

Changing the Face of Database Cloud Services with Personalized Service Level Agreements

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CIDR 2015

Astronomy

Biology

Geoscience

Oceanography

TPC-H



Many Data Management & Analytics Systems Available




PostgreSQL



Many Systems are Available as Cloud Services



 **EMR**
Managed Hadoop Framework

 **RDS**
MySQL, Postgres, Oracle, SQL Server, and Amazon Aurora

 **Redshift**
Managed Petabyte-Scale Data Warehouse Service



Google bigquery



Microsoft®
SQL Azure™

Cloud Services Today

Amazon EMR

Software Configuration

Which Hadoop Version?

Hadoop distribution Amazon

Use Amazon's Hadoop distribution. [Learn more](#)

AMI version

3.1.1

Determines the base configuration of the instances in your cluster, including the Hadoop version. [Learn more](#)

MapR

Use MapR's Hadoop distribution. [Learn more](#)

| Applications to be installed | Version | |
|------------------------------|----------|--|
| Hive | 0.11.0.2 | |
| Pig | 0.12.0 | |

Pig or Hive?

Additional applications

Select an application

Configure and add

Hardware Configuration

i Specify the [networking](#) and [hardware](#) configuration for your cluster. If you need more than 20 EC2 instances, [complete this form](#). [Request Spot instances](#) (unused EC2 capacity) to save money.

Network

Launch into EC2–Classic

Use a Virtual Private Cloud (VPC) to process sensitive data or connect to a private network. [Create a VPC](#)

i To create a cluster in a VPC, you must first create a VPC. For more information, [click here](#).

EC2 availability zone

No preference

Launch the cluster in a specific EC2 Availability Zone.

How many instances of the service?

| | EC2 instance type | Count | Request spot |
|--------|-------------------|-------|--------------------------|
| Master | m1.medium | 1 | <input type="checkbox"/> |
| Core | m1.medium | 2 | <input type="checkbox"/> |
| Task | m1.medium | 0 | <input type="checkbox"/> |

The Master instance assigns Hadoop tasks to core and task nodes, and monitors their status.

Core instances run Hadoop tasks and store data using the Hadoop Distributed File System (HDFS).

Task instances run Hadoop tasks.

Cloud Services Today

Amazon EMR

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How many instances of the service?

Cloud Services Today

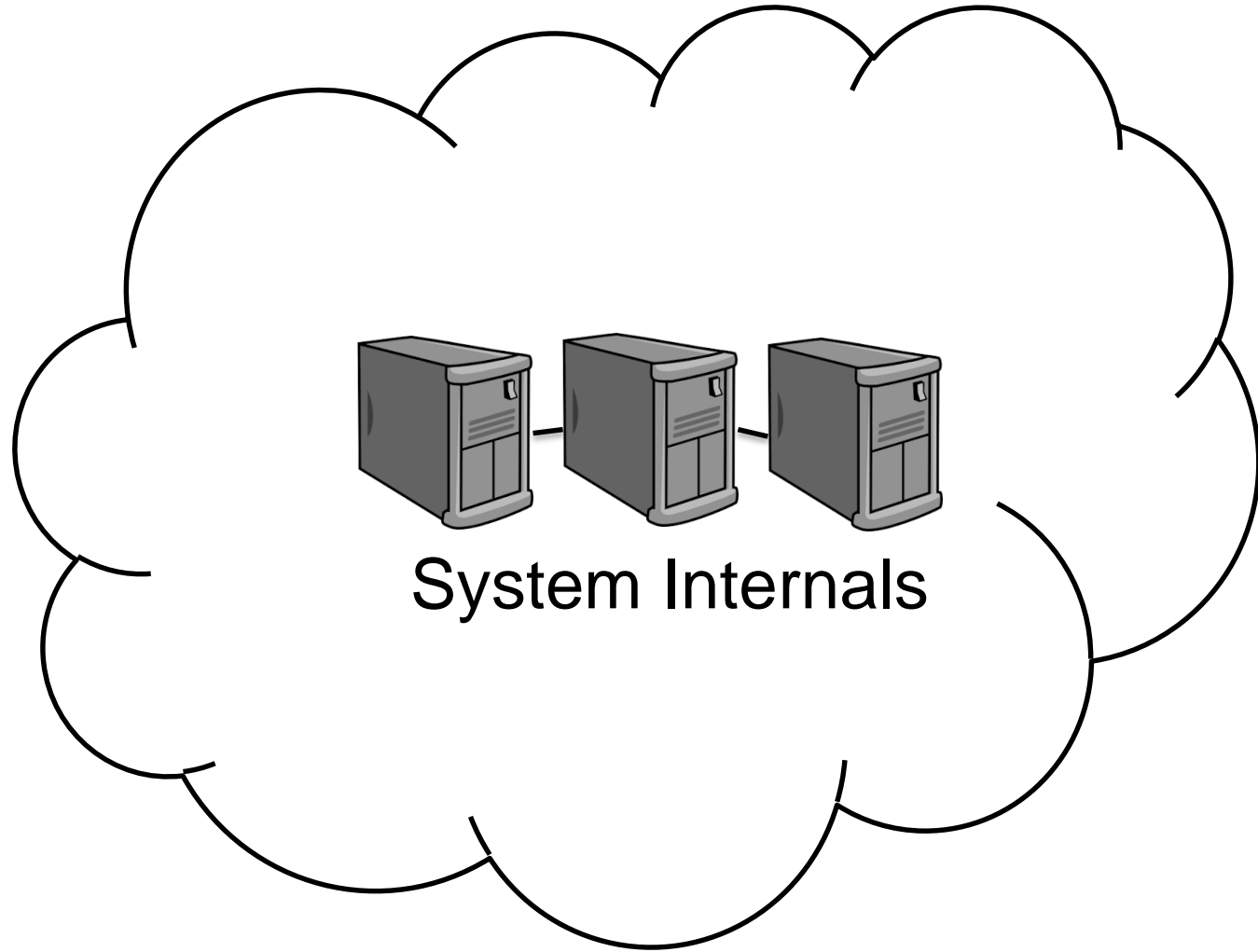
BigQuery

The screenshot displays the Google BigQuery web interface. On the left sidebar, there is a 'COMPOSE QUERY' button and a 'BigQuery Example' section with a dropdown menu showing 'BabyNames' and 'BabyNamePopularity'. The main area is titled 'New Query' and contains a SQL query: `1 SELECT name FROM [BabyNames.BabyNamePopularity] ORDER BY count DESC LIMIT 5`. Below the query editor, there are configuration options for 'Destination Table' (set to 'No table selected'), 'Write Preference' (radio buttons for 'Write if empty', 'Append to table', 'Overwrite table'), 'Results Size' (checkbox for 'Allow Large Results'), 'Results Schema' (checkbox for 'Flatten Results'), 'Query Caching' (checkbox for 'Use Cached Results'), and 'Query Priority' (radio buttons for 'Interactive', 'Batch'). At the bottom of the configuration section are buttons for 'RUN QUERY', 'Save Query', 'Save View', and 'Hide Options'. A status message indicates 'Query complete (2.2s elapsed, 15.0 KB processed)'. Below this, the 'Query Results' section shows the execution time '11:48am, 29 Dec 2014' and buttons for 'Download as CSV' and 'Save as Table'. The results are presented in a table with 5 rows and 2 columns: 'Row' and 'name'.

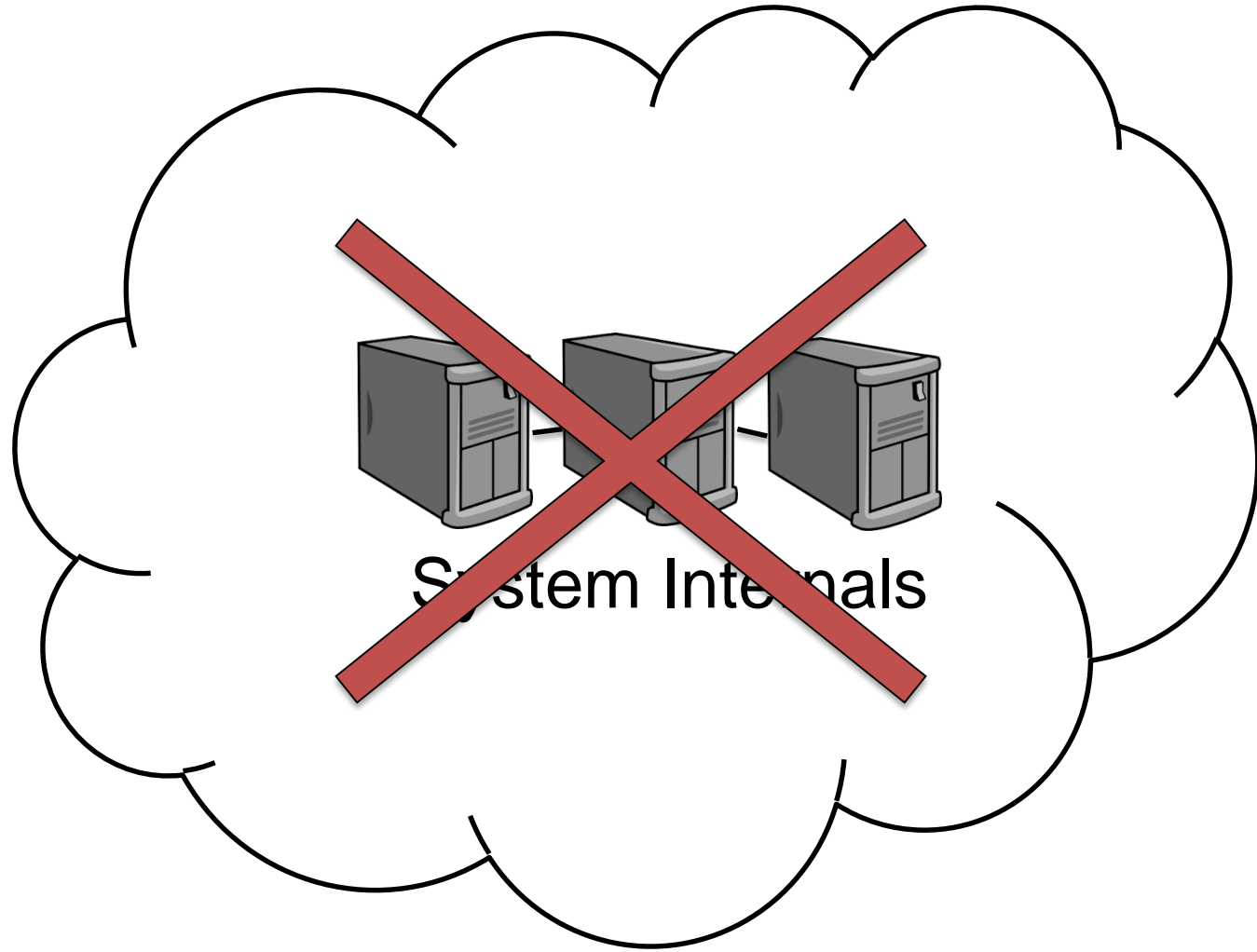
| Row | name |
|-----|---------|
| 1 | John |
| 2 | William |
| 3 | Mary |
| 4 | James |
| 5 | Charles |

How long will my query take?

Cloud Services Can Do Better!



Cloud Services Can Do Better!



Cloud Services Can Do Better!

Query:

- Query Capabilities
- Time
- Money



SELECT ...
FROM ...
WHERE ...



A new proposal

Time to Re-think the interface...

- Hide details of cluster deployment and resources
- Show users monetary costs and performance estimates on their data
- Let users pick the desired trade-off between options shown

Personalized Service Level
Agreements

A PSLA Example

Tier 1: \$0.10/hour

Fixed,
hourly **price**

Within 20 seconds:

SELECT <up to 10 attributes>
FROM <Fact | Dimension>
WHERE <up to 100% of data>

Expected
performance

Within 1 minute:

SELECT <up to 5 attributes>
FROM <JOIN Fact + 4 Dimensions>
WHERE <up to 10% of data>

Templates
capture
capabilities

Within 10 minutes:

SELECT <up to 10 attributes>
FROM <JOIN Fact + 8 Dimensions>
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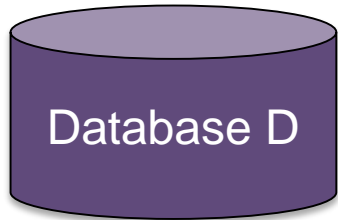
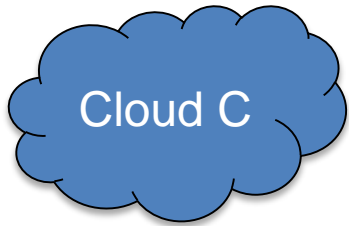
Tier 2: \$0.50/hour

Within 1 second:

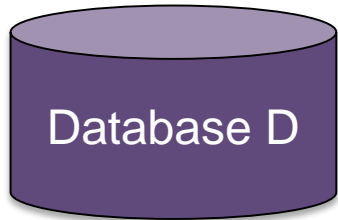
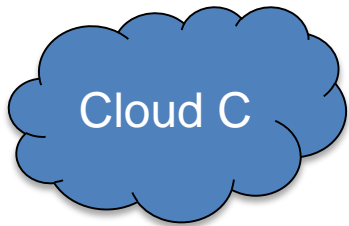
```
SELECT <up to 10 attributes>  
FROM <Fact | Dimension>  
WHERE <up to 100% of data>
```

