SCALING

DATA WORKLOADS
using the best of both worlds:

PANDAS AND SPARK

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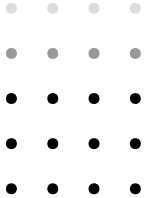
AGENDA



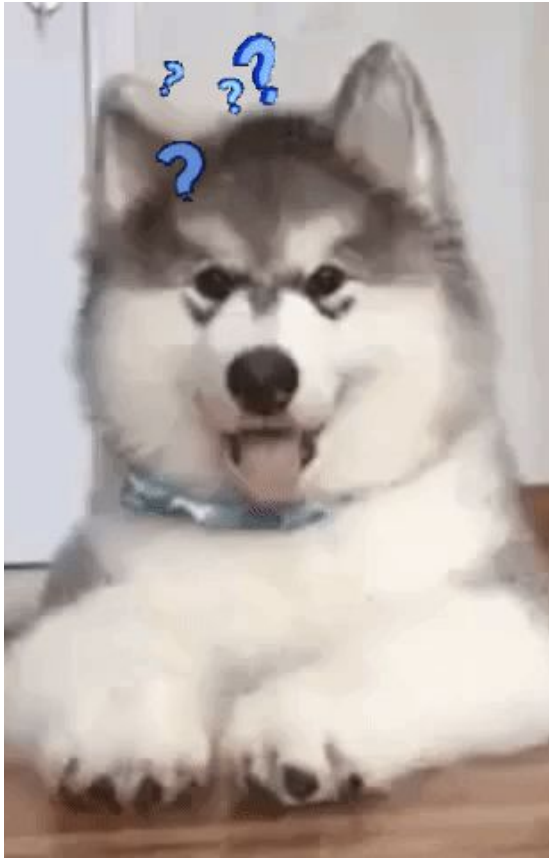
01 **pandas API on Spark**
Swapping pandas for pyspark.pandas

02 **pandas udf & function API**
Writing distributed UDFs

03 **Spark Connect**
Use Spark everywhere

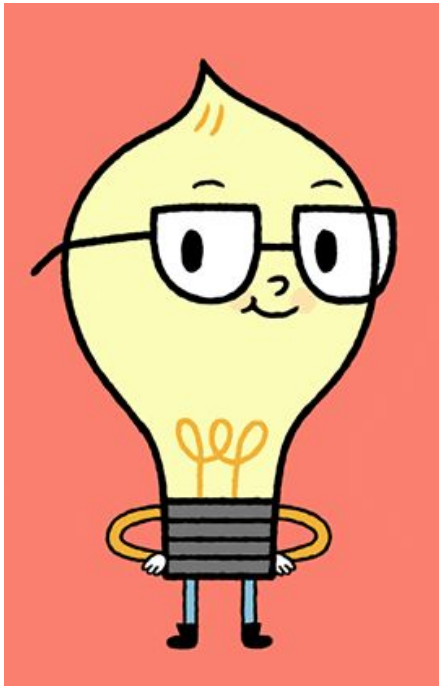
pandas is the de-facto library for data exploration and wrangling

Oh..will it scale?

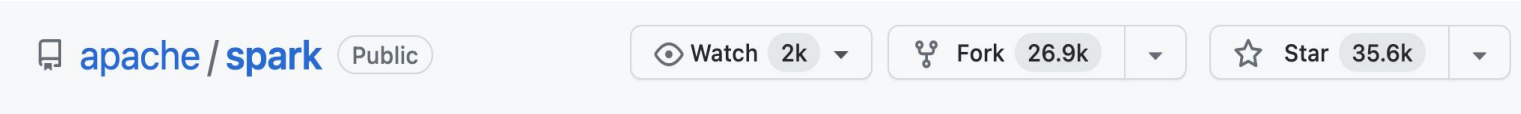


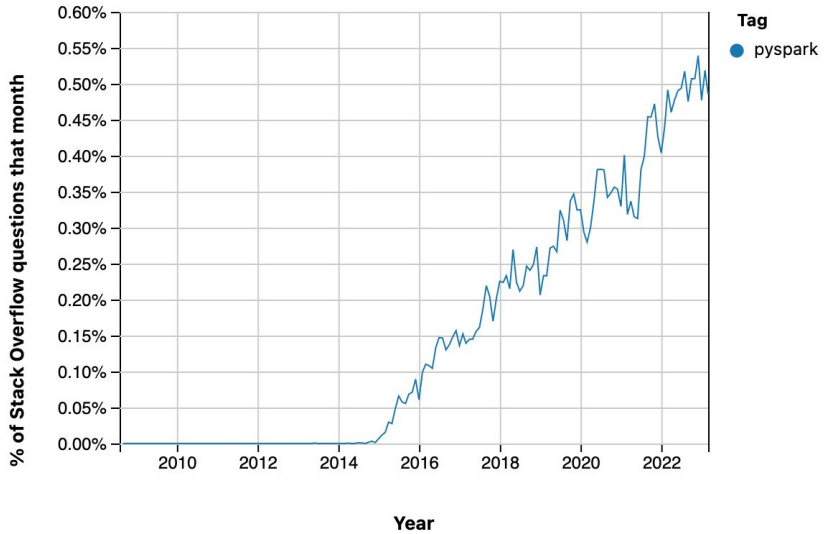
How do I scale?

1. Just….throw a bigger (and bigger) instance
2. Downsample data
3. Switch to a distributed data processing framework



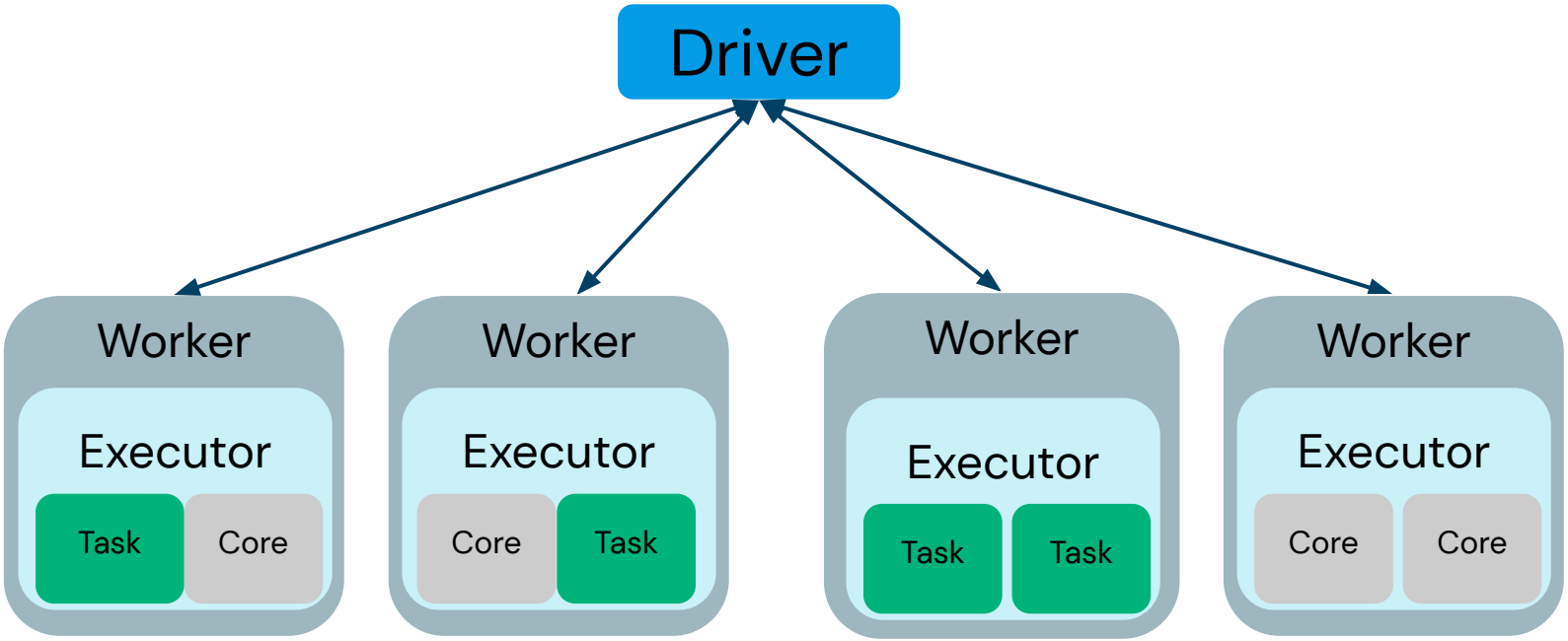
Spark is popular (PySpark too!)





