# Spark RDD

CELEBRATING 30 YEARS
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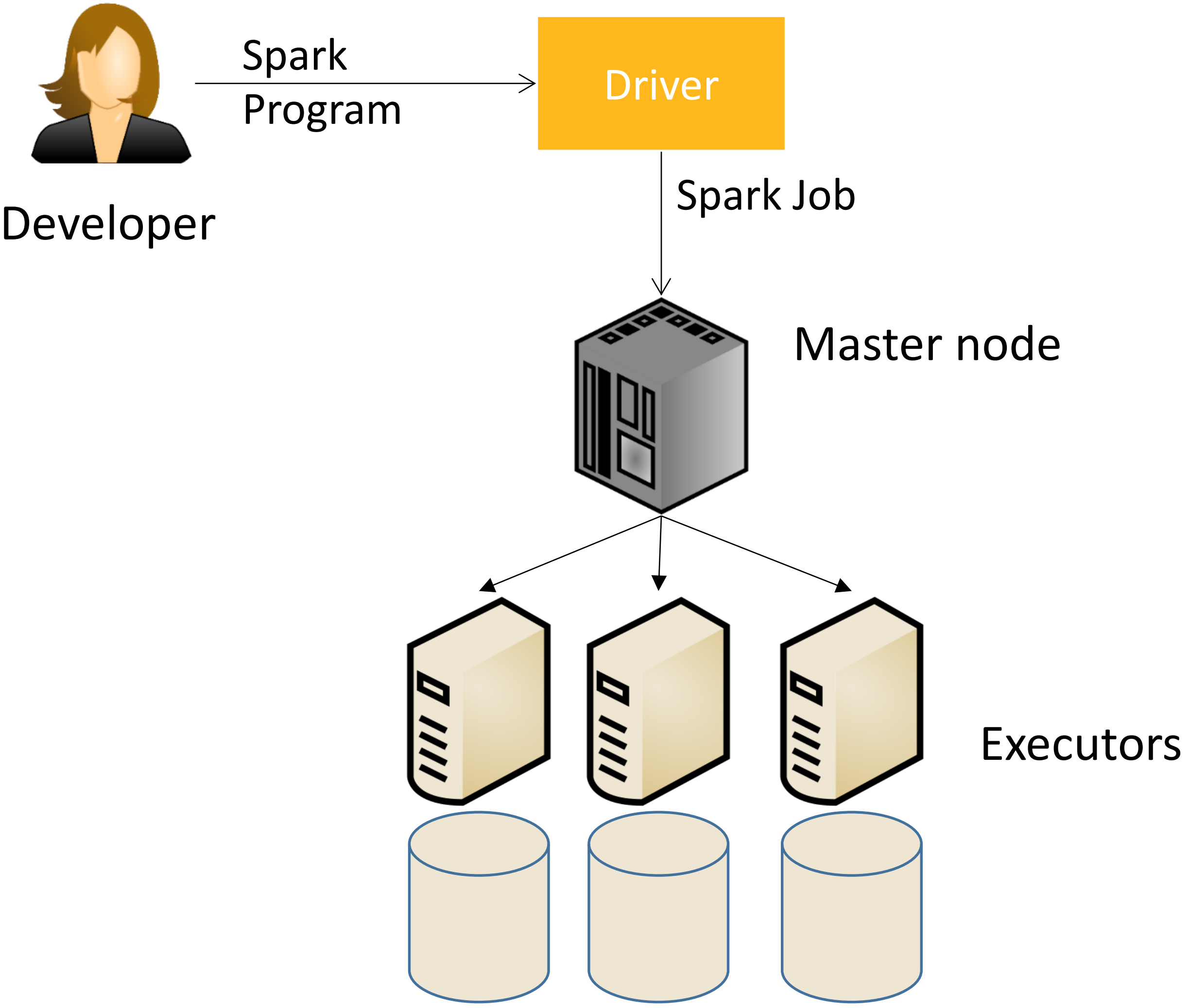
# Distributed Processing

- Once your data is stored in HDFS, the next step is to process it in parallel
- MapReduce
  - Abstracts your program in two functions, map and reduce
  - Was very limited and very low level

# RDD

- Resilient Distributed Datasets
- A distributed query processing engine
- The Spark counterpart to Hadoop MapReduce
- Designed for in-memory processing

