The Myria Big Data Management and Analytics System and Cloud Service

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UNIVERSITY OF WASHINGTON

http://myria.cs.washington.edu

UNIVERSITY of WASHINGTON

eScience Institute

ADVANCING DATA-INTENSIVE DISCOVERY IN ALL FIELDS

Acknowledgments

The Myria Team!

Our science collaborators!!

- Andrew Connolly, Tom Quinn, Sarah Loebman, Ariel Rokem, Ginger Armbrust, Yejin Choi

Our sponsors!!!

- National Science Foundation, Moore & Sloan Foundations, Washington Research Foundation, eScience Institute, ISTC Big Data, Petrobras, EMC, Amazon, and Facebook

Big Data

Management

Analytics

Science Apps

Efficient

Easy

Myria

Goals of the Myria stack

- Advance state-of-the-art in big data systems
- Focus on efficiency and productivity
- Test on real applications and support real users

Deliverables:

- Built a new big data mgmt & analytics system
- Deployed and operate Myria as a service
- Source code and demo service: http://myria.cs.washington.edu

Myria has been developed and is operated by

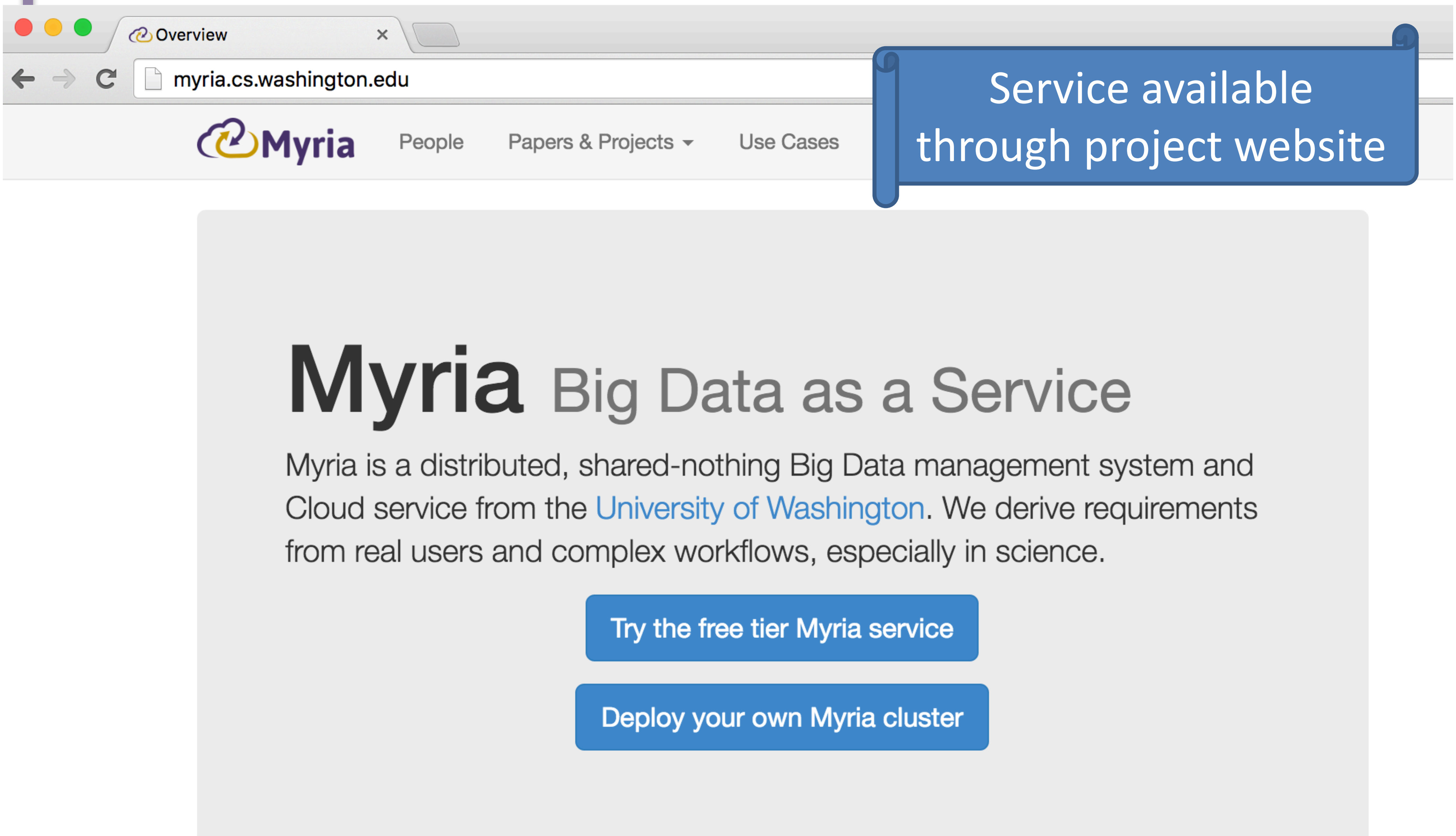
- Database Group in the Computer Science & Engineering Department at UW
- UW eScience Institute

Co-PIs: Dan Suciu and Bill Howe

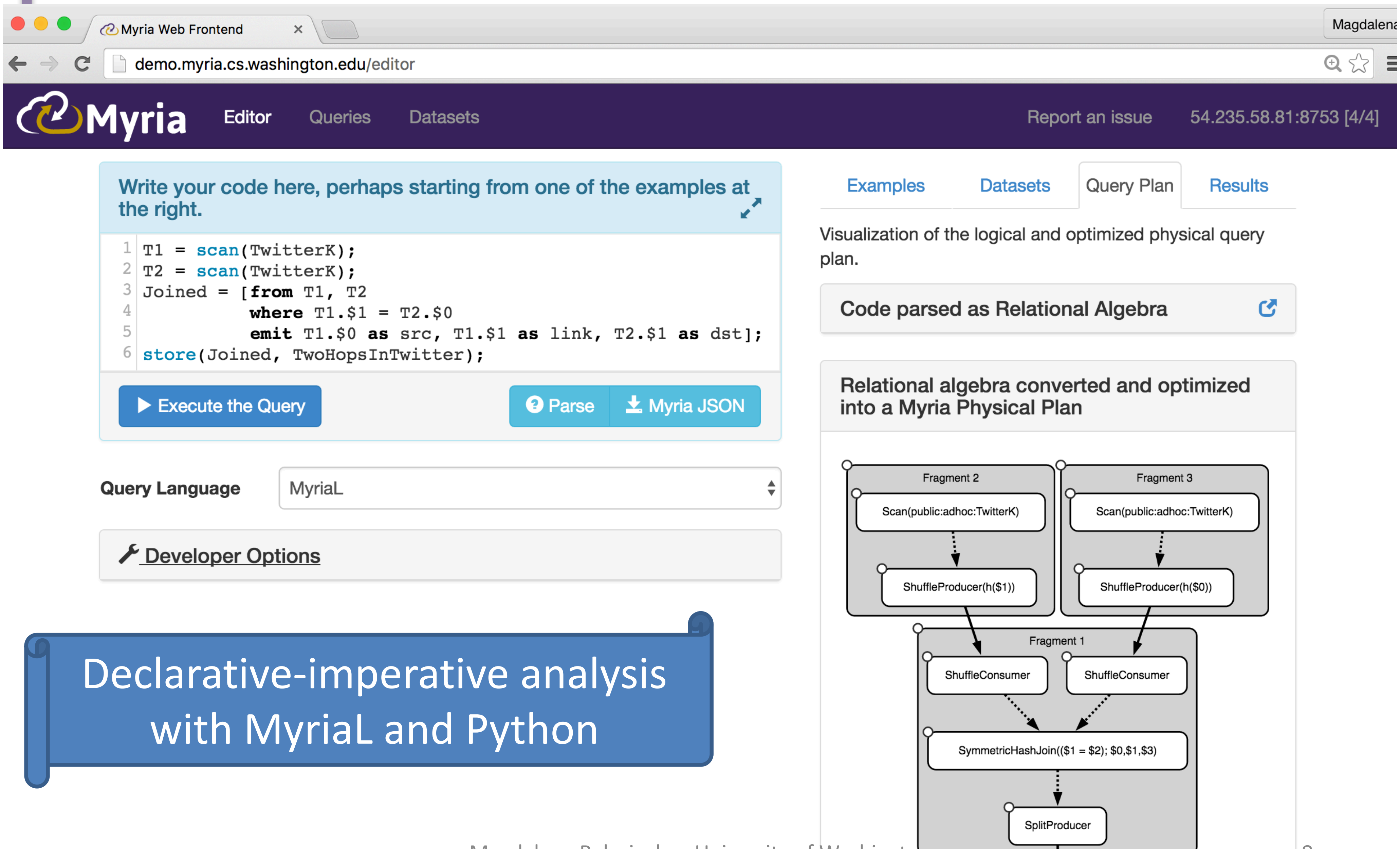
Myria Demo

Myria Cloud Service

Service available through project website



Analysis in the Browser with Myria



Declarative-imperative analysis with MyriaL and Python

Myria Operates Directly on Data in S3

Write your code here, perhaps starting from one of the examples at the right.

```
T1 = load("https://s3-us-west-2.amazonaws.com/uwdb/sampleData/TwitterK.csv",
csv(schema(a:int, b:int),skip=0));
store(T1, TwitterK, [a, b]);
```

Execute the Query

Parse

Myria JSON

For efficient processing, caches query results internally in cluster

MyriaL is Imperative+Declarative with Iterations

Write your code here, perhaps starting from one of the examples at the right.

