
数据技术嘉年华
// Data Technology Carnival
开源 · 融合 · 数智化 — 引领数据技术发展 释放数据要素价值
中国DBA联盟
All China DBA Union
墨天轮

Cost-Intelligent Data Analytics in the Cloud

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清華大學
Tsinghua University

交叉信息研究院
Institute for Interdisciplinary Information Sciences

Why Are Cloud Databases Different?

Traditional

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0110
1001
1010
```

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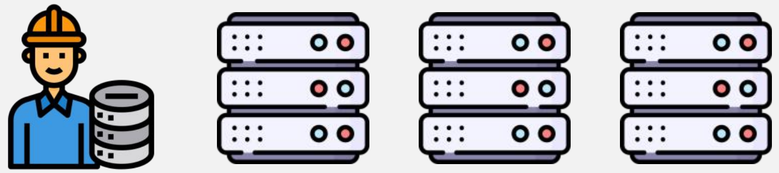

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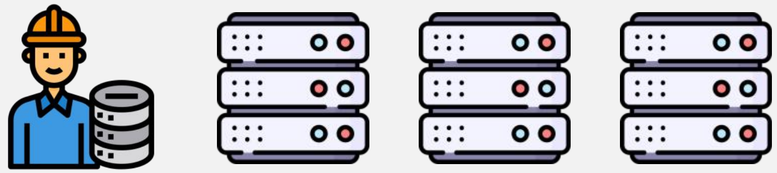

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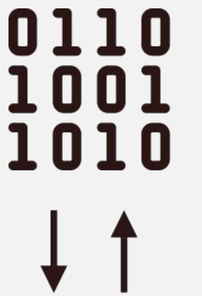

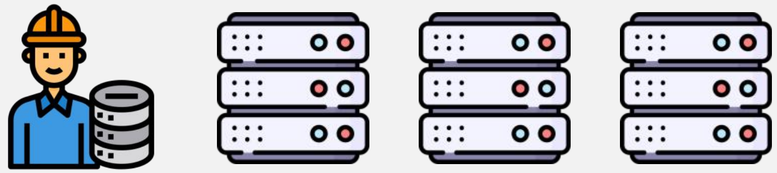

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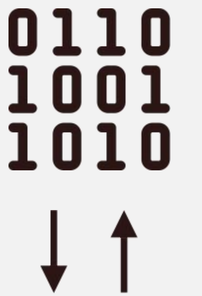

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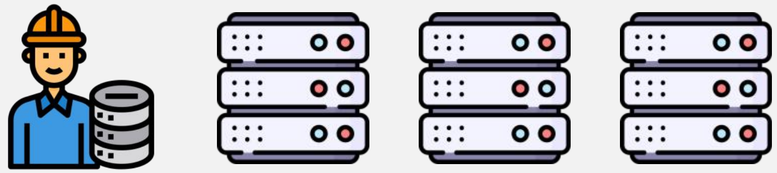

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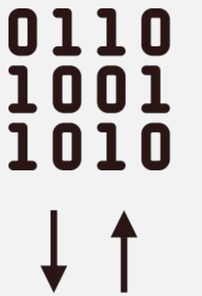

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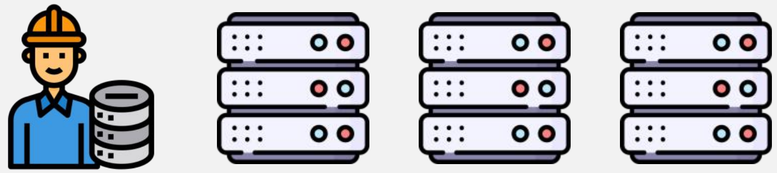
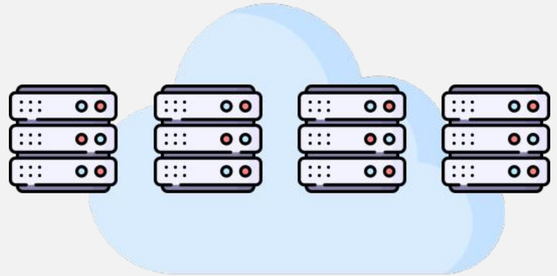


$$$

Cloud-Native

$ pay-as-you-go



• • • Elasticity

Database Optimization in the Cloud Era

User Profit

Π

Database Optimization in the Cloud Era

User Profit **Utility** **$ Cost**

$$\Pi = U(p) - C$$

Database Optimization in the Cloud Era

User Profit **Utility** **$ Cost**

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Fix, Large

Traditional

