

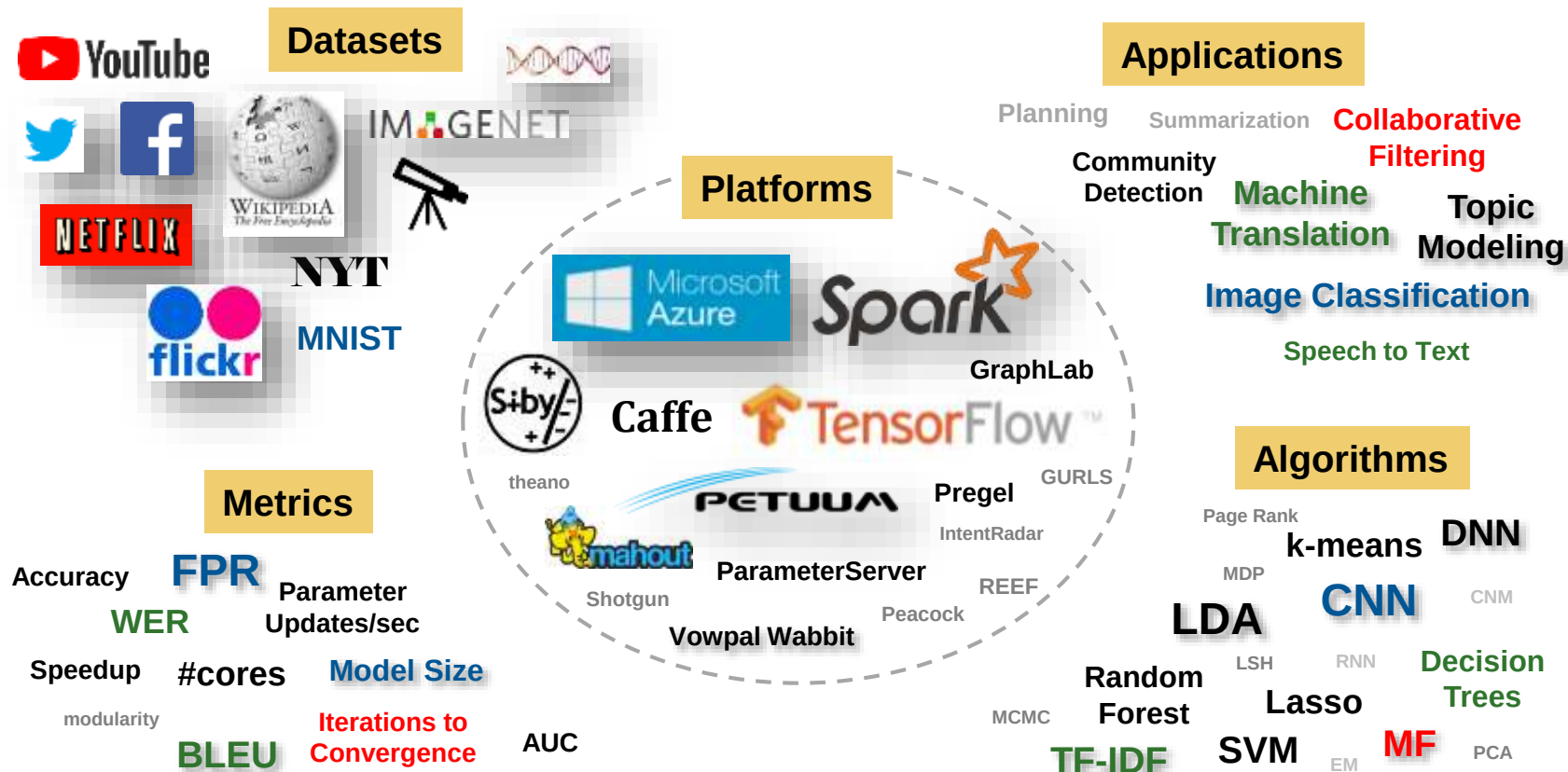


Research Review 2017

Measuring Performance of Big Learning Workloads

Dr. Scott McMillan, Senior Research Scientist

Project Introduction: Big Learning Landscape



Big Learning: Large-Scale Machine Learning on Big Data

Problem:

- Over 1,000 papers are published each year in Machine Learning.
- Most are empirical studies and few (if any) provide enough detail to reproduce the results.
- Complexity of systems begets complexity in metrics – often partially reported.
- Slows adoption by DoD of new advances in Machine Learning.

Solution:

- Facilitate consistent research comparisons and advancements of Big Learning systems by providing sound **reproducible** ways to measure and report performance.

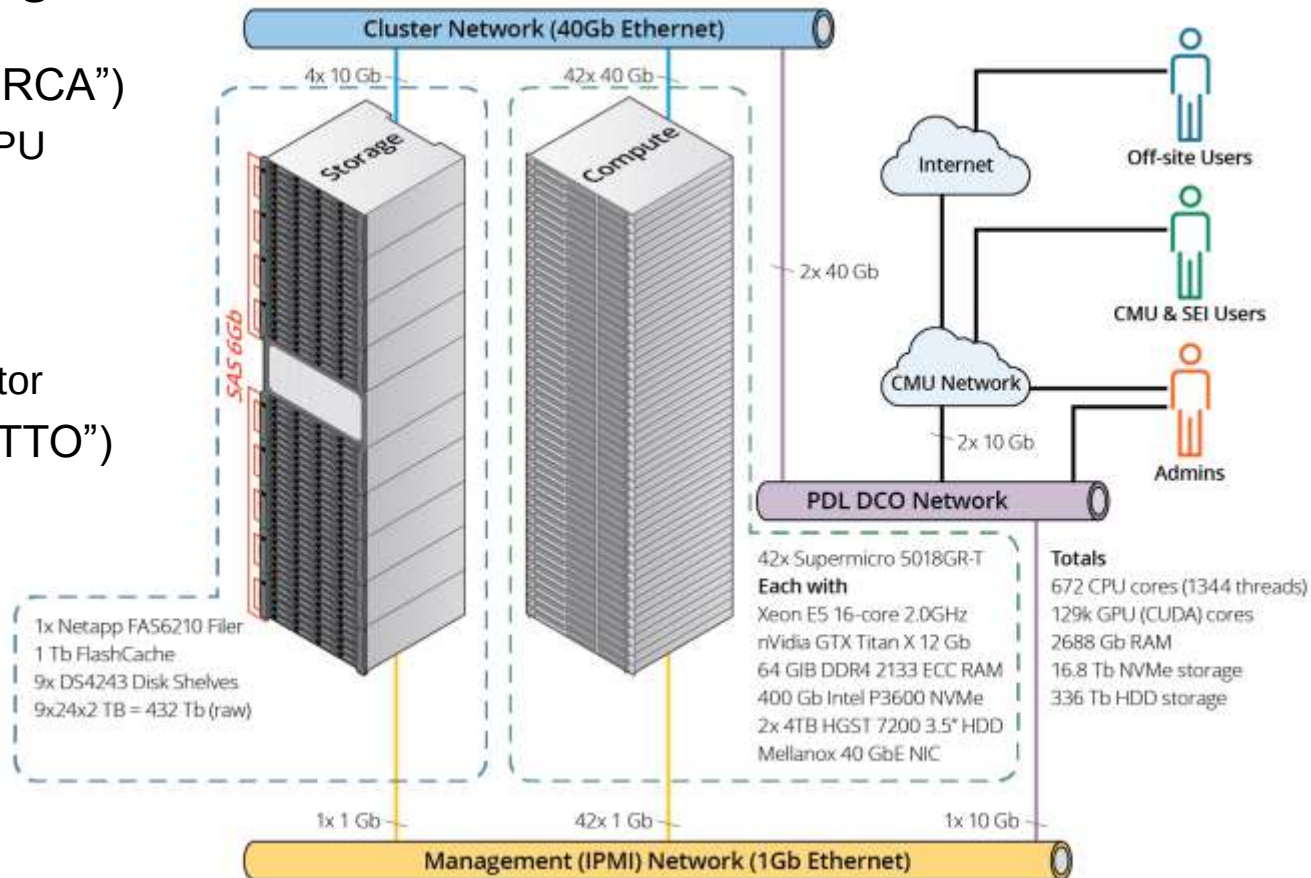
Approach:

- Develop technology platform for consistent (and complete) evaluation.
 - Performance of the computing system
 - Performance of the ML application
- Evaluate relevant Big Learning platforms using this benchmark: Spark+MLlib, Tensorflow, Petuum
- Collaborate with CMU's Big Learning Research Group

¹FACT SHEET: National Strategic Computing Initiative, 29 July 2015.

ORCA: Big Learning Cluster

- 42 compute nodes (“ORCA”)
 - 16 core (32 thread) CPU
 - 64GB RAM
 - 400GB NVMe
 - 8TB HDD
 - Titan X GPU accelerator
- Persistent storage (“OTTO”)
 - 400+ TB storage
- 40Ge networking



Performance Measurement Workbench (PMW) Architecture

Persistent Services

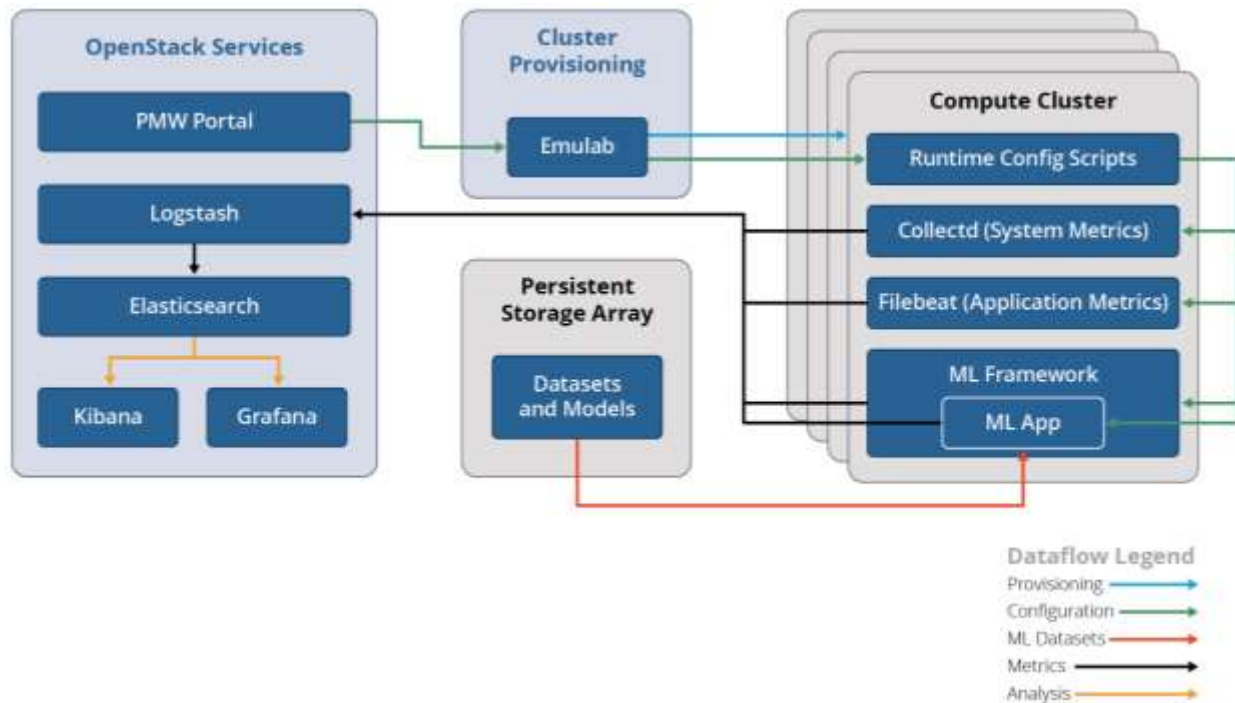
- OpenStack
- Web portal
 - simplifies provisioning
 - coordinates tools
- Data collection/analysis
 - “Elastic Stack”
 - Grafana

