AROMA: Automated Resource Allocation and Configuration of MapReduce Environment in the Cloud

Palden Lama and Xiaobo Zhou, ICAC '12 Proceedings of the 9th international conference on Autonomic computing Pages 63-72.

Summarized by: Drew Wicke
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Introduction

- Distributed data processing in the cloud (MapReduce Hadoop)
- Problems:
    - How to allocate VMs cost effectively.
    - How to set the parameters in Hadoop.
- Goal:
    - Meet job completion deadlines and minimize cost.
- Solution:
    - AROMA: Automatically allocate VMs and set Hadoop params. to meet deadlines and minimize costs.

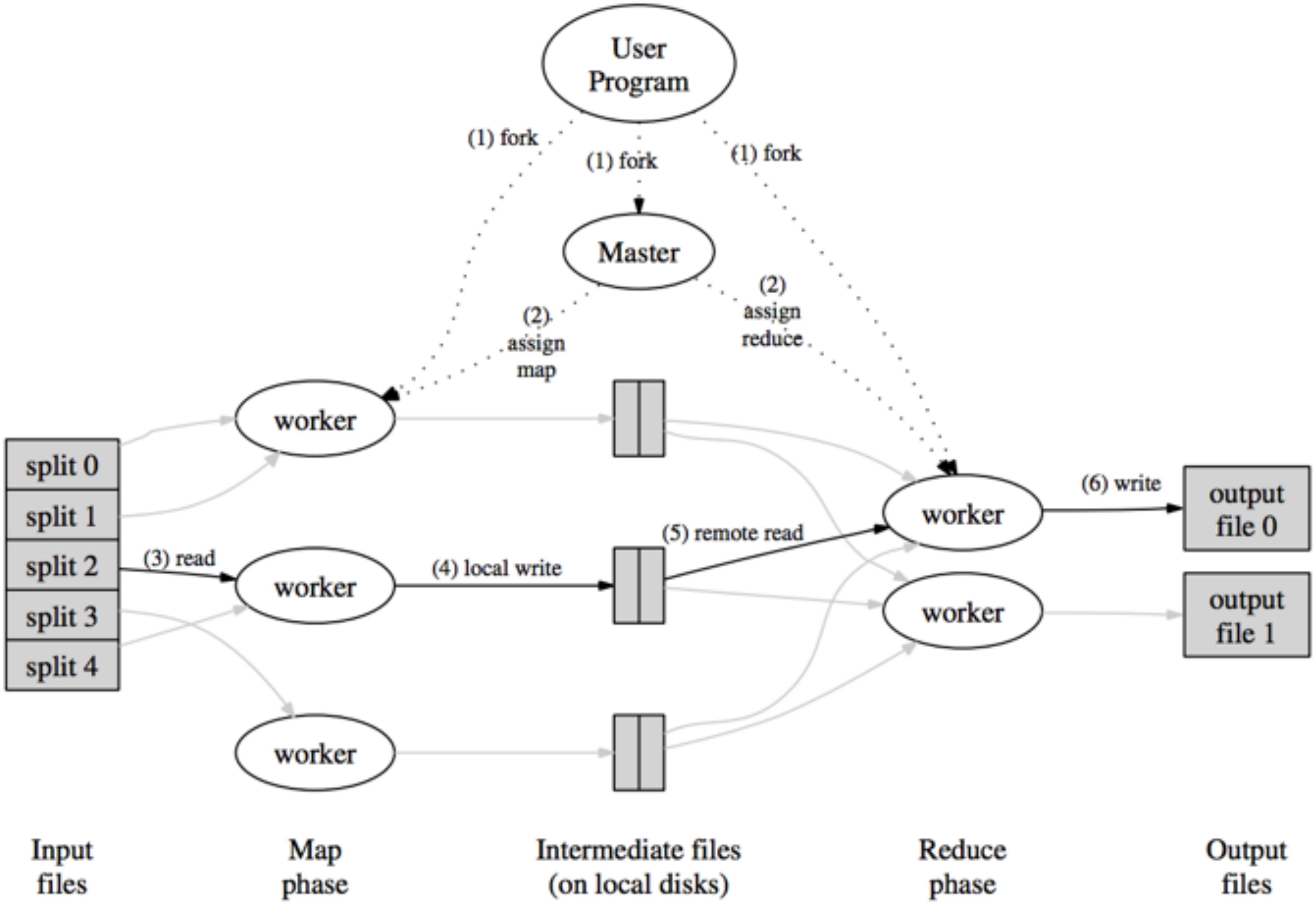
Challenges

- Heterogeneous dynamic cloud environment (not just Hadoop VMs) therefore same parameters might not produce same results.

