Spark & sparklyr part II

Programming for Statistical Science

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Supplementary materials

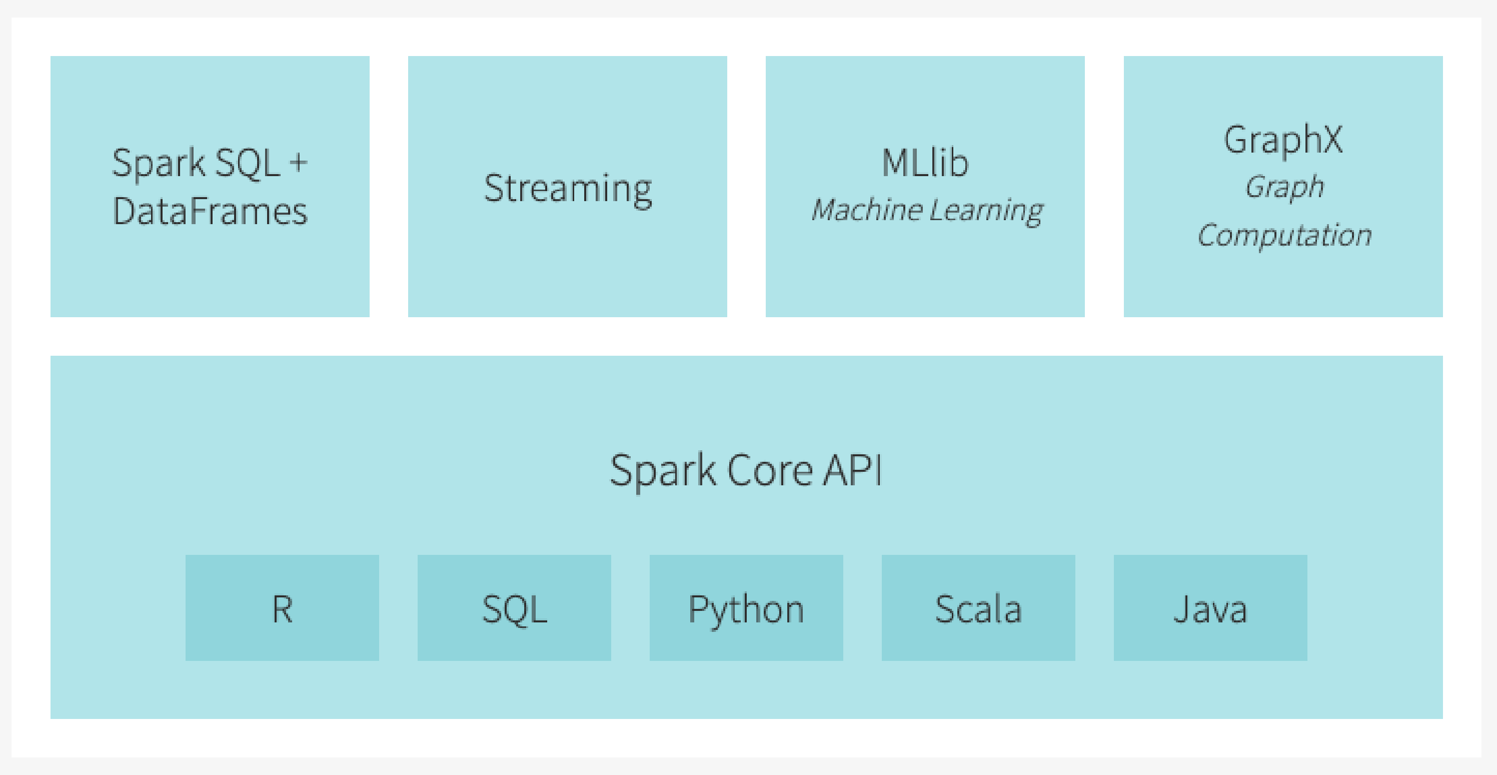
Full video lecture available in Zoom Cloud Recordings

