Lecture 5: Spark (continue)

COSC 526: Introduction to Data Mining

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Today Outline

- Log into your Jetstream account
- Complete discussion on Spark operations
- Zoom into WorkCount on Spark
  - What storage resources do we use and when
- Project
  - Two examples of projects: posters and 2-page abstract
- Assignment 5
- If time left, live chat with video

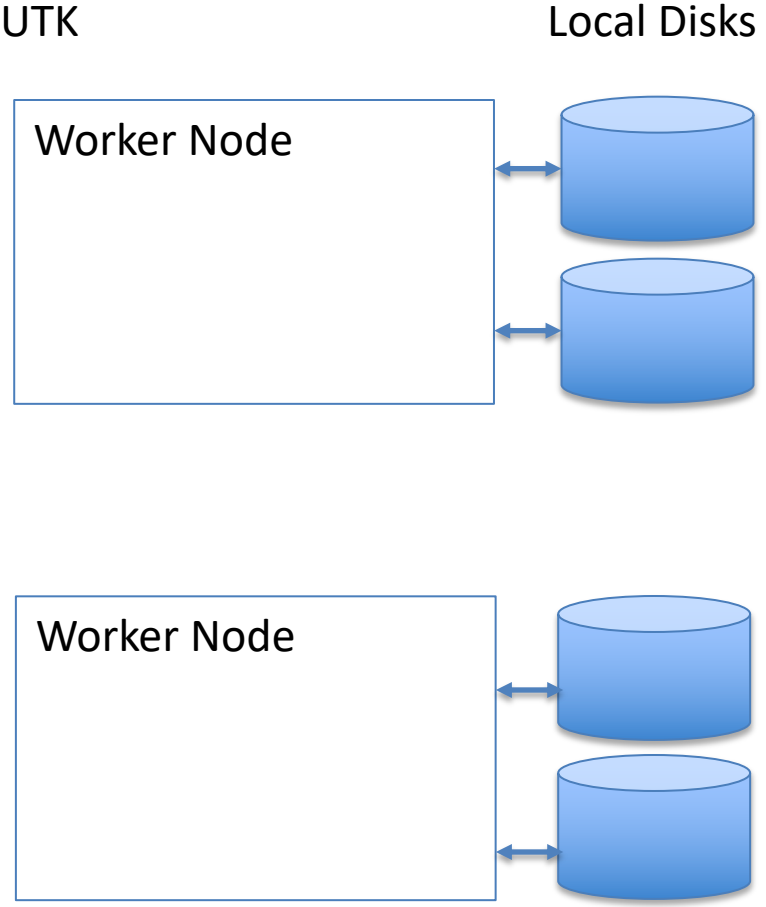
Spark Operations

Spark reference

4

Hypothetical Scenario

