MapReduce Online

UC Berkeley & *Yahoo!* Research

Presented by Hao Zhang

Outline

- Overview
- Pipelined MapReduce
- Online Aggregation
- Continuous Queries
- Conclusion

Overview

- MapReduce was originally designed for batch jobs
- Based on Hadoop framework
- Pipeline data between operators to extend MapReduce model beyond batch processing
- Extra options/functions based on pipelining
- Modified fault tolerance mechanism

Pipelined MapReduce

- Map tasks
  - Read input data and perform Map function
  - Use combiners to sort the intermediate output
  - Send intermediate output to Reduce tasks through TaskTracker
- Reduce tasks
  - Read intermediate data and sort it
  - Apply Reduce function to generate final output

Pipelined MapReduce

- Original MapReduce
  - Accumulate outputs of Map tasks and send them to corresponding Reduce tasks
- MapReduce Online
  - Pipeline output of Map tasks to Reduce tasks soon after they are produced
  - Separate Map function and output in different thread
  - Straightforward approach, needs rate adaption

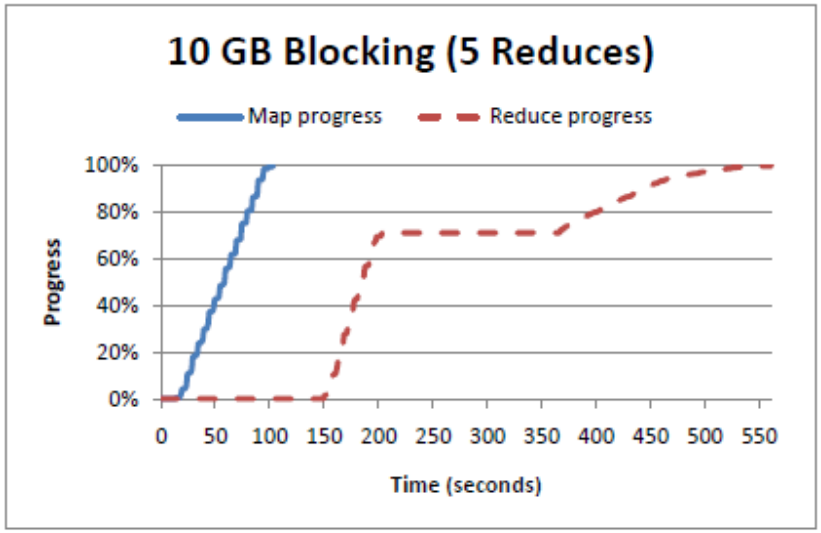
Pipelined MapReduce

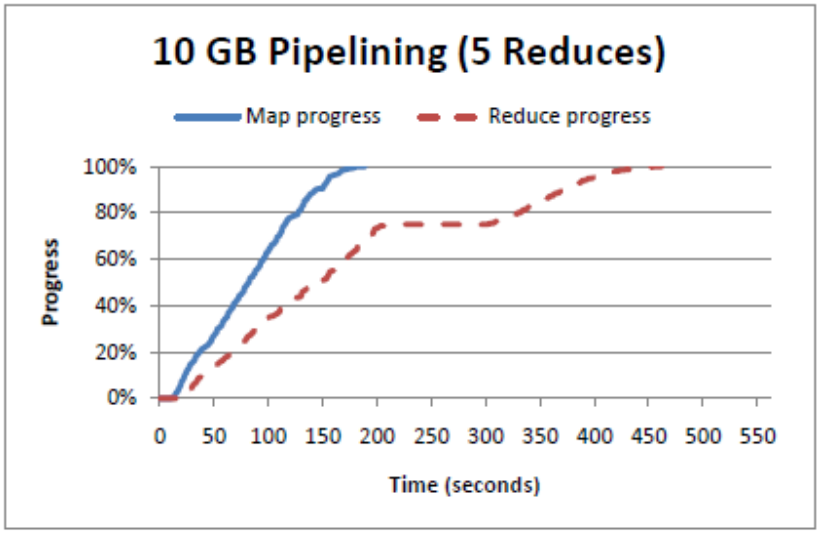
- Rate adaption
  - Reduce tasks may be unable to accept input at the moment
  - Balance the workload of combiners and Reduce tasks
  - Reduce transmission overhead