# Spark High-level Architecture



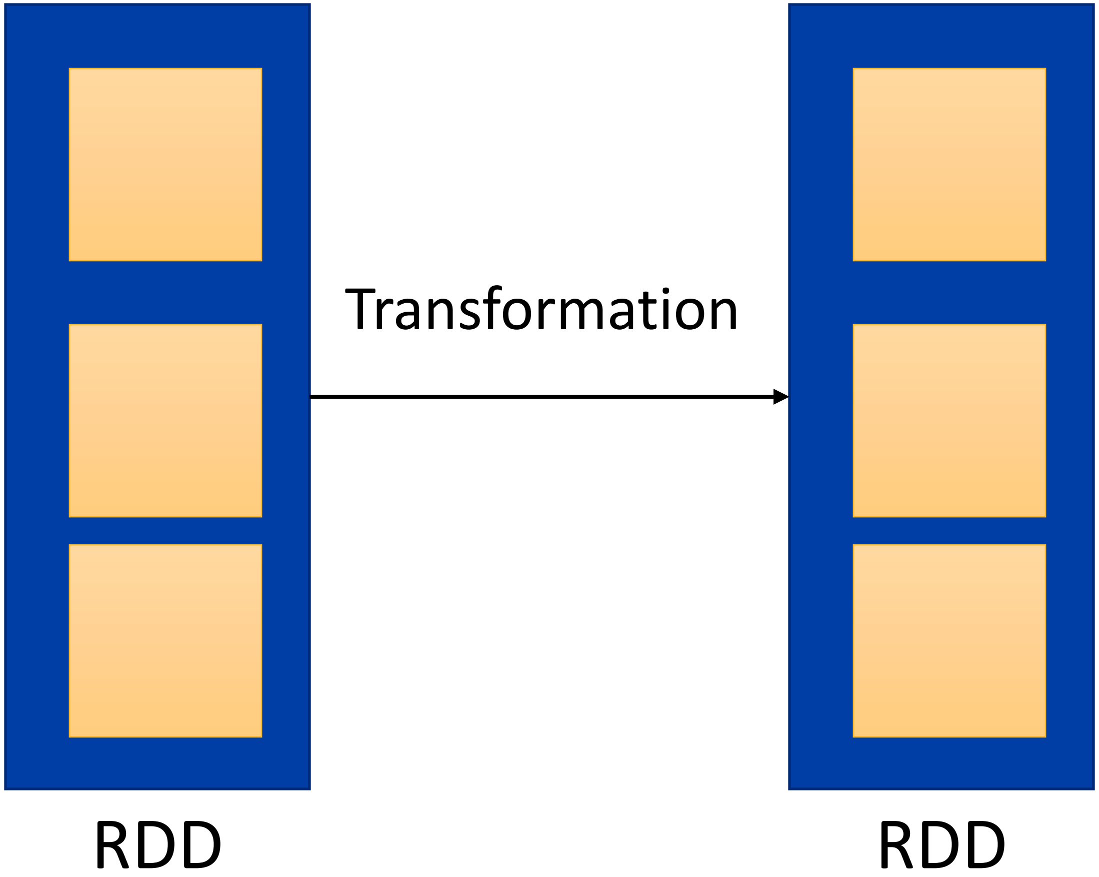
# RDD Abstraction

- RDD is a pointer to a distributed dataset
- Stores information about how to compute the data rather than where the data is
- Transformation: Converts an RDD to another RDD
- Action: Returns an answer of an operation over an RDD

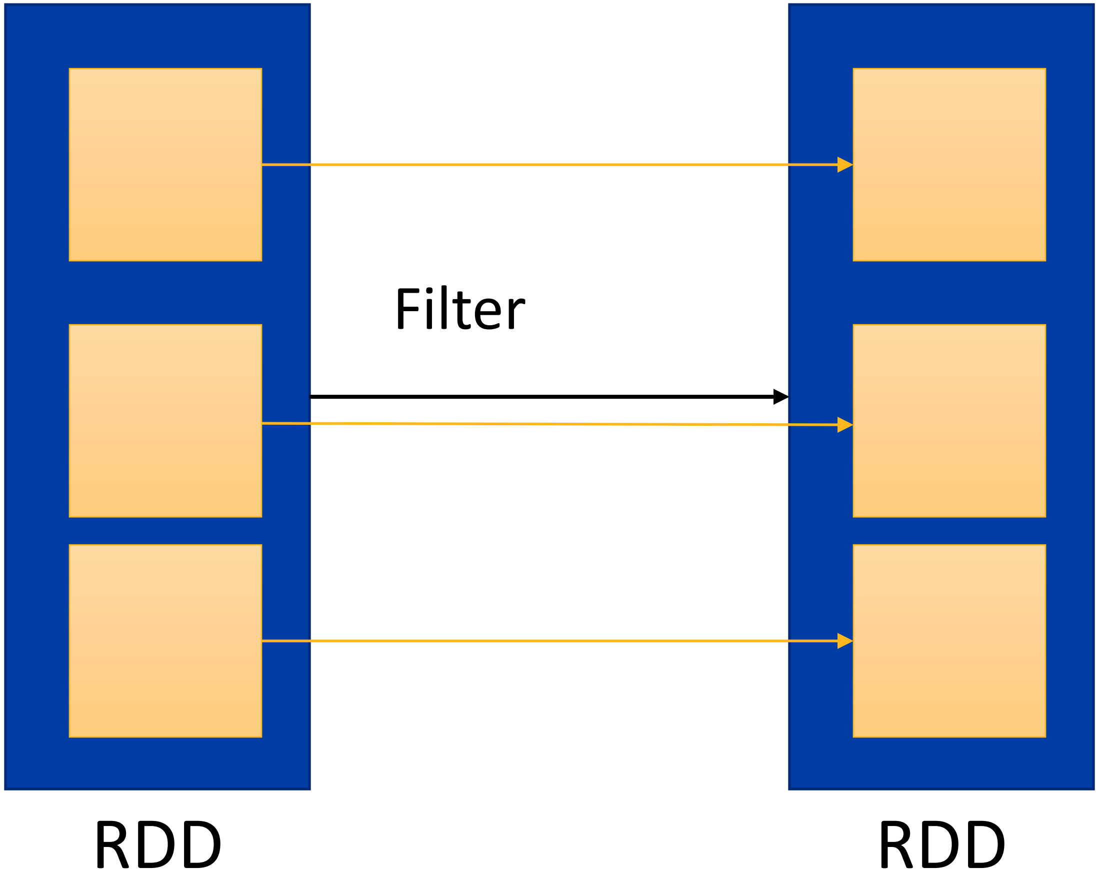
# Spark RDD Features

- Lazy execution: Collect transformations and execute on actions
- Lineage tracking: Keep track of the lineage of each RDD for fault-tolerance