Your laptop is connected to two desktop at UTK



Hypothetical Scenario

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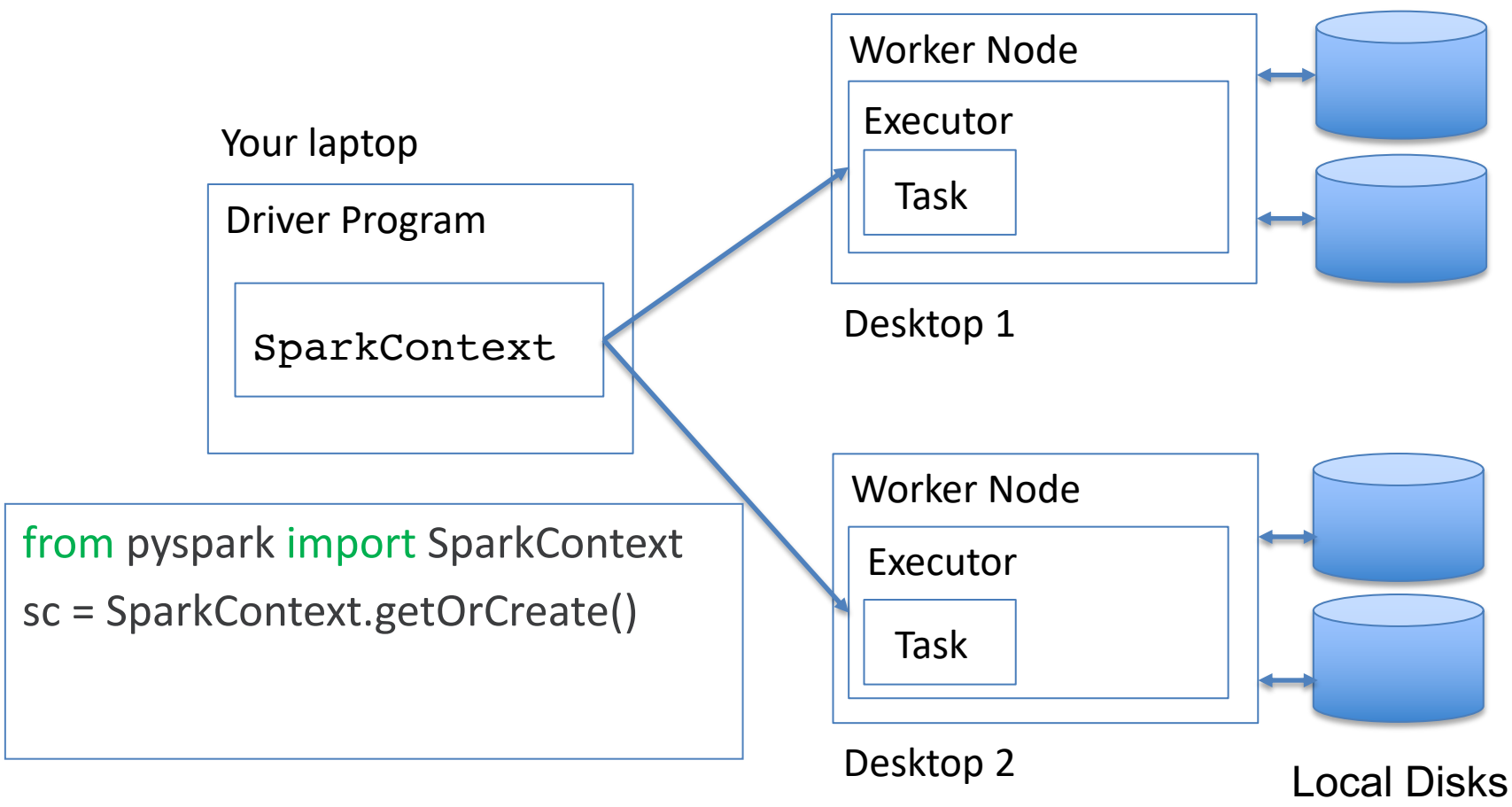
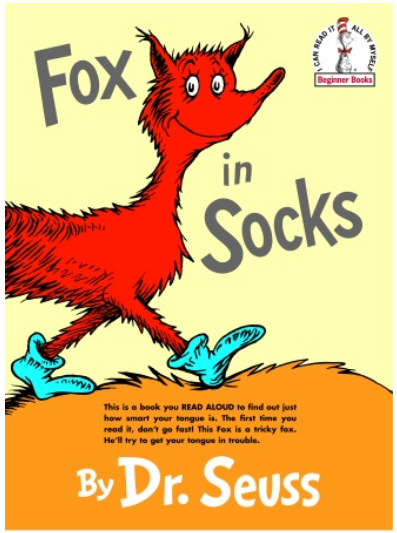



```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
```

Given the file “FoxInSocks.txt”

When tweetle beetles fight,
it’s called a tweetle beetle battle.
And when they battle in a puddle,
it’s a tweetle beetle puddle battle.
And when tweetle beetles battle with paddles in a puddle,
They call it a tweetle beetle puddle paddle battle.

