SI330: DATA MANIPULATION

SPARK DATAFRAMES

STARTING A 3-NODE CLUSTER ON AWS EMR, IMPORTING A NOTEBOOK TO S3, AND RUNNING IT

Create Cluster - Quick Options

Go to advanced options

General Configuration

Cluster name My cluster

Logging

S3 folder s3://aws-logs-834790723353-us-east-1/elasticmapreduce/

Launch mode Cluster Step execution

Software configuration

Release emr-5.23.0

Applications

- Core Hadoop: Hadoop 2.8.5 with Ganglia 3.7.2, Hive 2.3.4, Hue 4.3.0, Mahout 0.13.0, Pig 0.17.0, and Tez 0.9.1
- HBase: HBase 1.4.9 with Ganglia 3.7.2, Hadoop 2.8.5, Hive 2.3.4, Hue 4.3.0, Phoenix 4.14.1, and ZooKeeper 3.4.13
- Presto: Presto 0.214 with Hadoop 2.8.5 HDFS and Hive 2.3.4 Metastore
- Spark: Spark 2.4.0 on Hadoop 2.8.5 YARN with Ganglia 3.7.2 and Zeppelin 0.8.1

Use AWS Glue Data Catalog for table metadata

Hardware configuration

Instance type m3.xlarge

Number of instances 3 (1 master and 2 core nodes)

Security and access

EC2 key pair Proceed without an EC2 key pair — Learn how to create an EC2 key pair.

Permissions Default Custom

Use default IAM roles. If roles are not present, they will be automatically created for you with managed policies for automatic policy updates.

EMR role EMR_DefaultRole

EC2 instance profile EMR_EC2_DefaultRole

Cancel Create cluster

Amazon EMR

- Clusters
- Security configurations
- VPC subnets
- Events
- Notebooks
- Help
- What's new

Clone | Terminate | AWS CLI export

Cluster: My cluster Waiting Cluster ready after last step completed.

Summary | Application history | Monitoring | Hardware | Configurations | Events | Steps | Bootstrap actions

Connections: Enable Web Connection – Zeppelin, Spark History Server, Ganglia, Resource Manager ... (View All)

Master public DNS: ec2-3-85-144-90.compute-1.amazonaws.com SSH

Tags: -- View All / Edit

Summary

ID: j-2OIQM4GWBCEAI
Creation date: 2019-04-09 10:41 (UTC-4)
Elapsed time: 9 minutes
Auto-terminate: No
Termination protection: Off Change

Configuration details

Release label: emr-5.23.0
Hadoop distribution: Amazon
Applications: Ganglia 3.7.2, Spark 2.4.0, Zeppelin 0.8.1
Log URI: s3://aws-logs-834790723353-us-east-1/elasticmapreduce/
EMRFS consistent view: Disabled
Custom AMI ID: --

Network and hardware

Availability zone: us-east-1b
Subnet ID: subnet-c33d429f
Master: Running 1 m3.xlarge
Core: Running 2 m3.xlarge
Task: --

Create notebook

Name and configure your notebook

Name your notebook, choose a cluster or create one, and

Notebook name* 330_21_Big_Data_III

Names may only contain letters (a

Description

256 characters max.

Cluster* Choose an existing clust

Choose

Create a cluster

Security groups Use default security groups

Choose security groups

AWS service role* EMR_Notebooks_DefaultRole

Notebook location* Choose an S3 location where files for this notebook are saved.

Use the default S3 location
s3://aws-emr-resources-834790723353-us-east-1/notebooks/

Choose an existing S3 location in us-east-1

▸ Tags

* Required

Cancel Create notebook

Choose a cluster

The listed clusters meet notebook requirements. They are in an EC2-VPC, running EMR 5.18.0 or later, and have Hadoop, Spark, and Livy installed. Learn more

The notebook can be opened once the cluster is in Waiting or Running status.

Filter: Filter clusters ... 1 cluster (all loaded)

Name	ID	Status
My cluster	j-2OIQM4GWBCEAI	Waiting Cluster ready

Cancel Choose cluster

Notebook: 330_21_Big_Data_III Pending Notebook is attaching to cluster j-2OIQM4GWBCEAI. Notebook can now be used in local mode.