$$C_{sunk} + C_e$$

Database Optimization in the Cloud Era

User Profit **Utility** **$ Cost**

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Fix, Large

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p t $C_{sunk} + C_e$

Database Optimization in the Cloud Era

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Fix, Large

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$$p \quad t \qquad C_{sunk} + C_e$$

Cloud-Native

$$p \qquad \Delta C$$

← Enabled by **Elasticity**

Database Optimization in the Cloud Era

User Profit **Utility** **$ Cost**

$$\Pi = U(p) - C$$

Fix, Large

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p t $C_{sunk} + C_e$

Cloud-Native

p ΔC ← Enabled by **Elasticity**

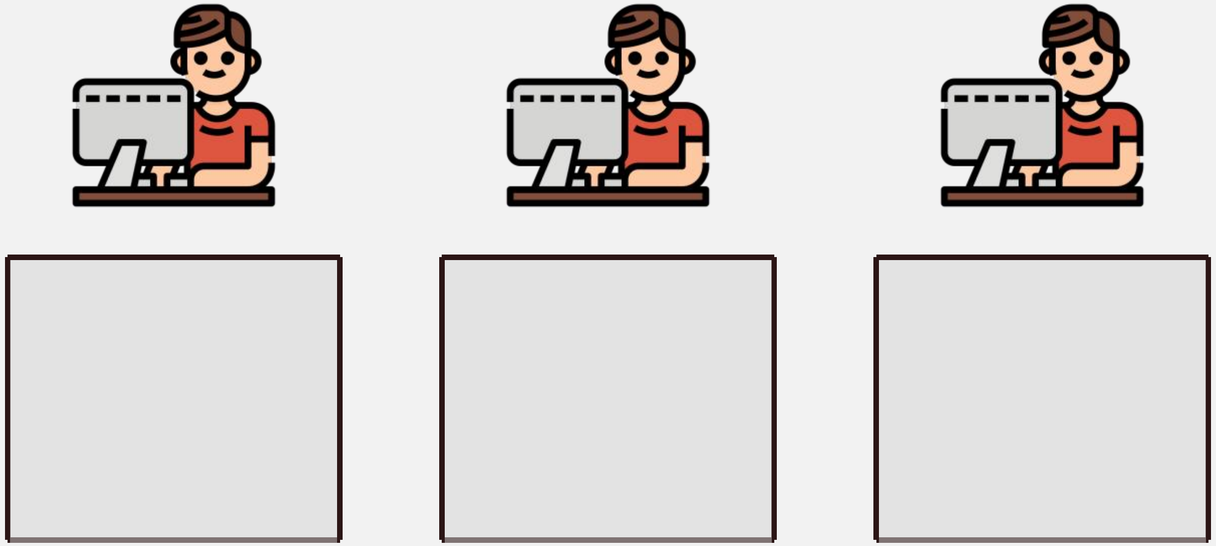
Bi-Objective Optimization

Cost From Different Perspectives



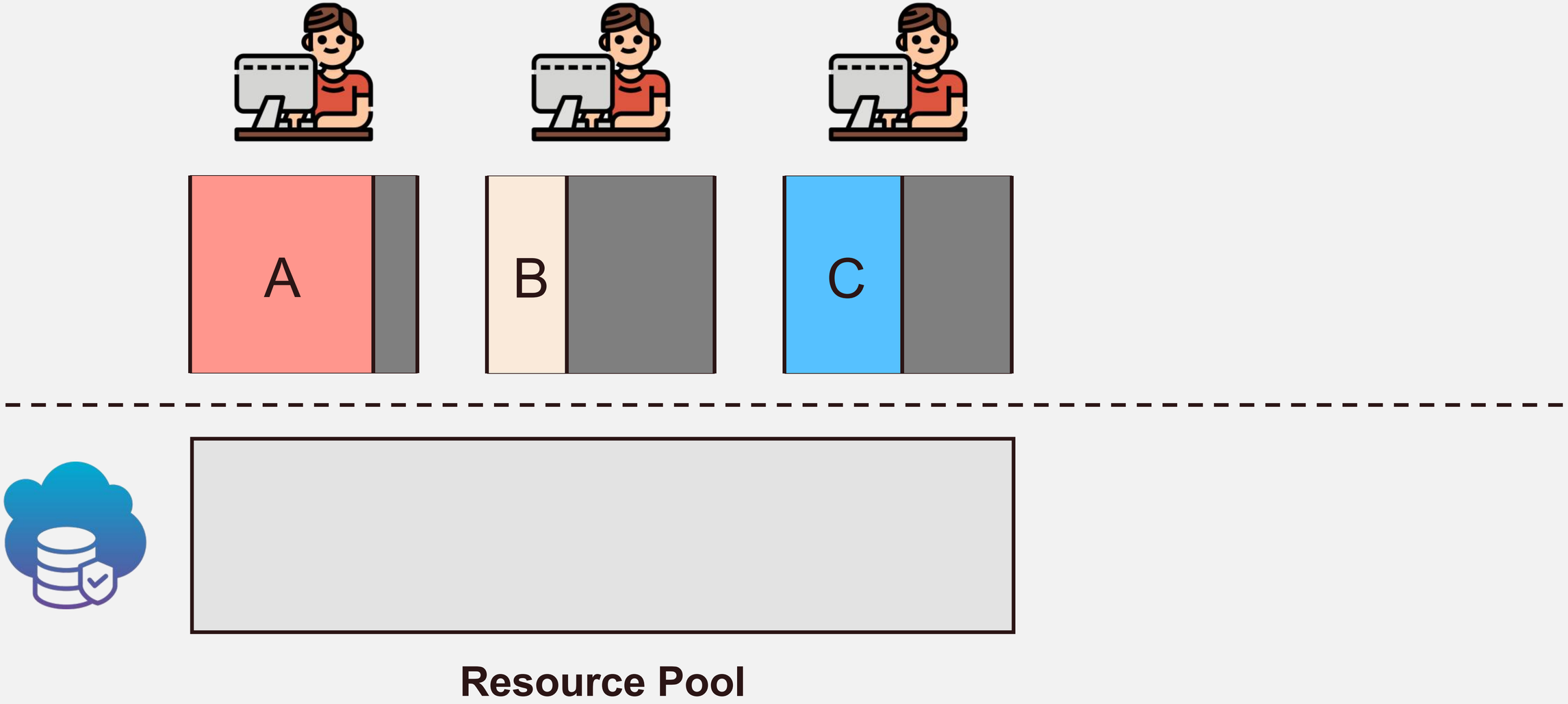
Resource Pool

Cost From Different Perspectives



Resource Pool

Cost From Different Perspectives



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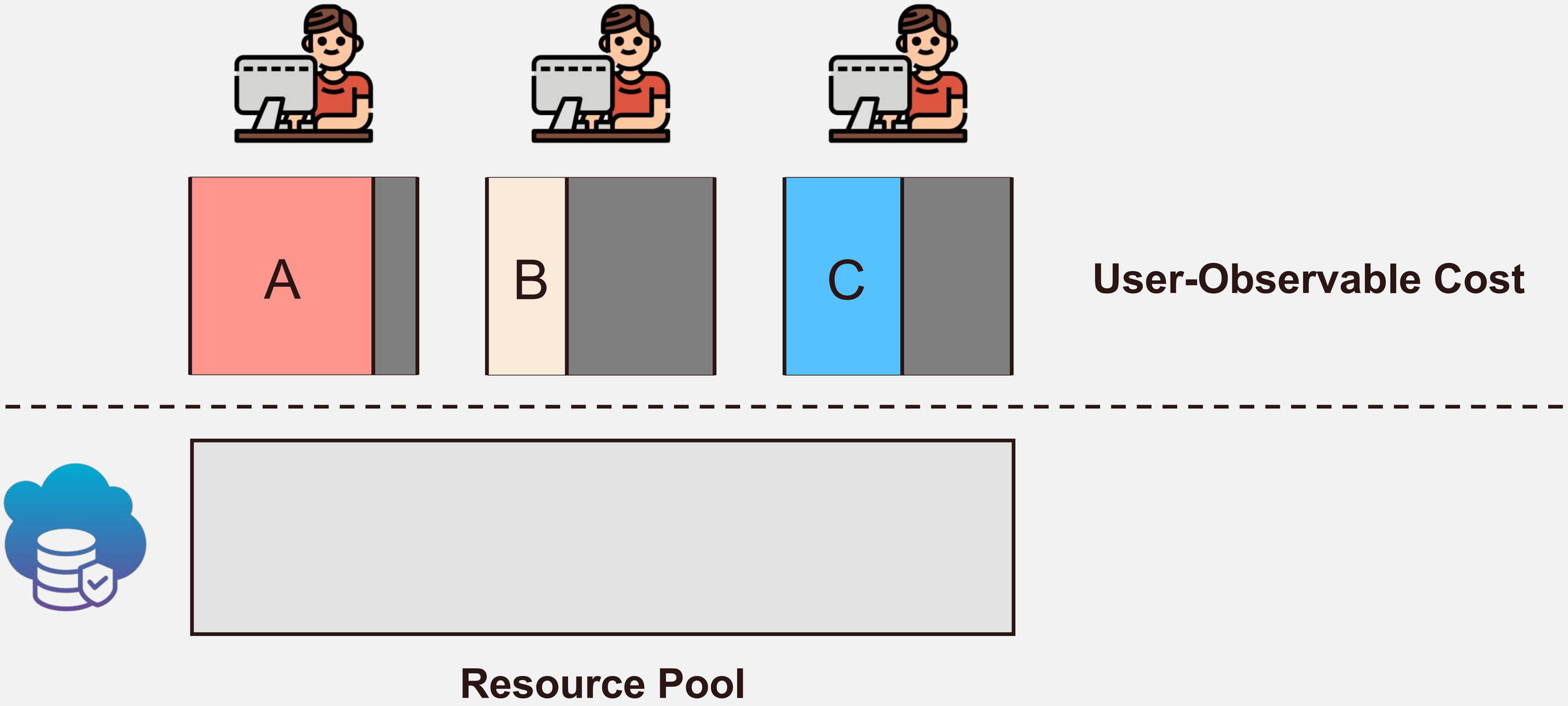

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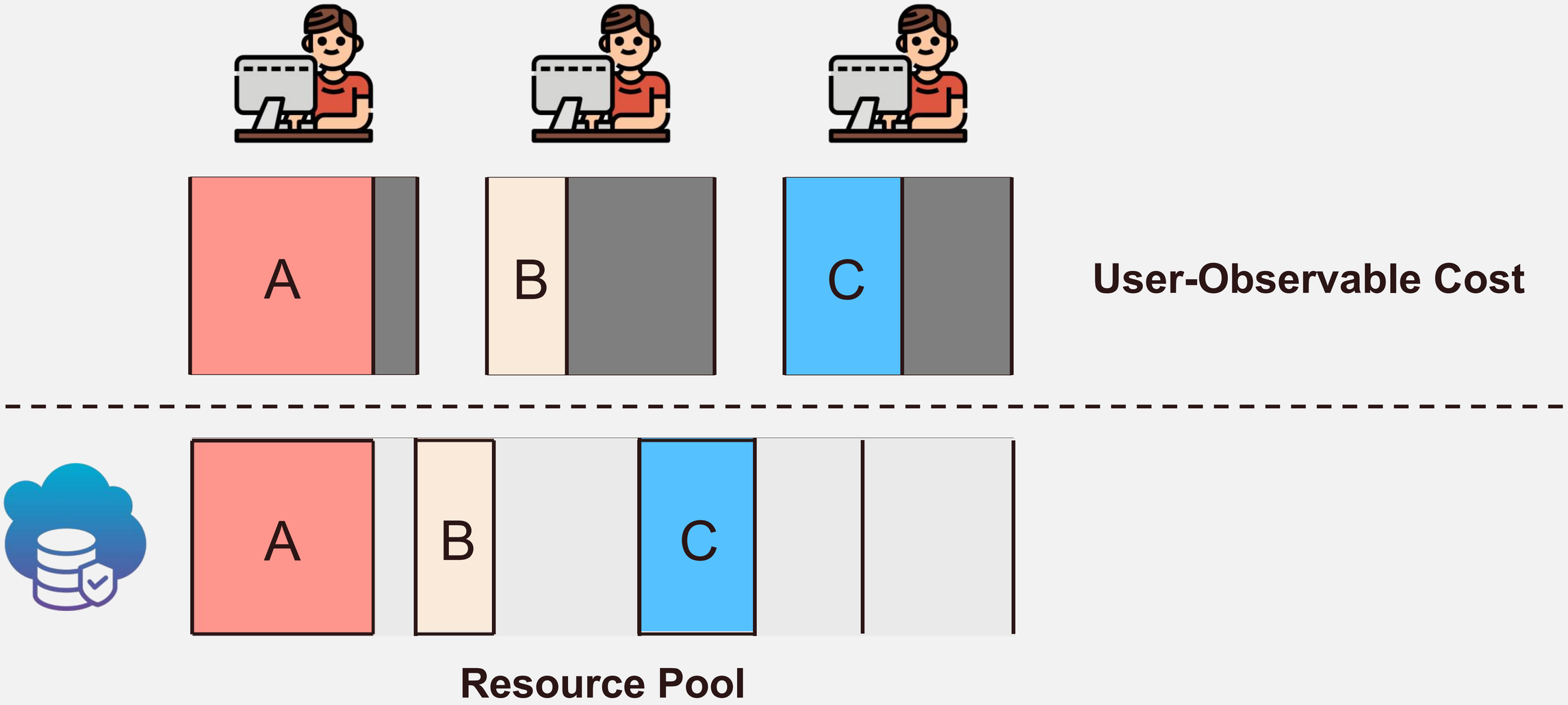

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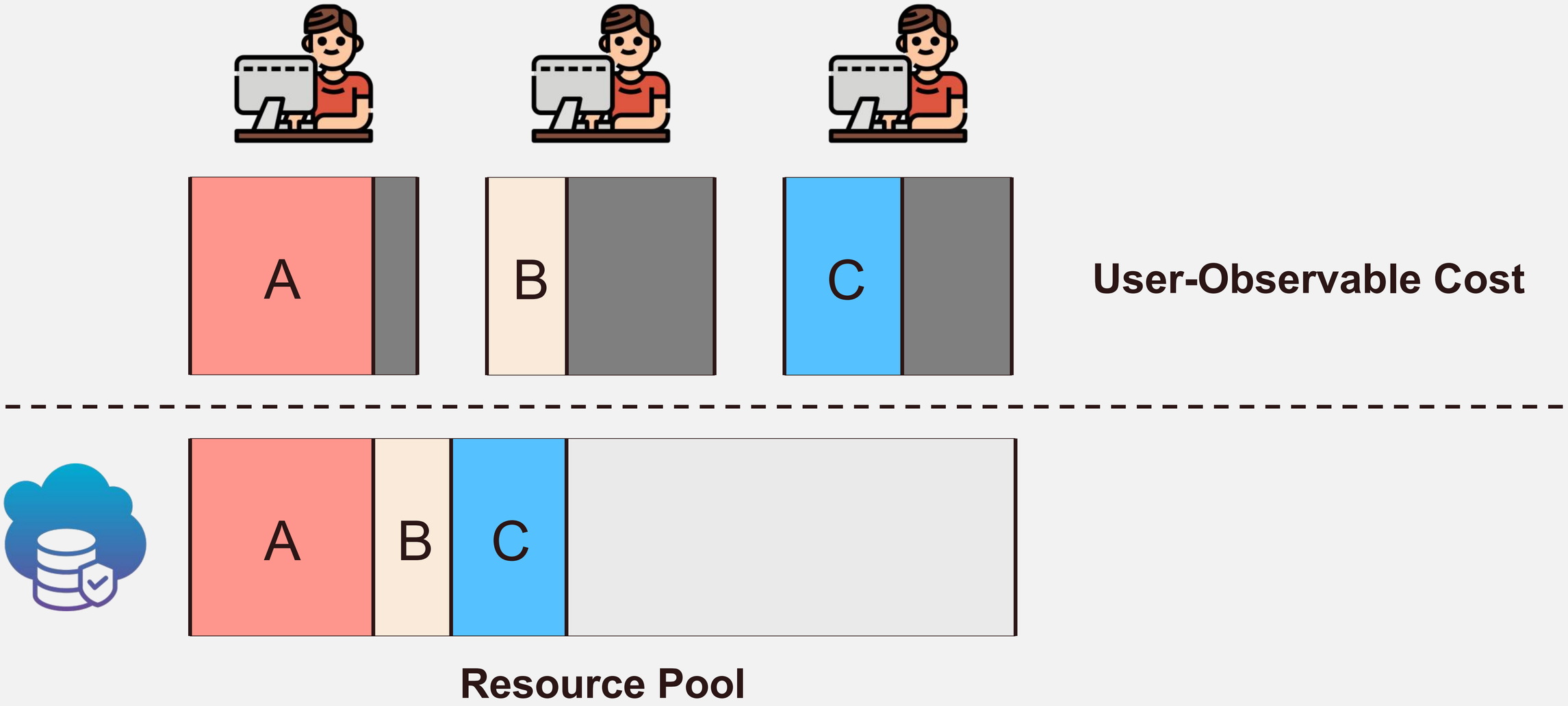

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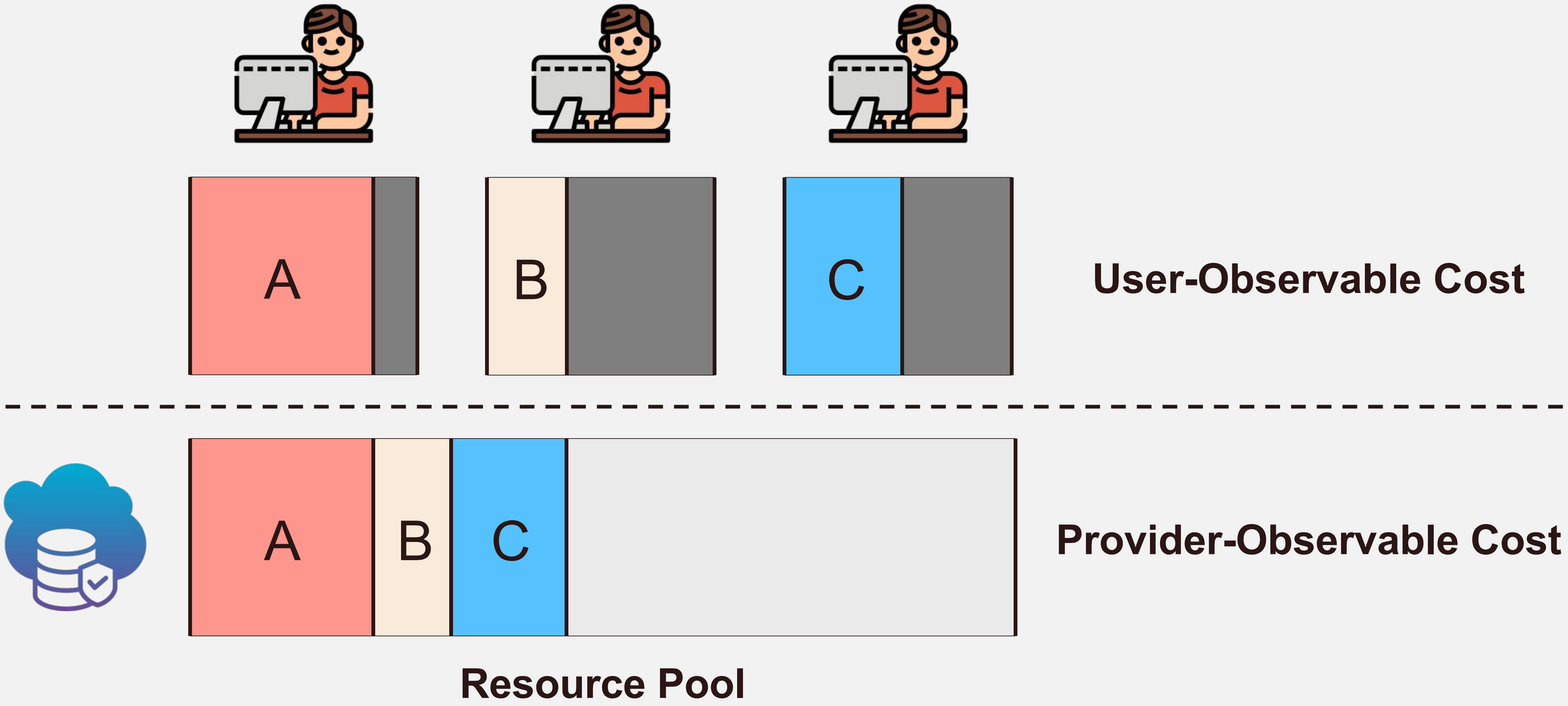

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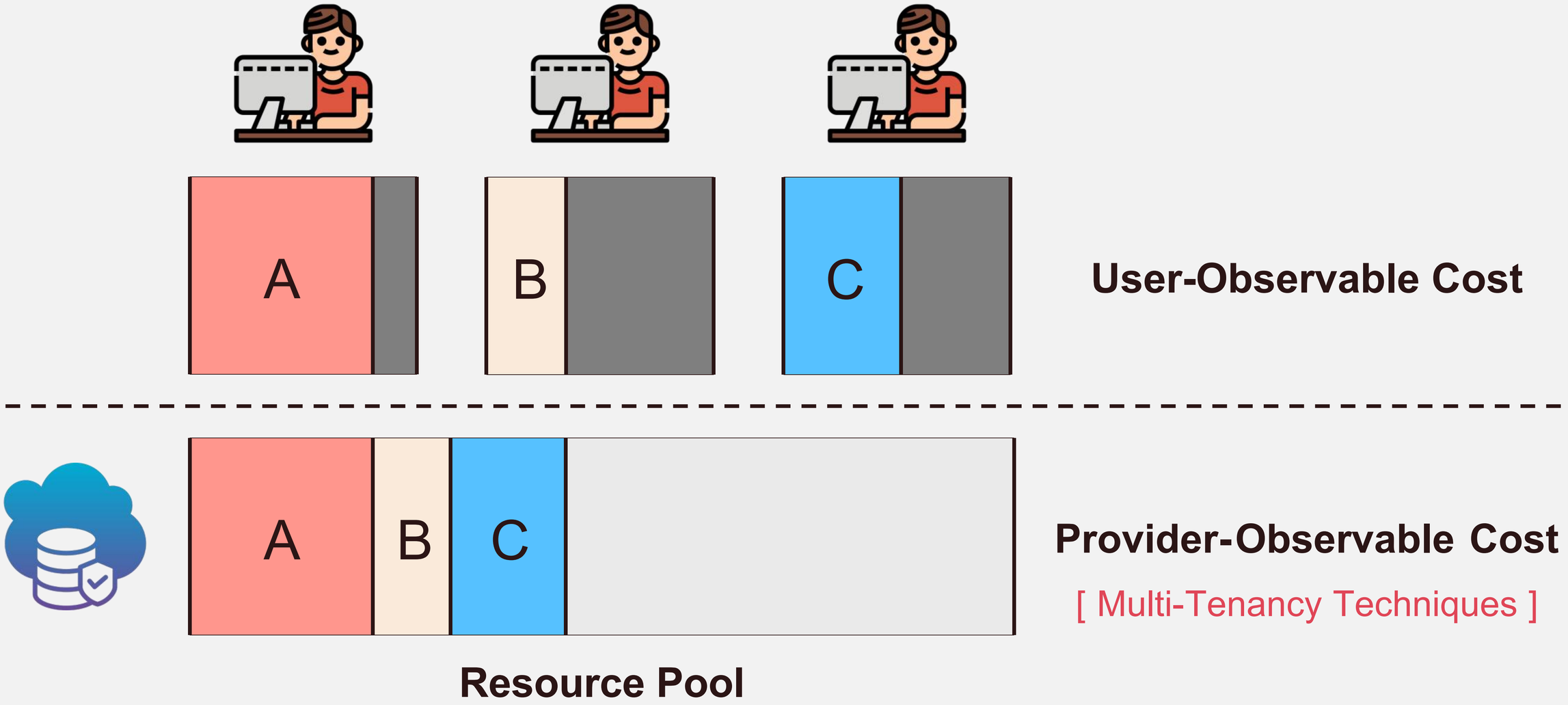

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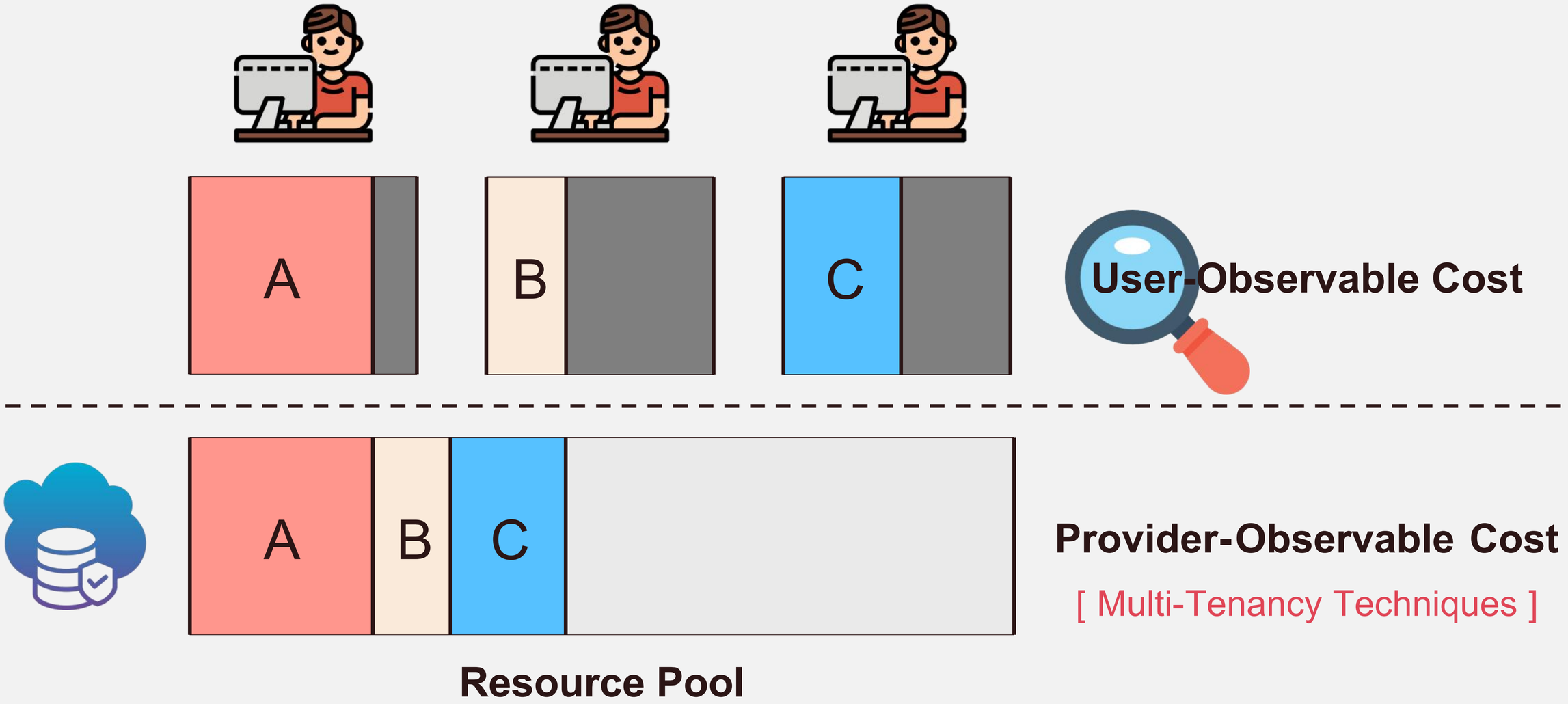


