Resilient Distributed Datasets

The Fundamental Data Structure in Spark

Outline

(of this segment)

- Common Data Structures in Statistical Programming
- Basic Concepts in Spark
- RDDs
- The Spark Workflow
- Workflow Template

Common Data Structures

Vectors

And vectorized computing

- What is vectorization?
- Why is it fast?

Vectors

And functional programming

- How is it related to functional programming?
- Why Functional Programming matters?

Functional Programming

What is it?

Here are some things we care about:

- Functions as first-class objects
  - Anonymous Functions
- Side-effects (or not)

Functions as first-class objects

One of my goals for Python was to make it so that all objects were "first class." By this, I meant that I wanted all objects that could be named in the language (e.g., integers, strings, functions, classes, modules, methods, etc.) to have equal status. That is, they can be assigned to variables, placed in lists, stored in dictionaries, passed as arguments, and so forth.

-- Guido van Rossum
(http://python-history.blogspot.in/2009/02/first-class-everything.html)

First-class Functions

Functions as first-class objects

- being expressible as an anonymous literal value
- **being storable in data structures having an intrinsic identity (independent of any given name)**
- being passable as a parameter to a procedure/function
- being returnable as the result of a procedure/function
- being constructible at runtime
- being transmissible among distributed processes
- being storable outside running processes

Anonymous Functions

A function has no name

- Why?
- Lambda

Side-effects

Thinking about parallelism

- Functions in Programming
- Functions in Mathematics
- Functions in Distributed or Parallel Programming

Generating Random Numbers?

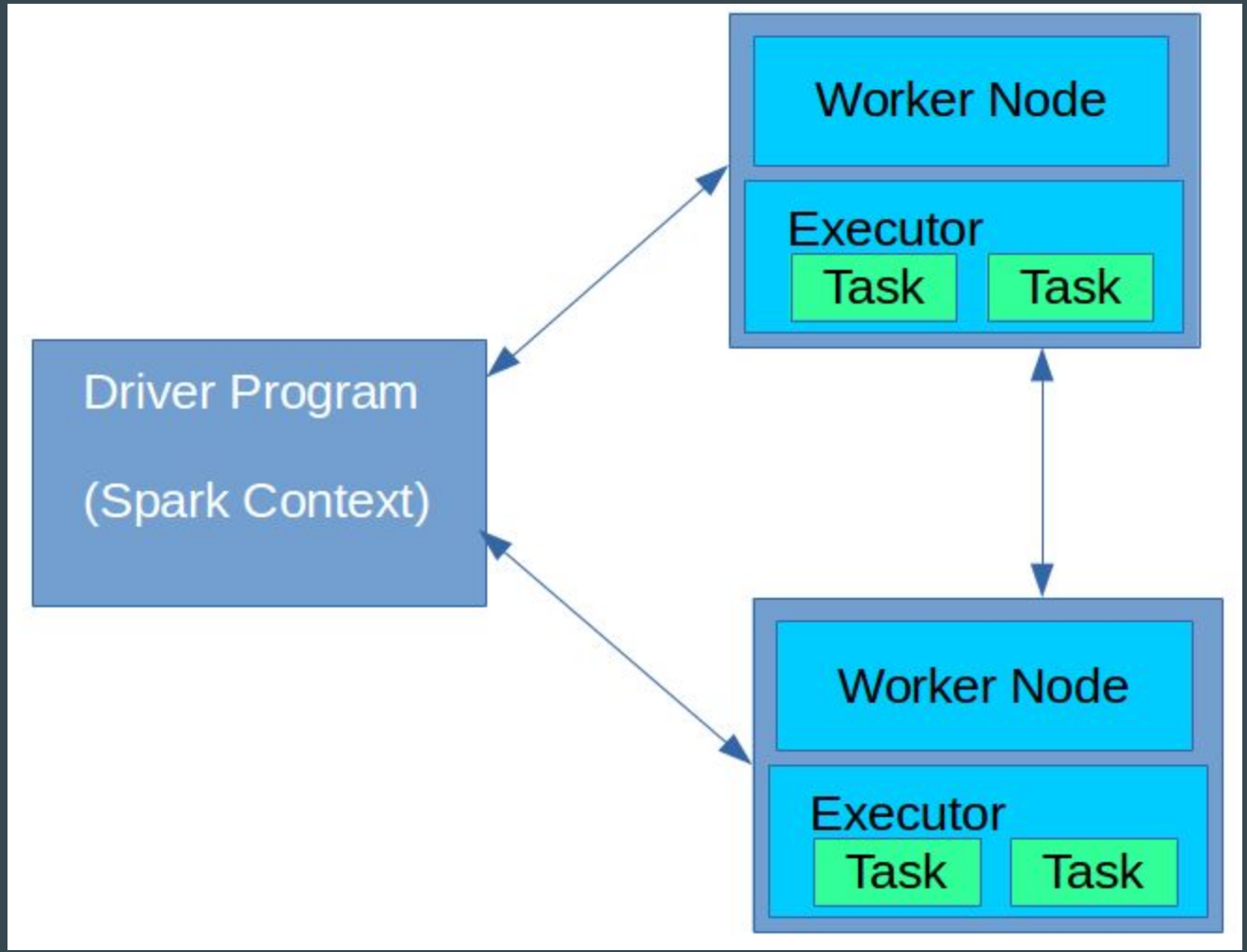
Where does this leave us?