Open Stop Delete

Notebook

Notebook ID: e-57P1H88BYJF47OEZIOIACZPY5

Description: --

Last modified: 1 second ago

Last modified by: ...assumed-role/vocstartsoft/user266495=cteplovs@umich.edu

Created on: 2019-04-09 10:51 (UTC-4)

Created by: ...assumed-role/vocstartsoft/user266495=cteplovs@umich.edu

Service IAM role: EMR_Notebooks_DefaultRole

Notebook tags: creatorUserId = AROAJEOPKG4T7CS7RAHI2:user266495=cteplovs@umich.edu View All / Edit

Notebook location: s3://aws-emr-resources-834790723353-us-east-1/notebooks/

Cluster

Cluster: My cluster

Cluster Id: j-2OIQM4GWBCEAI

Cluster status: Waiting Cluster ready after last step completed.

Cluster tags: --

Step logs: s3://aws-logs-834790723353-us-east-1/elasticmapreduce/

AWS Management Console

AWS services

Find Services

You can enter names, keywords or acronyms.

Example: Relational Database Service, database, RDS

Recently visited services

- EMR
- IAM
- RDS
- S3
- EC2

All services

Compute
- EC2
- Lightsail
- ECR
- ECS
- EKS
- Lambda
- Batch
- Elastic Beanstalk
- Serverless Application Repository

Storage
- S3
- EFS
- FSx

Management & Governance
- AWS Organizations
- CloudWatch
- AWS Auto Scaling
- CloudFormation
- CloudTrail
- Config
- OpsWorks
- Service Catalog
- Systems Manager
- Trusted Advisor
- Managed Services
- Control Tower
- AWS License Manager
- AWS Well-Architected Tool

AWS Cost Management
- AWS Cost Explorer
- AWS Budgets
- AWS Marketplace Subscriptions

Mobile
- AWS Amplify
- Mobile Hub
- AWS AppSync
- Device Farm

AR & VR
- Amazon Sumerian

aws Services Resource Groups vocstartsoft/user266495=ctepl... Global Support

Amazon S3 › aws-emr-resources-834790723353-us-east-1 › notebooks › e-57P1H88BYJF47OEZIOIACZPY5

Overview

Type a prefix and press Enter to search. Press ESC to clear.

Upload + Create folder Download Actions US East (N. Virginia)

Viewing 1 to 2

Name	Last modified	Size	Storage class
metadata	--	--	--
330_21_Big_Data_III.ipynb	Apr 9, 2019 10:54:02 AM GMT-0400	38.8 KB	Standard

Viewing 1 to 2

Notebook: 330_21_Big_Data_III Ready Notebook is ready to run jobs on cluster j-2OIQM4GWBCEAI.

Open Stop Delete

Notebook

Notebook ID: e-57P1H88BYJF47OEZIOIACZPY5

Description: --

Last modified: 2 minutes ago

Last modified by: ...assumed-role/vocstartsoft/user266495=cteplovs@umich.edu

Created on: 2019-04-09 10:51 (UTC-4)

Created by: ...assumed-role/vocstartsoft/user266495=cteplovs@umich.edu

Service IAM role: EMR_Notebooks_DefaultRole

Notebook tags: creatorUserId = AROAJEOPKG4T7CS7RAHI2:user266495=cteplovs@umich.edu View All / Edit

Notebook location: s3://aws-emr-resources-834790723353-us-east-1/notebooks/

Cluster

Cluster: My cluster

Cluster Id: j-2OIQM4GWBCEAI

Cluster status: Waiting Cluster ready after last step completed.

