

Basic introduction to PySpark

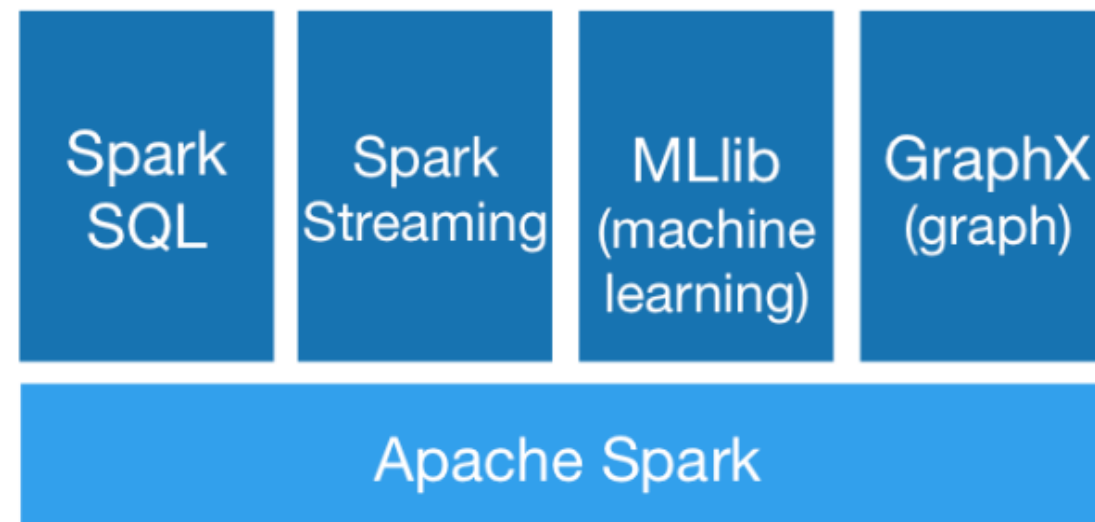
BUILDING DATA ENGINEERING PIPELINES IN PYTHON



Oliver Willekens
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What is Spark?

- A fast and general engine for large-scale data processing
- 4 libraries built on top of Spark core:



- API in several languages
 - Java, Scala, Python (“PySpark”), R

When to use Spark

Spark is used for:

- Data processing at scale
- Interactive analytics
- Machine learning

Spark is **not** used for:

- When you have only little data
- When you have only simple operations

Business case: finding the perfect diaper

Find the perfect diaper based on:

- qualitative attributes e.g. comfort
- quantitative attributes e.g. price

Scraped data available:

- *prices.csv*: pricing details per model per store
- *ratings.csv*: user ratings per model

Starting the Spark analytics engine

```
from pyspark.sql import SparkSession

spark = SparkSession.builder.getOrCreate()
```

Reading a CSV file

```
prices = spark.read.csv("mnt/data_lake/landing/prices.csv")  
prices.show()
```

```
+-----+-----+-----+-----+-----+-----+-----+  
|      _c0|      _c1|      _c2|      _c4|      _c5|      _c6|      _c7|  
+-----+-----+-----+-----+-----+-----+-----+  
|   store|countrycode|      brand|price|currency|quantity|      date|  
|    Aldi|         BE|Diapers-R-Us| 6.8|    EUR|      40|2019-02-03|  
|Carrefour|        FR|    Nappy-k| 5.7|    EUR|      30|2019-02-06|  
|   Tesco|        IRL|    Pampers| 6.3|    EUR|      35|2019-02-07|  
|      DM|        DE|    Huggies| 6.8|    EUR|      40|2019-02-01|  
+-----+-----+-----+-----+-----+-----+-----+
```

Reading a CSV file with headers

```
prices = spark.read.options(header="true").csv("mnt/data_lake/landing/prices.csv")
prices.show()
```

```
+-----+-----+-----+-----+-----+-----+
|  store|countrycode|      brand|price|currency|quantity|      date|
+-----+-----+-----+-----+-----+-----+
|    Aldi|        BE|Diapers-R-Us| 6.8|    EUR|      40|2019-02-03|
|Carrefour|        FR|    Nappy-k| 5.7|    EUR|      30|2019-02-06|
|   Tesco|        IRL|    Pampers| 6.3|    EUR|      35|2019-02-07|
|      DM|        DE|    Huggies| 6.8|    EUR|      40|2019-02-01|
+-----+-----+-----+-----+-----+-----+
```