Different tiers
of service

Goals

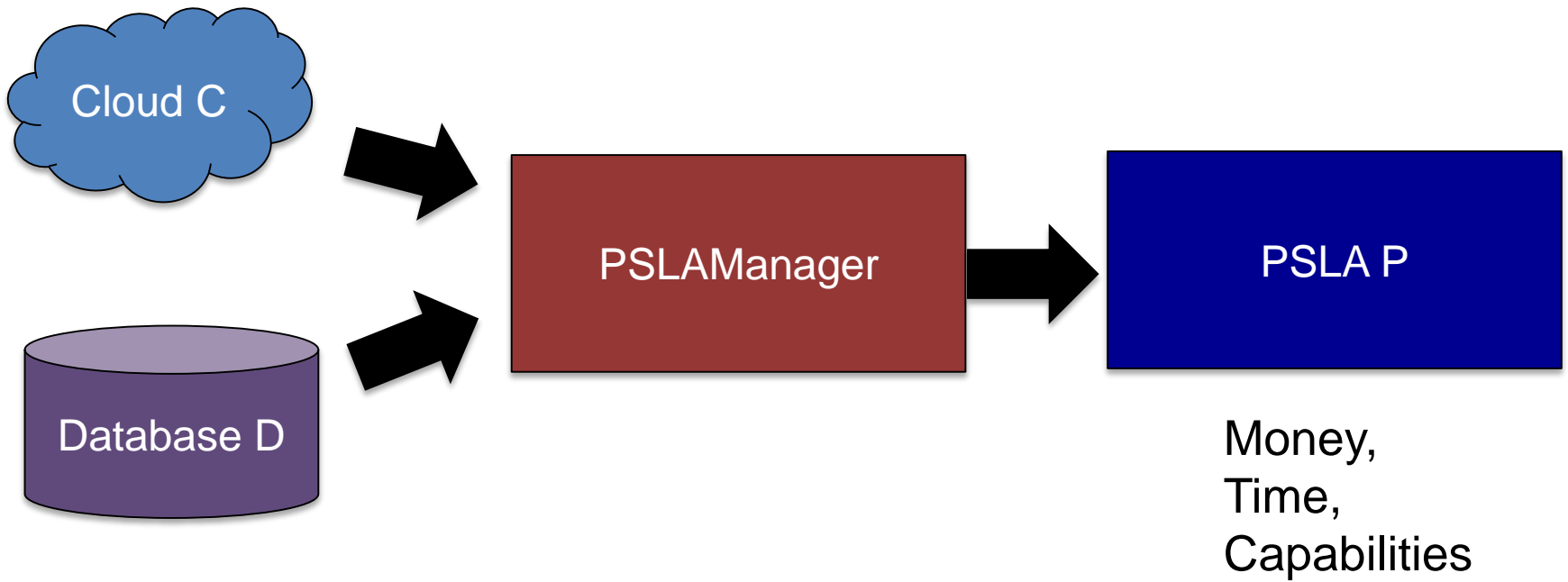


Goals

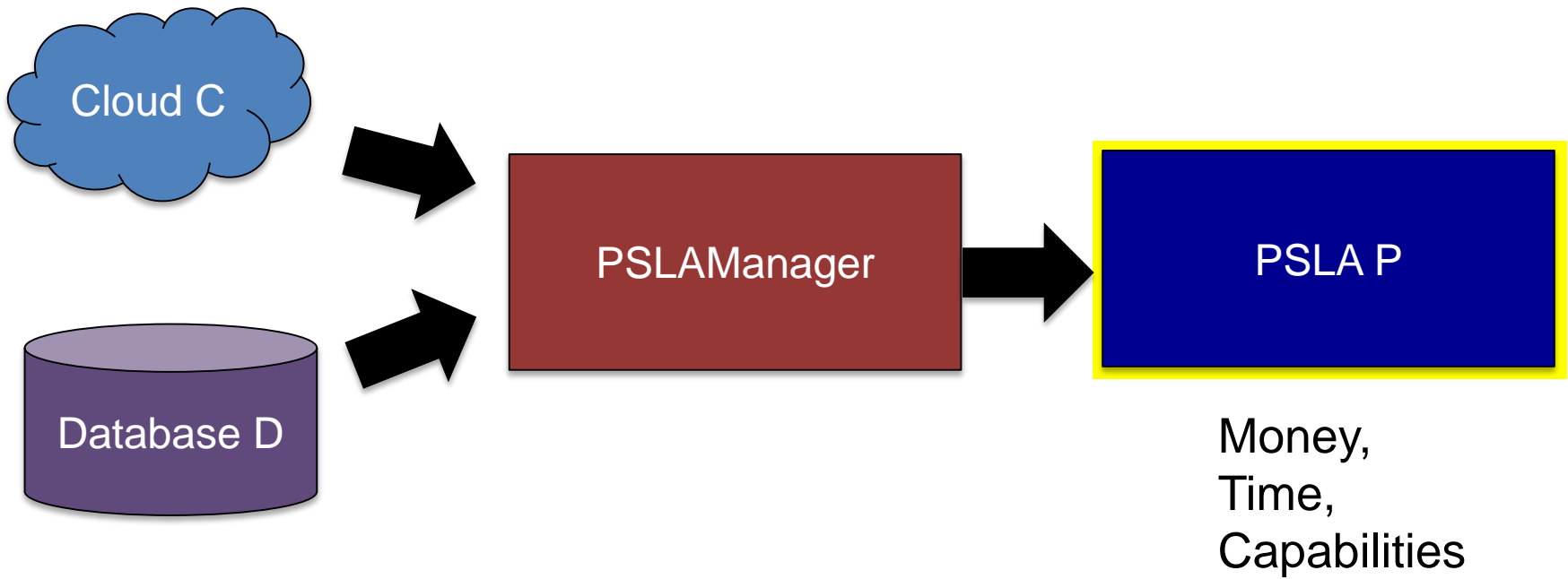


Money,
Time,
Capabilities

Goals

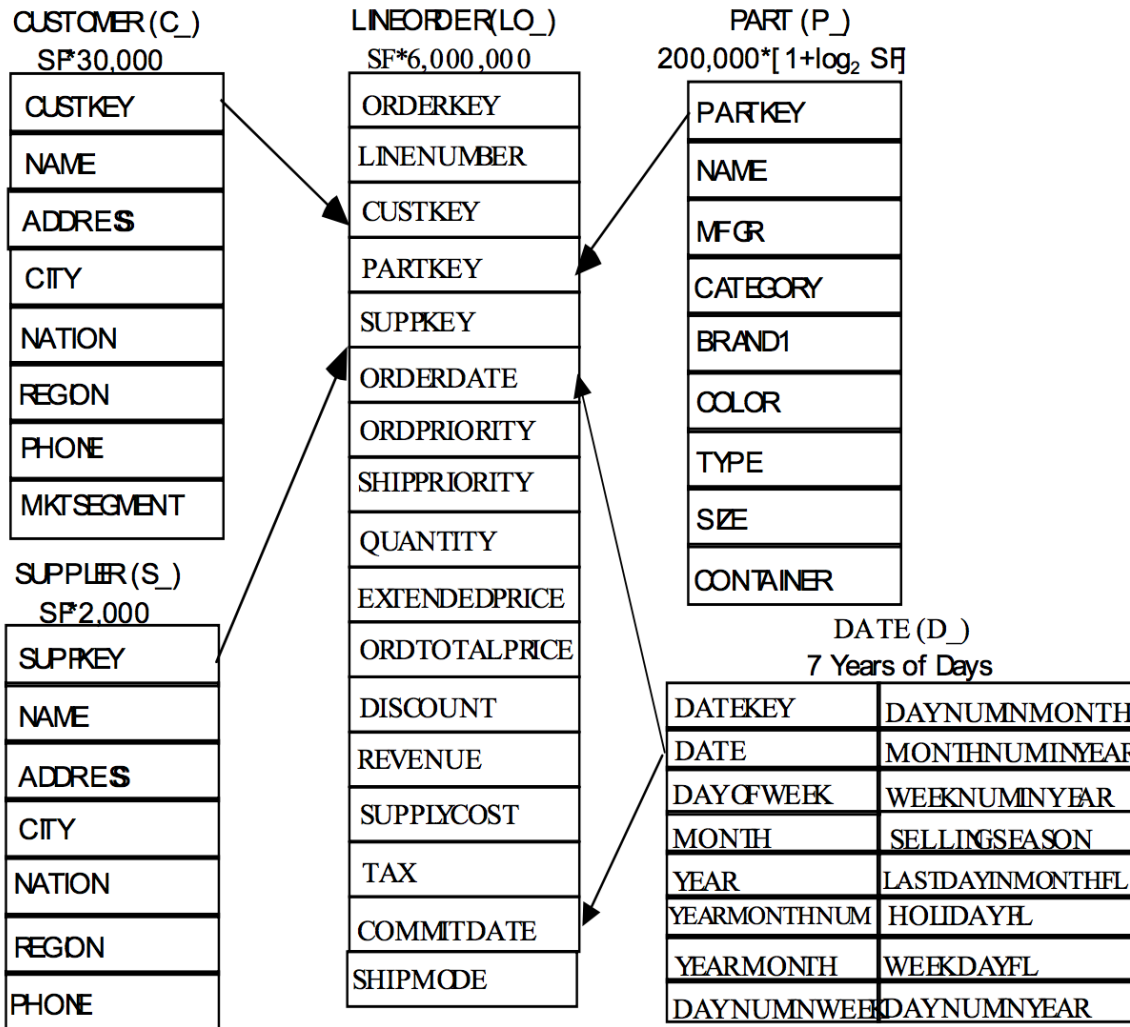


Goals



Example of a Real PSLA

TPC-H Star Schema Benchmark



- Based on TPC-H
- 10GB



Myria is a data management service in the cloud that we built at UW.

It has a parallel, shared-nothing back-end query execution engine called MyriaX

PSLA for Myria


| Tier #1 | |
|---|-------------------|
| Query Template | Runtime (seconds) |
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| Tier #2 | |
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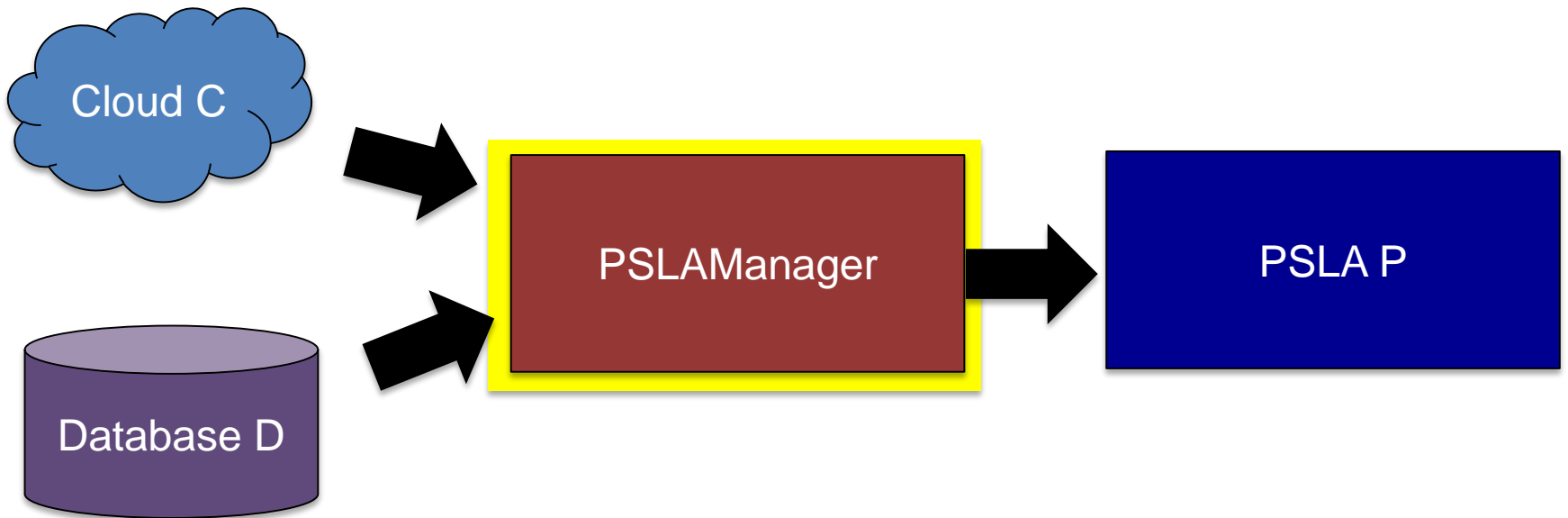
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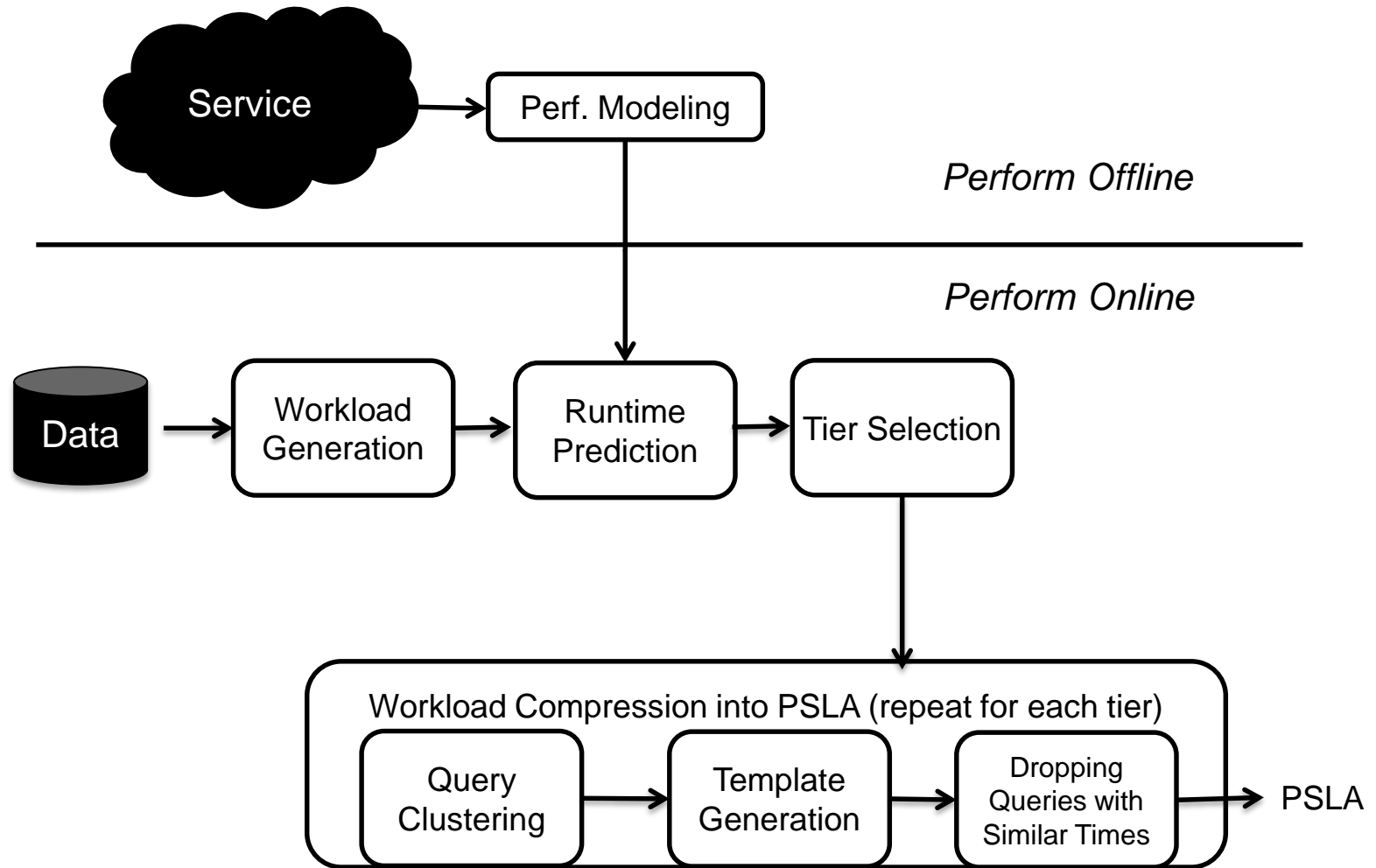
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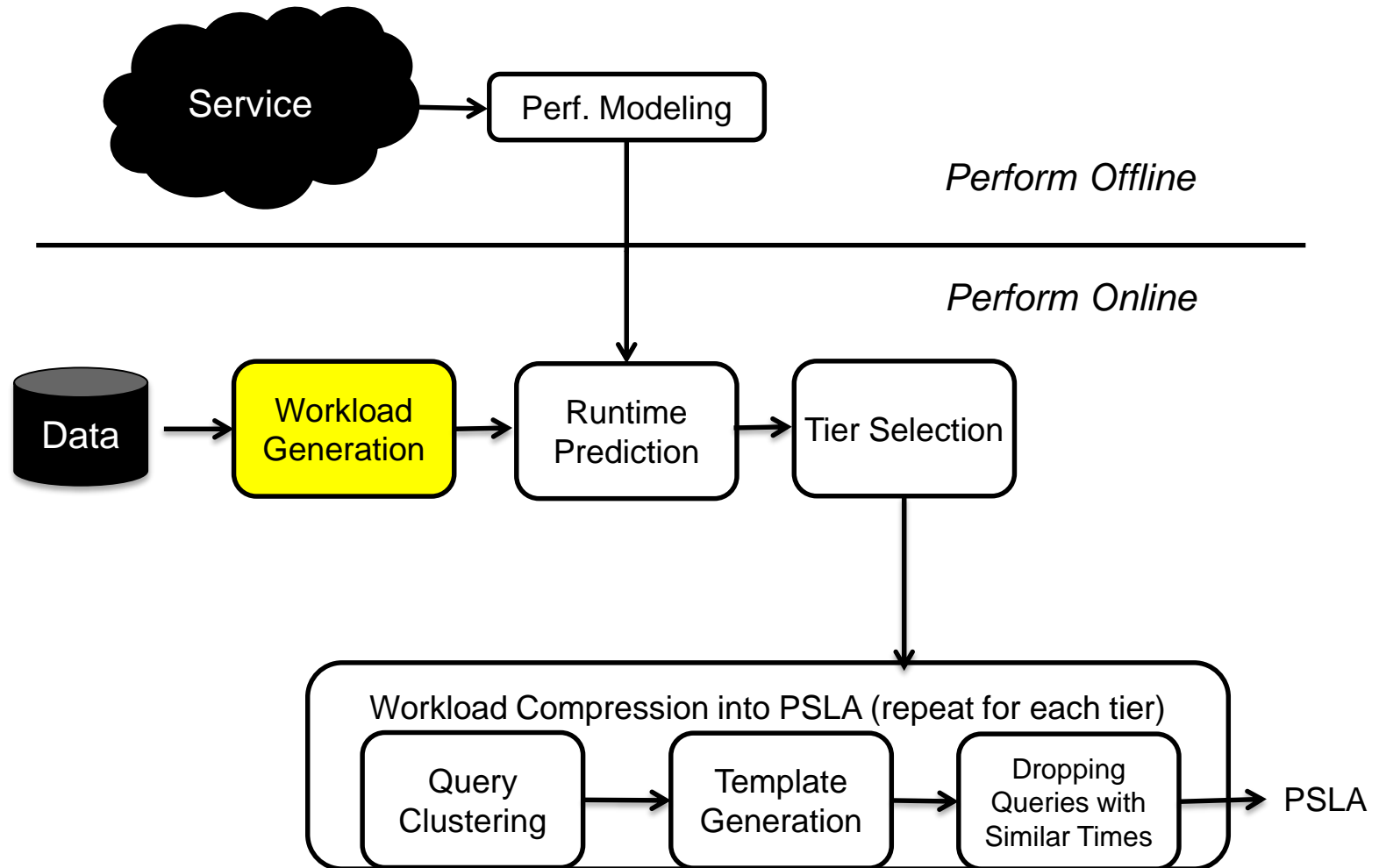
PSLAManager



