API de DataFrames

- Funcionalidades similares a SQL
- Los DF funcionan como los RDDs: son inmutables y lazy
- No se pueden cambiar los datos de un DF directamente => hay que transformarlo en otro
- Son lazy porque no devuelven resultados, devuelven otro DF
- La API puede usarse para seleccionar, filtrar, agrupar, hacer join, ….

select

```
df = spark.read.json("gente.json")
```

```
df.show()
```

```
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  19| Justin|
+----+-------+
```

```
df.select(df.age).show()
```

```
+----+
| age|
+----+
|null|
|  30|
|  19|
+----+
```

```
df.select(df["name"]).show()
```

```
+-------+
|   name|
+-------+
|Michael|
|   Andy|
| Justin|
+-------+
```

```
df.select('age').show()
```

```
+----+
| age|
+----+
|null|
|  30|
|  30|
|  19|
+----+
```

drop

- Devuelve un DF donde no está la columna(s) especificada(s)

```
df.drop(df.age).show()
```

```
+-------+
|   name|
+-------+
|Michael|
|   Andy|
| Justin|
+-------+
```

Filtrar datos: where y filter

```
df.filter(df.age > 20).show()
```

```
+---+----+
|age|name|
+---+----+
| 30|Andy|
+---+----+
```

```
df.filter("age > 20").show()
```

```
+---+----+
|age|name|
+---+----+
| 30|Andy|
+---+----+
```

```
df.where(df.age > 20).show()
```

```
+---+----+
|age|name|
+---+----+
| 30|Andy|
+---+----+
```

```
df.where("age > 20").show()
```

```
+---+----+
|age|name|
+---+----+
| 30|Andy|
+---+----+
```

Seleccionar las primeras n filas: limit

```
df.limit(1).show()
```

```
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
+----+-------+
```

Añadir y renombrar columnas: withColumnRenamed y withColumn

```
df.withColumnRenamed('age', 'edad').show()
```

```
+----+-------+
|edad|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  19| Justin|
+----+-------+
```

```
df.withColumn('age2', df.age + 2).show()
```

```
+----+-------+----+
| age|   name|age2|
+----+-------+----+
|null|Michael|null|
|  30|   Andy|  32|
|  19| Justin|  21|
+----+-------+----+
```

Ordenar: orderBy

```
df.sort(df.age.desc()).show()
```

```
+----+-------+
| age|   name|
+----+-------+
|  30|   Andy|
|  19| Justin|
|null|Michael|
+----+-------+
```

```
df.sort(df.age).show()
```

```
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  19| Justin|
|  30|   Andy|
+----+-------+
```

Añadimos nueva fila en fichero json

```
df.orderBy(["age", "name"], ascending=[0, 1]).show()
```

```
+----+-------+
| age|   name|
+----+-------+
|  30|   Andy|
|  30|   Mary|
|  19| Justin|
|null|Michael|
+----+-------+
```

Funciones SQL para hacer cálculos sobre los datos

- Funciones escalares
  - Devuelven un valor para cada fila
- Funciones agregadas
  - Devuelven un valor para un grupo de filas
- UDFs (User-defined functions)
  - Permiten extender la funcionalidad de Spark SQL
- Funciones de ventanas
  - Devuelven varios valores para un grupo de filas

Funciones escalares

`abs, hypot, log, cbrt, …`	Cálculos matemáticos
`length, trim, substring, …`	Operaciones en cadenas
`year, date_add, …`	Operaciones con fechas

```
from pyspark.sql.functions import *
```

```
df.select(cbrt('age')).show()
```

```
+------------------+
|         CBRT(age)|
+------------------+
|              null|
|3.1072325059538586|
|3.1072325059538586|
| 2.668401648721945|
+------------------+
```

Funciones agregadas

- `min, max , count, avg (mean)` **y** `sum`
- **Se** `usan` **con** `groupBy` **o en el método** `select` **o** `withColumn`

```
df.groupBy().avg('age').show()
```

```
+------------------+
|          avg(age)|
+------------------+
|26.333333333333332|
+------------------+
```

- `groupBy`
  - agrupa por columnas
  - devuelve DataFrame

```
df.groupBy(['name', df.age]).count().show()
```

```
+-------+----+-----+
|   name| age|count|
+-------+----+-----+
|   Andy|  30|    1|
|Michael|null|    1|
| Justin|  19|    1|
+-------+----+-----+
```

