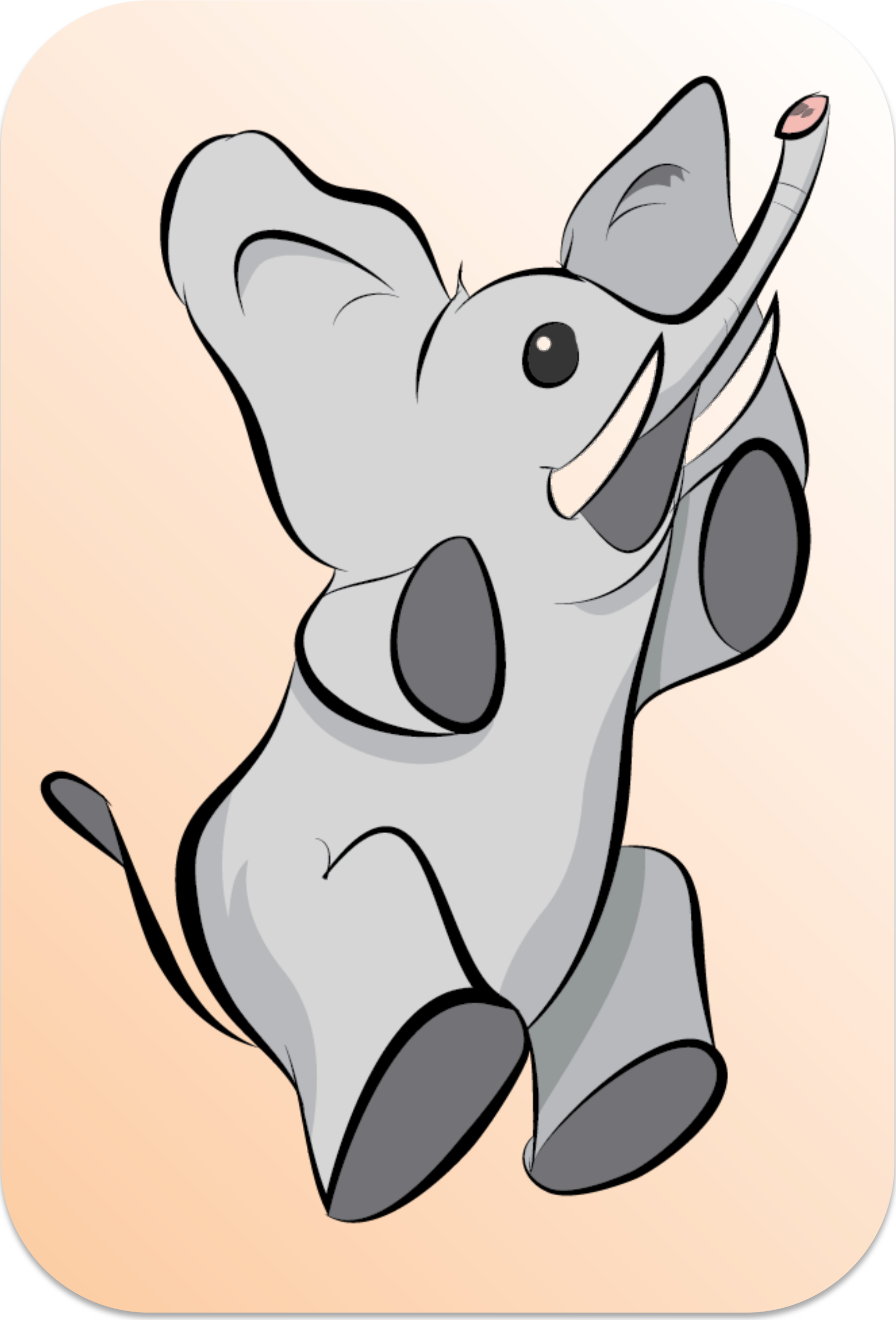
*custom illustration by @dpbays*

CLEMSON UNIVERSITY

# JUMMP: Job Uninterrupted Maneuverable MapReduce Platform

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# Motivation [1 of 2]

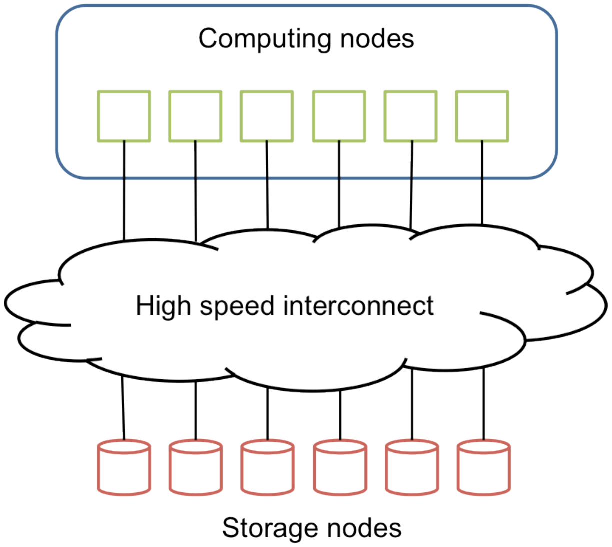
- Hadoop is the de-facto implementation of the MapReduce programming model and used in many different disciplines
- Academic shared environment clusters accommodate a wide variety of research applications within a set of financial, technical, and administrative constraints.
- The Job Uninterrupted Maneuverable MapReduce Platform is an automated scheduling platform
  - Enables the integration of Hadoop into the existing large scale computational infrastructure
  - Supports high availability and continuous computing for research and education

