CSC 735 – Data Analytics

Chapter 8

Joins

Joins

- Allow us to bring together the data from multiple datasets
- This allows us to analyze the combined dataset in ways that we couldn't with just each individual dataset
  - Customers table
  - Transactions table
- Every join must have a join expression (condition) and a join type

Join Expressions

- The join expression is used to decide which rows from the left dataset join with which rows in the right dataset

Join Types

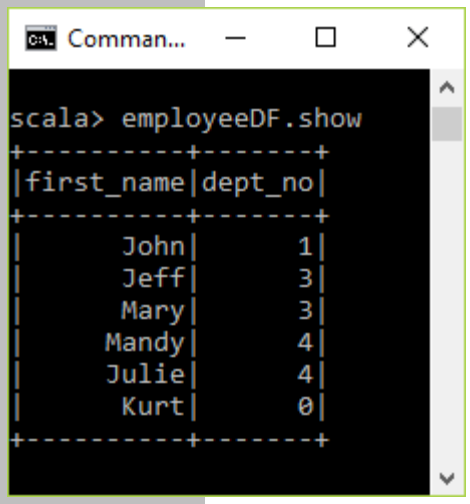
- A join type determines **what** should be in the result of the join
- Join types include: inner joins, outer joints, …

Inner Joins

- The most commonly used join type with the join expression containing the **equality comparison**
- The result will contain the rows for which the join expression evaluates to true
- Inner join is the default join type

Creating the Datasets

```
case class Employee(first_name:String, dept_no:Long)

val employeeDF = Seq( Employee("John", 1),
                      Employee("Jeff", 3),
                      Employee("Mary", 3),
                      Employee("Mandy", 4),
                      Employee("Julie", 4),
                      Employee("Kurt", null.asInstanceOf[Int])
                     ).toDF

employeeDF.createOrReplaceTempView("employees")
```

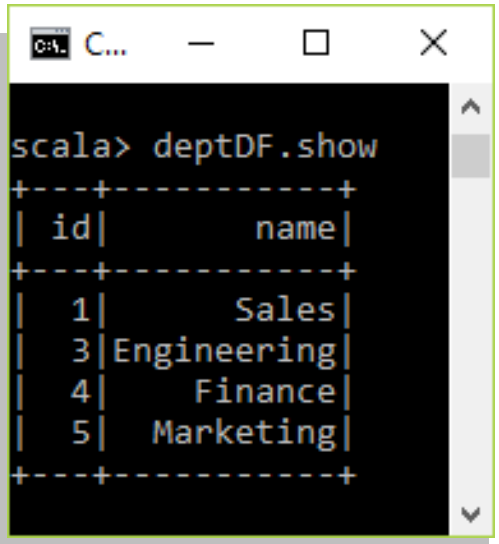


Creating the Datasets

```
case class Dept(id:Long, name:String)

val deptDF = Seq( Dept(1, "Sales"),
                  Dept(3, "Engineering"),
                  Dept(4, "Finance"),
                  Dept(5, "Marketing")
                 ).toDF

deptDF.createOrReplaceTempView("departments")
```

Creating the Datasets

```
case class Dept(id:Long, name:String)

val deptDF = Seq( Dept(1, "Sales"),
                  Dept(3, "Engineering"),
                  Dept(4, "Finance"),
                  Dept(5, "Marketing")
                 ).toDF

deptDF.createOrReplaceTempView("departments")
```



Example

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, joinExpression).show
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      Jeff|      3|  3|Engineering|
|      Mary|      3|  3|Engineering|
|     Mandy|      4|  4|    Finance|
|     Julie|      4|  4|    Finance|
+----------+-------+---+-----------+
```

Inner Joins

```
val joinExpression = employeeDF.col("dept_no") === deptDF.col("id")
```

Inner Joins

```
val joinExpression = employeeDF.col("dept_no") === deptDF.col("id")

employeeDF.join(deptDF, joinExpression, "inner").show

//employeeDF.join(deptDF, joinExpression).show

//spark.sql("""select * from employees JOIN departments
                on dept_no == id""").show
```

Inner Joins

