Structural Bioinformatics Training Workshop & Hackathon 2018

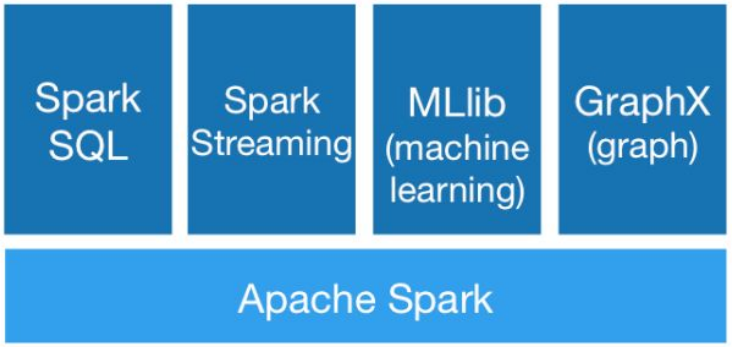
Apache Spark Introduction

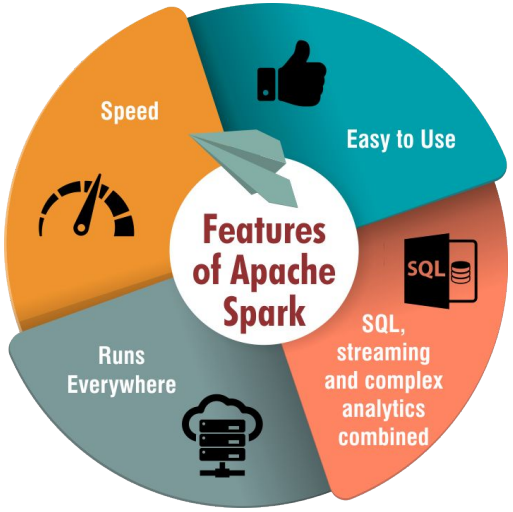
Mars Huang
Structural Bioinformatics Laboratory
San Diego Supercomputer Center
UC San Diego

Introduction to Apache Spark

Apache Spark is an open-source software framework that provides a distributed environment designed to store and process big data.

Apache Spark Ecosystem





Core API: Python, Java, R, Scala

Spark offers support for multiple languages and makes it easy to build parallel applications.

Initialize and close Spark

```
from pyspark.sql import SparkSession
```

SparkSession initializes the spark application

```
spark = SparkSession.builder.master("local[*]")
                    .appName("Tutorial_Example")
                    .getOrCreate()
```

SparkContext is the entry point for interacting with Spark RDD

```
sc = spark.sparkContext
```

Always remember to stop a SparkSession

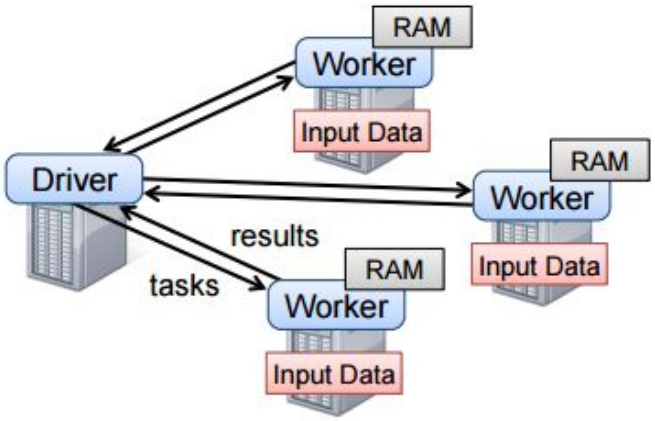
```
spark.stop()
```

More information:
https://spark.apache.org/docs/latest/configuration.html#available-properties

Distributed data structures

Spark revolves around the concept of a *resilient distributed dataset* (RDD):

- core Spark abstraction
- represents partitions across the cluster nodes
- enables parallel processing of datasets
- partitions can be in-memory or on-disk
- partitions can be recomputed on failure



There are two ways to create RDDs:

- parallelizing an existing collection in your driver program
- referencing a dataset in an external storage system

Create RDD

Parallelizing an existing collection:

```
data = [1, 2, 3, 4, 5]
distData = sc.parallelize(data, 4)
```

Collection *Number of partitions*

Referencing to a datasets on external storage:

```
distFile = sc.textFile("<path to your file>")
```