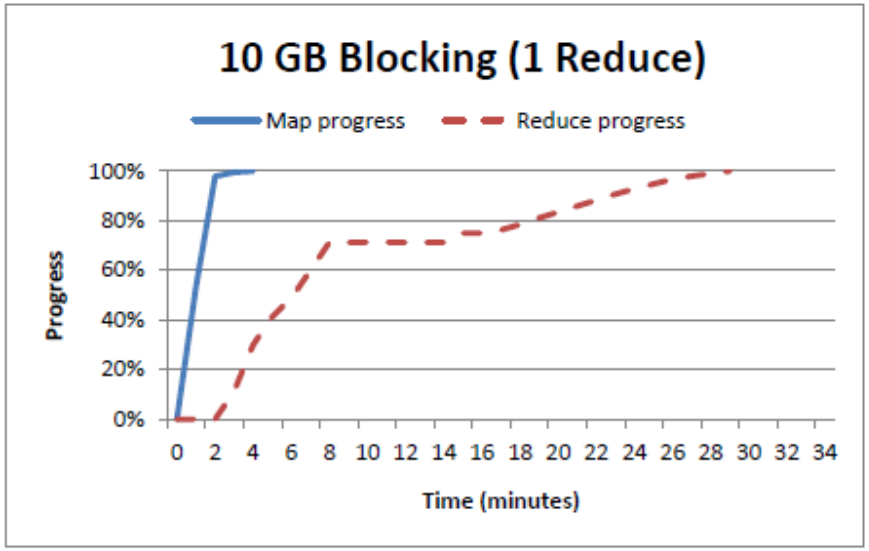
Pipelined MapReduce

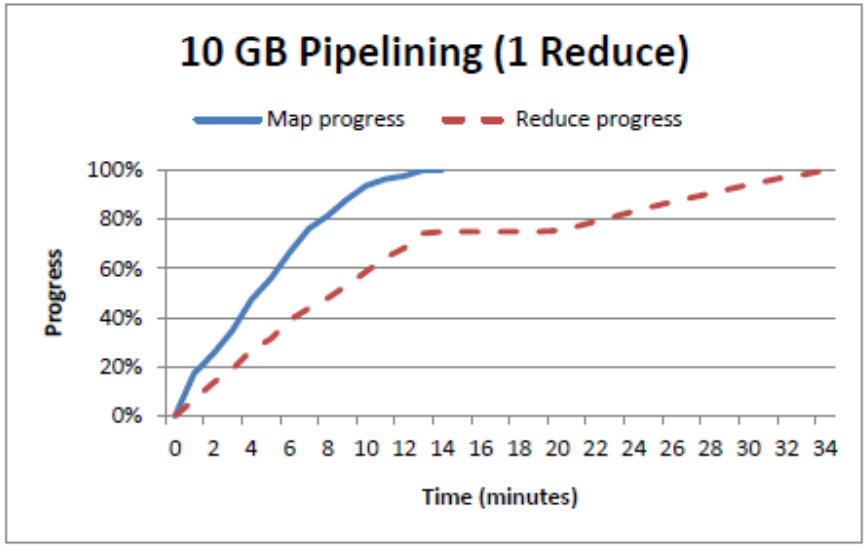
- Pipelining scheme
  - Enables early utilization of Reduce tasks
  - Reduce the effect of combiners by moving sorting work from combiners to Reduce tasks
  - May reduce overall performance if Reduce tasks are the bottlenecks

Pipelined MapReduce









Pipelined MapReduce

- Modifications on fault tolerance
  - Split intermediate data into more files
  - Reduce tasks keep intermediate data as “tentative” until informed
  - Map tasks retain intermediate data in disk until job finishes
  - More complicated scheme but more robust to task failure

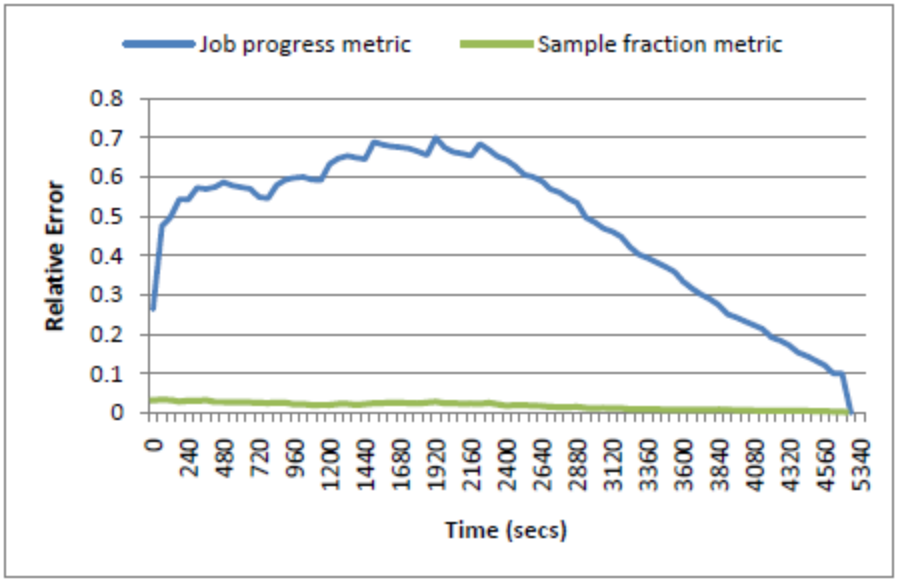
Pipelined MapReduce

- Pipelining between jobs
  - Final result cannot be generated before job finished
  - Used for online aggregation
  - Needs task scheduling on high level