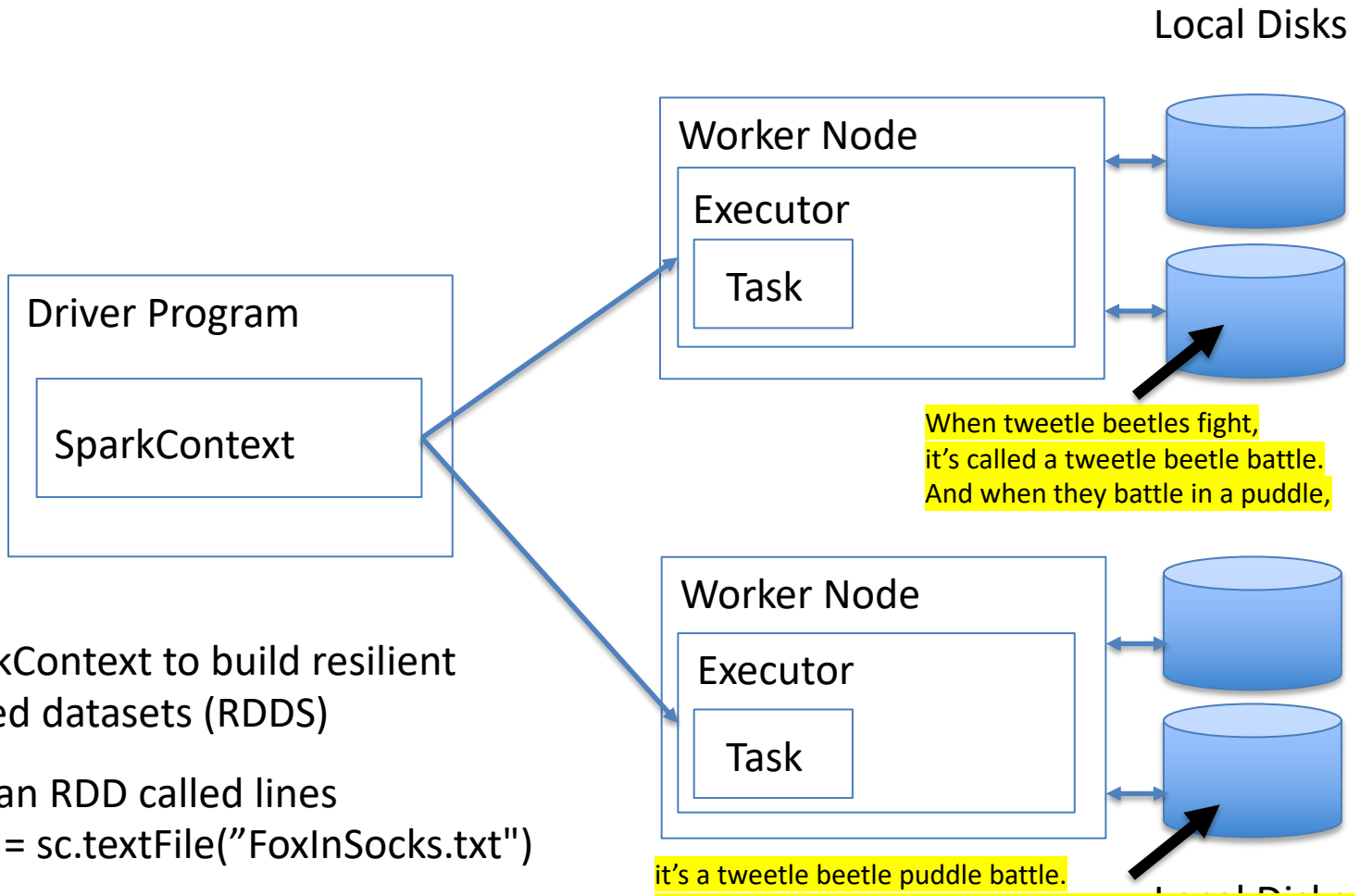



```
# Create an RDD called lines
>>> lines = sc.textFile(”FoxInSocks.txt")
```

File lines automatically distributed across nodes of 2-node cluster

Node 1	When tweetle beetles fight, it’s called a tweetle beetle battle. And when they battle in a puddle,
Node 2	it’s a tweetle beetle puddle battle. And when tweetle beetles battle with paddles in a puddle, They call it a tweetle beetle puddle paddle battle.

Spark Core Concepts



Use SparkContext to build resilient distributed datasets (RDDS)

```
# Create an RDD called lines
>>> lines = sc.textFile("FoxInSocks.txt")
```

Operations

- **Transformations:** lazily evaluated—no immediate computation
  - "Return" new RDDs obtained by transforming an old RDD
  - Input: RDD type → OPERATION → Output: RDD type
- **Actions:** cause all *queued* transformations to be applied
  - Return a list or value to the driver (serial) process
  - Input: RDD → OPERATION → Output: NOT a RDD type (e.g., integer)

Transformations I (Cont.)

From Book in Chap 2

- Transformations (lazily evaluated—no immediate computation)

Function Name	Purpose	Example	Result
map	Apply a function to each element in the RDD and return an RDD of the result	`rdd.map(x => x + 1)`	`{2, 3, 4, 4}`
flatMap	Apply a function to each element in the RDD and return an RDD of the contents of the iterators returned. Often used to extract words.	`rdd.flatMap(x => x.to(3))`	`{1, 2, 3, 2, 3, 3, 3}`
filter	Return an RDD consisting of only elements which pass the condition passed to filter	`rdd.filter(x => x != 1)`	`{2, 3, 3}`
distinct	Remove duplicates	`rdd.distinct()`	`{1, 2, 3}`
sample(withReplacement, fraction, [seed])	Sample an RDD	`rdd.sample(false, 0.5)`	non-deterministic

Transformations II (Cont.)

