



MySQL HeatWave Implementation Associate

Exam 1Z0-915-1



Alexandre Fagundes

alexandre.af.fagundes@oracle.com

Cloud Architect, Oracle Latin America

Oracle MySQL Database Administration Certification Paths



MySQL HeatWave Implementation Certified Associate Rel 1

[Overview](#) [Path Steps](#) [Resources](#)

Certification
Paths

Categories

Software

Oracle Database

MySQL HeatWave Implementation Certified Associate Rel 1 Certification Overview

A MySQL HeatWave Implementation Certified Associate has demonstrated the knowledge required to provision, configure, and manage MySQL HeatWave for transactions, analytics, machine learning, and Lakehouse.

Individuals who earn this certification understand how to manage user accounts, connectivity, machine learning, and analytics with MySQL HeatWave Lakehouse.

Exam 1Z0-915-1: MySQL HeatWave Implementation Associate

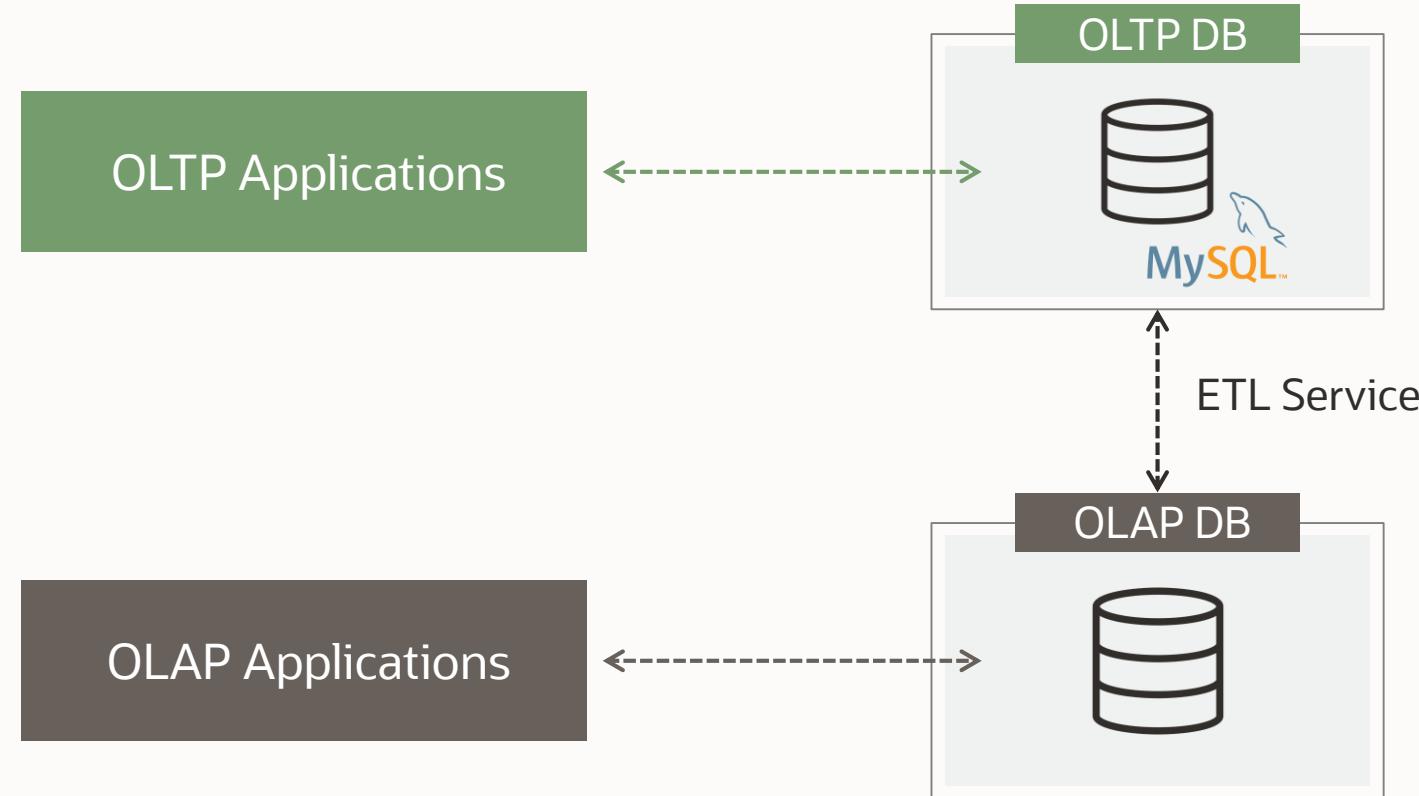
- Create and Manage MySQL Database Service Instances
- Migrate an On-Premise Database to the Cloud
- Monitor Instances and Adjust Use of Resources
- Configure MySQL DB Systems
- Manage MySQL DB Systems
- Back Up MySQL DB Systems
- Migrate Your Data to MySQL Database Service
- MySQL Database Service High Availability
- Implement MySQL HeatWave for Query Acceleration

https://education.oracle.com/mysql-heatwave-implementation-associate-rel1/pexam_1Z0-915-1

MySQL Heatwave Overview



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

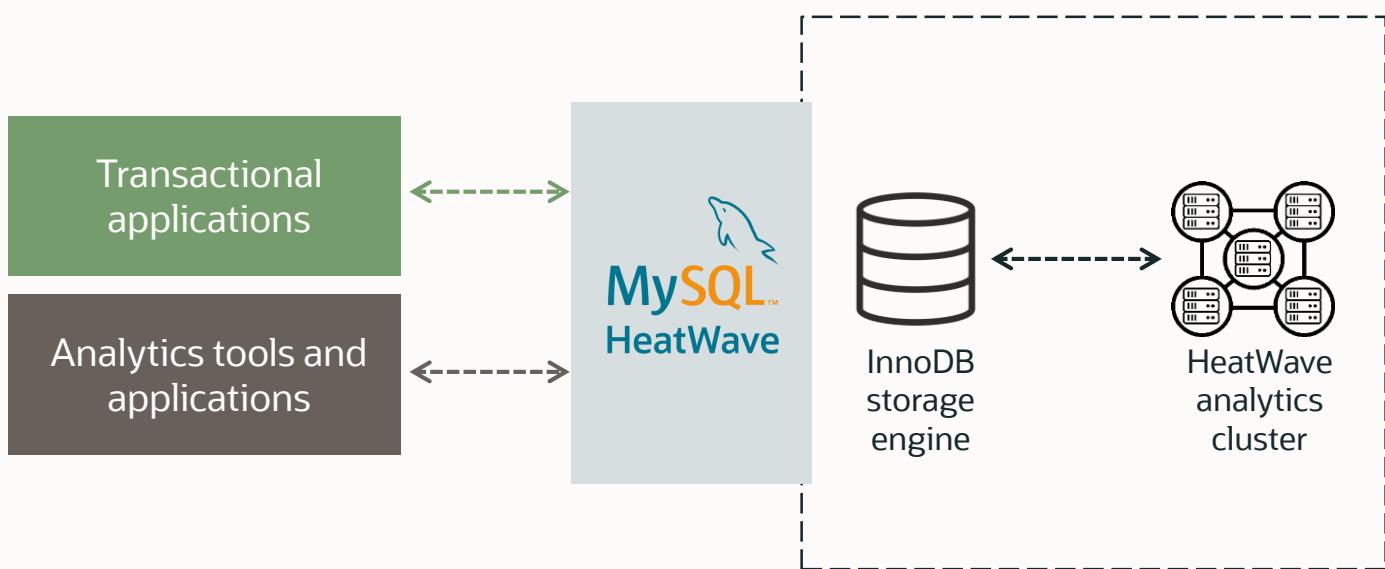
MySQL HeatWave: fully managed database service

