SPARK SUMMIT 2017

Dr. Elephant for Monitoring & Tuning Apache Spark Jobs on Hadoop

Carl Steinbach (LinkedIn)
Simon King (Pepperdata)

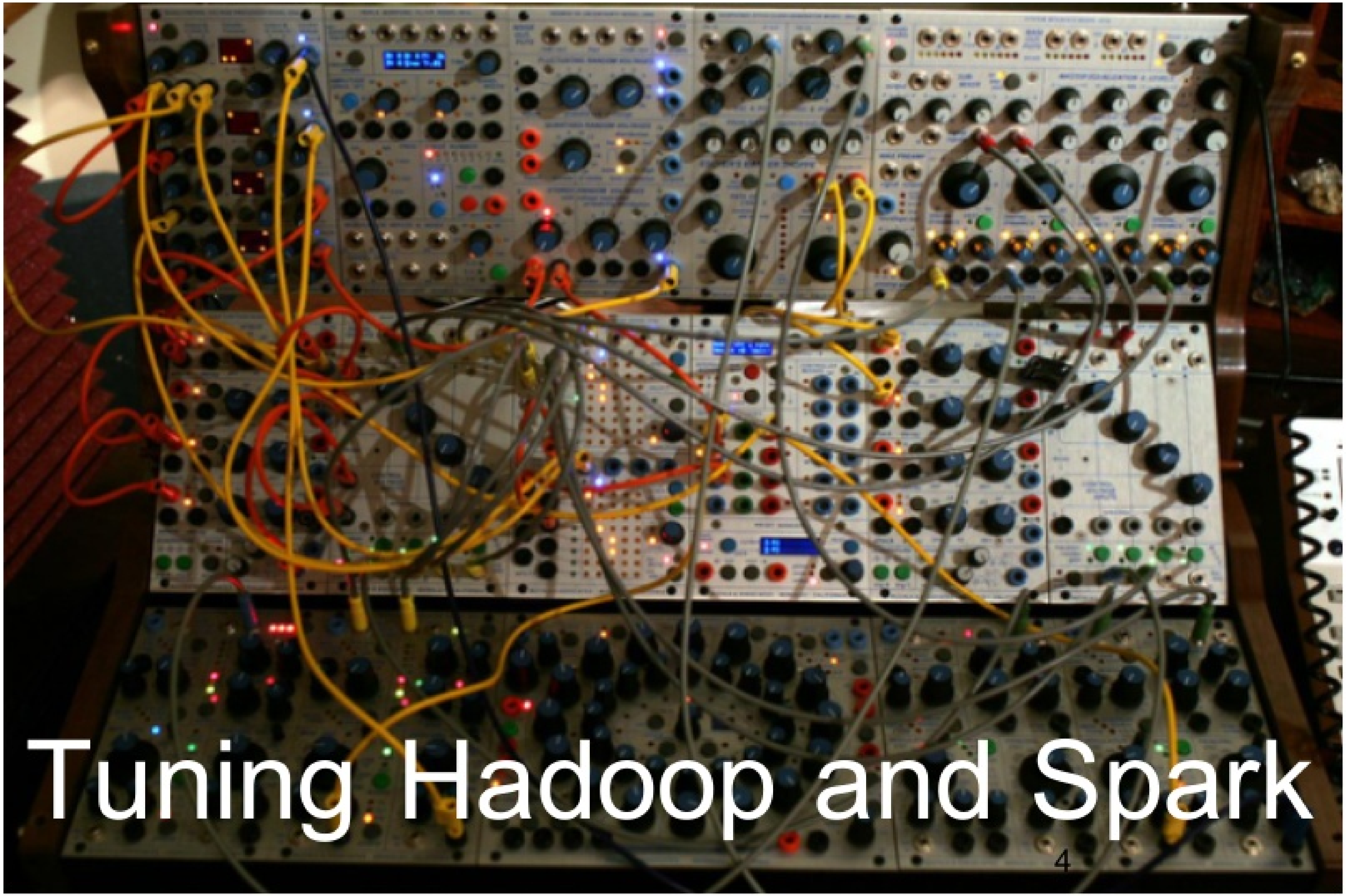
Hadoop @ LinkedIn c. 2015

- > 10 clusters
- > 10,000 nodes
- > 1,000 users

- Thousands of queries and flows in development
- Spark, Pig, Hive, Scalding, Gobblin, Cubert, ...

What we learned along the way

Scaling Hadoop Infrastructure is Hard
Scaling User Productivity is Harder

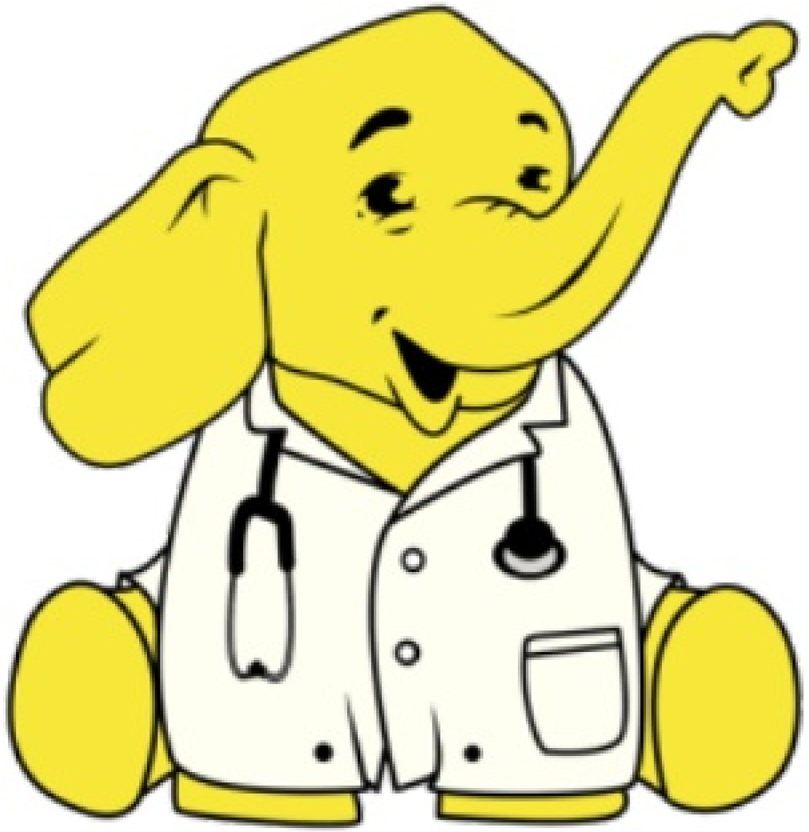


Tuning Hadoop and Spark

Some things we tried

- Training
  - doesn’t scale
  - interferes with productivity
- Expert Review
  - doesn’t scale
  - long wait times

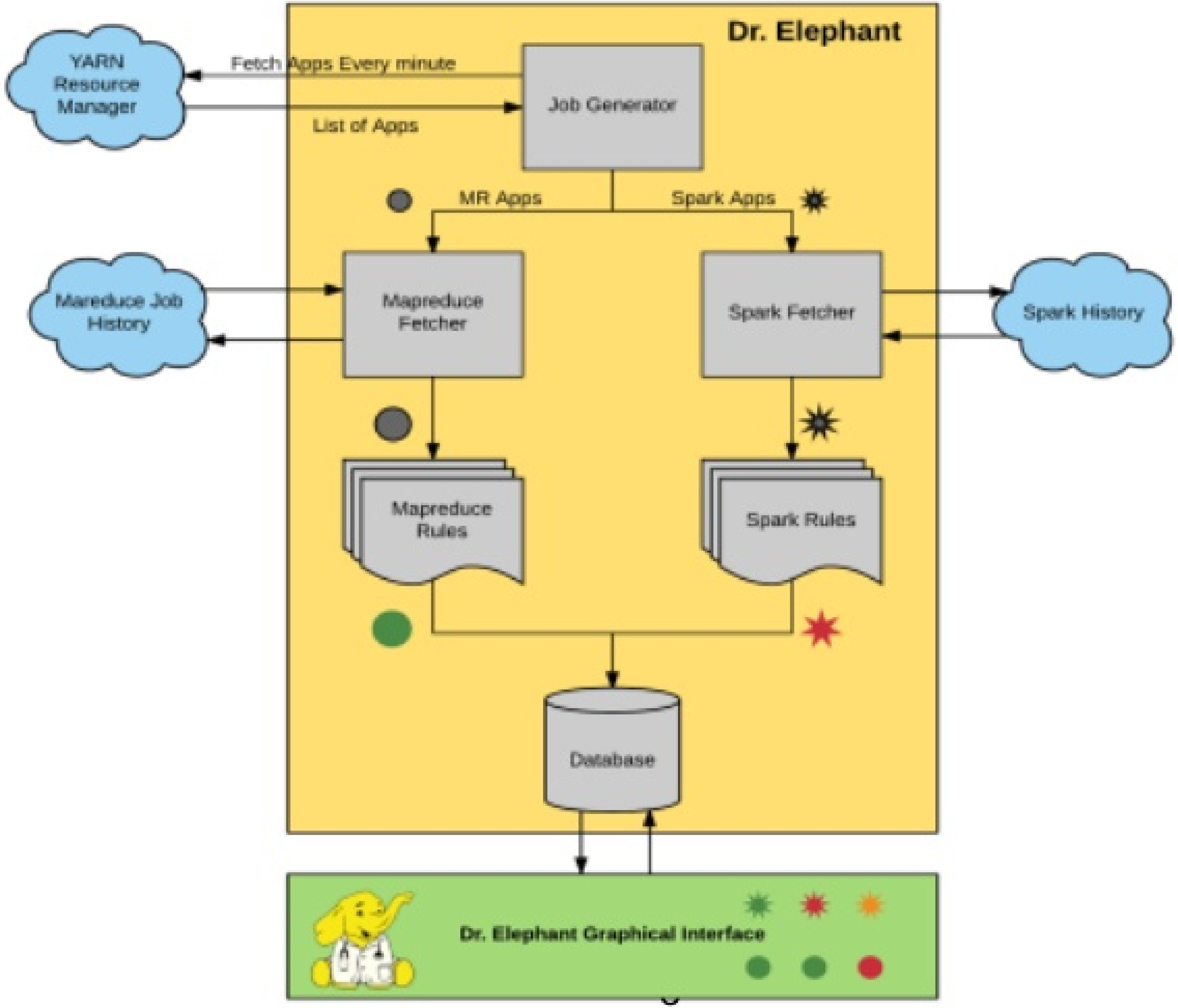
Birth of Dr. Elephant!



