# Who are you

- Java developer since 2001
- Java Trainer since 2003
- Java consultant since 2008
- Java architect since 2009
- InWhite Owner
- DemocraC startup founder since 2014
- Big Data Technical Leader at
  Naya technologies since 2015

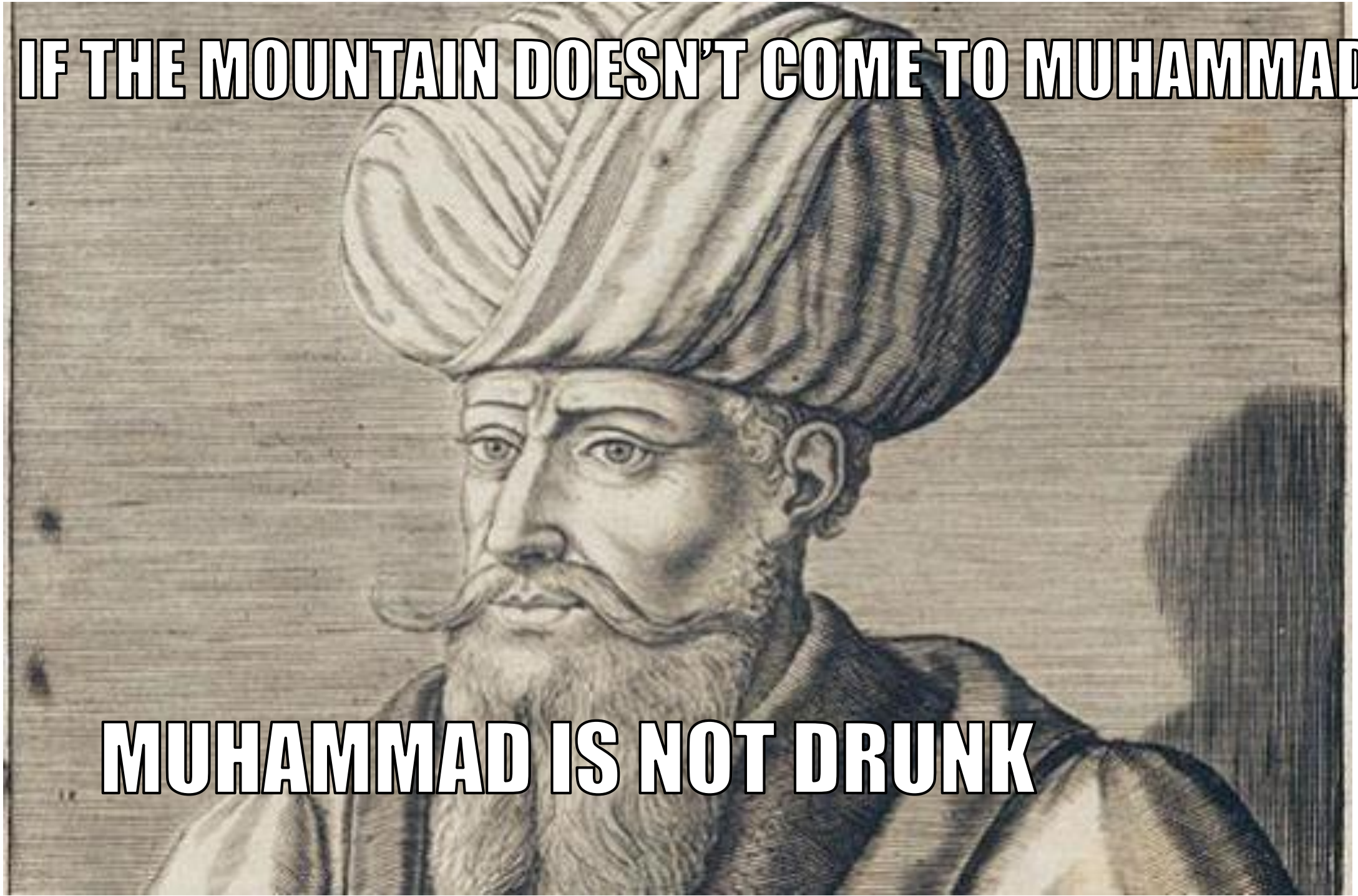
# Spark

evgenyb@naya-tech.co.il

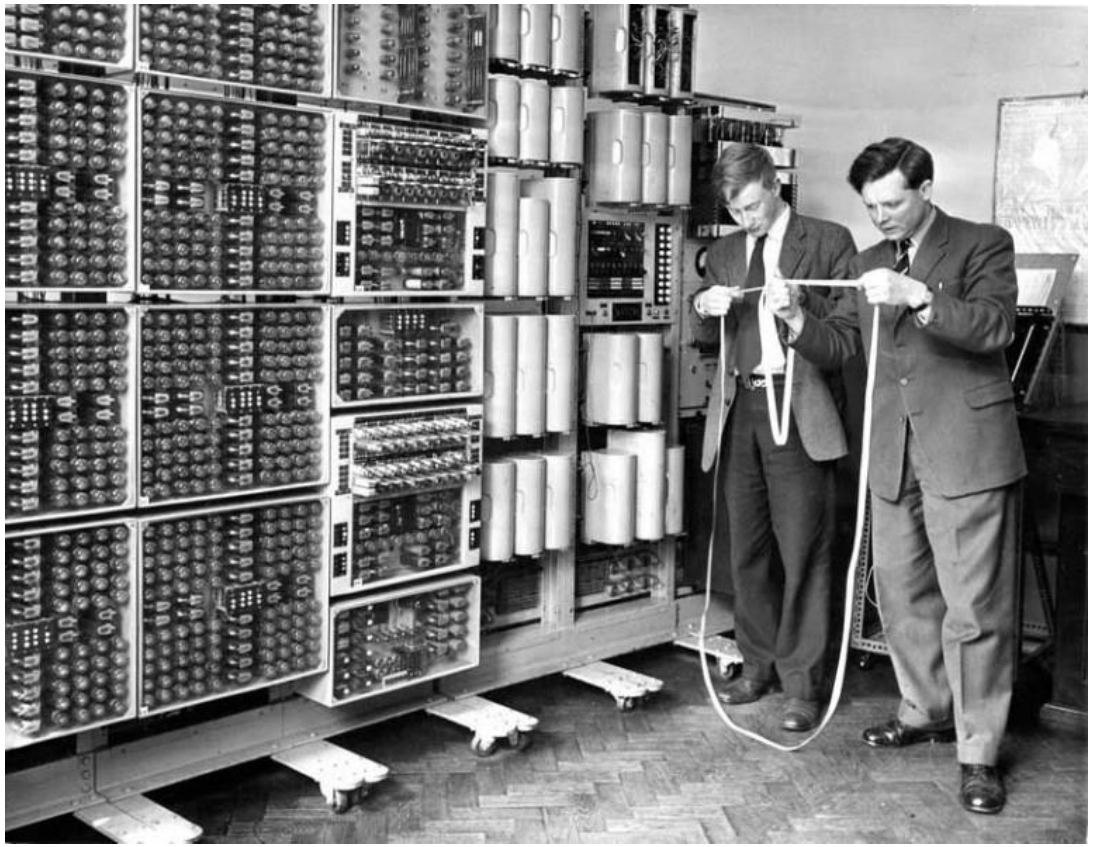
# Agenda

- Hadoop ecosystem
- Functional programming
- Scala – what we need to know
- Spark API

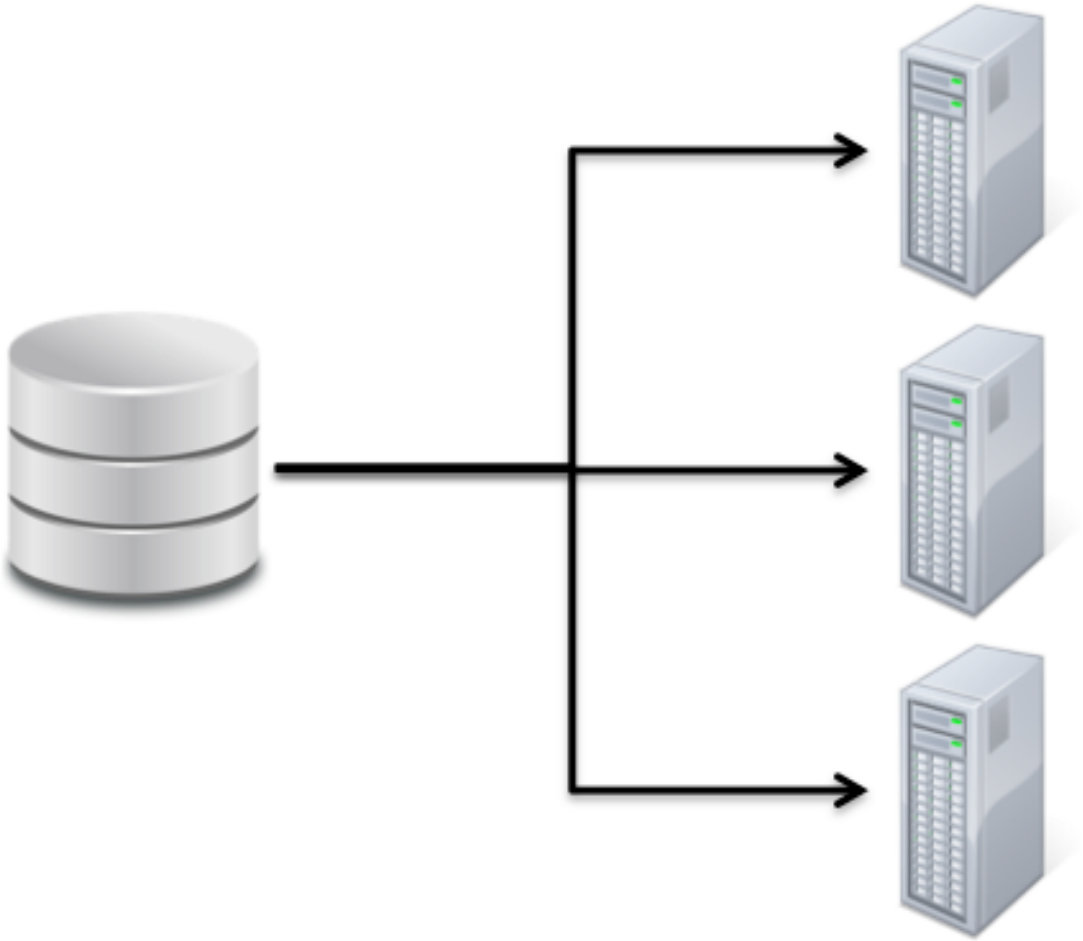
# Data locality


IF THE MOUNTAIN DOESN'T COME TO MUHAMMAD
MUHAMMAD IS NOT DRUNK

# Yesterday against today

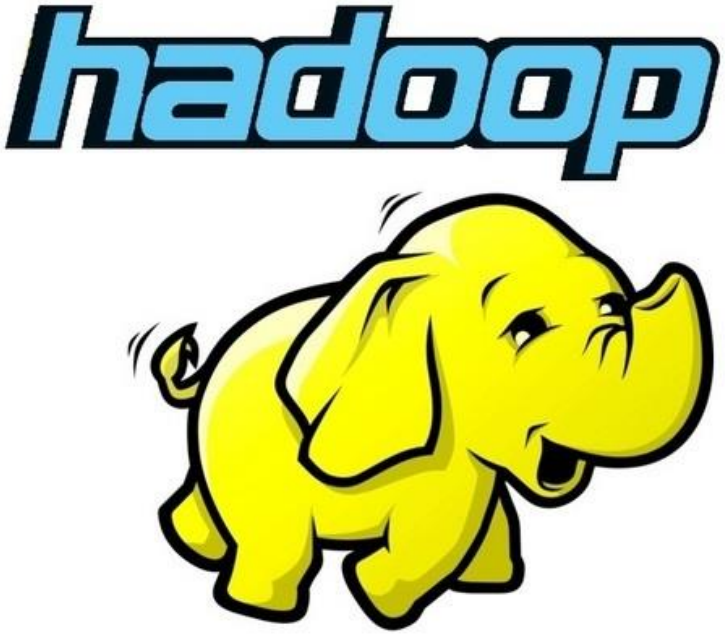


# The bottleneck



## New model

# Hadoop Sucks….



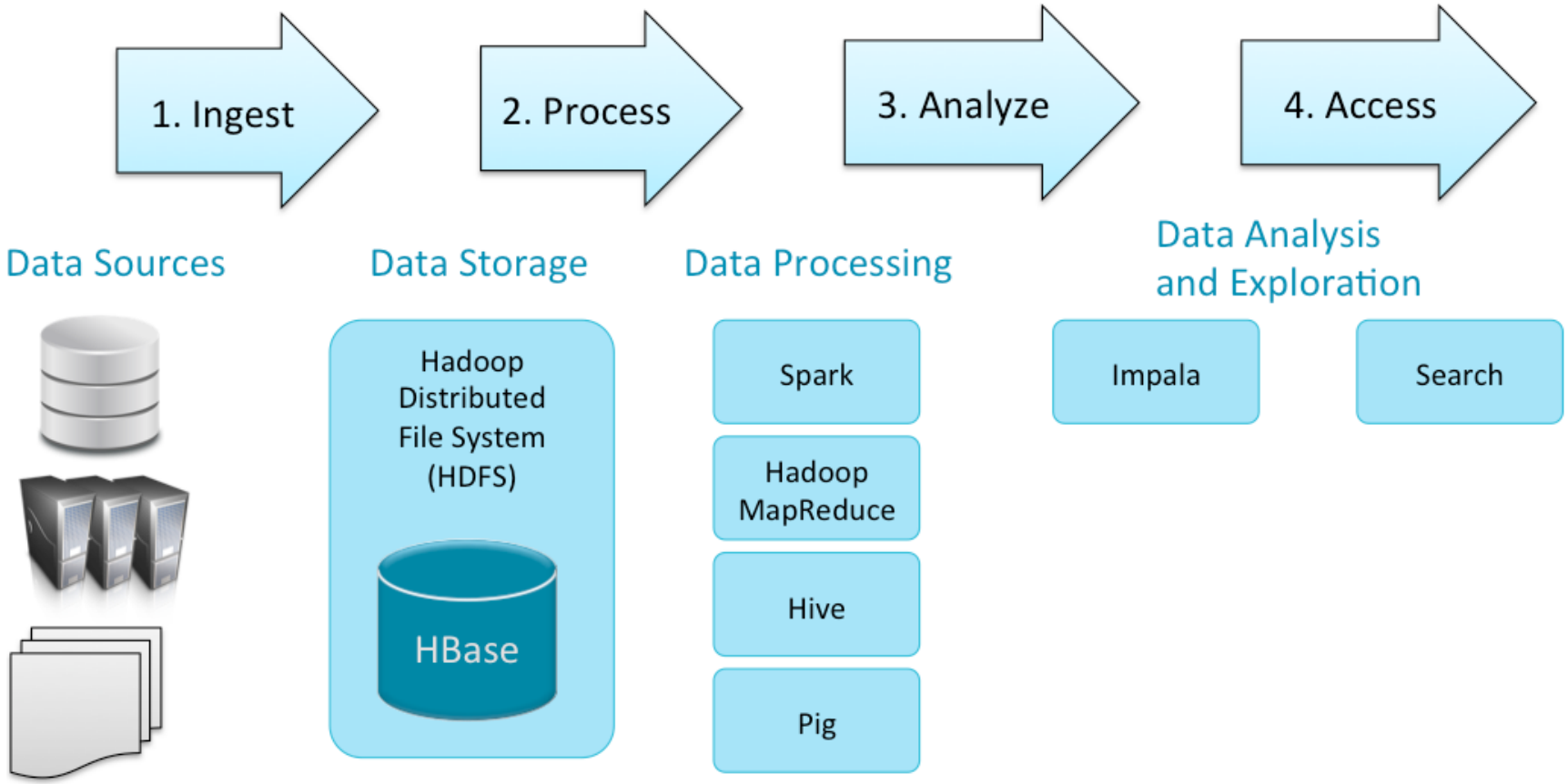

# Hadoop implementations

- Vanilla
- Hortonworks
- Cloudera

# Hadoop ecosystem includes

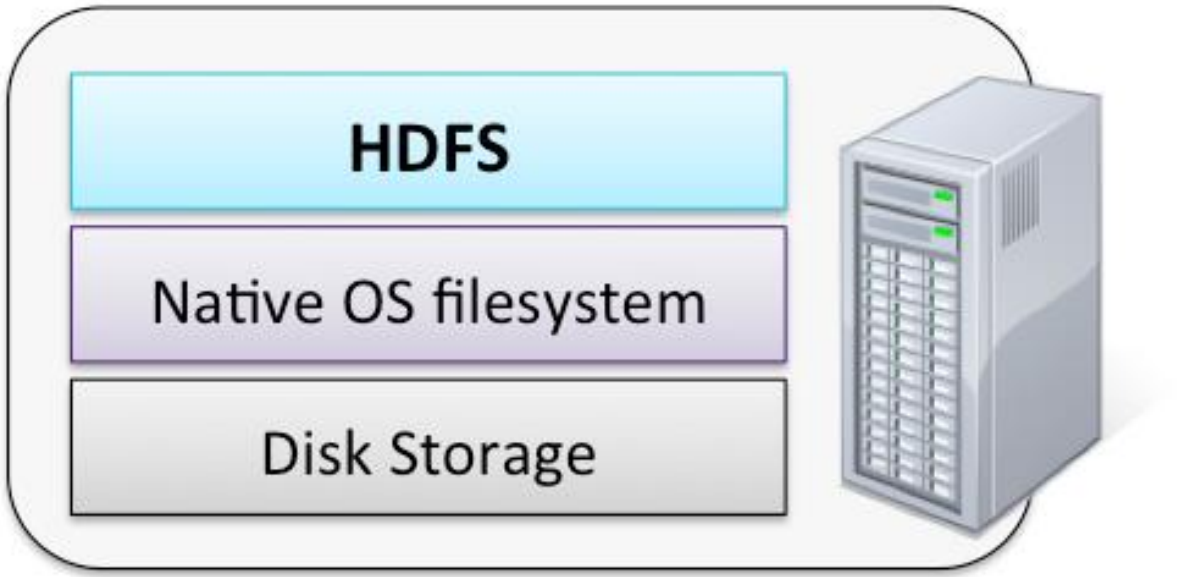
- HDFS
- HBASE
- Hue
- Yarn
- Sqoop
- Flume
- Hive
- Spark (Cloudera, Hortonworks)
- Solr
- Pig
- Impala (Cloudera)
- Zookeeper
- Oozie

# The process


1. Ingest
2. Process
3. Analyze
4. Access
Data Sources
Data Storage
Data Processing
Data Analysis and Exploration
Hadoop Distributed File System (HDFS)
HBase
Spark
Hadoop MapReduce
Hive
Pig
Impala
Search