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	✓



One database is better than two



One service for OLTP & OLAP

No ETL duplication

Unmatched performance, at a fraction of the cost

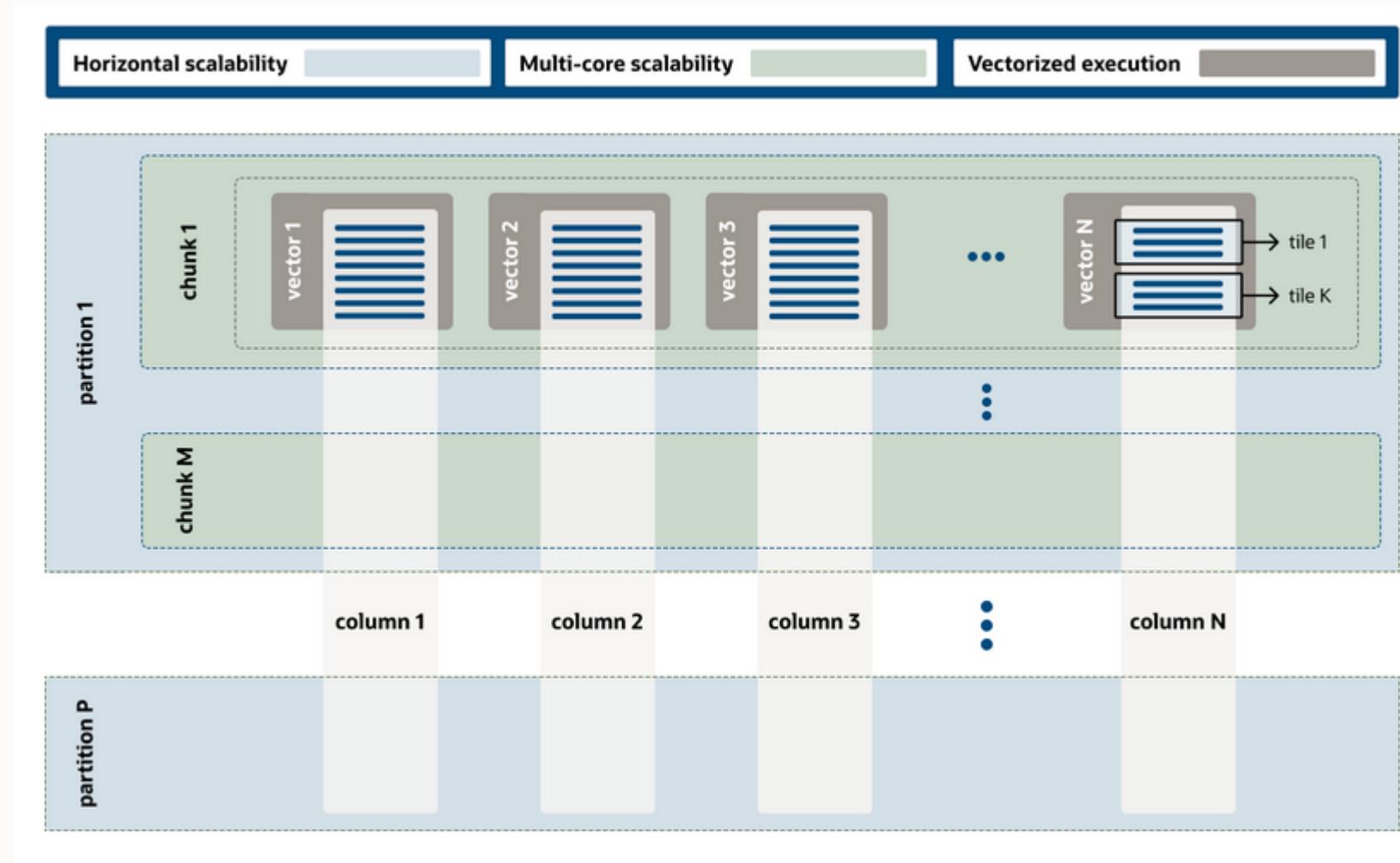
Real-time analytics

Improved security

Applications work without changes

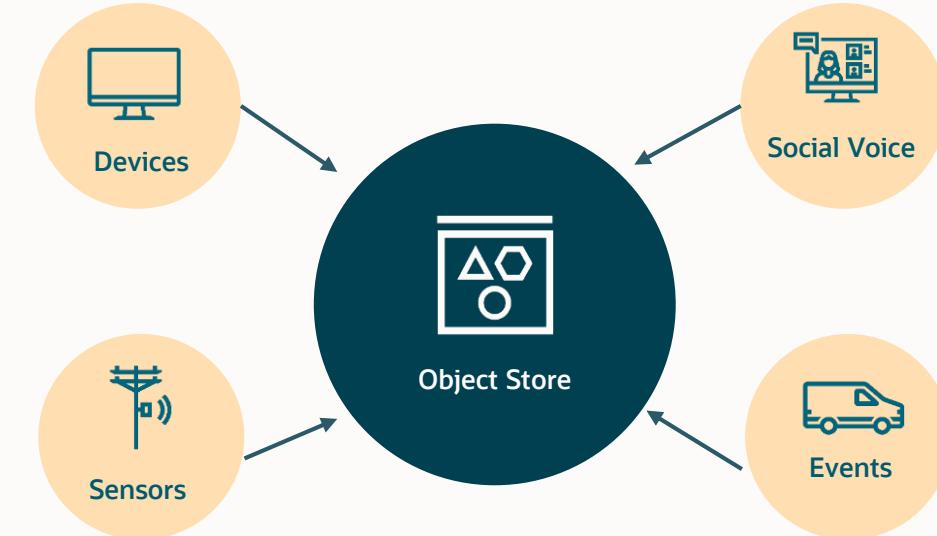
1>2 with MySQL HeatWave

In-Memory hybrid columnar processing



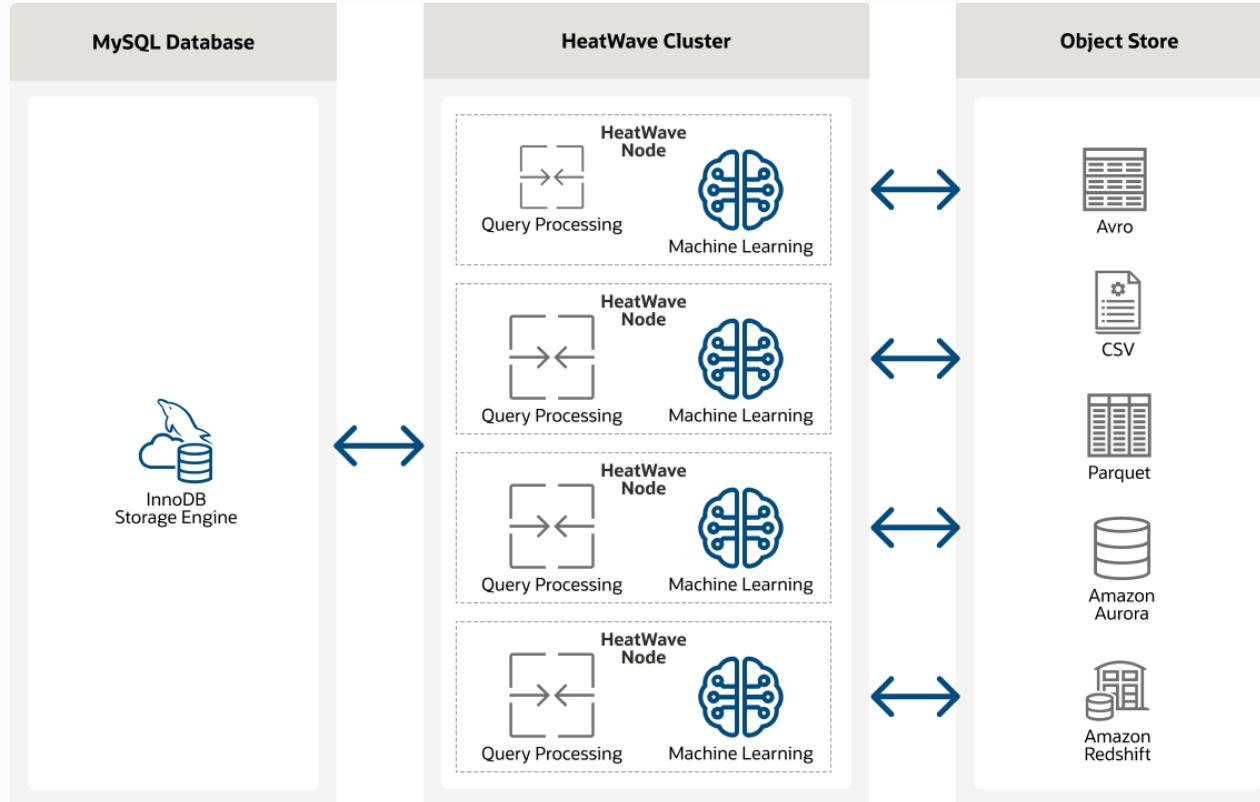
Massive amount of data stored in files

- 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

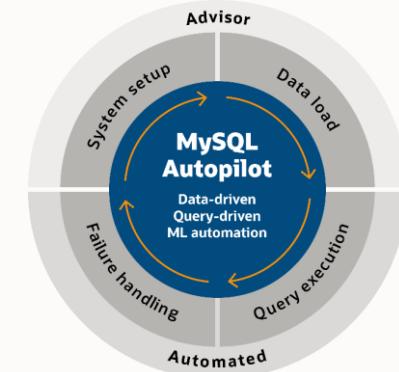
STANDARD SQL syntax generated by MySQL Autopilot, no human required

1. System Setup

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

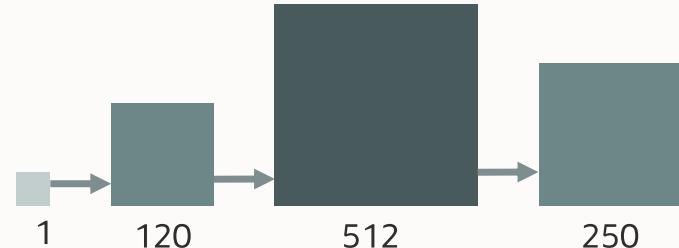
2. Run query across files and tables

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



HeatWave scales out

Flexible, fast and highly scalable



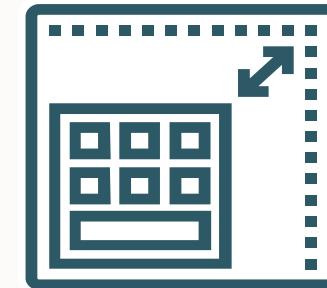
Scale to any cluster size

- 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

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

06:48 UTC

[Show backup windows per region](#)

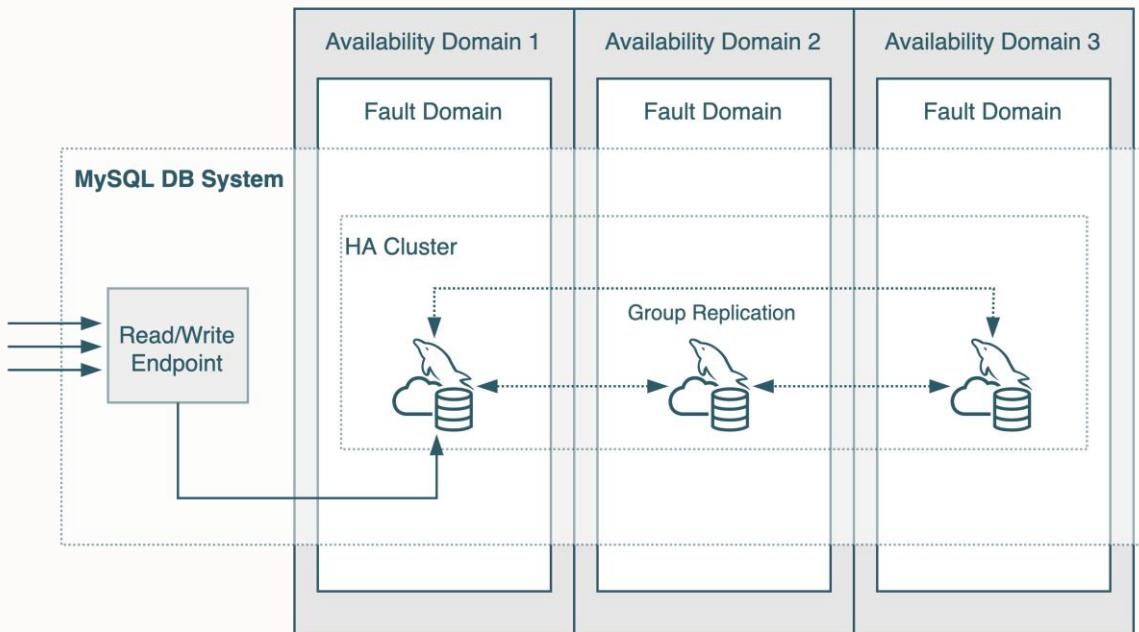


High Availability



High Availability

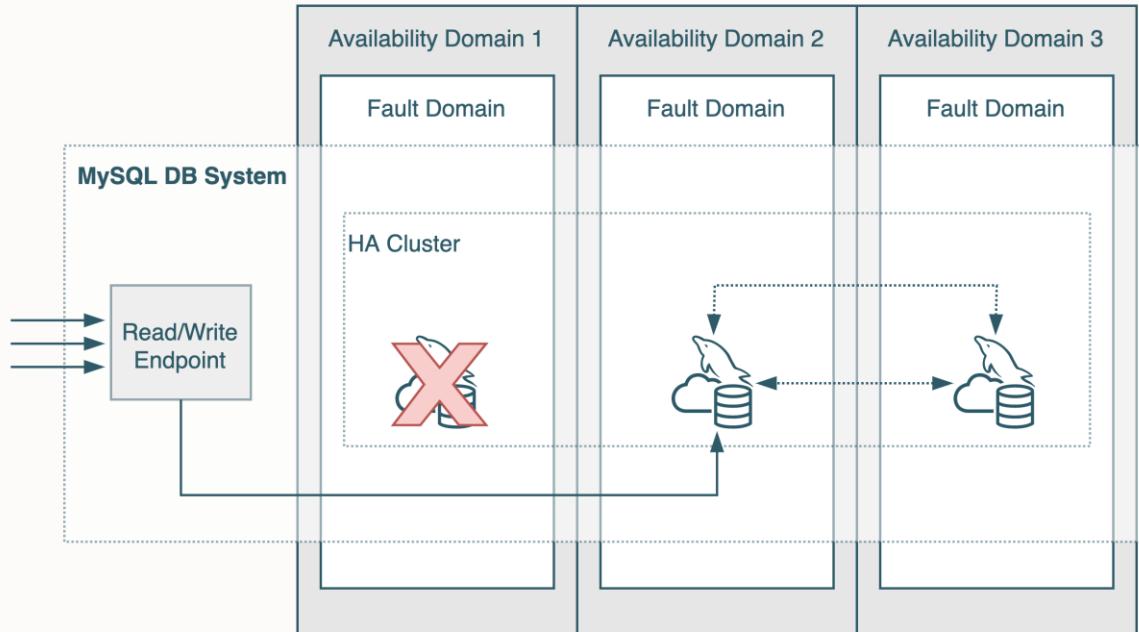
Single-click HA



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. The "Standalone" and "HeatWave" options are disabled. The "High Availability" option is selected, indicated by a blue border and a checked checkbox. Below the selection, it says "Run a DB system with 3 MySQL instances providing automatic failover and zero data loss". The "Create Administrator credentials" section shows a "Username" field with "admin" and "Create" and "Cancel" buttons. At the bottom, there are links for "Terms of Use and Privacy" and "Cookie Preferences", and a copyright notice: "Copyright © 2022, Oracle and/or its affiliates. All rights reserved." A small Oracle logo is in the bottom right corner.

High Availability

Single-click HA



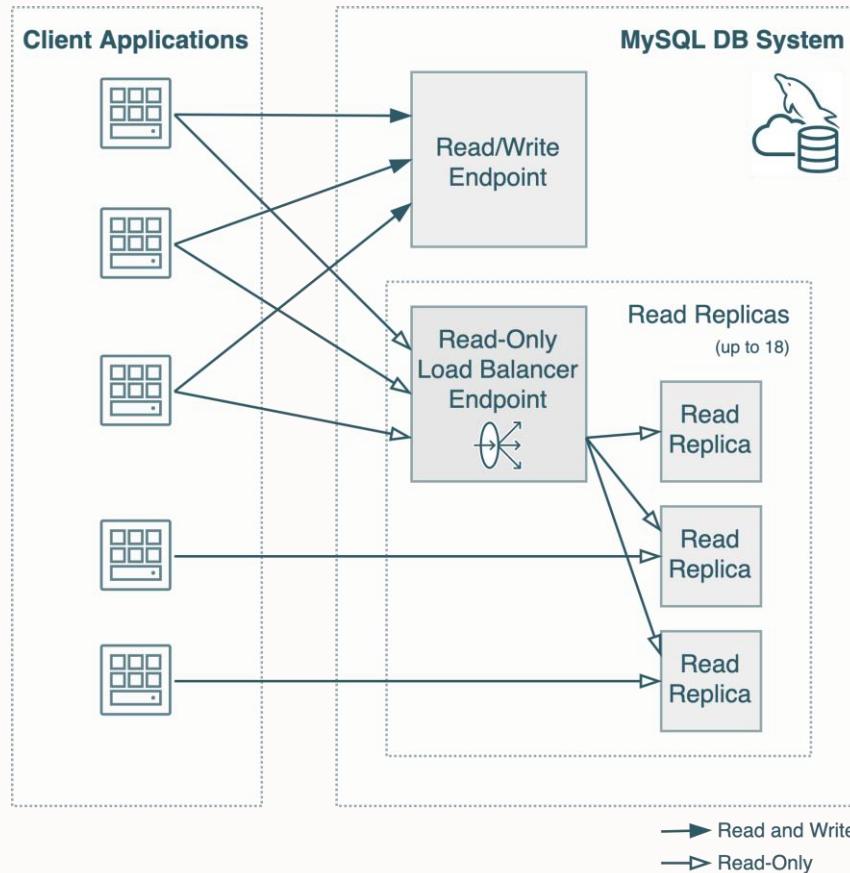
- SLA **99.99%**
- Automatic failover
- Zero Data Loss during failure event
- Option to manually switch-over
- Rolling upgrades during maintenance

