



ORACLE

# MySQL HeatWave



One MySQL Database for OLTP, OLAP, and Machine Learning

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## Purpose Statement

This document provides an overview of MySQL HeatWave. It is intended solely to help you assess the business benefits of MySQL HeatWave and to plan your I.T. projects.

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Due to the nature of the product architecture, it may not be possible to safely include all features described in this document without risking significant destabilization of the code.

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

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## Executive Summary

MySQL is the world's most popular open source database because of its reliability, high-performance, and ease of use. It powers the world's most trafficked web sites including Facebook, Twitter, YouTube and Booking.com. MySQL combines the benefits of a widely adopted open source database solution with a strong ecosystem, millions of users, and the backing of Oracle.

Open source software is the driving force behind much of the innovation we are seeing today. The fastest growing companies in the world are using MySQL to deliver modern applications that are disrupting entire industries including ecommerce, advertising, retail, media and entertainment, travel and many more. Large enterprises are following the lead of these innovators by using MySQL to build modern, agile organizations.

It is no surprise that cloud computing infrastructure and services are largely built on open source software. Cloud computing services enable the next step to innovating faster and increasing business agility. According to Gartner<sup>1</sup>, cloud-native platforms are one of the 2022 Top Strategic Technology Trends.

MySQL HeatWave is the only MySQL database service 100% built, managed and supported by the MySQL team.

- **CIOs can improve business agility** and respond to changing market conditions
- **DevOps teams and DBAs can improve productivity** by automating manual database tasks
- **Developers can get applications to market faster** using the most modern tools
- **Data analysts and scientists can accelerate machine learning initiatives** using native, in database technologies
- **Executive management can make timely business decision** based on real-time data analytics

The amount of data that organizations have to now manage is massive. In fact, according to the IDC<sup>2</sup>, the sum of the world's data – the DataSphere — will grow from 64 zettabytes in 2020 to a mind-boggling 181 ZB by 2025. Another eye-opening fact is that all this data is moving to the cloud. By 2025, 49% of data will be stored in public cloud environments and nearly 30% of the data generated will be consumed in real-time by 2025.

The companies that will thrive in the evolving digital landscape, will be those that make data and analytics the core part of their strategy and business functions. According to McKinsey<sup>3</sup>, 92% of company leaders surveyed believed that their business model would not remain viable at the current rate of digitization. This fear of disruption is the leading driver behind the investment in modern data analytics platforms. Fortune 1000 companies are recognizing that they must leverage their data assets if they are to compete successfully against highly agile, data-driven competitors.

MySQL HeatWave is the only MySQL cloud service with a built-in, high performance, in-memory query accelerator—HeatWave. It overcomes the limitations of traditional data warehouse and analytics environments that use periodic long-running ETL batch jobs required to refresh data. MySQL HeatWave delivers:

- **A single MySQL database for OLTP, OLAP, and machine learning**
- **5400x MySQL query acceleration vs. Amazon RDS for MySQL**
- **1400x faster than Amazon Aurora**
- **6.5x faster than Amazon Redshift**
- **1/2 the cost of Amazon Aurora**
- **1/2 the cost of Amazon Redshift**
- **Run existing applications and BI without changes**

In this guide we will explore the ubiquity of MySQL, the state of the open source and cloud computing market, and look at how MySQL HeatWave can pave the way for organizations to become more innovative, data-driven organizations.

## MySQL: The World's Most Popular Open Source Database

MySQL is the world's most popular database with millions of downloads every year. DB-Engines ranks MySQL as the most popular open source database<sup>4</sup>. MySQL's popularity continues to rise, it won the DB-Engine "DBMS of the Year" award 2 years ago, recognizing that it gained more popularity than any other of the other 350 products monitored that year.

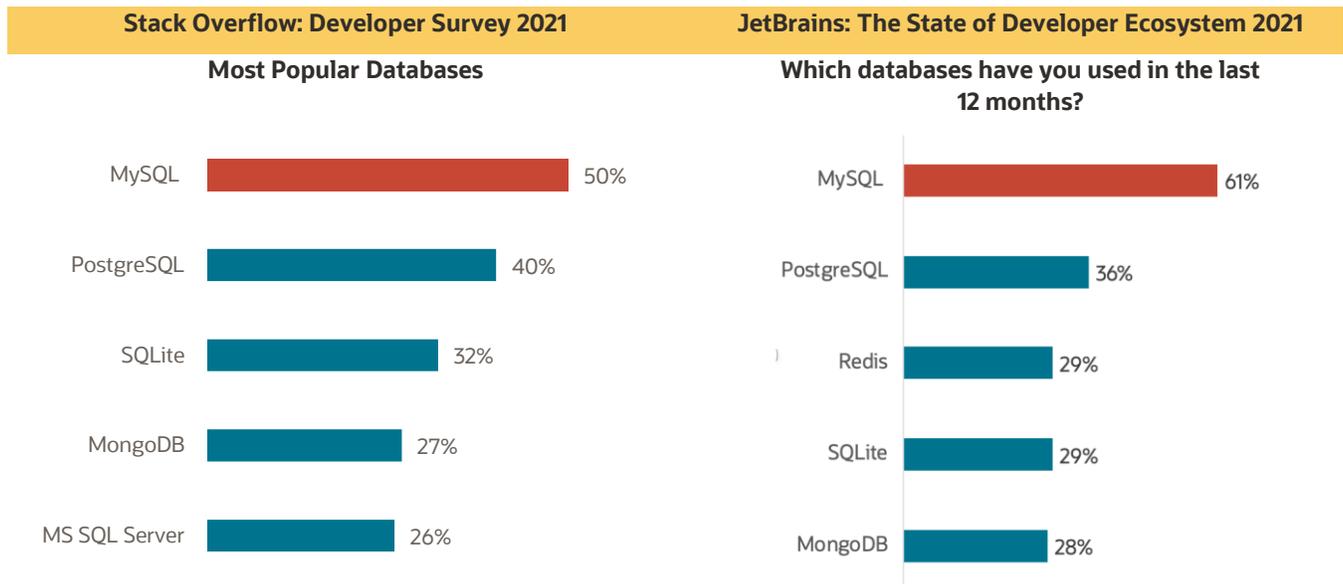
## DB-ENGINES: 2022 DATABASE RANKING

Rank			DBMS	Database Model	Mar 2022
Mar 2022	Feb 2022	Mar 2021			
1.	1.	1.	Oracle +	Relational, Multi-model <a href="#">i</a>	1251.32
2.	2.	2.	MySQL +	Relational, Multi-model <a href="#">i</a>	1198.23
3.	3.	3.	Microsoft SQL Server +	Relational, Multi-model <a href="#">i</a>	933.78
4.	4.	4.	PostgreSQL + <a href="#">c</a>	Relational, Multi-model <a href="#">i</a>	616.93

*MySQL is the world's most popular open source database.*

This leadership is a clear indicator of MySQL's ubiquity and the market's confidence in using MySQL for business-critical applications. With so many active installations, organizations can rest assured of finding developers and DBAs with MySQL experience and skills. Plus, there is an entire ecosystem of tools and applications that support MySQL.

According to recent surveys from Stack Overflow<sup>5</sup> and JetBrains<sup>6</sup>, MySQL is the most popular database among developers.



*MySQL is the most popular database among developers.*

## OPEN SOURCE IN THE ENTERPRISE

In 2021, 1,250 IT leaders were surveyed to determine how they think about open source software. The results were published in The State of Enterprise Open Source Report<sup>7</sup>. The survey found that 90% of IT leaders are using open source today. Also, open source databases are the 2<sup>nd</sup> most popular enterprise open source technology choice.

Open source technologies are often adopted to get applications into production faster. These projects are frequently unfunded and can't wait for IT approval. They start small and solve an immediate need, but over time evolve into business-critical applications.

As is often the case with MySQL, customers successfully deploying their first project using an open source software stack continue using it for additional projects. As organizations consolidate and standardize on a select few IT supported technologies, MySQL becomes a strategic part of their technology infrastructure.