- No performance models for such a complex distributed processing framework.

Note that a technical report in 2011 and a workshop paper in 2012 give performance models for Hadoop.

Lin, Xuelian, et al. "A practical performance model for hadoop mapreduce." Cluster Computing Workshops (CLUSTER WORKSHOPS), 2012 IEEE International Conference on. IEEE, 2012.



MapReduce

from
Dean, Jeffrey, and Sanjay Ghemawat. "MapReduce: Simplified Data Processing on Large Clusters." To appear in OSDI (2004): 1.

MapReduce Parameters

- Number of Reducers.
- Size of memory buffer for sorting map output.
- Number of concurrent connections to fetch input from Mapper.

Experiment Setup

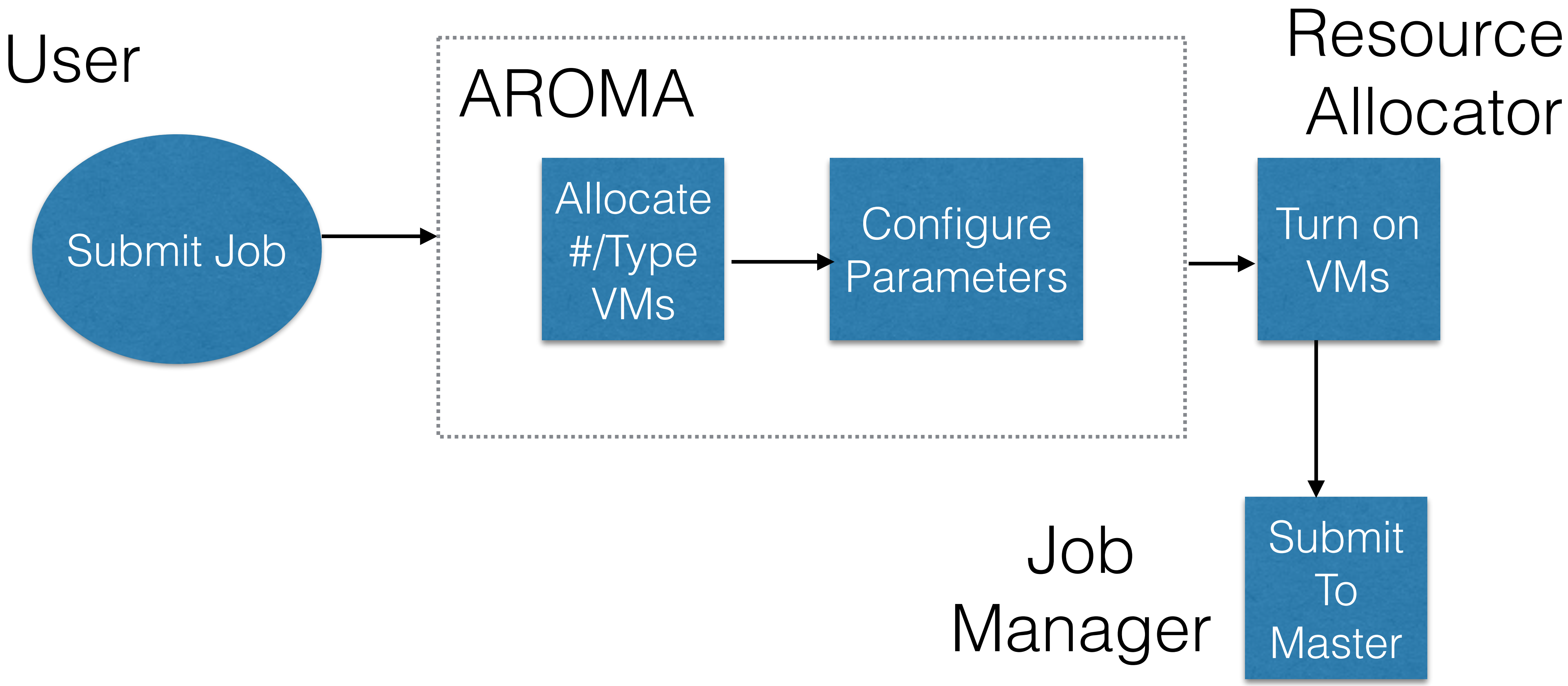
- Seven HP Pro-Liant BL460CG6 blade server modules and a HP EVA storage area network. (Custom built cloud environment).