Provisioning

- Emulab
- “bare-metal” provisioning

Hardware Resources

- Compute cluster
- Data storage



Performance Measurement Workbench (PMW) Architecture

Persistent Services

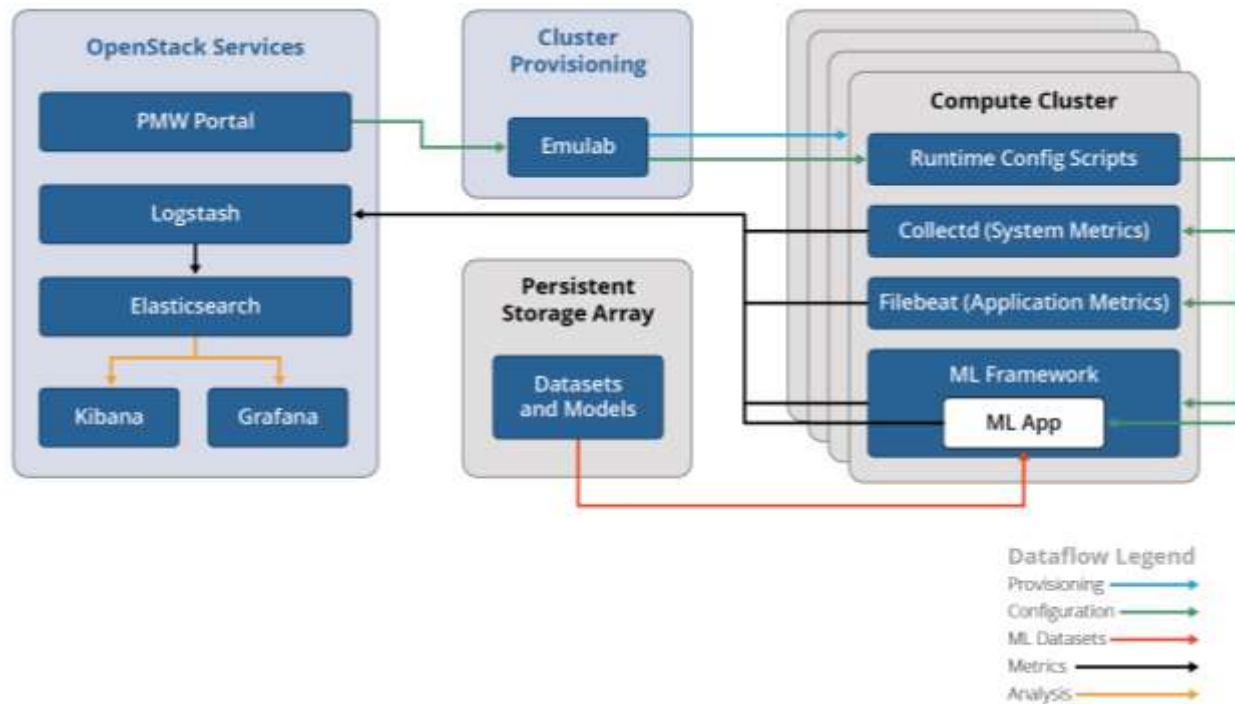
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Provisioning

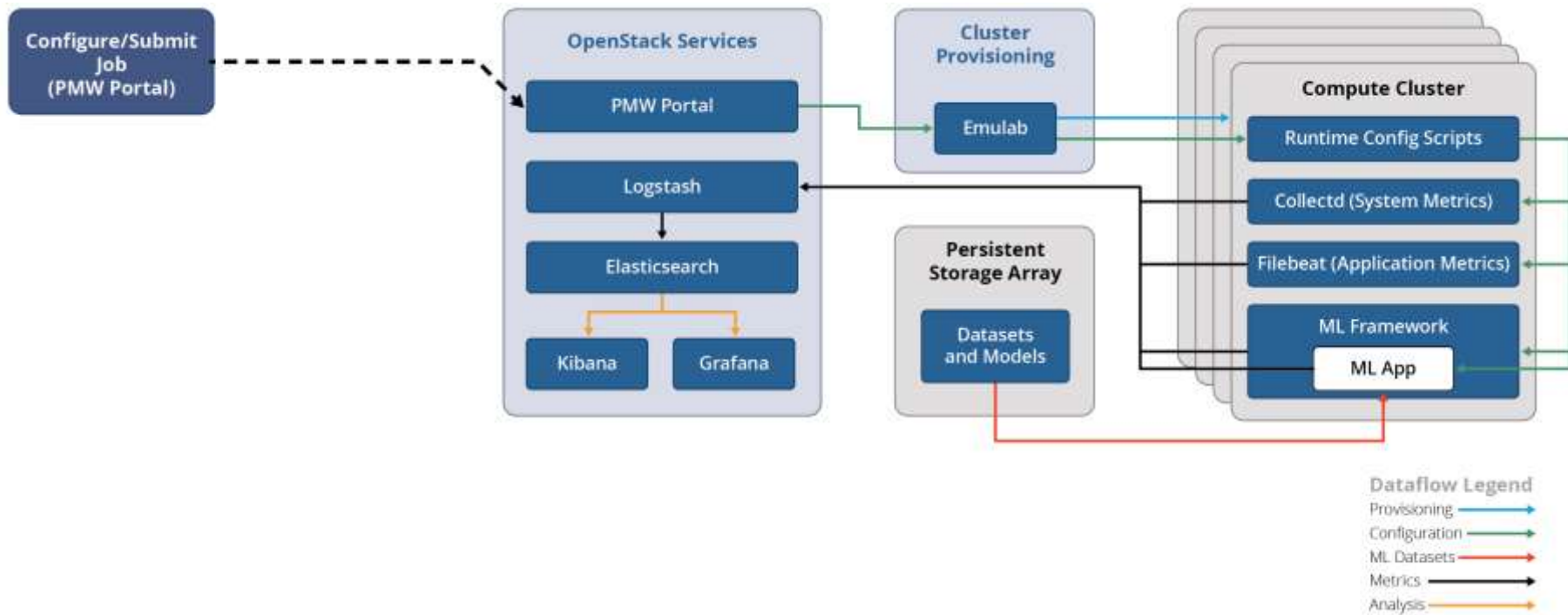
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Hardware Resources

