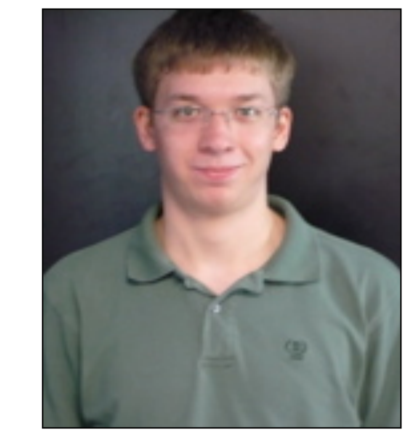
Spark



Distributed Memory Abstractions for Cluster Computing

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Motivation

- MapReduce & Dryad are highly successful, but use acyclic an data flow model that is not suitable for all applications
- *Can we provide similarly powerful high-level abstractions for a broader class of apps?*

Spark Goals

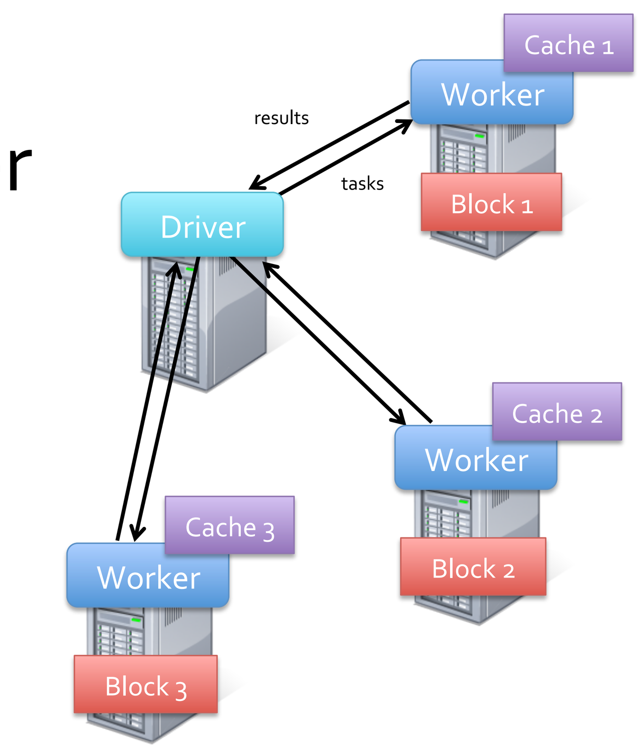
- Support cluster applications that reuse *working sets* of data, including:
  - Iterative algorithms
  - Interactive data mining
- Provide automatic fault tolerance and load balancing similar to MapReduce
- Ease of programming through integration into Scala language

Programming Model

- *Resilient Distributed Datasets* (RDDs)
  - Collections of objects stored across cluster nodes that can be rebuilt on failure
  - Created by applying transformations (e.g. map) to data in stable storage
  - Can be explicitly cached for reuse
- *Parallel operations* on RDDs (reduce, etc)
- *Restricted shared variables* (broadcast variables and accumulators)

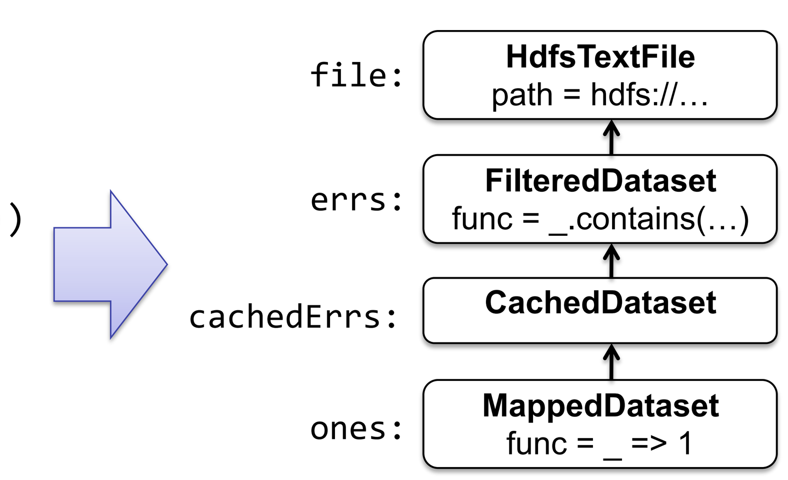
Architecture

- Nodes cache partitions of RDDs as requested by user
- Fault tolerance achieved through *lineage*
  - RDD handles contain enough info to rebuild from source data



RDD Lineage Example

```
// Cache an RDD containing all the
// lines with "ERROR" in a log file
file = spark.textFile("hdfs://...")
errs = file.filter(_.contains("ERROR"))
cachedErrs = errs.cache()

// Count errors using the cached RDD
ones = cachedErrs.map(_ => 1)
count = ones.reduce(_+_)
```



Broadcast Variables

```
// Define a broadcast variable
bv = spark.broadcast(someBigObject)

// Use it in a parallel operation
dataset.foreach(element => {
  doStuff(bv.value)
})

// Use bv in a 2nd parallel operation;
// cached copy on each node is reused
dataset.foreach(element => {
  doOtherStuff(bv.value)
})
```

