



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación

ALOJA-ML: A Framework for Automating Characterization and Knowledge Discovery in Hadoop Deployments

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Sydney, Australia

Brief Introduction

« Hadoop

- Environment for parallel task execution (Map-Reduce)
- Complex distributed runtime executions

« Initial Motivation

- Hadoop optimization requires run and examine multiple executions
- Modeling behaviors to estimate execution performance
- ... then observe Hadoop behavior without running lots of executions



The ALOJA Project

« ALOJA framework:

“Which Hadoop & data-center configuration is the best in cost-effectiveness terms?”

- Provide **expert-guided to automated** analysis
 - User schedule Hadoop executions
 - Framework runs and collect monitor information
 - Information is shown to the user for comparing configs. & deployments

« The project:

- Joint initiative Barcelona Supercomputing Center – Microsoft Research
- Towards comparing Big-Data deployment providers and configurations
- Seeking to provide knowledge and tools to the community

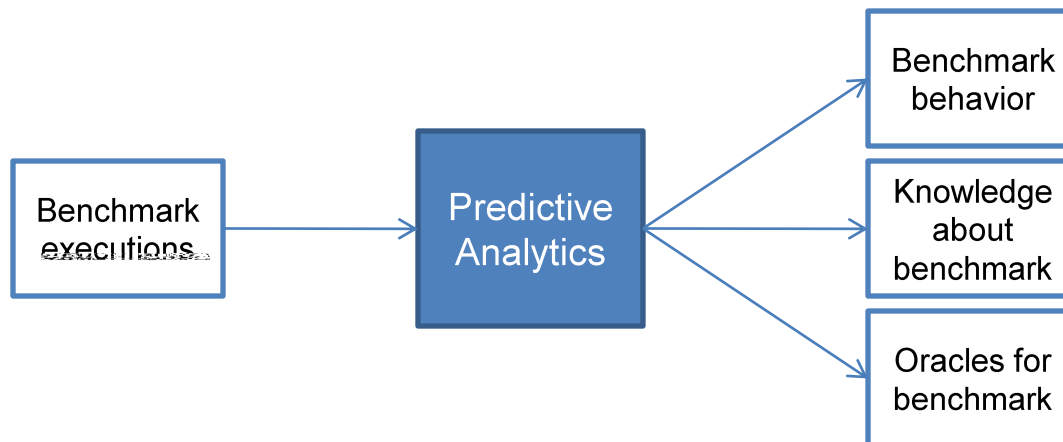


Benchmarks and Predictive Analytics

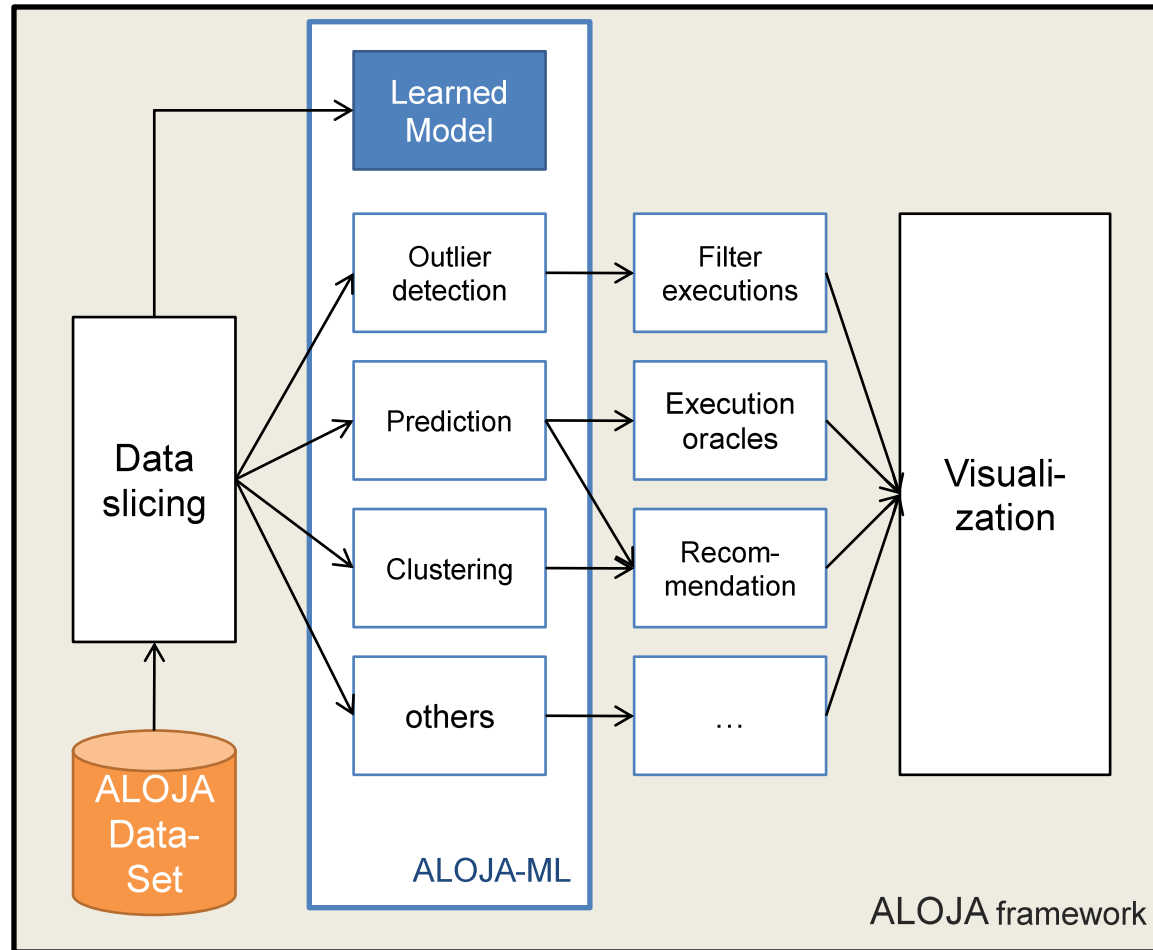
« Predictive Analytics

- Deploy **model-based methods** enhancing analysis