From Book in Chap 2

- Transformations (lazily evaluated—no immediate computation)

RDDs for the examples in the table:
rdd = {1, 2, 3}
other = {3, 4, 5}

Function Name	Purpose	Example	Result
union	Produce an RDD contain elements from both RDDs	`rdd.union(other)`	`{1, 2, 3, 3, 4, 5}`
intersection	RDD containing only elements found in both RDDs	`rdd.intersection(other)`	`{3}`
subtract	Remove the contents of one RDD (e.g. remove training data)	`rdd.subtract(other)`	`{1, 2}`
cartesian	Cartesian product with the other RDD	`rdd.cartesian(other)`	`{(1, 3), (1, 4), … (3,5)}`

Actions

From Book in Chap 2

RDD for the examples in the table:
rdd = {1, 2, 3, 3}

Function Name	Purpose	Example (In Scala)	Result
collect()	Return all elements from the RDD	`rdd.collect()`	`{1, 2, 3, 3}`
count()	Number of elements in the RDD	`rdd.count()`	`4`
take(num)	Return num elements from the RDD	`rdd.take(2)`	`{1, 2}`
top(num)	Return the top num elements the RDD	`rdd.top(2)`	`{3, 3}`
takeOrdered(num)(ordering)	Return num elements based on providing ordering	`rdd.takeOrdered(2)(myOrdering)`	`{3, 3}`

Function Name	Purpose	Example (In Scala)	Result
takeSample(withReplacement, num, [seed])	Return num elements at random	`rdd.takeSample(false, 1)`	non-deterministic
reduce(func)	Combine the elements of the RDD together in parallel (e.g. sum)	`rdd.reduce((x, y) => x + y)`	9
fold(zero)(func)	Same as reduce but with the provided zero value	`rdd.fold(0)((x, y) => x + y)`	9
aggregate(zeroValue)(seqOp, combOp)	Similar to reduce but used to return a different type	`rdd.aggregate(0, 0)({case (x, y) => (y._1() + x, y._2() + 1)}, {case (x, y) => (y._1() + x._1(), y._2() + x._2())})`	(9, 4)
foreach(func)	Apply the provided function to each element of the RDD	`rdd.foreach(func)`	nothing