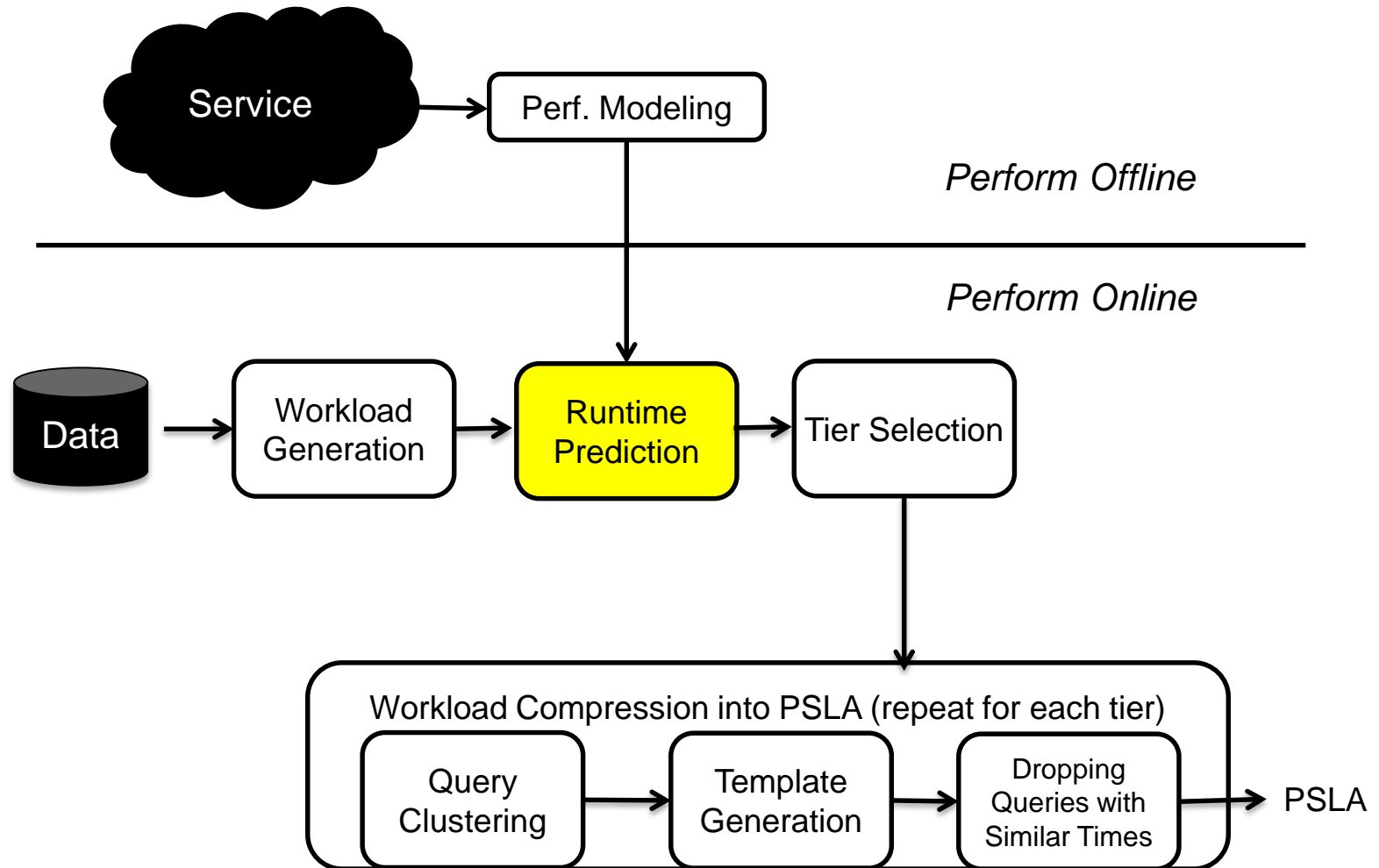
PSLAManager Workflow



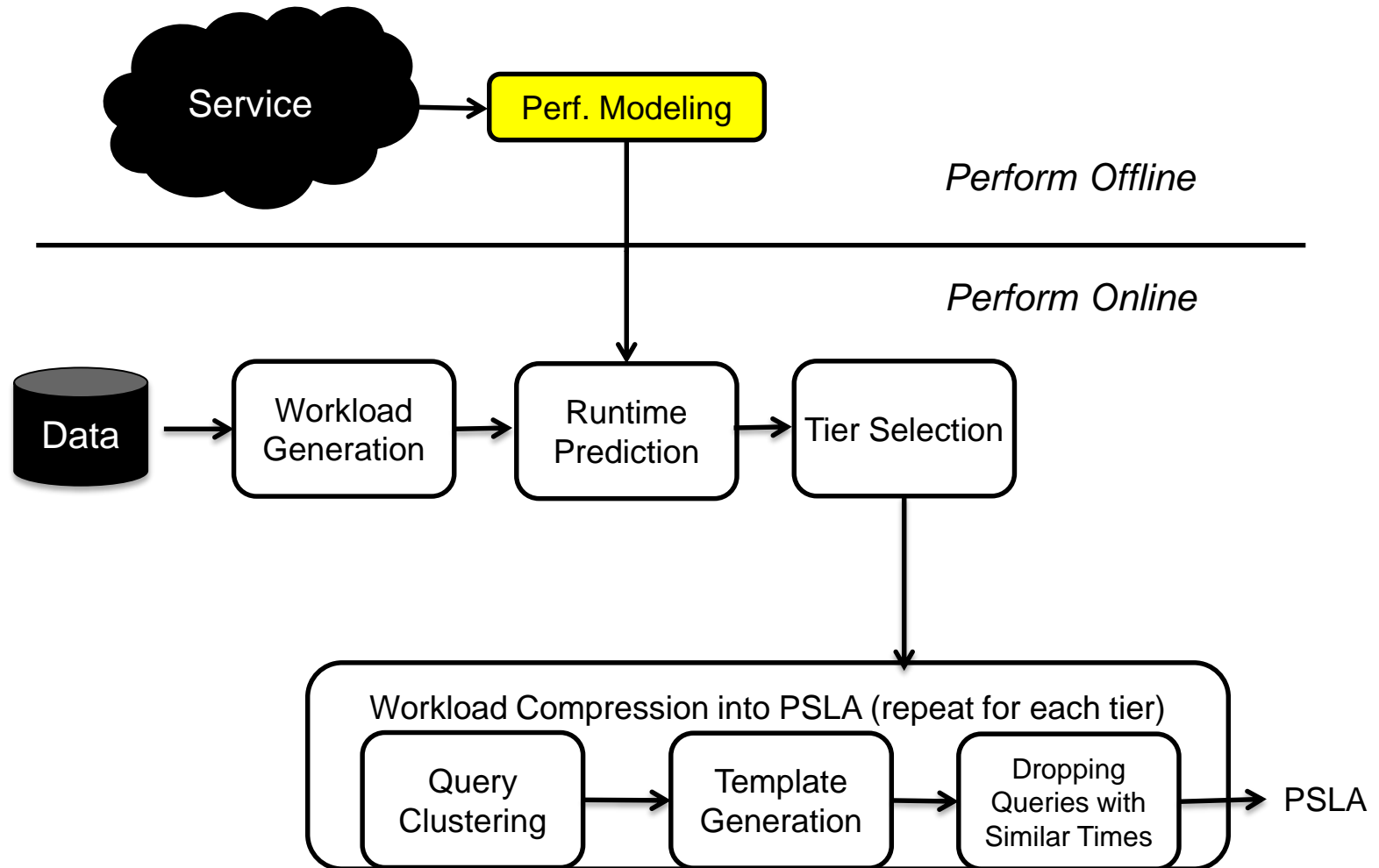
PSLAManager Workflow



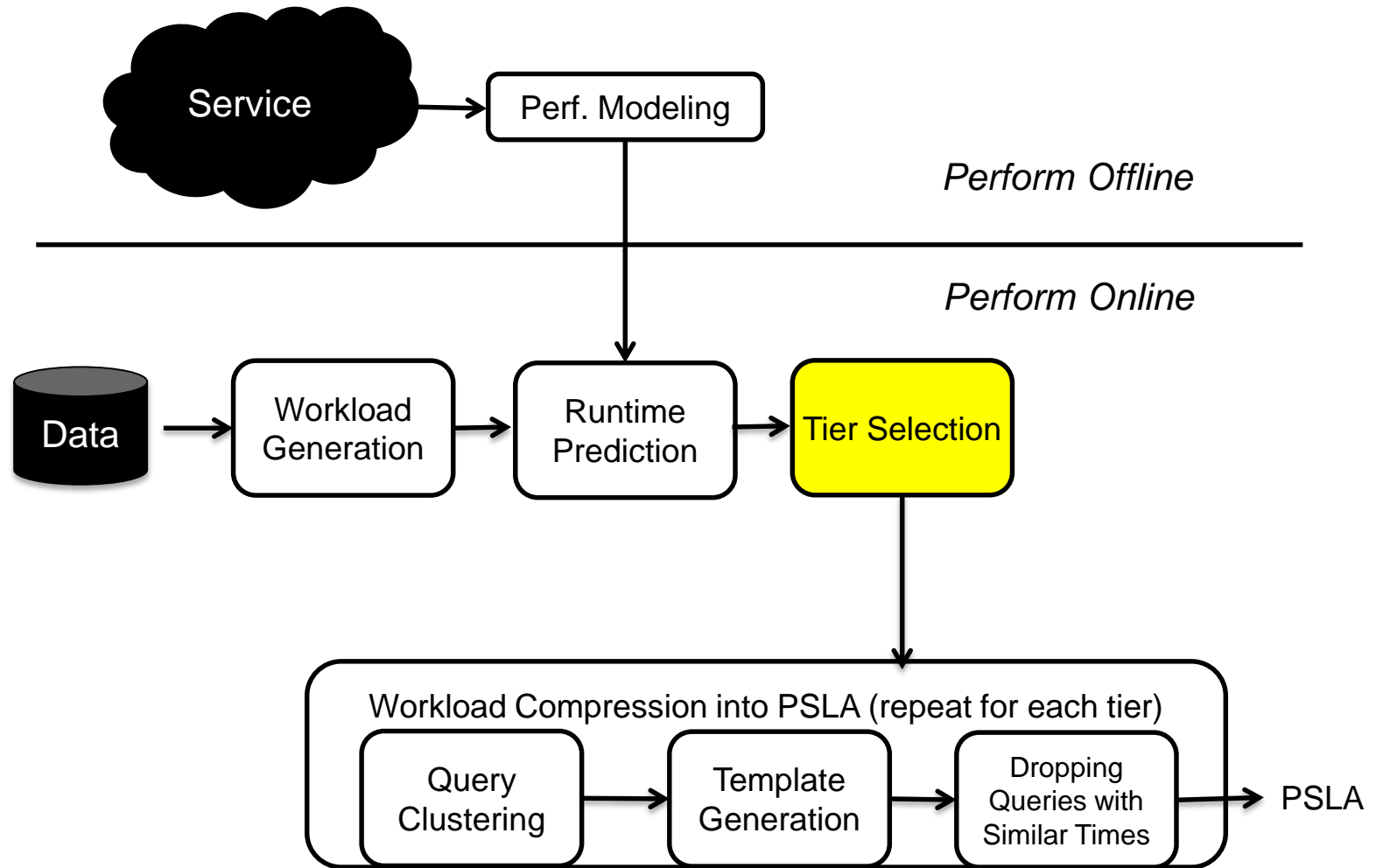
PSLAManager Workflow



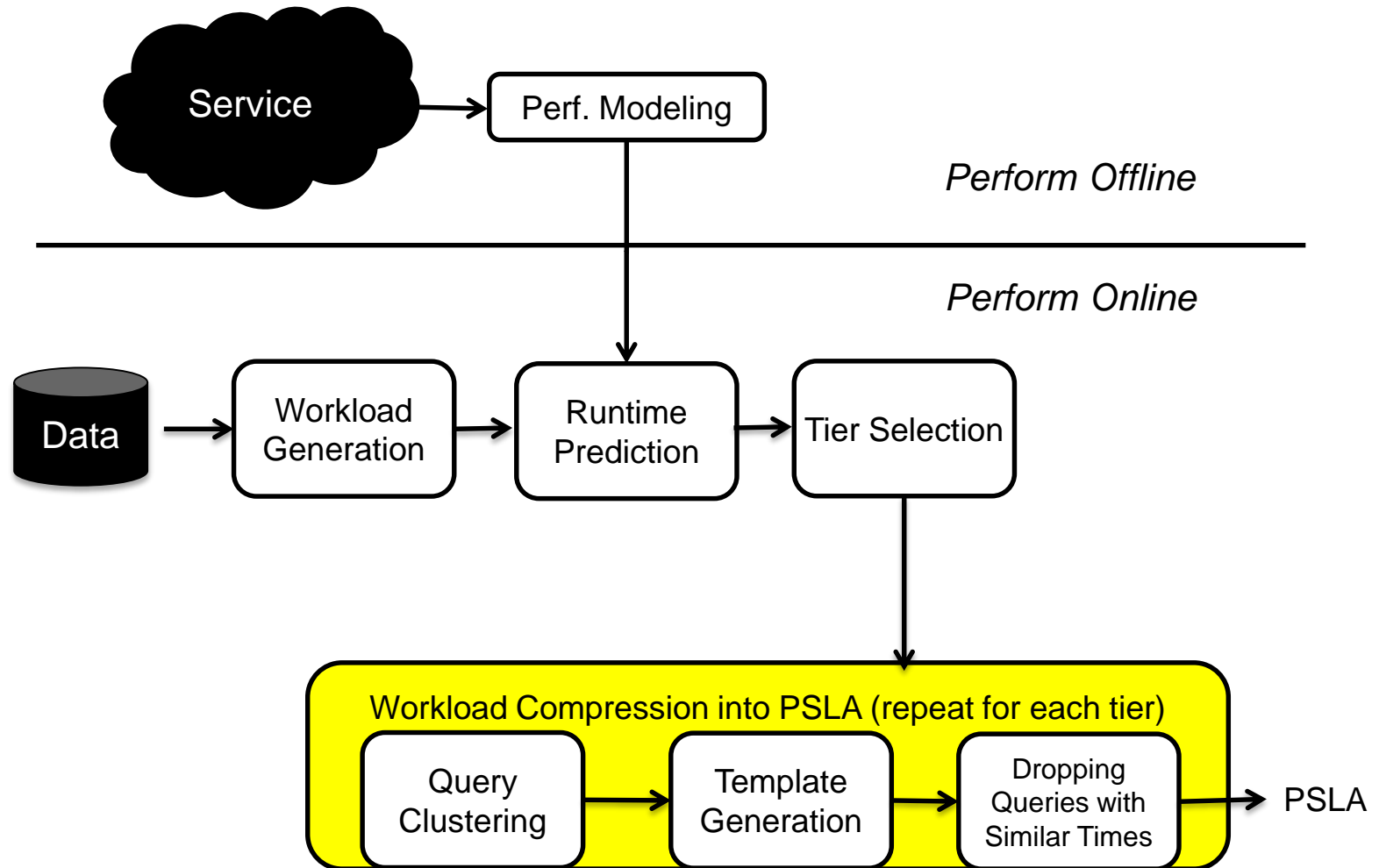
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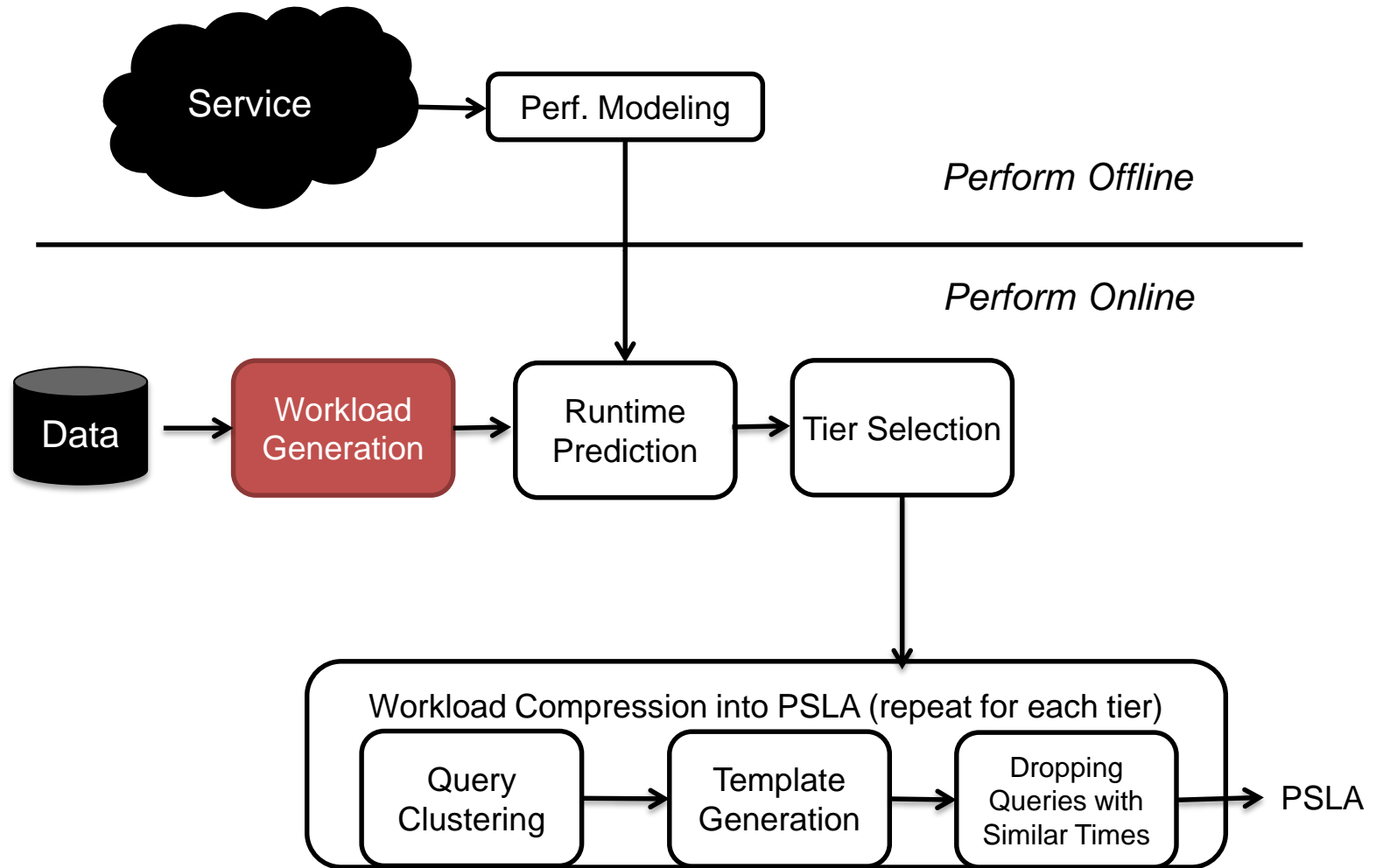
PSLAManager Workflow