Additional resources

- `sparklyr`: R interface for Apache Spark
- R Front End for Apache Spark
- Mastering Spark with R

Recall

The Spark ecosystem



Spark SQL + DataFrames

Streaming

MLlib
Machine Learning

GraphX
Graph Computation

Spark Core API

R

SQL

Python

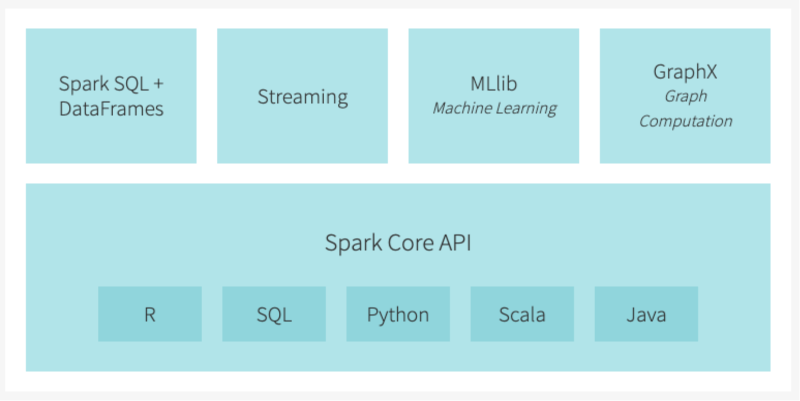
Scala

Java

What is `sparklyr`?

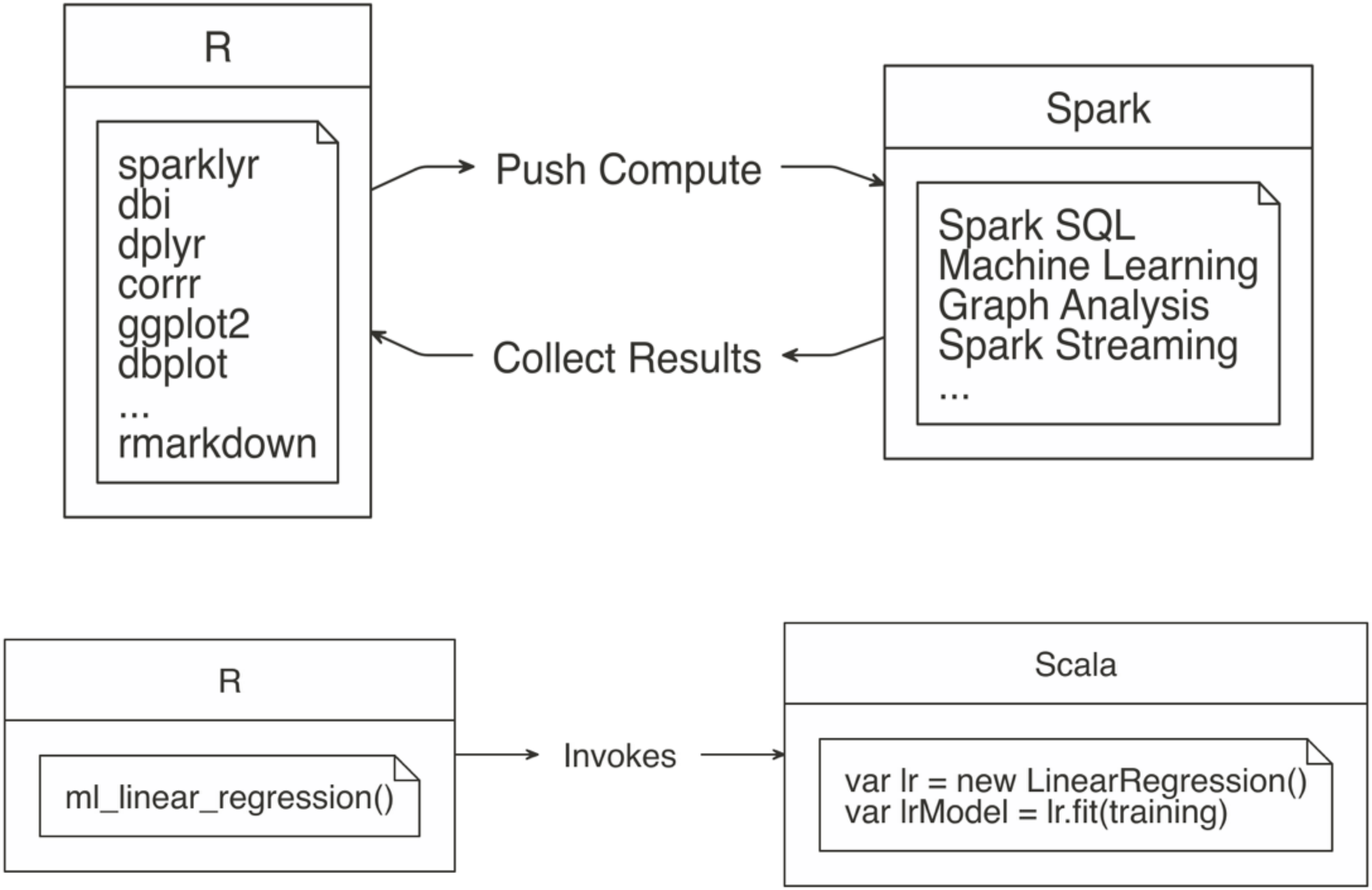
Package `sparklyr` provides an R interface for Spark. It works with any version of Spark.

