



Tech: Project Kit

Applications with MySQL HeatWave

Technical Presentation



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MySQL: An extremely popular database



MySQL is the #1 Open Source Database



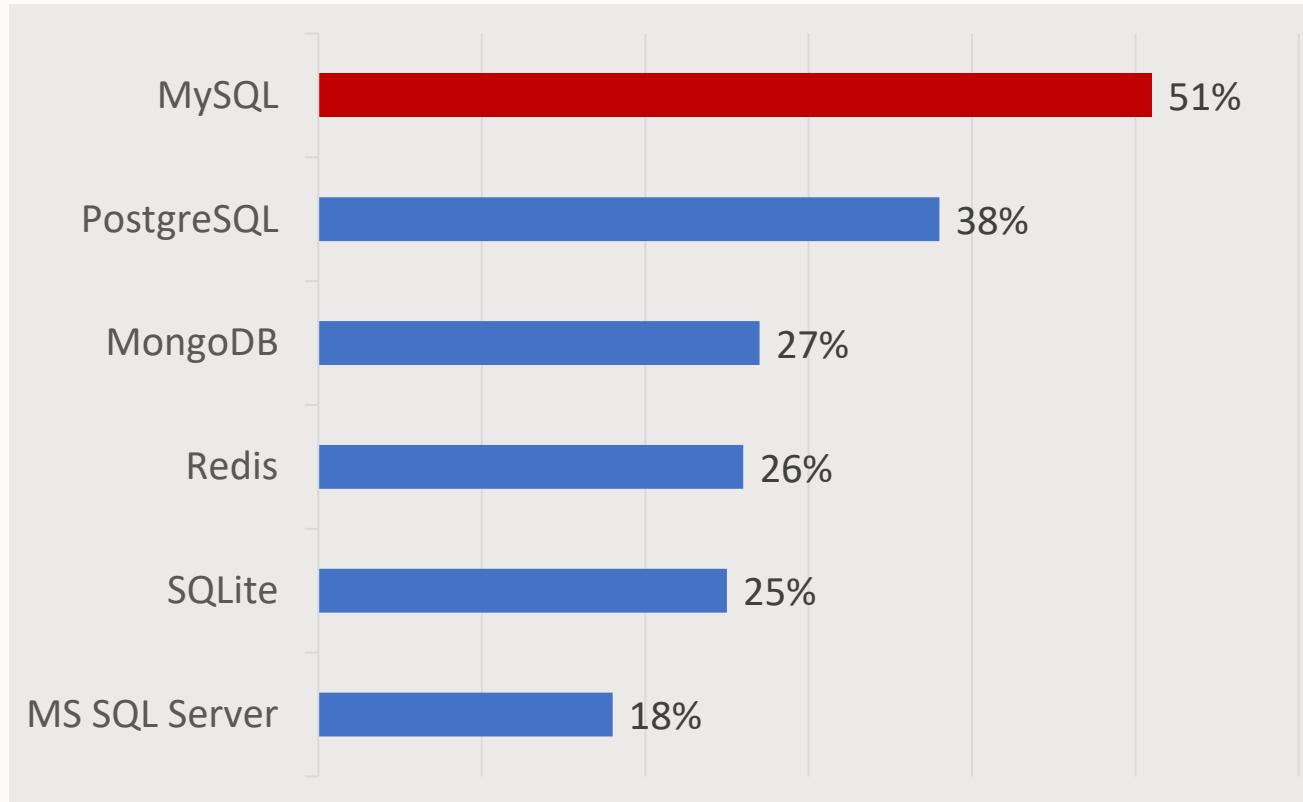
Rank			DBMS	Database Model	Mar 2024
Mar 2024	Feb 2024	Mar 2023			
1.	1.	1.	Oracle 	Relational, Multi-model 	1221.06
2.	2.	2.	MySQL 	Relational, Multi-model 	1101.50
3.	3.	3.	Microsoft SQL Server 	Relational, Multi-model 	845.81
4.	4.	4.	PostgreSQL 	Relational, Multi-model 	634.91
5.	5.	5.	MongoDB 	Document, Multi-model 	424.53

DB-ENGINES

MySQL is the most popular database for developers



Which databases have you used in the last 12 months?



[Jetbrains survey 2023](#)

Innovative organizations across many industries run MySQL – Do you?

Social

facebook



Linkedin



Pinterest

E-Commerce

Booking.com

NETFLIX

U B E R



淘宝网
Taobao.com

阿里巴巴
Alibaba.com™

Tech

APPDYNAMICS
part of Cisco

GitHub

HubSpot

zendesk

intuit
mint

New Relic

Finance

Bank of America



J.P.Morgan

citi

Fidelity
INVESTMENTS

VISA

CA

Manufacturing

TESLA



TOYOTA

CAT®

MySQL powers Open Source applications

Custom Apps Development



django



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

Want to leverage ML and generative AI on all their data

Spend too much time on manual management tasks

Want to use multiple clouds

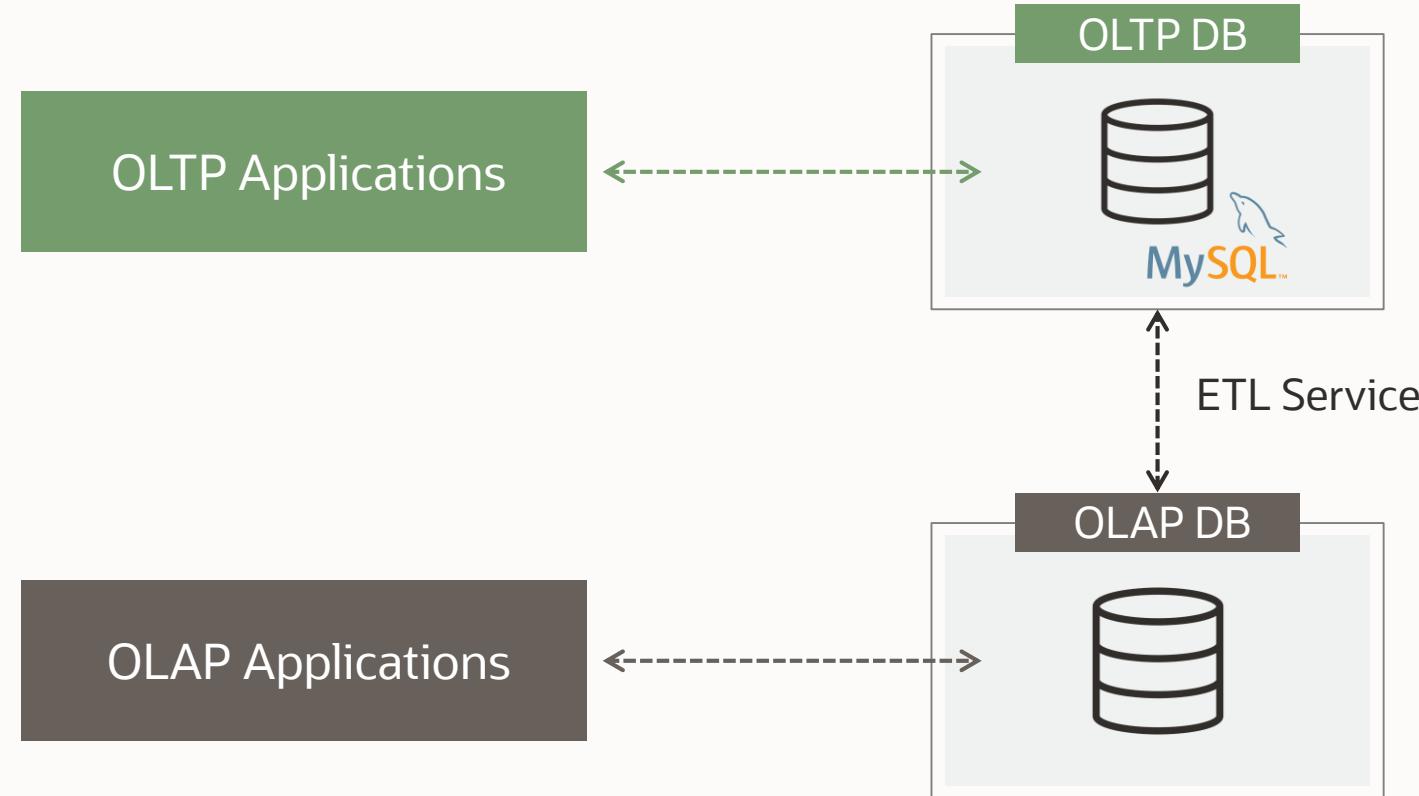
We provide one MySQL cloud database service for OLTP and real-time analytics across data warehouses and data lakes—without ETL duplication

We provide automated in-database ML with an explanation of models and results, without ETL, plus generative AI with Vector store (private preview)

We provide a fully managed database service with machine learning-powered automation and built-in advanced security features

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

Social, eCommerce, gaming, healthcare, fintech, IoT apps. Analytics and ML tools.