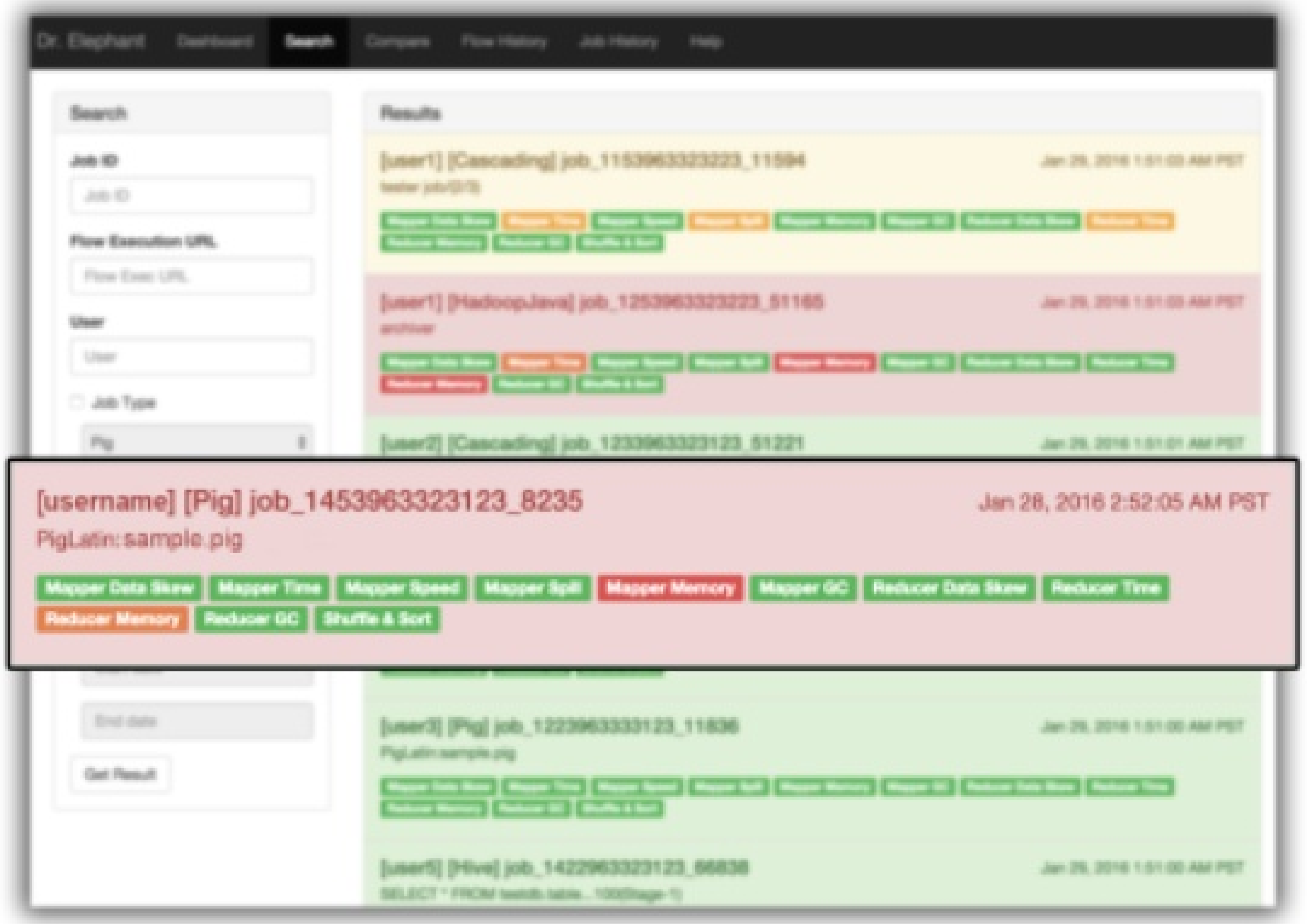
What does Dr. Elephant do?

- Performance monitoring and tuning service
- Finds common mistakes
- Provide actionable advice
- Compare performance changes over time

Architecture



Dr. Elephant User Interface



Results

[user1] [Cascading] job_1153963323223_11594 Jan 29, 2016 1:51:03 AM PST
tester job/(2/3)

Mapper Data Skew · Mapper Time · Mapper Speed · Mapper Spill · Mapper Memory · Mapper GC · Reducer Data Skew · Reducer Time · Reducer Memory · Reducer GC · Shuffle & Sort

[user1] [HadoopJava] job_1253963323223_51165 Jan 29, 2016 1:51:03 AM PST
archiver

Mapper Data Skew · Mapper Time · Mapper Speed · Mapper Spill · Mapper Memory · Mapper GC · Reducer Data Skew · Reducer Time · Reducer Memory · Reducer GC · Shuffle & Sort

[user2] [Cascading] job_1233963323123_51221 Jan 29, 2016 1:51:01 AM PST

[username] [Pig] job_1453963323123_8235 Jan 28, 2016 2:52:05 AM PST
PigLatin:sample.pig

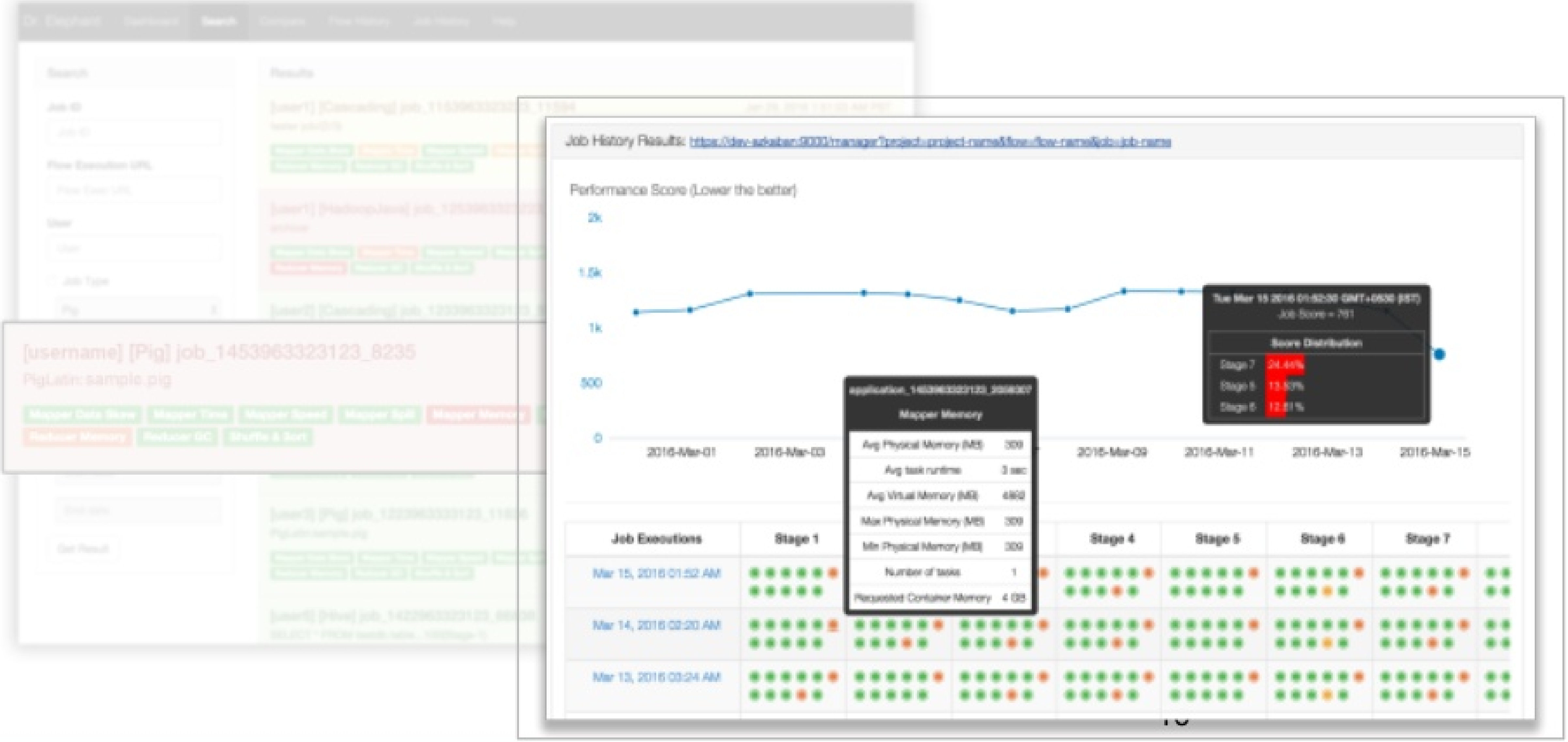
Mapper Data Skew · Mapper Time · Mapper Speed · Mapper Spill · Mapper Memory · Mapper GC · Reducer Data Skew · Reducer Time · Reducer Memory · Reducer GC · Shuffle & Sort

