

Apache Spark Monitoring and Debugging



Estimated time needed: 30 minutes

This lab will instruct you on how to monitor and debug a Spark application through the web UI.

Objectives

After completing this lab, you will be able to:

1. Start a Spark Standalone Cluster and connect with the PySpark shell.
2. Create a DataFrame and open the application web UI.
3. Debug a runtime error by locating the failed task in the web UI.
4. Run an SQL query to monitor, then scale up by adding another worker to the cluster.

Exercise 1 : Start a Spark Standalone Cluster

In this exercise, you will initialize a Spark Standalone Cluster with a Master and one Worker. Next, you will start a PySpark shell that connects to the cluster and open the Spark Application Web UI to monitor it. We will be using the Theia terminal to run commands and docker-based containers to launch the Spark processes.

Task A : Download Sample Data for Spark

1. Open a Theia terminal by clicking on the menu item `Terminal -> New Terminal`.
2. Use the following command to download the data set we will be using in this lab to the container running Spark.

- ```
1. 1
1. wget https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-BD0225EN-SkillsNetwork/labs/data/cars.csv
```

Copied! Executed!

### Task B : Initialize the Cluster

1. Stop any previously running containers with the command:

- ```
1. 1
1. for i in `docker ps | awk '{print $1}' | grep -v CONTAINER`; do docker kill $i; done
```

Copied! Executed!

2. Remove any previously used containers:

Ignore any errors that say “No such container”

- ```
1. 1
1. docker rm spark-master spark-worker-1 spark-worker-2
```

Copied! Executed!

3. Start the Spark Master server:

- ```
1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8

1. docker run \
2.   --name spark-master \
3.   -h spark-master \
4.   -e ENABLE_INIT_DAEMON=false \
5.   -p 4040:4040 \
6.   -p 8080:8080 \
7.   -v `pwd`:~/home/root \
8.   -d bde2020/spark-master:3.1.1-hadoop3.2
```

Copied! Executed!

4. Start a Spark Worker that will connect to the Master:

- ```
1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7

1. docker run \
2. --name spark-worker-1 \
3. --link spark-master:spark-master \
4. -e ENABLE_INIT_DAEMON=false \
5. -p 8081:8081 \
6. -v `pwd`:~/home/root \
7. -d bde2020/spark-worker:3.1.1-hadoop3.2
```

Copied! Executed!

### Task C : Connect a PySpark Shell to the Cluster and Open the UI

1. Launch a PySpark shell in the running Spark Master container:

- ```
1. 1
2. 2
3. 3
4. 4

1. docker exec \
2.   -it `docker ps | grep spark-master | awk '{print $1}'` \
3.   /spark/bin/pyspark \
4.   --master spark://spark-master:7077
```

Copied! Executed!