Stack Overflow Trends

Spark: A distributed processing engine



But…it's a new syntax

```pandas
# pandas
import pandas as pd

pdf = pd.read_parquet("your_data.parquet")
pdf_filtered = pdf.loc[pdf["quantity"] > 10, ["data", "quality"]]
pdf
```

```pyspark
# PySpark
from pyspark.sql import SparkSession
spark = SparkSession.builder().getOrCreate()

df = spark.read.format("parquet").load("your_data.parquet")
df_filtered = df.select("date", "quantity").filter("quantity > 10")
df_filtered.show()
```

Differences

	Spark dataframe	pandas dataframe
Mutability	No	Yes
Processing	Distributed	Single-machine • Driver-only
Preserves row order	No • No indices	Yes • Has indices
Evaluation	Lazy	Eager

01

pyspark.pandas

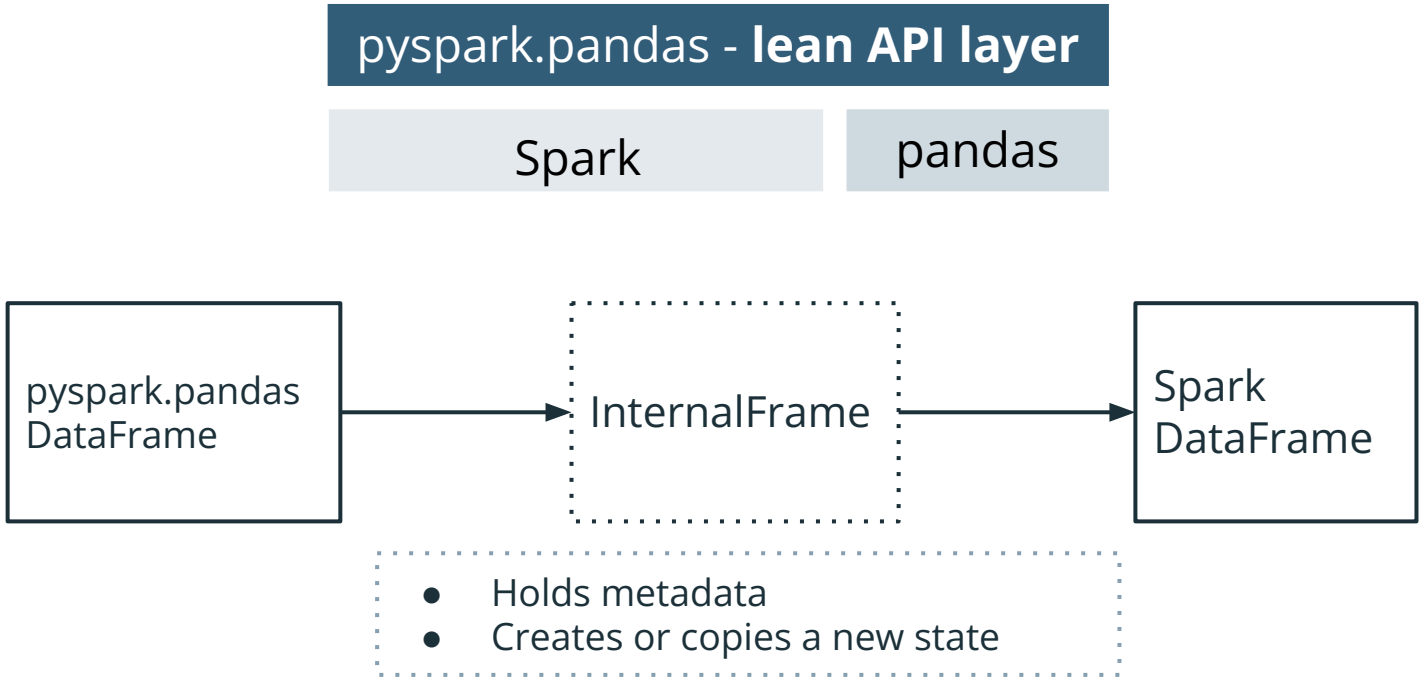
Don’t want to learn PySpark? No problem.

Pyspark.pandas = easy transition to distributed environment

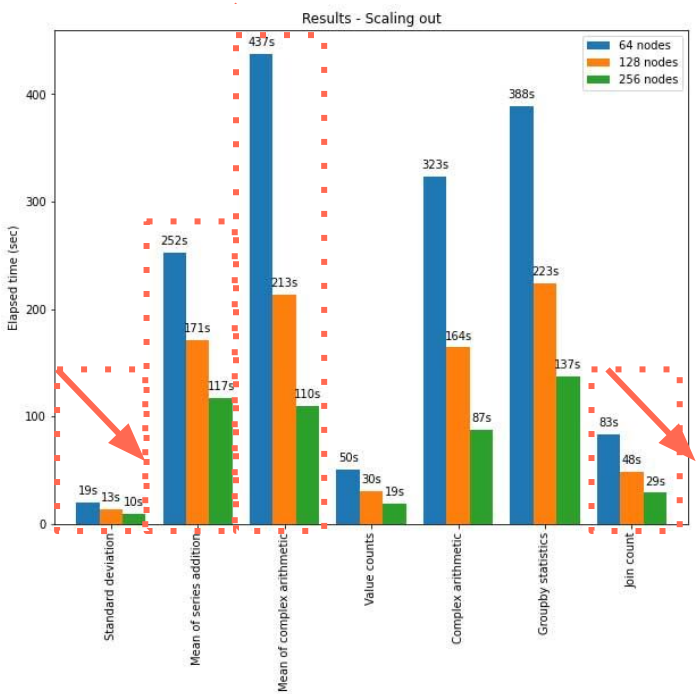
- Announced in April 2019 as "Koalas"
  - Integrated into the PySpark library in 2021
- Unifies pandas and Spark: no need to learn a new syntax!
- Scale up your code easily


```
# import pandas as pd
import pyspark.pandas as ps

pdf = ps.read_parquet("your_data.parquet")
pdf_filtered = pdf.loc[pdf["quantity"] > 10, ["data", "quality"]]
pdf
```

