Spark Uber Development Kit

Kelvin Chu, Hadoop Platform, Uber
Gang Wu, Hadoop Platform, Uber

UBER

Spark Summit 2016
June 07, 2016

Uber Mission

"Transportation as reliable as running water, everywhere, for everyone"

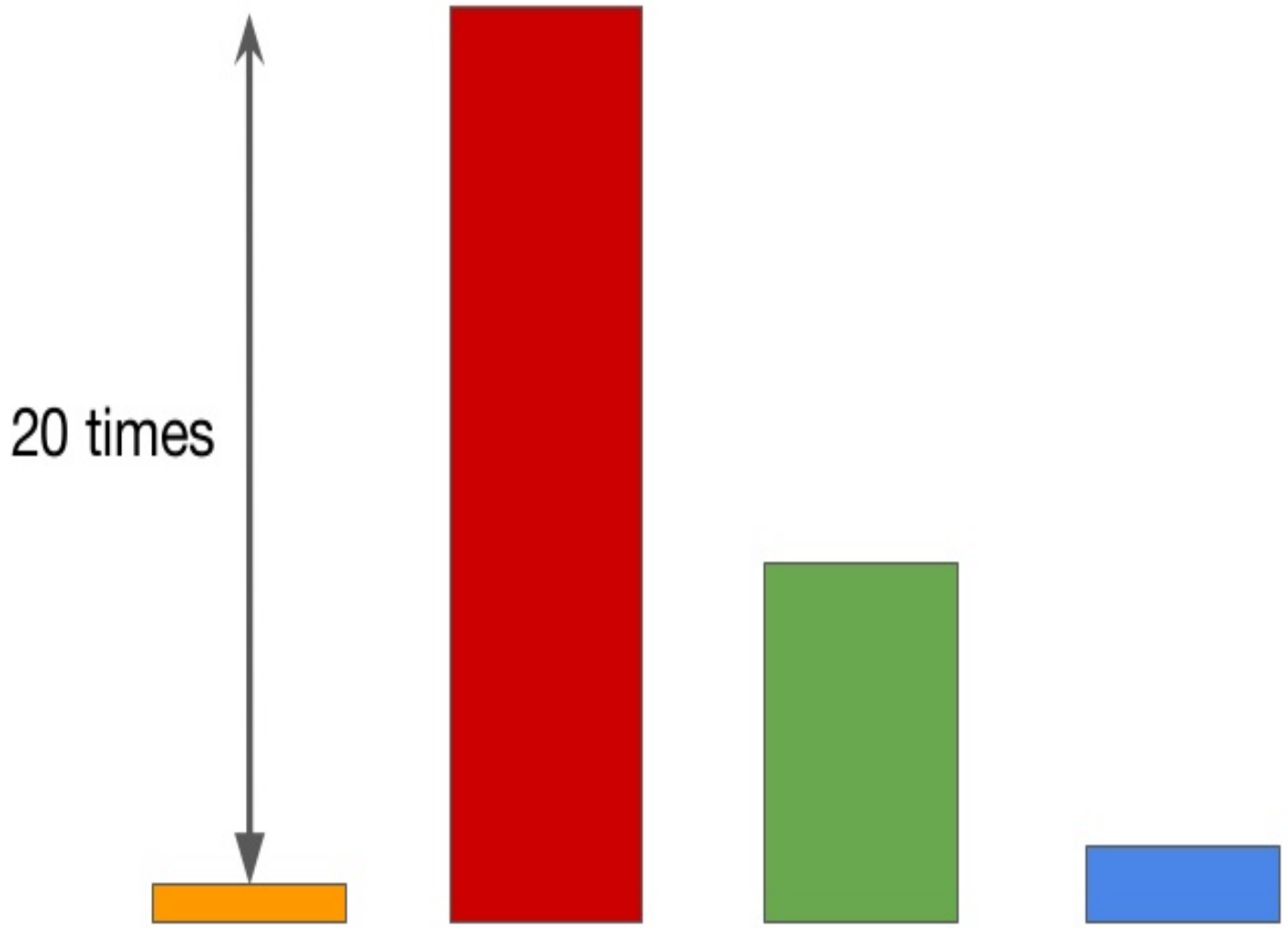
About Us

- Hadoop team of Data Infrastructure at Uber
- Schema systems
- HDFS data lake
- Analytics engines on Hadoop
- Spark computing framework and toolings

Execution Environment

Complexity

Cluster Sizes



YARN

Mesos

Docker

JVM

Parquet

ORC

Sequence

Text

Home Built Services

Hive

Kafka

ELK

Consequence:

Pretty hard for beginners, sometimes hard for experienced users too.