One of the main drivers of the adoption of open source software is the Total Cost of Ownership savings. For example, MySQL enables organizations to reduce their database TCO by over 90% compared to Microsoft SQL Server. Other reasons cited for using enterprise open source include higher quality software, better security, access to the latest innovations and designed to work in the cloud. As a result, the adoption of Enterprise Open Source is expected to rise from 36% to 44% over the next two years.

## THE MOST INNOVATIVE COMPANIES RELY ON MySQL

MySQL is the database of choice for web developers. It is being used by the world's most innovative companies including Twitter, Facebook, Netflix and Uber. Many of these companies did not exist 20 years ago. Today they are disrupting multiple industries and are operating at a scale that is hard to imagine. They are nimble organizations where developers have the power and resources to evolve products and services quickly and shape the user experience in new ways.

Below is a table which highlights some the MySQL users and the scale at which they are operating.

Company	Description
	Facebook is one of the Top 10 most trafficked web sites in the world. They have 2.8 billion monthly active users. 55 million status updates and 350 million photos are uploaded every day.
	Booking.com is one of the Top 100 most trafficked web sites in the world. They have 28 million reported accommodation listings and more than 1.5 million room nights are reserved daily on their platform.
	Netflix is one of the Top 20 most trafficked web sites in the world. They have over 167 million subscribers. 165 million hours of Netflix are watched everyday across the globe.
	Twitter is one of the most widely used social media platforms in the world with over 330 million monthly active users. There are 500 million tweets sent each day or 6,000 tweets every second.
	Airbnb has about 150 million users with more than 5 million listings worldwide, covering 65,000 cities
	There are over 75 million active Uber riders across the world and Uber fulfills 40 million rides per month.

SaaS is one of the main categories of the cloud computing market. The SaaS market is expected to grow from USD \$130.69 billion in 2021 to USD \$716.52 billion in 2028 at a CAGR of 27.5%<sup>8</sup>. Some of the most innovative, fastest growing ISVs are delivering their applications in a SaaS model and are choosing MySQL for its ease of use, reliability, performance, and scalability. Users benefit from faster time to value, low up-front costs, better security, and more flexibility.

Below is a table which highlights some the leading SaaS companies using MySQL:

Company	Description
	Zendesk is a leading SaaS provider of CRM applications with close to \$1B in annual revenue.
	Hubspot is a leading SaaS provider of marketing and sales applications with close to \$1B in annual revenue.
	Github is a leading SaaS provider of software development version control with 40 million users and 100 million repositories.
	Square is a leading provider of payment and point-of-sale solutions with over \$4B in annual revenue.
	Mint is a leading SaaS provider of personal finance applications with over 20 million users.

With each new release, MySQL performance and scalability continue to improve, enabling companies to keep pace with the growth in users and data. Plus, new features such as the MySQL Document Store, MySQL Shell and X Dev API, as well as MySQL InnoDB Cluster are helping customers meet evolving data management requirements and improve developer productivity.

## MySQL HeatWave

There are many reasons to move to the cloud – the cloud helps organizations improve agility, reduce costs, access the latest innovations, become more secure and more. Let’s take a look at how MySQL HeatWave can help you realize some of these benefits.

### IMPROVE ORGANIZATIONAL AGILITY

Organizational agility is the single biggest benefit of moving to the cloud. The ability to adapt quickly to fast changing market conditions and competitive actions, could be the determining factor in the success or failure of your business.

In the traditional on-premises model, business units often have to wait months before they can get started on new projects because their IT department doesn’t have the resources to dedicate to new initiatives. Business units find themselves having to go through the lengthy process of budget approval, hardware and software procurement and IT staff resource allocation before getting started on a new project.

MySQL HeatWave enables you to:

- **Improve business agility** to quickly take advantage of new business opportunities or changing priorities.
- **Deploy applications in hours or days and not months**, by immediately provisioning database instances and compute capacity from Oracle Cloud.
- **Adapt quickly** to changing market conditions and respond to competitors’ actions.
- **Eliminate lengthy processes** associated with budgeting, purchasing, configuring, and maintaining your own computing and database infrastructure.
- **Reduce the risk of projects getting delayed** or never getting started because of IT resource bottlenecks.

## CLOUD EMPOWERS DEVELOPERS THROUGH AUTOMATION

Databases hold data that is highly critical to the organization. In an on-premises environment, deploying a database is a multi-step process that requires the provisioning of compute, storage and networking components, configuring them properly, making sure the database is secure and meets regulatory requirements. The IT department then prioritizes the requests, allocates the resources, configures and manages the database. This process is time consuming, error prone and requires specialized skills.

According to CIO.com, finding skilled IT staff is one of the top challenges IT leaders are facing in 2022<sup>9</sup>. This lack of technical skills comes at a time when IT complexity is increasing. To solve this IT skills gap problem, organizations are turning to fully managed services like MySQL HeatWave.

MySQL HeatWave is a fully managed service that eliminates a lot of the manual tasks that are associated with managing your own infrastructure, as seen below.

			
		MySQL On-Premises	MySQL HeatWave
Database	Automation		
	High Availability	✗	✓
	Backup	✗	✓
	Security Patch & Upgrade	✗	✓
OS	Provision & Configure	✗	✓
	OS Security Patch & Upgrade	✗	✓
Server	OS Installation	✗	✓
Storage	Hardware Purchase & Maintenance	✗	✓
Data Center	Storage Purchase & Maintenance	✗	✓
	Rack & Space	✗	✓
	Power, HVAC, Networking	✗	✓

MySQL HeatWave is a fully managed service that automates many of the manual tasks. It enables you to:

- **Instantly provision MySQL instances** and connect to a production ready, pre-configured MySQL database.
- **Automate database specific** tasks such as configuration, security patching, backup, and monitoring.
- **Choose from multiple compute shapes** depending on your application and capacity requirements.
- **Store data in fast, reliable, and secure cloud storage** by leveraging the Oracle Block Volumes advantages like high-performance NVMe SSD technology, integration with highly durable Object Storage, and built-in encryption.
- **Enable fast, predictable networking with end-to-end network security** including a Virtual Cloud Network (VCN).
- **Monitor the health of your resources**, optimize the performance of your applications and set alarms to respond to anomalies in real time using the integration with Oracle Cloud Infrastructure Monitoring service.
- **Access to dozens of additional Oracle Cloud Services** enabling organizations to embrace the shift to the cloud.
- **Free up developer, DBA and DevOps time** to focus on value added tasks that are core to your business.

## HIGH AVAILABILITY

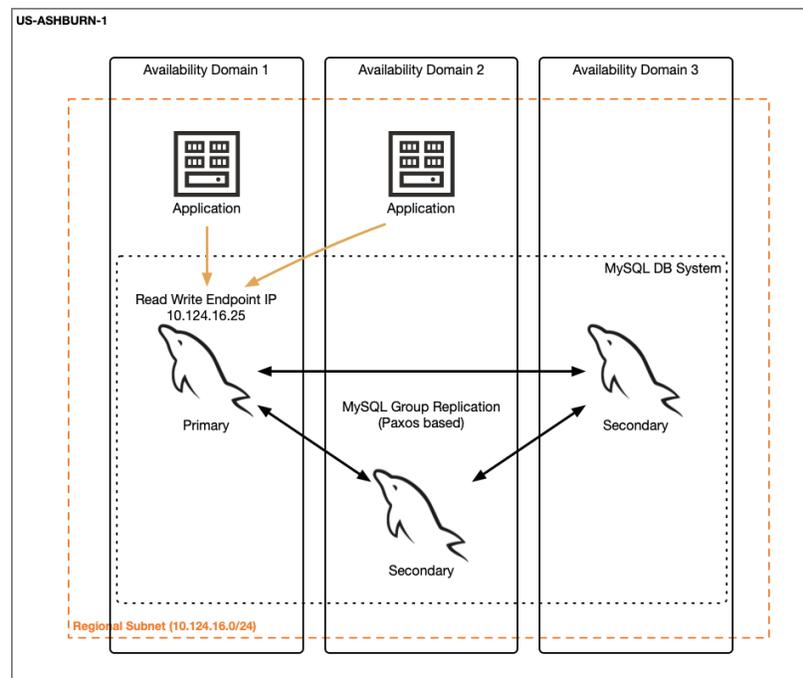
Organizations with business-critical processes must calculate the impact of outages to their bottom line. Companies must ensure their high availability database implementation can cope with failures ranging from server failures, network failures, power failures and entire data center failures. Organizations can protect their data and ensure business continuity using native MySQL HA technologies available in cloud Regions, Availability Domains and Fault Domains provided by Oracle Cloud Infrastructure.

