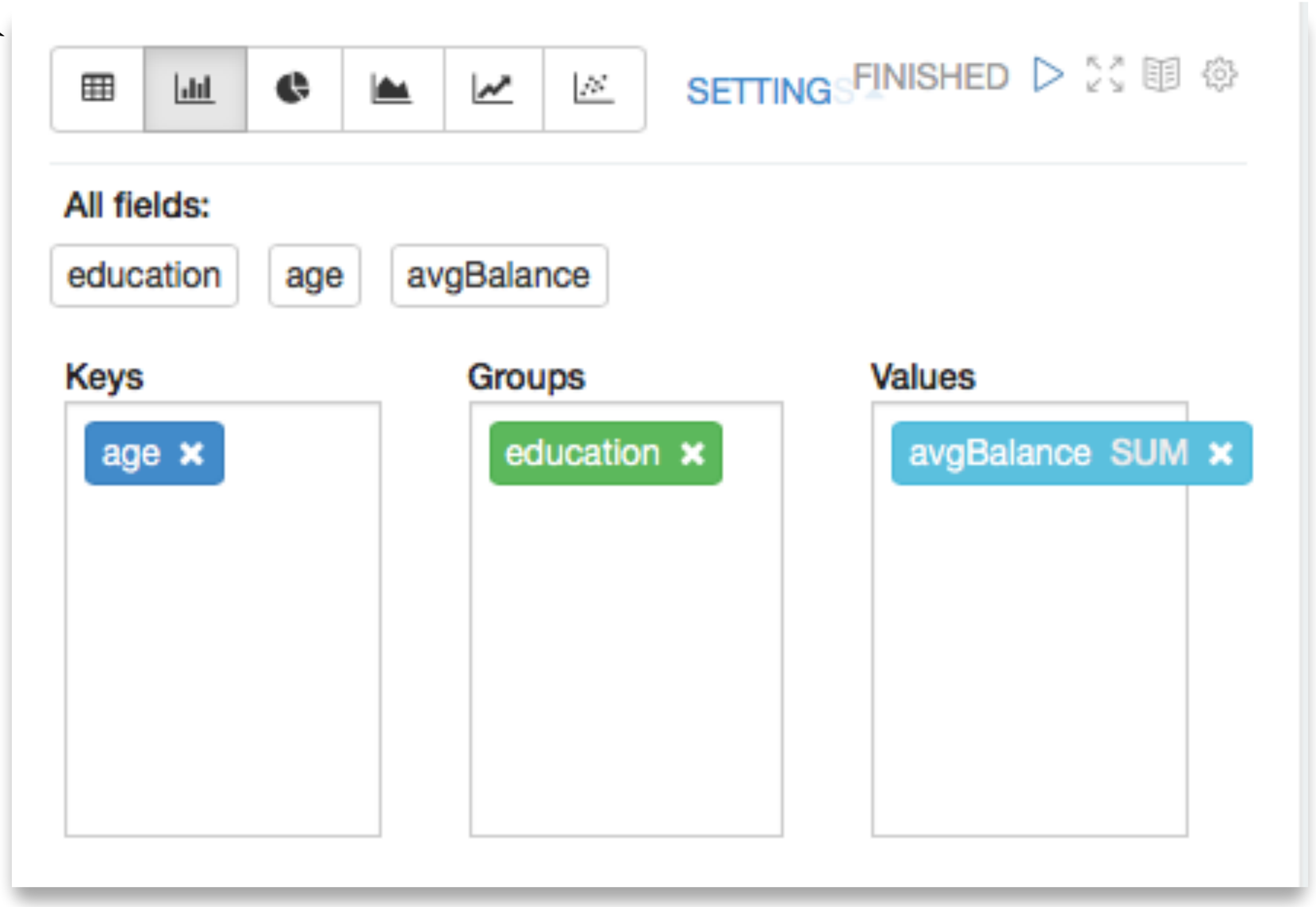

%sql
FINISHED
SELECT marital, COUNT(1) AS statusCount
FROM bank
GROUP BY marital
ORDER BY statusCount DESC
marital
statusCount
married
27,214
single
12,790
divorced
5,207

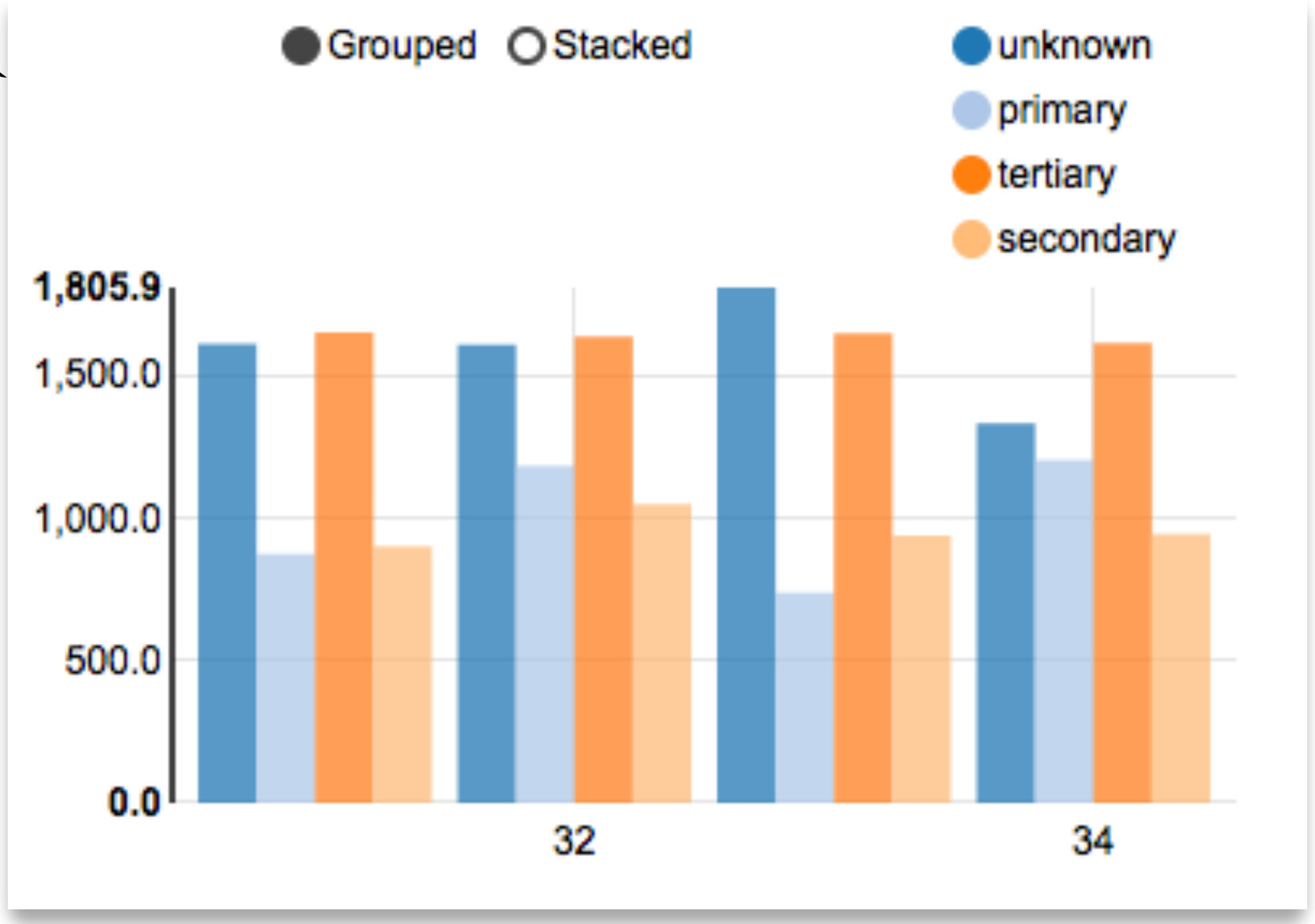

SETTINGS
FINISHED
married
single
divorced
divorced
single
married
Took 1 seconds

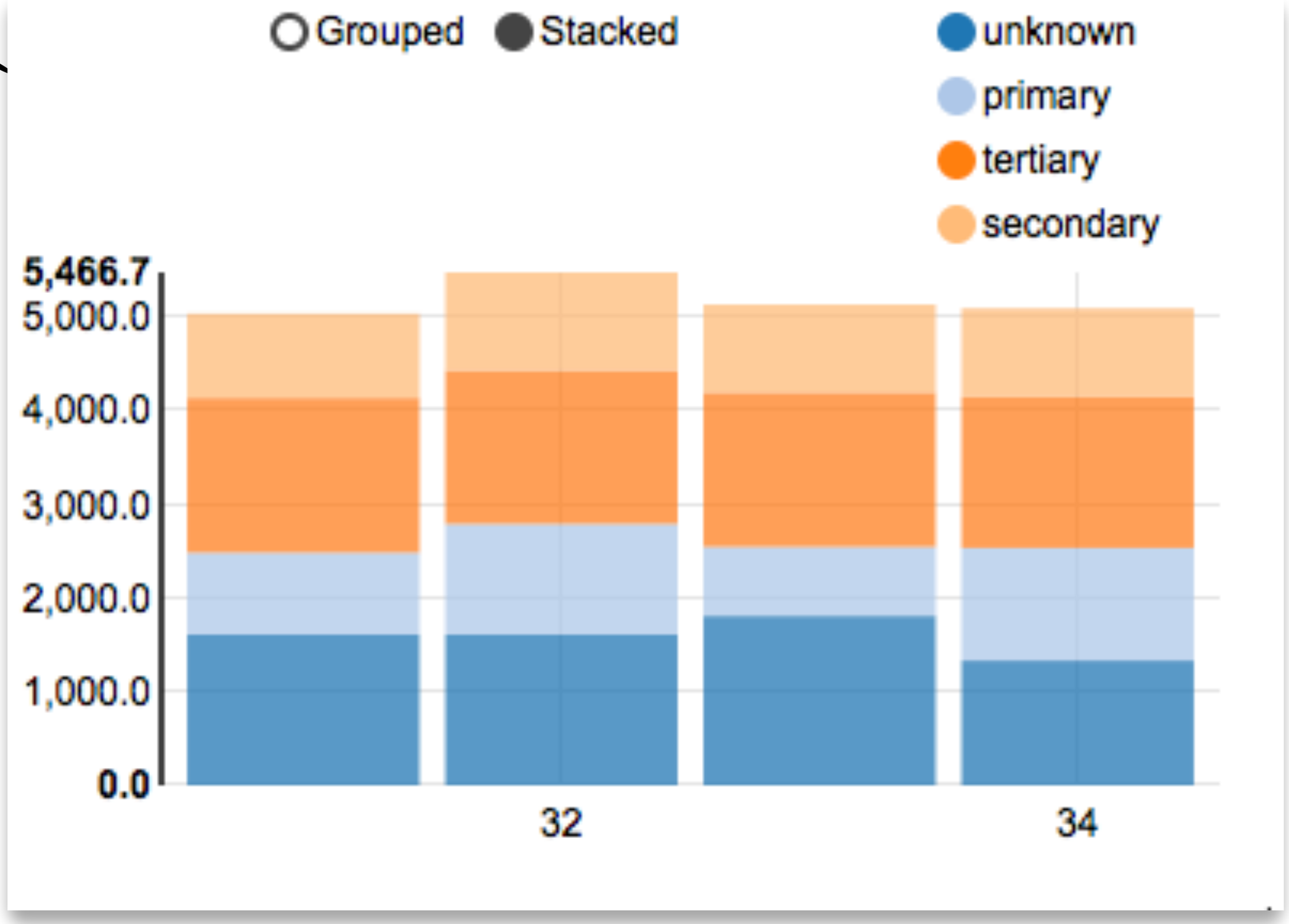

SETTINGS
FINISHED
married
single
divorced
divorced
single
12,790.00
single
married