2. Create a DataFrame in the shell with:

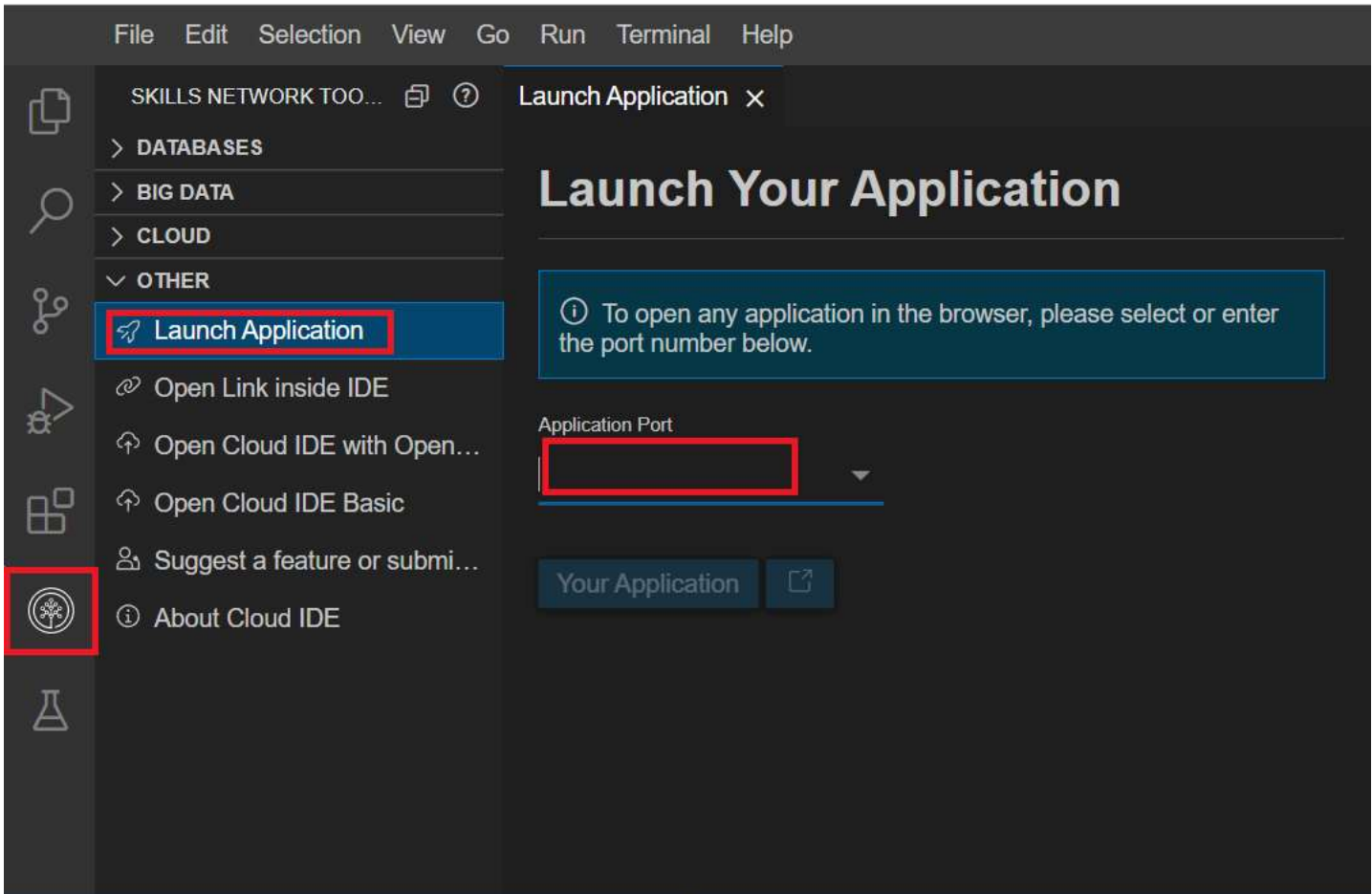
NOTE: Press Enter twice to proceed after running the command in shell

- ```
1. 1
2. 2
3. 3
4. 4

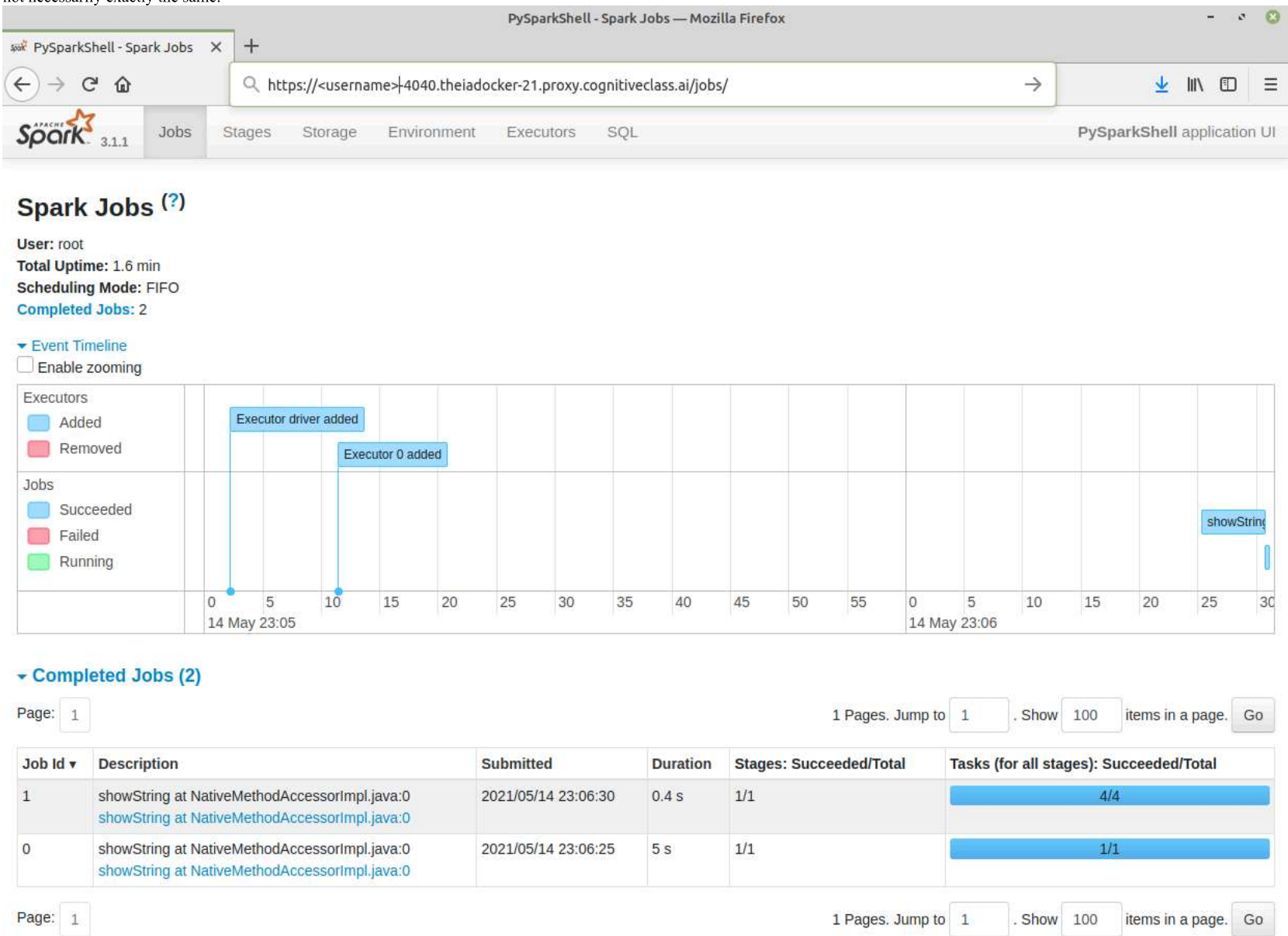
1. df = spark.read.csv("/home/root/cars.csv", header=True, inferSchema=True) \
2. .repartition(32) \
3. .cache()
4. df.show()
```