A region is composed of one or more availability domains. Each availability domain has three fault domains. By deploying instances across multiple availability domains and fault domains, organizations can deploy redundant database instances and eliminate single points of failure.

- **Availability Domains** distribute your instances so they don't share infrastructure such as data center power, cooling, and network within a region.
- **Fault Domains** distribute your instances so they are not on the same physical hardware within a single availability domain.

## NATIVE MySQL HIGH AVAILABILITY

High availability is built on native MySQL Group Replication. In a high availability deployment, 3 MySQL instances are provisioned and spread across different physical locations (spread across Availability or Fault Domains). One instance will be the primary, accepting the database traffic, the other instances are kept up to date using a Paxos based protocol and are permanently on standby, ready to take over database traffic in case of failure, without any data loss.



*Native MySQL Group Replication for High Availability*

## RTO/RPO

The two most important parameters to define a high availability strategy are Recovery Time Objective (RTO) and Recovery Point Objective (RPO).

- **Recovery Time Objective (RTO)** is the maximum length of time that a system can be down, after a failure or disaster occurs, before unacceptable consequences impact the business (financial losses, customer impact, etc.).
- **Recovery Point Objective (RPO)** is the maximum amount of data a system may lose, after a failure or disaster occurs, before unacceptable consequences impact the business (financial losses, customer impact, etc.).

MySQL instances are deployed across multiple Availability or Fault domains to deliver a better RTO and RPO:

- **RPO = 0 (No Data Loss)**
- **RTO = Minutes**

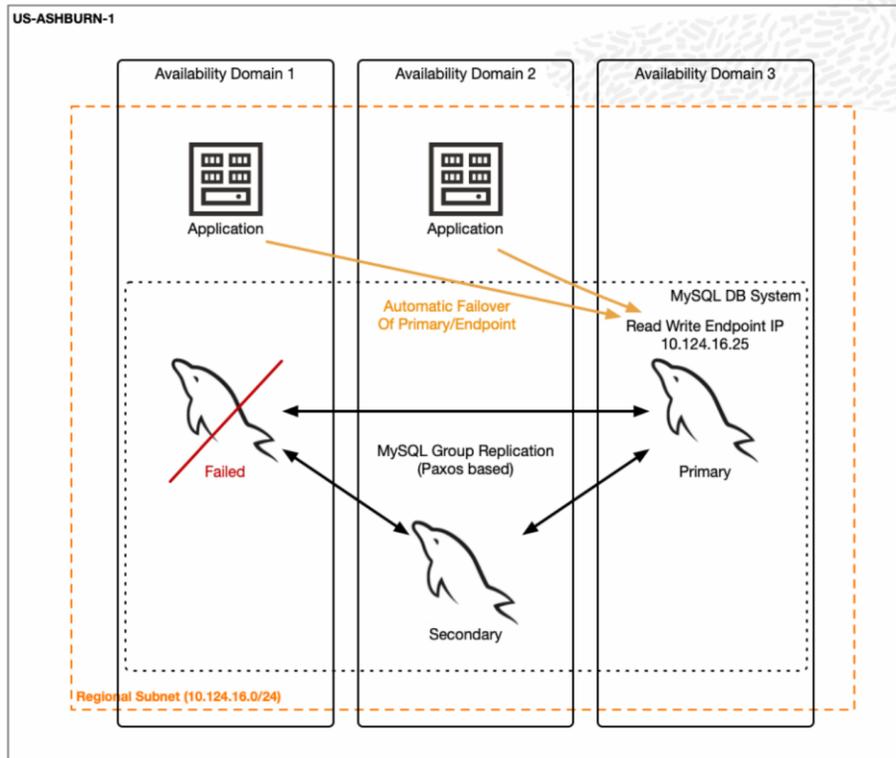
## HIGH AVAILABILITY PLACEMENT

To provide maximum redundancy, we optimize the placement of database instances:

- In regions with multiple Availability Domains, database instances are placed in different Availability Domains.
- In regions with a single Availability Domain, database instances are placed in different Fault Domains.

## AUTOMATIC FAILOVER

High Availability provides an integrated, automatic failure detection mechanism. When there is a failure, the group detects and reaches consensus on the failure, and then promotes a secondary member to be the new primary. Once the failed database server comes back online, it rejoins the group and is brought up to date automatically. It is also possible to manually switchover a secondary server to take over as the primary server. Applications can still, without reconfiguration, connect to the database endpoint IP address, regardless of which instance is the currently promoted primary.



*Automatic failure detection and promotion of a secondary member to be primary.*

## SECURITY AND REGULATORY COMPLIANCE

Massive data breaches continue to make news headlines. Every year there are thousands of data breaches and hundreds of millions of records stolen. According to the Cost of Data Breach Report<sup>10</sup>, a breach of 1 million records in 2021 has grown to an average total cost of \$52 million, while a breach of 50 million records yields an average total cost of \$400 million. As you might expect, security continues to be one of the top Investment priorities for CIOs.

Government and industry regulatory compliance is another top priority for CIOs. Over 100 countries have now adopted data protection laws. GDPR is one of the most wide-ranging data protection regulatory schemes and includes data privacy rights, data security standards, data breach notification requirements, and fines for failing to comply.

A company running its own on-premises servers, carries the entire burden of security and regulatory compliance. For example, they are responsible for implementing mechanisms to enforce user access policies, installing hardware and software firewalls, ensuring security patches are installed promptly, backups are scheduled, and encryption is enabled. If not managed properly, on-premises servers can leave an organization vulnerable to security threats and out of compliance. One way to mitigate this risk, is to leverage cloud providers who have implemented best practices and dedicated resources focused on data protection and regulatory compliance.

## ORACLE CLOUD INFRASTRUCTURE SECURITY

MySQL HeatWave is built on Oracle Cloud Infrastructure (OCI). OCI is a second-generation infrastructure-as-a-service (IaaS) offering architected on security-first design principles, a significant improvement over first-generation public cloud. The

Oracle Cloud Infrastructure architecture was designed for the security of the platform through isolated network virtualization, highly secure firmware installation, a controlled physical network, and network segmentation.

## COST ADVANTAGES OF THE CLOUD: CAPEX VS. OPEX

Traditionally, companies that use on-premises infrastructure require a significant CapEx investment to acquire space, equipment, software, and a workforce. This model gave them control over system configuration, software updates, security, performance optimization, but at what cost? Future requirements can be unpredictable, making capacity planning difficult. Getting stuck with capacity you don't need is wasting money. Not enough capacity means you are limiting your company's ability to deliver new projects and respond to business opportunities.

MySQL HeatWave is a fully managed service running on Oracle Gen 2 Cloud Infrastructure. It enables you to:

- **Switch from a CapEx to an OpEx expense model** as a more flexible approach to lower your business expenses.
- **Reinvest CapEx savings** back into your business to grow revenues and improve profits.
- **Eliminate the huge up-front costs** associated with buying, operating, and maintaining your own on-premises computing infrastructure.
- **Pay for what you use, when you use it** with a flexible, pay-as-you-go pricing model with no up-front commitments.
- **Reduce the unnecessary spending on the excess capacity** required to handle peak demand. Realize savings in the cloud by running at near 100% utilization.
- **Free up your IT talent** from infrastructure maintenance and focus on delivering better products and services that are core to your business.