ORACLE
Analytics Cloud

Apache Zeppelin



↓ Queries

↑ Results

MySQL HeatWave



OLTP



Analytics



In-database ML



Autopilot

Object Store



Parquet

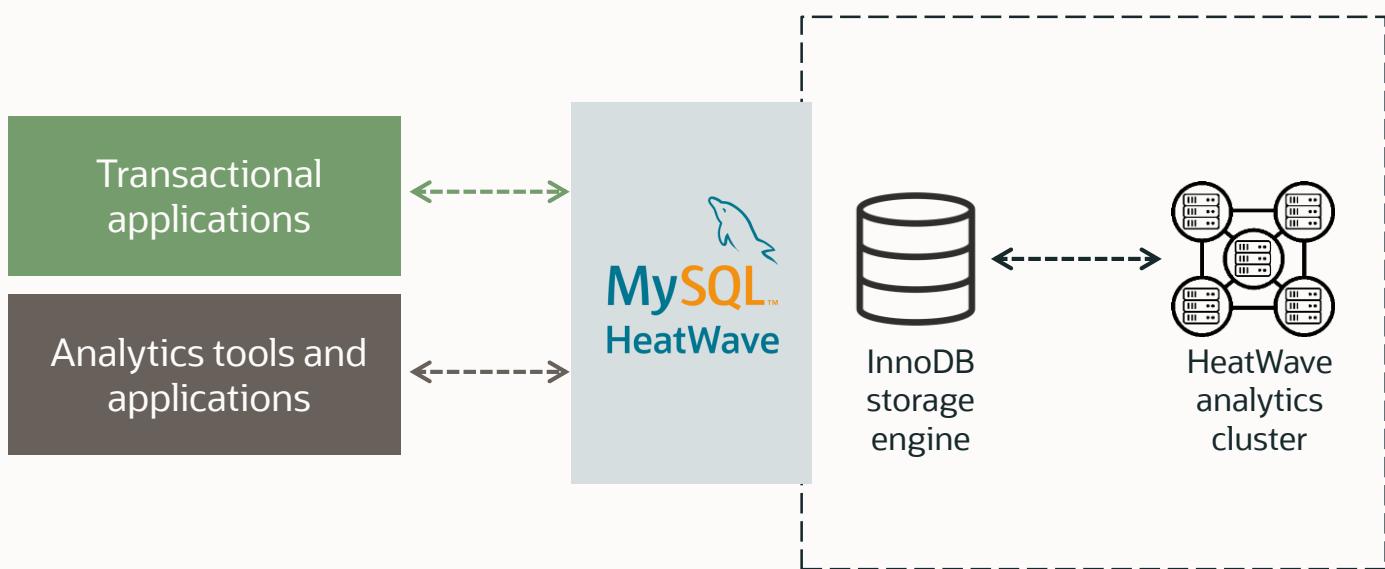


Database exports

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 OLTP & OLAP

No ETL duplication

Unmatched performance, at a fraction of the cost

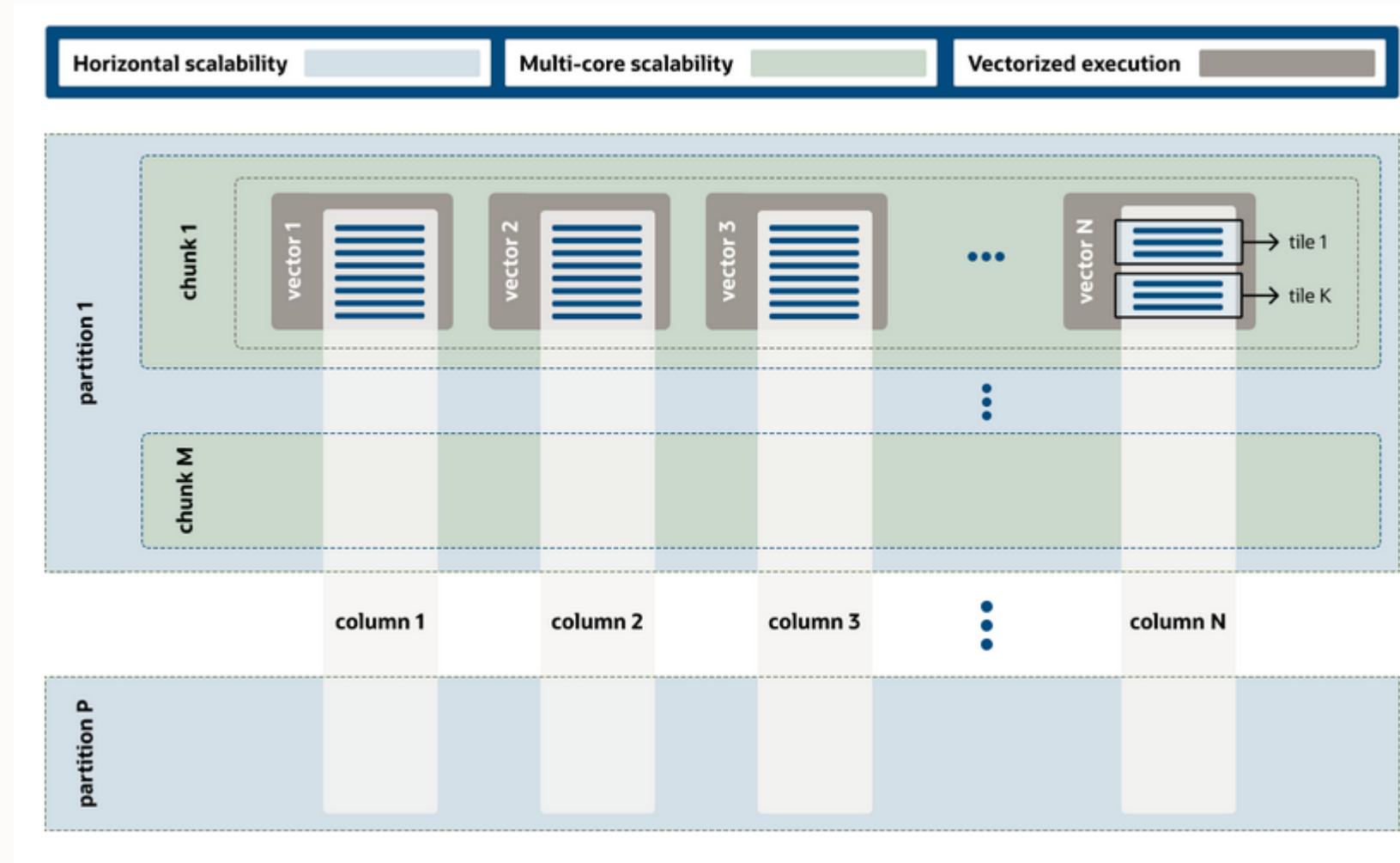
Real-time analytics

Improved security

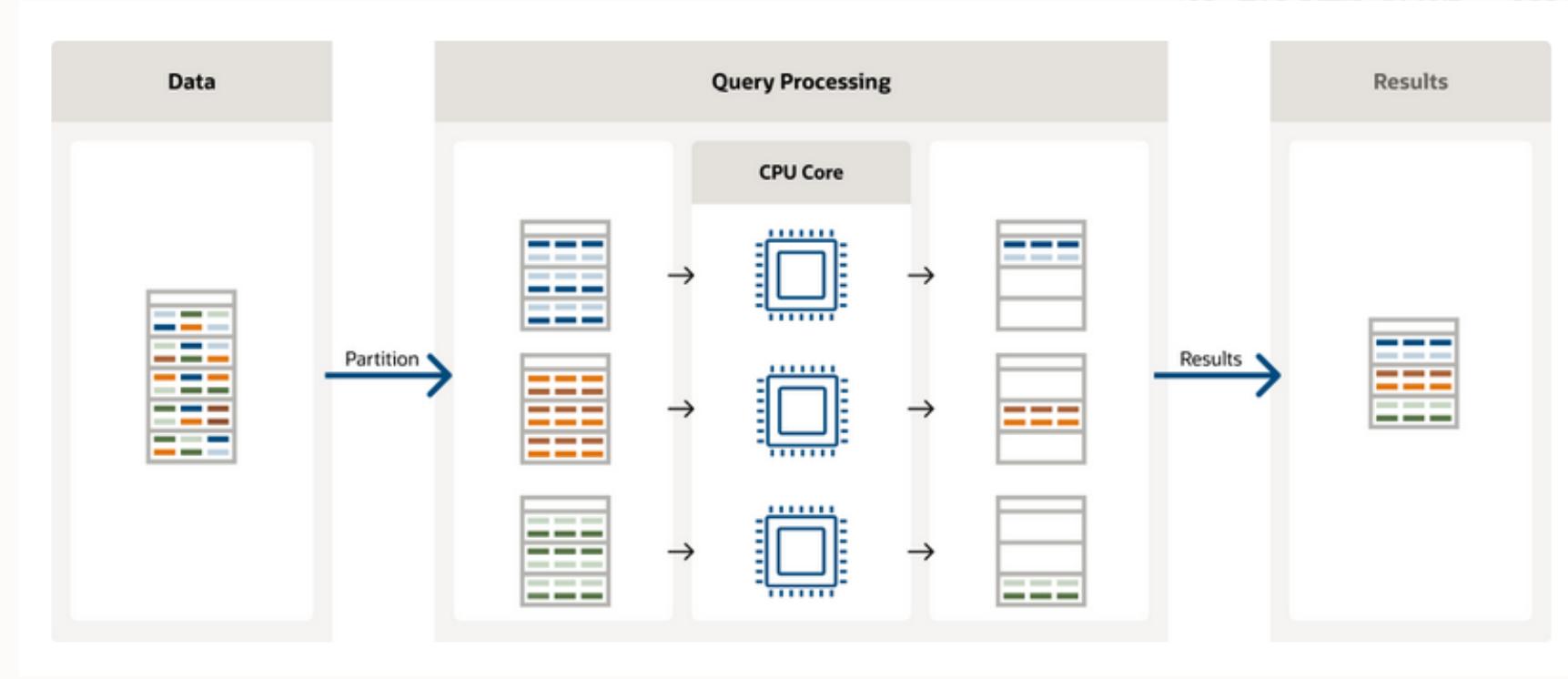
Applications work without changes

1>2 with MySQL HeatWave

In-Memory hybrid columnar processing



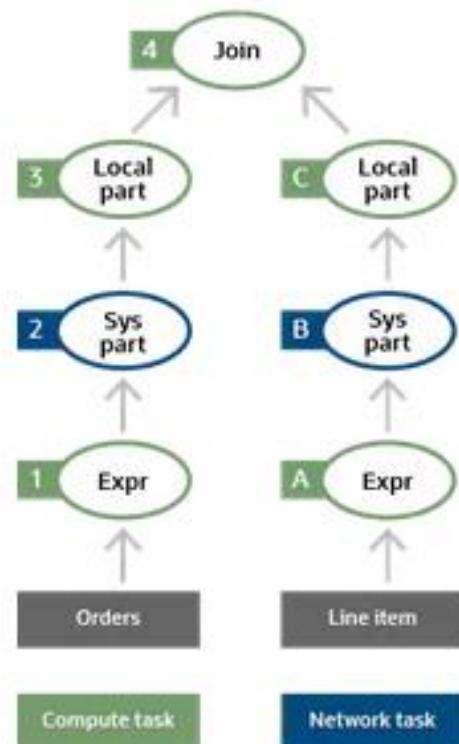
Massively parallel architecture



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

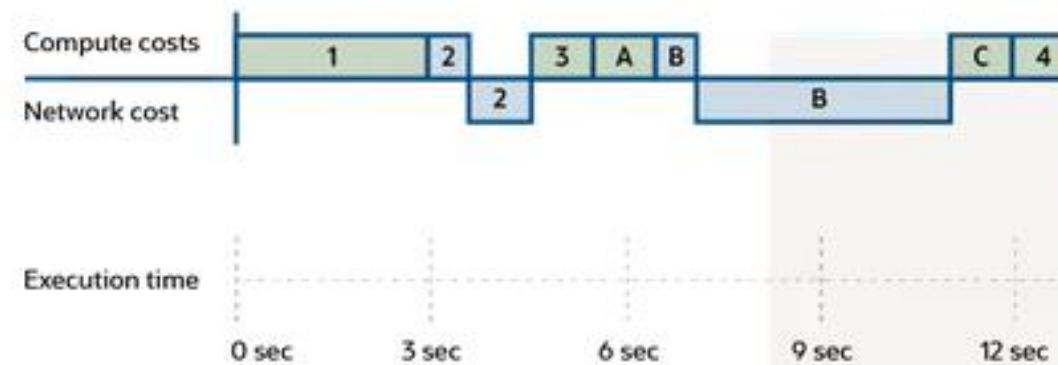
Overlap compute with communication

Example query plan



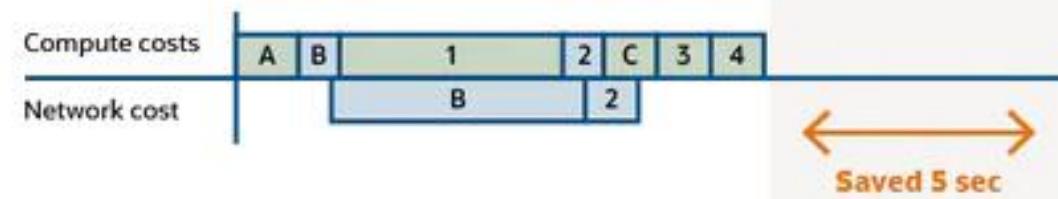
Previously

- 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)

Edit Backup Plan

Enable automatic backups
Enables automatic backups. You must also specify a retention period, and select a backup window.

Backup retention period *Optional*
The retention period defines how long to store the backups, in days. [\(i\)](#)

▼ ▲

Enable point in time restore [\(i\)](#)
Enables you to restore from a DB system at a point in time.

Select backup window