Copied!

3. Click on the Skills Network button on the left, it will open the “Skills Network Toolbox”. Then click OTHER then Launch Application. From there you should be able to enter the port number as 4040 and launch the Spark Application UI in your browser.



4. Verify you can see the application jobs page that should look like the following, although not necessarily exactly the same:



## Exercise 2 : Run an SQL Query and Debug in the Application UI

In this exercise, you will define a user-defined function (UDF) and run a query that results in an error. We will locate that error in the application UI and find the root cause. Finally, we will correct the error and re-run the query.

### Task A : Run an SQL Query

1. Define a UDF to show engine type. Copy and paste the code and click Enter.

```
1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8

1. from pyspark.sql.functions import udf
2. import time
3.
4. @udf("string")
5. def engine(cylinders):
6. time.sleep(0.2) # Intentionally delay task
7. eng = {6: "V6", 8: "V8"}
8. return eng[cylinders]
```

Copied!

2. Add the UDF as a column in the DataFrame

```
1. 1
1. df = df.withColumn("engine", engine("cylinders"))
```

Copied!

3. Group the DataFrame by “cylinders” and aggregate other columns

```
1. 1
1. dfg = df.groupby("cylinders")
```

Copied!

```
1. 1
1. dfa = dfg.agg({"mpg": "avg", "engine": "first"})
```

Copied!


```
1. 1
1. dfa.show()
```

Copied!

4. The query will have failed and you should see lots of messages and outputs in the console.  
The next task will be to locate the error in the Application UI and determine the root cause.

## Task B : Debug the error in the Application UI

- Find the error in the Application UI  
Open UI to the Jobs, look at list of Failed Jobs, click on first job.