MySQL Heatwave for OLTP



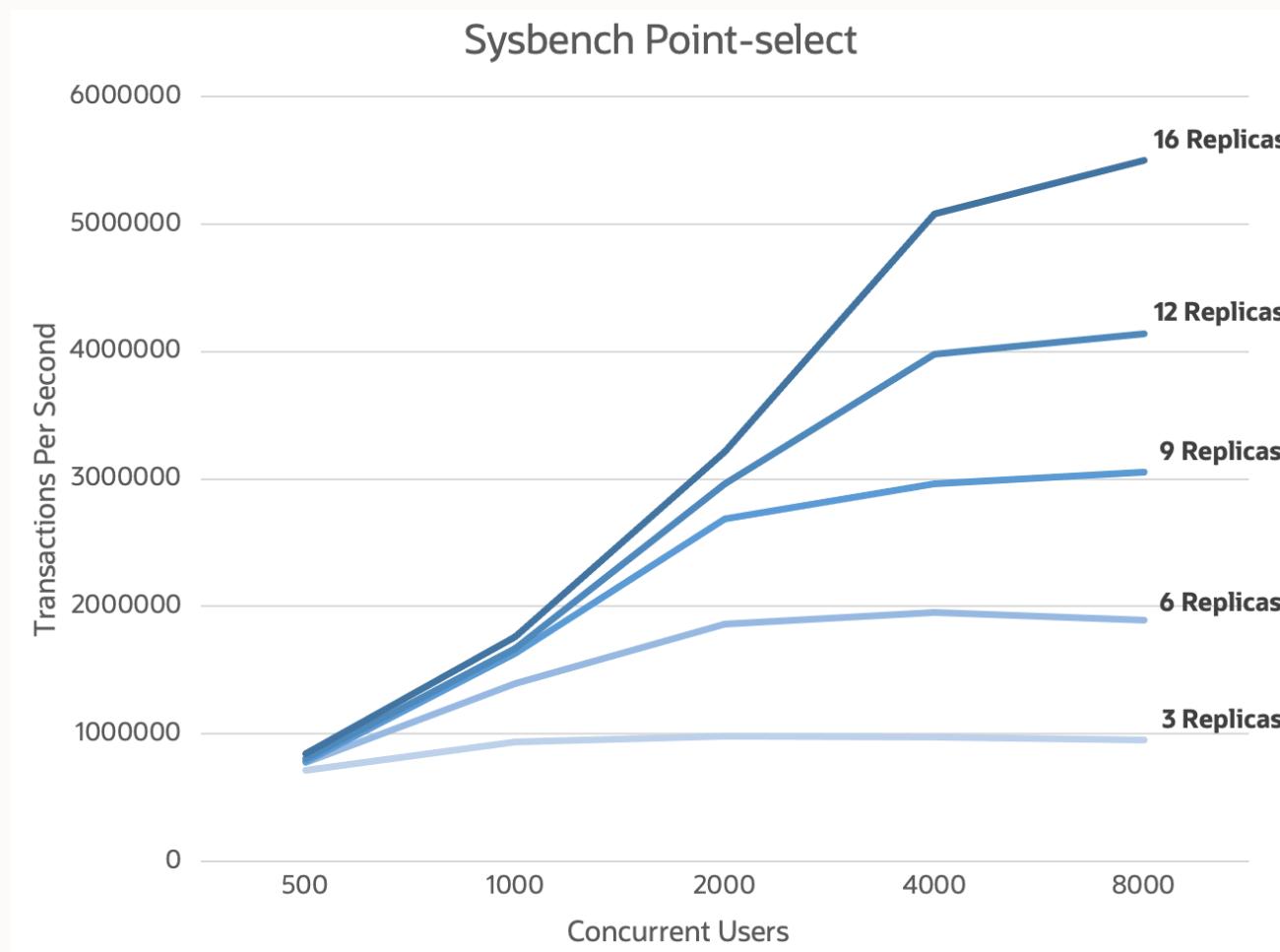
Read Replicas

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



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

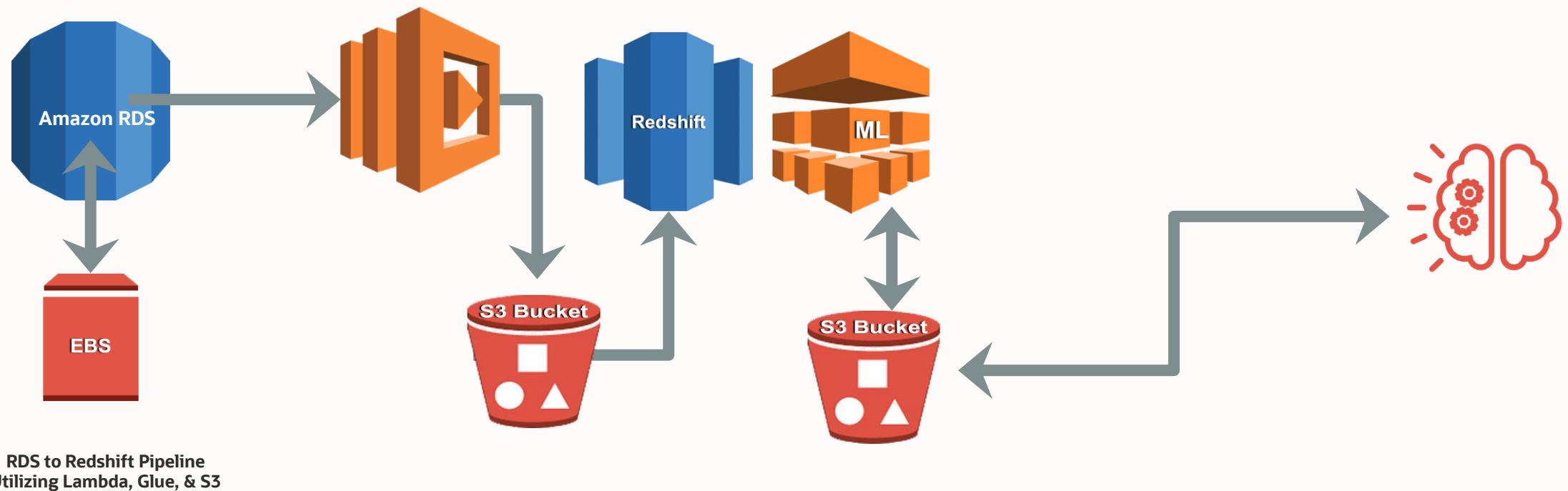
Endpoints

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 >

In-Database ML and generative AI with all their data

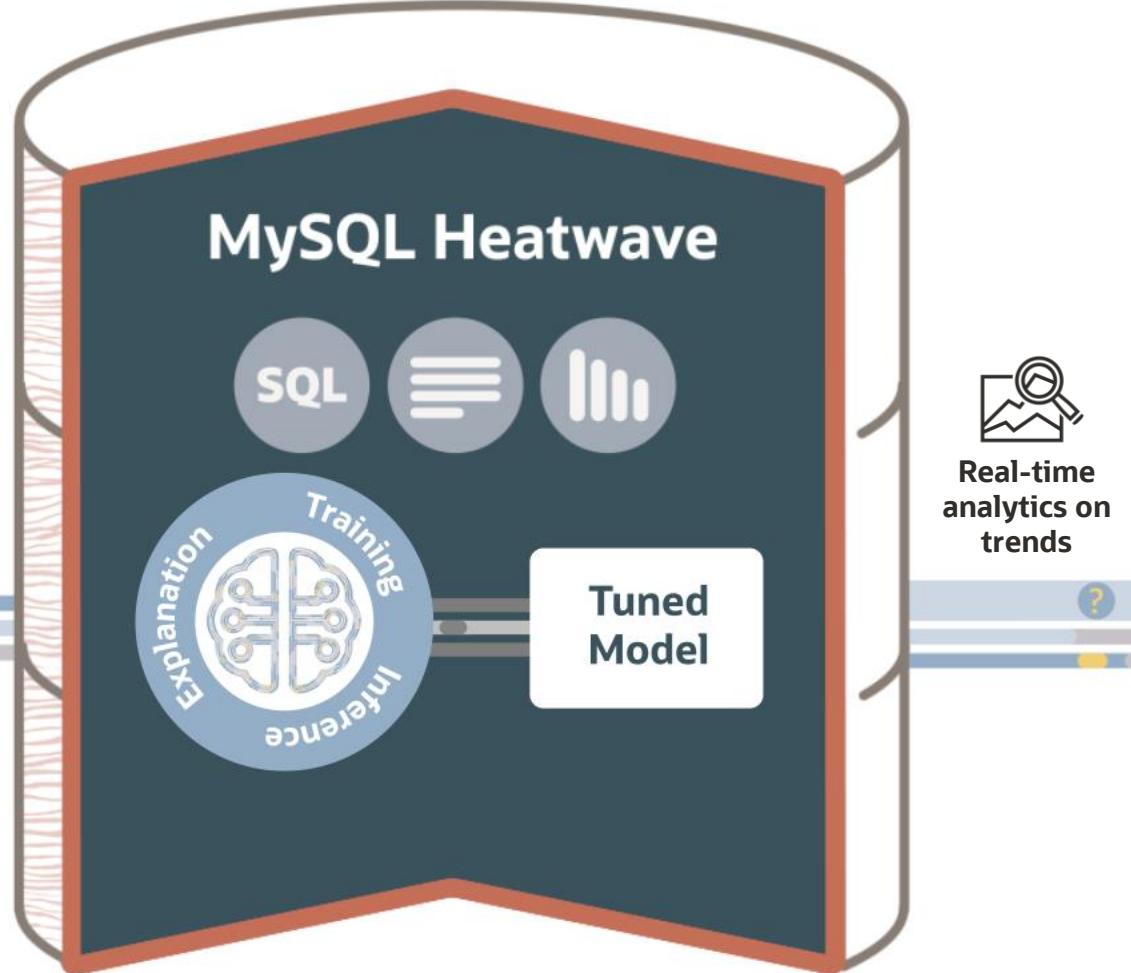
The pain of using AWS services

Amazon Redshift with RDS and ML Modeling

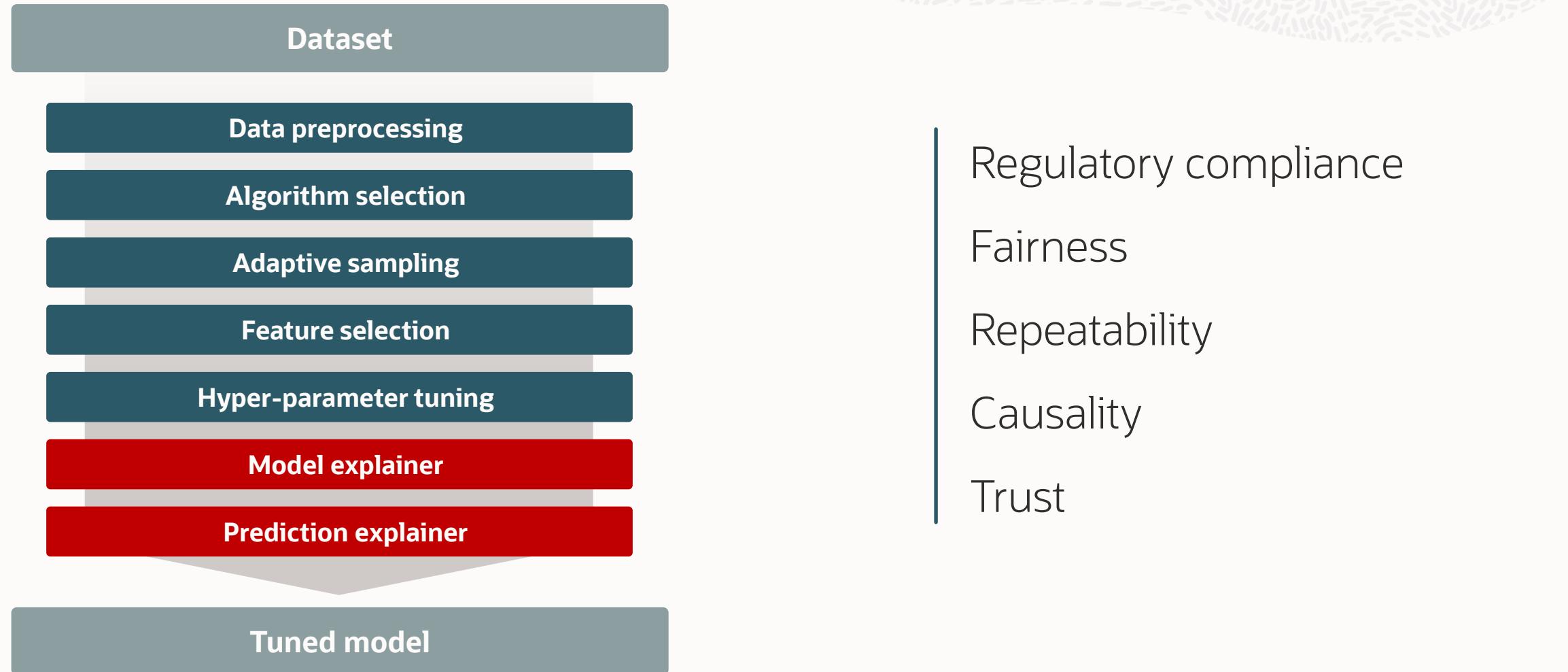


Redshift ML does NOT provide in-database ML; exports data to SageMaker via Amazon S3

