Writing Standalone Spark Programs

Matei Zaharia

UC Berkeley

www.spark-project.org

Outline

Setting up for Spark development

Example: PageRank

PageRank in Java

Testing and debugging

Building Spark

Requires: Java 6+, Scala 2.9.1+

```
git clone git://github.com/mesos/spark
cd spark
sbt/sbt compile

# Build Spark + dependencies into single JAR
# (gives core/target/spark*assembly*.jar)
sbt/sbt assembly

# Publish Spark to local Maven cache
sbt/sbt publish-local
```

Adding it to Your Project

Either include the Spark assembly JAR, or add a Maven dependency on:

groupId: `org.spark-project`
artifactId: `spark-core_2.9.1`
version: `0.5.1-SNAPSHOT`

Creating a SparkContext

```
import spark.SparkContext
import spark.SparkContext._
```

Important to get some implicit conversions

```
val sc = new SparkContext(
  “masterUrl”, “name”, “sparkHome”, Seq(“job.jar”))
```

Mesos cluster URL, or local / local[N]

Job name

Spark install path on cluster

List of JARs with your code (to ship)

Complete Example

```
import spark.SparkContext
import spark.SparkContext._

object WordCount {
  def main(args: Array[String]) {
    val sc = new SparkContext(
      “local”, “WordCount”, args(0), Seq(args(1)))
    val file = sc.textFile(args(2))
    file.map(_.split(“ ”))
        .flatMap(word => (word, 1))
        .reduceByKey(_ + _)
        .saveAsTextFile(args(3))
  }
}
```

Static singleton object

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Why PageRank?

Good example of a more complex algorithm

- Multiple stages of map & reduce

Benefits from Spark's in-memory caching

- Multiple iterations over the same data

Basic Idea

Give pages ranks (scores) based on links to them

- » Links from many pages ➔ high rank
- » Link from a high-rank page ➔ high rank

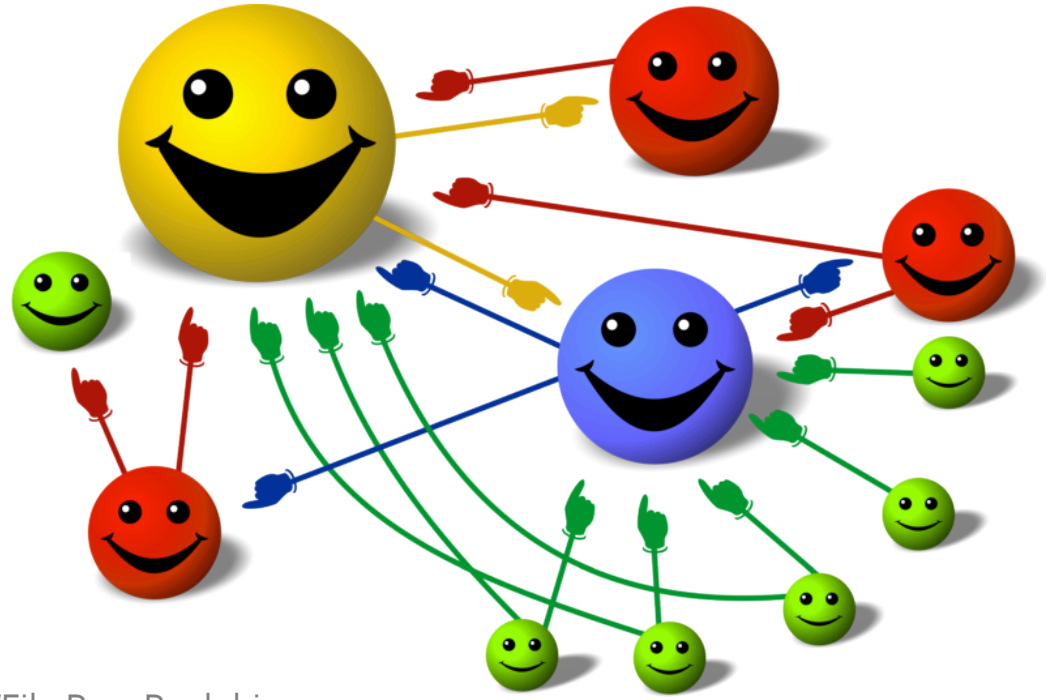
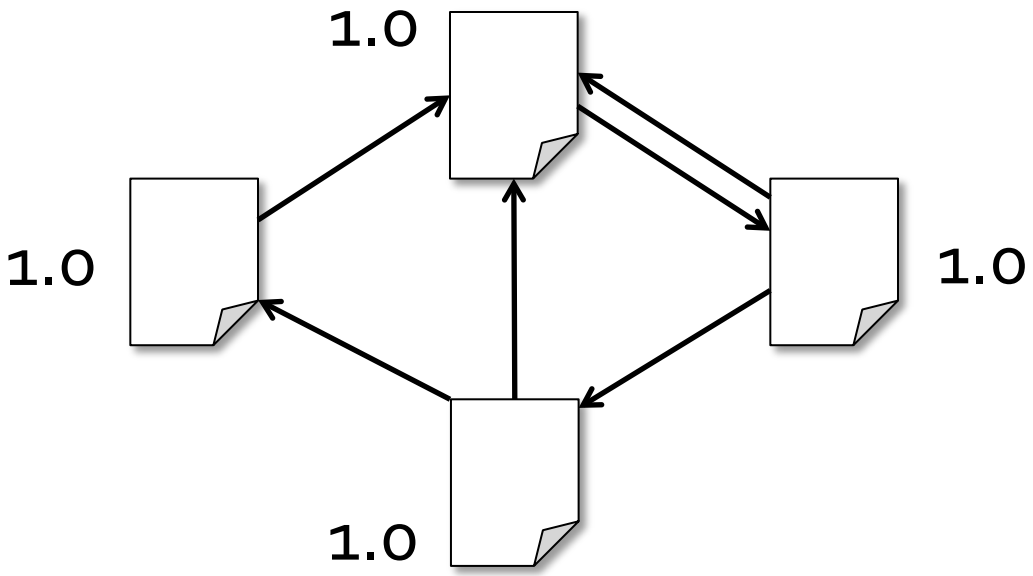