- Predict behavior elements and apply them to extract knowledge
- Used also for recommendation (of configurations/set-ups)
- Or even anomaly detection mechanisms

« ALOJA-ML: the ALOJA predictive ~~component~~ component for modeling benchmarks



Modeling Hadoop – P.A. Layer



Modeling and prediction as a service
layer in the framework

Modeling Hadoop – Data-sets

« The ALOJA data-set

- Over +40.000 Hadoop benchmark executions
- Input features: Benchmark info, Configuration info, Deployment info, ...
- Output features: Service Level Objects, Used Resources, ...

« Hadoop Executions:

- ...from different Hadoop versions
- ...from different underlying infrastructure
- ...with different input sizes (100GB–1TB)
- ...with some anomalous executions
- ...

Benchmarks	
hadoop, terasort, sort, wordcount, kmeans, ...	
PageRank, distcount, dfsio, write	
Hardware Configurations	
Network	Ethernet, Infiniband
Storage	SSD, HDD, Remote Disks, ...
Cluster	Local nodes, VM description
Software Configurations	
Maps	2 to 32
I/O Bandwidth	1 to 100
I/O File Number	1K to 250K
Replicas	1 to 3
Block Size	32MB to 256MB
Compression Algs.	None, BZIP2, GZIP, Snappy
Hadoop-Info	Version

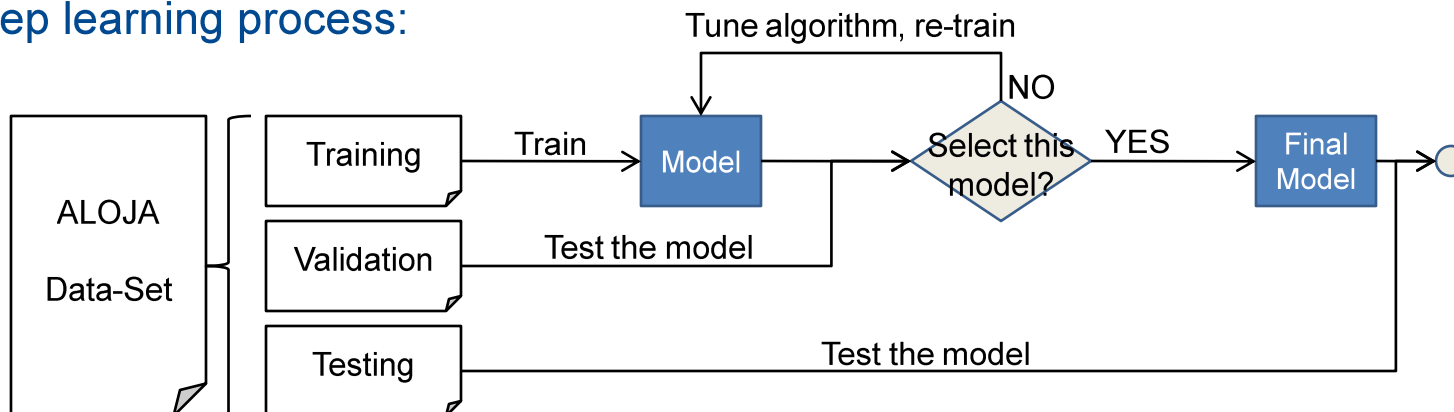
Configuration parameters on data-set



Modeling Hadoop – Methodology

Methodology

- 3-step learning process:



- Different learning algorithms: (10% trainings, 50% testings)
- Different learning algorithms: Regression trees; Nearest-neighbors methods; Linear/Multinomial regressions; Neural networks

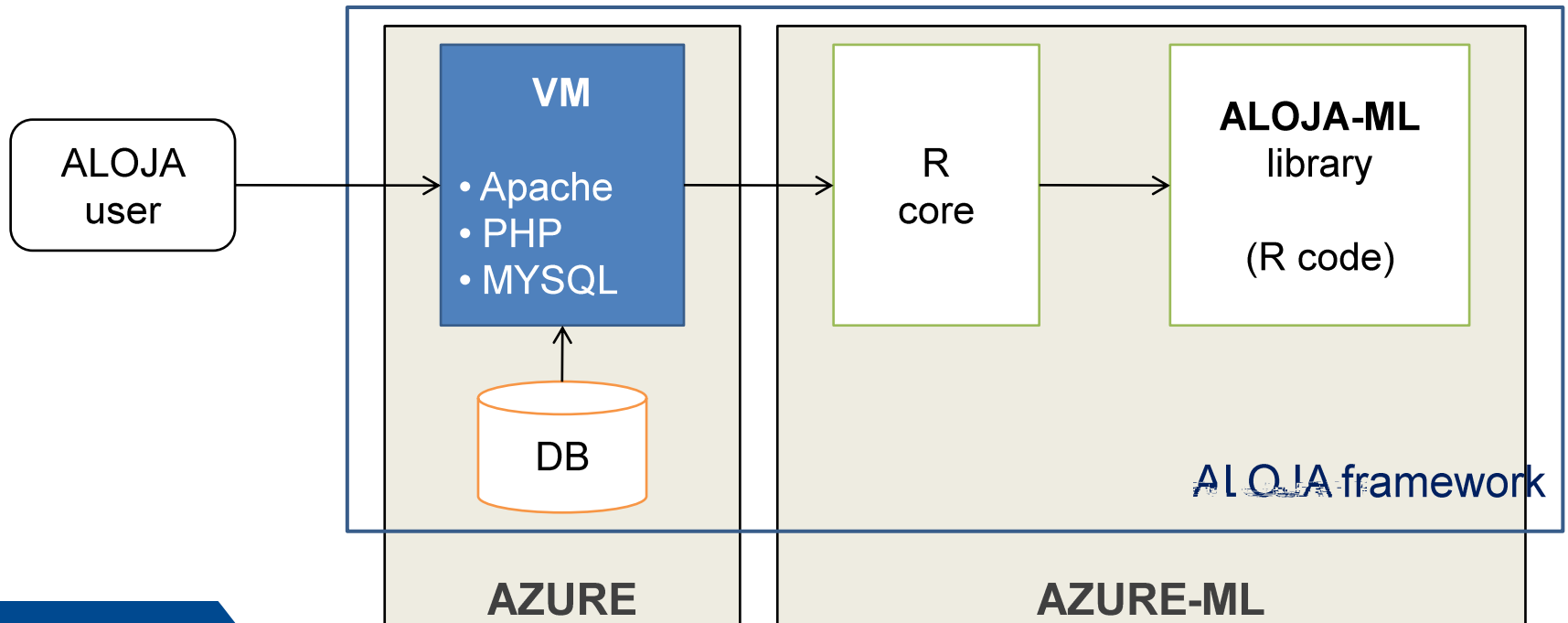
Learning results

- Mean Absolute Errors ~250s (ranges in [100s, 6000s])
- Relative Absolute Errors between [0.10, 0.25]
 - Depend on benchmark and # of examples per benchmark
 - Some executions are/may be anomalies

Implementation and Technology

Software infrastructure

- Environment (ALOJA): Hadoop + LAMP + Vagrant
- Data mining tools (ALOJA-ML): R-cran + Java (for RWeka)
- Methods can run locally or at Microsoft **AZURE** and **AZURE-ML**