- Use `dplyr` to translate R code into Spark SQL
- Work with Spark's MLlib
- Interact with a stream of data



The interface between R and Spark is young. If you know Scala, a great project would be to contribute to this R and Spark interaction by making Spark libraries available as an R package.

Workflow



```
ml_linear_regression()
```

```
var lr = new LinearRegression()
var lrModel = lr.fit(training)
```

Source: https://therinspark.com/

Preliminaries

Configure and connect

```r
library(sparklyr)
library(tidyverse)
library(future)
# add some custom configurations
conf <- list(
  sparklyr.cores.local = 4,
  `sparklyr.shell.driver-memory` = "16G",
  spark.memory.fraction = 0.5
)
```

`sparklyr.cores.local` - defaults to using all of the available cores

`sparklyr.shell.driver-memory` - limit is the amount of RAM available in the computer minus what would be needed for OS operations

`spark.memory.fraction` - default is set to 60% of the requested memory per executor

```r
# create a spark connection
sc <- spark_connect(master = "local", version = "3.0", config = conf)
```

Spark Streaming

What is Spark Streaming?

> "Spark Streaming makes it easy to build scalable fault-tolerant streaming applications."

Streaming data:

- Financial asset prices (stocks, futures, cryptocurrency, etc.)
- Twitter feed
- Purchase orders on Amazon

Think of streaming data as real-time data. Streams are most relevant when we want to process and analyze this data in real time.

The role of `sparklyr`

`sparklyr` provides an R interface for interacting with Spark Streaming by allowing you to

- run `dplyr`, SQL, and pipeline machine learning models against a stream of data;
- read in many file formats (CSV, text, JSON, parquet, etc.) from a stream source;
- write stream results in the file formats specified above;
- integration with Shiny that allows you to get the contents of a stream in your app.

Spark Streaming process

Streams in Spark follow a **source** (think reading), **transformation**, and **sink** (think writing) process.

Source:

There exists a set of `stream_read_*()` functions in `sparklyr` for reading the specified file type in as a Spark DataFrame stream.

Transformation:

Spark (via `sparklyr`) can then perform data wrangling, manipulations, and joins with other streaming or static data, machine learning pipeline predictions, and other R manipulations.

Sink:

There exists a set of `stream_write_*()` functions in `sparklyr` for writing a Spark DataFrame stream as the specified file type.

