



Big Data TechCon, April 2013
dean.wampler@thinkbiganalytics.com
polyglotprogramming.com/talks



Scalding for Hadoop

Monday, March 25, 13

Using Scalding to leverage Cascading to write MapReduce jobs. Some prior exposure to Cascading is useful, but not assumed.
(All photos are © Dean Wampler, 2005–2013, All Rights Reserved. Otherwise, the presentation is free to use.)

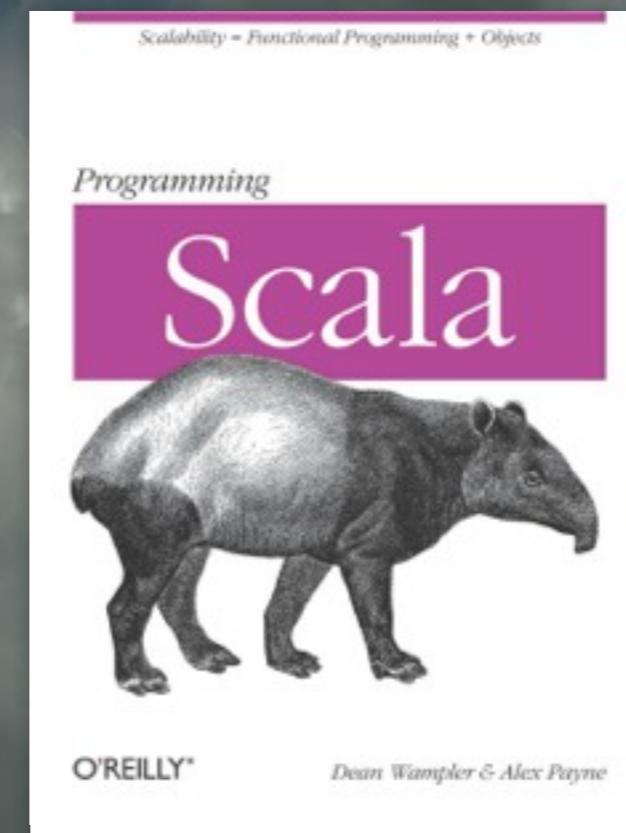
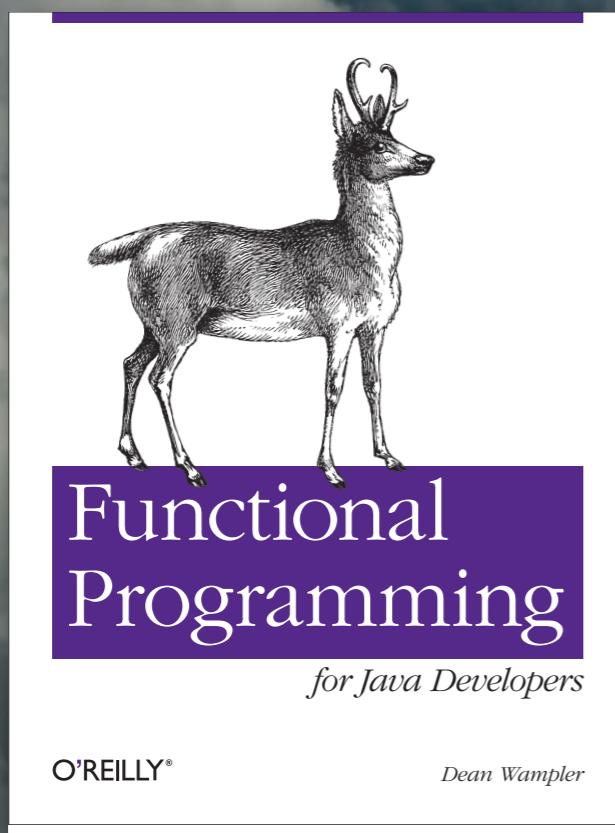
About Me...

dean.wampler@thinkbiganalytics.com

[@deanwampler](https://twitter.com/deanwampler)

github.com/thinkbiganalytics

github.com/deanwampler



Monday, March 25, 13

My books and contact information.

My Sessions

Talks:
Beyond MapReduce
Scalding for Hadoop

Tutorials
Hadoop Data Warehousing with Hive
Crash Course in Machine Learning

Monday, March 25, 13

A busy conference for me!!

How many of you have
all the time in the world
to get your work done?

How many of you have
all the time in the world
to get your work *done*?

Then why are you
doing *this*:

```

import org.apache.hadoop.io.*;
import org.apache.hadoop.mapred.*;
import java.util.StringTokenizer;

class WCMapper extends MapReduceBase
    implements Mapper<LongWritable, Text, Text, IntWritable> {

    static final IntWritable one = new IntWritable(1);
    static final Text word = new Text(); // Value will be set in a non-thread-safe way!

    @Override
    public void map(LongWritable key, Text valueDocContents,
        OutputCollector<Text, IntWritable> output, Reporter reporter) {
        String[] tokens = valueDocContents.toString().split("\\s+");
        for (String wordString: tokens) {
            if (wordString.length > 0) {
                word.set(wordString.toLowerCase());
                output.collect(word, one);
            }
        }
    }
}

class Reduce extends MapReduceBase
    implements Reducer[Text, IntWritable, Text, IntWritable] {

    public void reduce(Text keyword, java.util.Iterator<IntWritable> valuesCounts,
        OutputCollector<Text, IntWritable> output, Reporter reporter) {
        int totalCount = 0;
        while (valuesCounts.hasNext()) {
            totalCount += valuesCounts.next().get();
        }
        output.collect(keyword, new IntWritable(totalCount));
    }
}

```

The “simple”
Word Count
algorithm

This is intentionally too small to read and we’re not showing the main routine, which roughly doubles the code size. The “Word Count” algorithm is simple, but the Hadoop MapReduce framework is in your face. It’s very hard to see the actual “business logic”. Plus, your productivity is terrible. Yet, many Hadoop developers insist on working this way...