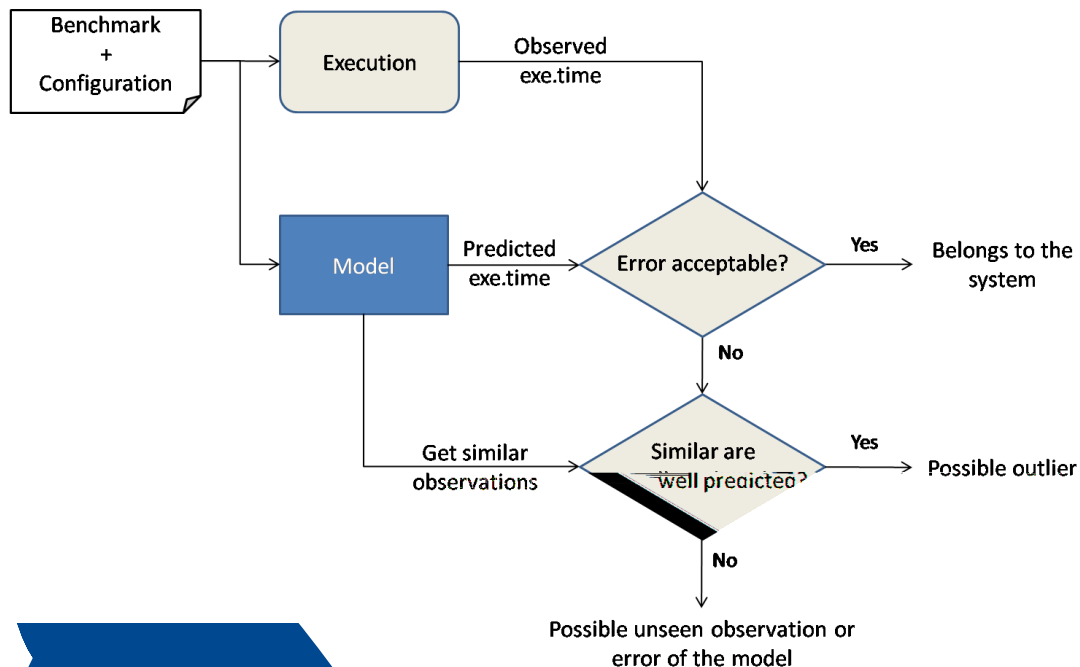


Case of use 1: Anomaly Detection

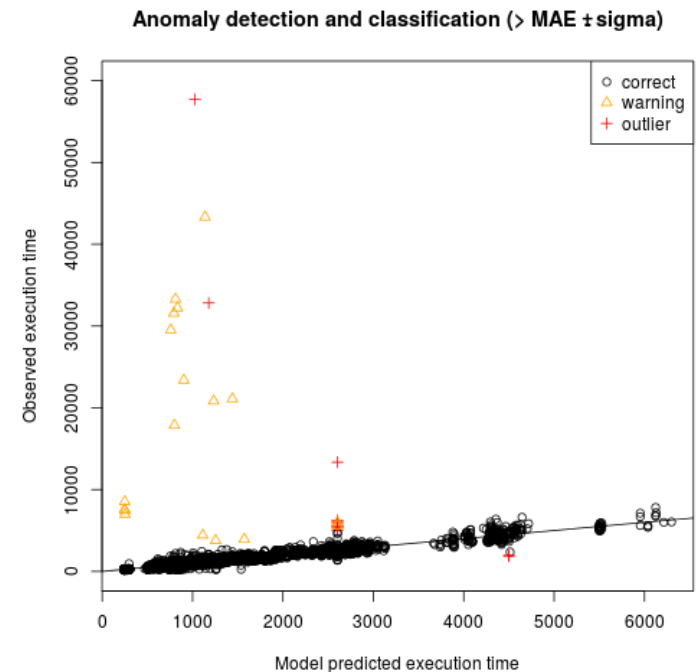
« Anomaly Detection

- Model-based detection procedure
- Pass executions through the model
- Executions not fitting the model are considered “out of the system”

Anomaly detection procedure:



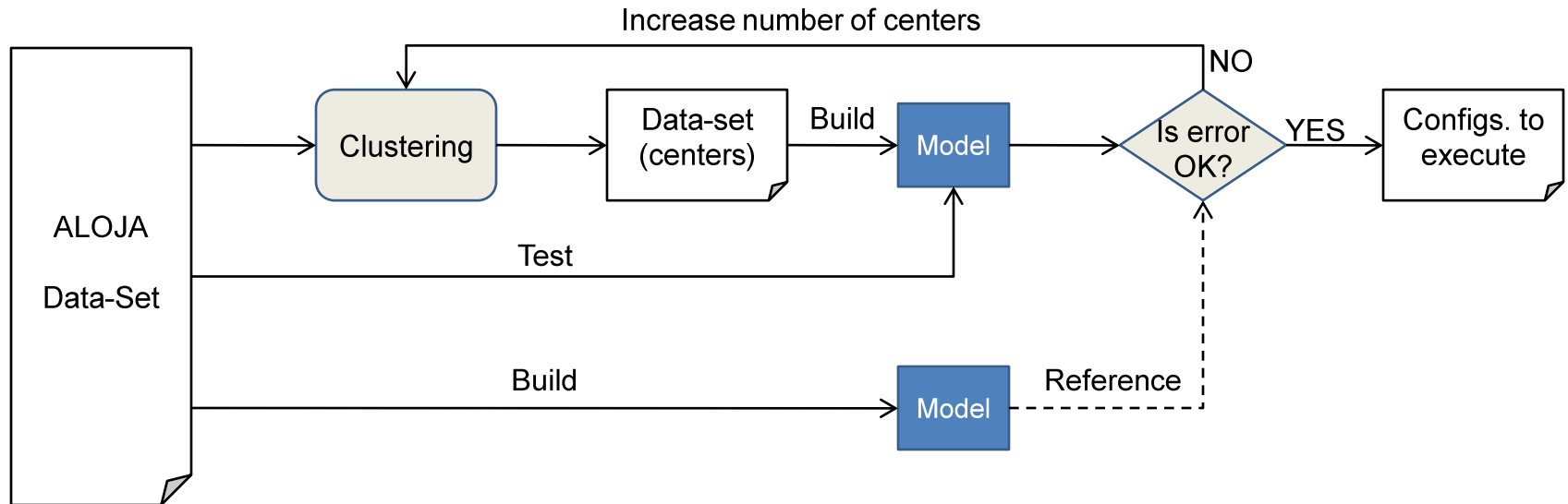
Testing ALOJA Data-set:



Case of use 2: Guided Benchmarking – Method

Guided Benchmarking

- Best subset of configurations for modeling a Hadoop deployment
- Clustering to get the “representative execution” for each similar subset of executions