# Motivation [2 of 2]

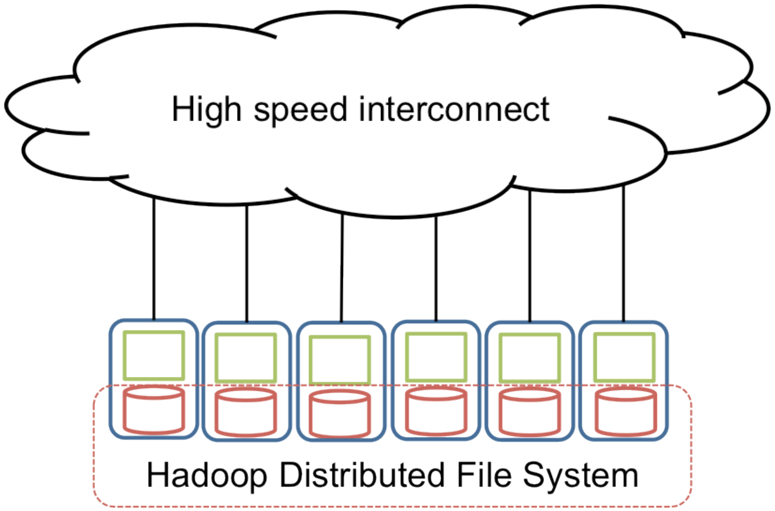
- User Considerations
  - Research that uses Hadoop as a tool for the research
  - Study on the Hadoop eco-system that consider different hardware and software configurations
  - Academic course project requiring individual clusters

# Motivation [2 of 2]

- Environmental Considerations
  - Cost of hardware, space, power and cooling
  - Technology differences of Hadoop and traditional HPC configurations
  - Support of the Hadoop runtime environment



Traditional HPC Environments



Hadoop Clusters

# Design Objectives

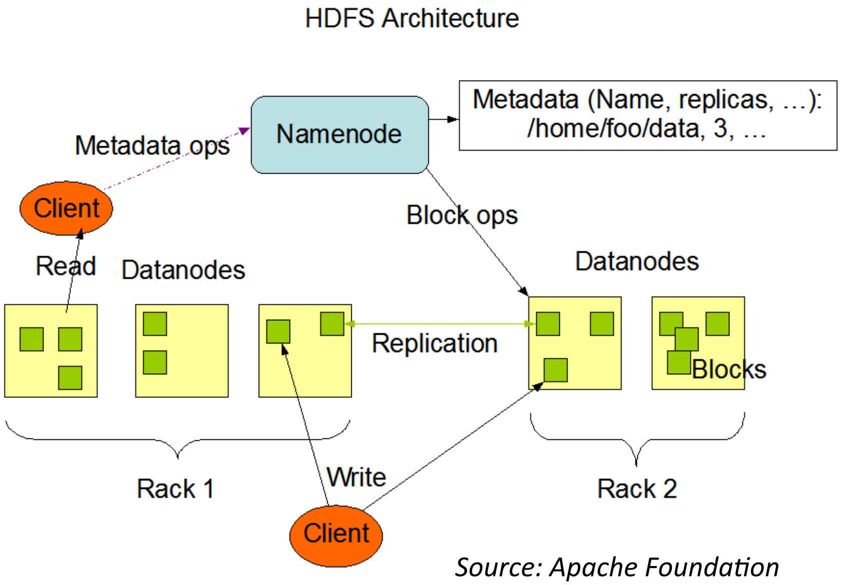
- Provision individual Hadoop clusters within an academic HPC environment:
  - As dynamic execution environment on demand by users
  - In user space without root privileges
  - Minimal interactions from system administrators
  - Exist with environment beyond reservation limitations in semi-persistent manner

# Hadoop Overview [1 of 3]

- Hadoop is Apache Foundation's open-source implementation Google projects and research
- Hadoop Distributed File System (HDFS)
  - Implementation of the Google File System
  - Highly fault-tolerant distributed file system
- MapReduce Framework
  - Implementation of Google MapReduce
  - Application framework for process big data in-parallel across clusters

# Hadoop Overview [2 of 3]

- HDFS Nodes:
  - *NameNode (NN)*
  - *Data Node (DN)*
- MapReduce Nodes
  - *JobTracker* (JT)
  - *TaskTracker (TT)*

