Spark dplyr

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Load sparklyr and establish the Spark connection.

```
library(dplyr, warn.conflicts = FALSE)
library(sparklyr)

# start the sparklyr session locally or to the master container
if(system("test \"/bin/spark-class/\" && echo 1 || echo 0") == 1) {
  master <- "spark://master:7077"
} else{
  master <- "local"
}
sc <- spark_connect(master = master)
```

sparklyr has a dplyr compatible back-end to Spark.

5.2 Spark dplyr

dplyr is an R package for performing operations on structured data. The data is always a table-like structure, i.e., an R data.frame (or tibble), a SQL data table, or a Spark DataFrame among others. Ideally, the structure should be in tidy form, i.e., each row is an observation and each column is a variable. Tidy data matches its semantics with how it is stored.

Besides providing functions for manipulating data frames in R, dplyr forms an interface for manipulating DataFrames directly in Spark using R. The user can performs operations on Spark DataFrames such as:

- selecting, filtering, and aggregating;
- sampling (by window functions);
- performing joins;

As we will see in Sections 5.2.1 and 5.2.2 below, dplyr can be used to:

- convert R data frames to Spark DataFrames using the copy_to function, or
- convert Spark DataFames to R data frames using the collect function.

Perhaps the most powerful feature of dplyr is its support for building data-science workflows in both R and Spark using the forward-pipe operator (%>%) from the magrittr package.

5.2.1 dplyr Verbs

dplyr verbs manipulate structured data in the form of tables. When the tables are Spark DataFrames, dplyr translates the commands to Spark SQL statements. The dplyr's principal verbs and their SQL equivalents are:

- `select` (SELECT);
- `filter` (WHERE);
- `arrange` (ORDER);
- `summarise` (aggregators such as sum, min, etc.);
- `mutate` (operators such as +, *, log, etc.).

We use the `flights` data from the `nycflights13` packages to illustrate some of the `dplyr` verbs. For descriptions of the variables, select the `nycflights13` package and then click on the data sets of interest. First, we copy the `flights` and the airlines data frames to Spark.

```
library(nycflights13)
flights_sdf <- copy_to(sc, flights, "flights_sdf", overwrite = TRUE)
airlines_sdf <- copy_to(sc, airlines, "airlines_sdf", overwrite = TRUE)
src_tbls(sc)
```

```
## [1] "airlines_sdf" "flights_sdf"
```

By default these Spark DataFrames are cached into memory, but they are not partitioned across nodes. Note that we have used `sdf` as a suffix for Spark DataFrames to distinguish them from R data frames, which either have no suffix or use `df`.

Suppose we want to find the flights with a departure delay greater than 1000 minutes with supporting information about the flight.

```
select(flights_sdf,  carrier, flight, year:day, arr_delay, dep_delay) %>%
  filter(dep_delay > 1000) %>%
  arrange(desc(dep_delay))
```

```
## # Source:     spark<?> [?? x 7]
## # Ordered by: desc(dep_delay)
##   carrier flight  year month   day arr_delay dep_delay
##   <chr>    <int> <int> <int> <int>     <dbl>     <dbl>
## 1 HA          51  2013     1     9      1272      1301
## 2 MQ        3535  2013     6    15      1127      1137
## 3 MQ        3695  2013     1    10      1109      1126
## 4 AA         177  2013     9    20      1007      1014
## 5 MQ        3075  2013     7    22       989      1005
```

Here we are building a Spark workflow using `magrittr` pipes, which is a strong feature of R for building data science workflows. If the full name of the carrier is wanted, we need to join `flights_sdf` with `airlines_sdf`. This will be done in the next section.

The average delay for all flights is computed with the `summarise` verb:

```
summarise(flights_sdf, mean(dep_delay))
```

```
## Warning: Missing values are always removed in SQL.
## Use `mean(x, na.rm = TRUE)` to silence this warning
## This warning is displayed only once per session.
```

```
## # Source: spark<?> [?? x 1]
##   `mean(dep_delay)`
##               <dbl>
## 1              12.6
```

Thus, the average delay for all flights is 12.64 minutes.

