BigData and Machine Learning with Hadoop and Spark Frameworks

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January 25th 2021 / Master Data-AI

Outline I

Outline II

Objectifs

Objectifs

- General Overview on Hadoop and Spark
- Introduce to Hadoop
- Introduction to Spark Framework

Audience and Prerequisites

- Audience : computer science and data scientist students
- Prerequisites :
  - sequential programming in java and python
  - elementary of machine learning, data analytics
  - image processing
- Material(Slide+TPs) available at :
  git clone `https://github.com/jgratien/BigDataHadoopSparkDaskCourse.git`

Motivation

Introduction to Bigdata

BigData

- What is Bigdata?
- What are the BigData issues?

Outline

Hadoop Framework

Introduction to Hadoop

- Hadoop definition
  - Java opensource software framework
  - Data storage management
  - Parallel data analysis
  - part of Apache project supported by the Apache Software Foundation

Hadoop Framework

Introduction to Hadoop

- Hadoop History
  - 1990 - 2000 : World Wide Web
  - Yahoo, AltaVisa,. . . : first search engines
  - Nutch open source project created by Doug Cutting and Mike Cafarella
  - 2006 : Nutch project is split:
    the distributed storage and computing framework -> Hadoop
  - 2008 : Hadoop 1.0 (Open Source Project proposed by Yahoo)
  - 2012 : Hadoop 2.0 release
  - 2017 : Hadoop 3.0

Hadoop Framework

Introduction to Hadoop

Why Hadoop?

- BigData issues :
  - increasing amount of data amount
  - distributed storage facilities
  - parallel data processing management
  - fault tolerance management

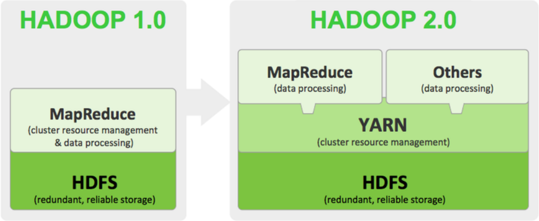
Outline

Hadoop Framework

Hadoop Framework Architecture

the basic Hadoop Framework based of 4 main modules :

- HDFS : Hadoop Distributed File System
- YARN : Yest Another Ressource Negotiator
- Map : parallel data processing
- Reduce : collecting data and producing results



Hadoop Framework

Hadoop Ecosystem

Hadoop ecosystem :

- Ambari : Hadoop component and services web interface management
- Cassandra : Distributed Data Base system
- Flume : Data Stream management layer
- HBase : NoSql distributed Data Base
- HCatalog : data storage management
- Hive : data storage with a SQL API
- Oozie : task framework
- Pig : HDFS data processing framework
- Solr : data indexing framework
- Sqoop : SQL DB and Hadoop data transfer framework
- Zookeeper : distributed data processing management

Hadoop Framework

Hadoop distributions

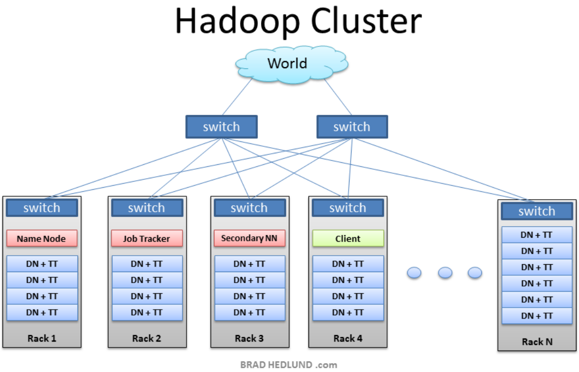
Hadoop Distributions :

- Hortonworks
- Cloudera
- MAPR

Outline

Hadoop Framework

Hadoop Cluster



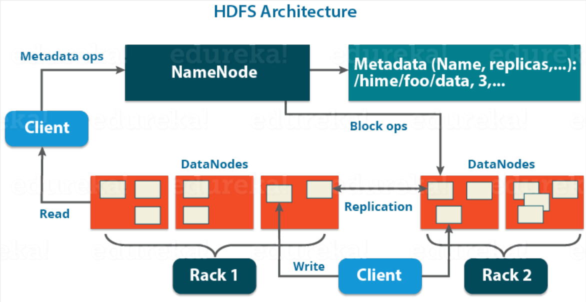
Purpose : Scalability, Fault tolerance and Reliality management

Hadoop Framework

Hadoop Cluster

Concepts

- NameNode
- DataNode
- Replication
- Block, Blocksize



HDFS : Hadoop Distributed Filesystem

Hadoop Framework: HDFS

HDFS commands

HDFS commands :

Starting HDFS

```
# Format nodes
> hadoop namenode -format

# Starting HDFS services
> start-dfs.sh
```

Shutting down HDFS

```
# Stopping HDFS services
> stop-dfs.sh
```

Hadoop Framework: HDFS

HDFS commands

HDFS commands :

Inserting Data into HDFS

```
# Step 1 : Create input directory
> $HADOOP_HOME/bin/hadoop fs -mkdir /usr/input

# Step 2 : copy data from local filesystem to hdfs
    filesystem
> $HADOOP_HOME/bin/hadoop fs -put /home/file.txt /
    user/input

# Step 3 : check results with ls cmd
> $HADOOP_HOME/bin/hadoop fs -ls /usr/input
```

Hadoop Framework: HDFS

HDFS commands

HDFS commands :

Retreiving Data from HDFS

```
# Step 1 : view data
> $HADOOP_HOME/bin/hadoop fs -cat /user/outputfile

# Step 2 : get data from hdfs filesystem to local
    filesystem
> $HADOOP_HOME/bin/hadoop fs -get /user/output/ /
    home/hadoop_out

# Step 3 : check results with ls cmd
> $HADOOP_HOME/bin/hadoop fs -mkdir /usr/input
```