The main routine I’ve omitted contains boilerplate details for configuring and running the job. This is just the “core” MapReduce code. In fact, Word Count is not too bad, but when you get to more complex algorithms, even conceptually simple ideas like relational-style joins and group-bys, the corresponding MapReduce code in this API gets very complex and tedious very fast!

Notice the green, which I use for all the types, most of which are infrastructure types we don’t really care about. There is little yellow, which are function calls that do work. We’ll see how these change...

```

import org.apache.hadoop.io.*;
import org.apache.hadoop.mapred.*;
import java.util.StringTokenizer;

class WCMapper extends MapReduceBase
    implements Mapper<LongWritable, Text, Text, IntWritable> {

    static final IntWritable one = new IntWritable(1);
    static final Text word = new Text(); // Value will be set in a non-thread-safe way!

    @Override
    public void map(LongWritable key, Text valueDocContents,
        OutputCollector<Text, IntWritable> output, Reporter reporter) {
        String[] tokens = valueDocContents.toString().split("\\s+");
        for (String wordString: tokens) {
            if (wordString.length > 0) {
                word.set(wordString.toLowerCase());
                output.collect(word, one);
            }
        }
    }
}

class Reduce extends MapReduceBase
    implements Reducer[Text, IntWritable, Text, IntWritable] {

    public void reduce(Text keyword, java.util.Iterator<IntWritable> valuesCounts,
        OutputCollector<Text, IntWritable> output, Reporter reporter) {
        int totalCount = 0;
        while (valuesCounts.hasNext())
            totalCount += valuesCounts.
        }
        output.collect(keyword, new IntWritable(totalCount));
    }
}

```

Green
types.

Yellow
operations.

This is intentionally too small to read and we're not showing the main routine, which roughly doubles the code size. The "Word Count" algorithm is simple, but the Hadoop MapReduce framework is in your face. It's very hard to see the actual "business logic". Plus, your productivity is terrible. Yet, many Hadoop developers insist on working this way...

The main routine I've omitted contains boilerplate details for configuring and running the job. This is just the "core" MapReduce code. In fact, Word Count is not too bad, but when you get to more complex algorithms, even conceptually simple ideas like relational-style joins and group-bys, the corresponding MapReduce code in this API gets very complex and tedious very fast!

Notice the green, which I use for all the types, most of which are infrastructure types we don't really care about. There is little yellow, which are function calls that do work. We'll see how these change...

Your tools should:

*Minimize boilerplate
by exposing the
right abstractions.*

Your tools should:

*Maximize expressiveness
and extensibility.*

Monday, March 25, 13

Expressiveness – ability to tell the system what you need done.

Extensibility – ability to add functionality to the system when it doesn't already support some operation you need.



Use Cascading (Java)

(Solution #1)

10

Monday, March 25, 13

Cascading is a Java library that provides higher-level abstractions for building data processing pipelines with concepts familiar from SQL such as a joins, group-bys, etc. It works on top of Hadoop's MapReduce and hides most of the boilerplate from you.

See <http://cascading.org>.

```

import org.cascading.*;
...
public class WordCount {
    public static void main(String[] args) {
        Properties properties = new Properties();
        FlowConnector.setApplicationJarClass( properties, WordCount.class );

        Scheme sourceScheme = new TextLine( new Fields( "line" ) );
        Scheme sinkScheme = new TextLine( new Fields( "word", "count" ) );
        String inputPath = args[0];
        String outputPath = args[1];
        Tap source = new Hfs( sourceScheme, inputPath );
        Tap sink = new Hfs( sinkScheme, outputPath, SinkMode.REPLACE );

        Pipe assembly = new Pipe( "wordcount" );

        String regex = "(?<!\\pL)(?=\\pL)[^ ]*(?<=\\pL)(?!\\pL)";
        Function function = new RegexGenerator( new Fields( "word" ), regex );
        assembly = new Each( assembly, new Fields( "line" ), function );
        assembly = new GroupBy( assembly, new Fields( "word" ) );
        Aggregator count = new Count( new Fields( "count" ) );
        assembly = new Every( assembly, count );

        FlowConnector flowConnector = new FlowConnector( properties );
        Flow flow = flowConnector.connect( "word-count", source, sink, assembly );
        flow.complete();
    }
}

```

11

Monday, March 25, 13

Here is the Cascading Java code. It's cleaner than the MapReduce API, because the code is more focused on the algorithm with less boilerplate, although it looks like it's not that much shorter. HOWEVER, this is all the code, where as previously I omitted the setup (main) code. See <http://docs.cascading.org/cascading/1.2/userguide/html/ch02.html> for details of the API features used here; we won't discuss them here, but just mention some highlights.

Note that there is still a lot of green for types, but now they are almost all domain-related concepts and less infrastructure types. The infrastructure is less "in your face." There is still little yellow, because Cascading has to wrap behavior in Java classes, like GroupBy, Each, Count, etc. Also, the API emphasizes composing behaviors together in an intuitive and powerful way.

```

import org.cascading.*;
...
public class WordCount {
    public static void main(String[] args) {
        Properties properties = new Properties();
        FlowConnector.setApplicationJarClass( properties, WordCount.class );

        Scheme sourceScheme = new TextLine( new Fields( "line" ) );
        Scheme sinkScheme = new TextLine( new Fields( "word", "count" ) );
        String inputPath = args[0];
        String outputPath = args[1];
        Tap source = new Hfs( sourceScheme, inputPath );
        Tap sink = new Hfs( sinkScheme, outputPath, SinkMode.REPLACE );

        Pipe assembly = new Pipe( "wordcount" );

        String regex = "(?<!\\pL)(?=\\pL)[^ ]*(?<=\\pL)(?!\\pL)";
        Function function = new RegexGenerator( new Fields( "word" ), regex );
        assembly = new Each( assembly, new Fields( "line" ), function );
        assembly = new GroupBy( assembly, new Fields( "word" ) );
        Aggregator count = new Count( new Fields( "count" ) );
        assembly = new Every( assembly, count );

        FlowConnector flowConnector = new FlowConnector( properties );
        Flow flow = flowConnector.connect( "word-count".source.sink.assembly );
        flow.
    }
}

```

“Flow” setup.