Funciones agregadas (II)

- La función agg permite aplicar funciones agregadas a todo el DF

```
df.agg({"age": "max"}).show()
```

```
+--------+
|max(age)|
+--------+
|      30|
+--------+
```

```
df.agg(min(df.age)).show()
```

```
+--------+
|min(age)|
+--------+
|      19|
+--------+
```

rollup y cube

- Dos funciones más para agrupamiento y agregación
- **groupBy** – calcula valores agregados para todas las combinaciones de valores en las columnas especificadas

```
+-------+-----+----+
|  coche| name|sexo|
+-------+-----+----+
|Renault|María|   F|
|   Seat| Juan|   M|
|   Seat| Pepa|   F|
|Renault| Luis|   M|
|Renault|Diego|   M|
|   Seat|Elisa|   F|
+-------+-----+----+
```

```
df.groupBy(df.coche,df.sexo).count().show()
```

```
+-------+----+-----+
|  coche|sexo|count|
+-------+----+-----+
|   Seat|   M|    1|
|Renault|   F|    1|
|Renault|   M|    2|
|   Seat|   F|    2|
+-------+----+-----+
```

rollup (a, b, c) => (a, b, c), (a, b), (a), ()

```
+-------+-----+----+
|  coche| name|sexo|
+-------+-----+----+
|Renault|María|   F|
|   Seat| Juan|   M|
|   Seat| Pepa|   F|
|Renault| Luis|   M|
|Renault|Diego|   M|
|   Seat|Elisa|   F|
+-------+-----+----+
```

```
df.rollup(df.coche,df.sexo).count().show()
```

```
+-------+----+-----+
|  coche|sexo|count|
+-------+----+-----+
|   Seat|null|    3|
|   Seat|   F|    2|
|   null|null|    6|
|   Seat|   M|    1|
|Renault|null|    3|
|Renault|   F|    1|
|Renault|   M|    2|
+-------+----+-----+
```

cube(a, b, c) => (a, b, c), (a, b), (b, c), (a, c), (a), (b), (c), ()

```
+-------+-----+----+
|  coche| name|sexo|
+-------+-----+----+
|Renault|María|   F|
|   Seat| Juan|   M|
|   Seat| Pepa|   F|
|Renault| Luis|   M|
|Renault|Diego|   M|
|   Seat|Elisa|   F|
+-------+-----+----+
```

```
df.cube(df.coche,df.sexo).count().show()
```

```
+-------+----+-----+
|  coche|sexo|count|
+-------+----+-----+
|   Seat|null|    3|
|   Seat|   F|    2|
|   null|   F|    3|
|   null|null|    6|
|   Seat|   M|    1|
|   null|   M|    3|
|Renault|null|    3|
|Renault|   F|    1|
|Renault|   M|    2|
+-------+----+-----+
```

join

inner, outer, left_outer, right_outer, leftsemi

por defecto

```
df2 = spark.read.json("gente_sex.json")
```

```
df2.show()
```

```
+-------+---+
|   name|sex|
+-------+---+
|Michael|  M|
|   Andy|  M|
|   Mary|  F|
| Justin|  M|
+-------+---+
```

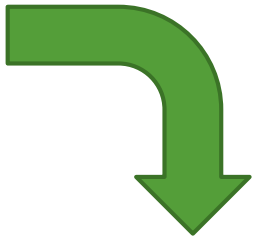
```
df.join(df2, df.name == df2.name, 'inner').drop(df.name).show()
```

```
+----+-------+---+
| age|   name|sex|
+----+-------+---+
|null|Michael|  M|
|  30|   Andy|  M|
|  30|   Mary|  F|
|  19| Justin|  M|
+----+-------+---+
```

User-Defined Functions (UDFs)

- Permiten extender las funcionalidades de Spark SQL

```
+-------+--------------------+
|book_id|               temas|
+-------+--------------------+
|      1|<policial>;<terror>|
|      2|        <aventuras>|
+-------+--------------------+
```



```
+--------------------+-----------------+
|               temas|countTemas(temas)|
+--------------------+-----------------+
|<policial>;<terror>|                2|
|        <aventuras>|                1|
+--------------------+-----------------+
```

UDFs (II)