## HeatWave

The amount of data that companies need to manage is growing exponentially and more data is being consumed in real-time. The competitive landscape is changing quickly as startups threaten to disrupt larger incumbents with new products and services using data and analytics at the core of their services. For example, the insurance industry is ripe for disruption, and data analytics is playing a huge part. Startups are enabling insurers to deliver personalized products and services using app and device data. As a result, insurance companies become more relevant to their customers and build ongoing relationships. This same scenario is playing out across industries including retail, transportation, manufacturing, and finance.

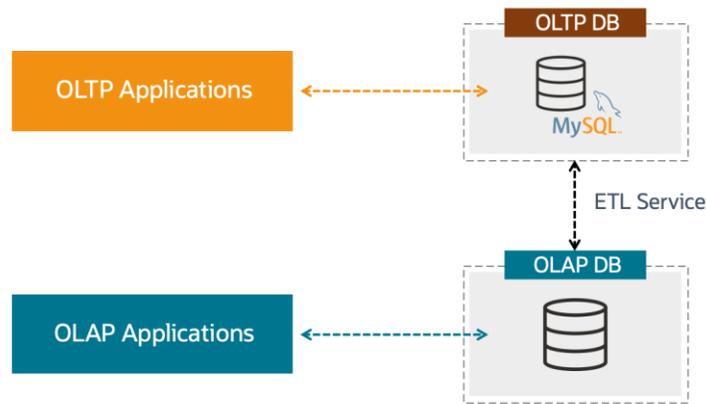
## CHALLENGES OF EXISTING SOLUTIONS

There are several challenges that companies face that make it difficult to deliver modern data and analytics solutions. Running analytic queries against an OLTP database is inherently slow. As a result, customers must rely on 2 separate databases for OLTP and OLAP workloads.

- **OLTP databases** are row-based and deliver high performance for large numbers of small transactions using simple queries. Applications run essential transactional business processes and are updated frequently with millisecond response times.
- **OLAP databases** are columnar for handling large volumes of data using complex queries to aggregate and summarize data. Applications run decision support systems and are updated periodically with long-running batch jobs.

Having to rely on separate OLTP and OLAP databases introduces additional risk, cost, and complexity. For example:

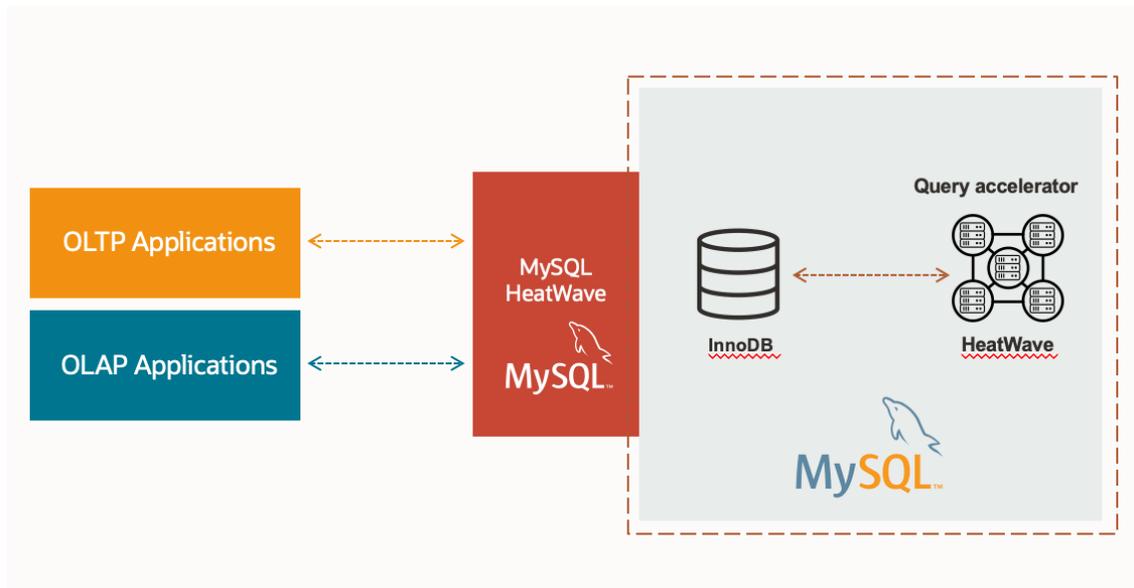
- **Lengthy ETL processes** with only periodic updates of data
- **Stale data** making it difficult to make critical decisions with the most current information
- **Additional cost** of maintaining 2 separate databases
- **Additional skills** required to manage the complexity of 2 separate systems



Separate OLTP and OLAP databases require lengthy ETL processes that introduce risk, cost & complexity

## SINGLE MySQL DATABASE FOR OLTP AND OLAP

MySQL HeatWave is the only MySQL service that provides a single solution for running OLTP and OLAP workloads. It enables customers to run both OLTP and OLAP workloads in MySQL, within a single database platform, without the need to ETL data to a separate database for analytic processing. No changes to existing applications are necessary.



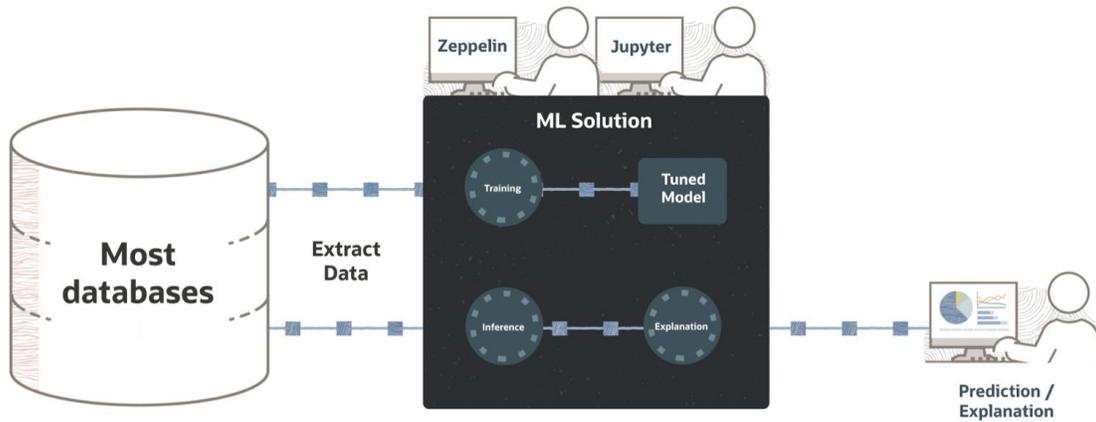
MySQL HeatWave provides a single MySQL database for OLTP and OLAP workloads.

## HEATWAVE ML: NATIVE IN-DATABASE MACHINE LEARNING

HeatWave ML delivers native, in-database machine learning, enabling developers and data analysts to build, train, deploy, and explain machine learning models within MySQL HeatWave.

### CHALLENGES OF EXISTING MACHINE LEARNING SYSTEMS

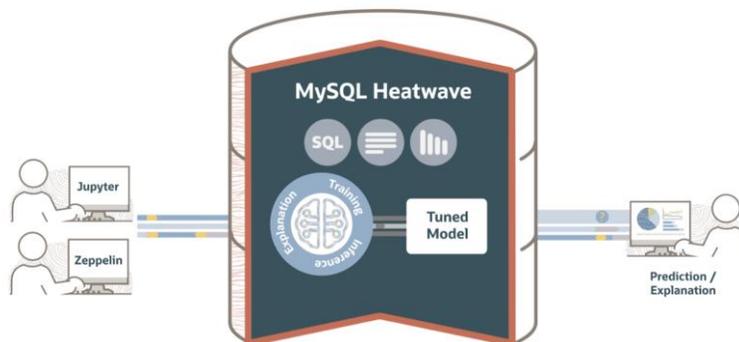
The issue with existing machine learning systems, is that they don't provide an easy way to build machine learning models using the data in their database. Developers, data analysts, and data scientists typically need to move/ETL data to separate machine-learning products or cloud services to build and train machine-learning models. This takes time, delays organizations' ability to obtain quick answers, and increases costs. Security and compliance risks also increase as data is moved between systems. Additionally, developers and data analysts may need to learn new tools and languages.