SETTINGS
FINISHED
Grouped
Stacked
statusCount
27,214.0
25,000.0
20,000.0
15,000.0
10,000.0
5,000.0
0.0
married
single
divorced

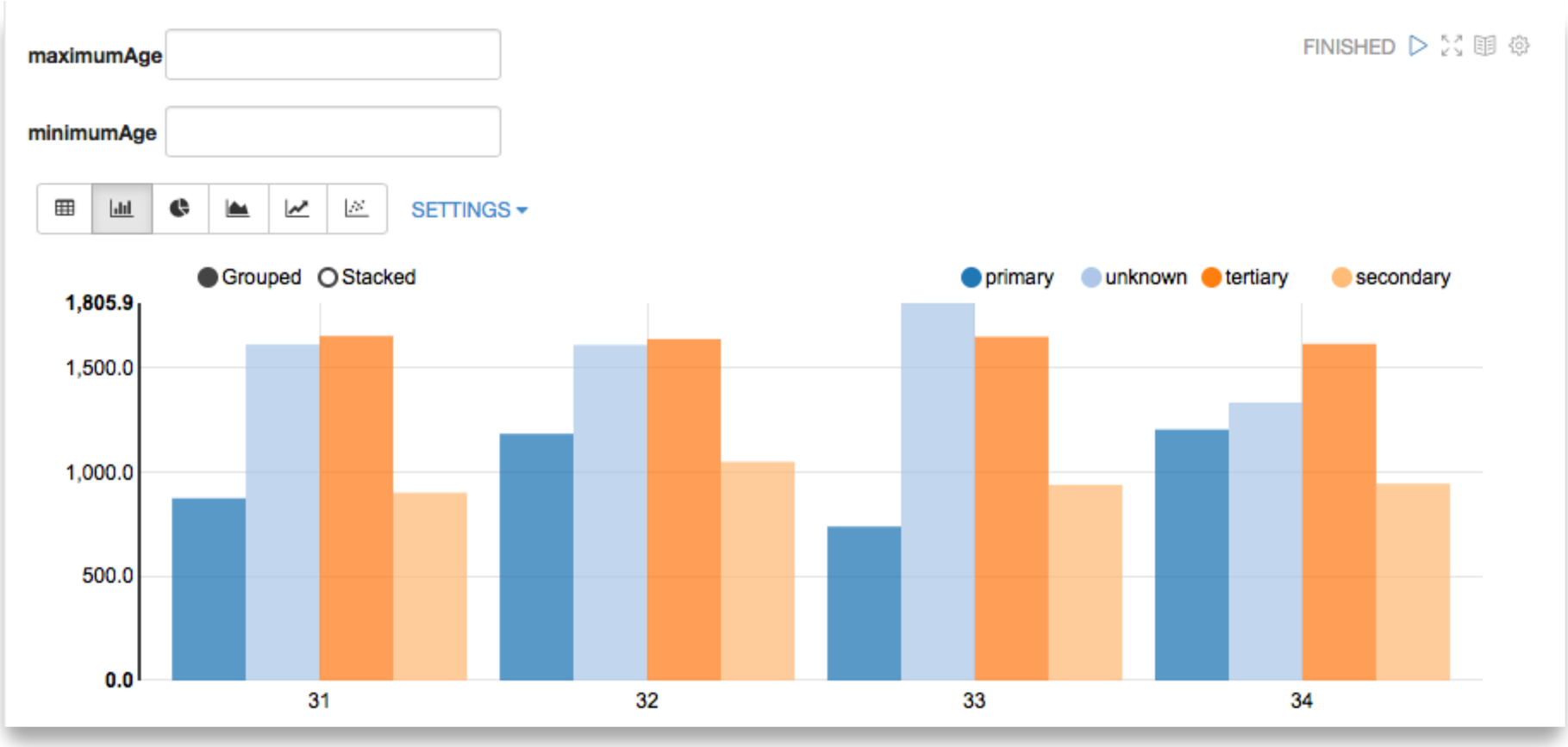

```
%sql
SELECT education, age, AVG( balance) as avgBalance
FROM bank
WHERE age > 20 AND age < 35
GROUP BY age, education
ORDER BY age ASC
```


SETTINGS
FINISHED
All fields:
education
age
avgBalance
Keys
age
Groups
education
Values
avgBalance SUM


Grouped
Stacked
unknown
primary
tertiary
secondary
1,805.9
1,500.0
1,000.0
500.0
0.0
32
34

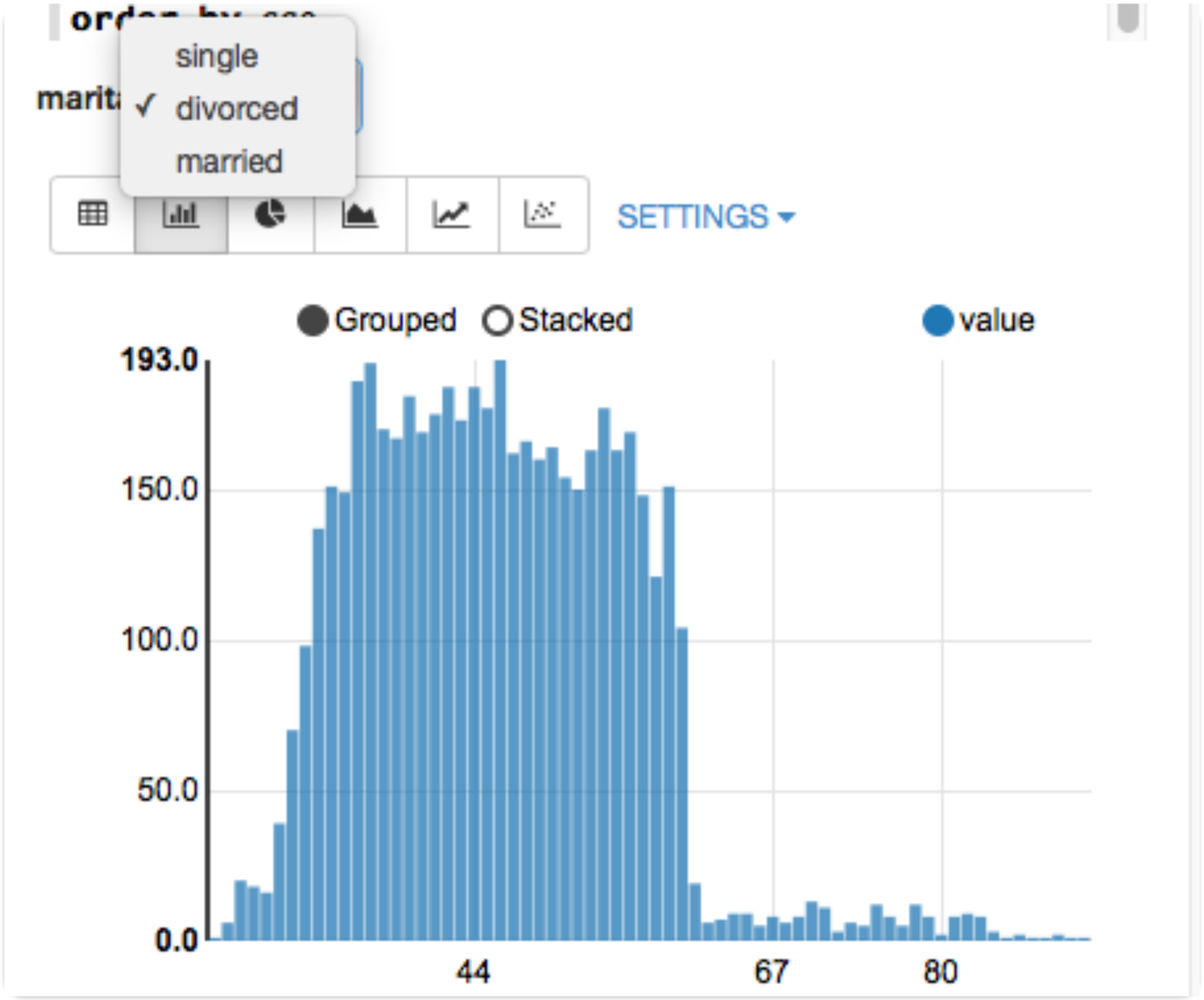

Grouped
Stacked
unknown
primary
tertiary
secondary
5,466.7
5,000.0
4,000.0
3,000.0
2,000.0
1,000.0
0.0
32
34