- Hadoop jobs: Sort, Wordcount and Grep (standard examples from Hadoop distribution).

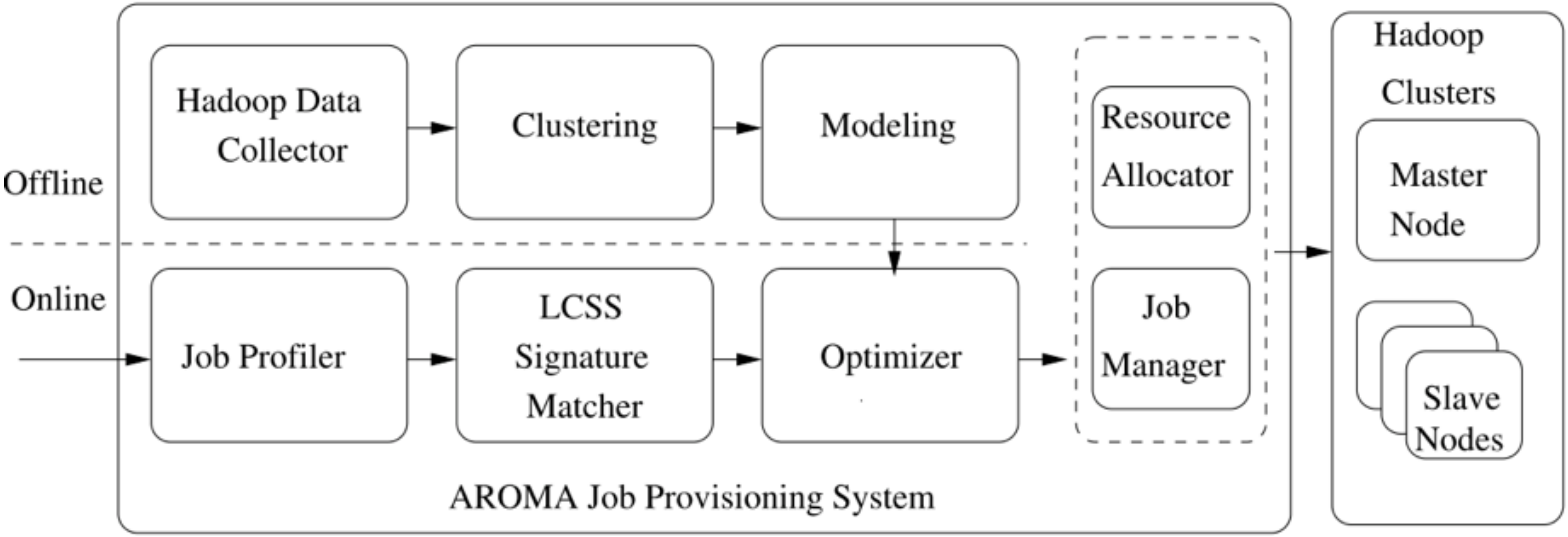
- RandomWriter and RandomTextWriter tools in the Hadoop package to generate data of various sizes for the Sort,WordCount and Grep programs.

- Compare AROMA to default.