Machine learning in action with MySQL HeatWave



HeatWave AutoML automates the ML lifecycle | All models can be explained



Auto Pilot

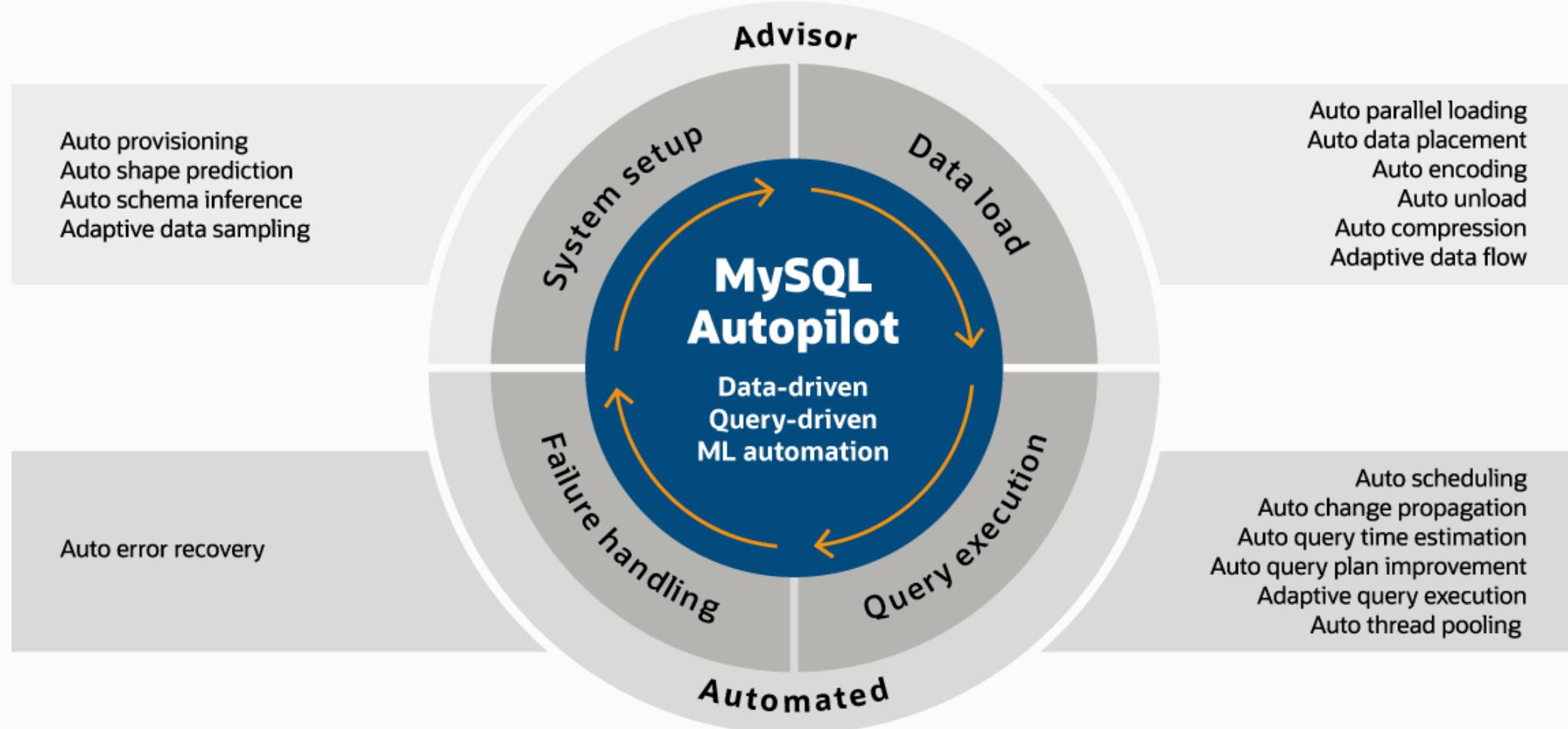
Manual management tasks consume resources



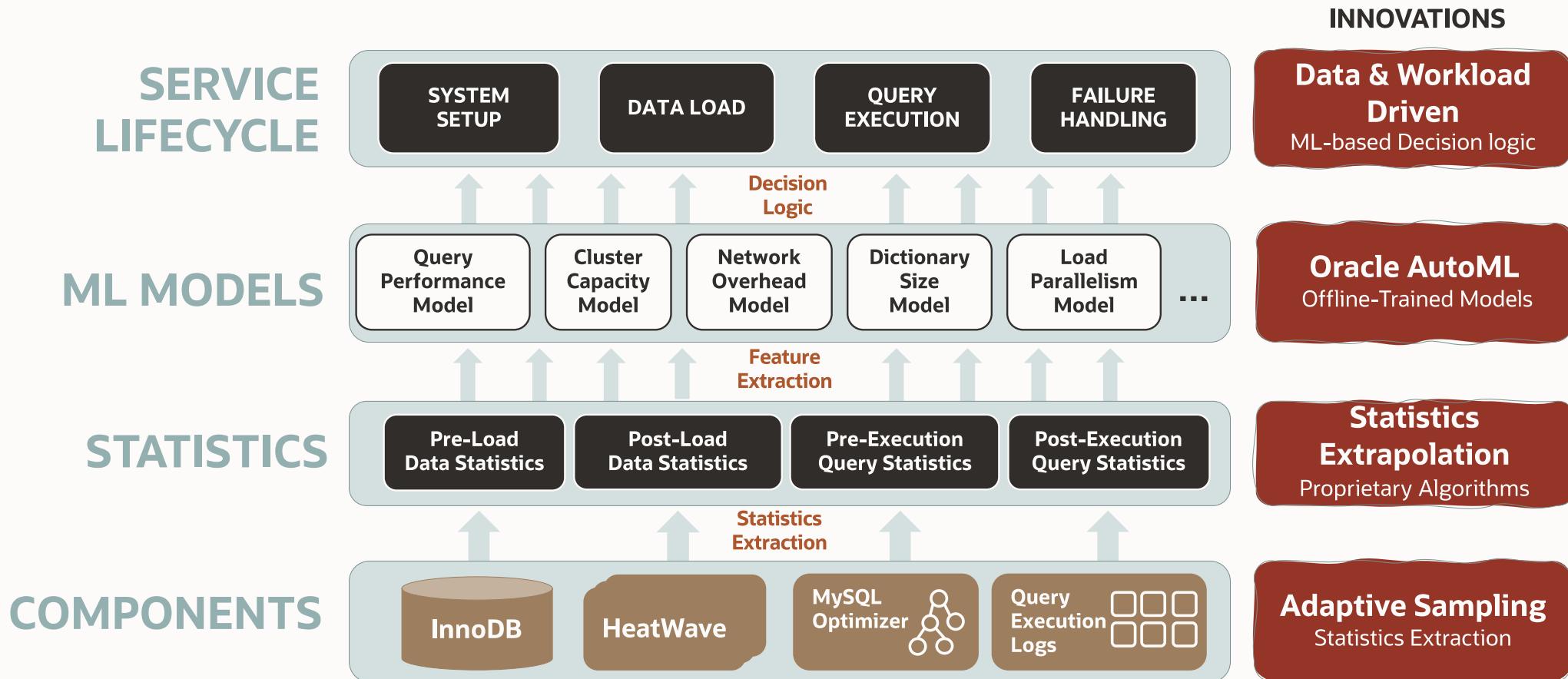
- **On-premises:**
 - Database management: provisioning, configuration, backup, HA, patching, security & more
 - Operating system management: installation, patching, upgrades...
 - Infrastructure management: purchase and maintenance of servers, storage
 - Data center management: space, power, cooling,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

Machine learning-powered automation for MySQL HeatWave

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

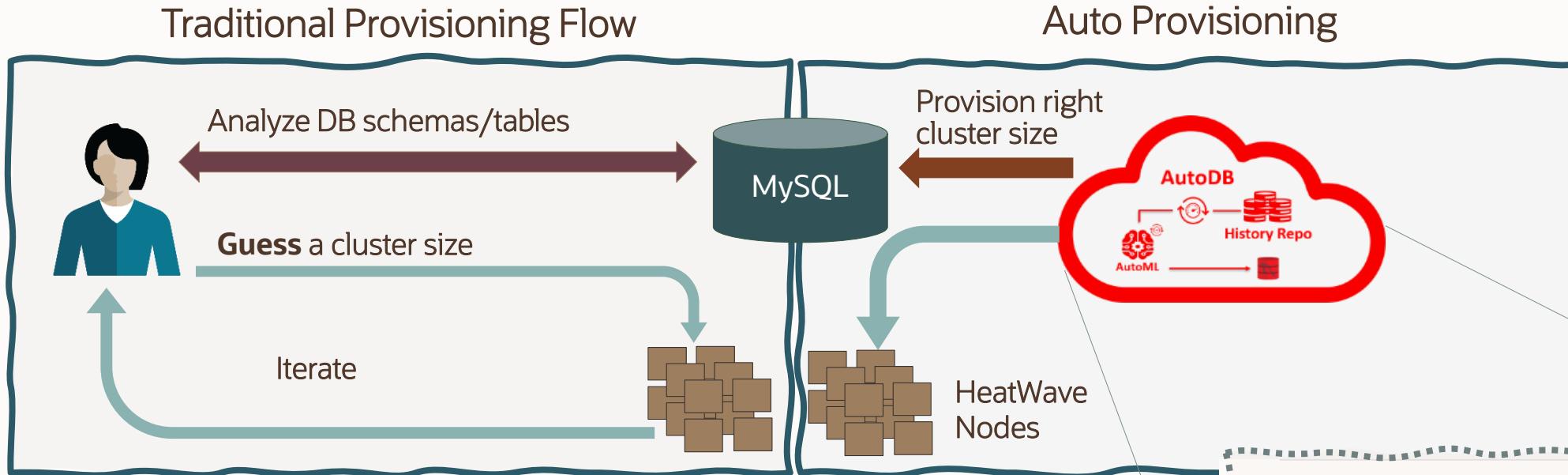


MySQL Autopilot Architecture

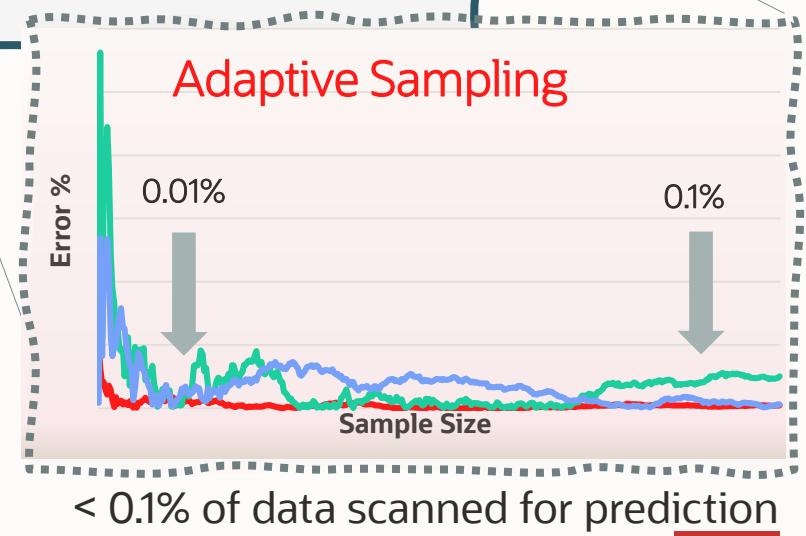


Auto Provisioning

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%



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

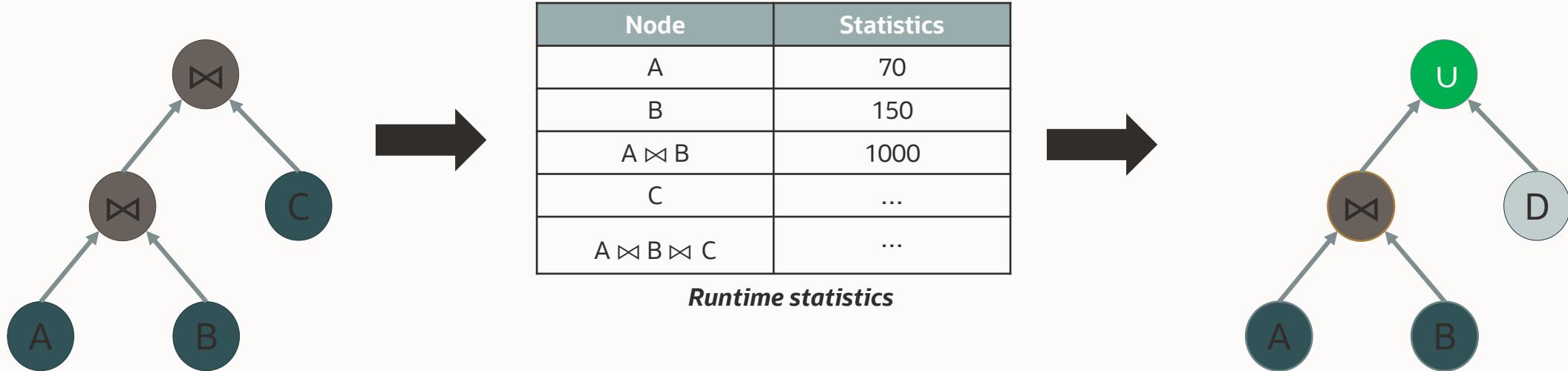
Sufficient MySQL host memory available to load all tables.
HeatWave cluster memory might be insufficient to load all the tables.