[user3] [Pig] job_1223963333123_11836 Jan 29, 2016 1:51:00 AM PST
PigLatin:sample.pig

Mapper Data Skew · Mapper Time · Mapper Speed · Mapper Spill · Mapper Memory · Mapper GC · Reducer Data Skew · Reducer Time · Reducer Memory · Reducer GC · Shuffle & Sort

[user5] [Hive] job_1422963323123_66838 Jan 29, 2016 1:51:00 AM PST
SELECT * FROM testdb.table...100(Stage-1)

Dr. Elephant User Interface



[user1] [Cascading] job_1153963323123_11594

[user1] [HadoopJava] job_1253963323123

[user2] [Cascading] job_1233963323123

[username] [Pig] job_1453963323123_8235

PigLatin: sample.pig

[user3] [Pig] job_1223963323123_11806

PigLatin:sample.pig

[user5] [Hive] job_1423963323123_88830

Job History Results: https://dev-azkaban:9000/manager?project=project-name&flow=flow-name&job=job-name

Performance Score (Lower the better)

Tue Mar 15 2016 01:52:00 GMT+0530 (IST)
Job Score = 761

Score Distribution	
Stage 7	24.44%
Stage 5	13.50%
Stage 6	12.81%

application_1453963323123_2008307

Mapper Memory	
Avg Physical Memory (MB)	309
Avg task runtime	3 sec
Avg Virtual Memory (MB)	4862
Max Physical Memory (MB)	309
Min Physical Memory (MB)	309
Number of tasks	1
Requested Container Memory	4 GB

Job Executions	Stage 1	Stage 4	Stage 5	Stage 6	Stage 7
Mar 15, 2016 01:52 AM					
Mar 14, 2016 02:20 AM					
Mar 13, 2016 03:24 AM					

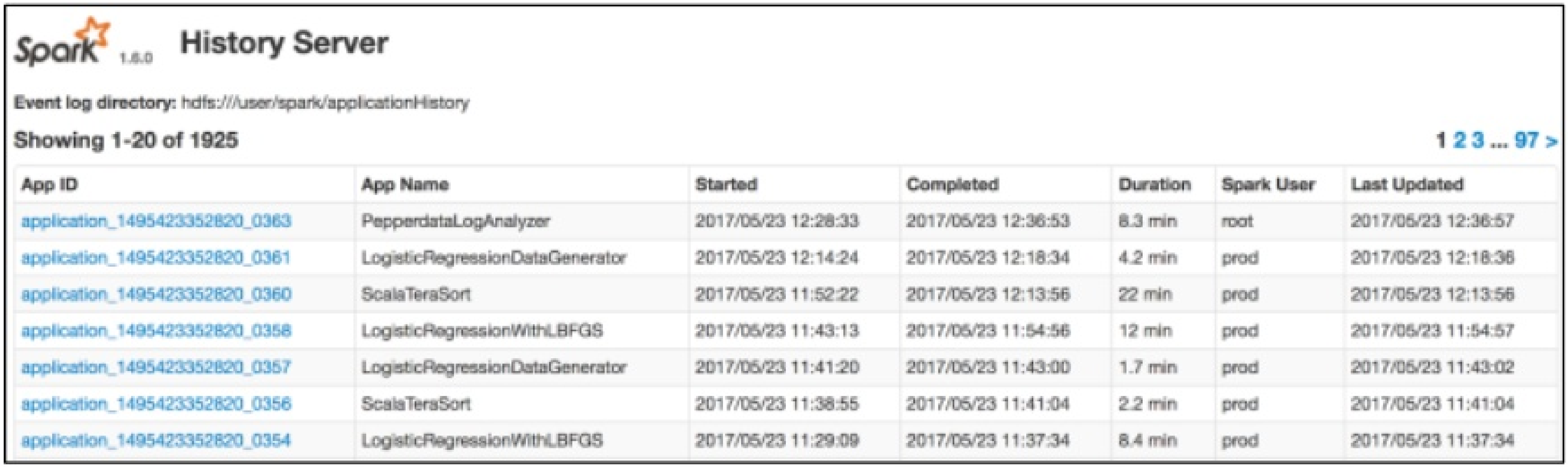
Dr. Elephant Community

Outline

- Spark Event Logs and Spark History Server
- Dr. Elephant for Spark
- Pepperdata's Application Profiler

simon@pepperdata.com

Spark History Server



History Server

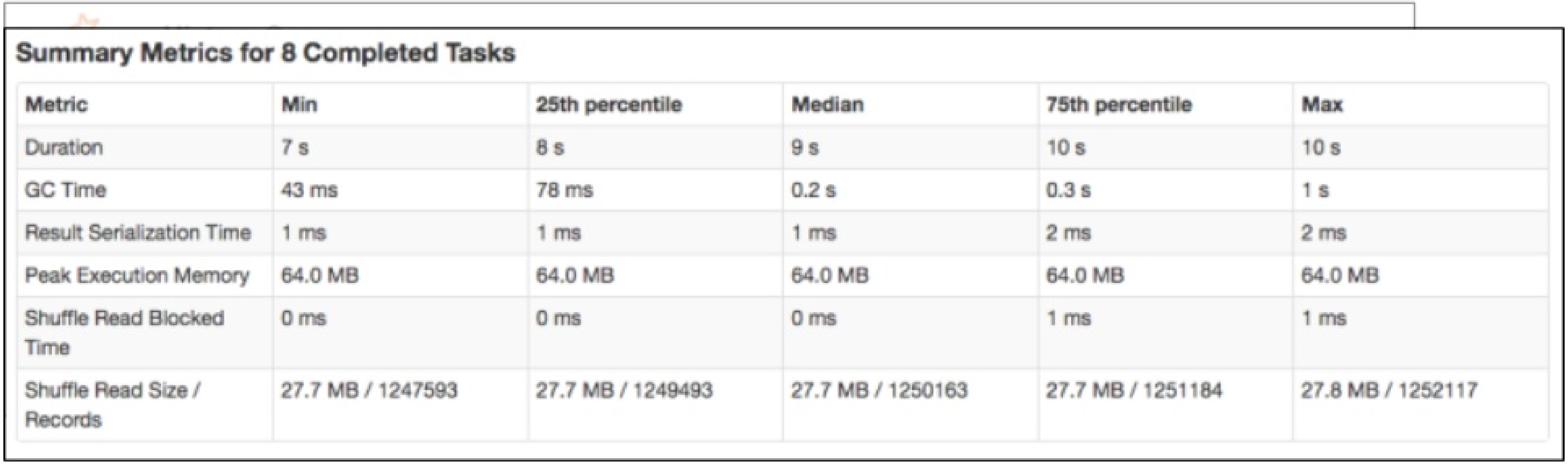
Event log directory: hdfs:///user/spark/applicationHistory

