Data Engineering with Apache Spark

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Intro, Slides And Code

- Slides: https://github.com/medale/prez-spark-dataengineering/blob/master/presentation/SparkDataEngineering.pdf
- Spark Data Engineering Code Examples: https://github.com/medale/prez-spark-dataengineering

Data Science Mission

- ID malicious GitHub Pull Requests?
- Source: https://www.gharchive.org/

Data Engineering Mission

- https://www.gharchive.org/
  - 2/12/2011-12/31/2014 Timeline API (now deprecated).
  - From 1/1/2015 to now Events API.
  - Since 2015: About 20-40MB/hour * 37900 hours ~1TB
- Store: Fast, time-based access when specifying yyyy, mm, dd, hh (or prefix combination)
- Side effect: Learn more about Spark batch processing

Data engineering

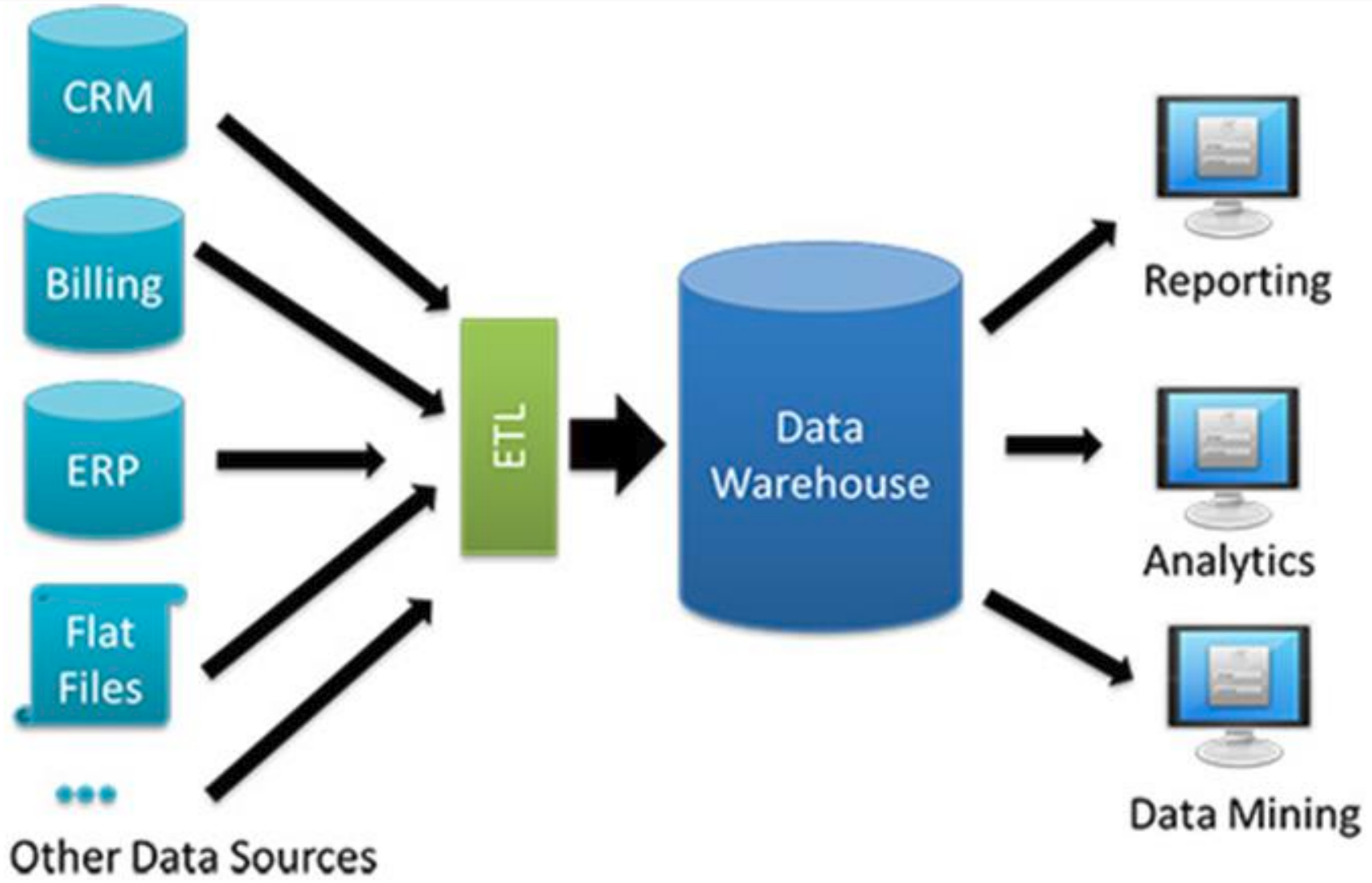


Figure 1: Swiss Army Knife for Big Data

Figure 2: Laptop

Apache Spark: Data engineering for larger dataset (Vertical Scaling)

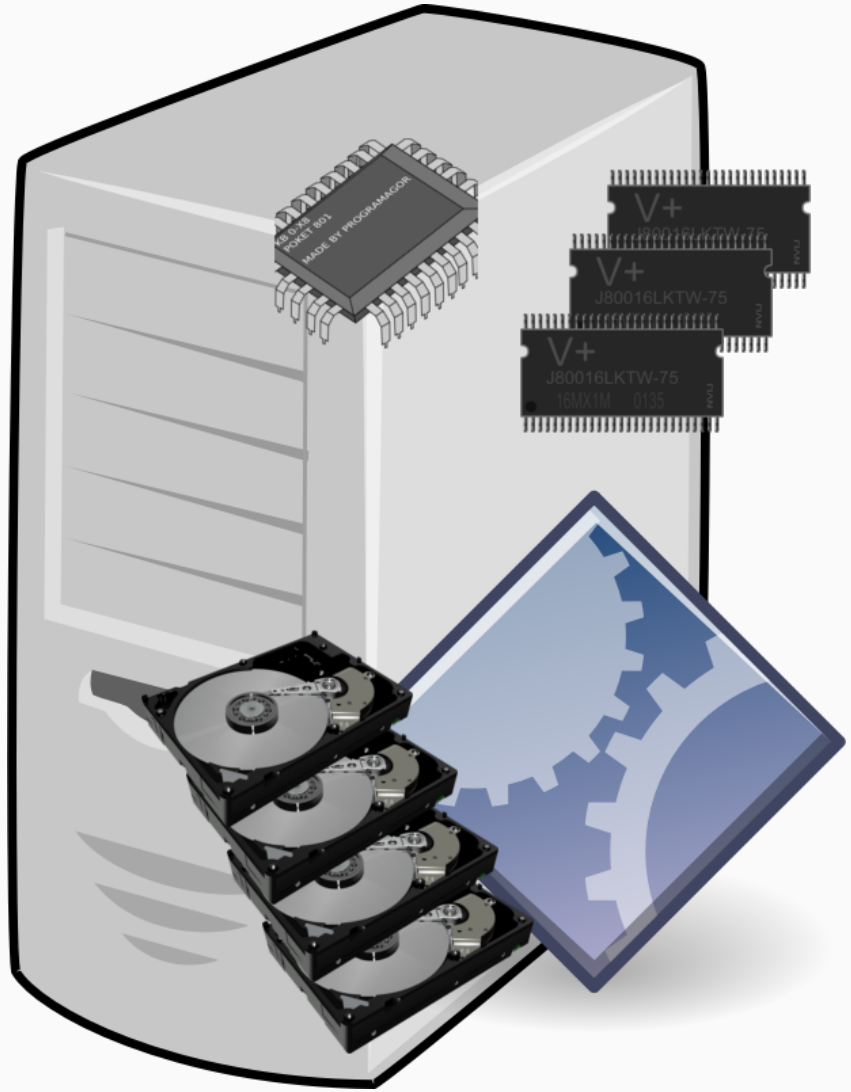
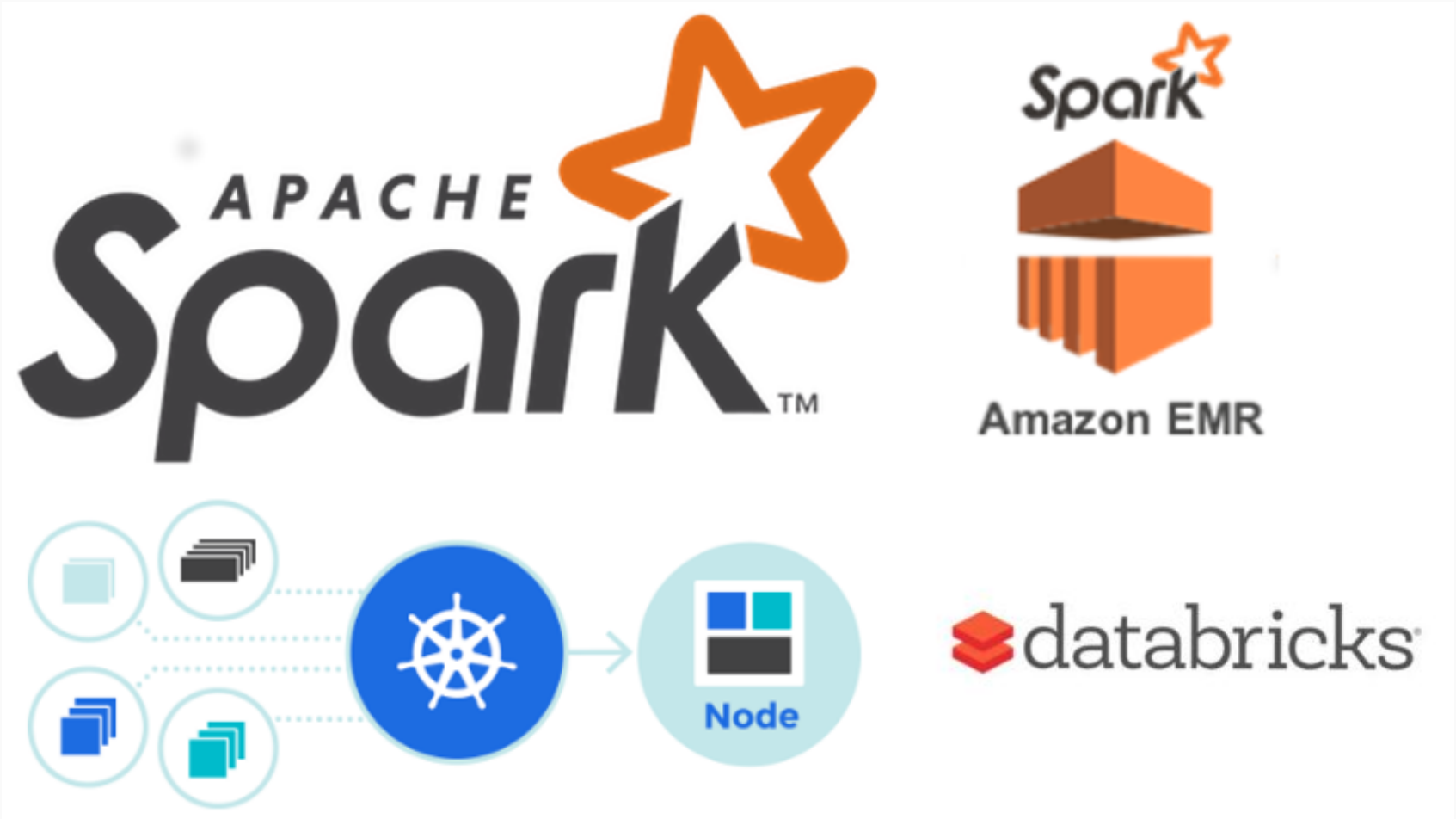