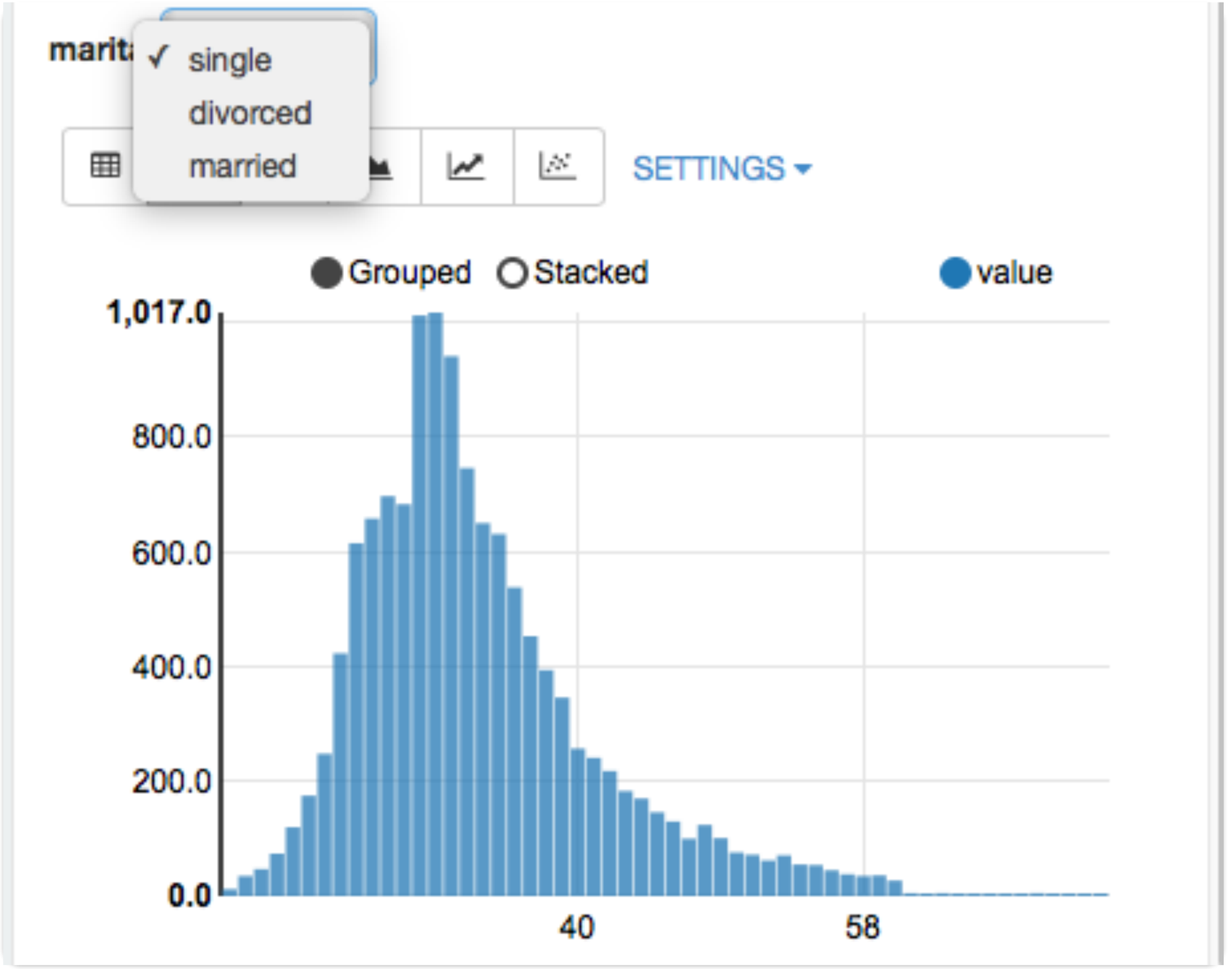

```
%sql
SELECT education, age, AVG( balance) as
avgBalance
FROM bank
WHERE age > ${minimumAge=30} AND age < $
{maximumAge=35}
GROUP BY age, education
ORDER BY age ASC
```


maximumAge
minimumAge
FINISHED
SETTINGS
Grouped
Stacked
primary
unknown
tertiary
secondary
1,805.9
1,500.0
1,000.0
500.0
0.0
31
32
33
34


maxAge
40
minAge
35
SETTINGS
Grouped
Stacked
unknown
primary
tertiary
secondary
2,171.6
2,000.0
1,500.0
1,000.0
500.0
0.0
36
37
38
39

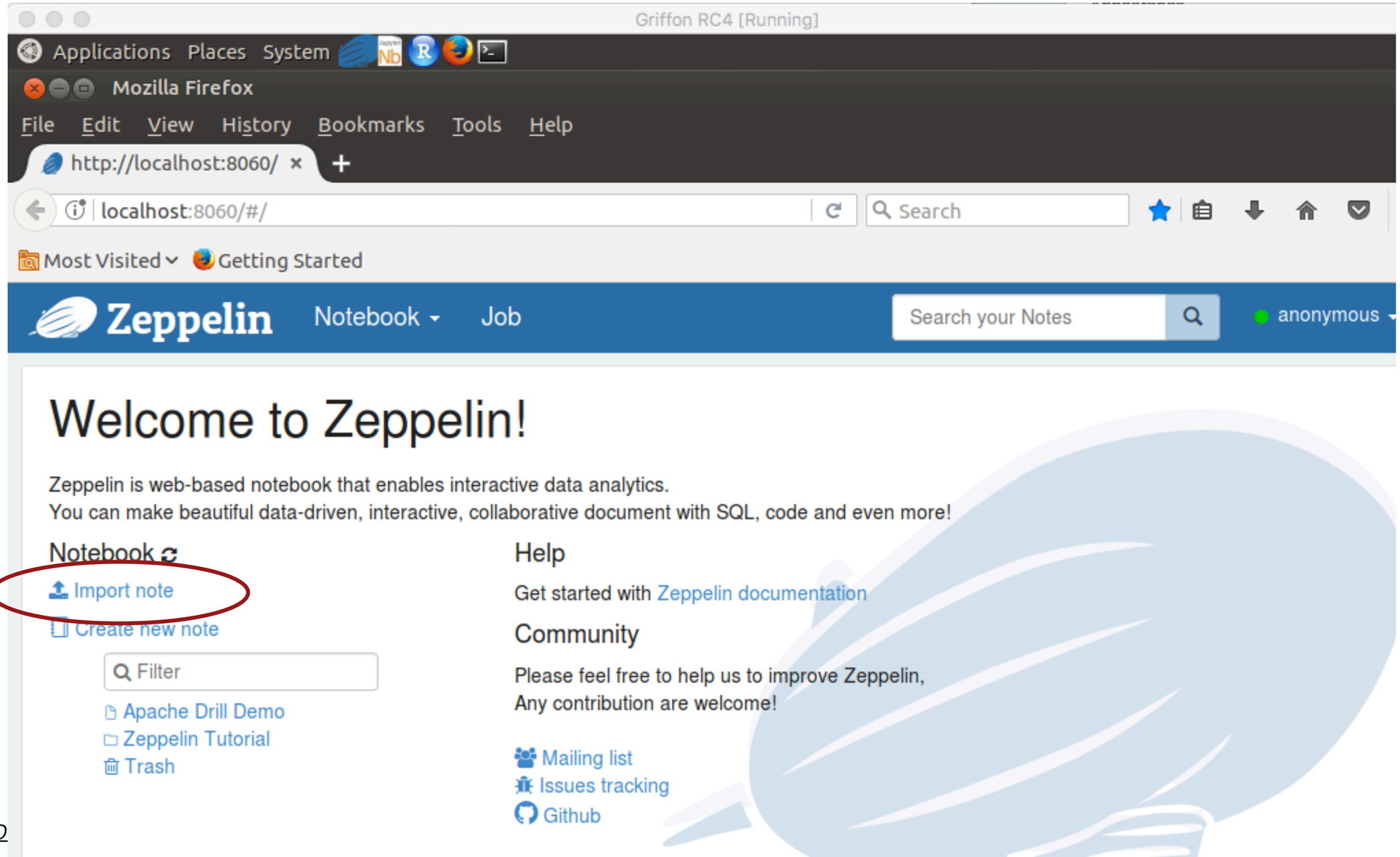

```
%sql
SELECT age, count(1) value
FROM bank
WHERE marital="${marital=single,single|divorced|married}"
GROUP BY age
ORDER BY age
```


single
divorced
married
SETTINGS
Grouped
Stacked
value
193.0
150.0
100.0
50.0
0.0
44
67
80

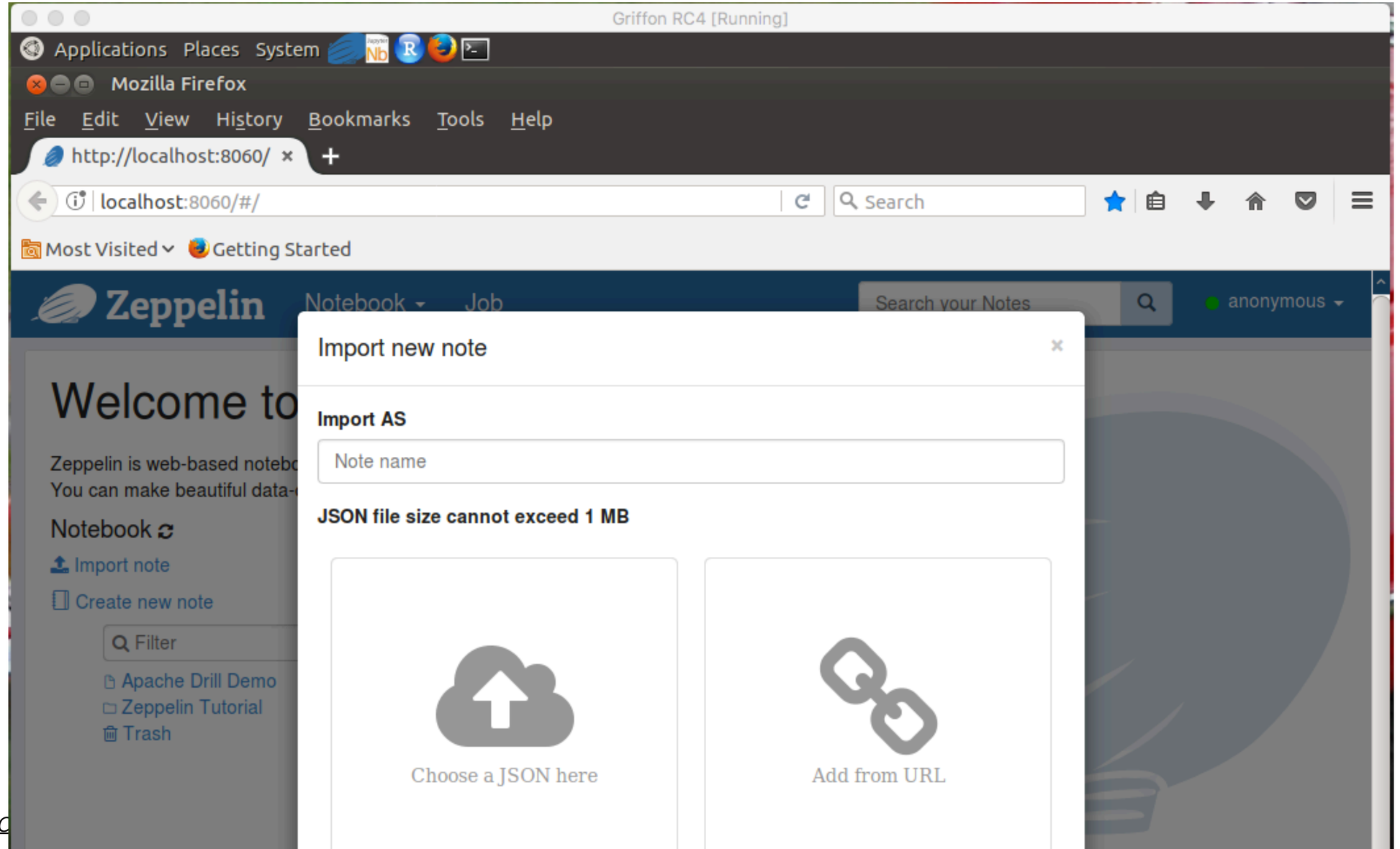

marita
single
divorced
married
SETTINGS
Grouped
Stacked
value
1,017.0
800.0
600.0
400.0
200.0
0.0
40
58

Importing a notebook

Importing a notebook



Importing a notebook

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Spark

Apache Spark™ is a fast and general engine for large-scale data processing.