*Separate machine learning products and cloud services increase risk, cost & complexity.*

## NATIVE, IN-DATABASE MACHINE LEARNING WITH HEATWAVE ML

HeatWave ML delivers native, in-database machine learning, enabling developers and data analysts to build, train, deploy, and explain machine learning models within MySQL HeatWave. They can easily and securely apply machine learning training, inference, and explanation to data stored inside MySQL HeatWave. As a result, they can accelerate ML initiatives, increase security, and reduce costs. Developers and data analysts can build machine learning models using familiar SQL commands; they don't have to learn new tools and languages. Additionally, HeatWave ML is integrated with popular notebooks such as Jupyter and Apache Zeppelin.

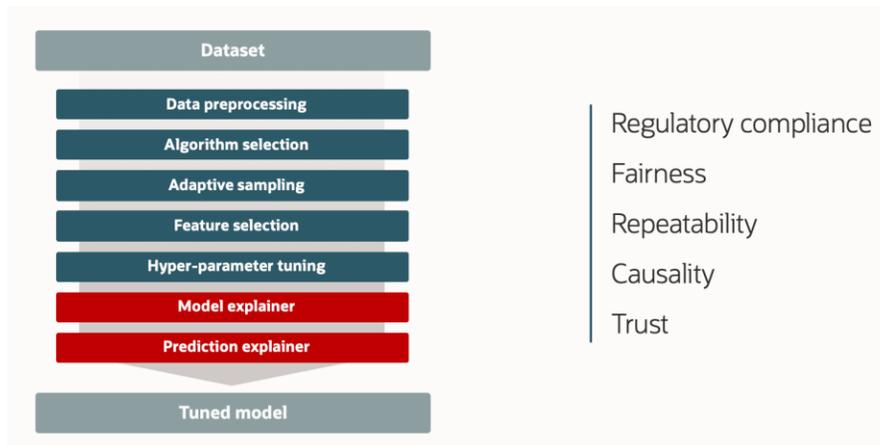


*Native, in database machine with HeatWave ML makes machine learning with MySQL easy and secure.*

## AUTOMATE THE MACHINE LEARNING LIFECYCLE

HeatWave ML automates the machine learning lifecycle, including algorithm selection, intelligent data sampling for model training, feature selection, and hyperparameter optimization—saving data analysts and data scientists significant time and effort.

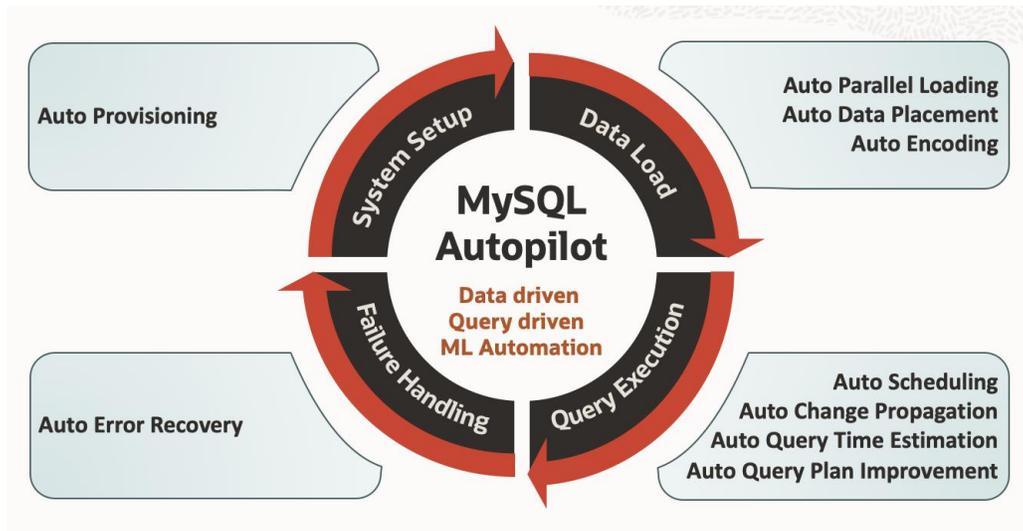
All the models trained by HeatWave ML are explainable. HeatWave ML delivers predictions with an explanation of the results, improving reliability, fairness, trust, and regulatory compliance. If for example a customer is refused a loan or credit card, it is possible to explain why.



HeatWave ML delivers predictions with an explanation of the results.

## MySQL AUTOPILOT FOR MACHINE LEARNING-BASED AUTOMATION

MySQL HeatWave provides comprehensive machine learning-based automation for optimal HeatWave cluster provisioning, data loading, query execution, and failure handling—improving performance, scalability and uptime while significantly reducing manual database administration tasks.



MySQL AutoPilot features for machine learning based automation.

### System Setup

- **Auto provisioning** predicts the number of HeatWave nodes required for running a workload by adaptive sampling of table data on which analytics is required. This means that customers no longer need to manually estimate the optimal size of their cluster. No other database service provides this capability.

### Data Layout

- **Auto parallel load** optimizes the load time and memory usage by predicting the optimal degree of parallelism for each table being loaded into HeatWave. No other cloud vendor offers this capability.
- **Auto data placement** predicts the column on which tables should be partitioned in-memory to achieve the best performance for queries. It also predicts the expected gain in query performance with the new column

recommendation. This minimizes data movement across nodes due to suboptimal choices that can be made by operators when manually selecting the column. No other database service provides this rich capability.

- **Auto encoding** determines the optimal representation of columns being loaded into HeatWave taking the queries into consideration. This optimal representation provides the best query performance and minimizes the size of the cluster to minimize the cost.

### Query Execution

- **Auto query plan improvement** learns various statistics from the execution of queries and improves the execution plan of future queries. This improves the performance of the system as more queries are run. No other database service provides this capability.
- **Auto query time estimation** estimates the execution time of a query prior to executing the query. For customers, this provides a prediction of how long a query will take, enabling them to decide if the duration of the query is too long and instead run a different query.
- **Auto change propagation** intelligently determines the optimal time when changes in MySQL Database should be propagated to the HeatWave Scale-Out Data Management layer. This ensures that changes are being propagated at the right optimal cadence. No other cloud vendor offers this capability.
- **Auto scheduling** determines which queries in the queue are short running and prioritizes them over long running queries in an intelligent way to reduce overall wait time. Most other databases use the First In, First Out (FIFO) mechanism for scheduling.

### Failure Handling

- **Auto error recovery** provisions new nodes and reloads necessary data if one or more HeatWave nodes is unresponsive due to software or hardware failure.

## SCALE OUT STORAGE USING OCI OBJECT STORE

HeatWave gives you the flexibility of using the OCI Object Store as a separate storage layer. Data is stored in OCI Object Storage in an in-memory, compressed, encrypted format. HeatWave data can be read directly from OCI object storage in parallel by multiple HeatWave nodes. Operations such as error recovery, restart, and upgrades are much faster since data can be reloaded extremely fast from the object store into the HeatWave Cluster.

