



# MySQL Database Service with HeatWave



5400x Faster than Amazon RDS

1400x Faster than Amazon Aurora

August, 2021

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## PURPOSE STATEMENT

This document provides an overview of the MySQL Database Service and HeatWave. It is intended solely to help you assess the business benefits of MySQL Database Service 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 in 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 innovate faster and increase business agility. According to Gartner<sup>1</sup>, by 2022, public cloud services will be essential for 90% of data and analytics innovation.

The MySQL Database Service in Oracle Cloud Infrastructure (OCI) 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 and DBAs can improve productivity** by automating manual database tasks
- **Developers can get applications to market faster** using the most modern tools
- **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 33 zettabytes in 2018 to a mind-boggling 175ZB 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 and analytics platforms. Fortune 1000 companies are recognizing that they must leveraging their data assets if they are to compete successfully against highly agile, data-driven competitors.

HeatWave provides the only massively-scalable integrated query accelerator. It is only available in Oracle Cloud Infrastructure (OCI) and overcomes the limitations of traditional data warehouse and analytics environments that use periodic long-running ETL batch jobs required to refresh data. HeatWave delivers:










- **5400x MySQL query acceleration**
- **1400x faster than Amazon Aurora**
- **1/2 the cost of Amazon Aurora**
- **1/2 the cost of Amazon Redshift**
- **A single MySQL database for OLTP and OLAP**
- **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 the MySQL Database Service with 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>. In addition, MySQL is the database management system that gained more popularity in the DB-Engines Ranking within the last year than any of the other 350 monitored database systems. MySQL was named DBMS of the Year 2019<sup>5</sup>.

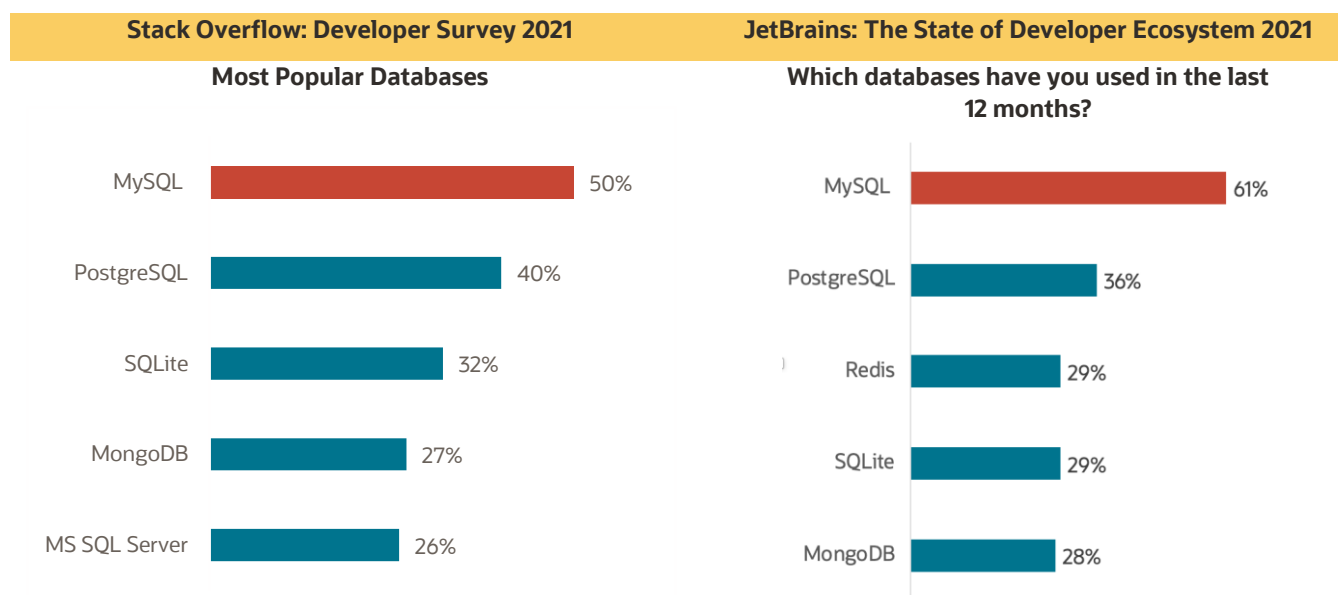
## DB-Engines: 2021 Database Ranking

Rank	Rank			DBMS	Database Model	Aug 2021
	Aug 2021	Jul 2021	Aug 2020			
1.	1.	1.	1.	Oracle 	Relational, Multi-model 	1269.26
2.	2.	2.	2.	MySQL 	Relational, Multi-model 	1238.22
3.	3.	3.	3.	Microsoft SQL Server 	Relational, Multi-model 	973.35
4.	4.	4.	4.	PostgreSQL 	Relational, Multi-model 	577.05
5.	5.	5.	5.	MongoDB 	Document, Multi-model 	496.54

*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>6</sup> and JetBrains<sup>7</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>8</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 out of a need to get applications into production faster. These projects are frequently un-funded and can't wait for IT approval. They start small and solve an immediate need, but over time many evolve into a business-critical applications.