How does it work under the hood

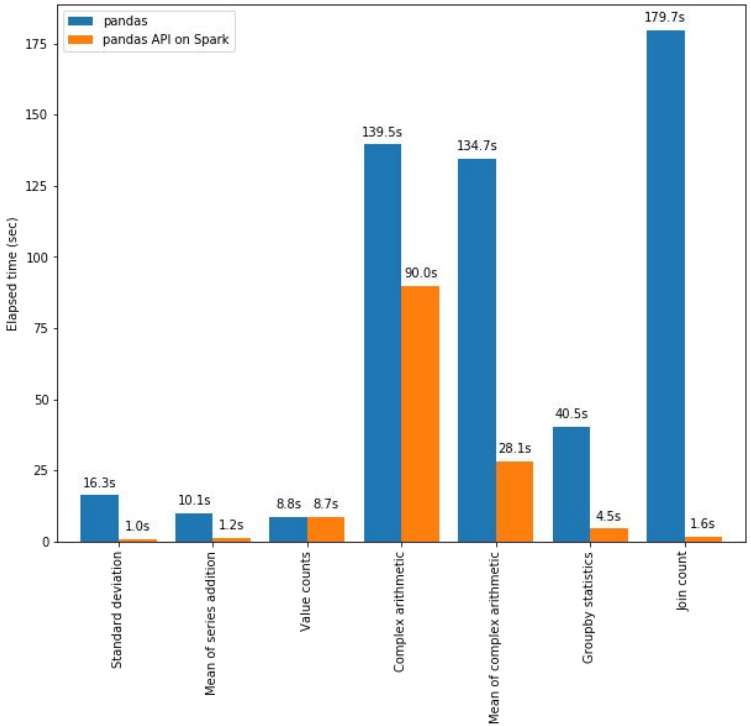


Distributed cluster: it scales almost linearly with # of nodes



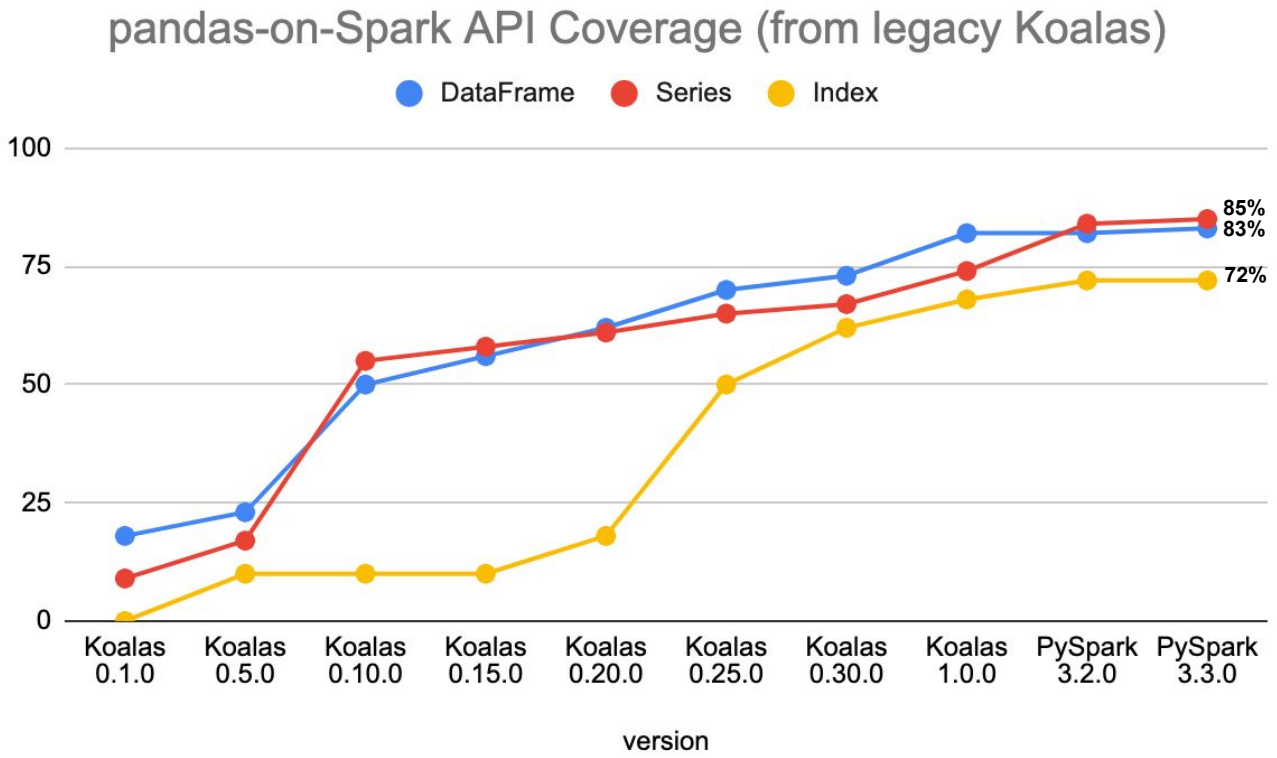
Read blog post here

Single-node cluster: it's faster than pandas



Read blog post here

API coverage



Supported pandas API

Best practice: index choices

```
ps.set_option("compute.default_index_type", "sequence")
```

sequence

- Implements a sequence one-by-one
- Whole partition might end up in single node
- Avoid when data is large

Distributed-sequence (default)

- Implements a sequence one-by-one for each group-by and group-map approach
- Better than `sequence` when data is large

distributed

- Does not increase one-by-one
- Index is indeterministic
- ***Most performant***