AROMA


User
Submit Job
AROMA
Allocate #/Type VMs
Configure Parameters
Resource Allocator
Turn on VMs
Job Manager
Submit To Master

AROMA - workflow



Offline Phase

- Process log files.
- Collect resource utilization data.
- Produce performance models.

Clustering

- Group jobs with similar utilization patterns of CPU, network and disk resources.

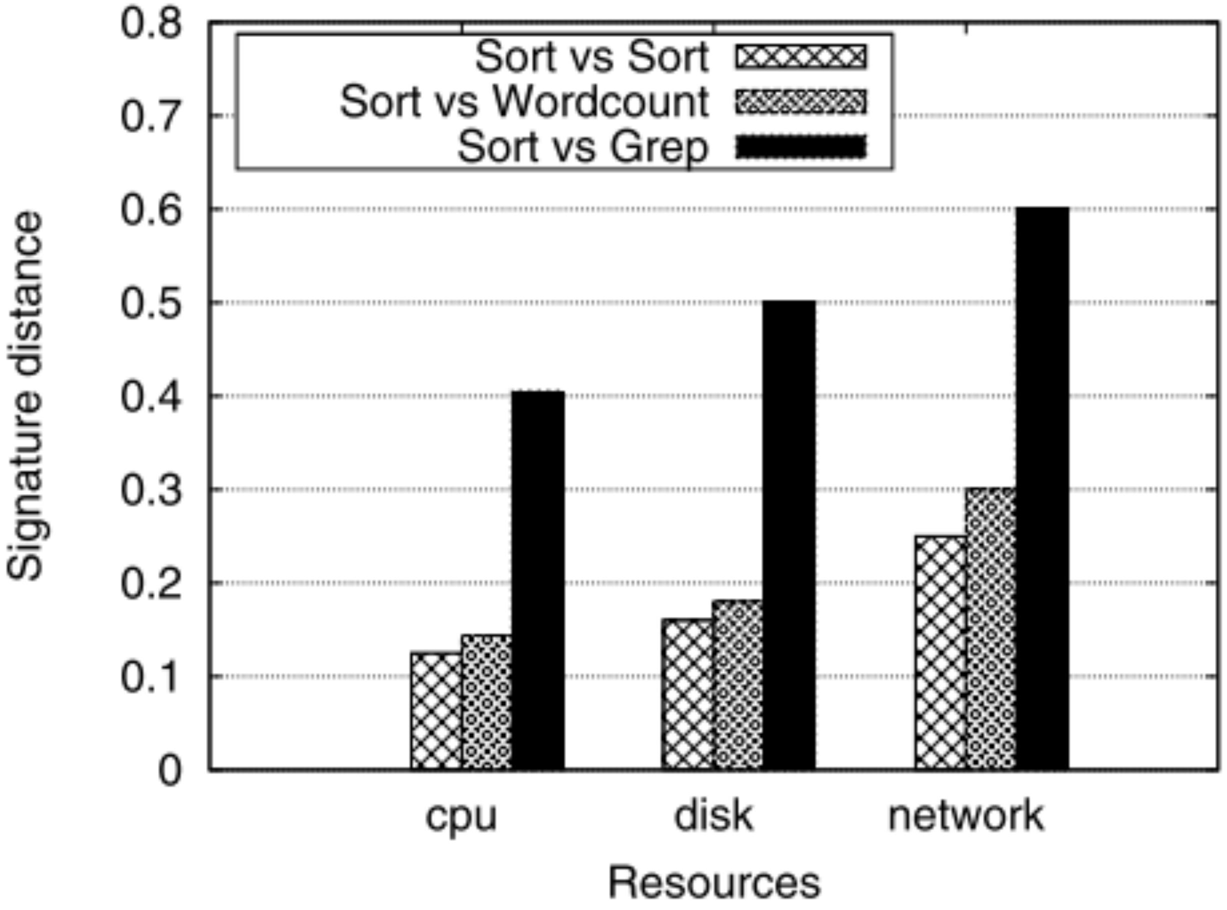
- K-Mediod based clustering technique, minimizes a sum of pairwise dissimilarities (rather than distances as is with k-means).