As is often the case with MySQL, customers are successful deploying their first project using open source software and then use 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 that companies realize. 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, it is not surprising to see that the adoption of Enterprise Open Source is expected to rise from 36% to 44% over the next two years.

According to the Gartner State of the Open-Source DBMS Market Research Report<sup>9</sup>, by 2022, more than 70% of new in-house applications will be developed on an Open Source Database Management System (OSDBMS). 89% of organizations reported using open source DBMS.






## The Most Innovative Companies Rely on MySQL

MySQL became the database of choice for web developers. It is being used by 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. These are nimble organizations where developers have the power and resources to evolve products and services quickly and shape the user experience in new ways. These disruptors are using MySQL to innovate faster.

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 to \$220.21 billion at a CAGR of 13.1% through 2022<sup>10</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 realize value, low up-front costs, better security, and more flexibility. Below is a table which highlights some of 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 continues 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, MySQL InnoDB Cluster are helping our customers meet the evolving data management requirements and improve developer productivity.

## GROWTH OF CLOUD DATABASE MARKET

The move to the cloud is the single most significant technology shift organizations will face over the next decade. Even though this shift has been going on for some time, what we see now is only the beginning. Gartner projects the Cloud Services Industry to grow exponentially through 2022. More than \$1.3 trillion in IT spending will be directly or indirectly affected by the shift to cloud by 2022<sup>11</sup>. In fact, the market size and growth of the cloud services industry is nearly 3x the growth of overall IT services.

If we look at the DBMS market, similar growth rates and shifts in spending are also taking place. Gartner published a research report titled, The Future of the DBMS Market Is Cloud<sup>12</sup>. In the report they shared the following information:

- The overall DBMS Market grew to \$65B in 2020 and grew 17% from 2019-2020.
- \$26B of the DBMS market is from DBMS Cloud Services, which grew 50% from 2019-2020.





The evidence is clear, all organizations, big and small, will be using the cloud in increasing amounts.

## USE CASES: MYSQL DATABASE SERVICE WITH 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 Database Service uses the same database as MySQL On-Premises. Additionally, it integrates with your existing Oracle technologies.

### 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 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 400x. Make faster business decisions and eliminate the complexity and risk of having to use separate databases for OLTP and OLAP workloads.

### Hybrid OLTP & OLAP Workloads

Run both transactional (OLTP) and real-time operational intelligence processing (OLAP) workloads simultaneously within a single database platform

### Hybrid Cloud Deployment Flexibility

MySQL Database Service is 100% compatible with MySQL On-Premises, giving you complete deployment flexibility between on-premises, cloud or a hybrid model for your different workloads. Move your MySQL workloads seamlessly without lock-in. Keep your OLTP workloads on-premise and offload your analytics workloads to HeatWave.

### Power SaaS Applications

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

## MYSQL DATABASE SERVICE IN ORACLE CLOUD

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 many others. Let's take a look at how the MySQL Database Service 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.

The MySQL Database Service in Oracle Cloud Infrastructure enables you to:



- **Improve business agility** to quickly take advantage of new business opportunities or changing priorities.
- **Deploy applications in hours or days**, 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 a projects getting delayed** or never 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 and making sure the database is secure and meets regulatory requirements. The IT department then prioritizes the request, allocates the resources, configures and manages the database. This process is time consuming, error prone and requires specialized skills.

According to Forrester, 75% of businesses have a digital strategy, but only 16% claim to have the skills to deliver it<sup>15</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 the MySQL Database Service.