Input and
output taps.

Assemble
pipes.

Monday, March 25, 13

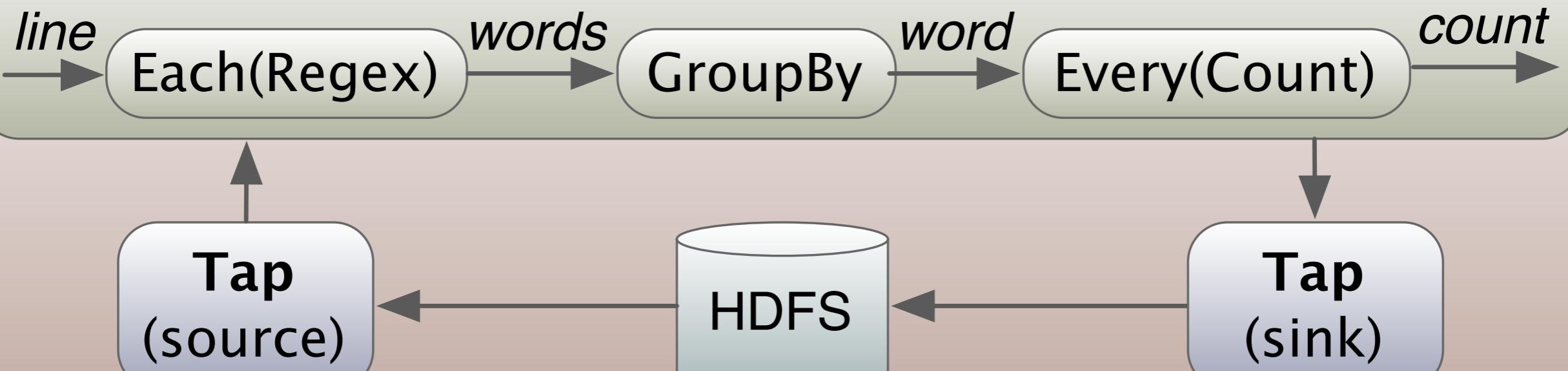
Here is the Cascading Java code. It's cleaner than the MapReduce API, because the code is more focused on the algorithm with less boilerplate, although it looks like it's not that much shorter. HOWEVER, this is all the code, where as previously I omitted the setup (main) code. See <http://docs.cascading.org/cascading/1.2/userguide/html/ch02.html> for details of the API features used here; we won't discuss them here, but just mention some highlights.

Note that there is still a lot of green for types, but now they are almost all domain-related concepts and less infrastructure types. The infrastructure is less “in your face.” There is still little yellow, because Cascading has to wrap behavior in Java classes, like GroupBy, Each, Count, etc. Also, the API emphasizes composing behaviors together in an intuitive and powerful way.

Word Count

Flow

Pipe ("word count assembly")



Copyright © 2011-2012, Think Big Analytics, All Rights Reserved

Monday, March 25, 13

Schematically, here is what Word Count looks like in Cascading. See <http://docs.cascading.org/cascading/1.2/userguide/html/ch02.html> for details.

Use Scalding (Scala)

(Solution #2)

14

Monday, March 25, 13

Scalding is a Scala “DSL” (domain-specific language) that wraps Cascading providing an even more intuitive and more boilerplate-free API for writing MapReduce jobs. <https://github.com/twitter/scalding>

Scala is a new JVM language that modernizes Java’s object-oriented (OO) features and adds support for functional programming, as we’ll describe shortly.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
  TextLine( args("input") )
    .read
    .flatMap('line -> 'word) {
      line: String =>
        line.trim.toLowerCase.split("\\\\W+")
    }
    .groupBy('word) { group => group.size('count) }
  }
  .write(Tsv(args("output")))
}
```

That's it!!

15

Monday, March 25, 13

This Scala code is almost pure domain logic with very little boilerplate. There are a few minor differences in the implementation. You don't explicitly specify the "Hfs" (Hadoop Distributed File System) taps. That's handled by Scalding implicitly when you run in "non-local" mode. Also, I'm using a simpler tokenization approach here, where I split on anything that isn't a "word character" [0-9a-zA-Z_].

There is much less green, in part because Scala infers types in many cases, but also because fewer infrastructure types are required. There is a lot more yellow for the functions that do real work!

What if MapReduce, and hence Cascading and Scalding, went obsolete tomorrow? This code is so short, I wouldn't care about throwing it away! I invested little time writing it, testing it, etc.

```
CREATE EXTERNAL TABLE docs (line STRING)
LOCATION '/path/to/corpus';
```

```
CREATE TABLE word_counts
AS SELECT word, count(1) AS count FROM
(SELECT explode(split(line, '\s')) AS word
FROM docs) w GROUP BY word
ORDER BY word;
```

Hive

16

Monday, March 25, 13

Here is the Hive equivalent (more or less, we aren't splitting into words using a sophisticated regular expression this time). Note that Word Count is a bit unusual to implement with a SQL dialect (we'll see more typical cases later), and we're using some Hive SQL extensions that we won't take time to explain (like ARRAYS), but you get the point that SQL is wonderfully concise... when you can express your problem in it!!