Hadoop Framework: HDFS

HDFS commands list

Commande name	Description
fs -help <cmd-name>	return cmd usage
fs -ls <path>	list <path> directory contents
fs -lsr <path>	ls ,recursively with sub dirs
fs -du <path>	show disk usage in bytes
fs -dus <path>	show disk usage in bytes and summary
fs -test [ezd] <path>	return 1 if path exists; has 0 length; or is a directory, otherwize 0
fs -cat <filename>	
fs -tail [-f] <filename>	

Hadoop Framework: HDFS

HDFS commands list

Commande name	Description
fs -mv <src><dest>	move file or directory within HDFS
fs -cp <src> <dest>	copy file or directory within HDFS
fs -rm <path>	remove file or directory within HDFS
fs -rmr <path>	rm recursively
fs -put <localSrc> <dest>	copy files or dirs from local FS to HDFS

Hadoop Framework: HDFS

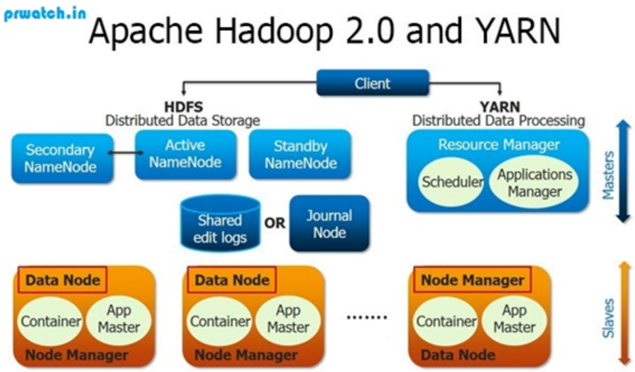
HDFS commands list

Commande name	Description
fs -copyFromLocal <localSrc> <dest>	identical to put
fs -moveFromLocal <localSrc> <dest>	move file or dirs from local FS to HDFS
fs -get [-crc] <src> <localDest>	copy file or dirs from HDFS to local FS
fs -getmerge [-crc] <src> <localDest>	copy all files from HDFS and merge to a single file in FS
fs -copyToLocal <localSrc> <dest>	copy file or dirs from HDFS to local FS
fs -moveToLocal <localSrc> <dest>	move file or dirs from HDFS to local FS
fs -mkdir <path>	create directory in HDFS

Outline

Hadoop Framework

YARN



Hadoop Framework

YARN

Starting YARN

```
# Starting YARN services
> start-yarn.sh
```

Shutting down YARN

```
# Stopping YARN services
> stop-yarn.sh
```

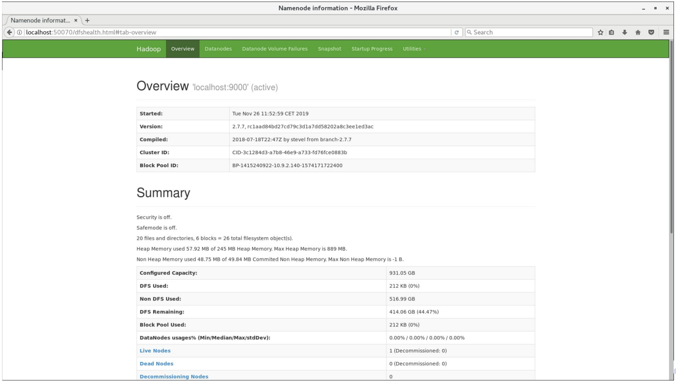
Hadoop Web tools

Hadoop Web Tools

Web tools on : `http://<hostname>:<port>`

<hostname>:<port> (default localhost:50070) are defined in hdfs-site.xml

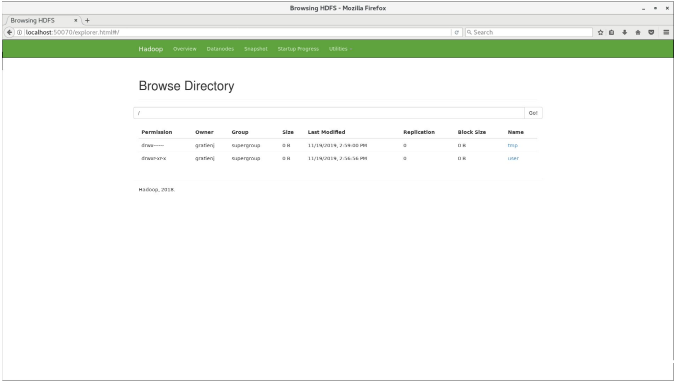
Overview web page:



Hadoop Web tools

Hadoop Web Tools

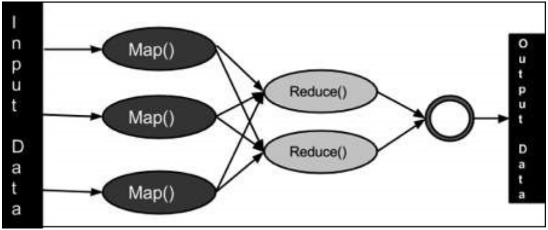
File browser web page:



Outline

Hadoop Framework

MapReduce Framework



MapReduce Framework

Hadoop Framework

MapReduce Framework

MapReduce Algorithm :

- Programming model ;
- Two stages:
  - Map stage :
    - Mapper jobs;
    - data are processed in parallel by mapper jobs;
  - Reduce Stage :
    - Reducer jobs;
    - mapper output data are processed Reducer jobs;
    - Reducer jobs produce new set of output stored in HDFS.