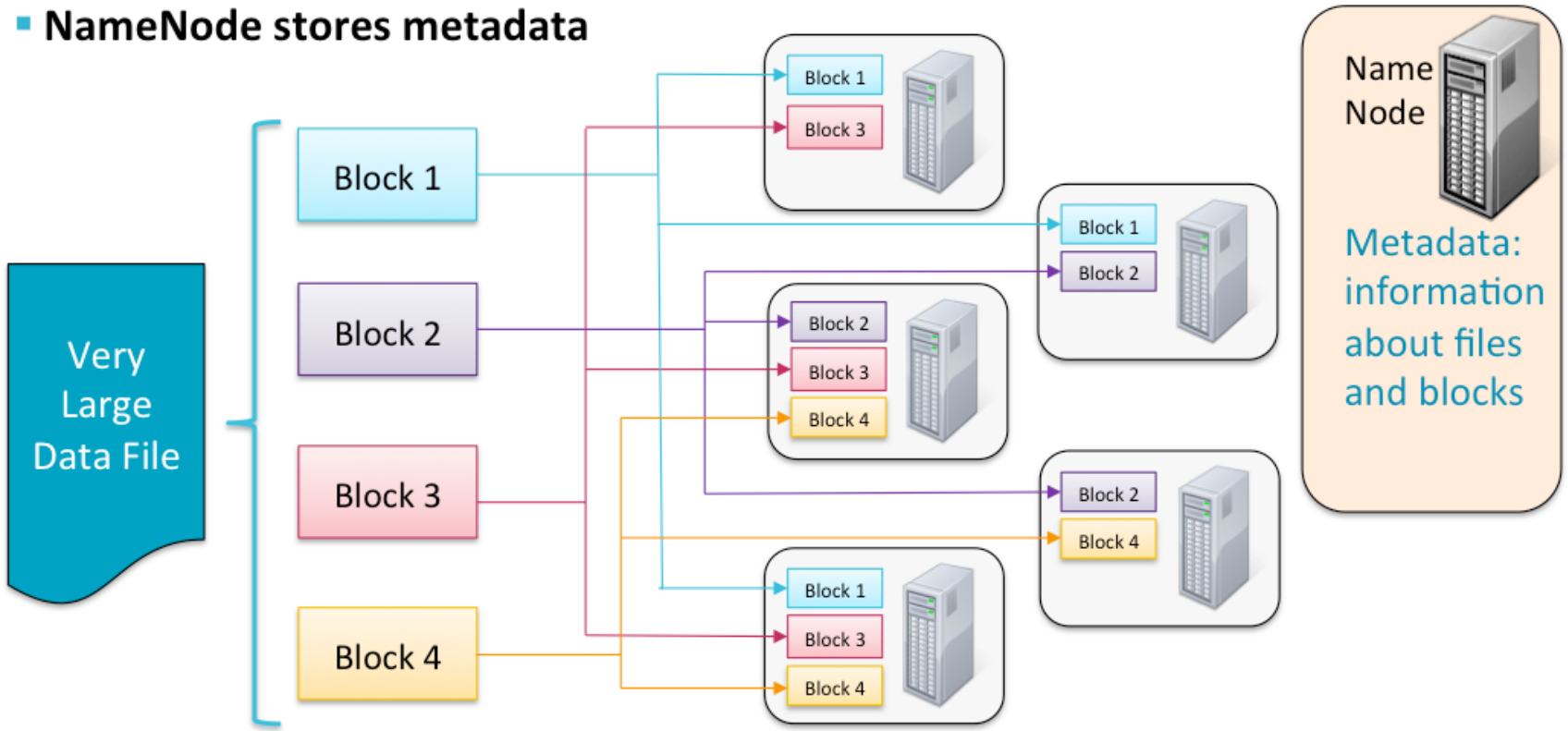
# Storing data in Hadoop

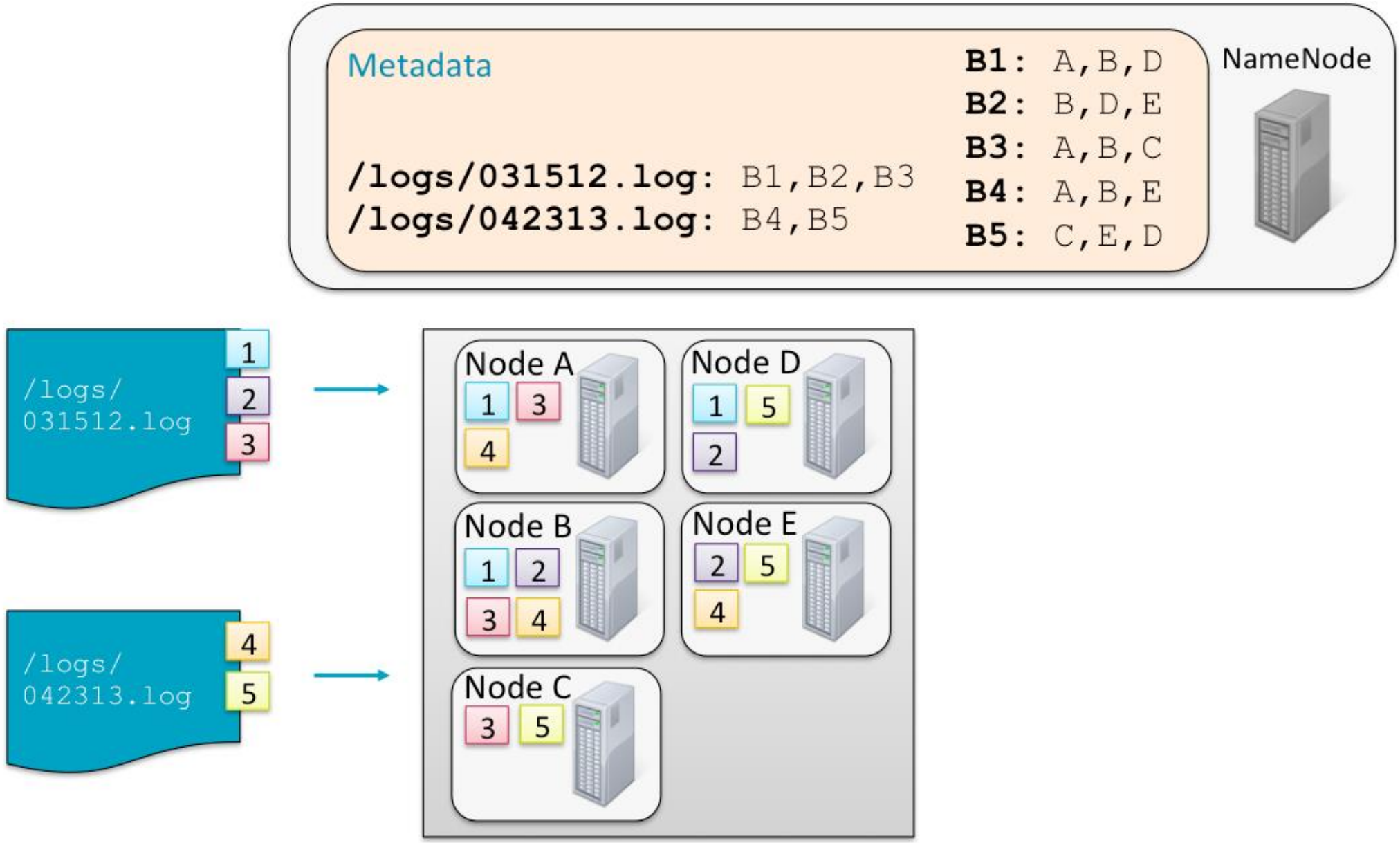
- Hadoop Distributed File System (HDFS)
- Apache Hbase  - no sql distributed database

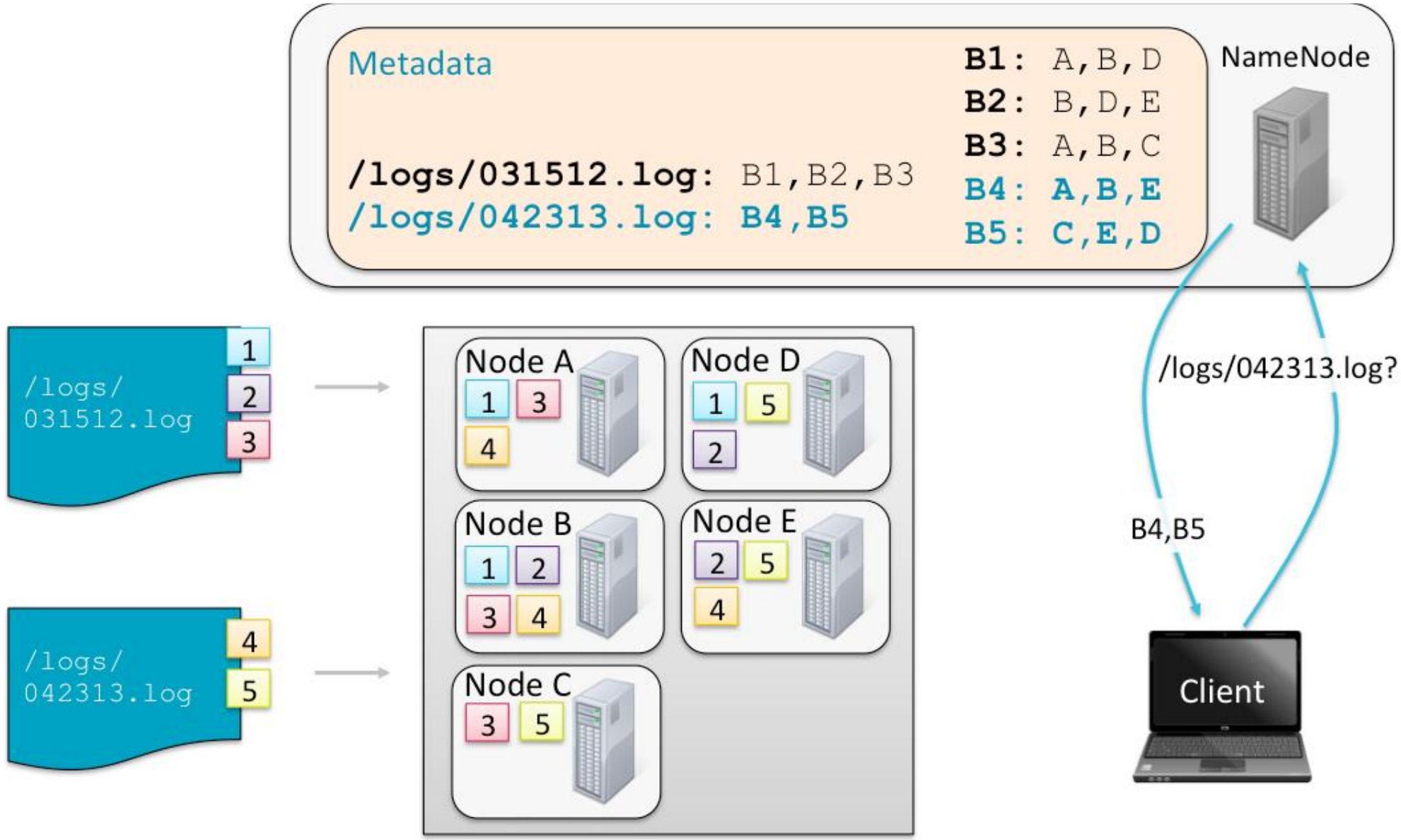


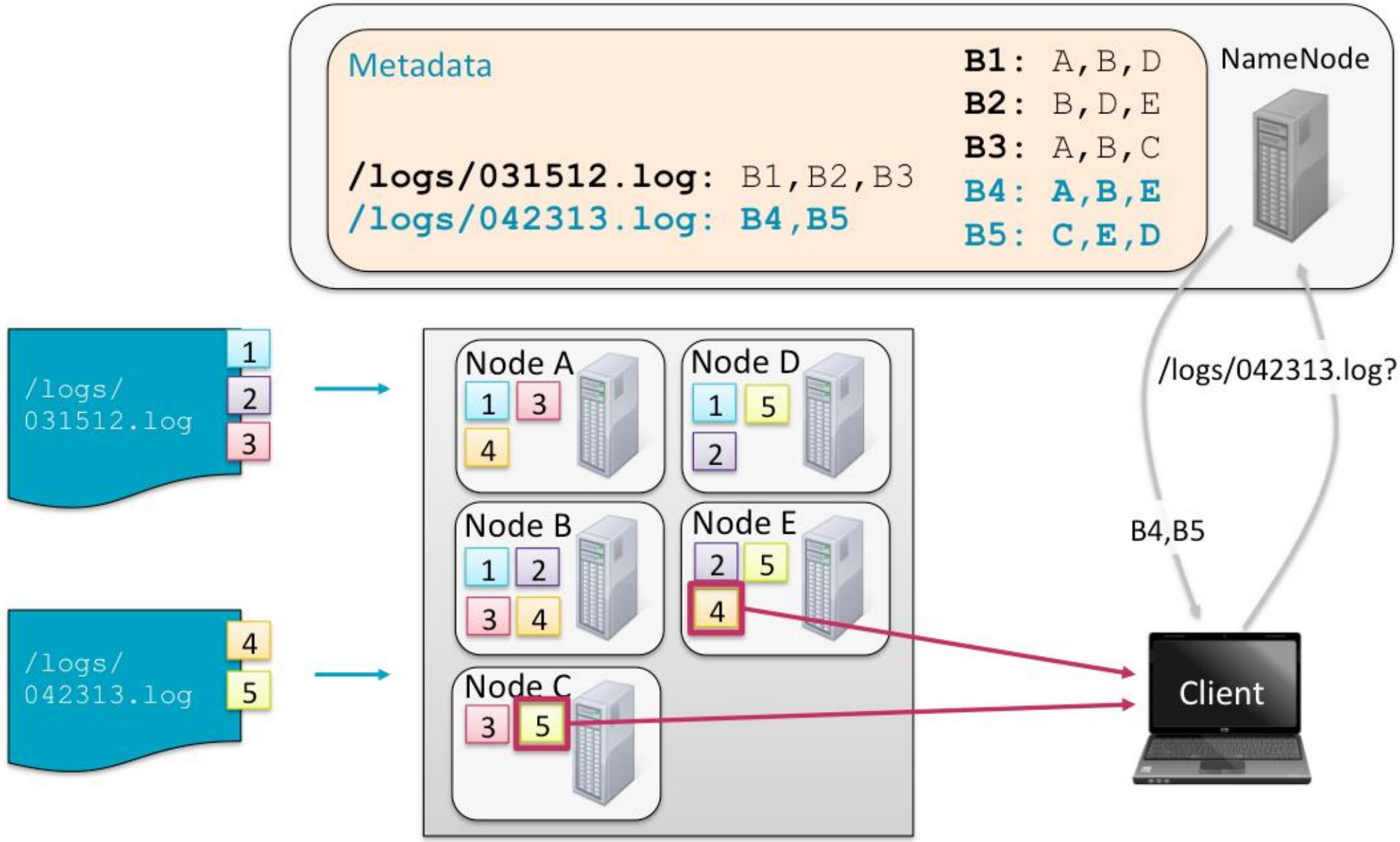
# How files stored in HDFS

- **Data files are split into 128MB blocks which are distributed at load time**
- **Each block is replicated on multiple data nodes (default 3x)**
- **NameNode stores metadata**




Metadata
/logs/031512.log: B1,B2,B3
/logs/042313.log: B4,B5
B1: A,B,D
B2: B,D,E
B3: A,B,C
B4: A,B,E
B5: C,E,D
NameNode
/logs/
031512.log
1
2
3
/logs/
042313.log
4
5
Node A
1
3
4
Node D
1
5
2
Node B
1
2
3
4
Node E
2
5
4
Node C
3
5


Metadata
/logs/031512.log: B1,B2,B3
/logs/042313.log: B4,B5
B1: A,B,D
B2: B,D,E
B3: A,B,C
B4: A,B,E
B5: C,E,D
NameNode
/logs/042313.log?
B4,B5
Client
/logs/
031512.log
1
2
3
/logs/
042313.log
4
5
Node A
1
3
4
Node D
1
5
2
Node B
1
2
3
4
Node E
2
5
4
Node C
3
5


Metadata
/logs/031512.log: B1,B2,B3
/logs/042313.log: B4,B5
B1: A,B,D
B2: B,D,E
B3: A,B,C
B4: A,B,E
B5: C,E,D
NameNode
/logs/042313.log?
B4,B5
/logs/
031512.log
1
2
3
/logs/
042313.log
4
5
Node A
1
3
4
Node D
1
5
2
Node B
1
2
3
4
Node E
2
5
4
Node C
3
5
Client

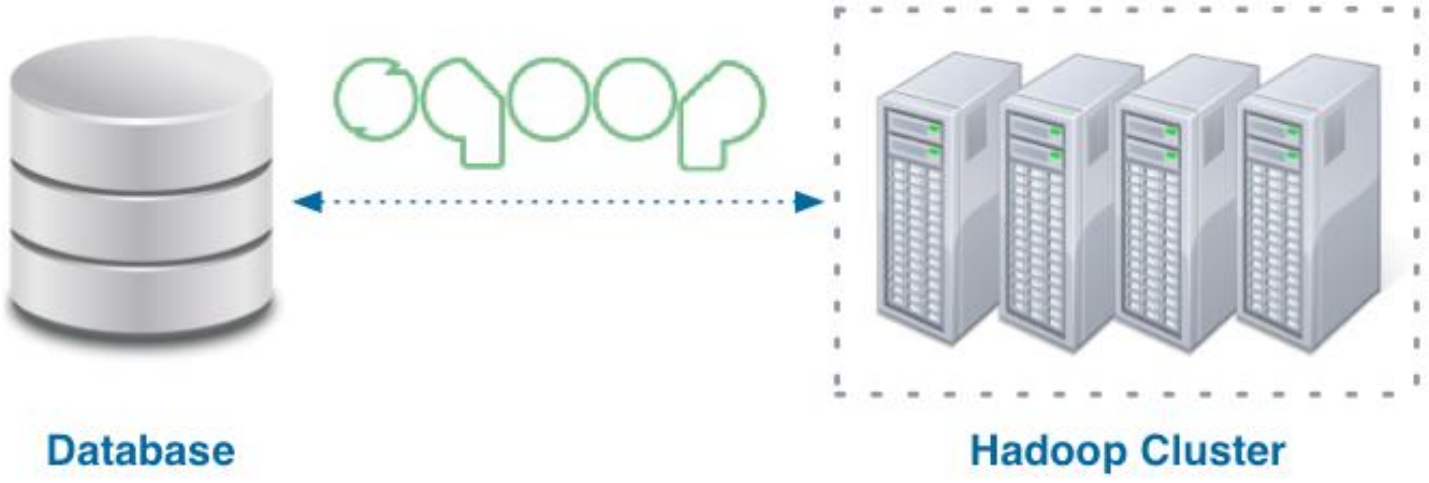
# HDFS: cmd

- hdfs dfs –put bigFile.txt bigFile.txt
- hdfs dfs –ls
- hdfs dfs –get /user/jeka/ bigFile.txt bigFile.txt
- hdfs dfs –mkdir myDir
- hdfs dfs –rm –r backupDir


BUT ALL OUR DATA IN RELATIVE DATABASES

# Sqoop

- Tool for migrating data from relative db to Hadoop and visa versa
- Supports
  - Netezza, Mongo, MySQL, Teradata, Oracle



# Import Data

- sqoop --all-tables
  --connect jdbc:mysql://host/schema
  --username user
  --password 1234

# Import Data

- sqoop --all-tables
  --connect jdbc:mysql://host/schema
  --username user
  --password 1234
  --incremental lastmodified
  --check-column date
  --last-value ‘2016-06-10 11:00:00’

# Import Data

- sqoop --all-tables
  --connect jdbc:mysql://host/schema
  --username user
  --password 1234
  --columns “id, name, date”
  --where “state=‘UA’ ”

# Import Data

- sqoop --all-tables
  --connect jdbc:mysql://host/schema
  --username user
  --password 1234
  --incremental lastmodified
  --check-column id
  --last-value 66666

# Import Data

- sqoop --all-tables
  --connect jdbc:mysql://host/schema
  --username user
  --password 1234
  -m 16  (parallelism. Default is 4)

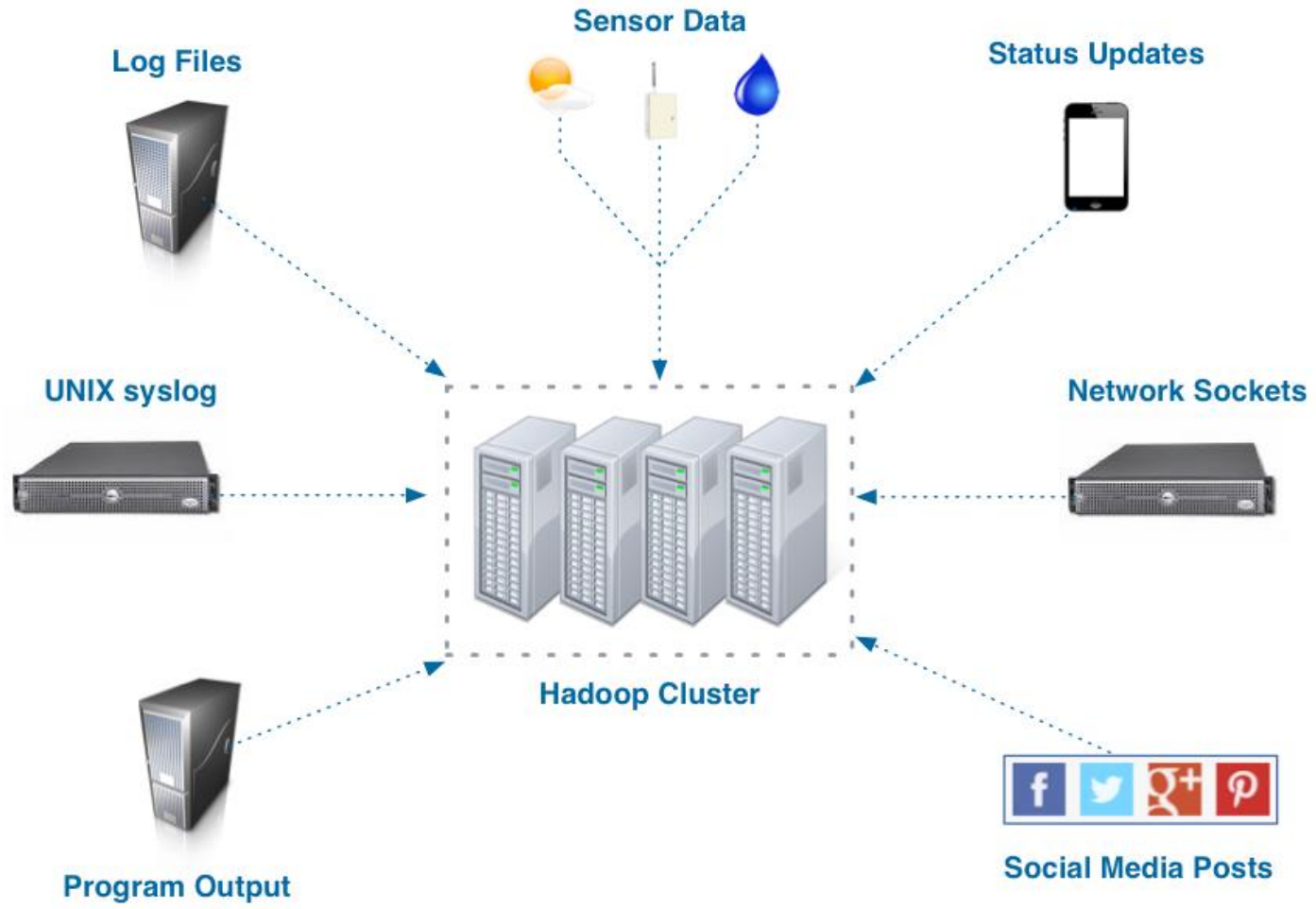
# Export

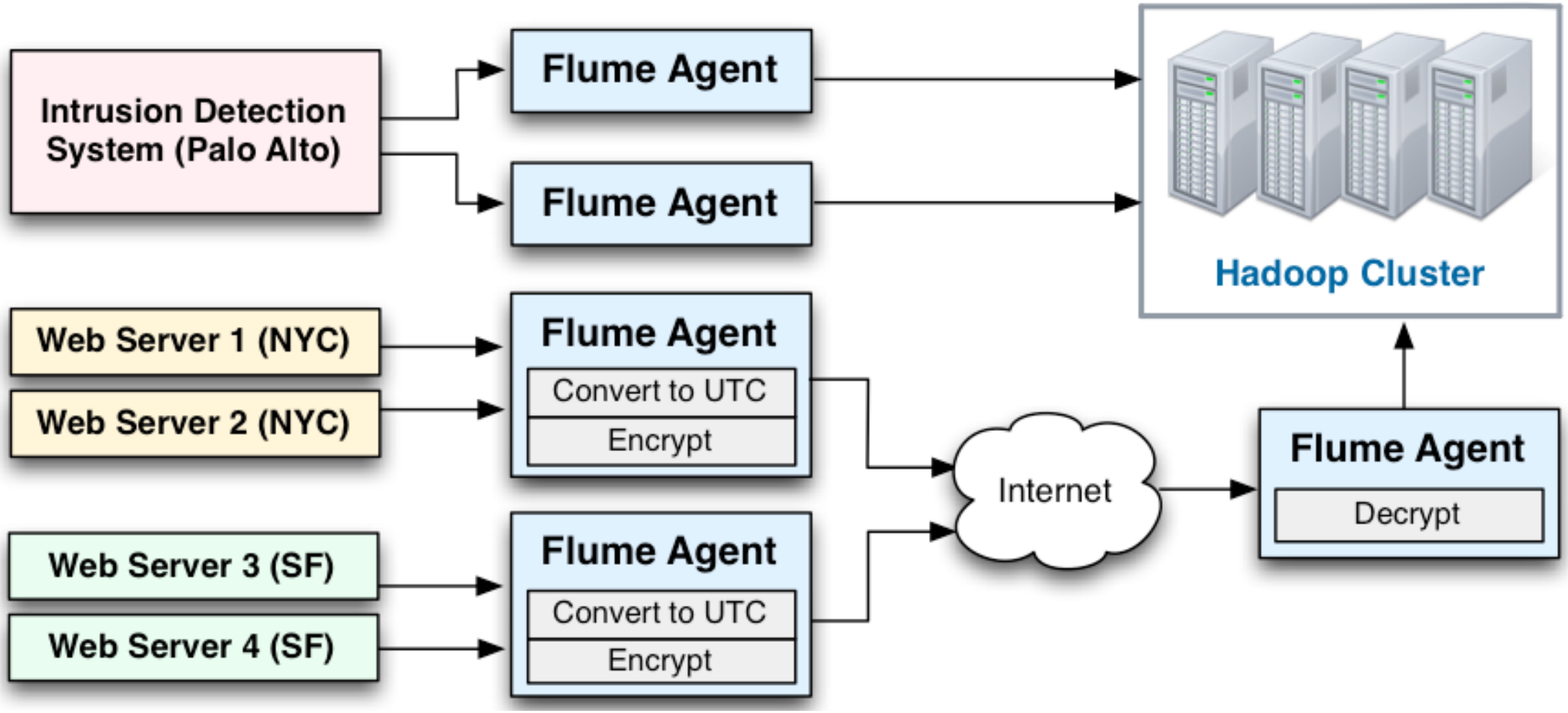
```
sqoop export \
  --connect jdbc:mysql://dbhost/loudacre \
  --username dbuser --password pw \
  --export-dir /loudacre/recommender_output \
  --update-mode allowinsert \
  --table product_recommendations
```

