Performance and Scalability of Broadcast in Spark

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Spark Objectives

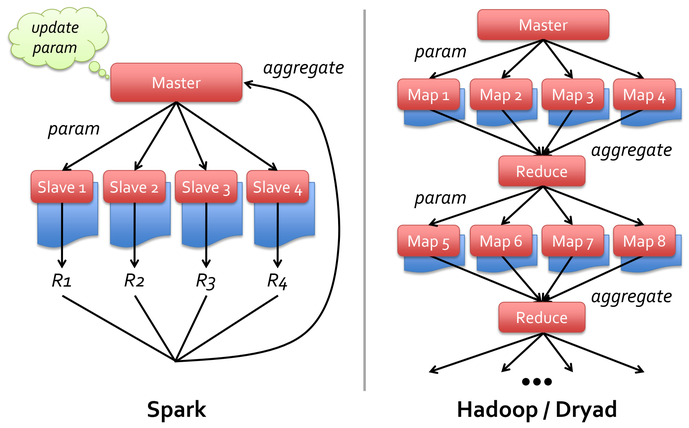
- Support *iterative* jobs
  - » Machine learning researchers in our lab identified this as a workload that Hadoop doesn't perform well on
- Experiment with programmability
  - » Leverage Scala to integrate cleanly into programs
  - » Support *interactive* use from Scala interpreter
- Retain MapReduce's fine-grained fault-tolerance

Programming Model

- Reliable distributed datasets (RDD)
  - » HDFS files, "parallelized" Scala collections
  - » Can be transformed with map and filter
  - » Can be *cached* across parallel operations
  - » Users can customize persistence
- Parallel operations
  - » foreach, reduce, collect
  - » No support for "grouped reduce" as of now
- Shared variables
  - » Accumulators (add-only)
  - » Broadcast variables (read-only)

Job Execution Model

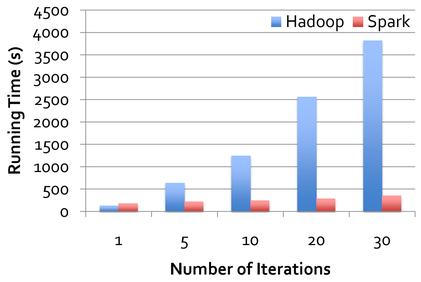
- Master partitions a job into multiple slices and sends them to multiple slaves
- Slave scheduling on remote machines are handled by the underlying Nexus framework



- Users can explicitly cache RDDs in memory for reuse in multiple MapReduce like iterations

Performance Evaluation

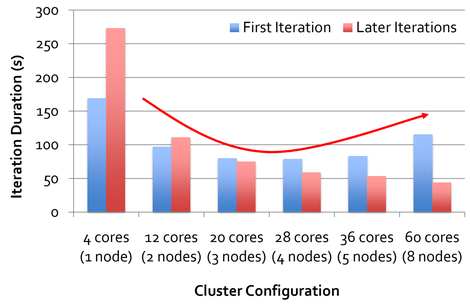
Logistic Regression



- **Goal:** find the best line separating two sets of points
- **Hadoop:** 127 s / iteration
- **Spark:** 1st iteration 174 s; 6s in each of the later iterations
- 29 GB dataset on 20 EC2 m1.xlarge machines, each with 4 cores

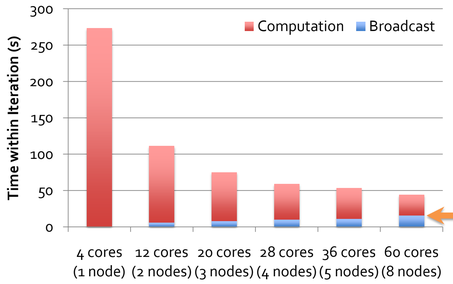
Alternating Least Squares

- **Matrix factorization:** given matrix R (*m* x *u*), find A (*m* x *k*) and B (*k* x *u*)
- Collaborative filtering for the Netflix prize
- 2+ GB dataset of users and ratings matrix (R)
- k is the dimension of the feature vector
- k = 60 on EC2 m2.xlarge master and c1.xlarge slaves