Hadoop Framework

MapReduce Framework

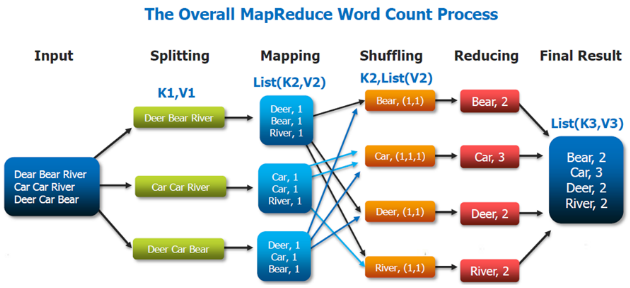
Input and Output :

- Input : <key,value> pairs
  - key and values classes must implement Writable Interface;
  - key class have to implemente WritableComparable Interface;
- Job : (Input)$\rightarrow$ map $\rightarrow$ <k2,v2> $\rightarrow$ reduce $\rightarrow$ <k3,v3>(Output)

	Input	Output
Map	<k1,v1>	list(<k2,v2>)
Reduce	<k2,v2>	list(<k3,v3>)

Hadoop Framework

MapReduce Framework



Hadoop Framework

Java exemple

WordCount Java class

```
import org.apache.hadoop.*;
public class WordCount  {
  public static class  TokenizerMapper extends Mapper<Object, Text, Text, IntWritable> {
    public void map(Object key, Text value, Context context)
                    throws IOException, InterruptedException {
        ... ;
    }
  }
  public static class IntSumReducer extends Reducer<Text,IntWritable,Text,IntWritable>  {
    public void reduce(Text key, Iterable<IntWritable> values,Context context)
                     throws IOException, InterruptedException  {
         ... ;
    }
  }
  public static void main(String[] args) throws Exception {
  ...;
  }
}
```

Hadoop Framework

Java exemple

Word Count Mapper Java class

```java
public class WordCount
{
  public static class TokenizerMapper extends Mapper<Object, Text, Text, IntWritable>
  {
    public void map(Object key, Text value, Context context)
                    throws IOException, InterruptedException
    {
      StringTokenizer itr = new StringTokenizer(value.toString());
      while (itr.hasMoreTokens()) {
        word.set(itr.nextToken());
        context.write(word, one);
      }
    }
  }
}
```

Hadoop Framework

Java exemple

WordCount Reducer Java class

```java
public class WordCount
{
   public static class IntSumReducer extends Reducer<Text,IntWritable,Text,IntWritable>
   {
        private IntWritable result = new IntWritable();
        void reduce(Text key, Iterable<IntWritable> values,Context context)
                    throws IOException, InterruptedException
        {
           int sum = 0;
           for (IntWritable val : values) {
              sum += val.get();
           }
           result.set(sum);
           context.write(key, result);
        }
   }
}
```

Hadoop Framework

Java exemple

Main test function

```
public class WordCount
{
  public static void main(String[] args) throws Exception
  {
    Configuration conf = new Configuration();
    Job job = Job.getInstance(conf, "word␣count");
    job.setJarByClass(WordCount.class);
    job.setMapperClass(TokenizerMapper.class);
    job.setCombinerClass(IntSumReducer.class);
    job.setReducerClass(IntSumReducer.class);
    job.setOutputKeyClass(Text.class);
    job.setOutputValueClass(IntWritable.class);
    FileInputFormat.addInputPath(job, new Path(args[0]));
    FileOutputFormat.setOutputPath(job, new Path(args[1]));
    System.exit(job.waitForCompletion(true) ? 0 : 1);
  }
}
```

Hadoop Framework

Java exemple

Suppose we have two test files file01 and file02 in current directory

Prepare Test Data

```
// Two test file file01 file02 in current directory
$ ls
   file01
   file02
$ hdfs dfs -put file01 /user/gratienj/input
$ hdfs dfs -cat /user/gratienj/input/file01
   Hello World Bye World
$ hdfs dfs -put file02 /user/gratienj/input
$ hdfs dfs -cat /user/gratienj/input/file02
  Hello Hadoop Goodbye Hadoop
```

Hadoop Framework

Java exemple

Suppose the Java Project is compiled and generates the jar file BigDataTP1.jar

Run application

```
$ hadoop jar BigDataTP1.jar hadoop.WordCount /user/gratienj/input /user/gratienj/output
```

Check results

```
$ hdfs dfs -cat /user/gratienj/output/part-r-00000
Bye 1
Goodbye 1
Hadoop 2
Hello 2
World 2
```

Hadoop Framework

Python example

Python example with Hadoop Streaming

Mapper python script

```python
#!/usr/bin/env python
"""mapper.py"""
import sys
# input comes from STDIN (standard input)
for line in sys.stdin:
    line = line.strip()
    words = line.split()
    for word in words:
        print('%s\t%s' % (word, 1))
```

Hadoop Framework

Python example

Reducer python script Part 1

```
from operator import itemgetter
import sys
current_word = None
current_count = 0
word = None
```

Hadoop Framework

Python example

Reducer python script Part 2

```python
for line in sys.stdin: # input comes from STDIN
    line = line.strip()
    word, count = line.split('\t', 1)
    try:
        count = int(count)
    except ValueError:
        continue
    if current_word == word:
        current_count += count
    else:
        if current_word:
            print('%s\t%s' % (current_word, current_count)) # write result to STDOUT
        current_count = count
        current_word = word
if current_word == word: # do not forget to output the last word if needed!
    print('%s\t%s' % (current_word, current_count))
```

Hadoop Framework

Python example

Python example with Hadoop Streaming : Part 1

Copy test files on HDFS

```
$ hdfs dfs -copyFromLocal /home/gratienj/test/books /user/gratienj/input/books
```

Run application

```
$ hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-2.7.7.jar \
 -file /home/hduser/mapper.py    -mapper /home/hduser/mapper.py \
 -file /home/hduser/reducer.py   -reducer /home/hduser/reducer.py \
 -input /user/gratienj/input/books/* -output /user/gratienj/books-output
```