Image: en.wikipedia.org/wiki/File:PageRank-hi-res-2.png

Algorithm

1. Start each page at a rank of 1
2. On each iteration, have page p contribute $rank_p$ / $|neighbors_p|$ to its neighbors
3. Set each page's rank to 0.15 + 0.85 × contribs



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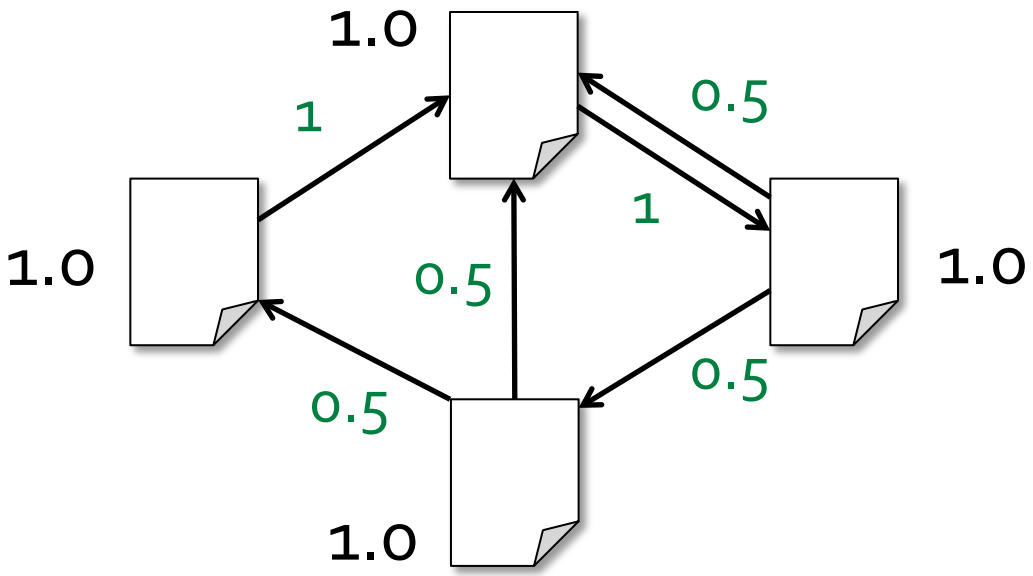

