ORACLE

Tech: Project Kit

Applications with MySQL HeatWave

Technical Presentation

Alexandre Fagundes
alexandre.af.fagundes@oracle.com
Cloud Architect, Oracle Latin America

MySQL: An extremely popular database

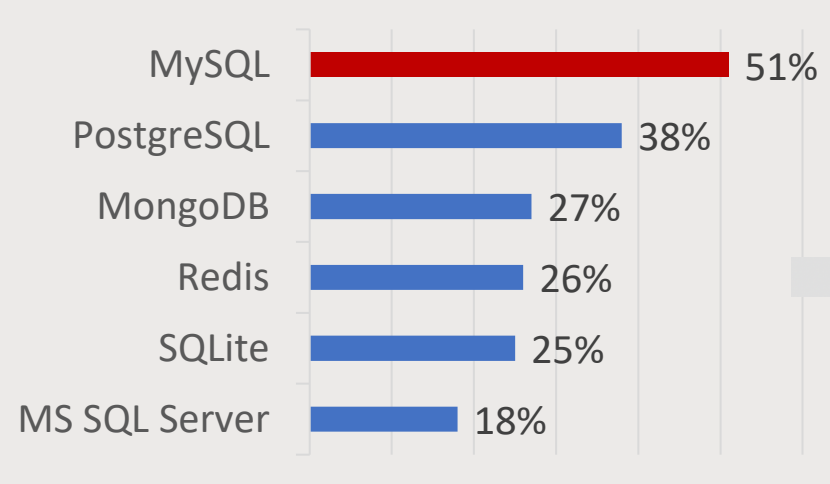
MySQL is the #1 Open Source Database

And the most popular database for developers

Rank Sep 2024	Rank Aug 2024	Rank Sep 2023	DBMS	Database Model	Sep 2024
1.	1.	1.	Oracle	Relational, Multi-model	1286.59
2.	2.	2.	MySQL	Relational, Multi-model	1029.49
3.	3.	3.	Microsoft SQL Server	Relational, Multi-model	807.76
4.	4.	4.	PostgreSQL	Relational, Multi-model	644.36
5.	5.	5.	MongoDB	Document, Multi-model	410.24

DB-ENGINES

Which databases have you used in the last 12 months?



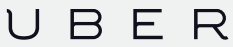
JET BRAINS

Jetbrains developer survey 2023

Innovative organizations across many industries run MySQL – Do you?

Social

E-Commerce



Tech

Finance

Manufacturing

MySQL powers Open Source applications

Custom Apps Development

Content management and eCommerce

Learning platforms

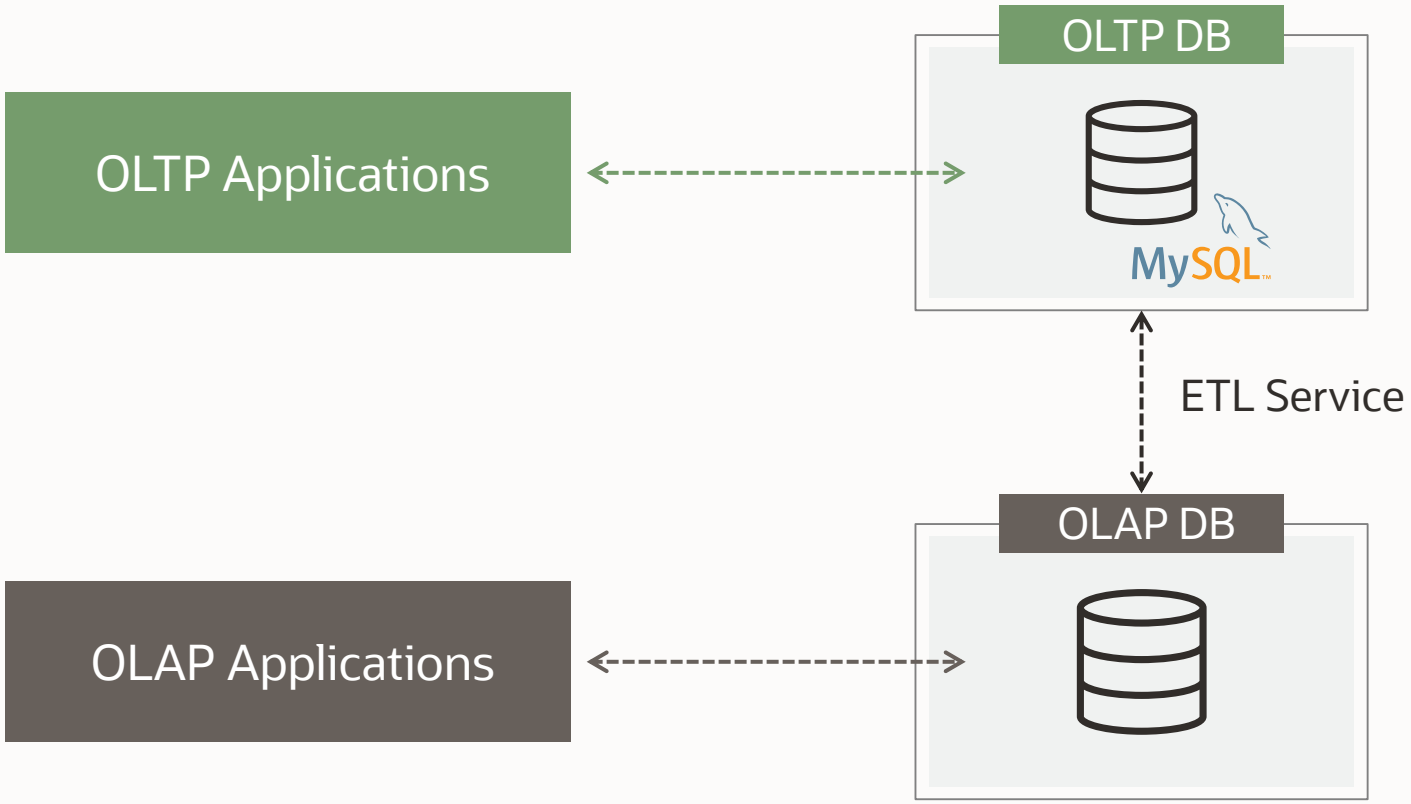
Challenges for developers and DBAs…

…And how MySQL HeatWave uniquely addresses them

What we've heard from customers

Complex and costly to use separate systems for transactions and analytics	We provide one MySQL cloud database service for OLTP and real-time analytics across data warehouses and data lakes—without ETL duplication
Want to leverage ML and generative AI on all their data	We provide automated in-database ML with an explanation of models and results, without ETL, plus generative AI with Vector store (private preview)
Spend too much time on manual management tasks	We provide a fully managed database service with machine learning-powered automation and built-in advanced security features
Want to use multiple clouds	MySQL HeatWave is available on OCI, AWS, Azure, and in your data center

MySQL is optimized for OLTP, not designed for analytic processing



Separate analytics database

Complex ETL

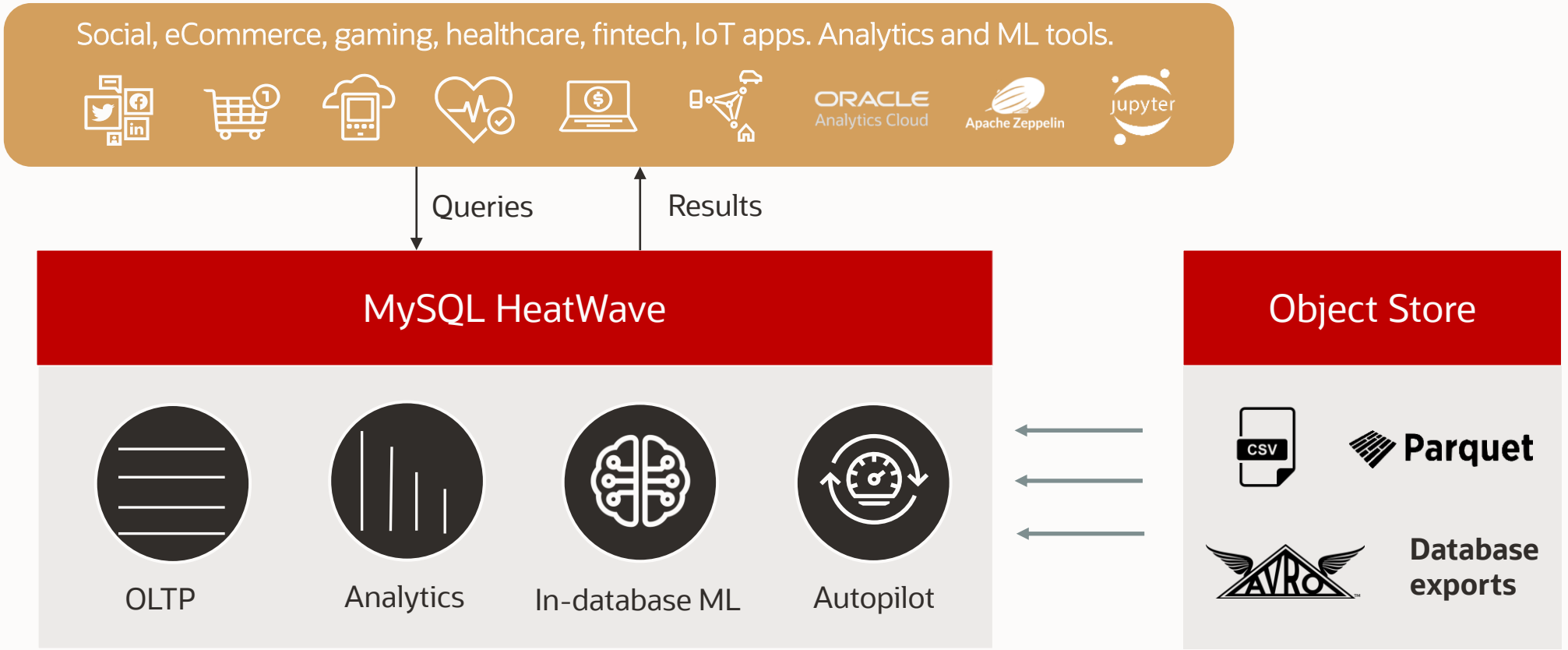
No real-time analytics

Security & compliance risks

Increased costs

MySQL HeatWave overview

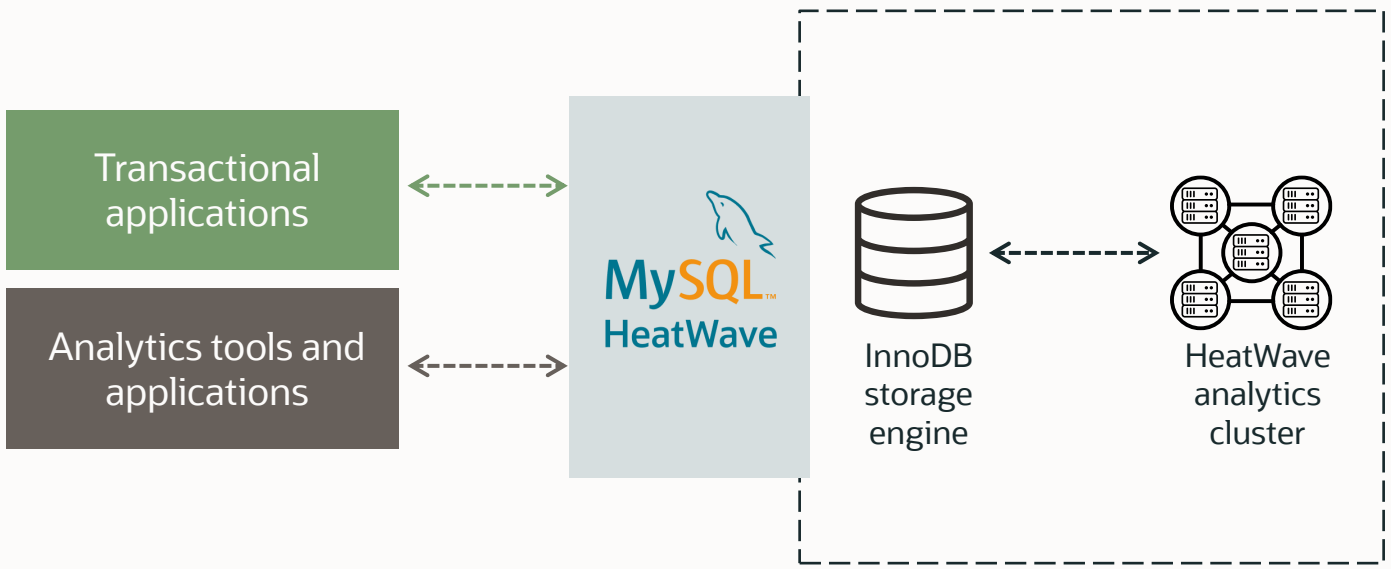
Transactions, real-time analytics across data warehouse and data lake, and machine learning in one database service