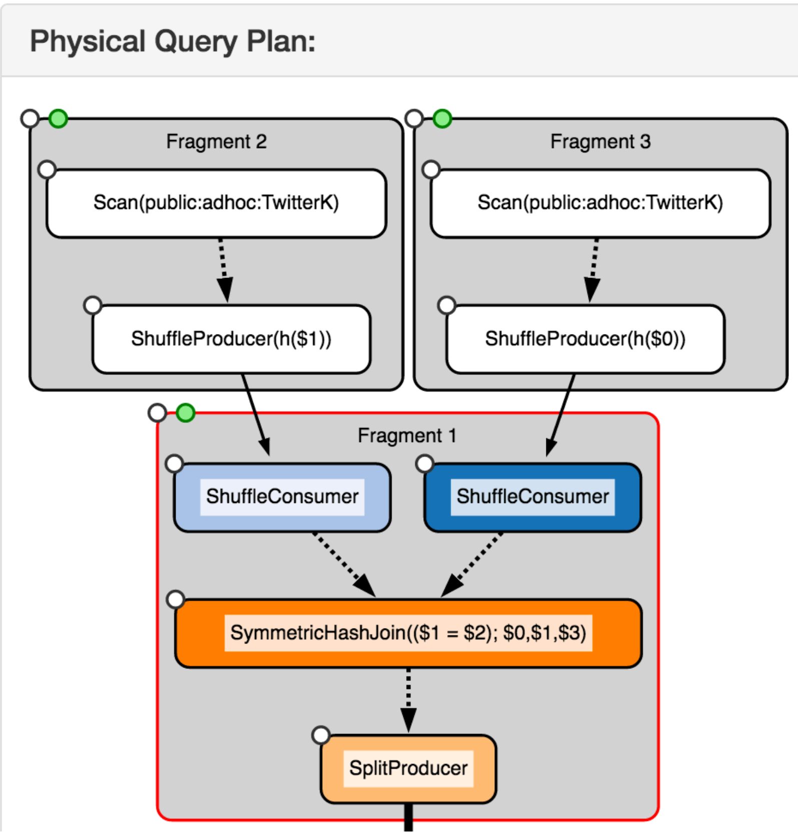
```
E = scan(TwitterK);
V = select distinct E.$0 from E;
CC = [from V emit V.$0 as node_id, V.$0 as component_id];
do
  new_CC = [from E, CC where E.$0 = CC.$0 emit E.$1, CC.$1] + CC;
  new_CC = [from new_CC emit new_CC.$0, MIN(new_CC.$1)];
  delta = diff(CC, new_CC);
  CC = new_CC;
while [from delta emit count(*) > 0];
comp = [from CC emit CC.$1 as id, count(CC.$0) as cnt];
store(comp, TwitterCC);
```

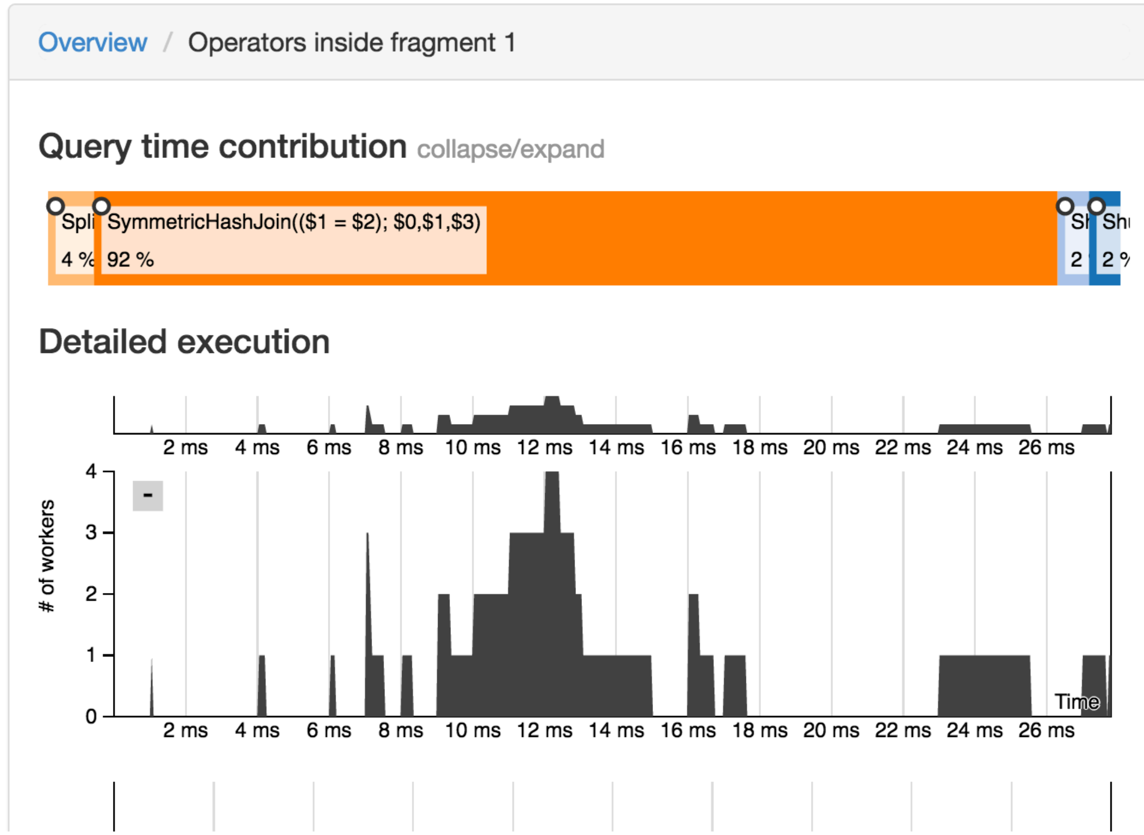
Execute the Query

Parse

Myria JSON

Myria Provides Details of Query Execution





Myria Service includes Jupyter Notebook

Home | myria

demo.myria.cs.washington.edu:8888/notebooks/myria.ipynb

jupyter myria (read only)

File Edit View Insert Cell Kernel Help — Python 2

Markdown CellToolbar

Slide Type Fragment

In [45]:

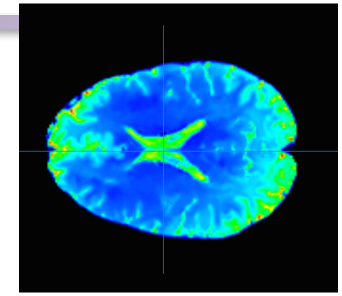
```
%%query --Embed MyriaL in Jupyter notebook by using the "%%query" prefix

insurance = scan(insurance);

descriptives = [from insurance emit min(eq_site_deductible) as min_deductible,
                                    max(eq_site_deductible) as max_deductible,
                                    avg(eq_site_deductible) as mean_deductible,
                                    stdev(eq_site_deductible) as stdev_deductible];

store(descriptives, descriptives);
```

Out[45]:

	max_deductible	mean_deductible	min_deductible	stdev_deductible
0	14112	89.045455	0	989.204846

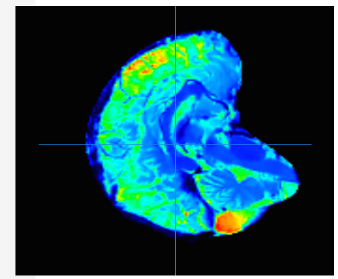
Jupyter notebook available directly with Myria service

Myria Supports Python User-Defined Functions



```
#define python function
def denoise(dt):
    from dipy.denoise import nlmeans
    from dipy.denoise.noise_estimate import estimate_sigma
    image = dt[0]
    mask = dt[1]
    sigma = estimate_sigma(image)
    denoised_data = nlmeans.nlmeans(image, sigma=sigma, mask=mask)
    return denoised_data
```

MRI data analysis



Data from the Human Connectome project

```
#register python functions
connection.create_function("denoise",inspect.getsource(denoise),inSchema, outType,  py,denoise
```

```
#this query takes 2.40 mins
query = MyriaQuery.submit(
    """T1=scan(public:blob_operator:binarydata);
imgs = [from T1 emit PYUDF(denoise, T1.images, T1.mask) As denoised];
store(imgs, Denoised_imgs);""")
print query.status
```

Python UDFs enable running legacy code and complex analytics beyond SQL/MyriaL

Users Can Deploy Own Service

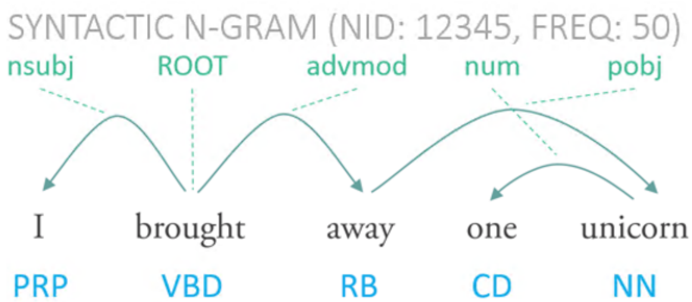
```
pip install myria-cluster
```

```
myria-cluster create [OPTIONS] CLUSTER_NAME
```