The backup window start time defines the start of the time period during which your DB system is backed up.

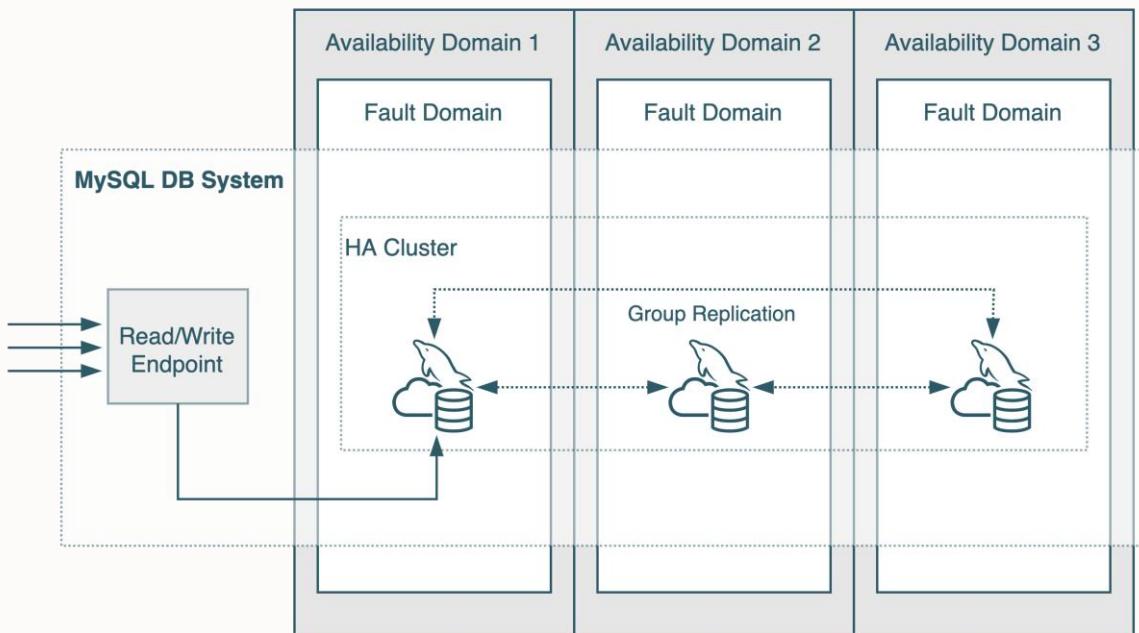
Window start time

[Show backup windows per region](#)



High Availability

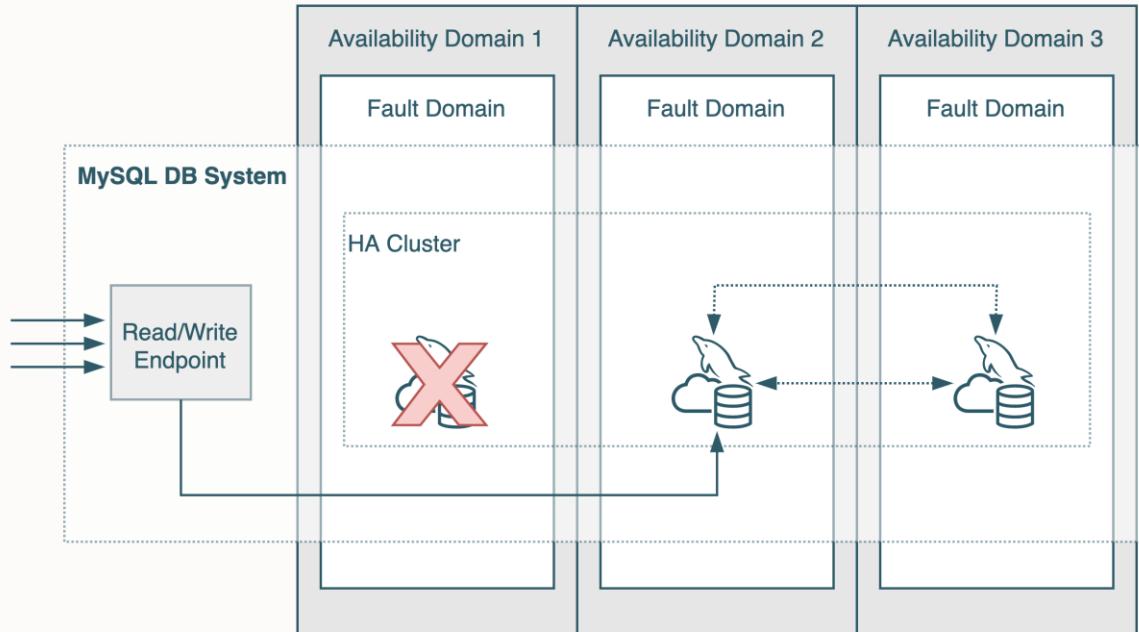
Single-click HA



Screenshot of the Oracle Cloud Create DB System interface. The page title is "Create DB System". The "Name" field is filled with "mysql-ocw-ha". The "Description" field is optional and empty. There are three options for the DB System type: "Standalone" (Single-instance DB System), "High Availability" (Run a DB system with 3 MySQL instances providing automatic failover and zero data loss, which is selected and highlighted with a blue border and checkedmark), and "HeatWave" (DB System that allows you to enable HeatWave for accelerated query processing, suitable for running both OLTP and OLAP workloads). Below the type selection is a section for "Create Administrator credentials" with a "Username" field containing "admin". At the bottom are "Create" and "Cancel" buttons, and links for "Terms of Use and Privacy" and "Cookie Preferences". The footer copyright notice is "Copyright © 2022, Oracle and/or its affiliates. All rights reserved." A red bar at the bottom right contains the Oracle logo.