3.2.0-SNAPSHOT

Jobs

Stages

Storage

Environment

Executors

SQL

PySparkShell  
application UI

### Spark Jobs (?)

User: root  
Total Uptime: 1.4 min  
Scheduling Mode: FIFO  
Completed Jobs: 4

▶ Event Timeline

#### ▼ Completed Jobs (4)

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

| Job Id ▼ | Description                                                                                                                    | Submitted           | Duration | Stages: Succeeded/Total | Tasks (for all stages): Succeeded/Total |
|----------|--------------------------------------------------------------------------------------------------------------------------------|---------------------|----------|-------------------------|-----------------------------------------|
| 3        | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">showString at NativeMethodAccessorImpl.java:0</a> | 2021/07/07 22:08:48 | 39 ms    | 1/1 (1 skipped)         | 1/1 (1 skipped)                         |
| 2        | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">showString at NativeMethodAccessorImpl.java:0</a> | 2021/07/07 22:08:47 | 0.5 s    | 2/2                     | 2/2                                     |
| 1        | <a href="#">csv at NativeMethodAccessorImpl.java:0</a><br><a href="#">csv at NativeMethodAccessorImpl.java:0</a>               | 2021/07/07 22:08:46 | 1 s      | 1/1                     | 1/1                                     |
| 0        | <a href="#">csv at NativeMethodAccessorImpl.java:0</a><br><a href="#">csv at NativeMethodAccessorImpl.java:0</a>               | 2021/07/07 22:08:44 | 1 s      | 1/1                     | 1/1                                     |

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

- This will bring up the Job details with a list of stages for that job. In the list of Failed Stages, click on the first failed stage to show the stage details with a list of tasks for that stage.

|   |                                                                                                                                              |                     |       |     |          |  |  |          |
|---|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|-----|----------|--|--|----------|
|   | <a href="#">+details</a>                                                                                                                     |                     |       |     |          |  |  |          |
| 2 | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:08:47 | 0.2 s | 1/1 | 20.6 KiB |  |  | 23.4 KiB |
| 1 | <a href="#">csv at NativeMethodAccessorImpl.java:0</a><br><a href="#">NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a>        | 2021/07/07 22:08:46 | 1 s   | 1/1 | 20.6 KiB |  |  |          |
| 0 | <a href="#">csv at NativeMethodAccessorImpl.java:0</a><br><a href="#">NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a>        | 2021/07/07 22:08:44 | 1 s   | 1/1 | 20.6 KiB |  |  |          |

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

#### ▼ Skipped Stages (2)

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

| Stage Id ▼ | Description                                                                                                                                  | Submitted | Duration | Tasks: Succeeded/Total | Input | Output | Shuffle Read | Shuffle Write |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------|------------------------|-------|--------|--------------|---------------|
| 6          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | Unknown   | Unknown  | 0/1                    |       |        |              |               |
| 4          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | Unknown   | Unknown  | 0/1                    |       |        |              |               |

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

#### ▼ Failed Stages (1)

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

| Stage Id ▼ | Description                                                                                                                                  | Submitted           | Duration | Tasks: Succeeded/Total | Input    | Output | Shuffle Read | Shuffle Write | Failure Reason                                                                                                                  |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------|------------------------|----------|--------|--------------|---------------|---------------------------------------------------------------------------------------------------------------------------------|
| 7          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:15:19 | 2 s      | 0/32 (28 failed) (6    | 45.5 KiB |        | 8.1 KiB      |               | Job aborted due to stage 7.0 failed 4 t<br>Lost task 3.3 in sta<br>(192.168.1.33 exe<br>org.apache.spark.i<br>Traceback (most r |

- Here we see lots of failed tasks. Looking at the first one, the far right column shows details of the failure.



## Details for Stage 7 (Attempt 0)

Resource Profile Id: 0  
Total Time Across All Tasks: 17 s  
Locality Level Summary: Node local: 28; Process local: 6  
Input Size / Records: 45.5 KiB / 22  
Shuffle Read Size / Records: 8.1 KiB / 136  
Associated Job Ids: 4

- ▶ DAG Visualization
- ▶ Show Additional Metrics
- ▶ Event Timeline

### Summary Metrics for 0 Completed Tasks

| Metric | Min | 25th percentile | Median | 75th percentile | Max |
|--------|-----|-----------------|--------|-----------------|-----|
|--------|-----|-----------------|--------|-----------------|-----|