Toy example

Let's leave out the transformation step and simply define a streaming process that reads files from a folder `input_source/` and immediately writes them to a folder `output_source/`.

```
dir.create("input_source/")
dir.create("output_source/")
stream <- stream_read_text(sc, path = "input_source/") %>%
  stream_write_text(path = "output_source/")
```

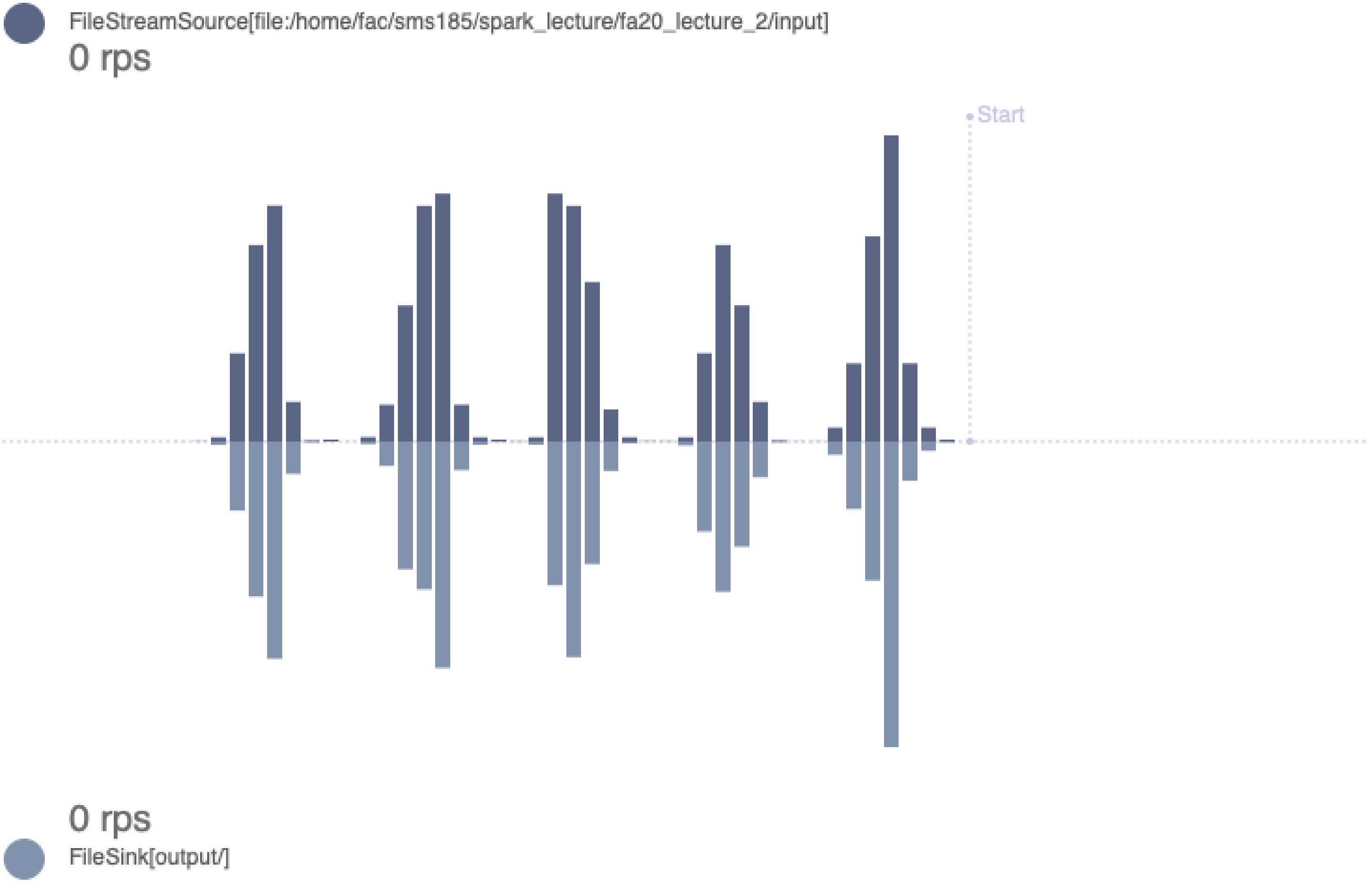
Generate 100 test files to see that they are being read and written to and from the correct directories. Function `stream_view()` launches a Shiny gadget to visualize the given stream. You can see the rows per second (rps) being read and written.

```
stream_generate_test(interval = .2, iterations = 100,
                            path = "input_source/")
stream_view(stream)
```