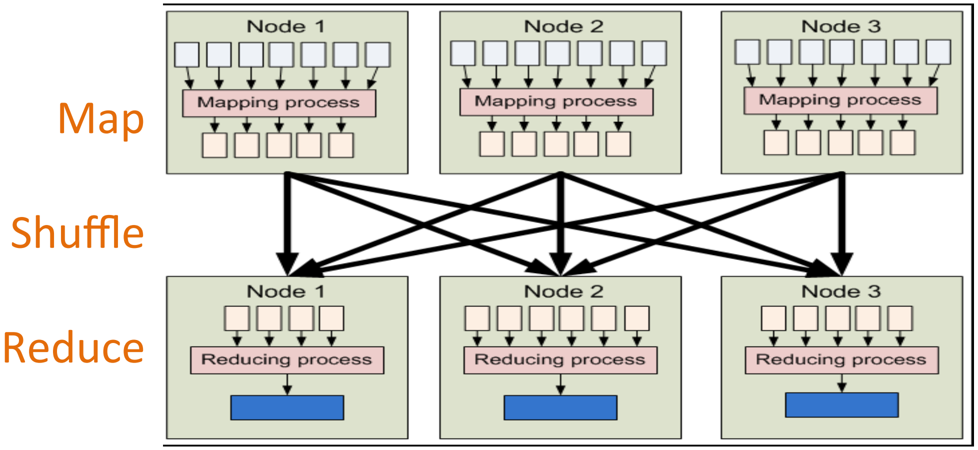


*Source: Apache Foundation*

- Traditionally single NN and JT in cluster
- Multiple DNs and TTs

# Hadoop Overview [3 of 3]

- Map Phase
  - Key-value pair input mapped to key-value pair outputs
- Shuffle Phase
  - Transfer of map output to reducers as input
- Reduce Phase
  - Operation on set of values for each key in map out



*Source: Yahoo*

# JUMMP Design

- JUMMP is a Hadoop cluster where DN/TT continuously move throughout HPC environment while allowing survivability of Hadoop cluster
- Configured with two variables:
  - *n:* number of DataNodes / TaskTracker
  - $t_j$: scheduled time between jumps
- Built with Palmetto HPC Cluster at Clemson
  - Uses PBS Professional Scheduler, compatible with open source versions of PBS.
- Dedicated NN/JT node outside of scheduler
- Each DN/TT reserved with its own PBS job

# Jumping Node Actions

- Launch DN/TT daemons and join Hadoop Cluster
- Perform Hadoop cluster duties as normal DN/TT would
- Await trigger to “jump” (time or event based)

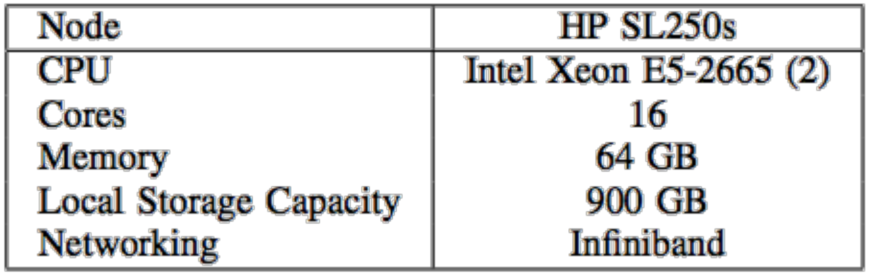
1. Schedule replacement DN/TT PBS job
2. Stop Hadoop daemons
3. Decommission and blacklist itself from cluster
4. End PBS job

# Performance Analysis

- DataNode and TaskTracker cause distinct degradation on performance due to jumps
- DataNode jumps cause re-replication of data blocks located in the jumping node
- TaskTracker jumps cause MapReduce tasks to be rescheduled that were executing on jumping node
- TaskTracker jumps cause cluster to be "undersized" until replacement is fully operational

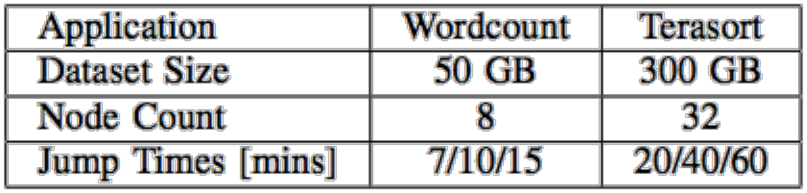
# Experiment Design

- Pool of 96 homogenous nodes within Palmetto (shown in Table I)
- Benchmarks and Datasets from Purdue's PUMA project
- 100 runs of each experiment (shown in table II) on consistent dataset
- Baseline and three different jump times
- Recorded task times, job times, and jump times



| Node | HP SL250s |
|---|---|
| CPU | Intel Xeon E5-2665 (2) |
| Cores | 16 |
| Memory | 64 GB |
| Local Storage Capacity | 900 GB |
| Networking | Infiniband |