```
inpt = load '/path/to/corpus'  
    using TextLoader as (line: chararray);  
words = foreach inpt generate  
    flatten(TOKENIZE(line)) as word;  
grpd = group words by word;  
cntd = foreach grpd generate group, COUNT(words);  
dump cntd;
```

Pig

17

Monday, March 25, 13

Pig is more expressive for non-query problems like this.



What Is Scala?

18

*Scala is a
modern, concise,
object-oriented and
functional language
for the JVM.*

<http://scala-lang.org>

Monday, March 25, 13

I'll explain what I mean for these terms in the next few slides.

Modern.

Reflects the 20 years
of *language evolution*
since Java's *invention*.

Monday, March 25, 13

Java was a good compromise of ideas for the state-of-the-art in the early 90's, but that was ~20 years ago! We've learned a lot about language design and effective software development techniques since then.

Concise.

Type *inference*, syntax
for *common OOP* and
FP *idioms, APIs.*

Monday, March 25, 13

Briefly, type inference reduces “noise”, allowing the logic to shine through. Scala has lots of idioms to simplify class definition and object creation, as well as many FP idioms, such as anonymous functions. The collection API emphasizes the important data transformations we need...

*Object-Oriented
Programming.
Fixes flaws in Java's
object model.
Composition/reuse
through traits.*

Monday, March 25, 13

Scala fixes flaws in Java's object model, such as the essential need for a mix-in composition mechanism, which Scala provides via traits. For more on this, see Daniel Spiewak's keynote for NEScala 2013: "[The Bakery from the Black Lagoon](#)".

"

Functional Programming.

*Most natural fit
for data!
Robust, scalable.*

Monday, March 25, 13

It may not look like it, but this is actually the most important slide in this talk; FP is the most appropriate tool for data, since everything we do with data is mathematics. FP also gives us the idioms we need for robust, scalable concurrency.

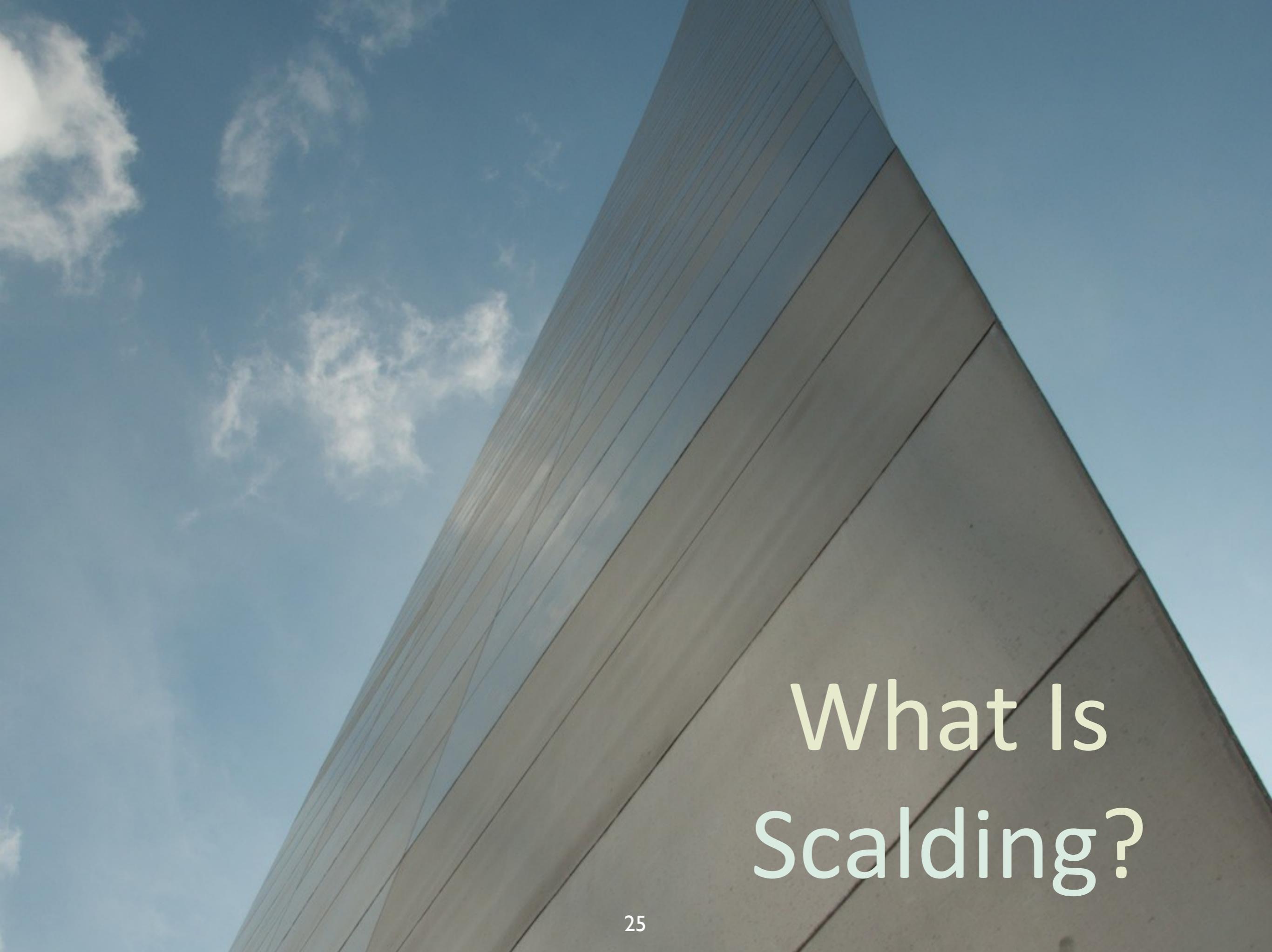
JVM.

Designed for the *JVM*.

*Interoperates with all
Java software.*

Monday, March 25, 13

But Scala is a JVM language. It interoperates with any Java, Clojure, JRuby, etc. libraries.



What Is Scalding?

25

Scalding is a *Scala*
Big Data library based
on *Cascading*,
developed by
Twitter.

<https://github.com/twitter/scalding>

Monday, March 25, 13

I say “based on” Cascading, because it isn’t just a thin Scala veneer over the Java API. It adds some different concepts, hiding some Cascading API concepts (e.g., IO specifics), but not all (e.g., groupby function <=> GroupBy class).

*Scalding adds a
Matrix API useful for
graph and machine-
learning algorithms.*

Note: *Cascalog* is a
Clojure alternative for
Cascading. Also adds
Logic-Programming
based on *Datalog*.

<https://github.com/nathanmarz/cascalog>

Monday, March 25, 13

For completeness, note that Cascalog is a Clojure alternative. It is also notable for its addition of Logic-Programming features, adapted from Datalog. Cascalog was developed by Nathan Marz, now at Twitter, who also invented Storm.

Note: *PyCascading* is a
Python alternative for
Cascading. Also from
Twitter. Uses *Jython*.

<https://github.com/twitter/pycascading>

Monday, March 25, 13

Twitter also developed a Python API for Cascading. In fact, there are many language bindings. See cascading.org.



Moar Scalding!

30

Monday, March 25, 13

More examples, starting with a deeper look at our first example.

Returning to our
first example.