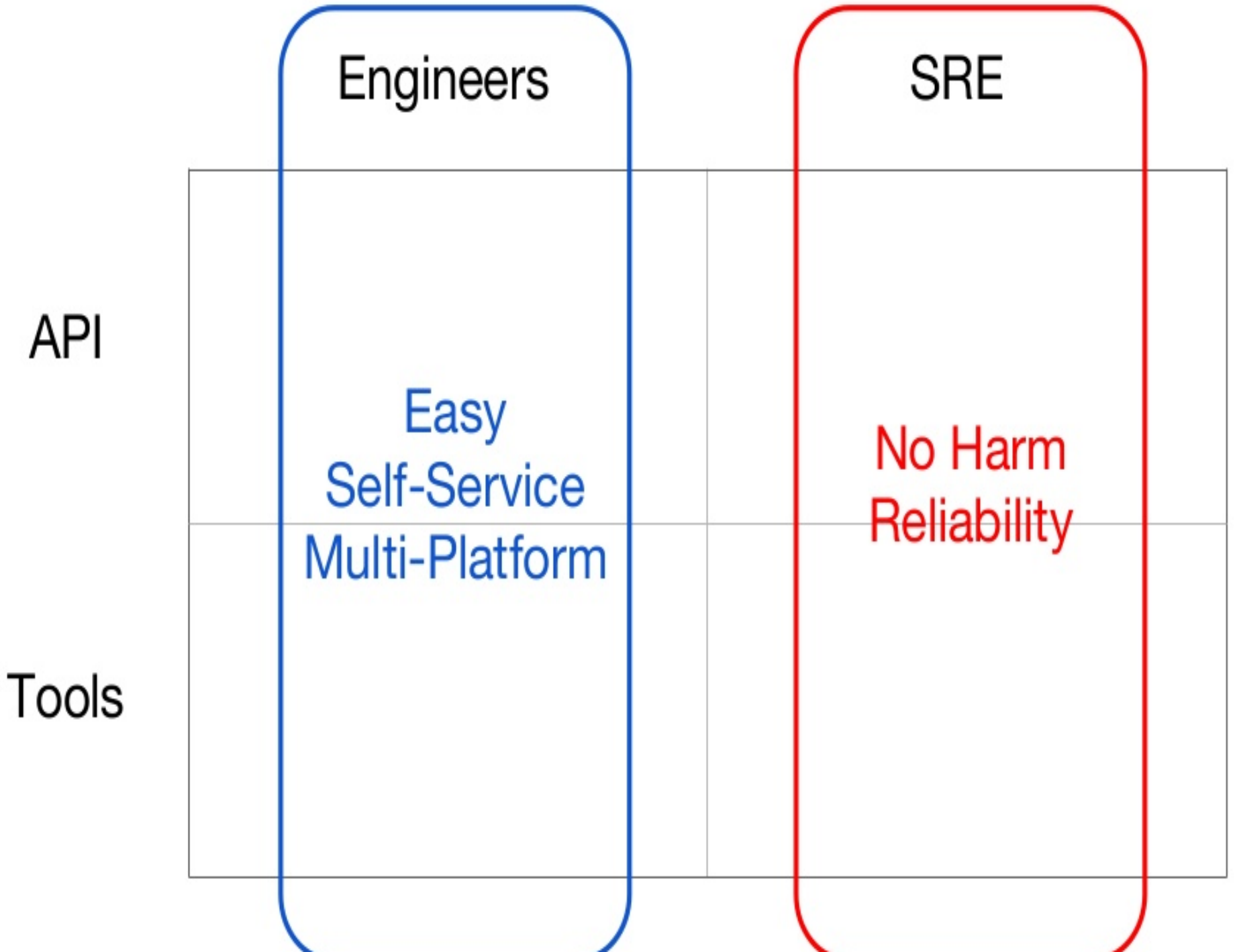
Goals:

Multi-Platform: Abstract out environment

Self-Service: Create and run Spark jobs super easily

Reliability: Prevent harm to infrastructure systems


Engineers
SRE
API
Tools


Engineers
SRE
API
Tools
Easy
Self-Service
Multi-Platform
No Harm
Reliability

	Engineers	SRE
API	• SCBuilder • Kafka dispersal	
Tools	• SparkPlug	

SCBuilder

Encapsulate cluster environment details

- Builder Pattern for SparkContext
- Incentive for users:
  - performance optimized (default can't pass 100GB)
  - debug optimized (history server, event logs)
  - don't need to ask around YARN, history servers, HDFS configs
- Best practices enforcement:
  - SRE approved CPU and memory settings
  - resource efficient serialization