Cluster tags: --

Step logs: s3://aws-logs-834790723353-us-east-1/elasticmapreduce/

SPARK APIS

- Three APIs:
  - RDDs (last week)
  - DataSets
  - DataFrames

SPARK RDDS:

- Resilient Distributed Datasets
- low-level
- support creation, transformations, and actions
- creation:
  - parallelize() an existing data structure;
    load a file with textFile()
- transformations return a new RDD (e.g. map(), reduce())
- actions return non-RDDs (e.g. count(), collect()

SPARK DATASETS

- distributed collection of data
- only available via Scala and Java (i.e. no Python interface)
- we will not be using Datasets

SPARK DATAFRAMES

- our main focus will be on Spark DataFrames
- DataFrames are Spark Datasets organized into named columns (sound familiar?)
- they're *tables*
- conceptually very similar to pandas and R DataFrames

SPARK DATAFRAMES: GETTING STARTED

- all interaction is via a SparkSession

```
from pyspark.sql import SparkSession

spark = SparkSession \
    .builder \
    .appName("Python Spark SQL basic example") \
    .getOrCreate()
```

- entry point to programming Spark with the DataFrame API
- to create a SparkSession, use the builder pattern shown above ON NON-DATABRICKS PLATFORMS
- more of less equivalent to SparkContext from last week
- NOTE: DATABRICKS GIVES YOU THIS "FOR FREE"

CREATING SPARK DATAFRAMES

- once you have a SparkSession you can create a DataFrame
- a DataFrame can be created from:
  - a list
  - an RDD
  - a specially formatted JSON file

CREATING A DATAFRAME FROM A LIST

- list of tuples: include a list of column names
- list of values: specify value type

```
# create a DataFrame from a list of tuples
df_from_other_list = spark.createDataFrame(
    [('Chris',67),('Frank',70)], ['name','score'])
df_from_other_list.show()
```

```
+-----+-----+
| name|score|
+-----+-----+
|Chris|   67|
|Frank|   70|
+-----+-----+
```

```
# create a DataFrame from a list of values;
# note that you must specify the data type
from pyspark.sql.types import FloatType
df_from_list = spark.createDataFrame(
    [1.0,2.0,3.0,4.0,5.0], FloatType())
df_from_list.show()
```

```
+-----+
|value|
+-----+
|  1.0|
|  2.0|
|  3.0|
|  4.0|
|  5.0|
+-----+
```

CREATING A DATAFRAME FROM AN RDD

- simple of you're ok with default column names
- need to create a pyspark.sql.Row if you want better column names

```
# create an RDD
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
lot_rdd = sc.parallelize([('Chris',67),('Frank',70)])
```

```
# create a DataFrame from an RDD
dfPeople = spark.createDataFrame(lot_rdd)
dfPeople.show()
```

```
# create a Row to include column names
from pyspark.sql import Row
```

```
lot_rdd_named_columns = lot_rdd \
    .map(lambda x: Row(name=x[0], score=int(x[1])))
dfPeople_named_columns = spark \
    .createDataFrame(lot_rdd_named_columns)
dfPeople_named_columns.show()
```

```
+-----+---+
|   _1| _2|
+-----+---+
|Chris| 67|
|Frank| 70|
+-----+---+
```

```
+-----+-----+
| name|score|
+-----+-----+
|Chris|   67|
|Frank|   70|
+-----+-----+
```

CREATING A DATAFRAME FROM A JSON FILE

```
# read a specially formatted JSON file (one JSON object per line)
df = spark.read.json("business.json")
# Displays the content of the DataFrame to stdout
df.show()
```

```
+--------------------+--------------------+--------------------+--------------------+-------------+--------------------
+-------+-------------+--------------+--------------------+-----------------+-----------+-----------+-----+-----+
|             address|          attributes|         business_id|          categories|         city|                
hours|is_open|     latitude|     longitude|                name|     neighborhood|postal_code|review_count|stars|state
+--------------------+--------------------+--------------------+--------------------+-------------+--------------------
+-------+-------------+--------------+--------------------+-----------------+-----------+-----------+-----+-----+
|4855 E Warner Rd,...|[true,null,null,n...|FYWN1wneV18bWNgQj...|[Dentists, Genera...|     Ahwatukee|
[7:30-17:00,7:30-...|      1|   33.3306902|  -111.9785992|    Dental by Design|                
```