```
val joinExpression = employeeDF.col("dept_no") === deptDF.col("id")

employeeDF.join(deptDF, joinExpression, "inner").show

employeeDF.join(deptDF, joinExpression).show

spark.sql("""select * from employees JOIN departments
                on dept_no == id""").show
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, joinExpression).show
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      Jeff|      3|  3|Engineering|
|      Mary|      3|  3|Engineering|
|     Mandy|      4|  4|    Finance|
|     Julie|      4|  4|    Finance|
+----------+-------+---+-----------+
```

Inner Joins (cont.)

- The join expression can be specified inside the join transformation

```
employeeDF.join(deptDF, 'dept_no === 'id).show
```

Inner Joins (cont.)

- The join expression can be specified inside the join transformation

```
employeeDF.join(deptDF, 'dept_no === 'id).show
```

- The join expression can be specified using the where transformation

```
employeeDF.join(deptDF).where('dept_no === 'id).show
```

Inner Joins (cont.)

- The join expression can be specified inside the join transformation

```
employeeDF.join(deptDF, 'dept_no === 'id).show
```

- The join expression can be specified using the where transformation

```
employeeDF.join(deptDF).where('dept_no === 'id).show
```

- If the column names are not unique, we need to specify which DF a particular column comes from

```
employeeDF.join(deptDF, employeeDF.col("dept_no") === deptDF.col("id")).show
```

Left Outer Joins

- The result includes the rows from the inner join plus
  the nonmatching rows from the left dataset

Left Outer Joins

- The result includes the rows from the inner join plus
  the nonmatching rows from the left dataset
- For nonmatching rows, Spark fills in null for the columns of the right dataset

Left Outer Joins

- The result includes the rows from the inner join plus
  the nonmatching rows from the left dataset
- For nonmatching rows, Spark fills in null for the columns of the right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_outer").show
+----------+-------+----+-----------+
|first_name|dept_no|  id|       name|
+----------+-------+----+-----------+
|      John|      1|   1|      Sales|
|      Jeff|      3|   3|Engineering|
|      Mary|      3|   3|Engineering|
|     Mandy|      4|   4|    Finance|
|     Julie|      4|   4|    Finance|
|      Kurt|      0|null|       null|
+----------+-------+----+-----------+
```

Left Outer Joins

- The result includes the rows from the inner join plus
  the nonmatching rows from the left dataset
- For nonmatching rows, Spark fills in null for the columns of the right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_outer").show
+----------+-------+----+-----------+
|first_name|dept_no|  id|       name|
+----------+-------+----+-----------+
|      John|      1|   1|      Sales|
|      Jeff|      3|   3|Engineering|
|      Mary|      3|   3|Engineering|
|     Mandy|      4|   4|    Finance|
|     Julie|      4|   4|    Finance|
|      Kurt|      0|null|       null|
+----------+-------+----+-----------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Left Outer Joins – SQL Way

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees LEFT OUTER JOIN departments on dept_no == id").show
+----------+-------+----+-----------+
|first_name|dept_no|  id|       name|
+----------+-------+----+-----------+
|      John|      1|   1|      Sales|
|      Jeff|      3|   3|Engineering|
|      Mary|      3|   3|Engineering|
|     Mandy|      4|   4|    Finance|
|     Julie|      4|   4|    Finance|
|      Kurt|      0|null|       null|
+----------+-------+----+-----------+
```

Right Outer Joins

- Analogous to left outer join type
- Result contains matching rows + nonmatching rows from the right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "right_outer").show
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      Mary|      3|  3|Engineering|
|      Jeff|      3|  3|Engineering|
|     Julie|      4|  4|    Finance|
|     Mandy|      4|  4|    Finance|
|      null|   null|  5|  Marketing|
+----------+-------+---+-----------+
```

Right Outer Joins

- Analogous to left outer join type
- Result contains matching rows + nonmatching rows from the right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "right_outer").show
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      Mary|      3|  3|Engineering|
|      Jeff|      3|  3|Engineering|
|     Julie|      4|  4|    Finance|
|     Mandy|      4|  4|    Finance|
|      null|   null|  5|  Marketing|
+----------+-------+---+-----------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Right Outer Joins – SQL Way