### ▶ Aggregated Metrics by Executor

#### Tasks (34)

Show 

20

 entries

Search:

|       | Task |         |        |                |             |              |                                                  |                     |          |         |                      |
|-------|------|---------|--------|----------------|-------------|--------------|--------------------------------------------------|---------------------|----------|---------|----------------------|
| Index | ID   | Attempt | Status | Locality level | Executor ID | Host         | Logs                                             | Launch Time         | Duration | GC Time | Input Size / Records |
| 0     | 5    | 0       | FAILED | PROCESS_LOCAL  | 0           | 192.168.1.33 | <a href="#">stdout</a><br><a href="#">stderr</a> | 2021-07-07 22:15:19 | 1 s      |         | 2.1 KiB / 1          |
| 0     | 20   | 1       | FAILED | PROCESS_LOCAL  | 0           | 192.168.1.33 | <a href="#">stdout</a><br><a href="#">stderr</a> | 2021-07-07 22:15:20 | 0.4 s    |         | 2.1 KiB / 1          |
| 0     | 31   | 2       | KILLED | PROCESS_LOCAL  | 0           | 192.168.1.33 | <a href="#">stdout</a><br><a href="#">stderr</a> | 2021-07-07 22:15:20 | 0.4 s    |         | 2.1 KiB / 1          |
| 1     | 6    | 0       | FAILED | PROCESS_LOCAL  | 0           | 192.168.1.33 | <a href="#">stdout</a><br><a href="#">stderr</a> | 2021-07-07 22:15:19 | 1 s      | 19.0 ms | 2 KiB / 1            |
| 1     | 23   | 1       | FAILED | PROCESS_LOCAL  | 0           | 192.168.1.33 | <a href="#">stdout</a><br><a href="#">stderr</a> | 2021-07-07 22:15:20 | 0.6 s    |         | 2 KiB / 1            |
| 1     | 37   | 2       | KILLED | PROCESS_LOCAL  | 0           | 192.168.1.33 | <a href="#">stdout</a><br><a href="#">stderr</a> | 2021-07-07 22:15:20 | 0.6 s    |         | 2 KiB / 1            |

Click to expand the details.

APACHE

Spark

3.2.0-SNAPSHOT

stderr log page for app-20210707220734-0000/0

[Back to Master](#)

Showing 102400 Bytes: 39045 - 141445 of 141445

```
return f(*args, **kwargs)
File "<ipython-input-2-12484af4df99>", line 8, in engine
 KeyError: 4

 at
org.apache.spark.api.python.BasePythonRunner$ReaderIterator.handlePythonException(PythonRunner.scala:517)
 at org.apache.spark.sql.execution.python.PythonUDFRunner$$anon$2.read(PythonUDFRunner.scala:84)
 at org.apache.spark.sql.execution.python.PythonUDFRunner$$anon$2.read(PythonUDFRunner.scala:67)
 at org.apache.spark.api.python.BasePythonRunner$ReaderIterator.hasNext(PythonRunner.scala:470)
 at org.apache.spark.InterruptibleIterator.hasNext(InterruptibleIterator.scala:37)
 at scala.collection.Iterator$$anon$11.hasNext(Iterator.scala:489)
 at scala.collection.Iterator$$anon$10.hasNext(Iterator.scala:458)
 at scala.collection.Iterator$$anon$10.hasNext(Iterator.scala:458)
 at
org.apache.spark.sql.catalyst.expressions.GeneratedClass$GeneratedIteratorForCodegenStage1.sort_addToSorter_0$(Unknown Source)
 at
org.apache.spark.sql.catalyst.expressions.GeneratedClass$GeneratedIteratorForCodegenStage1.processNext(Unknown Source)
```

Scroll down a little until you can see the last part of the Python error that shows the cause. You should be able to see this was caused by a `KeyError` in our UDF `engine()`.

You could also view these errors by looking at the column that has links to the logs and click on “std err” to show the standard error log.

Close the PySpark browser tab.

4. In the Theia terminal, fix the UDF by adding an entry to the dictionary of engine types and provide a default for all other types. Copy and paste this code and click `Enter`.

```
1. 1
2. 2
3. 3
4. 4
5. 5

1. @udf("string")
2. def engine(cylinders):
3. time.sleep(0.2) # Intentionally delay task
4. eng = {4: "inline-four", 6: "V6", 8: "V8"}
5. return eng.get(cylinders, "other")
```

Copied!

5. Re-run the query. You will have to add the “engine” column again and enter the query since we changed the UDF.

```
1. 1

1. df = df.withColumn("engine", engine("cylinders"))
```

Copied!

```
1. 1

1. dfg = df.groupby("cylinders")
```

Copied!

```
1. 1

1. dfa = dfg.agg({"mpg": "avg", "engine": "first"})
```

Copied!

```
1. 1

1. dfa.show()
```

Copied!