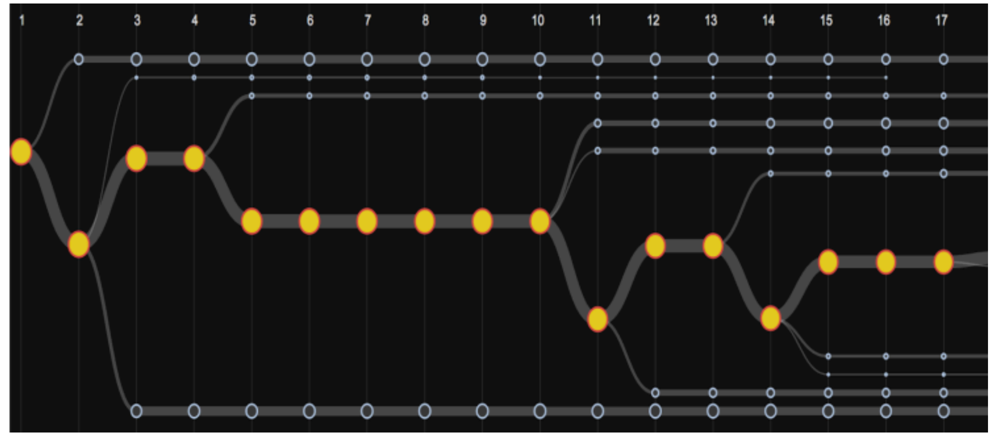
```
myria-cluster stop/start/destroy […]
```