More on indices
More best practices

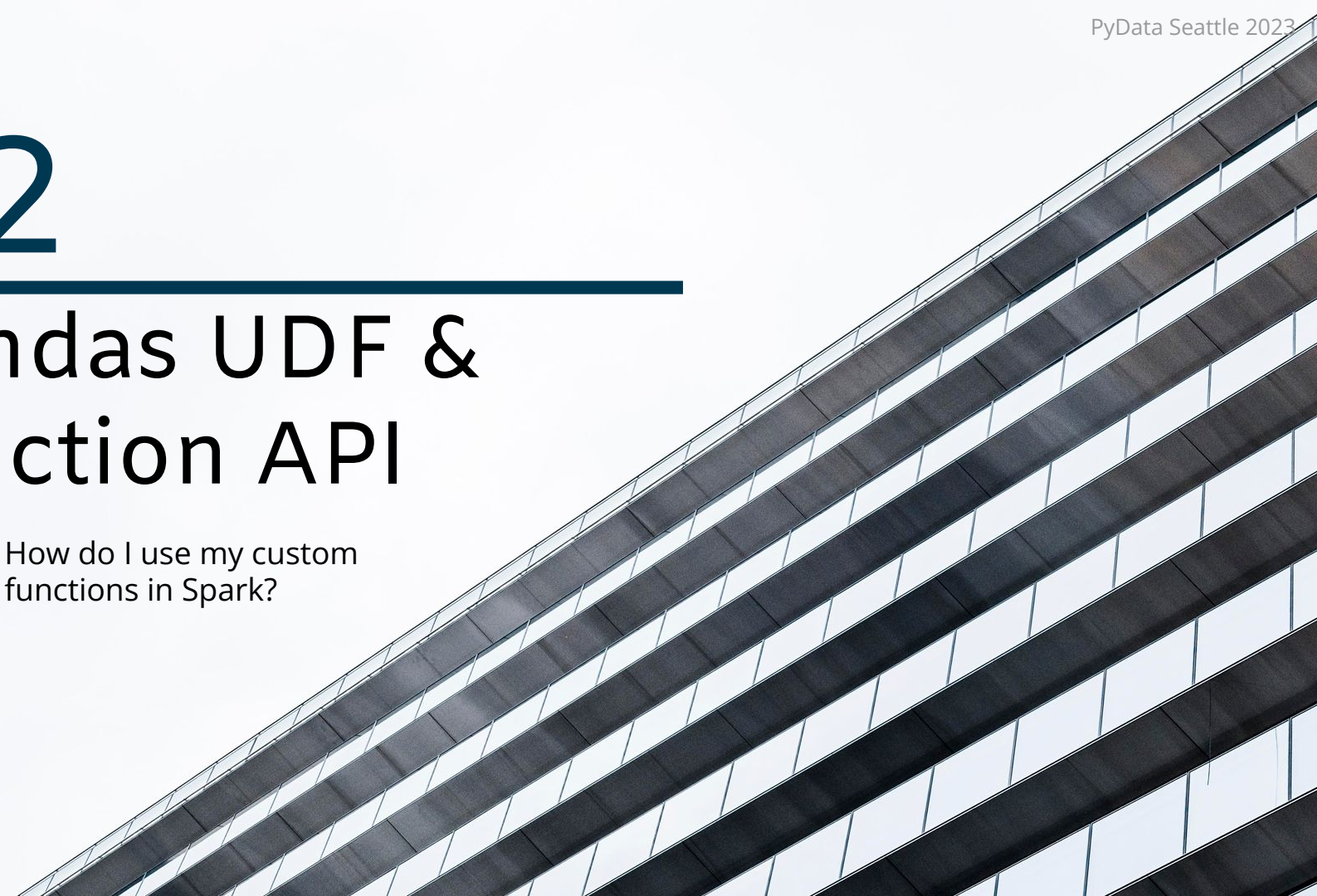
Should I learn PySpark or pyspark.pandas?

- If you know `pandas` but want to scale out to bigger data, then use `pyspark.pandas`
- If you are interested in learning PySpark and want to use Spark for streaming, then learn `PySpark`

02

pandas UDF & function API

How do I use my custom functions in Spark?



pandas friends in PySpark What is what?

- pandas UDF
  - Works as a function, internally an expression
  - Consistent with Scala UDFs and regular Python UDFs
  - Returns a regular PySpark column
  - e.g., `pandas_udf`

- pandas function APIs
  - Works as an API in DataFrame, query plan internally
  - Consistent with APIs such as map, mapGroups, etc.
  - e.g., `DataFrame.mapInPandas`

pandas friends in PySpark What is what?

- pandas UDF

```
@pandas_udf("long")
def pandas_plus_one(v: pd.Series) -> pd.Series:
   return v + 1
```

- pandas function APIs

```
def pandas_plus_one(v: pd.DataFrame) -> pd.DataFrame:
   return v + 1

df.mapInPandas(pandas_plus_one, df.schema)
```

pandas UDF

- Annotate the type you want to take as the input and output
- PySpark decides how to execute them
- They are (de)serialized and executed in the vectorized manner

```
@pandas_udf("int")
def my_udf1(v: pd.Series) -> pd.Series:
   return v + 1
```

Type what you want

```python
@pandas_udf("int")
def my_udf1(v: pd.Series) -> pd.Series:
   return v + 1  # Plus one for each value
```

```python
@pandas_udf("int")
def my_udf2(v: pd.Series) -> int:
   return v.sum()  # Sum of the whole column
```

```python
@pandas_udf("int")
def my_udf3(pdf: pd.DataFrame) -> pd.Series:
   return pdf.sum(axis=0)  # Sum of each row
```

Supported type hints

pandas function API

- (Optionally) annotate the type you want to take as the input and output
- PySpark decides how to execute them based on which API you choose
- They are (de)serialized and executed in the vectorized manner

```
def pandas_filter(iterator: Iterator[pd.DataFrame]) ->
Iterator[pd.DataFrame]:
   for pdf in iterator:
       yield pdf[pdf.id == 1]

df.mapInPandas(pandas_filter, df.schema)
```

Call what you want

```
def subtract_mean(pdf: pd.DataFrame) -> pd.DataFrame:
    return pdf.assign(v=pdf.v - v.mean())
df.groupby("id").applyInPandas(subtract_mean, df.schema)
```

```
def asof_join(left: pd.DataFrame, right: pd.DataFrame) -> pd.DataFrame:
    return pd.merge_asof(left, right, on="time", by="id")
df1.groupby("id").cogroup(df2.groupby("id")
    ).applyInPandas(asof_join, "time int, id int, v1 double, v2 string")
```

```
def pandas_filter(itr: Iterator[pd.DataFrame]) -> Iterator[pd.DataFrame]:
    for pdf in itr:
        yield pdf[pdf.id == 1]
df.mapInPandas(pandas_filter, df.schema)
```