PSLAManager Workflow



PSLAManager Workflow



Query Workload Generation

- Which queries to generate?
 - Joins drive performance
 - Think about possible combinations of joins

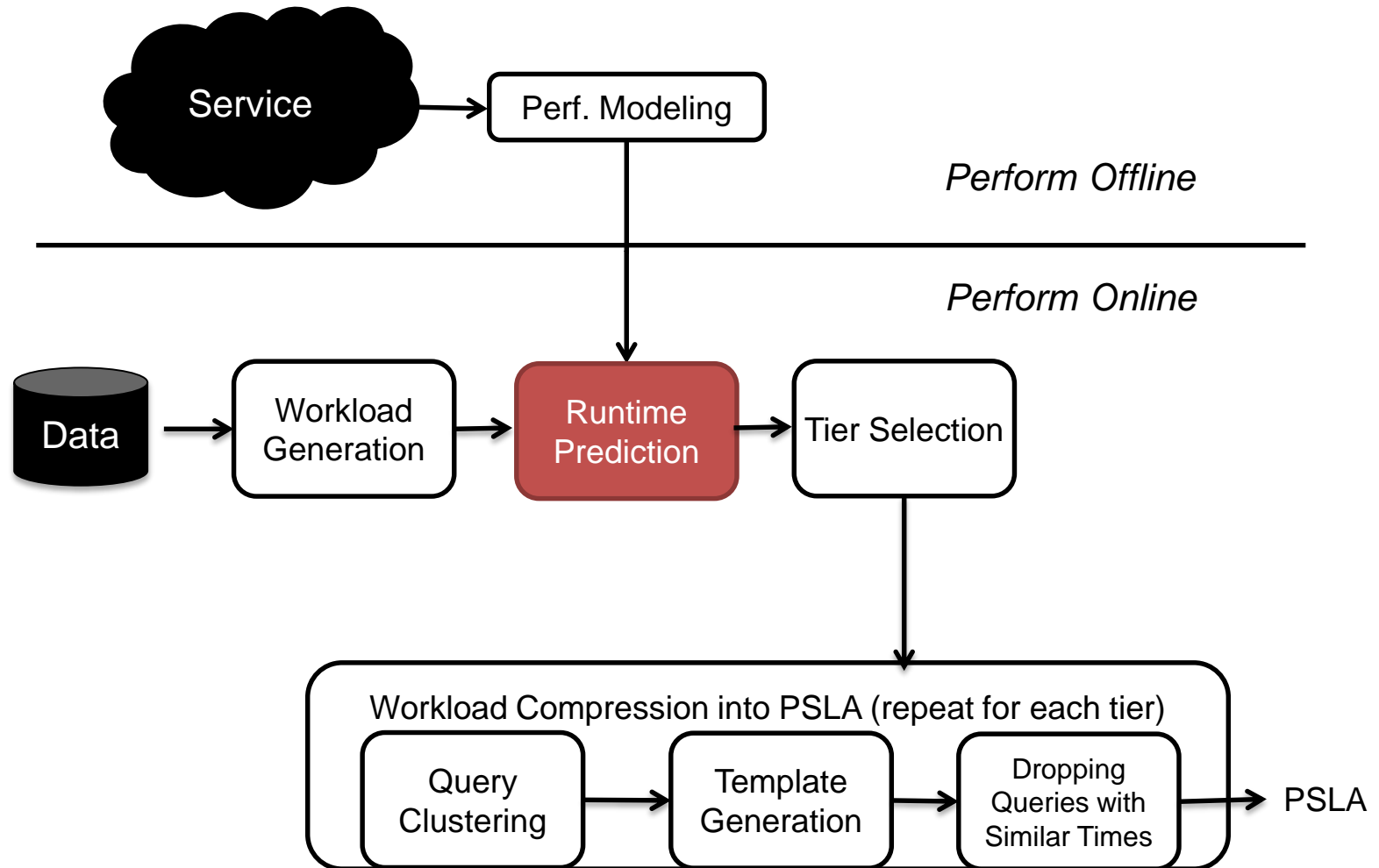
Consider: All possible 2-way joins

Tables in Order by Size: Lineitem, Part, Customer, Supplier, Date

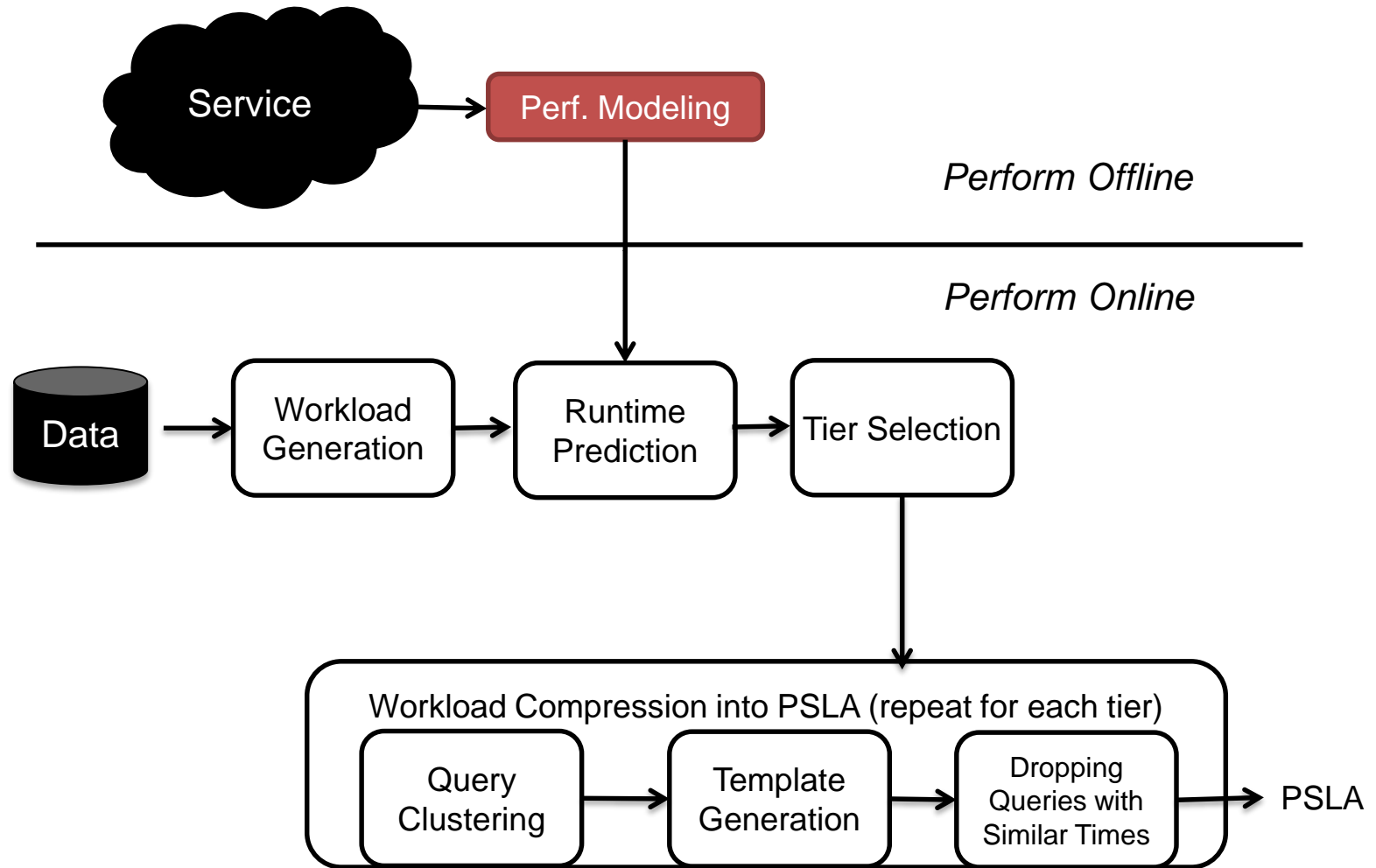
(Lineitem  Part) \geq (Customer  Date), (Lineitem  Supplier), etc.

- Only consider most expensive queries
- Build toward more complex queries, include selections and projections