Data remains in object store, processing is done in HeatWave

For both non-MySQL and MySQL workloads

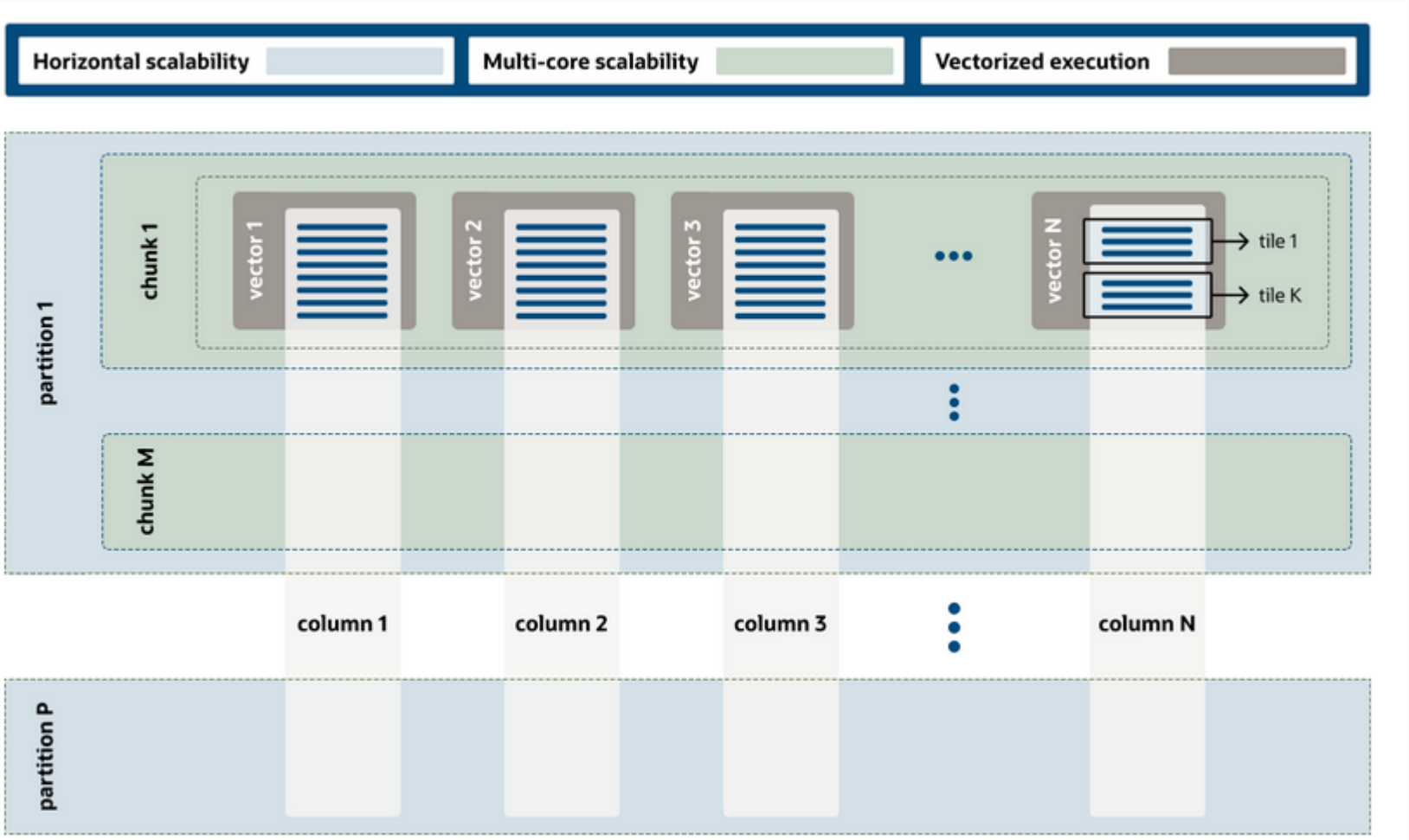
One database is better than two



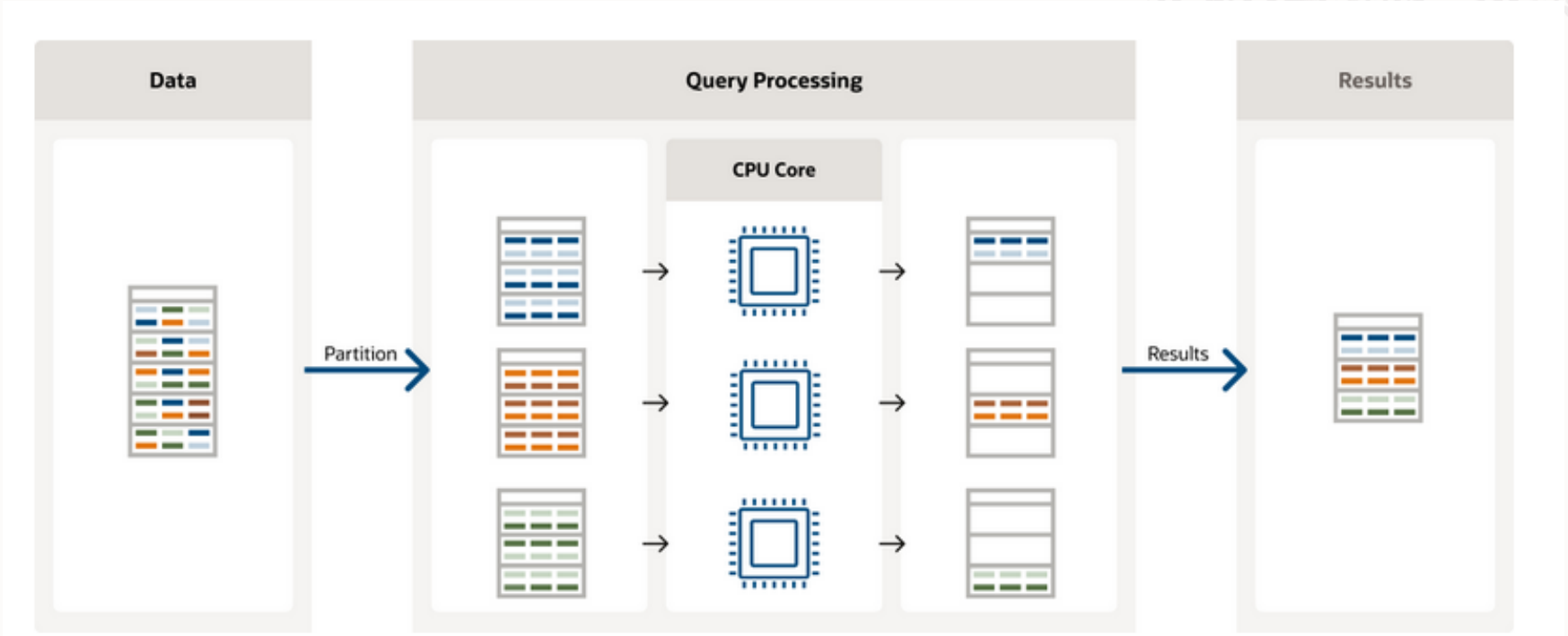
- One service for OTLP & OLAP
- No ETL duplication
- Unmatched performance, at a fraction of the cost
- Real-time analytics
- Improved security
- Applications work without changes

1>2 with MySQL HeatWave

In-Memory hybrid columnar processing

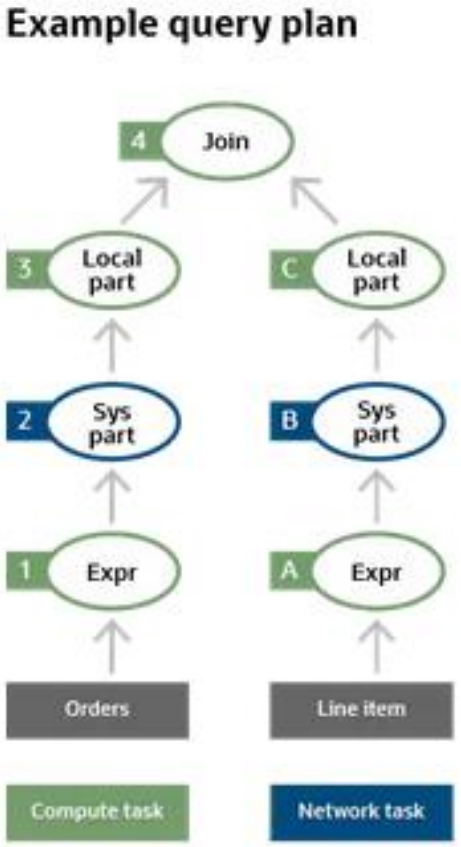


Massively parallel architecture



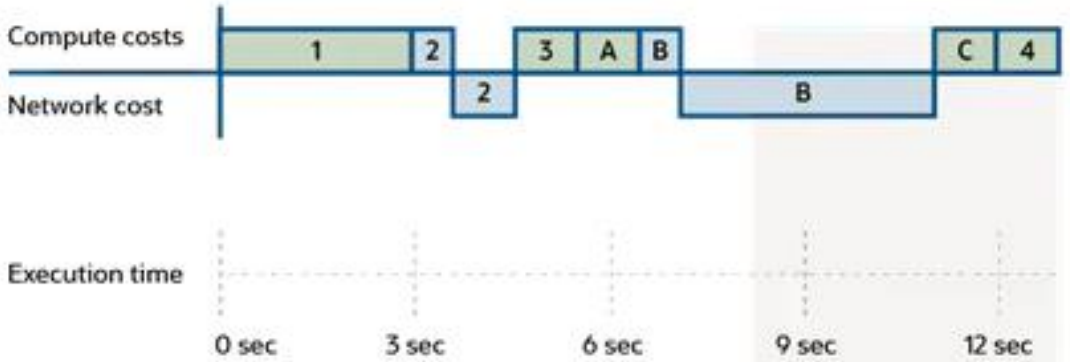
- High-fanout partitioning
- Machines & CPU cores can further process partitioned data in parallel
- Optimized for cache size and memory hierarchy of underlying hardware

Overlap compute with communication



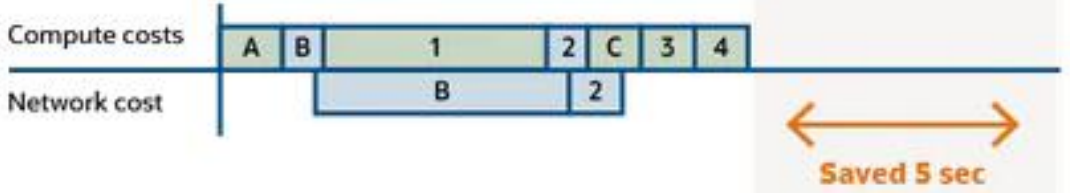
Previously

- No overlap
- Execution time = 13 sec



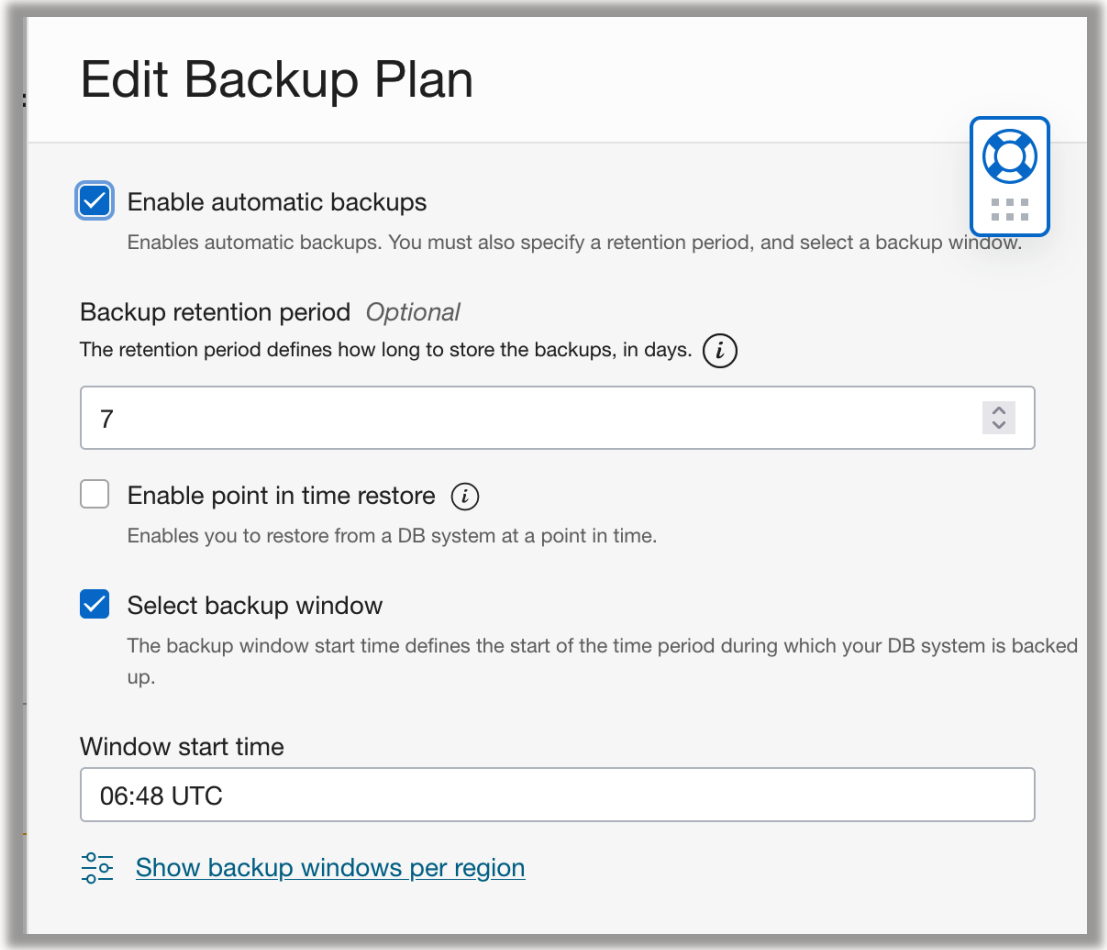
From March 2022

- Overlap network time with compute
- Execution time = 8 sec



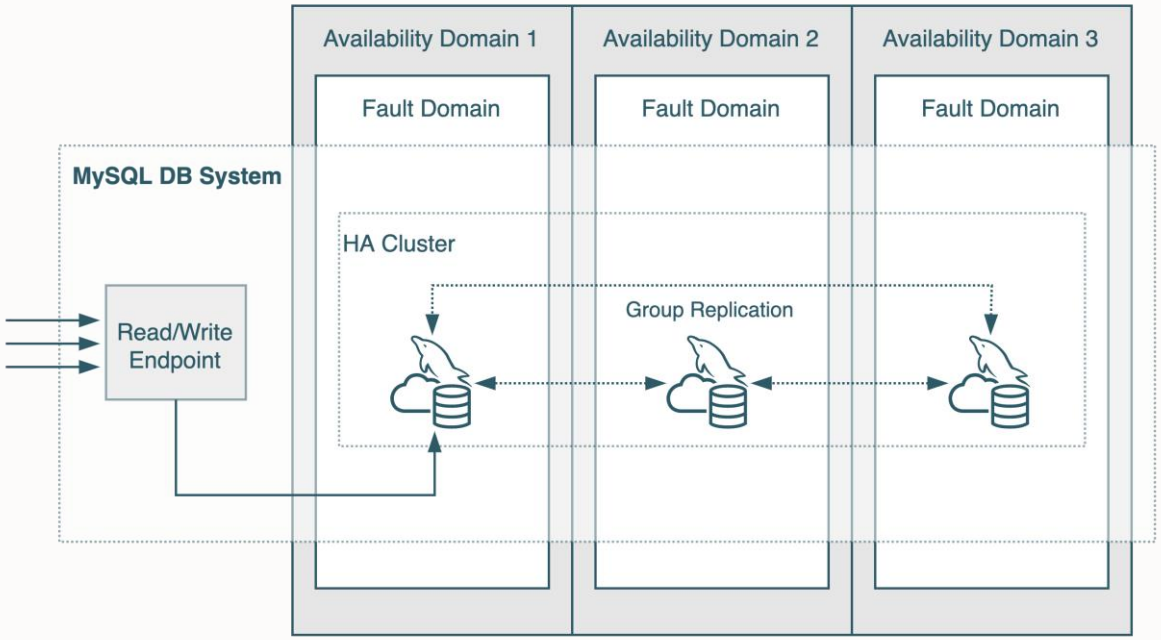
Backups
Manual or Automatic

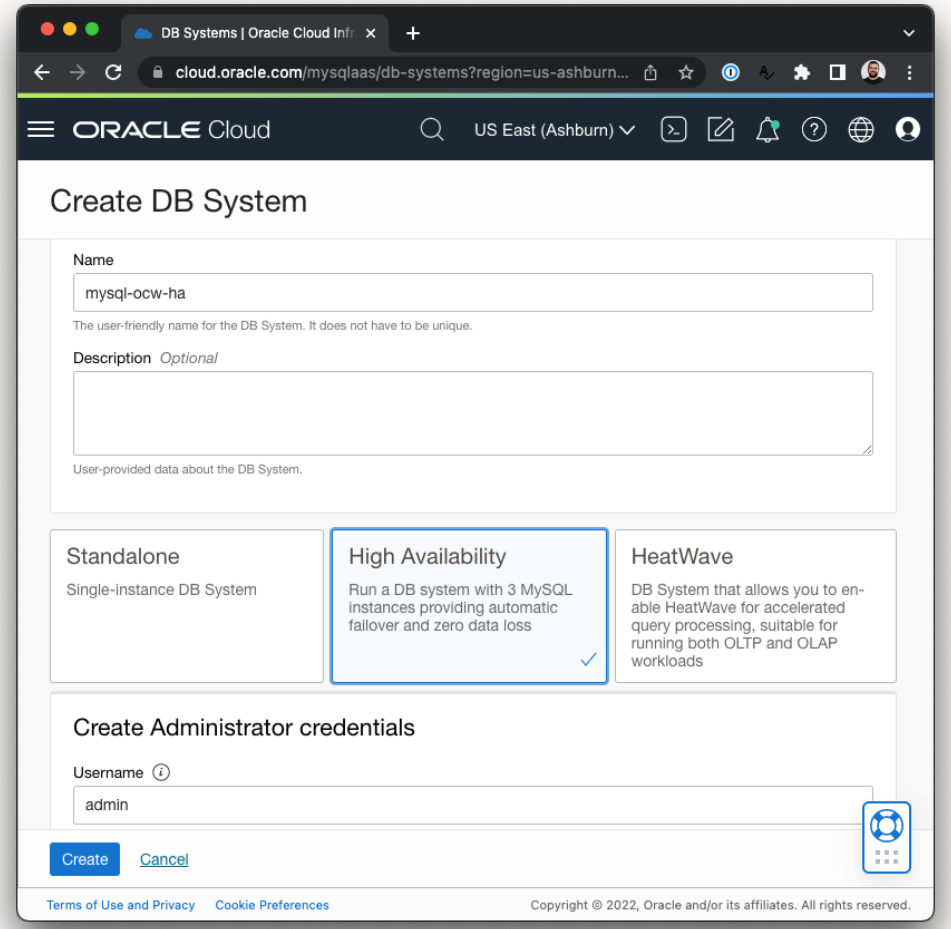
- Retention Period
- When to Backup
- Full or Incremental
- Point-in-Time Recovery (only non-HA DB Systems)