Showing 1-20 of 1925

1 2 3 ... 97 >

App ID	App Name	Started	Completed	Duration	Spark User	Last Updated
application_1495423352820_0363	PepperdataLogAnalyzer	2017/05/23 12:28:33	2017/05/23 12:36:53	8.3 min	root	2017/05/23 12:36:57
application_1495423352820_0361	LogisticRegressionDataGenerator	2017/05/23 12:14:24	2017/05/23 12:18:34	4.2 min	prod	2017/05/23 12:18:36
application_1495423352820_0360	ScalaTeraSort	2017/05/23 11:52:22	2017/05/23 12:13:56	22 min	prod	2017/05/23 12:13:56
application_1495423352820_0358	LogisticRegressionWithLBFGS	2017/05/23 11:43:13	2017/05/23 11:54:56	12 min	prod	2017/05/23 11:54:57
application_1495423352820_0357	LogisticRegressionDataGenerator	2017/05/23 11:41:20	2017/05/23 11:43:00	1.7 min	prod	2017/05/23 11:43:02
application_1495423352820_0356	ScalaTeraSort	2017/05/23 11:38:55	2017/05/23 11:41:04	2.2 min	prod	2017/05/23 11:41:04
application_1495423352820_0354	LogisticRegressionWithLBFGS	2017/05/23 11:29:09	2017/05/23 11:37:34	8.4 min	prod	2017/05/23 11:37:34

Spark History Server



Summary Metrics for 8 Completed Tasks

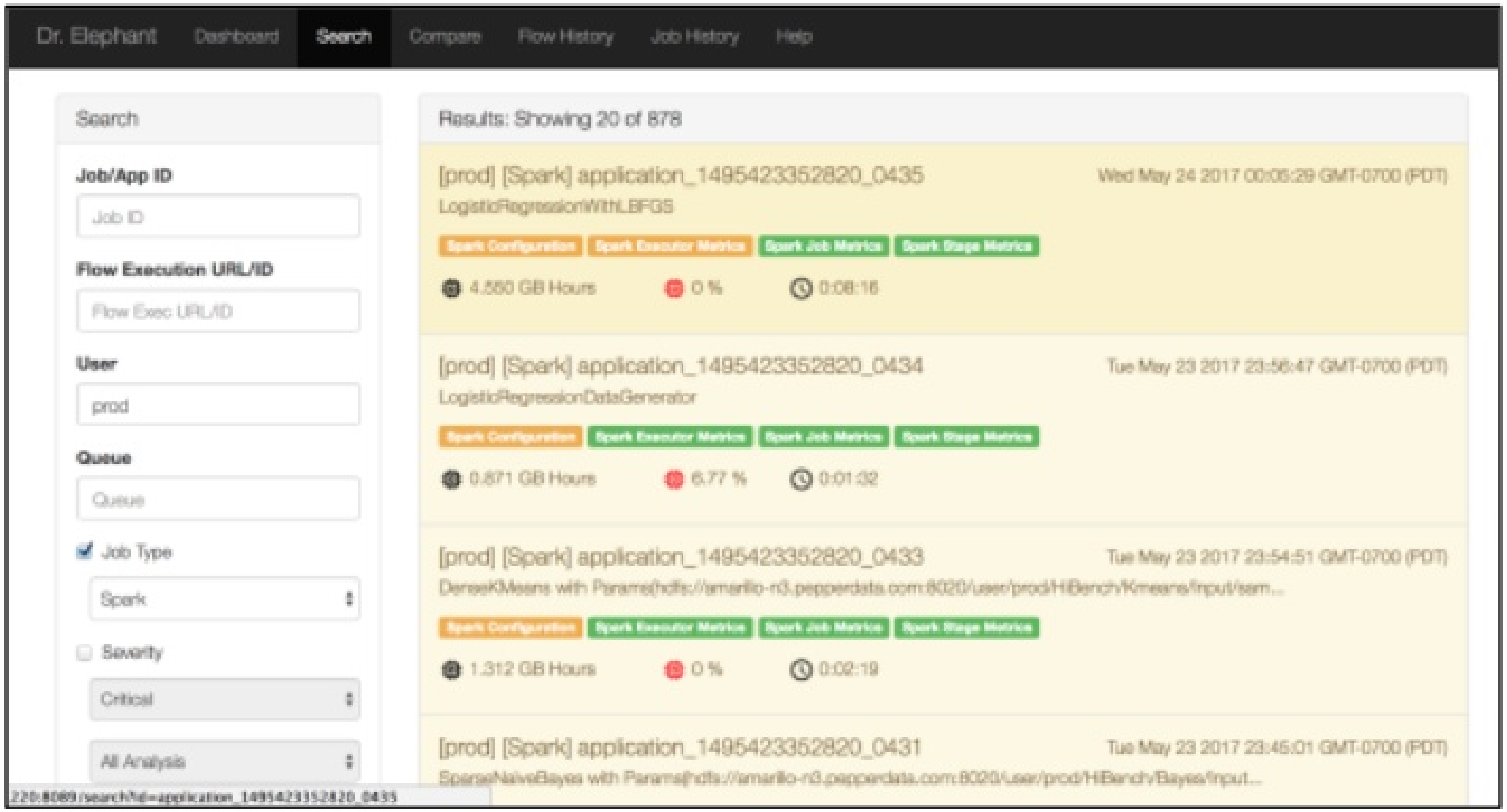
Metric	Min	25th percentile	Median	75th percentile	Max
Duration	7 s	8 s	9 s	10 s	10 s
GC Time	43 ms	78 ms	0.2 s	0.3 s	1 s
Result Serialization Time	1 ms	1 ms	1 ms	2 ms	2 ms
Peak Execution Memory	64.0 MB	64.0 MB	64.0 MB	64.0 MB	64.0 MB
Shuffle Read Blocked Time	0 ms	0 ms	0 ms	1 ms	1 ms
Shuffle Read Size / Records	27.7 MB / 1247593	27.7 MB / 1249493	27.7 MB / 1250163	27.7 MB / 1251184	27.8 MB / 1252117

Spark Event Logs

Spark Event Logs

```
{"Event":"SparkListenerTaskEnd","Stage ID":9,"Stage Attempt ID":0,"Task Type":"ResultTask","Task End Reason":{"Reason":"Success"},"Task Info":{"Task
    ID":775,"Index":55,"Attempt":0,"Launch Time":1495496382885,"Executor ID":"9","Host":"amarillo-
    rm.pepperdata.com","Locality":"PROCESS_LOCAL","Speculative":false,"Getting Result Time":0,"Finish
    Time":1495496481595,"Failed":false,"Accumulables":[{"ID":7,"Name":"peakExecutionMemory","Update":"76154696","Value":"601560113","Internal":true}]},"Task Metrics":{"Host
    Name":"amarillo-rm.pepperdata.com","Executor Deserialize Time":11,"Executor Run Time":98690,"Result Size":1366,"JVM GC Time":51928,"Result Serialization
    Time":0,"Memory Bytes Spilled":0,"Disk Bytes Spilled":0,"Shuffle Read Metrics":{"Remote Blocks Fetched":114,"Local Blocks Fetched":6,"Fetch Wait Time":5,"Remote Bytes
    Read":743674,"Local Bytes Read":41686,"Total Records Read":120}}}
{"Event":"SparkListenerTaskEnd","Stage ID":9,"Stage Attempt ID":0,"Task Type":"ResultTask","Task End Reason":{"Reason":"Success"},"Task Info":{"Task
    ID":770,"Index":50,"Attempt":0,"Launch Time":1495496382879,"Executor ID":"8","Host":"amarillo-
    n1.pepperdata.com","Locality":"PROCESS_LOCAL","Speculative":false,"Getting Result Time":0,"Finish
    Time":1495496487808,"Failed":false,"Accumulables":[{"ID":7,"Name":"peakExecutionMemory","Update":"96536946","Value":"698097059","Internal":true}]},"Task Metrics":{"Host
    Name":"amarillo-n1.pepperdata.com","Executor Deserialize Time":4,"Executor Run Time":104915,"Result Size":1366,"JVM GC Time":68939,"Result Serialization
    Time":0,"Memory Bytes Spilled":0,"Disk Bytes Spilled":0,"Shuffle Read Metrics":{"Remote Blocks Fetched":111,"Local Blocks Fetched":9,"Fetch Wait Time":10,"Remote Bytes
    Read":921999,"Local Bytes Read":74622,"Total Records Read":120}}}
{"Event":"SparkListenerTaskEnd","Stage ID":9,"Stage Attempt ID":0,"Task Type":"ResultTask","Task End Reason":{"Reason":"Success"},"Task Info":{"Task
    ID":769,"Index":49,"Attempt":0,"Launch Time":1495496382874,"Executor ID":"5","Host":"amarillo-
    rm.pepperdata.com","Locality":"PROCESS_LOCAL","Speculative":false,"Getting Result Time":0,"Finish
    Time":1495496507584,"Failed":false,"Accumulables":[{"ID":7,"Name":"peakExecutionMemory","Update":"105946616","Value":"804043675","Internal":true}]},"Task
    Metrics":{"Host Name":"amarillo-rm.pepperdata.com","Executor Deserialize Time":9,"Executor Run Time":124690,"Result Size":1366,"JVM GC Time":81294,"Result Serialization
    Time":0,"Memory Bytes Spilled":0,"Disk Bytes Spilled":0,"Shuffle Read Metrics":{"Remote Blocks Fetched":108,"Local Blocks Fetched":12,"Fetch Wait Time":2,"Remote Bytes
    Read":972911,"Local Bytes Read":113196,"Total Records Read":120}}}
```

Dr. Elephant



Search

Job/App ID

Job ID

Flow Execution URL/ID

Flow Exec URL/ID

User

prod

Queue

Queue

☑ Job Type

Spark

□ Severity

Critical

All Analysis

220:8089/search?id=application_1495423352820_0435

Results: Showing 20 of 878

[prod] [Spark] application_1495423352820_0435 Wed May 24 2017 00:06:29 GMT-0700 (PDT)

LogisticRegressionWithLBFGS

Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics

4.550 GB Hours 0 % 0:08:16

[prod] [Spark] application_1495423352820_0434 Tue May 23 2017 23:56:47 GMT-0700 (PDT)

LogisticRegressionDataGenerator

Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics

0.871 GB Hours 6.77 % 0:01:32

[prod] [Spark] application_1495423352820_0433 Tue May 23 2017 23:54:51 GMT-0700 (PDT)

DenseKMeans with Params(hdfs://amarillo-n3.pepperdata.com:8020/user/prod/HiBench/Kmeans/Input/sam...