Stop the stream and remove the `input_source/` and `output_source/` directories.

```
stream_stop(stream)
unlink("input_source/", recursive = TRUE)
unlink("output_source/", recursive = TRUE)
```

Stream viewer



● FileStreamSource[file:/home/fac/sms185/spark_lecture/fa20_lecture_2/input]
0 rps
Start
0 rps
● FileSink[output/]

Toy example details

```
stream <- stream_read_text(sc, path = "input_source/") %>%
  stream_write_text(path = "output_source/")
```

The output writer is what starts the streaming job. It will start monitoring the input folder, and then write the new results in the `output_source/` folder.

The stream query defaults to micro-batches running every 5 seconds. This can be adjusted with `stream_trigger_interval()` and `stream_trigger_continuous()`.

Example with transformations

Using the tibble `diamonds` from `ggplot2`, let's create a stream, do some aggregation, and output the process to memory as a Spark DataFrame. Using Spark memory as the target will allow for aggregation to happen during processing. *On all but Kafka, aggregation is not allowed for any file output.*

```r
dir.create("input_source/")
stream_generate_test(df = diamonds, path = "input_source/",
                     iterations = 1)
```

```r
stream <- stream_read_csv(sc, path = "input_source/") %>%
  select(price) %>%
  stream_watermark() %>%   # add a timestamp
  group_by(timestamp) %>%  # do a grouping by the timestamp
    summarise(
      min_price  = min(price, na.rm = TRUE),
      max_price  = max(price, na.rm = TRUE),
      mean_price = mean(price, na.rm = TRUE),
      count      = n()
  ) %>%
  stream_write_memory(name = "diamonds_sdf")
```

Object `diamonds_sdf` will be a Spark DataFrame to which our summarized streaming computations are written.

Example with transformations

Generate some test data using `diamonds`.

```
stream_generate_test(df = diamonds, path = "input_source/", iterations =
```

We can periodically check the results.

```
tbl(sc, "diamonds_sdf")
```

Stop the stream and remove the `input_source/` and `output_source/` directories.

```
stream_stop(stream)
unlink("input_source/", recursive = TRUE)
```

Shiny and streaming

Shiny’s reactive framework is well suited to support streaming information, which you can use to display real-time data from Spark using `reactiveSpark()`. It can take a Spark DataFrame (or an object coercable to one), and it returns a reactive data source. You can use it similar to how you used reactive tibble objects.

To demonstrate the functionality of `reactiveSpark()`, we'll again use the NYC yellow taxi trip data from January 2009.

https://www1.nyc.gov/site/tlc/about/tlc-trip-record-data.page

```
taxi_path <- str_c("/home/fac/sms185/.public_html/data/taxi/",
                   "yellow_tripdata_2009-01.csv")

taxi_tbl <- spark_read_csv(sc, name = "yellow_taxi_2009",
                           path = taxi_path)
```