INFERRING SCHEMA

- from previous example, df.printSchema() gives:

```
root
 |-- address: string (nullable = true)
 |-- attributes: struct (nullable = true)
 |    |-- AcceptsInsurance: boolean (nullable = true)
 |    |-- AgesAllowed: string (nullable = true)
 |    |-- Alcohol: string (nullable = true)
 |    |-- Ambience: struct (nullable = true)
 |    |    |-- casual: boolean (nullable = true)
 |    |    |-- classy: boolean (nullable = true)
 |    |    |-- divey: boolean (nullable = true)
 |    |    |-- hipster: boolean (nullable = true)
 |    |    |-- intimate: boolean (nullable = true)
 |    |    |-- romantic: boolean (nullable = true)
 |    |    |-- touristy: boolean (nullable = true)
 |    |    |-- trendy: boolean (nullable = true)
 |    |    |-- upscale: boolean (nullable = true)
 |    |-- BYOB: boolean (nullable = true)
 |    |-- BYOBCorkage: string (nullable = true)
 |    |-- BestNights: struct (nullable = true)
 |    |    |-- friday: boolean (nullable = true)
 |    |    |-- monday: boolean (nullable = true)
 |    |    |-- saturday: boolean (nullable = true)
 |    |    |-- sunday: boolean (nullable = true)
 |    |    |-- thursday: boolean (nullable = true)
 |    |    |-- tuesday: boolean (nullable = true)
 |    |    |-- wednesday: boolean (nullable = true)
 |-- is_open: long (nullable = true)
 |-- latitude: double (nullable = true)
 |-- longitude: double (nullable = true)
 |-- name: string (nullable = true)
 |-- neighborhood: string (nullable = true)
 |-- postal_code: string (nullable = true)
 |-- review_count: long (nullable = true)
 |-- stars: double (nullable = true)
 |-- state: string (nullable = true)
```

CREATING A DATA FRAME FROM A FILE (IN GENERAL)

- spark can load a number of different formats: json, parquet, jdbc, orc, libsvm, csv, text

```
df = spark.read.load("examples/src/main/resources/people.json", format="json")
```

COLUMN SELECTION

```
# Select only the "name" column
df.select("name").show()
```

```
+--------------------+
|                name|
+--------------------+
|    Dental by Design|
| Stephen Szabo Salon|
|Western Motor Veh...|
|    Sports Authority|
|Brick House Taver...|
|             Messina|
|          BDJ Realty|
|         Soccer Zone|
|    Any Given Sundae|
|Detailing Gone Mo...|
|   East Coast Coffee|
|CubeSmart Self St...|
|T & T Bakery and ...|
|Complete Dental Care|
|Showmars Governme...|
|      Alize Catering|
|      T & Y Nail Spa|
|Meineke Car Care ...|
|Senior's Barber Shop|
|Maxim Bakery & Re...|
+--------------------+
only showing top 20 rows
```

COLUMN SELECTION WITH MANIPULATION

```
# Select all businesses, but increment the review_count by 1
df.select(df['name'], df['review_count'] + 1).show()
```

```
+--------------------+------------------+
|                name|(review_count + 1)|
+--------------------+------------------+
|    Dental by Design|                23|
| Stephen Szabo Salon|                12|
|Western Motor Veh...|                19|
|    Sports Authority|                10|
|Brick House Taver...|               117|
|             Messina|                 6|
|          BDJ Realty|                 6|
|         Soccer Zone|                10|
|    Any Given Sundae|                16|
|Detailing Gone Mo...|                 8|
|   East Coast Coffee|                 4|
|CubeSmart Self St...|                24|
|T & T Bakery and ...|                39|
|Complete Dental Care|                 6|
|Showmars Governme...|                 8|
|      Alize Catering|                13|
|      T & Y Nail Spa|                21|
|Meineke Car Care ...|                10|
|Senior's Barber Shop|                66|
|Maxim Bakery & Re...|                35|
+--------------------+------------------+
only showing top 20 rows
```

FILTERING

```
# Select businesses with 4 or more stars
df.filter(df['stars'] >= 4).show()
```

GROUPBY AND SORTING

```
# Count businesses by stars
df.groupBy("stars").count().show()
```

```
+-----+-----+
|stars|count|
+-----+-----+
|  3.5|32038|
|  4.5|24796|
|  2.5|16148|
|  1.0| 3788|
|  4.0|33492|
|  3.0|23142|
|  2.0| 9320|
|  1.5| 4303|
|  5.0|27540|
+-----+-----+
```

```
# Count businesses by stars and sort the output
df.groupBy("stars").count().sort("stars",ascending=False).show()
```

```
+-----+-----+
|stars|count|
+-----+-----+
|  5.0|27540|
|  4.5|24796|
|  4.0|33492|
|  3.5|32038|
|  3.0|23142|
|  2.5|16148|
|  2.0| 9320|
|  1.5| 4303|
|  1.0| 3788|
+-----+-----+
```