1. Importar módulo udf

```
from pyspark.sql.functions import udf
```

2. Definir la función

```
def countTemas (s): return s.count("<")
```

3. Registrar la función como UDF

```
countTemas_udf = udf(countTemas)
```

4. Llamarla

```
df.select(df.temas,countTemas_udf(df.temas)).show()
```

Funciones de ventana

- A diferencia de las agregadas, no agrupan en una fila de salida por grupo
- Permiten definir un grupo móvil de filas (llamados marcos) relacionadas con la fila actual de alguna forma y que se usan para los cálculos sobre dicha fila.
- Ej: medias móviles o sumas acumulativas
  - => requieren subconsultas o joins complejos para calcularlas
- Cada fila tiene un marco único asociado

Primer ejemplo

productRevenue

product	category	revenue
Thin	Cell phone	6000
Normal	Tablet	1500
Mini	Tablet	5500
Ultra thin	Cell phone	5000
Very thin	Cell phone	6000
Big	Tablet	2500
Bendable	Cell phone	3000
Foldable	Cell phone	3000
Pro	Tablet	4500
Pro2	Tablet	6500

- Queremos contestar dos preguntas
  1. ¿Cuáles son el primer y segundo producto con mas ingresos por categoría?
  2. ¿Cuál es la diferencia entre los ingresos de cada producto y los ingresos del producto con mas ingresos en la misma categoría?

Primera pregunta

productRevenue

product	category	revenue
Thin	Cell phone	6000
Normal	Tablet	1500
Mini	Tablet	5500
Ultra thin	Cell phone	5000
Very thin	Cell phone	6000
Big	Tablet	2500
Bendable	Cell phone	3000
Foldable	Cell phone	3000
Pro	Tablet	4500
Pro2	Tablet	6500

product	category	revenue
Pro2	Tablet	6500
Mini	Tablet	5500
Thin	Cell Phone	6000
Very thin	Cell Phone	6000
Ultra thin	Cell Phone	5500

En SQL

```
SELECT
  product,
  category,
  revenue
FROM (
  SELECT
    product,
    category,
    revenue,
    dense_rank() OVER (PARTITION BY category ORDER BY revenue DES
  FROM productRevenue) tmp
WHERE
  rank <= 2
```

```
+----------+----------+-------+----+
|  category|   product|revenue|rank|
+----------+----------+-------+----+
|Cell phone|      Thin|   6000|   1|
|Cell phone| Very thin|   6000|   1|
|Cell phone|Ultra thin|   5000|   2|
|Cell phone|  Bendable|   3000|   3|
|Cell phone|  Foldable|   3000|   3|
|    Tablet|      Pro2|   6500|   1|
|    Tablet|      Mini|   5500|   2|
|    Tablet|       Pro|   4500|   3|
|    Tablet|       Big|   2500|   4|
|    Tablet|    Normal|   1500|   5|
+----------+----------+-------+----+
```

En Spark SQL

- Paso 1. Definir una especificación de ventana
  - Define qué filas se incluyen en el marco asociado a una fila dada
  - Hay que especificar tres cosas
    - El particionamiento => filas incluidas en el marco
    - El ordenamiento => cómo se ordenan las filas en un una partición
    - El marco => qué filas se incluyen en el marco asociado a una fila, basándose en su posición relativa con respecto a dicha fila. Ej: las 3 anteriores

```
windowSpec.rowsBetween(start, end)
windowSpec.rangeBetween(start, end)
```

```
from pyspark.sql import Window
```

```
overCategory=Window.partitionBy(df.category).orderBy(df.revenue.desc())
```

En Spark SQL (II)

- Paso 2. Usar una función de ventana

	DataFrame API
Ranking functions	rank
	denseRank
	percentRank
	ntile
	rowNumber
Analytic functions	cumeDist
	firstValue
	lastValue
	lag
	lead