Automatically inferred data types

```
from pprint import pprint  
pprint(prices.dtypes)
```

```
[('store', 'string'),  
 ('countrycode', 'string'),  
 ('brand', 'string'),  
 ('price', 'string'),  
 ('currency', 'string'),  
 ('quantity', 'string'),  
 ('date', 'string')]
```


Enforcing a schema

```
schema = StructType([StructField("store", StringType(), nullable=False),
                        StructField("countrycode", StringType(), nullable=False),
                        StructField("brand", StringType(), nullable=False),
                        StructField("price", FloatType(), nullable=False),
                        StructField("currency", StringType(), nullable=True),
                        StructField("quantity", IntegerType(), nullable=True),
                        StructField("date", DateType(), nullable=False)])

prices = spark.read.options(header="true").schema(schema).csv("mnt/data_lake/landing/prices.csv")
print(prices.dtypes)
```

```
[('store', 'string'), ('countrycode', 'string'), ('brand', 'string'),
 ('price', 'float'), ('currency', 'string'), ('quantity', 'int'), ('date', 'date')]
```

Let's practice!

BUILDING DATA ENGINEERING PIPELINES IN PYTHON

Cleaning data

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Reasons to clean data

Most data sources are not ready for analytics. This could be due to:

- Incorrect data types
- Invalid rows
- Incomplete rows
- Badly chosen placeholders

Can we automate data cleaning?

Data cleaning depends on the context

- Can our system cope with data that is 95% clean and 95% complete?
- What are the implicit standards in the company?
 - regional datetimes vs. UTC
 - column naming conventions
 - ...
- What are the low-level details of the systems?
 - representation of unknown / incomplete data
 - ranges for numerical values
 - meaning of fields

Selecting data types

Data type	Value type in Python
ByteType	Good for numbers that are within the range of -128 to 127.
ShortType	Good for numbers that are within the range of -32768 to 32767.
IntegerType	Good for numbers that are within the range of -2147483648 to 2147483647.
FloatType	float
StringType	string
BooleanType	bool
DateType	datetime.date

Badly formatted source data

```
cat bad_data.csv # prints the entire file on stdout
```

```
store,countrycode,brand,price,currency,quantity,date  
Aldi,BE,Diapers-R-Us,6.8,EUR,40,2019-02-03  
-----  
Kruidvat,NL,Nappy-k,5.6,EUR,40,2019-02-15  
DM,AT,Huggies,7.2,EUR,40,2019-02-01
```

Spark's default handling of bad source data

```
prices = spark.read.options(header="true").csv('landing/prices.csv')
prices.show()
```

```
+-----+-----+-----+-----+-----+-----+-----+
|          store|countrycode|          brand|price|currency|quantity|          date|
+-----+-----+-----+-----+-----+-----+-----+
|          Aldi|          BE|Diapers-R-Us|  6.8|      EUR|         40|2019-02-03|
|-----...|          null|          null| null|      null|         null|          null|
|          Kruidvat|          NL|          Nappy-k|  5.6|      EUR|         40|2019-02-15|
|          DM|          AT|          Huggies|  7.2|      EUR|         40|2019-02-01|
+-----+-----+-----+-----+-----+-----+-----+
```


Handle invalid rows

```
prices = (spark
          .read
          .options(header="true", mode="DROPMALFORMED")
          .csv('landing/prices.csv'))
```

```
+-----+-----+-----+-----+-----+-----+
|  store|countrycode|      brand|price|currency|quantity|      date|
+-----+-----+-----+-----+-----+-----+
|    Aldi|          BE|Diapers-R-Us| 6.8|    EUR|      40|2019-02-03|
|Kruidvat|          NL|    Nappy-k| 5.6|    EUR|      40|2019-02-15|
|      DM|          AT|    Huggies| 7.2|    EUR|      40|2019-02-01|
+-----+-----+-----+-----+-----+-----+
```