Figure 3: Beefed-up Server

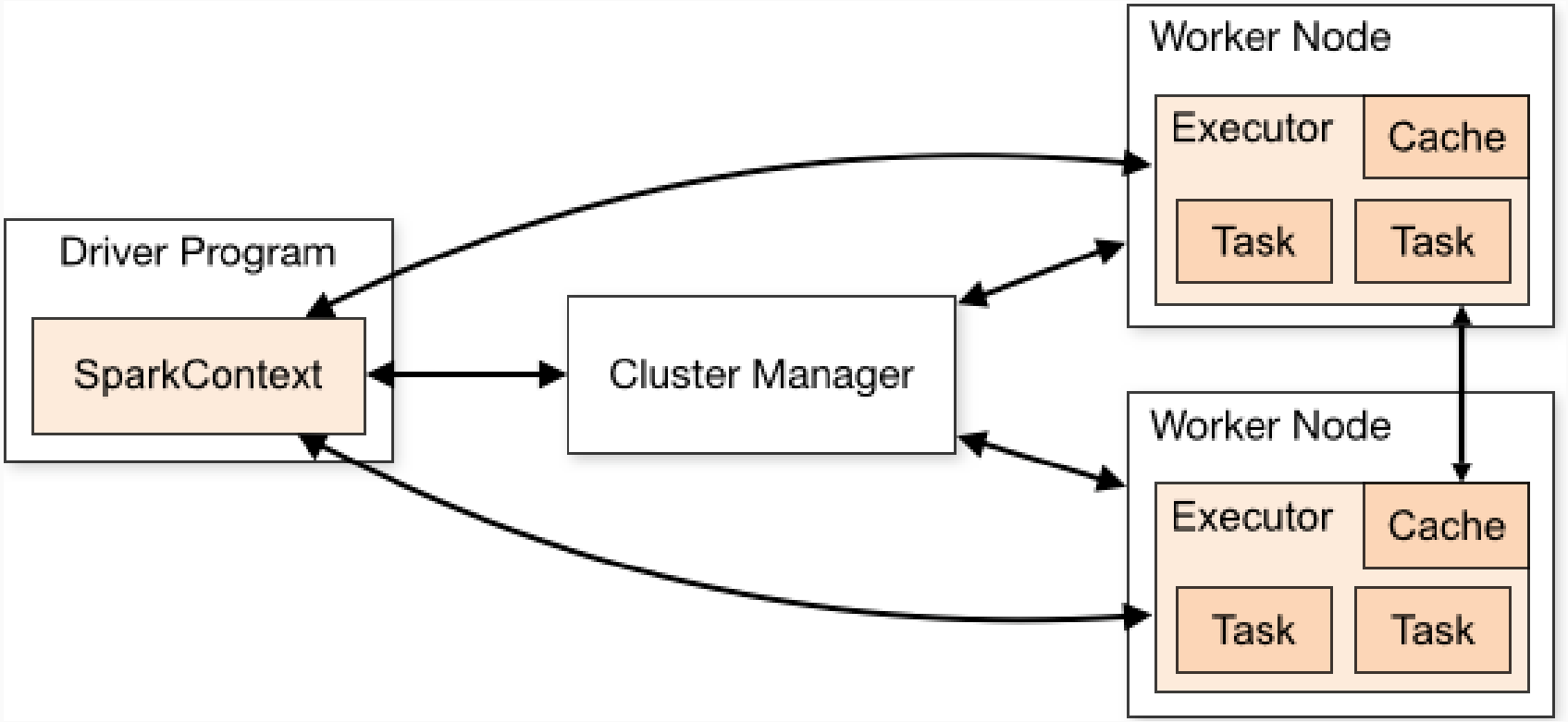
Apache Spark: Data engineering for large datasets (Horizontal Scaling)