```
import com.twitter.scalding._
```

```
class WordCountJob(args: Args) extends Job(args) {  
    TextLine( args("input") )  
        .read  
        .flatMap('line -> 'word) {  
            line: String =>  
                line.trim.toLowerCase.split("\\\\W+")  
        }  
        .groupBy('word) { group => group.size('count) }  
    }  
    .write(Tsv(args("output")))  
}
```

Import the library.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
  TextLine( args("input") )
    .read
    .flatMap('line -> 'word) {
      line: String =>
        line.trim.toLowerCase.split("\\\\W+")
    }
    .groupBy('word) { group => group.size('count) }
  }
  .write(Tsv(args("output")))
}
```

Create a “Job” class.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
    TextLine( args("input") )
        .read
        .flatMap('line -> 'word) {
            line: String =>
            line.trim.toLowerCase.split("\\\\W+")
        }
        .groupBy('word) { group => group.size('count) }
    }
    .write(Tsv(args("output")))
}
```

Open the user-specified input as text.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
  TextLine( args("input") )
    .read
    .flatMap('line -> 'word) {
      line: String =>
        line.trim.toLowerCase.split("\\\\W+")
    }
    .groupBy('word) { group => group.size('count) }
  }
  .write(Tsv(args("output")))
}
```

Split each 'line into 'words, a collection and flatten the collections.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
  TextLine( args("input") )
    .read
    .flatMap('line -> 'word) {
      line: String =>
        line.trim.toLowerCase.split("\\\\W+")
    }
    .groupBy('word) { group => group.size('count) }
  }
  .write(Tsv(args("output")))
}
```

Group by each 'word and determine the size of each group.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
  TextLine( args("input") )
    .read
    .flatMap('line -> 'word) {
      line: String =>
        line.trim.toLowerCase.split("\\\\W+")
    }
    .groupBy('word) { group => group.size('count) }
  }
  .write(Tsv(args("output")))
}
```

Write tab-separated
words and counts.

```
import com.twitter.scalding._

class WordCountJob(args: Args) extends Job(args) {
  TextLine( args("input") )
    .read
    .flatMap('line -> 'word) {
      line: String =>
        line.trim.toLowerCase.split("\\\\W+")
    }
    .groupBy('word) { group => group.size('count) }
  }
  .write(Tsv(args("output")))
}
```

Profit!!

Joins



Monday, March 25, 13

An example of doing a simple inner join between stock and dividend data.

```
import com.twitter.scalding._

class StocksDivsJoin(args: Args) extends Job(args){
  val stocksSchema = ('synd, 'close, 'volume)
  val divsSchema = ('dymd, 'dividend)
  val stocksPipe = new Tsv(args("stocks"), stockSchema)
    .read
    .project('synd, 'close)
  val divsPipe = new Tsv(args("dividends"), divsSchema)
    .read

  stocksPipe
    .joinWithTiny('synd -> 'dymd, dividendsPipe)
    .project('synd, 'close, 'dividend)
    .write(Tsv(args("output")))
}
```

Load stocks and dividends data in separate pipes for a given stock, e.g., IBM.

```

import com.twitter.scalding._

class StocksDivsJoin(args: Args) extends Job(args){
    val stocksSchema = ('synd, 'close, 'volume)
    val divsSchema = ('dymd, 'dividend)
    val stocksPipe = new Tsv(args("stocks"), stockSchema)
        .read
        .project('synd, 'close)
    val divsPipe = new Tsv(args("dividends"), divsSchema)
        .read

    stocksPipe
        .joinWithTiny('synd -> 'dymd, dividendsPipe)
        .project('synd, 'close, 'dividend)
        .write(Tsv(args("output")))
}

```

Capture the schema as values.

```

import com.twitter.scalding._

class StocksDivsJoin(args: Args) extends Job(args){
  val stocksSchema = ('synd, 'close, 'volume)
  val divsSchema = ('dymd, 'dividend)
  val stocksPipe = new Tsv(args("stocks"), stockSchema)
    .read
    .project('synd, 'close)
  val divsPipe = new Tsv(args("dividends"), divsSchema)
    .read
}

stocksPipe
  .joinWithTiny('synd -> 'dymd, dividendsPipe)
  .project('synd, 'close, 'dividend)
  .write(Tsv(args("output")))
}

```

Load the stock and dividend records into separate pipes, project desired stock fields.

```
import com.twitter.scalding._

class StocksDivsJoin(args: Args) extends Job(args){
  val stocksSchema = ('synd, 'close, 'volume)
  val divsSchema = ('dymd, 'dividend)
  val stocksPipe = new Tsv(args("stocks"), stockSchema)
    .read
    .project('synd, 'close)
  val divsPipe = new Tsv(args("dividends"), divsSchema)
    .read
```

```
stocksPipe
```

```
  .joinWithTiny('synd -> 'dymd, dividendsPipe)
  .project('synd, 'close, 'dividend)
  .write(Tsv(args("output")))
```