# RDD



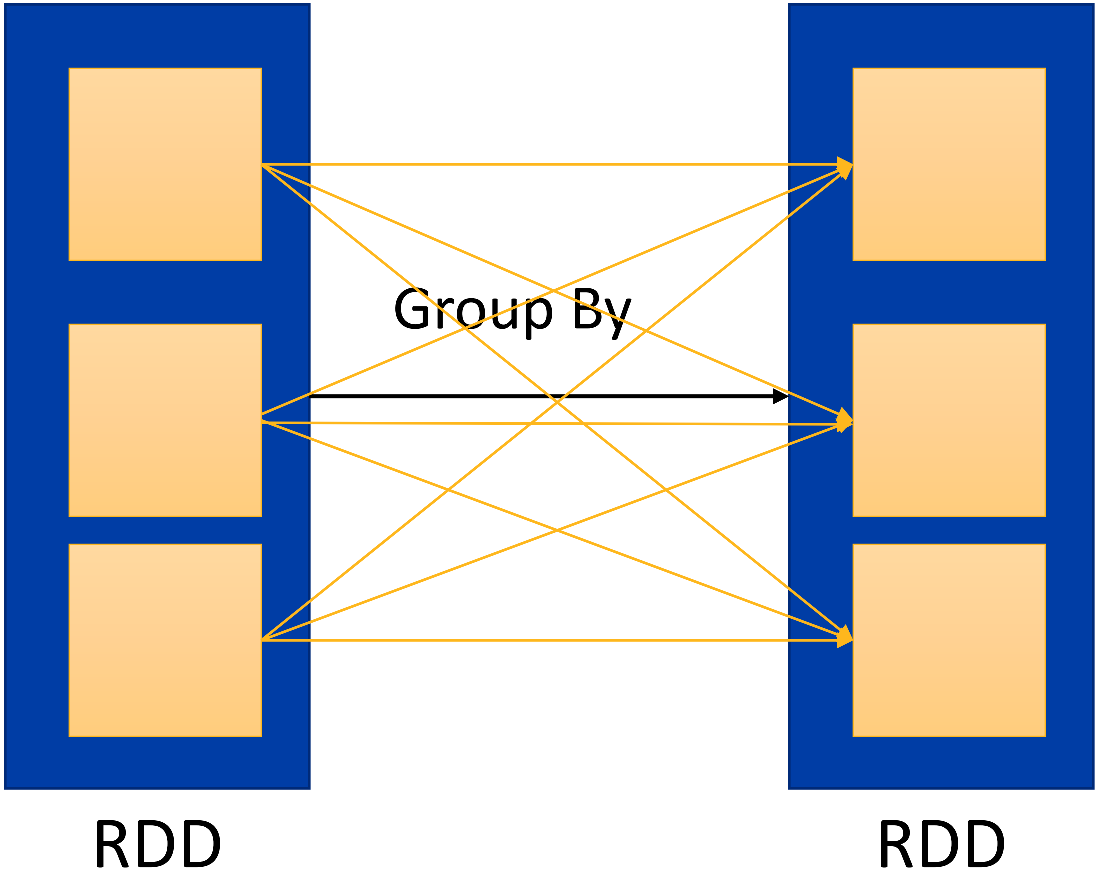
# Filter Operation



Similarly, the map (projection) operation

Narrow dependency

# GroupBy (Shuffle) Operation

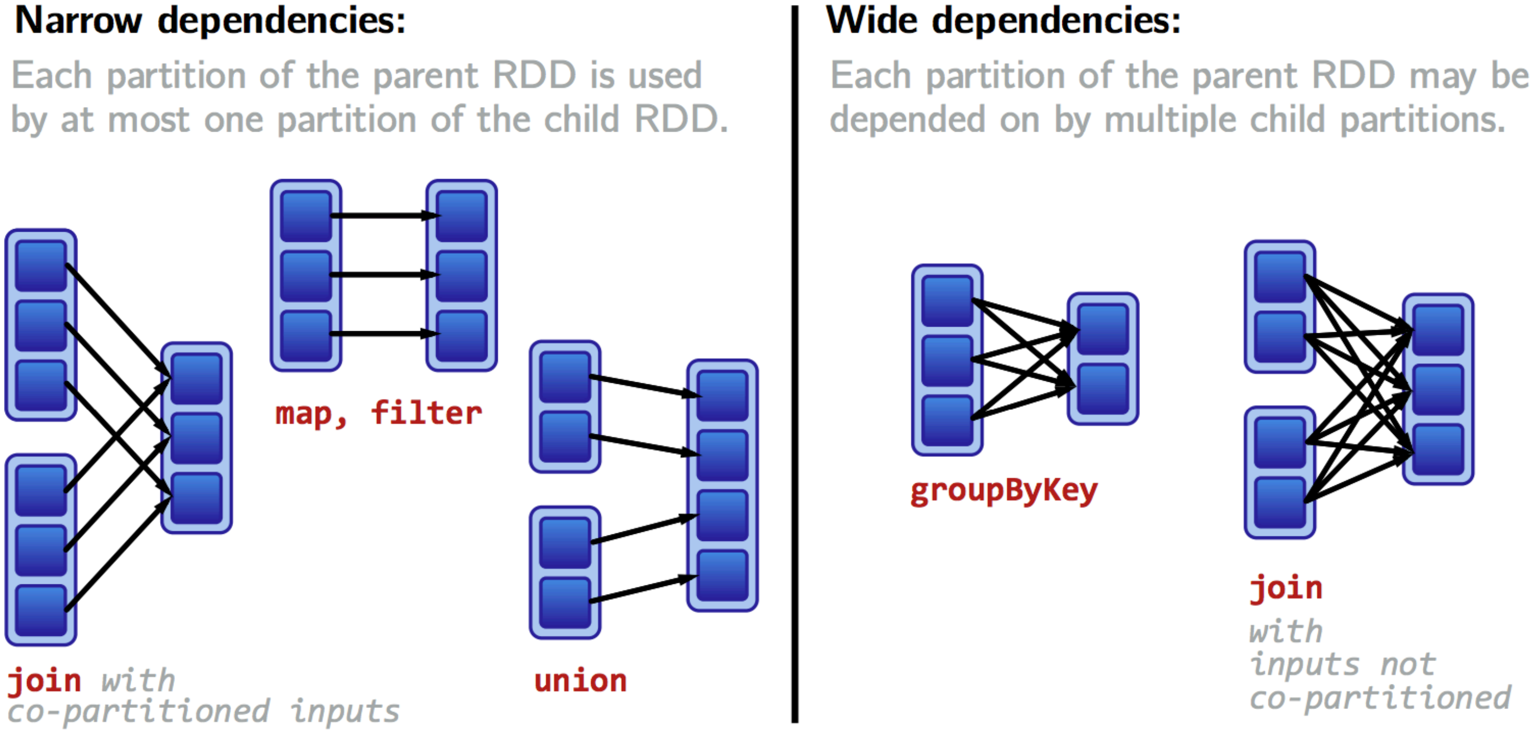


Similar operation **Join**

Wide dependency

# Types of Dependencies

- Narrow dependencies
- Wide dependencies



**Narrow dependencies:**

Each partition of the parent RDD is used by at most one partition of the child RDD.