Example Myria Applications

Natural Language Processing



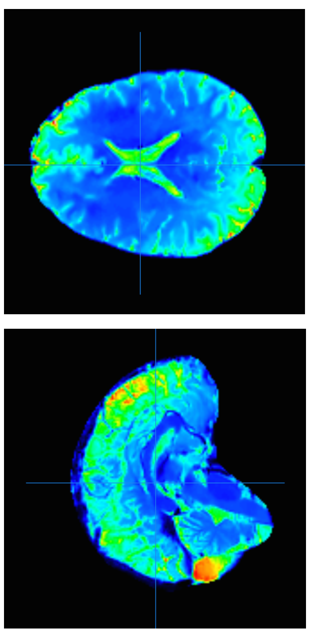
Picture from Leila Zilles



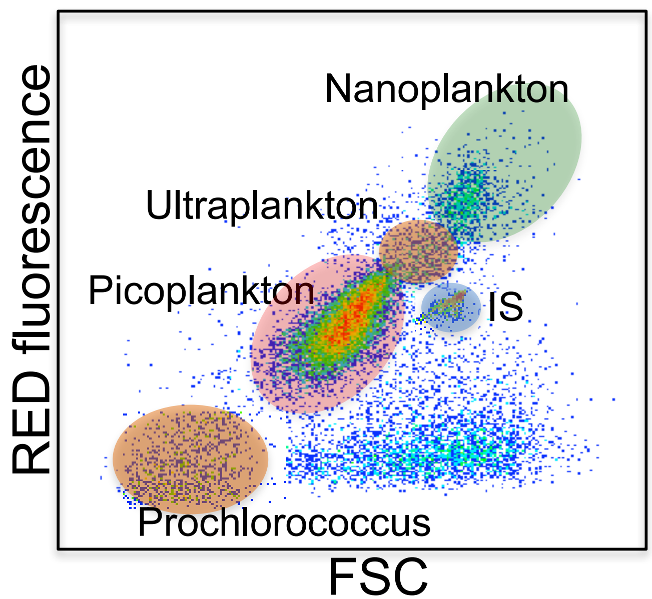
MyMergerTree Screenshot

Astronomy

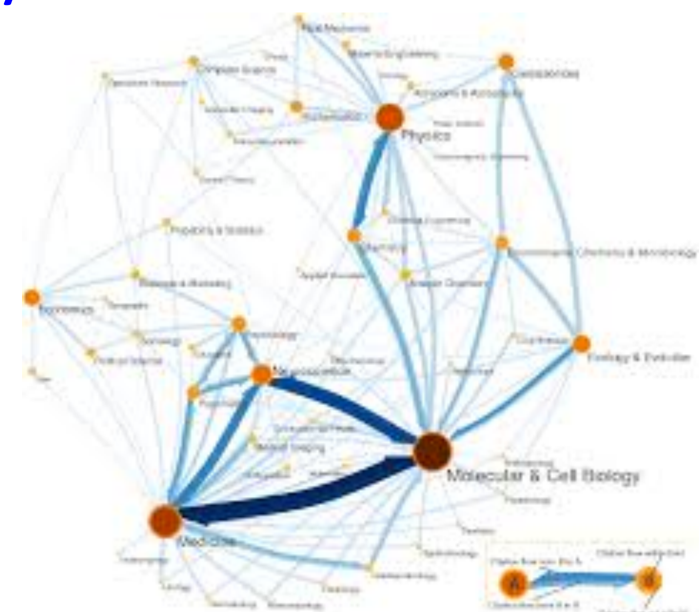
Neuroscience



Data from the Human Connectome project



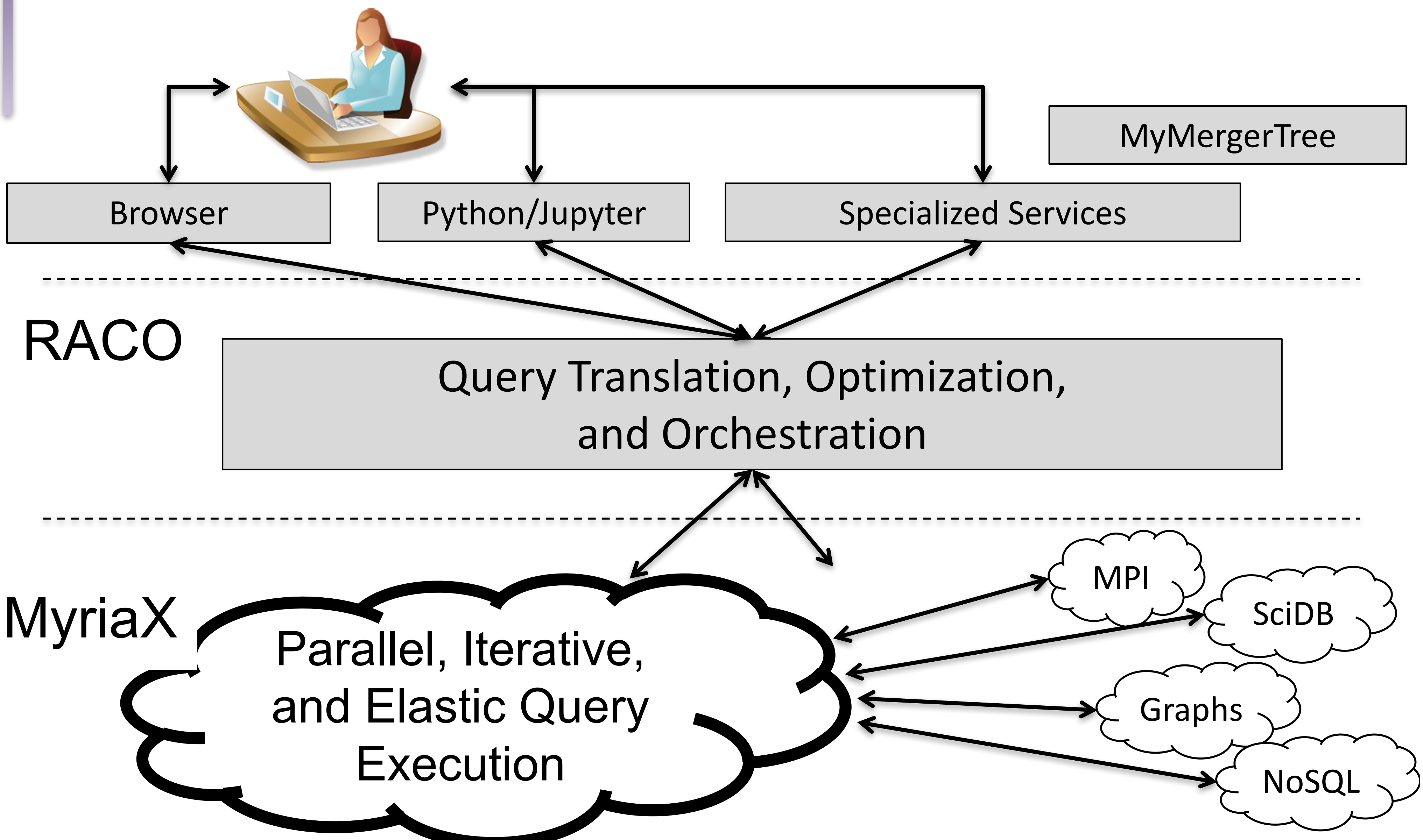
Oceanography



Bibliometrics

Myria Internals

Myria Polystore Stack



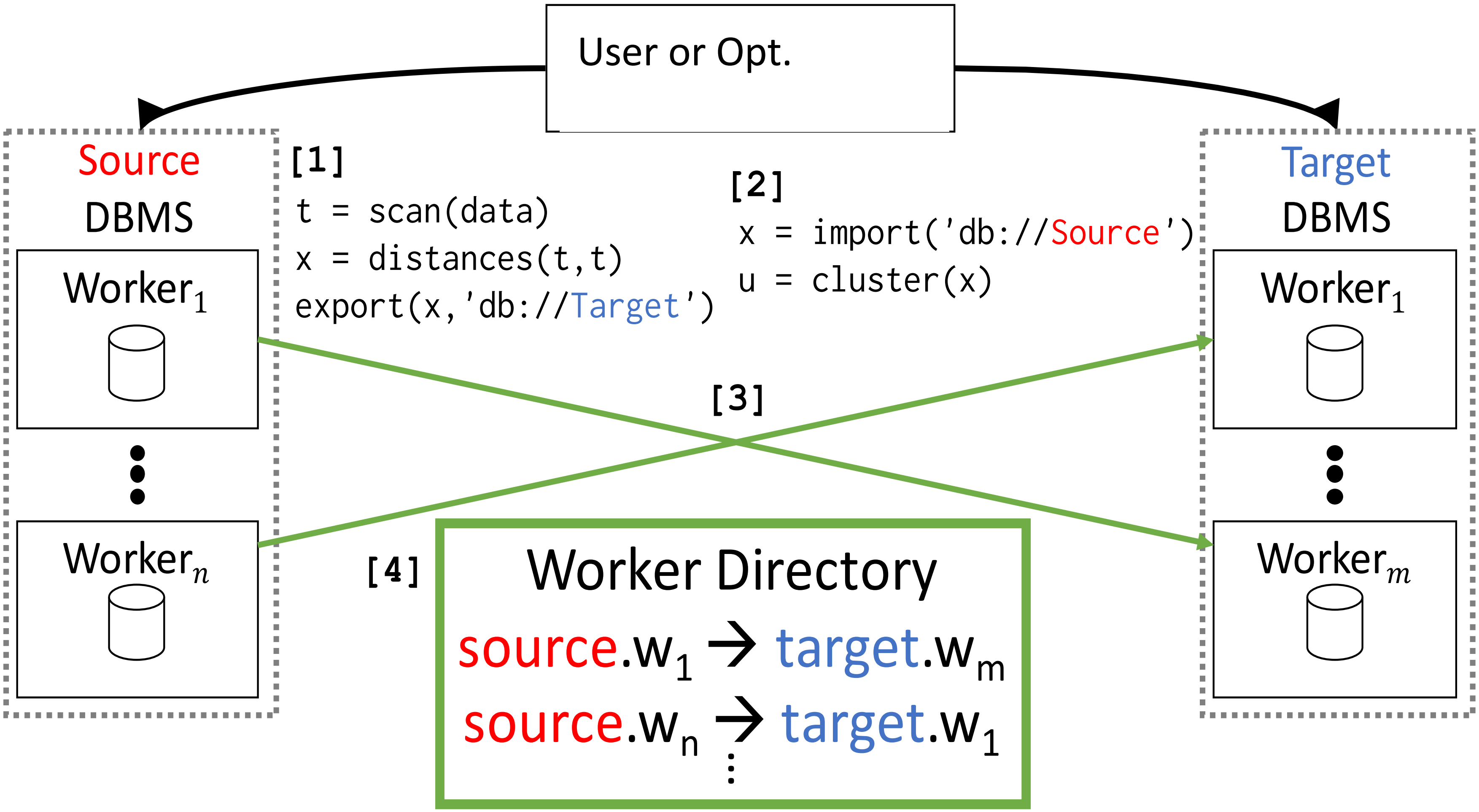
Myria's Data Model and Query Interface

- Relational Algebra Compiler (RACO)
  - Myria's query optimizer and federator
- RACO core: relational algebra extended with
  - Iterations for multi-pass algorithms
  - Flatmap to explode non-1NF attribute values into many tuples
  - Stateful apply for windowed and neighborhood functions
- Query language: MyriaL (Imperative+Declarative)
  - Each statement is declarative (SQL, comprehensions, function calls)
  - Statements are combined with imperative constructs
    - Variable assignment
    - Iteration
- Python UDFs/UDAs
  - Minimize barriers to adoption and run legacy code
- Python API
  - Fluent API with Python lambda functions

Polystore Optimization

- Rule-based opt. with three types of rules
  - Optimize logical Myria algebra plans
  - Translate logical plans into back-end specific physical plans
  - Optimize back-end specific physical plans
- To add a new back-end, developer must specify
  - Tree representation of query language
  - Rules that translate Myria algebra into this representation
  - Administrative functions including one to submit queries
- Data model independence
  - Myria hides the existence of various back-ends
  - Users write MyriaL scripts assuming relational model
  - Back-ends include select array, graph, and key-value systems

Federated Query Execution

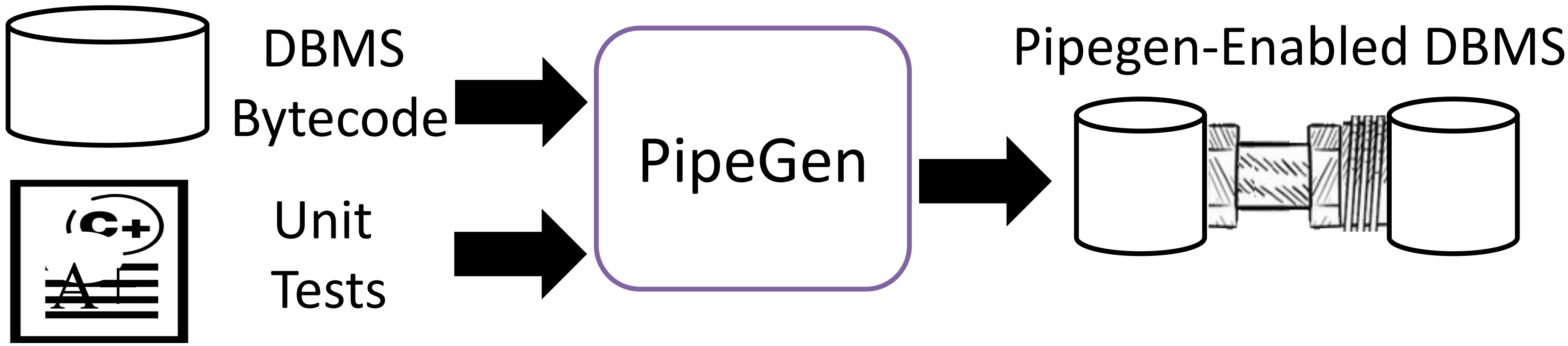


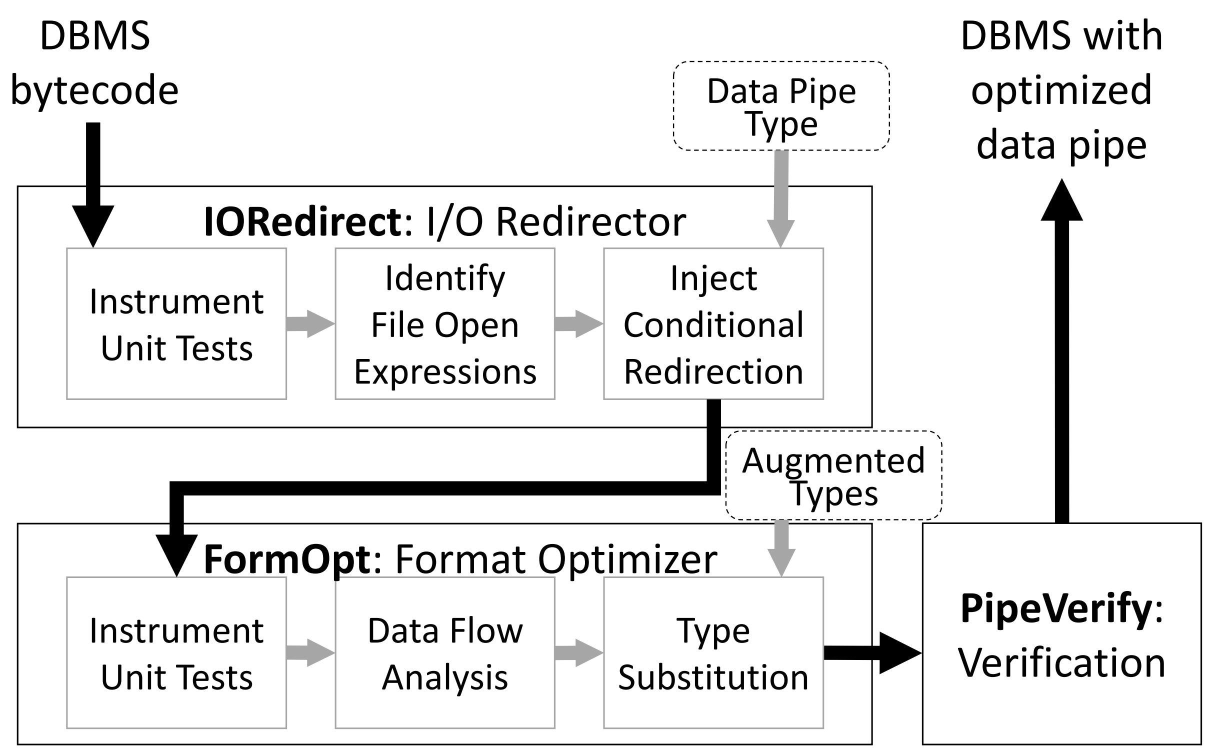
Federated plans require fast data movement