# Apache flume

- Distributed service for ingesting streaming data
- Good for reading logs, messaging system, kafka (mostly)
- Can be replaced by spark streaming

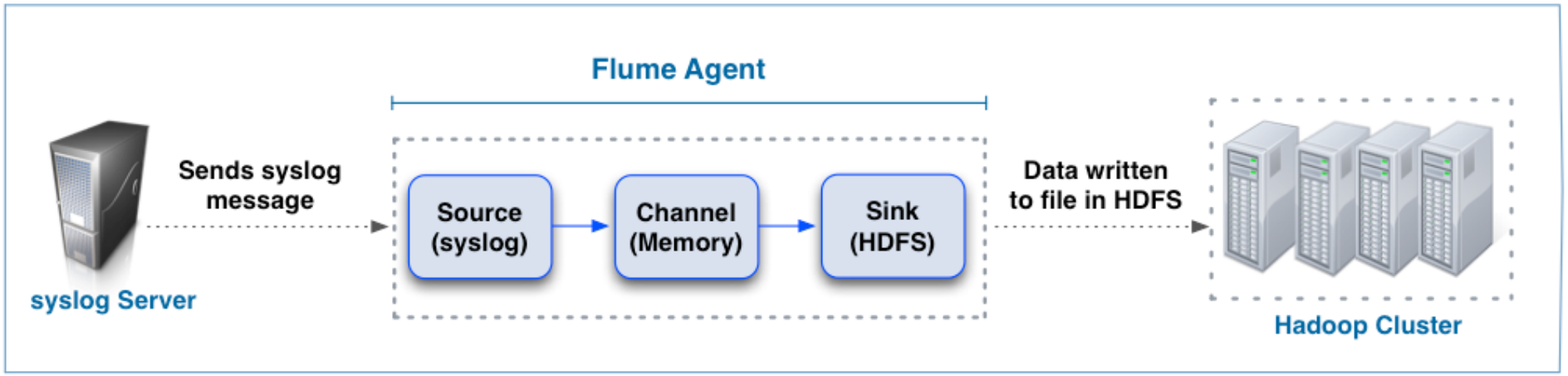
# Where from Flume can fetch data?




Intrusion Detection System (Palo Alto)
Flume Agent
Flume Agent
Hadoop Cluster
Web Server 1 (NYC)
Web Server 2 (NYC)
Flume Agent
Convert to UTC
Encrypt
Web Server 3 (SF)
Web Server 4 (SF)
Flume Agent
Convert to UTC
Encrypt
Internet
Flume Agent
Decrypt

# Channel can be changed (not only memory)

- **This diagram illustrates how syslog data might be captured to HDFS**
  1. Message is logged on a server running a syslog daemon
  2. Flume agent configured with syslog source receives event
  3. Source pushes event to the channel, where it is buffered in memory
  4. Sink pulls data from the channel and writes it to HDFS



# Flume channels

- Memory – RAM
  - Super fast, but in case rocket will fail, all data will be lost
- File – stores data on local disk
  - Works slower, but you rocket is not a dangerous anymore
- JDBC – stores data in database with JDBC
  - Work even more slower, but you dba’s can will not be unemployed

Everything configured via property file

$ bin/flume-ng agent -n $agent_name -c conf -f conf/flume-conf.properties.template

```
# Name the components on this agent
a1.sources = r1
a1.sinks = k1
a1.channels = c1
# Describe/configure the source
a1.sources.r1.type = netcat
a1.sources.r1.bind = localhost
a1.sources.r1.port = 44444
# Describe the sink
a1.sinks.k1.type = logger
# Use a channel which buffers events in memory
a1.channels.c1.type = memory
a1.channels.c1.capacity = 1000
a1.channels.c1.transactionCapacity = 100
# Bind the source and sink to the channel
a1.sources.r1.channels = c1
a1.sinks.k1.channel = c1
```

# Hive

- Uses SQL-like syntax (HiveQL)
- Delegate to map reduce API, so not so fast
- Good for batch processes
- Convenient for dba’s

# Impala (cloudera)

- Like Hive, but much faster
- Written on C
- Work on cluster
- Uses ram
- Works very fast
- Needs a lot of free memory (RAM)

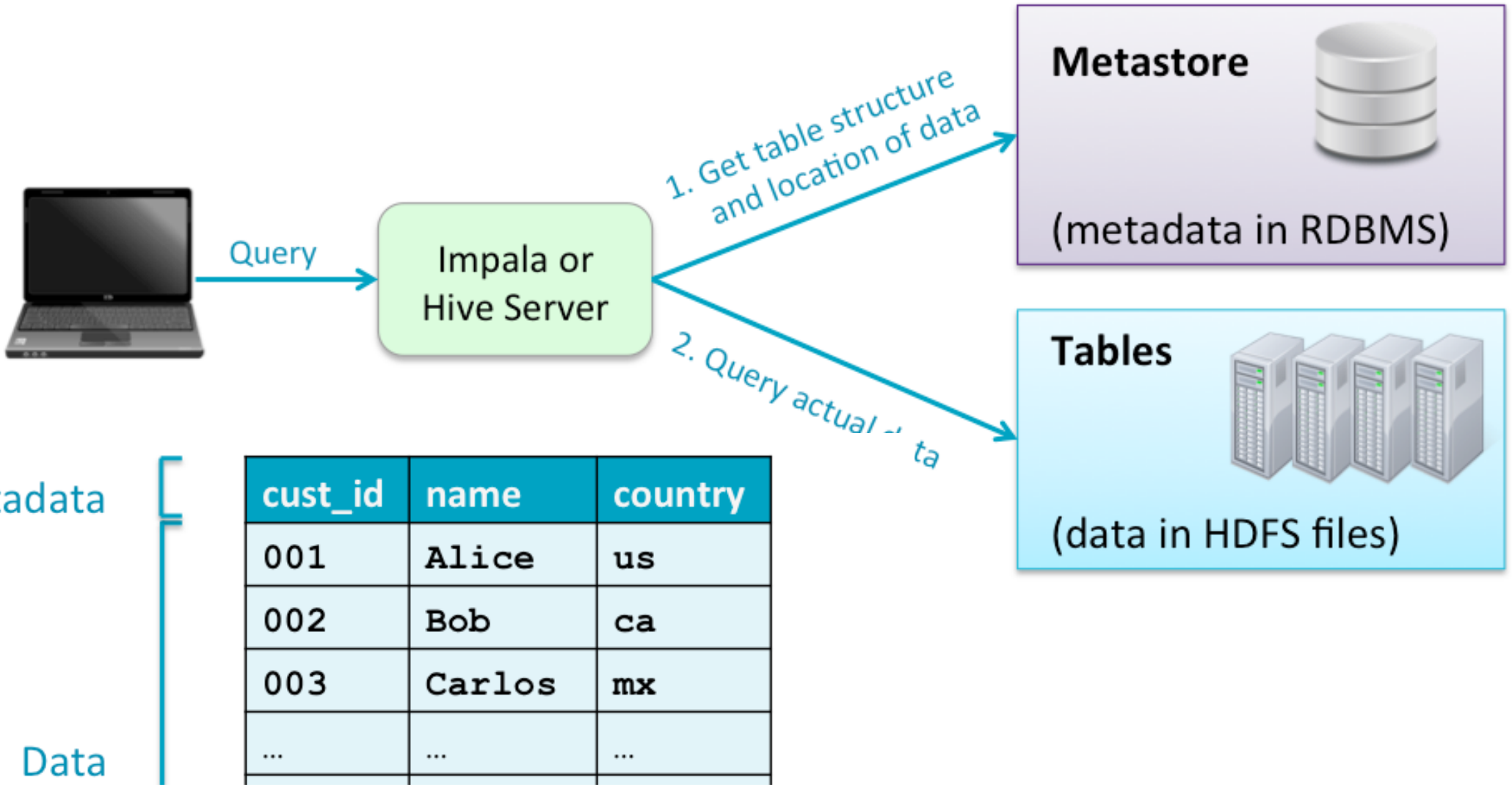
# Why not to use Impala instead of Hive always?

- Needs a lot of RAM
- Needs a lot of RAM
- Officially is supported only by Cloudera

# Hive / Impala syntax example

```
> SELECT lname,fname FROM customers WHERE state = 'CA'
limit 50;

Query: select lname,fname FROM customers WHERE state =
'CA' limit 50
+------------+------------+
| lname      | fname      |
+------------+------------+
| Ham        | Marilyn    |
| Franks     | Gerard     |
| Preston    | Mason      |
| Cortez     | Pamela     |
…
| Falgoust   | Jennifer   |
+------------+------------+
Returned 50 row(s) in 0.17s
```

# How impala / hive stores data



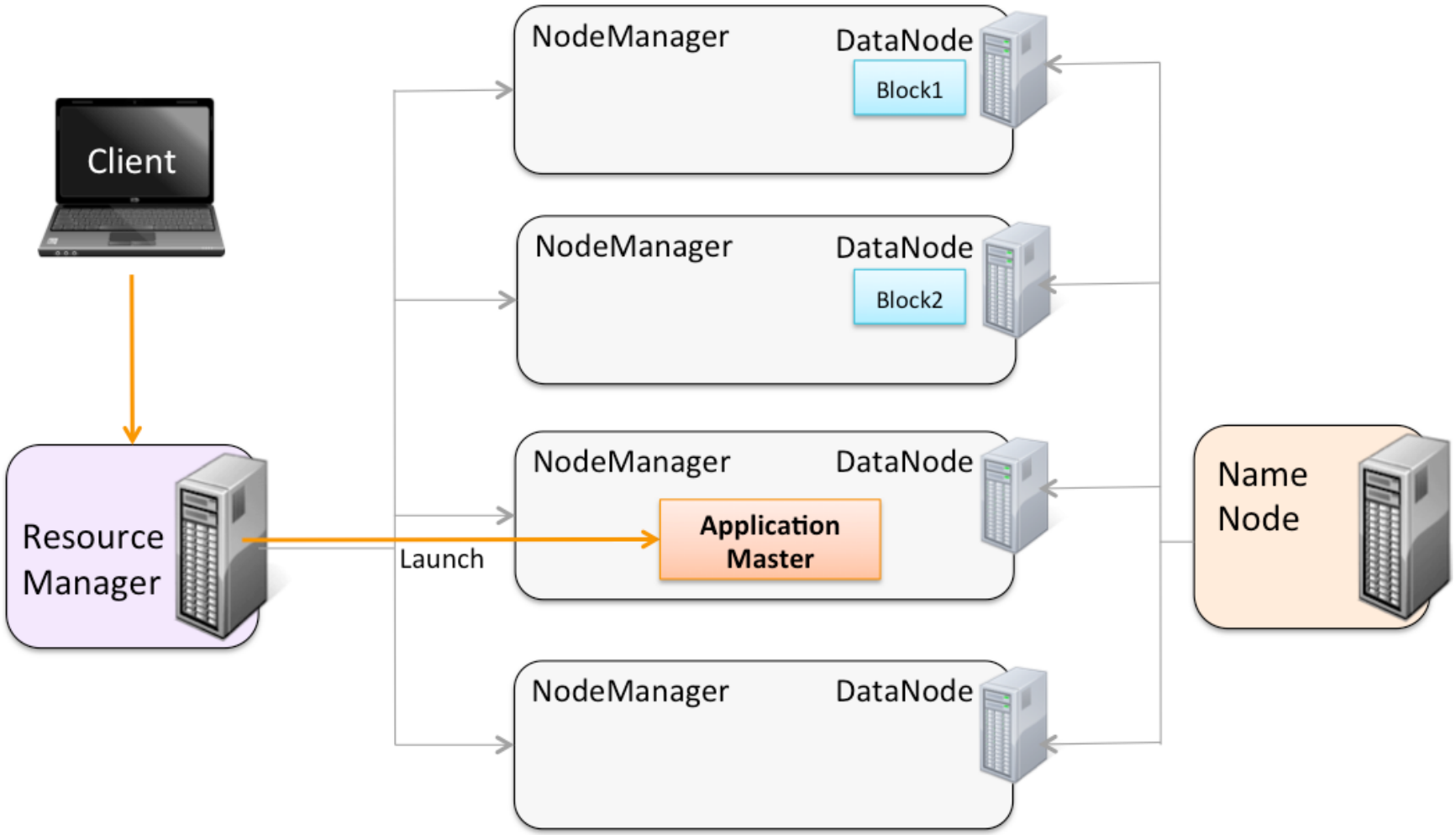
# Where tables come from?

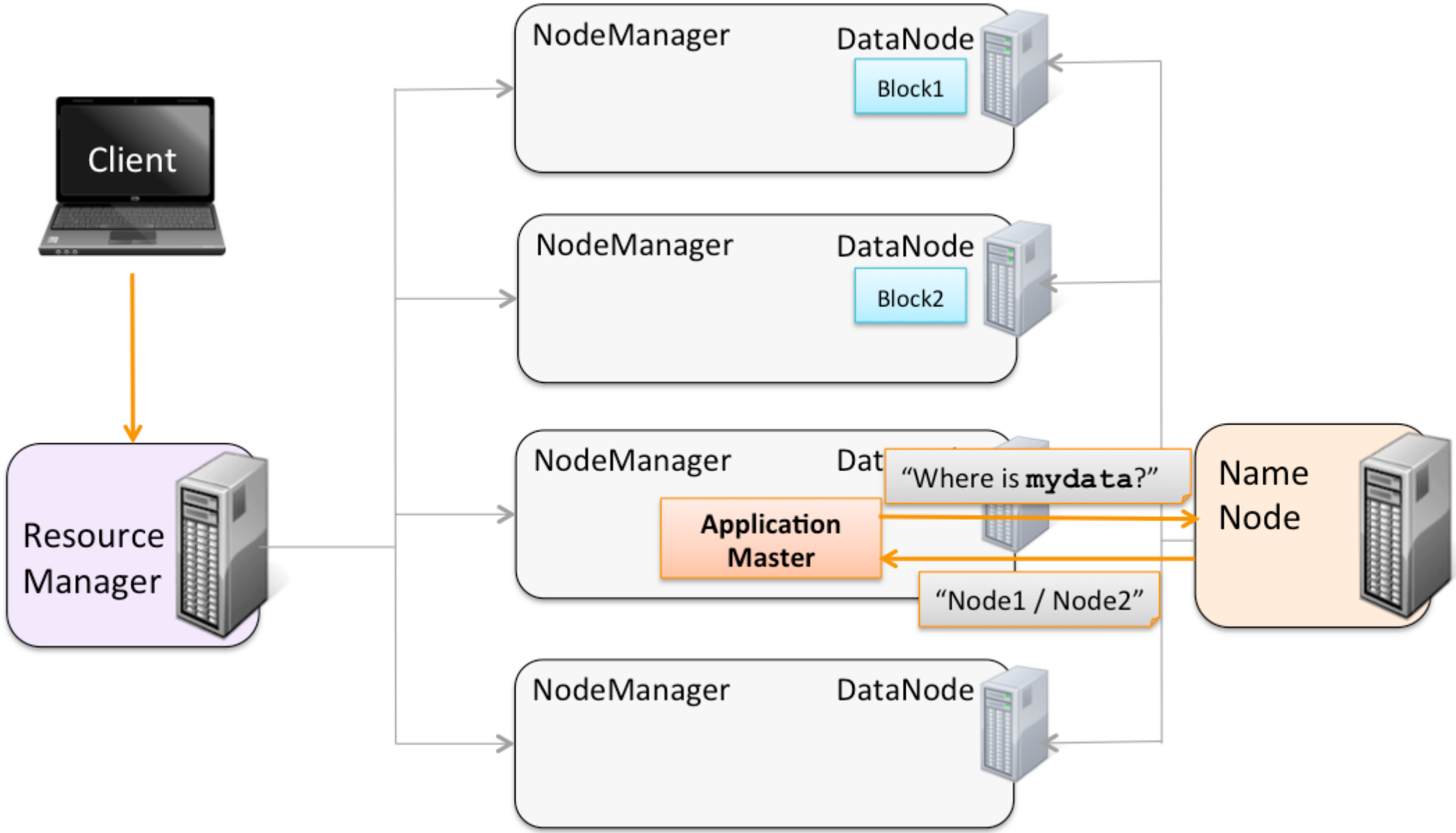
```
CREATE TABLE tablename (colname DATATYPE, ...)
   ROW FORMAT DELIMITED
   FIELDS TERMINATED BY char
   STORED AS {TEXTFILE|SEQUENCEFILE|…}
```

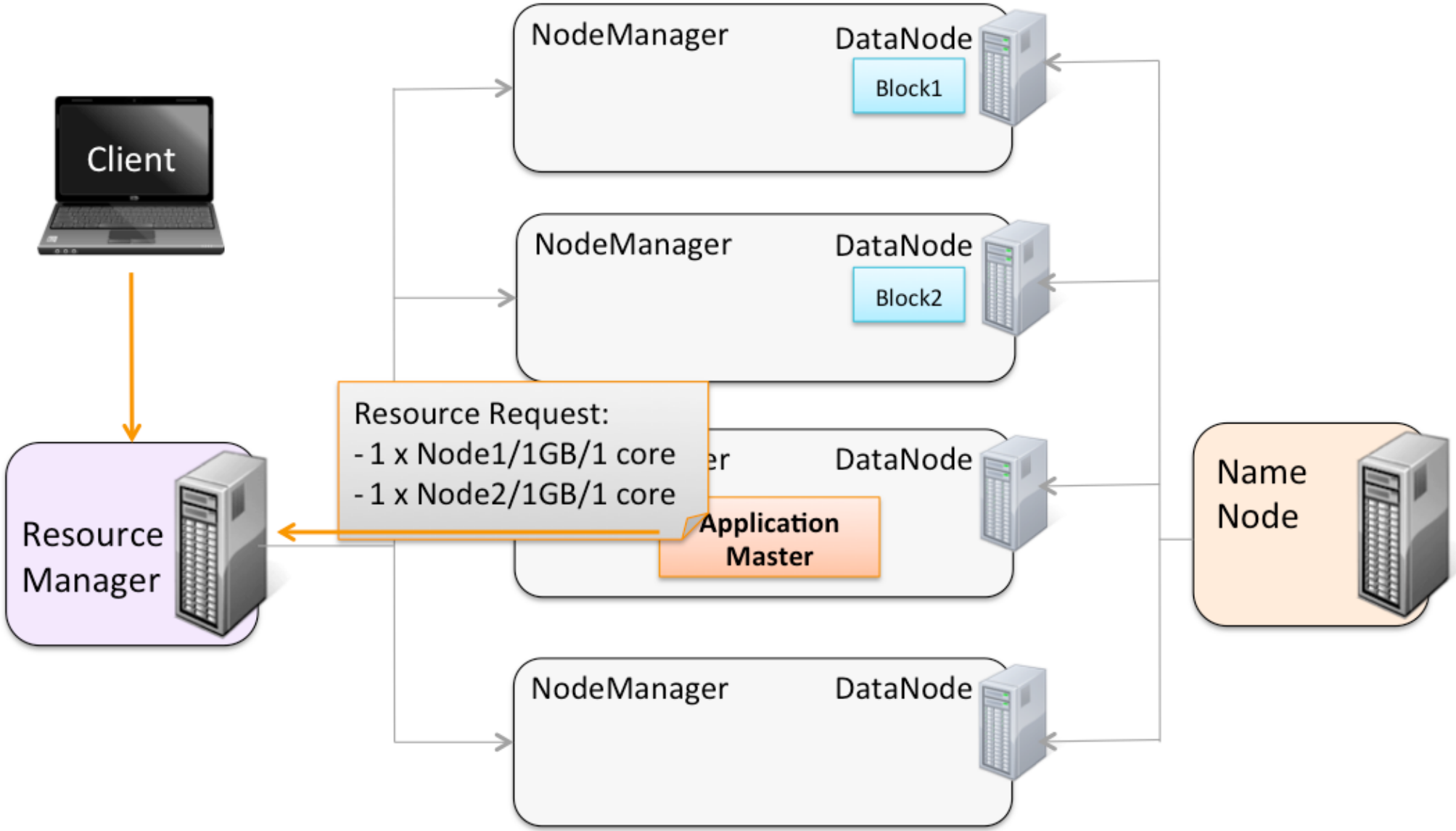
# Yarn – yet another resource negotiator

- Resource manager – coordinates all cluster processes
- Job scheduler
- Allows to run several task for processing data simultaneously
  - Batch programs(Spark, Map Reduce)
  - Interactive SQL (Impala)
  - Advanced Analytics(Spark, Impala)
  - Streaming (Spark Streaming)