Hadoop Framework

Python example

Python example with Hadoop Streaming : Part 2

Check results

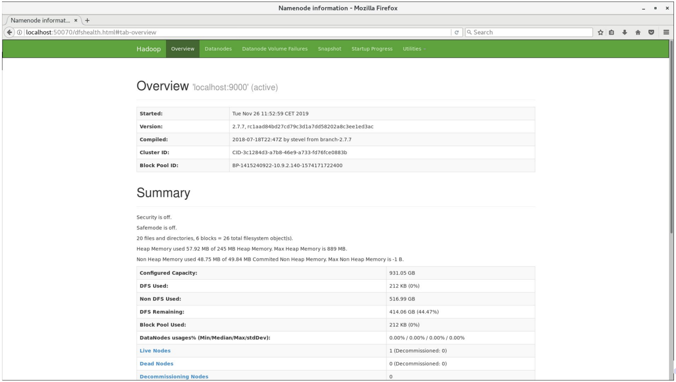
```
$ hdfs dfs -ls /user/gratienj/books-ouput
Found 1 items
/user/gratienj/books-output/part-00000
$ hdfs dfs -cat /user/gratienj/books-output/part-00000
```

Hadoop Web tools

Ambari Server Tools

Ambari Server : tools to manage and monitor applications for Apache Hadoop

Web page : `http://<ambari-server-hostname>:8080`



Outline

Spark Framework

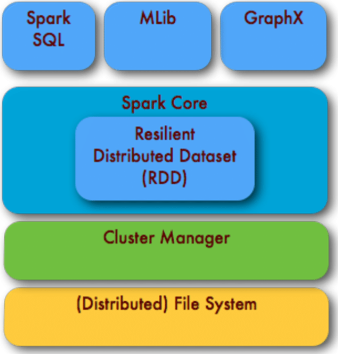
Introduction to Spark

- Spark : Big Data framework for data processing
- History
  - 2009 : AMPLab, UC Berkeley University
  - 2010 : Open source as an Apache project
- Complete and Unified framework
  - Hadoop (MapReduce)
  - Storm (Streaming)
  - Languages : Java, Scala, Python
  - SQL

Outline

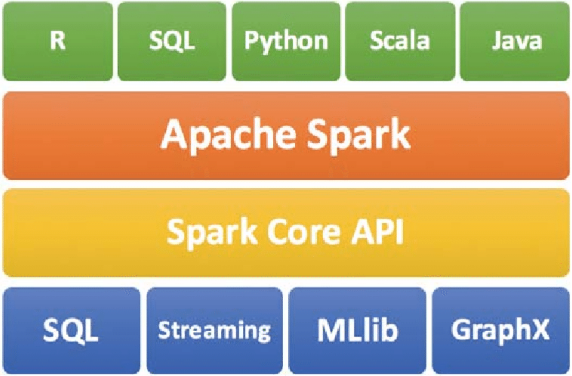
Spark Framework

Apache Spark Architecture



Spark Framework

Apache Spark Ecosystem



Outline

Spark Framework

Spark Core : Spark configuration

Spark Cluster Configurations :

- Local mode
- Cluster mode
- Client mode

Spark parallel concepts:

- multiple executors (private JVM)
- multiple cores per executor

Spark Framework

Spark Core : Spark configuration

Configuring a SparkContext

```
import pyspark
from pyspark import SparkConf
sc_conf = SparkConf()
sc_conf.setAppName(app_name)
sc_conf.setMaster('local[*]')
sc_conf.set('spark.executor.memory', '4g')
sc_conf.set('spark.executor.cores', nb_cores)
sc_conf.set('spark.driver.memory', '16G')
sc_conf.set('spark.cores.max', '32')
sc_conf.set('spark.driver.maxResultSize', '10G')
sc_conf.set('spark.logConf', True)
```

Spark Framework

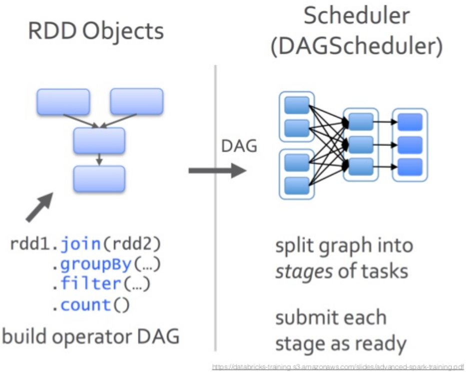
Spark Core : Spark context

Create a SparkContext

```
import pyspark
from pyspark import SparkContext
sc =SparkContext()
```

Spark Framework

Spark Core : Data concepts



Spark Framework

Spark Core : Data concepts

Spark Data concepts :

- **RDD** : Resilient Distributed Data, list of <key,value>
- **Transformations** : apply lambda to creating new RDDs
- **DAG** : pipeline of transformation
- **Actions** : operations on the RDD producing results
- **Scheduler** : perform actions on DAG
- **Stage** : parallel operations
- **Pipeline** : sequence of stages

Spark Framework

Spark Core : RDD

Create a Spark RDD

```python
import pyspark
from pyspark import SparkContext
sc =SparkContext()

nums= sc.parallelize([1,2,3,4])

nums.take(1)
```

Output

```
[1]
```

Spark Framework

Spark Core : RDD Transformationq and Actions

Spark RDD transformations and Actions

```
sc =SparkContext()
nums= sc.parallelize([1,2,3,4])
squared = nums.map(lambda x: x*x).collect()
for num in squared:
    print('%i ' % (num))
```

Output

```
1
4
9
16
```

Spark Framework

Spark Core : RDD Transformations and Actions

Transformation :

- apply lambda function to RDD
- create a new RDD
- lazy evaluation
- create a DAG

Spark Framework

Spark Core : RDD Transformations and Actions

Examples :

Commande name	Description
map()	apply to each RDD line
flatMap()	apply to all RDD elements
mapPartition	apply per partition
filter()	apply to a selection of lines
groupBy()	create new set of (key,value)
groupByKey()	
reduceByKey()	
sample()	selection of lines
union()	fusion of two RDDs
join()	union without duplicate keys

Spark Framework

Spark Core : RDD Transformations and Actions

Actions :