High Availability

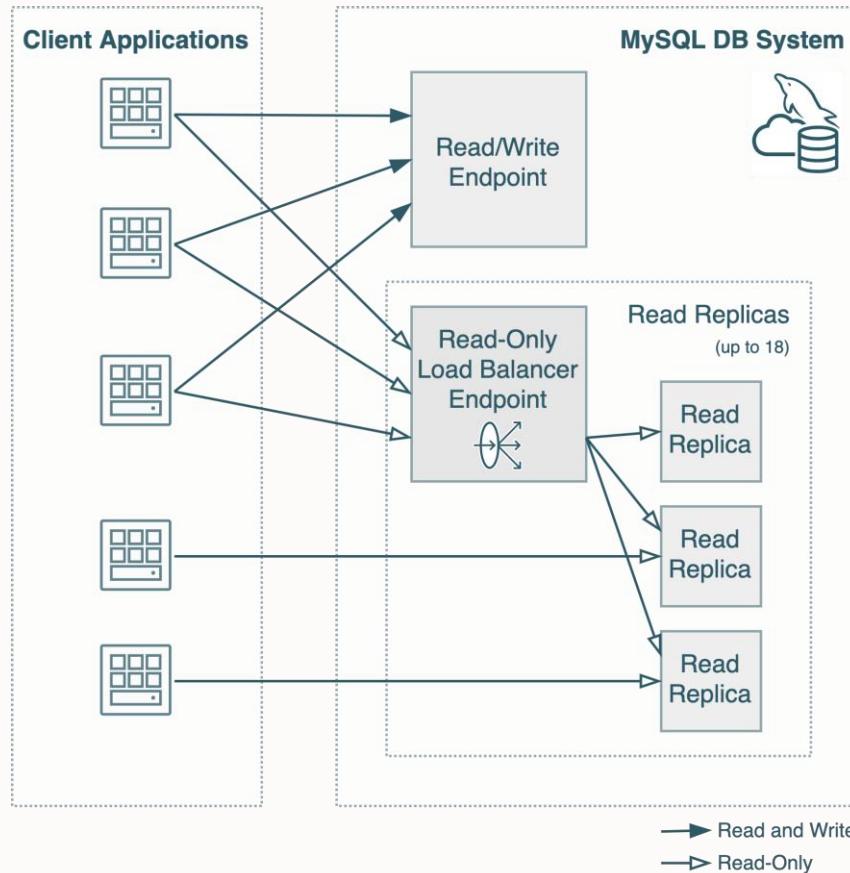
Single-click HA



- 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 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



Create read replica

Create a read replica for the DB system **dbsystem**

Name: mysqlreadreplica20230130171946

Description Optional: Write a description

Hide advanced options

Deletion plan Tags

Delete protected
Protects the read replica and its associated DB system against delete operations. By default, read replicas and DB systems are not delete protected. If you want to delete either the read replica or its associated DB system, deselect the option.

Create read replica **Cancel**

Load Balancer

Use Your Replicas Efficiently



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

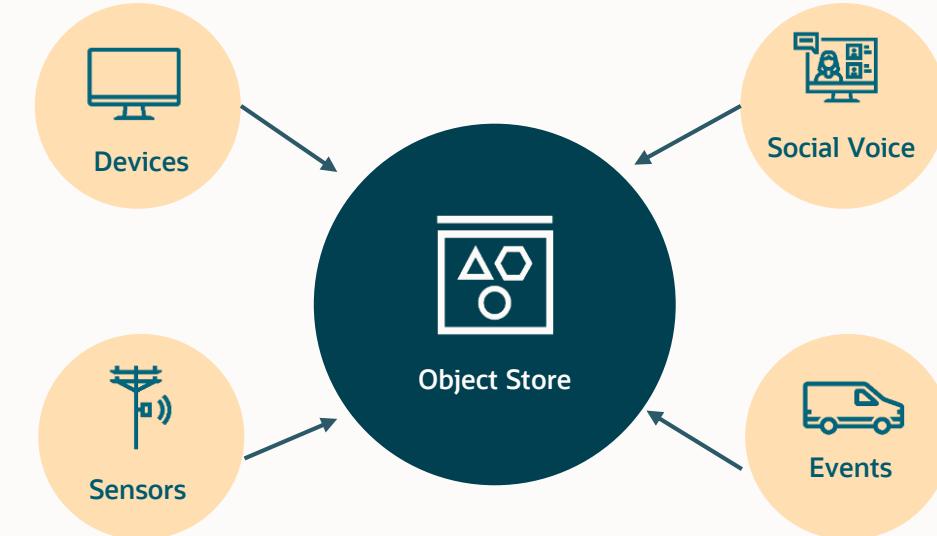
- Managed by the service
- Materializes as a Read-Only endpoint
- Round robins traffic across Read Replicas
- Manages Read Replica backends automatically

Endpoints

Endpoints									<input type="text"/> Search
Endpoint	State	Modes	Type	Hostname	Address	MySQL Port	MySQL X Protocol Port		
Read replica load balancer	● Active	READ	Load balancer	-	100.101.74.228	3306	33060	:	
mysqlreadreplica20230130171946	● Active	READ	Read replica	-	100.101.74.146	3306	33060	:	
DB system primary	● Active	READ, WRITE	Primary DB system	-	100.101.74.80	3306	33060	:	
Showing 3 Items									< 1 of 1 >

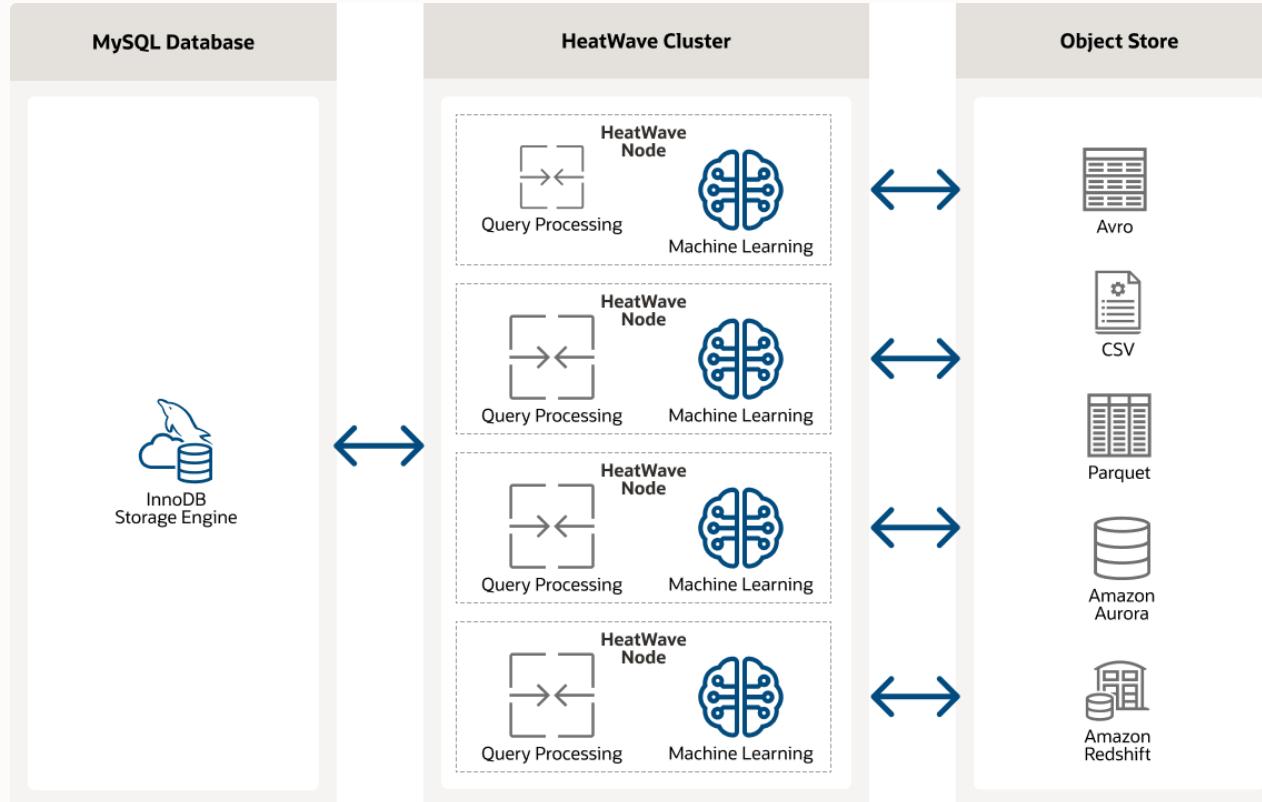
Massive amount of data stored in files

- 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

Very simple to query files in the object store

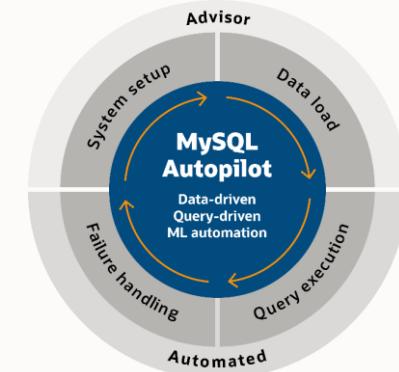
STANDARD SQL syntax generated by MySQL Autopilot, no human required