**Wide dependencies:**

Each partition of the parent RDD may be depended on by multiple child partitions.

map, filter
join with co-partitioned inputs
union
groupByKey
join with inputs not co-partitioned

Credit: https://github.com/rohgar/scala-spark-4/wiki/Wide-vs-Narrow-Dependencies

# Examples of Transformations

- map
- mapToPair
- flatMap
- reduceByKey
- filter
- sample
- join
- union
- partitionBy

# Examples of Actions

- count
- collect
- save(path)
- persist
- reduce

# How RDD can be helpful

- Consolidate operations
  - Combine transformations
- Iterative operations
  - Keep the output of an iteration in memory till the next iteration
- Data sharing
  - Reuse the same data without having to read it multiple times

# Java Examples

- Apache Spark homepage
  - https://spark.apache.org

```
# Initialize the Spark context
JavaSparkContext spark =
    new JavaSparkContext("local", "CS226-Demo");
```

# Examples

```
# Initialize the Spark context
JavaSparkContext spark =
    new JavaSparkContext("local", "CS226-Demo");


# Hello World! Example. Count the number of lines in the file
JavaRDD<String> textFileRDD =
                  spark.textFile("nasa_19950801.tsv");
long count = textFileRDD.count();
System.out.println("Number of lines is "+count);
```

# Examples

```
# Count the number of OK lines (response code 200)
JavaRDD<String> okLines = textFileRDD.filter(new
Function<String, Boolean>() {
    @Override
    public Boolean call(String s) throws Exception {
        String code = s.split("\t")[5];
        return code.equals("200");
    }
});
long count = okLines.count();
System.out.println("Number of OK lines is "+count);
```

# Examples

```
# Count the number of OK lines (response code 200)
# Shorten the implementation using lambdas (Java 8 and above)
JavaRDD<String> okLines =
 textFileRDD.filter(s -> s.split("\t")[5].equals("200"));


long count = okLines.count();
System.out.println("Number of OK lines is "+count);
```

# Examples

```
# Make it parametrized by taking the response code as a
command line argument
String inputFileName = args[0];
String desiredResponseCode = args[1];
...
JavaRDD<String> textFileRDD = spark.textFile(inputFileName);
JavaRDD<String> okLines = textFileRDD.filter(new
Function<String, Boolean>() {
    @Override
    public Boolean call(String s) {
        String code = s.split("\t")[5];
        return code.equals(desiredResponseCode);
    }
});
```

# Examples

```
# Count by response code
# Important! Not all transformations and actions are on the
getting started guide
JavaPairRDD<Integer, String> linesByCode =
textFileRDD.mapToPair(new PairFunction<String, Integer,
String>() {
    @Override
    public Tuple2<Integer, String> call(String s) {
        String code = s.split("\t")[5];
        return new Tuple2<Integer,
String>(Integer.valueOf(code), s);
    }
});
Map<Integer, Long> countByCode = linesByCode.countByKey();
System.out.println(countByCode);
```

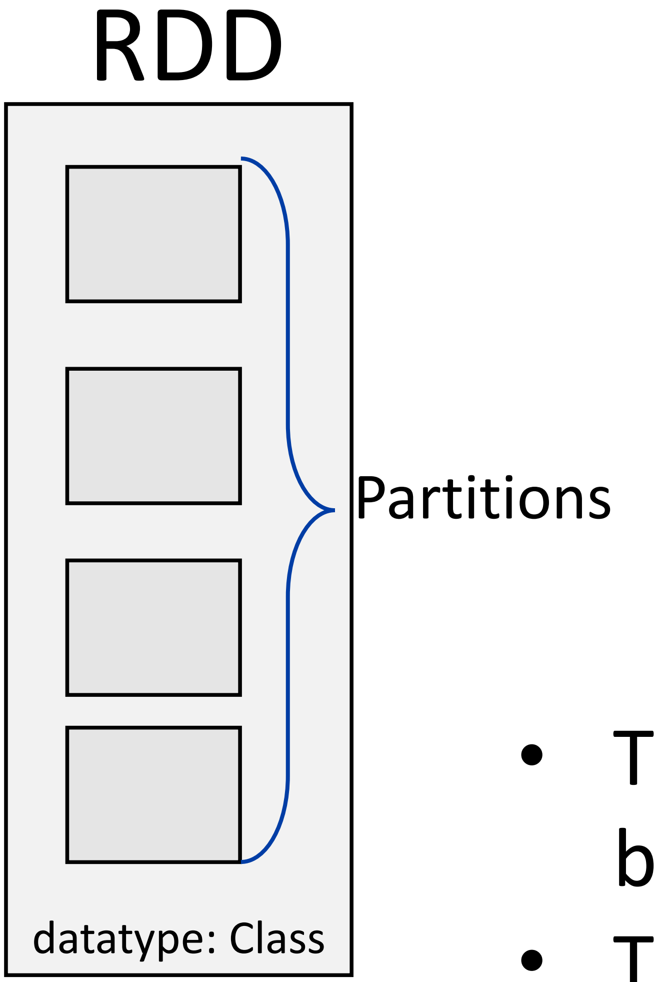
# How Spark RDD works internally

# Sample Program

```
JavaRDD<String> textFileRDD = spark.textFile(inputFileName);
JavaRDD<Long> lengths = textFileRDD
        .map(line => line.length());
long size = lengths.reduce((a,b) => a+b);
```