- get results on a pipeline of transformations
- perform all the transformation
- real evaluation

Examples :

Commande name	Description
getNumPartition() reduce() collect()	 apply lambda to all elements create a collection
count() max(), min() sum()	count elements stats

Spark Framework

Spark SQL : DataFrame

Unified Data Abstraction

Image credit: http://barrymieny.deviantart.com/

DATABRICKS

Spark Framework

Spark Core : RDD

Create a Spark SQL context

```
from pyspark.sql import Row
from pyspark.sql import SQLContext
sqlContext = SQLContext(sc)
```

Create a DataFrame

```
list_p=[('John',19),('Smith',29),('Adam',35)]
rdd = sc.parallelize(list_p)
ppl_rdd=rdd.map(lambda x: Row(name=x[0], age=int(x
    [1])))
ppl_df_rdd = sqlContext.createDataFrame(ppl_rdd)
```

Spark Framework

Spark SQL : DataFrame

Print DataFrame Schema

```
DF_ppl.printSchema()
root
 |-- age: long (nullable = true)
 |-- name: string (nullable = true)
```

Spark Framework

Spark SQL : DataFrame

Print DataFrame Schema

```
df = sqlContext.read.csv(SparkFiles.get("adult_data.csv"), header=True, inferSchema= True)
df_string.printSchema()
root
 |-- age: string (nullable = true)
 |-- workclass: string (nullable = true)
 |-- fnlwgt: string (nullable = true)
 |-- education: string (nullable = true)
 |-- education_num: string (nullable = true)
 |-- marital: string (nullable = true)
 |-- occupation: string (nullable = true)
 |-- relationship: string (nullable = true)
 |-- race: string (nullable = true)
 |-- sex: string (nullable = true)
 |-- capital_gain: string (nullable = true)
 |-- capital_loss: string (nullable = true)
 |-- hours_week: string (nullable = true)
 |-- native_country: string (nullable = true)
 |-- label: string (nullable = true)
```

Spark Framework

Spark SQL : DataFrame

Select columns

```
df.select('age','fnlwgt')
    .show(5)
```

Select columns

```
+---+------+
|age|fnlwgt|
+---+------+
| 39| 77516|
| 50| 83311|
| 38|215646|
| 53|234721|
| 28|338409|
+---+------+
only showing top 5 rows
```

Spark Framework

Spark SQL : DataFrame

Select columns

```
df.groupBy("education").
    count().sort("count",
    ascending=True).show()
```

Select columns

```
+------------+-----+
|   education|count|
+------------+-----+
|   Preschool|   51|
|     1st-4th|  168|
|     5th-6th|  333|
|   Doctorate|  413|
|        12th|  433|
|         9th|  514|
| Prof-school|  576|
|     7th-8th|  646|
|        10th|  933|
|  Assoc-acdm| 1067|
|        11th| 1175|
|   Assoc-voc| 1382|
|     Masters| 1723|
|   Bachelors| 5355|
|Some-college| 7291|
|     HS-grad|10501|
```

Spark Framework

Spark SQL : DataFrame

Describe data: describe() functions give a summary of statistics :

- count,
- mean,min,max
- standarddeviation

Describe

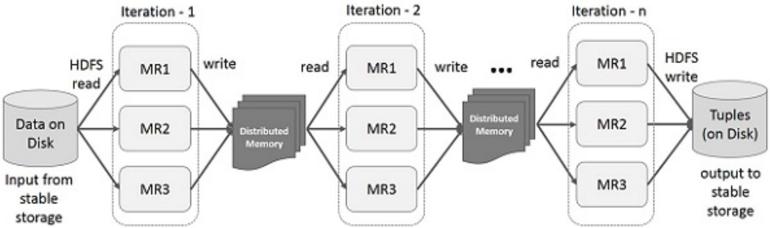
```
df.describe('capital_gain').show()
```

Describe

```
+-------+------------------+
|summary|      capital_gain|
+-------+------------------+
|  count|             32561|
|   mean|1077.6488437087312|
| stddev| 7385.292084840354|
|    min|                 0|
|    max|             99999|
+-------+------------------+
```

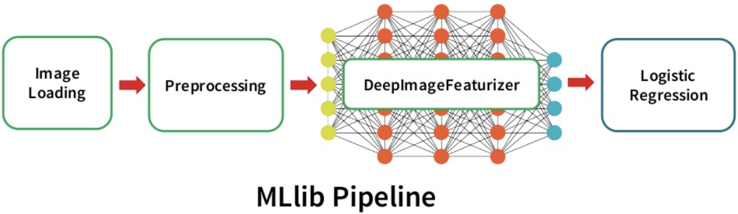
Spark Framework

Spark Mlib



Spark Framework

Spark Mlib



Spark Framework

Spark Mlib

Mlib provides tools for Machine learning

- set of classifier and regression algorithms
- create models from Spark Dataframe
- set of tools to evaluate the predicting models
- concept of pipeline to process Data

Spark Framework

Spark Mlib Pipeline

Spark Pipeline : a sequence of stages (Transformer, Estimator)

- String Indexer : convert Categorical Data to numerics
- Standard Scaler on Continuous Values
- VectorAssembler : features must be a dense vector

Spark Framework

Spark Mlib : Data processing

StringIndexer

```
from pyspark.ml.feature import StringIndexer
df_rdd = ...
# Create String Indexer to convert "cat_key" to "
    ind_key"
string_indexer = StringIndexer(inputCol="cat_key",
    outputCol="encoded_key")
# Create model
model = string_indexer.fit(df_rdd)
# Transform RDD
encoded_df_rdd = model.transform(df_rdd)
```

Spark Framework

Spark Mlib : Data processing

OneHotEncoder

```python
from pyspark.ml.feature import OneHotEncoder
encoder = OneHotEncoder(dropLast=False, inputCol="
    encoded_key", outputCol="vec_key")
vec_df_rdd = encoder.transform(encoded_df_rdd)
```