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

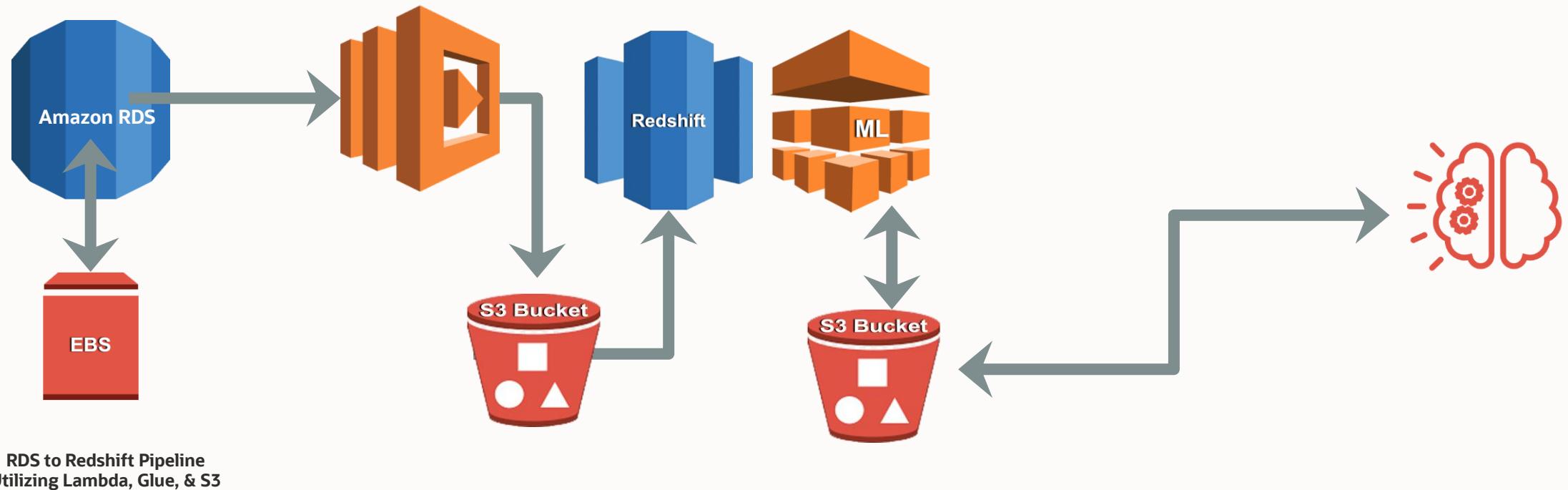
```
➤ mysql> SELECT count(*) FROM Sensor, SALES WHERE Sensor.degrees > 30 AND Sensor.date =  
SALES.date;
```



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

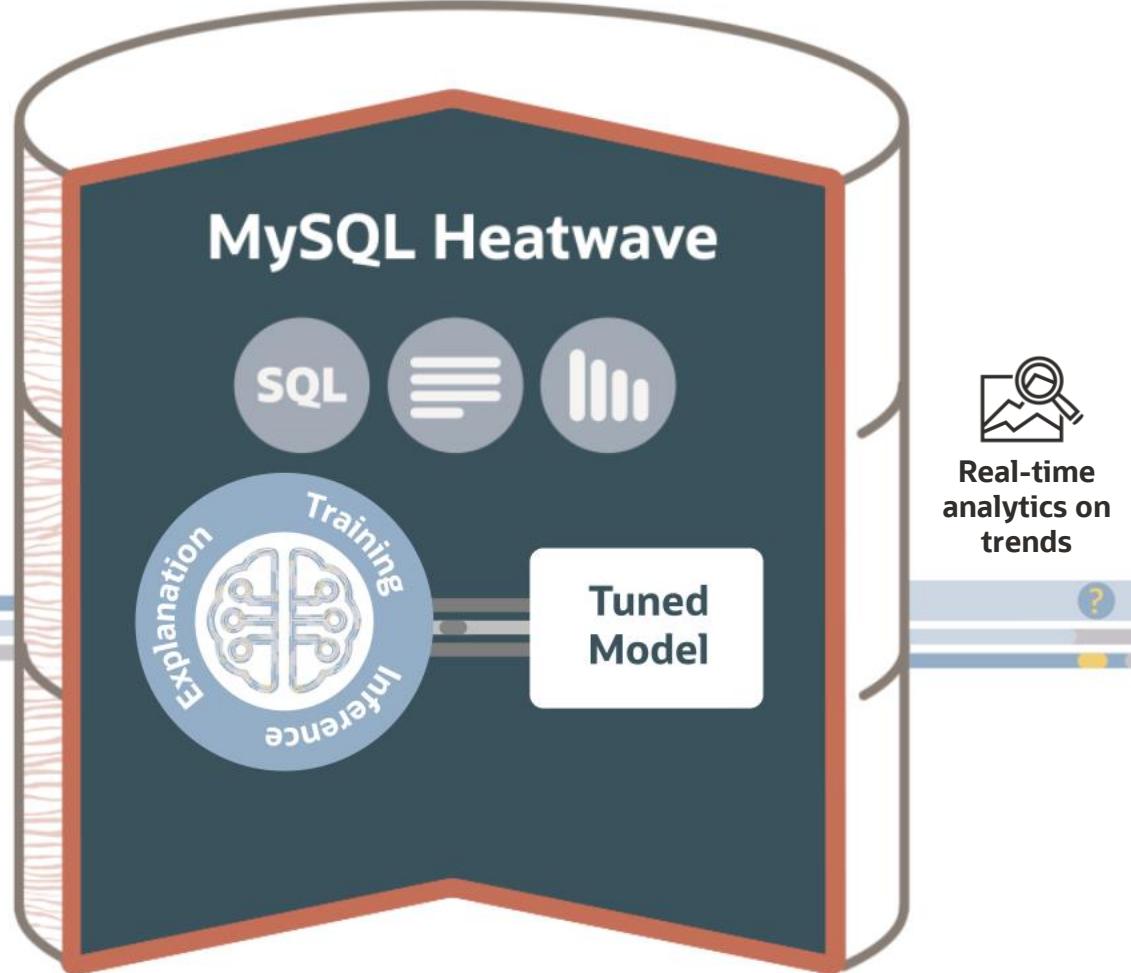
The pain of using AWS services

Amazon Redshift with RDS and ML Modeling



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

Machine learning in action with MySQL HeatWave



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

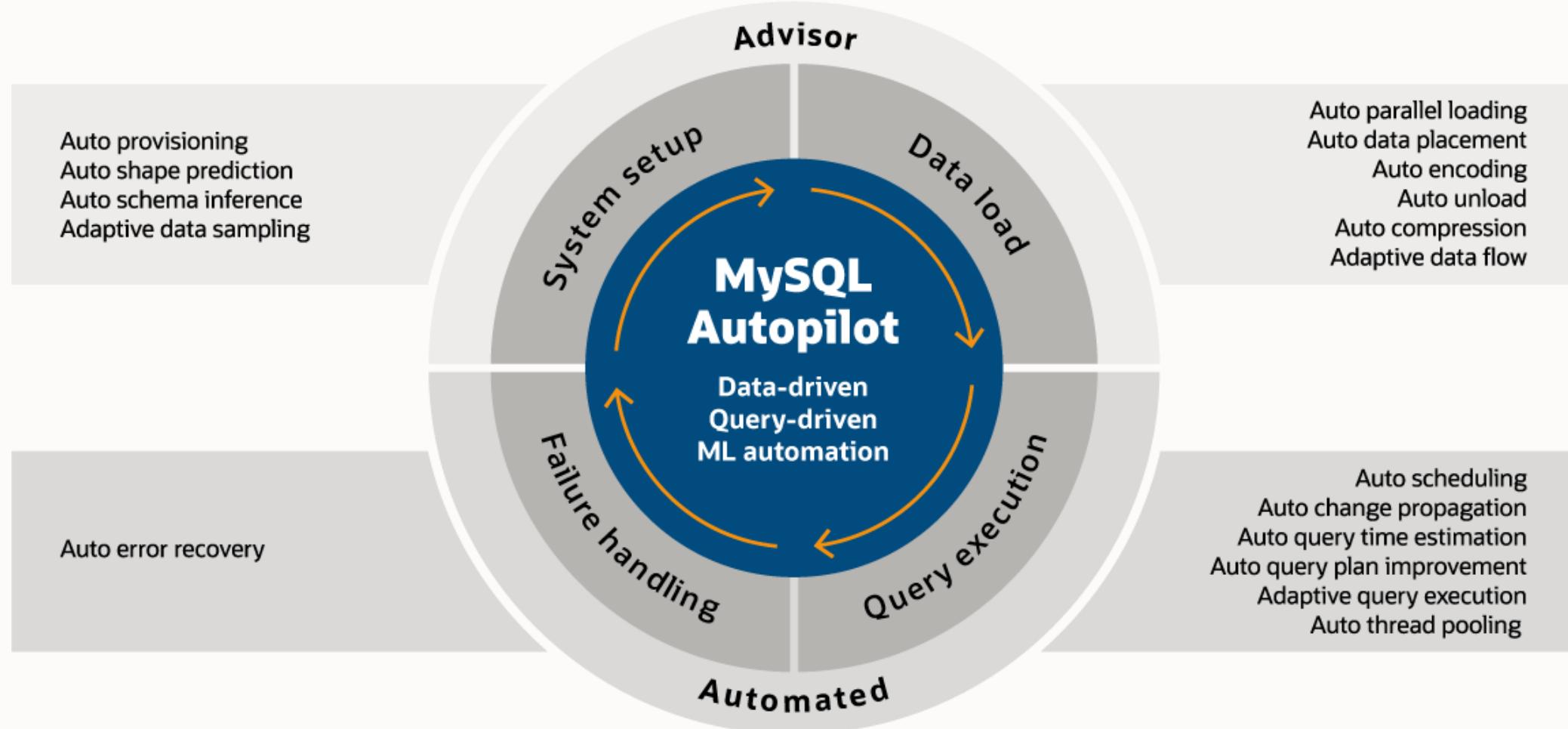
100% developed, managed, and supported by Oracle