# RDD Creation

- sparkContext.textFile("…")



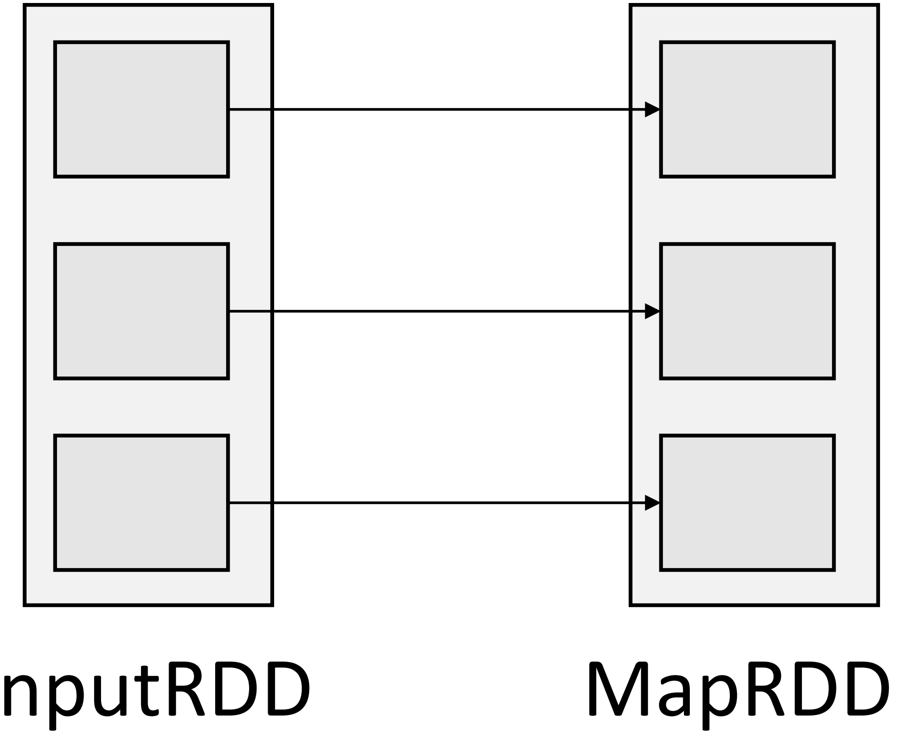
**Partition**

PartitionID: 0 → n-1
File: Path
Offset: Long
Length: Long
Locations: String[]

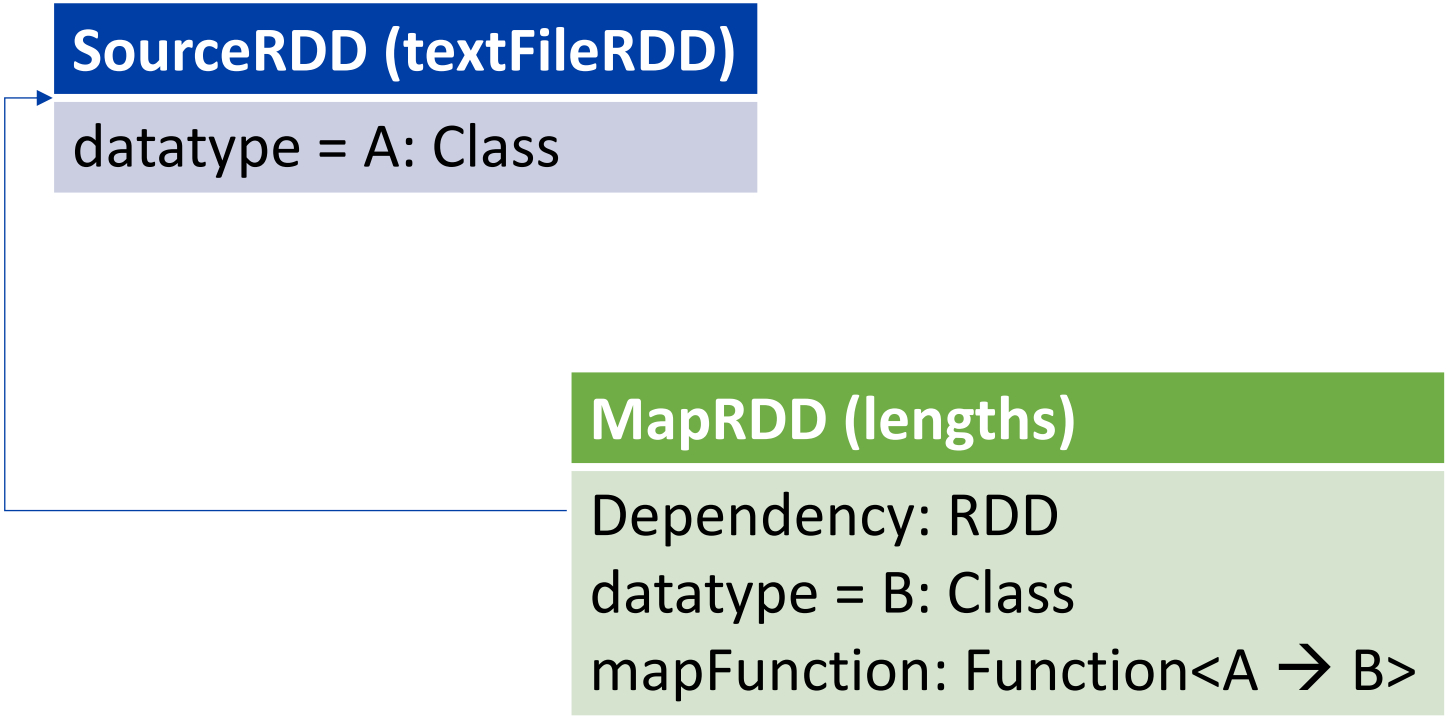
- The partitions are defined based on the metadata
- The file is not opened