Supported API

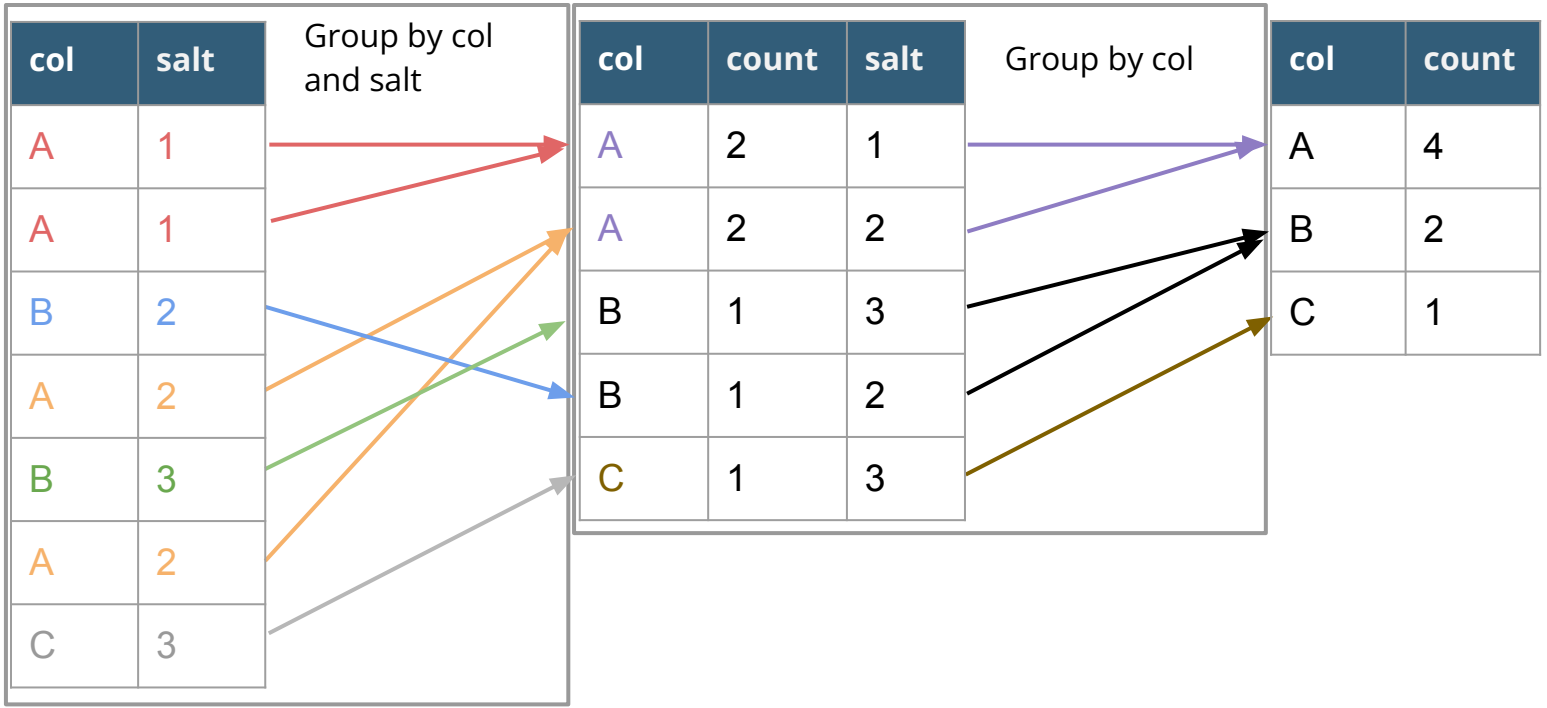
ML: Train on grouped instances

```
def train_my_model(pdf: pd.DataFrame) -> pd.DataFrame:
  x, y = pdf[["feature_1"]], pdf["label"]
  rf = RandomForestClassifier()
  rf.fit(x, y)

  # Evaluate the model
  predictions = rf.predict(X)
  d_id, n_used, auc = (
      pdf["device_id"].iloc[0], pdf.shape[0], auc(y, predictions)
  )

  return pd.DataFrame(
      [[device_id, n_used, auc]], columns=["d_id", "n_used","auc"])
```

ML: Train on grouped instances

```
# `spark_df` is Spark DataFrame
model_directories_df = spark_df.groupby("device_id")
                               .applyInPandas(
                                train_my_model,
                                schema="device_id INT, n_used INT, auc FLOAT")
```

OOM (Out–of-Memory)? Salt it



OOM (Out–of-Memory)? Salt it

```
df.groupby(col).applyInPandas(subtract_mean, df.schema)
```

```
(df.withColumn("salt", (rand * n).cast(IntegerType))
   .groupBy("salt", col)
   .applyInPandas(subtract_mean, df.schema)
   .groupBy(col)
   .agg(...))
```

Debug? Performance?

- How to debug implementation errors?
  - Make sure it works on a single node before distributing in Spark
  - If you are using iterators (i.e. `mapInPandas`), use Python closures
  - Remote Debugging, Memory Profiler and Python Profilers

- Make sure your functions are optimized! No for-loops

- Make sure your data is properly partitioned
  - `pyspark_df.repartition("{n or col_name}").mapInPandas(...)`

- Use Spark UI to debug performance issues
  - Add print statements in your functions
  - Go to your Jobs tab -> Stages tab and check the standard errors/outputs

03

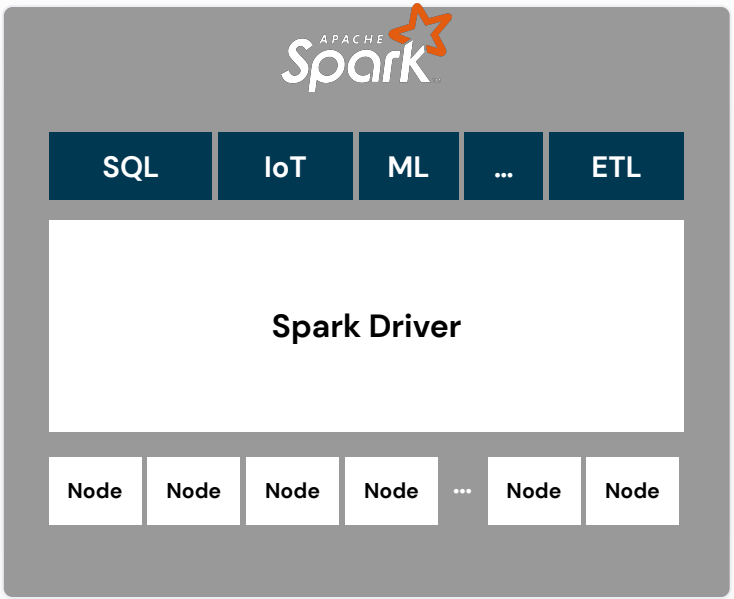
Spark Connect

Run Spark everywhere

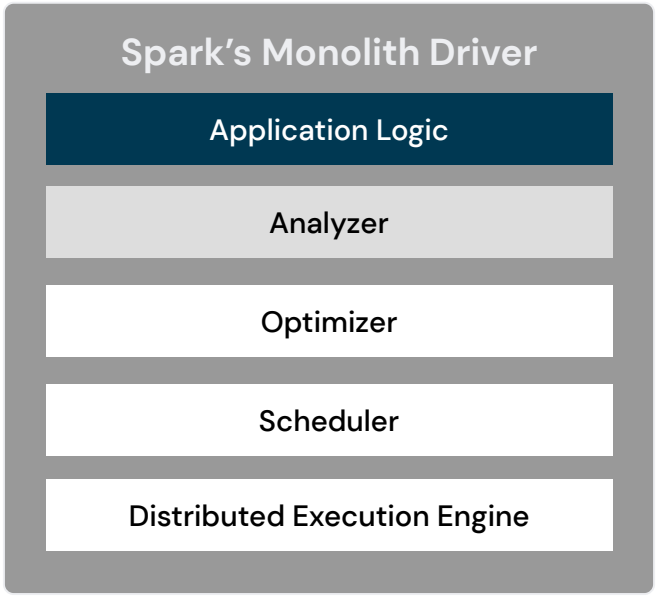
Spark is often associated with data centers and large clusters

10s to 100s of apps and users

1000s of nodes



If you zoom in …

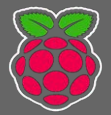


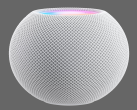
Data applications don’t just live in data centers anymore

Interactive Development (notebooks / IDEs)