- Longest Common Subsequence (LCSS) distance measure to deal with noise.

Clustering

Sort and Wordcount are in the same cluster.

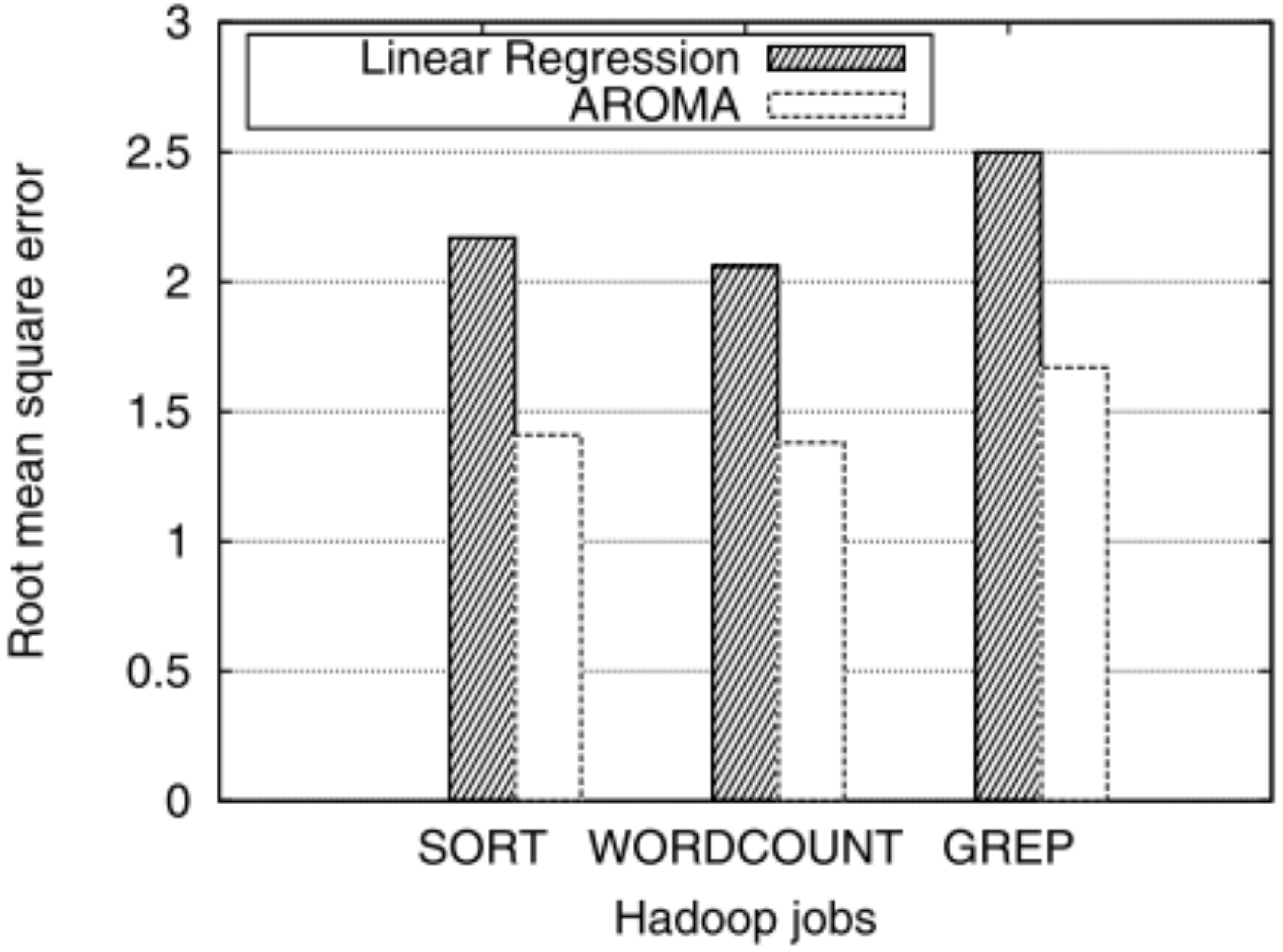
Grep is in the second cluster.