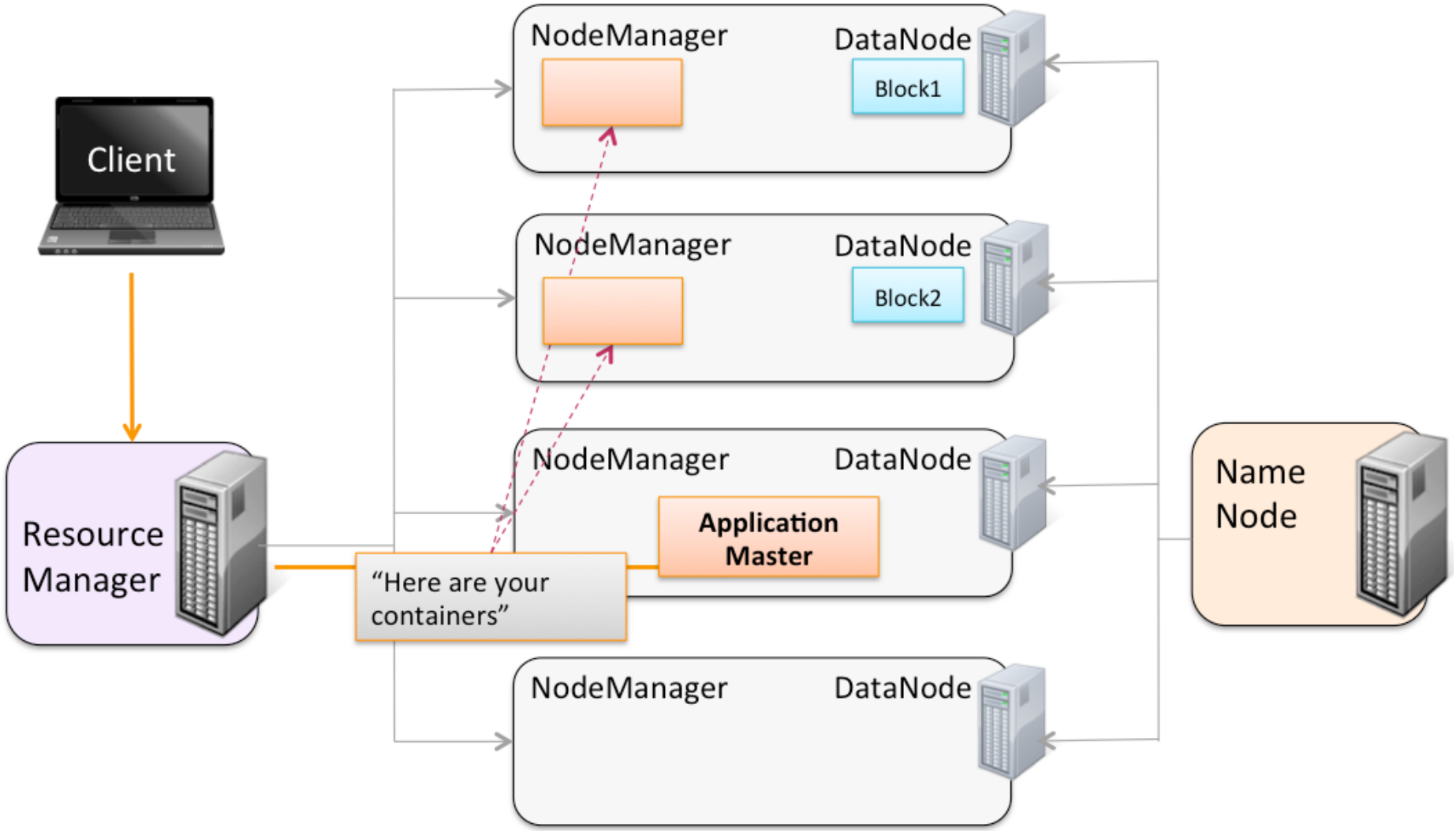
# Running with yarn

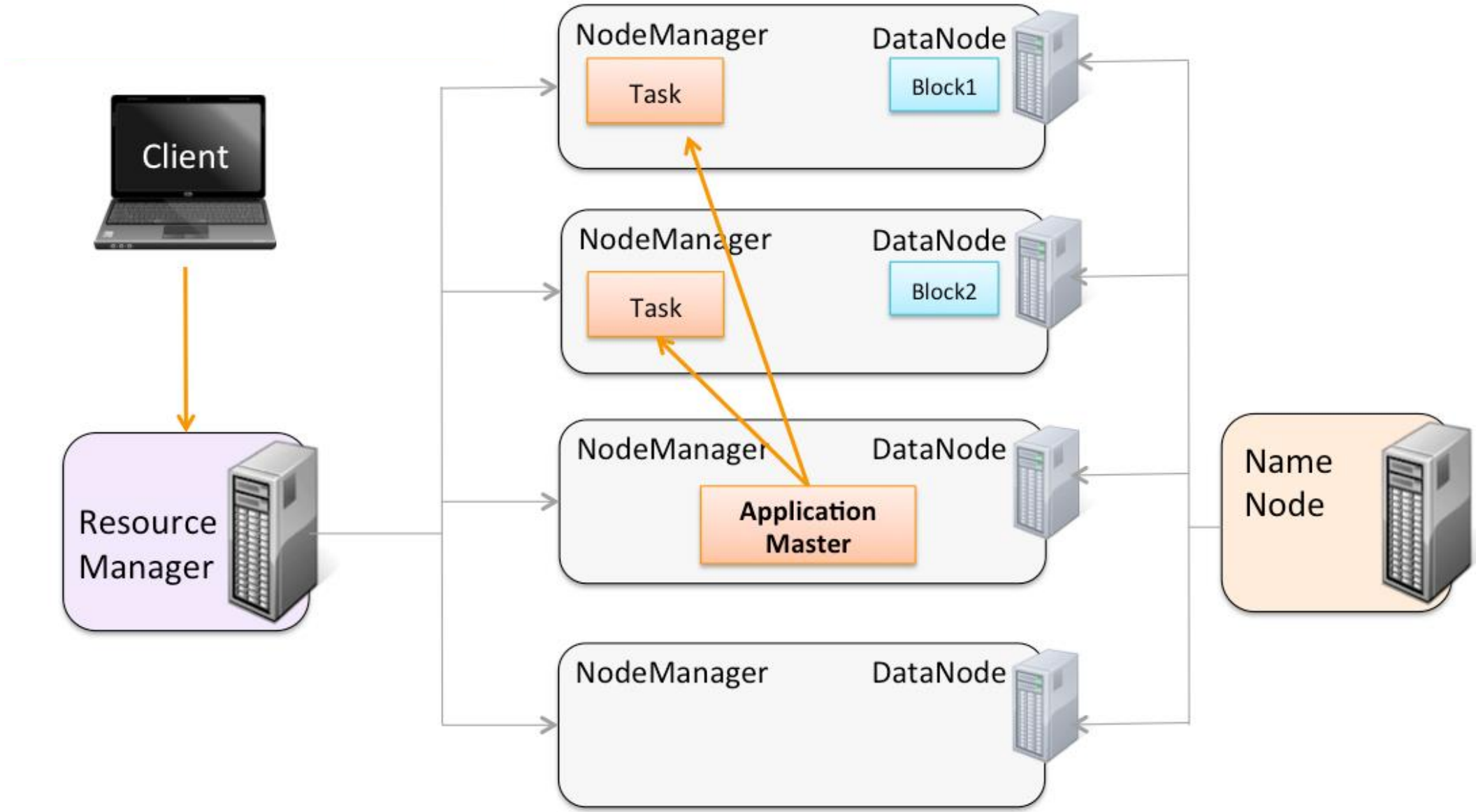


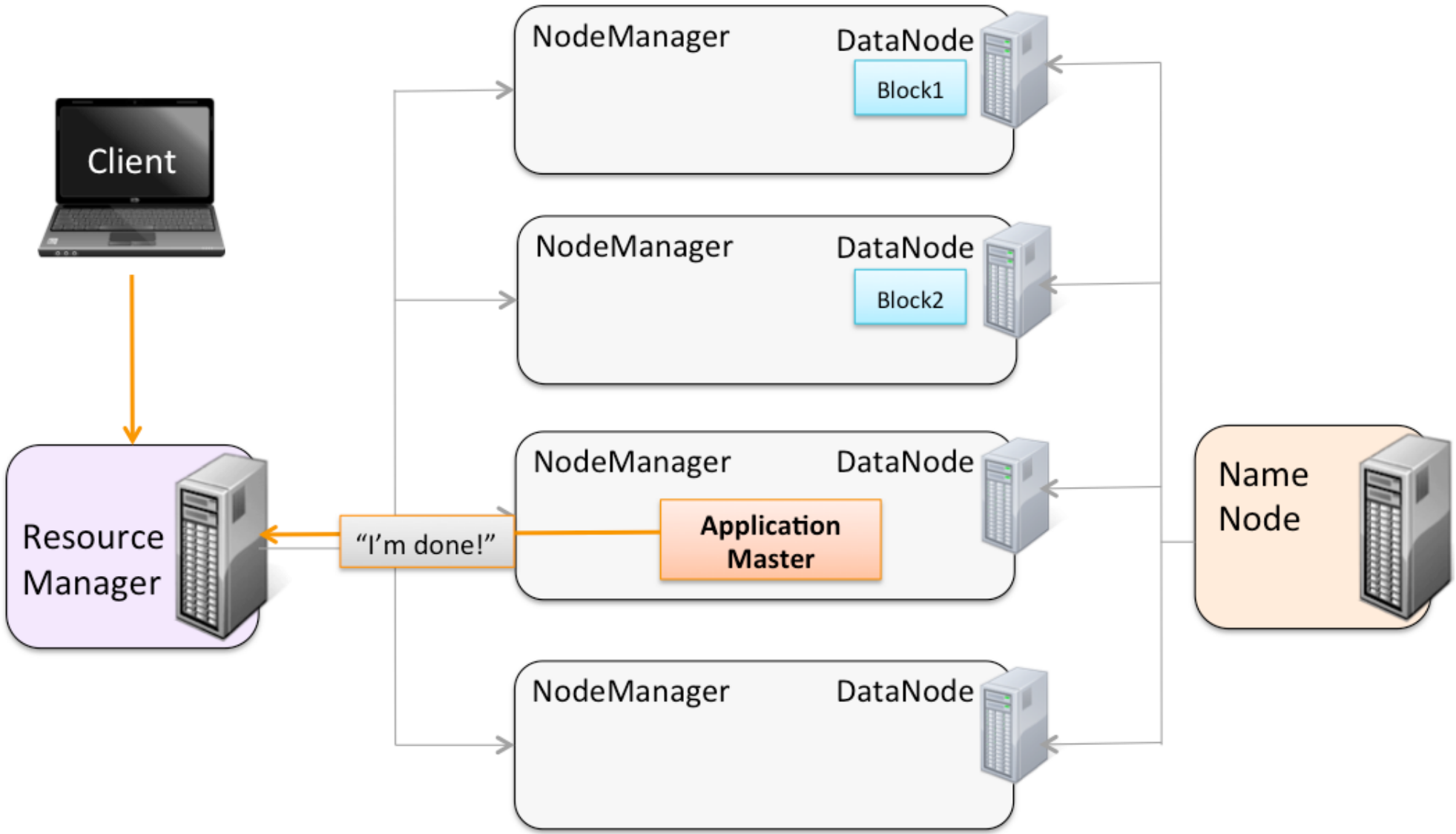

Client
Resource Manager
NodeManager
DataNode
Block1
NodeManager
DataNode
Block2
NodeManager
Dat
Application Master
"Where is mydata?"
"Node1 / Node2"
Name Node
NodeManager
DataNode


NodeManager
DataNode
Block1
NodeManager
DataNode
Block2
Client
Resource Request:
- 1 x Node1/1GB/1 core
- 1 x Node2/1GB/1 core
DataNode
Application Master
Resource Manager
Name Node
NodeManager
DataNode

# Will try to allocate the same machines which store the processed data




Client
Resource Manager
NodeManager
Task
DataNode
Block1
NodeManager
Task
DataNode
Block2
NodeManager
Application Master
DataNode
NodeManager
DataNode
Name Node

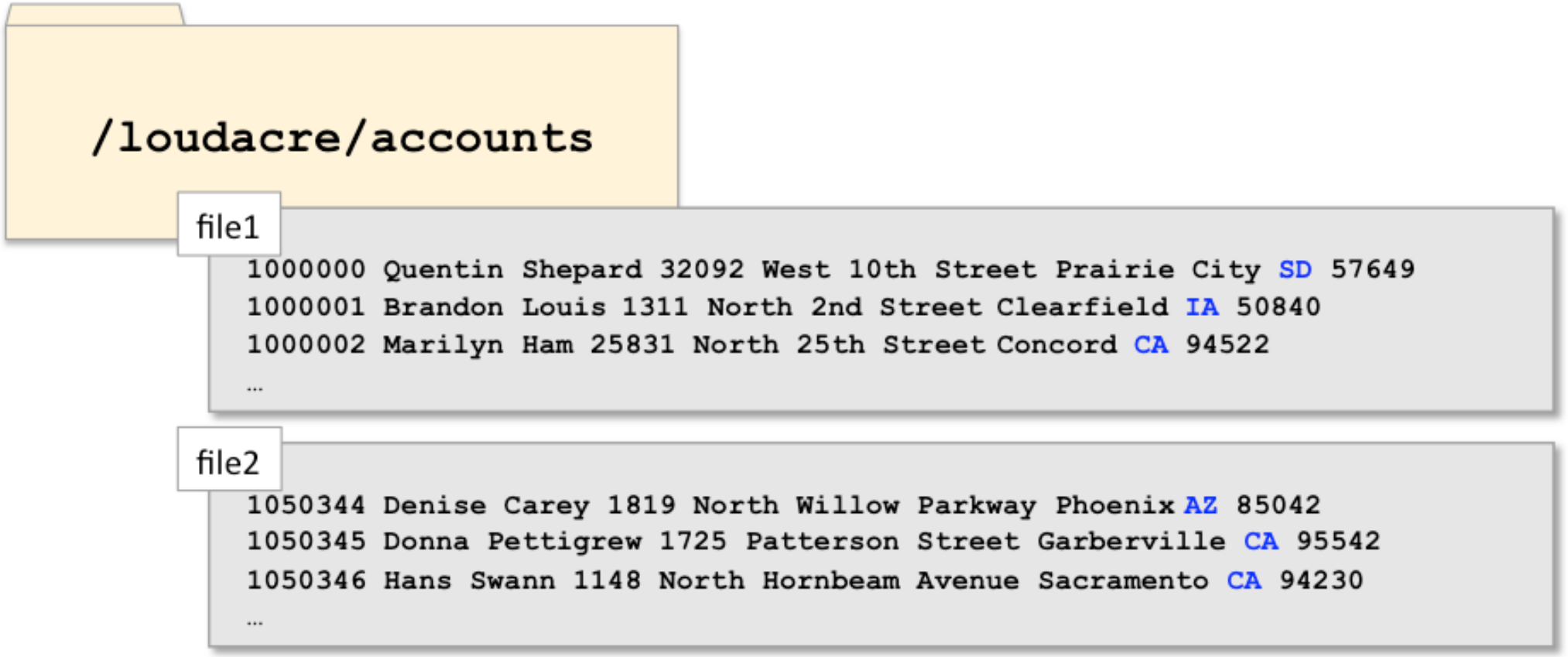

Client
Resource Manager
"I'm done!"
NodeManager
DataNode
Block1
NodeManager
DataNode
Block2
NodeManager
DataNode
Application Master
NodeManager
DataNode
Name Node

# File formats you should know

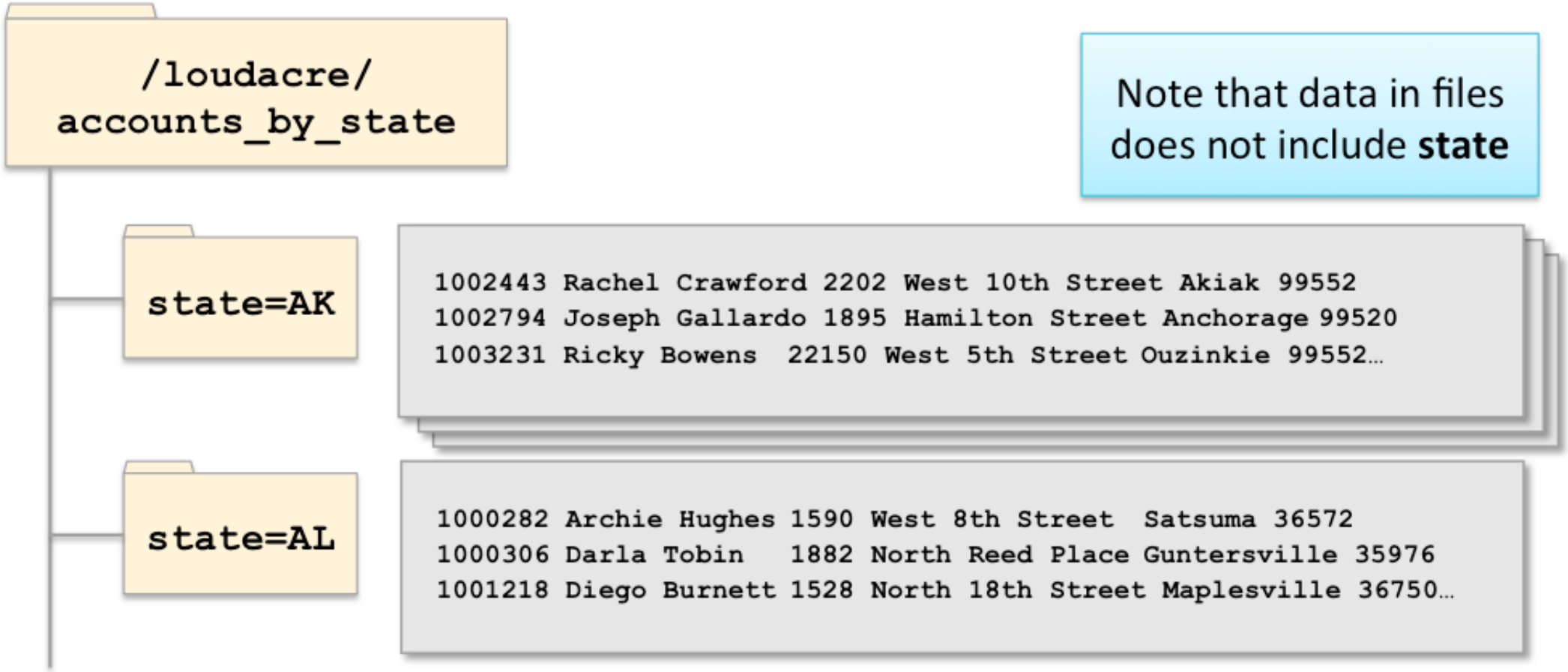
- parquet - like csv but compressed
- avro – like json, but compressed

# Partitioning

- By default all files of dataset exist in one HDFS directory



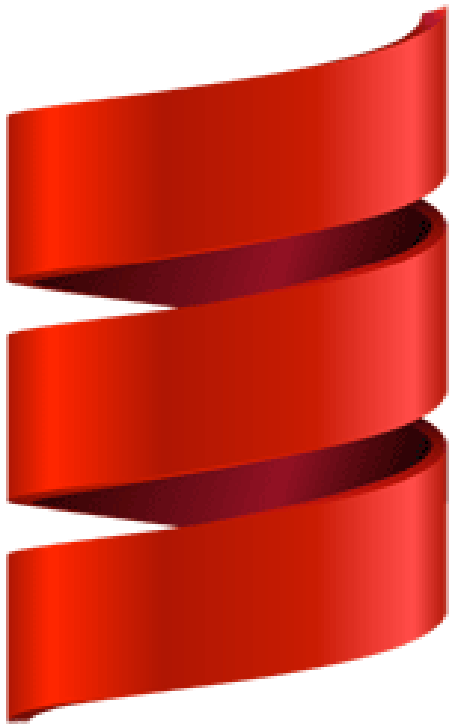
# More effecient



# This is not my Job – sysadmin should know it


ONE DOES NOT SIMPLY
CAN WRITE EFFECTIVE SPARK CODE

If you do not understand how your data will be stored you will not be able to write effective code



# Scala

# What is Scala

**Scala was developed by Martin Odersky starting in 2001**

- Sca (scalable) La (language)

**Scala is a superset of Java**

- Scala runs on the Java Virtual Machine (JVM) and compiles to Java bytecode, and is compatible with Java programs
- All Java programs can be ported to Scala, but some Scala programs cannot be ported to Java

**Multi-paradigm**

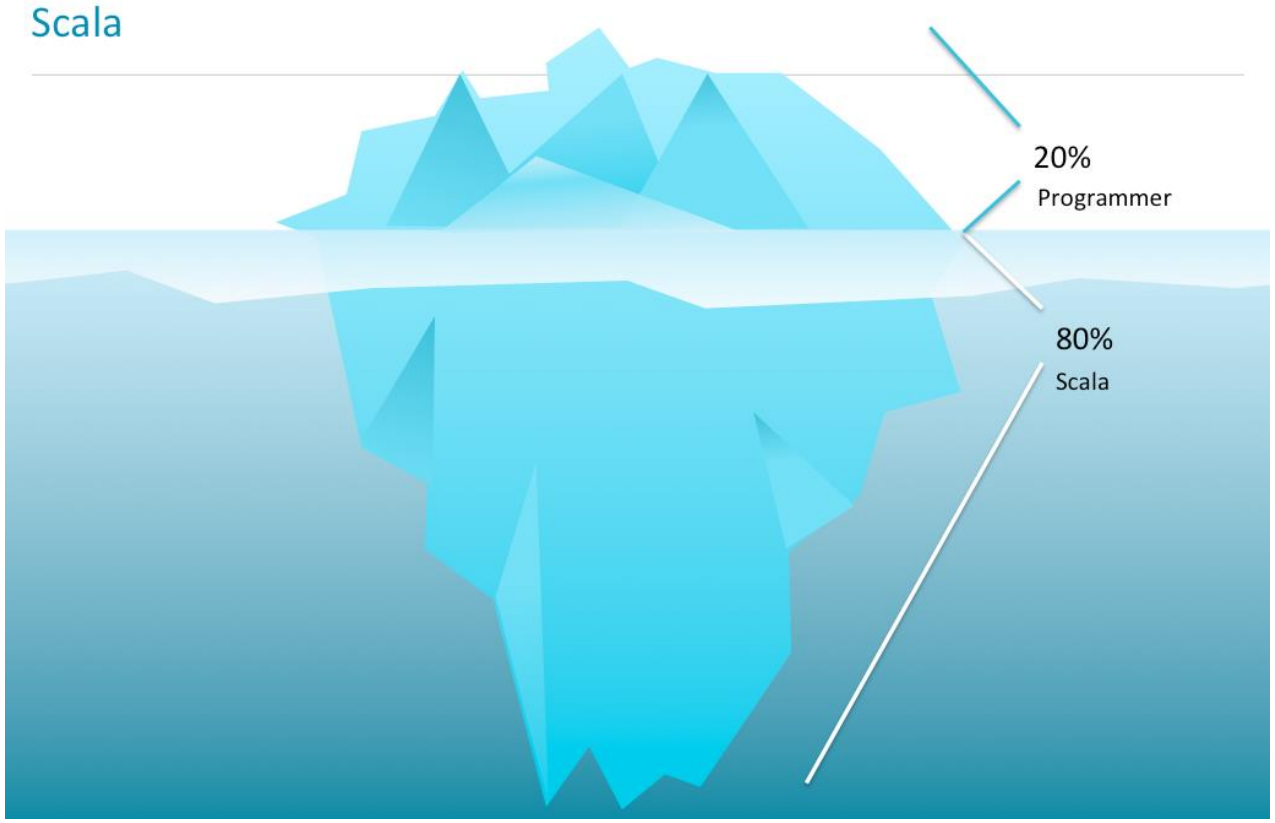
- Scala has features of imperative programming, object oriented programming, and functional programming, allowing the developer to cross paradigms within a single program as needed