High Availability

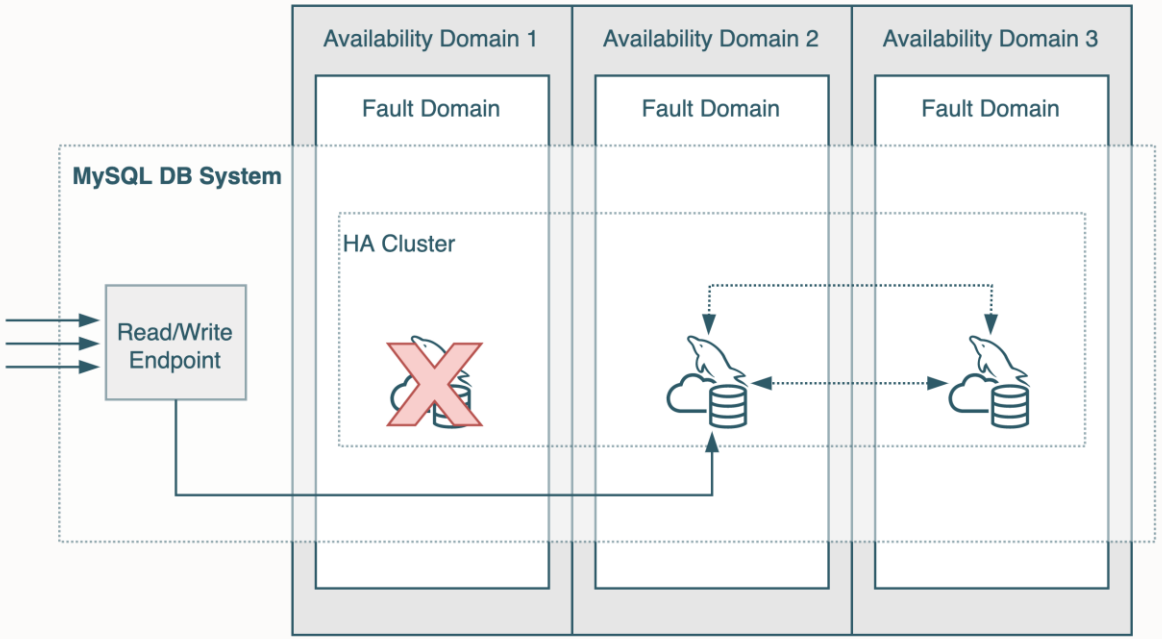
Single-click HA





High Availability

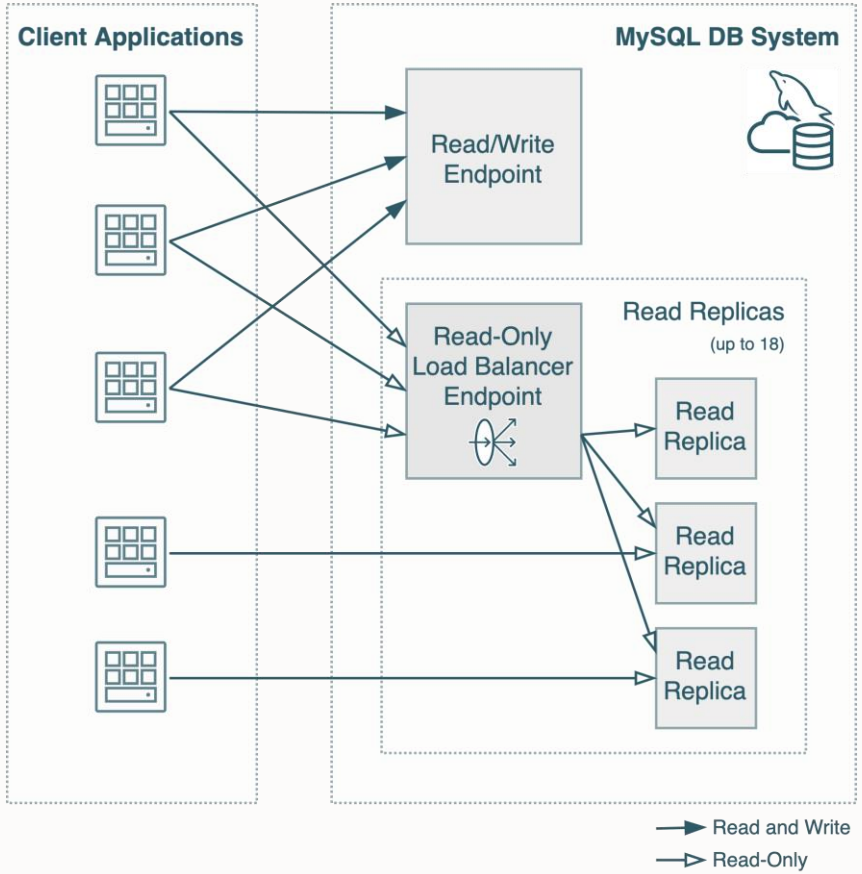
Single-click HA



- SLA **99.99**%
- Automatic failover
- Zero Data Loss during failure event
- Option to manually switch-over
- Rolling upgrades during maintenance

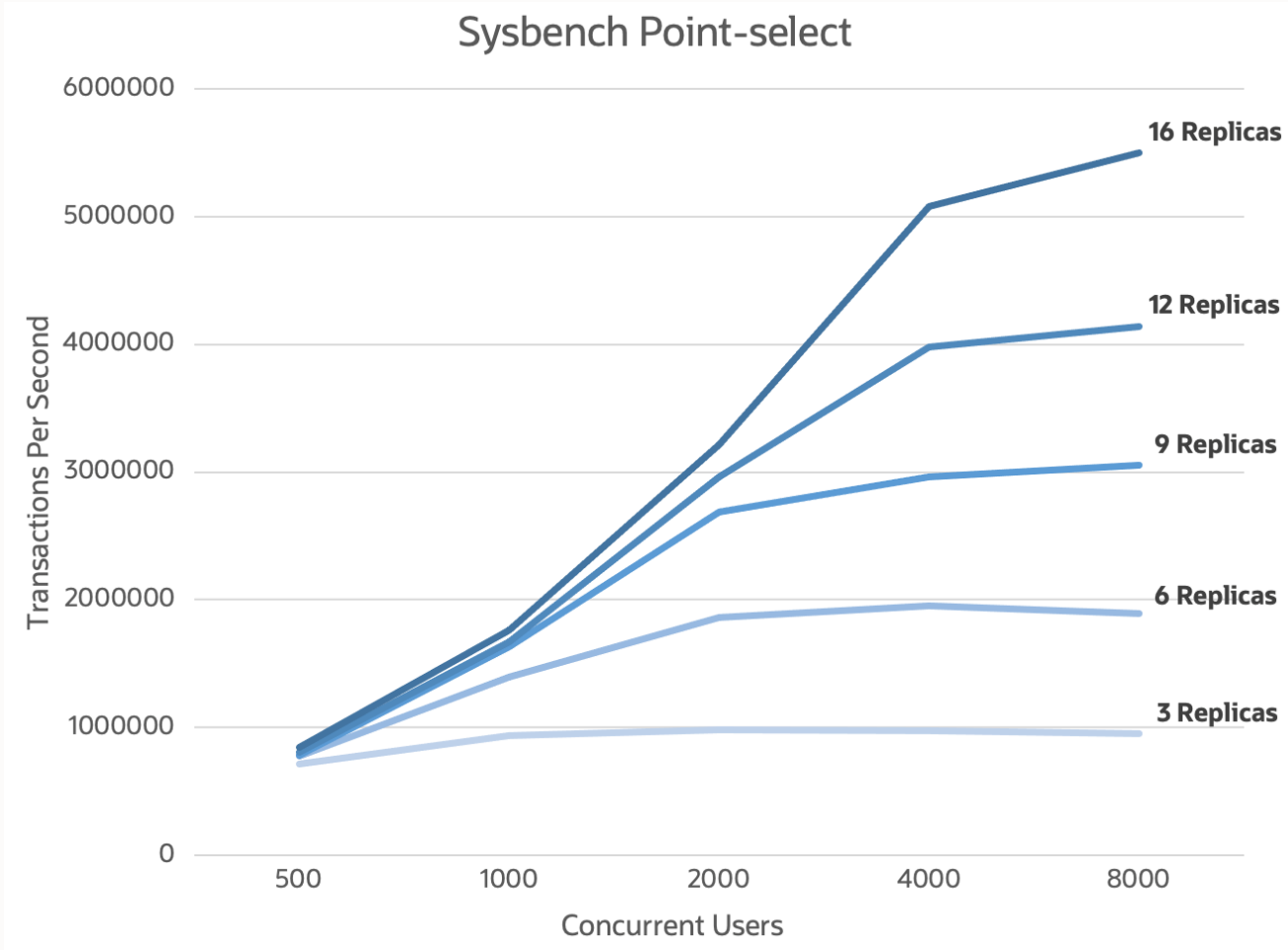
Read Replicas

Scale Read Workloads



- Increase capacity for read-intensive workloads
- Add and remove Read Replicas for horizontal elasticity
- Easy to deploy and maintain
- Built-in Load Balancer for the read-only endpoint
- HA Cluster is ready for switchover or failover

Read Scalability

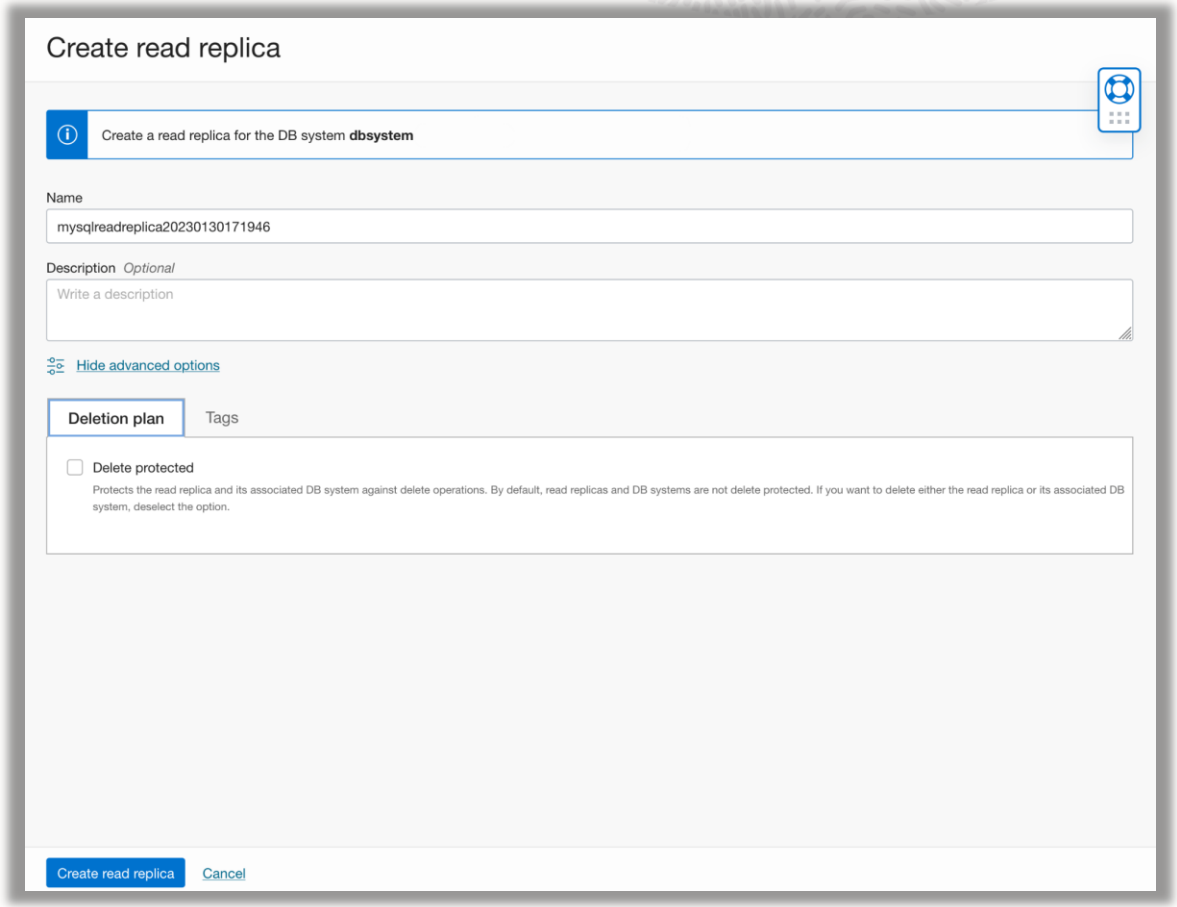


Read Replicas

Single-click Read Replicas

- A single click creates a Read Replica
  - Provision
  - Launch
  - Setup Replication
  - Monitor and Manage

- Read Replicas are associated with a DB System
  - RO endpoints in the DB System
  - Up to 18 max per DB System
  - Requires a shape of 4 OCPUs or larger
  - CLI, SDK and Terraform support

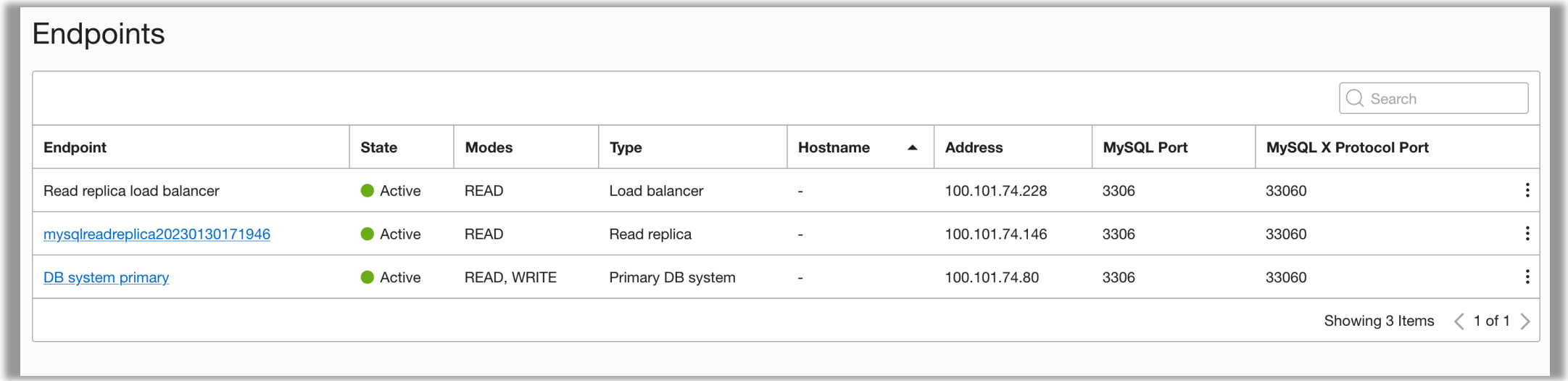


Load Balancer

Use Your Replicas Efficiently

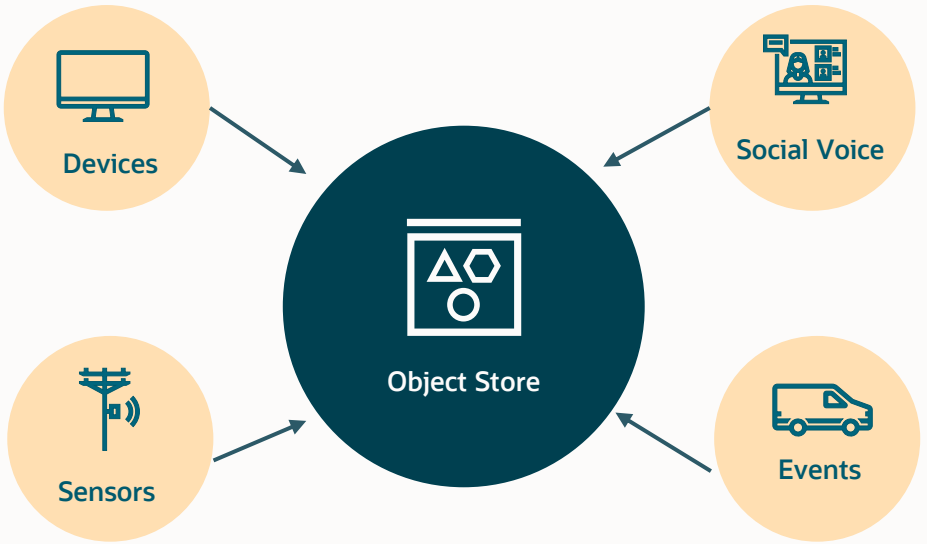
When using Read Replicas a Load Balancer Endpoint is automatically provisioned in your DB System.