- Is Python a Functional Programming language?
- Is Scala a Functional Programming language?
- Is R a Functional Programming language?
- Is Spark a functional programming language?

Where does this leave us?

- Is Python a Functional Programming language?
- Is Scala a Functional Programming language?
- Is R a Functional Programming language?
- Is Spark a functional programming language?
  - No, silly, it's not even a programming language?
  - But functions are first class objects in Python and Scala

Some Basic Concepts


Worker Node
Executor
Task
Task
Driver Program
(Spark Context)
Worker Node
Executor
Task
Task

Spark Context

- Represents a connection to a computing cluster
- In pySpark shell, a sparkContext is automatically created
  - A variable called *sc*
- In other modes (say Jupyter notebooks), we have to create it ourselves

Driver Program

Every Spark application consists of a driver program

- launches various parallel operations on a cluster
  - defines distributed datasets on the cluster, then applies operations to them
- contains application's *main* function
- accesses Spark through a SparkContext object

Executor

Worker Nodes

- The typical worker nodes of the cluster
- Managed by the Driver Program

Let’s simulate counting words in a text file.

RDDs

What are RDDs

Can read from and written to distributed storages like HDFS or S3

- Resilient
  - Can be rebuilt from a lineage (fault tolerant)
- Distributed
  - partitioned across machines

    accessed via parallel operations (fast)
- Vectorised
- Immutable
  - read-only collection of objects
- Cached
  - Because RDDs can be cached in memory of worker nodes, they can be good at iterative applications

What are RDDs

A broader look

- Vectorization as a common pattern in other statistical programming languages
  - R
  - Python
- Functional Programming
- We just discussed these ideas

Let’s see it in practice

Let's use lambda to create an anonymous function to count the number of lines in a file containing Python

Spark_Activities_01_Basics.ipynb

Activity 2: Using Anonymous Functions

Let’s see it in practice

We’ll go ahead and calculate the number of primes less than a given large number

Spark_Activities_01_Basics.ipynb

Activity 3: Couting Primes

The Spark Workflow

Working with RDDs

The simple, wrong and useful description of the process

- RDDs are created and distributed across worker nodes
- The Driver distributs code (transformations) across the cluster to be executed by workers on their partitions of the RDD
- Results are then sent back to the driver for aggregation (Actions)

Laziness

Working with RDDs

Spark applications are manipulation of RDDs through transformations and actions

- Define RDD(s) by
  - accessing data stored on disk (HDFS, Cassandra, HBase, Local Disk)
  - parallelizing some collection in memory
  - transforming an existing RDD
  - caching or saving
- Invoke operations on the RDD(s) by passing closures (functions) to each element of the RDD
- Use the resulting RDDs with actions (e.g. count, collect, save, etc.). Actions kick off the computing on the cluster.

Working with RDDs

Variable and Scoping

When Spark runs a closure on a worker, any variables used in the closure are copied to that node, but are maintained within the local scope of that closure.

Spark provides two types of shared variables that can be interacted with by all workers in a restricted fashion

Working with RDDs

Broadcasts and Accumulators

- *Broadcast* variables are distributed to all workers, but are read-only. Broadcast variables can be used as lookup tables or stopword lists.
- *Accumulators* are variables that workers can "add" to using associative operations and are typically used as counters.

Workflow Template

More examples

Word and Line counting

Spark_Activities_01_Basics.ipynb

Activity 4: Word and Line Counting

The Template

Spark_Activities_01_Basics.ipynb

Activity 5: Workflow Template

- main()
- if __name__ == "__main__":

Sample Application

Spark_Activities_01_Basics.ipynb

Activity 6: Sample Application