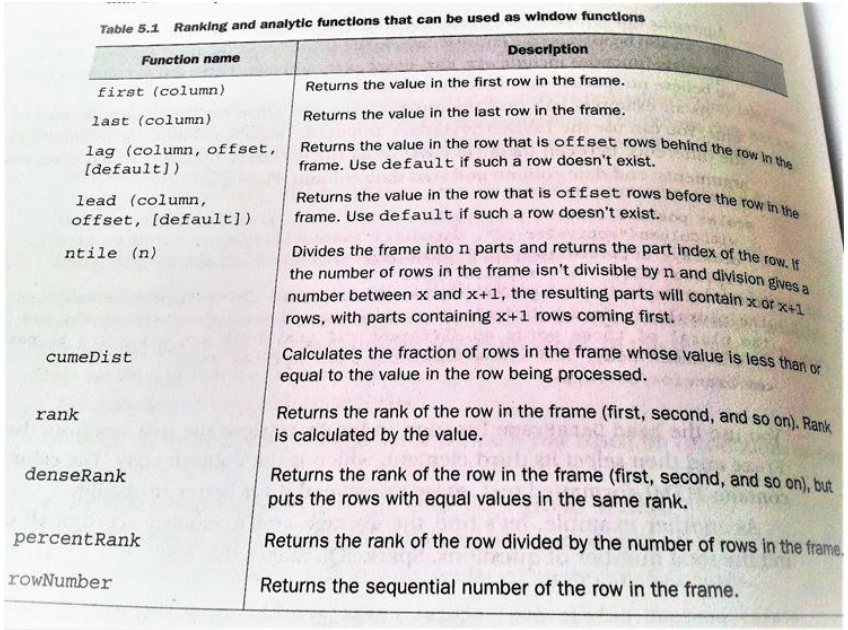


Table 5.1 Ranking and analytic functions that can be used as window functions

Function name	Description
`first (column)`	Returns the value in the first row in the frame.
`last (column)`	Returns the value in the last row in the frame.
`lag (column, offset, [default])`	Returns the value in the row that is `offset` rows behind the row in the frame. Use `default` if such a row doesn't exist.
`lead (column, offset, [default])`	Returns the value in the row that is `offset` rows before the row in the frame. Use `default` if such a row doesn't exist.
`ntile (n)`	Divides the frame into `n` parts and returns the part index of the row. If the number of rows in the frame isn't divisible by `n` and division gives a number between `x` and `x+1`, the resulting parts will contain `x` or `x+1` rows, with parts containing `x+1` rows coming first.
`cumeDist`	Calculates the fraction of rows in the frame whose value is less than or equal to the value in the row being processed.
`rank`	Returns the rank of the row in the frame (first, second, and so on). Rank is calculated by the value.
`denseRank`	Returns the rank of the row in the frame (first, second, and so on), but puts the rows with equal values in the same rank.
`percentRank`	Returns the rank of the row divided by the number of rows in the frame.
`rowNumber`	Returns the sequential number of the row in the frame.

- También funciones agregadas

En Spark SQL (III)

- Hay que indicar que la función se va a usar como función de ventana con el método `over`

```
ranked = df.withColumn("rank", dense_rank().over(overCategory))
```

```
ranked.show()
```

```
+----------+----------+-------+----+
|  category|   product|revenue|rank|
+----------+----------+-------+----+
|Cell phone|      Thin|   6000|   1|
|Cell phone| Very thin|   6000|   1|
|Cell phone|Ultra thin|   5000|   2|
|Cell phone|  Bendable|   3000|   3|
|Cell phone|  Foldable|   3000|   3|
|    Tablet|      Pro2|   6500|   1|
|    Tablet|      Mini|   5500|   2|
|    Tablet|       Pro|   4500|   3|
|    Tablet|       Big|   2500|   4|
|    Tablet|    Normal|   1500|   5|
+----------+----------+-------+----+
```

```
ranked.where(ranked.rank <= 2).show()
```

```
+----------+----------+-------+----+
|  category|   product|revenue|rank|
+----------+----------+-------+----+
|Cell phone|      Thin|   6000|   1|
|Cell phone| Very thin|   6000|   1|
|Cell phone|Ultra thin|   5000|   2|
|    Tablet|      Pro2|   6500|   1|
|    Tablet|      Mini|   5500|   2|
+----------+----------+-------+----+
```