Kafka Dispersal

Kafka as data sink of RDD result

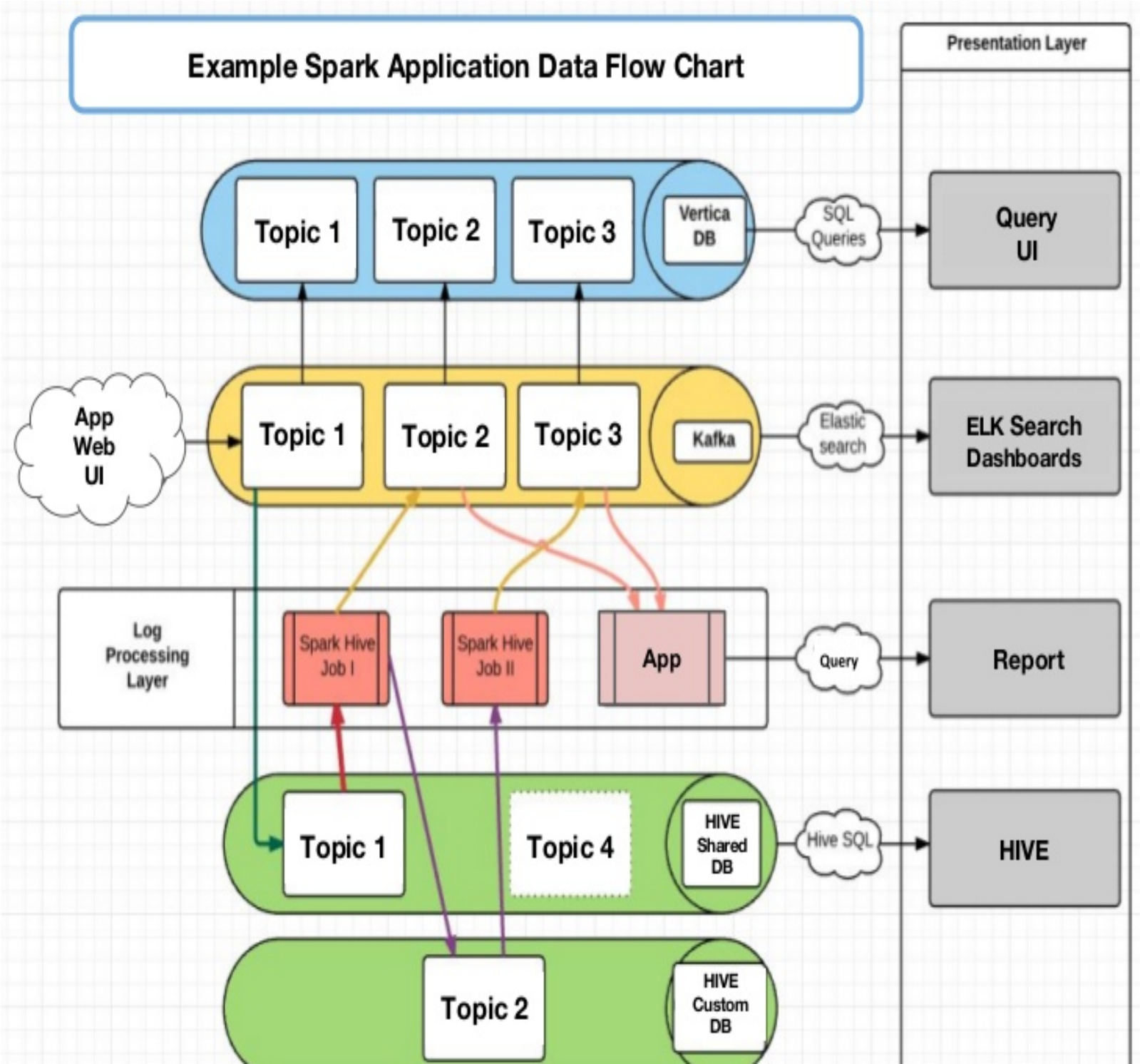
```
publish(data: RDD, topic: String, schemaId: Int, appId: String)
```

- Incentive for users:
  - RDD as first class citizen => parallelization
  - built-in HA
- Best practices enforcement:
  - rate limiting
  - message integrity by schema
  - bad messages tracking

SparkPlug

Kickstart job development

- A collection of popular job templates
  - Two commands to run the first job in Dev
- One use case per template
  - e.g. Ozzie + SparkSQL + Incremental processing
  - e.g. Incremental processing + Kafka dispersal
- Best Practices
  - built-in unit tests, test coverage, Jenkins
  - built-in Kafka, HDFS mocks


Example Spark Application Data Flow Chart
Presentation Layer
Topic 1
Topic 2
Topic 3
Vertica DB
SQL Queries
Query UI
App Web UI
Topic 1
Topic 2
Topic 3
Kafka
Elastic search
ELK Search Dashboards
Log Processing Layer
Spark Hive Job I
Spark Hive Job II
App
Query
Report
Topic 1
Topic 4
HIVE Shared DB
Hive SQL
HIVE
Topic 2
HIVE Custom DB


NUMBER OF EVENTS
View | Zoom Out | message
msg.event_name : SkillRecord (0) count per 1h | (789 hits)
100
80
60
40
20
0
00:00
03-03
00:00
03-05
00:00
03-07
EVENT NAME
1000
800
600
400
200
0
OperatorSession (789)
Missing field (0)
Other values (0)
Title: Job
Term
Count
Action
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 404
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 58
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 57
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 53
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 40
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 33
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 25
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 22
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 14
TERM_NAME_XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 6
Missing field 0
Other values 77
ENV
Term
Count
Action
production 412
staging 377
Missing field 0
Other values 0
TITLE
nkarpu 15%
mprase 15%
gguda 10%
TITLE
SPA01 44%
SPA04 51%
TITLE: WORKFLOW ENV NAME
Production_Training 52%
TITLE: WORKFLOW ENV ID
2 52%
5 32%
TITLE: LOCATION
A 49%
B 51%

	Engineers	SRE
API	• Geo-spatial processing • SCBuilder • Kafka dispersal	
Tools	• SparkPlug	

GeoSpatial UDF

Commonly used UDFs

within(trip_location, city_shape)