- **Speed:** Run programs up to 100x faster than Hadoop MapReduce **in memory**, or 10x faster on disk.
- **Ease of Use:** Write applications quickly in Java, Scala, Python via **PySpark**, R.
- **Generality:** Combine SQL, **streaming**, and complex analytics.
- **Runs Everywhere:** Spark runs on Hadoop, Mesos, standalone, or in the cloud. It can access diverse data sources including HDFS, Cassandra, HBase, and S3.

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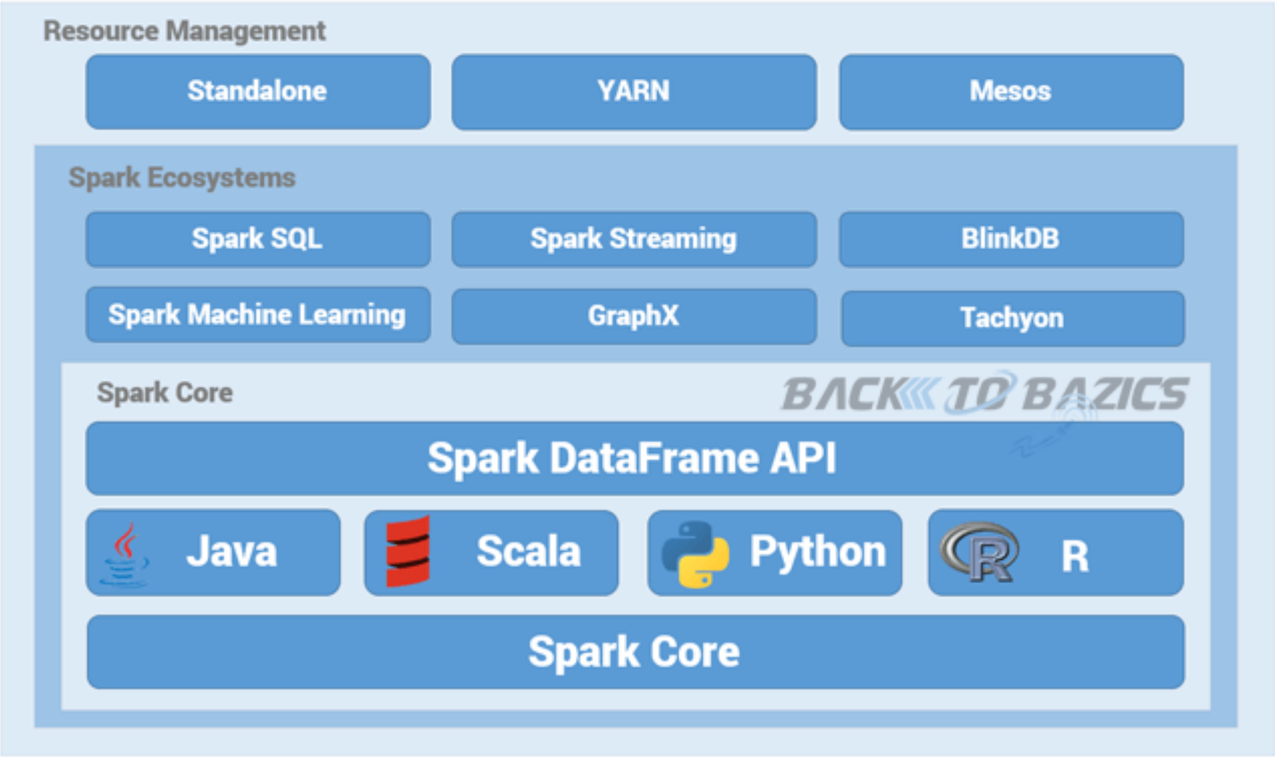
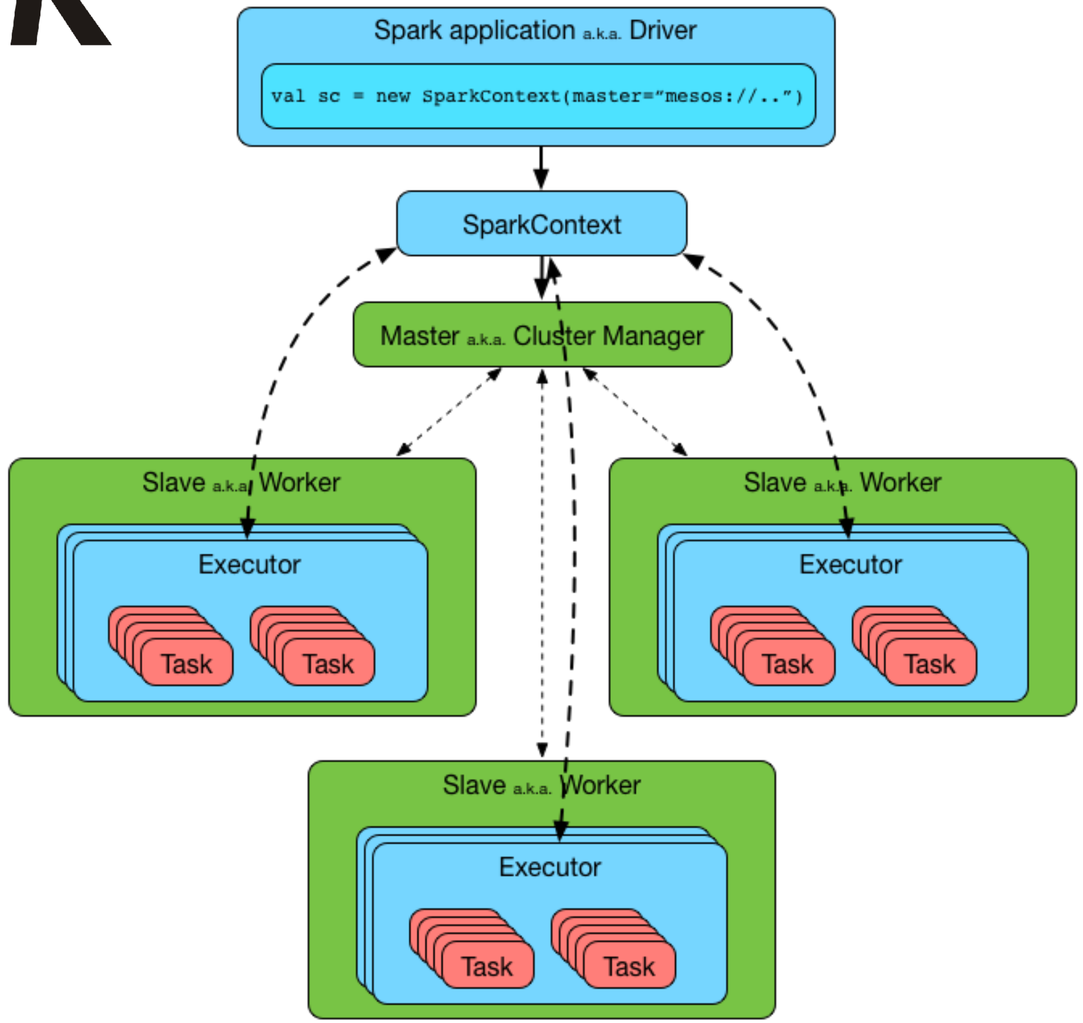
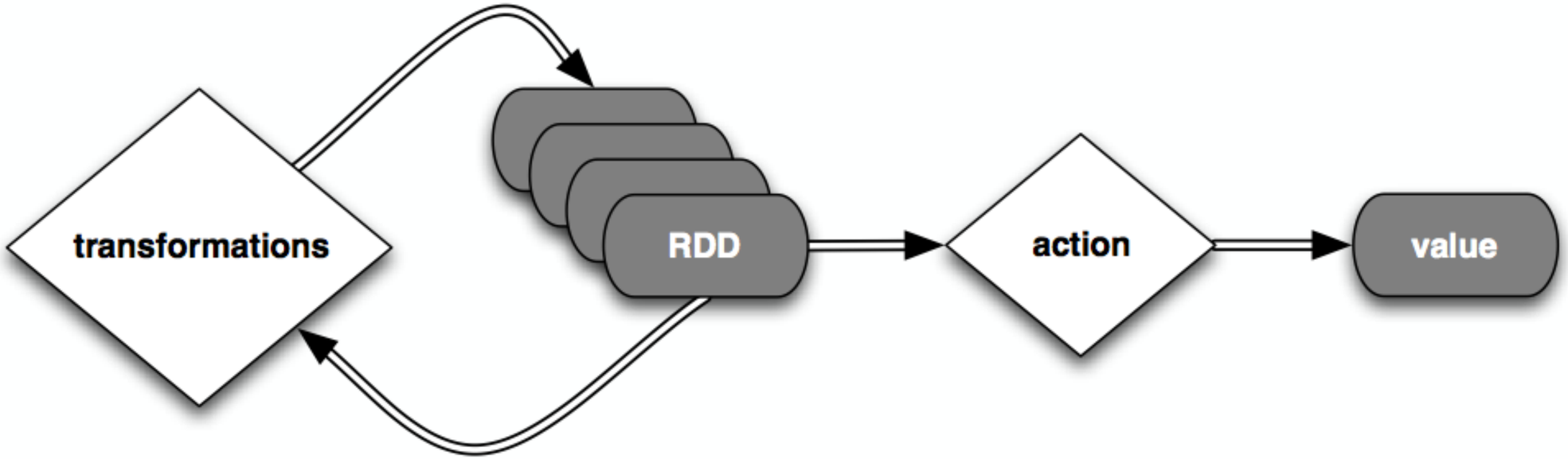
Spark





Spark has two classes of operations: transformations, and actions.


transformations
RDD
action
value

rdd - **R**esilient **D**istributed **D**ataset


```
from operator import add

f = sc.textFile("README.md")
wc = f.flatMap( lambda x: x.split(' '))
    .map( lambda x: (x, 1 ))
    .reduceByKey(add)

wc.saveAsTextFile( "wc_out.txt" )
```


```
from pyspark.sql import SQLContext
from pyspark import SparkContext
sc = SparkContext()

sqlCtx = SQLContext(sc)

#Load a text file and convert each line to a dictionary
lines = sc.textFile("examples/src/main/resources/people.txt")

parts = lines.map(lambda l: l.split(","))
people = parts.map(lambda p: {"name": p[0], "age": int(p[1])})

peopleTable = sqlCtx.inferSchema(people)
peopleTable.registerAsTable("people")

# SQL can be run over SchemaRDDs that have been registered as a table
teenagers = sqlCtx.sql("SELECT name FROM people WHERE age >= 13 AND age <= 19")

teenNames = teenagers.map(lambda p: "Name: " + p.name)
teenNames.collect()
```