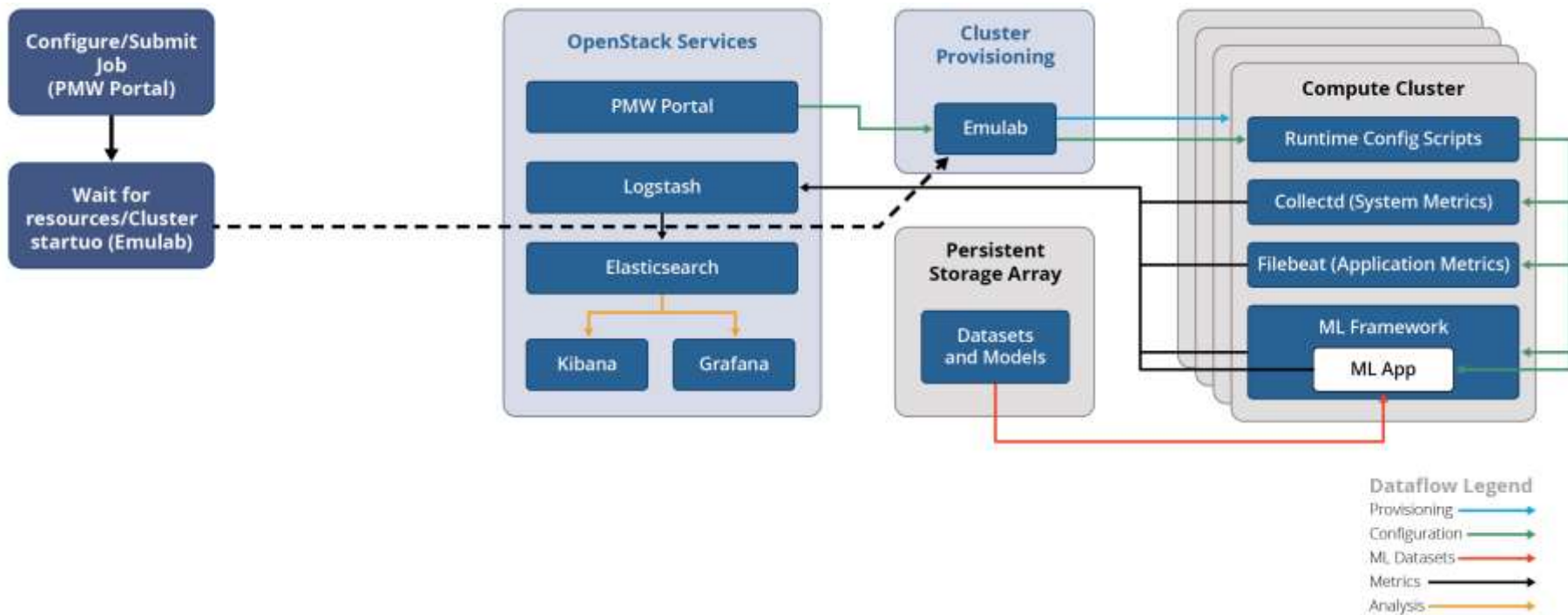
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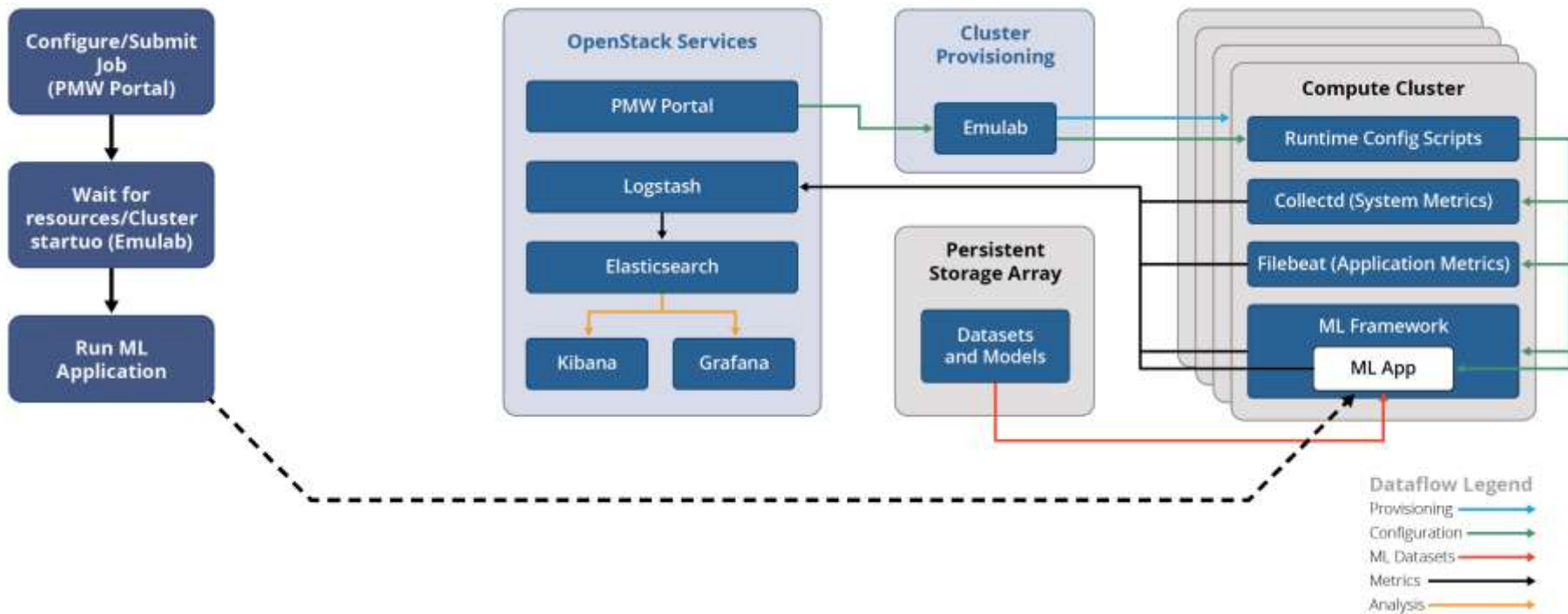
PMW Workflow