- Managed by the service
- Materializes as a Read-Only endpoint
- Round robins traffic across Read Replicas
- Manages Read Replica backends automatically



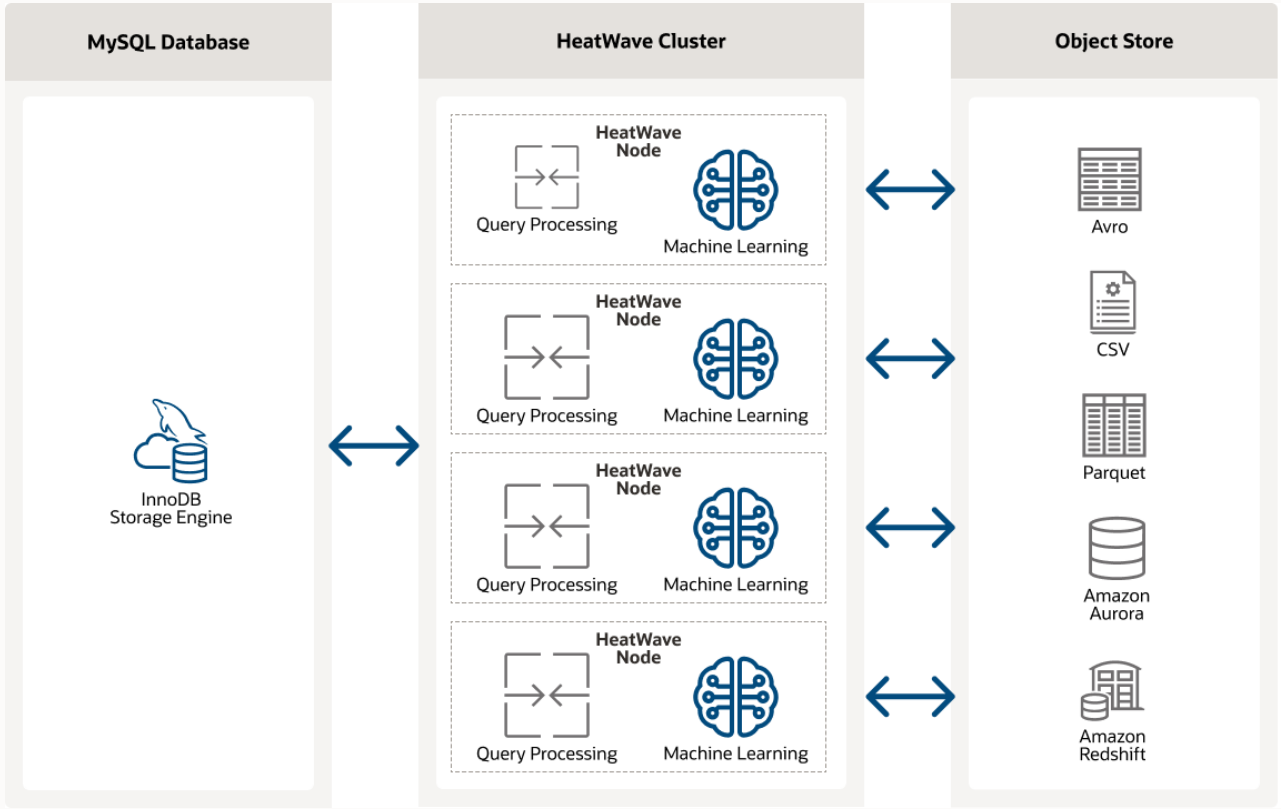
Massive amount of data stored in files

- Databases are systems of record
- Files are repository for other types of data (e.g IoT, web content, log files)
- Over 80% of the data we generate is in files
- 99.5% of collected data remains unused
  - Lack of time, resources, and expertise to process different data formats across different data sources



MySQL HeatWave Lakehouse

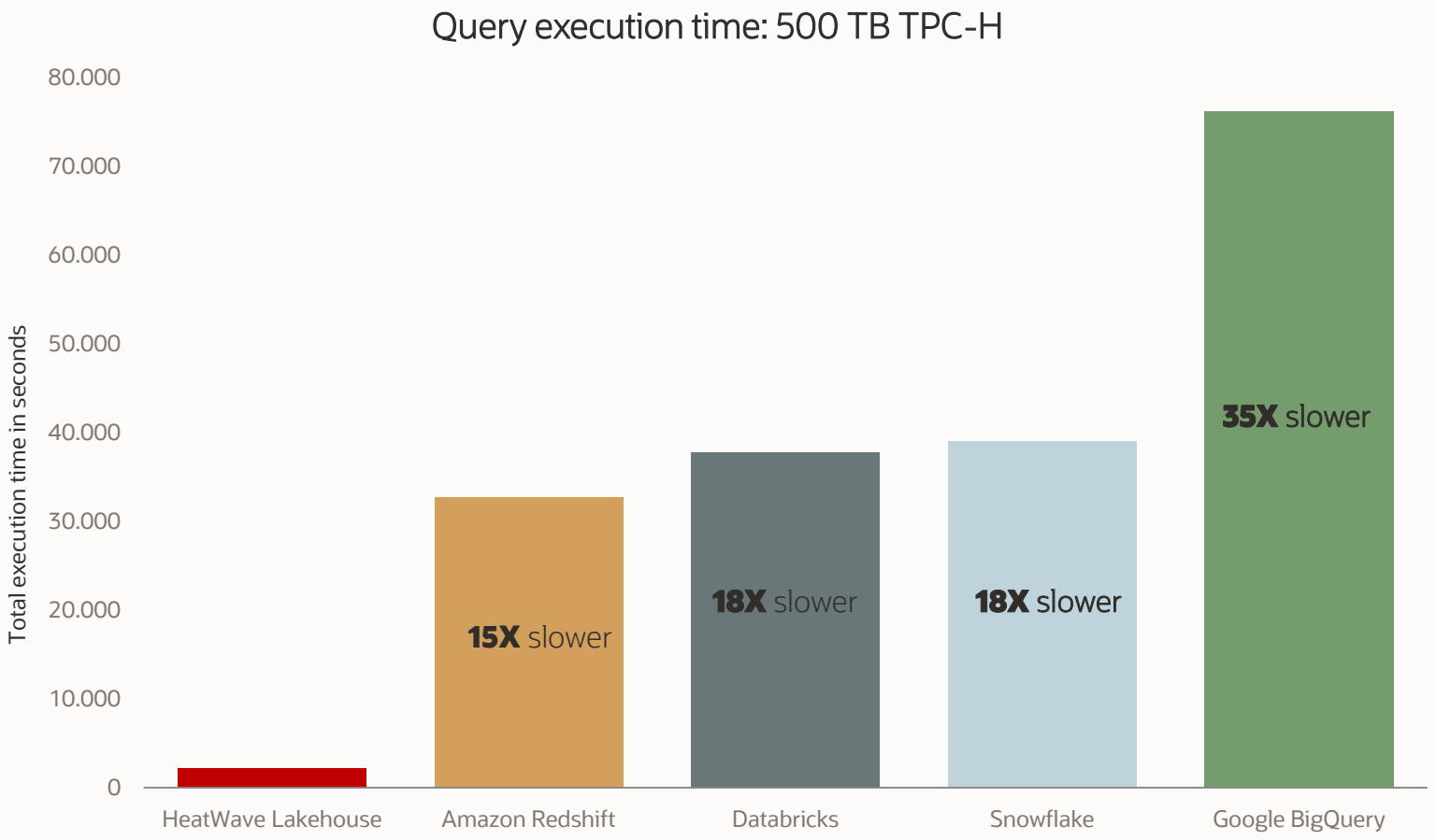
Query half a PB data in the object store—in a variety of file formats



- Query data in MySQL, in the object store, or across both—using standard SQL syntax
- Up to 500 TB of data—the HeatWave cluster scales to 512 nodes
- Querying the data in the object store is as fast as querying the database – **an industry first!**
- Scale out data processing in the object store, data is not copied to the MySQL Database: for both MySQL and non-MySQL workloads

Query performance of HeatWave Lakehouse

15X faster than Redshift, 18X faster than Snowflake, 18X faster than Databricks, 35X faster than BigQuery



Significantly reduces time-to-insights

Configuration: MySQL HeatWave Lakehouse: 512 nodes; Snowflake: 4X-Large Cluster; Databricks: 3X-Large Cluster; Amazon Redshift: 20-ra3.16xlarge; Google BigQuery: 6400 slots
Benchmark queries are derived from the TPC-H benchmarks, but results are not comparable to published TPC-H benchmark results since these do not comply with the TPC-H specifications.

Very simple to query files in the object store

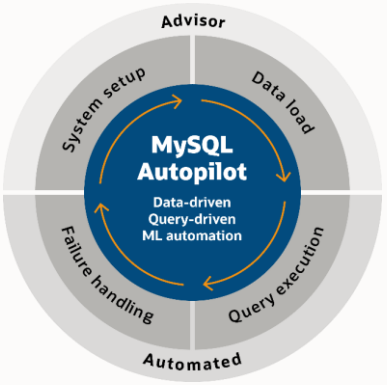
STANDARD SQL syntax generated by MySQL Autopilot, no human required

1. **System Setup**

- Run MySQL Autopilot on object store to determine cluster size and schema mapping
- Execute DDLs generated by Autopilot

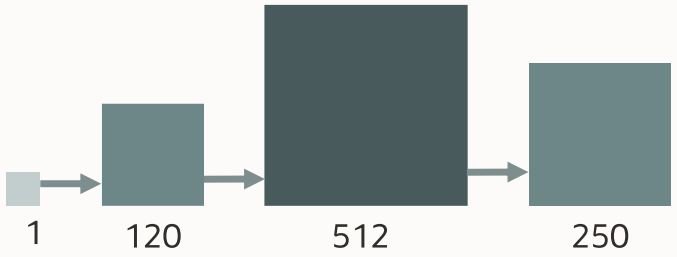
2. **Run query across files and tables**

```
mysql> SELECT count(*) FROM Sensor, SALES WHERE Sensor.degrees > 30 AND Sensor.date =
SALES.date;
```



HeatWave scales out

Flexible, fast and highly scalable

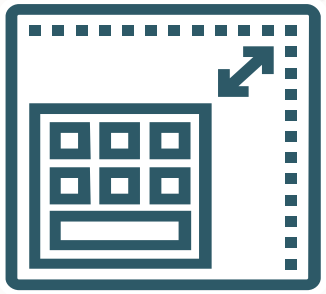


Scale to any cluster size

- Flexible cluster size up to 512 HeatWave nodes
- Scale to any size based on workload and performance requirements

Fast provisioning

- Provision cluster in less than 16 mins for up to 512 nodes
- Pause & resume cluster to minimize cost

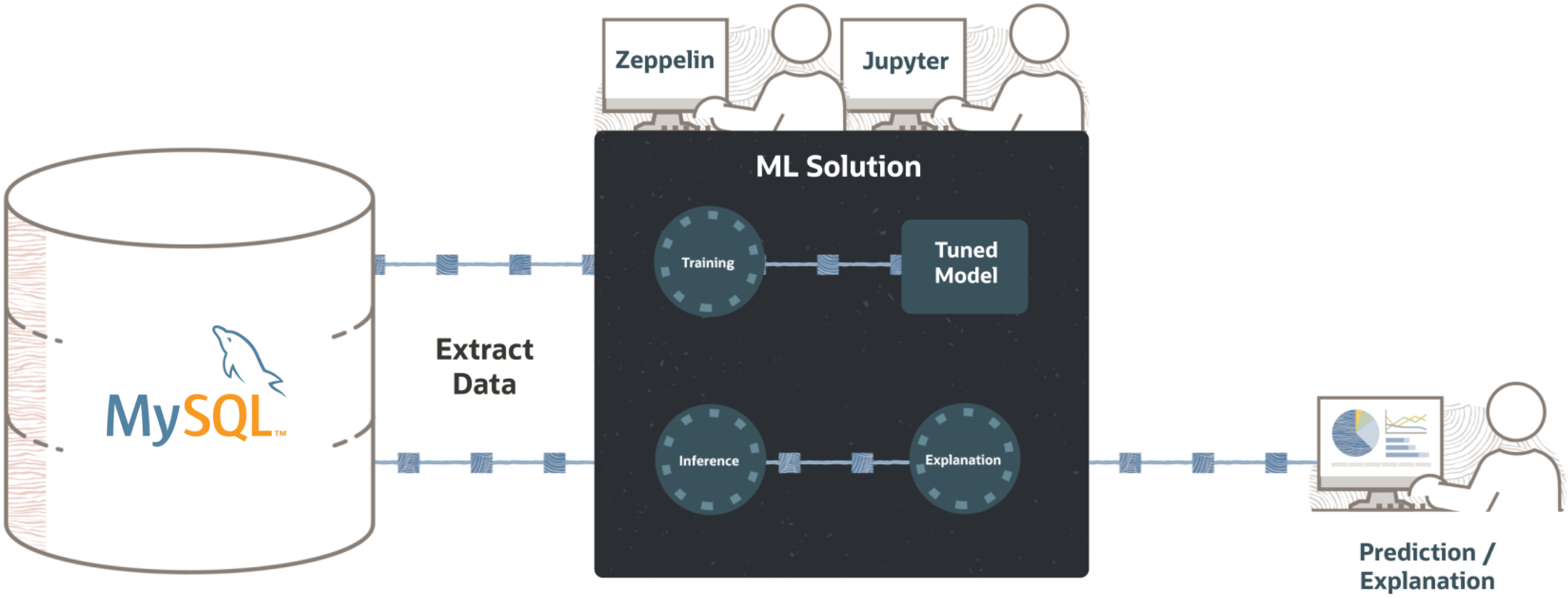


High Scale Factor

- Load performance scales with cluster size
- Query performance scales with cluster size

Challenge #2: Organizations want to leverage ML and generative AI with all their data