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees RIGHT OUTER JOIN departments on dept_no == id").show
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      Mary|      3|  3|Engineering|
|      Jeff|      3|  3|Engineering|
|     Julie|      4|  4|    Finance|
|     Mandy|      4|  4|    Finance|
|      null|   null|  5|  Marketing|
+----------+-------+---+-----------+
```

Outer Joins (aka Full Outer Joins)

- Combines both the left outer join and the right outer join

```
employeeDF.join(deptDF, 'dept_no === 'id, "outer").show
spark.sql("""select *
            from employees FULL OUTER JOIN departments
            on dept_no == id""").show
```

Joins - Databricks Comm

Secure | https://community.cloud.databricks.com/?o=8616461472726830#notebook/253770...

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Joins (Scala)

Attached: cluster 3

```scala
employeeDF.join(deptDF, 'dept_no === 'id, "outer").show
```

(5) Spark Jobs

```
+----------+-------+----+-----------+
|first_name|dept_no|  id|       name|
+----------+-------+----+-----------+
|      Kurt|      0|null|       null|
|      null|   null|   5|  Marketing|
|      John|      1|   1|      Sales|
|      Jeff|      3|   3|Engineering|
|      Mary|      3|   3|Engineering|
|     Mandy|      4|   4|    Finance|
|     Julie|      4|   4|    Finance|
+----------+-------+----+-----------+
```

Command took 2.16 seconds -- by jamilsaquer@missouristate.edu at 10/22/2018, 10:35:26 PM on cluster 3

Cmd 18

```scala
spark.sql("select * from employees FULL OUTER JOIN departments on dept_no == id").show
```

(5) Spark Jobs

```
+----------+-------+----+-----------+
|first_name|dept_no|  id|       name|
+----------+-------+----+-----------+
|      Kurt|      0|null|       null|
|      null|   null|   5|  Marketing|
|      John|      1|   1|      Sales|
|      Jeff|      3|   3|Engineering|
|      Mary|      3|   3|Engineering|
|     Mandy|      4|   4|    Finance|
|     Julie|      4|   4|    Finance|
+----------+-------+----+-----------+
```

Send Feedback

Left Semi Joins

- It is similar to the inner join but contains rows only from the left dataset
- I.e., the result dataset contains only the rows in the left dataset that have matching rows in the other dataset

Left Semi Joins - Example

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_semi").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
+----------+-------+
```

Left Semi Joins - Example

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_semi").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
+----------+-------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Left Semi Joins - Example

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_semi").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
+----------+-------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "inner").show
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      Jeff|      3|  3|Engineering|
|      Mary|      3|  3|Engineering|
|     Mandy|      4|  4|    Finance|
|     Julie|      4|  4|    Finance|
+----------+-------+---+-----------+
```

Left Semi Joins - Example

Command Prompt - spark-shell

```
scala> deptDF.join(employeeDF, 'dept_no === 'id, "left_semi").show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
+---+-----------+
```

Left Semi Joins - Example

Command Prompt - spark-shell

```
scala> deptDF.join(employeeDF, 'dept_no === 'id, "left_semi").show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
+---+-----------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

Left Semi Joins – SQL Way

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees LEFT SEMI JOIN departments on dept_no == id").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
+----------+-------+
```

Left Semi Joins – Equivalent SQL Commands

- You can achieve left semi join with IN or EXISTS in SQL

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees where dept_no in (select id from departments)").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
+----------+-------+
```

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees where exists (select 'a' from departments where id = dept_no)").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
+----------+-------+
```

Left Anti Joins

- Left anti join results in rows from only the left dataset if, and only if, there is **NO matching** row in right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_anti").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      Kurt|      0|
+----------+-------+
```

Left Anti Joins

- Left anti join results in rows from only the left dataset if, and only if, there is NO matching row in right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_anti").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      Kurt|      0|
+----------+-------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Left Anti Joins

- Left anti join results in rows from only the left dataset if, and only if, there is NO matching row in right dataset

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF, 'dept_no === 'id, "left_anti").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      Kurt|      0|
+----------+-------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

Command Prompt - spark-shell

```
scala> deptDF.join(employeeDF, 'dept_no === 'id, "left_anti").show
+---+---------+
| id|     name|
+---+---------+
|  5|Marketing|
+---+---------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Left Anti Joins – Equivalent SQL Commands

- You can think of anti joins as a NOT IN or NOT EXISTS SQL style filter

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees where dept_no not in (select id from departments)").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      Kurt|      0|
+----------+-------+
```