# Scala concepts

- Pure functions
- Immutable data
- Implicit looping and iteration over collections

# Scala & Java

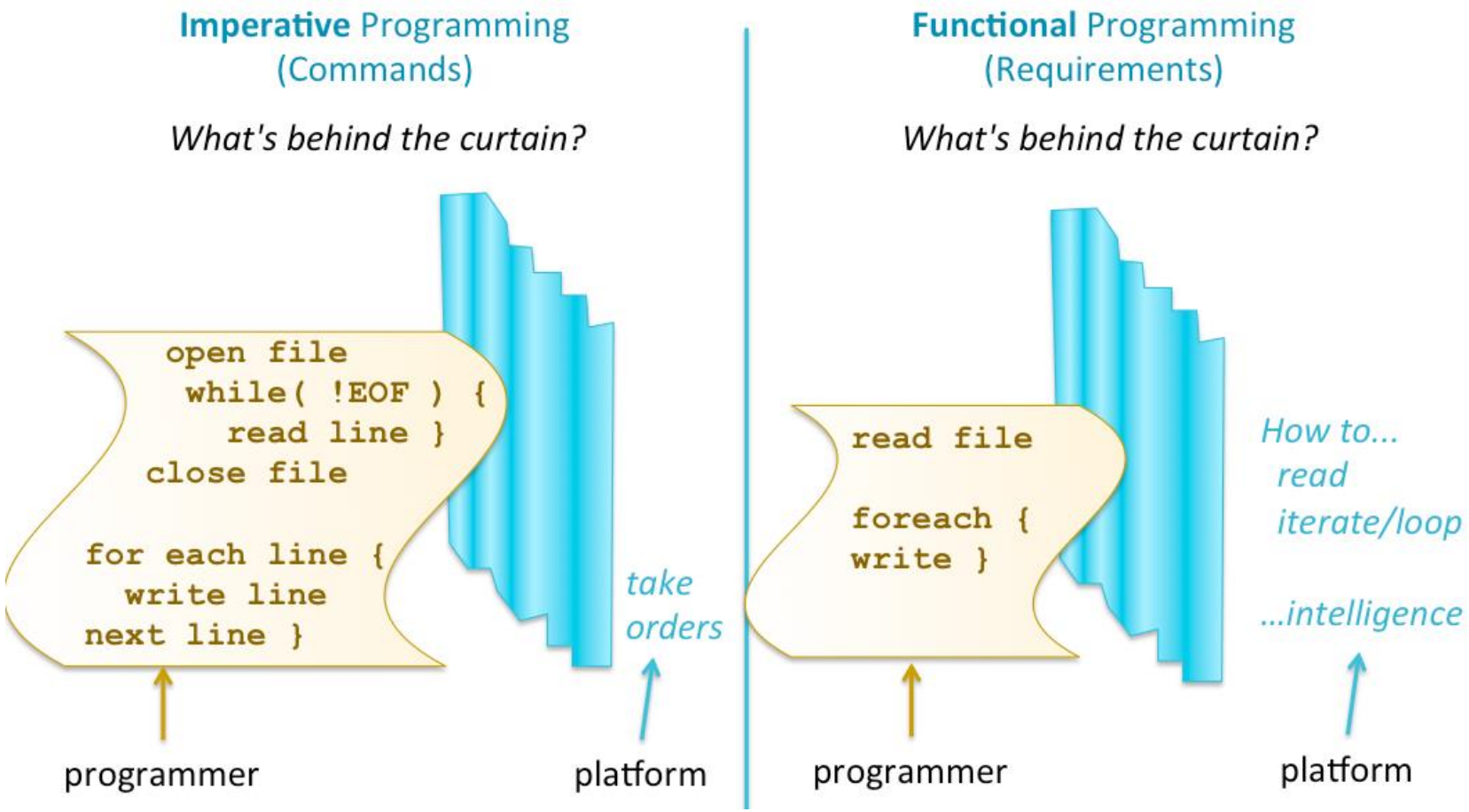
- All Java types are available
  - But in most cases the developers will use Scala types analogs
- Scala is expensive



# Scala concepts

- Code blocks are expressions  - all code blocks always return a value even if there is nothing to return
- Functions can be passed as parameters to other functions
  - function1(function2)

# Functional programing rules!

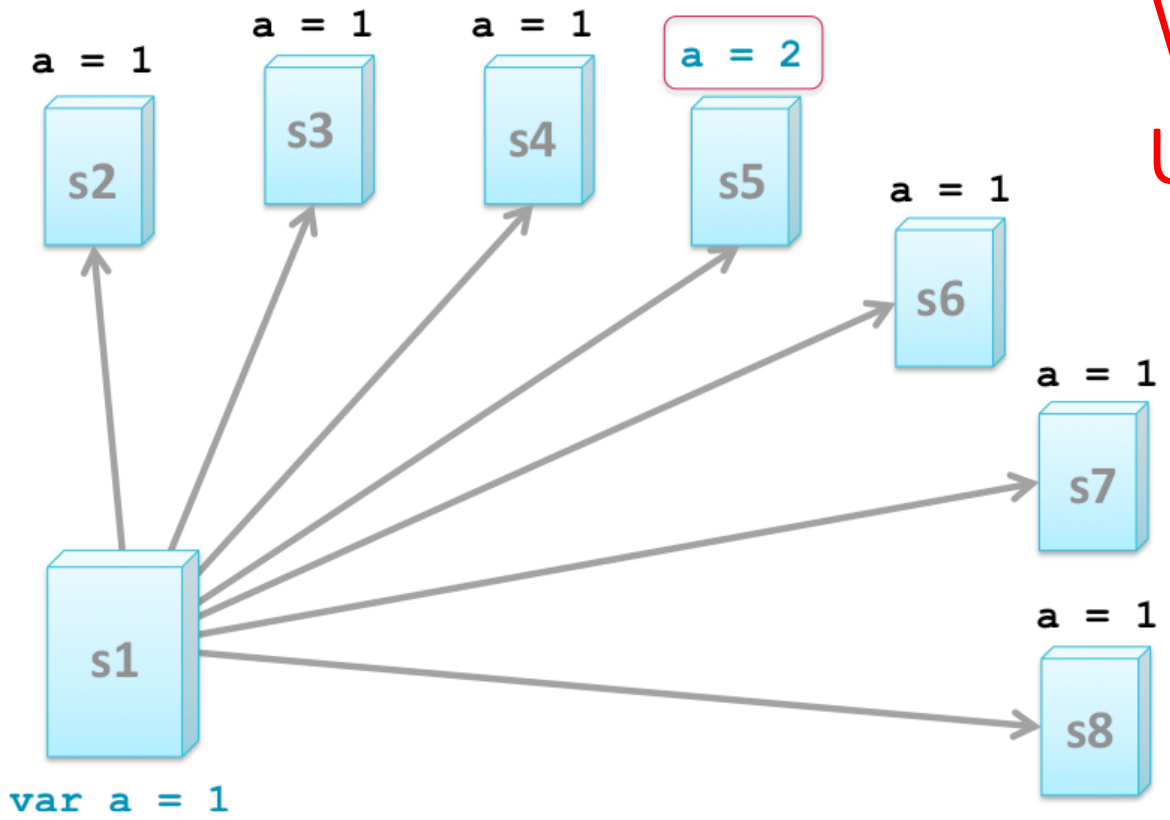


# Immutable vs Mutable

- When you declare variables:
  - val – immutable
  - var – mutable
- Collections
  - scala.collections.immutable
  - scala.collections.mutable

# Why immutable is good?

- Because mutable is bad




Who is responsible to update the others?

# Code example

```
import scala.io.Source
object Main {
  def main(args: Array[String]) {
    Source.fromFile("filename").foreach(print)
  }

}
```

# Scala variables

Syntax: [ **var** | **val** ] ***name: type = value***

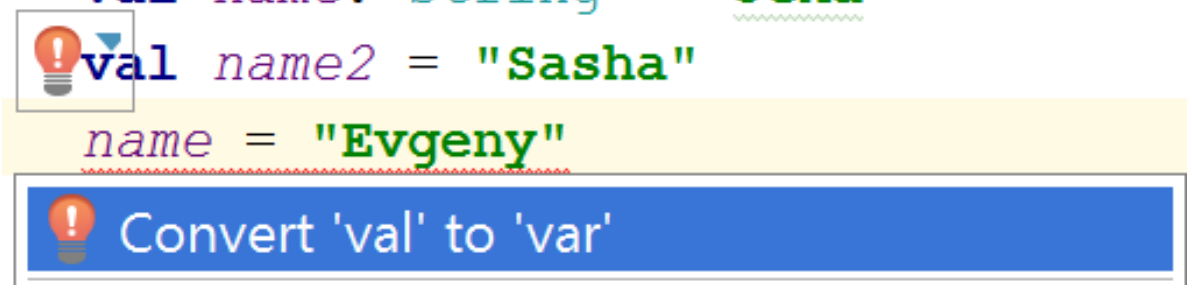
```
val name: String = "Jeka"
val name2 = "Sasha"

var age: Int = 37
var age2 = 28;
```

```
var age: Int = 37
var age2 = 28
age  = "sd"
```

# This is not javascript

```
var age: Int = 37
var age2 = 28
age  = "sd"
```

```
val name: String = "Jeka"
val name2 = "Sasha"
name = "Evgeny"
```



# Scala types – the important ones

| Type | Description | Example |
|---|---|---|
| `Int` | 4 byte integer | `3` |
| `Long` | 8 byte integer | `32754L` |
| `Double` | 8 byte floating point | `3.1415` |
| `Float` | 4 byte floating point | `3.1415F` |
| `Char` | single character | `'c'` (single quotes) |
| `String` | sequence of characters | `"iFruit"` (double quotes) |
| `Boolean` | true or false | `true` (case sensitive) |

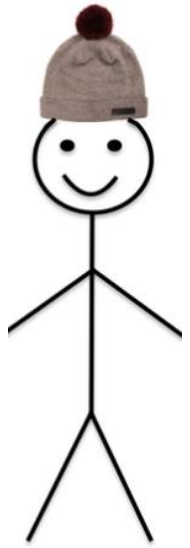
# Special type - Unit

- When function returns nothing it returns the Unit

```
val myreturn = println("Hello, world")
> myreturn: Unit = ()
```

*Just for information*

**This is Unit.**
**There is only one Unit in Scala**
**Unit can’t be created**
**Unit – is built in singleton**
**Be like Unit**



# Special type - Any

```
val myreturn = if (true) "hi"
> res2: Any = hi

val mystring = myreturn.asInstanceOf[String]
> myreturn: String = hi
```

*Just for information*

**This is Any.**
**Any – like Object, but wider**
**Any – solves problem with generic collections and primitives**
**Be like Any**

# Scala is strange

- Scala loves (this braces) – because the people who invented Scala loved mathematic

```
val list = List("java","scala","groovy")
list.foreach(println)
```

- In case method doesn’t take arguments you can omit the braces

```
print(list.getClass)
```

# No one is primitive

```
val x = 12
val  y = x.toDouble

val  isTrue = x.equals(x)

val  z = x.*(Math.sqrt(4))
```

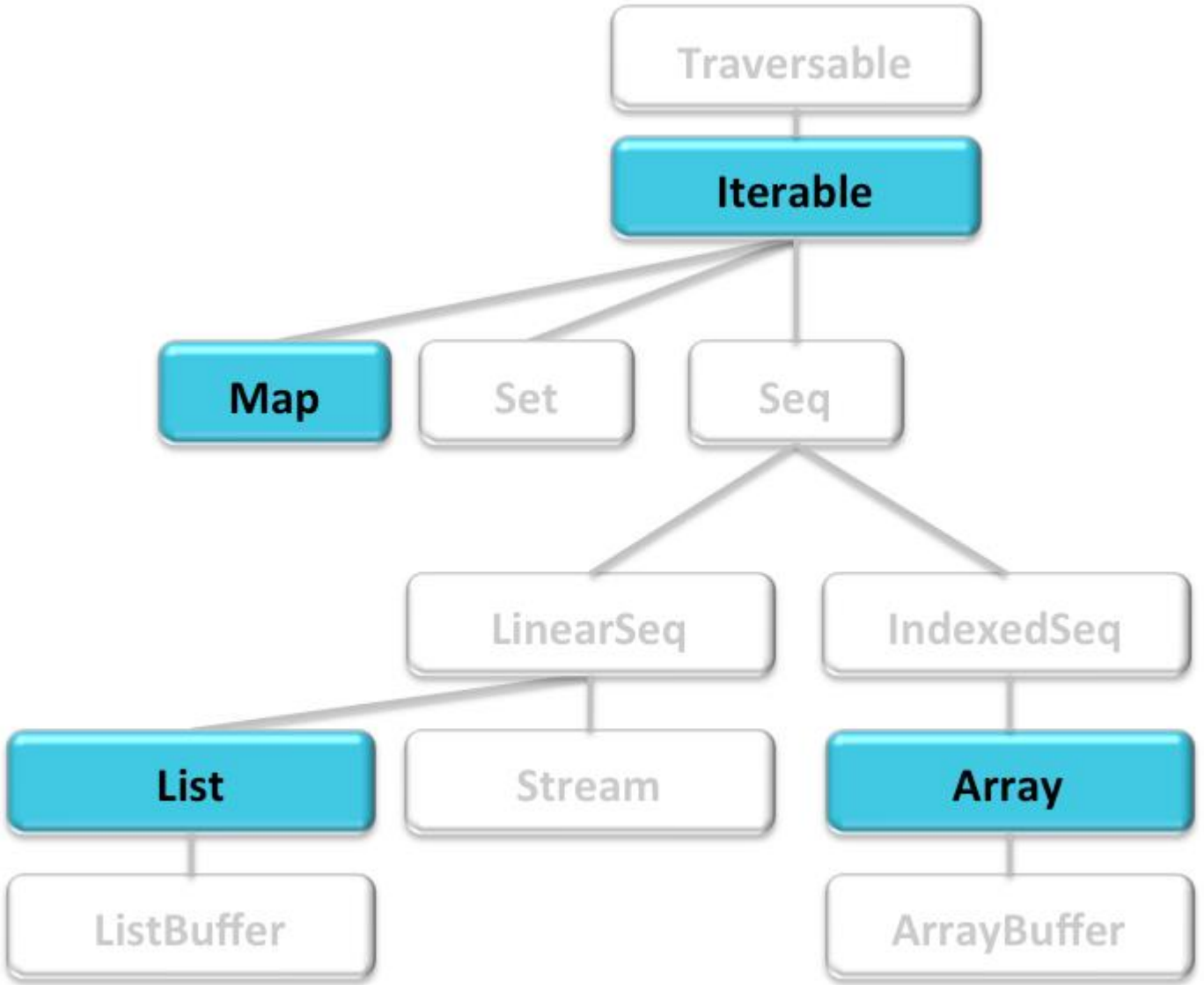
# Strings

```
var str = "Scala"
val c: Char = str(0)  // c = S
val pair: (String, String) = str.splitAt(2)
val sc: String = pair._1
val ala: String = pair._2
str = str.sorted


val endsWith: Boolean = str.sorted.toUpperCase().endsWith("la")

println(s"sum ${age+age2}")
```

# Collections: Muttable & Immutable

- By default Scala uses immutable collections
- So their methods returns new collection back
- If you will use val when you will declare immutable collection several methods will disappear

# Collections



- Traversable – abstraction, main method: foreach
- Iterable – adds possibility to iterate.
- Seq – adds possibility to apply by index

```
val seq: Seq[Int] = Seq(2, 4, 6, 8)
val four: Int = seq(2)
```

# What does this code?

```
val set: Set[Int] = Set(2, 4, 6, 8)
set +=1
val b: Boolean = set(3)
print(b)
```

Compilation error

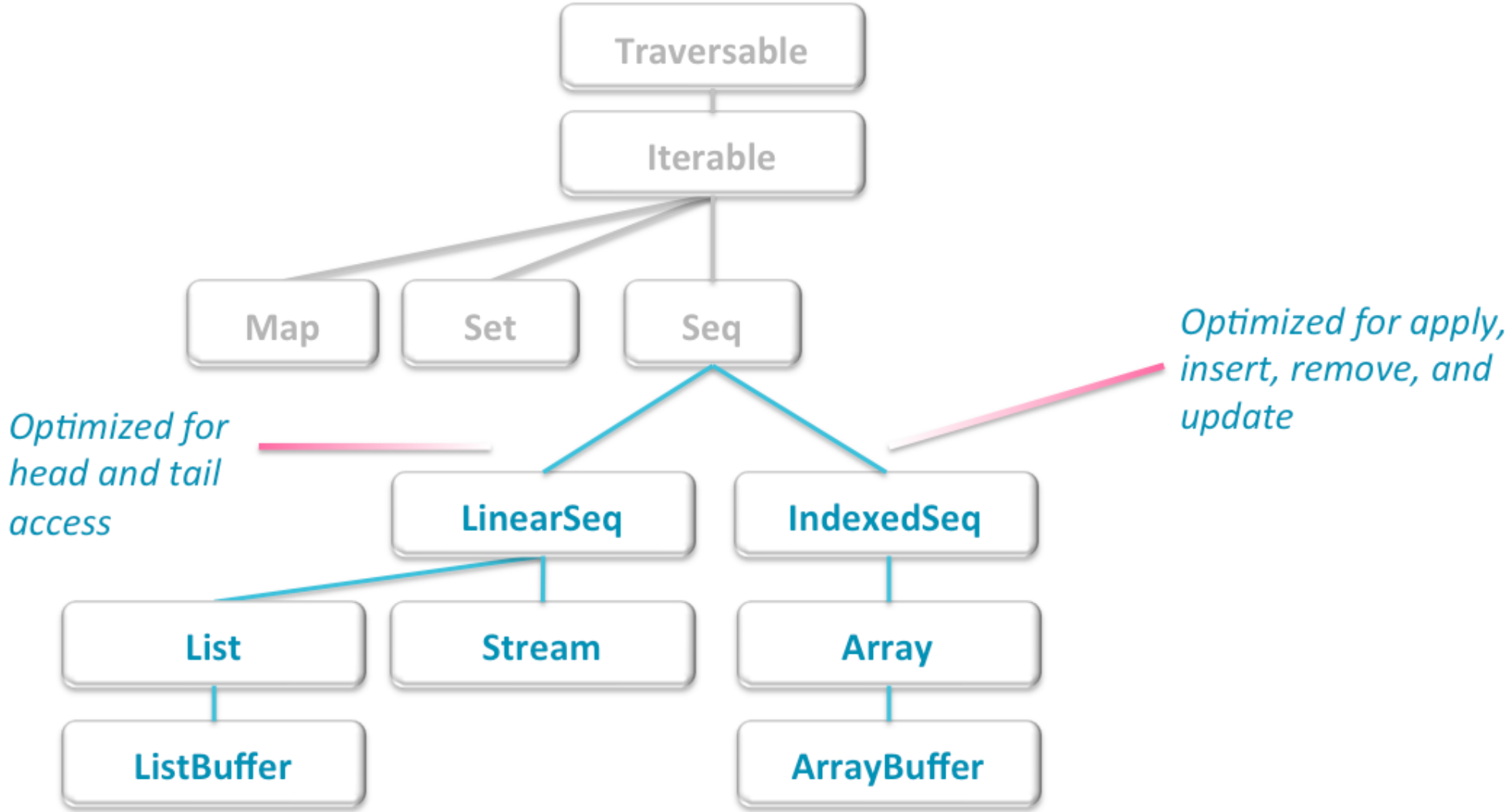
# And now?

```
var set: Set[Int] = Set(2, 4, 6, 8)
set = set.drop(2)
set +=1
val b: Boolean = set(3)
print(b)
```

False

# Map

```
var nameToAge: Map[String, Int] = Map("Jeka" -> 37, "Sasha" -> 30)
nameToAge += ("Mikola" -> 22)
```

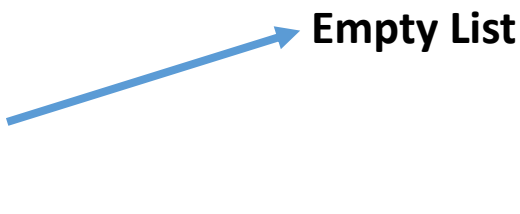



*Buffers are mutable versions – supporting insert, remove, append methods*

# List

- scala.collection.immutable.List
- scala.collection.mutable.List
- But we gonna talk about Immutable

# List




```
val emptyList: List[Int] = Nil
```

```
val list = 1::2::emptyList
```

```
val list: List[Int] = List.apply(1,2,3)
```

```
val list: List[Int] = List(1,2,3)
```

**You can use index as well:** `println(list(1))`

# Generic is good, but will it work?

```
val list: List[Object] = List("abc", 1)
```

**Will it work?**

# Generic is good, but will it work?

```
val list: List[Object] = List("abc", 1)
```

**Compilation error ☹**

# You can work without generic, but…

```
val list = List("abc", 1)
```

# Any – everything incuding primitive

```
val list: List[Any] = List("abc", 1)
```

**AnyRef – also exists**

# List methods

- sum – in case this is list of numbers
- max – for comparable
- take(x) – returns list with x elements
- sorted
- reverse
- union
- intersect