EXPLODE

- create a row for each value in a list/array/etc.

```
# create a DataFrame from a list of tuples
df_from_other_list2 = spark.createDataFrame(
    [('Chris',[67,42]),('Frank',[70,72])], ['name','scores']
)
df_from_other_list2.show()
```

```
+-----+--------+
| name|  scores|
+-----+--------+
|Chris|[67, 42]|
|Frank|[70, 72]|
+-----+--------+
```

```
from pyspark.sql.functions import explode
```

```
df_exploded = df_from_other_list2.withColumn('score',explode('scores'))
```

```
df_exploded.show()
```

```
+-----+--------+-----+
| name|  scores|score|
+-----+--------+-----+
|Chris|[67, 42]|   67|
|Chris|[67, 42]|   42|
|Frank|[70, 72]|   70|
|Frank|[70, 72]|   72|
+-----+--------+-----+
```

WHEN... OTHERWISE

```
import pyspark.sql.functions as F
from pyspark.sql.functions import col
df_exploded.withColumn('good', F.when(df_exploded['score']>50,1).otherwise(0)).show()
```

```
+-----+--------+-----+----+
| name|  scores|score|good|
+-----+--------+-----+----+
|Chris|[67, 42]|   67|   1|
|Chris|[67, 42]|   42|   0|
|Frank|[70, 72]|   70|   1|
|Frank|[70, 72]|   72|   1|
+-----+--------+-----+----+
```

JOIN

- The following code is a complex example in which we have two DataFrames: people and department. We are filtering people with age > 30 and joining to department as shown. We are then grouping by department name and (people) gender, then aggregating two variables: the average salary and the maximum age.

```
people.filter(people.age > 30).join(department, people.deptId == department.id) \
  .groupBy(department.name, "gender").agg({"salary": "avg", "age": "max"})
```

JOIN

join(*other*, *on=None*, *how=None*)

Joins with another **DataFrame**, using the given join expression.

Parameters:
- **other** – Right side of the join
- **on** – a string for the join column name, a list of column names, a join expression (Column), or a list of Columns. If *on* is a string or a list of strings indicating the name of the join column(s), the column(s) must exist on both sides, and this performs an equi-join.
- **how** – str, default `inner`. Must be one of: `inner`, `cross`, `outer`, `full`, `full_outer`, `left`, `left_outer`, `right`, `right_outer`, `left_semi`, and `left_anti`.

The following performs a full outer join between `df1` and `df2`.

```
>>> df.join(df2, df.name == df2.name, 'outer').select(df.name, df2.height).collect()
[Row(name=None, height=80), Row(name=u'Bob', height=85), Row(name=u'Alice', height=None)]
```