Left Anti Joins – Equivalent SQL Commands

- You can think of anti joins as a NOT IN or NOT EXISTS SQL style filter

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees where dept_no not in (select id from departments)").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      Kurt|      0|
+----------+-------+
```

Command Prompt - spark-shell

```
scala> spark.sql("select * from employees where not exists (select 'a' from departments where id = dept_no)").show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      Kurt|      0|
+----------+-------+
```

Cross (aka Cartesian) Joins

- Simple to use because no join expression is needed
- Every single row in the left dataset will join with every single row in the right dataset
- Size of the result dataset can be huge
- Better to specify as a transformation

```
employeeDF.crossJoin(deptDF).show

//SQL Way
spark.sql("select * from employees CROSS JOIN departments").show()
```

Cross Joins

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Cross Joins

Command Prompt - spark-shell

```
scala> employeeDF.crossJoin(deptDF).show(25)
+----------+-------+---+-----------+
|first_name|dept_no| id|       name|
+----------+-------+---+-----------+
|      John|      1|  1|      Sales|
|      John|      1|  3|Engineering|
|      John|      1|  4|    Finance|
|      John|      1|  5|  Marketing|
|      Jeff|      3|  1|      Sales|
|      Jeff|      3|  3|Engineering|
|      Jeff|      3|  4|    Finance|
|      Jeff|      3|  5|  Marketing|
|      Mary|      3|  1|      Sales|
|      Mary|      3|  3|Engineering|
|      Mary|      3|  4|    Finance|
|      Mary|      3|  5|  Marketing|
|     Mandy|      4|  1|      Sales|
|     Mandy|      4|  3|Engineering|
|     Mandy|      4|  4|    Finance|
|     Mandy|      4|  5|  Marketing|
|     Julie|      4|  1|      Sales|
|     Julie|      4|  3|Engineering|
|     Julie|      4|  4|    Finance|
|     Julie|      4|  5|  Marketing|
|      Kurt|      0|  1|      Sales|
|      Kurt|      0|  3|Engineering|
|      Kurt|      0|  4|    Finance|
|      Kurt|      0|  5|  Marketing|
+----------+-------+---+-----------+
```

Comman...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

C...

```
scala> deptDF.show
+---+-----------+
| id|       name|
+---+-----------+
|  1|      Sales|
|  3|Engineering|
|  4|    Finance|
|  5|  Marketing|
+---+-----------+
```

Handling Duplicate Column Names

- A problem with joins is that a resulting DF can have multiple columns with the same name
- If a DF has two columns with the same name, it would be difficult to refer to these columns

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deptDF2.show
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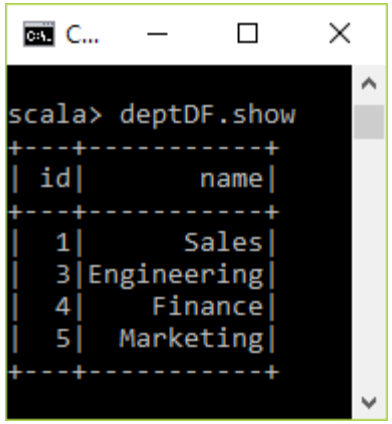

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+---+-----------+
```

```
scala> deptDF2.show
+---+-----------+-------+
| id|       name|dept_no|
+---+-----------+-------+
|  1|      Sales|      1|
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|  4|    Finance|      4|
|  5|  Marketing|      5|
+---+-----------+-------+
```

Handling Duplicate Column Names

```
val dupNameDF = employeeDF.join(deptDF2,
    employeeDF.col("dept_no") === deptDF2.col("dept_no"))
```

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scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

```
scala> deptDF2.show
+---+-----------+-------+
| id|       name|dept_no|
+---+-----------+-------+
|  1|      Sales|      1|
|  3|Engineering|      3|
|  4|    Finance|      4|
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+---+-----------+-------+
```