Accumulators

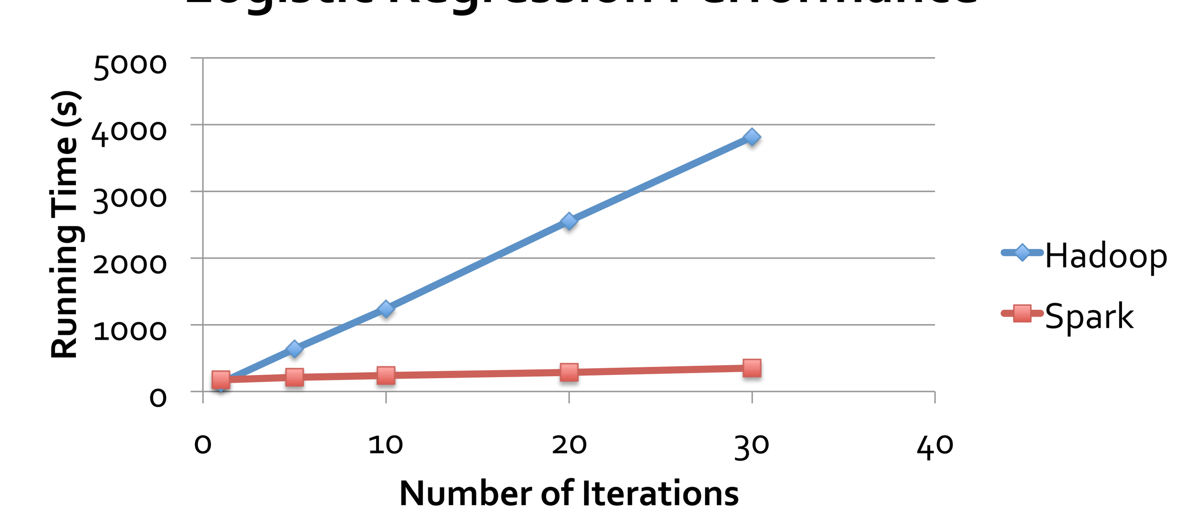
```
// Create accumulator with value 0
accum = spark.accumulator(0)

// Use it in a parallel operation
dataset.foreach(element => {
  accum += doStuff()
})

// Read value in driver program
println(accum.value)
```

Interactive Spark

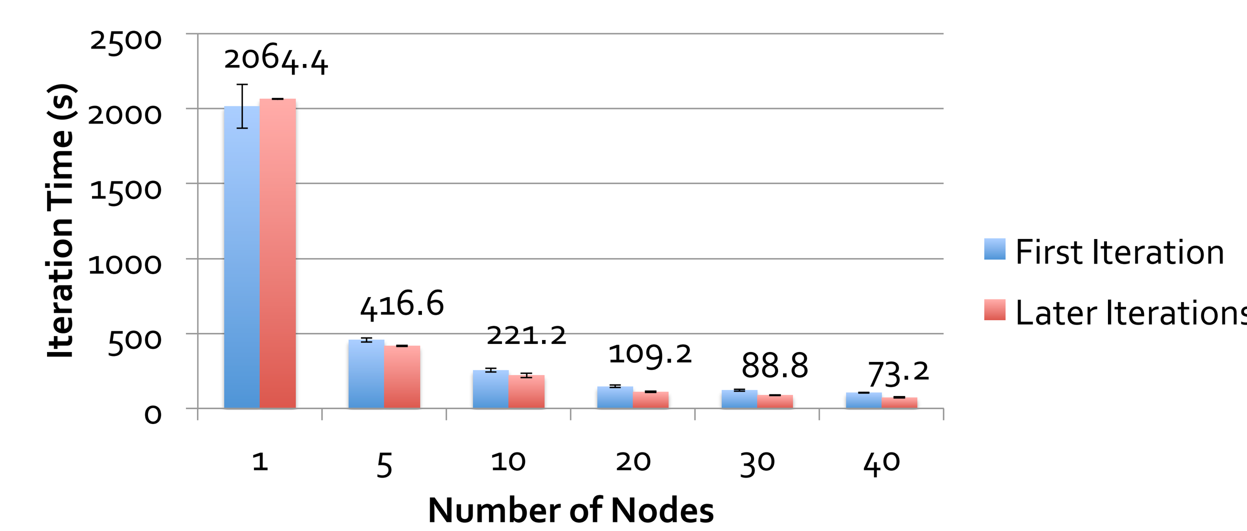
- Modified Scala interpreter to enable interactive use of Spark
  - Bytecode analysis & modified class generation strategy used to capture dependencies for each statement
  - Remote class loading on slave nodes

Results

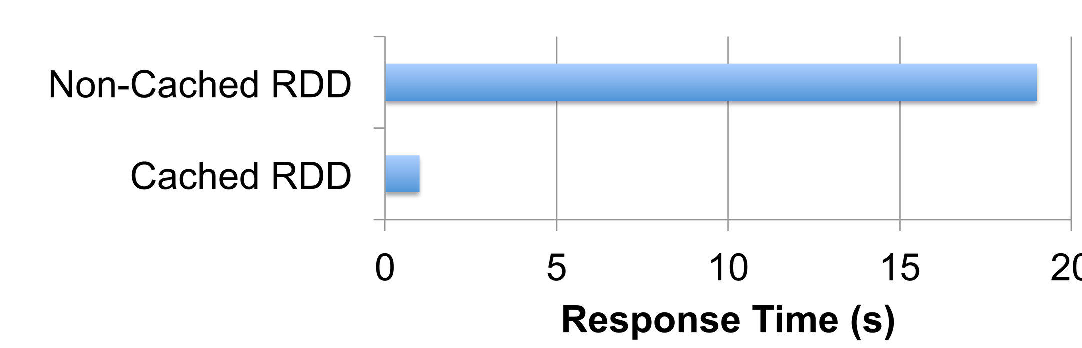
Logistic Regression Performance



Alternating Least Squares Performance



Interpreter Response Time



(Full-text search on 40 GB Wikipedia dataset)

Future Work

- Add other memory abstractions that can be supported well in clusters (e.g. updatable datasets, streams)
- More RDD storage options (e.g. caching on disk, replication, control over partitioning)
- Debugging tools that leverage lineage to replay parts of jobs