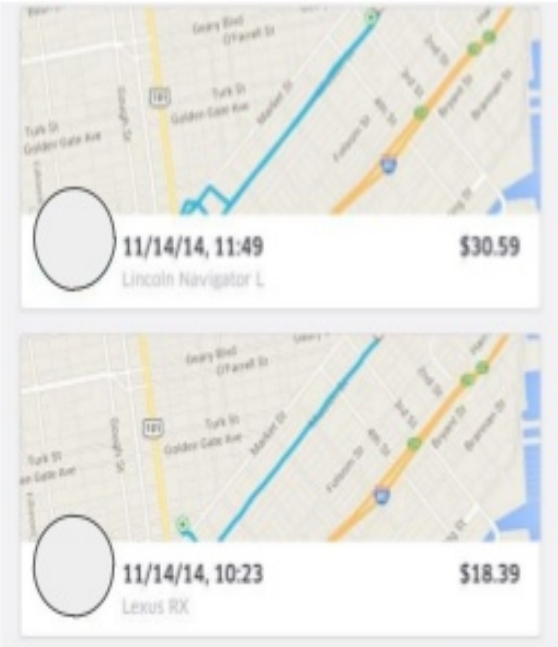
Find if a car is inside a city

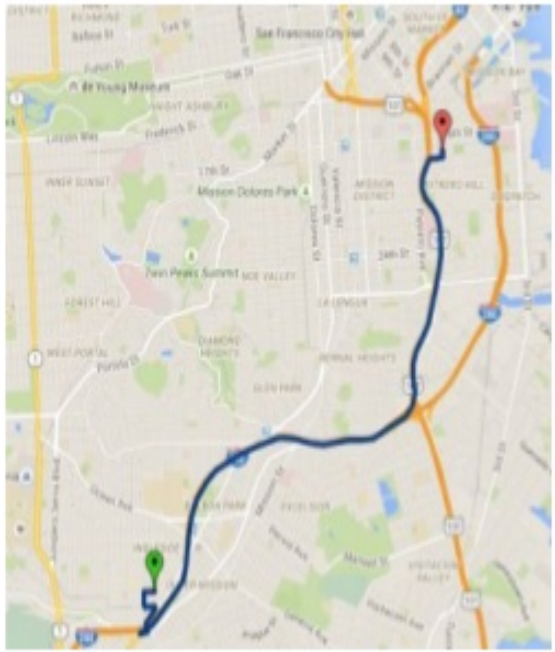
contains(geofence, auto_location)

Find all autos in one area

GeoSpatial UDF

Commonly used UDFs





overlaps(trip1, trip2)

Find trips that have similar routes

intersects(trip_location, gas_location)

Find all gas stations a trip route has passed by

Spatial Join

Common query at Uber

Objective: associate all trips with city_id for a single day.

```
SELECT trip.trip_id, city.city_id
FROM trip JOIN city
WHERE contains(city.city_shape, trip.start_location)
AND trip.datestr = '2016-06-07'
```

Spatial Join

Problem

It takes nearly ONE WEEK to run at Uber's data scale.

1. Spark does not have broadcast join optimization for non-equation join.

2. Not scalable, only one executor is used for cartesian join.

Spatial Join

Build a UDF to broadcast geo-spatial index

Spatial Join

Runtime Index Generation

1. Build Index

Index data is small but change often (city table)

Get fields from geo tables (city_id and city_shape)

Build QuadTree or RTree index at Spark Driver

Spatial Join

Executor Execution

2. Broadcast Index

UDF code is part of the Spark UDK jar.

⇒ get_city_id(location), returns city_id of a location

Use the broadcasted spatial index for fast spatial retrieval

Spatial Join

Runtime UDF Generation

3. Rewrite Query (2 mins only! compared to 1 week before)

```
SELECT
    trip_id,  get_city_id(start_location)
FROM
    trip
WHERE
    datestr = '2016-06-07'
```

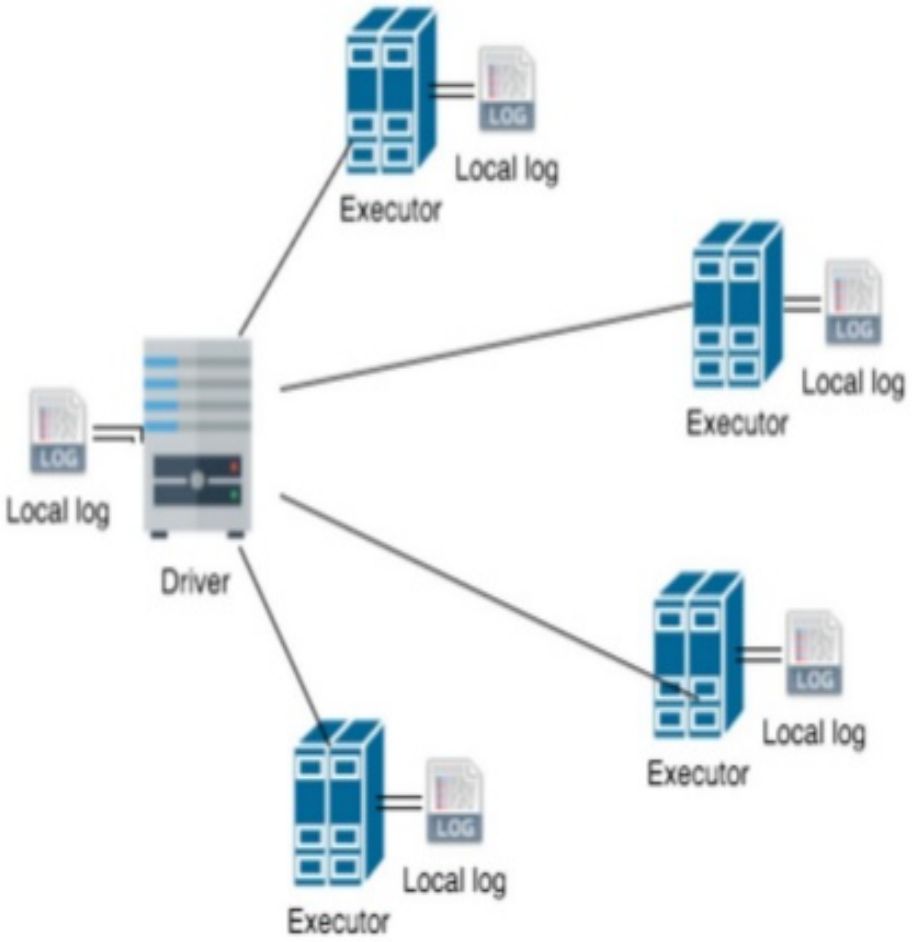
	Engineers	SRE
API	• Geo-spatial processing • SCBuilder • Kafka dispersal	
Tools	• SparkChamber • SparkPlug	