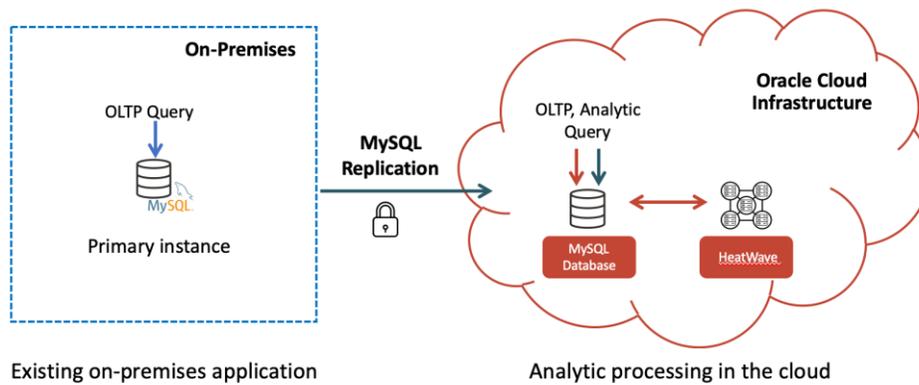
### 100X FASTER RECOVERY

When data is loaded from MySQL into HeatWave, a copy of the in-memory representation is made to the scale-out data management layer, which is built on OCI object store. Any changes made to data in MySQL are transparently propagated to this data layer. During a reload operation, data is accessed from the HeatWave data layer, in parallel, by multiple HeatWave nodes. The loading of data from the scale out data management layer does not require any transformation. The result is that reload to HeatWave is very fast, scales with the size of data, and can be done in constant time irrespective of the data size. This leads to a dramatic improvement in the performance of operations that require reloading data into HeatWave like error recovery, restart and upgrade. For example, for a 10TB HeatWave cluster, the time it takes to recover and reload data reduces from 7.5 hours to 4 minutes, a 100x improvement.

## EASILY ADD ANALYTICS TO ON-PREMISES MySQL APPLICATIONS

MySQL users who wanted to run analytics queries on operational data have had to either sacrifice performance or move their data to a separate analytics database. This same issue exists for users of database cloud services. For example, for customers to run analytic workloads in Amazon AWS, users have to ETL data out of Amazon RDS or Amazon Aurora into Amazon Redshift, adding additional complexity.

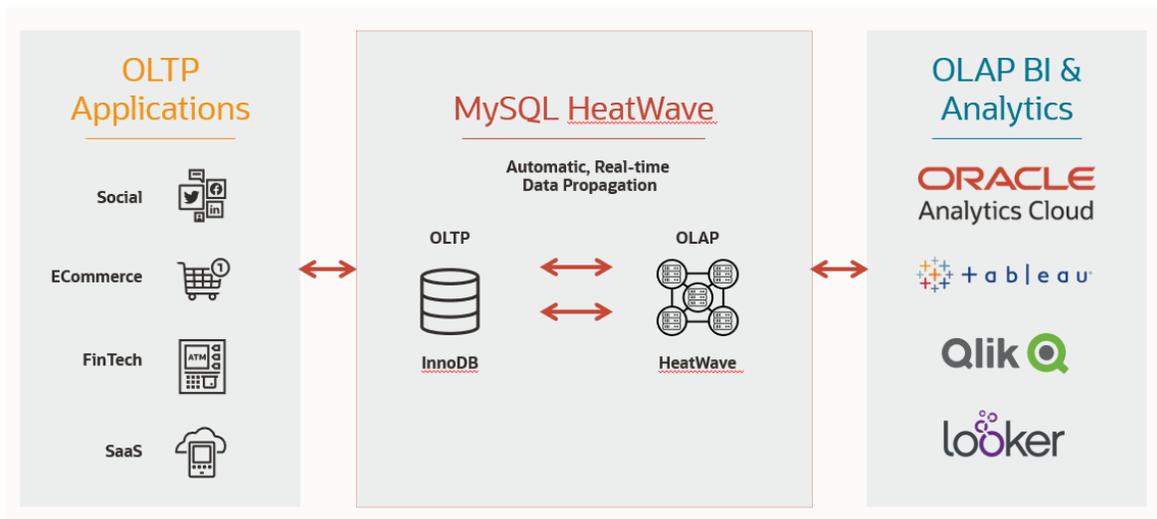
MySQL users have the flexibility of running analytics in the cloud using HeatWave, while keeping their OLTP workloads on-premises. MySQL Shell and in-bound replication make it quick and easy to move data to the Oracle Cloud for real-time analysis.



Easily run analytics in the cloud against your on-premises MySQL databases.

## EXISTING APPLICATIONS AND BI APPS WORK AS IS

HeatWave is 100% native to MySQL. It is easy to use, compatible with existing applications, and benefits from a significant ecosystem of third-party tools. Since HeatWave is 100% compatible with the standard MySQL syntax, there are no changes required to MySQL queries or applications. HeatWave also supports the same BI and data visualization tools as MySQL Database, such as Oracle Analytics Cloud, Tableau and Looker.



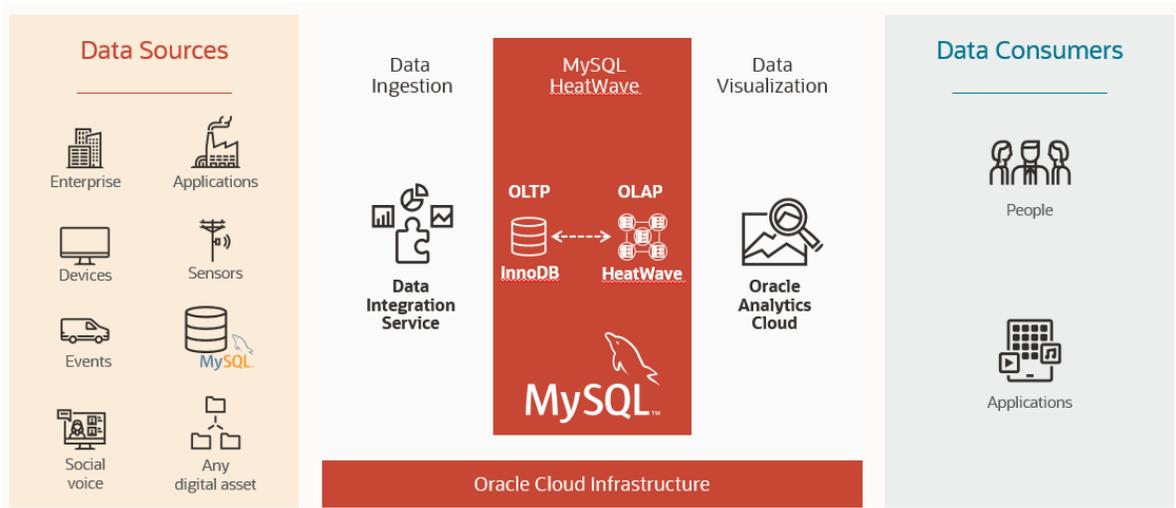
HeatWave works with existing applications, BI, and Data Visualization tools.

## INTEGRATION WITH SERVICES IN ORACLE CLOUD

OCI offers a wide range of services including data analytics and data integration services. Native integration with these services makes it easier for existing applications to use HeatWave.

Oracle Analytics Cloud (OAC) provides the industry's most comprehensive cloud analytics in a single unified platform, including self-service visualization and inline data preparation, enterprise reporting, advanced analytics, and self-learning analytics that deliver proactive insights. Integration with OAC provides a BI visualization platform for users to analyze their MySQL data.

OCI Data Integration provides extract, transform and load (ETL) capabilities to target data warehousing scenarios on the OCI platform. It supports various data sources, starting with relational, cloud and Hadoop. Integration with OCI Data Integration allows users to easily transform and import data from data sources other than MySQL to HeatWave, expanding the scope of data that can be used with HeatWave.



*Integration with Oracle Cloud Services provides end-to-end Integration from Data Ingestion to Data Visualization*

## Use Cases: MySQL HeatWave

### MOVE WORKLOADS TO THE CLOUD

Move MySQL workloads to the cloud to free up resources and focus on your business while improving security. MySQL HeatWave is 100% compatible with MySQL on-premises, making it easy to move workloads to the cloud or to use a hybrid cloud model with some applications on-premises.