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

Please refer to the user manual for more details.

Auto Query Plan Improvement

Optimizer learns and improves query plan based on queries executed earlier



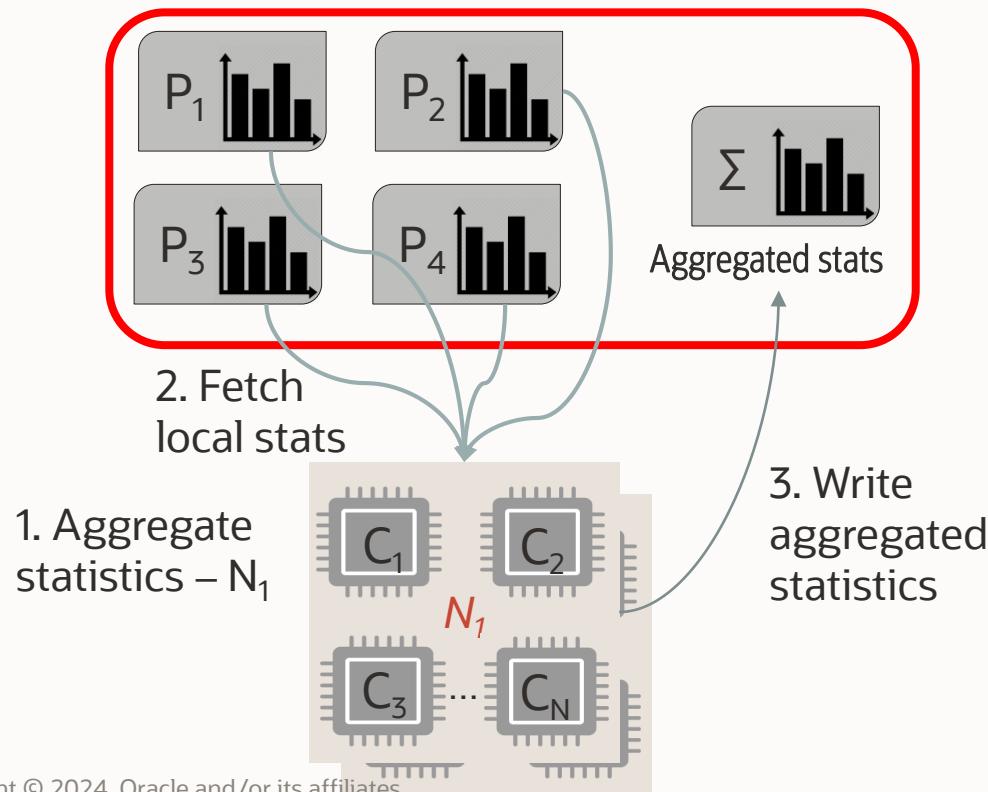
- Traditional caching techniques are not intelligent
- With Autopilot, system gets better as more queries are run
- For example, Autopilot improves TPCH, TPCDS 24TB performance by 40%

MySQL Autopilot helps with HeatWave Lakehouse query performance

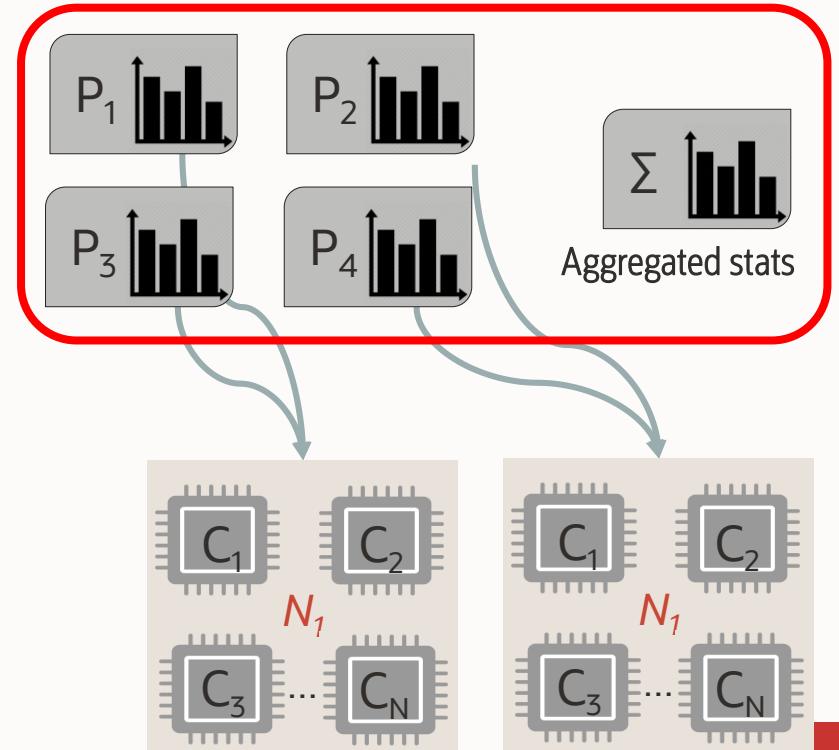
Statistics are computed while loading files into HeatWave storage

1. Local statistics are computed on the fly

2. Statistics aggregated during load



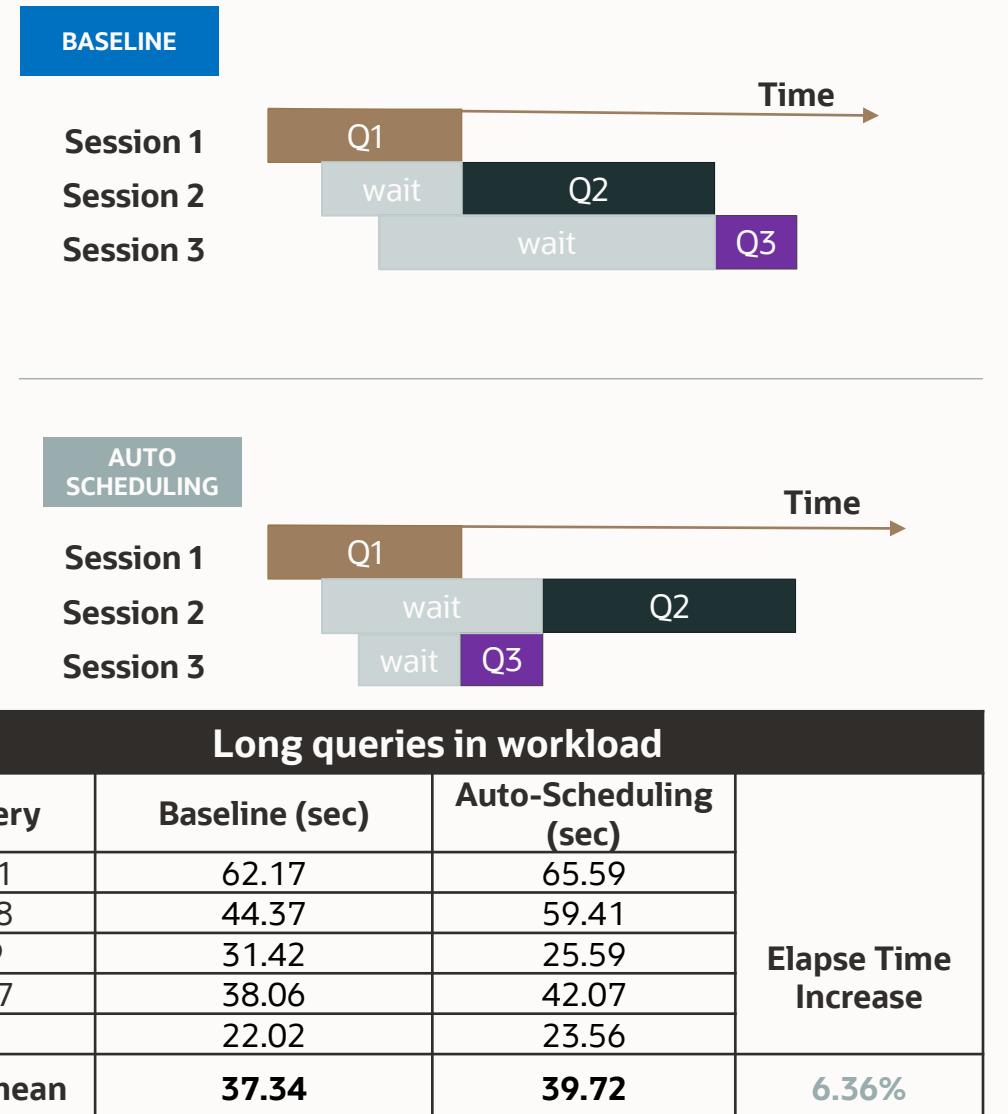
3. Statistics available for queries



Auto Scheduling

Reduces wait time for mixed (OLTP + OLAP) workloads

- Analytic queries usually take longer than OLTP queries
- HeatWave predicts execution time of each query
- Short queries are prioritized over long running queries
- System reduces wait time for shorter queries without changing total execution time



Auto compression

Optimal column compression based on workload characteristics without manual intervention

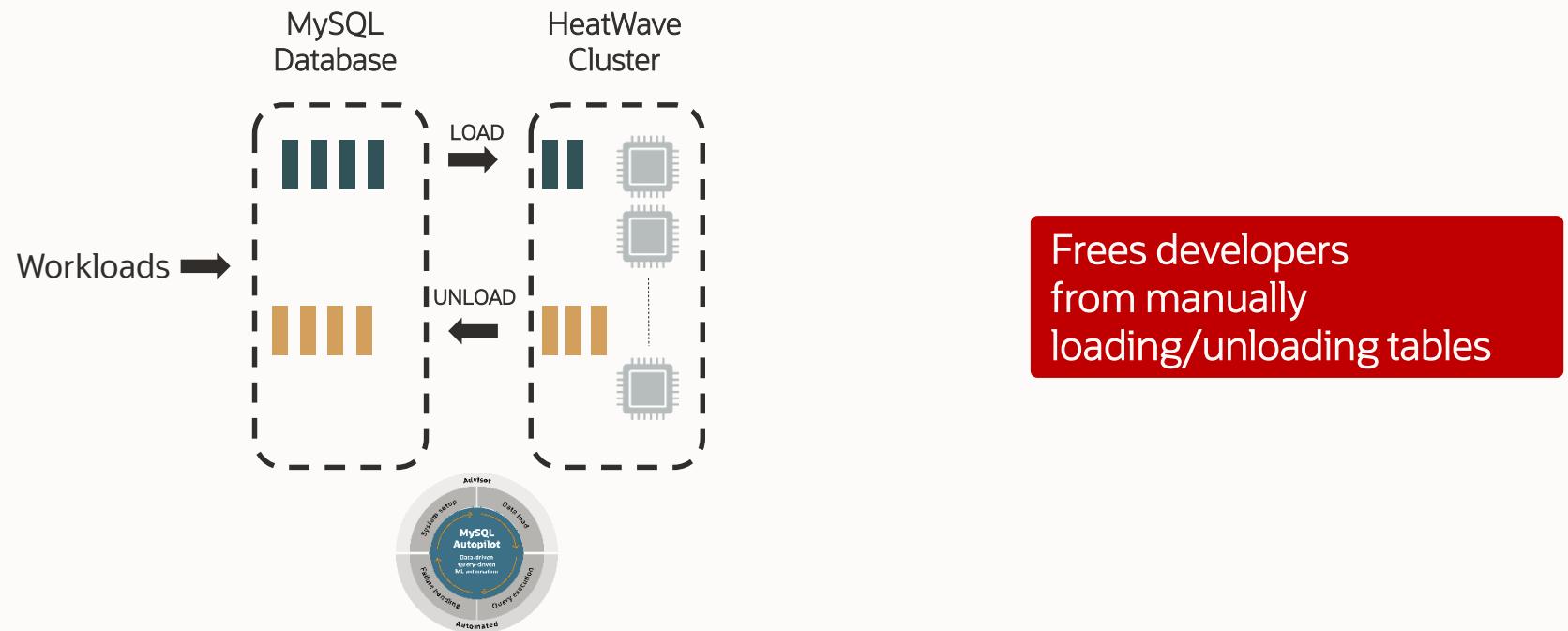
- Introduced multiple compression algorithms
- HeatWave selects optimal compression for each column based on data and query characteristics
- Improves memory consumption and query performance

4TB	ORIGINAL MEMORY	NEW MEMORY	% MEMORY SAVINGS	PERFORMANCE IMPACT
TPCDS	324GB	243GB	25%	6% better
TPCH	308GB	291GB	6%	10% better