# Transformations

- Transforms one RDD to another
- Does not apply the transformation immediately
- E.g., Map



# Map RDD



**SourceRDD (textFileRDD)**

datatype = A: Class

**MapRDD (lengths)**

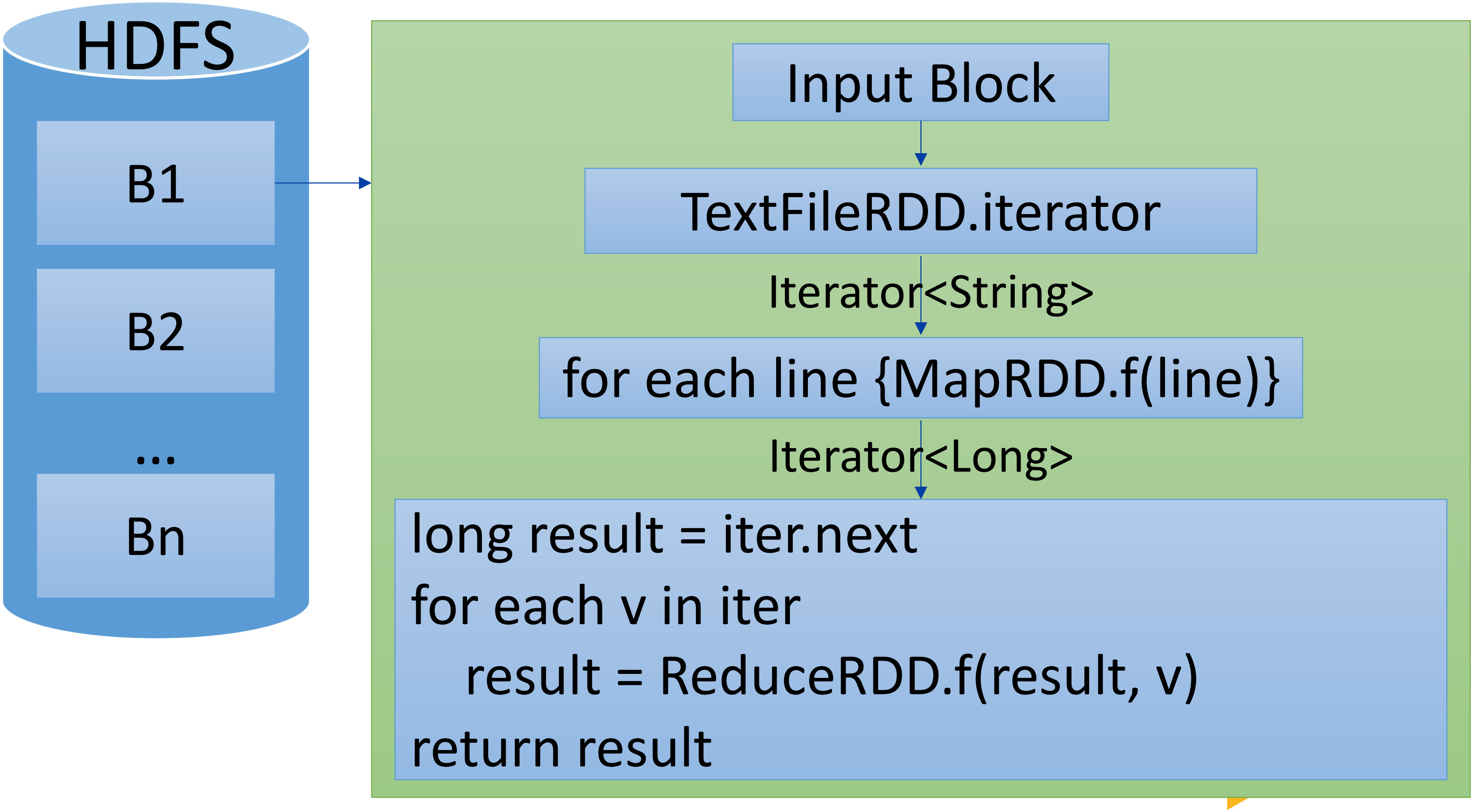
Dependency: RDD

datatype = B: Class

mapFunction: Function<A → B>

# Action: reduce(a+b)

- Launches the Spark job



HDFS

B1

B2

...