Figure 4: Multiple cooperating Servers

Cluster Manager - Manage cores, memory, special capabilities



Anatomy of a Spark Application



Source: Apache Spark website

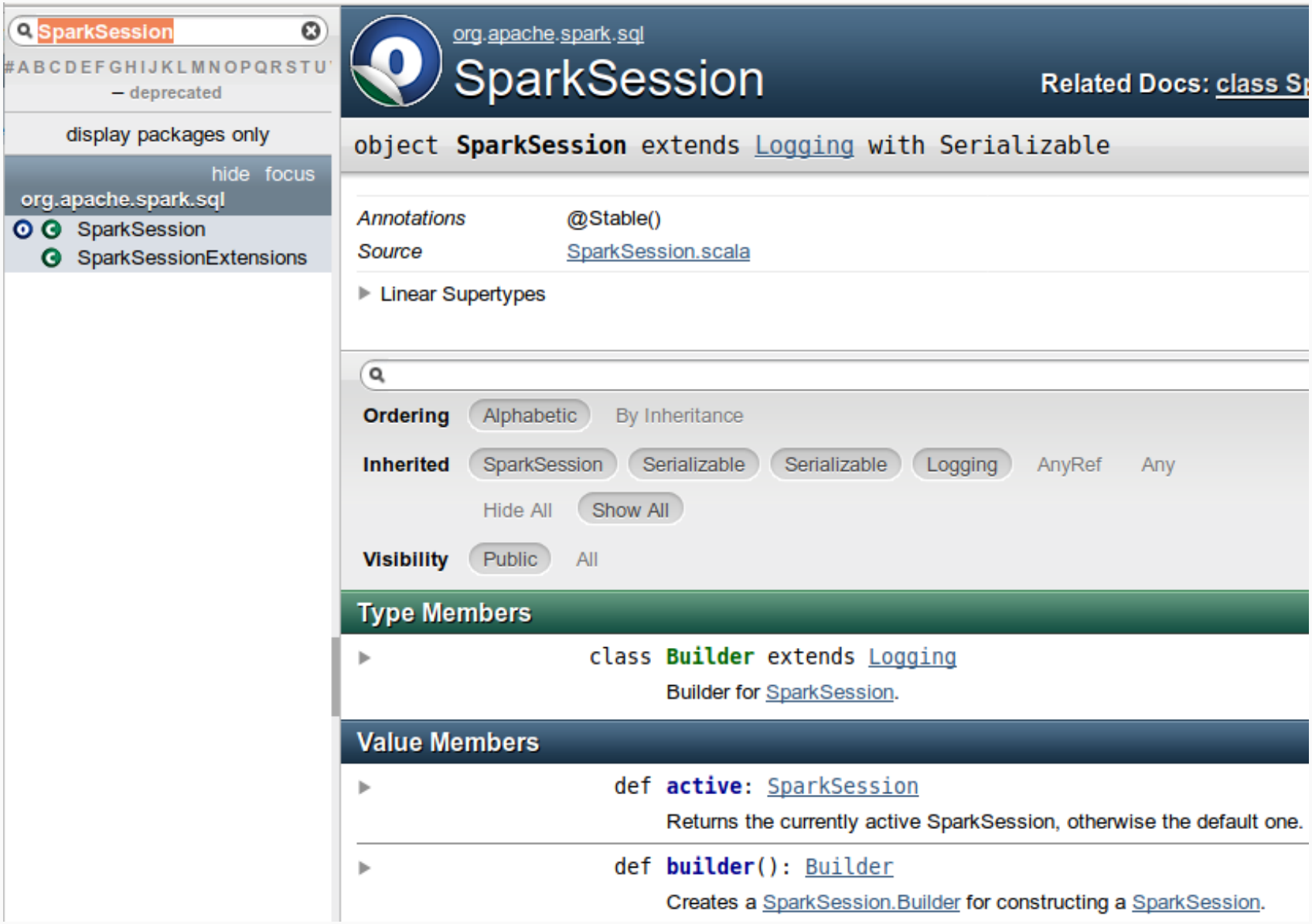
Hello, Spark World!

```
import org.apache.spark.sql.SparkSession

object HelloSparkWorld {

  val RecordsUrl = "file:///datasets/github/data"

  def process(spark: SparkSession): (Long,Long) = {
    val records = spark.read.json(RecordsUrl)
    val totalEventCount = records.count()
    val prs = records.where(records("type") === "PullRequestEvent")
    val pullRequestEventCount = prs.count()
    (totalEventCount, pullRequestEventCount)
  }

  def main(args: Array[String]): Unit = {
    val spark = SparkSession.builder().appName("HelloSparkWorld").getOrCreate()
    val (total, prs) = process(spark)
    println(s"Total events: ${total}, pr events: ${prs}.")
    spark.stop()
  }
}
```

SparkSession - Gateway to the Cluster

```
def main(args: Array[String]): Unit = {

    val spark = SparkSession.builder().
        appName("HelloSparkWorld").
        getOrCreate()
    ...
    spark.stop()
```

API - SparkSession Object



API - SparkSession Class, DataFrame = Dataset[Row]

```
//spark.read - DataFrameReader
val records: DataFrame =
   spark.read.json(RecordsUrl)
```

spark.read: DataFrameReader - Input

- csv
- json
- jdbc
- parquet
- text - DataFrame with “value” column
- textFile - Dataset[String]
- Third party:
  - https://spark-packages.org: Avro, Redshift, MongoDB...
  - Spark Cassandra Connector (DataStax github)

DataFrame Schema

```
scala> records.printSchema
root
 |-- actor: struct (nullable = true)
 |    |-- display_login: string (nullable = true)
 |    |-- id: long (nullable = true)
   ...
 |-- created_at: string (nullable = true)
 |-- id: string (nullable = true)
 |-- payload: struct (nullable = true)
 |    |-- comment: struct (nullable = true)
 |    |    |-- body: string (nullable = true)
   ...
 |-- public: boolean (nullable = true)
 |-- repo: struct (nullable = true)
 |    |-- id: long (nullable = true)
 |    |-- url: string (nullable = true)
 |-- type: string (nullable = true)
```

GitHub Event Data

```
cd /datasets/github/data
wget http://data.gharchive.org/2019-04-28-0.json.gz
wget http://data.gharchive.org/2019-04-28-1.json.gz
wget http://data.gharchive.org/2019-04-28-13.json.gz
```

Preliminary Exploration

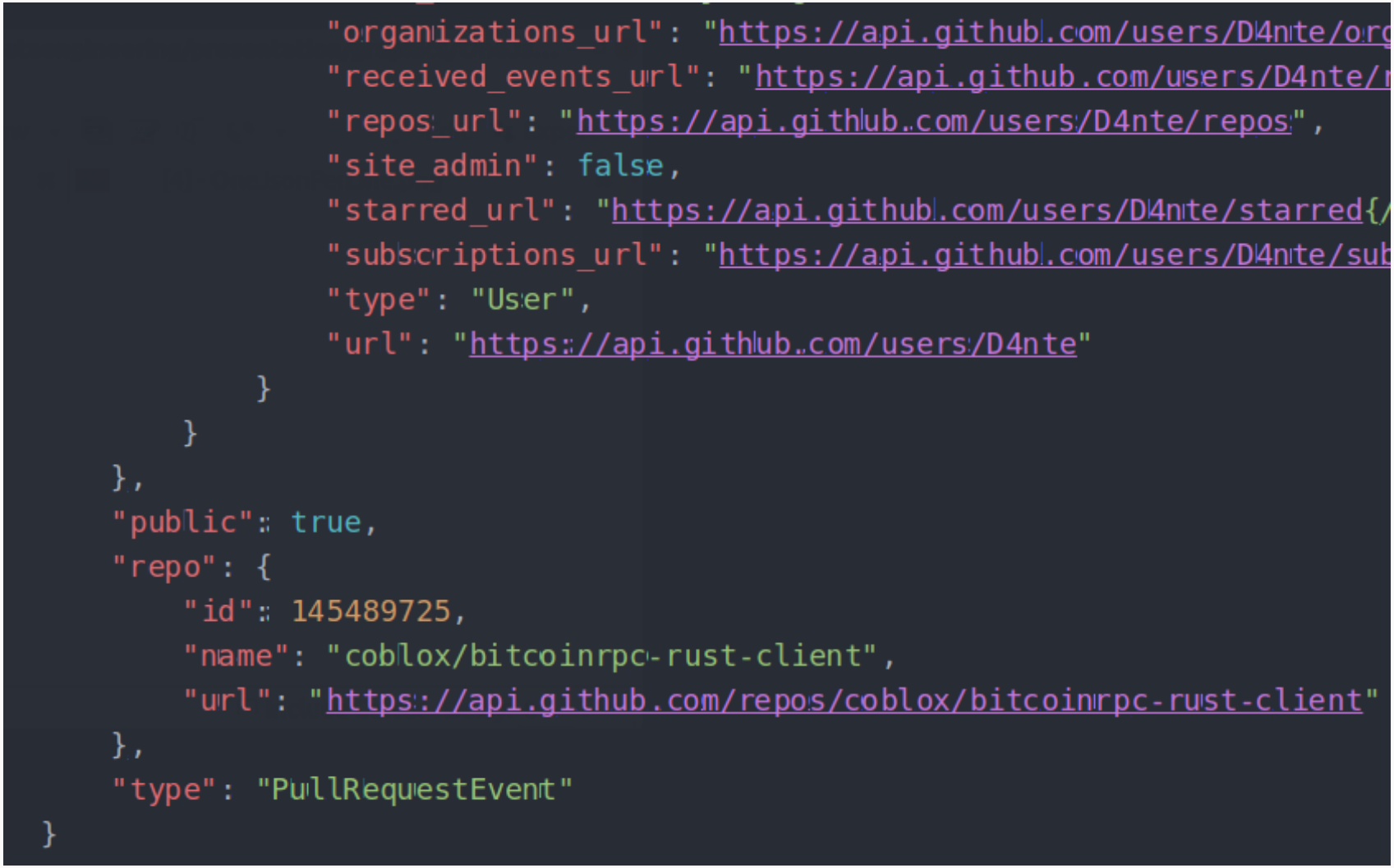
```
# creates 2019-04-28-0.json
gunzip 2019-04-28-0.json.gz

# 95865
wc -l 2019-04-28-0.json
```