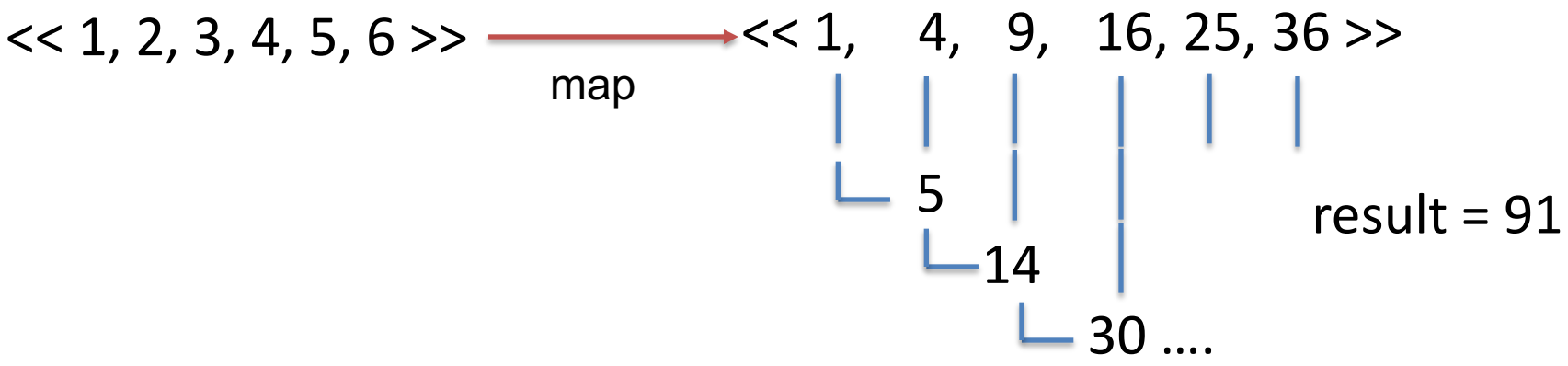
From Book in Chap 2

Use *reduce* Operation on Numbers

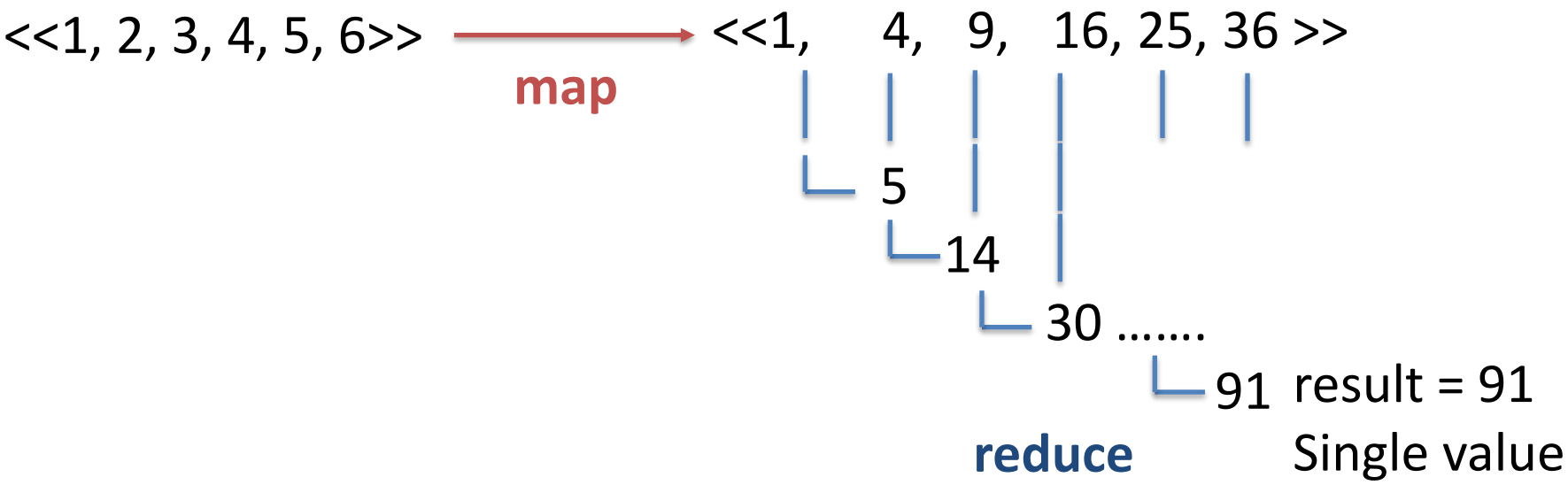
In [1]

```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()


numbers = sc.parallelize([1, 2, 3, 4, 5, 6])
squared = numbers.map(lambda x: x * x)
result = squared.reduce(lamba x, y: x+y) # single value
```