Bn

Input Block

TextFileRDD.iterator

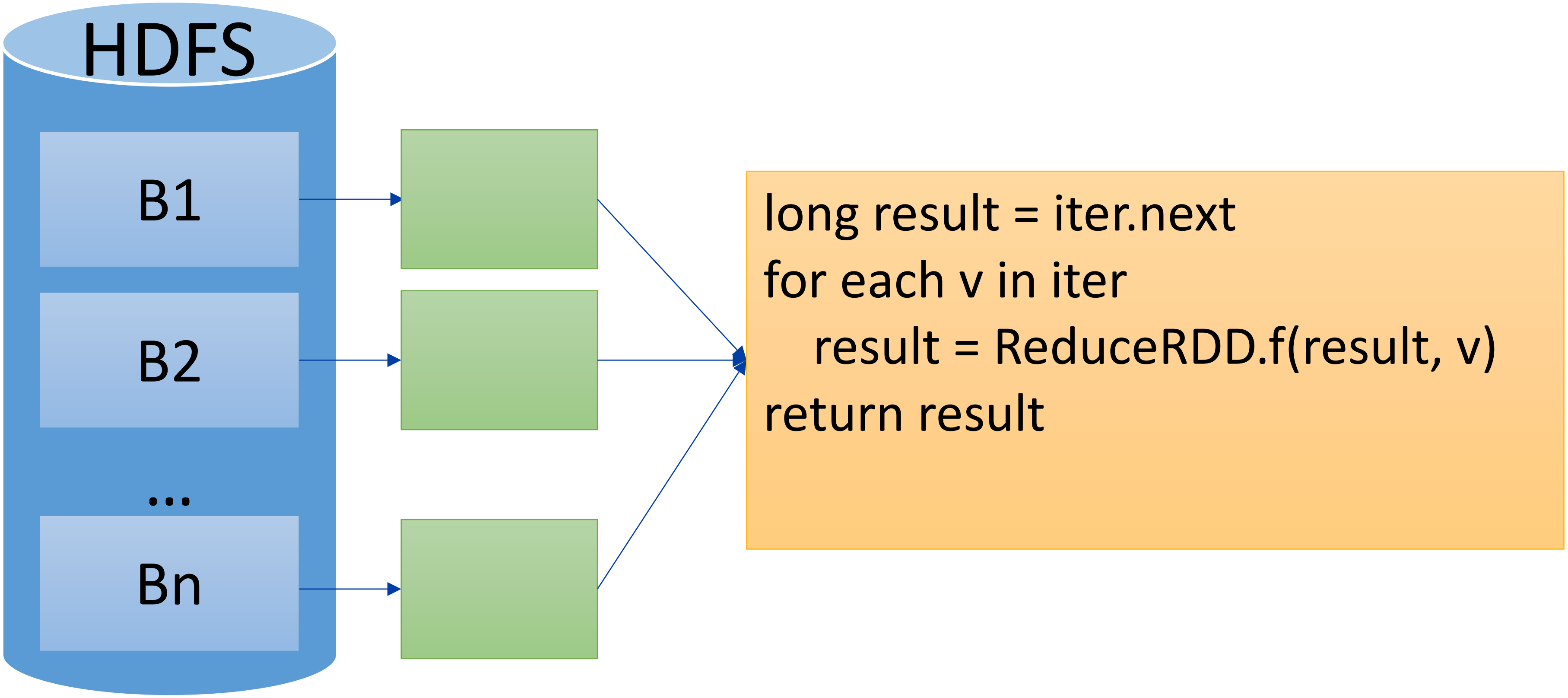
Iterator<String>

for each line {MapRDD.f(line)}

Iterator<Long>

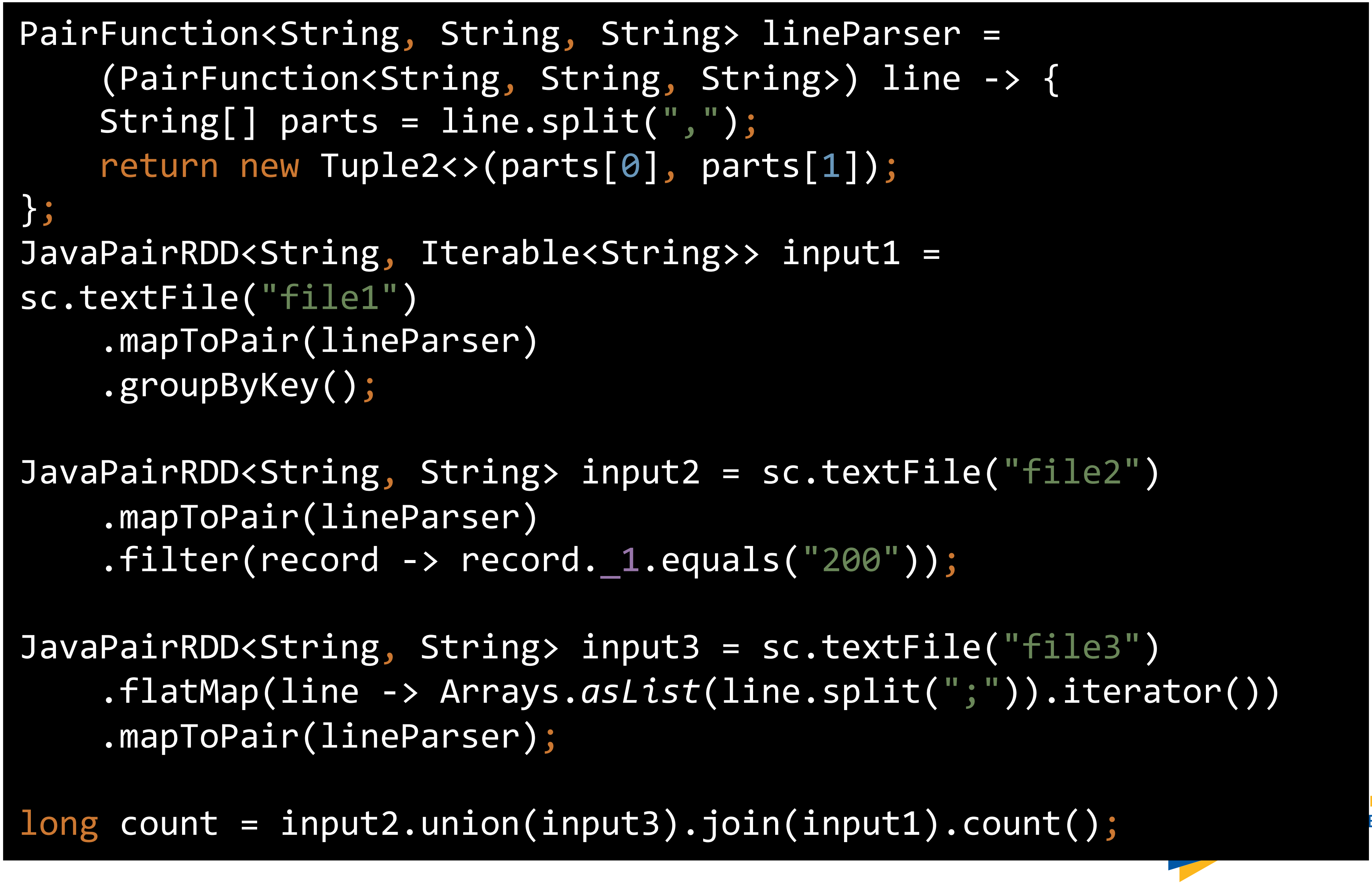
```
long result = iter.next
for each v in iter
    result = ReduceRDD.f(result, v)
return result
```