The significance of null

```
store,countrycode,brand,price,currency,quantity,date
Aldi,BE,Diapers-R-Us,6.8,EUR,40,2019-02-03
Kruidvat,,Nappy-k,5.6,EUR,,2019-02-15
```

```
prices = (spark.read.options(header="true")
          .schema(schema)
          .csv('/landing/prices_with_incomplete_rows.csv'))
prices.show()
```

```
+-----+-----+-----+-----+-----+-----+
| store|countrycode| brand|price|currency|quantity| date|
+-----+-----+-----+-----+-----+-----+
| Aldi| BE|Diapers-R-Us| 6.8| EUR| 40|2019-02-03|
|Kruidvat| null| Nappy-k| 5.6| EUR| null|2019-02-15|
+-----+-----+-----+-----+-----+-----+
```

Supplying default values for missing data

```
prices.fillna(25, subset=['quantity']).show()
```

```
+-----+-----+-----+-----+-----+-----+
| store|countrycode| brand|price|currency|quantity| date|
+-----+-----+-----+-----+-----+-----+
| Aldi| BE|Diapers-R-Us| 6.8| EUR| 40|2019-02-03|
|Kruidvat| null| Nappy-k| 5.6| EUR| 25|2019-02-15|
+-----+-----+-----+-----+-----+-----+
```

Badly chosen placeholders

Example: contracts of employees

```
employees = spark.read.options(header="true").schema(schema).csv('employees.csv')
```

```
+-----+-----+-----+-----+
|employee_name|department|start_date|end_date|
+-----+-----+-----+-----+
|      Bob|marketing|2012-06-01|2016-05-02|
|    Alice|      IT|2018-04-03|9999-12-31|
+-----+-----+-----+-----+
```

Conditionally replace values

```
from pyspark.sql.functions import col, when
from datetime import date, timedelta
one_year_from_now = date.today().replace(year=date.today().year + 1)

better_frame = employees.withColumn("end_date",
    when(col("end_date") > one_year_from_now, None).otherwise(col("end_date")))

better_frame.show()
```

```
+-----+-----+-----+-----+
|employee_name|department|start_date|end_date|
+-----+-----+-----+-----+
|      Bob|marketing|2012-06-01|2016-05-02|
|    Alice|      IT|2018-04-03|      null|
+-----+-----+-----+-----+
```

Let's practice!

BUILDING DATA ENGINEERING PIPELINES IN PYTHON

Transforming data with Spark

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Why do we need to transform data?

Process:

1. Collect data
2. “Massage” data: involves cleaning and business logic
3. **Derive insights**

Example:

1. Collect data from *booking.com* and *hotels.com*.
2. Standardize hotel names, normalizing review scores.
3. Join datasets, filter on location and rank results.

Common data transformations

1. Filtering rows

```
country | purchase_order
-----|-----
India   | 87254800912
Ukraine | 32498562223
```

European purchases?

```
country | purchase_order
-----|-----
Ukraine | 32498562223
```

Common data transformations

1. Filtering rows
2. Selecting and renaming columns

```
country | purchase_order | store_keep
-----|-----|-----
Ukraine | 32498562223         | Oksana D.
Spain   | 74398221190         | Pedro R.
```

->

```
country_of_purchase | purchase_order
-----|-----
Ukraine             | 32498562223
Spain                | 74398221190
```

Common data transformations

1. Filtering rows
2. Selecting and renaming columns
3. Grouping and aggregation

```
country | purchase_order | price          country | total_revenue
-----|-----|-----          -----|-----
Ukraine | 32498562223         | $12          Ukraine | $12
Spain   | 74398221190         | $54          Spain   | $80
Spain   | 49876776100         | $26
```

=>

Common data transformations

1. Filtering rows
2. Selecting and renaming columns
3. Grouping and aggregation
4. Joining multiple datasets

```
country | purchase_order | price      purchase_order | category
-----|-----|-----
Ukraine | 32498562223      | $12      + 32498562223      | food
Spain   | 74398221190      | $54      49876776100      | electronics
Spain   | 49876776100      | $26      74398221190      | clothing
```

Common data transformations

1. Filtering rows
2. Selecting and renaming columns
3. Grouping and aggregation
4. Joining multiple datasets
5. Ordering results

country		purchase_order		price		country		purchase_order		price
-----		-----		-----		-----		-----		-----
Spain		74398221190		\$26	=>	Ukraine		32498562223		\$12
Ukraine		32498562223		\$12		Spain		74398221190		\$26
Spain		49876776100		\$54		Spain		49876776100		\$54