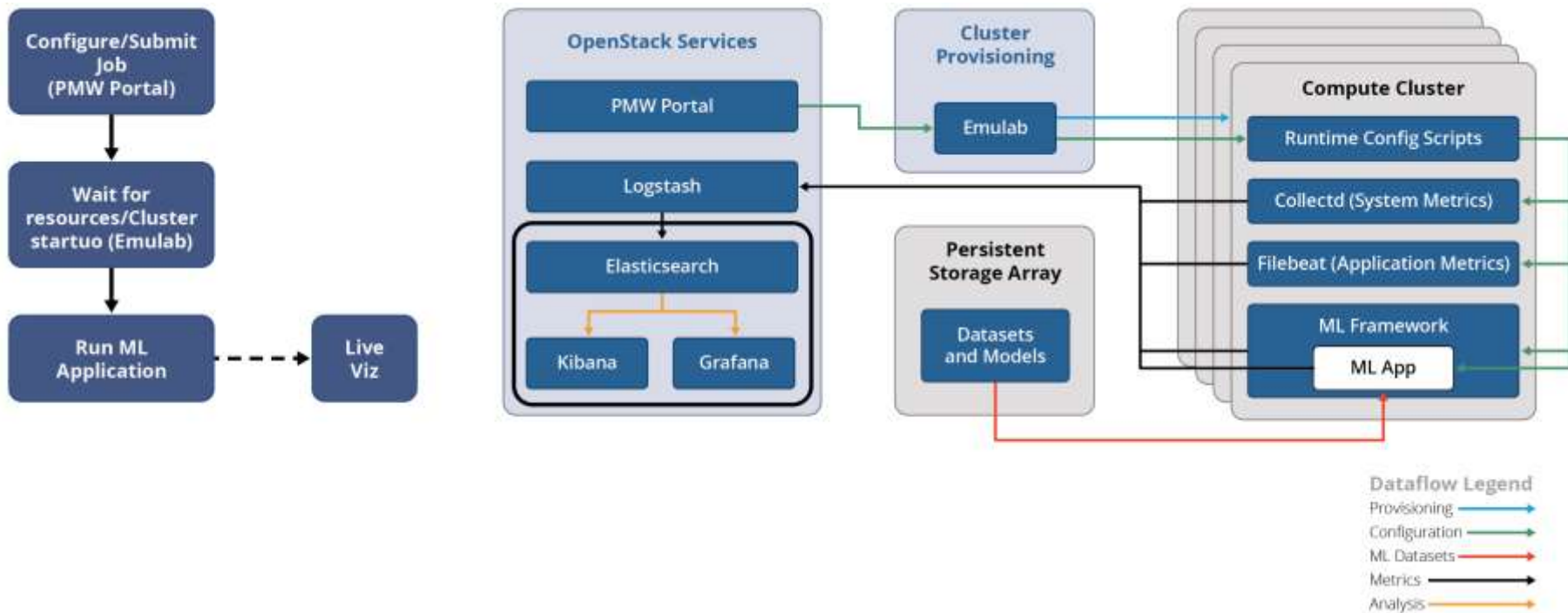
PMW Workflow



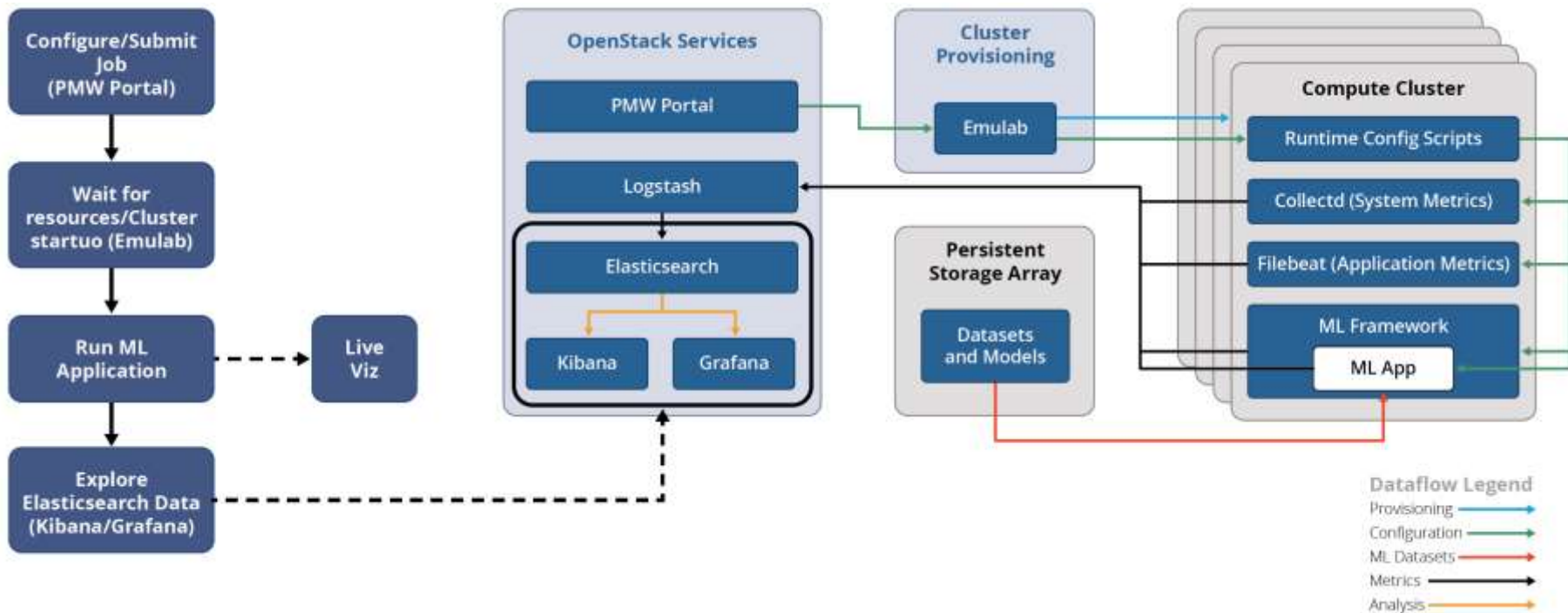
PMW Workflow



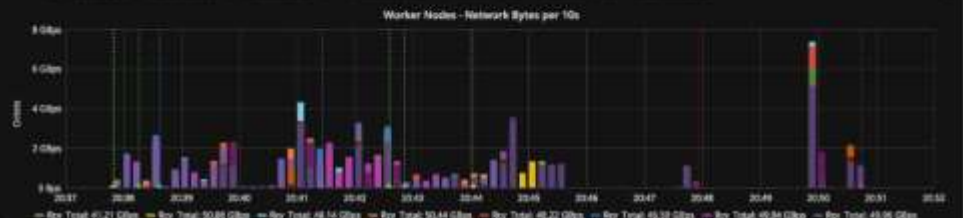
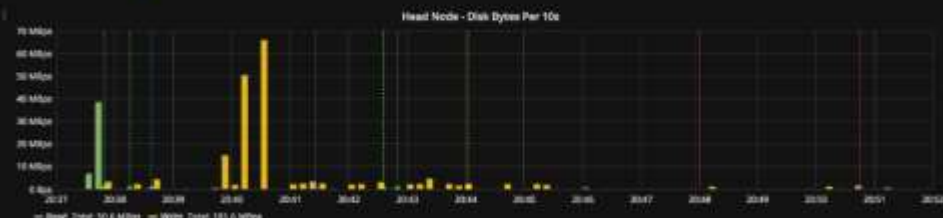
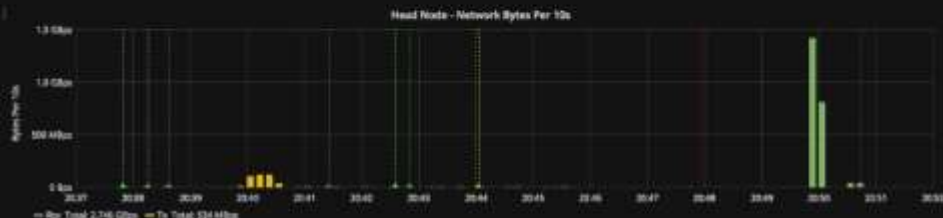
PMW Workflow