Editor: one JSON per line

Pretty Print One Record?

```
# default 1000 lines - xaa, xab...
split 2019-04-28-0.json
mkdir temp
cd temp

# 1 file per line
split -1 ../xaa

# xac's a PullRequestEvent
python -m json.tool < xac > pretty.json
```

Open pretty.json in Atom - PullRequestEvent



Starting Spark Standalone Cluster Manager

```
# Start on master
$SPARK_HOME/sbin/start-master.sh --host 192.168.1.232

# Start one or more workers
$SPARK_HOME/sbin/start-slave.sh spark://192.168.1.232:7077
```

Spark Standalone Cluster Manager UI - idle

Spark Master at spark://192.168.1.230:7077

URL: spark://192.168.1.230:7077
Alive Workers: 1
Cores in use: 8 Total, 0 Used
Memory in use: 30.4 GB Total, 0.0 B Used
Applications: 0 Running, 0 Completed
Drivers: 0 Running, 0 Completed
Status: ALIVE

Workers (1)

Worker Id	Address	State	Cores	Memory
worker-20190430220608-192.168.1.230-37667	192.168.1.230:37667	ALIVE	8 (0 Used)	30.4 GB (0.0 B Used)

Running Applications (0)

Application ID	Name	Cores	Memory per Executor	Submitted Time	User	State	Duration

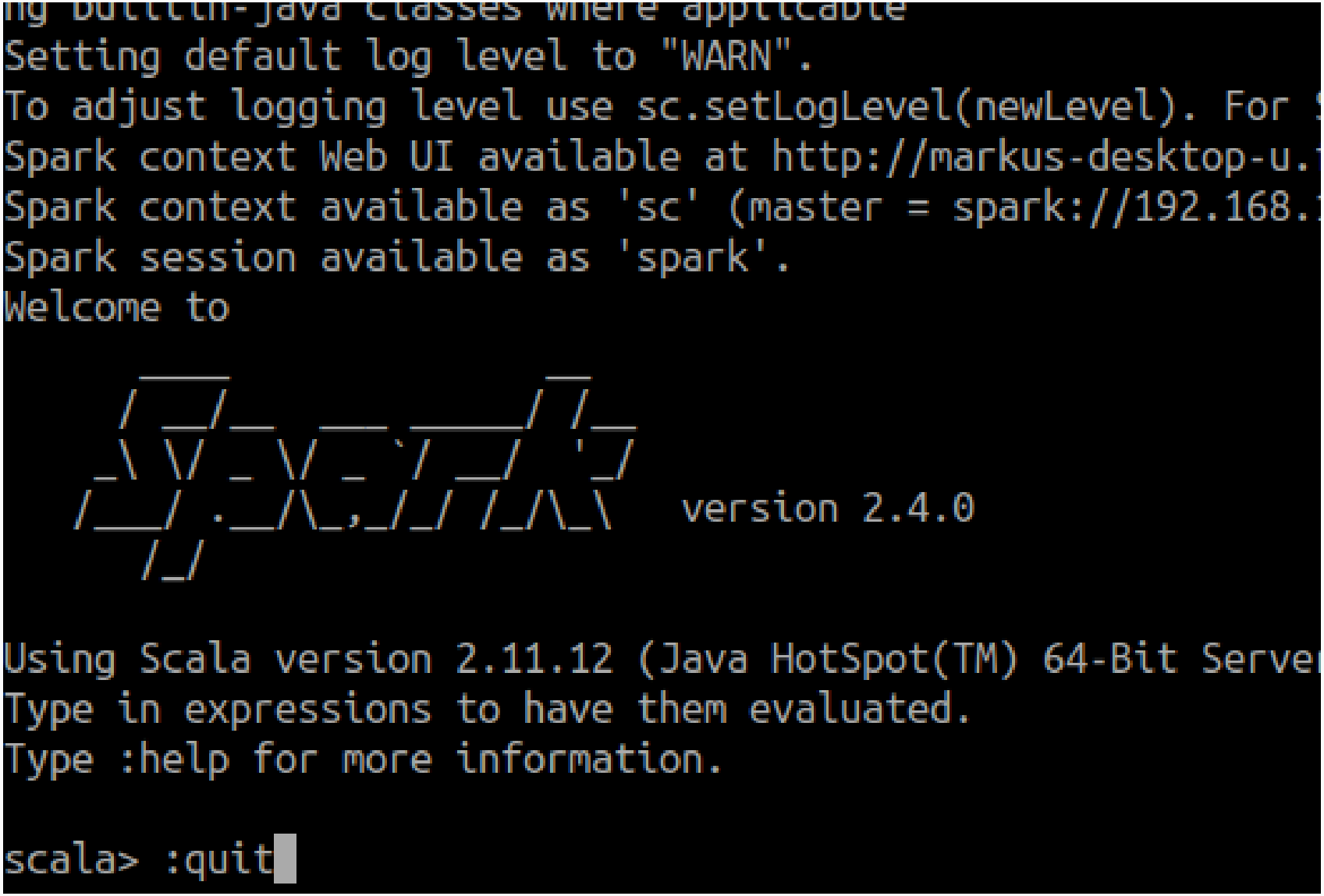
Completed Applications (0)

Application ID	Name	Cores	Memory per Executor	Submitted Time	User	State	Duration

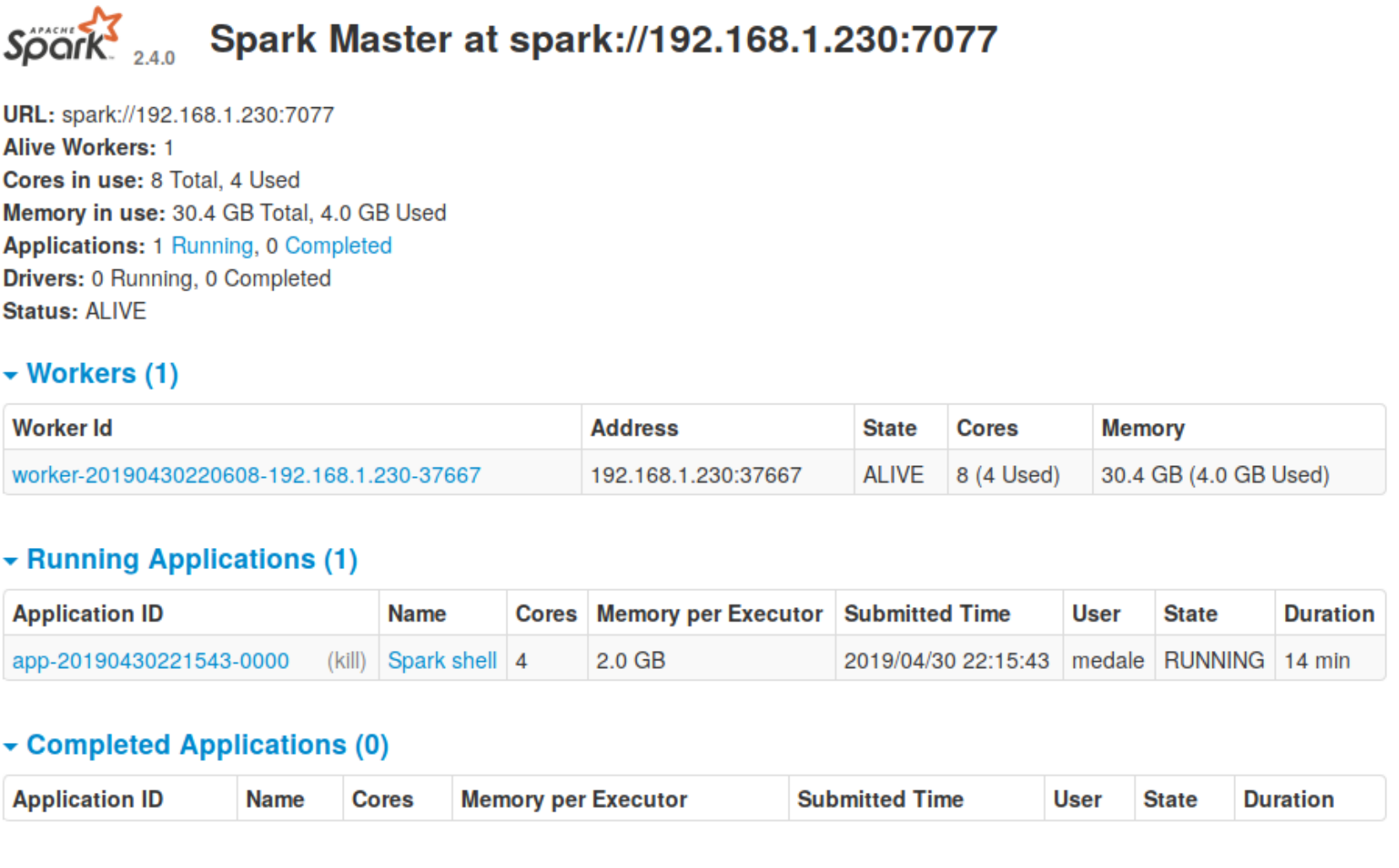
Running spark-shell in cluster

```
spark-shell --master spark://192.168.1.232:7077 \
 --driver-memory 1g \
 --executor-memory 2g \
 --total-executor-cores 4 \
 --executor-cores 2 \
 --jars /tmp/dataset-0.9.0-SNAPSHOT-fat.jar
```