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



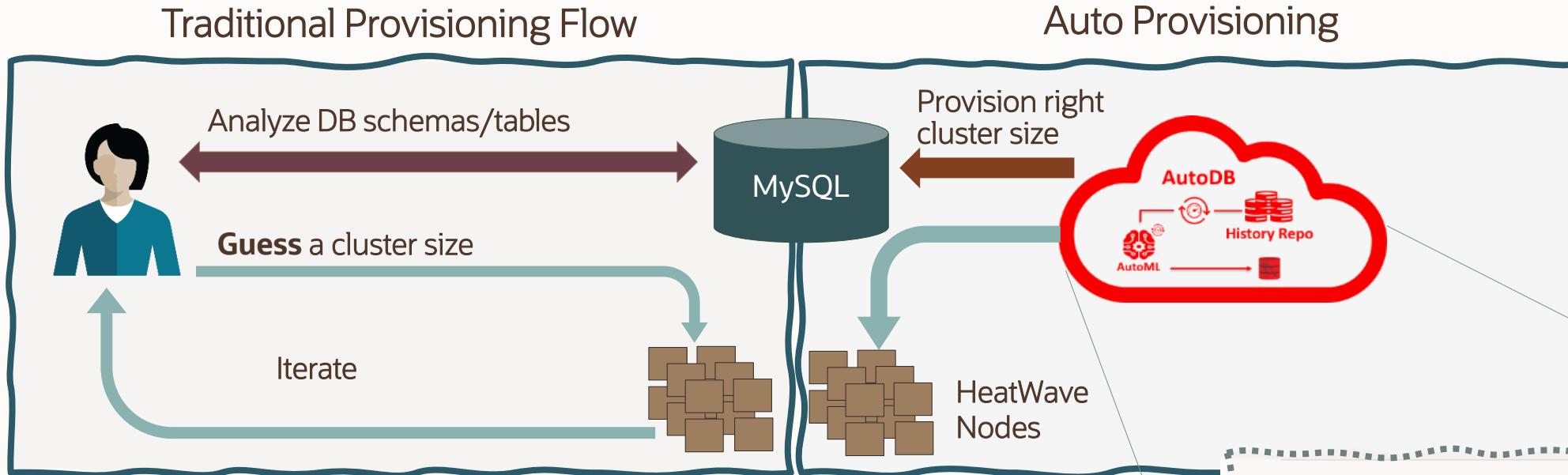
Machine learning-powered automation for MySQL HeatWave

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

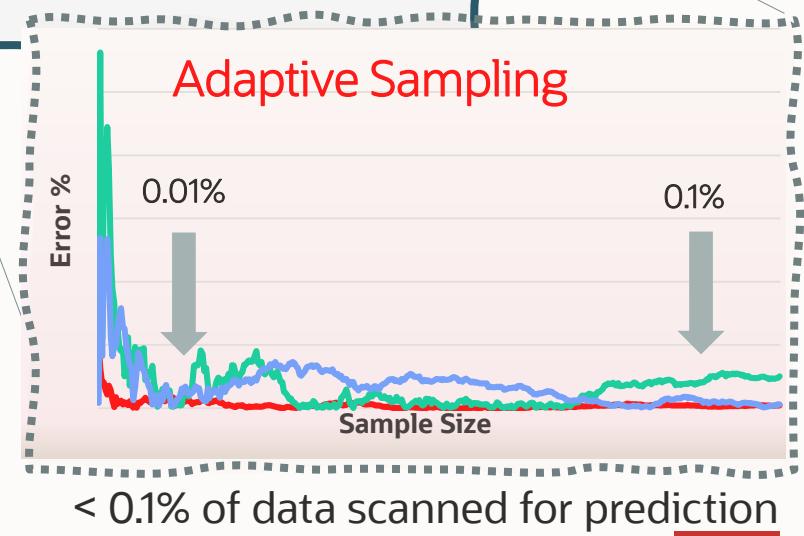


Auto Provisioning

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%



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	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.

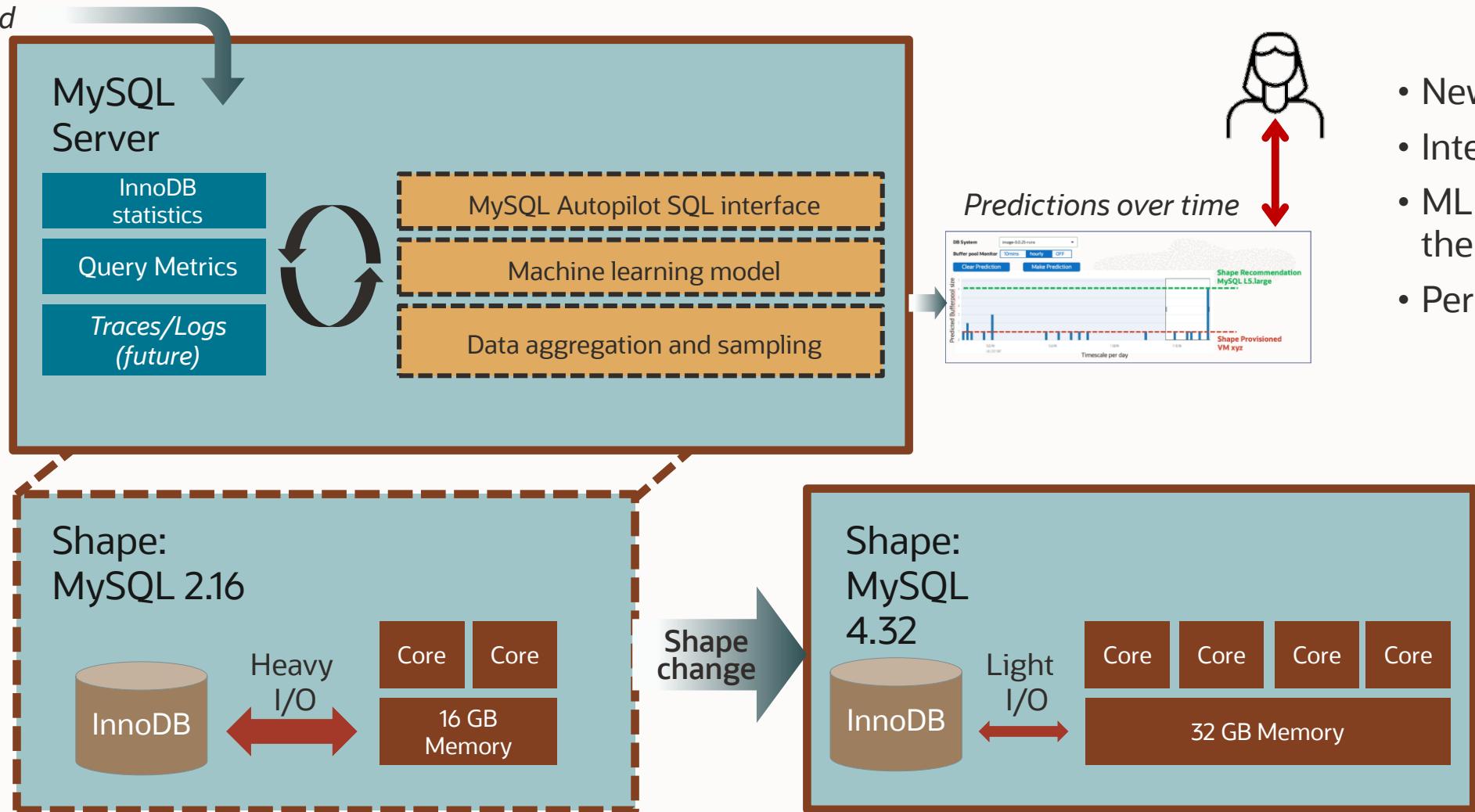
The estimated load time assumes a cluster with sufficient size: 151 512-GB nodes

Please refer to the user manual for more details.