### DEVELOP NEW CLOUD NATIVE APPLICATIONS

Improve business agility by developing modern, cloud-native MySQL-based applications. Developers can provision resources quickly and easily without the bottleneck of IT. DBAs and DevOps teams can focus on value added projects using a fully managed database service that automates time consuming tasks such as patching, upgrades, backups, security fixes, etc...

### DELIVER REAL-TIME DATA ANALYTICS

HeatWave accelerates MySQL query performance by 5400X. Make faster business decisions and eliminate the complexity and risk of having to use separate databases for OLTP and OLAP workloads.

### ACCELERATE MACHINE LEARNING INITIATIVES

HeatWave ML enables developers and data analysts to build, train, deploy, and explain machine learning models within MySQL. Native, in-database machine learning eliminates the complexity and risk of having to use a separate machine learning service.

### HYBRID OLTP & OLAP WORKLOADS

Run both transactional (OLTP) and analytics (OLAP) workloads simultaneously within a single database platform

### HYBRID CLOUD DEPLOYMENT FLEXIBILITY

MySQL HeatWave is 100% compatible with MySQL on-Premises, giving you the to keep your OLTP applications on-premises and offload your analytics workloads to MySQL HeatWave in the cloud.

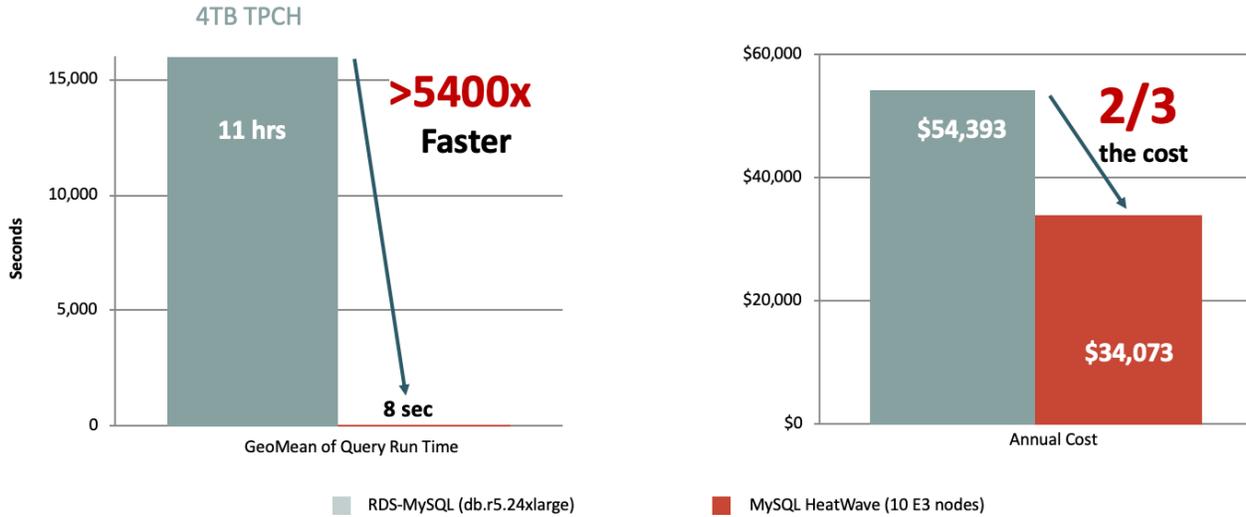
### POWER SAAS APPLICATIONS

MySQL has long been an extremely popular embedded database for ISVs, and it powers numerous SaaS applications today. As an ISV, you can scale your SaaS applications globally by leveraging Oracle Cloud Infrastructure and MySQL HeatWave.

## Faster and Lower Costs

### 5400X FASTER AND 2/3 THE COST OF AMAZON RDS

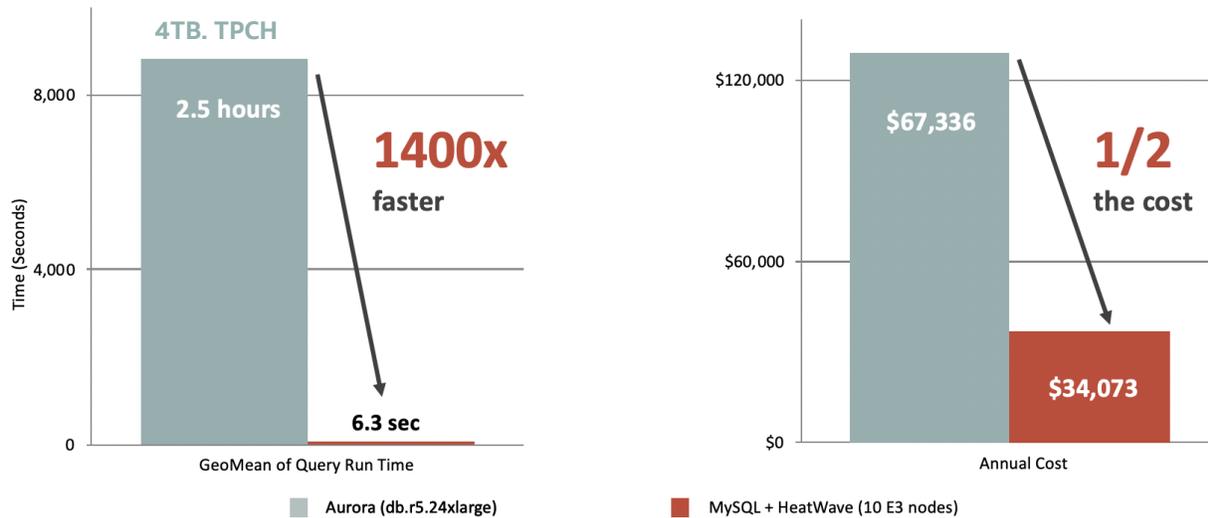
Performance benchmark results based on the TPC-H decision support benchmark show a 5400x acceleration against Amazon RDS for MySQL using HeatWave.



TPC-H Benchmarks show MySQL HeatWave is 5400x faster than Amazon RDS

### 1400X FASTER AND 1/2 THE COST OF AMAZON AURORA

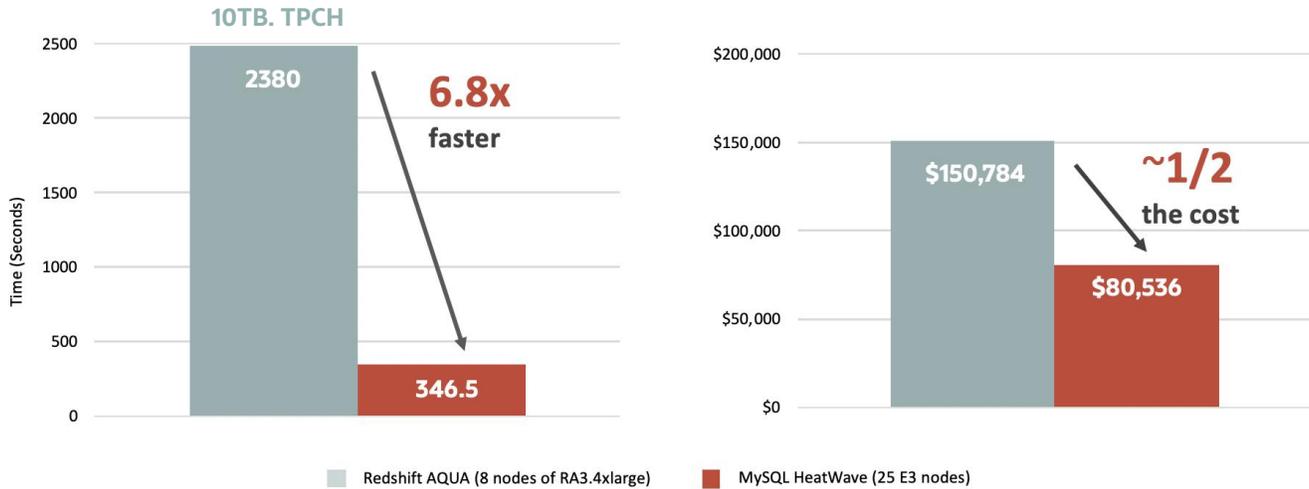
MySQL HeatWave provides superior performance benefits over Amazon Aurora. When comparing MySQL HeatWave against Amazon Aurora, using industry standard TCP-H benchmarks, MySQL HeatWave is 1400x faster. When comparing the 1-year Total Cost of Ownership (TCO) of both solutions, MySQL HeatWave is less than 1/2 the cost of Amazon Aurora.