Segunda pregunta

productRevenue

product	category	revenue
Thin	Cell phone	6000
Normal	Tablet	1500
Mini	Tablet	5500
Ultra thin	Cell phone	5000
Very thin	Cell phone	6000
Big	Tablet	2500
Bendable	Cell phone	3000
Foldable	Cell phone	3000
Pro	Tablet	4500
Pro2	Tablet	6500

product	category	revenue	revenue_difference
Pro2	Tablet	6500	0
Mini	Tablet	5500	1000
Pro	Tablet	4500	2000
Big	Tablet	2500	4000
Normal	Tablet	1500	5000
Thin	Cell Phone	6000	0
Very thin	Cell Phone	6000	0
Ultra thin	Cell Phone	5500	500
Foldable	Cell Phone	3000	3000
Bendable	Cell Phone	3000	3000

Segunda pregunta (II)

```
df.withColumn('reveDiff',max(df.revenue).over(overCategory) - df.revenue).show()
```

```
+----------+----------+-------+--------+
|  category|   product|revenue|reveDiff|
+----------+----------+-------+--------+
|Cell phone|      Thin|   6000|       0|
|Cell phone| Very thin|   6000|       0|
|Cell phone|Ultra thin|   5000|    1000|
|Cell phone|  Bendable|   3000|    3000|
|Cell phone|  Foldable|   3000|    3000|
|    Tablet|      Pro2|   6500|       0|
|    Tablet|      Mini|   5500|    1000|
|    Tablet|       Pro|   4500|    2000|
|    Tablet|       Big|   2500|    4000|
|    Tablet|    Normal|   1500|    5000|
+----------+----------+-------+--------+
```

Missing values

- Los datos pueden contener campos vacíos o strings equivalentes “N/A”, null, …
- Tres opciones para limpiarlos
  1. Eliminar filas que contienen null

Drop(“all”) elimina filas que tienen NULL en todas las columnas

```
df.show()
```

```
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  30|   Mary|
|  19| Justin|
+----+-------+
```

```
df.na.drop().show()
```

```
+---+------+
|age|  name|
+---+------+
| 30|  Andy|
| 30|  Mary|
| 19|Justin|
+---+------+
```

```
df.na.drop("all").show()
```

```
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  30|   Mary|
|  19| Justin|
+----+-------+
```

Missing values (II)

2. Rellenar valor null con constantes

```
df.na.fill(0).show()
```

```
+---+-------+
|age|   name|
+---+-------+
|  0|Michael|
| 30|   Andy|
| 30|   Mary|
| 19| Justin|
+---+-------+
```

3. Sustituir ciertos valores por otros

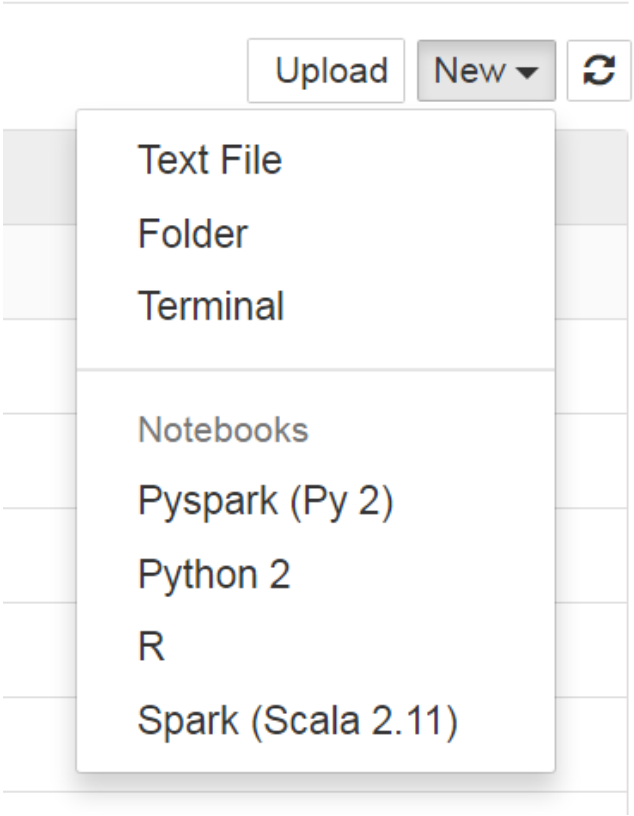
```
df.na.replace('Justin','Justine').show()
```

```
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  30|   Mary|
|  19|Justine|
+----+-------+
```

no específico para null values

La shell

- Arrancar una ventana de terminal



- [vmuser@vm-ipnb-spark ~]$ spark-sql

Bibliografía

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