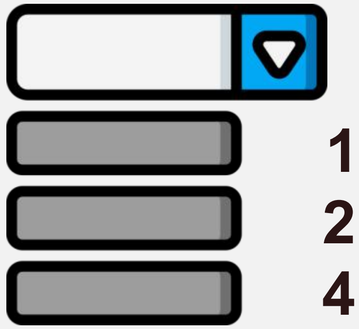
Cost Control Is Still Difficult

Workload

Cost Control Is Still Difficult

Workload

Choose your cluster size

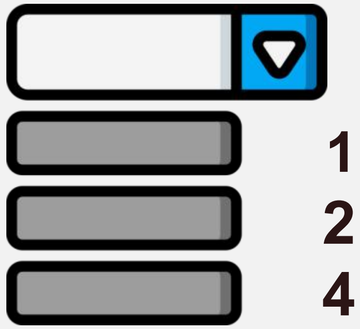


1 server **A**
2 server **A**
4 server **A**
8 server **A**
1 server **B**
2 server **B**
⋮

Cost Control Is Still Difficult

Workload

Choose your cluster size



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→ **Fixed cluster size the entire workload**

Cost Control Is Still Difficult

Workload

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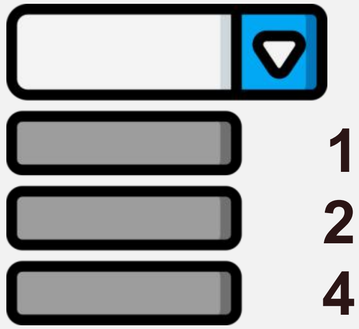

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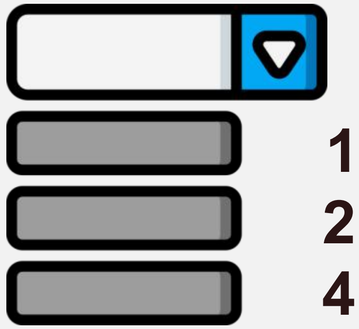
→ **Fixed cluster size the entire workload**

→ **Users tend to over-provision**

Cost Control Is Still Difficult

Workload

Choose your cluster size



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→ **Fixed cluster size the entire workload**

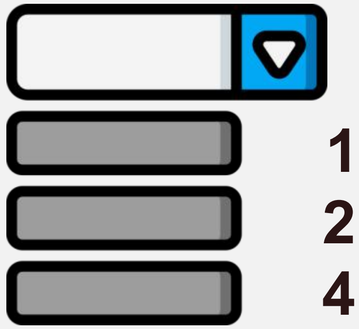
→ **Users tend to over-provision**

Resource Waste!

Cost Control Is Still Difficult

Workload

Choose your cluster size



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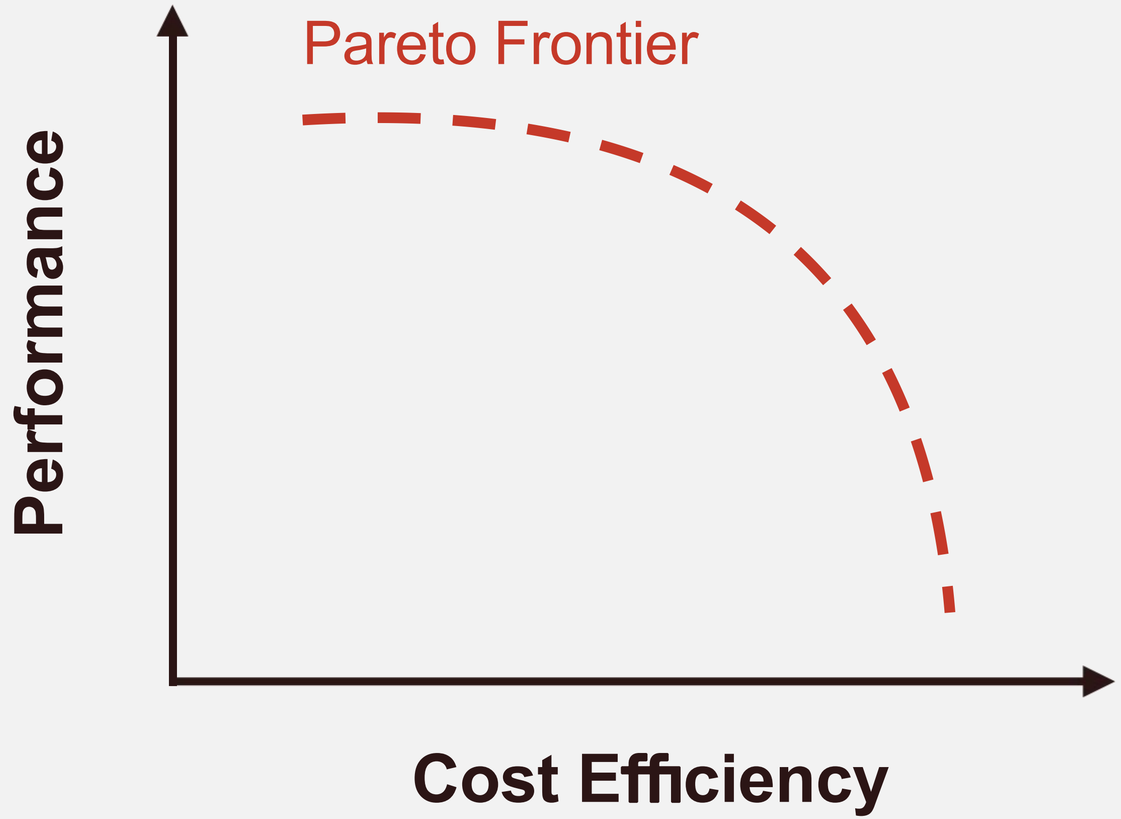
DBA

$$$

- Build Indexes
- Build Materialized Views
- Re-partition Data
- Change Data Format
- Re-train a Learned Module

Cost Intelligence

The system's ability to **self-adapt** to stay at **Pareto-optimal** in the performance-cost trade-of under diferent workloads and user constraints.