Once the query completes without errors, you should see output similar to this.

```
1. 1
```

2. 2  
3. 3  
4. 4  
5. 5  
6. 6  
7. 7  
8. 8  
9. 9

|    |                     |                      |               |
|----|---------------------|----------------------|---------------|
| 1. | +-----+-----+-----+ |                      |               |
| 2. | cylinders           | avg(mpg)             | first(engine) |
| 3. | +-----+-----+-----+ |                      |               |
| 4. |                     | 6 19.985714285714288 | V6            |
| 5. |                     | 3 20.55              | other         |
| 6. |                     | 5 27.366666666666664 | other         |
| 7. |                     | 4 29.286764705882348 | inline-four   |
| 8. |                     | 8 14.963106796116506 | V8            |
| 9. | +-----+-----+-----+ |                      |               |

Copied!

## Exercise 3 : Monitor Application Performance with the UI

Now that we have run our query successfully, we will scale up our application by adding a worker to the cluster. This will allow the cluster to run more tasks in parallel and improve the overall performance.

### Task A : Add a Worker to the Cluster

1. View the Stages tab, then click on the stage with 32 tasks. In that stage our UDF is being applied to each partition of the DataFrame.

3.2.0-SNAPSHOT

Jobs

Stages

Storage

Environment

Executors

SQL

PySparkShell  
application UI

### Stages for All Jobs

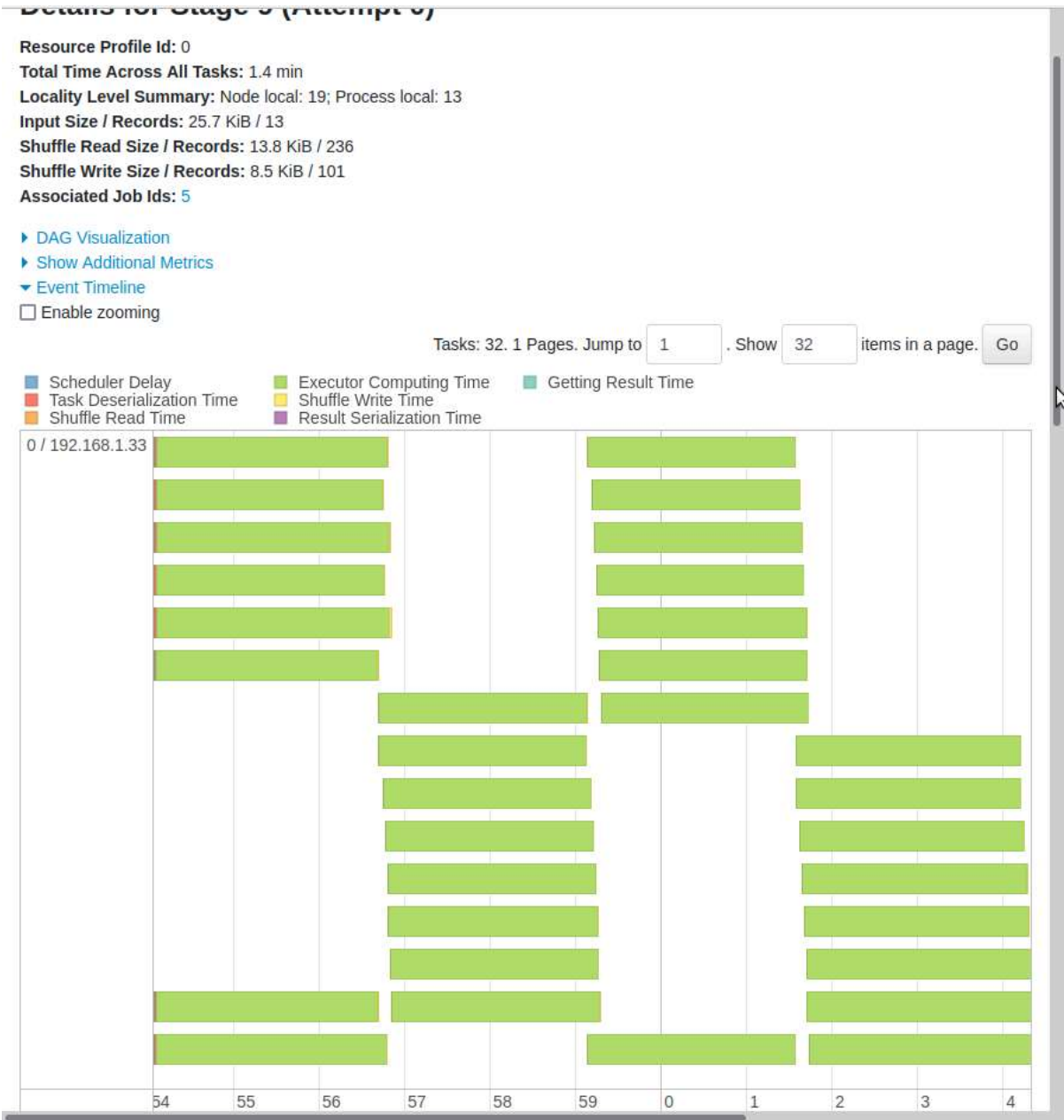
Completed Stages: 8  
Skipped Stages: 7  
Failed Stages: 1