VectorAssembler

```python
from pyspark.ml.feature import  VectorAssembler
assembler = VectorAssembler(inputCols=[key1,key2,
    key3], outputCol="features")
ass_df_rdd = assembler.transform(df_rdd)
```

Spark Framework

Spark Mlib : Data processing

Pipeline

```
from pyspark.ml import Pipeline
# DEFINE LIST OF STAGES
stages = [[label_indexer],[cat_key_indexer,encoder
    ],[assembler]]

# DEFINE PIPELINE
pipeline = Pipeline(stages=stages)

# APPLY PIPELINE
pipelineModel = pipeline.fit(df_rdd)
model_df_rdd = pipelineModel.transform(rdd_df)
```

Spark Framework

Spark ML : ML pipeline Part 1

create DataFrame

```
rdd.map(lambda x: (x["newlabel"], DenseVector(x["
    features"])))
sqlContext.createDataFrame(input_data, ["label", "
    features"])
```

Split data

```
randomSplit([.8,.2],seed=1234)
```

Spark Framework

Spark ML : ML pipeline Part 2

Train model

```
lr=LogisticRegression(labelCol="label",featuresCol=
    "features",maxIter=10, regParam=0.3)
lr.fit()
```

Make prediction

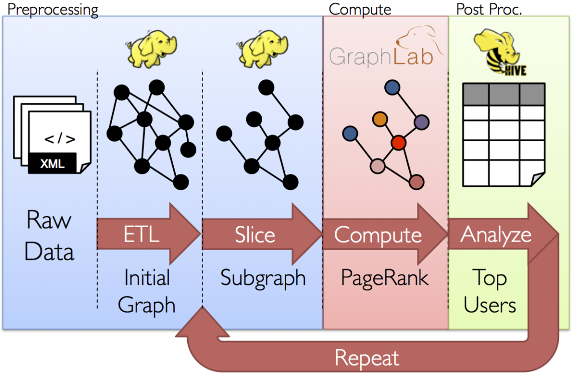
```
lr.transform()
```

Spark Framework

Spark Streaming

Spark Framework

Spark GraphX



Outline

Dask Framework

Introduction to Dask

- Dask : Open source python framework for data processing
- developped with community projects like : Numpy, Pandas, and Scikit-Learn
- supported by: Anaconda, CapitalOne, NSF, Nvidia,. . .
- High-level collections: Dask provides high-level Array, Bag, and DataFrame collections that mimic NumPy, lists, and Pandas but can operate in parallel on datasets that donât fit into main memory. Daskâs high-level collections are alternatives to NumPy and Pandas for large datasets.
- Low-Level schedulers: Dask provides dynamic task schedulers that execute task graphs in parallel. Used as an alternative to direct use of threading or multiprocessing libraries in complex cases or other task scheduling systems like Luigi or IPython parallel.

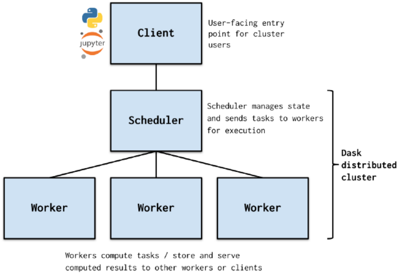
Outline

Dask Framework

Dask Architecture

Dask architecture:

- Dask Cluster
- Dask Scheduler
- Dask collections



Dask Framework

Dask Cluster

Various Dask cluster types:

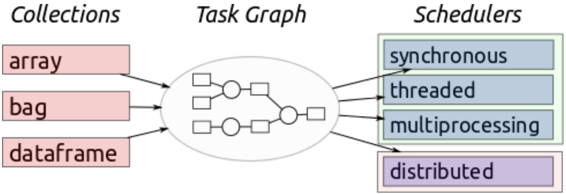
- Hadoop/Spark clusters running YARN
- HPC clusters running job managers like SLURM, SGE, PBS, LSF, or others common in academic and scientific labs
- Kubernetes clusters

Dask Framework

Dask Scheduler

Dask Scheduler:

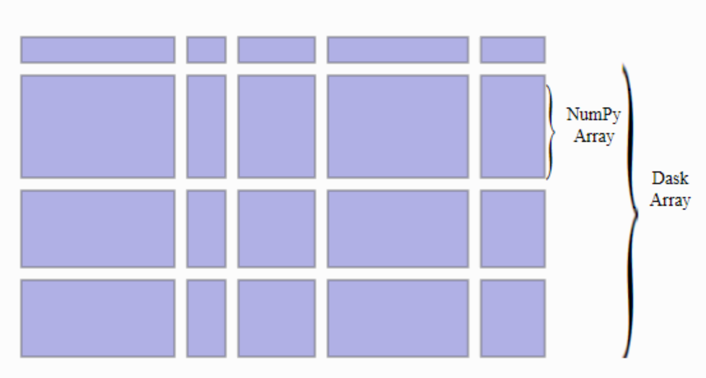
- Single machine scheduler : Optimized for larger-than-memory use. Simple, easy and cheap to use, but does not scale as it only runs on a single machine.
- Distributed scheduler : More sophisticated, fully asynchronous



Dask Framework

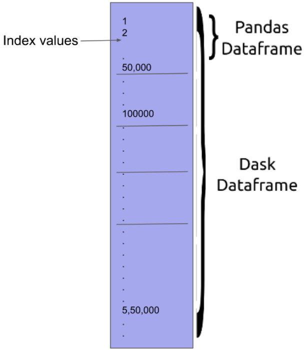
Dask collections

Dask Array



Dask Framework

Dask DataFrame



Dask DataFrame

Dask framework

Dask installation

Installation

```
conda install dask
```

OR

Installation

```
pip install dask[complete]
```

Dask framework

Dask starting cluster

Installation

```python
from dask.distributed import LocalCluster, Client
cluster = LocalCluster()
client = Client(cluster)
```