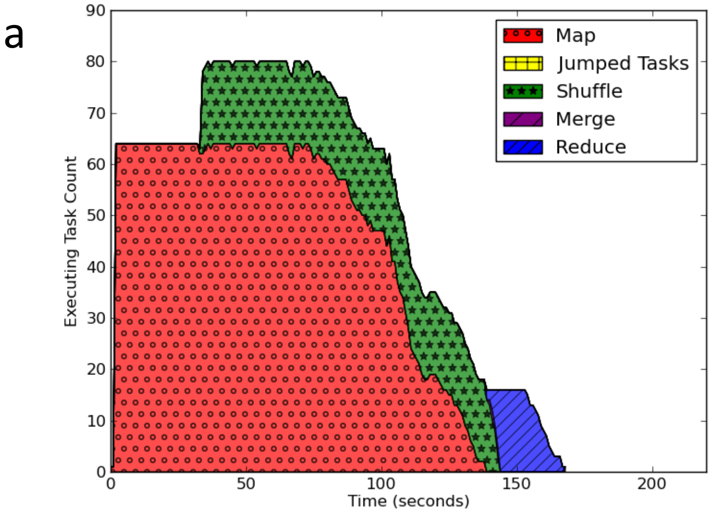
TABLE I: Node Configuration

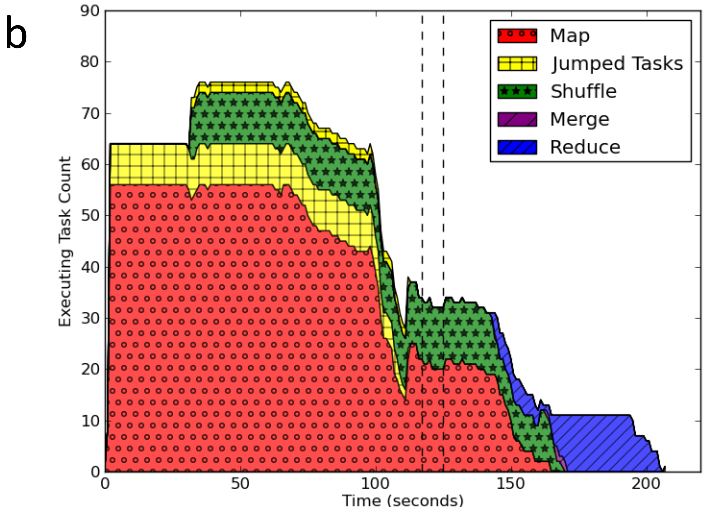


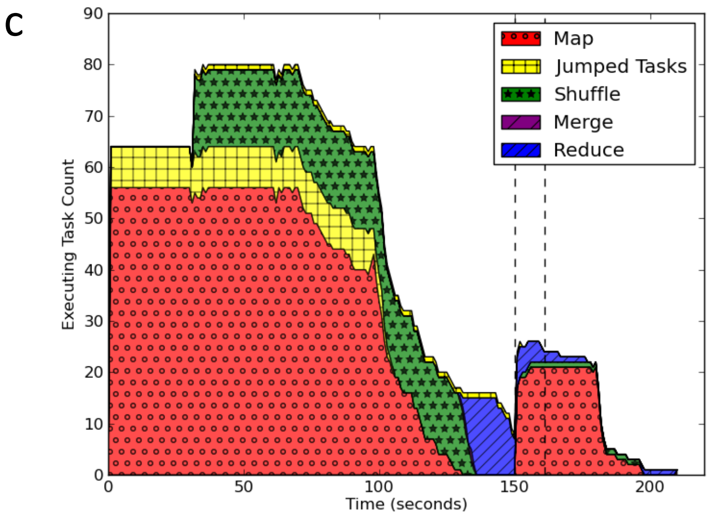
| Application | Wordcount | Terasort |
|---|---|---|
| Dataset Size | 50 GB | 300 GB |
| Node Count | 8 | 32 |
| Jump Times [mins] | 7/10/15 | 20/40/60 |