We can use mutate together with summarise to compute the average speed:

```
mutate(flights_sdf, speed = distance / air_time * 60) %>%
  summarise(mean(speed))
```

```
## # Source: spark<?> [?? x 1]
##   `mean(speed)`
##           <dbl>
## 1          394.
```

The average speed is 394.27 miles/hour.

5.2.2 Laziness

dplyr evaluates lazily, i.e., it:

- does not pull data into R until you ask for it;
- delays doing work until required.

We pull data into R using the collect function.

The average delay computed above keeps the computation in Spark whether or not we explicitly assign the result to a Spark DataFrame. Consider:

```
mean_dep_delay_sdf <- summarise(flights_sdf, mean(dep_delay))
mean_dep_delay_sdf # this statement causes Spark to evaluate the above expression
```

```
## # Source: spark<?> [?? x 1]
##   `mean(dep_delay)`
##               <dbl>
## 1              12.6
```

```
class(mean_dep_delay_sdf)
```

```
## [1] "tbl_spark" "tbl_sql"   "tbl_lazy"  "tbl"
```

The result is identical to the computation above, but here we can explore the structure of mean_dep_delay_sdf. Notice its inheritance path. mean_dep_delay_sdf is the table version of a Spark DataFrame, which is a type of SQL table, which is a lazy table, i.e., not evaluated from the first statement in the chunk.

Next we collect mean_dep_delay_sdf into R and get an R data frame.

```
mean_dep_delay <- collect(mean_dep_delay_sdf)
mean_dep_delay
```

```
## # A tibble: 1 x 1
##   `mean(dep_delay)`
##               <dbl>
## 1              12.6
```

```
class(mean_dep_delay)
```

```
## [1] "tbl_df"     "tbl"        "data.frame"
```

Here, the tibble data frame inherits from tibble, which in turn is a type of data.frame.

5.2.3 Grouping and Shuffling

The group_by function allows us to perform calculations for the groups (or levels) of a variable.

Suppose we want to compare the departure delays for AA (American Airlines), DL (Delta Air Lines), and UA (United Air Lines) for the month of May.

```
carrier_dep_delay_sdf <- flights_sdf %>%
  filter(month == 5, carrier %in% c('AA', 'DL', 'UA')) %>%
  select(carrier, dep_delay) %>%
  arrange(carrier)
carrier_dep_delay_sdf
```

```
## # Source:     spark<?> [?? x 2]
## # Ordered by: carrier
##    carrier dep_delay
##    <chr>       <dbl>
##  1 AA             -5
##  2 AA             -7
##  3 AA              0
##  4 AA              0
##  5 AA             -4
##  6 AA             -6
##  7 AA             -3
##  8 AA             -5
##  9 AA             -2
## 10 AA             -7
## # ... with more rows
```

The arrange statement in the above workflow is not advised since it causes Spark shuffling, but is given here to illustrate the verb. At this point we have only subsetted the Spark DataFrame by filtering rows and selecting columns.

Next we group-by carrier and summarise the results.

```
carrier_dep_delay_sdf %>%
  group_by(carrier) %>%
  summarise(count = n(), mean_dep_delay = mean(dep_delay))
```

```
## # Source: spark<?> [?? x 3]
##   carrier count mean_dep_delay
##   <chr>   <dbl>          <dbl>
## 1 AA       2803           9.66
## 2 DL       4082           9.74
## 3 UA       4960          12.3
```

The group_by function seems innocent enough, but it may not be so. It has some of the same problems as Hadoop. Hadoop is terrible for complex workflows since data is constantly read from and written to HDFS and each cycle of MapReduce involves the dreaded shuffle.

Unless data is spread among the nodes of a cluster by group, which is not likely, then the data will need to be moved for analysis by shuffling it. This can be time consuming and should be avoided if possible, e.g., by partitioning according to groups in the first place.