Parse Apache Access Logs using RDD map

```
# Version 1: Parsing of Apache Logs via RDD
regex_pattern = '^(\S+) (\S+) (\S+) \[([\w:/]+\s[+\-]\d{4})\] "(\S+) (\S+) (\S+)" (\d{3}) (\d+)'

def map_apache_log(line):

    match = re.search(regex_pattern, line)
    if match is None:
        log_row = Row(
            Host='null',
            ClientID='null',
            UserID='null',
            DateTime='null',
            Method='null',
            Endpoint='null',
            Protocol='null',
            Response='null',
            SizeBytes='null')
    else:
        log_row = Row(
                Host=match.group(1),
                ClientID=match.group(2),
                UserID=match.group(3),
                DateTime=match.group(4),
                Method=match.group(5),
                Endpoint=match.group(6),
                Protocol=match.group(7),
                Response=match.group(8),
                SizeBytes=match.group(9))

    return log_row
```

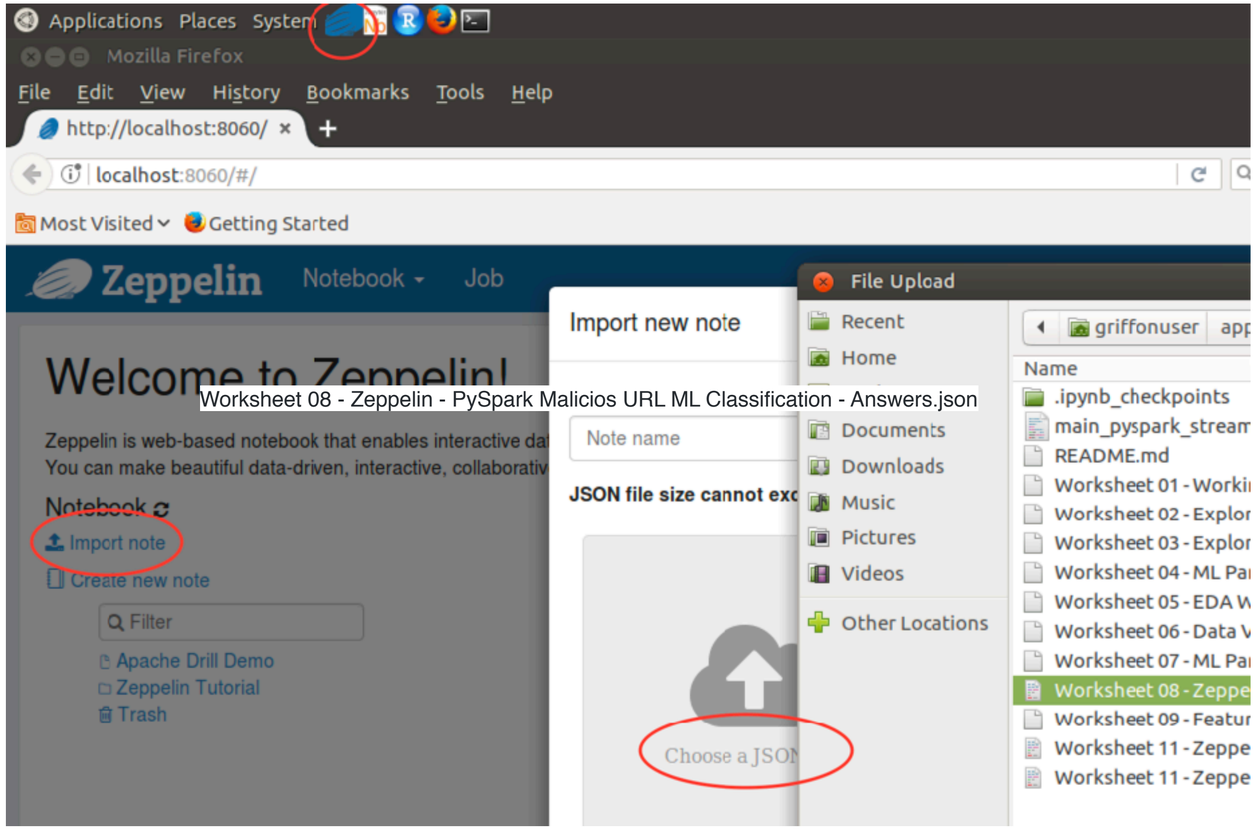
```
%pyspark

DATA_HOME = '/home/griffonuser/applied-ds/data/'

fname = DATA_HOME + 'apache-access.log'

# read rdd, map each row (see function above) and convert to DataFrame
rdd = sc.textFile(fname).map(map_apache_log)
df_from_rdd = rdd.toDF()
df_from_rdd = df_from_rdd.na.drop(how='any')

# Define data types
to_datetime = udf(lambda x: datetime.strptime(x, '%d/%b/%Y:%H:%M:%S %z'), TimestampType())

df_from_rdd = df_from_rdd.withColumn("Response", df_from_rdd.Response.cast(IntegerType())) \
                         .withColumn("SizeBytes", df_from_rdd.SizeBytes.cast(IntegerType()))
df_from_rdd = df_from_rdd.na.drop(how='any')
df_from_rdd = df_from_rdd.withColumn("DateTime", to_datetime(col("DateTime")))

df_from_rdd.show()
df_from_rdd.printSchema()
```

```
+--------+--------------------+--------------------+--------------+------+--------+--------+---------+------+
|ClientID|            DateTime|            Endpoint|          Host|Method|Protocol|Response|SizeBytes|UserID|
+--------+--------------------+--------------------+--------------+------+--------+--------+---------+------+
|       -|2012-08-03 17:09:...|/html/quickcrossf...| 208.115.113.85|   GET|HTTP/1.1|     200|     8770|     -|
|       -|2012-08-03 17:09:...|/geotechnical/pro...| 208.115.113.85|   GET|HTTP/1.1|     200|    20813|     -|
|       -|2012-08-03 17:09:...|/geotechnical/pro...| 208.115.113.85|   GET|HTTP/1.1|     200|    17070|     -|
```

sqlContext - DataFrames: ETL

pyspark.ml - DataFrames: Machine Learning

ETL and Machine Learning:
Detection of malicious URLs **in PySpark**



Worksheet 08 - Zeppelin - PySpark Malicios URL ML Classification - Answers.json

Bonus Worksheet 1 - Zeppelin - PySpark Malicious URL ML Classification - Answers.json

Import PySpark and Python libraries

```
%pyspark
# PySpark
from pyspark.sql.types import *
from pyspark.sql.functions import *
from pyspark.ml import feature
from pyspark.ml.classification import RandomForestClassifier, DecisionTreeClassifier
from pyspark.ml.evaluation import BinaryClassificationEvaluator, MulticlassClassificationEvaluator
from pyspark.ml.tuning import ParamGridBuilder, CrossValidator
# Python
import json
import pandas as pd
import numpy as np
import re, sys, os
from datetime import datetime
```

sc, sqlContext and spark

SparkContext represents the connection to a Spark cluster and is the main entry point for Spark functionality. In Zeppelin notebook **sc** as well as **sqlContext** and **spark** session are automatically loaded.

In a regular Python script you would load them as follows and run the Python script in a terminal with **spark-submit <path/to/script>.py**

```
from pyspark import SparkConf, SparkContext
from pyspark.sql import SQLContext
from pyspark.sql import SparkSession

## CREATE SparkContext sc
conf = (SparkConf()
         .setMaster("local")
         .setAppName("Test1")
         .set("spark.executor.memory", "6g"))
sc = SparkContext(conf = conf)

## CREATE SQLContext sqlContext
sqlContext = SQLContext(sc)

## CREATE SparkSession
spark = SparkSession(sc) \
    .builder \
    .appName("Test2") \
    .getOrCreate()
```

Load csv data using sqlContext

```
# PySpark version
customSchema = StructType([ \
    StructField("url", StringType(), True), \
    StructField("isMalicious", IntegerType(), True), \
    StructField("domain", StringType(), True), \
    StructField("created", TimestampType(), True), \
    StructField("isIP", StringType(), True), \
                                ])

fname = DATA_HOME + 'url_data_small.csv'

# Version 1: pre-defining schema
df = sqlContext.read \
    .format('com.databricks.spark.csv') \
    .options(header='true') \
    .load(fname, schema=customSchema)
```

```
# Version 2: Letting Spark infer Schema for you
df = sqlContext.read \
    .format('com.databricks.spark.csv') \
    .options(header='true', inferSchema="true") \
    .load(fname)

# Drop certain columns, easier to use select method
df = df.select([c for c in df.columns if c not in ['domain']])
print('Length of DataFrame: ', df.count())
df.show(5)
df.printSchema()
```

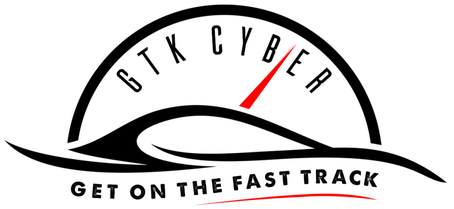
PySpark DataFrames are similar to pandas
http://spark.apache.org/docs/latest/sql-programming-guide.html

ML Feature Engineering: Apply custom Python function to df

```
%pyspark
def H_entropy(x):
    # Calculate Shannon Entropy
    prob = [ float(x.count(c)) / len(x) for c in dict.fromkeys(list(x)) ]
    H = - np.sum([ p * np.log2(p) for p in prob ])
    return np.float(H)

def digits(x):
    # Find Number of Digits
    pattern = re.compile('([0-9])')
    return len(re.findall(pattern, x))

def calc_duration(x):
    # Calculate time difference
    delta = datetime.today() - x
    return delta.days
```

```
%pyspark
# Define User Defined Function
udf_length = udf(lambda x: len(x))
udf_entropy = udf(lambda x: H_entropy(x))
udf_digits = udf(lambda x: digits(x))
udf_duration = udf(lambda x: calc_duration(x))

# Apply UDF to one column of the df and add as new column to it.
df2 = df.withColumn('Length', udf_length(col('url')).cast(IntegerType()))\
        .withColumn('EntropyDomain', udf_entropy(col('url')).cast(FloatType()))\
        .withColumn('DigitsCount', udf_digits(col('url')).cast(IntegerType()))\
        .withColumn('DurationCreated', udf_duration(col('created')).cast(IntegerType()))
df2.show(5)
```