Dashboard usually on `http://localhost:8787/status`

Dashboard

```python
#To see where the port of the dashboard is, use this command
print(client.scheduler_info()['services'])
# {'dashboard': 8787} --> means you can access it at localhost:8787
```

Dask framework

Dask Collections

Dask Bag

```
import dask.bag as db
b = db.from_sequence([1, 2, 3, 4, 5, 6, 7, 8, 9, 10], npartitions=2)
```

Dask Array

```
import dask.array as da
x = da.random.random((10000, 10000), chunks=(1000, 1000))
```

Dask DataFrame

```
from dask import datasets
import dask.dataframe as dd
df = datasets.timeseries()
```

Dask framework

Dask Distributed

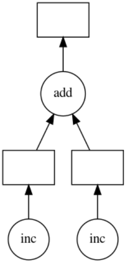
Dask Delayed function

```python
from dask import delayed
@delayed
def inc(x):
    return x + 1
@delayed
def add(x, y):
    return x + y
```

Dask Lazy evaluation

```python
x = inc(15)
y = inc(30)
total = add(x, y)

# execute all tasks
total.compute()
```



Dask framework

Dask Distributed

Dask Future

```
from dask import delayed
def inc(x):
    return x + 1
def dec(x):
    return x - 1
def add(x, y):
    return x + y
```

Dask Lazy evaluation

```
from dask.distributed import Client
c = Client(n_workers=4)

x = c.submit(inc, 1)
y = c.submit(dec, 2)
total = c.submit(add, x, y)
```

Dask framework

Dask Distributed

Dask evaluation

```python
# execute all tasks
total.compute()

from dask.distributed import progress
# to show progress bar
progress(f)

#to get results
c.gather(total)

# to get in memory or on disk
total.persist()

# release values by deleting the futures
del f, fut, x, y, total
```

Dask framework

Dask Distributed

Dask evaluation

```
# execute all tasks
total.compute()
```

Dask progess

```
from dask.distributed import progress
# to show progress bar
progress(f)
```

Dask get results

```
# get result.
c.gather(f)
```

Dask persist

Dask framework

Dask Distributed

Dask asynchronism

```
from dask.distributed import as_completed
def func(x):
    ...
    return y
futures = [c.submit(func, x) for x in range(n)]
iterator = as_completed(futures)
for res in iterator:
    print("RES␣Y␣:",res.result())
```

TPs

- TP 0 : Hadoop Installation
- TP 1 : WorldCount
- TP 2 : DataBase request
- TP 3 : Spark Installation
- TP 4 : Spark Compute PI
- TP 5 : Spark Image Processing
- TP 6 : Spark ML
- TP 7 : Dask

Outline

TPs

TP0 : Installation Hadoop

Hadoop Installation: hadoop-2.7.7.tar.gz

Installation

```
> cd /home/hduser
> mkdir local ; cd local
> wget https://www.apache.org/dist/hadoop/core/
    hadoop-2.7.7/hadoop-2.7.7.tar.gz
> tar xvfz hadoop-2.7.7.tar.gz
> mv hadoop-2.7.7 hadoop
> chown -R hduser:hadoop hadoop
```

TPs

TP0 : Installation Hadoop

Env parameter settings

```
# Set JAVA_HOME (we will also configure JAVA_HOME directly for Hadoop later on)
export JAVA_HOME=/usr/local/Java/1.8.0-xxx

# Set Hadoop-related environment variables
export HADOOP_HOME=/home/hduser/local/hadoop

export HADOOP_CONF_DIR=${HADOOP_HOME}/etc/hadoop
export HADOOP_MAPRED_HOME=$HADOOP_HOME
export HADOOP_COMMON_HOME=$HADOOP_HOME
export HADOOP_HDFS_HOME=$HADOOP_HOME
export YARN_HOME=$HADOOP_HOME

export PATH=${HADOOP_HOME}/bin:${HADOOP_HOME}/sbin:$PATH
```

TPs

TP0 : Installation Hadoop

Configuration files settings

```
# CREATE HADOOP TMP DIR
> mkdir -p /home/hduser/app/hadoop/tmp
> chown hduser:hadoop /home/hduser/app/hadoop/tmp
> chmod 750 /home/hduser/app/hadoop/tmp

# CREATE HDFS WORKINGDIR TO MNG HDFS File System
> mkdir -p /home/hduser/var/local/hadoop/hdfs/data
> chmod -R 777 /home/hduser/var/local/hadoop/hdfs
```

TPs

TP0 : Installation Hadoop

Configuration files in /home/hduser/local/hadoop/etc/hadoop

hadoop-env.sh modification

```
JAVA_HOME="true␣java␣JOME␣path"
export JAVA_HOME=${JAVA_HOME}
```

core-site.xml settings

```
<property>
        <name>hadoop.tmp.dir</name>
        <value>/home/hduser/app/hadoop/tmp</value>
        <description>A base for other temporary directories.</description>
</property>
<property>
        <name>fs.default.name</name>
        <value>hdfs://localhost:9000</value>
        <description>The name of the default file system.</description>
</property>
```

TPs

TP0 : Installation Hadoop

Configuration files in `/home/hduser/local/hadoop/etc/hadoop`

hdfs-site.xml settings

```
<property>
    <name>dfs.data.dir</name>
    <value>/home/hduser/var/local/hadoop/hdfs/data</value>
    <final>true</final>
</property>

<property>
        <name>dfs.replication</name>
        <value>1</value>
</property>
```

TPs

TP0 : Installation Hadoop

Configuration files in /home/hduser/local/hadoop/etc/hadoop
Copy mapred-site.xml.template mapred-site.xml

mapred-site.xml settings

```
<property>
        <name>mapred.job.tracker</name>
        <value>localhost:9001</value>
</property>
```