Spark Debugging

1. Tons of local log files across many machines.

2. Overall file size is huge and difficult to be handled by a single machine.

3. Painful for debugging, which log is useful?



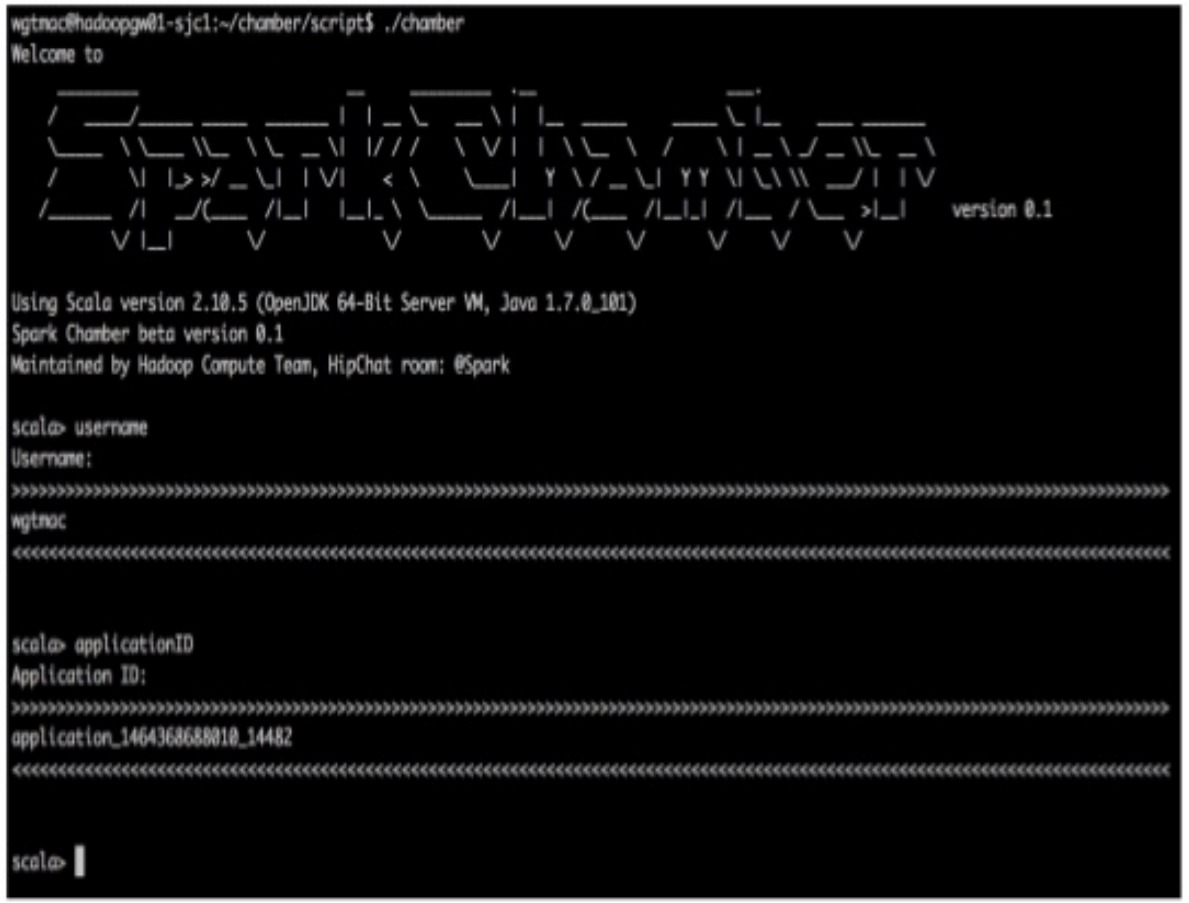
Spark Chamber

Distributed Log Debugger for Spark

Interactive

Extend Spark Shell by Hooks.

Easy to adopt for Spark developers.