Spark User Defined Functions
https://docs.databricks.com/spark/latest/spark-sql/udf-in-python.html



ML example: Load feature matrix

```
fname = DATA_HOME + 'url_features_final_df_spark.csv'
df = sqlContext.read \
    .format('com.databricks.spark.csv') \
    .options(header='true', inferSchema="true") \
    .load(fname)
print(df.columns)
print('Length of DataFrame: ', df.count(), '\nColumns: ', len(df.columns))
```

```
['isMalicious', 'isIP', 'Length', 'LengthDomain', 'DigitsCount', 'EntropyDomai
'us', 'cc', 'pt', 'tv', 'cokr', 'su', 'ws', 'orguk', 'club', 'pro26', 'all', '
n', 'new', 'news43', 'nte', 'ort', 'pro46', 'res', 'sta', 'ste', 'ter', 'the51
mazon', 'amazonaws', 'ancestry', 'annstringer', 'answers', 'apple', 'aquatixbo
, 'cndoubleegret', 'co', 'computantest', 'dedivan', 'directxex', 'downf468', '
gmart', 'home', 'iask', 'imdb', 'in', 'instagram', 'intnet', 'ip', 'jaaeza', '
'manta', 'mhcable', 'mobile', 'muralove', 'myjino', 'mylife', 'myspace', 'myut
ingshu8', 'pinterest', 'plus', 'qq', 'qualifiedplans', 'reia', 'rumormillnews'
', 'tripod', 'tvseriesfinale', 'twitter', 'u', 'unitedstatesreferral', 'usa',
ube', 'DurationCreated']
Length of DataFrame:  87380
Columns:  158
```

Getting features and target vector in correct format

```
%pyspark

features_names = df.columns
features_names.remove('isMalicious')

assembler = feature.VectorAssembler(inputCols=features_names, outputCol='features')
data = assembler.transform(df).select('features', 'isMalicious') # X (features) and target(label)
data.show(5)
```

```
+--------------------+-----------+
|            features|isMalicious|
+--------------------+-----------+
|(157,[1,2,3,4,5,8...|          0|
|(157,[1,2,4,6,156...|          0|
|(157,[1,2,3,4,5,6...|          0|
|(157,[1,2,4,6,50,...|          0|
|(157,[1,2,3,4,5,6...|          0|
+--------------------+-----------+
only showing top 5 rows
```

As opposed to Python's sklearn, in PySpark **features** and **target** labels will remain in **ONE** DataFrame!!!

- Column that contains the target labels has to be explicitly declared
- Features will be assembled to a vector or more specifically a SparseVector.

Simple train test split

```
%pyspark
## split train-test
seed=333
(train, test) = data.randomSplit([0.8,0.2], seed=seed)
train.show(5)
train.printSchema()
train.cache()
test.cache()
print(train.take(1))
```

Spark ML Lib: Decision Tree Classifier

```
%pyspark
## train model
clf = DecisionTreeClassifier(featuresCol="features",labelCol="isMalicious")
# clf = RandomForestClassifier(featuresCol="features",labelCol="isMalicious")
# fit model
model = clf.fit(train)
# make predictions
predictions = model.transform(test)
predictions.show(5)
```

```
+--------------------+-----------+--------------+--------------------+----------+
|            features|isMalicious|  rawPrediction|         probability|prediction|
+--------------------+-----------+--------------+--------------------+----------+
|(157,[1,2,3,4,5,6...|          0|[7239.0,1018.0]|[0.87671066973477...|       0.0|
|(157,[1,2,3,4,5,6...|          0| [7693.0,250.0]|[0.96852574593982...|       0.0|
|(157,[1,2,3,4,5,6...|          0|[7239.0,1018.0]|[0.87671066973477...|       0.0|
|(157,[1,2,3,4,5,6...|          0|[7239.0,1018.0]|[0.87671066973477...|       0.0|
|(157,[1,2,3,4,5,6...|          0|[4272.0,2722.0]|[0.61080926508435...|       0.0|
+--------------------+-----------+--------------+--------------------+----------+
only showing top 5 rows
```

http://spark.apache.org/docs/latest/api/python/pyspark.ml.html

Model Evaluation

```
%pyspark
eval1 = BinaryClassificationEvaluator(rawPredictionCol="prediction", labelCol="isMalicious", metricName="areaUnderROC")
areaunderROC = eval1.evaluate(predictions)

print('areaUnderROC of Decision Tree Classification: ', areaunderROC)
# print('Feature names: ', df.columns)
```

```
areaUnderROC of Decision Tree Classification:  0.8128223827076657
```


GTK CYBER
GET ON THE FAST TRACK


Spark

Integrate Spark with ElasticSearch and Kibana

- ETL (Extract Transform Load)
- Machine Learning

- Real-time indexing and searching
- Optimized for timestamped data

- Dashboards (geomap, barcharts, piecharts, timelion)

Bonus Worksheet 2 - Zeppelin Part1 - PySpark + ELK + Kafka - Answers.json

Batch Analysis of PCAP (csv) in PySpark

```
fname = DATA_HOME + 'maccdc2012_00000.csv.gz'

df = sqlContext.read\
    .format('com.databricks.spark.csv')\
    .options(delimiter="|", header="false", inferSchema="true")\
    .load(fname)

colNames = ["frameNumber", "frameTime", "frameProtocols", "frameLen", "tcpLen", "tcpHdrlen",
    "ipSrc", "ipDst", "tcpSrcport", "tcpDstport", "tcpFlags", "country", "city", "lat", "lon"]

mapping = dict(zip(['_c'+str(i) for i in range(len(df.columns))], colNames))
df = df.select([col(c).alias(mapping.get(c, c)) for c in df.columns])
df = df.na.drop(how='any')
# df.printSchema()

selectedCols = ["frameTime", "ipSrc", "ipDst", "tcpSrcport", "tcpDstport", "frameLen", "lat", "lon"]
df = df.select(selectedCols)  # or select specific cols only
df.show()
df.printSchema()
```

```
+------------------+-------------+-------------+----------+----------+--------+---------+-----------+
|         frameTime|        ipSrc|        ipDst|tcpSrcport|tcpDstport|frameLen|      lat|        lon|
+------------------+-------------+-------------+----------+----------+--------+---------+-----------+
|Mar 16, 2012 08:3...|192.168.202.76|   64.4.23.149|     51655|     40006|      70|37.339401|-121.894997|
|Mar 16, 2012 08:3...|192.168.202.76|  157.56.52.15|     51658|     40046|      70|47.680099|-122.120598|
|Mar 16, 2012 08:3...|192.168.202.76|   64.4.23.149|     51659|        80|      70|37.339401|-121.894997|
|Mar 16, 2012 08:3...|192.168.202.76| 157.55.56.150|     51660|       443|      70|41.849998| -87.650002|
|Mar 16, 2012 08:3...|192.168.202.76|157.55.235.162|     51661|     40030|      70|53.333099|    -6.2489|
```

tshark CLI was used to export PCAP fields to delimiter separated files

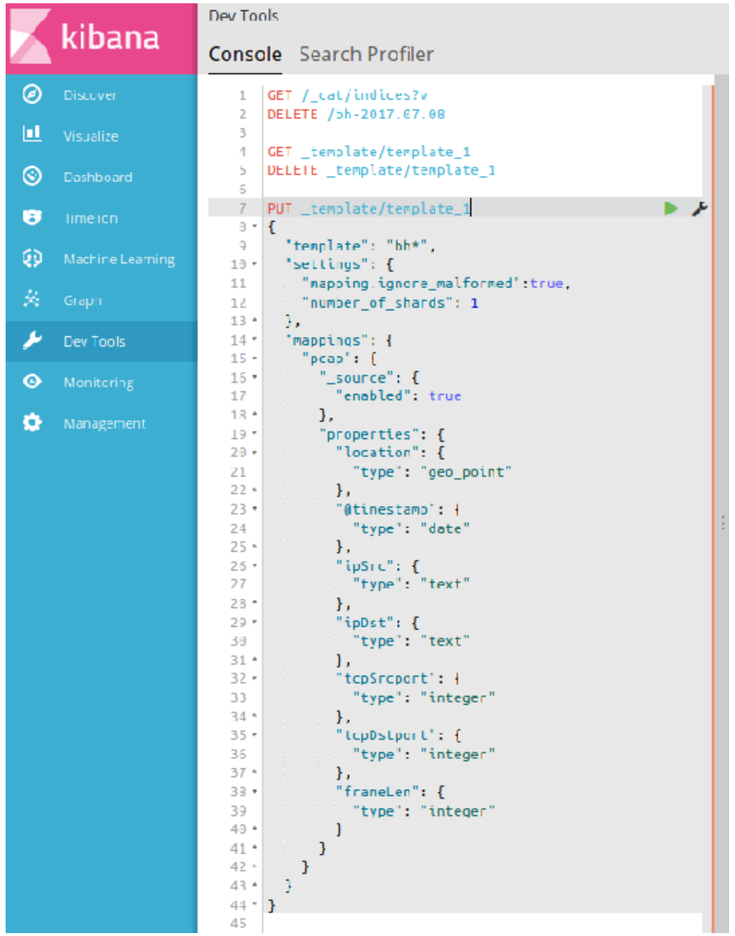
Apply UDFs to DataFrame

```
%pyspark
def datetime_iso8601(x):

    date = datetime.strptime(str(x), '%b %d, %Y %H:%M:%S.%f000 %Z')
    date = date.isoformat()
    string = str(date)
    return string

def join_location(x, y):
    string = str(x) + "," + str(y)
    return string

toES_datetime = udf(lambda x: datetime_iso8601(x), StringType())
to_datetime = udf(lambda x: datetime.strptime(str(x), '%b %d, %Y %H:%M:%S.%f000 %Z'), TimestampType())
toLocation_str = udf(lambda x, y: join_location(x, y), StringType())

df = df.withColumn("@timestamp", toES_datetime(col("frameTime")))\
       .withColumn("location", toLocation_str(col("lat"), col("lon")))\
       .withColumn("frameTime", to_datetime(col("frameTime")))
df1 = df

df1 = df1.select(["ipSrc", "ipDst", "tcpSrcport", "tcpDstport", "@timestamp", "location", "frameLen"])

print(df1.count())
df1.cache()  # save/cache, don't recompute
df1.show()
df1.printSchema()
```

```
2661
+--------------+--------------+----------+----------+--------------------+--------------------+--------+
|         ipSrc|         ipDst|tcpSrcport|tcpDstport|          @timestamp|            location|frameLen|
+--------------+--------------+----------+----------+--------------------+--------------------+--------+
|192.168.202.76|   64.4.23.149|     51655|     40006|2012-03-16T08:30:...|37.339401,-121.89...|      70|
|192.168.202.76|  157.56.52.15|     51658|     40046|2012-03-16T08:30:...|47.680099,-122.12...|      70|
```