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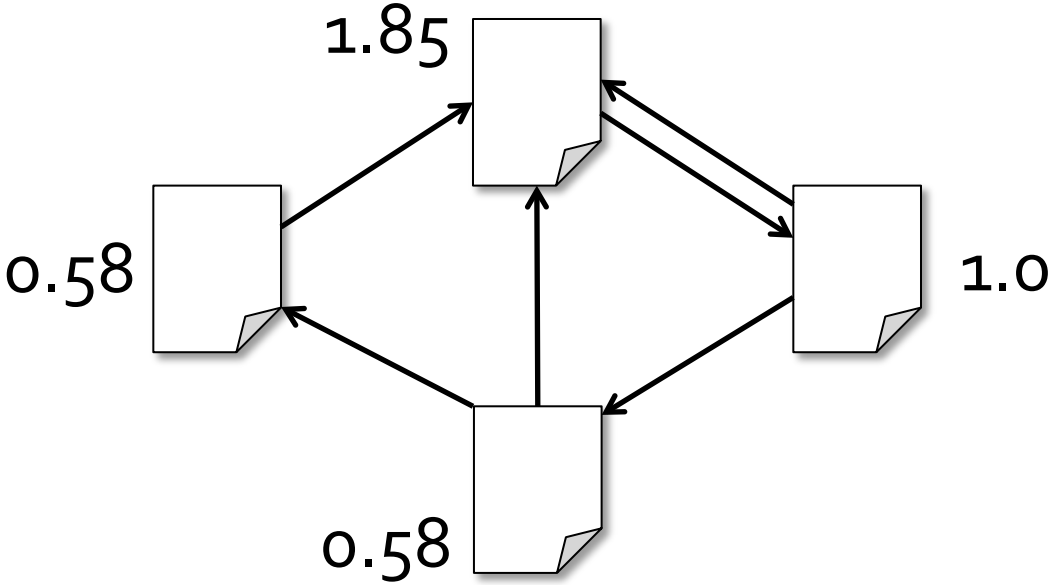

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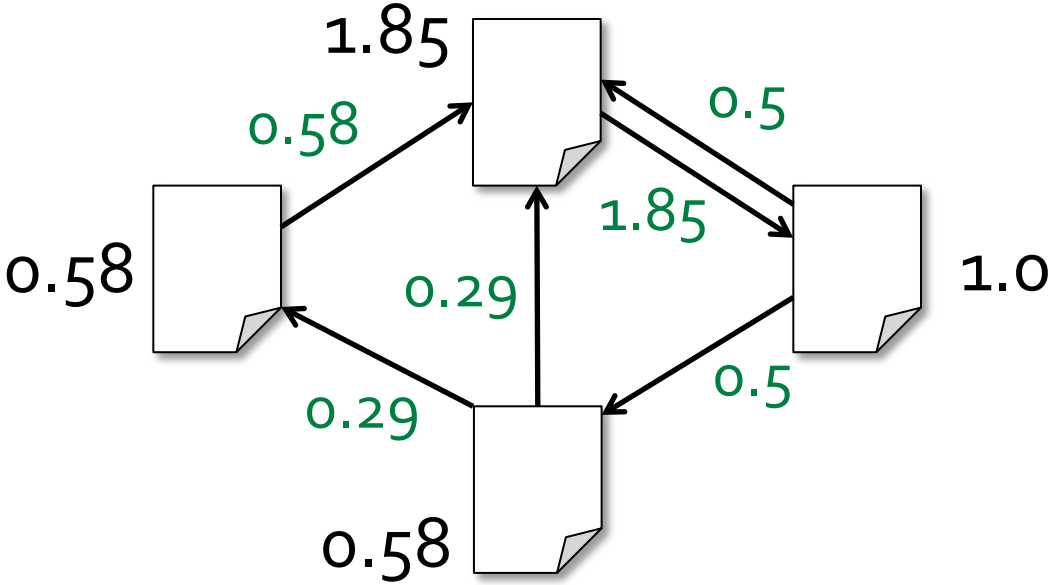