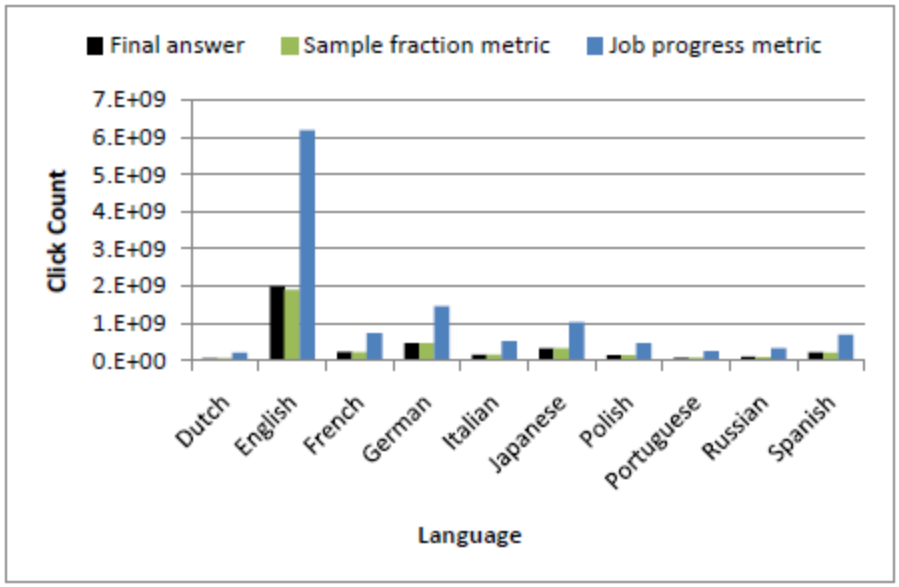
Online Aggregation

- Generate rough approximation in a much shorter period of time
- Progress metric can only be estimated
- Approximation metric should be defined by users, otherwise the error would be too large

Online Aggregation



(a) Relative approximation error over time



(b) Example approximate answer

Online Aggregation

- Rely on users to provide proper metric
- Multi-job online aggregation is possible and can be easily supported
- Fault tolerance in multi-job online aggregation needs storage of approximations to recover from failure

Continuous Queries

- Used to analyze constantly arriving data stream
- Original MapReduce model introduces large latency and has to re-compute all data
- Modified version runs continuously and make use of previous results

Continuous Queries

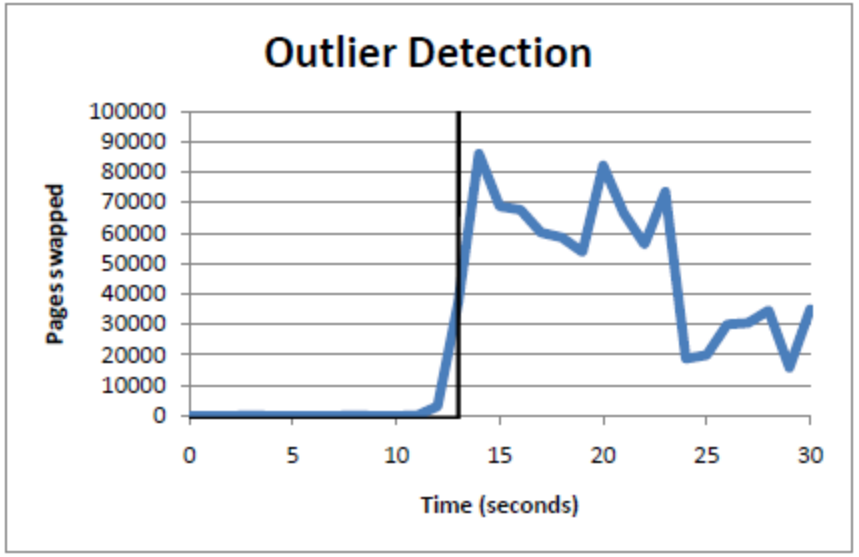
- No major modification to MapReduce Online
- Minor modifications:
  - Force Map tasks to send output to Reduce tasks promptly
  - Invoke Reduce tasks periodically
  - Reduce tasks should be able to utilize previous results

Continuous Queries

- Modifications on fault tolerance
  - Map tasks can no longer retain all output
  - Recovering from failure can only rely on finite history
  - Need to checkpoint states of the tasks periodically
  - Cannot apply to all functions

Continuous Queries

Application Example: Monitoring system



Conclusion

- Pipelining scheme can only reduce completion time when reduce tasks are not the bottleneck
  - Provide pipelining scheme as an option
  - Automatically determine the number of tasks
- Fault tolerance needs more states and checkpoints, but could reduce repetitive work
- Online aggregation and continuous queries are potential research areas

Discussion

- Is optimal scheduling feasible?
- To what extend would scheduling improve the performance?
- Is MapReduce the ideal framework for continuous work?