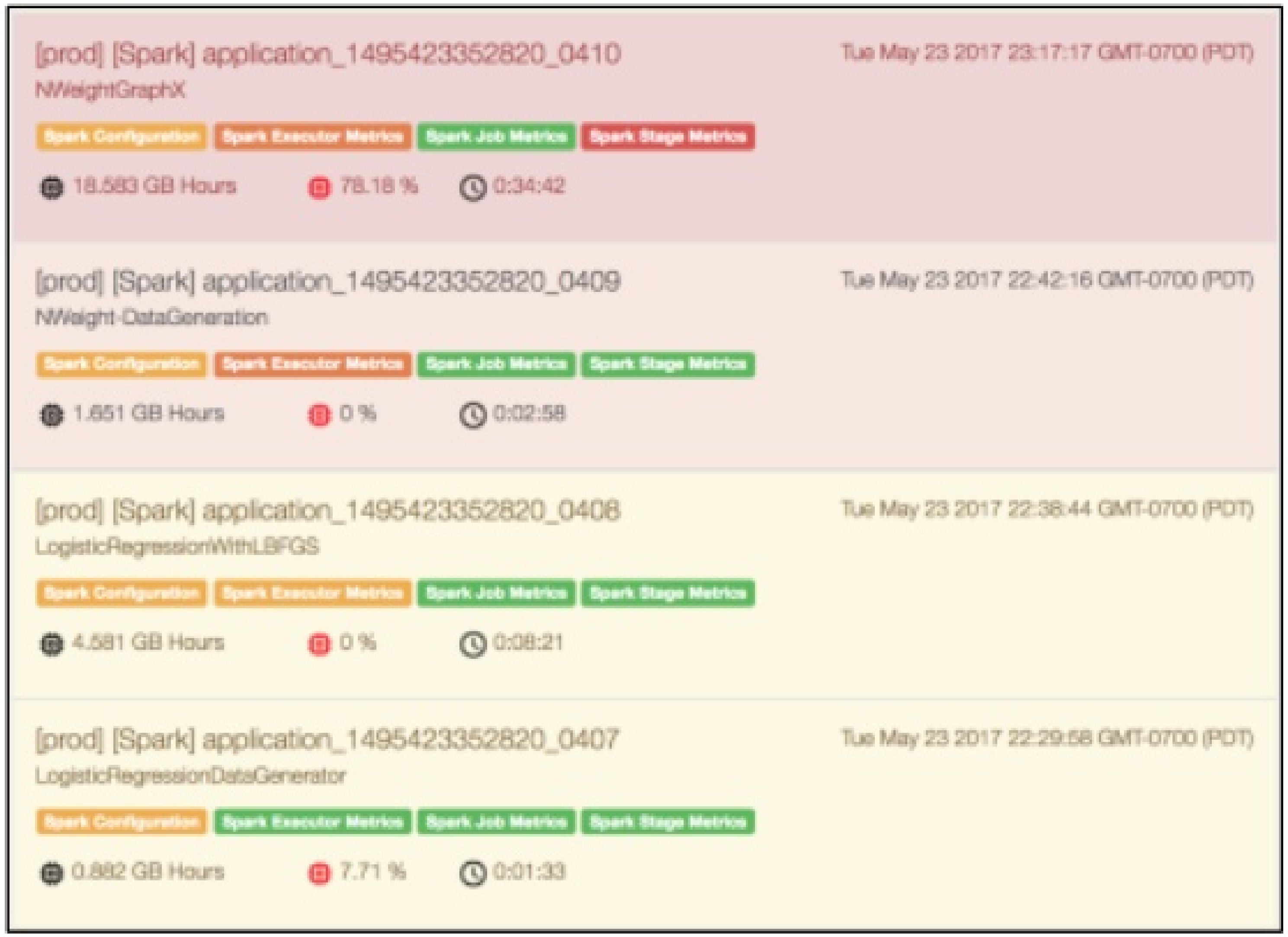
Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics

1.312 GB Hours 0 % 0:02:19

[prod] [Spark] application_1495423352820_0431 Tue May 23 2017 23:46:01 GMT-0700 (PDT)

SparseNaiveBayes with Params(hdfs://amarillo-n3.pepperdata.com:8020/user/prod/HiBench/Bayes/Input...

Spark Application Heuristics



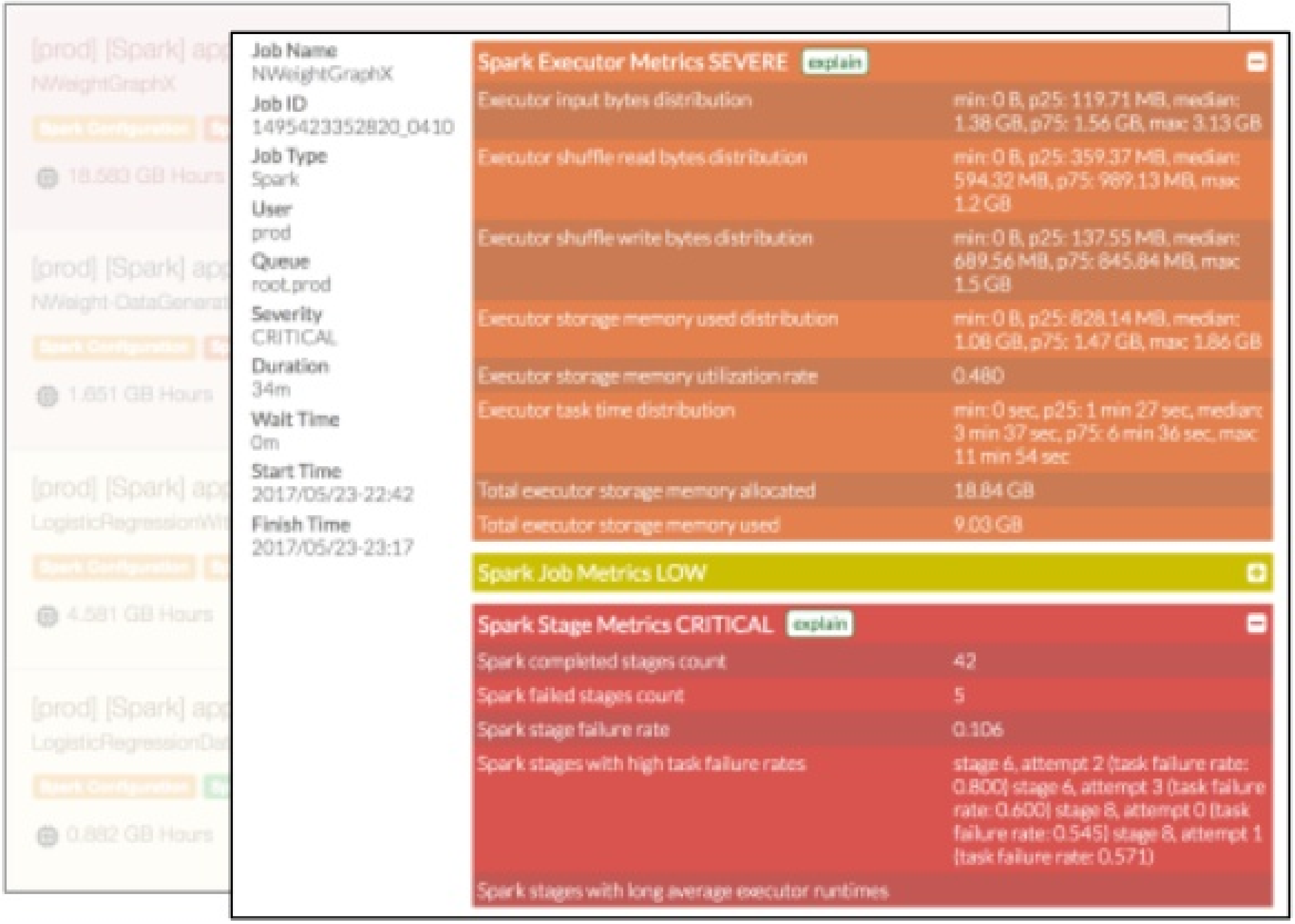
[prod] [Spark] application_1495423352820_0410 Tue May 23 2017 23:17:17 GMT-0700 (PDT)
NWeightGraphX
Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics
18.583 GB Hours 78.18 % 0:34:42