Need to ETL data to a separate ML solution for training and inference

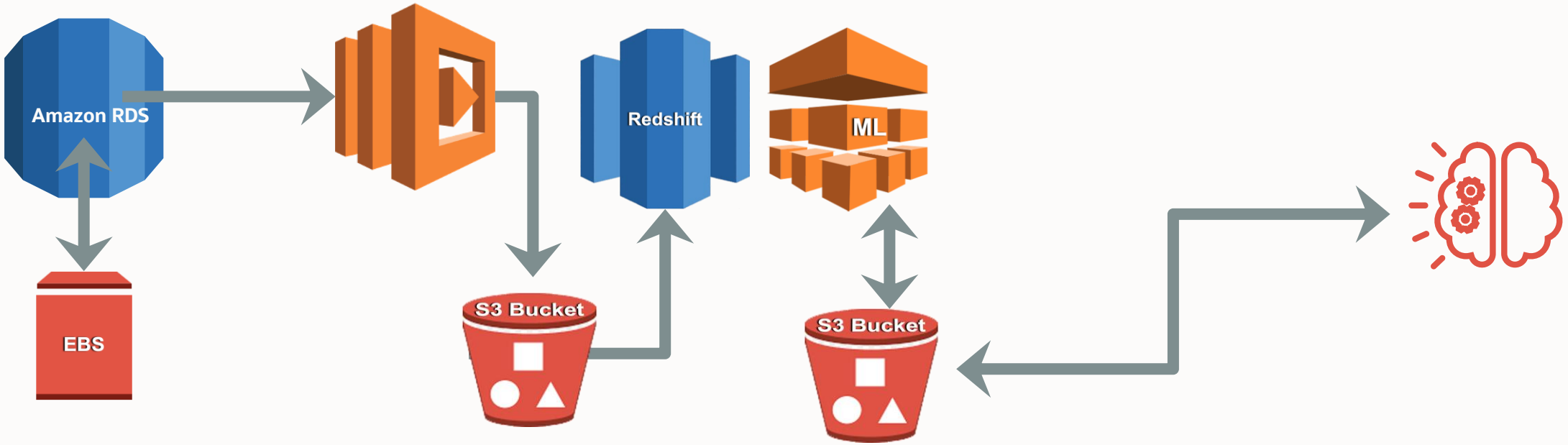


- Complex, time-consuming
- Increases costs and risks
- Need to learn new tools/languages

And it gets worse when using other databases…

The pain of using AWS services

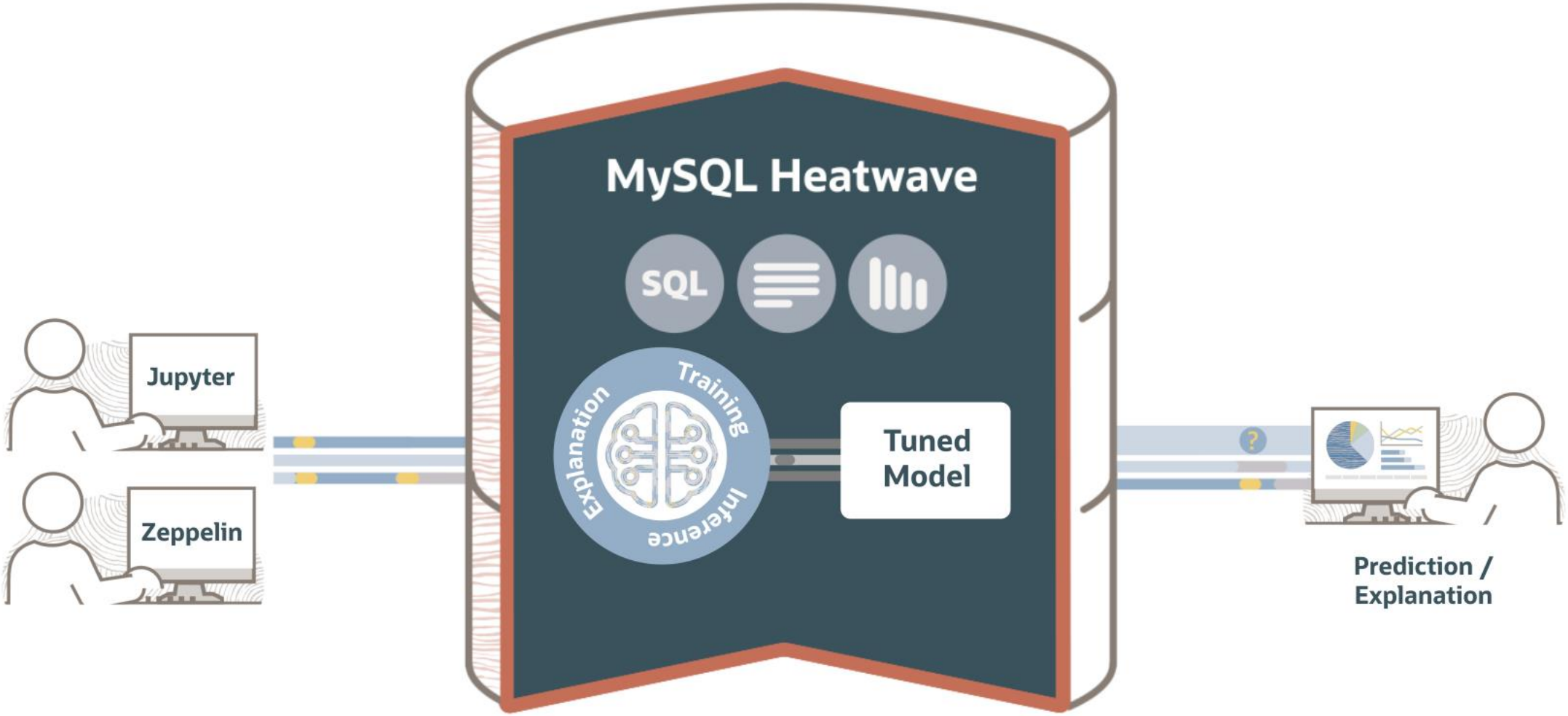
Amazon Redshift with RDS and ML Modeling



RDS to Redshift Pipeline
Utilizing Lambda, Glue, & S3

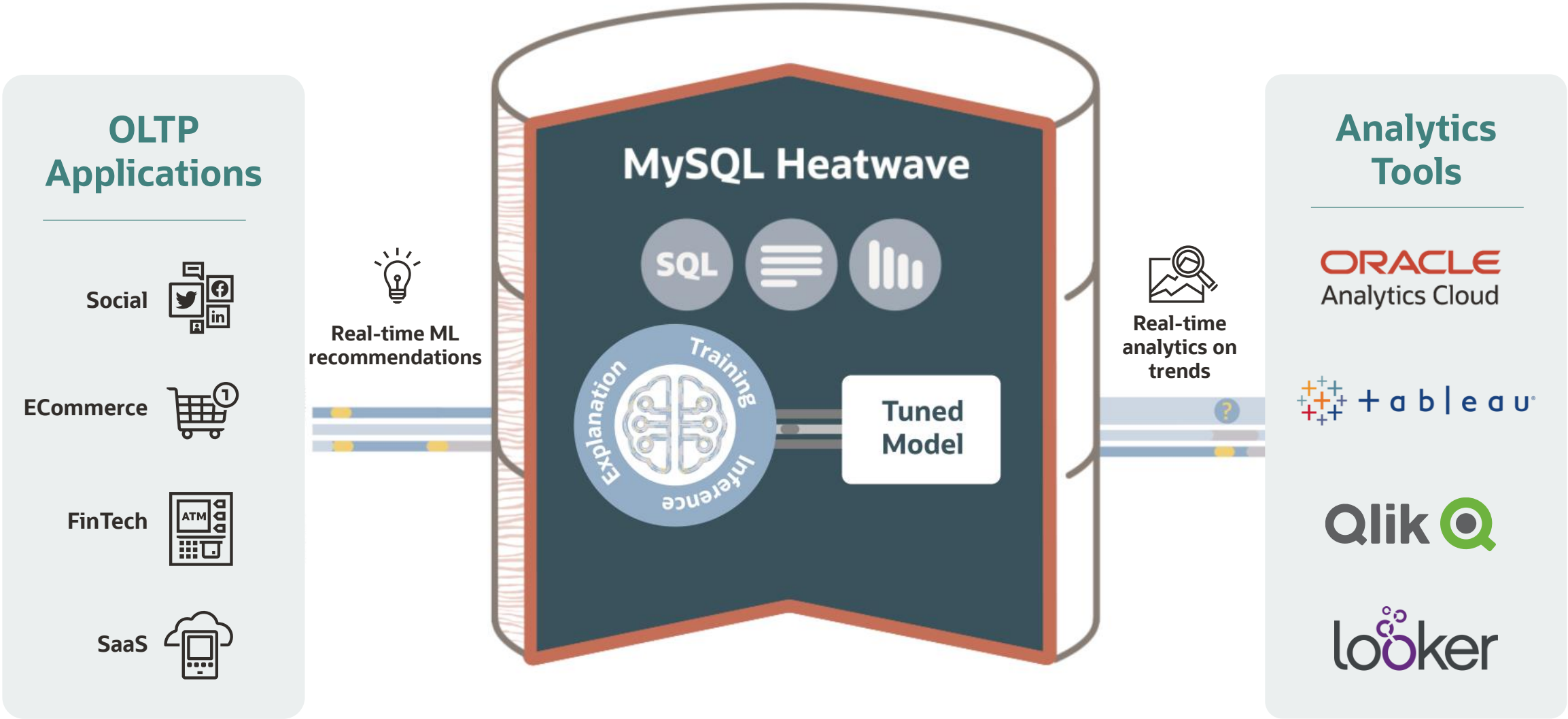
Redshift ML does NOT provide in-database ML; exports data to SageMaker via Amazon S3

In-database machine learning with MySQL HeatWave



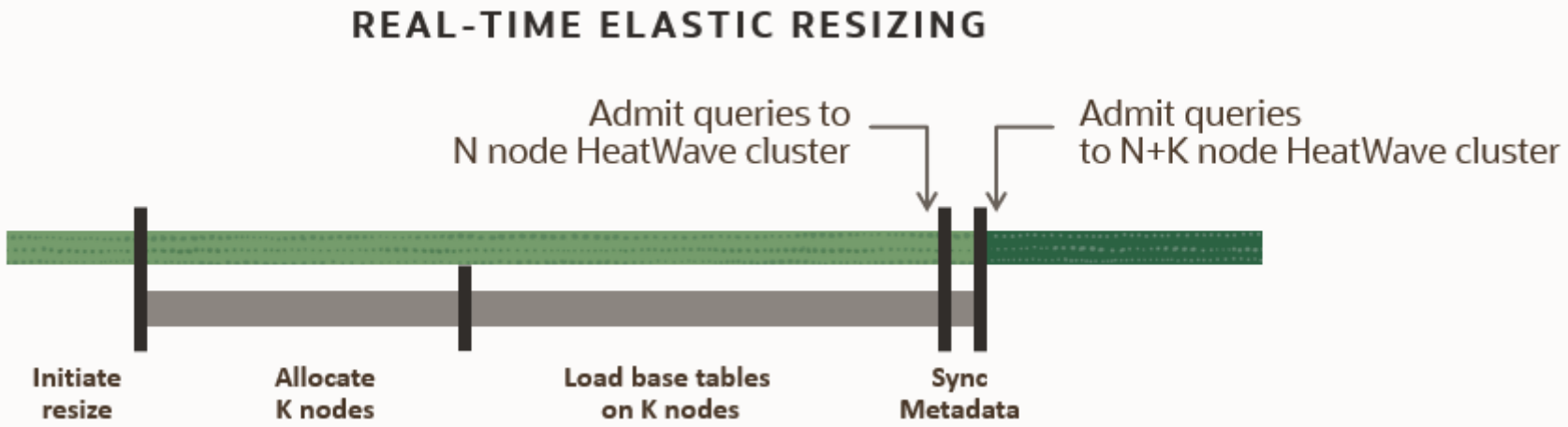
Accelerate ML initiatives, increase security, and reduce costs

Machine learning in action with MySQL HeatWave



Zero downtime for OLTP, OLAP, and ML workloads

Increase or decrease the size of your HeatWave cluster by any number of nodes



With Redshift Elastic resize:

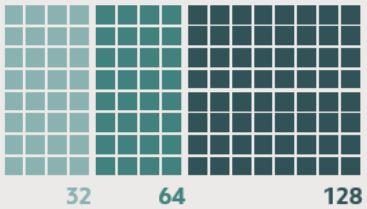
- Data unavailable 4 to 8 min
- Several limitations (node type, count…)
- Data skew between nodes can severly degrade query performance

RA3 with Redshift Managed Storage*		
ra3.xlplus	4	32 GiB
ra3.4xlarge	12	96 GiB
ra3.16xlarge	48	384 GiB

Redshift users (RA3 – current generation) are forced to select "T-shirt size" instances: 4,12,48

Snowflake

Only scale to their sizes



Challenge #3: Organizations spend too much time on manual management tasks

Manual management tasks consume resources

- **On-premises**:
  - Database management: provisioning, configuration, backup, HA, patching, security & more
  - Operating system management: installation, patching, upgrades…
  - Infrastructure management: purchase and maintenance of servers, storage
  - Data center management: space, power, cooling, disaster recovery & more

- **In the cloud with a managed database service:**
  - Provisioning: right-sizing a database
  - Data loading: optimizing load time, memory usage, encoding, data placement
  - Query execution: performance tuning, prioritization of queries
  - Failure handling: actions to handle an error recovery

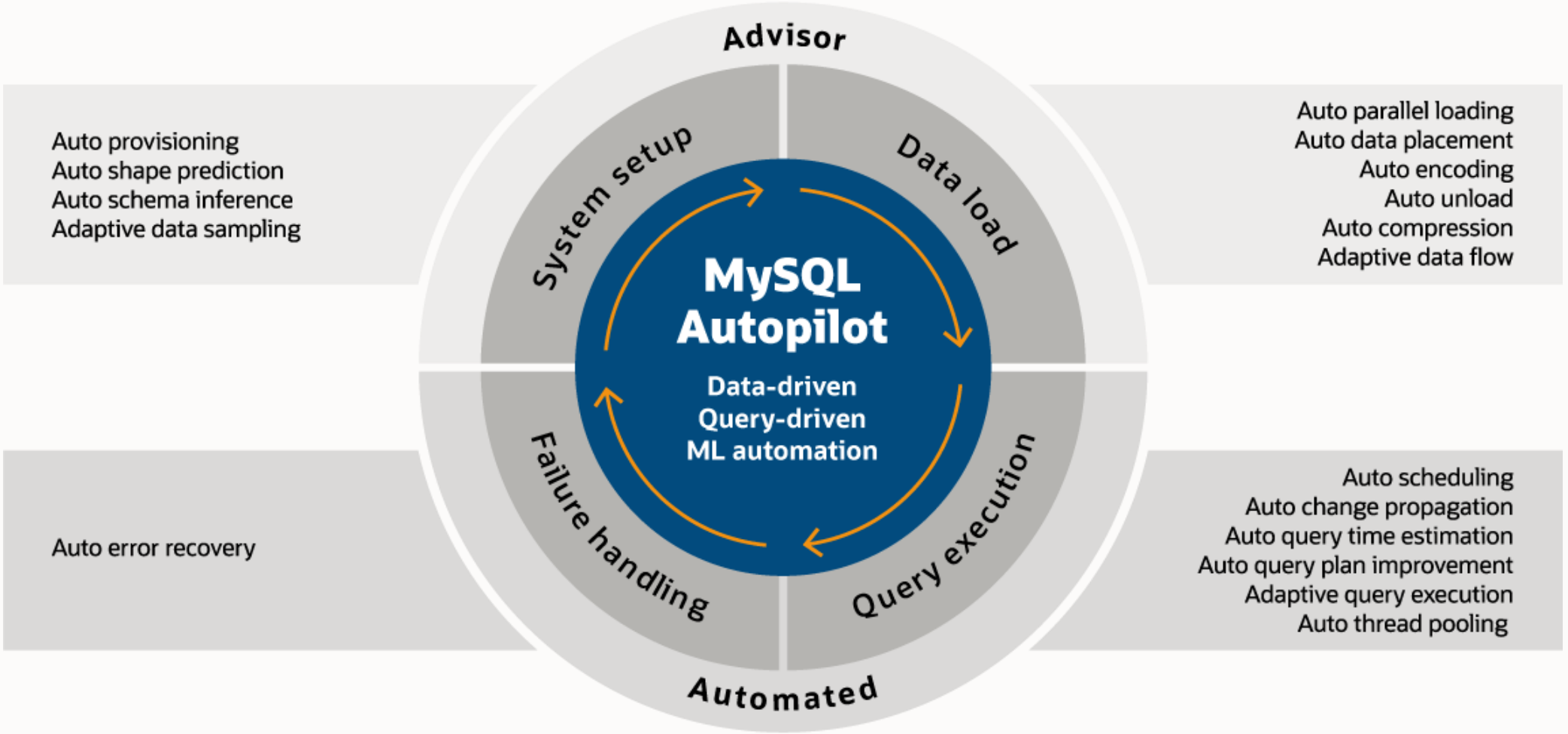
MySQL HeatWave: fully managed database service