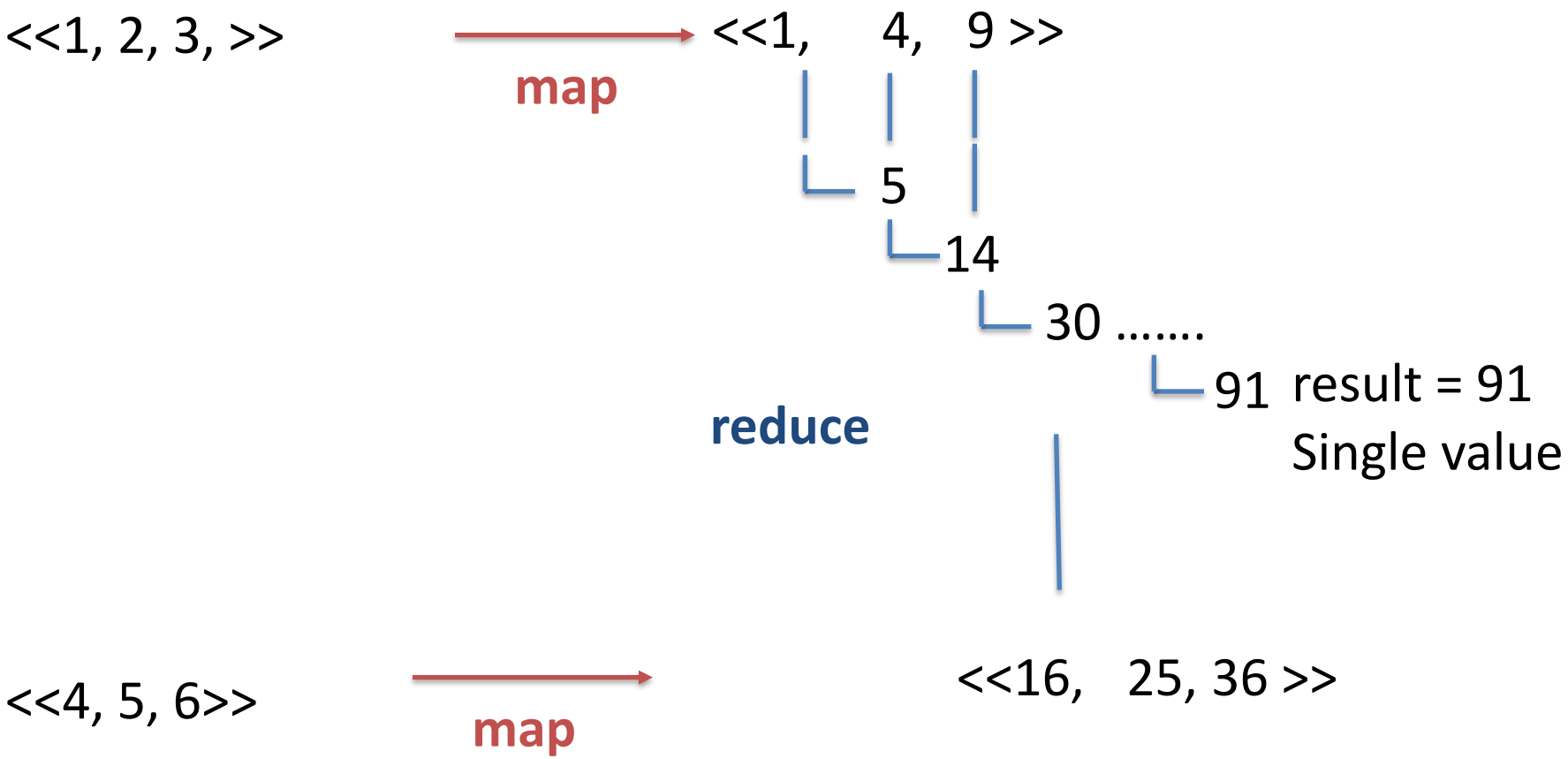


Use *reduce* Operation on Numbers (I)