Recall the prices dataset

```
prices = spark.read.options(header="true").schema(schema).csv('landing/prices.csv')
```

```
+-----+-----+-----+-----+-----+-----+
| store|countrycode| brand|price|currency|quantity| date|
+-----+-----+-----+-----+-----+-----+
| Aldi| BE|Diapers-R-Us| 6.8| EUR| 40|2019-02-03|
| Kruidvat| BE| Nappy-k| 4.8| EUR| 30|2019-01-28|
| Carrefour| FR| Nappy-k| 5.7| EUR| 30|2019-02-06|
| Tesco| IRL| Pampers| 6.3| EUR| 35|2019-02-07|
| DM| DE| Huggies| 6.8| EUR| 40|2019-02-01|
+-----+-----+-----+-----+-----+-----+
```

Filtering and ordering rows

```
prices_in_belgium = prices.filter(col('countrycode') == 'BE').orderBy(col('date'))
```

```
+-----+-----+-----+-----+-----+-----+
| store|countrycode| brand|price|currency|quantity| date|
+-----+-----+-----+-----+-----+-----+
|Kruidvat| BE| Nappy-k| 4.8| EUR| 30|2019-01-28|
| Aldi| BE|Diapers-R-Us| 6.8| EUR| 40|2019-02-03|
+-----+-----+-----+-----+-----+-----+
```

- Function `col` creates Column objects
- Method `orderBy` sorts values by a certain column.

Selecting and renaming columns

```
prices.select(  
  
)
```


Selecting and renaming columns

```
prices.select(  
    col("store"),  
    col("brand")  
)
```

Selecting and renaming columns

```
prices.select(  
    col("store"),  
    col("brand").alias("brandname")  
)
```

```
+-----+-----+  
|   store| brandname|  
+-----+-----+  
|    Aldi|Diapers-R-Us|  
| Kruidvat|    Nappy-k|  
|Carrefour|    Nappy-k|  
| Kruidvat|    Nappy-k|  
|    Tesco|    Pampers|  
|        DM|    Huggies|  
|        DM|    Huggies|  
+-----+-----+
```

Reducing duplicate values

```
prices.select(  
    col("store"),  
    col("brand").alias("brandname")  
)distinct()
```

```
+-----+-----+  
|   store| brandname|  
+-----+-----+  
|      DM|   Huggies|  
| Kruidvat| Nappy-k|  
| Carrefour| Nappy-k|  
|      Aldi|Diapers-R-Us|  
|   Tesco|   Pampers|  
+-----+-----+
```

Grouping and aggregating with mean()

```
(prices
 .groupBy(col('brand'))
 .mean('price')
).show()
```

```
+-----+-----+
|      brand|      avg(price)|
+-----+-----+
|Diapers-R-Us| 6.800000190734863|
|      Pampers| 6.300000190734863|
|      Huggies|              7.0|
|      Nappy-k|5.3666666348775225|
+-----+-----+
```

Grouping and aggregating with agg()

```
(prices
 .groupBy(col('brand'))
 .agg(
     avg('price').alias('average_price'),
     count('brand').alias('number_of_items')
 )
).show()
```

```
+-----+-----+-----+
|      brand|      average_price|number_of_items|
+-----+-----+-----+
|Diapers-R-Us| 6.800000190734863|          1|
|    Pampers| 6.300000190734863|          1|
|    Huggies|              7.0|          2|
|    Nappy-k|5.3666666348775225|          3|
```

Joining related data

```
+-----+-----+-----+-----+-----+-----+-----+
| store|countrycode| brand| model|price|currency|quantity| date|
+-----+-----+-----+-----+-----+-----+-----+
| Aldi| BE|Diapers-R-Us|6months| 6.8| EUR| 40|2019-02-03|
| Kruidvat| BE| Nappy-k|2months| 4.8| EUR| 30|2019-01-28|
|Carrefour| FR| Nappy-k|2months| 5.7| EUR| 30|2019-02-06|
| Tesco| IRL| Pampers|3months| 6.3| EUR| 35|2019-02-07|
| DM| DE| Huggies|newborn| 6.8| EUR| 40|2019-02-01|
+-----+-----+-----+-----+-----+-----+-----+
```

```
+-----+-----+-----+-----+
| brand| model|absorption_rate|comfort|
+-----+-----+-----+-----+
|Diapers-R-Us|6months| 2| 3|
| Nappy-k|2months| 3| 4|
| Pampers|3months| 4| 4|
| Huggies|newborn| 3| 5|
+-----+-----+-----+-----+
```

