An Introduction to SparkR

The Apache Spark Framework

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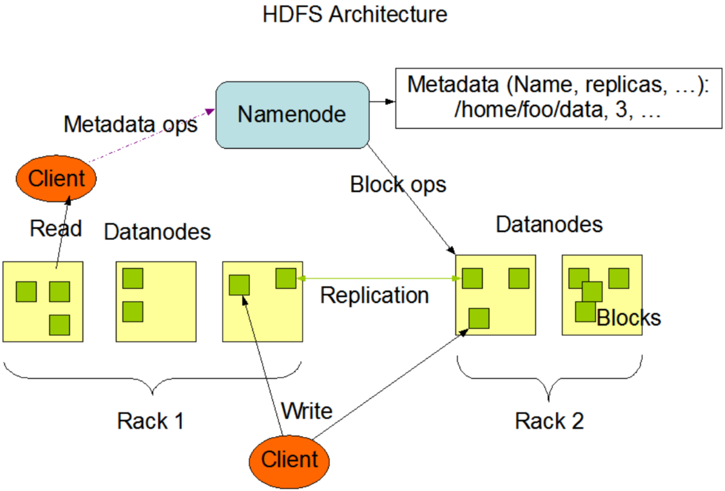
Hadoop Distributed Filesystem (HDFS)

- Based on Google filesystem
- Fault tolerant (distributed blocks, multiple replicas)
- One client can write, multiple clients read
- Only sequential r/w-operations (no random access)

Hadoop Distributed Filesystem (HDFS)

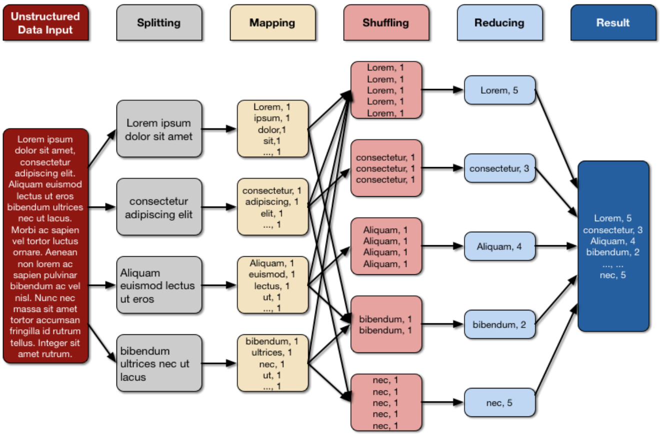


MapReduce Paradigm

- MapReduce: Simplified Data Processing on Large Clusters (Dean and Gemawat 2004, OSDI)
- Splits computations in *map* and *reduce* phase
- Handles
  - Details of input data partitioning
  - Scheduling program's execution across a set of machines
  - Machine failures
  - Required inter-machine communication

Backgrou

MapReduce Data and Process Flow of Word Count


Unstructured Data Input
Splitting
Mapping
Shuffling
Reducing
Result
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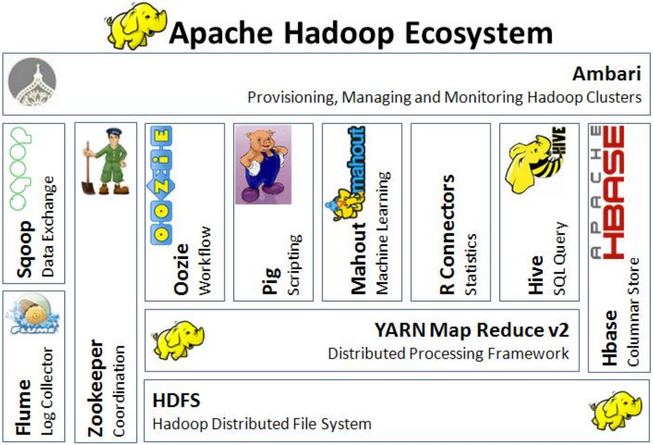
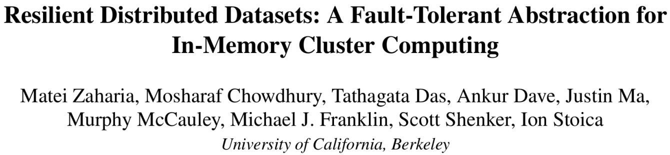
Lorem, 1 Lorem, 1 Lorem, 1 Lorem, 1 Lorem, 1
consectetur, 1 consectetur, 1 consectetur, 1
Aliquam, 1 Aliquam, 1 Aliquam, 1 Aliquam, 1
bibendum, 1 bibendum, 1
nec, 1 nec, 1 nec, 1 nec, 1 nec, 1
Lorem, 5
consectetur, 3
Aliquam, 4
bibendum, 2
nec, 5
Lorem, 5 consectetur, 3 Aliquam, 4 bibendum, 2 ...., ... nec, 5

Hadoop Ecosystem



Matei Zaharia et al. Paper



Resilient Distributed Datasets: A Fault-Tolerant Abstraction for In-Memory Cluster Computing

Matei Zaharia, Mosharaf Chowdhury, Tathagata Das, Ankur Dave, Justin Ma,
Murphy McCauley, Michael J. Franklin, Scott Shenker, Ion Stoica
University of California, Berkeley

Spark Concept

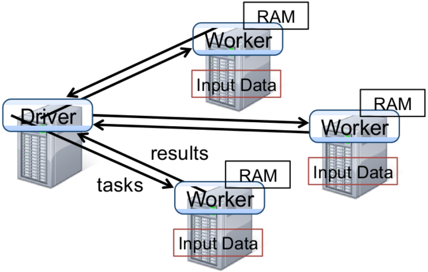


Figure 2: Spark runtime. The user's driver program launches multiple workers, which read data blocks from a distributed file system and can persist computed RDD partitions in memory.