Reduces memory usage to save costs

Auto load and unload

- Automatically loads tables or columns into HeatWave to optimize performance of user workload
- Automatically unloads tables less frequently used than other tables to optimize performance without increasing cost



Auto Unload

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

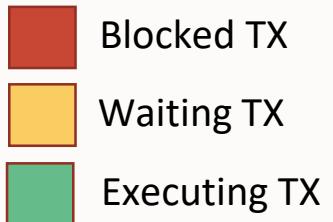
HEATWAVE UNLOAD ADVISOR				
SCHEMA NAME	TABLE NAME	REASON	MEMORY GAIN (HEATWAVE NODES)	MEMORY GAIN (HOST)
'tpch1'	'LINEITEM'	LAST QUERIED ON "2023-03-02 10:24:06"	732.00 MiB	0 bytes
'tpch1'	'ORDERS'	LAST QUERIED ON "2023-03-02 10:24:12"	164.00 MiB	0 bytes
'tpch1'	'PARTSUPP'	NEVER QUERIED	148.00 MiB	0 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

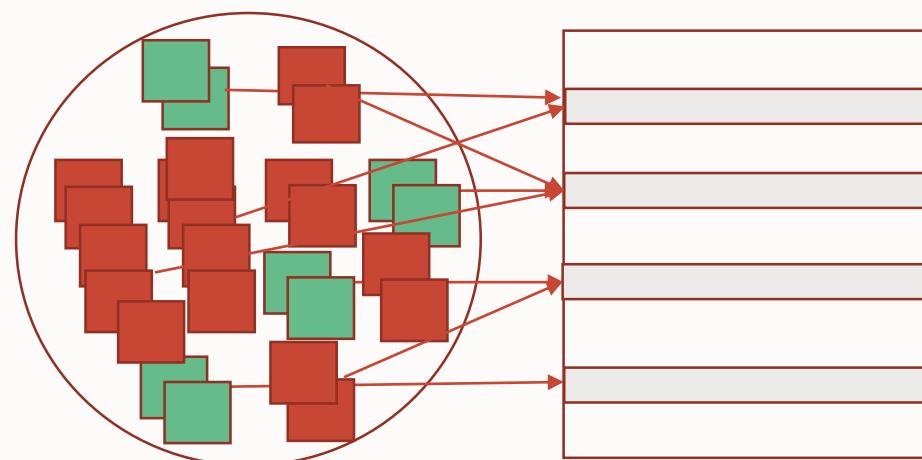
Provides explanation for
the recommendation

Auto Thread Pooling

Provides higher and sustained throughput for OLTP workloads

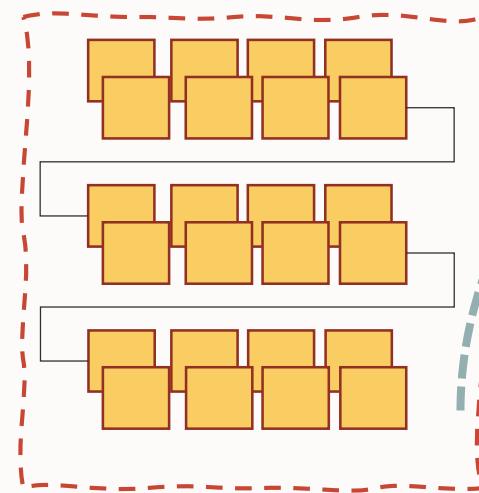


Execution Window

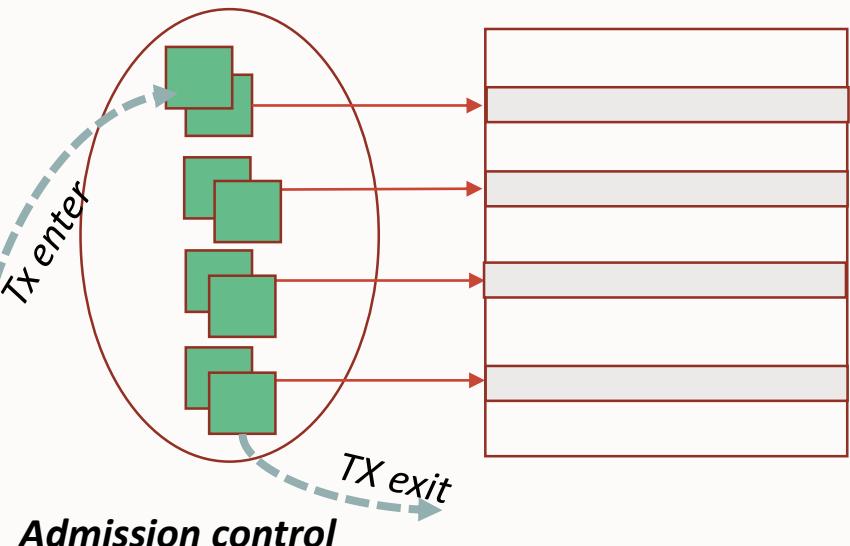


DB Table

Waiting transactions



Execution window



Admission control

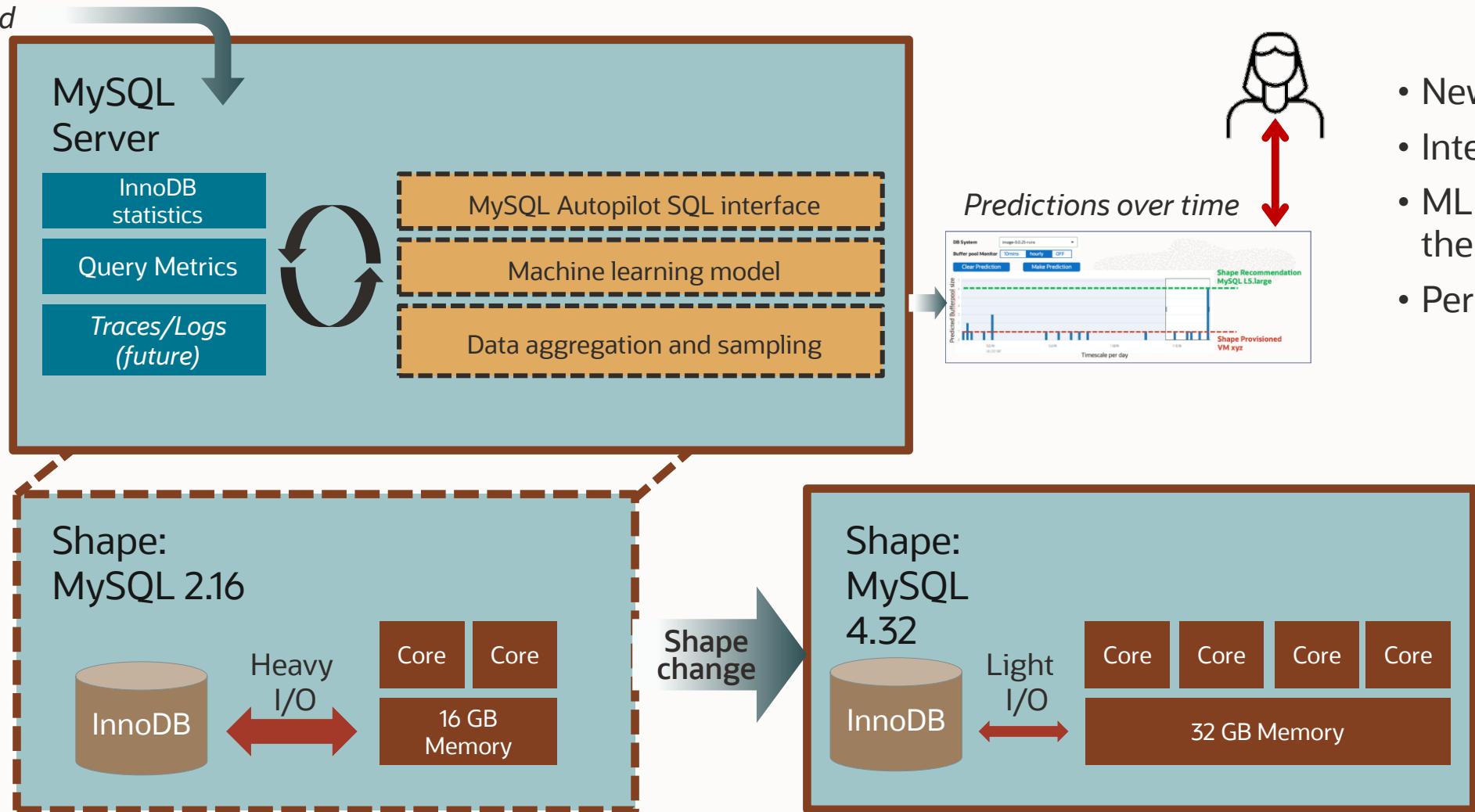
✗ Blocked TXs create resource contention on executing TXs

✓ Allowing fewer TXs reduces resource contention

Auto Shape Prediction

Determines the optimal instance type

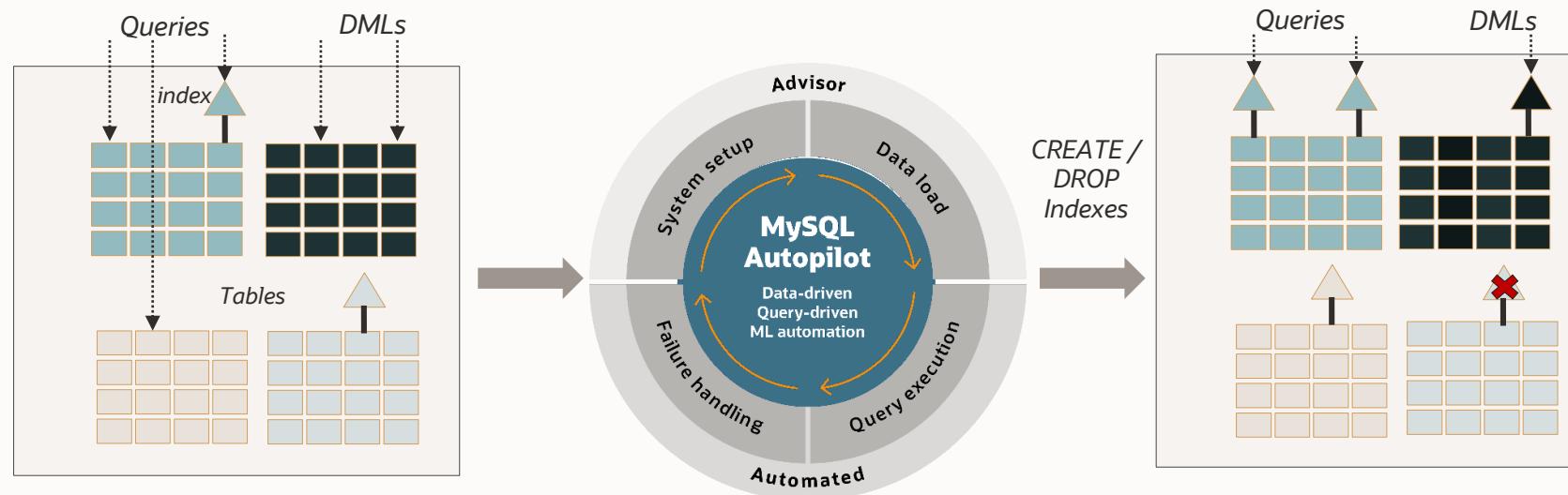
Workload



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

MySQL Autopilot indexing (LA)

Recommends secondary indexes for OLTP workloads



Autopilot indexing features

The screenshot shows the MySQL HeatWave Autopilot Index Advisor interface. At the top, there are tabs for 'Query Editor', 'Manage Data in HeatWave', and 'Autopilot Index Advisor'. The 'Autopilot Index Advisor' tab is selected. Below it, there are buttons for 'Apply Selected Recommendations', 'Show Affected Queries', and 'Refresh'. The main area displays a table of recommendations:

Recommendation	Index ID	Reason	Table Name	Indexed Columns	Performance Improvement
Create	1	Missing Index	seats.customer	c_id_str	High
Create	2	Missing Index	seats.frequent_flyer	ff_c_id_str	Low
Create	3	Missing Index	seats.flight	f_depart_ap_id, f_arr...	Low
Drop	4	Unused Index	seats.flight	f_a_id	-
Drop	5	Duplicate Index	seats.flight	f_arrive_time	-

Below the table, there are summary statistics: '50 GiB' (Total DB System Storage), '4/5' (Selected Recommendations), '+17.1 MiB' (Estimated Storage Impact), and '1.24x' (Speedup with all 3 Create Recommendations). A bar chart titled 'Estimated Storage Impact of the Selected Recommendations' shows the impact of creating or dropping specific indexes. The legend indicates 'High Performance Impact' (Index ID 1, Index ID 2) and 'Low Performance Impact' (Index ID 4, Index ID 5).