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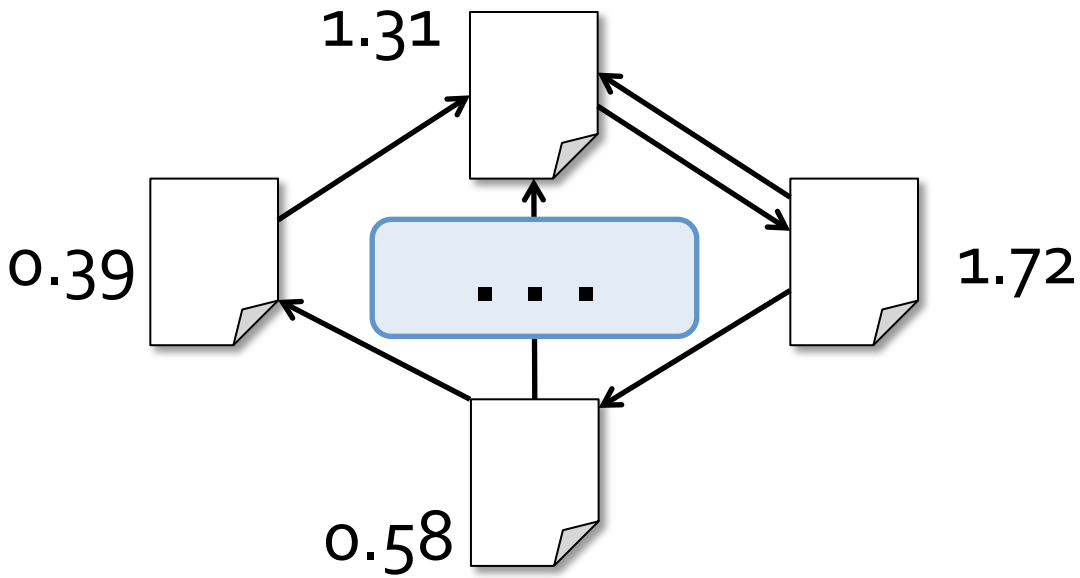

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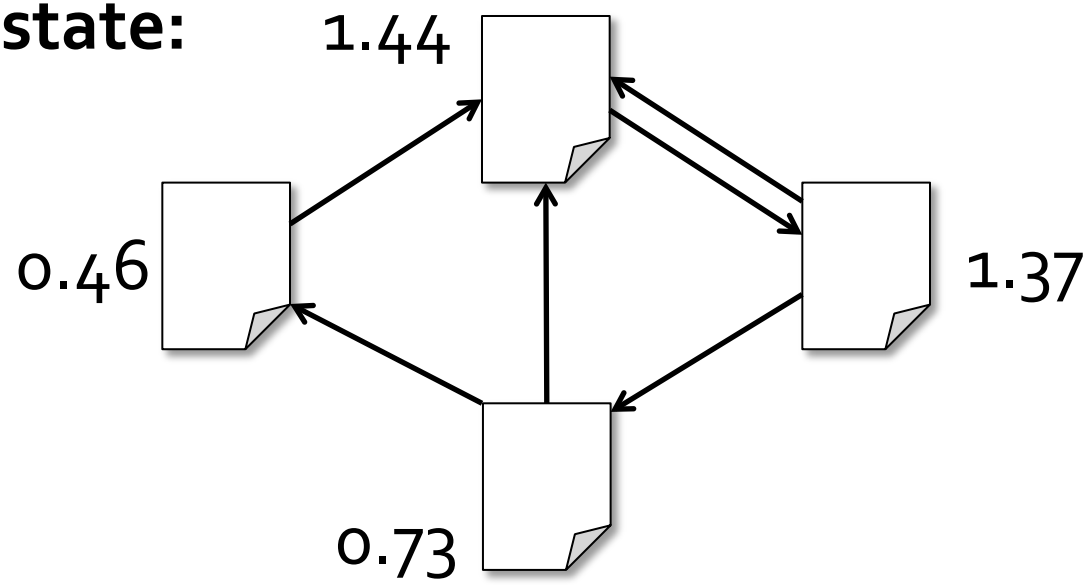
Final state:

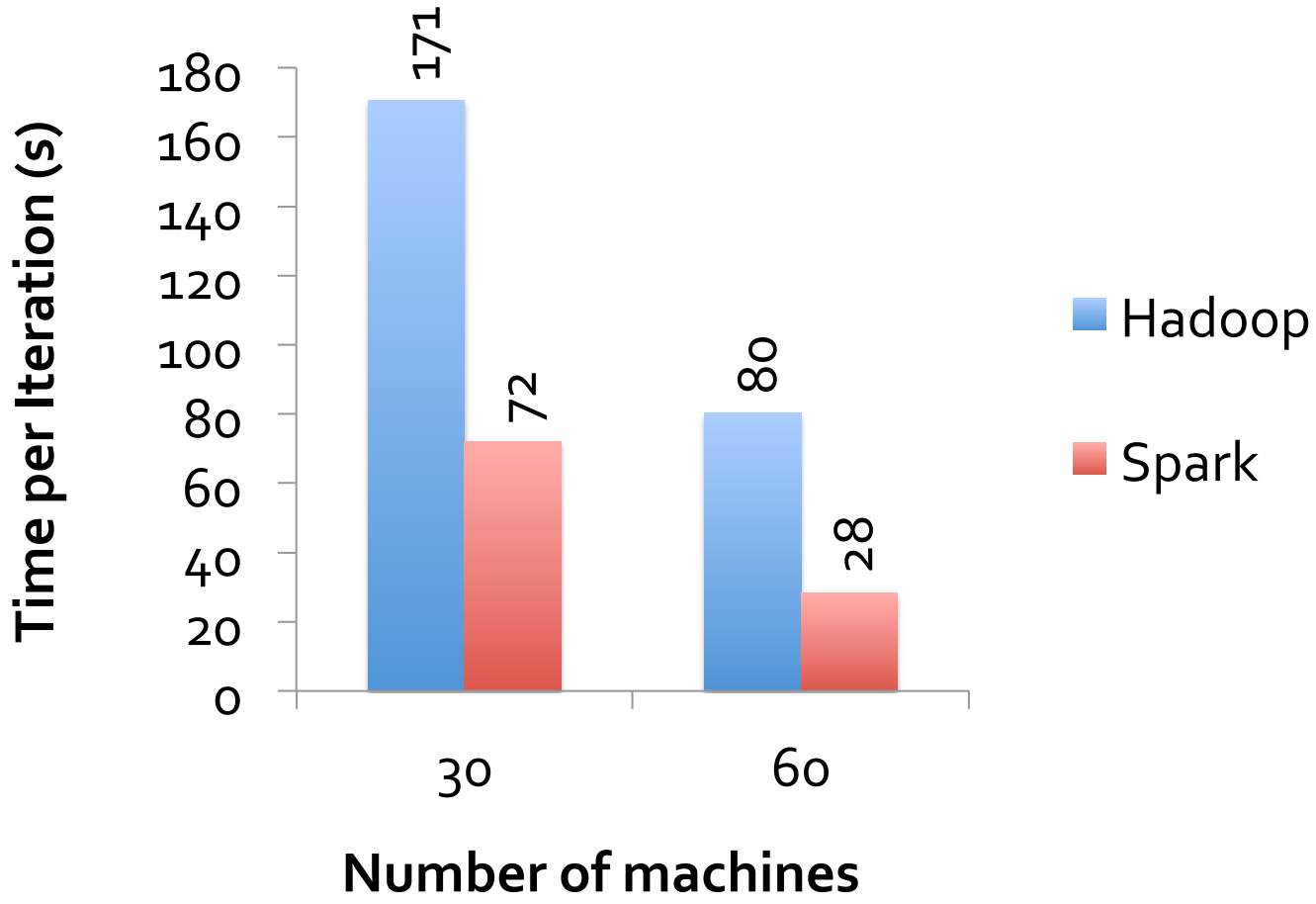


Spark Program

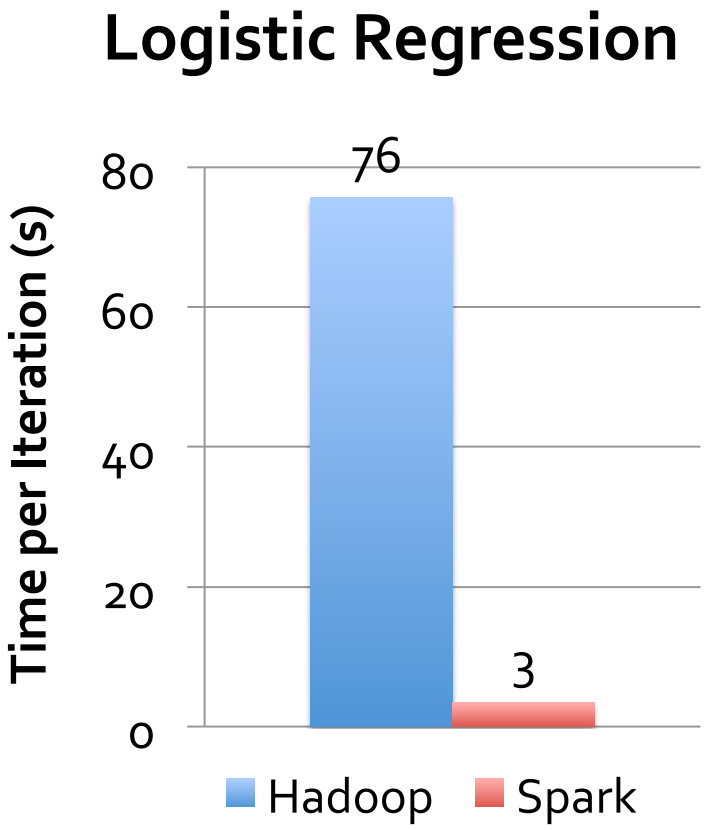
```
val links = // RDD of (url, neighbors) pairs
var ranks = // RDD of (url, rank) pairs

for (i <- 1 to ITERATIONS) {
  val contribs = links.join(ranks).flatMap {
    case (url, (links, rank)) =>
      links.map(dest => (dest, rank/links.size))
  }
  ranks = contribs.reduceByKey(_ + _)
                  .mapValues(0.15 + 0.85 * _)
}

ranks.saveAsTextFile(...)
```