Handling Duplicate Column Names

```
val dupNameDF = employeeDF.join(deptDF2,
    employeeDF.col("dept_no") === deptDF2.col("dept_no"))
dupNameDF.printSchema
root
 |-- first_name: string (nullable = true)
 |-- dept_no: long (nullable = false)
 |-- id: long (nullable = false)
 |-- name: string (nullable = true)
 |-- dept_no: long (nullable = false)
```

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scala> employeeDF.show
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|first_name|dept_no|
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Handling Duplicate Column Names

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    employeeDF.col("dept_no") === deptDF2.col("dept_no"))
dupNameDF.printSchema
root
 |-- first_name: string (nullable = true)
 |-- dept_no: long (nullable = false)
 |-- id: long (nullable = false)
 |-- name: string (nullable = true)
 |-- dept_no: long (nullable = false)

dupNameDF.select("dept_no")
```

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+----------+-------+
|first_name|dept_no|
+----------+-------+
|      John|      1|
|      Jeff|      3|
|      Mary|      3|
|     Mandy|      4|
|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

```
scala> deptDF2.show
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+---+-----------+-------+
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val dupNameDF = employeeDF.join(deptDF2,
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dupNameDF.printSchema
root
 |-- first_name: string (nullable = true)
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 |-- id: long (nullable = false)
 |-- name: string (nullable = true)
 |-- dept_no: long (nullable = false)

dupNameDF.select("dept_no")

org.apache.spark.sql.AnalysisException: Reference 'dept_no' is
ambiguous, could be: dept_no, dept_no.;
```

```
scala> deptDF2.show
+---+-----------+-------+
| id|       name|dept_no|
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+---+-----------+-------+
```

Handling Duplicate Column Names

- There are several ways to deal with duplicate columns

Handling Duplicate Column Names

- There are several ways to deal with duplicate columns
  - Using a different join API
  - Specifying a column name with its original DF
  - Renaming a column before the join
  - Dropping a column after the join

1. Using a Different Join API

- These versions of join automatically remove duplicate column names

- **join(right: DF, usingColumn: String): DF**
  Inner join with a single column
- **join(right: DF, usingColumns: Seq[String]): DF**
  Inner join with multiple columns
- **join(right: DF, usingColumns: Seq[String], joinType: String): DF**
  Join with multiple columns and a join type

Using a Different Join API – Example

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF2, "dept_no").show
+-------+----------+---+-----------+
|dept_no|first_name| id|       name|
+-------+----------+---+-----------+
|      1|      John|  1|      Sales|
|      3|      Jeff|  3|Engineering|
|      3|      Mary|  3|Engineering|
|      4|     Mandy|  4|    Finance|
|      4|     Julie|  4|    Finance|
+-------+----------+---+-----------+
```

Command ...

```
scala> deptDF2.show
+---+-----------+-------+
| id|       name|dept_no|
+---+-----------+-------+
|  1|      Sales|      1|
|  3|Engineering|      3|
|  4|    Finance|      4|
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+---+-----------+-------+
```

Co...

```
scala> employeeDF.show
+----------+-------+
|first_name|dept_no|
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|     Julie|      4|
|      Kurt|      0|
+----------+-------+
```

Using a Different Join API – Example

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF2, Seq("dept_no")).show
+-------+----------+---+-----------+
|dept_no|first_name| id|       name|
+-------+----------+---+-----------+
|      1|      John|  1|      Sales|
|      3|      Jeff|  3|Engineering|
|      3|      Mary|  3|Engineering|
|      4|     Mandy|  4|    Finance|
|      4|     Julie|  4|    Finance|
+-------+----------+---+-----------+
```

Using a Different Join API – Example

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF2, Seq("dept_no")).show
+-------+----------+---+-----------+
|dept_no|first_name| id|       name|
+-------+----------+---+-----------+
|      1|      John|  1|      Sales|
|      3|      Jeff|  3|Engineering|
|      3|      Mary|  3|Engineering|
|      4|     Mandy|  4|    Finance|
|      4|     Julie|  4|    Finance|
+-------+----------+---+-----------+
```

Command Prompt - spark-shell

```
scala> employeeDF.join(deptDF2, Seq("dept_no"), "left_semi").show
+-------+----------+
|dept_no|first_name|
+-------+----------+
|      1|      John|
|      3|      Jeff|
|      3|      Mary|
|      4|     Mandy|
|      4|     Julie|
+-------+----------+
```