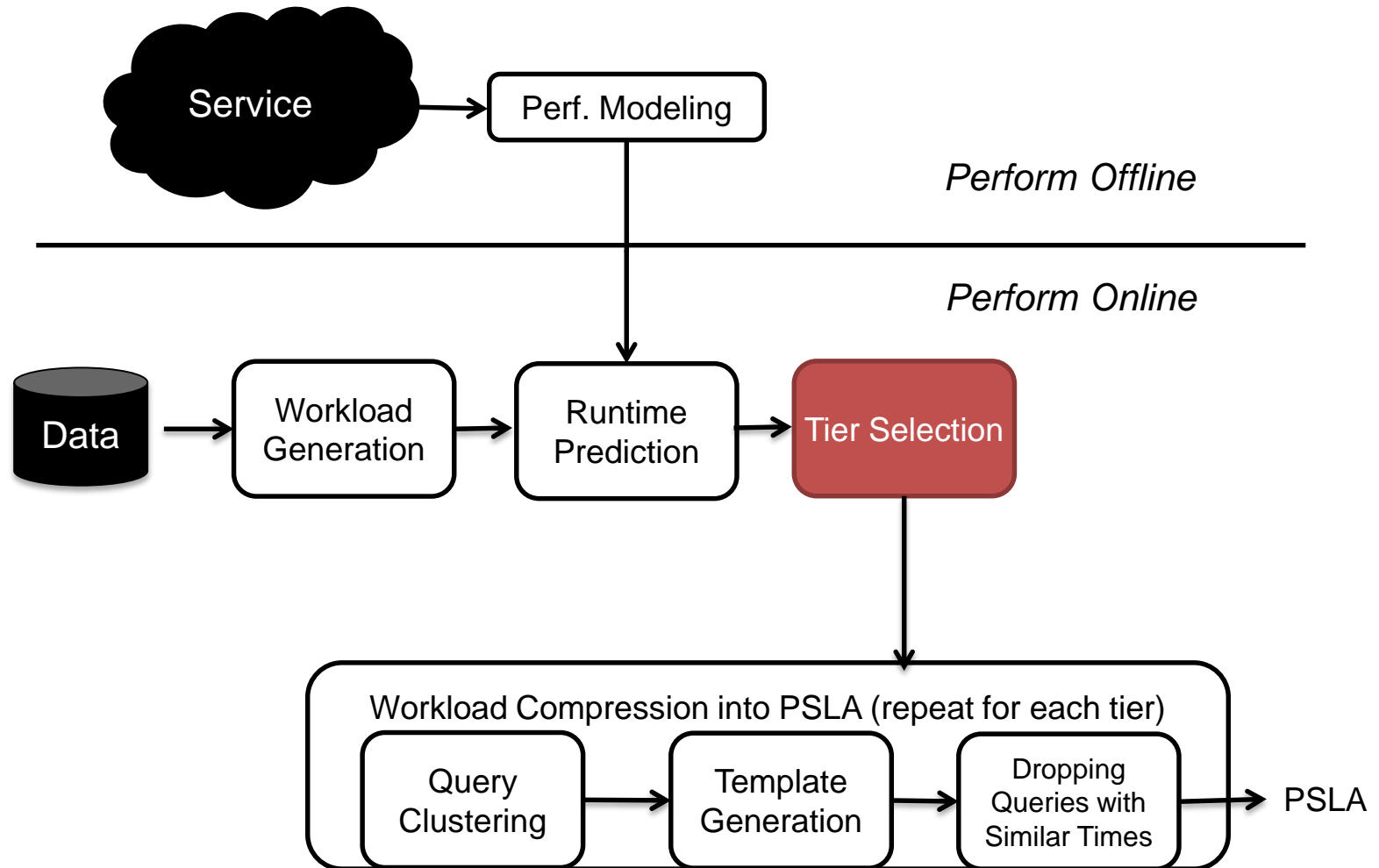
PSLAManager Workflow



PSLAManager Workflow

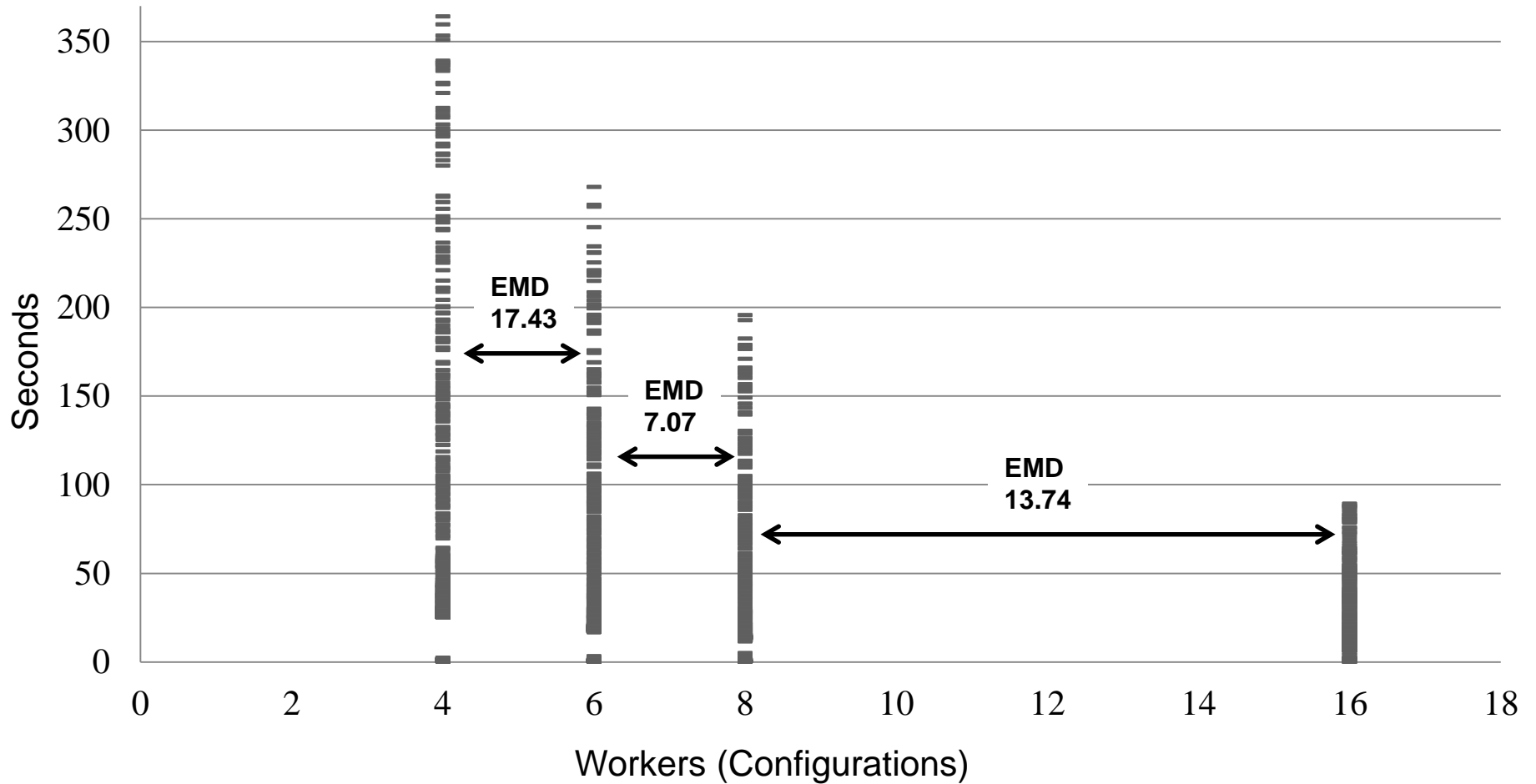


PSLAManager Workflow




Tier Selection

Runtime Distributions of Query Workload Per Configuration in Myria




Tier Selection


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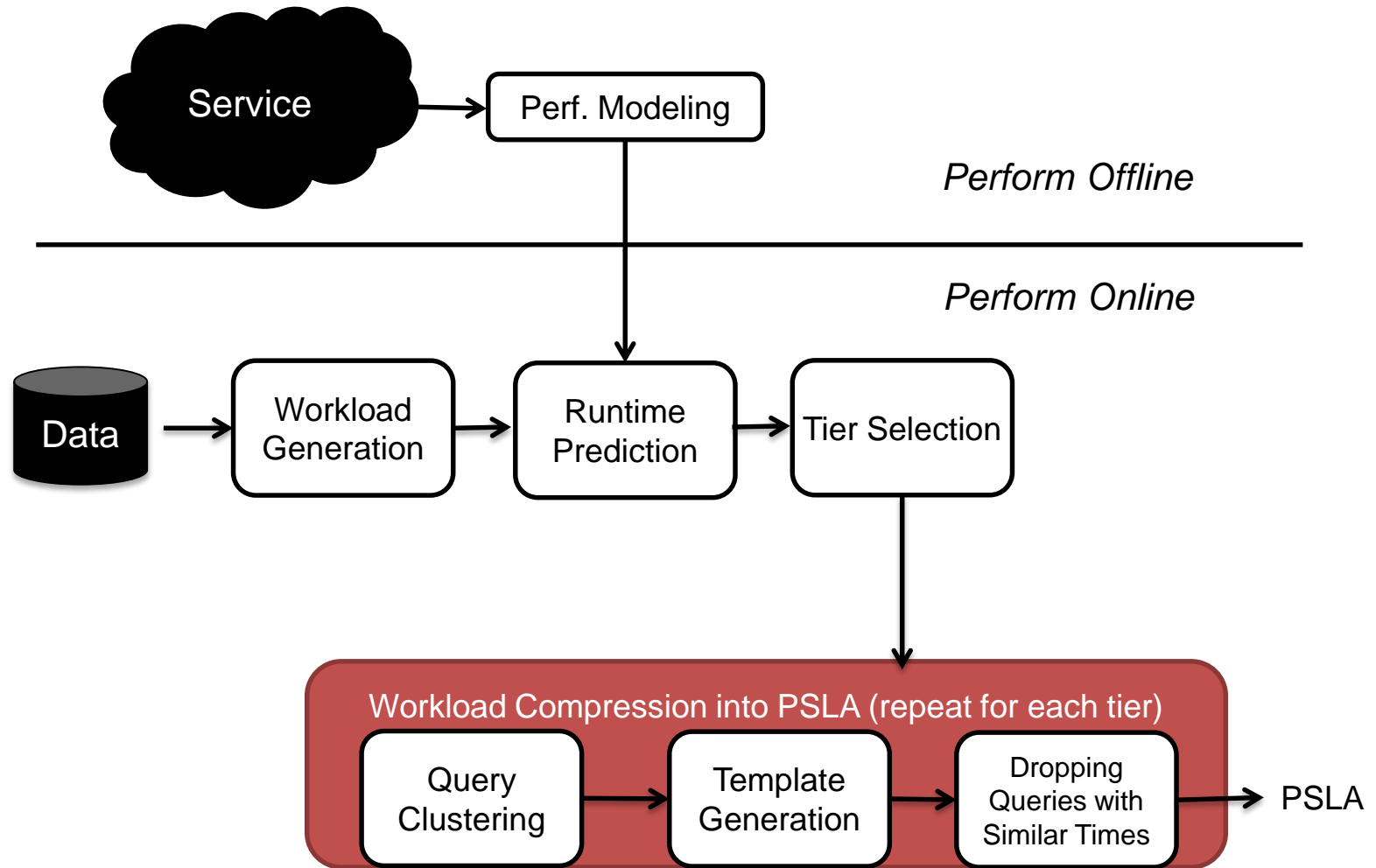
| Tier #3 | |
|--|-------------------|
| Query Template | Runtime (seconds) |
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 Purchase @ \$0.32/hour

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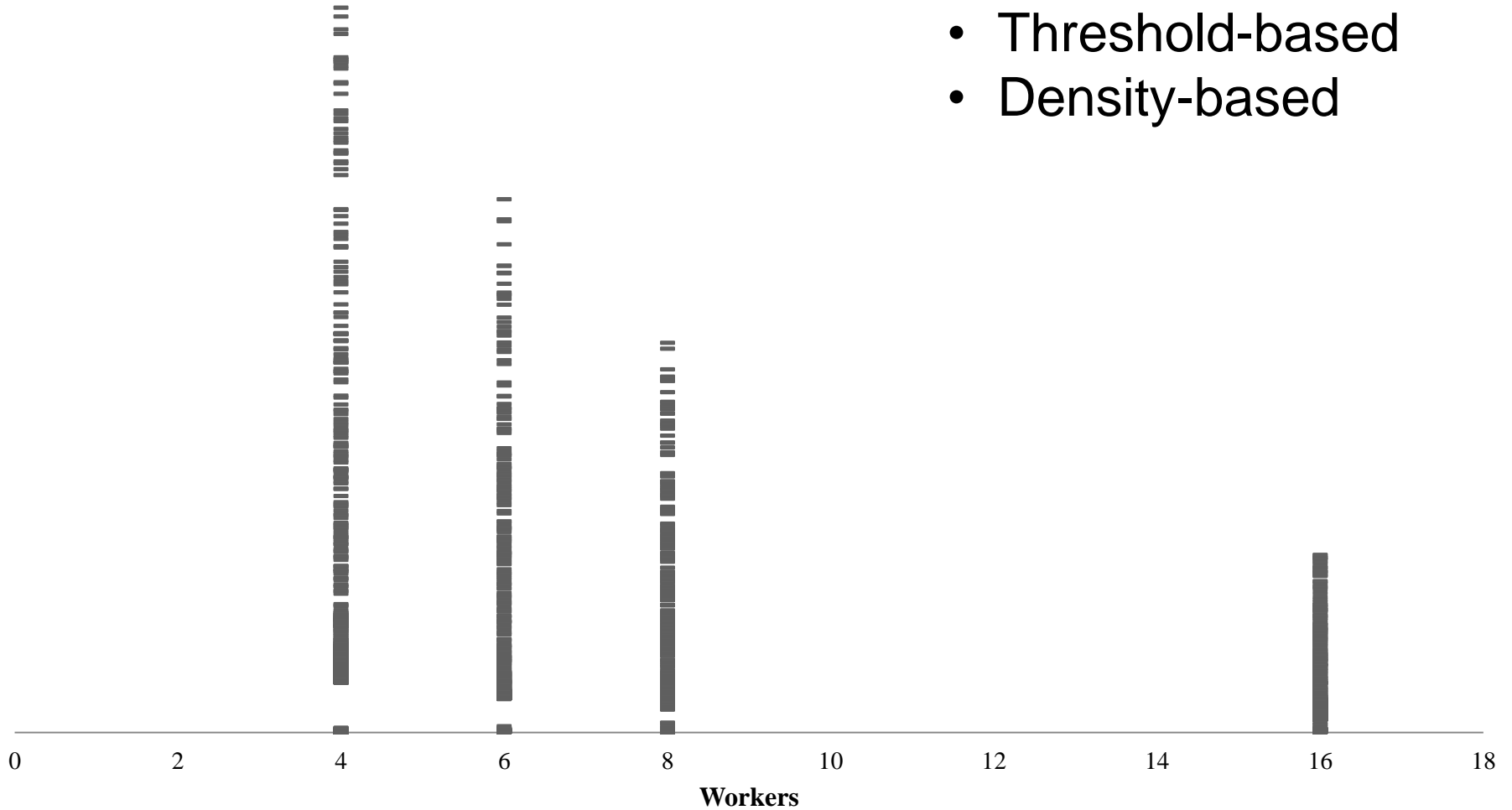
PSLAManager Workflow