Join stocks with smaller dividends on
dates, project desired fields.

```
# Invoking the script (bash)
scald.rb StocksDivsJoins.scala \
--stocks    data/stocks/IBM.txt \
--dividends data/dividends/IBM.txt \
--output    output/IBM-join.txt
```

```
# Output (not sorted!)
2010-02-08      121.88  0.55
2009-11-06      123.49  0.55
2009-08-06      117.38  0.55
2009-05-06      104.62  0.55
2009-02-06      96.14   0.5
2008-11-06      85.15   0.5
2008-08-06      129.16  0.5
2008-05-07      124.14  0.5
...
...
```

NGrams



44

Monday, March 25, 13

Compute ngrams in a corpus...

```
import com.twitter.scalding._

class ContextNGrams(args: Args) extends Job(args) {
  val ngramPrefix =
    args.list("ngram-prefix").mkString(" ")
  val keepN = args.getOrElse("count", "10").toInt
  val ngramRE = (ngramPrefix + """\s+(\w+)""").r

  // Sort (phrase, count) by count, descending.
  val countReverseComparator =
    (tuple1:(String,Int), tuple2:(String,Int)) => tuple1._2 > tuple2._2
  ...
}
```

Find, count, sort, all “I love _” in
Shakespeare’s plays...

```
...
val lines = TextLine(args("input"))
  .read
  .flatMap('line -> 'ngram) { text: String =>
    ngramRE.findAllIn(text).toIterable }
  .discard('num, 'line)
  .groupBy('ngram) { g => g.size('count) }
  .groupAll { g =>
    g.sortWithTake[(String, Int)](
      ('ngram, 'count) -> 'sorted_ngrams, keepN)(
        countReverseComparator)
  }
  .write(Tsv(args("output")))
}
```

```
import com.twitter.scalding._

class ContextNGrams(args: Args) extends Job(args) {
    val ngramPrefix =
        args.list("ngram-prefix").mkString(" ")
    val keepN = args.getOrElse("count", "10").toInt
    val ngramRE = (ngramPrefix + """\s+(\w+)""").r
```

```
// Sort (phrase,count) by count, descending.
val countReverseComparator =
  (tuple1:(String,Int), tuple2:(String,Int)) => tuple1._2 > tuple2._2
...
```

From user-specified args, the ngram prefix (“I love”), the # of ngrams desired, a matching regular expression.

```
import com.twitter.scalding._

class ContextNGrams(args: Args) extends Job(args) {
  val ngramPrefix =
    args.list("ngram-prefix").mkString(" ")
  val keepN = args.getOrElse("count", "10").toInt
  val ngramRE = (ngramPrefix + """\s+(\w+)""").r

  // Sort (phrase, count) by count, descending.
  val countReverseComparator =
    (tuple1:(String,Int), tuple2:(String,Int)) => tuple1._2 > tuple2._2
}

...
```

A function “value” we’ll use to sort ngrams
by frequency, descending.

```

...
val lines = TextLine(args("input"))
  .read
  .flatMap('line -> 'ngram) { text: String =>
    ngramRE.findAllIn(text).toIterable }
  .discard('num, 'line)
  .groupBy('ngram) { g => g.size('count) }
  .groupAll { g =>
    g.sortWithTake[(String, Int)](
      ('ngram, 'count) -> 'sorted_ngrams, keepN)(
        countReverseComparator)
  }
  .write(Tsv(args("output")))
}

```

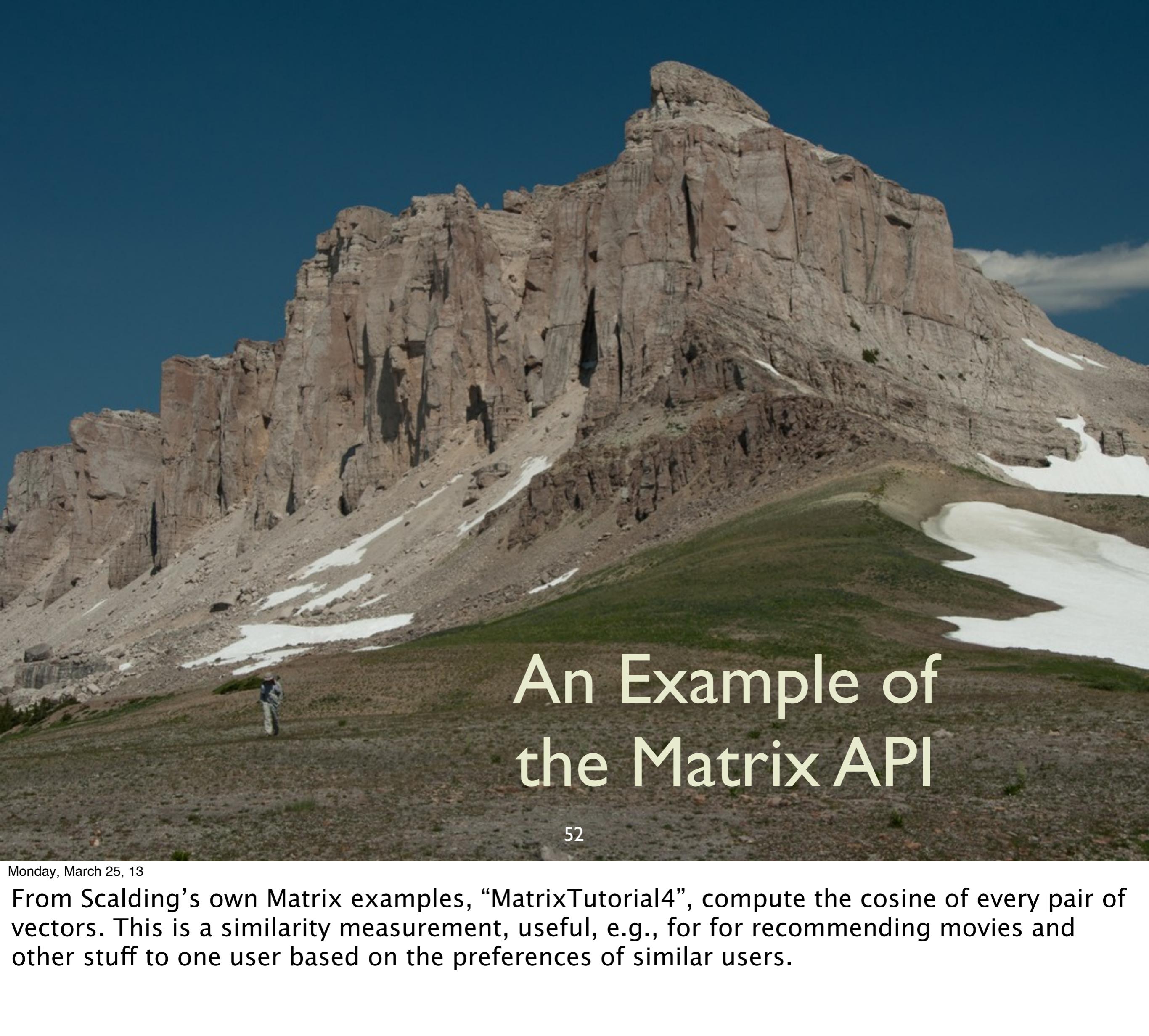
Read, find desired ngram phrases, project
desired fields, then group by ngram.

```
...
val lines = TextLine(args("input"))
  .read
  .flatMap('line -> 'ngram) { text: String =>
    ngramRE.findAllIn(text).toIterable }
  .discard('num, 'line)
  .groupBy('ngram) { g => g.size('count) }
  .groupAll { g =>
    g.sortWithTake[(String, Int)](
      ('ngram, 'count) -> 'sorted_ngrams, keepN)(
        countReverseComparator)
  }
  .write(Tsv(args("output")))
}
```