Data Movement with PipeGen

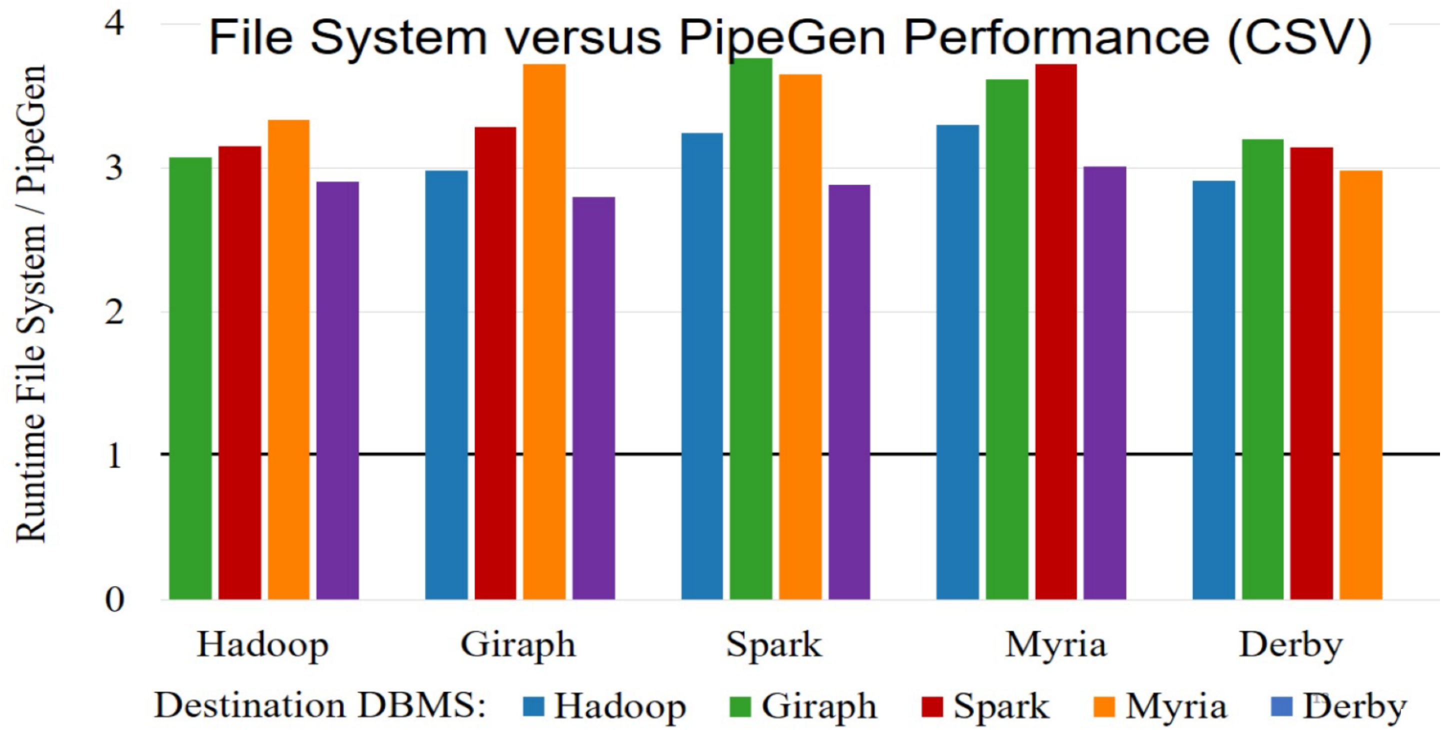
[PipeGen: Data Pipe Generator for Hybrid Analytics](#)

Brandon Haynes, Alvin Cheung, and Magdalena Balazinska. SOCC 2016.