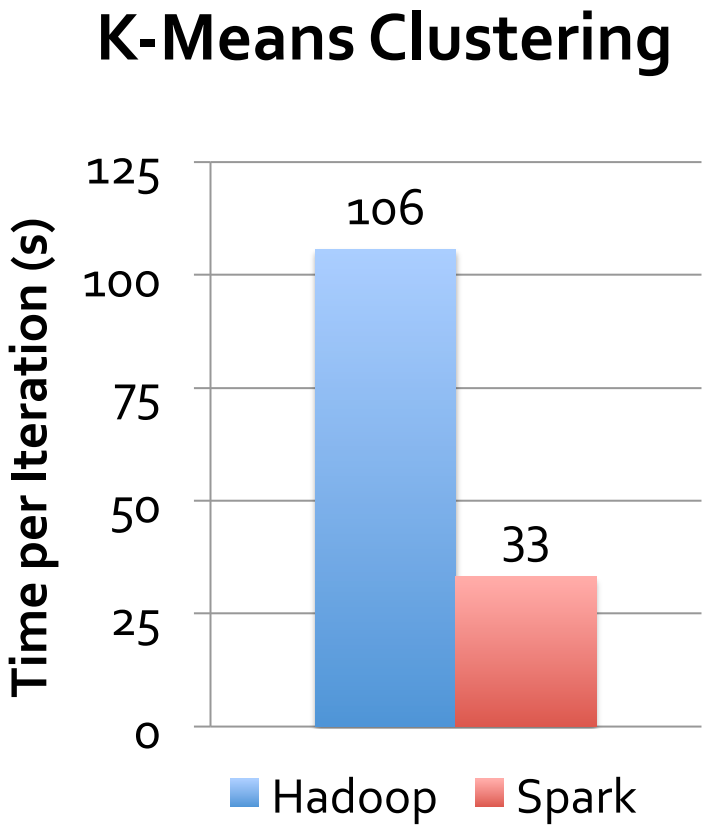
Coding It Up

PageRank Performance



Other Iterative Algorithms





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Differences in Java API

Implement functions by extending classes

» `spark.api.java.function.Function`, `Function2`, etc

Use special Java RDDs in `spark.api.java`

» Same methods as Scala RDDs, but take Java `Functions`

Special `PairFunction` and `JavaPairRDD` provide operations on key-value pairs

» To maintain type safety as in Scala

Examples

```
import spark.api.java.*;
import spark.api.java.function.*;

JavaSparkContext sc = new JavaSparkContext(...);
JavaRDD<String> lines = ctx.textFile("hdfs://...");

JavaRDD<String> words = lines.flatMap(
  new FlatMapFunction<String, String>() {
    public Iterable<String> call(String s) {
      return Arrays.asList(s.split(" "));
    }
  }
);

System.out.println(words.count());
```

Examples

```
import spark.api.java.*;
import spark.api.java.function.*;

JavaSparkContext sc = new JavaSparkContext(...);
JavaRDD<String> lines = ctx.textFile(args[1], 1);

class Split extends FlatMapFunction<String, String> {
  public Iterable<String> call(String s) {
    return Arrays.asList(s.split(" "));
  }
);

JavaRDD<String> words = lines.flatMap(new Split());

System.out.println(words.count());
```

Key-Value Pairs

```
import scala.Tuple2;

JavaPairRDD<String, Integer> ones = words.map(
  new PairFunction<String, String, Integer>() {
    public Tuple2<String, Integer> call(String s) {
      return new Tuple2(s, 1);
    }
  }
);

JavaPairRDD<String, Integer> counts = ones.reduceByKey(
  new Function2<Integer, Integer, Integer>() {
    public Integer call(Integer i1, Integer i2) {
      return i1 + i2;
    }
  }
);
```

Java PageRank

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Developing in Local Mode

Just pass `local` or `local[k]` as master URL

Still serializes tasks to catch marshaling errors

Debug in any Java/Scala debugger

Running on a Cluster

Set up Mesos as per Spark wiki

» github.com/mesos/spark/wiki/Running-spark-on-mesos

Basically requires building Mesos and creating config files with locations of slaves

Pass `master:port` as URL (default port is 5050)

Running on EC2

Easiest way to launch a Spark cluster

```
git clone git://github.com/mesos/spark.git

cd spark/ec2

./spark-ec2 -k keypair –i id_rsa.pem –s slaves \
       [launch|stop|start|destroy] clusterName
```

Details: tinyurl.com/spark-ec2

Viewing Logs

Click through the web UI at `master:8080`

Or, look at `stdout` and `stdout` files in the Mesos "work" directories for your program, such as:

`/tmp/mesos/slaves/<SlaveID>/frameworks/<FrameworkID>/executors/0/runs/0/stderr`

FrameworkID is printed when Spark connects, SlaveID is printed when a task starts

Common Problems

Exceptions in tasks: will be reported at master

```
17:57:00 INFO TaskSetManager: Lost TID 1 (task 0.0:1)
17:57:00 INFO TaskSetManager: Loss was due to
java.lang.ArithmeticException: / by zero
   at BadJob$$anonfun$1.apply$mcII$sp(BadJob.scala:10)
   at BadJob$$anonfun$1.apply(BadJob.scala:10)
   at ...
```

Fetch failure: couldn't communicate with a node

- » Most likely, it crashed earlier
- » Always look at first problem in log

Common Problems

NotSerializableException:

- Set `sun.io.serialization.extendedDebugInfo=true` to get a detailed trace (in `SPARK_JAVA_OPTS`)
- Beware of closures using fields/methods of outer object (these will reference the whole object)

For More Help

Join the Spark Users mailing list:

groups.google.com/group/spark-users

Come to the Bay Area meetup:

www.meetup.com/spark-users