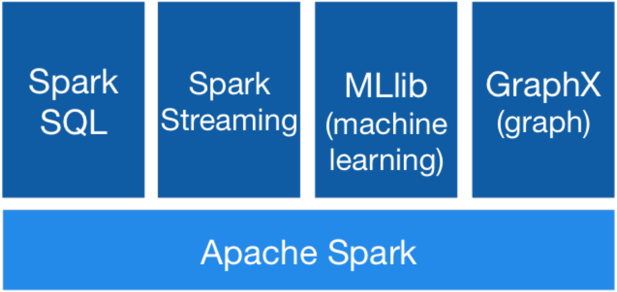
RDD Properties

- Resilient, distributed collections
- Immutable
- Transformations
  - map, filter, reduceByKey, join, ...
- Actions
  - reduce, collect, count, foreach, ...

RDD Example

```
scala> val textFile = sc.textFile("README.md")
textFile: spark.RDD[String] = spark.MappedRDD@2ee9b6e3

scala> textFile.count() // Number of items in this RDD
res0: Long = 126

scala> textFile.first() // First item in this RDD
res1: String = # Apache Spark


scala> val linesWithSpark = textFile.filter(line => line.contains("Spark"))
linesWithSpark: spark.RDD[String] = spark.FilteredRDD@7dd4af09


scala> textFile.filter(line => line.contains("Spark")).count()
res3: Long = 15
```

Spark Libraries



Spark SQL

Spark Streaming

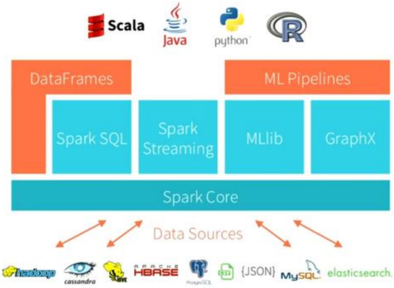
MLlib (machine learning)

GraphX (graph)

Apache Spark

Current Situation

- Current version 1.6.0 (January 2016)
- SparkR included since 1.3.0 (March 2015)



What is SparkR

- Light-weight frontend to Apache Spark from R
- SparkR's development is very *dynamic*
- Main feature: SparkR DataFrames
  - distributed collection of data organized into named columns
  - conceptually equivalent to
    - a table in a relational database or
    - a data frame in R

  ... but on large datasets
- GLM using MLib

R Example

```
df <- createDataFrame(sqlContext, faithful)

# Get basic information about the DataFrame
df
## DataFrame[eruptions:double, waiting:double]

# Displays the content of the DataFrame to stdout
head(df)
##  eruptions waiting
##1     3.600      79
##2     1.800      54
##3     3.333      74
```

R Example

```
# Filter the DataFrame to only retain rows with wait times shorter than 50 mins
head(filter(df, df$waiting < 50))
##  eruptions waiting
##1     1.750      47
##2     1.750      47
##3     1.867      48

# We use the 'n' operator to count the number of times each waiting time appears
head(summarize(groupBy(df, df$waiting), count = n(df$waiting)))
##  waiting count
##1      81    13
##2      60     6
##3      68     1

# We can also sort the output from the aggregation to get the most common waiting times
waiting_counts <- summarize(groupBy(df, df$waiting), count = n(df$waiting))
head(arrange(waiting_counts, desc(waiting_counts$count)))

##   waiting count
##1      78    15
##2      83    14
##3      81    13
```

Reading from Data Sources

```
sc <- sparkR.init(sparkPackages="com.databricks:spark-csv_2.11:1.0.3")
sqlContext <- sparkRSQL.init(sc)

people <- read.df(sqlContext, "./examples/src/main/resources/people.json", "json")
head(people)
##  age    name
##1  NA Michael
##2  30    Andy
##3  19  Justin

# SparkR automatically infers the schema from the JSON file
printSchema(people)
# root
#  |-- age: integer (nullable = true)
#  |-- name: string (nullable = true)

write.df(people, path="people.parquet", source="parquet", mode="overwrite")
```

Cluster setup

- Apache Spark in standalone mode
- 5 Servers
    - 1 master node
    - 4 worker nodes
- Node specifications
    - 2 x 4 core Intel Xeon Processor
    - 48 GB RAM
    - 1 GBit network to storage
    - 20 GBit IP over InfiniBand (interconnect)

Connecting to the Apache Spark Master

```
./bin/sparkR --master spark://10.110.100.120:7077 \
--packages com.databricks:spark-csv_2.10:1.3.0

R version 3.1.1 (2014-07-10) -- "Sock it to Me"
Copyright (C) 2014 The R Foundation for Statistical Computing
Platform: x86_64-unknown-linux-gnu (64-bit)

...
```