Big Data and Functional Programming

Jim Baker

jim.baker@{colorado.edu|python.org|rackspace.com}

Overview

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- A: functional programming
- Explore Big Data and FP, especially by thinking about functions and how they combine
- Specific approachs like MapReduce and the Lambda architecture
- Embracing failure and supporting scale free computation
- FP as the foundation of such companies as GOOG ($357B market cap), FB ($143B), TWTR ($24B)

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- Formerly, part of original developer team of Ubuntu Juju - lots of experience with ZooKeeper

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- Talk to me during lunch if you're interested

Lunch plans?

- Lunch today on the *practice of computer science*

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    - Meet at `WHEN` in C4C lobby

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- So `WHEN` should we meet?

What is “Big Data” anyway?

- Many definitions in common play

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- Many definitions in common play
- Useful summary paper on the these definitions - “Undefined By Data: A Survey of Big Data Definitions”, Jonathan Stuart Ward and Adam Barker, http://arxiv.org/pdf/1309.5821v1.pdf

Gartner

3 Vs of Big Data:

- Volume
- Velocity
- Variety

- Could equally be true of previous efforts in data warehousing, business intelligence

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- A bit of a leap to a CS definition

Oracle

Big data combines

- Relational database
- New types of data sources - cited as unstructured, but generally have some structure
- Need new tools to help with this combination

Plays with Oracle's preeminence as a proprietary RDBMS vendor

Intel

- Focus on volume
- "Generating a median of 300 terabytes (TB) of data weekly"

Intel helpfully sells hardware to process this data

Microsoft

Big data is the term increasingly used to describe the process of applying serious computing power - the latest in machine learning and artificial intelligence - to seriously massive and often highly complex sets of information.

Ward & Barker

Big data is a term describing the storage and analysis of large and or complex data sets using a series of techniques including, but not limited to: NoSQL, MapReduce and machine learning.

Still puzzled?

- Ward & Barker capture some key ideas

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- Still unsatisfying

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- Another approach: family of related computational models that support *scale free computing* on data

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- Every day evidence of scale free at work - think Google Search

MapReduce

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- Reduce - might also call this `fold`

Map

Related to such ideas as

- Scatter in scatter/gather
- Divide & conquer
- Problem partition

Data is consistently mapped to the same node in a given cluster

Reduce

Word count problem

- What is the word count problem?

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- Vs how we usually say it - “wordcount”

Scalding

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Scalding

- High-level domain specific language (DSL) in Scala for writing map-reduce jobs
- Runs on top of Cascalog
- Expect to see more of Scalding in this class
- Or perhaps your future work!

Word count in Scalding


```
import com.twitter.scalding._

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

Word count in Summingbird

```
def wordCount(
  source: Iterable[String],
  store: MutableMap[String, Long]) =
source.flatMap {
  sentence =>
  toWords(sentence).map(_ -> 1L)
  }.foreach {
  case (k, v) =>
  store.update(k, store.get(k) + v) }
```

Why is it classic?

- Actually useful

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- Machine translation of natural language
- Historical usage of words and phrases

Ranking followers with PageRank

```
val sc = new SparkContext(...)
val users = sc
  .textFile("hdfs://user_attributes.tsv")
  .map(line => line.split)
  .map( parts => (parts.head, parts.tail))
val followerGraph = Graph.textFile(sc, ...)
val graph = followerGraph.outerJoinVertices(users){
  case (uid, deg, Some(attrList)) => attrList
  case (uid, deg, None) => Array.empty[String] }
val pagerankGraph = Analytics.pagerank(graph)
val userInfoWithPageRank =
  graph.outerJoinVertices(pagerankGraph.vertices) {
    case (uid, attrList, Some(pr)) => (pr, attrList)
    case (uid, attrList, None) => (pr, attrList)
  }
println(userInfoWithPageRank.top(5))
```

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- Can also rewrite our functions in certain cases - query optimization

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- Referential transparency

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- But one that's not capturing some state

Referential transparency

Definition: e is *referentially transparent* if we can replace e with its v in **all usages**

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- $\Rightarrow$ certainly anything with side effects!

Monoids

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- Remember the definition of `foldLeft`

Twitter's Algebird

- Blog post announcing Algebird

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- Fantastic perspective - Programming isn't Math
- Foundation of Summingbird, Scalding

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- Back to this later! Let's explore one interesting detail...

At scale, sequencing is expensive!

- Local sequencing is fairly cheap

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- Local sequencing is fairly cheap
- Maintaining order requires communication
- Communication proceeds no faster than the speed of light
- Unless we have ansibles ;)

Question

How far does light in a vacuum approximately travel in one **nanosecond**?

- A - 1 kilometer
- B - 1 meter
- C - 1 foot
- D - 1 cm
- E - 1 mm

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  - But gives some insight into what a nanosecond really is

Data center design

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- Same core, same chip, same board, same unit, same rack, same aisle, same data center...
- Design focused on communication latency as much as it's storage, computation

Data centers, illustrated

- Google streetview in the datacenter

Multidata center coordination

- Big problem because of communication bottlenecks

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- What could possibly go wrong?!!

Special relativity and programming

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- Einstein was pondering the implication of two things:
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  - The speed of light (c) is constant, as established by the then recent Michelson-Morley experiment

Einstein's analysis

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- We cannot make statements about the whether two spatially-separated events are truly simultaneous
- We can only say something about causality - that A depends on B, which depends on C

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- Support such ideas as *leader election*, *distributed transactions*, and *distributed counters*
- Can we avoid coordination costs?
- $\Rightarrow$ yes! (at least sometimes)

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Eventual consistency

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Eventual consistency

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- Databases includign Cassandra, Riak, Dynamo

Shopping cart, with commutative operations

...

Restoring strong consistency across data centers

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- Google's Spanner database implements this idea
- Q: how does this avoid violating the relativity of simultaneity?