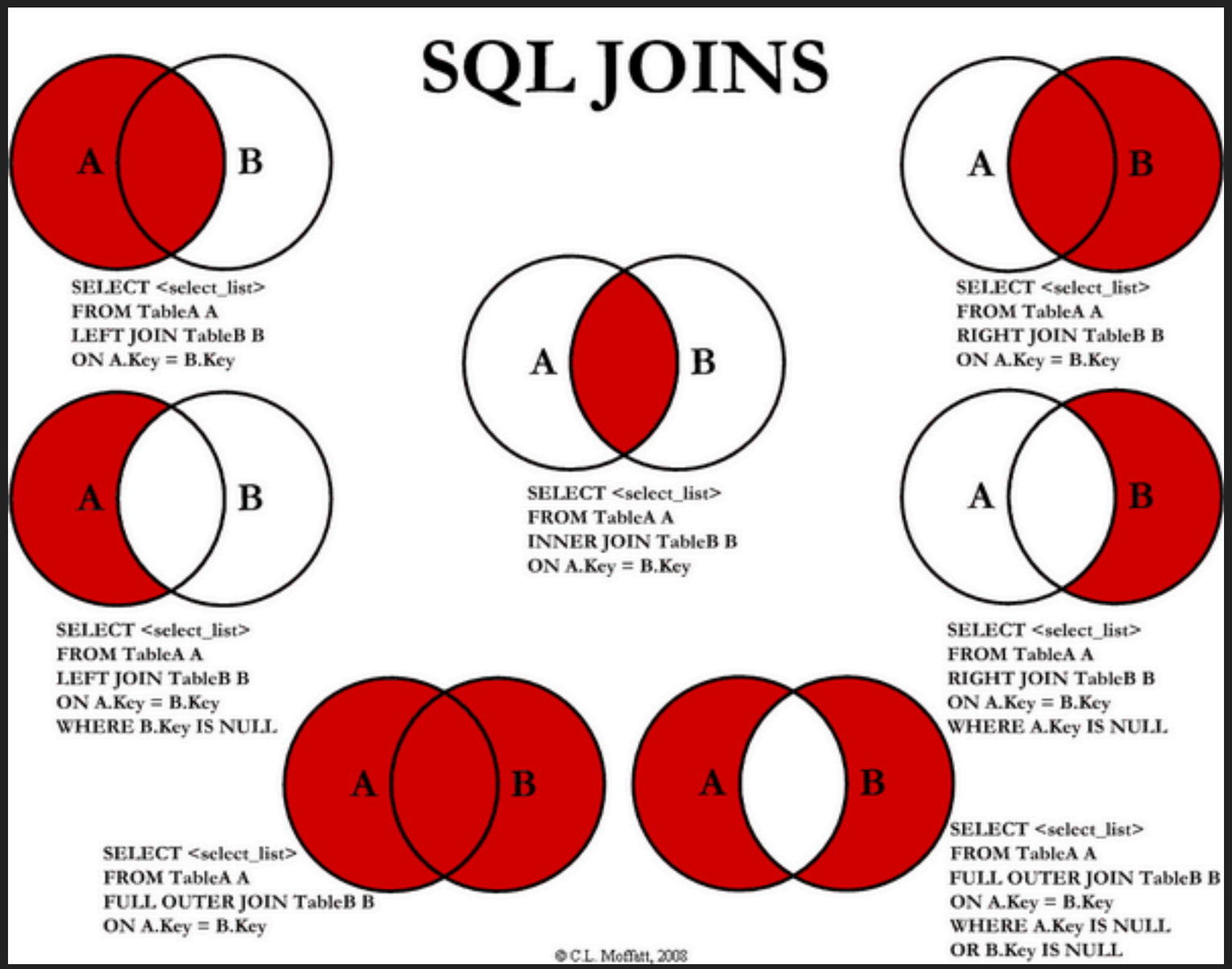
```
>>> df.join(df2, 'name', 'outer').select('name', 'height').collect()
[Row(name=u'Tom', height=80), Row(name=u'Bob', height=85), Row(name=u'Alice', height=None)]
```

```
>>> cond = [df.name == df3.name, df.age == df3.age]
>>> df.join(df3, cond, 'outer').select(df.name, df3.age).collect()
[Row(name=u'Alice', age=2), Row(name=u'Bob', age=5)]
```

```
>>> df.join(df2, 'name').select(df.name, df2.height).collect()
[Row(name=u'Bob', height=85)]
```

```
>>> df.join(df4, ['name', 'age']).select(df.name, df.age).collect()
[Row(name=u'Bob', age=5)]
```

SQL JOINS


SQL JOINS
A
B
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
SELECT <select_list>
FROM TableA A
INNER JOIN TableB B
ON A.Key = B.Key
SELECT <select_list>
FROM TableA A
RIGHT JOIN TableB B
ON A.Key = B.Key
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
WHERE B.Key IS NULL
SELECT <select_list>
FROM TableA A
RIGHT JOIN TableB B
ON A.Key = B.Key
WHERE A.Key IS NULL
SELECT <select_list>
FROM TableA A
FULL OUTER JOIN TableB B
ON A.Key = B.Key
SELECT <select_list>
FROM TableA A
FULL OUTER JOIN TableB B
ON A.Key = B.Key
WHERE A.Key IS NULL
OR B.Key IS NULL
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