- Considers query and DML performance
- Create & Drop recommendation
- Explanations for suggestions
- Performance & storage prediction

Heatwave and Multiple Clouds Architectures

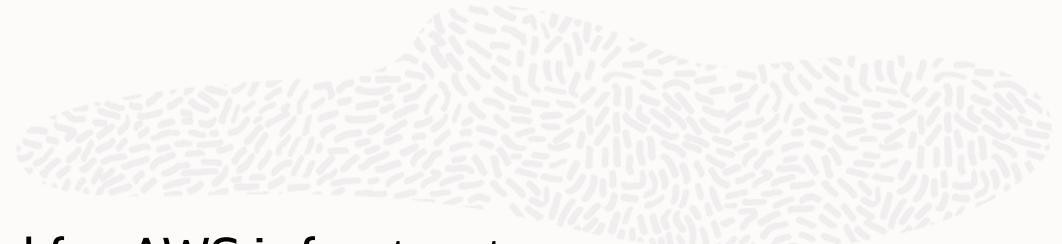
MySQL HeatWave is optimized for multiple clouds

Maximum flexibility and choice



Optimized for best price performance in each cloud

MySQL HeatWave on AWS

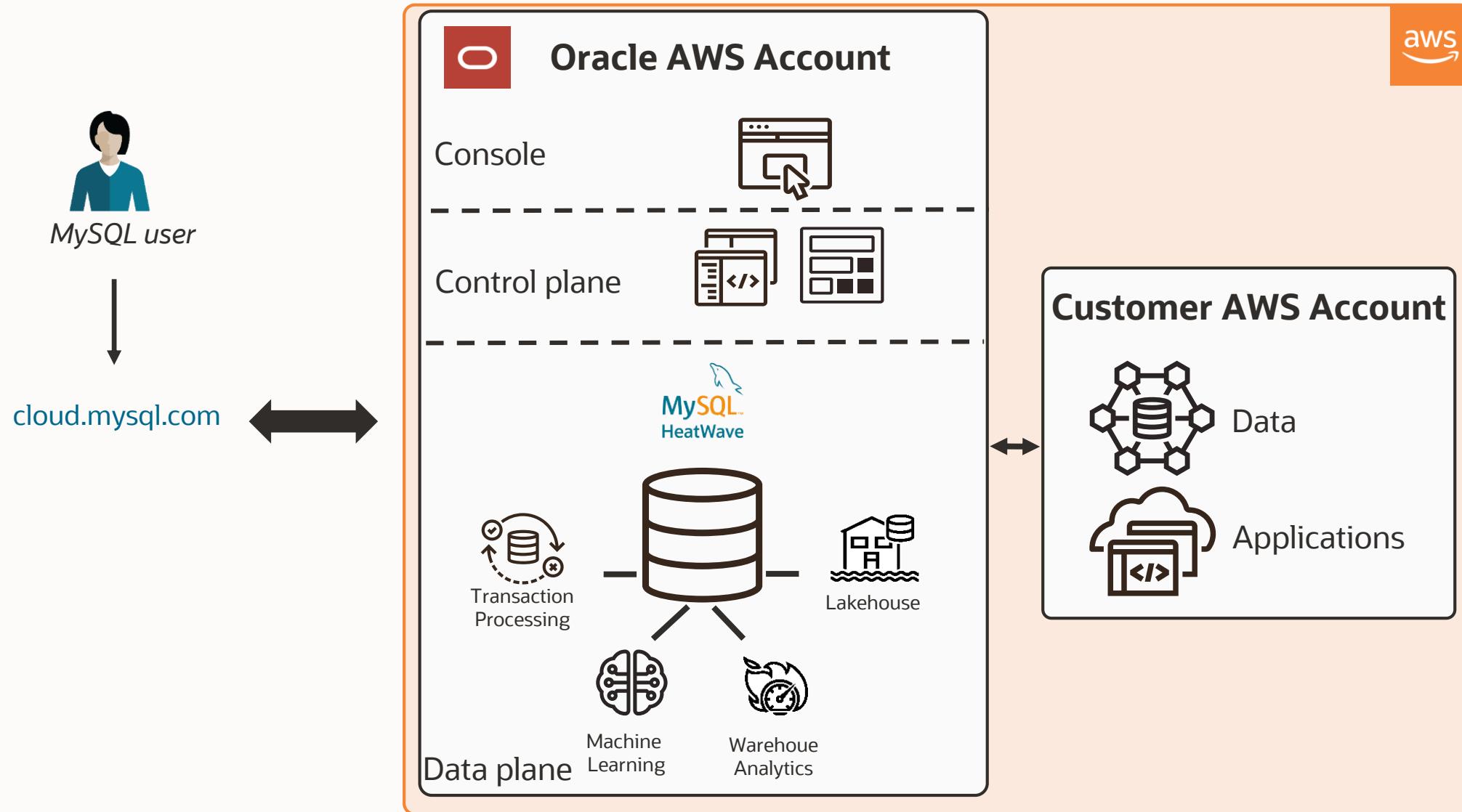


- MySQL HeatWave runs natively on AWS, optimized for AWS infrastructure
- Data doesn't leave AWS – saves egress cost, and avoids compliance approvals
- Lowest latency access to MySQL HeatWave
- Tight integration with the AWS ecosystem – S3, CloudWatch, PrivateLink
- Easier migration from other databases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

Combine 5 AWS services into ONE

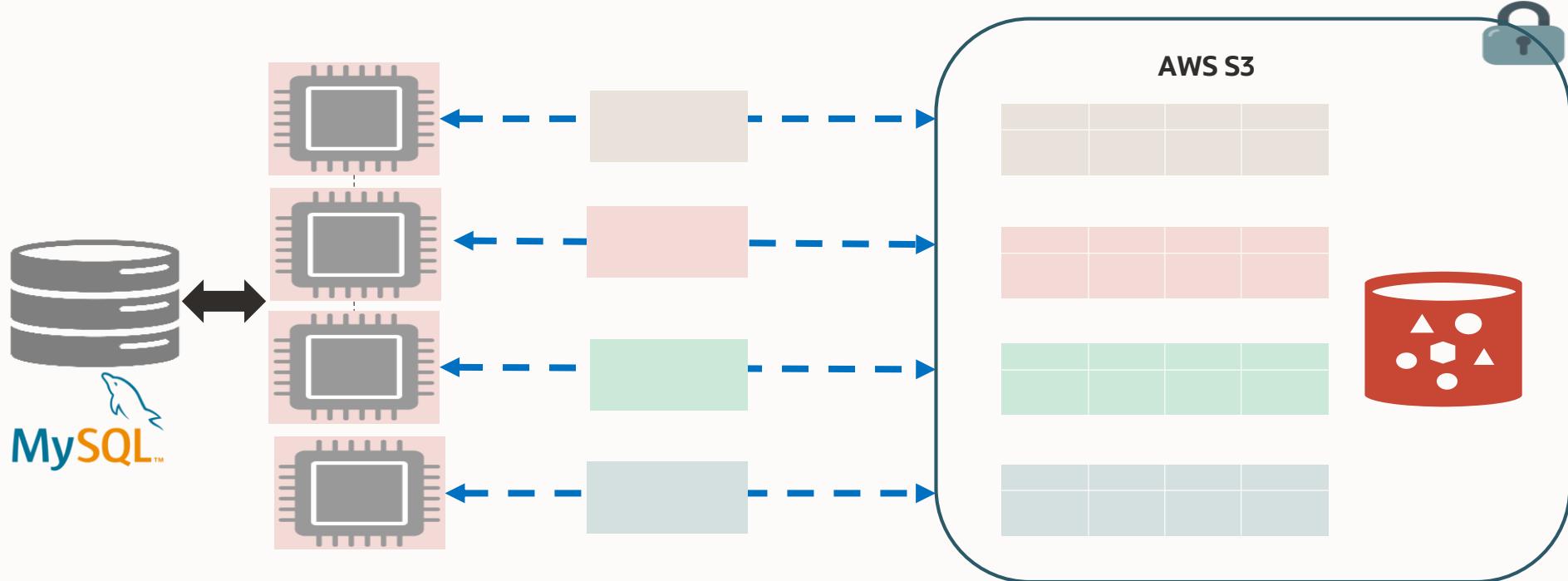
MySQL HeatWave on AWS

Data plane, control plane, and console run in AWS



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>

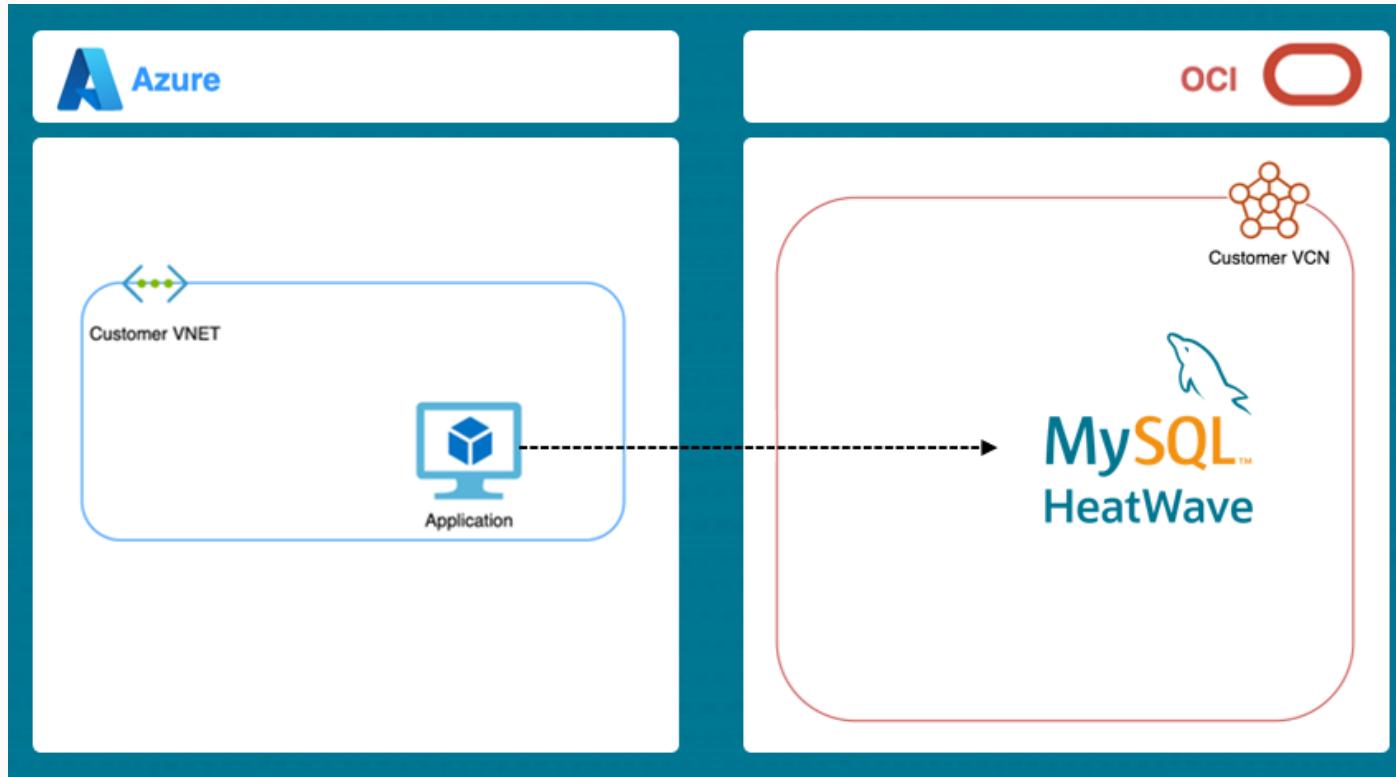
Key capabilities	Available on OCI	Available on AWS
Fully managed service	✓	✓
OLTP and OLAP in MySQL	✓	✓
Query acceleration for analytics and mixed workloads	✓	✓
Machine learning-powered automation (MySQL Autopilot for HeatWave and OLTP)*	✓	✓
Advanced security*	✓	✓
In-database machine learning (HeatWave 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