PMW Workflow



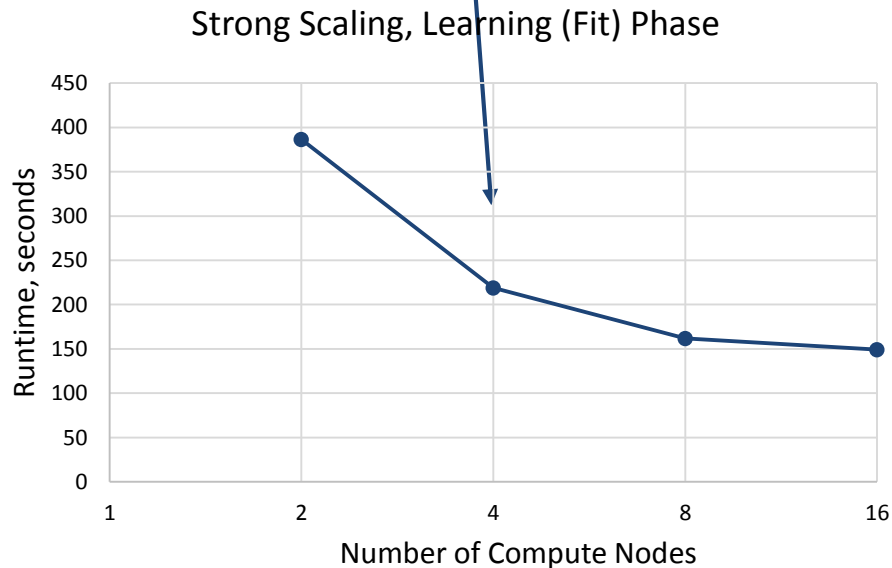
Dashboard (Live Display and Historic)



In-Depth Analysis

framework	algorithm	data_set	nodes_count *	load_training_phase_time	fit_phase_time	load_testing_phase_time	validate_phase_time
spark	linear_regression	5000_by_500000	3	68.713	386.479	18.952	321.56
spark	linear_regression	5000_by_500000	5	35.767	218.848	16.905	199.124
spark	linear_regression	5000_by_500000	9	26.86	161.769	14.948	164.846
spark	linear_regression	5000_by_500000	17	25.815	149.232	14.173	147.584

- Supports arbitrary queries
- Tabular data format
- Database format allows for queries across experiments
- Example: producing scaling plots



Approaching Complete Reproducibility

Configuration tracking

- Complete OS Image(s) used
 - Distribution version
 - Installed package versions
- ML Platform configuration/tuning parameters (Spark, Tensorflow, etc.)
- The ML application code command line parameters
- Dataset(s) used

- Caveats (future work)
 - Not tracking hardware firmware levels.
 - Application code not yet integrated with revision control system
 - Datasets assumed to be tracked independently

Questions?

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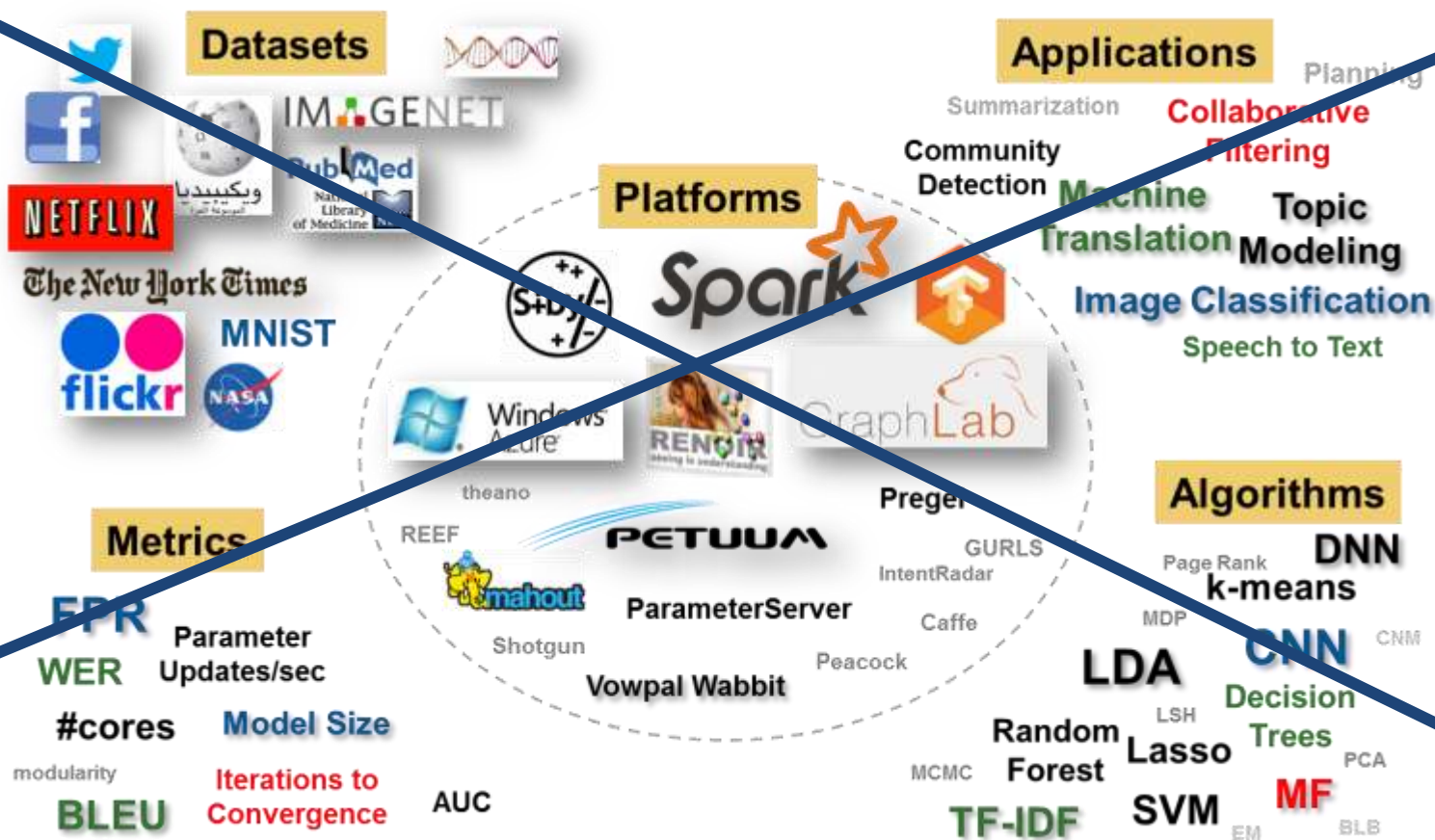
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Project Introduction: Big Learning Landscape