Spark Shell Startup



Spark Standalone Cluster Manager - 1 running application



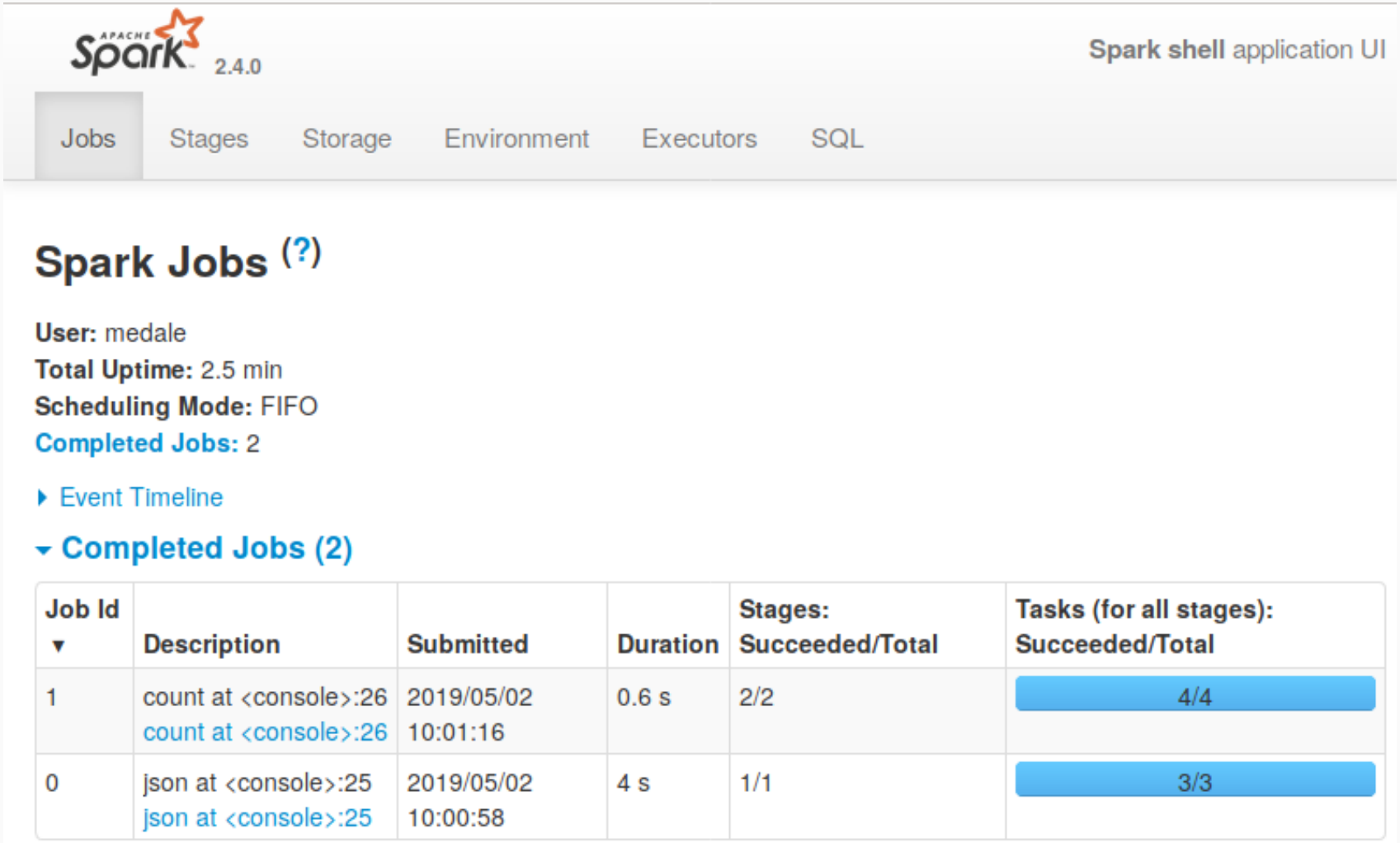
spark-shell auto-imports

```
scala> :imports
 1) import org.apache.spark.SparkContext._
 2) import spark.implicits._
 3) import spark.sql
 4) import org.apache.spark.sql.functions._
```

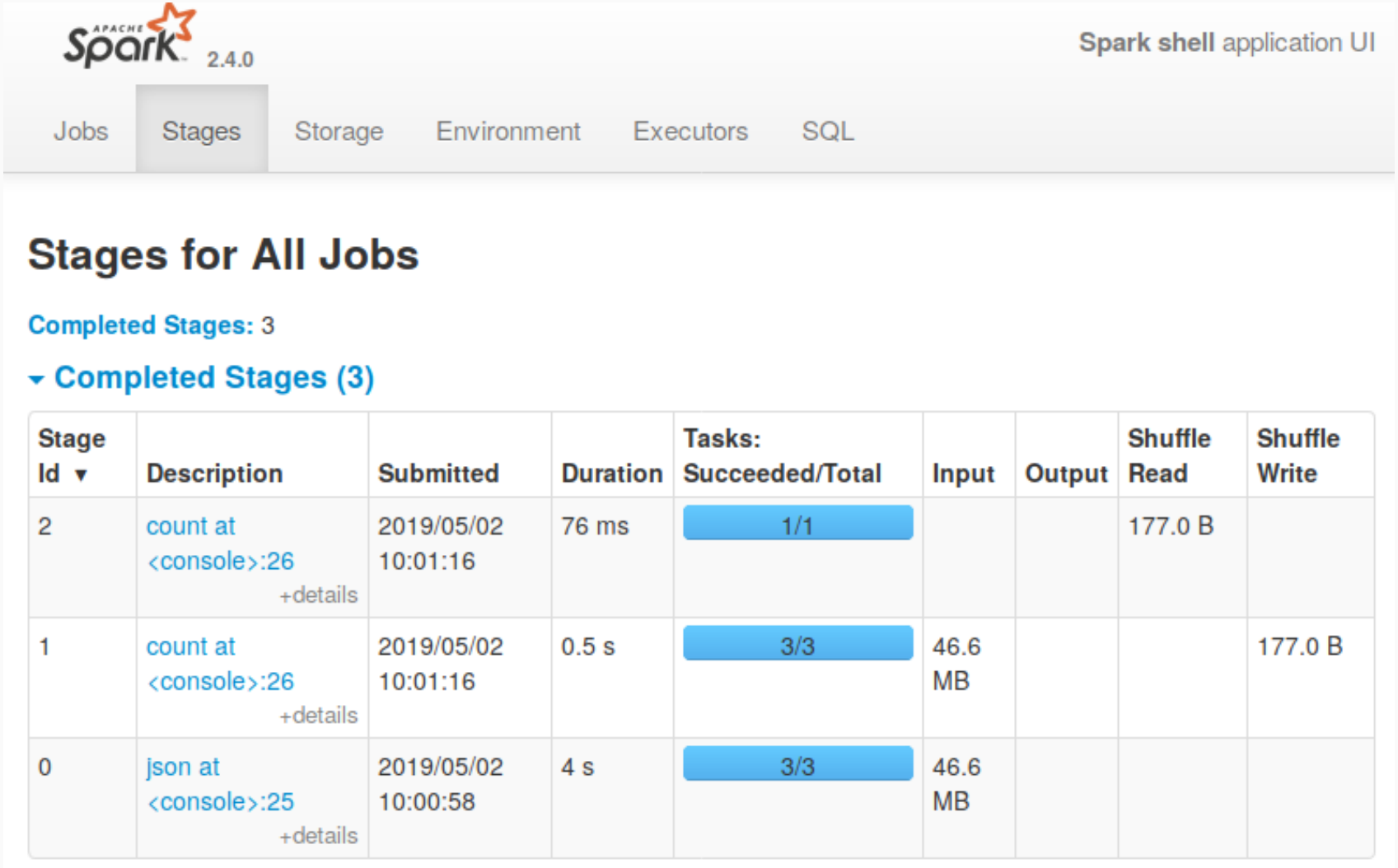
Data Exploration - schema and counting

```
val RecordsUrl = "file:///datasets/github/data"
val records = spark.read.json(RecordsUrl)
records.printSchema
//...
// |-- repo: struct (nullable = true)
// |    |-- id: long (nullable = true)
// |    |-- name: string (nullable = true)
// |    |-- url: string (nullable = true)
// |-- type: string (nullable = true)

records.count()
//147,374
```