# Array – mutable, but not resizable

```
val strings: Array[String] = Array("one", "two")
strings(0) = strings(0).toUpperCase
strings.update(1,"Два")
strings.foreach(println)
```

```
ONE
Два
```

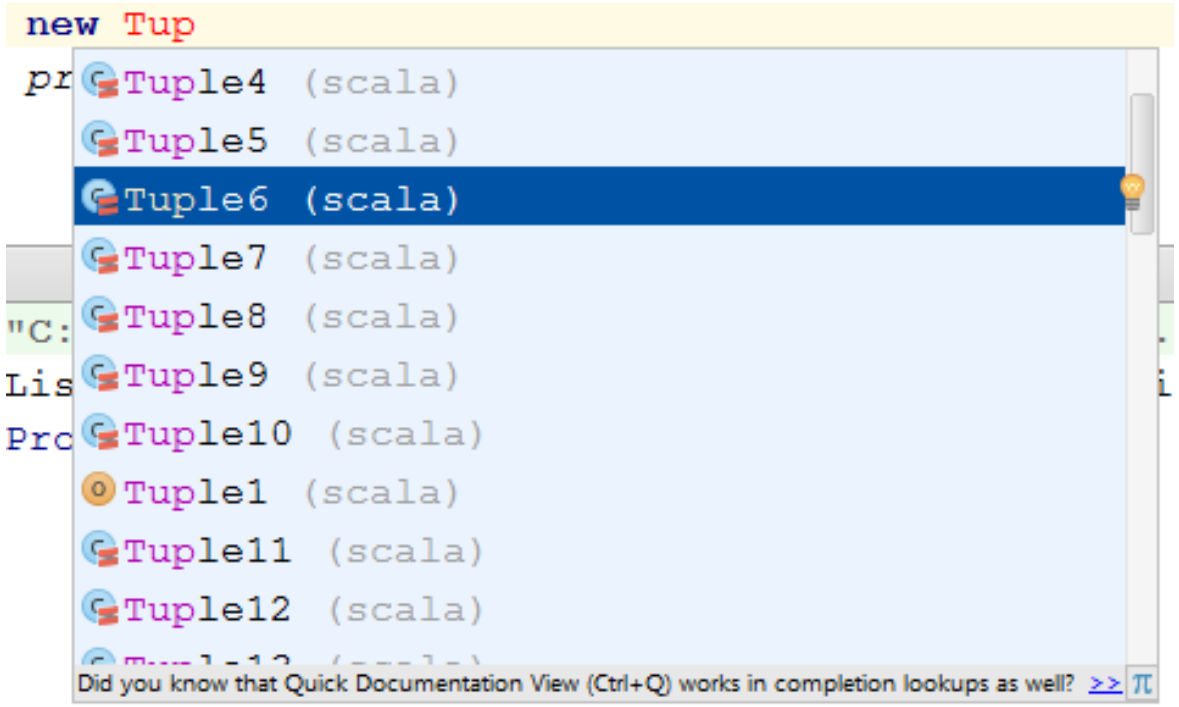
# ~~Pair~~ Tuples

```
val tuple1: (Int, String) = (1,"java")

val tuple2: (Int, String) = (40,"scala")
val tuple3: (Int, String) = (20,"groovy")
```

```
tuple1 = 1 -> "java"
```

```
val tuple: (LocalDateTime, String, Object) = (LocalDateTime.now(),"beanName",bean)

var tuples: List[(LocalDateTime, String, Object)] = List(tuple)
tuples = (LocalDateTime.now(), "beanName", bean) :: tuples
```

# Tuple – till 22



# Get from Tuple

```
val dateTime: LocalDateTime = tuple._1
val beanName: String = tuple._2
val bean: Object = tuple._3
```

```
tuples.foreach(tupple=>println(tuple._1))
```

# What else tuple can do?

- swap

```
var tuple1: (Int, String) = (1, "java")
val swap: (String, Int) = tuple1.swap
```

- Only for Tuple2

# You will never guess

```
val tuple: (LocalDateTime, String, Object) = (LocalDateTime.now(), "beanName", bean)
val prefix: String = tuple.productPrefix //prefix = Tuple3
val arity: Int = tuple.productArity  // arity = 3
```

# List zip, unzip

```
val words: List[String] = List("one", "two","three")
val ints: List[Int] = List(1,2)
val zip: List[(String, Int)] = words.zip(ints)
zip.foreach(println)
val unzip: (List[String], List[Int]) = zip.unzip
unzip._1.foreach(println)
```

```
(one,1)
(two,2)
one
two
```

# Map – are constructed of Tuple2

```
var intToString1: Map[Int, String] = Map(1 -> "one", 2 -> "two")
var intToString2: Map[Int, String] = Map((3, "tree"), (4, "four"))
println(intToString1(1))
```

- keys, values, contains…

```
intToString2(3)="Три"
```

Compilation error ☹

**scala.collection.mutable.Map**

# What will happen?

```
var intToString: Map[Int, String] = Map(1 -> "one", 2 -> "two")
println(intToString(13))
```

A. null
B. Nothing will be printed out

NoSuchElementException
D. NPE

```
intToString.getOrElse(13,"default value")
```

# Common convertions

- toArray
- toList
- toIterable
- String: toSet, toList, toArray

# Flow control

- While – like in Java, but you better use declarative approach

# For

```
for(i <- 0 to sorrentoPhones.length - 1) {
  println(sorrentoPhones(i))
}

for(i <- 0 until sorrentoPhones.length) {
  println(sorrentoPhones(i))
}

for(i <- 0 until sorrentoPhones.length by 2) {
  println(sorrentoPhones(i))
}
```

# For – with collections

```
for(model <- sorrentoPhones) {
  print(model + " ")
}
```

```
val phonebrands = List("iFruit","MeToo","Ronin")
val newmodels = List("Z1","Z-Pro","Elite-Z")

for( brand <- phonebrands; model <- newmodels ) {
   print(brand + " " + model + ", ")
}
```

# What will do this code?

```
val sorrentoPhones =
List("F00L","F01L","F10L","F11L","F20L","F21L","F22L","
F23L","F24L","F30L","F31L","F32L","F33L","F40L","F41L")

for( model <- sorrentoPhones ) {
  if ( model.contains("2") ) print(model + " ")
}
```

# This is better

```
for( model <- sorrentoPhones; if( model.contains("2")) ) {
  print(model + " ")
}
```

# Lazy variables

- def x = 1
- x – will be declared like integer and will value will be assigned to it, only when it will be used

# You can do this shit

```
def listPhones {
  println("MeToo")
  println("Titanic")
  println("iFruit")
  println("Ronin")
}
> listPhones: Unit

listPhones
> MeToo
> Titanic
> iFruit
> Ronin
```

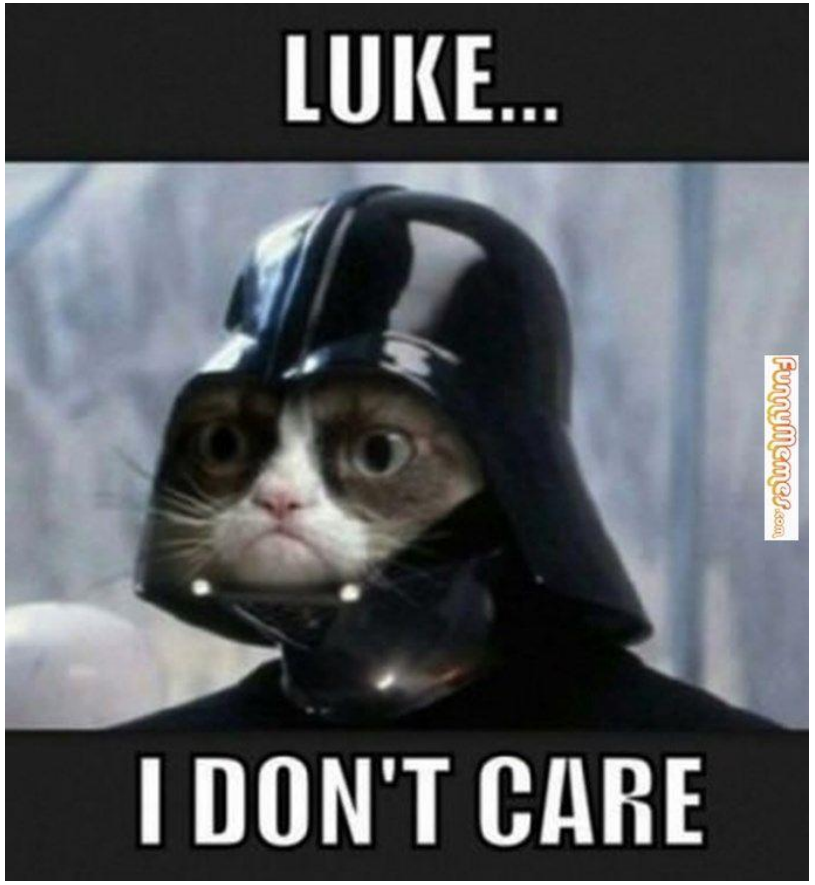
And this code can be written inside some method

# Functions declarations

```
def CtoF(celsius: Double) = {
   (celsius * 9/5) + 32
}
> CtoF: (celsius: Double)Double

CtoF(34.0)
> Double = 93.2

def CtoF(celsius: Double) =
   (celsius * 9/5 ) + 32

def CtoF(celsius: Double) =
   (celsius * 9/5 ) + 32 : Double
```

# We don’t care about braces

```
def UA2USD(ua: Double) = {ua * 25}

def UA2USD(ua: Double) = (ua * 25)

def UA2USD(ua: Double) = ua * 25
```



# Functions as parameter

```
def main(args: Array[String]) {
  def UA2USD(ua: Double) = ua * 25
  def convertList(myList: List[Double], convert: (Double) => Double): Unit = {
    for (n <- myList) {
      println(n, convert(n))
    }
  }
  val grivni: List[Double] = List(10,20,2)
  convertList(grivni,UA2USD)
}
```

```
(10.0,250.0)
(20.0,500.0)
(2.0,50.0)
```

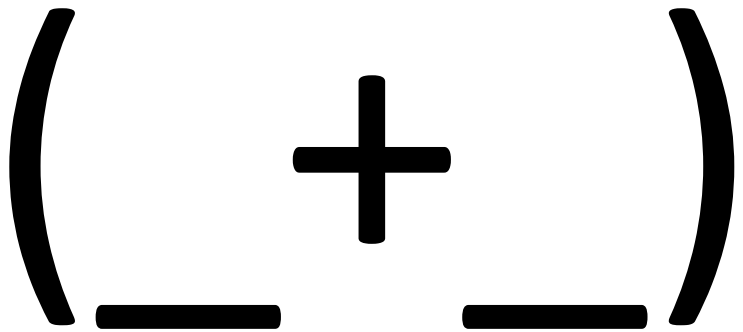
# Anonymous functions as parameter

```
def main(args: Array[String]) {
  def UA2USD(ua: Double) = ua * 25
  def convertList(myList: List[Double], convert: (Double) => Double): Unit = {
    for (n <- myList) {
      println(n, convert(n))
    }
  }
  val grivni: List[Double] = List(10,20,2)
  convertList(grivni,x => x * 25)
}
```

```
(10.0,250.0)
(20.0,500.0)
(2.0,50.0)
```

# The best Scala Spark operator

# The best Scala Spark operator



# First step to the ass (_+_)

```
val strings: List[String] = List("one","two","three")
strings.sortBy(_.length)
```

# Map function – second step to the ass

```
val strings: List[String] = List("one","two","three")
val stringLowerCased: List[String] = strings.map(_.toLowerCase)
val ints: List[Int] = strings.map(_.length).map(_+4)
```

# Filter function

```
phoneCelsius.filter(_ < 23)
> List[Double] = List(12.2)

TitanicPhones.filter(_.startsWith("2"))
> List[String] = List(2000, 2100, 2200, 2300, 2400, 2500

TitanicPhones.filter(_.length > 4 )
> List[String] = List(DeckChairs
```

# Pattern Matching

```
while (true) {
  val message: String = JOptionPane.showInputDialog(null, "what would you say")
  var answer: String = ""
  message match {
    case "hello" => answer = "shalom";
    case "how are you" => answer = "better than you";
    case "hi" => answer = "hi!";
  }
  println(answer)
}
```

What if man asks: “what is your name?”


IF MAN ASKS A GIRL WHAT IS HER NAME


IF MAN ASKS A GIRL WHAT IS HER NAME
THE GIRL WILL THROW AN EXCEPTION

```
while (true) {
  val message: String = JOptionPane.showInputDialog(null, "what would you say")
  var answer: String = ""
  message match {
    case "hello" => answer = "shalom";
    case "how are you" => answer = "better than you";
    case "hi" => answer = "hi!";
    case _ => answer = "enough";
  }
  println(answer)
}
```

```
while (true) {
  val message: String = JOptionPane.showInputDialog(null, "what would you say")
  var answer: String = message match {
    case "hello" => “Shalom";
    case "how are you" => “better than you";
    case "hi" => “Hola!";
    case _ => “enough";
  }
  println(answer)
}
```

# Option

```
val superPhone = Some("Model 6")
> superPhone: Some[String] = Some(Model 6)
superPhone.getOrElse("Not found")
> String = Model 6

val superPhone = None
> superPhone: None.type = None
superPhone.getOrElse("Not found")
> String = Not found
```

# Where Optional comes from?

```
def toTemp(in: String): Option[Double] = {
  try {
    Some(in.toDouble)
  } catch {
    case e: NumberFormatException => None
  }
}

val isATemp = "35.2"
val isNotATemp = "Warm"

toTemp(isATemp)
> Option[Double] = Some(35.2)
toTemp(isNotATemp)
> Option[Double] = None
```

# All together

```
toTemp(isATemp) match {
  case Some(i) => println(i)
  case None    => println("Not a Temperature")
}
> 35.2

toTemp(isNotATemp) match {
  case Some(i) => println(i)
  case None    => println("Not a Temperature")
}
> Not A Temperature
```

# Classes

- Like in Java (almost)
- Singletones


# Regular class

```
class Person(name: String) {
  val personName = name
  def printDetails(): Unit ={
    println(personName)
  }
}

def main(args: Array[String]) {
  val person: Person = new Person("Jeka")
  person.printDetails()
}
```

# Can be shorter

```
class Person(name: String) {
  def printDetails(): Unit ={
    println(name)
  }
}
```

# Overriding methods

```
class Person(name: String) {
  def printDetails(): Unit ={
    println(name)
  }

  override def toString: String = name
}
```

# Overriding methods

```
class Person(name: String) {
  def printDetails(): Unit ={
    println(name)
  }

  override def toString: String={
    "my name is "+name
  }
}
```

# Scala Singleton – generated by scala

```
object TestDevice {
   def main(args: Array[String]) {
      val a = new Device("iFruit 3000")
      println(a.display)
   }
}
```

```
$ scalac TestDevice.scala
```

Class: **`TestDevice.class`**
Companion Object: **`TestDevice$.class`**

# Imports

**`import pack1._`**

- Imports all classes from **`pack1`**
- Equivalent to Java **`import *.pack1`**

**`import pack1._, pack2._`**

- Imports all classes from **`pack1`** and from **`pack2`**

**`import pack1.Class1`**

- Imports only **`Class1`** from **`pack1`**

**`import pack1.(Class1, Class3}`**

- Imports only **`Class1`** and **`Class3`** from **`pack1`**

# More imports

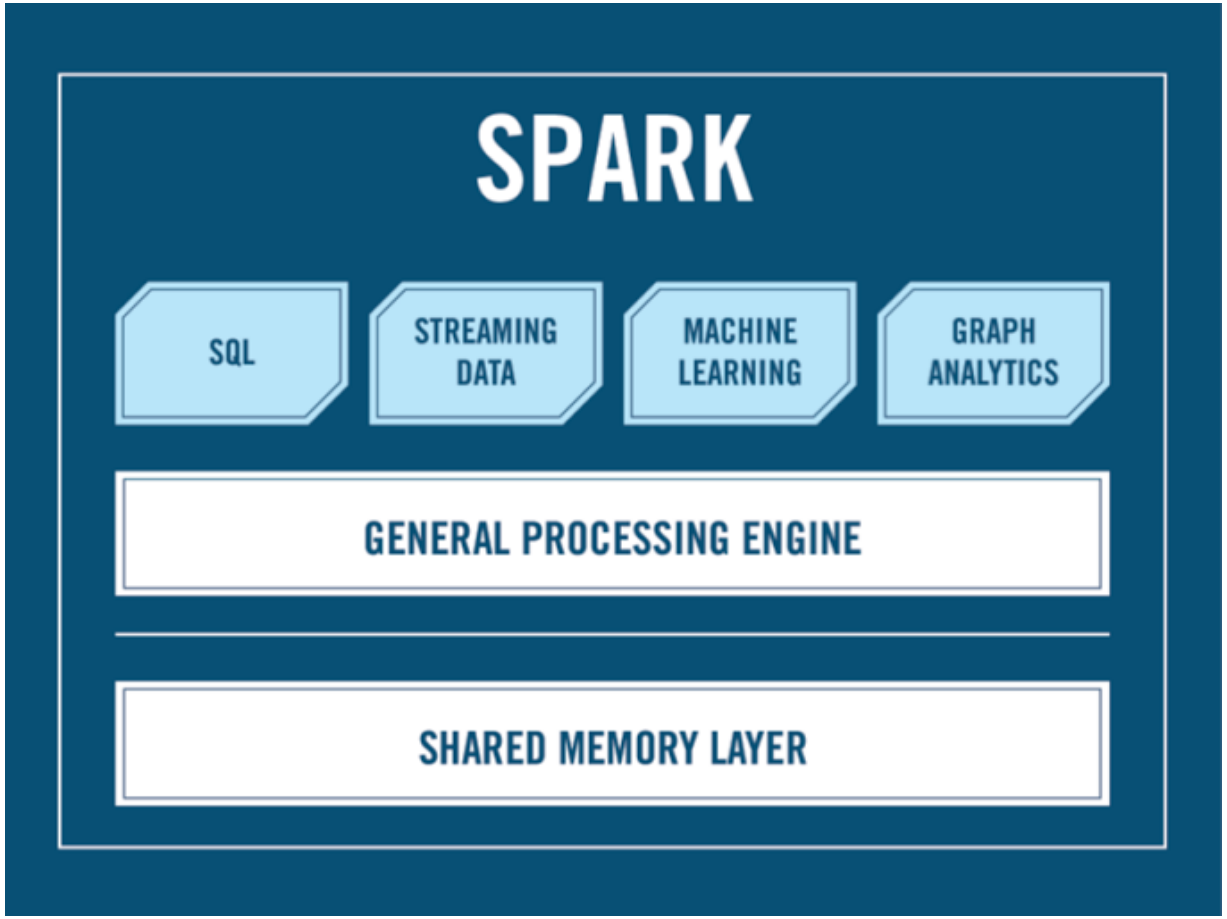
**`import pack1.Class1._`**

- Imports all members of **`Class1`** *including implicit definitions*
- No equivalent in Java

**`import pack1.{Class1 => MyClass}`**

- Imports **`Class1`** from pack1 and renames it **`MyClass`**
- This avoids collision with an existing function named **`Class1`**

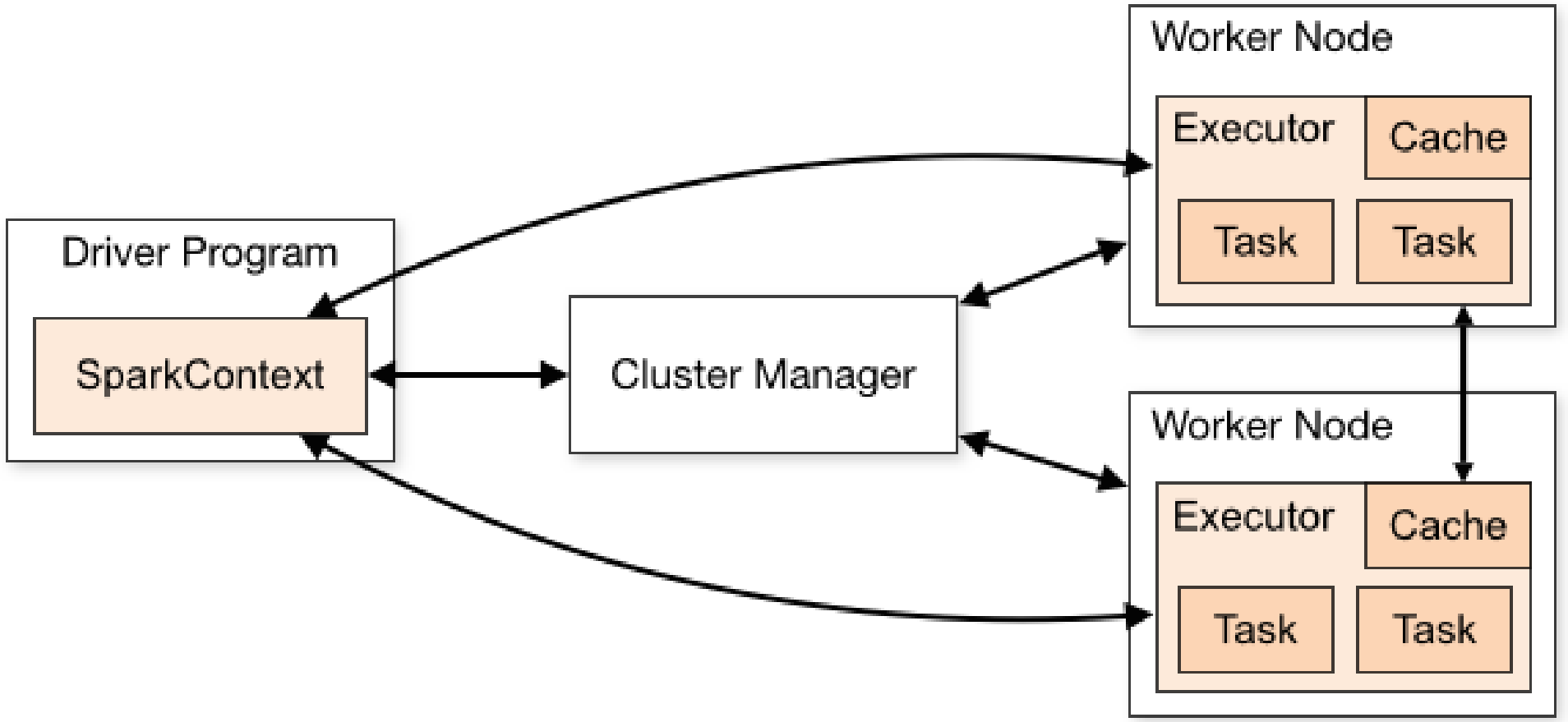
# And now!