Group all (ngram,count) tuples together
and sort descending by count. Write...

```
# Invoking the script (bash)
scald.rb ContextNGrams.scala \
--input data/shakespeare/plays.txt \
--output output/context-ngrams.txt \
--ngram-prefix "I love" \
--count 10

# Output (reformatted)
(I love thee,44),
(I love you,24),
(I love him,15),
(I love the,9),
(I love her,8),
...,
(I love myself,3),
...,
(I love Valentine,1),
...,
(I love France,1), ...
```

A large, rugged mountain peak with vertical rock faces and patches of snow at the base.

An Example of the Matrix API

52

Monday, March 25, 13

From Scalding's own Matrix examples, "MatrixTutorial4", compute the cosine of every pair of vectors. This is a similarity measurement, useful, e.g., for recommending movies and other stuff to one user based on the preferences of similar users.

```

import com.twitter.scalding._
import com.twitter.scalding.mathematics.Matrix

// Load a directed graph adjacency matrix where:
// a[i,j] = 1 if there is an edge from a[i] to b[j]
// and computes the cosine of the angle between
// every two pairs of vectors.
class MatrixCosine(args: Args) extends Job(args) {
  import Matrix._

  val schema = ('user1, 'user2, 'relation)
  val adjacencyMatrix = Tsv(args("input"), schema)
    .read
    .toMatrix[Long, Long, Double](schema)
  val normMatrix = adjacencyMatrix.rowL2Normalize

  // Inner product is equivalent to the cosine:
  // AA^T/(||A|| * ||A||)
  (normMatrix * normMatrix.transpose)
    .write(Tsv(args("output")))
}

}

```

```

import com.twitter.scalding._
import com.twitter.scalding.mathematics.Matrix

// Load a directed graph adjacency matrix where:
// a[i,j] = 1 if there is an edge from a[i] to b[j]
// and computes the cosine of the angle between
// every two pairs of vectors.
class MatrixCosine(args: Args) extends Job(args) {
  import Matrix._

  val schema = ('user1, 'user2, 'relation)
  val adjacencyMatrix = Tsv(args("input"), schema)
    .read
    .toMatrix[Long, Long, Double](schema)
  val normMatrix = adjacencyMatrix.rowL2Normalize

  // Inner product is equivalent to the cosine:
  // AA^T/(||A|| * ||A||)
  (normMatrix * normMatrix.transpose)
    .write(Tsv(args("output")))
}

```

Import matrix library.

```

import com.twitter.scalding._
import com.twitter.scalding.mathematics.Matrix

// Load a directed graph adjacency matrix where:
// a[i,j] = 1 if there is an edge from a[i] to b[j]
// and computes the cosine of the angle between
// every two pairs of vectors.
class MatrixCosine(args: Args) extends Job(args) {
  import Matrix._

  val schema = ('user1, 'user2, 'relation)
  val adjacencyMatrix = Tsv(args("input"), schema)
    .read
    .toMatrix[Long, Long, Double](schema)
  val normMatrix = adjacencyMatrix.rowL2Normalize

  // Inner product is equivalent to the cosine:
  // AA^T/(||A|| * ||A||)
  (normMatrix * normMatrix.transpose)
    .write(Tsv(args("output")))
}

```

Load into a matrix.

```

import com.twitter.scalding._
import com.twitter.scalding.mathematics.Matrix

// Load a directed graph adjacency matrix where:
// a[i,j] = 1 if there is an edge from a[i] to b[j]
// and computes the cosine of the angle between
// every two pairs of vectors.
class MatrixCosine(args: Args) extends Job(args) {
  import Matrix._

  val schema = ('user1, 'user2, 'relation)
  val adjacencyMatrix = Tsv(args("input"), schema)
    .read
    .toMatrix[Long, Long, Double](schema)
  val normMatrix = adjacencyMatrix.rowL2Normalize

```

```

    // Inner product is equivalent to the cosine:
    // AA^T/(||A|| * ||A||)
    (normMatrix * normMatrix.transpose)
    .write(Tsv(args("output")))
}

```

Normalize: $\sqrt{x^2 + y^2}$

```

import com.twitter.scalding._
import com.twitter.scalding.mathematics.Matrix

// Load a directed graph adjacency matrix where:
// a[i,j] = 1 if there is an edge from a[i] to b[j]
// and computes the cosine of the angle between
// every two pairs of vectors.
class MatrixCosine(args: Args) extends Job(args) {
  import Matrix._

  val schema = ('user1, 'user2, 'relation)
  val adjacencyMatrix = Tsv(args("input"), schema)
    .read
    .toMatrix[Long, Long, Double](schema)
  val normMatrix = adjacencyMatrix.rowL2Normalize

  // Inner product is equivalent to the cosine:
  // AA^T/(||A|| * ||A||)
  (normMatrix * normMatrix.transpose)
    .write(Tsv(args("output")))
}

```

Compute cosine!