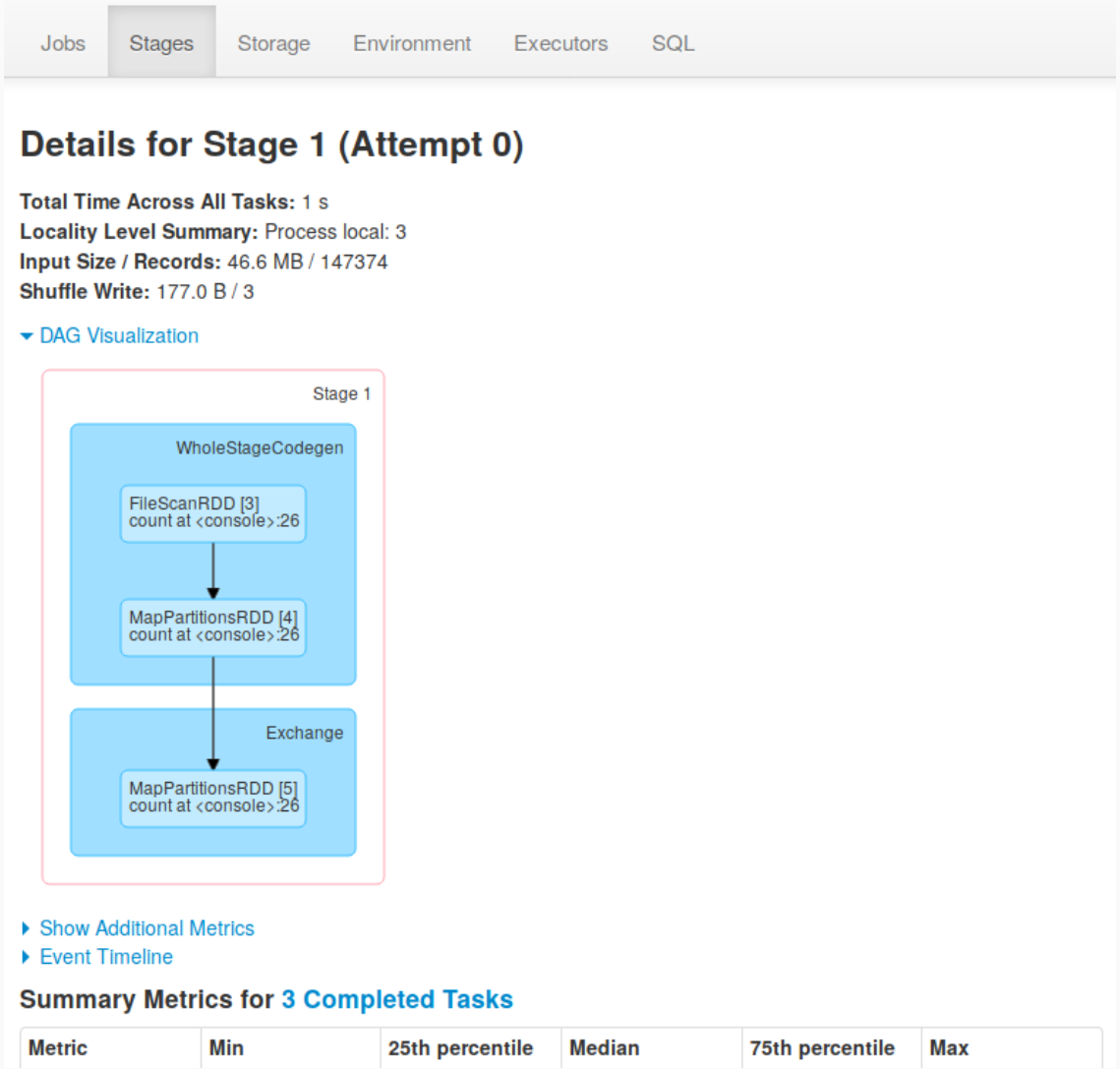
Spark Application UI - Jobs, stages, tasks