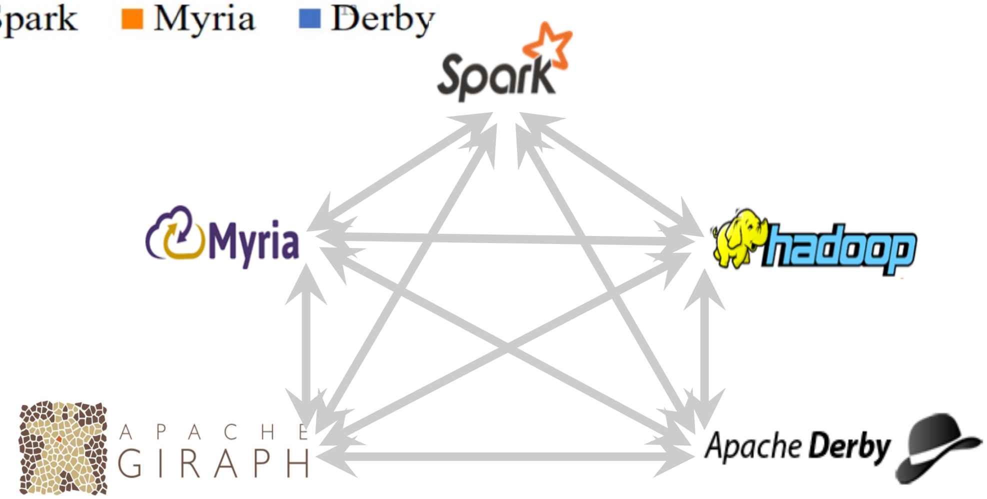




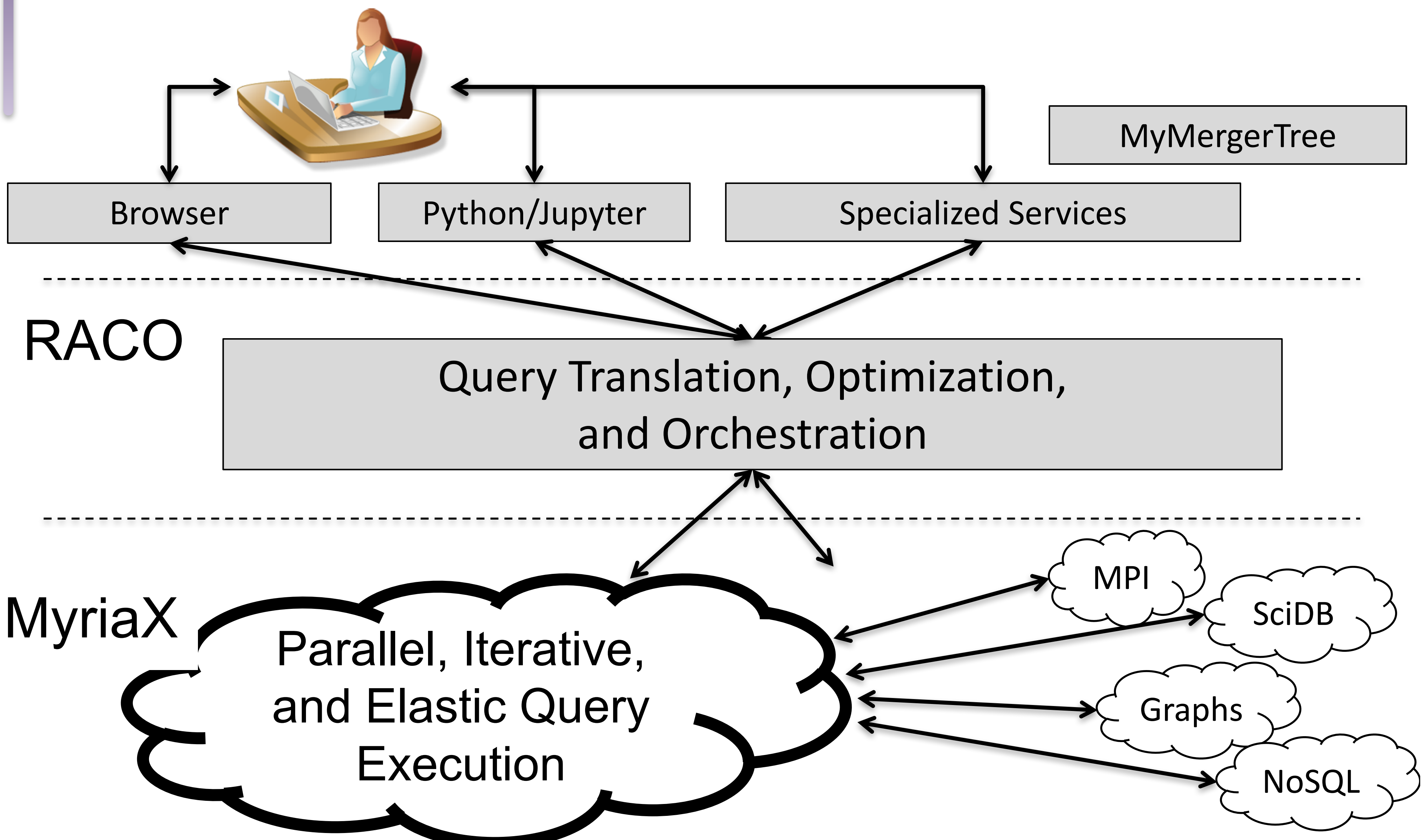
PipeGen's Performance



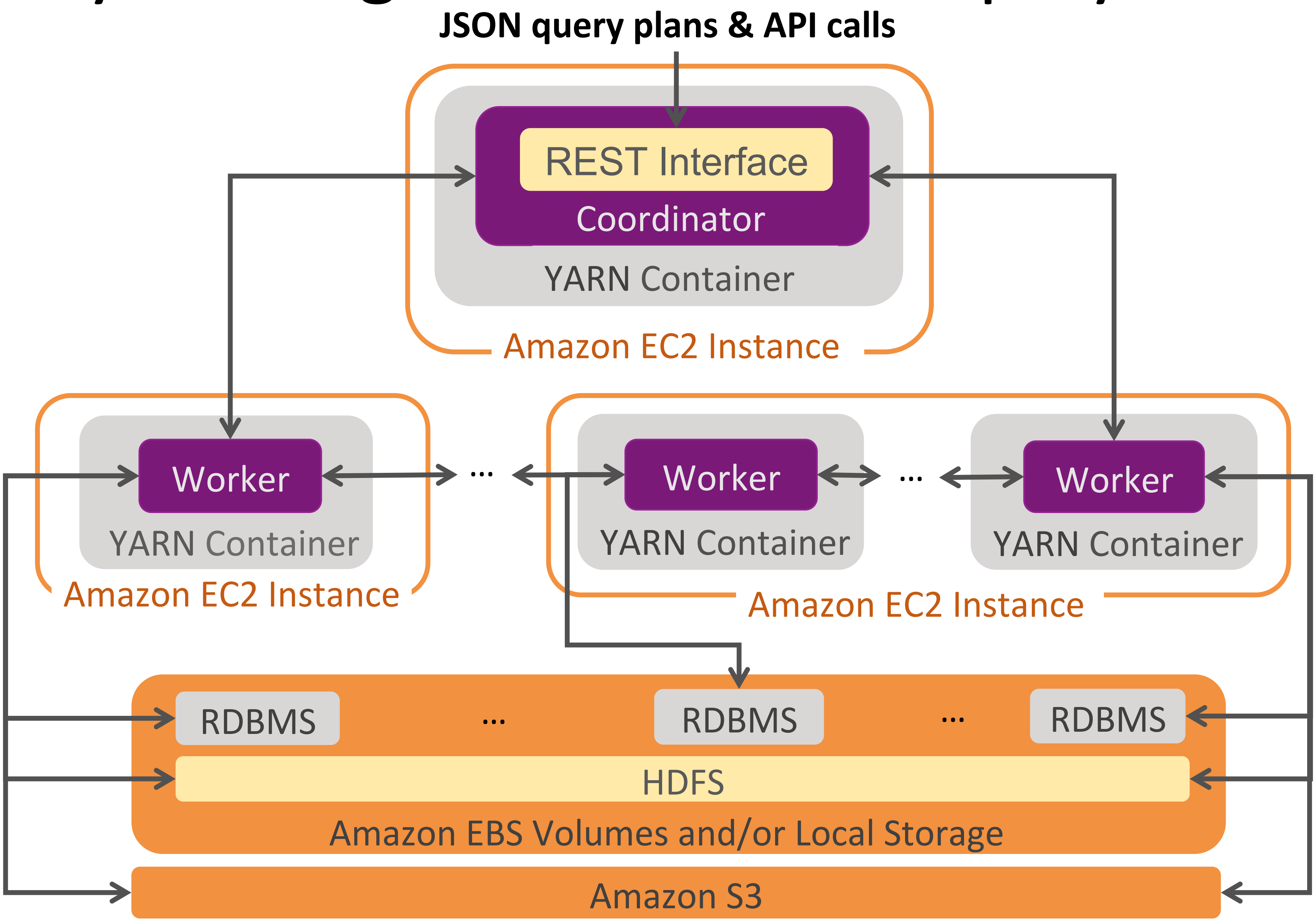
16-node cluster with 16 workers/tasks
Transfer 10^9 tuples with 4 ints and 3 doubles



Myria Polystore Stack



MyriaX Engine and Cloud Deployment



MyriaX Overview

- Data storage
  - Read data from S3, HDFS, local files
  - Parse CSV, TSV, and various scientific file formats
  - Store data in local relational DBMS instances
    - Fast storage with physical tuning (indexing, hash-partitioning)
- Query execution
  - Fundamentally a parallel DBMS
    - Fast, pipelined query execution
  - But scheduling more flexible to support elasticity
  - Novel features: Multiway joins and iterations
- Resource management
  - Executes on top of the YARN resource manager

Efficient Iterative Processing

[Asynchronous and Fault-Tolerant Recursive Datalog Evaluation in Shared-Nothing Engines]
Jingjing Wang, Magdalena Balazinska, and Daniel Halperin. **PVLDB** 8(12): 1542-1553 (**2015**)

- User specifies query declaratively
  - Subset of Datalog with aggregation
- Generate efficient, shared-nothing query plan
  - Small extensions to existing shared-nothing systems
- Plan amenable to runtime optimizations
  - Synchronous vs asynchronous
  - Different processing priorities
- Optimizations significantly affect performance

Myria's Optimized Iterations Example

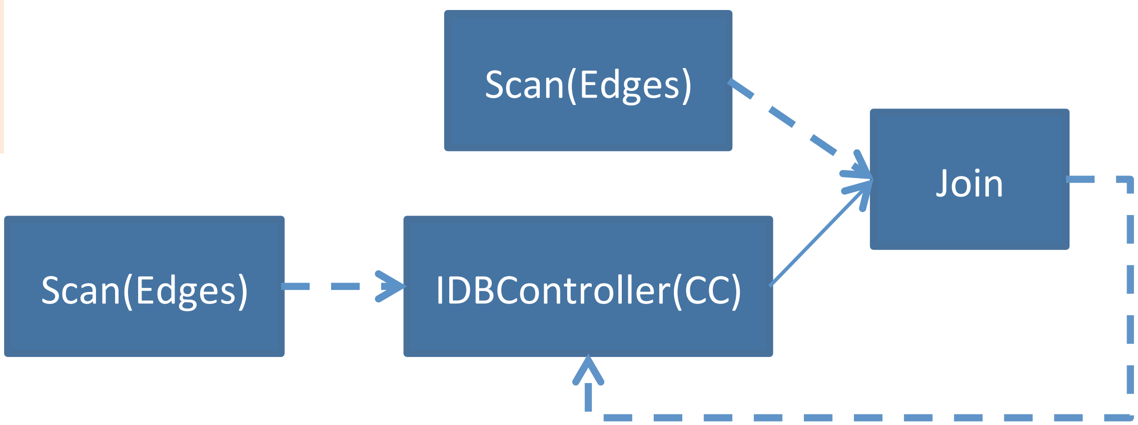
[Asynchronous and Fault-Tolerant Recursive Datalog Evaluation in Shared-Nothing Engines]
Jingjing Wang, Magdalena Balazinska, and Daniel Halperin. **PVLDB** 8(12): 1542-1553 (**2015**)

Declarative Query

```
E = scan(jwang:cc:graph);
V = select distinct E.$0 from E;
do
  CC := [$0, MIN($1)] <-
     [from V emit V.$0 as x, V.$0 as y] +
     [from E, CC where E.$0 = CC.$0 emit E.$1, CC.$1];
until convergence;
store(CC, CC);
```

// Can have multiple relations
// with recursive dep.

Compiled to a Distributed Query Plan



Performance Comparison with Spark

Declarative Query
(subset of Datalog with agg.)