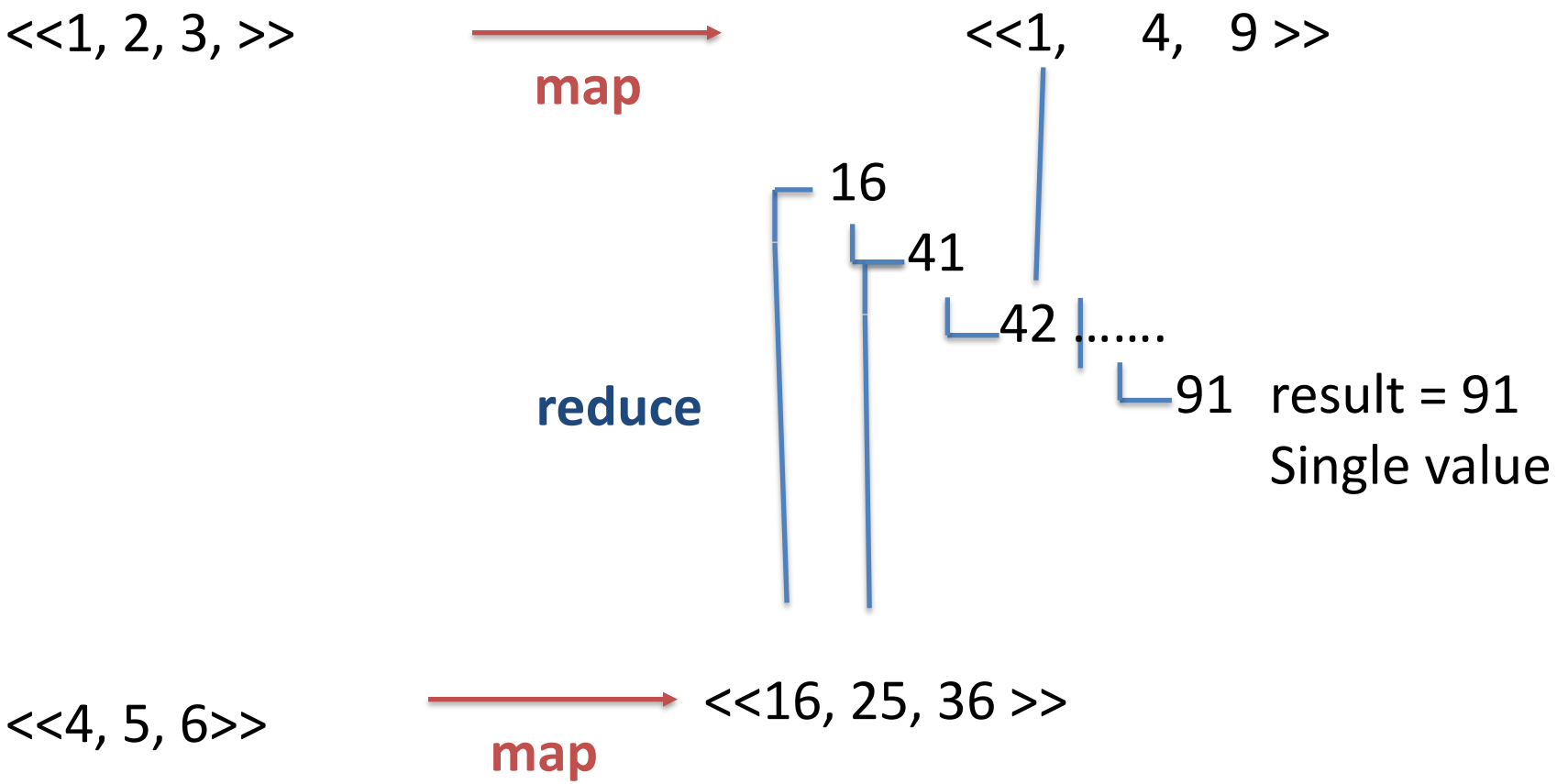


Note: Spark does **NOT** guarantee the order of operands

Use *reduce* Operation on Numbers (II)



Use *reduce* Operation on Numbers (III)



Use *reduceByKey* Operation on Numbers

This is an RDD

<< (B, 5), (B, 4),
(A,2), (B,3),
(A,1), (C, 0) >>

<< (B, 5), (B, 4),
(A,2), (B,3),
(A,1), (C, 0) >>

results = lists.**reduceByKey**(lamba x, y: x+y)

B [5, 4, 3] = 12
A [2, 1] = 3
C [0] = 0

<< (B, 12),
(A,3),
(C, 0) >>

This is an RDD

Given the file “FoxInSocks.txt”

When tweetle beetles fight,
it’s called a tweetle beetle battle.
And when they battle in a puddle,
it’s a tweetle beetle puddle battle.
And when tweetle beetles battle with paddles in a puddle,
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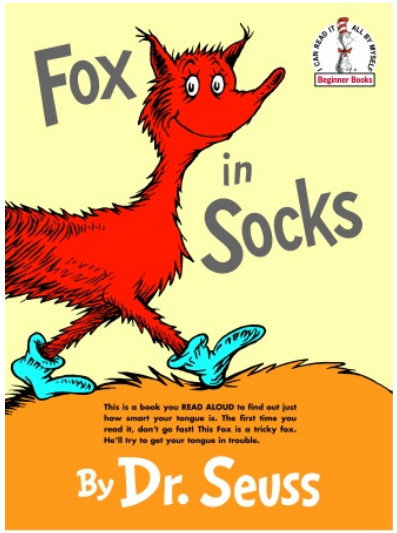

# Create an RDD called lines
>>> lines = sc.textFile(”FoxInSocks.txt")

File lines automatically distributed across nodes of 2-node cluster

Node 1	When tweetle beetles fight, it’s called a tweetle beetle battle. And when they battle in a puddle,
Node 2	it’s a tweetle beetle puddle battle. And when tweetle beetles battle with paddles in a puddle, They call it a tweetle beetle puddle paddle battle.

Create Key-Values in RDDs

In [3]

```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
lines = sc.textFile(”FoxInSocks.txt")
```

Node 1
<When tweetle beetles fight,>
<it’s called a tweetle beetle battle. >
<And when they battle in a puddle, >

Node 2
<it’s a tweetle beetle puddle battle. >
<And when tweetle beetles battle with paddles in a puddle,>
<They call it a tweetle beetle puddle paddle battle.>

Create Key-Values in RDDs

In [3]

```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
lines = sc.textFile(”FoxInSocks.txt")

pairs= lines.map(lambda x: (x.split(" ")[0], x))
```

Node 1
<When, When tweetle beetles fight,>
<it’s, it’s called a tweetle beetle battle. >
<And, And when they battle in a puddle, >

Node 2
<it’s, it’s a tweetle beetle puddle battle. >
<And, And when tweetle beetles battle with paddles in a puddle,>
<They, They call it a tweetle beetle puddle paddle battle.>

Create Key-Values in RDDs

In [3]

```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
lines = sc.textFile(”FoxInSocks.txt")

pairs= lines.map(lambda x: (x.split(" ")[0], x))
results = pairs.filter(lambda x: len(x[1]) < 28)
```

Node 1 <When, When tweetle beetles fight,>

Node 2

Create Key-Values in RDDs

In [3]

```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
lines = sc.textFile(”FoxInSocks.txt")

words = rdd.flatMap(lambda x: x.split(" "))
pairs= words.map(lambda x: (x, 1))
```

Node 1 <“When”,1)> <“tweetle”, 1> <“beetles”,1> <“fight”,1>
<it’s,1> <called,1> ….