Auto Shape Prediction

Determines the optimal instance type

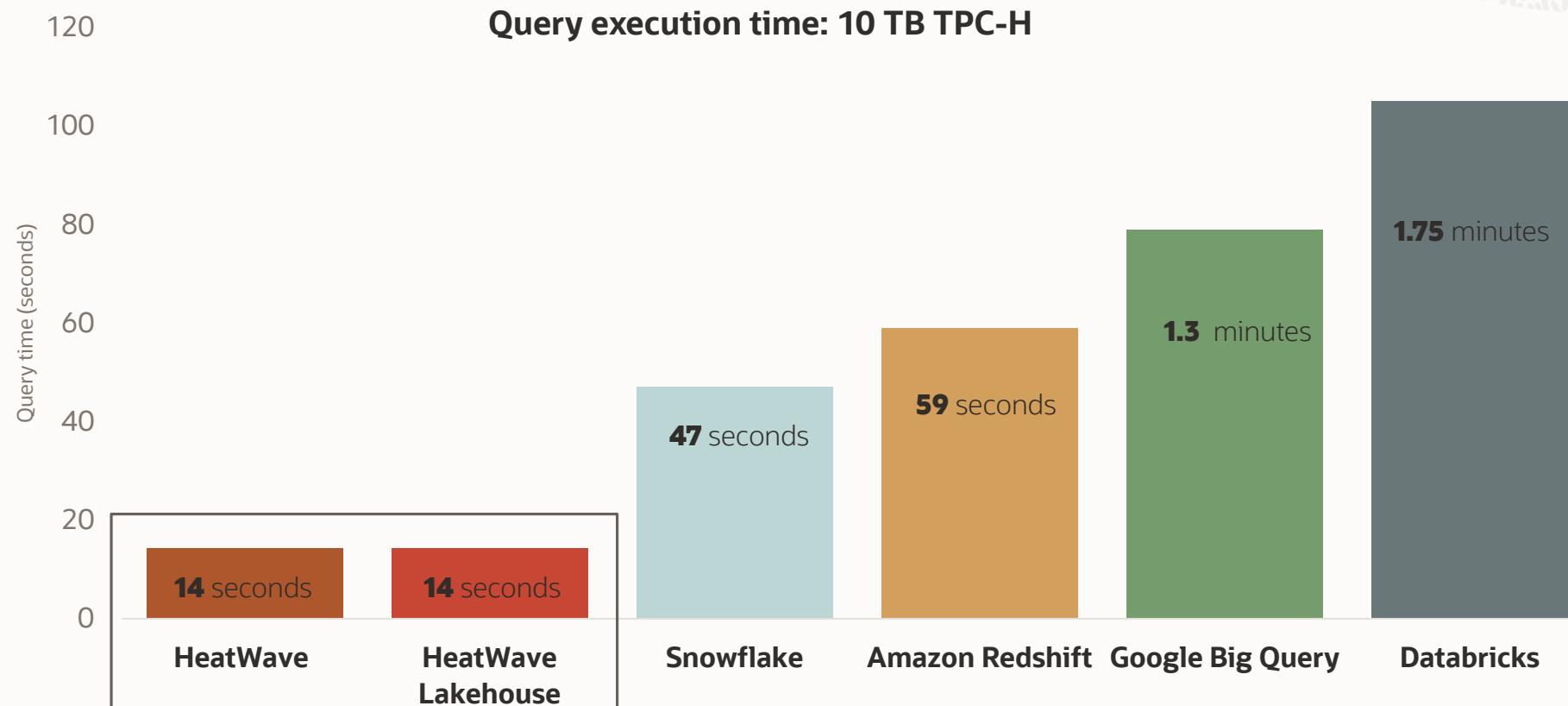
Workload



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

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

Roadmap of capabilities on OCI and AWS

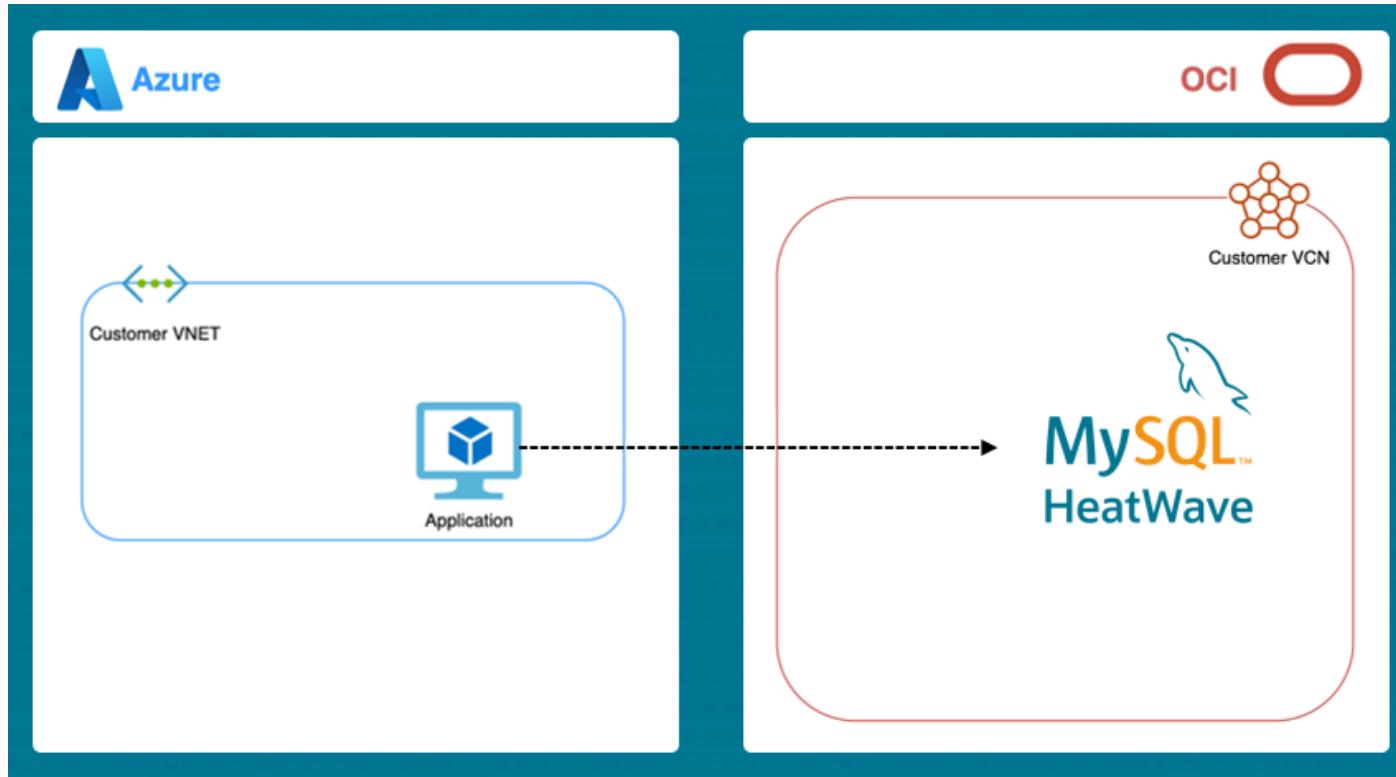
As of March 2024 - <https://www.oracle.com/mysql/roadmap>

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

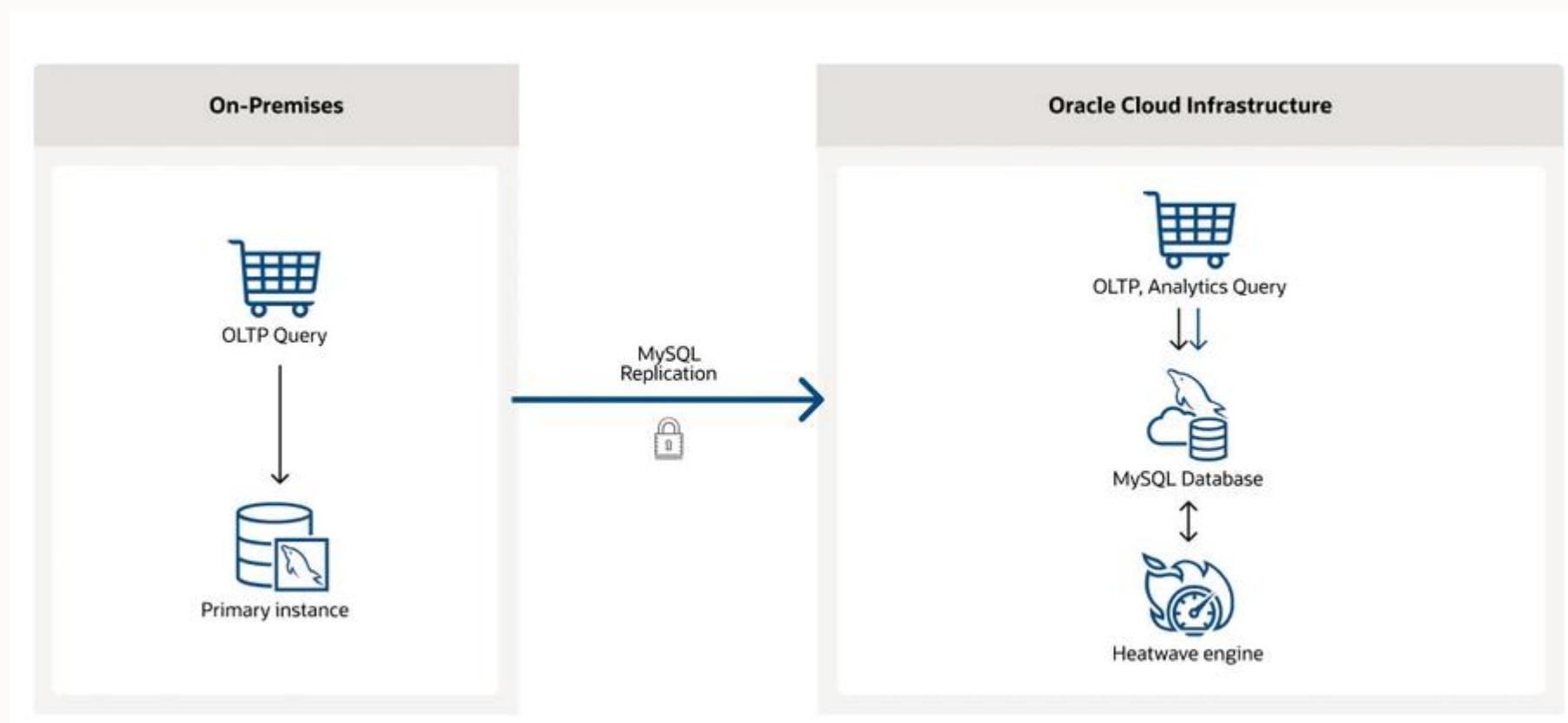


- Familiar Azure-native user experience
- Automated identity, networking, and monitoring integration
- Private interconnect and networking with < 2 ms latency
- Use Microsoft Azure services with MySQL HeatWave
- Collaborative support