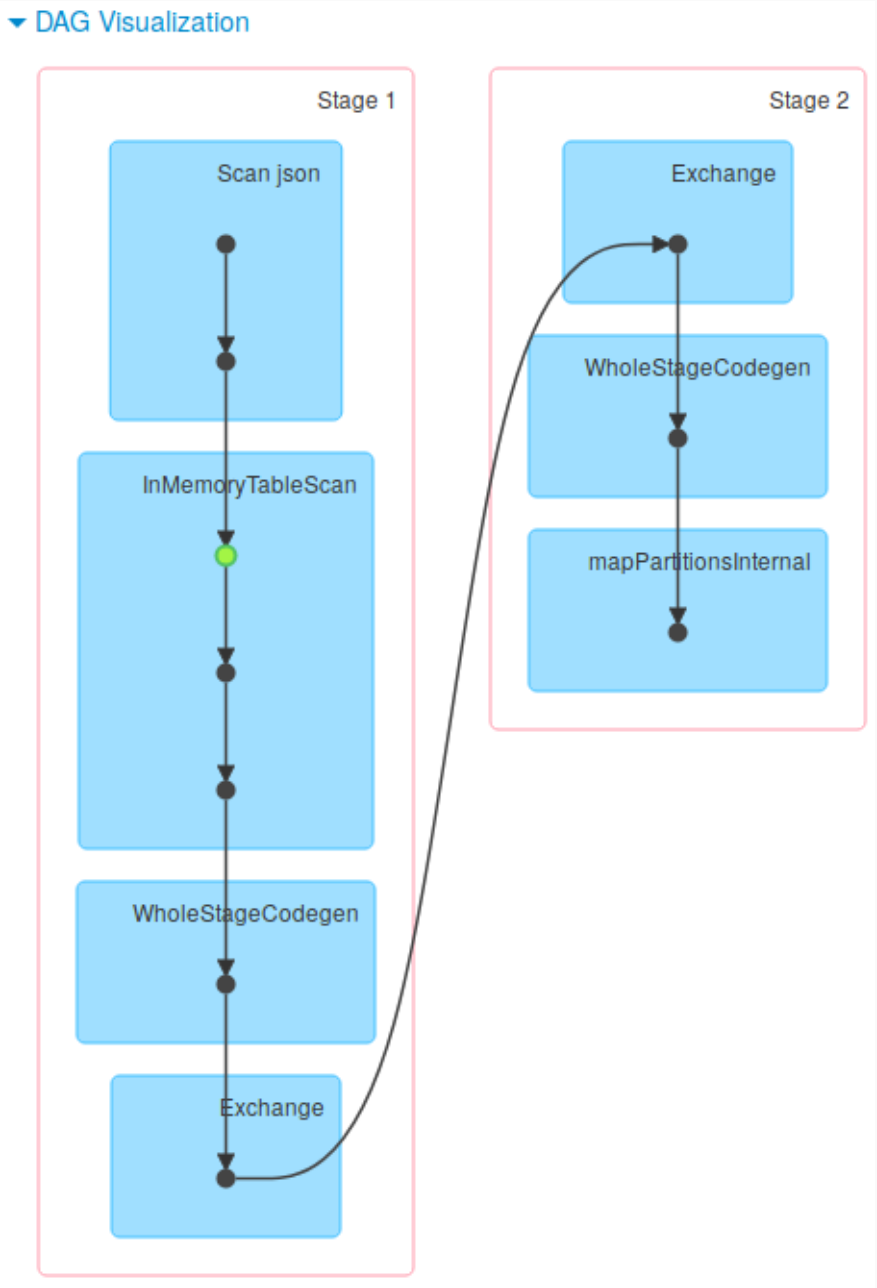
Spark Application UI - Stages



Spark Application UI - Stage details



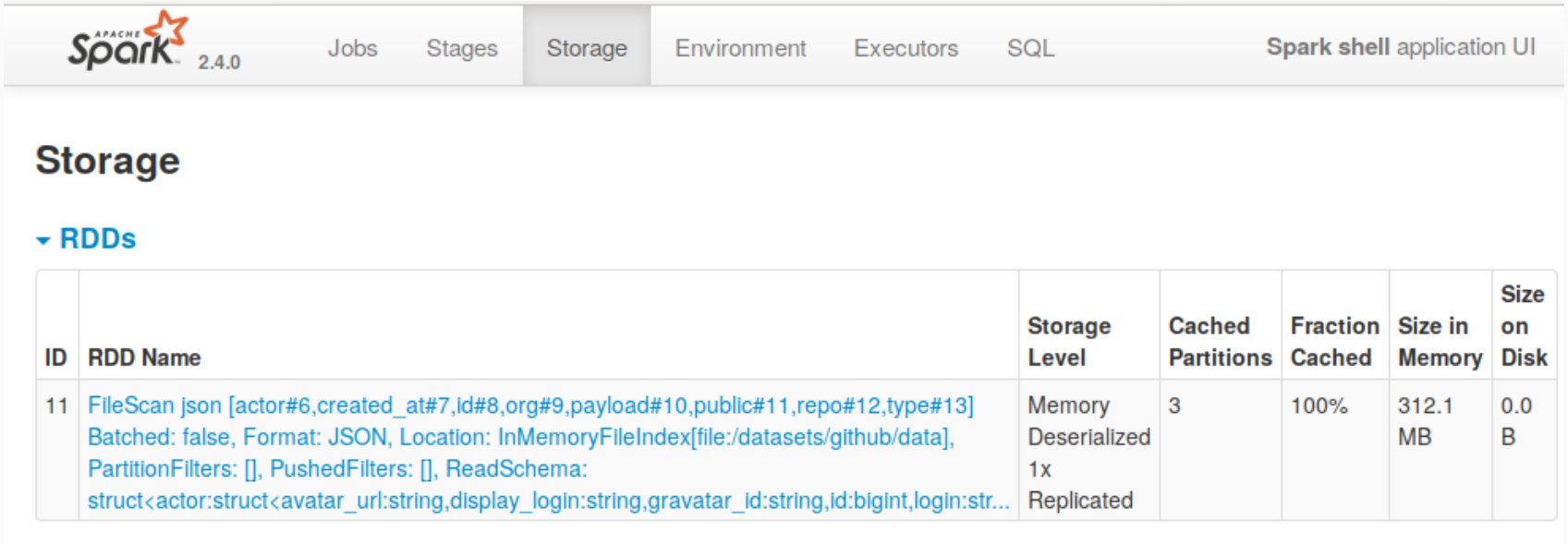
Job 1 - Stages 1 and 2 DAG



One Job = n lazy transformations, 1 action

```
//job0 (read twice - once for schema, once for count)
val records = spark.read.json(RecordsUrl)
//lazy transformation
records.cache()
//action 1 - end of job 1
records.count()
records.printSchema

//2 lazy transformations - immutable datasets
val types = records.select("type")
val distinctTypes = types.distinct()

//one eager action - job 2
distinctTypes.show()
+--------------------+
|                type|
+--------------------+
|           PushEvent|
...
|    PullRequestEvent|
+--------------------+
```

Spark Application UI - Storage (caching)



Default file system/file system URLs

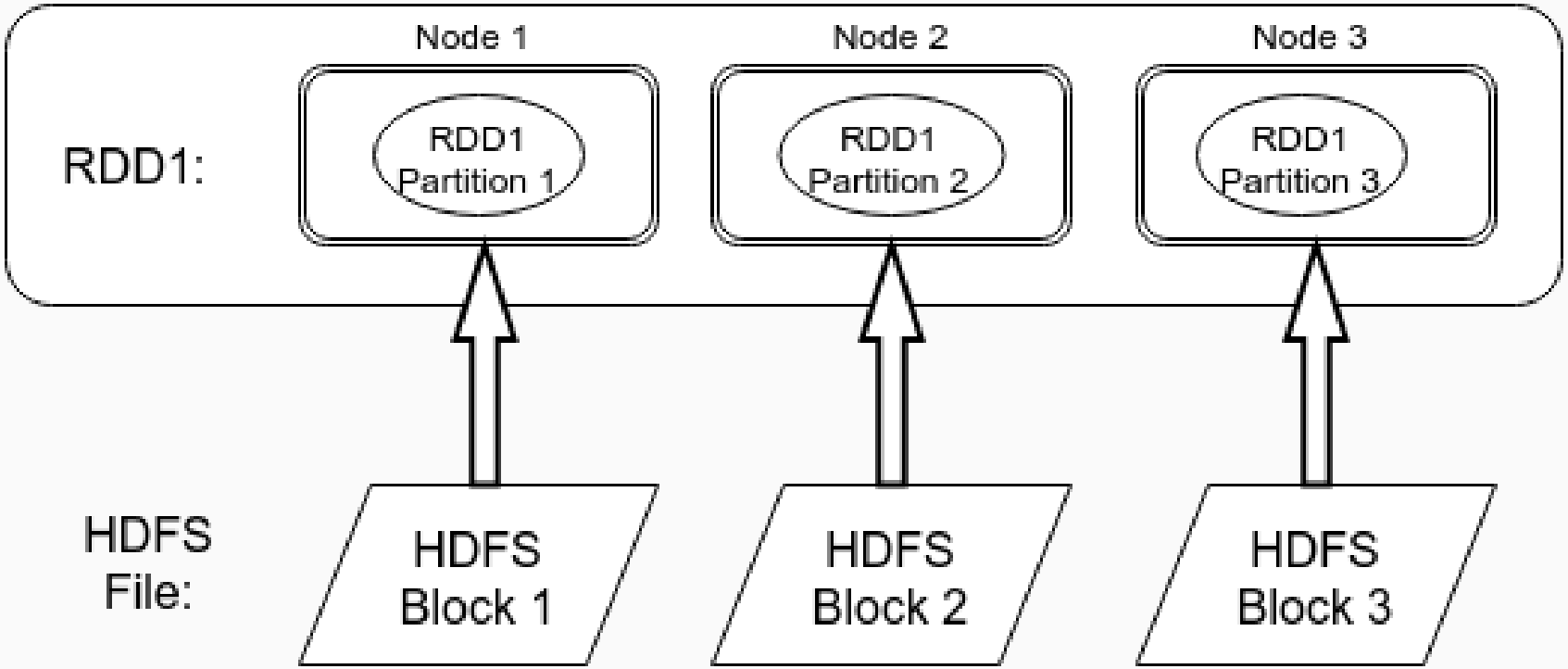
```
val hc = spark.sparkContext.hadoopConfiguration
hc.get("fs.defaultFS")
//res4: String = file:///

spark.read.json("/datasets/github/data")
spark.read.json("file:///datasets/github/data")

//hdfs://<name-node>:port
//s3a://<bucket-name>
```

Input partitions - splittable file?