2. Specifying a Column Name with its Original DF

- The joined DF remembers which columns come from which original DF during the joining process

```
dupNameDF.select(deptDF2.col("dept_no"))
```

Command Prompt - spark-shell

```
scala>  dupNameDF.select(deptDF2.col("dept_no")).show
+-------+
|dept_no|
+-------+
|      1|
|      3|
|      3|
|      4|
|      4|
+-------+
```

3. Renaming a Column before the Join

- Use the **withColumnRenamed** transformation before doing the join

```
employeeDF.withColumnRenamed("dept_no",
"department_number")
  .join(deptDF2, 'department_number === 'dept_no).show()
```

Command Prompt - spark-shell

```
scala> employeeDF.withColumnRenamed("dept_no",
     |     "department_number").join(deptDF2,
     |       'department_number === 'dept_no).show()
+----------+-----------------+---+-----------+-------+
|first_name|department_number| id|       name|dept_no|
+----------+-----------------+---+-----------+-------+
|      John|                1|  1|      Sales|      1|
|      Jeff|                3|  3|Engineering|      3|
|      Mary|                3|  3|Engineering|      3|
|     Mandy|                4|  4|    Finance|      4|
|     Julie|                4|  4|    Finance|      4|
+----------+-----------------+---+-----------+-------+
```

4. Dropping a Column after the Join

- We need to refer to the column via the original source DF

```
val dupNameDF = employeeDF.join(deptDF2,
    employeeDF.col("dept_no") === deptDF2.col("dept_no"))

dupNameDF.drop(deptDF2.col("dept_no")).select("dept_no").show
```

Command Promp...

```
scala> dupNameDF.drop(
     |   deptDF2.col("dept_no")
     |   ).select("dept_no").show
+-------+
|dept_no|
+-------+
|      1|
|      3|
|      3|
|      4|
|      4|
+-------+
```

Command Prompt - spark-shell

```
scala> dupNameDF.show
+----------+-------+---+-----------+-------+
|first_name|dept_no| id|       name|dept_no|
+----------+-------+---+-----------+-------+
|      John|      1|  1|      Sales|      1|
|      Jeff|      3|  3|Engineering|      3|
|      Mary|      3|  3|Engineering|      3|
|     Mandy|      4|  4|    Finance|      4|
|     Julie|      4|  4|    Finance|      4|
+----------+-------+---+-----------+-------+
```

How Spark Performs Joins

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How Spark Performs Joins

- Joins can be expensive
- There are two join strategies: **shuffle "hash" join** and **broadcast join**
- Strategy used is based on the size of the two datasets
- If both datasets are large (**big tables**), shuffle hash join is used
- When at least one of the datasets is a **small table**, **broadcast** join is used

Shuffle "Hash" Join

- A join combines the matching rows of two datasets
- Matching rows need to be brought to the same partition

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- Shuffle the rows with the same hash value to the same partition

Shuffle "Hash" Join

- A join combines the matching rows of two datasets
- Matching rows need to be brought to the same partition
- First, compute the hash value of the columns in the join expression of each row in each dataset
- Shuffle the rows with the same hash value to the same partition
- Join these rows

Broadcast "Hash" Join

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Broadcast "Hash" Join

- Applicable when one of the datasets is a small table
- Broadcast a copy of the entire small table to each of the partitions of the larger dataset
- Iterate through each row of the larger dataset to find the matching rows to join

Broadcast Hash Join

- Broadcast join is preferred when possible
- Spark can automatically figure out whether to use a broadcast hash join or shuffle hash join
- We can provide a hint to Spark to use a broadcast join

```
import org.apache.spark.sql.functions.broadcast
//print the explain plan to verify broadcast hash join strategy is used
employeeDF.join(broadcast(deptDF),
     employeeDF.col("dept_no") === deptDF.col("id")).explain()
== Physical Plan ==
*(1) BroadcastHashJoin [dept_no#634L], [id#640L], Inner, BuildRight, false
:- LocalTableScan [first_name#633, dept_no#634L]
+- BroadcastExchange HashedRelationBroadcastMode(List(input[0, bigint, false]))
   +- LocalTableScan [id#640L, name#641]
```