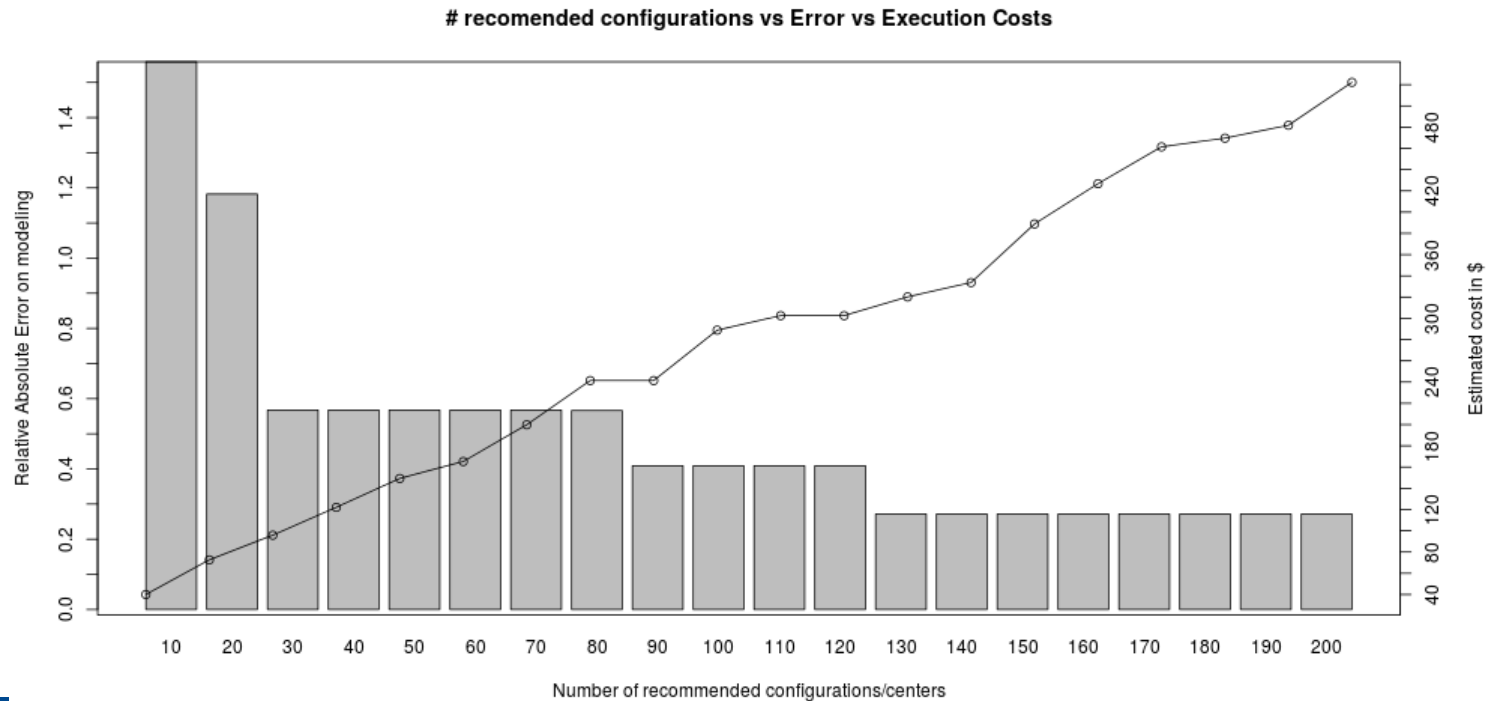


Case of use 2: Guided Benchmarking – Trade-off

Trade-off “# executions” vs. “deployment representation”

– Clustering methods

- # executions \sim running time/costs \sim fidelity to original benchmarking
- k-means: iterate over “k” \rightarrow trade-off “executions-accuracy”



Other cases

Tools for treating data, observed and predicted

Find best configuration

- Use models to predict search sub-spaces and order by execution time

Feature exploration:

- Use models to unfold search sub-spaces and retrieve feature rankings
- Then display that in a user-readable way

Net	Disk	IO.FBuf	Blk.Size	Prediction (s)
ETH	HDD	65536	128	2249.766
IB	HDD	65536	128	2737.112
ETH	SSD	65536	128	1036.366
IB	SSD	65536	128	1036.366
ETH	HDD	131072	128	2165.927
IB	HDD	131072	128	2653.273
ETH	SSD	131072	128	969.537
IB	SSD	131072	128	969.537
ETH	HDD	65536	256	2249.766
IB	HDD	65536	256	2737.112
ETH	SSD	65536	256	1036.366
IB	SSD	65536	256	1036.366

Disk=SSD

IO.FBuf=131072 -> 970s

IO.FBuf=65536 -> 1036s

Disk=HDD

Net=ETH

IO.FBuf=131072 -> 2166s

IO.FBuf=65536 -> 2250s

Net=IB

IO.FBuf=131072

Blk.size=128 -> 2653s

Blk.size=256 -> 2653s

IO.FBuf=65536

Blk.size=128 -> 2737s

Blk.size=256 -> 2737s

Net=ETH Disk=HDD IO.FBuf=131072 Blk.size=256 Prediction=2165.927s
 Net=IB Disk=HDD IO.FBuf=131072 Blk.size=256 Prediction=2653.273s
 Net=ETH Disk=SSD IO.FBuf=131072 Blk.size=256 Prediction=969.537s
 Net=IB Disk=SSD IO.FBuf=131072 Blk.size=256 Prediction=969.537s

Perasort=4 maps, sortfactor=10, no=comp

Conclusions

- « Predictive analytics enhancing benchmark cost-effectiveness visualization
- « Modeling behaviors → Realize predictions → Use in tools
 - Execution prediction [Planning, tuning configurations, ...]
 - Anomaly detection [Model-based + data-driven]
 - Recommendations [Parameters, HW deployments, data-center/providers]
- « Next steps:
 - New tools into the ALOJA-ML framework (knowledge extraction, pattern mining, ...)
 - Expand and detail features



Availability of the framework and the data-set

- Framework **on-line demo** available at <http://aloja.bsc.es>
 - Also downloadable to deploy locally
- Data-sets available with the framework
 - Also downloadable from the on-line demo

Check it out!





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Thanks for your attention

Questions?

(I'll be at the Poster session, for more information
and a live demo)

[Screen 1: Front page and ML tools]


ALOJA, Hadoop Benchmark Repository and Performance Analysis Tools

Benchmark Repository ▾ Config Evaluations ▾ Cost/Perf Evaluation ▾ Performance Details ▾ Prediction tools ▾ ALOJA Reference ▾ Blog ▾ BSC-MSR Centre

Welcome to the **ALOJA** project,

ALOJA is an initiative of the BSC-MSR research centre in Barcelona to explore Hadoop's performance. You can find introductory [Slides](#) and [Papers](#) in the ALOJA Reference menu.