100% developed, managed, and supported by Oracle

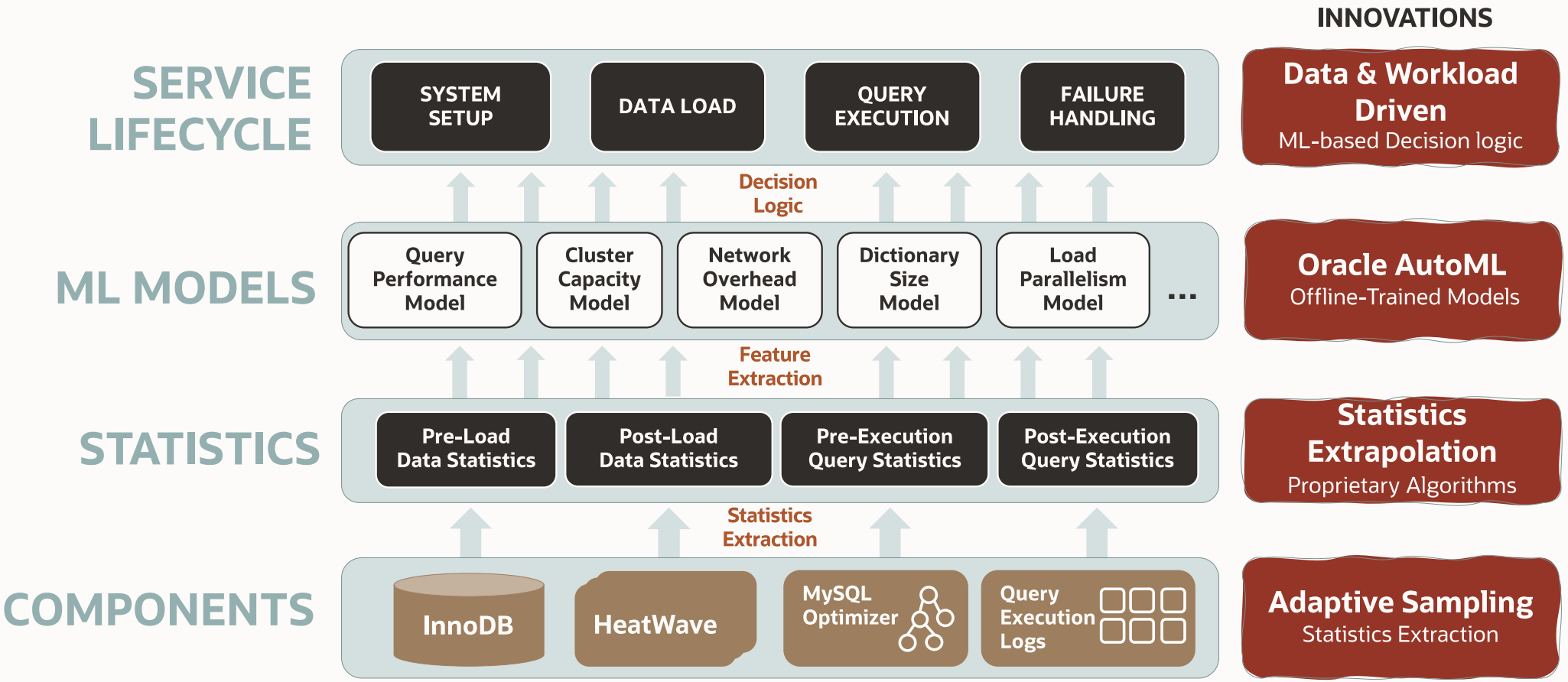
	Automation	MySQL HeatWave
Database	High Availability	✓
	Read Replicas	✓
	Backup	✓
	Query Acceleration	✓
	MySQL AutoPilot	✓
	HeatWave AutoML	✓
	HeatWave Lakehouse	✓
	Security Patch & Upgrade	✓
	Provision & Configure	✓
OS	OS Security Patch & Upgrade	✓
	OS Installation	✓
Server	Hardware Provisioning & Maintenance	✓
Storage	Storage Provisioning & Maintenance	✓
Data Center	Rack & Space	✓
	Power, HVAC, Networking	✓

Machine learning-powered automation for MySQL HeatWave

High query performance at scale, higher OLTP throughput, and the best price performance

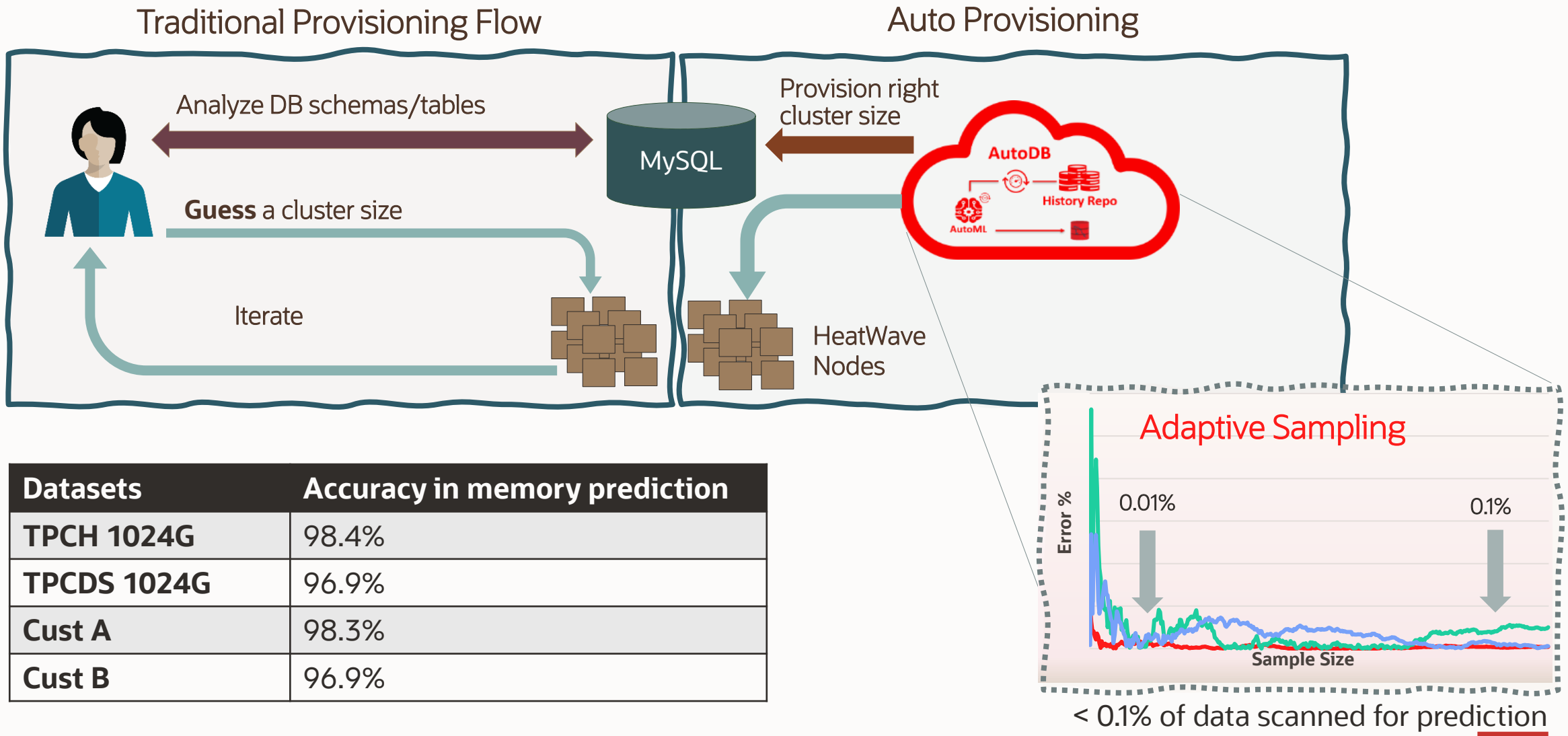


MySQL Autopilot Architecture



Auto Provisioning

Machine learning prediction of memory usage to estimate cluster size



Datasets	Accuracy in memory prediction
TPCH 1024G	98.4%
TPCDS 1024G	96.9%
Cust A	98.3%
Cust B	96.9%

< 0.1% of data scanned for prediction

Auto provisioning with MySQL HeatWave Lakehouse

How to determine the right cluster size required for processing data in object store?

```
•CALL sys.heatwave_load(@db_list, @options);
```

Output | Result #4 | Result #4.2 | Result #4.3 | **Result #4.4** | Result #4.5

CAPACITY ESTIMATION

Default encoding for string columns: VARLEN (unless specified in the schema)

Estimating memory footprint for 1 schema(s)

SCHEMA NAME	TOTAL OFFLOADABLE TABLES	ESTIMATED HEATWAVE NODE FOOTPRINT	ESTIMATED MYSQL NODE FOOTPRINT	TOTAL STRING COLUMNS	DICTIONARY ENCODED COLUMNS	VARLEN ENCODED COLUMNS	ESTIMATED LOAD TIME
`lakehouse`	6	75.49 TiB	10.50 MiB	142	0	142	1.40 h

Sufficient MySQL host memory available to load all tables.

HeatWave cluster memory might be insufficient to load all the tables.

The estimated load time assumes a cluster with sufficient size: 151 512-GB nodes

Please refer to the user manual for more details.

Auto Unload

The system recommends which tables can be unloaded based on workload history

HEATWAVE UNLOAD ADVISOR

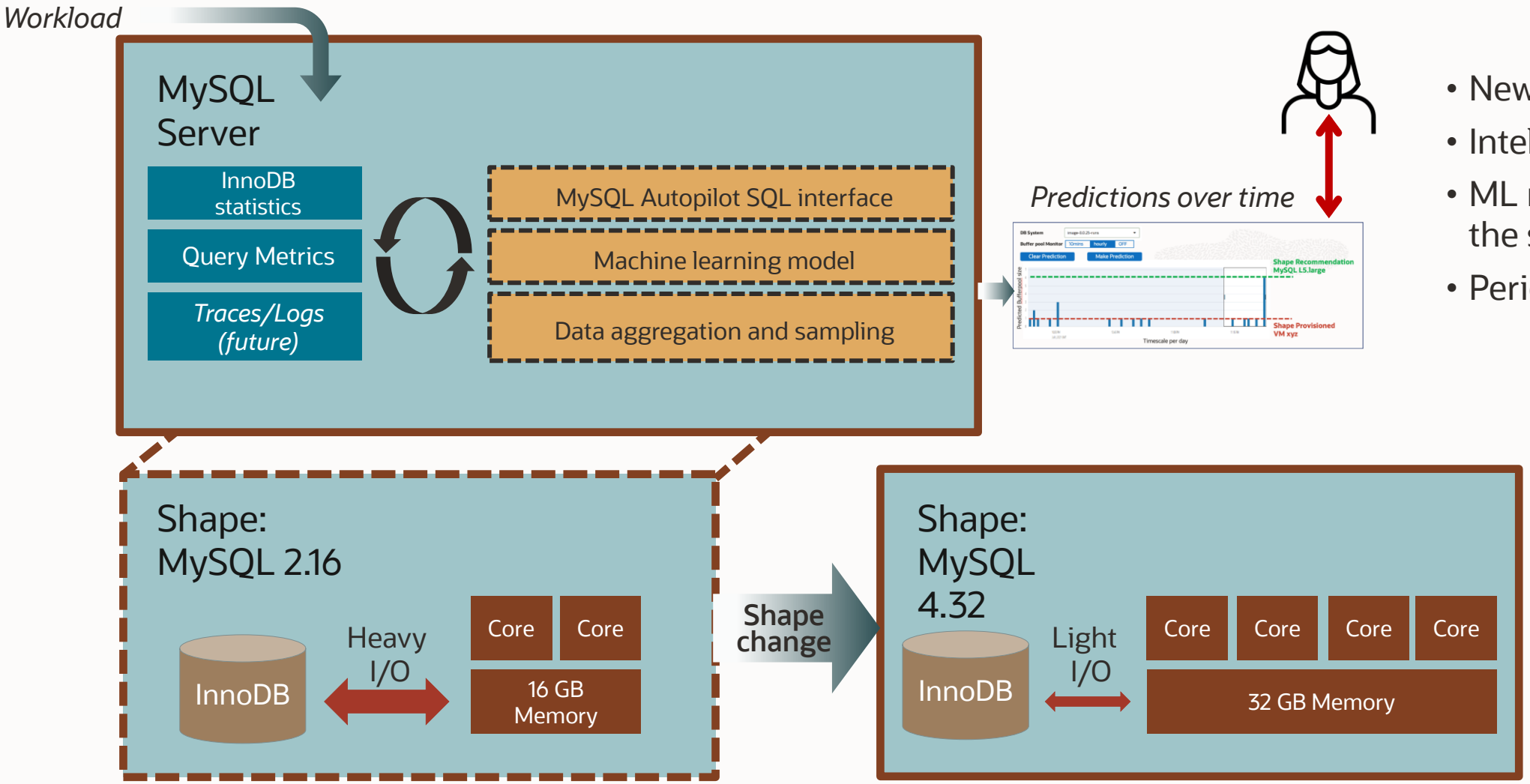
SCHEMA NAME	TABLE NAME	REASON	MEMORY GAIN (HEATWAVE NODES)	MEMORY GAIN (HOST)
`tpch1`	`LINEITEM`	LAST QUERIED ON "2023-03-02 10:24:06"	732.00 MiB	0 bytes
`tpch1`	`ORDERS`	LAST QUERIED ON "2023-03-02 10:24:12"	164.00 MiB	0 bytes
`tpch1`	`PARTSUPP`	NEVER QUERIED	148.00 MiB	0 bytes
`tpch1`	`CUSTOMER`	NEVER QUERIED	28.00 MiB	0 bytes
`tpch1`	`PART`	NEVER QUERIED	28.00 MiB	0 bytes
`tpch1`	`NATION`	NEVER QUERIED	4.00 MiB	0 bytes
`tpch1`	`REGION`	NEVER QUERIED	4.00 MiB	0 bytes
`tpch1`	`SUPPLIER`	NEVER QUERIED	4.00 MiB	0 bytes

Recommends which tables can be unloaded

Provides explanation for the recommendation

Auto Shape Prediction

Determines the optimal instance type



- New statistics
- Intelligent sampling
- ML models inside the server
- Periodic prediction

Auto Shape Prediction for best OLTP performance

Benchmark	BP Size (GB)	Buffer pool Hit Rate	Shape	Outcome
Twitter	5	89%	S	UPSIZE
Epinions	5	94%	S	UPSIZE
Smallbank	5	95%	S	UPSIZE
Sysbench TPC-C	5	93%	S	UPSIZE
Twitter	48	100%	L	DOWNSIZE
YCSB	48	100%	L	DOWNSIZE
Smallbank	48	100%	L	DOWNSIZE
Sysbench TPC-C	48	100%	L	DOWNSIZE