Workload Compression

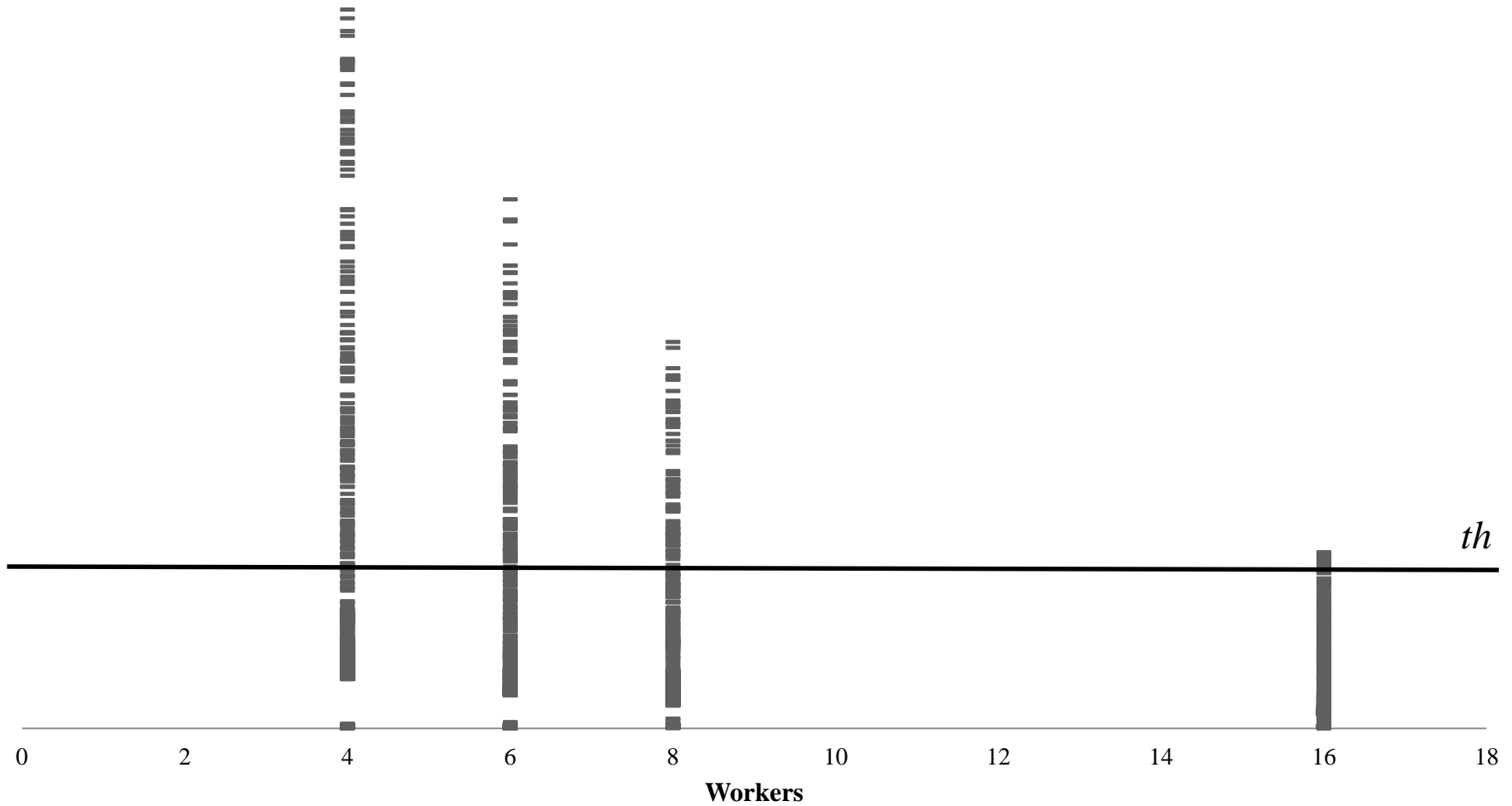
STEP 1: Query Clustering

- Threshold-based
- Density-based



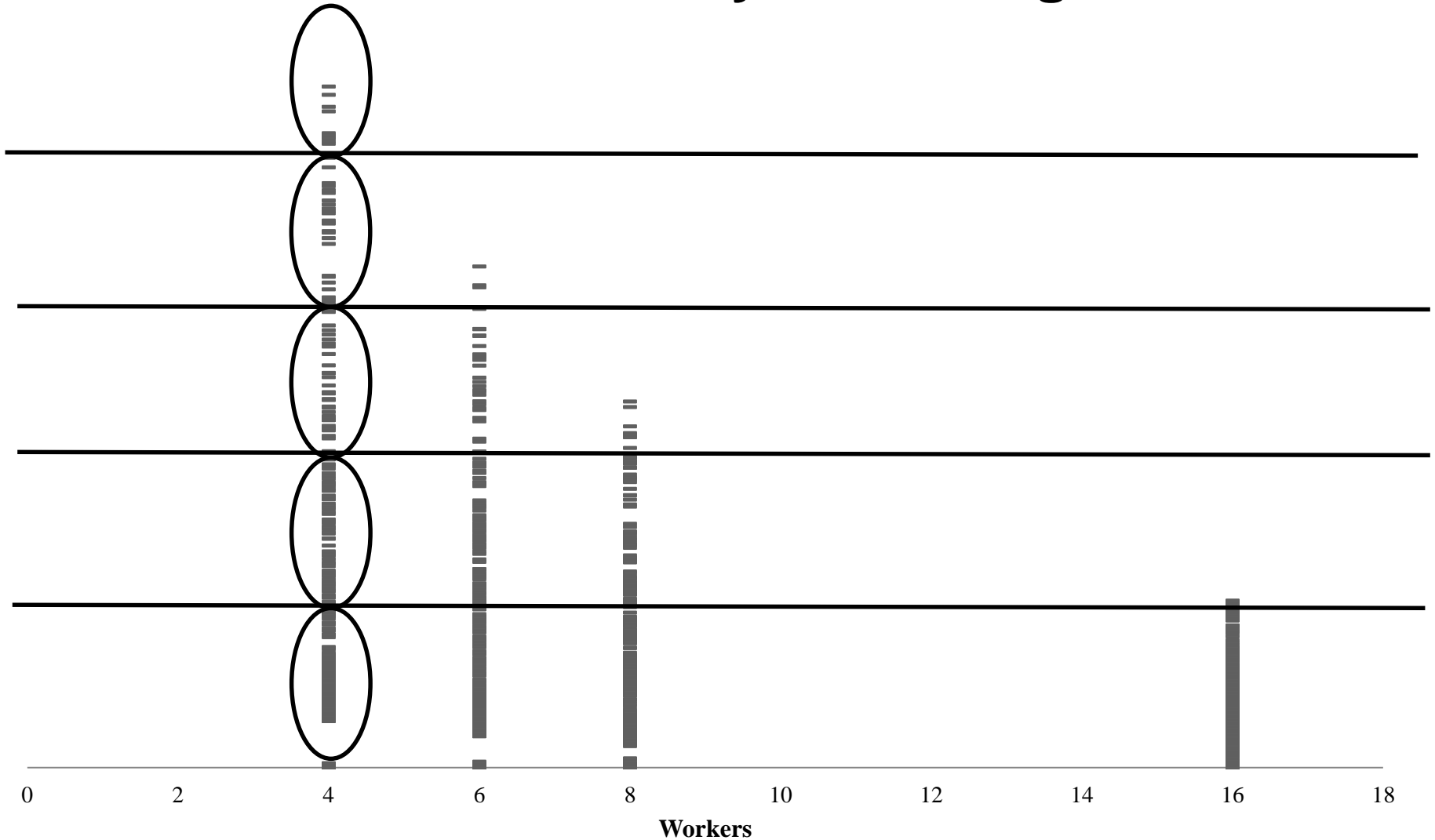
Workload Compression

STEP 1: Query Clustering



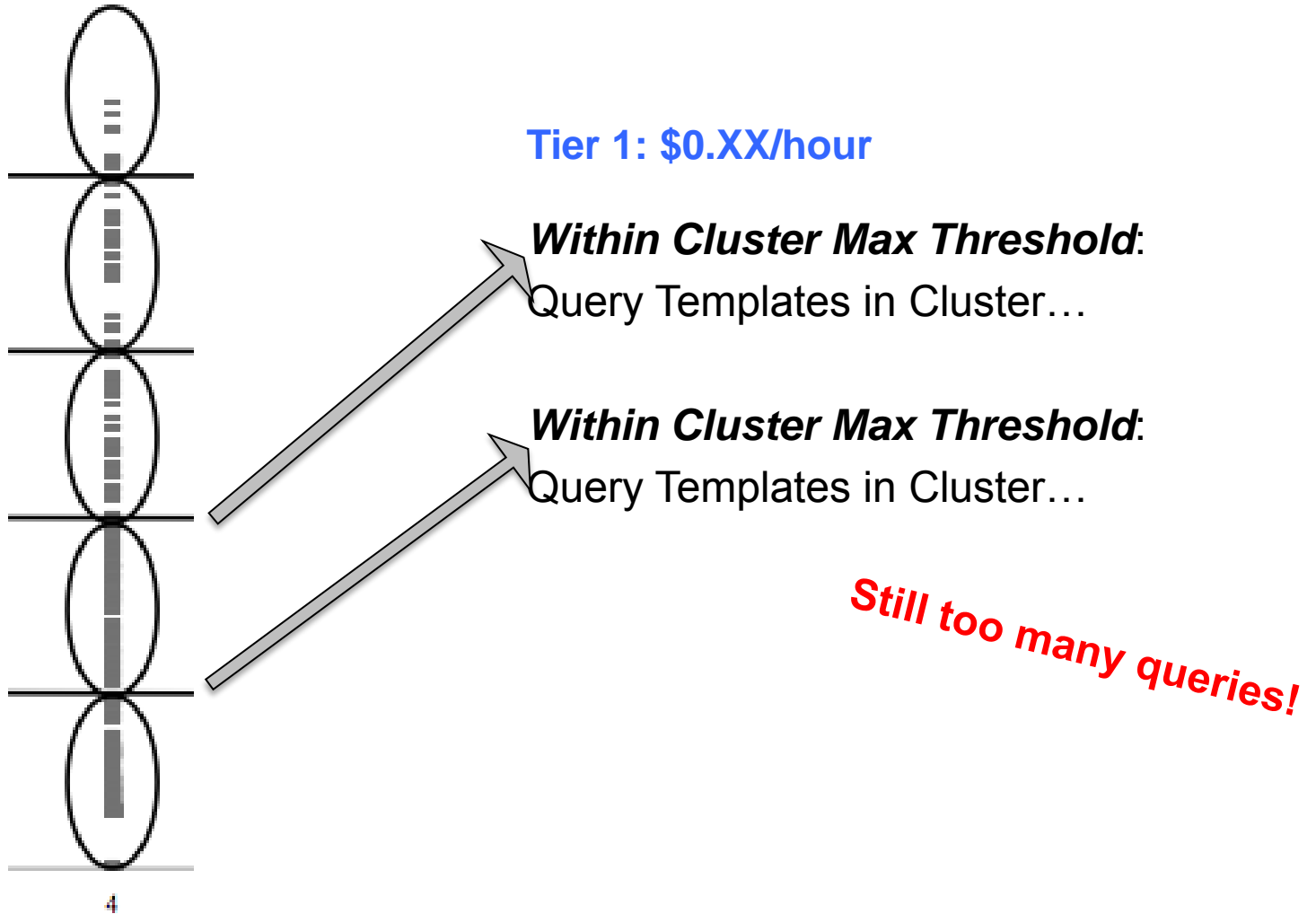
Workload Compression

STEP 1: Query Clustering



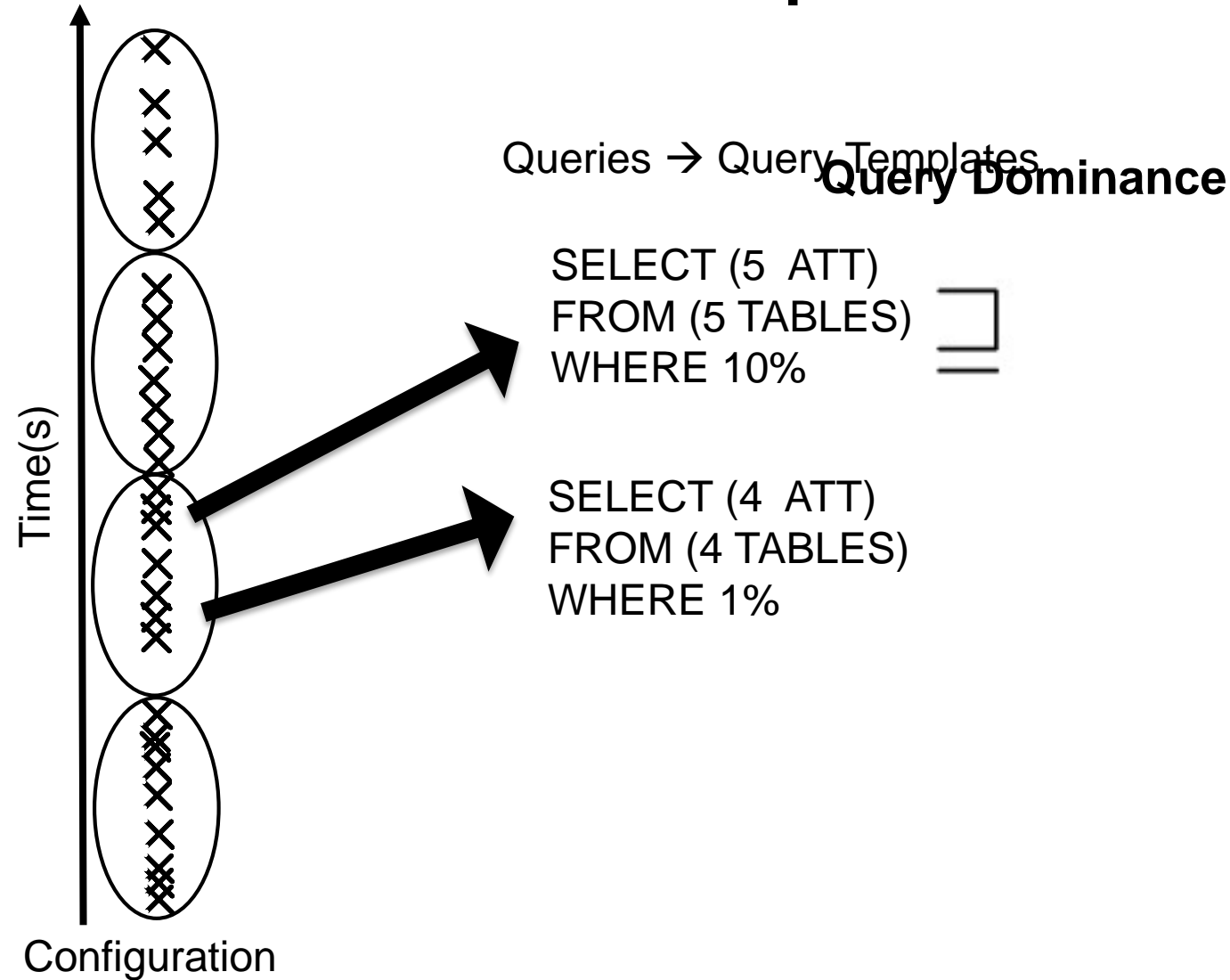
Workload Compression

STEP 1: Query Clustering



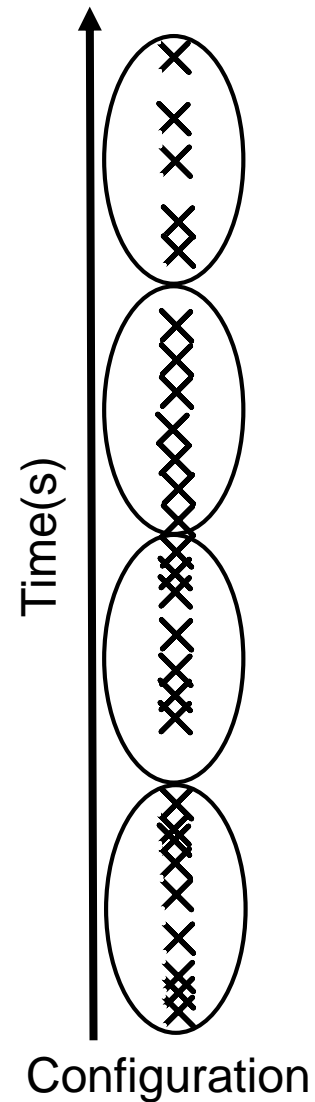
Workload Compression

STEP 2: Template Generation



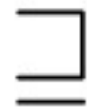
Workload Compression

STEP 2: Template Generation



Query Dominance

SELECT (5 ATT)
FROM (5 TABLES)
WHERE 10%



SELECT (4 ATT)
FROM (4 TABLES)
WHERE 1%

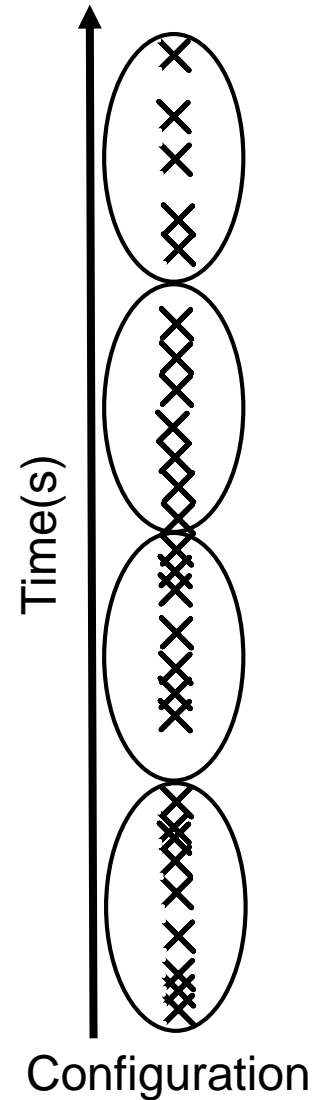
Attributes Projected

Tables

Selectivity

Workload Compression

STEP 2: Template Generation



Query Dominance

SELECT (5 ATT)
FROM (5 TABLES)
WHERE 10%



SELECT (4 ATT)
FROM (4 TABLES)
WHERE 1%

Attributes Projected

Tables

Selectivity

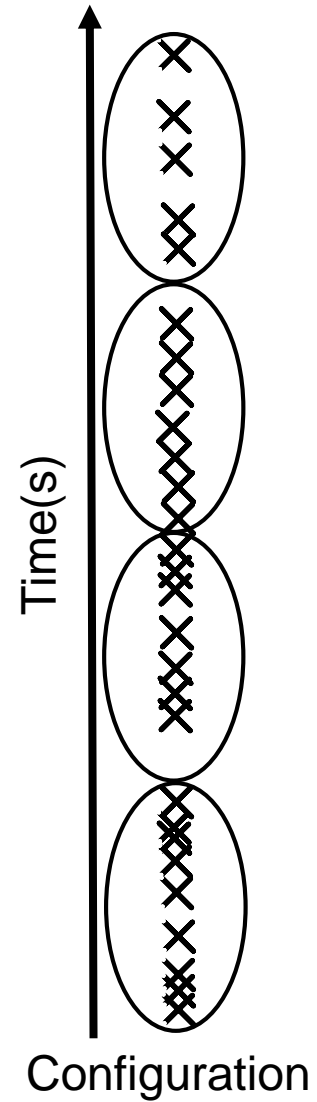
Given: q_i, q_j

$$q_i = (T_i, A_i, e_i) \quad q_j = (T_j, A_j, e_j)$$

$$q_i \supseteq q_j \iff T_i \supseteq T_j \wedge A_i \supseteq A_j \wedge e_i \supseteq e_j$$

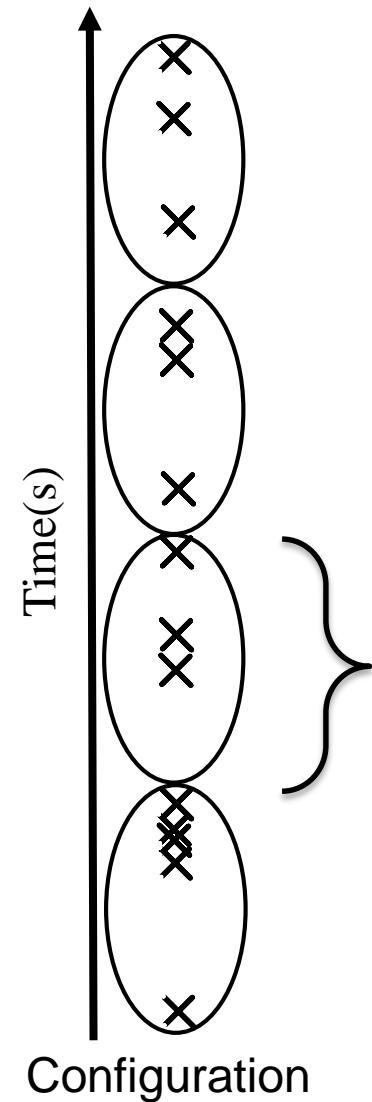
Workload Compression

STEP 2: Template Generation



Workload Compression

STEP 2: Template Generation

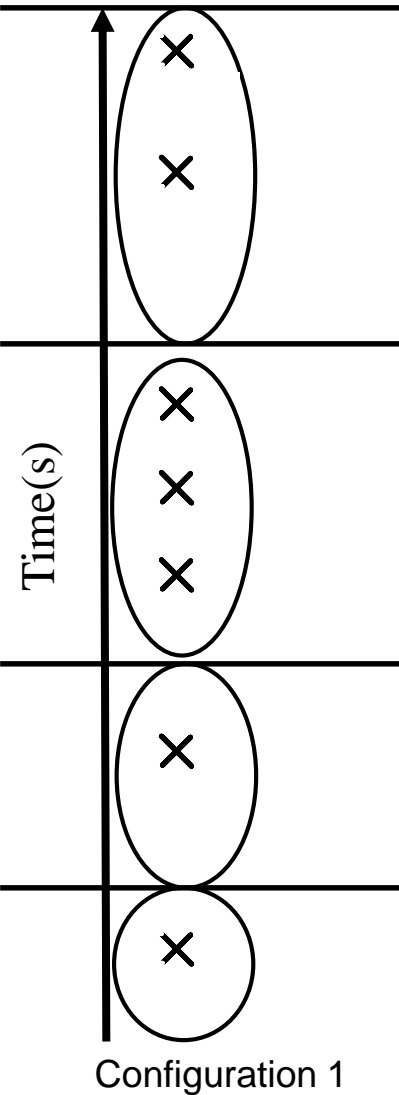


Root Query Template:

We call a query template a root query template if no other query template in the same cluster dominates it.