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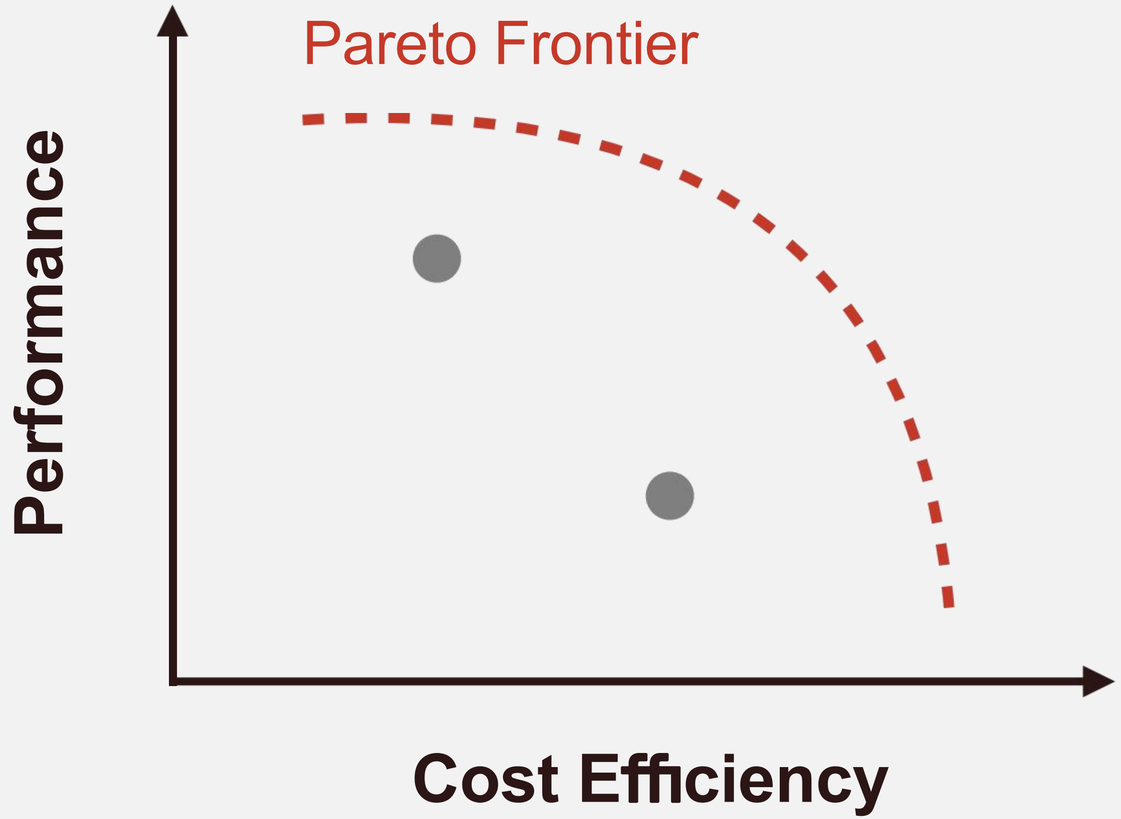

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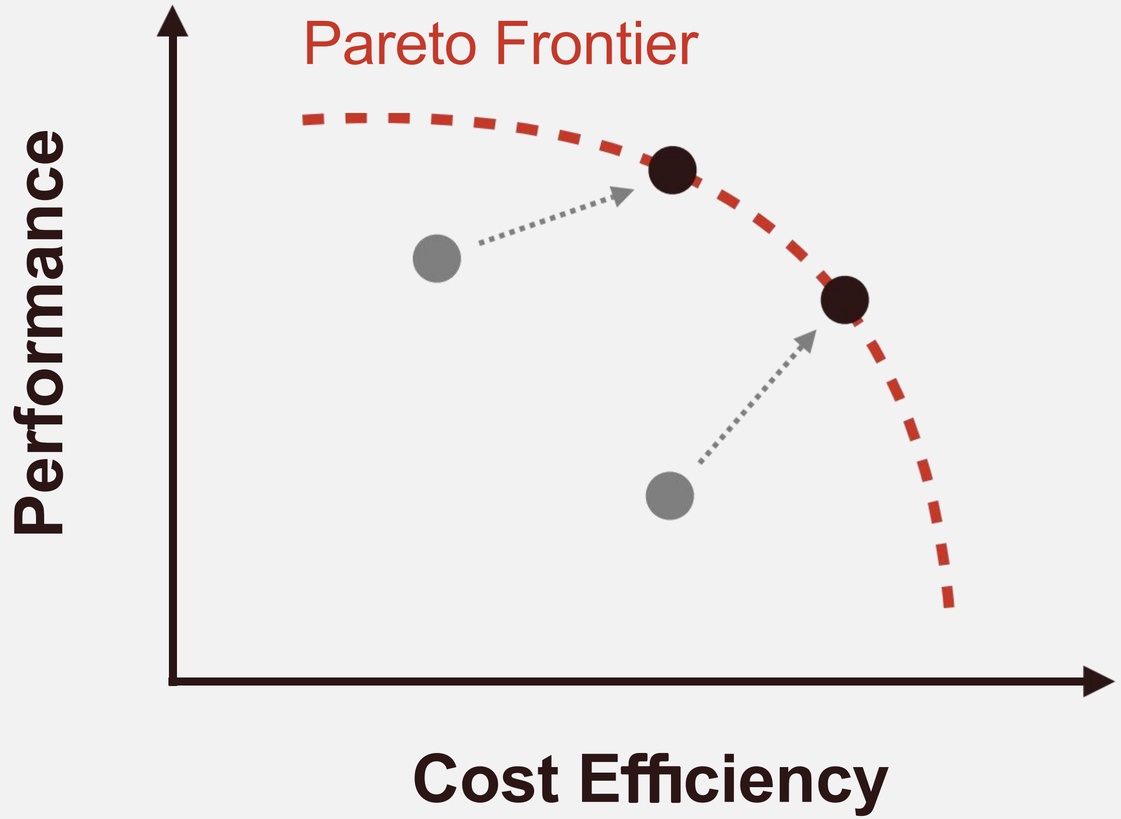
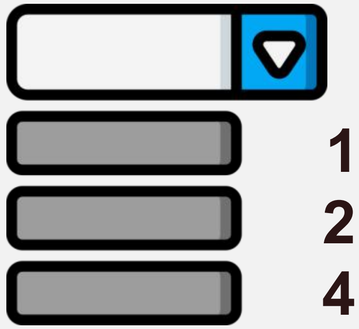


Interface of a Cost-Intelligent System

Workload

Choose your cluster size



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Interface of a Cost-Intelligent System

Workload 

Time: 10s  5min

Cost: $2  $0.1

DBA

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Interface of a Cost-Intelligent System

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Time: 10s  5min

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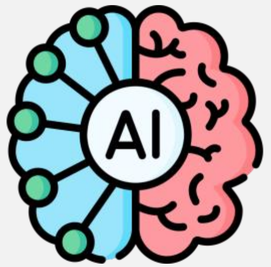

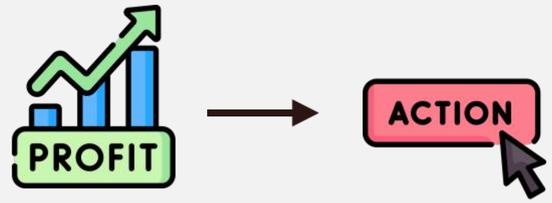

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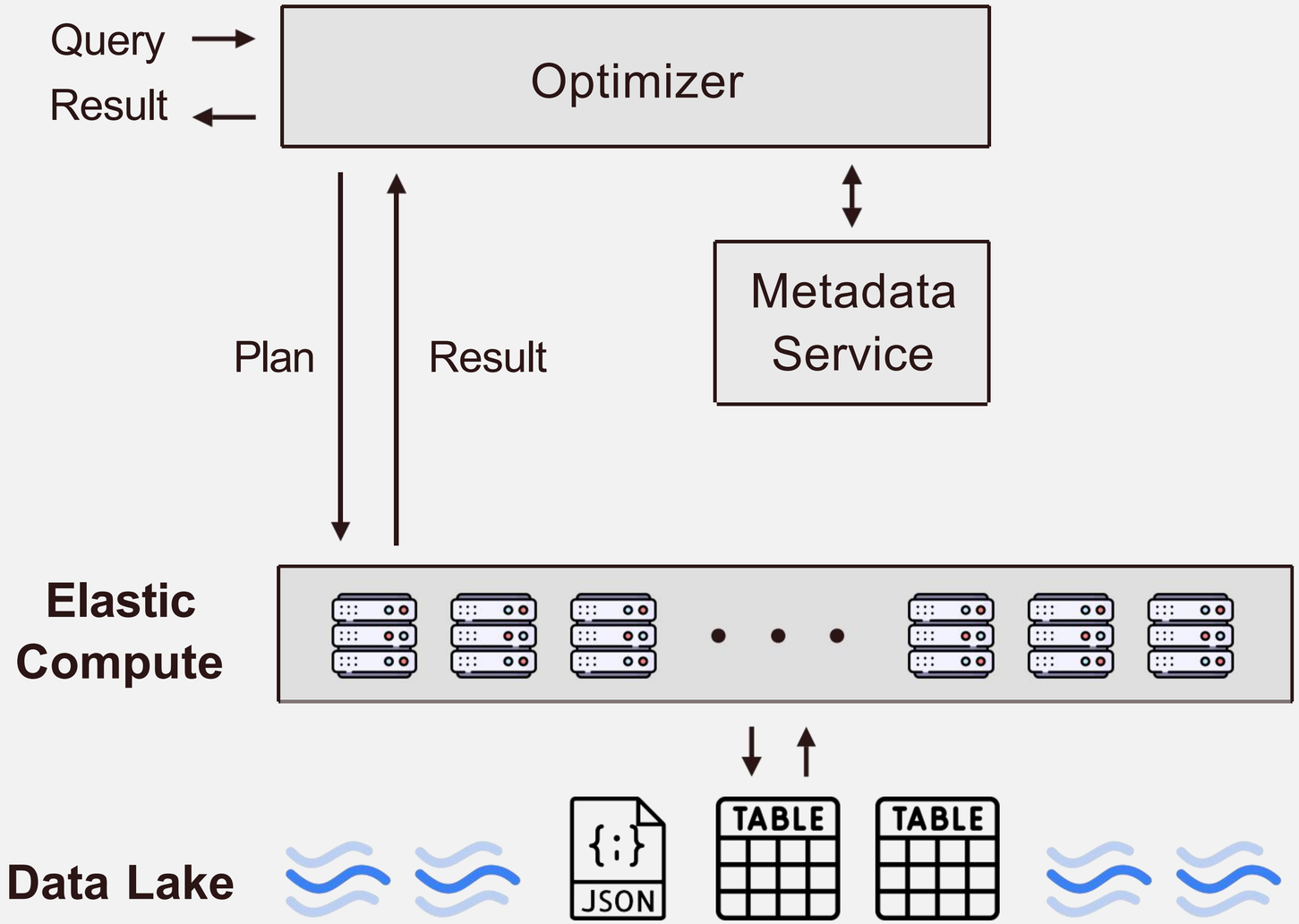
Base System Architecture



Automatic Resource Deployment

Workload

Automatic Resource Deployment

Workload

Config 1

× **100 min**

Config 2

× **1 min**

100 servers

Same $ Cost

Automatic Resource Deployment