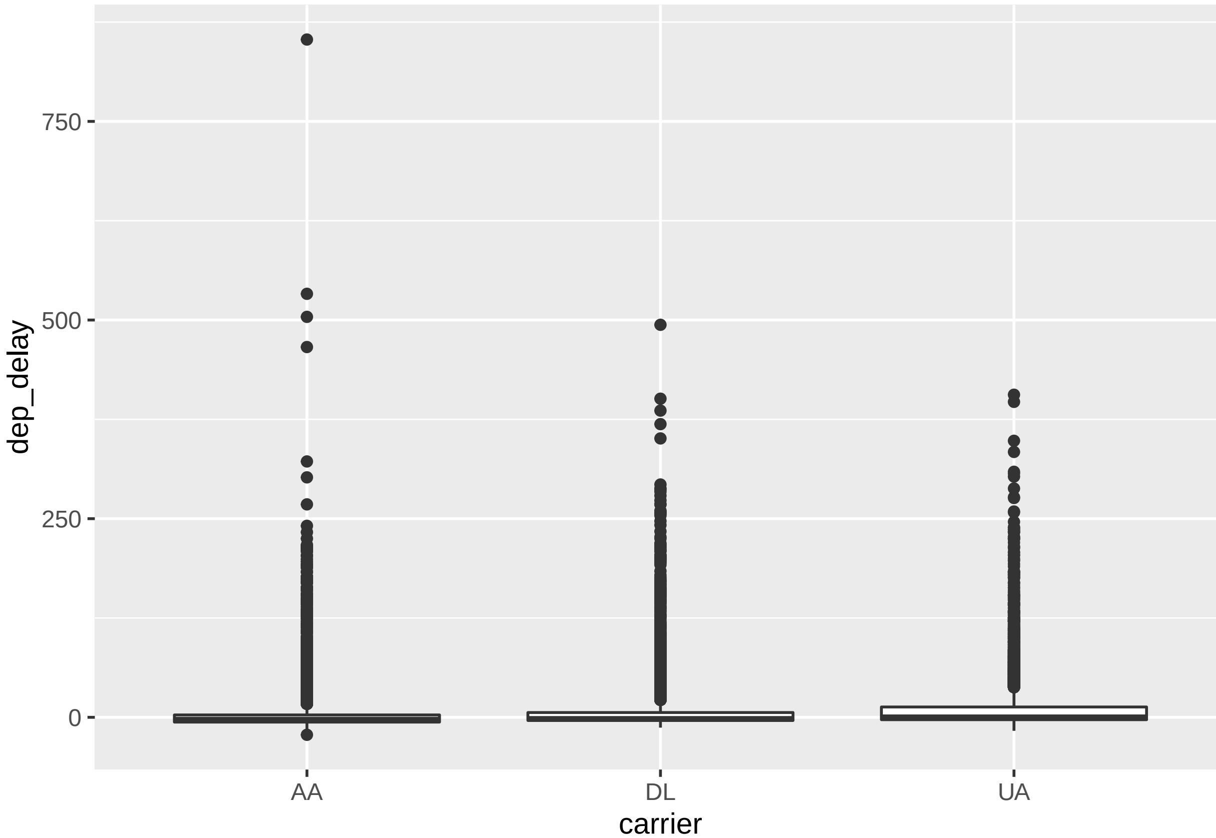
5.2.4 Analyses in R

R has powerful statistical functions through a huge number of R packages. We can take advantage of R by converting a Spark DataFrame into an R data frame and then do modeling and plotting using the dplyr's collect function.

```
carrier_dep_delay_df <- collect(carrier_dep_delay_sdf)
```

```r
library(ggplot2)
carrier_dep_delay_df %>%
  ggplot(aes(carrier, dep_delay)) + geom_boxplot()
```

```
## Warning: Removed 89 rows containing non-finite values (stat_boxplot).
```



5.2.5 Window Functions

An aggregation function, such as `mean()`, takes n inputs and return a single value, whereas a window function returns n values. The output of a window function depends on all its input values, so window functions don't include functions that work element-wise, like `+` or `round()`. Window functions in R include variations on aggregate functions, like `cummean()`, functions for ranking and ordering, like `rank()`, and functions for taking offsets, like `lead()` and `lag()`.

Similarly, Spark supports certain window functions.

```r
spark_disconnect(sc)
```