<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

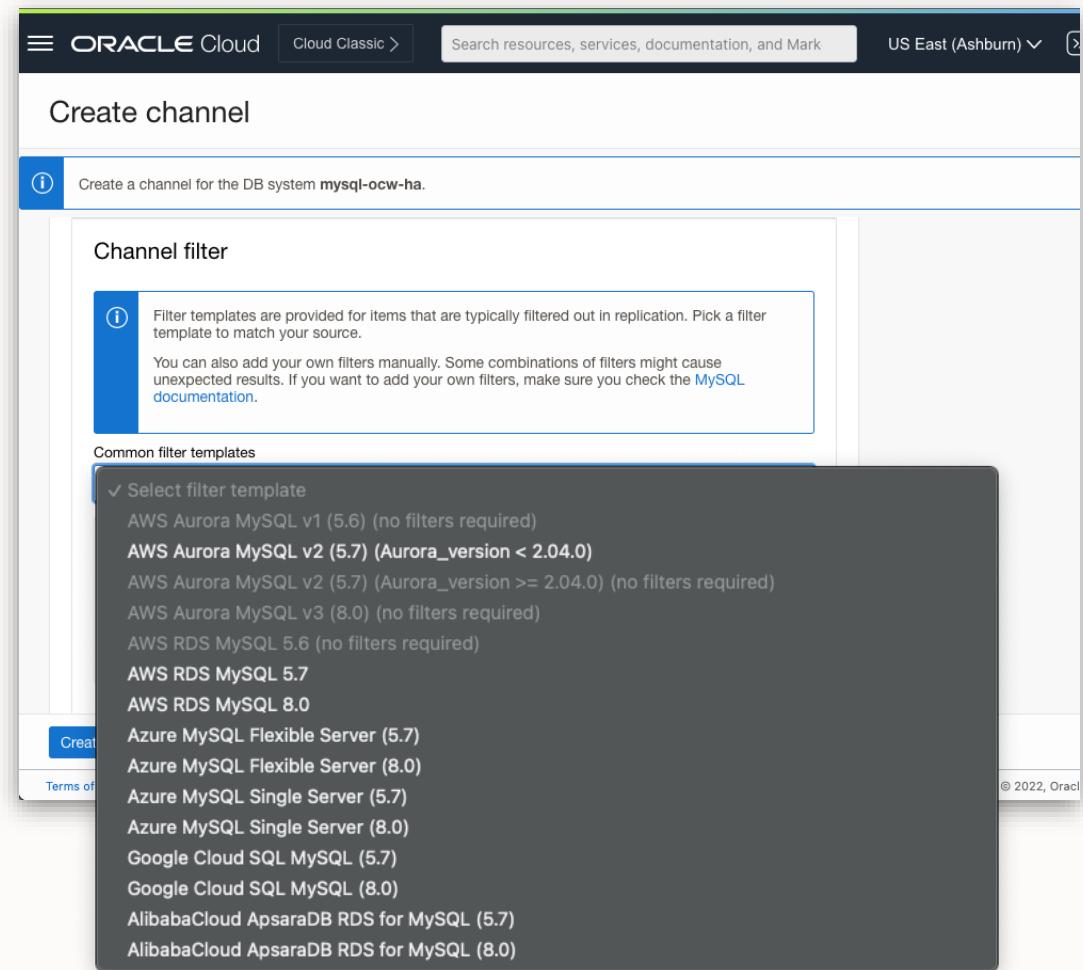
- DB System to DB System

Live Migrations

- Minimize downtime

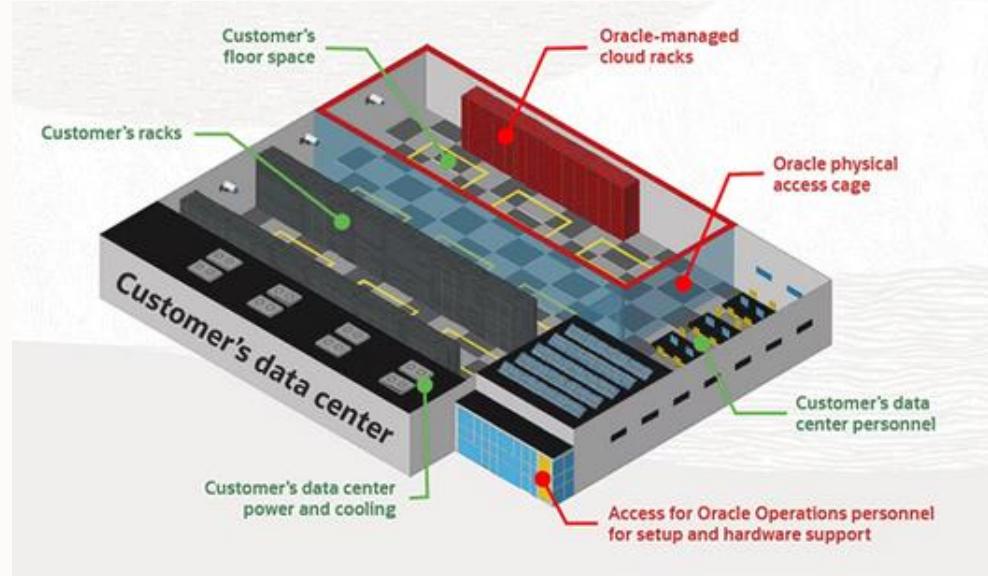
Hybrid deployments

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



Available in your data center

OCI Dedicated Region



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](#)

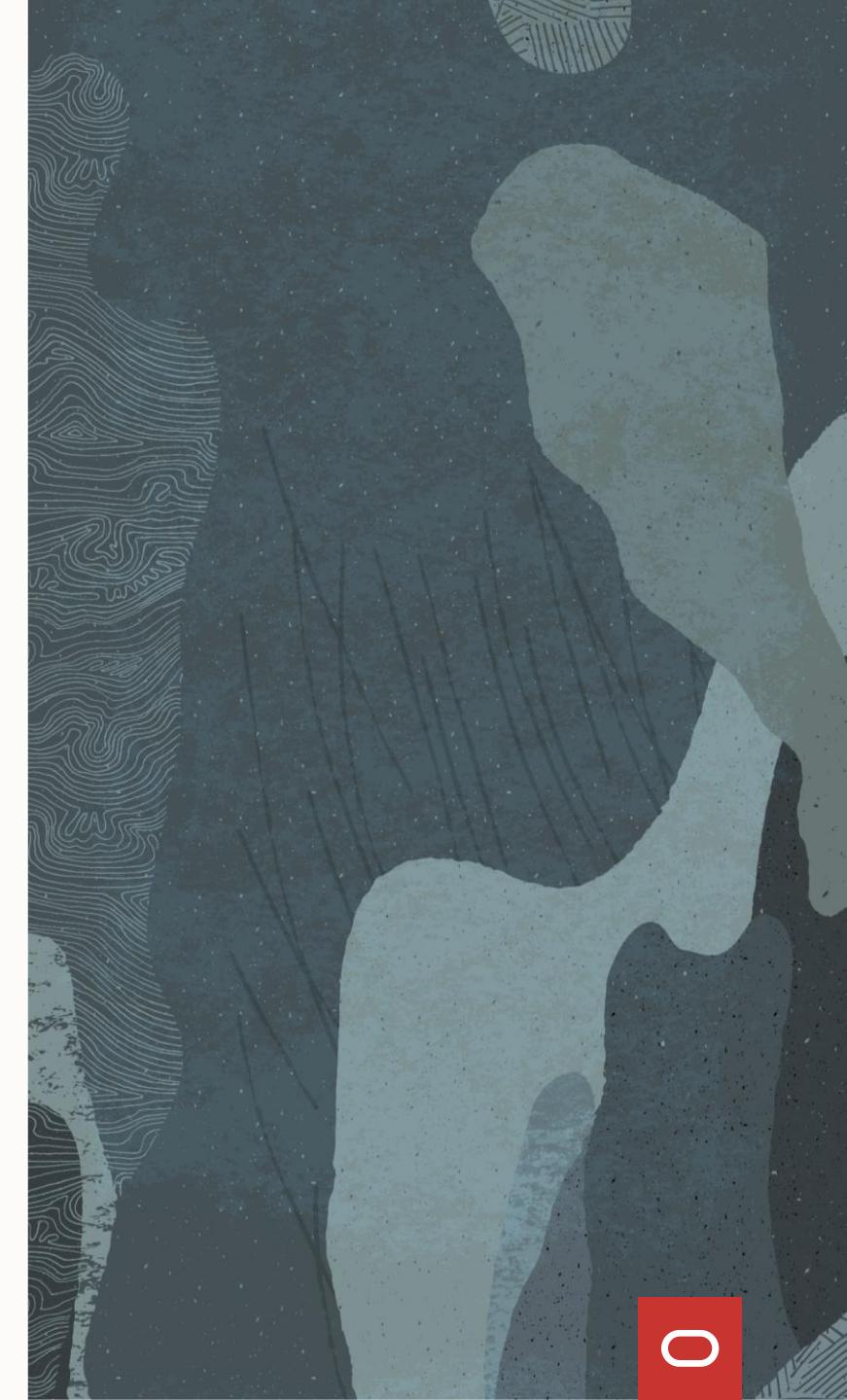
Request a free MySQL HeatWave workshop

» [Ask your account manager](#)



Learn more about MySQL HeatWave

» oracle.com/mysql



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