Shape	Throughput Improvement	Buffer pool Hit Rate
L	**6.2x**	100%
L	**2x**	99.6%
L	**1.5x**	100%
L	**1.8x**	99.4%
M	**1.02x**	100%
M	**1.04x**	100%
M	**0.98x**	99.2%
M	**0.96x**	100%

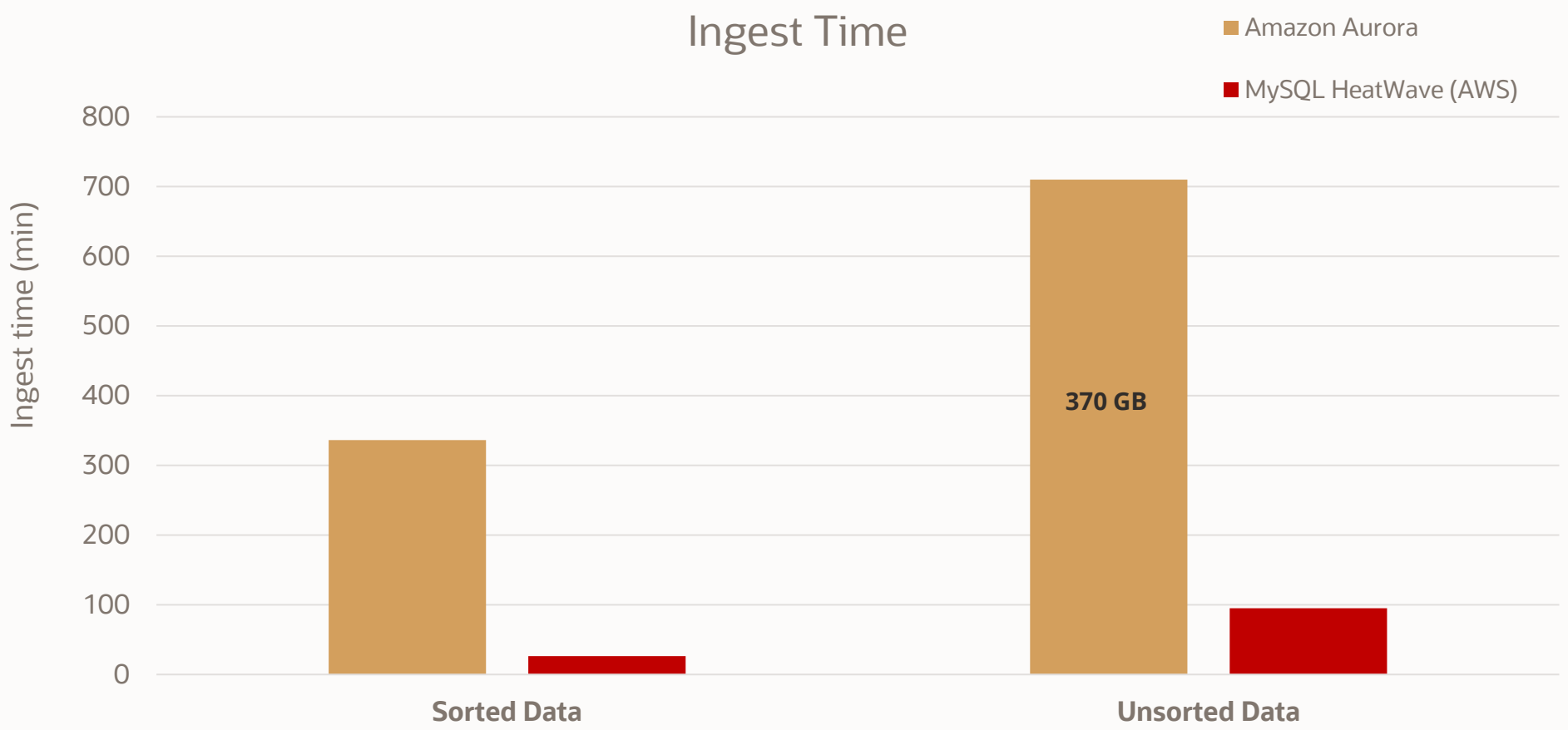
S : MySQL.2.16GB
M : MySQL.4.32GB
L : MySQL.8.64GB

Data ingestion into MySQL

- Transactional data needs to be loaded into MySQL database
- MySQL builds an Index Organized Table when data is loaded
- Speed of loading data determines how soon the data can be queried
- System resources are busy while data is being loaded

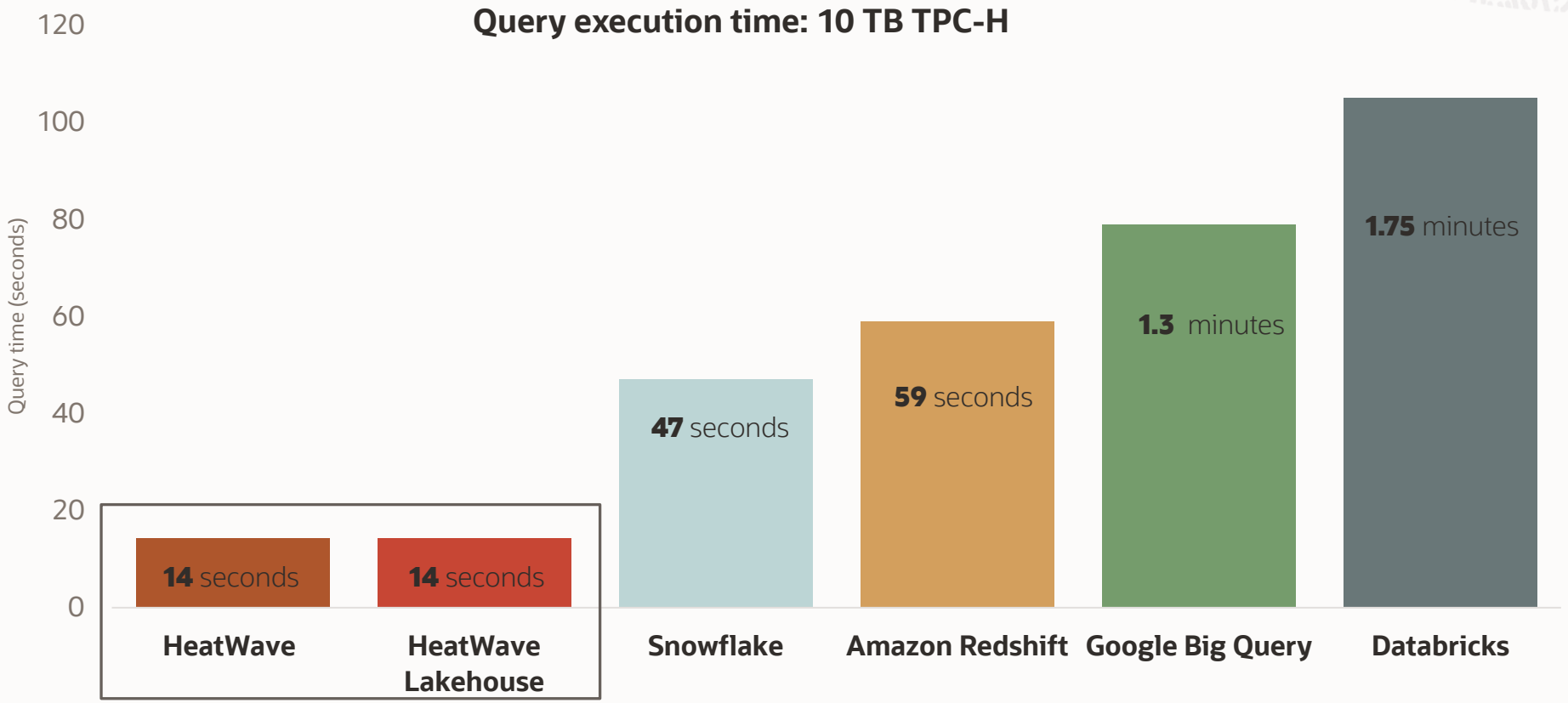
Bulk ingest performance for transactional data

10x faster than Amazon Aurora, uses less memory



Same performance with HeatWave for data in DB or in object store

Develop applications with data on object store without any performance impact



Significantly improves flexibility and reduces costs

Configuration: MySQL HeatWave Lakehouse: 512 nodes; Snowflake: 4X-Large Cluster; Databricks: 3X-Large Cluster; Amazon Redshift: 20-ra3.16xlarge; Google BigQuery: 6400 slots

Benchmark queries are derived from the TPC-H benchmarks, but results are not comparable to published TPC-H benchmark results since these do not comply with the TPC-H specifications.

Challenge #4: Organizations want to use multiple clouds

MySQL HeatWave is optimized for multiple clouds

Maximum flexibility and choice

Optimized for best price performance in each cloud

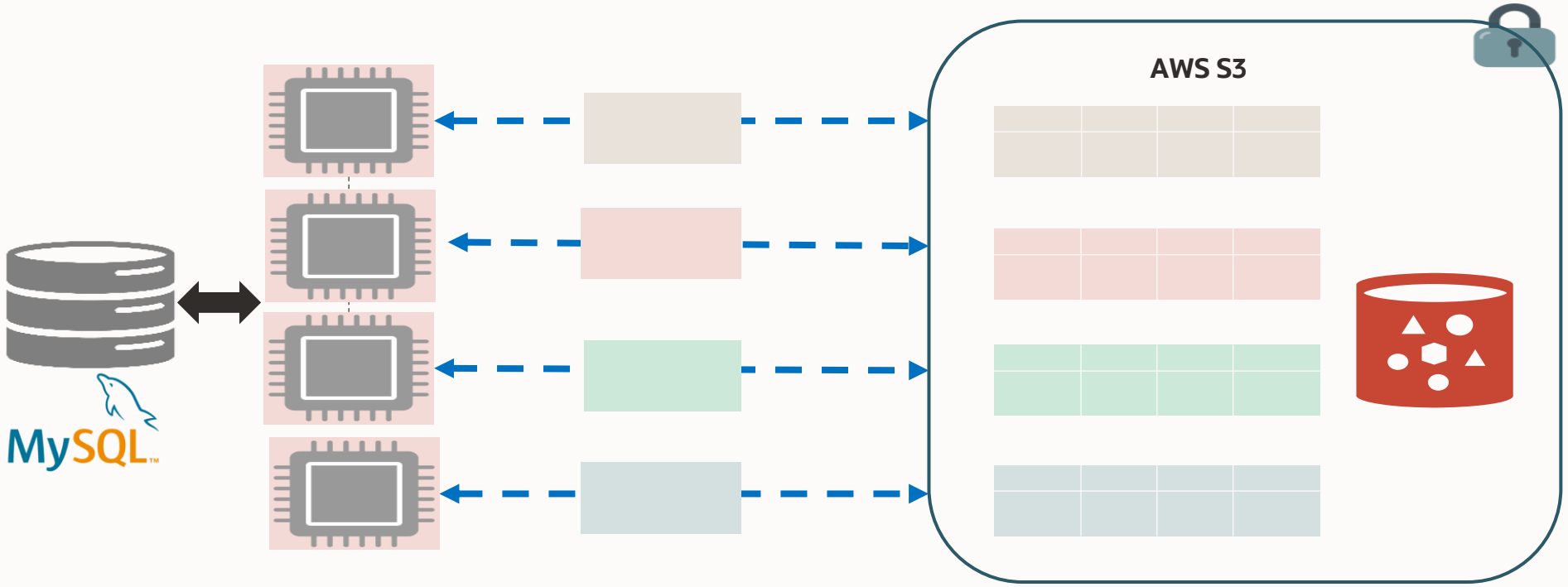
MySQL HeatWave on AWS

- MySQL HeatWave runs natively on AWS, optimized for AWS infrastructure
- Data doesn't leave AWS – saves egress cost, and avoids compliance approvals
- Lowest latency access to MySQL HeatWave
- Tight integration with the AWS ecosystem – S3, CloudWatch, PrivateLink
- Easier migration from other databases (e.g., Amazon Aurora, Redshift, Snowflake)

Combine 5 AWS services into ONE

Scalable HeatWave storage for AWS service

Data reload in MySQL HeatWave in constant time



- Improves reload performance
- Reload doesn't impact OLTP performance
- Improves availability

Table	Earlier	Now	Speedup
LINEITEM	140 min	3.5 min	40x
ORDERS	33 min	43 sec	46x
CUSTOMER	14 min	9 sec	93x

Roadmap of capabilities on OCI and AWS

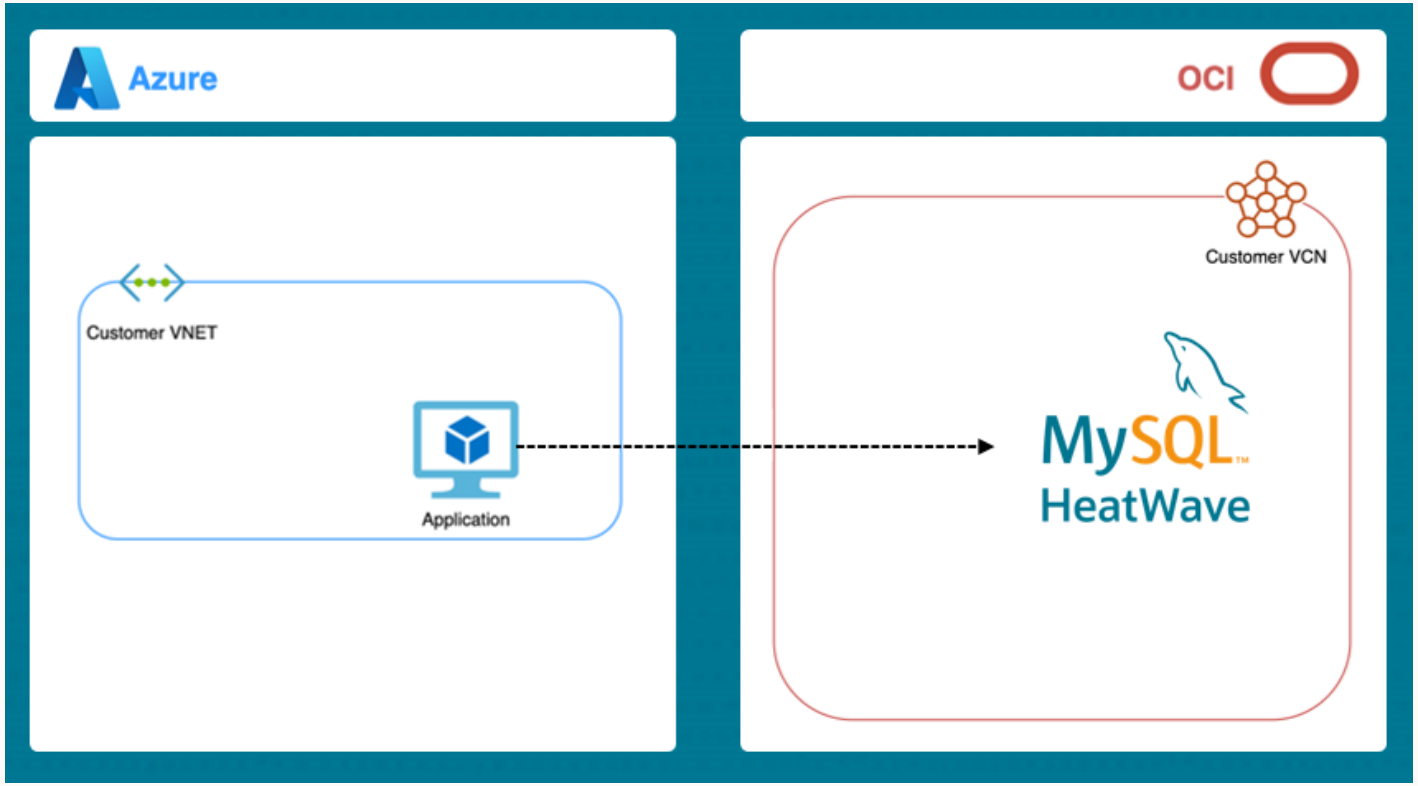
As of March 2024 - https://www.oracle.com/mysql/roadmap

Key capabilities	Available on OCI	Available on AWS
Fully managed service	✓	✓
OLTP and OLAP in MySQL	✓	✓
Query acceleration for analytics and mixed workloads	✓	✓
Machine learning-powered automation (MySQL Autopilot for HeatWave and OLTP)*	✓	✓
Advanced security*	✓	✓
In-database machine learning (HeatWave AutoML)	✓	✓
Scale-out data management	✓	✓
Interactive query and data management console	Coming soon	✓
Performance and workload monitoring from the console	Coming soon	✓
Interactive MySQL HeatWave AutoML console	Coming soon	✓
Adding HeatWave to any MySQL shape	Coming soon	✓
MySQL HeatWave Lakehouse	✓	Limited availability

* Auto thread pooling and auto shape prediction in MySQL Autopilot as well as the MySQL HeatWave database firewall will be available soon on OCI.