Performance Modeling

- For each cluster AROMA produces a performance model.
- Features are selected using a step-wise regression technique.
- Support Vector Machine (SVM) estimates the completion time of jobs belonging to a cluster for different input data sizes, resource allocations and configuration parameters.

SVM vs Linear Regression



Why compare to linear regression?

Note

- Stepwise Regression is very controversial [1-3].
- Possible overfitting [2].
- “It yields p-values that do not have the proper meaning, and the proper correction for them is a difficult problem” [3].
- Details in the paper on the stepwise regression are sparse.

[1] Whittingham, Mark J., et al. "Why do we still use stepwise modelling in ecology and behaviour?." Journal of animal ecology 75.5 (2006): 1182-1189.

[2] Babyak, Michael A. "What you see may not be what you get: a brief, nontechnical introduction to overfitting in regression-type models." Psychosomatic medicine 66.3 (2004): 411-421.

[3] http://www.stata.com/support/faqs/statistics/stepwise-regression-problems/

Online Phase

- Run a scaled down version of the job (reduced VMs and data size).
- Collect performance data (the resource utilization signature).
- Determine which cluster the job belongs to by comparing to cluster centroid using LCSS of the signatures.

Optimizer

- Solve the non-linear constrained optimization problem for minimizing the number of VMs allocated while constraining the time to less than the deadline and appropriate settings for Hadoop.

- Solved using a pattern search algorithm, the generating set search. No specific toolbox/ implementation is mentioned. No runtime or cost for calculating is mentioned.

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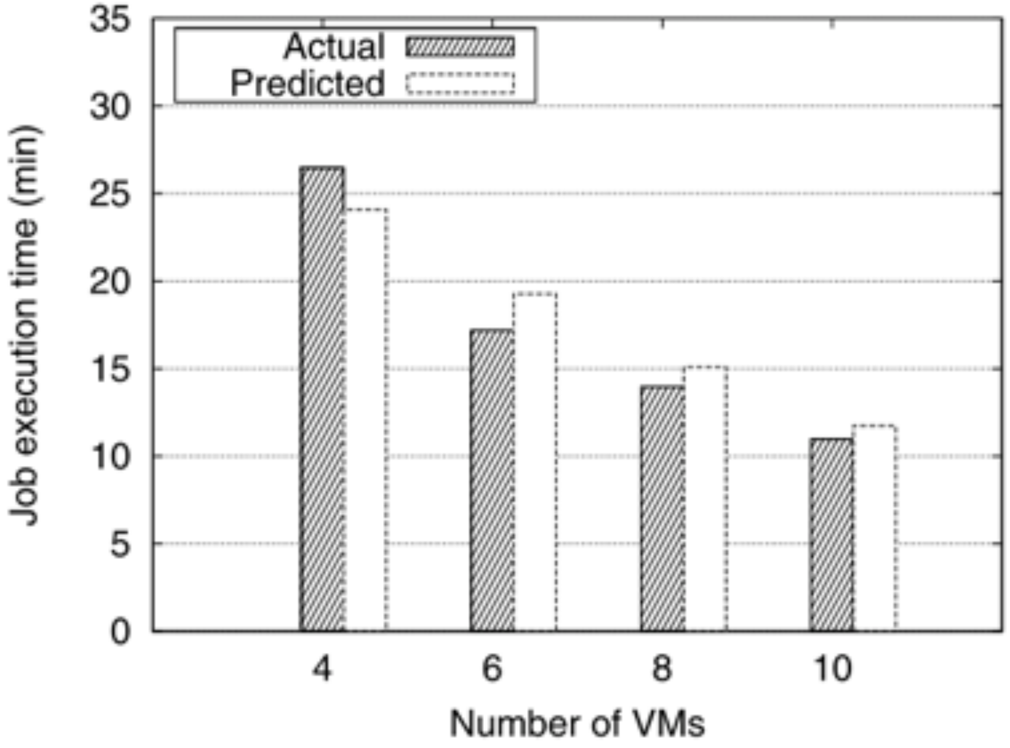
Experiments