1.) Transform datetime to isoformat and ‘lat’ and ‘lon’ to a format that geo_point in ES supports

Writing from PySpark to ElasticSearch

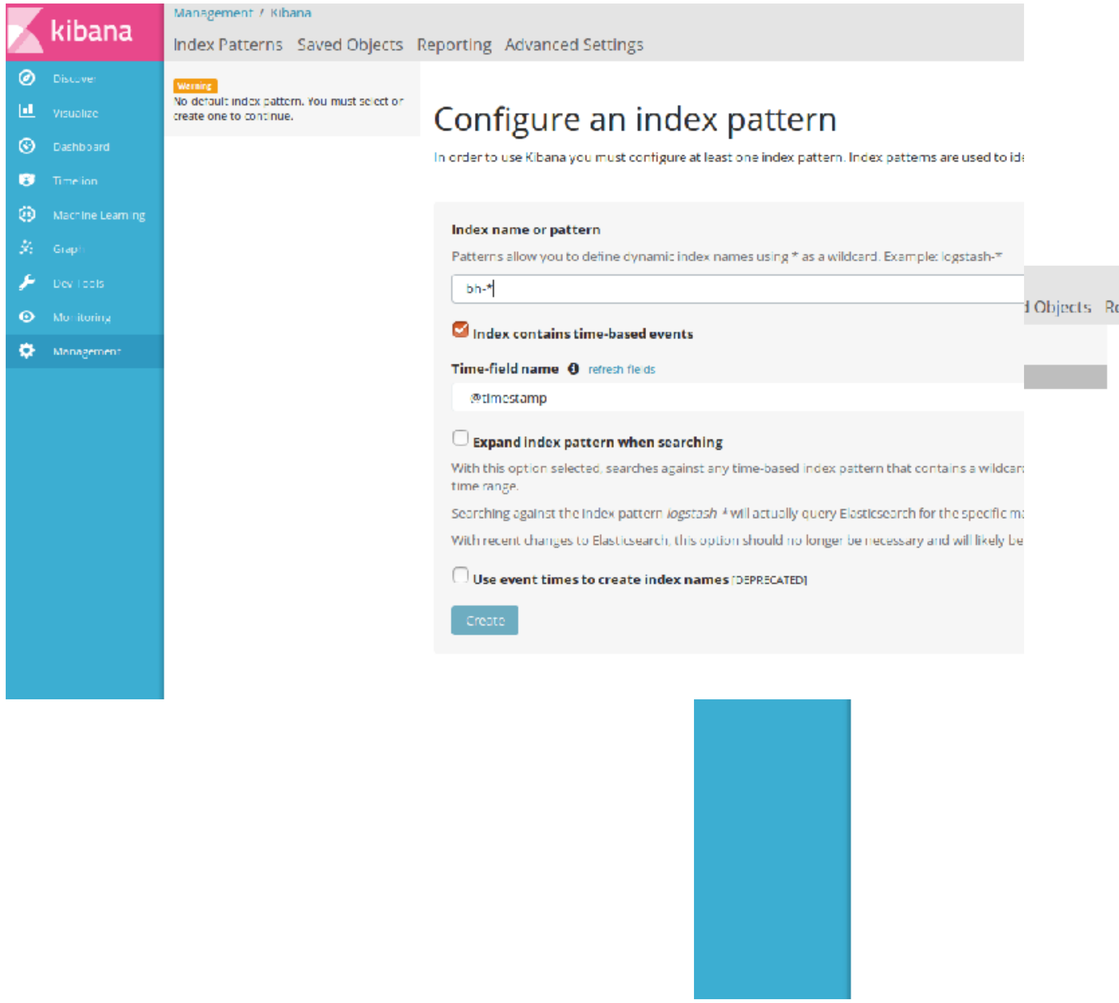


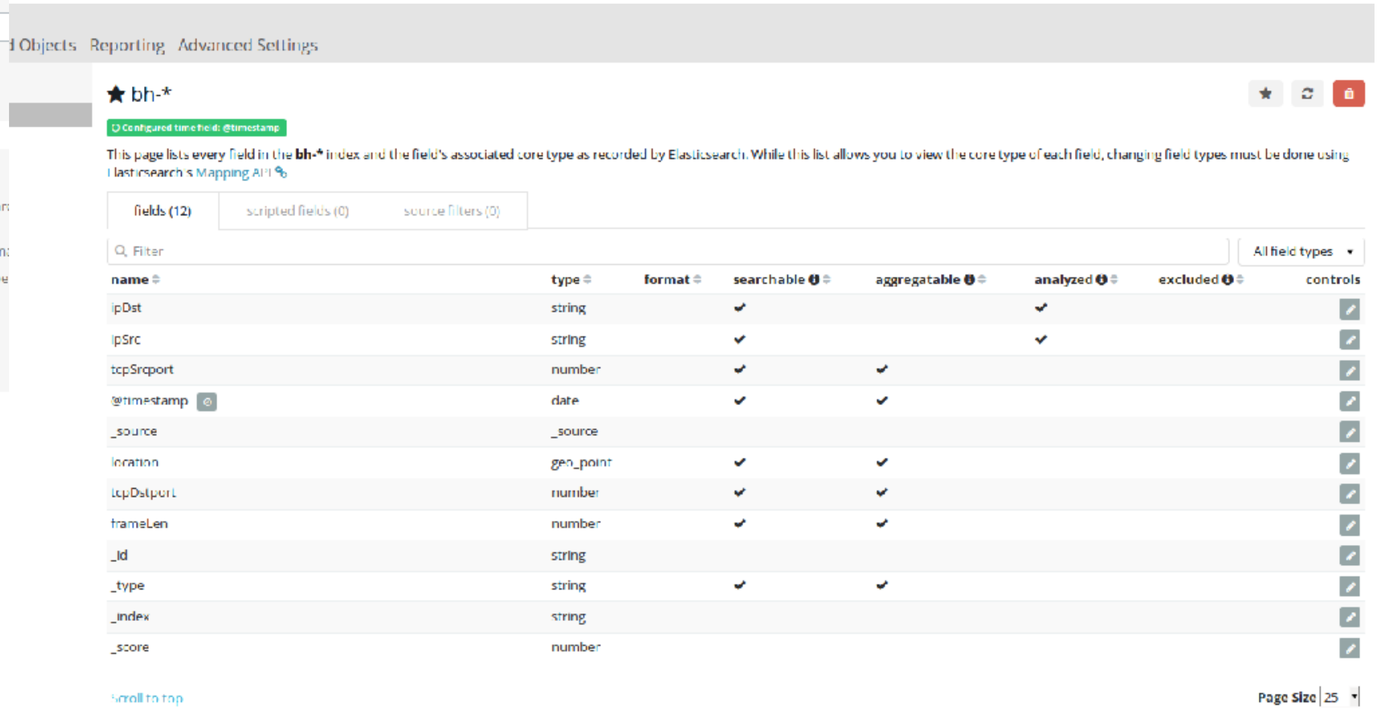
2.) Define mapping in ES

```
# Sink out to ElasticSearch
index_name = "bh-2017.07.08/pcap"

# Note: requires elasticsearch-hadoop jar corresponding
# to your ElasticSearch installation (https://jar-download.com/?search_box=elasticsearch-hadoop)

df1.write.format("org.elasticsearch.spark.sql").mode("append")\
    .option("es.resource", index_name)\
    .option("es.index.auto.create", "true")\
    .option("es.mapping.date.rich", "true")\
    .option("es.nodes.wan.only","false")\
    .option("es.net.ssl","false")\
    .option("es.nodes", "localhost")\
    .option("es.port", "9200")\
    .save()
```