MySQL HeatWave on Azure

Connecting to MySQL HeatWave on OCI from Azure VNET

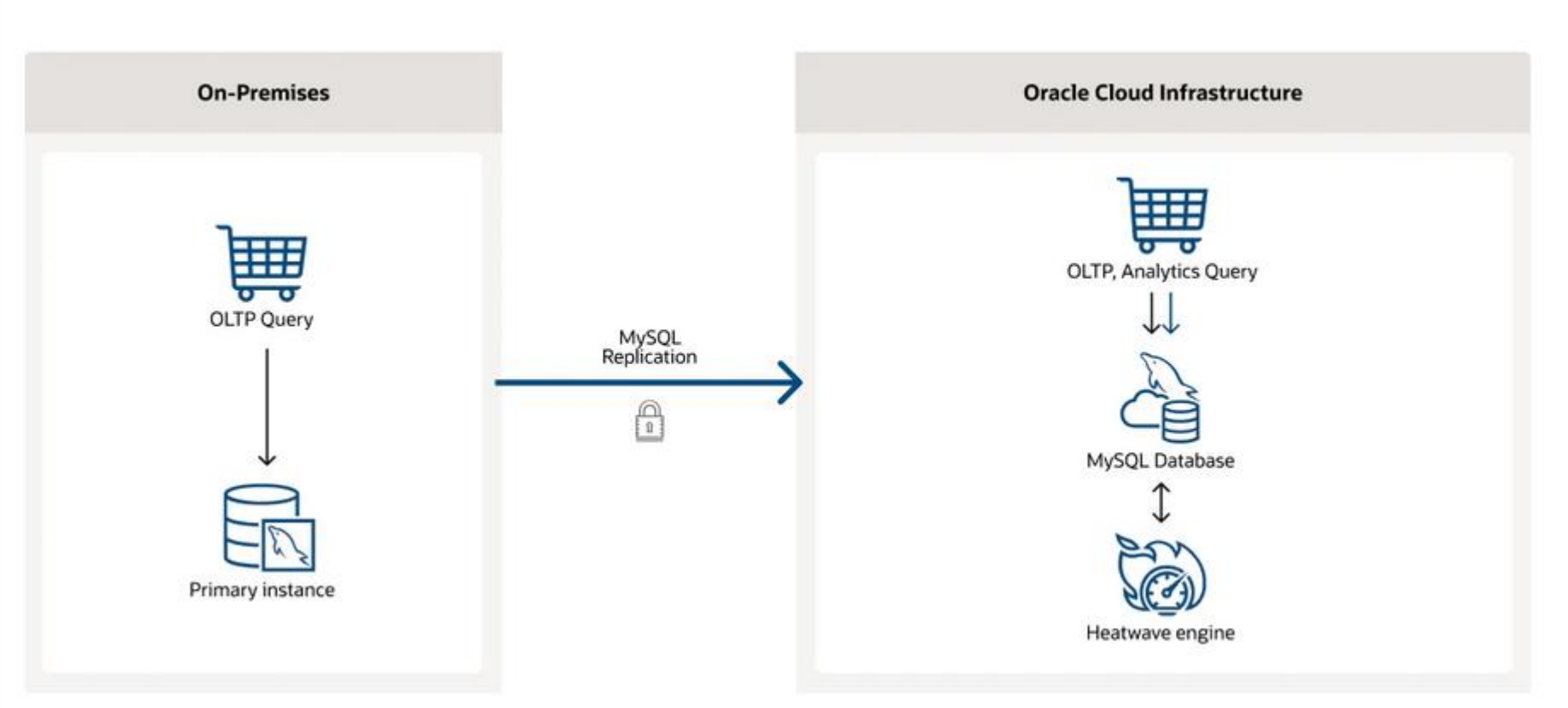


- Familiar Azure-native user experience
- Automated identity, networking, and monitoring integration
- Private interconnect and networking with < 2 ms latency
- Use Microsoft Azure services with MySQL HeatWave
- Collaborative support

https://www.oracle.com/cloud/azure/oracle-database-for-azure

Enabling hybrid deployments

OLTP on-premises, OLAP in the cloud



DB system Inbound and Outbound Replication

Cross-region replication

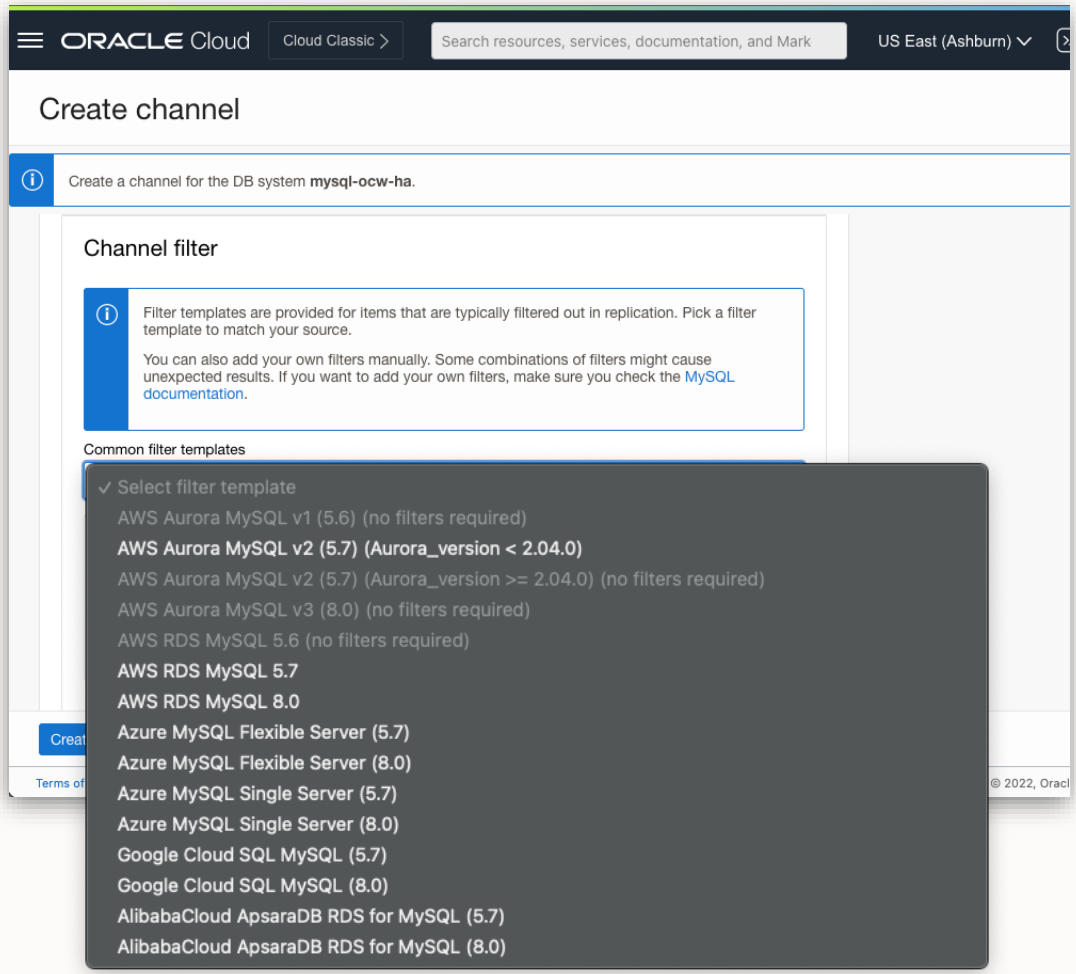
- DB System to DB System

Live Migrations

- Minimize downtime

Hybrid deployments

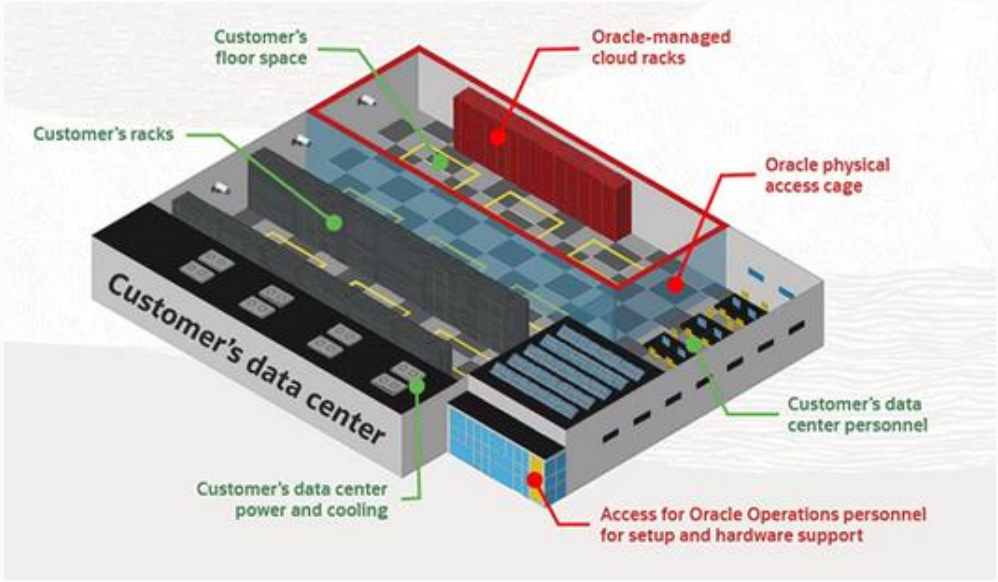
- On-premises and other cloud vendors
- Disaster Recovery
- Capacity bursting
- HeatWave for Analytics, ML, Lakehouse



Available in your data center

OCI Dedicated Region

MySQL HeatWave



Self-contained cloud region

MySQL HeatWave and all Oracle public cloud services in your data center

Public cloud economics and security

Meet data residency and latency requirements

Why MySQL HeatWave for new and existing applications?

Simplicity of OLTP, real-time analytics across DW and data lakes, and ML in ONE cloud database service

Eliminate the cost and complexity of separate analytics database, lakehouse, ML, and ETL services

Avoid the latency and security risks of data movement between data stores

MySQL and Amazon Aurora-based applications work without changes

Unmatched performance and price- performance

MySQL HeatWave:

- 4X faster than Redshift, 10X better price-perf
- 4X faster than Snowflake, 15X better price-perf
- 1,400X faster than Aurora, 2,200X better price-perf

MySQL HeatWave Lakehouse

- 11X better price-performance vs Redshift
- 15X better price-performance vs Databricks
- 19X better price-performance vs Snowflake
- 22X better price-performance vs BigQuery

MySQL Autopilot: automation to achieve high query performance at scale, higher OLTP throughput, and get the best price-performance

Ready for the distributed cloud

Deploy on OCI, AWS, Azure

Replicate data from OLTP on-premises apps to MySQL HeatWave for analytics in the cloud

Deploy in your data center with OCI Dedicated Region

Get started with MySQL HeatWave

Get $300 in credits and try free for 30 days

» **oracle.com/mysql/free**

Migrate to MySQL HeatWave with free expert guidance

» **Migration program**

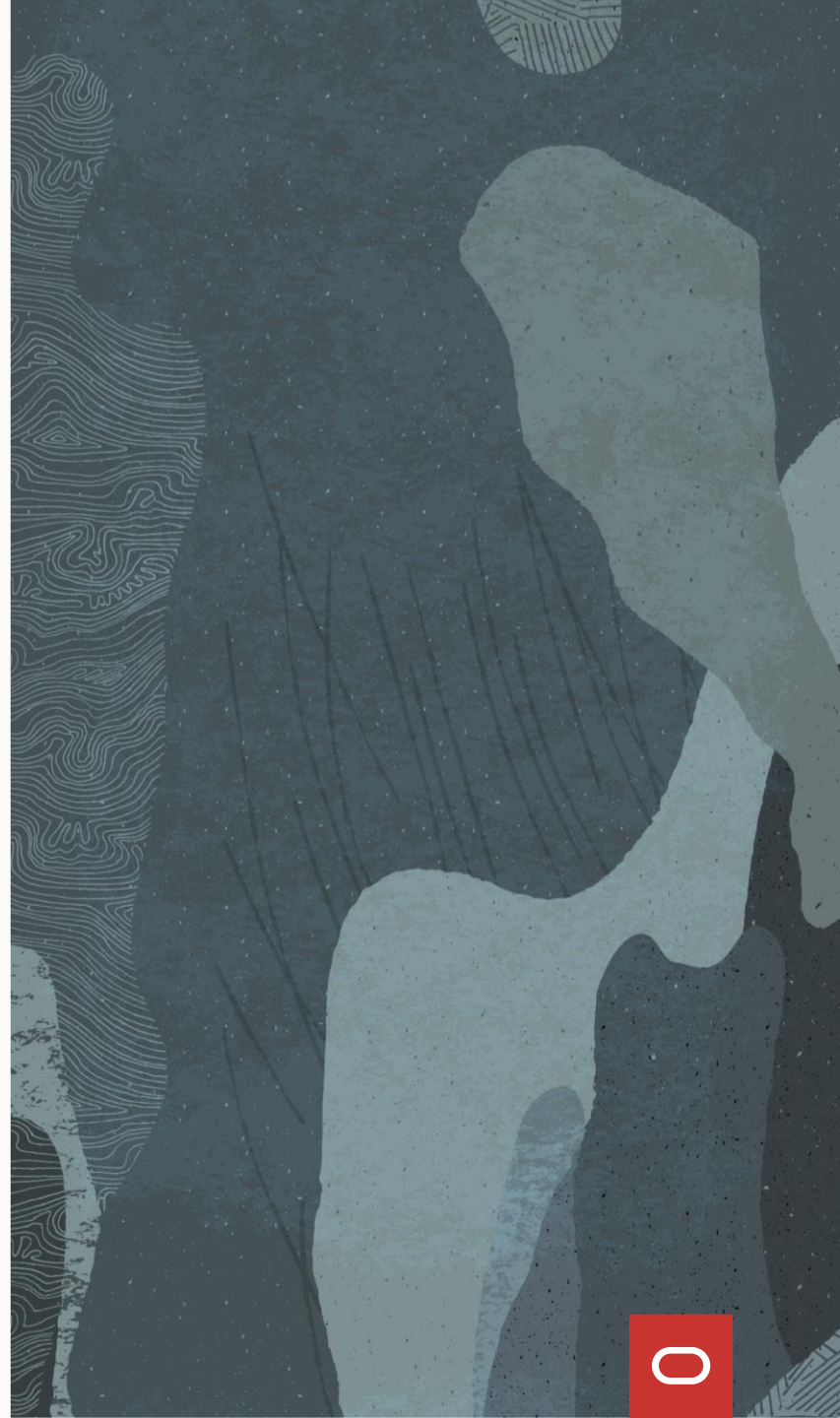
Request a free MySQL HeatWave workshop

» **Ask your account manager**

MySQL HeatWave

Learn more about MySQL HeatWave

» **oracle.com/mysql**

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