Collaboration with CMU

Big Learning Group

- Performs systems research in achieving scalability for large-scale machine learning platforms

Parallel Data Lab

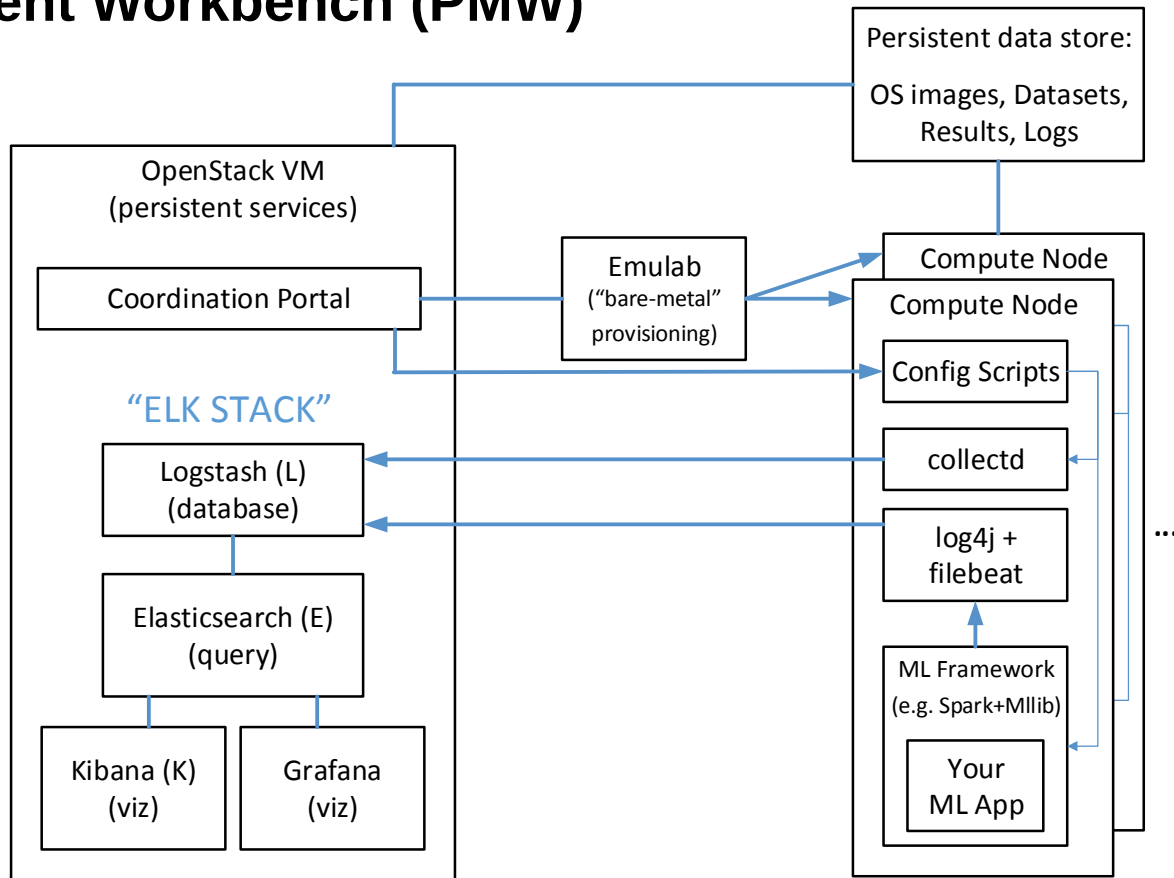
- Manages a data center on campus
- Houses many different large computing clusters including ours...

For unrestricted research

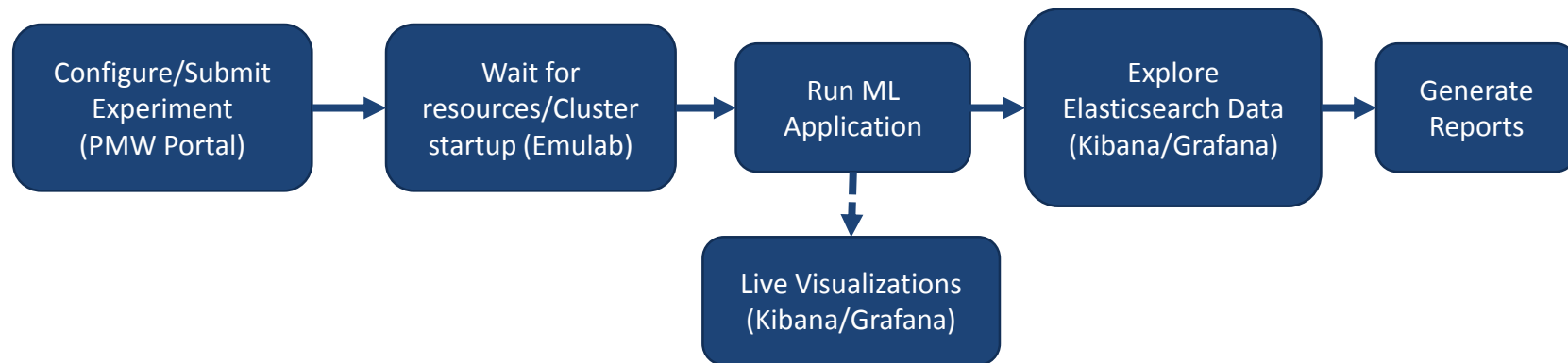
- Allows for collaboration with world-class researchers at CMU