Spark Chamber Session

```
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 0.1
      /_/

Using Scala version 2.10.5 (OpenJDK 64-Bit Server VM, Java 1.7.0_101)
Spark Chamber beta version 0.1
Maintained by Hadoop Compute Team, HipChat room: @Spark

scala> username
Username:
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
 my_user_name
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<


scala> applicationID
Application ID:
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
application_1464368688010_14482
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
```

```
scala> allApplicationIds
Recent Spark Applications:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
[    0]: application_1463943621508_147799    InspectorGadget            2016-05-24T17:42:56.237GMT
[    1]: application_1463943621508_148157    InspectorGadget            2016-05-24T17:42:56.773GMT
[    2]: application_1463943621508_147498    InspectorGadget            2016-05-24T17:28:01.696GMT
[    3]: application_1463943621508_148089    InspectorGadget            2016-05-24T17:42:57.023GMT
[    4]: application_1463943621508_147842    InspectorGadget            2016-05-24T17:42:59.347GMT
[    5]: application_1463943621508_147798    InspectorGadget            2016-05-24T17:43:01.423GMT
[    6]: application_1463943621508_147589    InspectorGadget            2016-05-24T17:28:36.430GMT
[    7]: application_1463943621508_147805    InspectorGadget            2016-05-24T17:42:57.561GMT
[    8]: application_1463943621508_147845    InspectorGadget            2016-05-24T17:42:56.266GMT
[    9]: application_1463943621508_147937    InspectorGadget            2016-05-24T17:42:59.013GMT
[   10]: application_1463943621508_148051    InspectorGadget            2016-05-24T17:42:55.401GMT
[   11]: application_1463943621508_148117    InspectorGadget            2016-05-24T17:42:55.583GMT
[   12]: application_1463943621508_148160    InspectorGadget            2016-05-24T17:42:59.121GMT
[   13]: application_1463943621508_147984    InspectorGadget            2016-05-24T17:43:00.954GMT
[   14]: application_1463943621508_147962    InspectorGadget            2016-05-24T17:43:00.844GMT
[   15]: application_1463943621508_148114    InspectorGadget            2016-05-24T17:42:56.078GMT
[   16]: application_1463943621508_148142    InspectorGadget            2016-05-24T17:43:11.641GMT
[   17]: application_1463943621508_148097    InspectorGadget            2016-05-24T17:43:00.286GMT
[   18]: application_1463943621508_147777    InspectorGadget            2016-05-24T17:28:38.652GMT
[   19]: application_1463943621508_148106    InspectorGadget            2016-05-24T17:42:55.861GMT
[   20]: application_1463943621508_148045    InspectorGadget            2016-05-24T17:42:59.113GMT
```

```
scala> setApplicationId("application_1463943621508_147842")

scala> hosts
Hosts (ExecutorId, HostName, LogWebUI):
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
[    0]: driver           hadoopworker348-sjc1      http://hadoopworker348-sjc1.pro
[    1]: executor(1)      hadoopworker347-sjc1      http://hadoopworker347-sjc1.pro
[    2]: executor(10)     hadoopworker313-sjc1      http://hadoopworker313-sjc1.pro
[    3]: executor(11)     hadoopcompute093-sjc1     http://hadoopcompute093-sjc1.pr
[    4]: executor(12)     hadoopworker490-sjc1      http://hadoopworker490-sjc1.pro
[    5]: executor(13)     hadoopworker373-sjc1      http://hadoopworker373-sjc1.pro
[    6]: executor(14)     hadoopworker255-sjc1      http://hadoopworker255-sjc1.pro
[    7]: executor(15)     hadoopworker542-sjc1      http://hadoopworker542-sjc1.pro
[    8]: executor(16)     hadoopworker549-sjc1      http://hadoopworker549-sjc1.pro
[    9]: executor(17)     hadoopworker311-sjc1      http://hadoopworker311-sjc1.pro
[   10]: executor(18)     hadoopworker437-sjc1      http://hadoopworker437-sjc1.pro
[   11]: executor(19)     hadoopworker288-sjc1      http://hadoopworker288-sjc1.pro
[   12]: executor(2)      hadoopcompute034-sjc1     http://hadoopcompute034-sjc1.pr
```

```
scala> firstException()
0th exception on ALL_HOSTS  :
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
(338)@hadoopcompute050-sjc1/executor(4) 16/05/28 01:49:54 ERROR executor.Executor: Exception in task 1.0 in stage 0.0 (TID 1)
java.lang.OutOfMemoryError: GC overhead limit exceeded
        at java.lang.Character.valueOf(Character.java:4389)
        at scala.runtime.BoxesRunTime.boxToCharacter(BoxesRunTime.java:58)
        at scala.util.Random$$anonfun$nextString$1.apply(Random.scala:88)
        at scala.collection.generic.GenTraversableFactory.fill(GenTraversableFactory.scala:91)
        at scala.util.Random.nextString(Random.scala:88)
        at com.uber.sparkplug.SparkSQLExample$$anonfun$main$1.apply$mcVI$sp(SparkSQLExample.scala:51)
        at com.uber.sparkplug.SparkSQLExample$$anonfun$main$1.apply(SparkSQLExample.scala:42)
        at com.uber.sparkplug.SparkSQLExample$$anonfun$main$1.apply(SparkSQLExample.scala:42)
        at scala.collection.Iterator$class.foreach(Iterator.scala:727)
        at org.apache.spark.InterruptibleIterator.foreach(InterruptibleIterator.scala:28)
        at org.apache.spark.rdd.RDD$$anonfun$foreach$1$$anonfun$apply$28.apply(RDD.scala:890)
        at org.apache.spark.rdd.RDD$$anonfun$foreach$1$$anonfun$apply$28.apply(RDD.scala:890)
        at org.apache.spark.SparkContext$$anonfun$runJob$5.apply(SparkContext.scala:1848)
        at org.apache.spark.SparkContext$$anonfun$runJob$5.apply(SparkContext.scala:1848)
        at org.apache.spark.scheduler.ResultTask.runTask(ResultTask.scala:66)
        at org.apache.spark.scheduler.Task.run(Task.scala:88)
        at org.apache.spark.executor.Executor$TaskRunner.run(Executor.scala:214)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor.java:1145)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(ThreadPoolExecutor.java:615)
        at java.lang.Thread.run(Thread.java:745)
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
```

```
scala> search("data count:")
Search result for data count::
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
[    0]: (309)@hadoopcompute050-sjc1/executor(4) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 2, data count: 5980
[    1]: (311)@hadoopcompute050-sjc1/executor(4) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 3, data count: 654245
[    2]: (314)@hadoopworker275-sjc1/executor(1) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 4, data count: 4539
[    3]: (316)@hadoopworker275-sjc1/executor(1) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 5, data count: 6777
[    4]: (321)@hadoopworker305-sjc1/executor(2) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 0, data count: 6434
[    5]: (323)@hadoopworker305-sjc1/executor(2) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 1, data count: 5432
[    6]: (328)@hadoopworker419-sjc1/executor(3) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 6, data count: 4887
[    7]: (330)@hadoopworker419-sjc1/executor(3) 16/05/28 01:49:05 INFO SparkChamberExample: Partition: 7, data count: 6012
[    8]: (342)@hadoopworker275-sjc1/executor(1) 16/05/28 01:49:55 INFO SparkChamberExample: Partition: 2, data count: 5980
[    9]: (344)@hadoopworker275-sjc1/executor(1) 16/05/28 01:49:55 INFO SparkChamberExample: Partition: 3, data count: 654245
[   10]: (408)@hadoopworker419-sjc1/executor(3) 16/05/28 01:50:44 INFO SparkChamberExample: Partition: 2, data count: 5980
[   11]: (410)@hadoopworker419-sjc1/executor(3) 16/05/28 01:50:44 INFO SparkChamberExample: Partition: 3, data count: 654245
[   12]: (480)@hadoopworker305-sjc1/executor(2) 16/05/28 01:51:45 INFO SparkChamberExample: Partition: 2, data count: 5980
[   13]: (482)@hadoopworker305-sjc1/executor(2) 16/05/28 01:51:45 INFO SparkChamberExample: Partition: 3, data count: 654245
[   14]: (923)@hadoopcompute094-sjc1/executor(2) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 6, data count: 4887
[   15]: (925)@hadoopcompute094-sjc1/executor(2) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 7, data count: 6012
[   16]: (941)@hadoopworker303-sjc1/executor(4) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 0, data count: 6434
[   17]: (943)@hadoopworker303-sjc1/executor(4) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 1, data count: 5432
[   18]: (952)@hadoopworker456-sjc1/executor(1) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 2, data count: 5980
[   19]: (954)@hadoopworker456-sjc1/executor(1) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 3, data count: 654245
[   20]: (961)@hadoopworker490-sjc1/executor(3) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 4, data count: 4539
[   21]: (963)@hadoopworker490-sjc1/executor(3) 16/05/28 01:52:47 INFO SparkChamberExample: Partition: 5, data count: 6777
[   22]: (983)@hadoopworker303-sjc1/executor(4) 16/05/28 01:54:36 INFO SparkChamberExample: Partition: 2, data count: 5980
[   23]: (985)@hadoopworker303-sjc1/executor(4) 16/05/28 01:54:36 INFO SparkChamberExample: Partition: 3, data count: 654245
[   24]: (1059)@hadoopworker490-sjc1/executor(3) 16/05/28 01:56:25 INFO SparkChamberExample: Partition: 2, data count: 5980
[   25]: (1061)@hadoopworker490-sjc1/executor(3) 16/05/28 01:56:25 INFO SparkChamberExample: Partition: 3, data count: 654245
[   26]: (1139)@hadoopworker341-sjc1/executor(6) 16/05/28 01:57:11 INFO SparkChamberExample: Partition: 2, data count: 5980
[   27]: (1141)@hadoopworker341-sjc1/executor(6) 16/05/28 01:57:11 INFO SparkChamberExample: Partition: 3, data count: 654245
```