Workload

Config 1

× **100 min**

Config 2

× **1 min**

100 servers

Same $ Cost

100x performance boost!

Automatic Resource Deployment

Workload

Config 1

× 100 min

Config 2

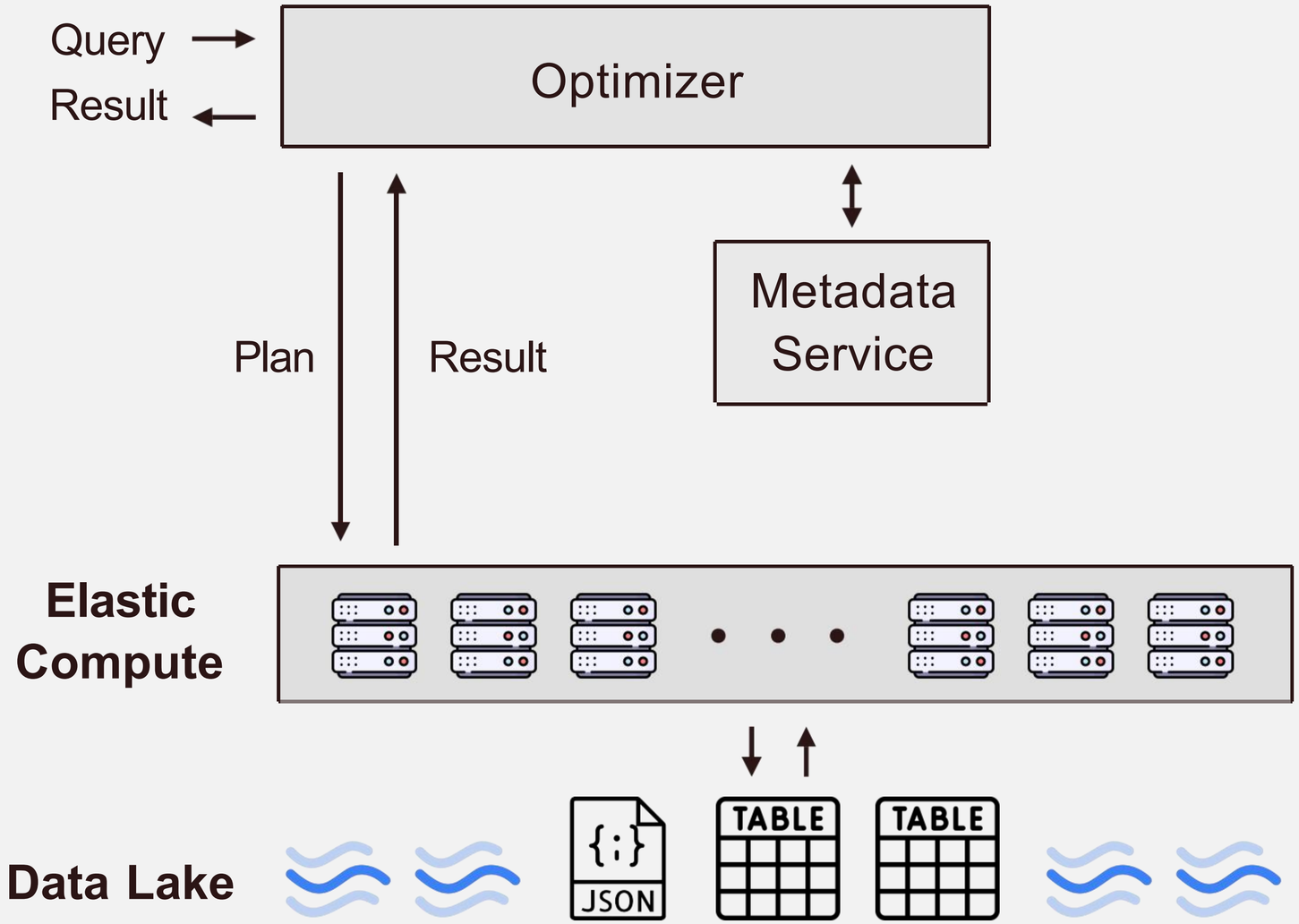
× 100 min

100 servers

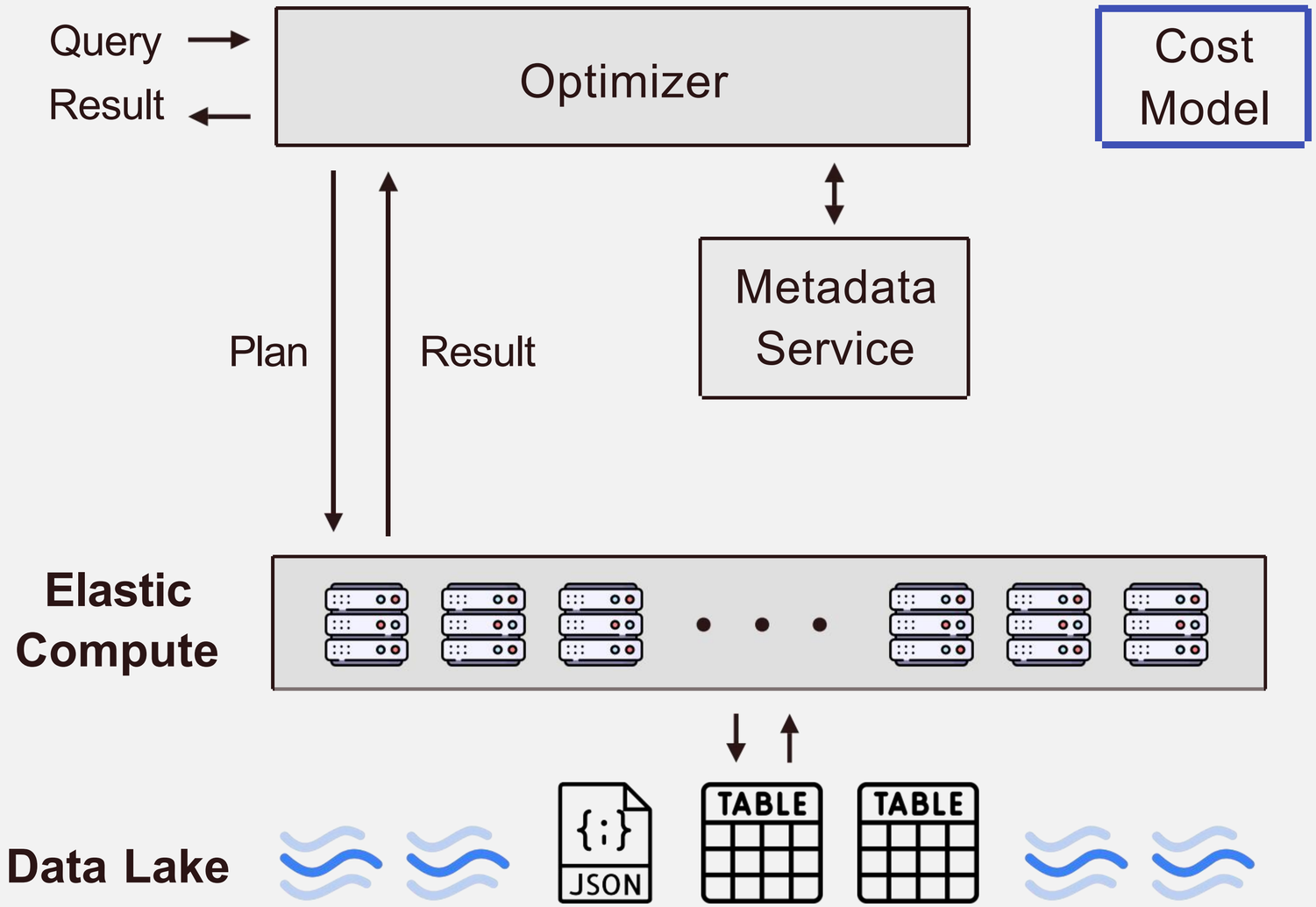
100x $ Cost

Same performance

System Architecture



System Architecture



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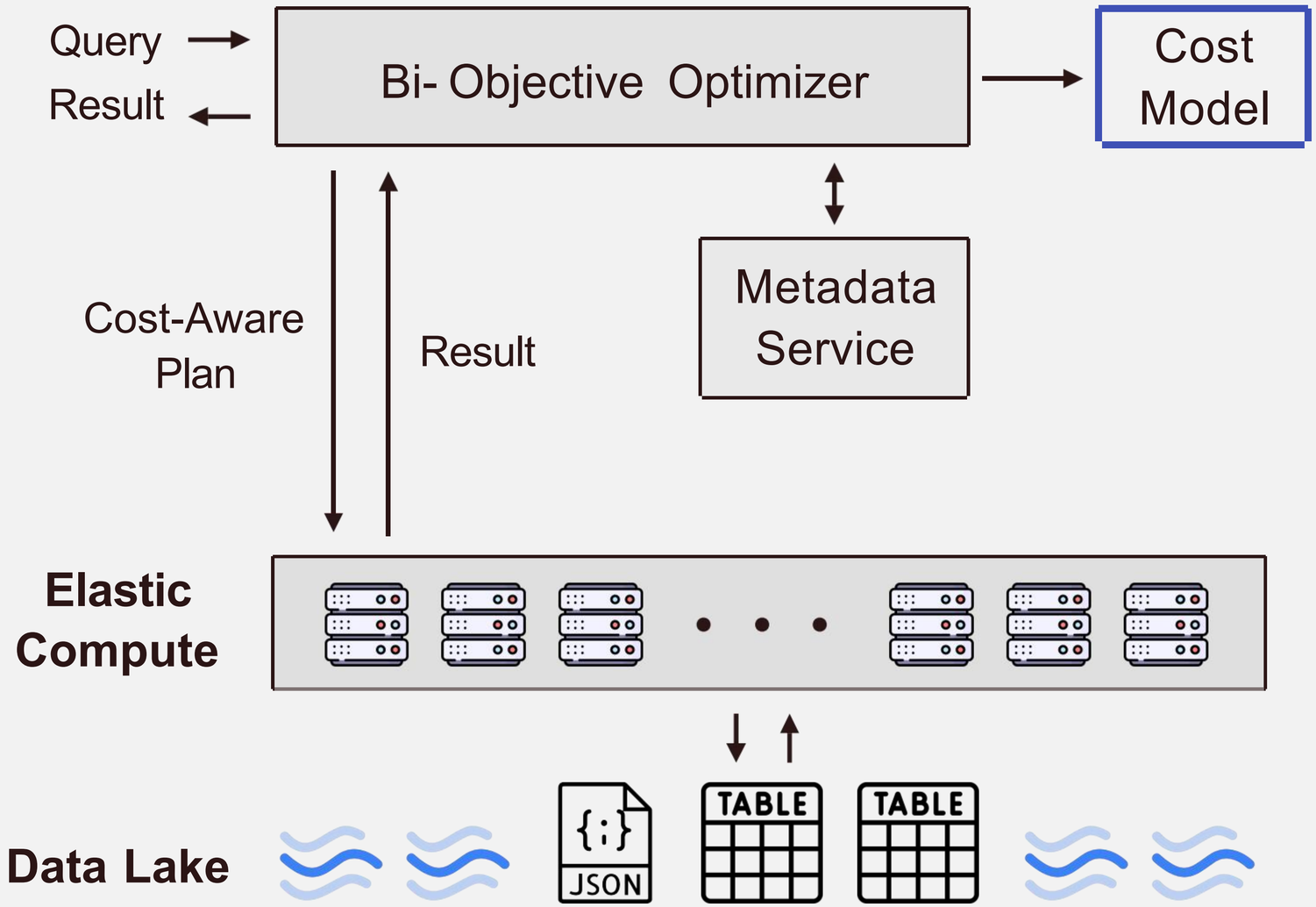

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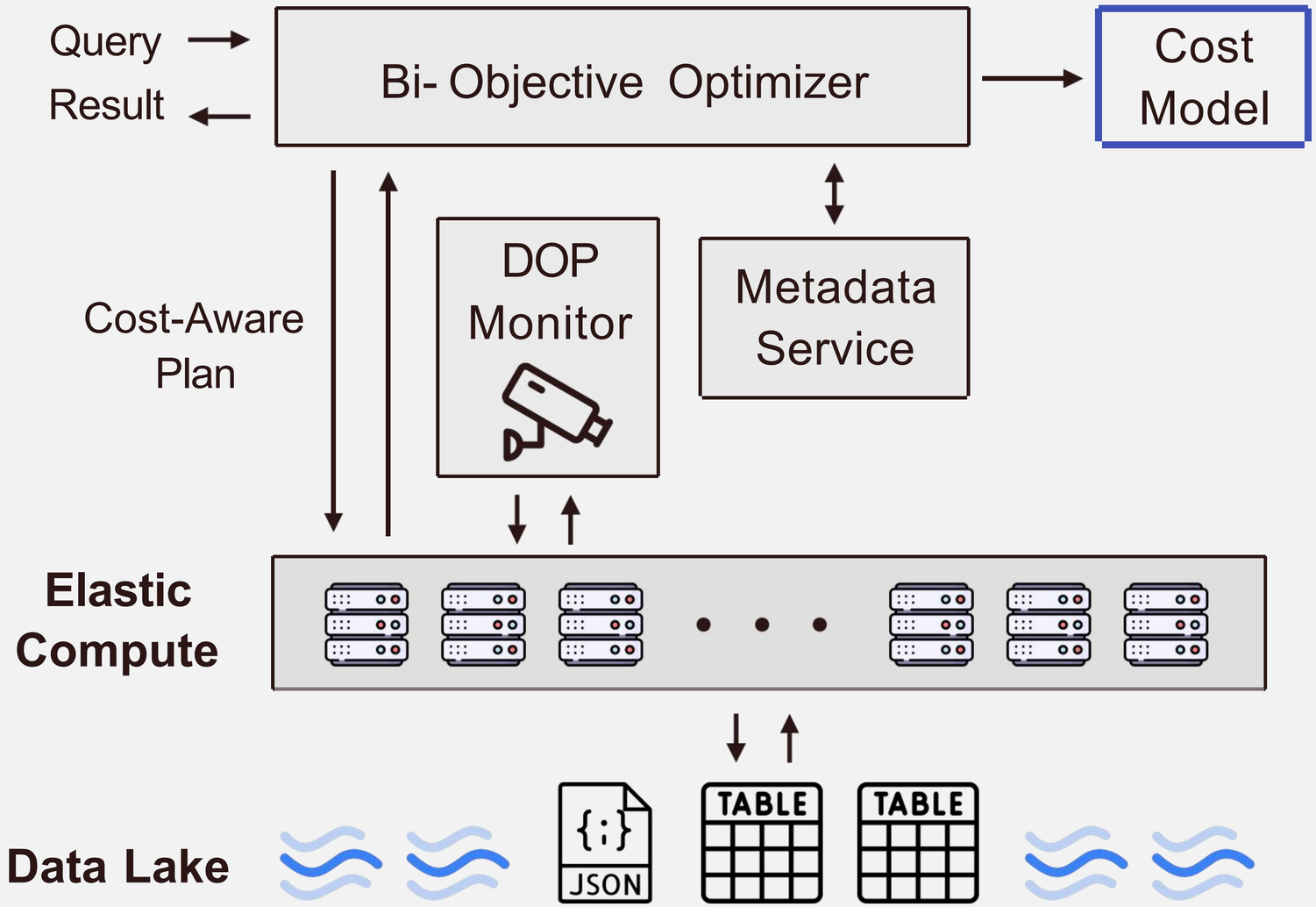
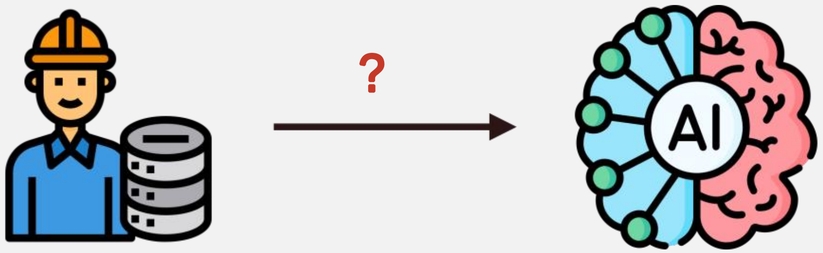


Cost-Oriented Database Auto-Tuning

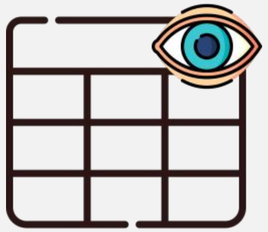
- Build Indexes
- Build Materialized Views
- Re-partition Data
- Change Data Format
- Re-train a Learned Module

DBA



Cost-Oriented Database Auto-Tuning

Under Fix Resources

+ 

Cost-Oriented Database Auto-Tuning

Under Fix Resources

- Speeds up a subset of queries
- MV update slows down writes
- MV takes extra space

Cost-Oriented Database Auto-Tuning

Under Fix Resources