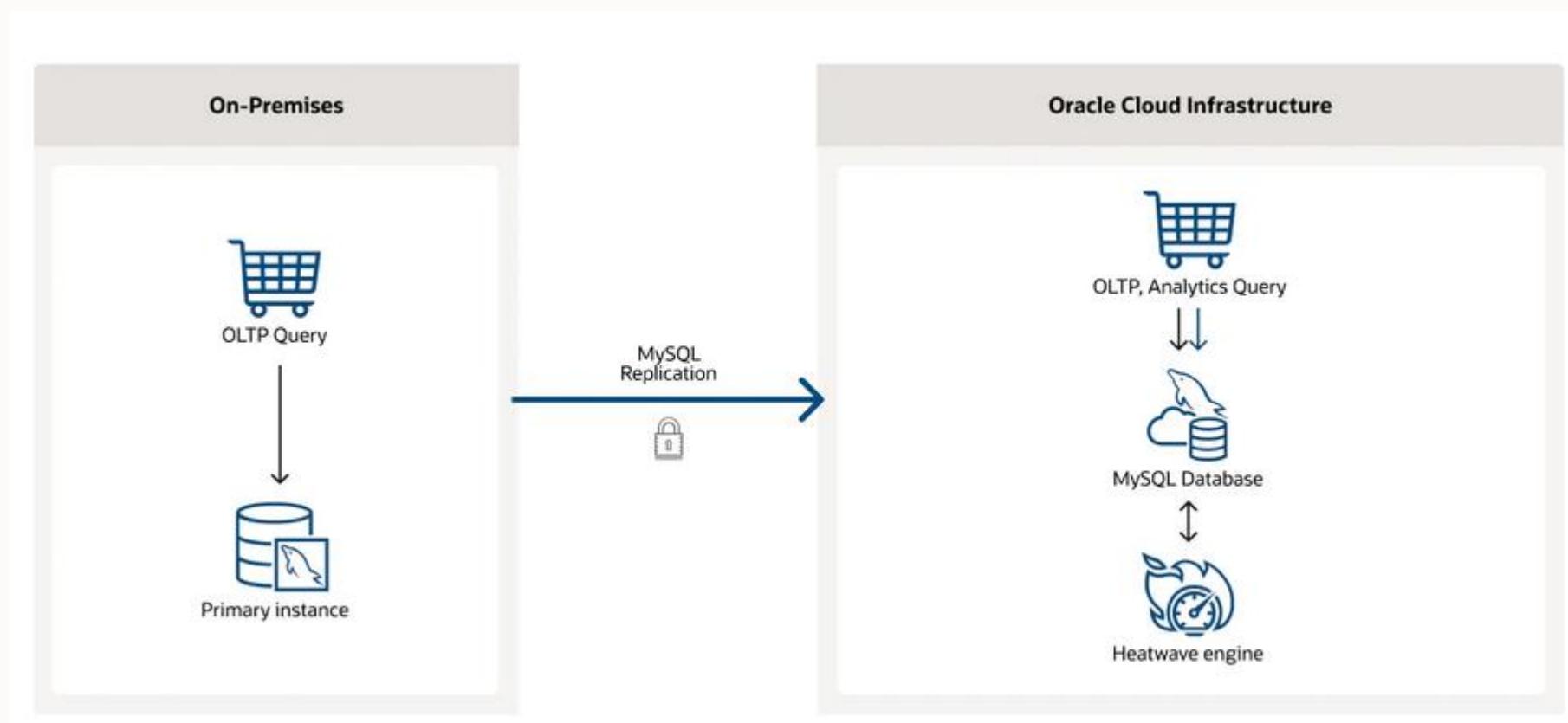


- Familiar Azure-native user experience
- Automated identity, networking, and monitoring integration
- Private interconnect and networking with < 2 ms latency
- Use Microsoft Azure services with MySQL HeatWave
- Collaborative support

<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

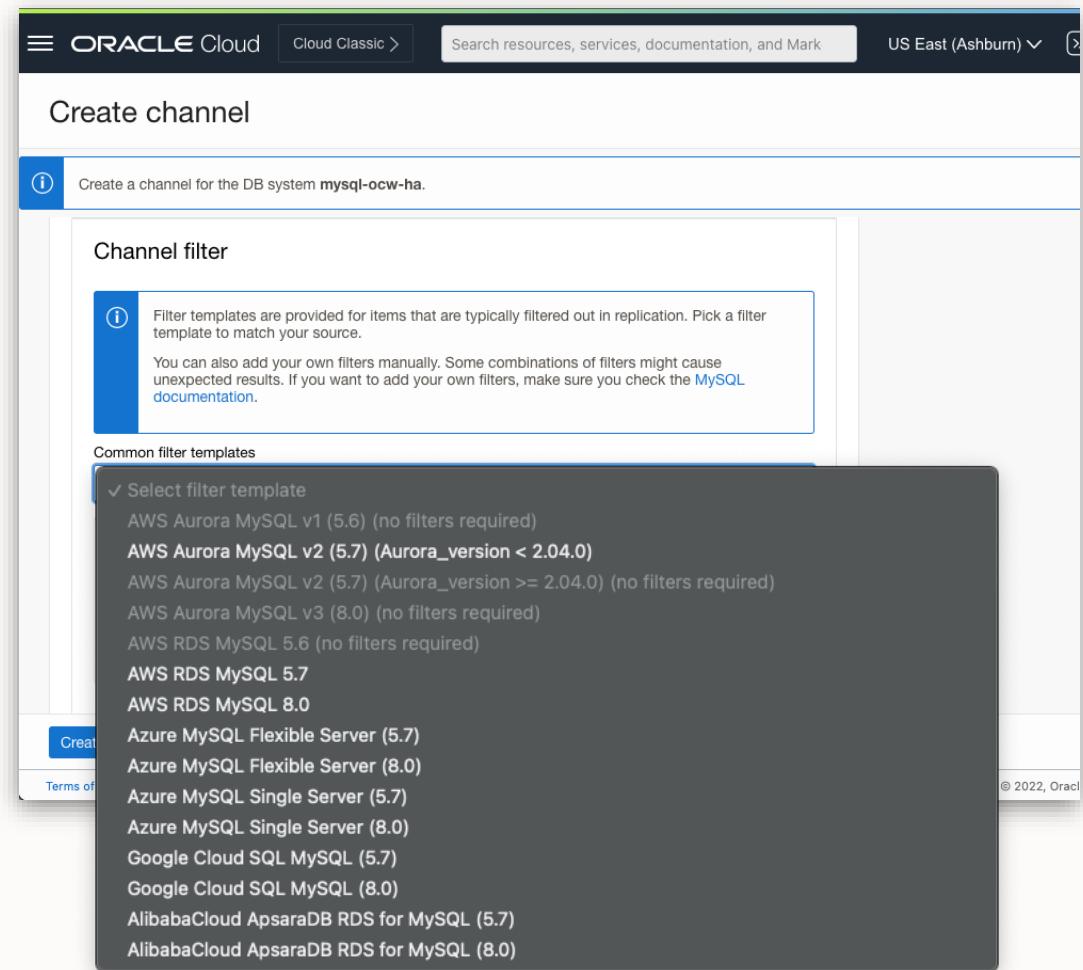
- DB System to DB System

Live Migrations

- Minimize downtime

Hybrid deployments

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



Inbound Replication Filters

Ignore Some of the Changes But Not Others



While migrating one may need to filter some traffic out from the replication stream.

- Ignoring a schema that will remain on premise
- Ignoring custom system objects from other cloud providers

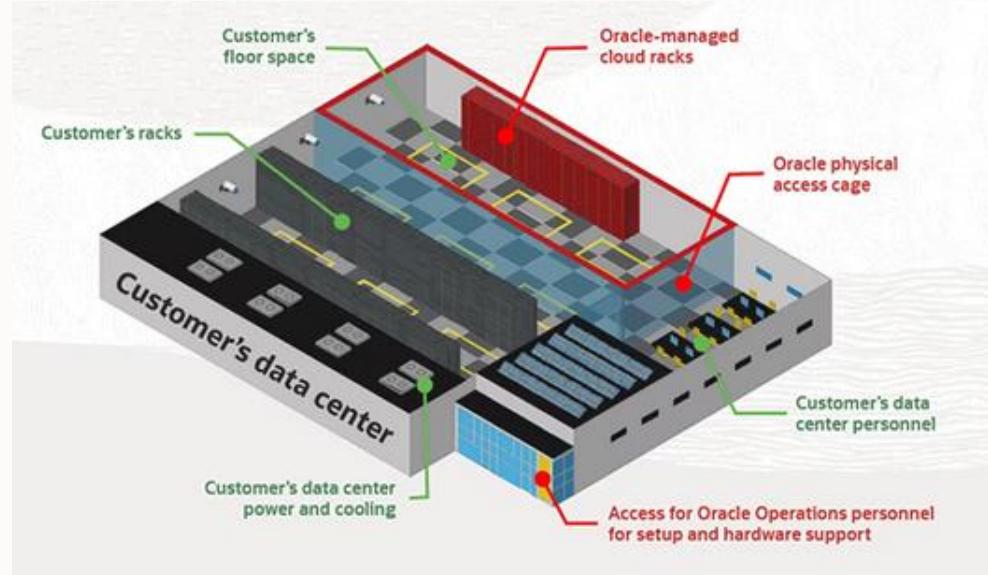
Noteworthy:

- Supports MySQL replication filters
- Console contains handy filter templates
- CLI, SDK and Terraform support

The screenshot shows the 'Create channel' dialog box. At the top, it says 'Create channel' and 'Create a channel for the DB system dbsystem'. Below that, there's a 'Name:' field set to 'dbsystem' and an 'OCID:' field with 'Show Copy' options. A 'Hide channel filter options' button is visible. The main area is titled 'Channel filter' with a sub-instruction: 'Filter templates are provided for items that are typically filtered out in replication. Pick a filter template to match your source.' It also notes that users can add their own filters manually. Below this, there's a 'Common filter templates' section with a dropdown menu labeled 'Select filter template'. At the bottom, there's a table-like structure for defining filters, with columns for 'Type' (dropdown) and 'Value' (input field). A 'Select a filter value' dropdown is shown next to the 'Value' column. A 'Add another filter' button is at the bottom right of the filter table.

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

Get started with MySQL HeatWave

Get \$300 in credits and try free for 30 days

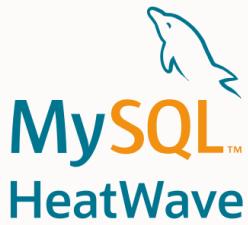
» oracle.com/mysql/free

Migrate to MySQL HeatWave with free expert guidance

» [Migration program](#)

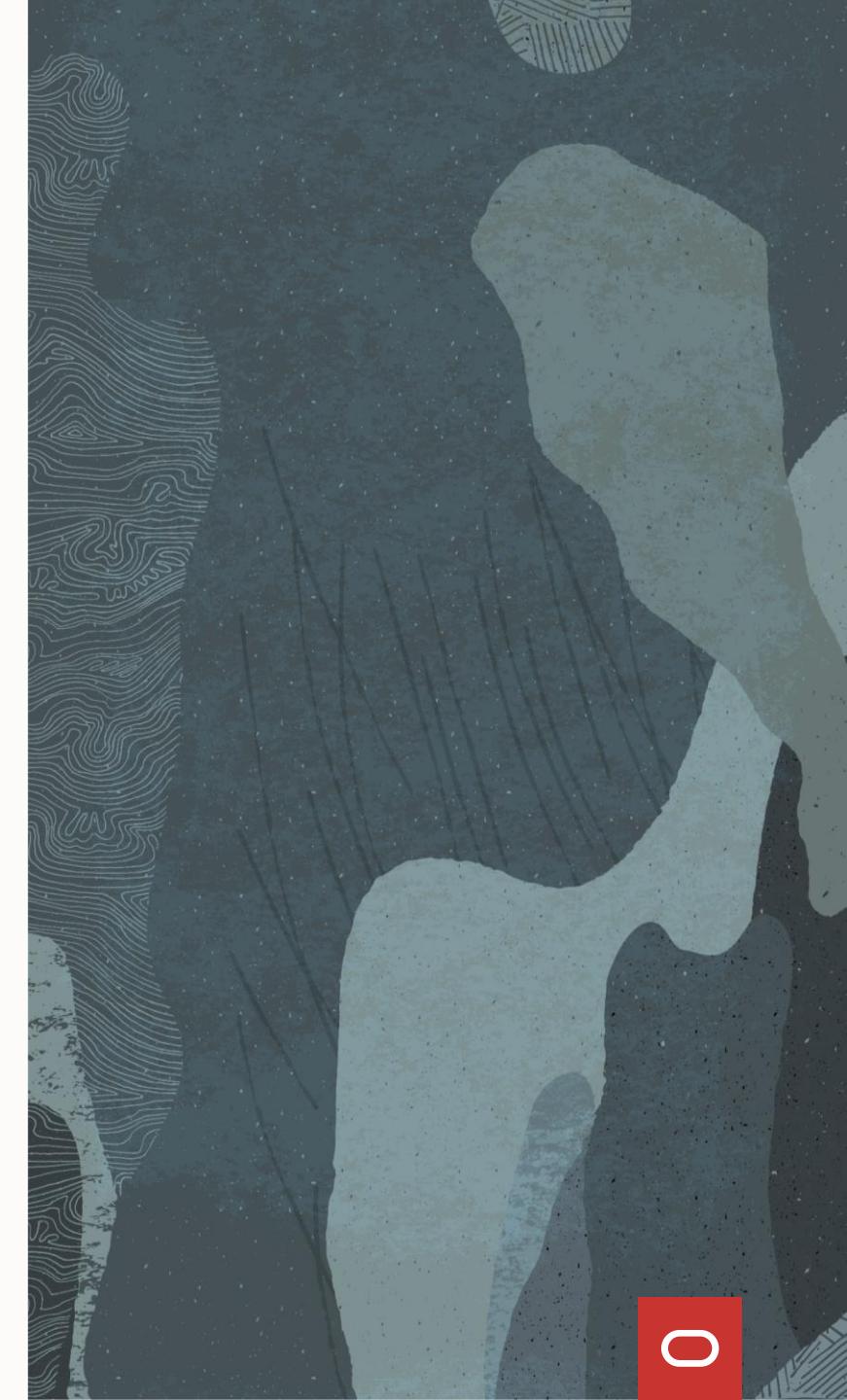
Request a free MySQL HeatWave workshop

» [Ask your account manager](#)



Learn more about MySQL HeatWave

» oracle.com/mysql



ORACLE