Executing a join with 2 foreign keys

```
ratings_with_prices = ratings.join(prices, ["brand", "model"])
```

```
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|      brand|  model|absorption_rate|comfort|      store|countrycode|price|currency|quantity|      date|
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|Diapers-R-Us|6months|          2|      3|      Aldi|          BE|  6.8|      EUR|        40|2019-02-01|
|      Nappy-k|2months|          3|      4| Kruidvat|          BE|  4.8|      EUR|        30|2019-01-15|
|      Nappy-k|2months|          3|      4|Carrefour|          FR|  5.7|      EUR|        30|2019-02-01|
|      Pampers|3months|          4|      4|      Tesco|          IRL|  6.3|      EUR|        35|2019-02-01|
|      Huggies|newborn|          3|      5|          DM|          DE|  6.8|      EUR|        40|2019-02-01|
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+

```

Let's practice!

BUILDING DATA ENGINEERING PIPELINES IN PYTHON

Packaging your application

BUILDING DATA ENGINEERING PIPELINES IN PYTHON



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Running your pipeline locally

Running a Python program:

```
python hello_world.py # script does something
```

Running a PySpark program *locally* is no different:

```
python my_pyspark_data_pipeline.py # script starts at least a SparkSession
```

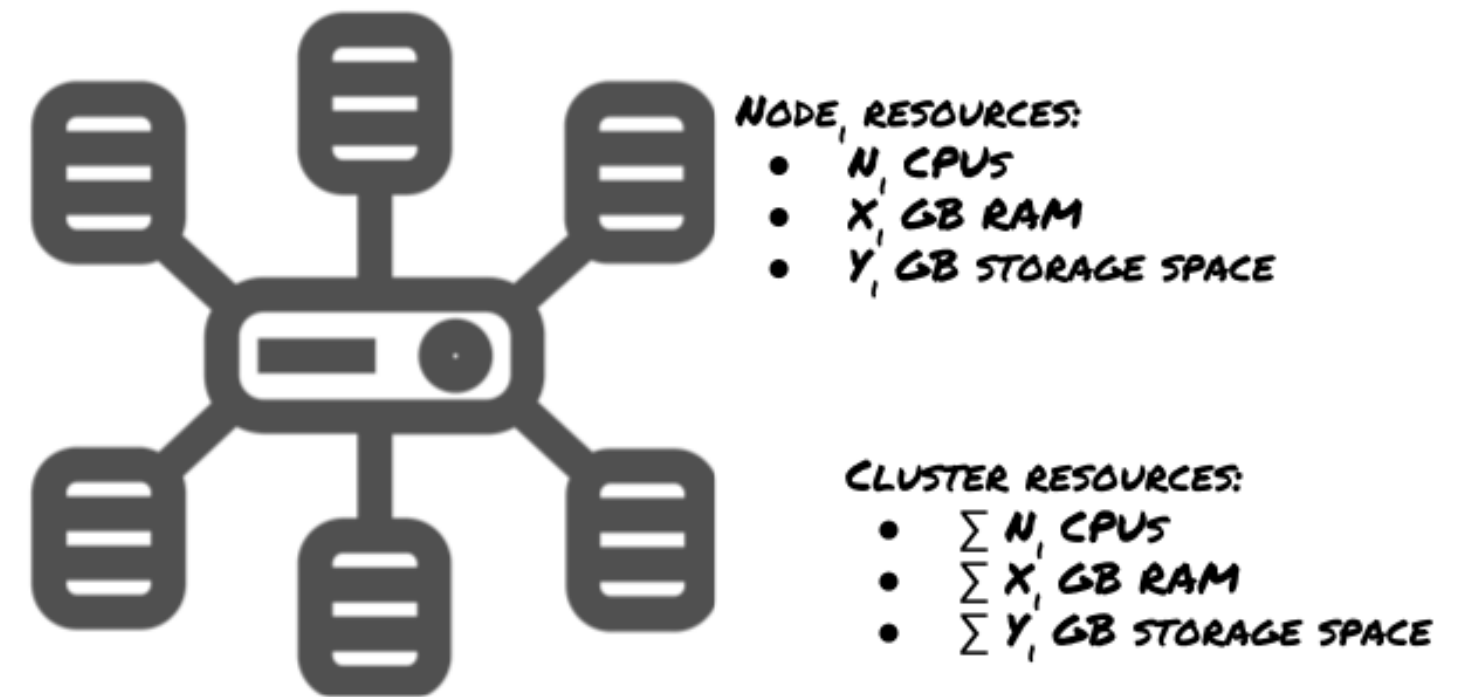
Conditions:

- local installation of Spark
- access to referenced resources
- classpath is properly configured

Using the “spark-submit” helper program

`spark-submit` comes with any Spark installation

1. sets up launch environment for use with the *cluster manager* and the selected *deploy mode*
2. invokes main class/app/module/function



CLUSTER MANAGER:

**"THESE ARE THE AVAILABLE RESOURCES.
WHO NEEDS SOMETHING?"**

Basic arguments of “spark-submit”

```
spark-submit \  
  --master "local[*]" \  
  --py-files PY_FILES \  
  MAIN_PYTHON_FILE \  
  app_arguments
```

On your path, if Spark is installed

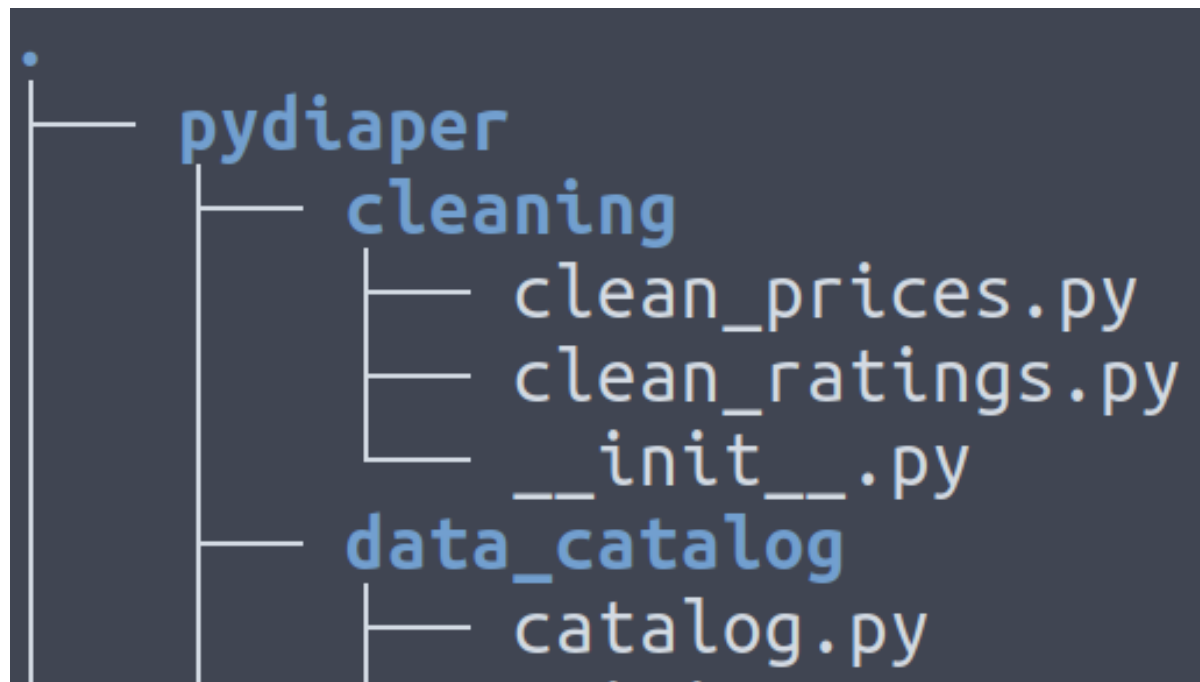
URL of the cluster manager

Comma-separated list of zip, egg or py

Path to the module to be run

Optional arguments parsed by main script

Collecting all dependencies in one archive



```
zip \
  --recurse-paths \
  dependencies.zip \
  pydiaper
```

```
spark-submit \
  --py-files dependencies.zip \
  pydiaper/cleaning/clean_prices.py
```

Let's practice!

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