TPs

TP0 : Installation Hadoop

Configuration files in /home/hduser/local/hadoop/etc/hadoop

yarn-site.xml settings

```
<configuration>
        <!-- Site specific YARN configuration properties -->
        <property>
                <name>yarn.nodemanager.aux-services</name>
                <value>mapreduce_shuffle</value>
        </property>
        <property>
                <name>yarn.nodemanager.auxservices.mapreduce.shuffle.class</name>
                <value>org.apache.hadoop.mapred.ShuffleHandler</value>
        </property>
</configuration>
```

TPs

TP0 : Installation Hadoop

Lauch all services

```
> $HADOOP_HOME/sbin/start-hdfs.sh
> $HADOOP_HOME/sbin/start-yarn.sh
```

Check lauched services

```
> jps

26867 DataNode
28228 Jps
27285 ResourceManager
26695 NameNode
27082 SecondaryNameNode
27420 NodeManager
```

Outline

TPs

TP1 : MapReduce with Hadoop

Project MapReduce :
`/home/hduser/BigDataHadoopSpark/TPs/TP1/MapReduce`
Two projects, A java Project and a python project

```
MapReduce|
         |--pom.xml
         |--bin|
         |--python|--mapper.py
         |         |--reduce.py
         |--src|--hadoop|--WordCount.Java
         |--target|
         |--test|wordcount|--file01
                          |--file02
                |books|--b0
                      |--b1
```

TPs

TP1 : MapReduce with Hadoop

Java project:

- create directory in hdfs `/user/hduser/input`
- copy the files of `MapReduce/test/wordcount` in `/user/hduser/input`
- generate Java project BigDataTP1

```
cd BigDataHadoopSpark/TPs/TP1/MapReduce
mvn package
```

- apply Java WordCount application
- check results

TPs

TP1 : MapReduce with Hadoop

Python project

- create directory in hdfs `/user/hduser/input/book`
- copy the files of `MapReduce/test/book` in `/user/hduser/input`
- apply Python WordCount application
- check results

Outline

Outline

TPs

TP3 : Installation Spark

Spark Installation: spark-2.4.0-bin-hadoop-2.7.tgz

Installation

```
> cd /home/hduser
> mkdir local ; cd local
> wget https://www.apache.org/dyn/closer.lua/spark/spark-2.4.4/spark-2.4.4-bin-hadoop2.7.tgz
> tar xvfz spark-2.4.0-bin-hadoop-2.7.7.tar.gz
> mv spark-2.4.0-bin-hadoop-2.7.7 spark
> export HADOOP_CONF_DIR=$HADOOP_HOME/etc/hadoop
> export SPARK_HOME=/home/hduser/local/spark
> export PATH=$SPARK_HOME/bin:$PATH
> export LD_LIBRARY_PATH=$HADOOP_HOME/lib/native:$LD_LIBRARY_PATH
```

TPs

TP3 : Installation PySpark

Installation

```
> cd /home/hduser
> export SPARK_HOME=/home/hduser/local/spark
> export PATH=$SPARK_HOME/bin:$PATH
> export LD_LIBRARY_PATH=$HADOOP_HOME/lib/native:$LD_LIBRARY_PATH
> export PYSPARK_PYTHON="path_to_python"
> pip install pyspark
> pip install findspark
> sbin/start-master.sh
> sbin/start-slave.sh spark://localhost:7077
```

TPs

TP3 : Installation PySpark

test Spark shell

```
> spark-shell

Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
Spark context Web UI available at http://localhost:4040
Spark context available as 'sc' (master = local[*], app id = local-1578948405576).
Spark session available as 'spark'.
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
␣␣␣/___/␣.__/\_,_/_/␣/_/\_\␣␣␣version␣3.0.0-preview2
␣␣␣␣␣␣/_/

Using␣Scala␣version␣2.12.10␣(Java␣HotSpot(TM)␣64-Bit␣Server␣VM,␣Java␣1.8.0_92)
Type␣in␣expressions␣to␣have␣them␣evaluated.
Type␣:help␣for␣more␣information.

scala>
```

TPs

TP3 : Installation PySpark

test Spark shell

```
> pyspark

Python 2.7.5 (default, Apr 11 2018, 07:36:10)
[GCC 4.8.5 20150623 (Red Hat 4.8.5-28)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
/work/irlin355_1/gratienj/BigData/local/spark/spark-3.0.0-preview2-bin-hadoop2.7/python/pyspark/
      context.py:219: DeprecationWarning: Support for Python 2 and Python 3 prior to version 3.6 is
      deprecated as of Spark 3.0. See also the plan for dropping Python 2 support at https://spark.
      apache.org/news/plan-for-dropping-python-2-support.html.
  DeprecationWarning)
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
␣␣␣/___␣/␣.__/\_,_/_/␣/_/\_\␣␣␣version␣3.0.0-preview2
␣␣␣␣␣␣/_/

Using␣Python␣version␣2.7.5␣(default,␣Apr␣11␣2018␣07:36:10)
```

TPs

TP3 : Test0 Test1 Test2

Test0 :

- create spark context
- create liste of integer
- partition list with spark
- print num of partions

Test1 :

- compute square of integer list
- print square list

Test2 :

- compute PI

Outline

TPs

TP4 : Spark ML, Data processing

Test0 :

- load `TPs/data/iris.csv` file in Panda DataFrame
- create Spark DataFrame
- show 5 first lines
- select two columns
- print some statistics on Spark Data frame

Outline

TPs

TP5 : Spark ML, Data processing

Spark ML :

- load `TPs/data/iris.csv` file in Panda DataFrame
- create Spark DataFrame
- create Pipeline to prepare date for machine learning
- compute a predicting model
- evaluate the predicting model

Outline

TPs

Project : Spark ML, Image processing

project :

- load Lena.jpg file
- develop a parallel median Filter in python with Spark

Outline

TPs

Test0 Test1 Test2 with Dask

Test0 :

- create Dask client
- create liste of integer
- partition list with dask
- print num of partions

Test1 :

- compute square of integer list
- print square list

Test2 :

- compute PI