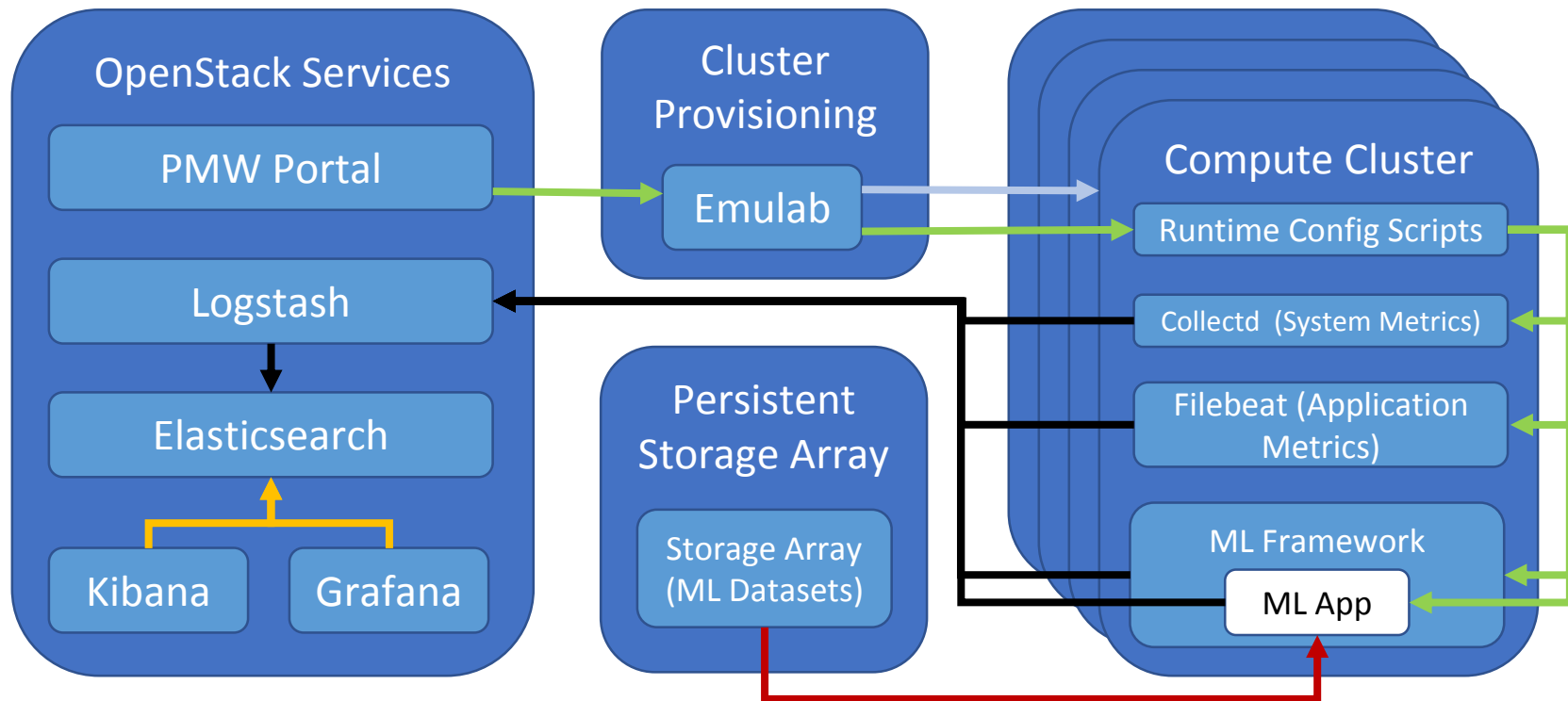
Performance Measurement Workbench (PMW)

- Emulab
 - “bare-metal” provisioning
 - ????
- Persistent Services
 - Web “portal” simplifies use
 - ELK Stack (now “Elastic Stack”)
- Data store
 - OS images
 - Experiments (data, application and models)
 - Logging data



PMW Workflow





Kibana

Time	executor_count	partitions	time_of_load	time_to_fit	time_to_validate	time_to_check_model	time_to_results	time_of_ml
* April 2nd 2017, 21:56:47.893	-	-	27.944	-	-	-	-	-
* April 2nd 2017, 21:57:11.490	-	512	-	-	-	-	-	-
* April 2nd 2017, 21:57:11.501	-	-	-	-	-	-	-	-
* April 2nd 2017, 22:00:00.430	-	-	-	168.92641902	-	-	-	-
* April 2nd 2017, 22:01:33.982	-	-	15.346	-	-	-	-	-
* April 2nd 2017, 22:01:50.772	-	-	-	-	-	-	-	-
* April 2nd 2017, 22:01:50.772	-	512	-	-	-	-	-	-
* April 2nd 2017, 22:02:44.217	-	-	-	-	163.786719084	-	-	-
* April 2nd 2017, 22:09:25.123	-	-	-	-	-	-	400.800829172	-
* April 2nd 2017, 22:09:25.321	-	-	-	-	-	401.102718115	-	-
* April 2nd 2017, 22:09:25.322	-	-	-	-	-	-	-	-
* April 2nd 2017, 22:09:25.322	-	-	-	-	-	-	-	733.818758963
* April 2nd 2017, 22:28:01.002	-	-	35.638	-	-	-	-	-
* April 2nd 2017, 22:28:25.794	-	512	-	-	-	-	-	-
* April 2nd 2017, 22:28:25.809	-	-	-	-	-	-	-	-
* April 2nd 2017, 22:32:01.939	-	-	-	216.128113985	-	-	-	-
* April 2nd 2017, 22:34:04.274	-	-	16.54	-	-	-	-	-
* April 2nd 2017, 22:34:21.856	-	512	-	-	-	-	-	-
* April 2nd 2017, 22:34:21.857	-	-	-	-	-	-	-	-
* April 2nd 2017, 22:35:19.683	-	-	-	-	197.741991043	-	-	-
* April 2nd 2017, 22:47:05.994	-	-	-	-	-	-	706.204623938	-
* April 2nd 2017, 22:47:06.192	-	-	-	-	-	706.508248044	-	-
* April 2nd 2017, 22:47:06.193	-	-	-	-	-	-	-	1120.38159585
* April 2nd 2017, 22:47:06.193	-	-	-	-	-	-	-	-
* April 2nd 2017, 23:08:56.023	-	-	84.725	-	-	-	-	-
* April 2nd 2017, 23:09:31.254	-	512	-	-	-	-	-	-
* April 2nd 2017, 23:09:31.266	-	-	-	-	-	-	-	-
* April 2nd 2017, 23:15:38.622	-	-	-	367.35312891	-	-	-	-