Read Perf:

Write Perf:

- ➔ Speeds up a subset of queries
- ➔ MV update slows down writes
- ➔ MV takes extra space

Cost-Oriented Database Auto-Tuning

Under Fix Resources

Read Perf: +

Write Perf:

- → Speeds up a subset of queries
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Cost-Oriented Database Auto-Tuning

Under Fix Resources

Read Perf: +

Write Perf: −

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Cost-Oriented Database Auto-Tuning

Under Fix Resources

Read Perf: + − −

Write Perf: − −

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Cost-Oriented Database Auto-Tuning

Under Fix Resources

- Speeds up a subset of queries
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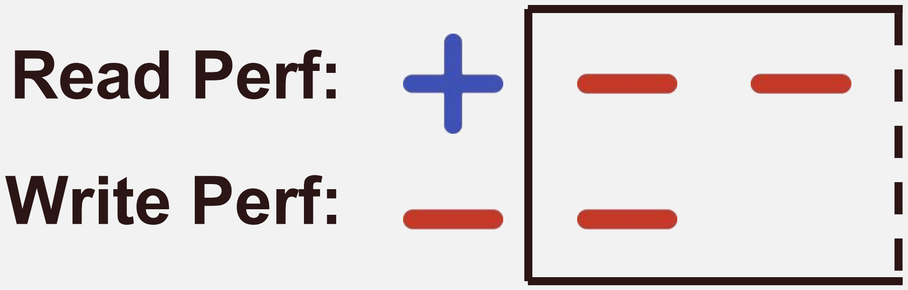
Resource Contention



Cost-Oriented Database Auto-Tuning

With Elastic Resources

- ➔ Speeds up a subset of queries
- ➔ MV update slows down writes
- ➔ MV takes extra space

Read Perf:

Write Perf:

Read Cost:

Write Cost:

Storage Cost:

Cost-Oriented Database Auto-Tuning

With Elastic Resources