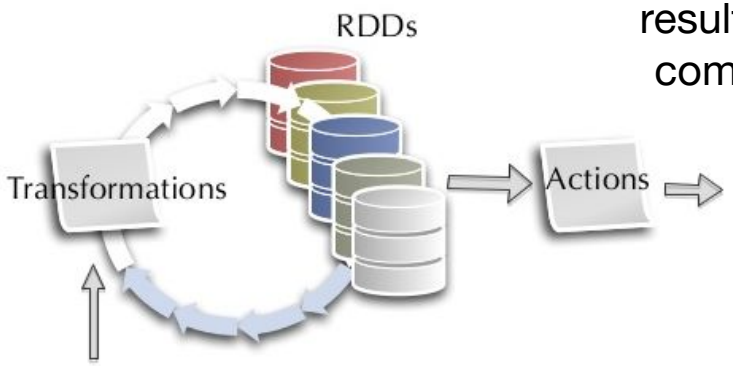
RDD operations

Spark provides a rich set of operators to manipulate RDDs

Transformations
map(func)
flatMap(func)
filter(func)
groupByKey()
reduceByKey(func)
mapValues(func)
…

Actions
take(N)
count()
collect()
reduce(func)
takeOrdered(N)
top(N)
…

Actions return final results of RDD computations



Transformations create new RDD from existing RDD

```
rdd1 = sc.parallelize(data)
rdd2 = rdd1.filter(func1)
rdd2.count()
rdd2.collect()
```

RDD actions: collect()

Spark RDD *collect* function returns all the elements of the dataset as a list

```
rdd = sc.parallelize([1, 2, 3, 4, 5])
output_list = rdd.collect()
```

Note:
Collect function is used in most of the problems in the exercise section.

RDD transformations: filter()

Filter :	filter(f : T ⇒ Bool)	Return a new dataset formed by selecting those elements of the source on which *func* returns true.

Passing lambda functions:

```
rdd2 = rdd1.filter(lambda x: x % 2 == 0)
```

RDD transformations: map() and flatMap()

Map :	map(f : T ⇒ U)	
FlatMap :	flatMap(f : T ⇒ List<U>)	

```
rdd1 = sc.parallelize(data,2)
rdd2 = rdd1.map(lambda x: x*x)

rdd4 = rdd1.flatMap(lambda x: [x**2, x**3])
```

Working with Key-Value Pairs: PairRDD

Calling a function that returns a tuple or list of size 2 will automatically generate a Key-Value Pair

```
emails = sc.textFile(textFilePath)
emails.map(lambda x: x.split('@')).collect()
```

SHOW EXAMPLE OF KEY-VALUE PAIR

Some methods on *SparkContext* produce pair RDD by default for reading files in certain Hadoop formats

```
sc.sequenceFile(path).collect()
```

Transformations on PairRDDs

When called on a dataset of (K, V) pairs, returns a dataset of (K, V) pairs where the values for each key are aggregated using the given reduce function *func: (V,V) => V*

```
pairRDD.reduceByKey(Function f)
```