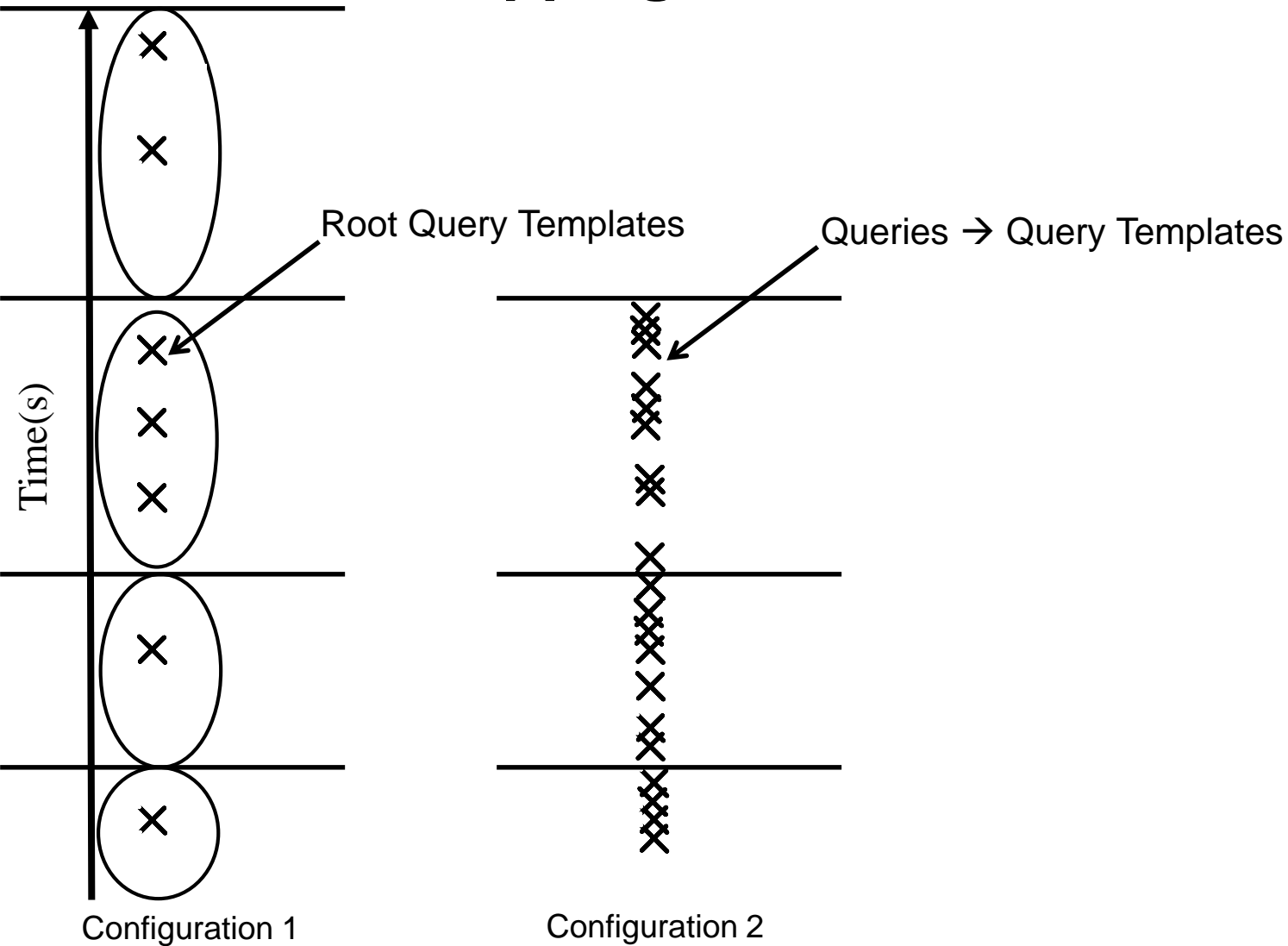
Workload Compression

STEP 3: Dropping Queries with Similar Times



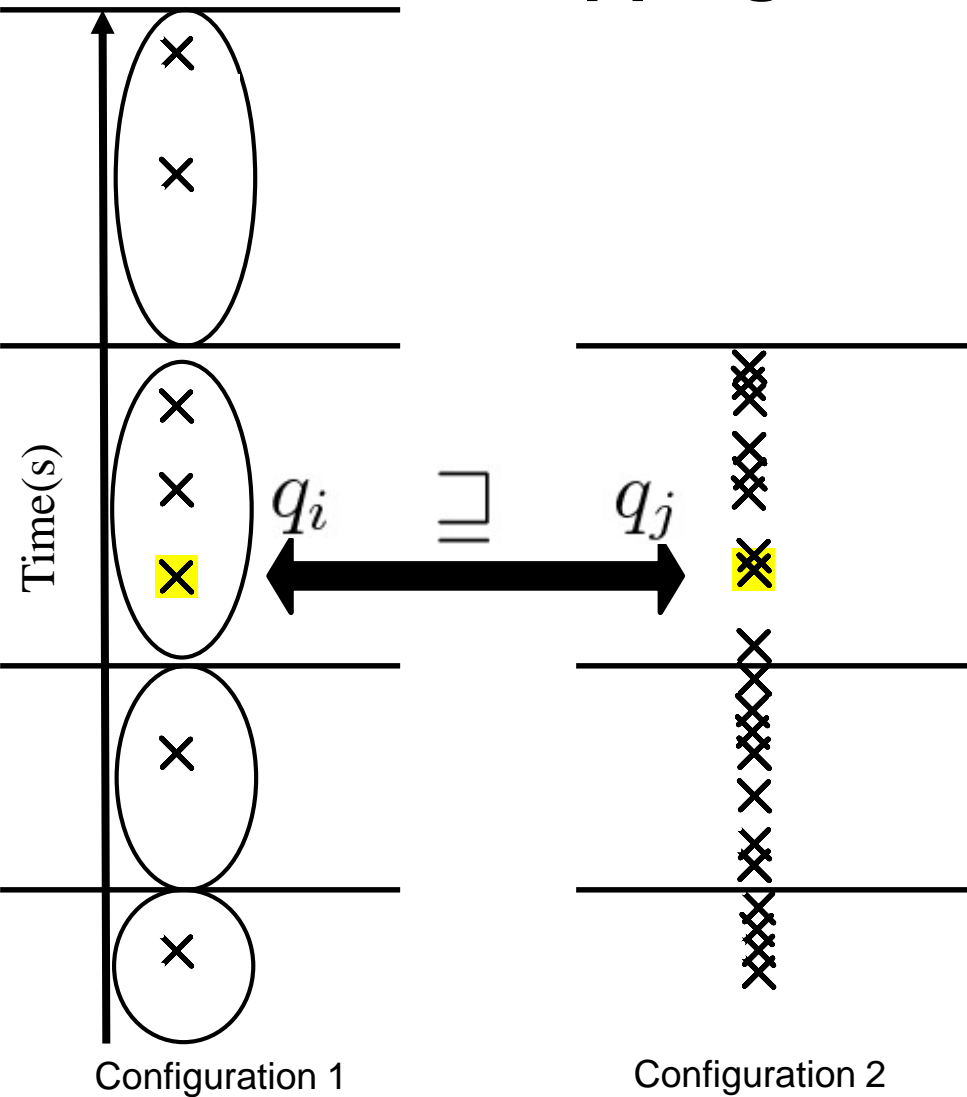
Workload Compression

STEP 3: Dropping Queries with Similar Times



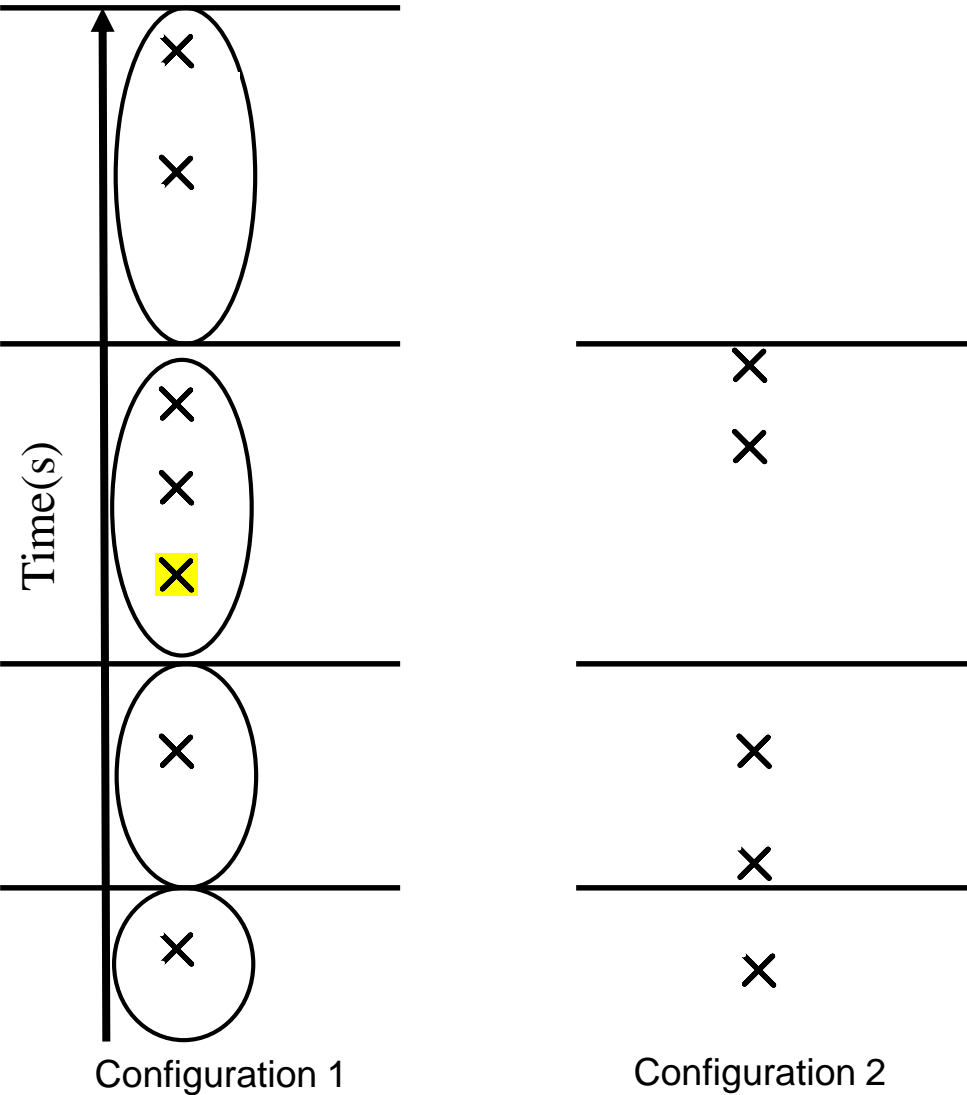
Workload Compression

STEP 3: Dropping Queries with Similar Times



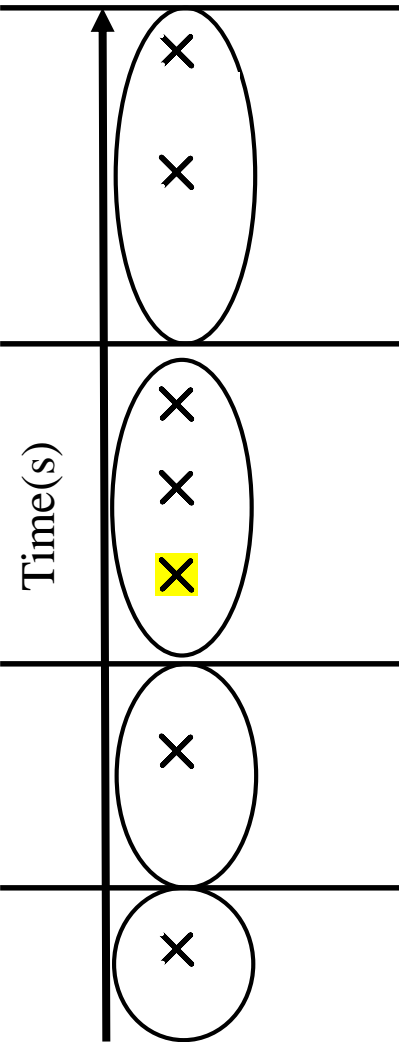
Workload Compression

STEP 3: Dropping Queries with Similar Times

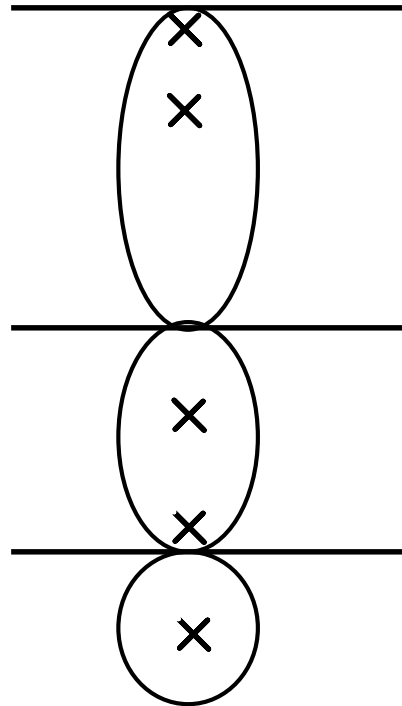


Workload Compression

STEP 3: Dropping Queries with Similar Times



Configuration 1



Configuration 2

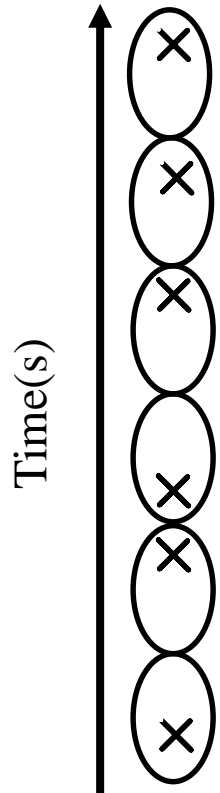
PSLA Quality Assessment

PSLA Quality Metrics

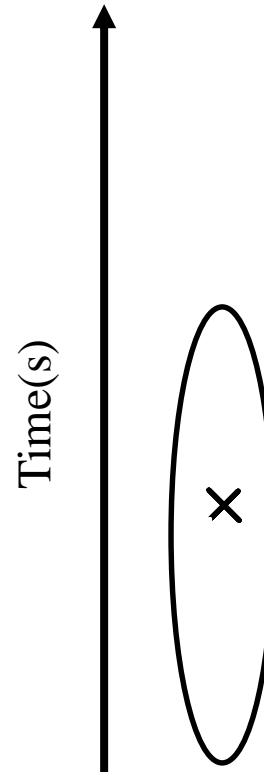
- PSLA Query Capabilities
- PSLA Complexity
- PSLA Performance Error Metric

$$RMSE(\{q_1, \dots, q_k\}, th) = \sqrt{\frac{1}{k} \sum_{i=1}^k \left(\frac{q_i - th}{th} \right)^2}$$