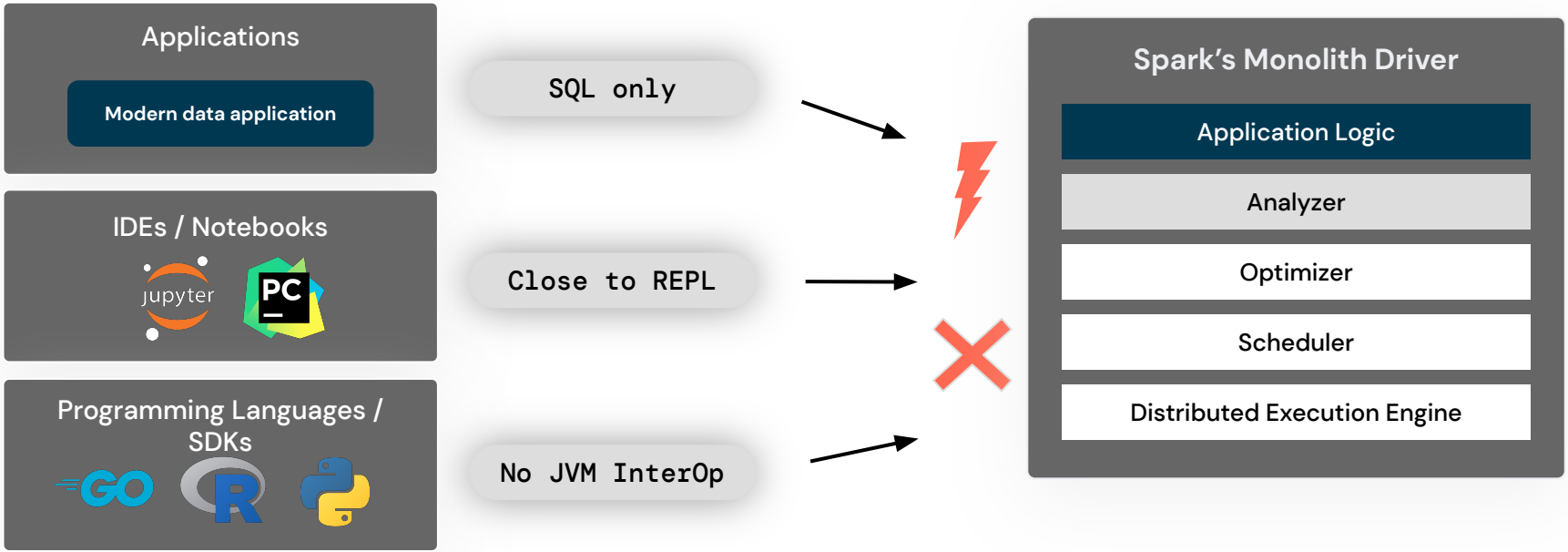

Application Servers / Web Services


Edge Devices

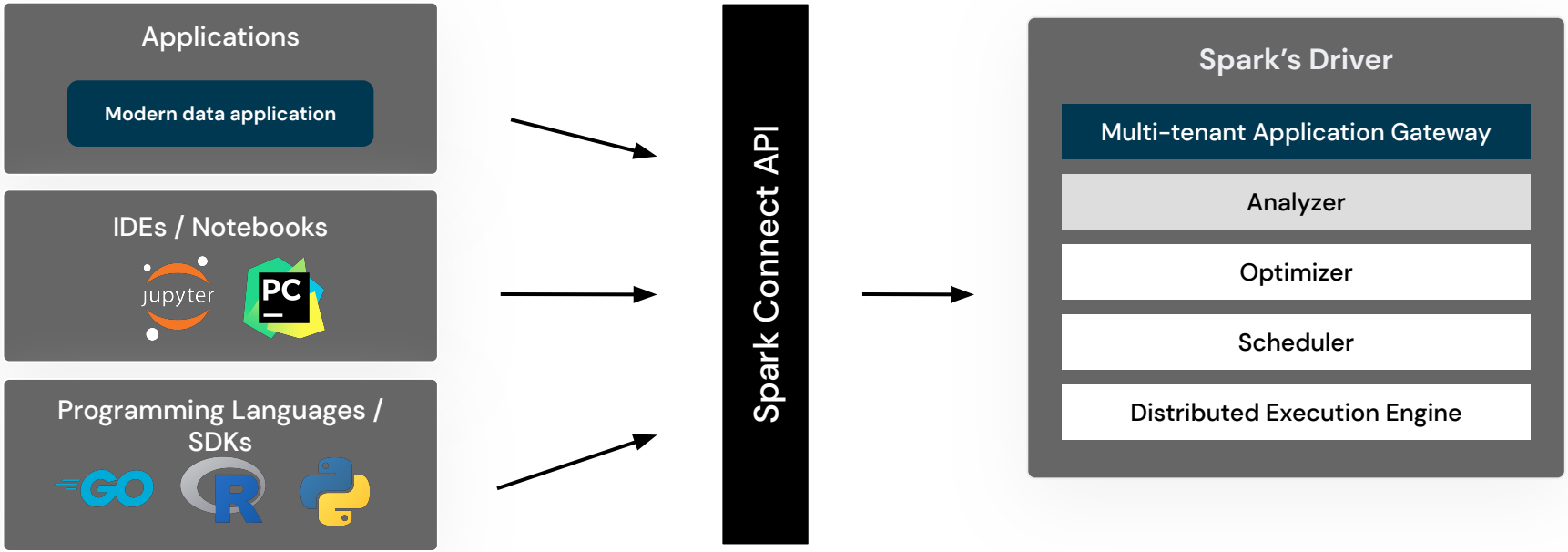


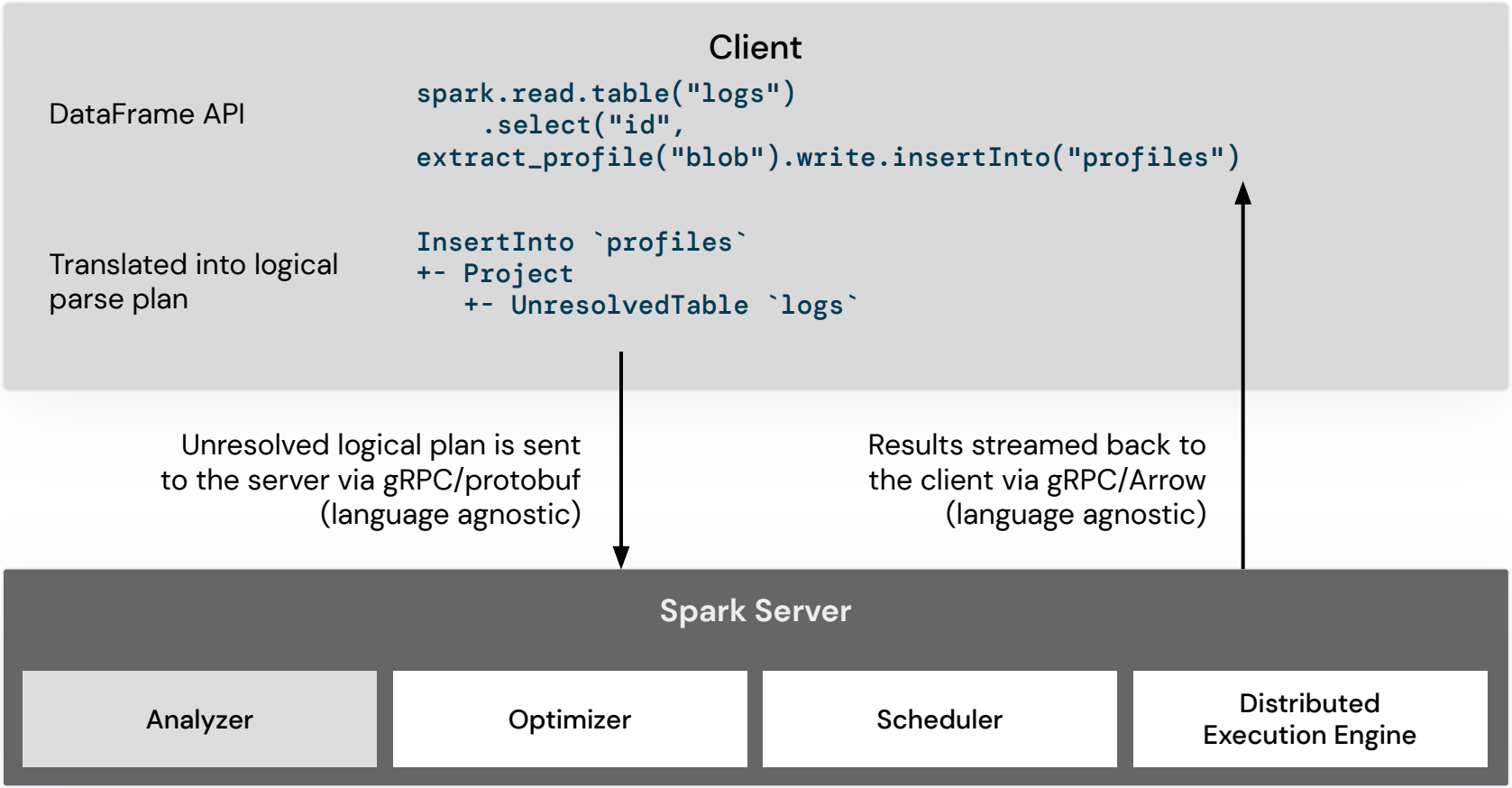



How to embed Spark in applications?



Thin client, with the full power of Apache Spark



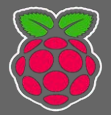

Client
DataFrame API
spark.read.table("logs")
.select("id",
extract_profile("blob").write.insertInto("profiles")
Translated into logical parse plan
InsertInto `profiles`
+- Project
+- UnresolvedTable `logs`
Unresolved logical plan is sent to the server via gRPC/protobuf (language agnostic)
Results streamed back to the client via gRPC/Arrow (language agnostic)
Spark Server
Analyzer
Optimizer
Scheduler
Distributed Execution Engine

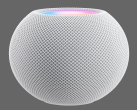
Power of Apache Spark, everywhere, with a thin client

Interactive Development (notebooks / IDEs)