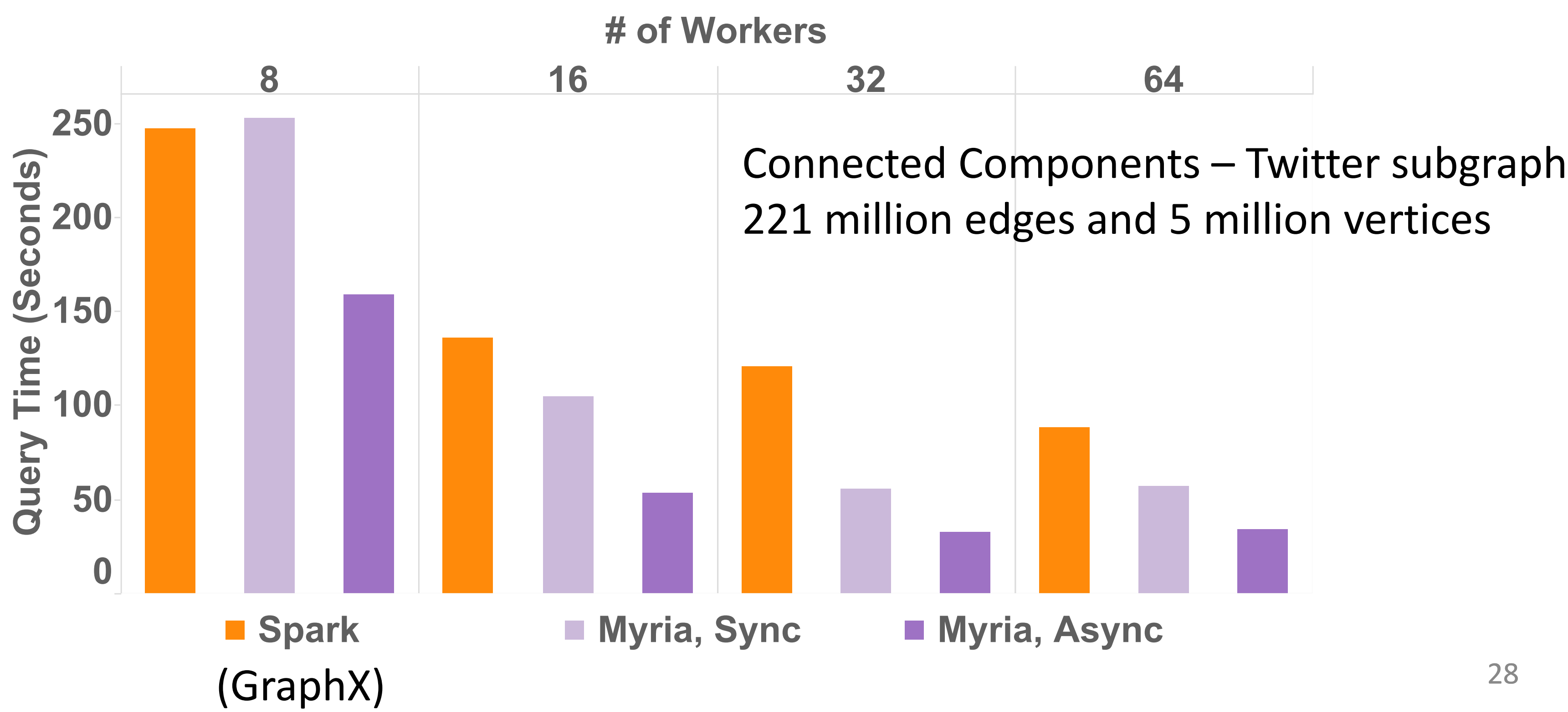
Shared-Nothing Query Plan
In-Memory Processing

Synchronous

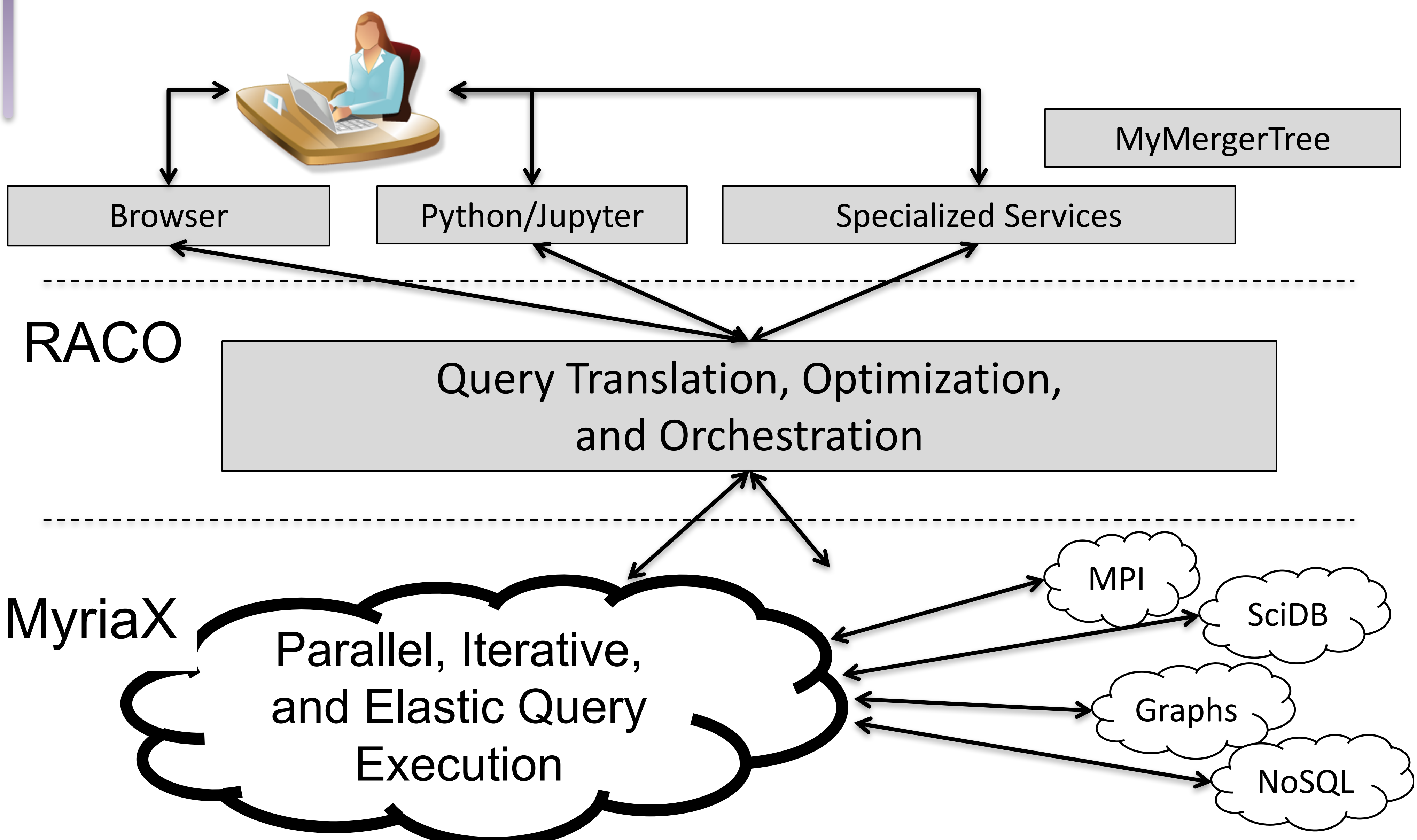
Asynchronous

Prioritize New Data

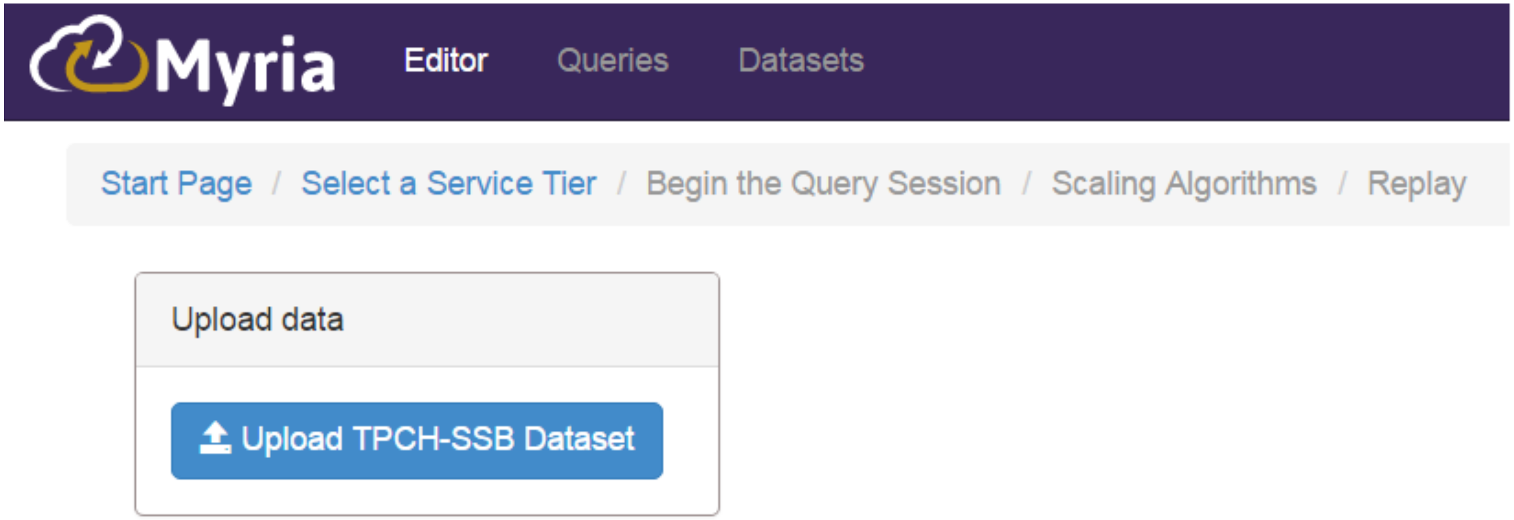
Prioritize Base Data



Myria Polystore Stack



Cloud Operation in Myria



Or point to data in Amazon S3

Myria's Personalized Service Level Agreements

[Changing the Face of Database Cloud Services with Personalized Service Level Agreements]
Jennifer Ortiz, Victor T. Almeida, and Magdalena Balazinska. **CIDR 2015**

Tier #1

Query Template	Runtime (seconds)
SELECT (17 attributes) FROM (lineitem) WHERE (1% of data selected) SELECT (9 attributes) FROM (part) WHERE (100% of data selected) SELECT (9 attributes) FROM (customer) WHERE (100% of data selected) SELECT (17 attributes) FROM (date) WHERE (100% of data selected)	10
SELECT (35 attributes) FROM (3 TABLES) WHERE (100% of data selected) SELECT (48 attributes) FROM (5 TABLES) WHERE (10% of data selected) SELECT (60 attributes) FROM (5 TABLES) WHERE (1% of data selected)	60
SELECT (49 attributes) FROM (5 TABLES) WHERE (100% of data selected) SELECT (60 attributes) FROM (5 TABLES) WHERE (10% of data selected)	300
SELECT (60 attributes) FROM (5 TABLES) WHERE (100% of data selected)	600