Scalding vs. Hive vs. Pig

58

Monday, March 25, 13

Some concluding thoughts on Scalding (and Cascading) vs. Hive vs. Pig, since I've used all three a lot.

A photograph showing a close-up of a vertical wooden pillar on the left, with a dark blue background. A white contrail from an airplane cuts across the frame from the bottom left towards the top right.

*Use Hive
for queries.*

59

Monday, March 25, 13

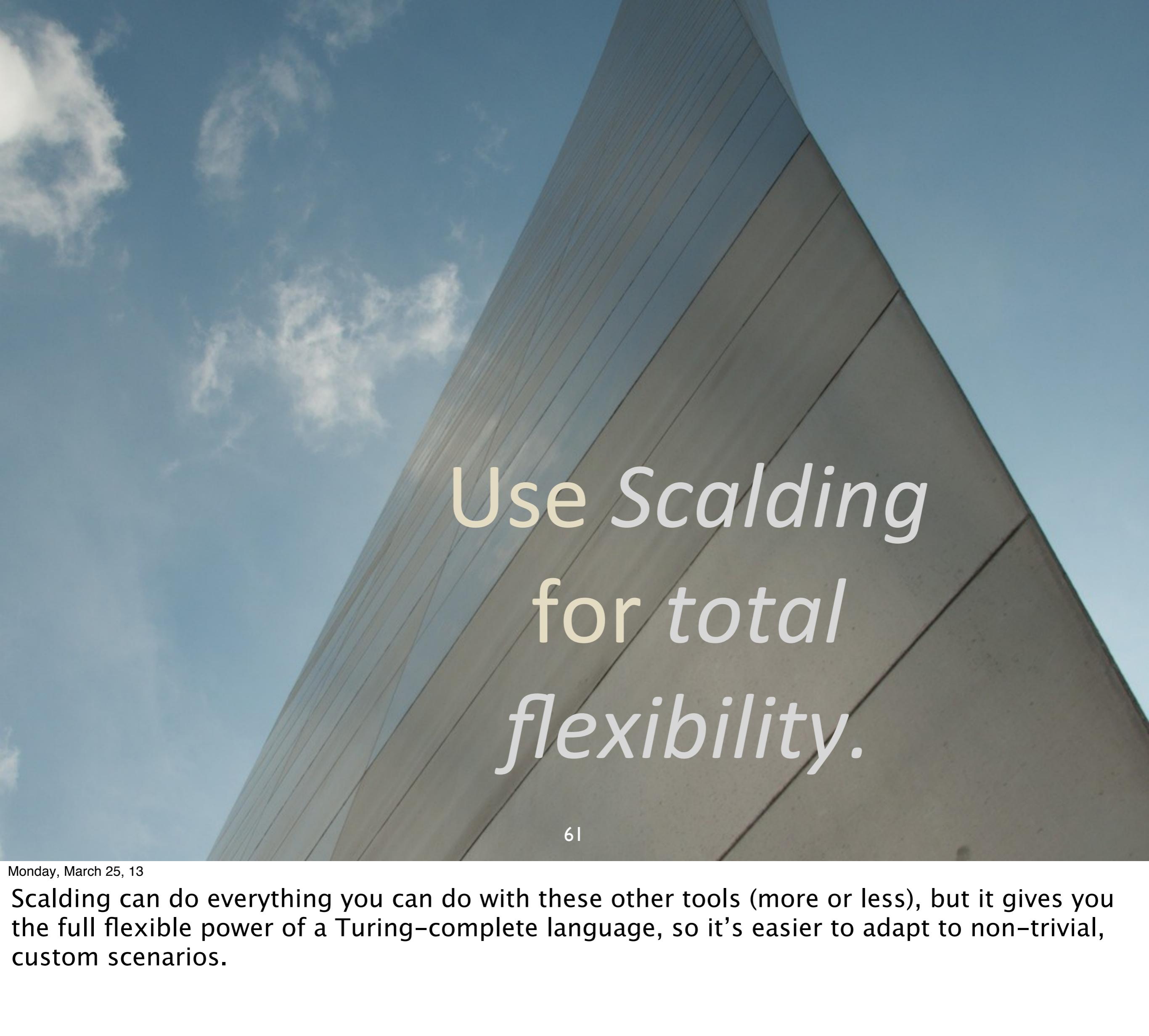
SQL is about as concise as it gets when asking questions of data and doing “standard” analytics. A great example of a “purpose-built” language. It’s great at what it was designed for. Not so great when you need to do something it wasn’t designed to do.



*Use Pig for
data flows.*

Monday, March 25, 13

Pig is great for data flows, such as sequencing transformations typical of ETL (extract, transform, and load). As you might expect for a purpose-built language, it is very concise for these purposes, but writing extensions is a non-trivial step (same for Hive).



Use *Scalding*
for *total*
flexibility.

61

Monday, March 25, 13

Scalding can do everything you can do with these other tools (more or less), but it gives you the full flexible power of a Turing-complete language, so it's easier to adapt to non-trivial, custom scenarios.

For more on
Scalding:

github.com/twitter/scalding

github.com/ThinkBigAnalytics/scalding-workshop

github.com/Cascading/Impatient/tree/master/part8



Thanks!

dean.wampler@thinkbiganalytics.com
polyglotprogramming.com/talks



63

Monday, March 25, 13

All pictures © Dean Wampler, 2005–2013. The rest of the presentation is free to reuse, but attribution is appreciated. Hire us!!