[prod] [Spark] application_1495423352820_0409 Tue May 23 2017 22:42:16 GMT-0700 (PDT)
NWeight-DataGeneration
Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics
1.651 GB Hours 0 % 0:02:58

[prod] [Spark] application_1495423352820_0408 Tue May 23 2017 22:38:44 GMT-0700 (PDT)
LogisticRegressionWithLBFGS
Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics
4.581 GB Hours 0 % 0:08:21

[prod] [Spark] application_1495423352820_0407 Tue May 23 2017 22:29:58 GMT-0700 (PDT)
LogisticRegressionDataGenerator
Spark Configuration | Spark Executor Metrics | Spark Job Metrics | Spark Stage Metrics
0.882 GB Hours 7.71 % 0:01:33

Spark Application Heuristics



[prod] [Spark] ap
NWeightGraphX
Spark Configuration
18.580 GB Hours

[prod] [Spark] ap
NWeight-DataGenera
Spark Configuration
1.651 GB Hours

[prod] [Spark] ap
LogisticRegressionWi
Spark Configuration
4.581 GB Hours

[prod] [Spark] ap
LogisticRegressionDa
Spark Configuration
0.882 GB Hours

Job Name
NWeightGraphX
Job ID
1495423352820_0410
Job Type
Spark
User
prod
Queue
root.prod
Severity
CRITICAL
Duration
34m
Wait Time
0m
Start Time
2017/05/23-22:42
Finish Time
2017/05/23-23:17

Spark Executor Metrics SEVERE explain

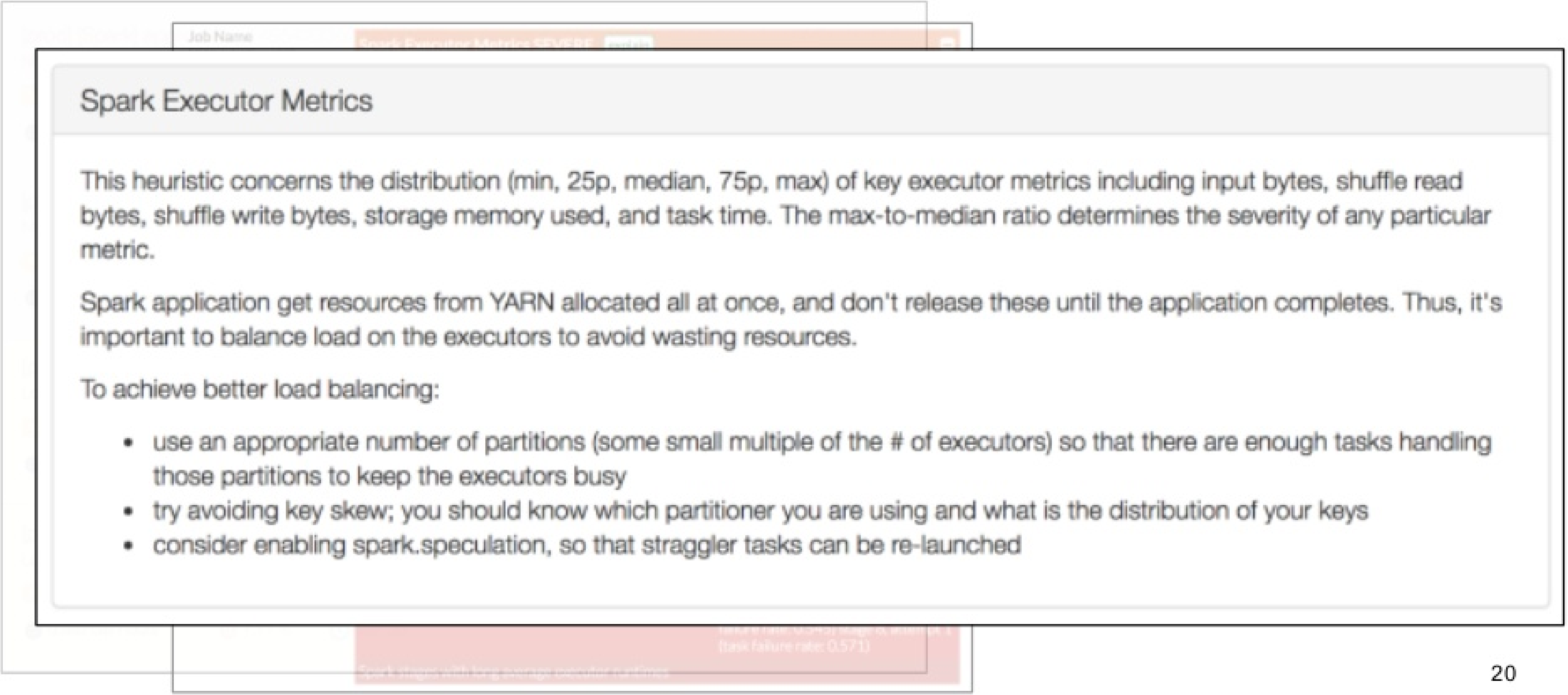
Executor input bytes distribution	min: 0 B, p25: 119.71 MB, median: 1.38 GB, p75: 1.56 GB, max: 3.13 GB
Executor shuffle read bytes distribution	min: 0 B, p25: 359.37 MB, median: 594.32 MB, p75: 989.13 MB, max: 1.2 GB
Executor shuffle write bytes distribution	min: 0 B, p25: 137.55 MB, median: 689.56 MB, p75: 845.84 MB, max: 1.5 GB
Executor storage memory used distribution	min: 0 B, p25: 828.14 MB, median: 1.08 GB, p75: 1.47 GB, max: 1.86 GB
Executor storage memory utilization rate	0.480
Executor task time distribution	min: 0 sec, p25: 1 min 27 sec, median: 3 min 37 sec, p75: 6 min 36 sec, max: 11 min 54 sec
Total executor storage memory allocated	18.84 GB
Total executor storage memory used	9.03 GB

Spark Job Metrics LOW

Spark Stage Metrics CRITICAL explain

Spark completed stages count	42
Spark failed stages count	5
Spark stage failure rate	0.106
Spark stages with high task failure rates	stage 6, attempt 2 (task failure rate: 0.800) stage 6, attempt 3 (task failure rate: 0.600) stage 8, attempt 0 (task failure rate: 0.545) stage 8, attempt 1 (task failure rate: 0.571)
Spark stages with long average executor runtimes	

Spark Application Heuristics



Spark Executor Metrics

This heuristic concerns the distribution (min, 25p, median, 75p, max) of key executor metrics including input bytes, shuffle read bytes, shuffle write bytes, storage memory used, and task time. The max-to-median ratio determines the severity of any particular metric.

Spark application get resources from YARN allocated all at once, and don't release these until the application completes. Thus, it's important to balance load on the executors to avoid wasting resources.

To achieve better load balancing:

- use an appropriate number of partitions (some small multiple of the # of executors) so that there are enough tasks handling those partitions to keep the executors busy
- try avoiding key skew; you should know which partitioner you are using and what is the distribution of your keys
- consider enabling spark.speculation, so that straggler tasks can be re-launched

1: Configuration Heuristics

- Display some basic config settings for your app
- Complain if some settings not explicitly set
- Recommend configuring an external shuffle service (especially if dynamic allocation is enabled)
- These recommendations won't change over multiple runs of an application

2: Stages and Jobs Heuristics

- Simple alarms showing stage and job failure rates
- Good for seeing when there’s a problem

3: Executor Heuristics

- Looks at the distribution across executors of several different metrics
- Outliers in these distributions probably indicate:
  - Suboptimal partitioning.
  - One or more slow executors due to external circumstances (cluster weather)

3: Partitions Heuristic

- Ideally data for each task will fit into the RAM available to that task.
- Cloudera has an excellent blog on Spark tuning:

(*observed shuffle write*) * (*observed shuffle spill memory*) * (*spark.executor.cores*)
(*observed shuffle spill disk*) * (*spark.executor.memory*) * (*spark.shuffle.memoryFraction*) * (*spark.shuffle.safetyFraction*)

http://blog.cloudera.com/blog/2015/03/how-to-tune-your-apache-spark-jobs-part-2/

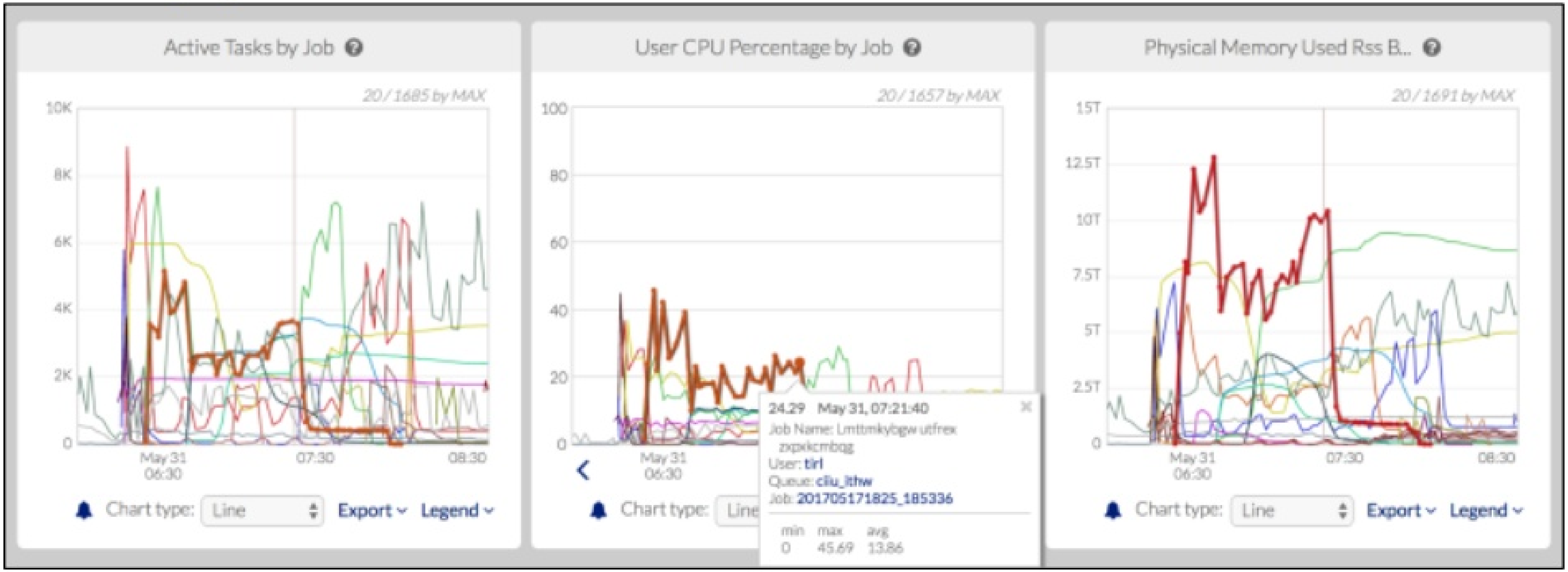
More Heuristics?

Yes, please! Dr. Elephant is open source.

Pepperdata

- Capacity Optimizer
- Policy Enforcer
- Cluster Analyzer

Pepperdata



24.29 May 31, 07:21:40

Job Name: Lmttmkybgw utfrex zxpxkcmbqg

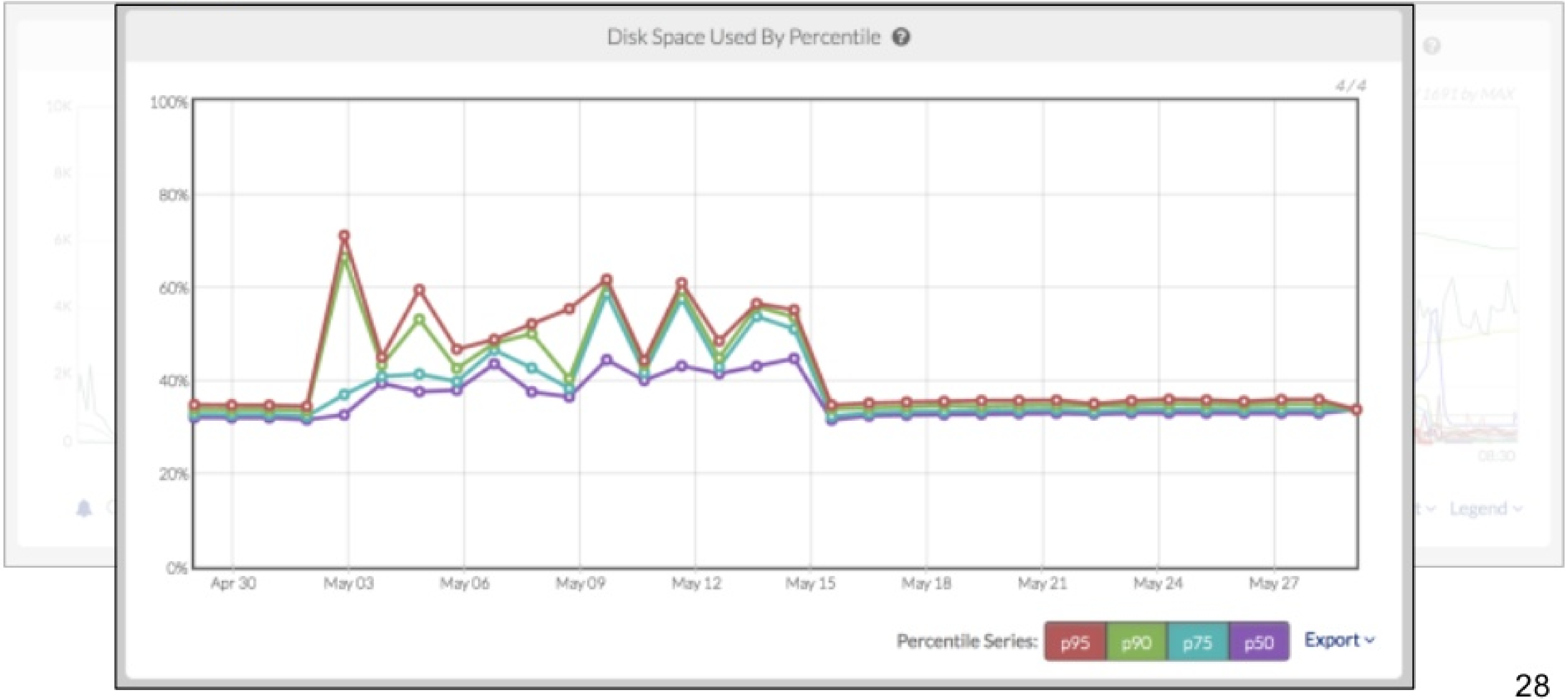
User: tirl

Queue: cliu_lthw

Job: 201705171825_185336

min	max	avg
0	45.69	13.86

Pepperdata


Disk Space Used By Percentile
4/4
100%
80%
60%
40%
20%
0%
Apr 30
May 03
May 06
May 09
May 12
May 15
May 18
May 21
May 24
May 27
Percentile Series:
p95
p90
p75
p50
Export
Legend