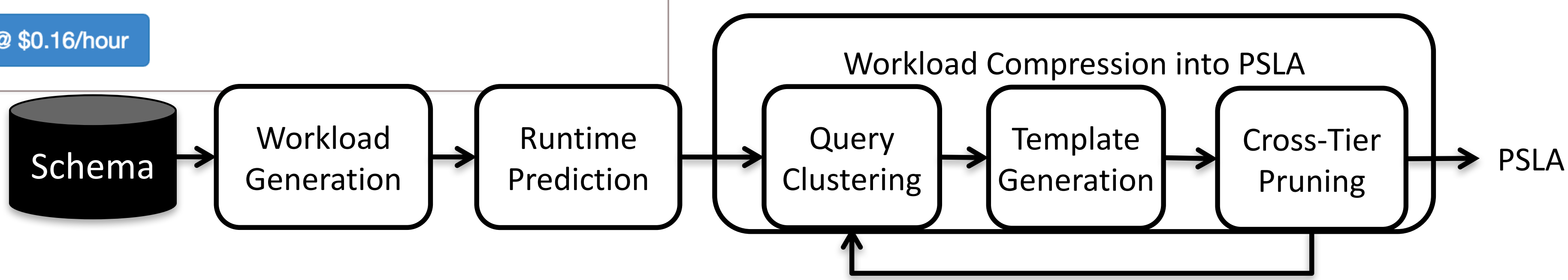
Purchase @ $0.16/hour

Tier #2

Query Template	Runtime (seconds)
SELECT (26 attributes) FROM (2 TABLES) WHERE (100% of data selected) SELECT (60 attributes) FROM (5 TABLES) WHERE (10% of data selected)	10
SELECT (60 attributes) FROM (5 TABLES) WHERE (100% of data selected)	300

Purchase @ $0.64/hour

Myria's SLA generation



Myria's PerfEnforce Subsystem

[PerfEnforce Demonstration: Data Analytics with Performance Guarantees]

Jennifer Ortiz, Brendan Lee, and Magdalena Balazinska. **SIGMOD 2016**.

Query Session

Write a Query...

```
SELECT *
FROM "public:adhoc:lineitem" AS L
WHERE l_linenumber = 7;
```

See SLA Runtime | Execute

Query Information

Expected Runtime (from SLA): 11.756 seconds

status: SUCCESS
seconds elapsed: 1.168460994

Cluster is using 12 workers

Previous Queries Log

Query: SELECT * FROM "public:adhoc:lineitem" AS L WHERE l_linenumber = 7;
Actual Runtime: 1.168460994
Expected Runtime: 11.756
Cluster Size Ran: 12

Myria's PerfEnforce Subsystem

[PerfEnforce Demonstration: Data Analytics with Performance Guarantees]

Jennifer Ortiz, Brendan Lee, and Magdalena Balazinska. **SIGMOD 2016**.

Query Session

How can the cloud provider guarantee these runtimes?

Write a Query...

```
SELECT *
FROM "public:adhoc:lineitem" AS L
WHERE l_linenumber = 7;
```

See SLA Runtime | Execute

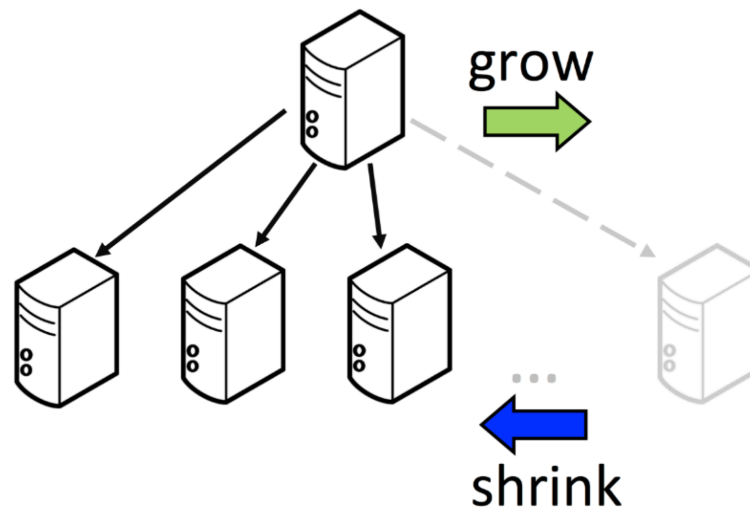
Query Information

Expected Runtime (from SLA): 11.756 seconds

status: RUNNING

seconds elapsed: 1.048921161

Cluster is using 6 workers

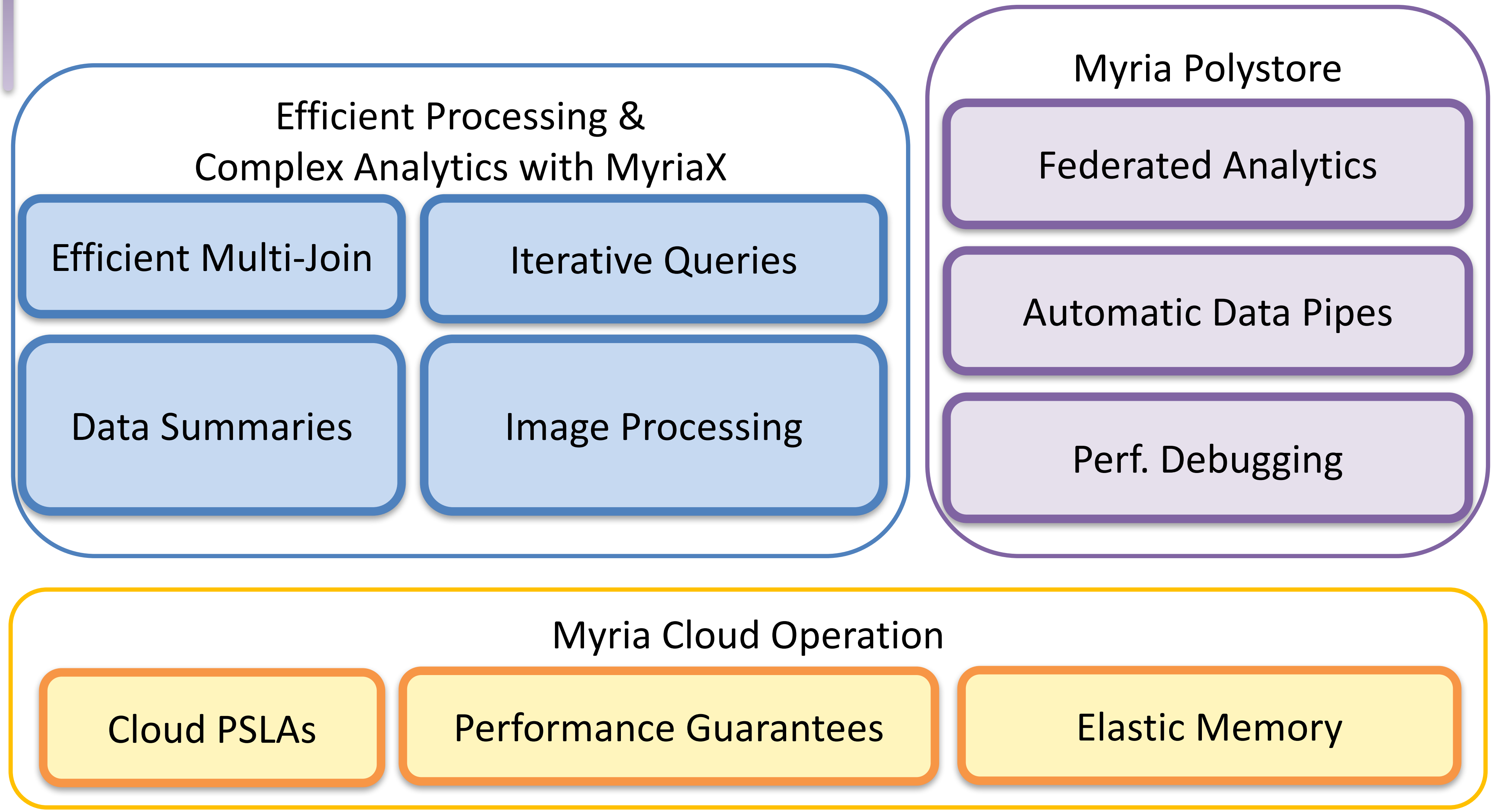


Previous Queries Log

Query: SELECT * FROM "public:adhoc:lineitem" AS L WHERE l_linenumber = 7;
Actual Runtime: 1.168460994
Expected Runtime: 11.756
Cluster Size Ran: 12

Cluster size changes during query session

Myria's Innovations Summary



Conclusion

- Highly expressive
  - MyriaL (RA+iterations) & Python
- Polystore with hybrid analytics
- High performance on variety of queries
- Available as a service
  - Focus on low barrier to entry
  - And turning users into self-sufficient experts
  - Also focus on the service provider: Operate Myria
- Source code and more info (includes videos)

  http://myria.cs.washington.edu/