TPC-H Benchmarks show MySQL HeatWave is 1400x faster than Amazon Aurora

## 6.8X FASTER AND 1/2 THE COST OF AMAZON REDSHIFT WITH AQUA

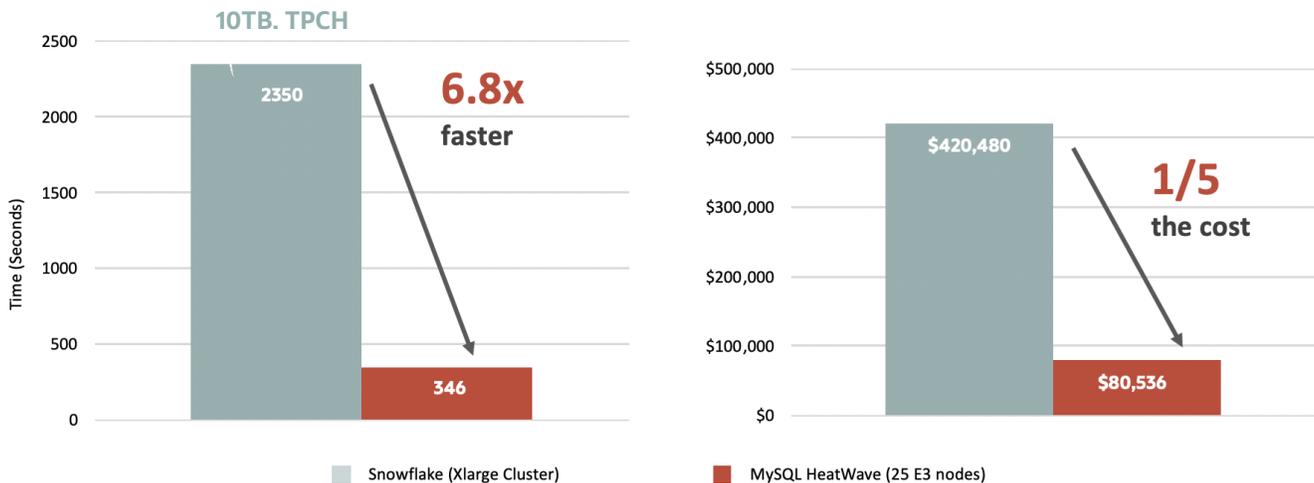
MySQL HeatWave provides superior performance benefits over Amazon Redshift with AQUA. When comparing MySQL HeatWave against Amazon Redshift with AQUA, using industry standard TPC-H benchmarks, MySQL HeatWave is 6.8x faster. When comparing the 1-year Total Cost of Ownership (TCO) of both solutions, MySQL HeatWave is ½ the cost of Amazon Redshift.



TPC-H Benchmarks show MySQL HeatWave is 6.8x faster than Amazon Redshift AQUA

## 6.8X FASTER AND 1/5 THE COST OF SNOWFLAKE

MySQL HeatWave provides superior performance benefits over Snowflake. When comparing MySQL HeatWave against Snowflake, using industry standard TPC-H benchmarks, MySQL HeatWave is 6.8x faster. When comparing the 1-year Total Cost of Ownership (TCO) of both solutions, MySQL HeatWave is 1/5 the cost of Amazon Snowflake.



TPC-H Benchmarks show MySQL HeatWave is 6.8x faster than Amazon RDS

## MIGRATION FROM AMAZON AURORA

If you have been using Amazon Aurora to manage your data, you will find that you can manage the same data using MySQL HeatWave for 1/2 of the cost on Amazon. You will also find that you can run your analytics queries 1400x faster than on Amazon Aurora.

MySQL HeatWave provides several migration tools and resources to migrate your database from Amazon Aurora.

Learn more:

<https://blogs.oracle.com/mysql/migrate-from-amazon-aurora-to-mysql-database-service-and-start-saving>

## 100% DEVELOPED, MANAGED AND SUPPORTED BY THE MySQL TEAM

MySQL HeatWave is the only MySQL public cloud database service 100% developed, managed and supported by the MySQL Team. That means you get the most up to date version of MySQL with new features and security fixes faster, including a tight feedback loop to the MySQL Engineering Team. MySQL Support, together with Oracle Premier Support, provides a unified 24/7 support solution for both cloud infrastructure and MySQL. No other cloud vendor can deliver such comprehensive technical support for MySQL.

## 100% COMPATIBLE WITH ON-PREMISES MySQL

Moving to the cloud is one of the Top 5 strategic priorities for CIOs. MySQL HeatWave is 100% compatible with on-premises MySQL, making it easier to migrate applications to the cloud without vendor lock in. Due to data location requirements or governance concerns, some applications or data may need to stay on premises. MySQL HeatWave provides organizations the flexibility of a hybrid deployment model.

## Conclusion

You already know that MySQL powers the leading eCommerce and SaaS companies. You also know that MySQL has a well-earned reputation for being easy to use, highly scalable, and cost-effective.

You've experienced the pain and cost of managing your database instances on your own infrastructure. For data analytics, you have experienced slow queries or the cost and complexity of managing a separate database for analytics. Data security is very important to you, so you have decided or are considering moving your applications to the cloud, with a fully managed and secure service.

Next, you must choose the right cloud platform for your business. MySQL HeatWave is the only cloud service with HeatWave, a real-time query accelerator that enables database admins and app developers to run OLTP, OLAP, and machine learning workloads directly inside their MySQL database. MySQL HeatWave is 1400X faster than Amazon Aurora, and 6.5x faster than Amazon Redshift at ½ the cost. No changes to existing applications are necessary.

It is the only cloud service 100% developed, managed, and supported by the MySQL Team. This ensures new features and security fixes at a faster pace with a unique tight feedback loop to the MySQL Engineering Team. Unlike proprietary forks of MySQL available in other cloud services, MySQL HeatWave is the only cloud service that is 100% compatible with on-premises MySQL for a seamless transition to the cloud and hybrid deployments. You'll also receive the highest level of MySQL expertise with a unified 24/7 support solution for both cloud infrastructure and MySQL.

In addition, Oracle Cloud Infrastructure delivers a highly secure and integrated cloud environment.

MySQL HeatWave on OCI will enable your business to easily deploy modern OLTP, OLAP, and machine learning applications globally with a secure, managed and supported cloud service from the MySQL Team.

Start Now!

<https://www.oracle.com/mysql/free/>

## Additional Resources

- MySQL HeatWave  
<http://www.oracle.com/mysql>
- Try MySQL HeatWave  
<https://www.oracle.com/mysql/free/>
- MySQL HeatWave vs. Amazon Aurora  
<https://www.oracle.com/mysql/heatwave/heatwave-vs-amazon-aurora/>
- MySQL HeatWave vs. Amazon Redshift  
<https://www.oracle.com/mysql/heatwave/heatwave-vs-amazon-redshift/>
- MySQL HeatWave vs. Snowflake  
<https://www.oracle.com/mysql/heatwave/heatwave-vs-amazon-redshift/>
- MySQL Enterprise Edition  
<https://www.mysql.com/products/enterprise/>
- Oracle Cloud Infrastructure  
<https://www.oracle.com/cloud/>

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- <sup>7</sup> State of Enterprise Open Source Report <https://www.redhat.com/en/enterprise-open-source-report/2021>. 2021
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