- Splittable: bzip2, parquet, avro
- Non-splittable: gzip (1 task per file)

```
hc.get("dfs.block.size")
//res6: String = 134217728
```

Resilient Distributed Datasets (RDDs)



RDDs - Not deprecated!

```scala
object RddProcessor {

  val DefaultEventInputUrl = "file:///datasets/github/data"

  def process(sc: SparkContext, inputUrl: String): (Long, Long) = {
    val records: RDD[String] = sc.textFile(inputUrl)
    println(s"We have a total of ${records.partitions.size} partitions.")
    val total = records.count()
    val prs = records.filter(r => r.contains("PullRequestEvent"))
    val totalPrs = prs.count()
    (total, totalPrs)
  }

  def main(args: Array[String]): Unit = {
    val spark = SparkSession.builder().
      appName( name = "RddProcessor").
      getOrCreate()

    val inputUrl = if (args.size > 0) {
      args(0)
    } else {
      DefaultEventInputUrl
    }
    process(spark.sparkContext, inputUrl)
    spark.stop()
  }
}
```

Datasets/DataFrames compiled to RDDs

- Catalyst query optimizer for built-in functions
- Project Tungsten - memory management
    - Row storage (Apache Arrow)
    - Encoders for Dataset objects (spark.implicits._)

Data Exploration - event type distribution

```
val prs = records.where(records("type") === "PullRequestEvent")
val pullRequestEventCount = prs.count()
//6699

//import spark.implicits._ - auto-imported by shell
val typeCounts = records.groupBy($"type").
   count.orderBy($"count".desc)
typeCounts.show
+--------------------+-----+
|                type|count|
+--------------------+-----+
|           PushEvent|82518|
|         CreateEvent|18313|
|          WatchEvent|16868|
|    PullRequestEvent| 6699|
...
```

Narrow vs. wide transformations

- narrow: all data from one partition
- wide: data from multiple parent partitions (shuffle)

Shuffle Partitions - Default

Job Id ▼	Description	Submitted	Duration	Stages: Succeeded/Total	Tasks (for all stages): Succeeded/Total
4	show at <console>:26 show at <console>:26	2019/05/02 10:54:53	0.8 s	2/2	203/203

Setting Shuffle Partitions

```
spark.conf.set("spark.sql.shuffle.partitions", "10")
```

Shuffle Partitions Optimized

Job Id ▼	Description	Submitted	Duration	Stages: Succeeded/Total	Tasks (for all stages): Succeeded/Total
5	show at <console>:26 show at <console>:26	2019/05/02 11:04:14	0.1 s	2/2	13/13

API - Some Dataset Transformations

- select
- where
- distinct
- limit
- orderBy
- join

API - Some Dataset Actions

- collect
- count
- take(n)
- head
- write - DataFrameWriter

DataFrameWriter

- csv
- jdbc
- parquet
- text

Just the PullRequestEvents and their schema

```
val texts = spark.read.text(RecordsUrl)
val prsText =
   texts.where($"value".contains("PullRequestEvent"))

val reparteds = prsText.repartition(2)
reparteds.write.text("file:///datasets/github/prs")
```

Writing partitions - Output directory (57MB/file)

```
ls
_SUCCESS
part-00000-9f85464d-c4e8-4b55-9d95-580acb3f30cd-c000.txt
part-00001-9f85464d-c4e8-4b55-9d95-580acb3f30cd-c000.txt
```

API - Column

- +, -, *, %
- ===, =!=, >, <, ...
- asc, desc
- startsWith, contains, endsWith, like, rlike
- isNull, isNaN, isIn

API - functions

- array functions, explode
- date/time functions
- math, string

Date Exploration

```
val prs = spark.read.json("file:///datasets/github/prs")
//prs: org.apache.spark.sql.DataFrame = [actor: struct<avatar_url: string,
//display_login: string ... 4 more fields>, created_at: string

prs.select("created_at").take(10)
//res15: Array[org.apache.spark.sql.Row] =
//Array([2019-04-28T01:37:47Z],
//[2019-04-28T01:30:24Z], [2019-04-28T01:23:30Z],...
```

Adding year, month, day, hour columns

```
val ymdhPrs = prs.withColumn("year", year($"created_at")).
     withColumn("month", month($"created_at")).
     withColumn("day", dayofmonth($"created_at")).
     withColumn("hour", hour($"created_at"))

ymdhPrs.printSchema
...
 |-- type: string (nullable = true)
 |-- year: integer (nullable = true)
 |-- month: integer (nullable = true)
 |-- day: integer (nullable = true)
 |-- hour: integer (nullable = true)
```

Saving to Parquet with partitioning columns

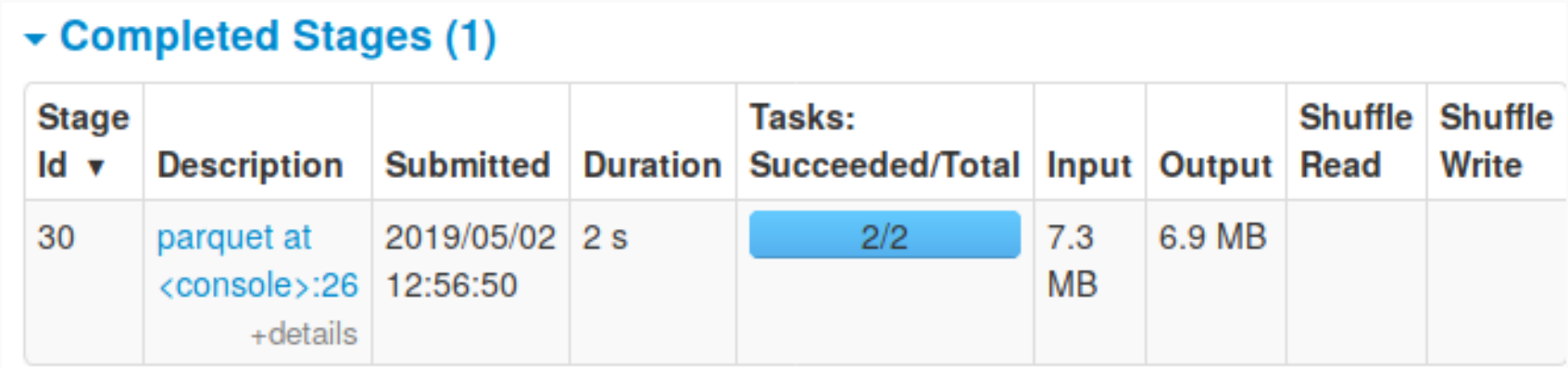
```
ymdhPrs.write.partitionBy("year","month","day","hour").
     parquet("file:///datasets/github/prs-ymdh")
```

```
/datasets/github/prs-ymdh/year=2019/month=4/day=28/hour=9
part-00000-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet
part-00001-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet
part-00002-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet

/datasets/github/prs-ymdh/year=2019/month=4/day=28/hour=20
part-00001-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet
part-00002-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet
part-00003-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet

/datasets/github/prs-ymdh/year=2019/month=4/day=28/hour=21
part-00000-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet
part-00003-afd2a04d-bdeb-48fe-9e43-12dc4fb3535a.c000.snappy.parquet
```

Reading from Parquet - schema and predicate pushdown

```
val mprs = spark.read.parquet("file:///datasets/github/prs-ymdh")
val oneHour = mprs.where("year = 2019 AND month = 04 AND " +
   "day = 28 AND hour = 21")

oneHour.explain(true)
...
== Optimized Logical Plan ==
Filter ((((((isnotnull(day#493) && isnotnull(year#491)) &&
↪  isnotnull(month#492))
&& isnotnull(hour#494)) && (year#491 = 2019)) && (month#492 = 4)) && (day#493
↪  = 28))
&& (hour#494 = 21))
+- Rela-
↪  tion[actor#483,created_at#484,id#485,org#486,payload#487,public#488,repo#489,
type#490,year#491,month#492,day#493,hour#494] parquet

oneHour.write.parquet("/datasets/github/one")
mprs.write.parquet("/datasets/github/all")
```

One Hour Completed Stage



▾ Completed Stages (1)

Stage Id ▾	Description	Submitted	Duration	Tasks: Succeeded/Total	Input	Output	Shuffle Read	Shuffle Write
30	parquet at <console>:26 +details	2019/05/02 12:56:50	2 s	2/2	7.3 MB	6.9 MB		

All Completed Stage

Stage Id ▼	Description	Submitted	Duration	Tasks: Succeeded/Total	Input	Output	Shuffle Read	Shuffle Write
31	parquet at <console>:26 +details	2019/05/02 12:56:54	3 s	4/4	27.5 MB	24.7 MB		

Storage size compression

- original gz - 47MB
- text only - 115MB
- parquet - 27.3MB

Apache Spark?

Figure 5: Questions?

And now for something completely different: Colon Cancer

- Screening saves lives!
  - Colonoscopy - talk to your doc
  - Dave Barry: A journey into my colon — and yours
- Colorectal Cancer Alliance

Questions?

- medale@asymmetrik.com
- https://github.com/medale/prez-spark-dataengineering/blob/master/presentation/SparkDataEngineering.pdf