This site is under constant development and it is in the process of being documented. For more information, browse the site, the [code](#), and send inquiries, feature requests or bug reports to: [hadoop@bsc.es](#)

If you're curious about the name of the project, visit [ALOJA](#) 

Site's content:

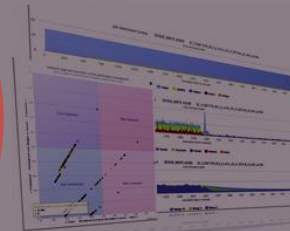
Section	Description
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Video DEMO of ALOJA	Brief video showcasing ALOJA's main online features (a bit outdated).
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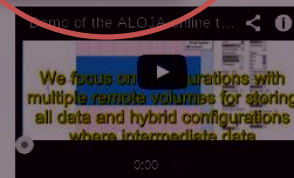
Benchmark Executions	This section presents the benchmark execution repository. It features more than 30,000 executions and counting. This tool allows you to browse, filter, search, and select distinct executions to compare and analyse its execution details.
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Hadoop Job Counters	The Hadoop Job Counters section allows to browse the counters output at each of the Hadoop executions, filter them, and to order by a specific counter the selected runs (or all). The section presents the summary of all the Job execution counters, Map and Reduce specific counters, and the I/O subsystem counters. It also features the details by task: to understand the running time of each Map or Reduce process.
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Modeling Data
Collapse Data
Predict Configurations
Parameter Evaluation (ML)
Anomaly Detection
Minimal Configurations
Variable Crossing
Variable Crossing (vs Exec.Time)
Variable Crossing (vs Prediction)
Data Summary



Fork me on GitHub



Job ID	Execution	Job Type	Running Time	Map	Reduce	IO Time	IO Size	IO Rate	IO Error	IO Retries	IO Success	IO Failure	IO Timeout	IO Aborted	IO Skipped	IO Ignored	IO Other	IO Total
1
2
3
4
5
6
7
8
9
10

Job ID	Execution	Job Type	Running Time	Map	Reduce	IO Time	IO Size	IO Rate	IO Error	IO Retries	IO Success	IO Failure	IO Timeout	IO Aborted	IO Skipped	IO Ignored	IO Other	IO Total
1
2
3
4
5
6
7
8
9
10

[Screen 2: Modeling benchmark data-sets]

ALOJA, Hadoop Benchmark Repository and Performance Analysis Tools

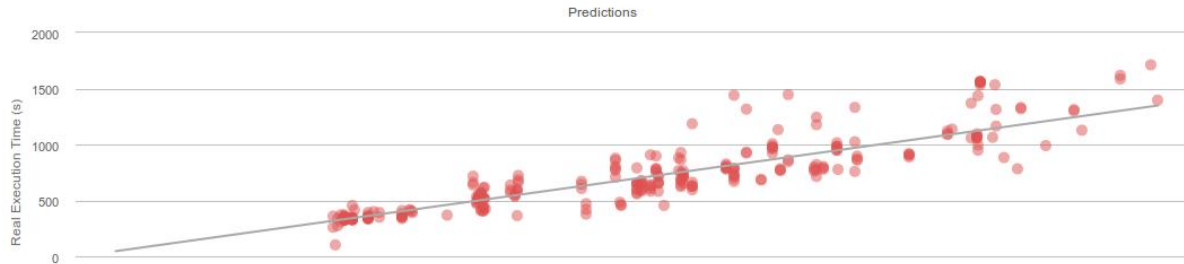


Home Benchmark Repository ▾ Config Evaluations ▾ Cost/Perf Evaluation ▾ Performance Details ▾ Prediction Tools ▾ ALOJA Reference ▾ Blog BSC-MSR Centre

Modeling Data: This tool is in charge of creating models and predictors for Hadoop datasets. Using machine learning algorithms, this tool creates a model from the data-set of executions selected through the right panel. Then returns a model (kept in the system), and the result of testing the model against a sample of executions to check its accuracy. Our methodology uses the 50% of the selected executions as training (tr), a 25% for validating the model (tv), and a 25% to test the model (tt).

To use the tool, select the specific set of executions that you want to model at the right menu, the method to train it, and as option if you want the model to admit future not-seen-yet values. Then observe how the quality of the model in the chart below. [MAE: Mean Absolute Error, RAE: Relative Absolute Error]

Predicted Exec.Time vs Real Exec.Time



Predefined views:

MLPrediction Default ▾

Apply

Filters

Learn Model

Reset

Basic filters

Hardware

Cluster datanodes: +

Benchmark h...