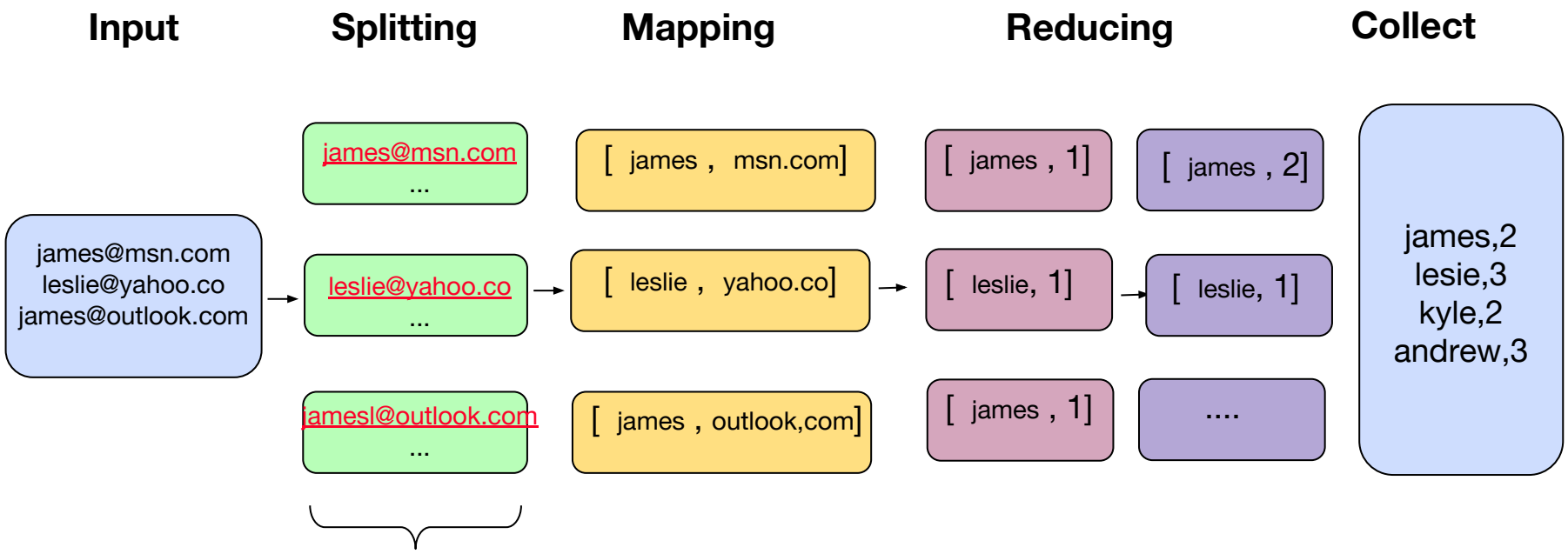
Actions on PairRDDs

collect()	Return all the elements of the dataset as an array at the driver program. This is usually useful after a filter or other operation that returns a sufficiently small subset of the data.
count()	Return the number of elements in the dataset.
first()	Return the first element of the dataset (similar to take(1)).
take(*n*)	Return an array with the first *n* elements of the dataset.

```
pairRDD.count()
```

saveAsTextFile(*path*)	Write the elements of the dataset as a text file (or set of text files) in a given directory in the local filesystem
saveAsSequenceFile(*path*)	Write the elements of the dataset as a Hadoop SequenceFile in a given path in the local filesystem

Count number of domains with the same username with Spark

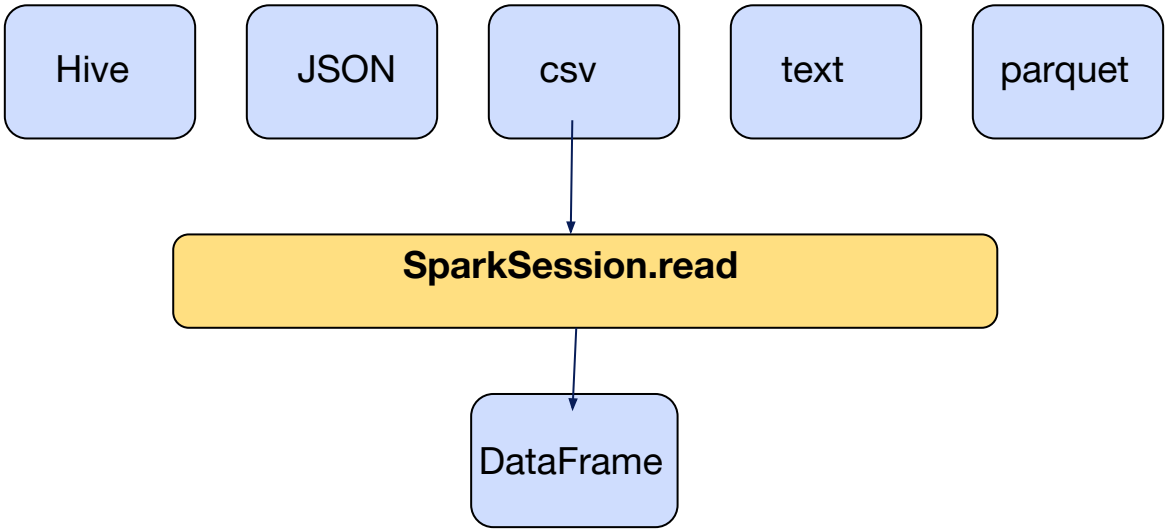



```
emails = sc.textFile("emails.txt")
```

```
pairRdd.reduceByKey(lambda x,y: x+y)
```

Spark DataFrame

A DataFrame distributed collection of data organized into named columns. It is conceptually equivalent to a table in relational databases or a dataframe in R/ Python




```
df = spark.read.csv("./cars.csv", header = True, inferSchema = True)
```

Spark DataFrame Operations

show(n)	Prints the first n rows to the console
filter()	Filter dataframe using given condition
select(cols)	Selects a few columns of a dataframe and returns a new dataframe
groupBy()	Group by values of a specific column, usually follows by an action (count)
sort(n)	Sort dataframe by a specific column
toPandas()	Transform a Spark Dataframe to a pandas DataFrame

```
df_2015 = df.filter(df['YEAR'] == 2015)

df_sub = df.select(df['Make'], df['Model'], df['Size'])

df_manufacturer = df.groupBy('Make').count()

df_sorted = df_manufacturer.sort('count', ascending=False)
```

Resources

- **Apache Spark Programming Guide**
  - https://spark.apache.org/docs/latest/programming-guide.html
- **Pyspark cheatsheet:**
  - https://s3.amazonaws.com/assets.datacamp.com/blog_assets/PySpark_Cheat_Sheet_Python.pdf
- **UC Berkeley Ampcamp**
  - http://ampcamp.berkeley.edu/
- **Coursera**
  - https://www.coursera.org/learn/hadoop/lecture/9cq0R/introduction-to-apache-spark
  - https://www.coursera.org/learn/hadoop/lecture/v7hd5/architecture-of-spark
- **edX**
  - https://www.edx.org/course/introduction-apache-spark-uc-berkeleyx-cs105x

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