Data preview

```
glimpse(taxi_tbl)
```

```
Rows: ??
Columns: 18
Database: spark_connection
$ vendor_name           <chr> "VTS", "VTS", "VTS", "DDS", "DDS", "DDS", "DDS", "V…
$ Trip_Pickup_DateTime  <dttm> 2009-01-04 02:52:00, 2009-01-04 03:31:00, 2009-01-…
$ Trip_Dropoff_DateTime <dttm> 2009-01-04 03:02:00, 2009-01-04 03:38:00, 2009-01-…
$ Passenger_Count       <int> 1, 3, 5, 1, 1, 2, 1, 1, 1, 1, 1, 1, 2, 2, 1, 1, 1, …
$ Trip_Distance         <dbl> 2.63, 4.55, 10.35, 5.00, 0.40, 1.20, 0.40, 1.72, 1.…
$ Start_Lon             <dbl> -73.99196, -73.98210, -74.00259, -73.97427, -74.001…
$ Start_Lat             <dbl> 40.72157, 40.73629, 40.73975, 40.79095, 40.71938, 4…
$ Rate_Code             <chr> "NA", "NA", "NA", "NA", "NA", "NA", "NA", "NA", "NA…
$ store_and_forward     <chr> "NA", "NA", "NA", "NA", "NA", "NA", "NA", "NA", "NA…
$ End_Lon               <dbl> -73.99380, -73.95585, -73.86998, -73.99656, -74.008…
$ End_Lat               <dbl> 40.69592, 40.76803, 40.77023, 40.73185, 40.72035, 4…
$ Payment_Type          <chr> "CASH", "Credit", "Credit", "CREDIT", "CASH", "CASH…
$ Fare_Amt              <dbl> 8.9, 12.1, 23.7, 14.9, 3.7, 6.1, 5.7, 6.1, 8.7, 5.9…
$ surcharge             <dbl> 0.5, 0.5, 0.0, 0.5, 0.0, 0.5, 0.0, 0.5, 0.0, 0.0, 0…
$ mta_tax               <chr> "NA", "NA", "NA", "NA", "NA", "NA", "NA", "NA", "NA…
$ Tip_Amt               <dbl> 0.00, 2.00, 4.74, 3.05, 0.00, 0.00, 1.00, 0.00, 1.3…
$ Tolls_Amt             <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
$ Total_Amt             <dbl> 9.40, 14.60, 28.44, 18.45, 3.70, 6.60, 6.70, 6.60, …
```

Sample Taxi data

Define a bounding box for NYC.

```
min_lat <- 40.5774
max_lat <- 40.9176
min_lon <- -74.15
max_lon <- -73.7004
```

Take a sample of about 10% of the trips, where the trip start is within our bounding box defined above.

```
taxi <- taxi_tbl %>%
  sample_frac(size = 0.1) %>%
  collect() %>%
  janitor::clean_names() %>%
  filter(start_lon >= min_lon, start_lon <= max_lon,
         start_lat >= min_lat, start_lat <= max_lat)
```

Streaming Shiny gadget

```r
library(shiny)
```

```r
unlink("shiny-stream", recursive = TRUE)
dir.create("shiny-stream", showWarnings = FALSE)
```

To generate test data, we'll do this with our own code.

```r
library(tidyverse)
write_stream_csv <- function(x, row, path = "shiny-stream/", pause = 2) {
  x %>%
    slice(row) %>%
    write_csv(file = str_c(path, "stream_", row, ".csv"))
  Sys.sleep(pause)
}

trips <- sample(1:nrow(taxi))
walk(trips, write_stream_csv, x = taxi)
```

Run this as a local background job from a script file. This way you can launch the Shiny App (on the next slide) in RStudio.

Streaming Shiny gadget

Once the local job starts running, launch the app to see how the plot updates as we simulate more taxi trips beginning.

```
ui <- function() {
  plotOutput("taxi_plot")
}

server <- function(input, output, session) {
  taxi_stream <- stream_read_csv(sc, path = "shiny-stream") %>%
    reactiveSpark()

  output$taxi_plot <- renderPlot({
    ggplot(taxi_stream(), aes(y = start_lat, x = start_lon)) +
      geom_point(alpha = 0.3) +
      labs(y = "Latitude", x = "Longitude") +
      theme_bw(base_size = 16)
  })
}

runGadget(ui, server)
```

References

1. A Gentle Introduction to Apache Spark. (2020). http://www.dcs.bbk.ac.uk/~dell/teaching/cc/book/databricks/spark-intro.pdf.

2. Javier Luraschi, E. (2020). Mastering Spark with R. https://therinspark.com/.

3. R Front End for Apache Spark. (2020). http://spark.apache.org/docs/latest/api/R/index.html.

4. sparklyr. (2020). https://spark.rstudio.com/.