Basic introduction to PySpark

BUILDING DATA ENGINEERING PIPELINES IN PYTHON

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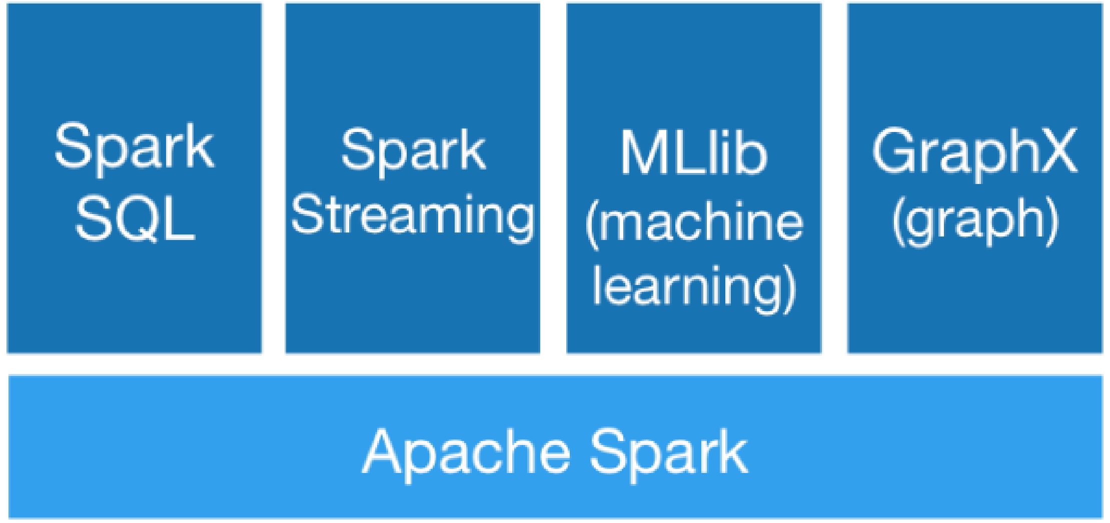
What is Spark?

- 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:

- qua**l**itative attributes e.g. comfort
- qua**nt**itative 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

```python
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|      da
+-----------+-------+---------------+-------+---------+-----------+-----+--------+--------+--------
|Diapers-R-Us|6months|              2|      3|     Aldi|         BE|  6.8|     EUR|      40|2019-02-
|     Nappy-k|2months|              3|      4| Kruidvat|         BE|  4.8|     EUR|      30|2019-01-
|     Nappy-k|2months|              3|      4|Carrefour|         FR|  5.7|     EUR|      30|2019-02-
|     Pampers|3months|              4|      4|    Tesco|        IRL|  6.3|     EUR|      35|2019-02-
|     Huggies|newborn|              3|      5|       DM|         DE|  6.8|     EUR|      40|2019-02-
+-----------+-------+---------------+-------+---------+-----------+-----+--------+--------+--------
```

Let's practice!

BUILDING DATA ENGINEERING PIPELINES IN PYTHON

Packaging your application

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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
```

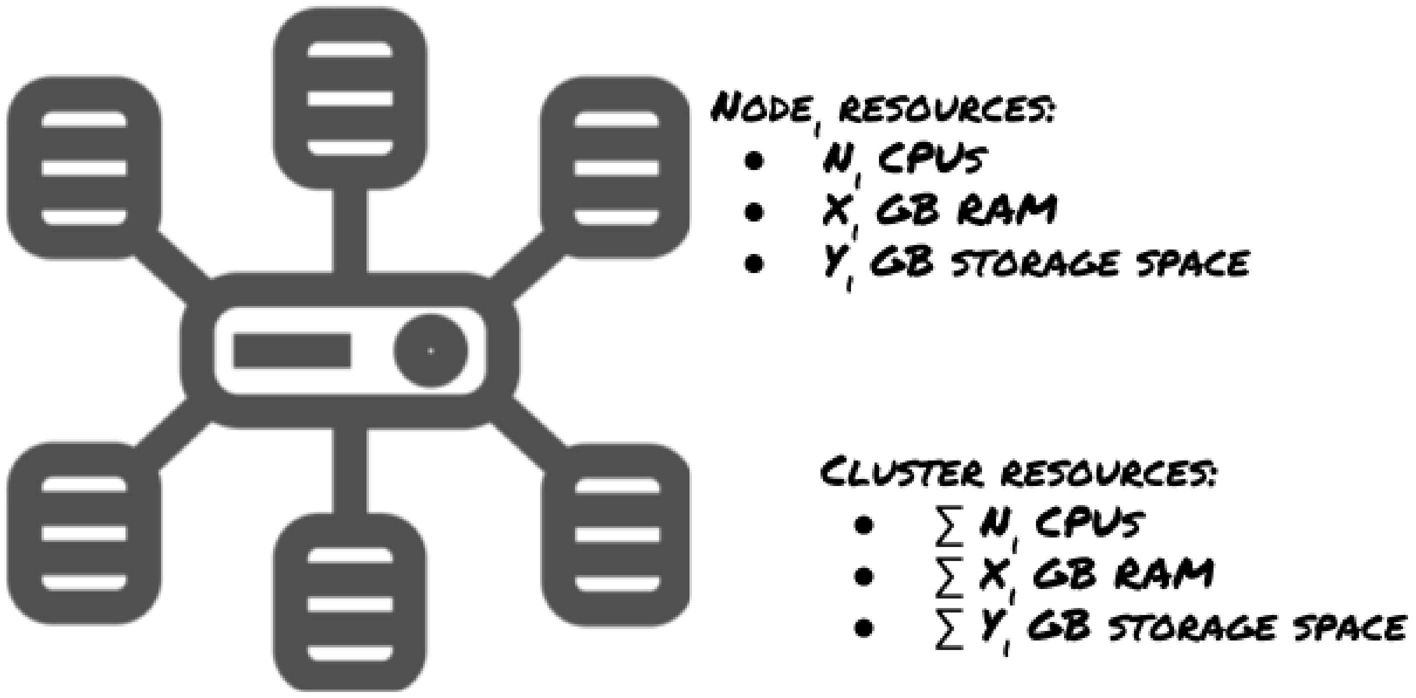
Conditions:

- 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

```
.
├── pydiaper
│   ├── cleaning
│   │   ├── clean_prices.py
│   │   ├── clean_ratings.py
│   │   └── __init__.py
│   ├── data_catalog
│   │   ├── catalog.py
```

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

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

Let's practice!

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