- Performance Model Accuracy
- Auto-configuration
- Resource Allocation and Configuration
- Adaptiveness to Ad-hoc Jobs

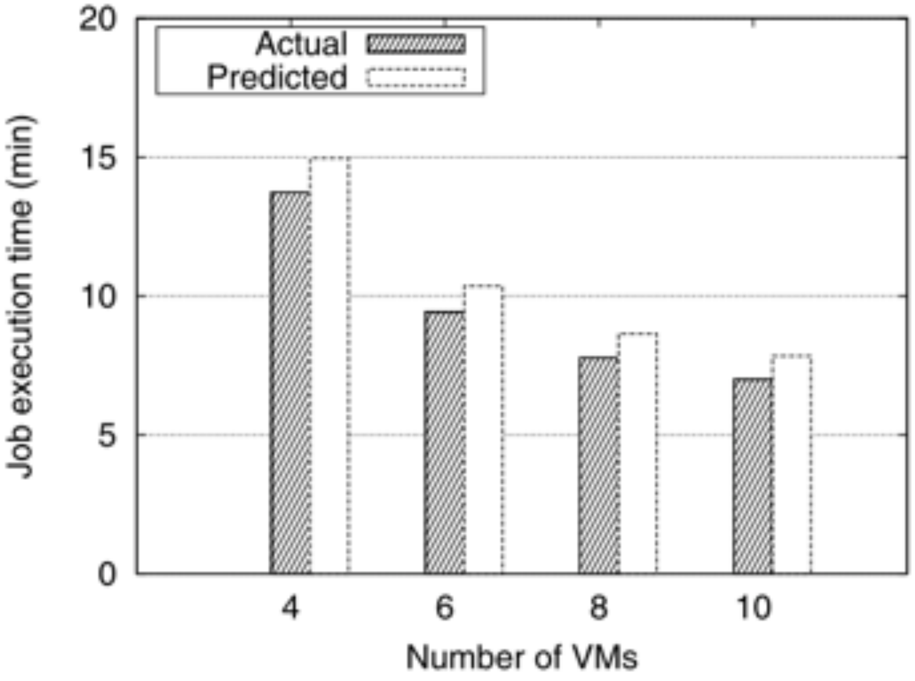
Performance Model Accuracy

Small VMs



(a) Sort.

Medium VMs



(a) Sort.

- Note that the relative error between the actual and predicted job completion time is less than 12% on all the cases (sort, word count and grep).

Auto-Configuration

- Only tested for the Hadoop Sort benchmark
- Parameters for Hadoop are auto-configured for both small and medium size VMs using **10 GB** input data
- Graphs showing the performance and cost for both small and medium sized VMs with 4, 6, 8 and 10 VMs.
- “The improvement in job performance and cost due to AROMA increases from 17% to 30% when using more number of [small] VMs.”
- However, the paper shows the Default vs AROMA parameters found for 6 small and medium VMs on **20 GB** input data, but no performance and cost graphs.

Resource Allocation and Configuration

- They next compared AROMA with and without auto-configuration

- They showed for the sorting problem that on average AROMA can produce a cost efficiency of 25%

- Demonstrated that AROMA’s optimizer is important to weed out costly configurations

Adaptiveness to Ad-hoc Jobs

- To test AROMAs adhoc ability they studied the wordcount problem with 10 GB input
- Found that AROMA is able to identify it as similar to the Sort job
- AROMA uses the info gathered in the staging area and the prediction data to scale the resource allocation and configurations
- They claim less than 12.5% error in prediction of execution time
- They show prediction versus actual execution times for 20 different configurations.

Conclusion

- AROMA automatically sets
    - VM configuration (number of homogenous VMs)
    - Hadoop configuration
- “Optimal job provisioning decisions with respect to resource allocation efficiency in the face of unpredictable input data sizes and performance expectation”

Questions

- Why did they not find or create performance models?
- Why did they examine so few test cases?
- Why did they use step-wise regression when other methods exist?
- What does AROMA stand for?