Spark Chamber

Distributed Log Debugger for Spark

Features

1. Get all recent Spark Application IDs.

2. Get first exception, all exceptions grouped by types sorted by time, etc.

3. Display CPU, memory, I/O metrics.

4. Dive into a specific driver/executor/machine

5. Search

Spark Chamber

Distributed Log Debugger for Spark

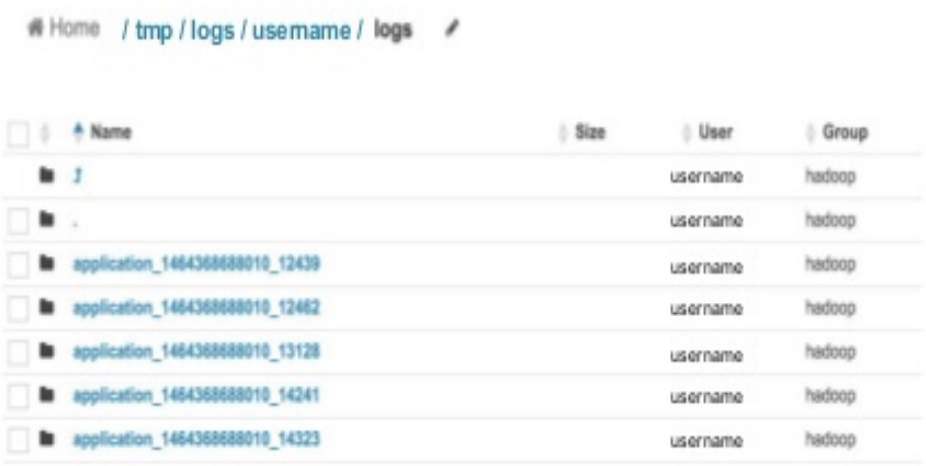
Security

Developer mode: debug developer's own Spark job.

SRE mode: view and check all users' Spark job information.

Spark Chamber

Enable Yarn Log Aggregation



YARN aggregates log files on HDFS

All application IDs of the same user are under same place.

Files are named after host names

One machine has one log file, regardless of # executors on that machine.