# Action: reduce(a+b)



```
long result = iter.next
for each v in iter
    result = ReduceRDD.f(result, v)
return result
```

# Running a complex DAG



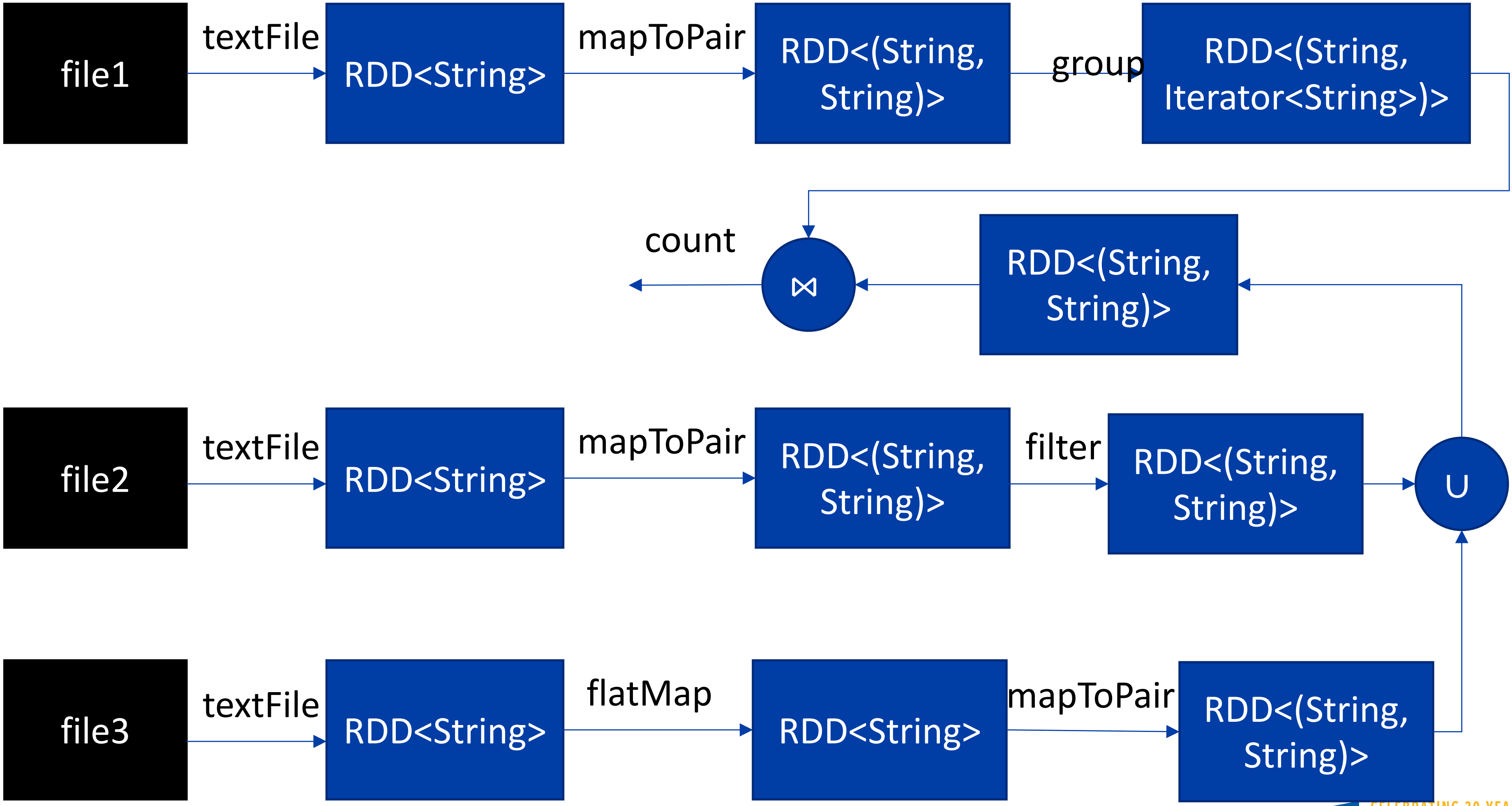
```
PairFunction<String, String, String> lineParser =
    (PairFunction<String, String, String>) line -> {
    String[] parts = line.split(",");
    return new Tuple2<>(parts[0], parts[1]);
};
JavaPairRDD<String, Iterable<String>> input1 =
sc.textFile("file1")
    .mapToPair(lineParser)
    .groupByKey();

JavaPairRDD<String, String> input2 = sc.textFile("file2")
    .mapToPair(lineParser)
    .filter(record -> record._1.equals("200"));

JavaPairRDD<String, String> input3 = sc.textFile("file3")
    .flatMap(line -> Arrays.asList(line.split(";")).iterator())
    .mapToPair(lineParser);

long count = input2.union(input3).join(input1).count();
```

# DAG Representation



# Further Reading

- Spark home page: http://spark.apache.org/
- Quick start: http://spark.apache.org/docs/latest/quick-start.html
- RDD documentation: http://spark.apache.org/docs/latest/rdd-programming-guide.html
- RDD Paper: Matei Zaharia *et al*. "Resilient Distributed Datasets: A Fault-tolerant Abstraction for In-memory Cluster Computing." NSDI’12