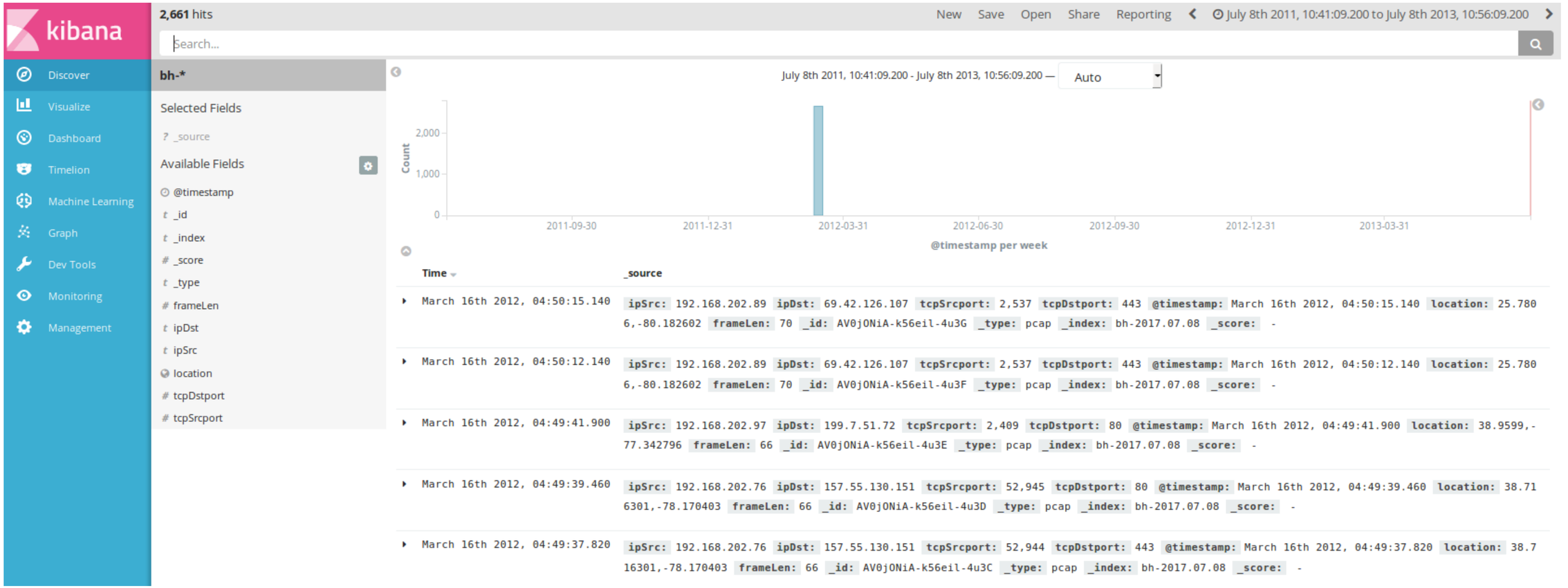
3.) Sink out to ES

Configure index pattern in ES

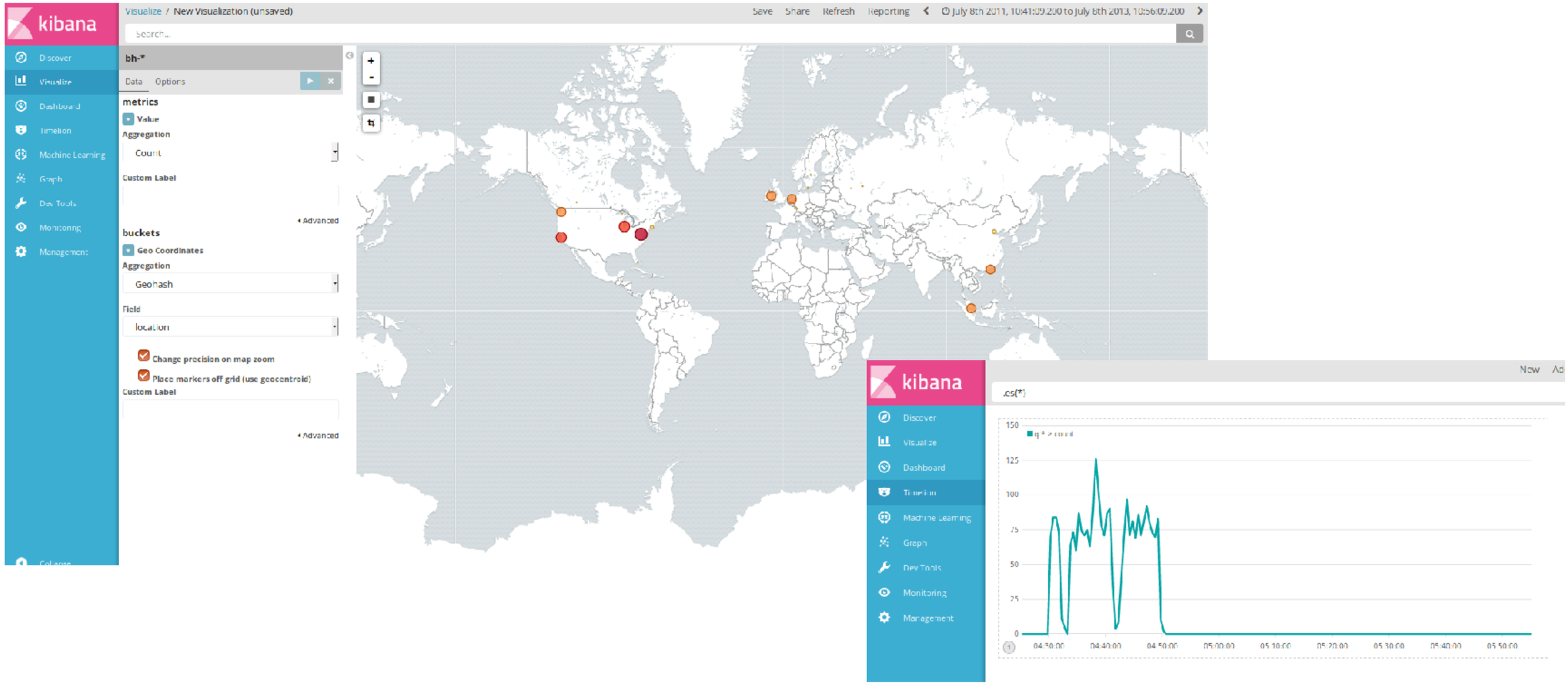




Searching in ES



Data Visualizations in Kibana



More ETL in PySpark (GroupBy and Aggregations)

```
%pyspark
exprs = [sum("frameLen").alias("frameLenSum"), count("ipSrc").alias("NPackets")]

df_agg = df.groupBy([window("frameTime", "5 seconds"), "ipSrc", "ipDst"])\
     .agg(*exprs).orderBy("window.start").na.drop(how="any")

df_agg.show()
df_agg.count()
# df_agg.createOrReplaceTempView("features")
```

```
+--------------------+--------------+--------------+-----------+--------+
|              window|         ipSrc|         ipDst|frameLenSum|NPackets|
+--------------------+--------------+--------------+-----------+--------+
|[2012-03-16 08:30...|192.168.202.76|  157.56.52.15|        350|       5|
|[2012-03-16 08:30...|192.168.202.76|   64.4.23.149|        280|       4|
```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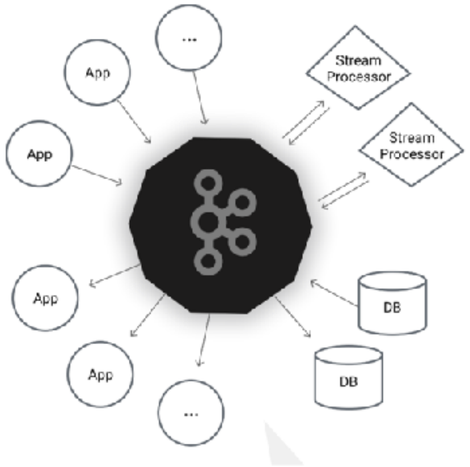
Spark


APACHE
kafka
TM
A distributed streaming platform

Kafka and Spark Structured Streaming

- PUBLISH & SUBSCRIBE to streams of data like a messaging system
- PROCESS streams of data efficiently and in real time
- STORE streams of data safely in a distributed replicated cluster



APACHE kafka™
A distributed streaming platform

Spark

Structured Streaming:
- Real-time analytics in micro-batches
- sqlContext/DataFrames

https://kafka.apache.org
https://spark.apache.org/docs/latest/structured-streaming-programming-guide.html

Create topic and initialize Kafka producer

```
# KAFKA

1. $KAFKA_HOME/bin/zookeeper-server-start.sh $KAFKA_HOME/config/zookeeper.properties (Start Zookeeper)
2. $KAFKA_HOME/bin/kafka-server-start.sh $KAFKA_HOME/config/server.properties (Start Kafka Server)
In GRIFFON skip step 1 and 2 and simply go to Applications > Big Data > Start Kafka
3. $KAFKA_HOME/bin/kafka-topics.sh --create --zookeeper localhost:2181 --replication-factor 1 --partitions 1 --topic testlogs (Create example topic "testlogs")
cd applied-ds
4. $KAFKA_HOME/bin/kafka-console-producer.sh --broker-list localhost:9092 --topic testlogs < data/stream/apache-access.log (Initialize Kafka Producer)
```

```
# Spark

5. Spark subscribe to Kafka topic using the Structured Streaming API (Kafka Consumer)
6. Spark DataFrame manipulations of incoming stream of messages
7. Spark Sink out (various options)
```

Docs:

- Kafka Quick Start (https://kafka.apache.org/quickstart)
- Spark Structured Streaming in micro-batches (http://spark.apache.org/docs/latest/structured-streaming-programming-guide.html)
- Kafka Integration (http://spark.apache.org/docs/latest/structured-streaming-kafka-integration.html)
- Zeppelin interpreter settings (https://zeppelin.apache.org/docs/0.5.0-incubating/interpreter/spark.html)

Bonus Worksheet 3 - Zeppelin Part2 - PySpark + ELK + Kafka - Answers.json

Subscribe to Kafka topic in PySpark

```
%pyspark

out_dir= DATA_HOME + "stream/out/out.csv"

while True:
    print("Kafka streaming running")
    ds0 = spark \
        .readStream \
        .format("kafka") \
        .option("kafka.bootstrap.servers", "localhost:9092") \
        .option("subscribe", "testlogs") \
        .load()

    # incoming values are in bytes, the next line deserializes the bytes and regular df operations can be applied
    ds0 = ds0.selectExpr("CAST(value AS STRING)", "CAST(timestamp AS STRING)")
    ds1 = parse_apache_log(ds0.select("value"))

    query = ds1.writeStream \
        .format("console") \
        .start()


    query.awaitTermination()
```

Parse Apache Access Log via DataFrame API

```
%pyspark
regex_pattern = '^(\S+) (\S+) (\S+) \[([\w:/]+\s[+\-]\d{4})\] "(\S+) (\S+) (\S+)" (\d{3}) (\d+)'
def parse_apache_log(df_raw):

    df = df_raw.select(regexp_extract('value', regex_pattern, 1).alias('Host'),
                       regexp_extract('value', regex_pattern, 2).alias('ClientID'),
                       regexp_extract('value', regex_pattern, 3).alias('UserID'),
                       regexp_extract('value', regex_pattern, 4).alias('DateTime'),
                       regexp_extract('value', regex_pattern, 5).alias('Method'),
                       regexp_extract('value', regex_pattern, 6).alias('Endpoint'),
                       regexp_extract('value', regex_pattern, 7).alias('Protocol'),
                       regexp_extract('value', regex_pattern, 8).alias('Response').cast(IntegerType()),
                       regexp_extract('value', regex_pattern, 9).alias('SizeBytes').cast(FloatType()))

    df = df.select([c for c in df.columns if c not in ['ClientID', 'UserID', 'Method']])
    # print('Length of DataFrame: ', df.count())
    return df
```

Streaming Analytics Console Output

```
Kafka streaming running
-------------------------------------------
Batch: 0
-------------------------------------------
+----+--------+--------+--------+--------+---------+
|Host|DateTime|Endpoint|Protocol|Response|SizeBytes|
+----+--------+--------+--------+--------+---------+
+----+--------+--------+--------+--------+---------+

-------------------------------------------
Batch: 1
-------------------------------------------
+---------------+--------------------+--------------------+--------+--------+---------+
|           Host|            DateTime|            Endpoint|Protocol|Response|SizeBytes|
+---------------+--------------------+--------------------+--------+--------+---------+
| 208.115.113.85|03/Aug/2012:10:09...|/html/quickcrossf...|HTTP/1.1|     200|   8770.0|
| 208.115.113.85|03/Aug/2012:10:09...|/geotechnical/pro...|HTTP/1.1|     200|  20813.0|
| 208.115.113.85|03/Aug/2012:10:09...|/geotechnical/pro...|HTTP/1.1|     200|  17070.0|
| 208.115.113.85|03/Aug/2012:10:09...|/geotechnical/pro...|HTTP/1.1|     200|  16885.0|
| 208.115.113.85|03/Aug/2012:10:09...|/geotechnical/pro...|HTTP/1.1|     200|  16077.0|
|  65.52.110.146|03/Aug/2012:10:23...|/geotechnical/ind...|HTTP/1.1|     200|   3664.0|
|               |                    |                    |        |    null|     null|
|213.186.119.134|03/Aug/2012:10:48...|/geotechnical/pro...|HTTP/1.1|     200|   4217.0|
|   66.249.73.3|03/Aug/2012:10:49...|         /robots.txt|HTTP/1.1|     404|    229.0|
|               |                    |                    |        |    null|     null|
|   180.76.6.26|03/Aug/2012:11:00...|/geotechnical/acc...|HTTP/1.1|     302|     26.0|
```

main_pyspark_streaming_apachelogs_kafka.py

Questions?