Pepperdata

- Capacity Optimizer
- Policy Enforcer
- Cluster Analyzer
- Application Profiler

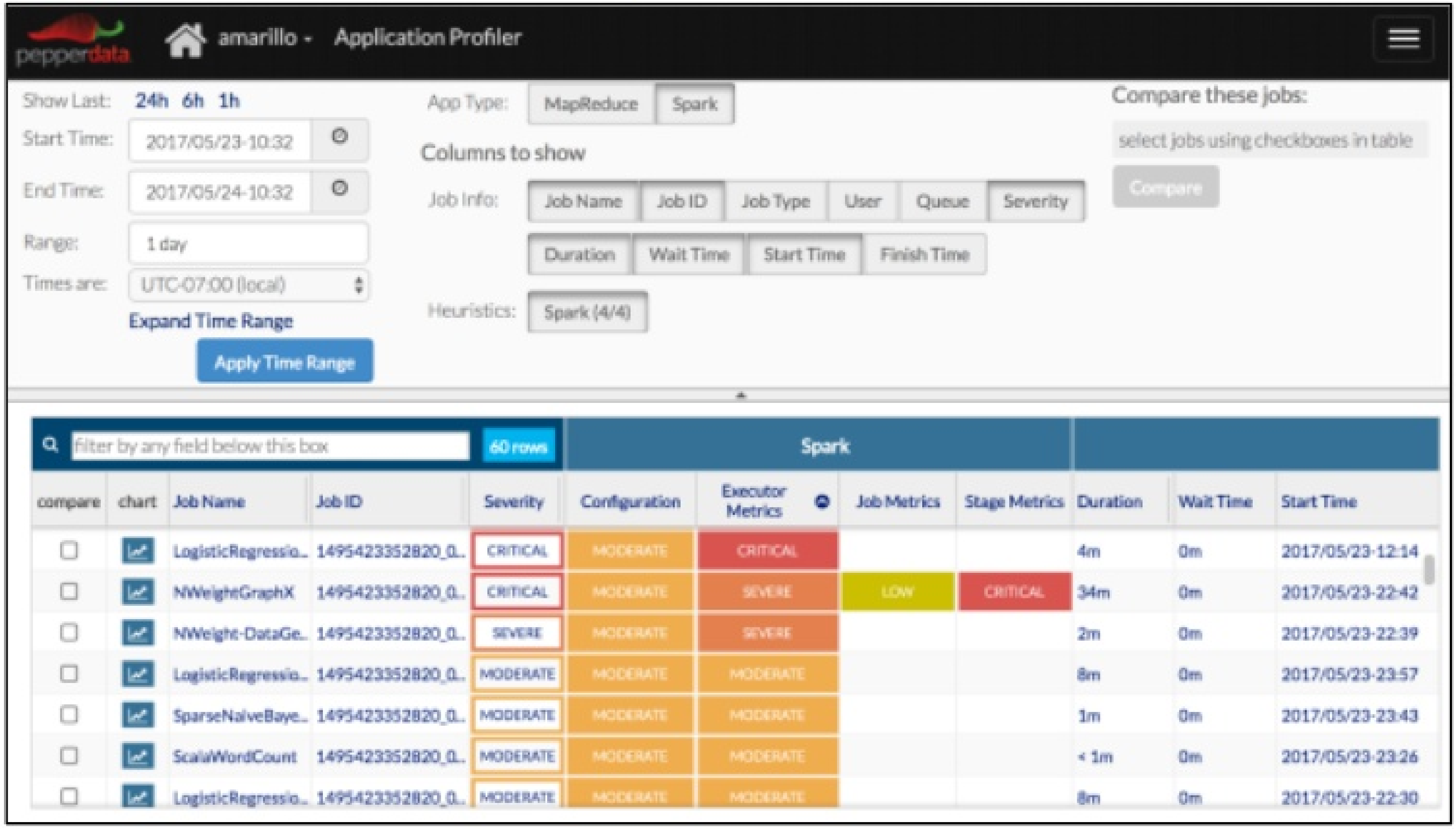
Mostly for Operators

For Developers

Application Profiler

- Benefits to our users:
  - Provide simple answers to simple questions
  - Combination of metrics for experts, simple actionable insights for users
  - Pepperdata support
- Why stay close to open source?
  - Heuristics

Application Profiler, Hardware and Cluster Weather



Show Last: 24h 6h 1h

Start Time: 2017/05/23-10:32

End Time: 2017/05/24-10:32

Range: 1 day

Times are: UTC-07:00 (local)

App Type: MapReduce | Spark

Columns to show

Job Info: Job Name | Job ID | Job Type | User | Queue | Severity

Duration | Wait Time | Start Time | Finish Time

Heuristics: Spark (4/4)

Compare these jobs: select jobs using checkboxes in table

filter by any field below this box | 60 rows

					Spark						
compare	chart	Job Name	Job ID	Severity	Configuration	Executor Metrics	Job Metrics	Stage Metrics	Duration	Wait Time	Start Time
☐		LogisticRegressio...	1495423352820_0...	CRITICAL	MODERATE	CRITICAL			4m	0m	2017/05/23-12:14
☐		NWeightGraphX	1495423352820_0...	CRITICAL	MODERATE	SEVERE	LOW	CRITICAL	34m	0m	2017/05/23-22:42
☐		NWeight-DataGe...	1495423352820_0...	SEVERE	MODERATE	SEVERE			2m	0m	2017/05/23-22:39
☐		LogisticRegressio...	1495423352820_0...	MODERATE	MODERATE	MODERATE			8m	0m	2017/05/23-23:57
☐		SparseNaiveBaye...	1495423352820_0...	MODERATE	MODERATE	MODERATE			1m	0m	2017/05/23-23:43
☐		ScalaWordCount	1495423352820_0...	MODERATE	MODERATE	MODERATE			< 1m	0m	2017/05/23-23:26
☐		LogisticRegressio...	1495423352820_0...	MODERATE	MODERATE	MODERATE			8m	0m	2017/05/23-22:30

Application Profiler, Hardware and Cluster Weather

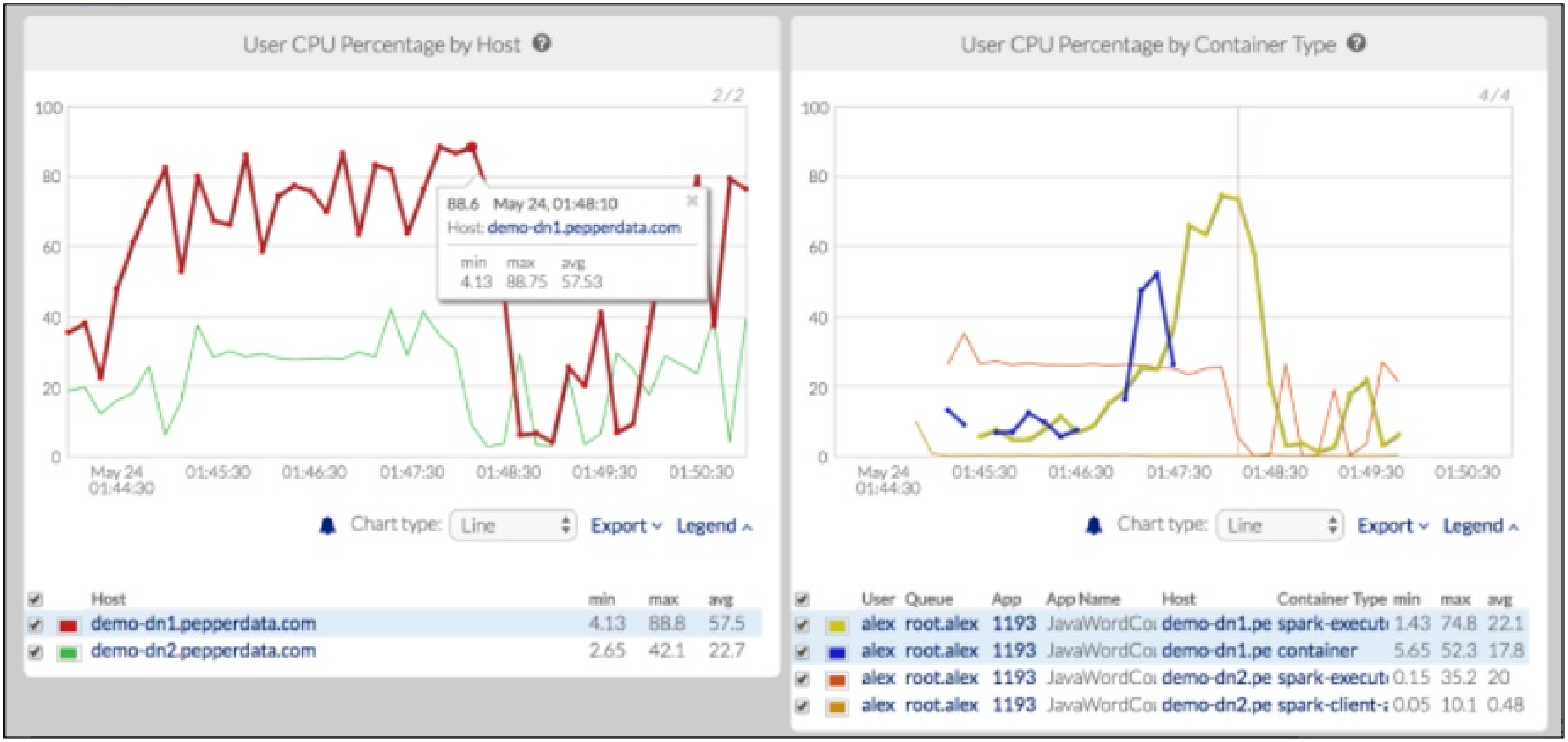


Chart type: Line

Chart type: Line

✓		Host	min	max	avg
✓	🟥	demo-dn1.pepperdata.com	4.13	88.8	57.5
✓	🟩	demo-dn2.pepperdata.com	2.65	42.1	22.7

✓		User	Queue	App	App Name	Host	Container Type	min	max	avg
✓	🟨	alex	root.alex	1193	JavaWordCo	demo-dn1.pe	spark-executi	1.43	74.8	22.1
✓	🟦	alex	root.alex	1193	JavaWordCo	demo-dn1.pe	container	5.65	52.3	17.8
✓	🟧	alex	root.alex	1193	JavaWordCo	demo-dn2.pe	spark-executi	0.15	35.2	20
✓	🟧	alex	root.alex	1193	JavaWordCo	demo-dn2.pe	spark-client-:	0.05	10.1	0.48

Thanks!

Stop by the Pepperdata booth (#101)

Come to the Dr Elephant Meetup:

6:00 PM Wednesday, June 7, 2017
LinkedIn San Francisco Office
222 2nd Street, San Francisco

Get involved with Dr. Elephant:

https://github.com/linkedin/dr-elephant

Contact us:

simon@pepperdata.com, csteinbach@linkedin.com