Spark Chamber

Use Spark to debug Spark

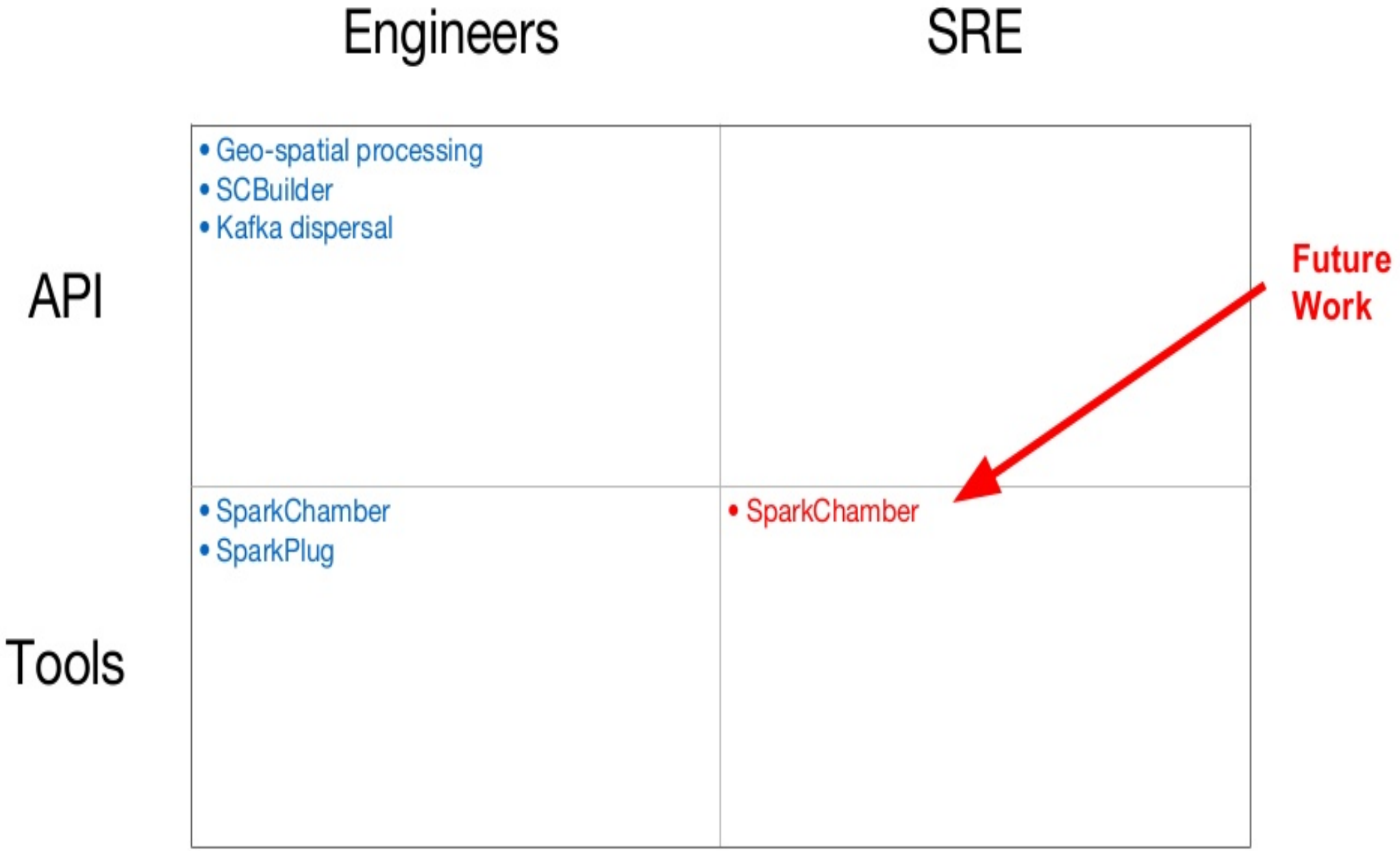
Extend the Spark Shell by Hooks:

1. For ONE application Id, distribute log files to different executors.

2. Extract each lines and save into DataFrame.

3. Sort log dataframe by time and hostname.

4. Retrieve target log via SparkSQL DataFrame APIs.


Engineers
SRE
API
Tools
• Geo-spatial processing
• SCBuilder
• Kafka dispersal
• SparkChamber
• SparkPlug
• SparkChamber
Future Work

Spark Chamber

SRE version - Cluster wide insights

- Dimensions - Jobs
  - All
  - Single team
  - Single engineer
- Dimensions - Time
  - Last month, week, day
- Dimensions - Hardware
  - Specific rack, pod

Spark Chamber

SRE version - Analytics and Machine Learning

- Analytics
  - Resource auditing
  - Data access auditing
- Machine Learning
  - Failures diagnostics
  - Malicious jobs detection
  - Performance optimization

Future Work

	Engineers	SRE
API	• Geo-spatial processing • SCBuilder • Kafka dispersal • Hive table registration (Didn't cover today) • Incremental processing (Didn't cover today) • Debug logging • Metrics • Configurations • Data Freshness	• Resource usage
Tools	• SparkChamber • SparkPlug • Unit testing (Didn't cover today) • Oozie integration (Didn't cover today)	• SparkChamber • Resource usage auditing • Data access auditing • Machine learning on jobs

SPARK: INTERACTIVE TO PRODUCTION

Today, Tuesday, June 7
4:50 PM – 5:20 PM
Room: Ballroom B

Dara Adib, Uber

Locality Sensitive Hashing by Spark

Tomorrow, Wednesday, June 8
5:25 PM – 5:55 PM
Room: Imperial

Alain Rodriguez, Fraud Platform, Uber
Kelvin Chu, Hadoop Platform, Uber

Thank you