#### ▼ Completed Stages (8)

Page: 11 Pages. Jump to 1. Show 100 items in a page. Go

| Stage Id ▼ | Description                                                                               | Submitted           | Duration | Tasks: Succeeded/Total | Input    | Output | Shuffle Read | Shuffle Write |
|------------|-------------------------------------------------------------------------------------------|---------------------|----------|------------------------|----------|--------|--------------|---------------|
| 15         | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:39:04 | 47 ms    | 3/3                    |          |        | 6.0 KiB      |               |
| 12         | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:39:04 | 0.2 s    | 1/1                    |          |        | 2.5 KiB      |               |
| 9          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:38:54 | 10 s     | 32/32                  | 25.7 KiB |        | 13.8 KiB     | 8.5 KiB       |
| 5          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:08:48 | 33 ms    | 1/1                    |          |        | 778.0 B      |               |
| 3          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:08:48 | 0.3 s    | 1/1                    |          |        | 829.0 B      |               |
| 2          | <a href="#">showString at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a> | 2021/07/07 22:08:47 | 0.2 s    | 1/1                    | 20.6 KiB |        |              | 23.4 KiB      |
| 1          | <a href="#">csv at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a>        | 2021/07/07 22:08:46 | 1 s      | 1/1                    | 20.6 KiB |        |              |               |
| 0          | <a href="#">csv at NativeMethodAccessorImpl.java:0</a><br><a href="#">+details</a>        | 2021/07/07 22:08:44 | 1 s      | 1/1                    | 20.6 KiB |        |              |               |

Looking at the timeline, you can see there is a single worker with id 0 / <ip-address> that can run up to a certain amount of tasks in parallel at one time. Adding another worker will allow an additional tasks to be run in parallel.



# Stages for All Jobs

Completed Stages: 23  
Skipped Stages: 30  
Failed Stages: 1

## Completed Stages (23)

| Stage Id ▾ | Description                                                                       | Submitted           | Duration | Tasks: Succeeded |
|------------|-----------------------------------------------------------------------------------|---------------------|----------|------------------|
| 53         | <a href="#">showString at NativeMethodAccessorImpl.java:0</a> <div>+details</div> | 2022/01/03 06:27:21 | 2 s      | 7                |
| 50         | <a href="#">showString at NativeMethodAccessorImpl.java:0</a> <div>+details</div> | 2022/01/03 06:27:19 | 2 s      | 10               |
| 47         | <a href="#">showString at NativeMethodAccessorImpl.java:0</a> <div>+details</div> | 2022/01/03 06:27:18 | 0.7 s    | 2                |
| 44         | <a href="#">showString at NativeMethodAccessorImpl.java:0</a> <div>+details</div> | 2022/01/03 06:27:17 | 0.3 s    |                  |

3. You will see that the additional worker with id 1 / <ip-address> is listed and now allows more tasks to be run in parallel. The task timeline should look similar to the following.



### Author(s)

Aije

### Other Contributor(s)

Lavanya

### Changelog

| Date       | Version | Changed by     | Change Description                                               |
|------------|---------|----------------|------------------------------------------------------------------|
| 2021-07-16 | 0.1     | Aije           | Initial version created                                          |
| 2022-01-03 | 0.2     | Lavanya        | Changed the instructions for second node                         |
| 2022-09-01 | 0.3     | K Sundararajan | Updated instructions for Launch Application as per new Theia IDE |

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