SPARK
SQL
STREAMING DATA
MACHINE LEARNING
GRAPH ANALYTICS
GENERAL PROCESSING ENGINE
SHARED MEMORY LAYER

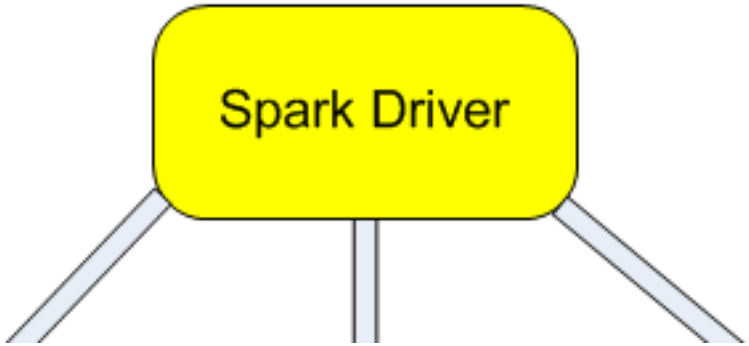
# Spark

- Release
  - Was born in UC Berkeley in  about 2009
  - First releases in 2012
  - Current version 2.3 several weeks ago
  - But still the most popular version is 2.2
- Written in scala
  - Scala is functional language that runs on JVM
- Spark api:
  - Scala, Python, Java, Java 8, R
- Writing spark
  - InteliJ, Eclipse, Spark-shell, Notebooks
- Running spark
  - Spark-Shell, Notebooks, Spark-submit
  - java –jar
- Running on cluster
  - You need cluster manager

# How does it work on cluster



# Driver, driver, what driver?

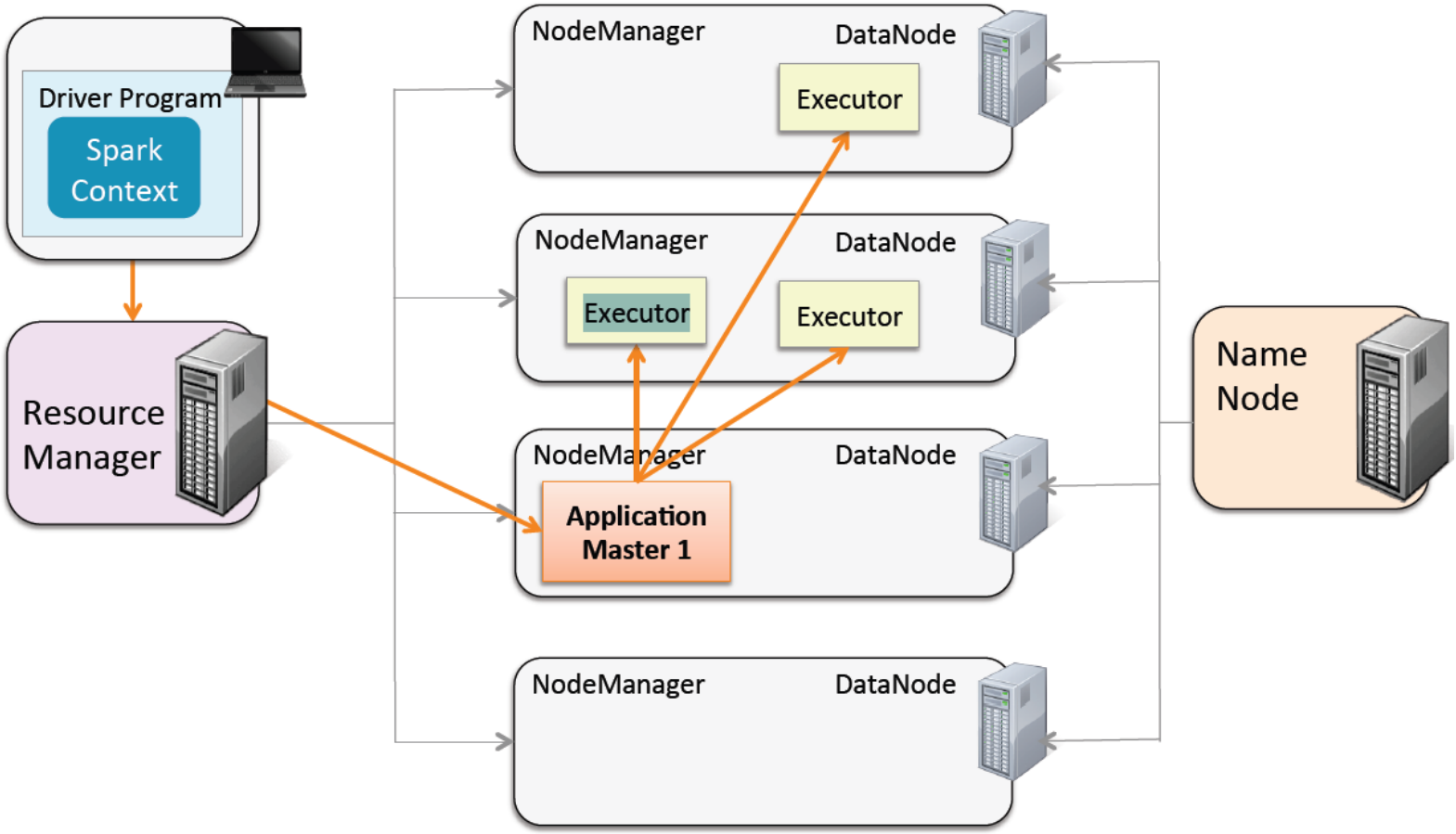



# What is a driver?

- Driver program - The process running the main() function of the application and creating the SparkContext
- Application which applies to Spark
- Like JDBC driver

# Spark with yarn

**Extremely important!**
Part of the code executed on driver
Part of the code executed on cluster



# RDD

Resilient

Distributed

Dataset

+-Stream

# How can you get RDD?

- From file or set of files (directory)
- From data in memory
- From another RDD

# File / directory

```
// from local file system
rdd = sc.textFile("file:/home/data/data.txt")

// from Hadoop using relative path of user, who run spark
application
rdd = sc.textFile("/data/data.txt")

// from hadoop
rdd = sc.textFile("hdfs://data/data.txt")

// all files from directory
rdd = sc.textFile("s3://data/*")

// all txt files from directory
rdd = sc.textFile("s3://data/*.txt")
```

# Memory

```
sc.parallelize([1, 2, 3])
```

# What is sc?

- SparkContext
- Main entry point for Spark functionality

```
conf = SparkConf().setAppName('appName').setMaster('local')
sc = SparkContext(conf=conf)
```

```
sc = SparkContext("local", "test")
```

# RDD has two kind of methods

- Transformation (intermediate) – always runs on cluster
- Action (terminal).
  - Can return value back to the driver
  - Can store RDD in HDFS

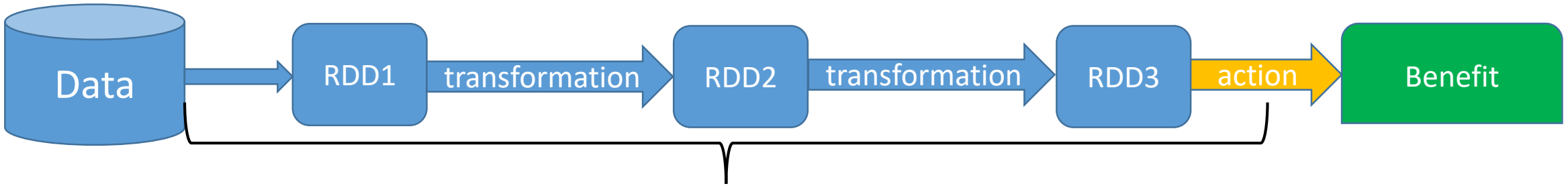
# Transformations

- **map**
- **flatMap**
- **filter**
- **mapPartitions, mapPartitionsWithIndex**
- **sample**
- **union, intersection, join, cogroup, cartesian** (*otherDataset*)
- **distinct**
- **reduceByKey, aggregateByKey, sortByKey**
- **pipe**
- **coalesce, repartition, repartitionAndSortWithinPartitions**

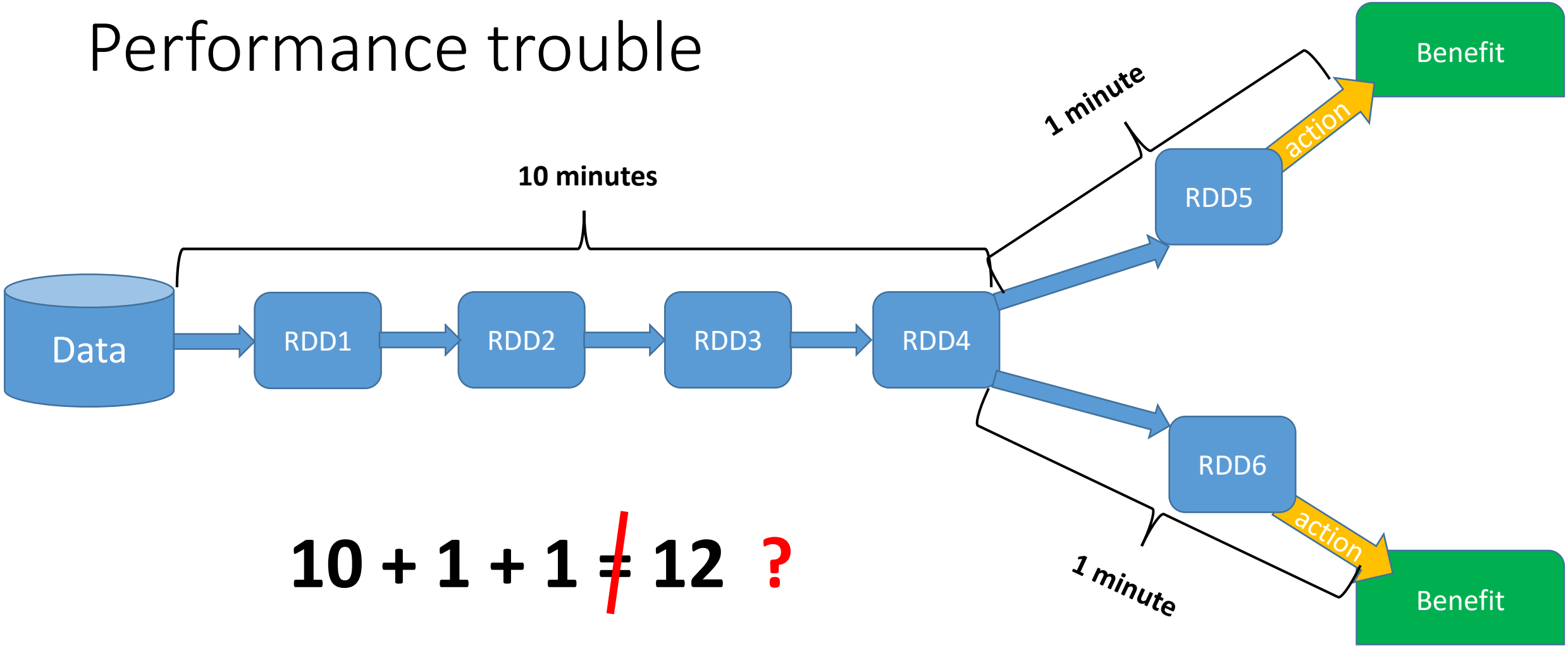
# Actions

- **reduce**
- **collect**
- **count, countByKey, countByValue**
- **first**
- **take, takeSample, takeOrdered**
- **saveAsTextFile, saveAsSequenceFile, saveAsObjectFile**
- **foreach**

# Rdd flow

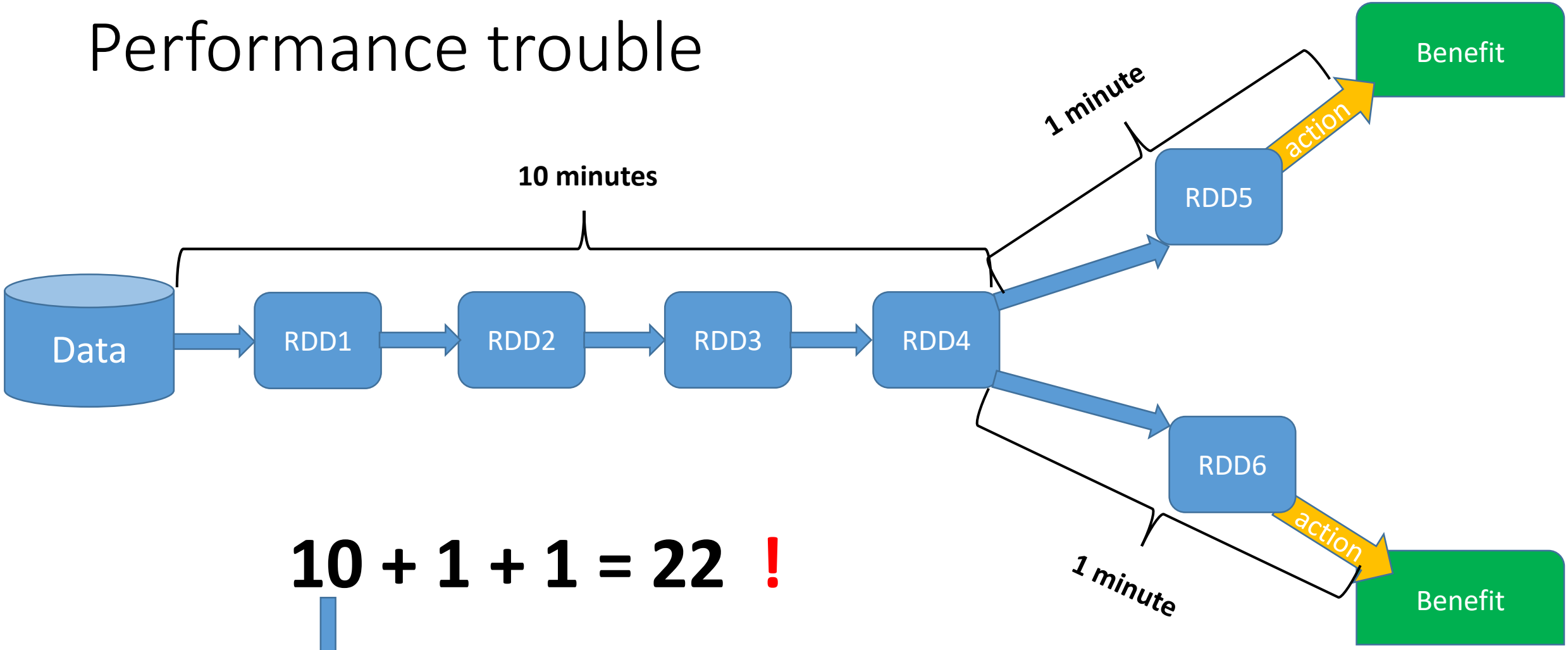

Data
RDD1
transformation
RDD2
transformation
RDD3
action
Benefit
Run on cluster

# Performance trouble




**10 + 1 + 1 ≠ 12 ?**

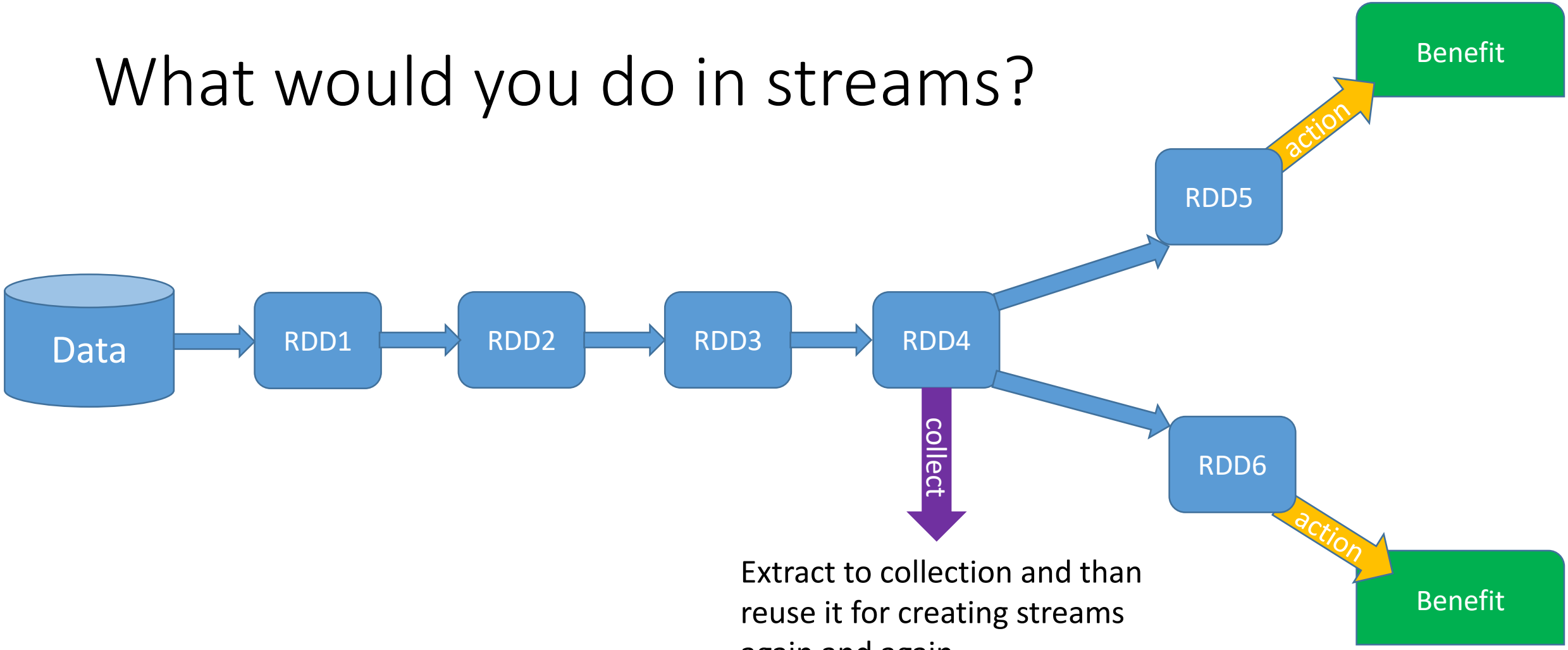
# Performance trouble




**10 + 1 + 1 = 22 !**

**(10 x 2)**

# What would you do in streams?




Extract to collection and than reuse it for creating streams again and again

Get Taxi™ tried this way

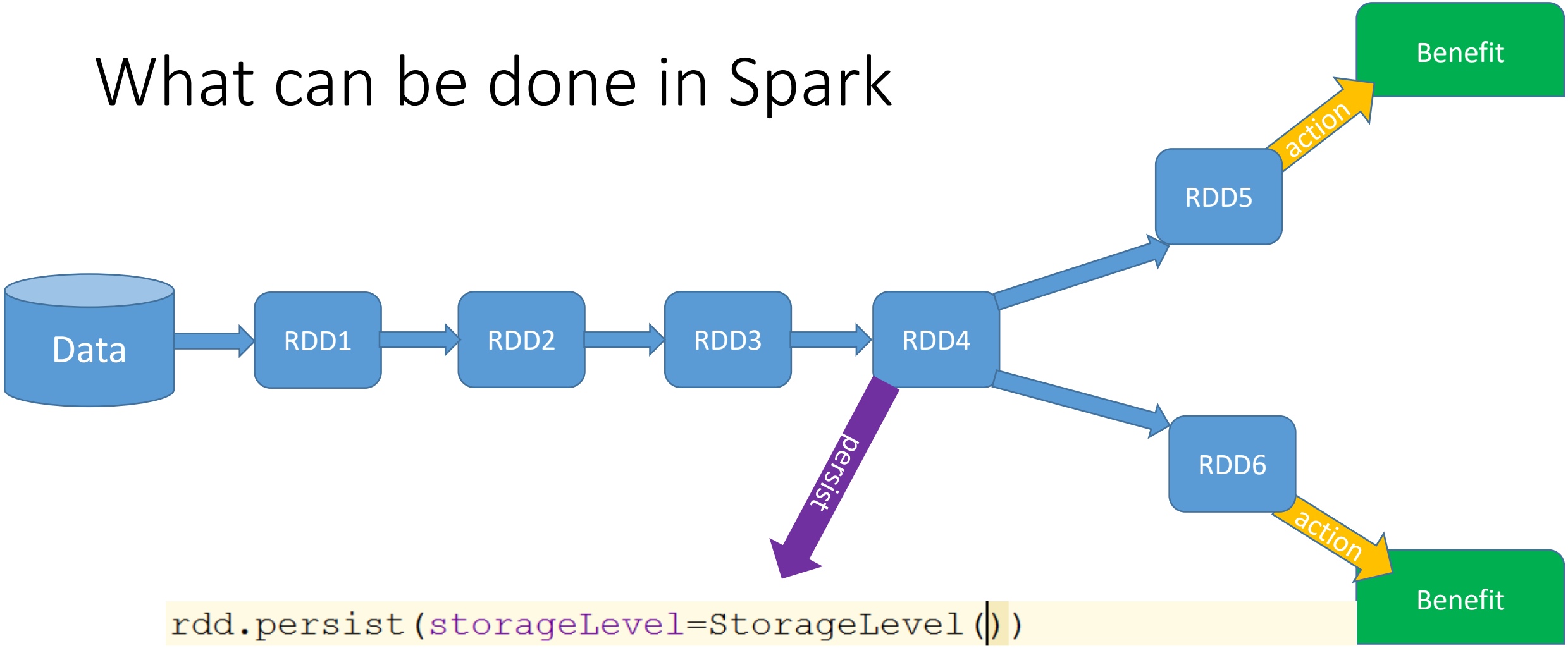
**Out of memory**


ONE DOES NOT SIMPLY
CAN WRITE EFFECTIVE SPARK CODE

You need to know when use

# Persist

# What can be done in Spark




```
rdd.persist(storageLevel=StorageLevel())
```

self, **useDisk,** useMemory, useOffHeap, deserialized, replication=1

# Let’s start writing spark

# Lab - I'll send you file like this one

File content:

104 Boston 9 Sat Feb 13 21:02:45 IST 2016
113 Blairsville 12 Sun Feb 21 07:24:36 IST 2016
114 Riverdale 10 Fri Feb 12 13:10:09 IST 2016
117 Flemington 5 Sun Feb 14 07:24:58 IST 2016
115 Boston 12 Wed Feb 10 12:39:00 IST 2016
115 Boston 10 Wed Feb 10 12:35:00 IST 2016

# What should be done

- Count number of lines
- Count amount of trips to Boston longer than 10 km
- Calculate sum of all kilometers trips to Boston
- Find all useless drivers (which have 0 km trips) and print their names
- Write names of 3 drivers with max total kilometers (sort top to down)
  **bonus**: the same but only for today
- Count number of 0 km trips per each driver, sort it and print
- Find cities where 0 trips happen most

# Performance Lab

- You need to count trips less than 5 km,
- Between 5 and 10 km
- Greater than 10 km
- Which kind of trips are most popular?