Application Servers / Web Services

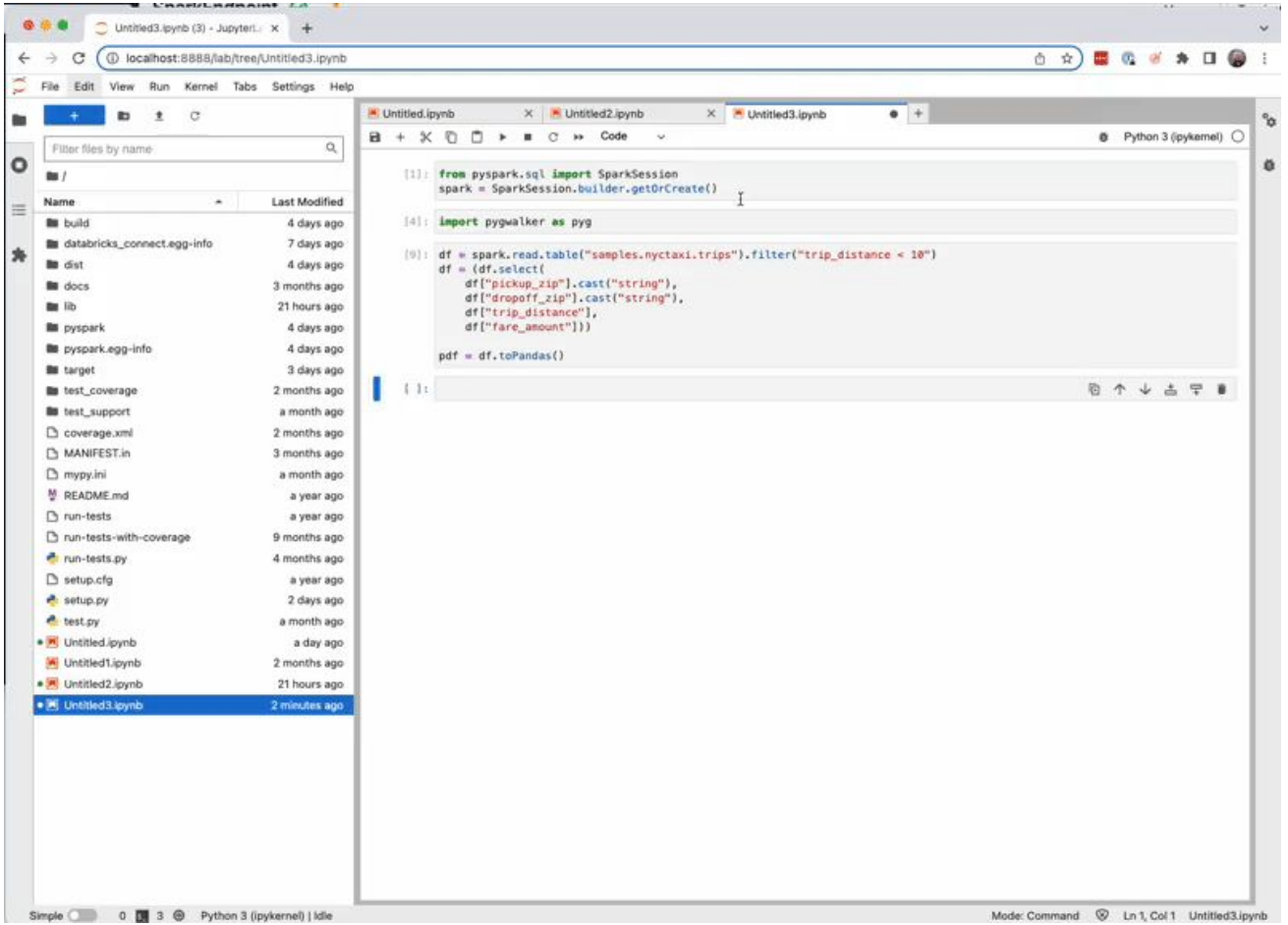

Edge Devices



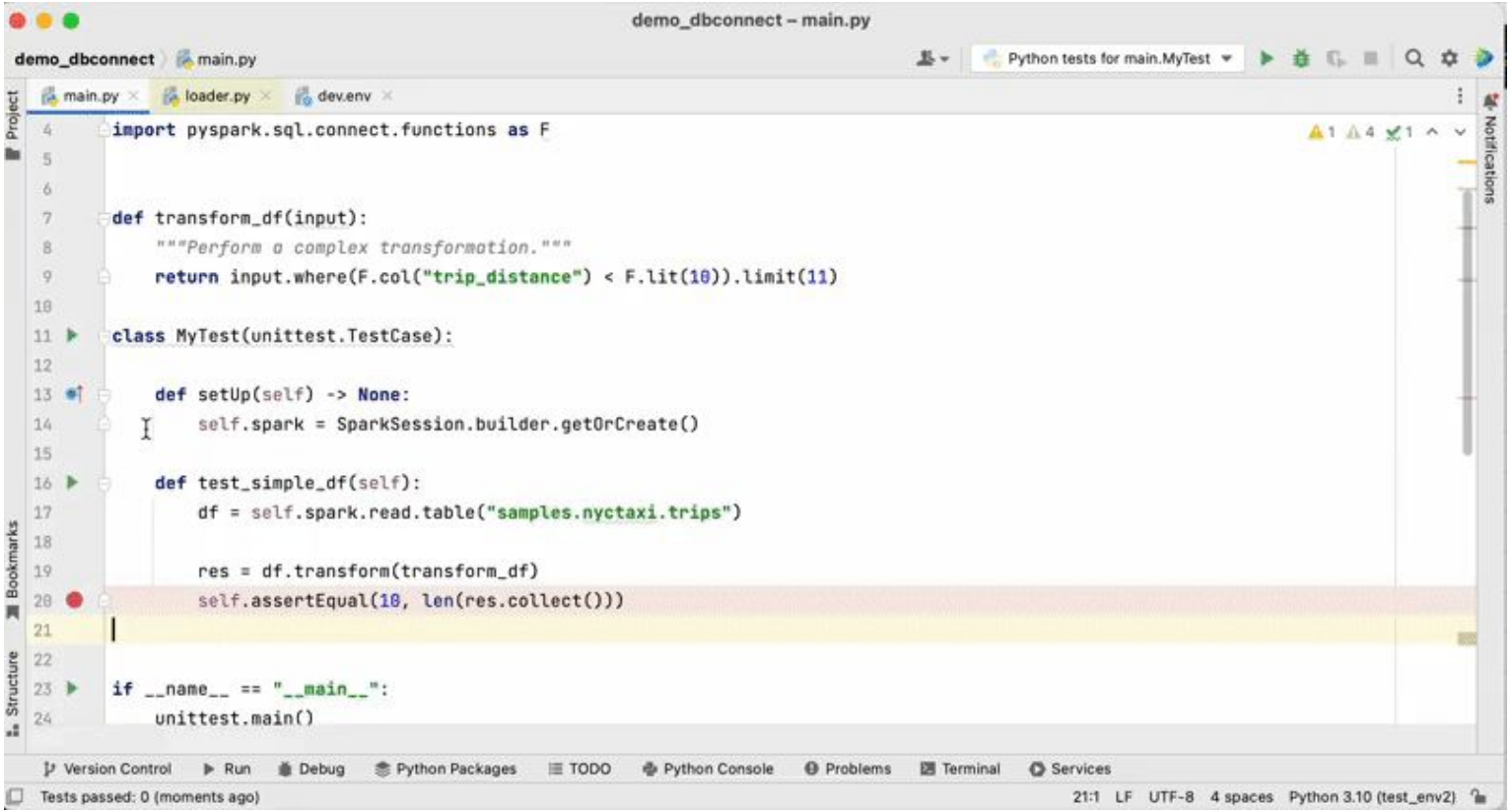



Power of Apache Spark, everywhere, with a thin client

Example: Jupyter visualization

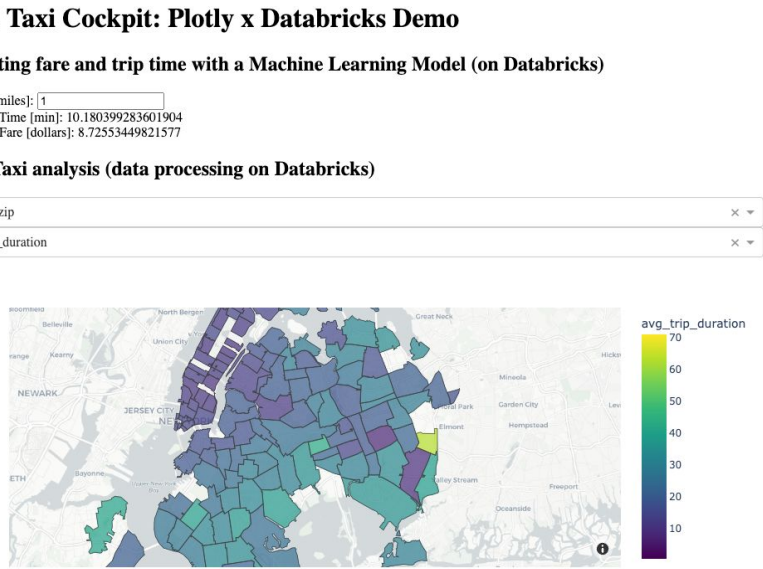


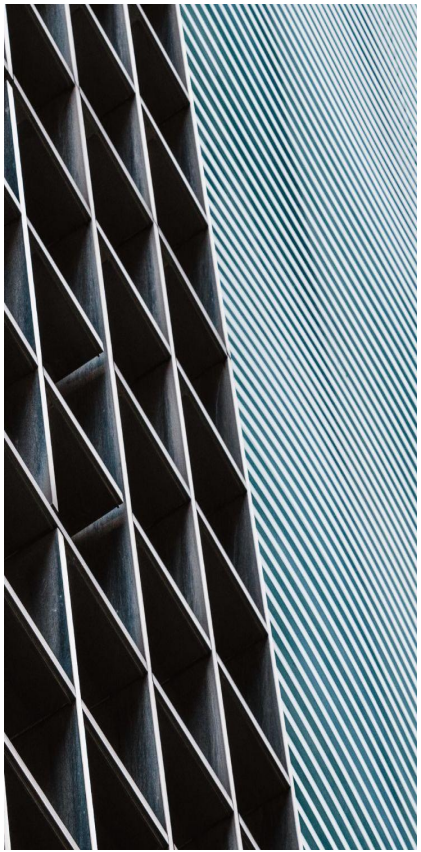
Example: IDE


demo_dbconnect – main.py
demo_dbconnect
main.py
Python tests for main.MyTest
main.py
loader.py
dev.env
Project
Notifications
Bookmarks
Structure
import pyspark.sql.connect.functions as F
def transform_df(input):
"""Perform a complex transformation."""
return input.where(F.col("trip_distance") < F.lit(10)).limit(11)
class MyTest(unittest.TestCase):
def setUp(self) -> None:
self.spark = SparkSession.builder.getOrCreate()
def test_simple_df(self):
df = self.spark.read.table("samples.nyctaxi.trips")
res = df.transform(transform_df)
self.assertEqual(10, len(res.collect()))
if __name__ == "__main__":
unittest.main()
Version Control
Run
Debug
Python Packages
TODO
Python Console
Problems
Terminal
Services
Tests passed: 0 (moments ago)
21:1
LF
UTF-8
4 spaces
Python 3.10 (test_env2)

Example: Run in your browser

```
def spark_session():
    with open("cluster.json") as f:
        config = json.load(f)

    host = config["workspaceUrl"]
    clusterId = config["clusterId"]
    token = config["token"]

    connStr = f"sc://{host}:443/;token={token};x-databricks-cluster-id={clusterId}"

    return SparkSession.builder.remote(connStr).getOrCreate()


spark = spark_session()

app = Dash(__name__)

app.layout = html.Div(children=[
    html.H1(children="NYC Taxi Cockpit: Plotly x Databricks Demo"),

    html.Div([
        html.H2("Predicting fare and trip time with a Machine Learning Model (on Databricks)"),
        html.Span([
            "Distance [miles]: ",
            dcc.Input(id="trip-distance", value="1", type="number")
        ``
```





QUESTIONS?

Slides:
bit.ly/pandas-spark