TABLE II: Experiment Parameters

# Characteristics of Impact





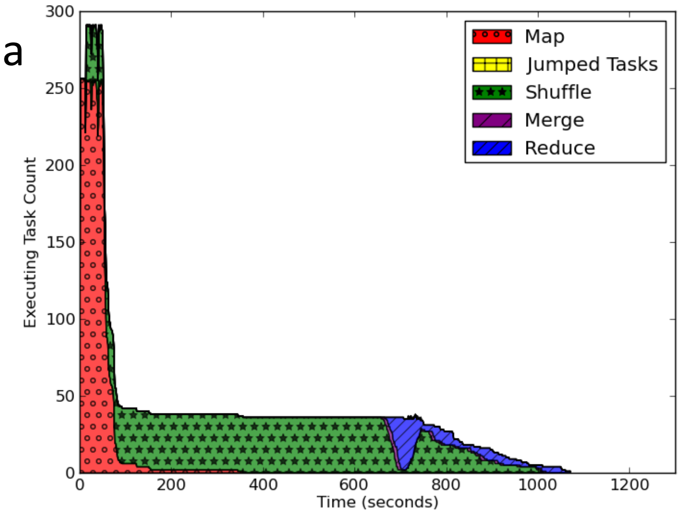


Wordcount on 50 GB with 8 nodes

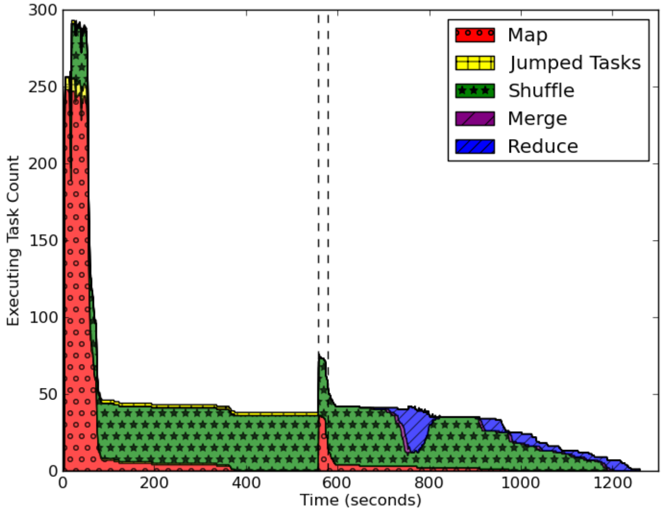
(a) No jump
(b) Jump during map phase
(c) Jump during reduce phase

# Characteristics of Impact

a



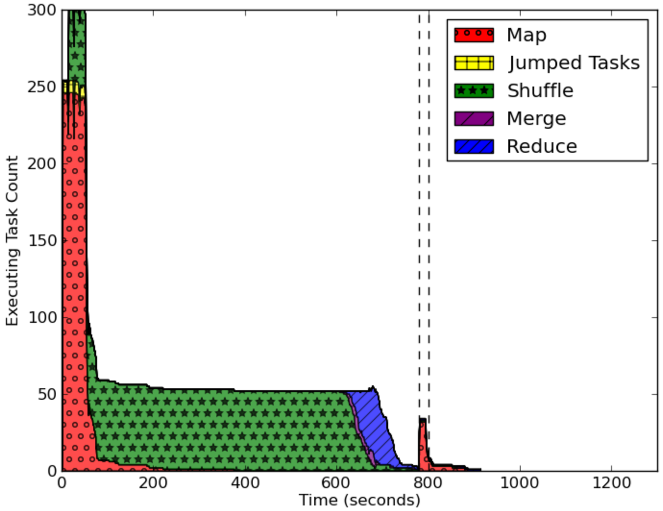
b



Terasort on 300 GB with 32 nodes

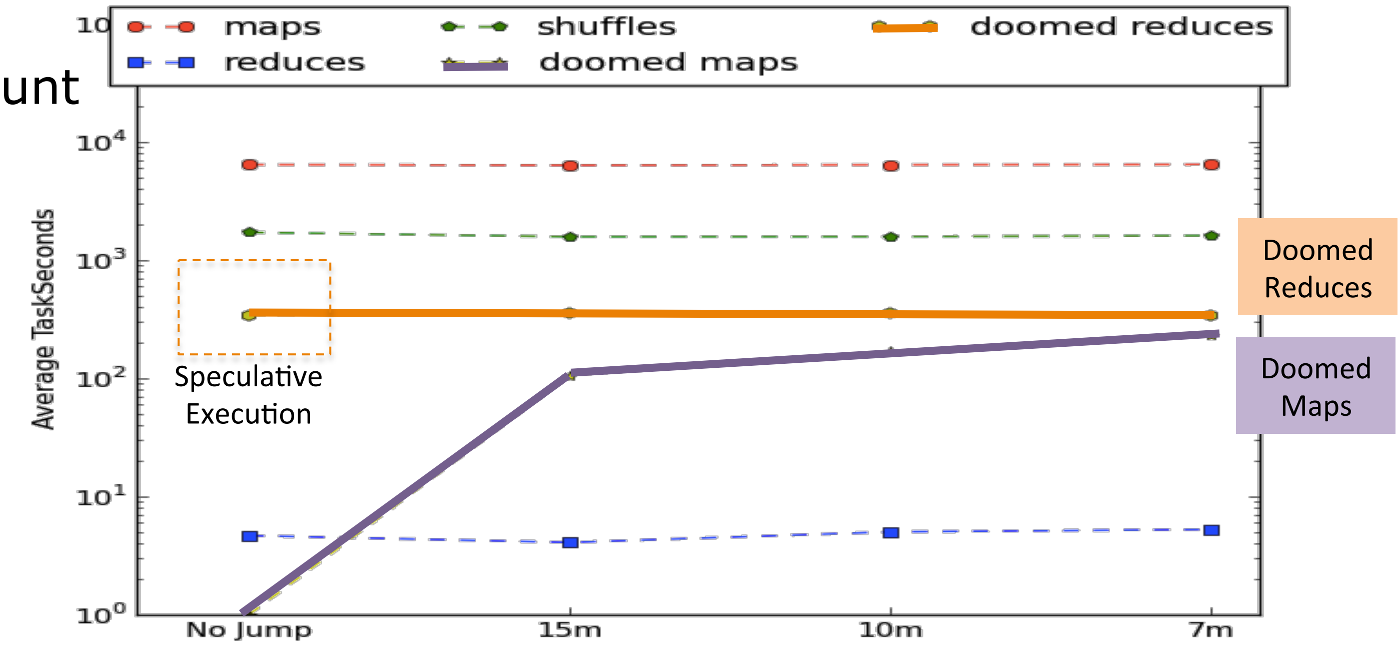
(a) No jump
(b) Jump during shuffle phase
(c) Jump during reduce phase