Quality Metric Trade-offs



High Complexity
Low Error

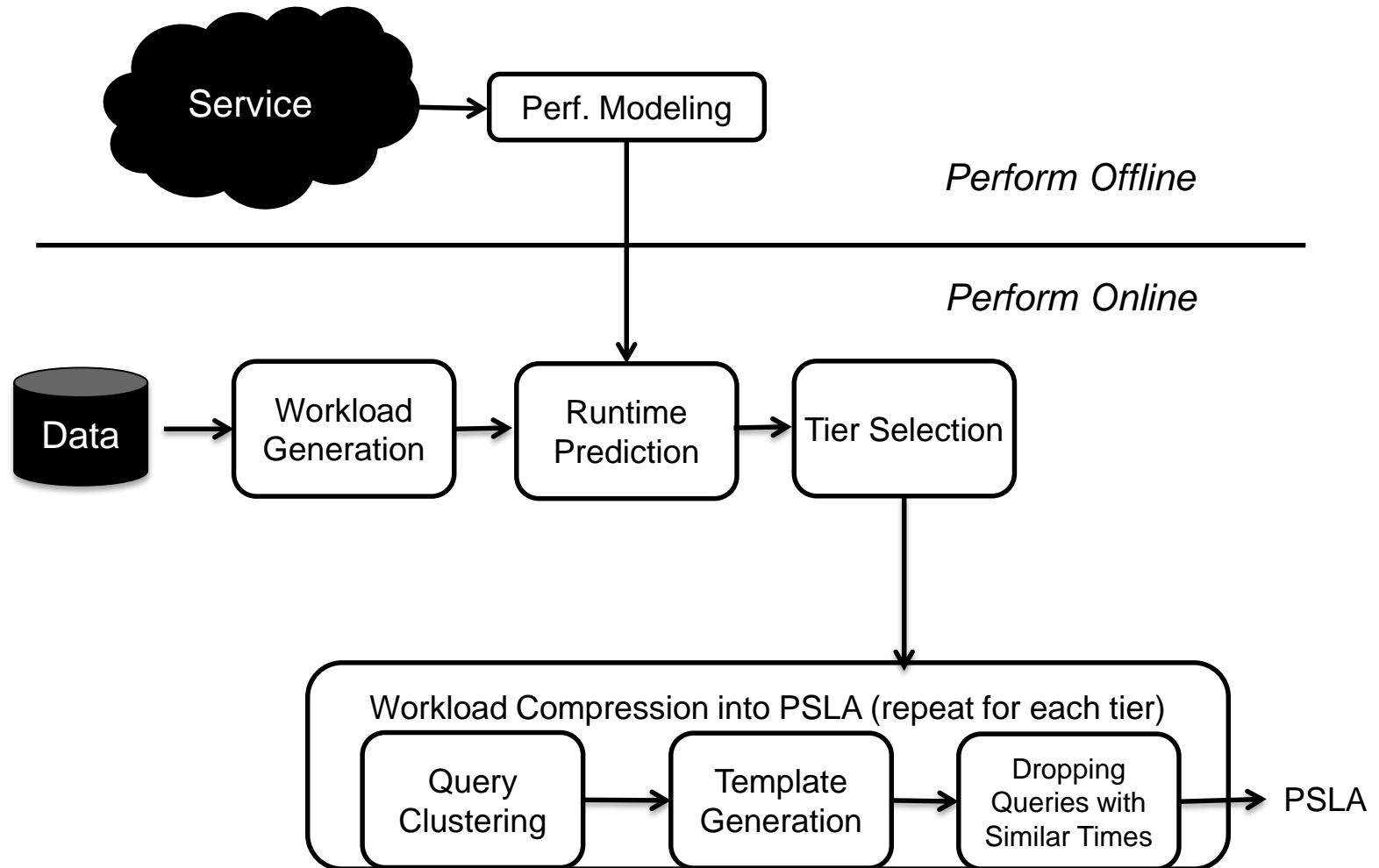


Low Complexity
High Error

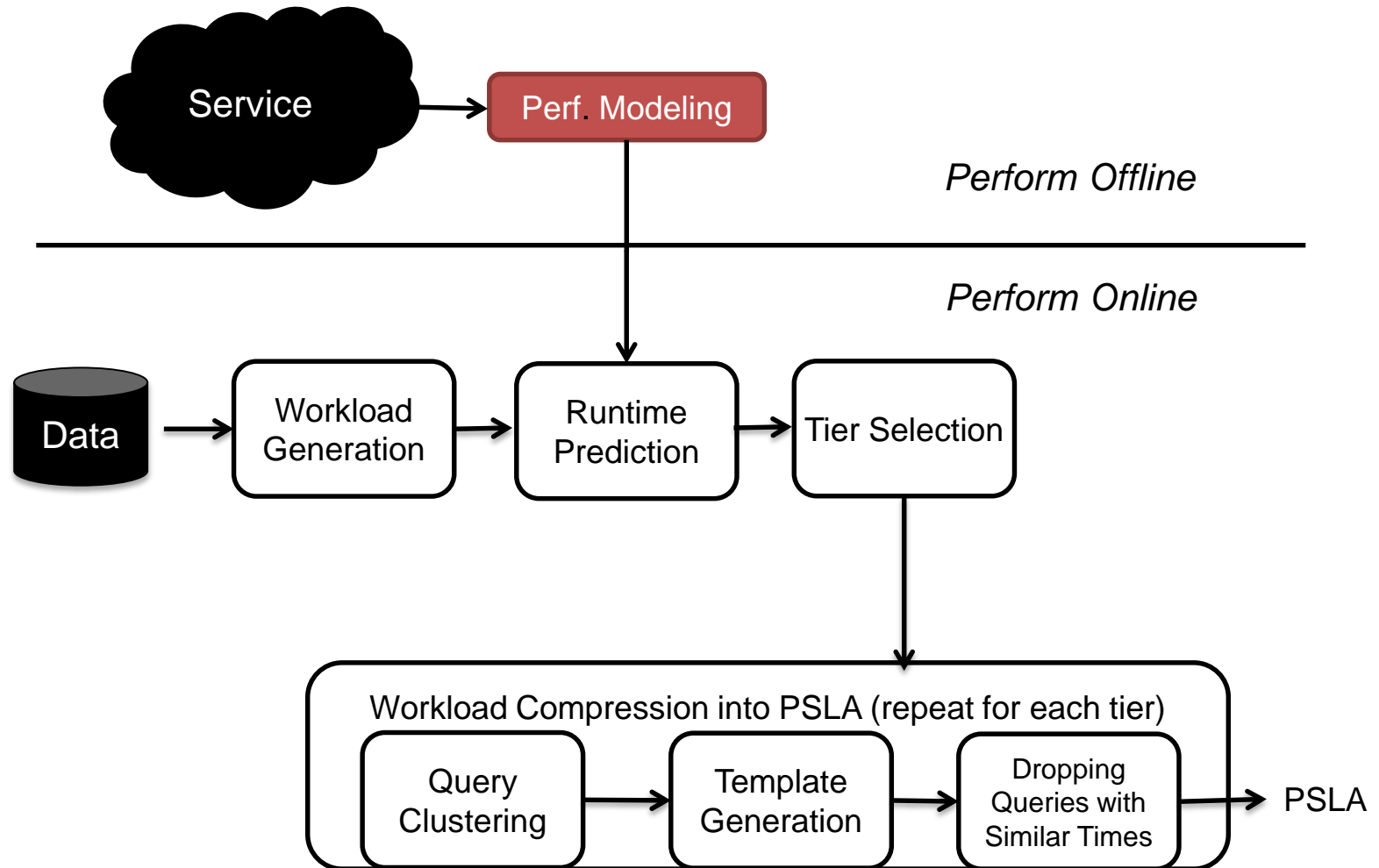
Found that a log interval is best without tuning

PSLA Evaluation on Predicted Runtimes

PSLAManager Workflow

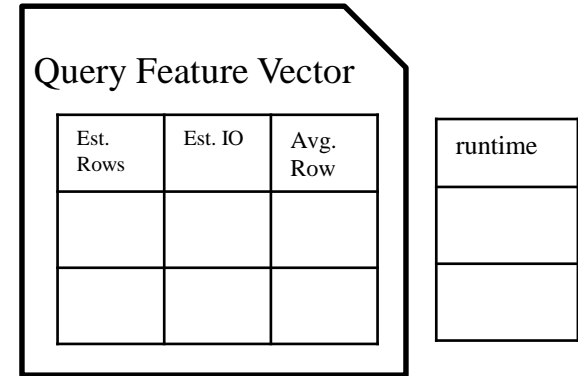
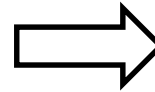
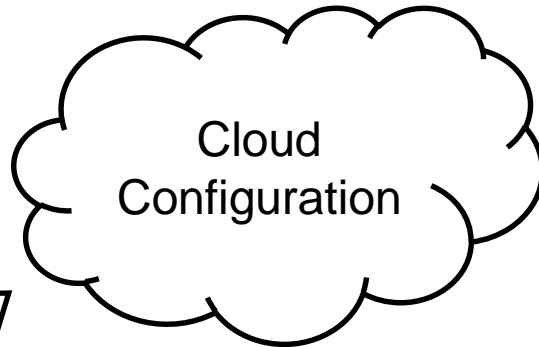


PSLAManager Workflow



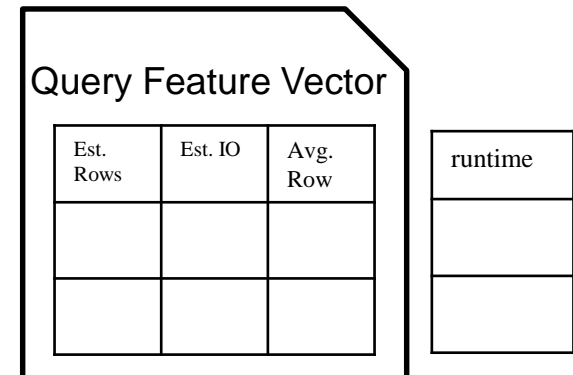
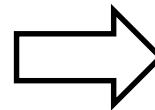
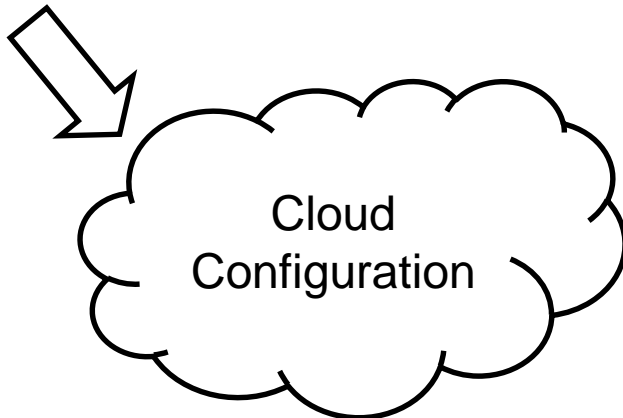
Performance Model (Offline)

**Train model
offline on
other data
and queries**



**Predict runtime from query
features**

Query workload

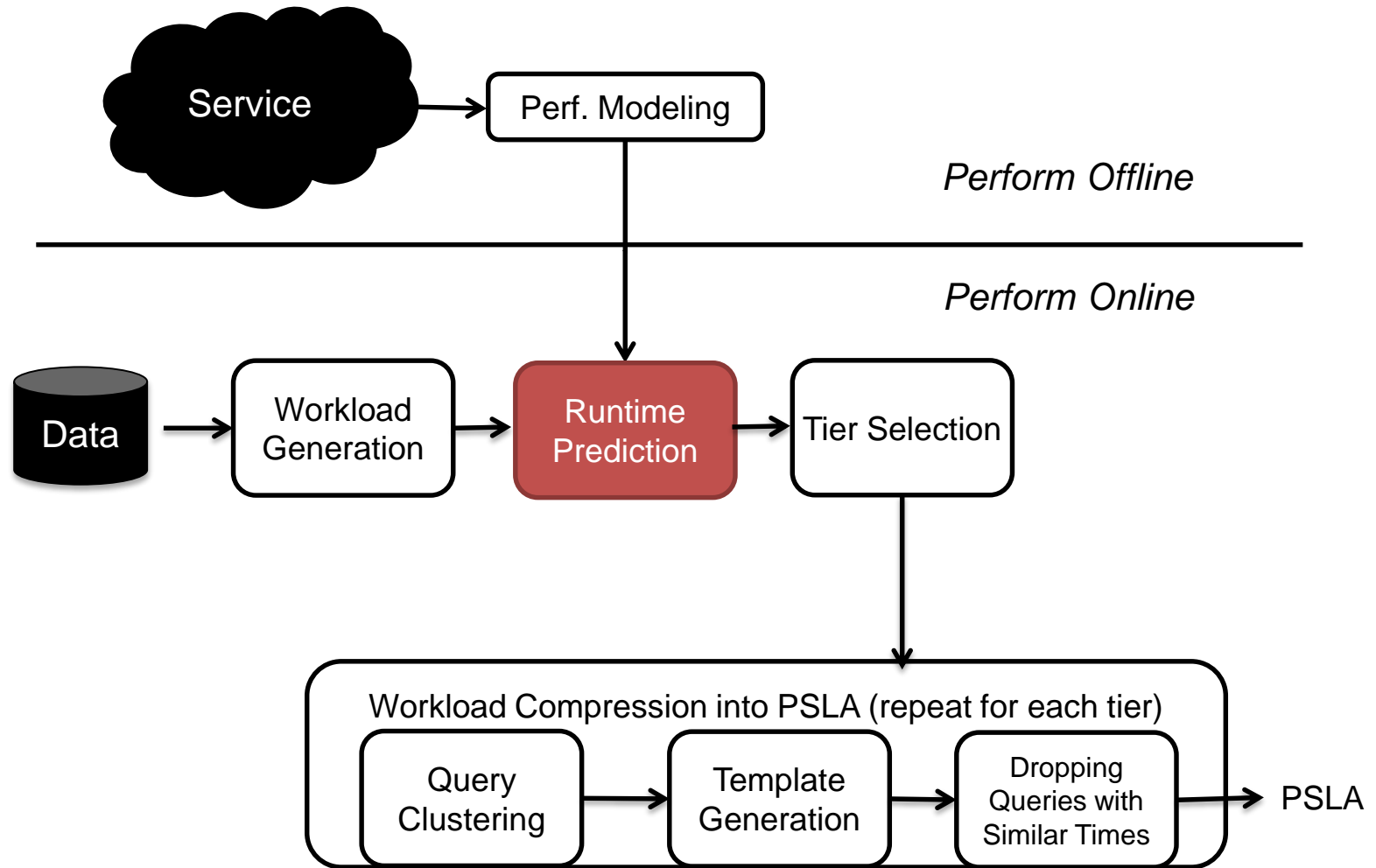


Based on Predicting Multiple Metrics for Queries: Better Decisions enabled by Machine Learning [Ganapathi et. al. 2009]

Training Dataset

- Synthetic Dataset
 - 10GB
 - 6 Tables
 - 61 Attributes

PSLAManager Workflow



Predicted Myria PSLA (Predicted Runtimes)

Tier #1

| Query Template | Runtime (seconds) |
|--|-------------------|
| SELECT (9 ATTR.) FROM (PART) SELECT (9 ATTR.) FROM (CUSTOMER) SELECT (17 ATTR.) FROM (DATE) SELECT (60 ATTR.) FROM (5 TABLES) WHERE 0.1% | 10 |
| SELECT (17 ATTR.) FROM (LINEITEM) SELECT (9 ATTR.) FROM (2 TABLES) SELECT (3 ATTR.) FROM (5 TABLES) SELECT (60 ATTR.) FROM (5 TABLES) WHERE 10% | 60 |
| SELECT (60 ATTR.) FROM (5 TABLES) | 300 |

 Purchase @ \$0.16/hour

Tier #2

| Query Template | Runtime (seconds) |
|---|-------------------|
| SELECT (27 ATTR.) FROM (5 TABLES) WHERE 10% SELECT (60 ATTR.) FROM (5 TABLES) WHERE 1% | 10 |
| SELECT (11 ATTR.) FROM (2 TABLES) SELECT (9 ATTR.) FROM (5 TABLES) | 60 |

 Purchase @ \$0.24/hour

Tier #3

| Query Template | Runtime (seconds) |
|--|-------------------|
|  Purchase @ \$0.32/hour | |

Tier #4

| Query Template | Runtime (seconds) |
|--|-------------------|
| SELECT (1 ATTR.) FROM (4 TABLES) | 10 |
|  Purchase @ \$0.64/hour | |

Looking Forward

- Direct extensions to the approach
 - Add support for indexes
 - Improve time predictions
- Longer-term future work
 - Can we guarantee the runtimes?
 - Can we update the PSLA as user queries data
 - Goal is to show increasingly more complex queries
- Usability testing

Conclusion

- Many cloud DBMSs exist
- Require users to reason about resources
- We propose to re-think that interface
- Personalized Service Level Agreements
 - Service Tiers
 - Price/Capabilities/Performance
- Important direction for cloud DBMSs