Node 2 <“it’s”, 1> <“a”,1> <“tweetle”,1> <“beetle”,1> <“puddle”,1>
<“battle”,1><“And”, 1> …

Create Key-Values in RDDs

In [3]

```
from pyspark import SparkContext
sc = SparkContext.getOrCreate()
lines = sc.textFile(”FoxInSocks.txt")

words = rdd.flatMap(lambda x: x.split(" "))
pairs= words.map(lambda x: (x, 1))
results = pairs.reduceByKey(lambda x, y: x + y)
```

Node 1 <“When”,2)> <“tweetle”, 2> <“beetles”,1> <“fight”,1>
<it’s,1> <called,1> ….

Node 2 <“it’s”, 1> <“a”,3> <“tweetle”,3> <“beetle”,2> <“puddle”,2>
<“battle”,2><“And”, 1> …

The Special Case of *ReduceByKey*

- Reduce takes a function and use it to combine values
- ReduceByKey takes a function and use it to combine values
- BUT ReduceByKey **DO NOT** implemented as an action
  - Return a new RDD consisting of each key and the reduced value for that key

WHY?

The Special Case of *ReduceByKey*

- Reduce takes a function and use it to combine values
- ReduceByKey takes a function and use it to combine values
- BUT ReduceByKey **DO NOT** implemented as an action
  - Return a new RDD consisting of each key and the reduced value for that key

WHY?

- *reduceByKey* runs several parallel reduce operations:
  - one for each key in the dataset
  - each operation combines values together which have the same key.
- Datasets can have very large numbers of keys!!!!

WordCount Benchmark

In [4]

```
# Initializing Spark in Python
from pyspark import SparkContext, SparkConf
conf = SparkConf().setMaster("local").setAppName("WordCount")
sc = SparkContext(conf=conf)
```

WordCount Benchmark

In [4]

```
# Initializing Spark in Python
from pyspark import SparkContext, SparkConf
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sc = SparkContext(conf=conf)
```

cluster URL

application name

WordCount Benchmark

In [4]

```
# Initializing Spark in Python
from pyspark import SparkContext, SparkConf
conf = SparkConf().setMaster("local").setAppName("WordCount")
sc = SparkContext(conf=conf)


lines  = sc.textFile("FoxInSocks.txt")
words  = lines.flatMap(lambda line: line.split())
pairs  = words.map(lambda word: (word, 1))
counts = pairs.reduceByKey(lambda a, b: a+b) # counts is an RDD!
```

cluster URL

application name

WordCount Benchmark

In [4]

```
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from pyspark import SparkContext, SparkConf
conf = SparkConf().setMaster("local").setAppName("WordCount")
sc = SparkContext(conf=conf)


lines  = sc.textFile("FoxInSocks.txt")
words  = lines.flatMap(lambda line: line.split())
pairs  = words.map(lambda word: (word, 1))
counts = pairs.reduceByKey(lambda a, b: a+b) # counts is an RDD!

results = counts.collect()
```

cluster URL

application name

WordCount Benchmark

In [4]

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from pyspark import SparkContext, SparkConf
conf = SparkConf().setMaster("local").setAppName("WordCount")
sc = SparkContext(conf=conf)


lines  = sc.textFile("FoxInSocks.txt")
words  = lines.flatMap(lambda line: line.split())
pairs  = words.map(lambda word: (word, 1))
counts = pairs.reduceByKey(lambda a, b: a+b) # counts is an RDD!

results = counts.collect()
```

cluster URL

application name

Invoke the **action collect()** which brings all the elements of the RDD counts to the driver.
The action causes all the queued up transformations to be applied.

Practical Problems
–
The MapReduce Sequential Implementation

Assignment 5

- Python has map and reduce functions:
  - Do not take advantage of parallel processing (i.e., they are sequential)
- Define three methods:
  (i.e., mapSequential, reduceSequential,
  and reduceByKeySequential)
- Extend Python's map and reduce functions to act like those in *Apache Spark*

Deadline: ***February 19 - 8AM ET***

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