c



# Performance Measurements

Wordcount

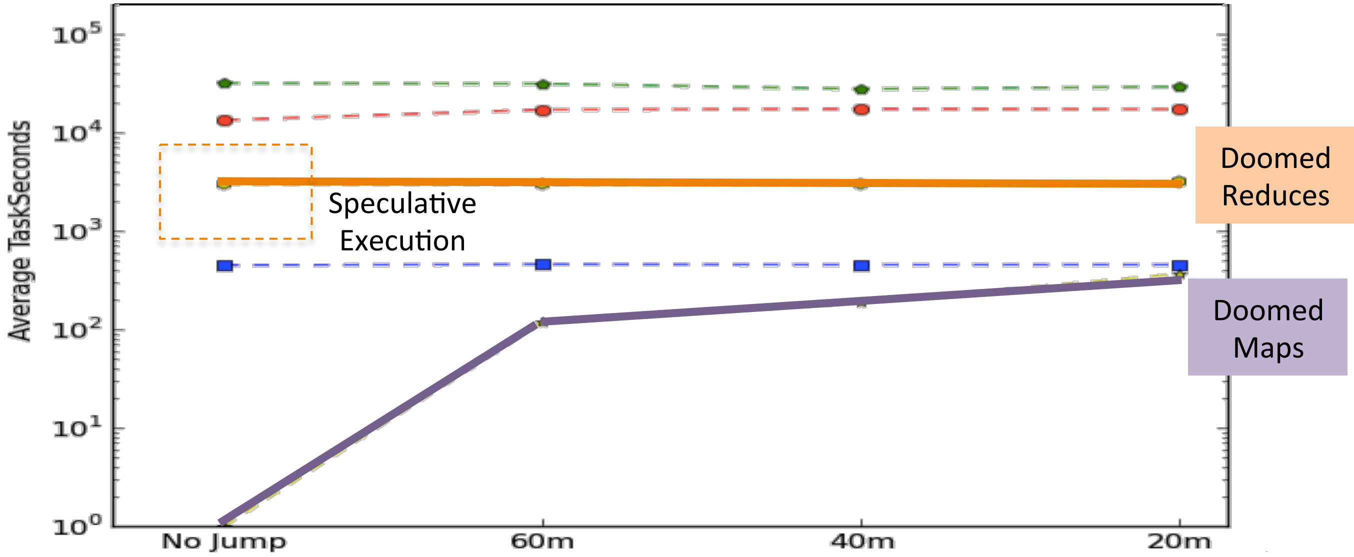


Speculative Execution

Doomed Reduces

Doomed Maps

Terasort



Speculative Execution

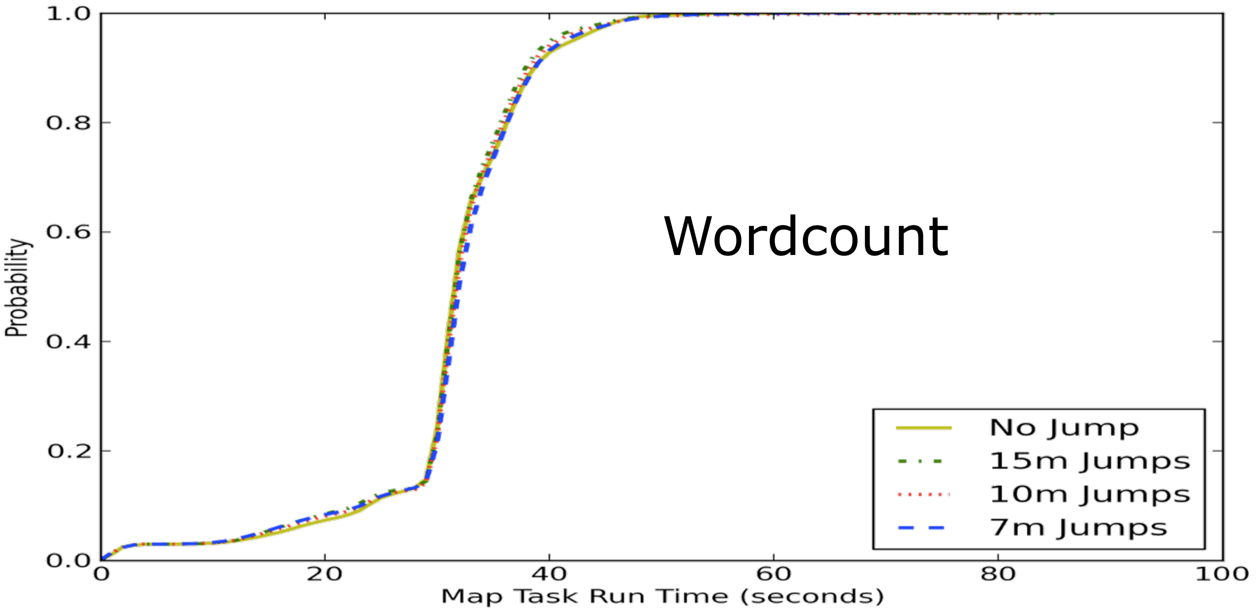
Doomed Reduces

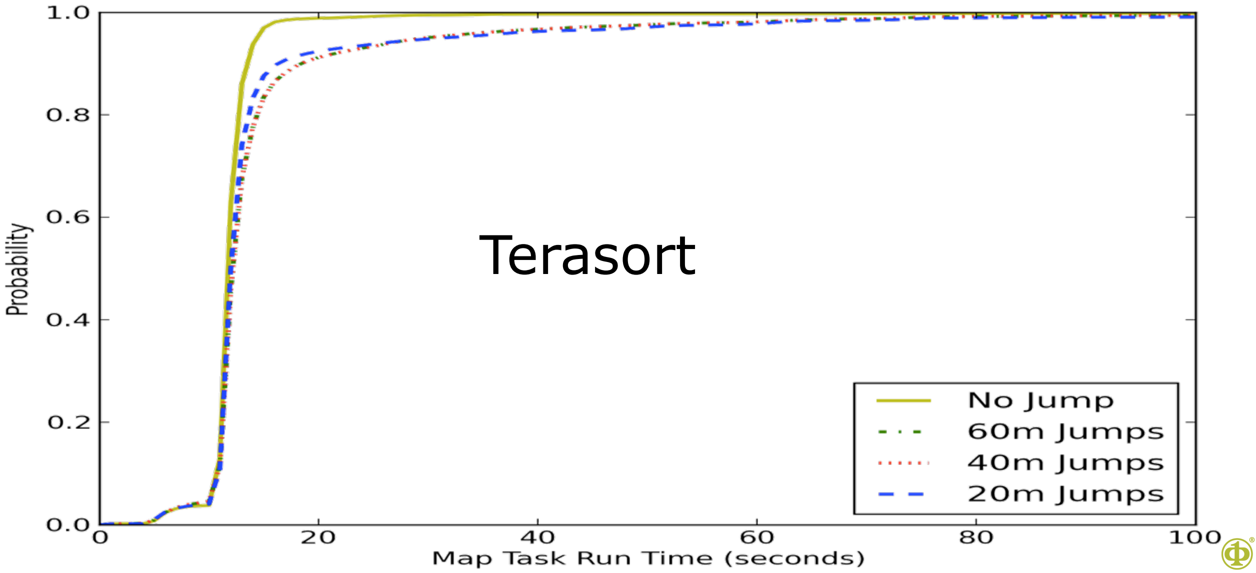
Doomed Maps

# Performance Measurements

Map Task – Insignificant

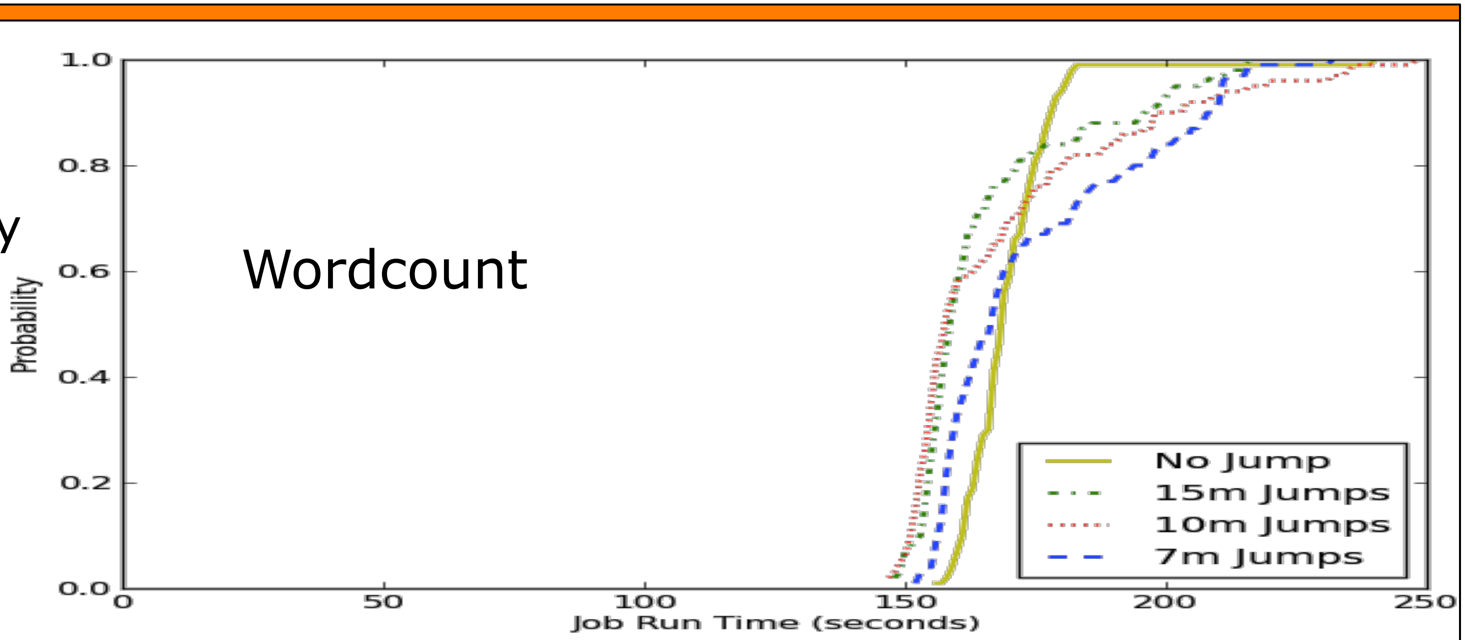
Fails to add doomed task execution time

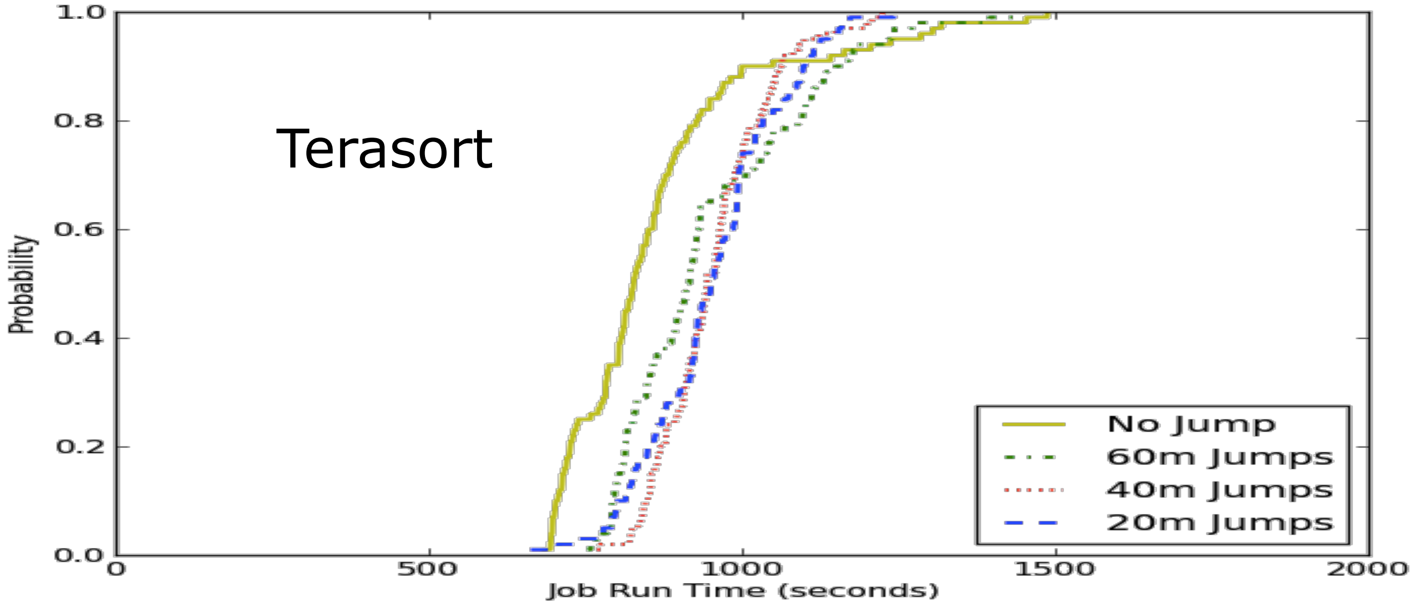




# Performance Measurements

Jobs- Affected by jump frequency





# Optimizing Jump Time

- Upper Bound
  - Maximum jump times to decrease overhead
  - Maximize nodes within cluster to increase parallel processing
  - Jump time must be less than maximum reservation window divided by the number of nodes
- Lower Bound
  - Hadoop behavior contributes to jump times
  - Must be greater than time to re-replicate all datablocks
  - Must be greater than the average execution time of the reduce tasks of currently executing MapReduce jobs

# Related Works

- SDSC myHadoop and Apache Hadoop-on-Demand (HOD)
  - Dynamically in userspace
  - HOD requires access to static external HDFS cluster
  - Limited to reservation limitations
  - Does not provide pseudo-persistent interactive capability
- FutureGrid and Amazon Elastic MapReduce Cloud
  - Use virtualization
  - Degraded I/O performance for data-intensive applications
- Mesos and Apache Hadoop YARN
  - New resource management mechanisms
  - Handle Hadoop and non-Hadoop processes
  - Still in development

# Conclusion

- Interactive pseudo-persistent MapReduce platform within the existing administrative structure of an academic high performance computing center

- As efficient as a persistent Hadoop cluster on dedicated computing resources, depending on the jump time

- Cluster remains stable, with good performance, in the presence of jumps that occur as frequently as the average length of reduce tasks

# Questions?

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*https://sourceforge.net/projects/jummp/*