Centralized HDFS Broadcast

- Initial implementation of the broadcast primitive
  - » Master stores serialized version of the variable in HDFS
  - » Slaves read from HDFS and deserializes
  - » HDFS becomes the **bottleneck**



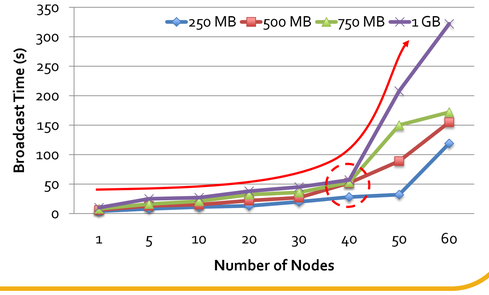
Breakdown of later iterations

- Broadcast time increases with the number of nodes
- Soon becomes the dominant factor

36% of iteration time spent on broadcast

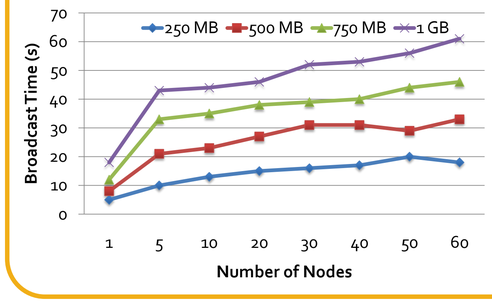
Broadcast-only experiments

- All nodes are running on EC2 m1.large instances (2 cores each)



Chained Streaming Broadcast

- Create forest of reliably streaming chains
  - » Master starts as a seed, divides the broadcasted variable into blocks, and starts broadcasting
  - » Slaves join the chain to receive broadcast
  - » Whoever is done starts a new chain as a seed

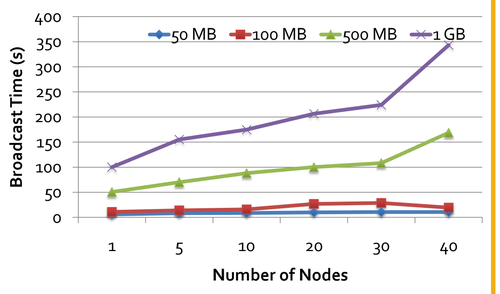


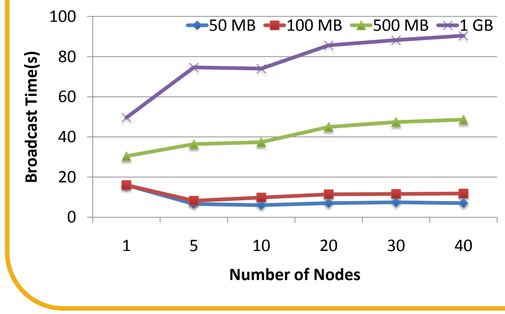
- Broadcast time increases sub-linearly
- Still room for optimization
- Block size is set to 4MB
- All nodes are on EC2 m1.large instances

BitTorrent

- Efficiently distribute files in really large p2p networks in presence of failure and churn
  - » Performance is not well-examined in high-speed reliable data center networks

- Default BitTornado settings
- All nodes are on EC2 m1.xlarge instances





- Broadcast time is stable
- Still room for optimization
- Piece size set to 4MB
- No upload/download limit
- #Simultaneous upload=8
- All nodes are on EC2 m1.xlarge instances

WIP/Future Work

- **SplitStream Broadcast**
  - » Utilizes full upload capacity of all the nodes
  - » Working implementation is completed
  - » Found to be not completely reliable in certain cases
- We are working on creating a reliable, dynamic SplitStream protocol