- → Speeds up a subset of queries
- → MV update slows down writes
- → MV takes extra space

Read Perf: +

Write Perf:

Read Cost: ↓ *X*

Write Cost:

Storage Cost:

Cost-Oriented Database Auto-Tuning

With Elastic Resources

- → Speeds up a subset of queries
- → MV update slows down writes
- → MV takes extra space

Read Perf: +

Write Perf: Same

Read Cost: ↓ x

Write Cost: y ↑

Storage Cost:

Cost-Oriented Database Auto-Tuning

With Elastic Resources

- → Speeds up a subset of queries
- → MV update slows down writes
- → MV takes extra space

Read Perf: +

Write Perf: Same

Read Cost: ↓ *x*

Write Cost: ↑ *y*

Storage Cost: ↑ *z*

Cost-Oriented Database Auto-Tuning

With Elastic Resources

- Speeds up a subset of queries
- MV update slows down writes
- MV takes extra space

Read Perf: +

Write Perf: Same

Read Cost: ↓ x

Write Cost: y ↑

Storage Cost: ↑ z

$x - y - z > 0$ ✓

Cost-Oriented Database Auto-Tuning

With Elastic Resources

- Speeds up a subset of queries
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Read Perf: +

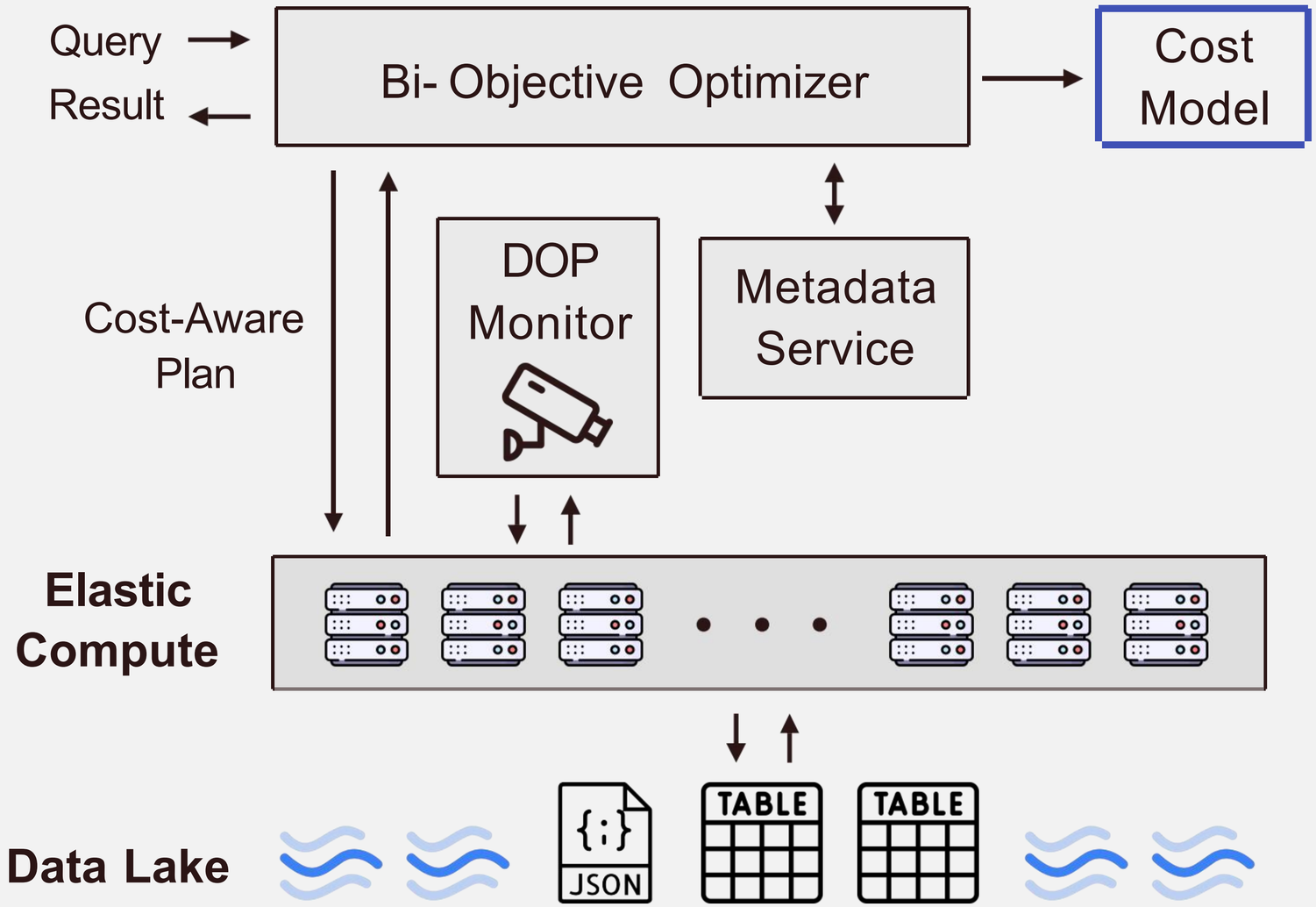
Write Perf: Same

Key Challenges:

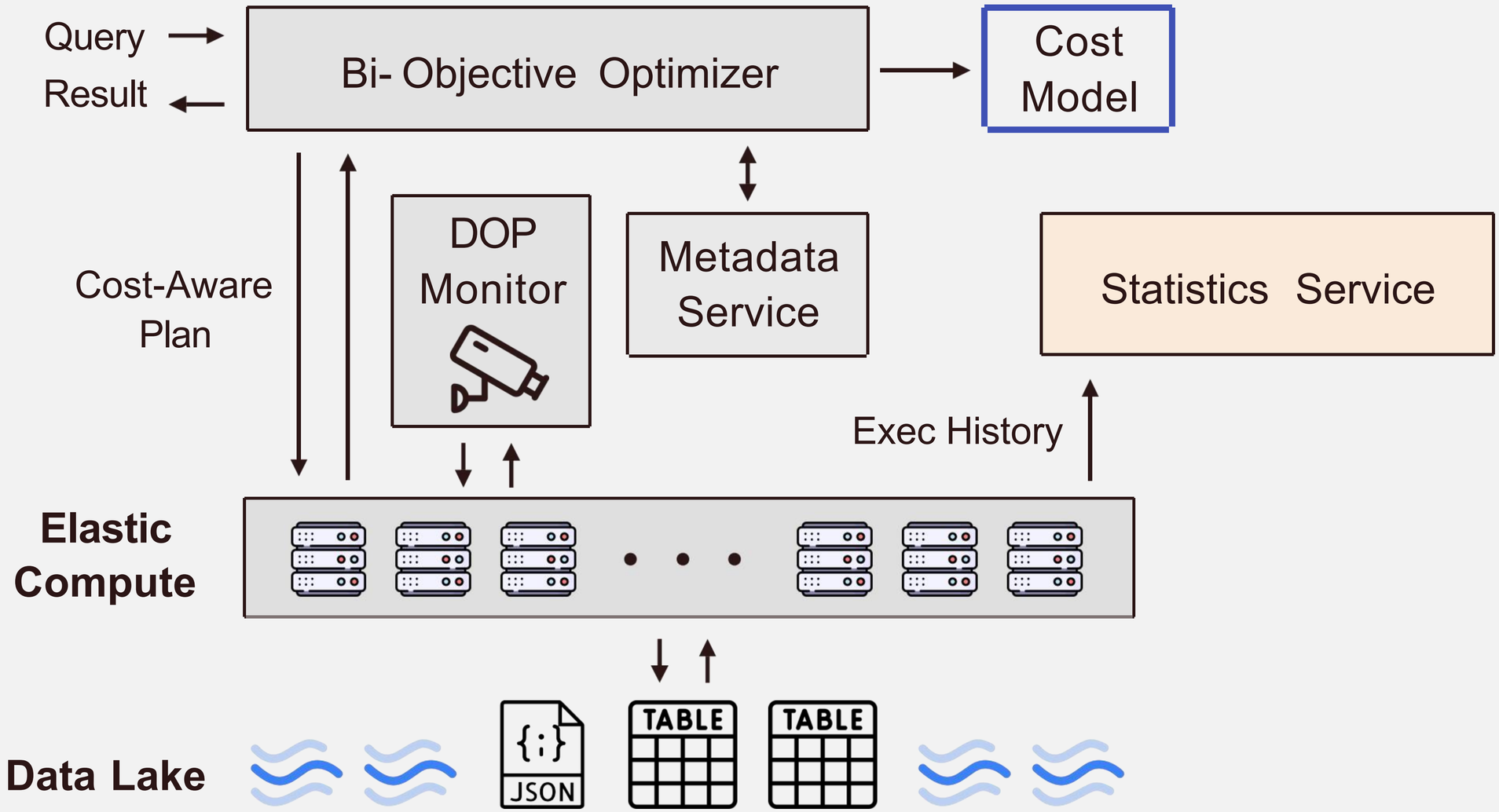
Accurate Cost Estimation

Accurate Workload Estimation

System Architecture



System Architecture



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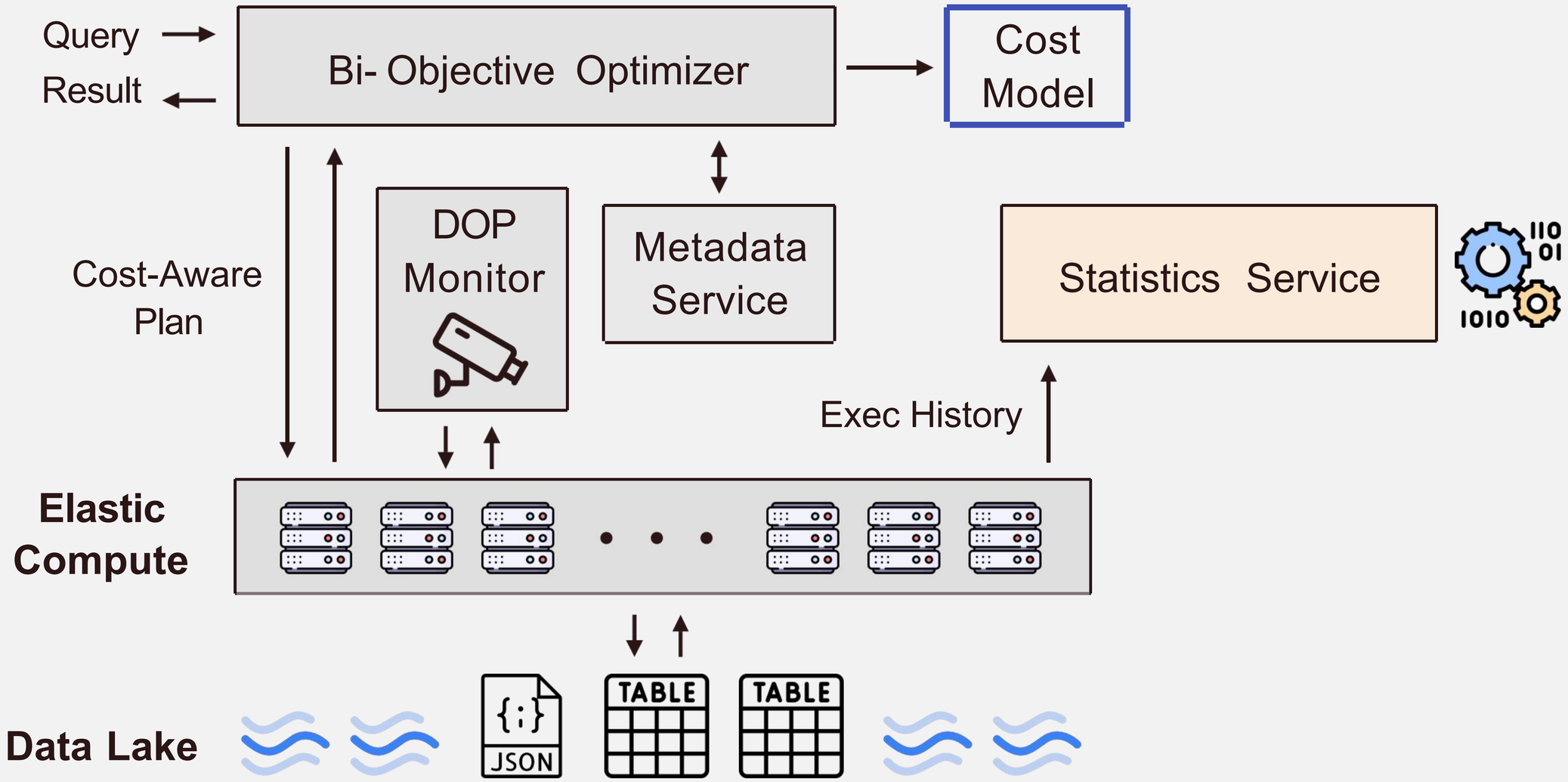

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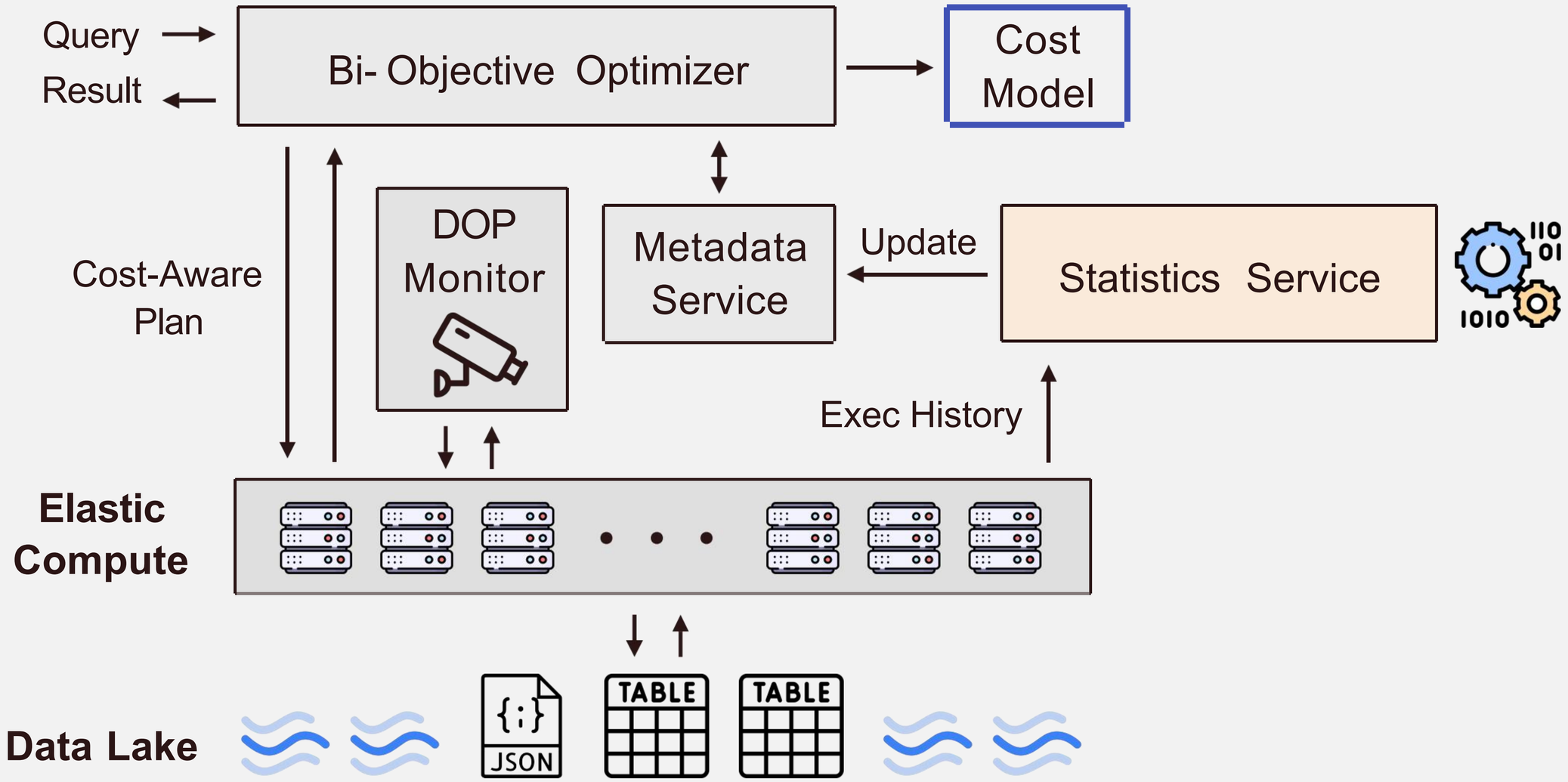

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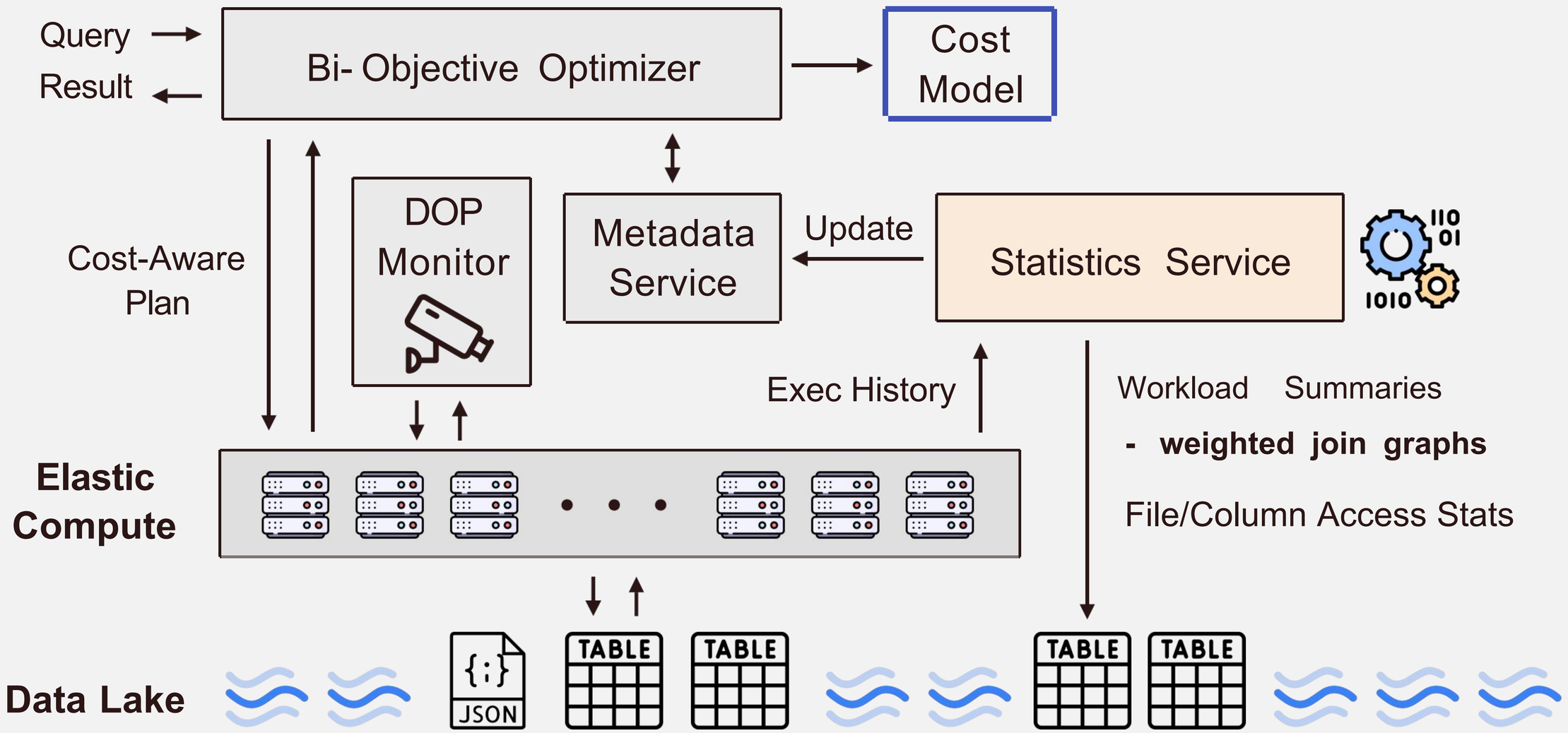

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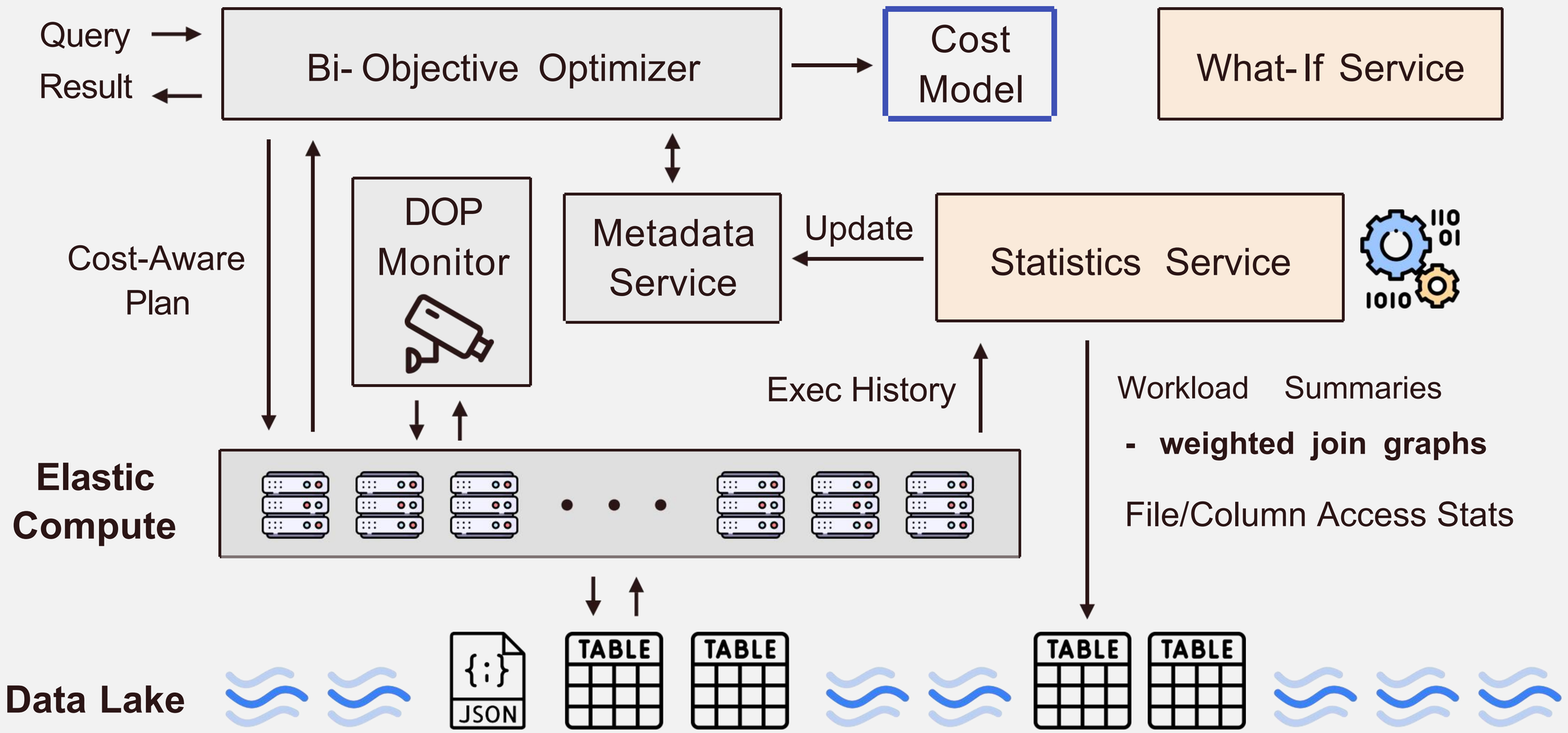
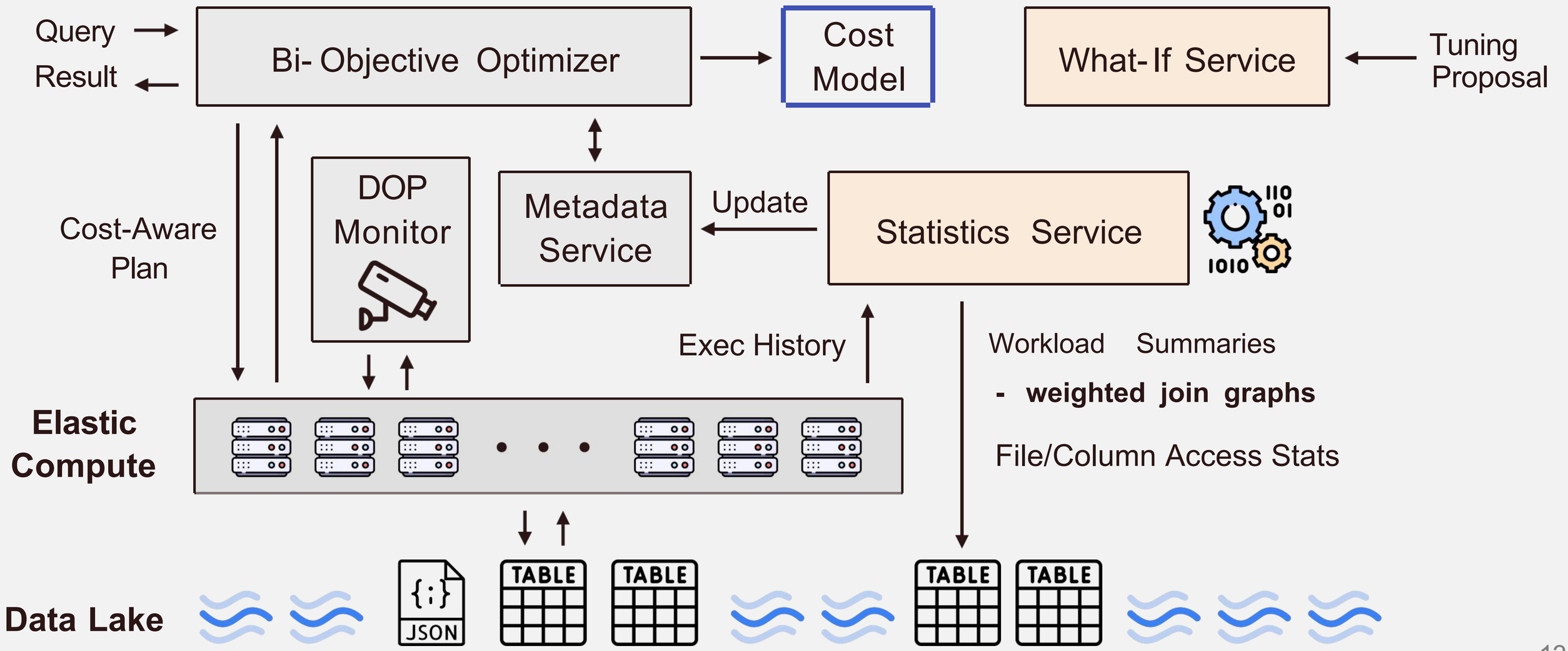
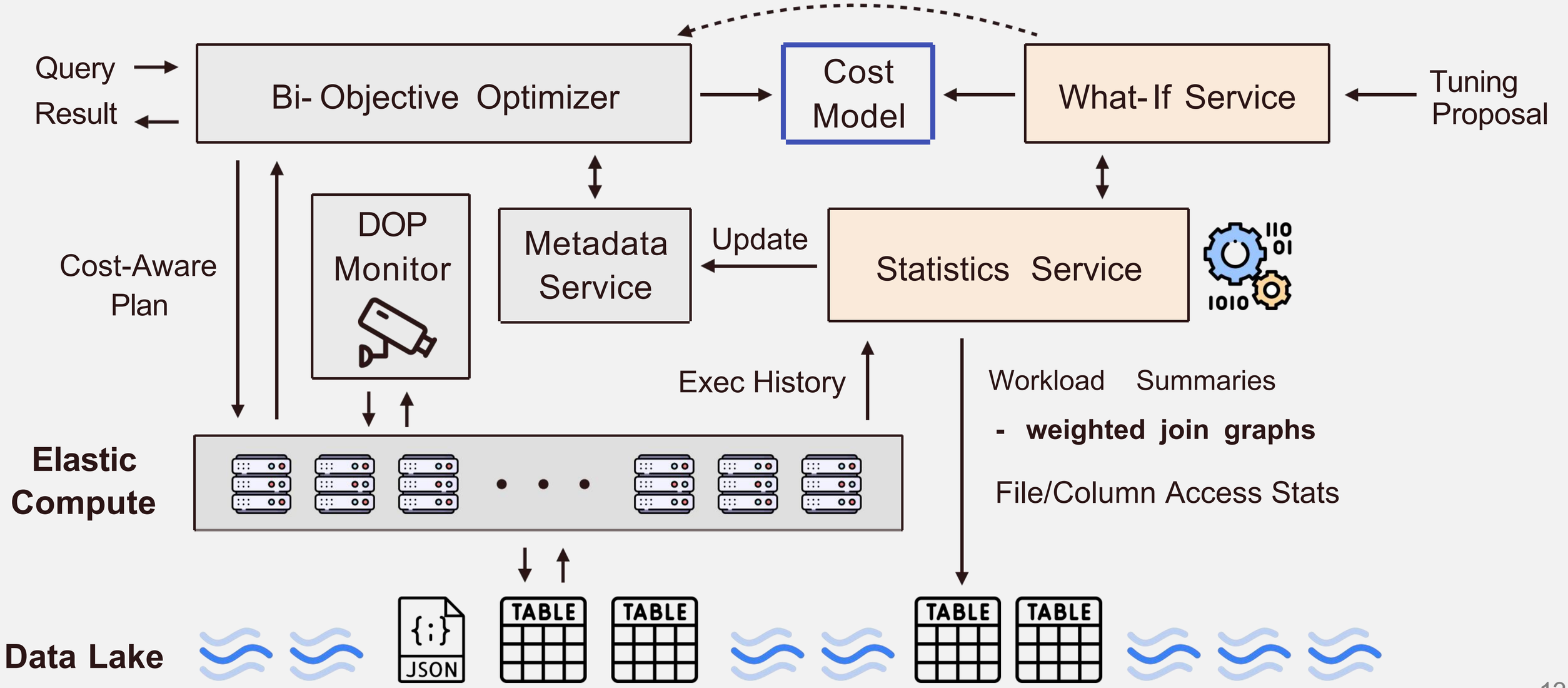


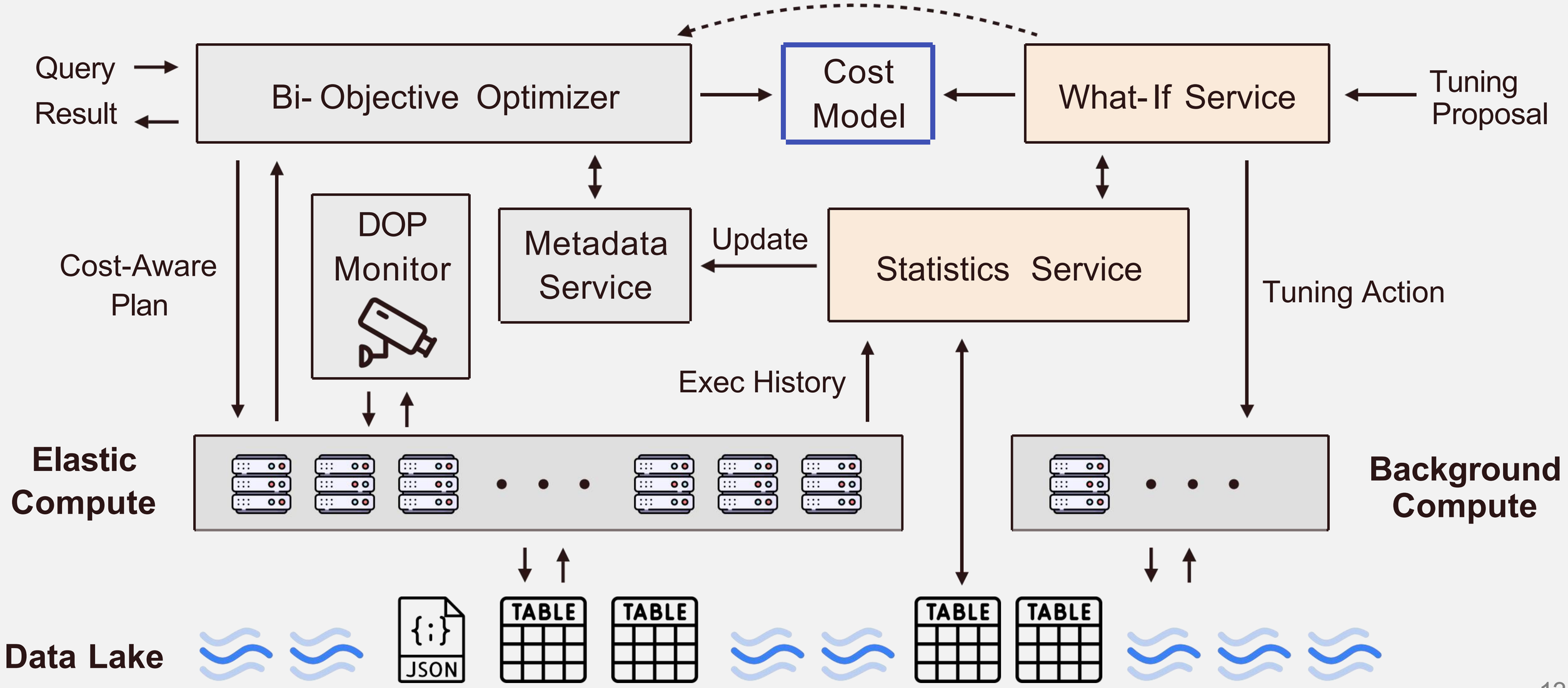
System Architecture



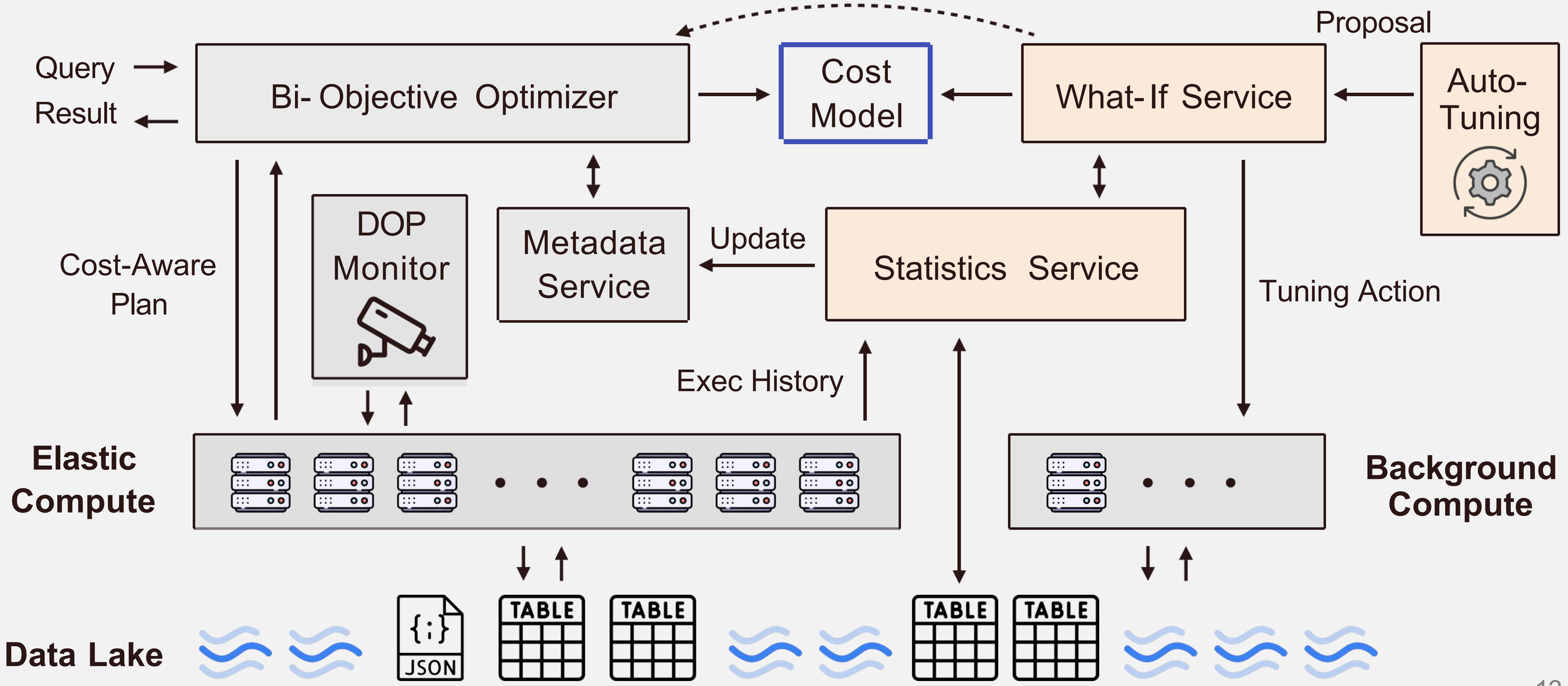
System Architecture



System Architecture

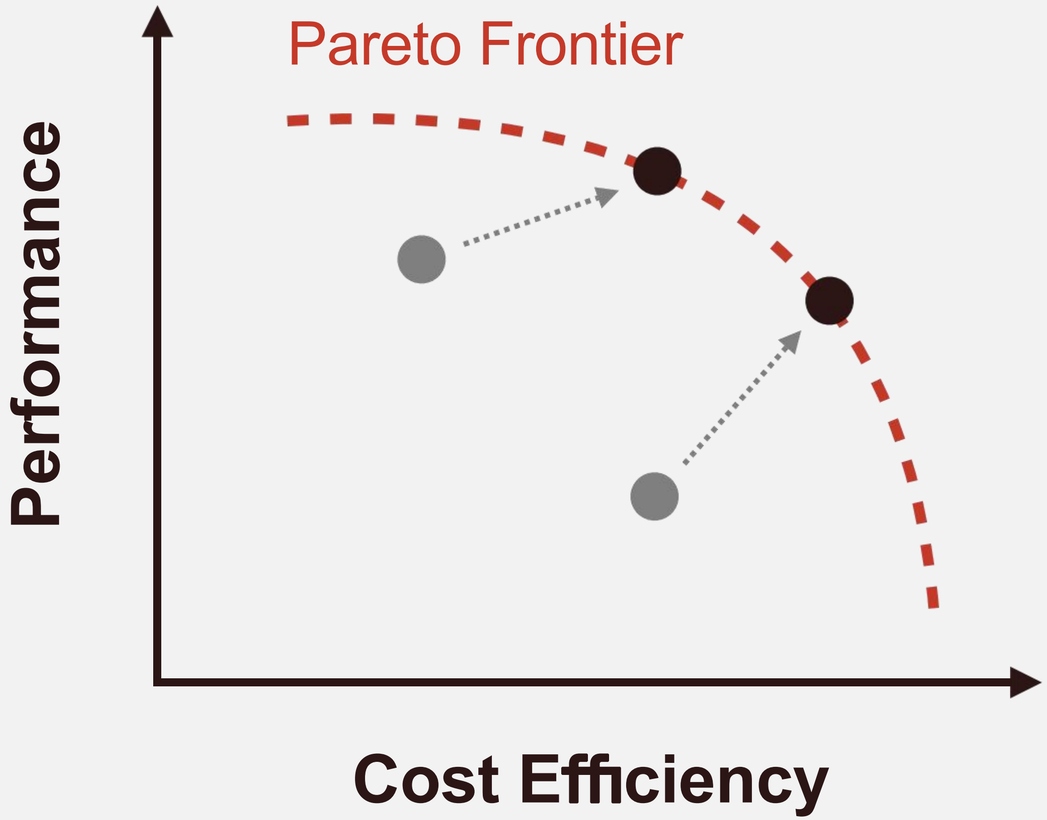


System Architecture



Towards Cost Intelligence

Cost is as important as performance in cloud-native databases



Time: 10s — 5min

Cost: $2 — $0.1

谢谢观看

THANKS FOR WATCHING