[Screen 3: Predicting configurations]

Predicted Configurations

Show 10 entries

Search:

	Benchmark	Net	Disk	Maps	IO.SFS	Rep	IO.FBuf	Comp	Blk.Size	Cluster	Bench.Type	Prediction
1	terasort	ETH	HDD	4	10	1	131072	Cmp0	128	CI15	HiBench	1019.1590000
2	terasort	ETH	HDD	4	10	1	65536	Cmp0	128	CI4	HiBench	618.2790000
3	terasort	ETH	HDD	4	10	1	65536	Cmp0	128	CI5	HiBench	2136.4190000
4	terasort	ETH	RR3	4	10	1	65536	Cmp0	128	CI6	HiBench	843.0730000
5	terasort	ETH	RR3	4	10	1	65536	Cmp0	128	CI19	HiBench	762.6890000
6	terasort	ETH	RR2	4	10	1	65536	Cmp0	128	CI19	HiBench	753.3910000
7	terasort	ETH	RR2	4	10	1	131072	Cmp0	128	CI19	HiBench	771.5810000
8	terasort	ETH	RR1	4	10	1	131072	Cmp0	128	CI19	HiBench	994.6670000
9	terasort	ETH	RL3	4	10	1	131072	Cmp0	128	CI8	HiBench	1203.0580000
10	terasort	ETH	HDD	4	10	1	65536	Cmp0	128	CI15	HiBench	1520.0000000

Showing 1 to 10 of 1,027 entries

Previous 1 2 3 4 5 ... 103 Next

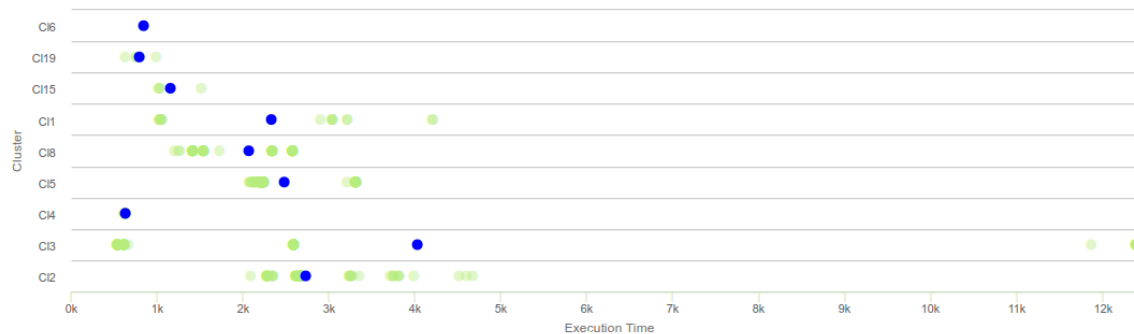
Plot Executions by Class

Feature selector:

Clusters

☒ Display Predicted ☐ Display Observed

Configurations by Attribute



Predicted Configurations Observed Configurations Predicted Average Per Value Observed Average Per Value

Predefined views:

MLFindAttrs Default

Apply

Filters

Generate Predictions

Reset

Basic filters

Benchmarks:

terasort

Clusters: (CL) + -

☐ 02/A7/3Dn
☐ 03/A7/8Dn
☐ 04/A7/8Dn

Networks: + -

☒ Ethernet
☐ InfiniBand

Disks: + -

☐ HD2
☐ HD3
☐ HD4
☐ HD5

Hardware

Hadoop configurations

Machine learning

Model to use:

41ed1f3ff1dd72dac

☒ Predict with unseen attributes

Advanced filters

ALOJA Related Publications

“ ALOJA project: automatic characterization of cost-effectiveness on Hadoop deployments

- Nicolas Poggi, David Carrera, Aaron Call, Rob Reinauer, Nikola Vujic, Daron Green and Jose Blakeley, et al. "ALOJA: a Systematic Study of Hadoop Deployment Variables to Enable Automated Characterization of Cost-Effectiveness". IEEE BigData 2014

“ ALOJA-ML: Predictive analytics tools for benchmarking on Hadoop deployments

- Prediction of benchmarking behavior, anomaly detection, ranking features...
 - Josep Ll. Berral, Nicolás Poggi, David Carrera, Aaron Call, Rob Reinauer, Daron Green. "ALOJA-ML: A Framework for Automating Characterization and Knowledge Discovery in Hadoop Deployments". ACM SIGKDD - KDD 2015
- Study of modeling of benchmarks, specifics vs general models
 - Josep Ll. Berral, Nicolas Poggi, David Carrera. "A Case of Study on Hadoop Benchmark Behavior Modeling Using ALOJA-ML". Technical session on WBDB'15.