ONE DOES NOT SIMPLY
CAN WRITE EFFECTIVE SPARK CODE

# Accumulator

- Accumulator will be delivered to all executors, and will accumulate some value, when accumulator will be grabbed to driver all values will be summarized.

```
accum = sc.accumulator(0, "myAcc")
accum += 1
total = accum.value
```

# More interesting lab:


# Pink Floyd is not like Britney or Ketty, or may be yes…

# Another lab

- Write function which will receive path to text file and variable x.
- Function should find x most popular words in the file
- your test should check, that word ‘yesterday’ is the most popular in song Yesterday of Beatles

# You need to filter out all garbage words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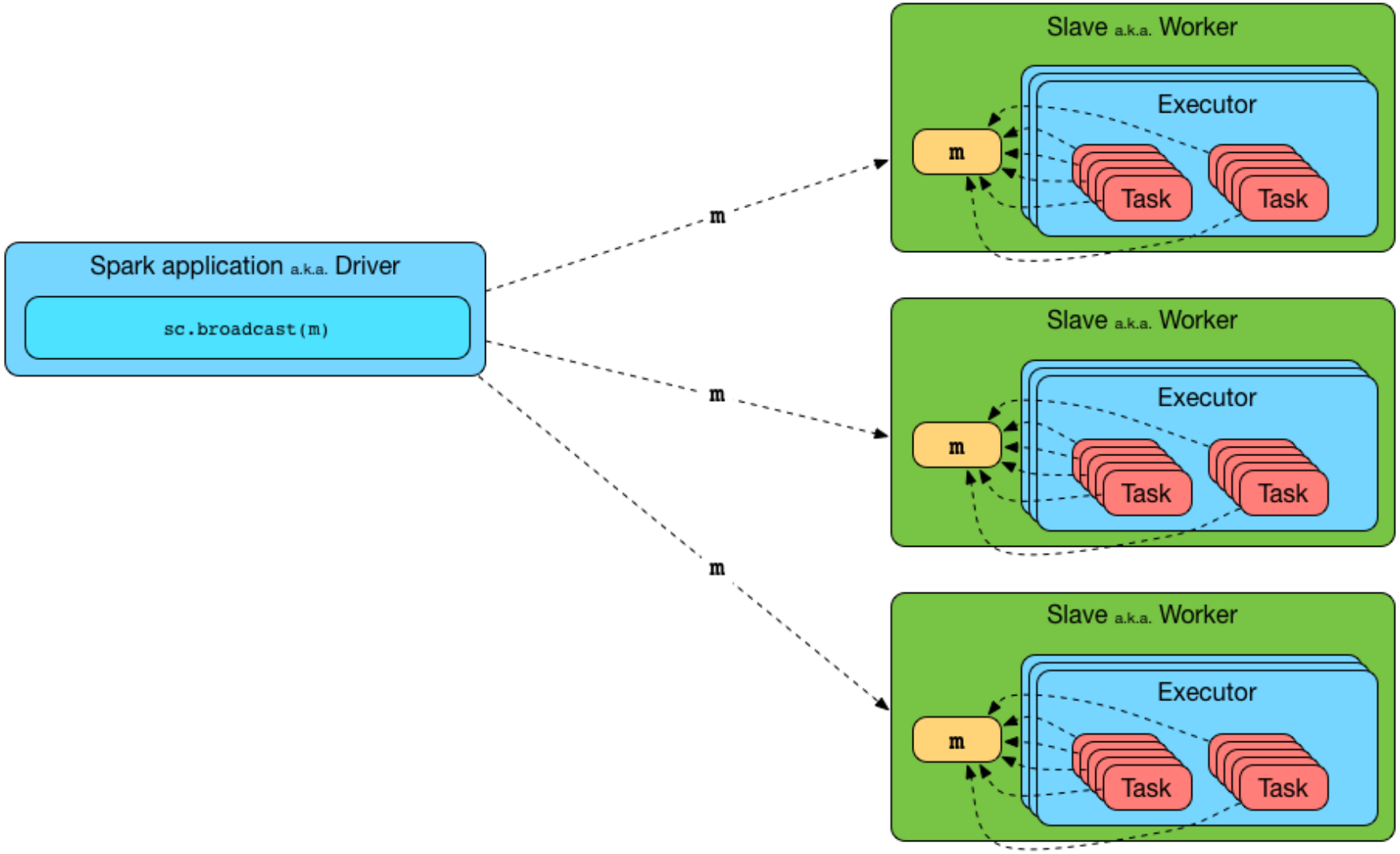
You need to know about

# Broadcast

```
listBroadcast = sc.broadcast(list)
List myList = listBroadcast.value()
```

# Broadcast


Spark application a.k.a. Driver
sc.broadcast(m)
m
m
m
Slave a.k.a. Worker
Executor
m
Task
Task
Slave a.k.a. Worker
Executor
m
Task
Task
Slave a.k.a. Worker
Executor
m
Task
Task

# Example

```
Israel, +9725423632
Israel, +9725454232
Israel, +9721454232
Israel, +9721454232
Spain, +34441323432
Spain, +34441323432
Israel, +9725423232
Israel, +9725423232
Spain, +34441323432
Russia, +78123343434
Russia, +78123343434
```

# Example

Israel, +9725423632
Israel, +9725454232
Israel, +9721454232
Israel, +9721454232
~~Spain, +34441323432~~
~~Spain, +34441323432~~
Israel, +9725423232
Israel, +9725423232
~~Spain, +34441323432~~
Russia, +78123343434
Russia, +78123343434

# Example

```
Israel, Orange
Israel, Orange
Israel, Pelephone
Israel, Pelephone
Israel, Hot Mobile
Israel, Orange
Russia, Megaphone
Russia, MTC
```

# Example

```
Orange
Orange
Pelephone
Pelephone
Hot Mobile
Orange
Megaphone
MTC
```

# Example

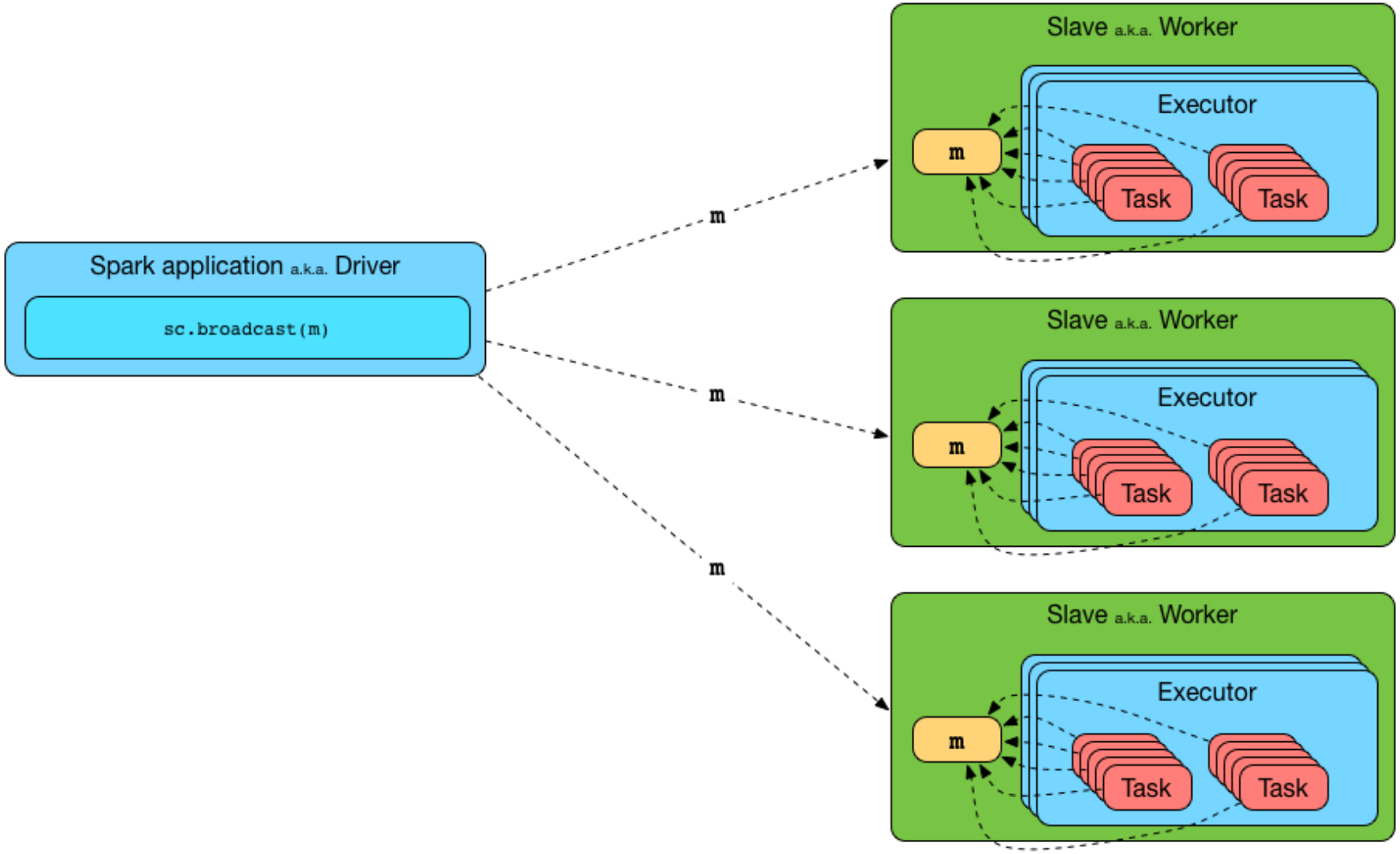
```
Israel, +9725423632
Israel, +9725454232
Israel, +9721454232
Israel, +9721454232
Spain, +34441323432
Spain, +34441323432
Israel, +9725423232
Israel, +9725423232
Spain, +34441323432
Russia, +78123343434
Russia, +78123343434
```

**Data which should be broadcasted**

Table of phone prefixes against operators

List of chosen countries

# Broadcast


Spark application a.k.a. Driver
sc.broadcast(m)
m
m
m
Slave a.k.a. Worker
Executor
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Task
Task
Slave a.k.a. Worker
Executor
m
Task
Task
Slave a.k.a. Worker
Executor
m
Task
Task

# DataFrames/Datasets

# Dataframes – since 1.3

- DataFrame/datasets are distributed collection of data organized into named columns
- RDD under the hood, but with lot of optimizations
- Use less memory if you use them smart
- Can be created from Hive tables, json like files, regular RDD, databases, all that have schema
- Have very wide DSL
- Related with SparkSession

# How to create SparkSession?

```
from pyspark.sql import SparkSession

sparkSession = SparkSession \
    .builder \
    .appName("Python Spark SQL basic example") \
    .config("spark.some.config.option", "some-value") \
    .getOrCreate()

sparkSession = SparkSession(sc)
```

# Create DataFrame from json file

```
sparkSession.read().json("data/*.json")
```

# Dataframes methods and functions

Agg, columns, count, distinct, drop, filter

groupBy, orderBy, registerTable, schema, show, select, where, withColumn

# Some dataframes methods

Agg, columns, count, distinct, drop, filter

groupBy, orderBy, registerTable, schema, show, select, where, withColumn

```
dataFrame.registerTempTable("myTable")

DataFrame frame = sparkSession.sql("select cl_id, cl_grp_id, dk_org_snw, dk_org_hnw,
         dk_org_cnp, dk_dir, dk_dat, DK_TIM_HR as dk_tim_hr, dk_spe, dk_sgt, dk_pet, dk_sgs, dk_sbp,\n" +
        "SUM(slu_atpt) slu_atpt, SUM(slu_succ) slu_succ, SUM(slu_fail) slu_fail, SUM(slu_dly) slu_dly\n" +
        "FROM myTable f join tdtim t on f.dk_tim = t.DK_TIM\n" +
        "WHERE dk_pet IN (1, 4)\n" +
        "group by cl_id, cl_grp_id, dk_org_snw, dk_org_hnw, dk_org_cnp, dk_dir, dk_dat, DK_TIM_HR,
        dk_spe, dk_sgt, dk_pet, dk_sgs, dk_sbp")
```

# Don’t tell him about this

# Why I don’t love sql

```
DataFrame dataFrame1 = sparkSession.sql("select  tdmco.CL_ID as cl_id, \n" +
        "\t\ttmdcl.CL_GRP_ID as cl_grp_id, \n" +
        "\t\ttdpet.DK_PET as dk_pet, \n" +
        "\t\ttdsgt.DK_SGT as dk_sgt, \n" +
        "\t\ttdsgs.DK_SGS as dk_sgs, \n" +
        "\t\ttddir.DK_DIR as dk_dir, \n" +
        "\t\ttdorg.DK_ORG as dk_org_cnp,\n" +
        "\t\tcase when data.INBOUND_IND = 0 then tdorg.DK_ORG when data.INBOUND_IND = 1 then tdmco.CL_ID end as dk_org_hnw,\n" +
        "\t\tcase when data.INBOUND_IND = 1 then tdorg.DK_ORG when data.INBOUND_IND = 0 then tdmco.CL_ID end as dk_org_snw,\n" +
        "\t\ttddat.DK_DAT as dk_dat,\n" +
        "\t\ttdtim.DK_TIM as dk_tim,\n" +
        "\t\tcast(case when spe1.DK_SPE is not null then spe1.DK_SPE when spe2.DK_SPE is not null then spe2.DK_SPE when spe3.DK_SPE is not null then spe3.DK_SPE else 0 end as big
        "\t\tcast(-999 as bigint) as dk_sgl, \n" +
        "\t\tcast(-999 as bigint) as dk_adt,\n" +
        "\t\tcast(0 as bigint) as dk_sbp,\n" +
        "\t\tdata.IMSI as dd_imsi,\n" +
        "\t\tMSISDN as dd_msisdn_min, \n" +
        "\t\tMSC as dd_msc, \n" +
        "\t\tHLR as dd_hlr, \n" +
        "\t\tSGSN_GT as dd_sgsn_gt, \n" +
        "\t\tSGSN_IP as dd_sgsn_ip,\n" +
        "\t\tcast(1 as bigint) as slu_atpt,\n" +
        "\t\tcast(case when data.STATUS = 'OK' then 1 else 0 end as bigint) as slu_succ,\n" +
        "\t\tcast(case when data.STATUS = 'Reject' then 1 else 0 end as bigint) as slu_fail,\n" +
        "\t\tcast(((unix_timestamp(substring(data.TIME_END,1,19))*1000)+(substring(data.TIME_END,21,3)))-((unix_timestamp(substring(data.TIME,1,19))*1000)+(substring(data.TIME,21
        "\t\tdata.STATUS as status\n" +
        "\t\t-- first_value(tmdsbsprf.PRF_ID) OVER (PARTITION BY tdmco.CL_ID,data.IMSI ORDER BY length(tmdsbsprf.MATCH_STR) desc,tmdsbsprf.MATCH_START) AS sbs_prf_if,\n" +
        "from data left join tdmco on (data.OWNER_CODE=tdmco.MCO_TAP_CD)\n" +
        "left join tmdcl on (tdmco.CL_ID=tmdcl.CL_ID)\n" +
        "left join tdpet on (data.OPCODE=tdpet.PET_CD)\n" +
        "left join tdsgt on (case when data.OPCODE = 2 then 'C' when data.OPCODE = 23 then 'P' end = tdsgt.SGT_CD)\n" +
        "left join tdsgs on (case when data.STATUS = 'OK' then 'S' when data.STATUS = 'Reject' then 'F' end = tdsgs.SGS_CD)\n" +
        "left join tddir on (case when data.INBOUND_IND = 0 then 'V' when data.INBOUND_IND = 1 then 'O' end = tddir.DIR_CD)\n" +
        "left join tdorg on (data.OP_ID = tdorg.ORG_TAP_CD)\n" +
        "left join tddat on (to_date(data.TIME) = to_date(tddat.DAT))\n" +
        "left join tdtim on (substring(data.TIME,12,8) = tdtim.TIM)\n" +
        "left join tdspe as spe1 on (case when data.STATUS = 'Reject' and data.MAP_ERR is null and TCAP_ERR is null then 255 end = spe1.SPE_CD and spe1.SPE_CAT = 'MAP')\n" +
        "left join tdspe as spe2 on (case when data.TCAP_ERR is null or (data.MAP_ERR is not null and data.TCAP_ERR is not null) then data.MAP_ERR end = spe2.SPE_CD and spe2.SPE_
        "left join tdspe as spe3 on (case when data.MAP_ERR is null and data.TCAP_ERR is not null then data.TCAP_ERR end = spe3.SPE_CD and spe3.SPE_CAT = 'TCAP')\n" +
        "-- left join tmdsbsprf on (tdmco.CL_ID = tmdsbsprf.org_tech_id and SUBSTR(data.IMSI, tmdsbsprf.MATCH_START, LENGTH(tmdsbsprf.MATCH_STR)) = tmdsbsprf.MATCH_STR and to_da
```

# functions: `import pyspark.sql.functions as func`

- sin, cos,tan,abs, cos, asin, isnull, not, rand, sqrt, when, expr, bin, atan, ceil, floor, factorial, greatest, least, log, log10, pow, round, sin, toDegrees, toRadians, md5, ascii, base64, concat, length, lower, ltrim, unbase64, repeat, reverse, split, substring, trim, upper, datediff, year, month, hour, last_day, next_day, dayofmonth, explode, udf…

# Dataframes methods and functions

- abs, cos, asin, isnull, not, rand, sqrt, when, expr, bin, atan, ceil, floor, factorial, greatest, least, log, log10, pow, round, sin, toDegrees, toRadians, md5, ascii, base64, concat, length, lower, ltrim, unbase64, repeat, reverse, split, substring, trim, upper, datediff, year, month, hour, last_day, next_day, dayofmonth, explode, udf
- Arithmetic operators also can be used

# How to apply to column?

- dataset[‘column_name’]
- dataset.column_name
- In some cases: ‘column_name’
- Example

- dataset = dataset.withColumn(‘sin_from_age’, func.sin(dataset[‘age’])
- dataset = dataset.withColumn(‘sin_from_age’, func.sin(dataset.age)
- dataset = dataset.withColumn(‘sin_from_age’, func.sin(‘age’)

# What collect, take or head will return?

- Row object

```
First_col_val = df2.head()[0]
x=df2.head.column_name
```

# Json file I'll send you


```
{"name":"Evgeny Borisov", "age":37, "keywords": ["spark", "java","spring","gradle","groovy","artifactory"]}
{"name":"Martin Odersky", "age":37, "keywords": ["scala"]}
{"name":"Baruch Sadogursky", "age":38, "keywords": ["docker", "spring","groovy","bintray","artifactory","linux"]}
{"name":"Motros Jeleznyak", "age":37, "keywords": ["python","ruby"]}
{"name":"Anton Arhipov", "age":37, "keywords": ["scala","groovy","gc","sbt","aspectJ"]}
{"name":"Viktor Gamov", "age":28,"keywords": ["spring","maven","spock","spring boot"]}
{"name":"Kirill Tolkachov", "age":28,"keywords": ["groovy", "spring","maven","spock","spring boot"]}
{"name":"Nikolay Alimenkov", "age":35,"keywords": ["java", "spring","maven","spock","TestNG","junit","mockito"]}
```

# Lab

- Print out file content
- Print out the schema
- Print out all column names
- Add column “salary” the value will be calculated by formula:
  age * number of technologies * 10 (bonus, instead of 10, multiply by 5 if age <5 or by 10 if age >= 5)
- Find developers the most popular technology and print out people which familiar with it

# Shops events data

{"product_id":12,"client_id":11,"cashbox_id":10}

There database with clients info
And file with products info

# tasks

- Print most effective cashbox_id
- Print most popular product name
- Print average age of people which by most expensive product

# Enrichment

- Join another dataframe
- Use withColumn with udf

# Joining dataframes

- df1.join(df2,df1.someColumn==df2.someColumn)
- df1.join(df2,func.col(‘Col_of_first_df’)==func.col(‘Col_of_second_df))

you can use aliases:  (in case dataframes names are very long)

- df1.alias(‘t1’)
- df2.alias(‘t2’)
- df1.join(df2,f.col(t1.col1)==f.col(t2.col2))

# Udf function

```
two_col_sum = udf(lambda x, y: x + y, IntegerType())

# integerType can be omitted

ds = ds.withColumn('new_col', two_col_sum(ds['col1'], ds['col2']))
```

# Udf function without lambda

```
@udf
def squared_udf(s):
  return SomeService.someFunction(s)
```

```
@udf ("long")
def squared_udf(s):
  return SomeService.someFunction(s)
```

# Udf optimizations

- Deterministic by default – means can be cached
- In case it is not, to avoid caching you declare it as non deterministic

```
random_udf = udf(lambda: int(random.random() * 100), IntegerType()).asNondeterministic()
```

# How to create Dataset from CSV

**First you need to create regular RDD from CSV file as always, using SparkContext**

```
dataset = sparkSession.createDataFrame(rdd, schema=['line'])
dataset.show(10)
```

# Another example: create Dataset from CSV

```
word_pairs_rdd = sc\
    .textFile(getcwd() + "\\data\\songs\\britney\\pink_floyd.txt")\
    .flatMap(lambda line: line.split())\
    .map(lambda word: (word.lower(), 1))\
    .persist()


word_pairs_df = ss.createDataFrame(word_pairs_rdd, schema=['word', 'count'])
word_pairs_df.show(10)
```

# Creating typed schema

```
from pyspark.sql.types import *

schema = StructType([
    StructField("name", StringType(), True),
    StructField("age", IntegerType(), True)])

df3 = spark.createDataFrame(rdd, schema)

row = df3.take(1)

#row is: [Row(name=u'Alice', age=1)
```