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

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

MySQL Database Service 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

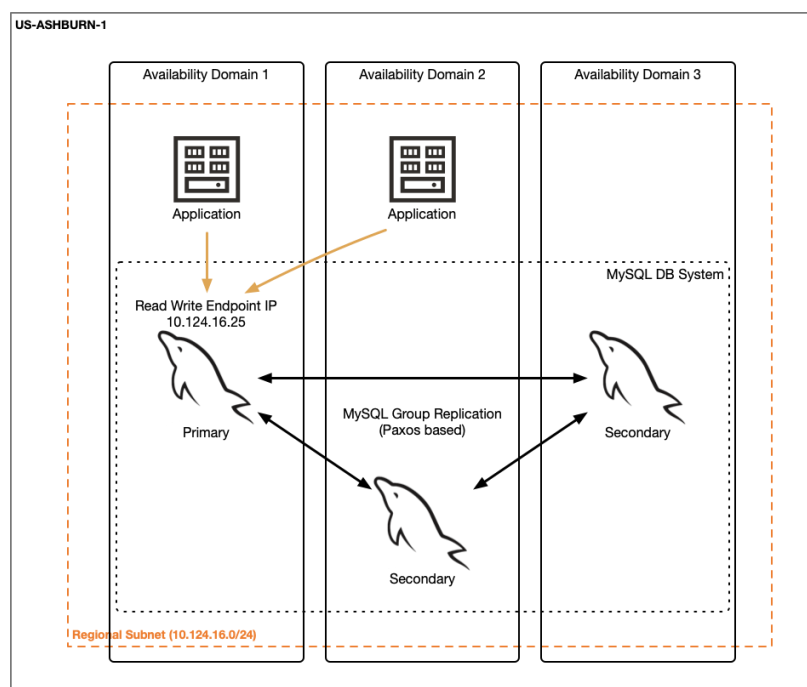
Organizations with business-critical processes must calculate the impact of outages to their bottom line. Companies must ensure their high availability database implementation can cope with failures ranging from server failures, network failures, power failures and entire data center failures. Organizations can protect their data and ensure business continuity using native MySQL HA technologies available in MySQL Database Service and 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** distributes your instances so they don't share infrastructure such as data center power, cooling and network within a region.
- **Fault Domains** distributes your instances so they are not on the same physical hardware within a single availability domain.

## Native MySQL High Availability

MySQL Database Service HA 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 standby, ready to take over the database traffic in case of failure, without any data loss.



*MySQL Database Service uses 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 Database Service High Availability deploys instances across multiple Availability or Fault domains to deliver a better RTO and RPO:

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

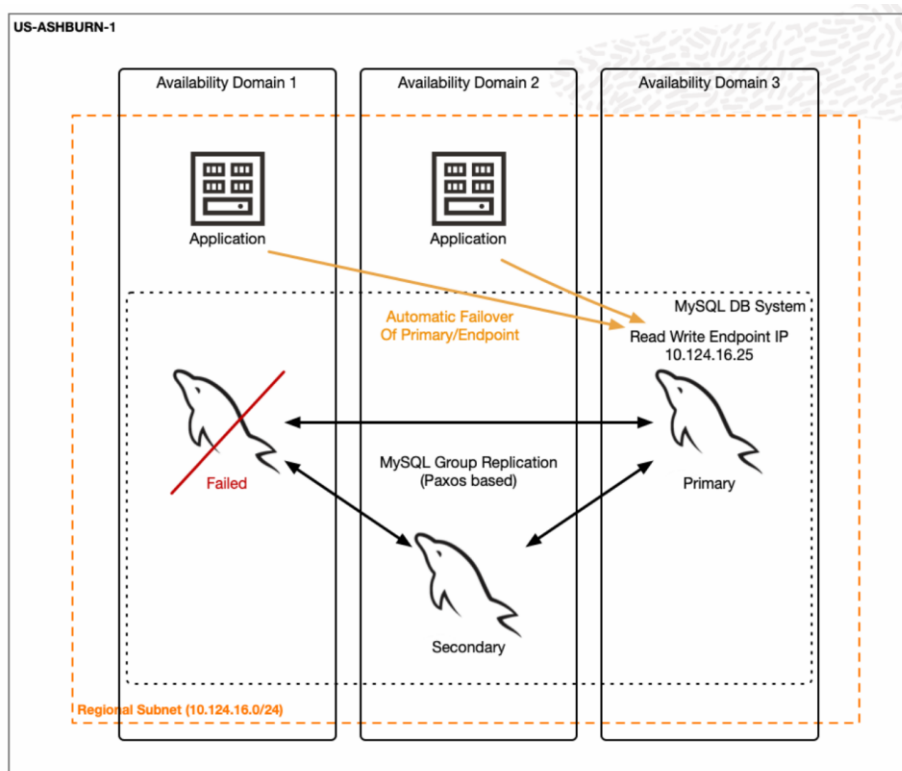
## MDS High Availability Placement

To provide maximum redundancy in MDS High Availability, 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

MDS 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.



*MySQL Database Service provides automatic failure detection promotes 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 Ponemon Institute<sup>14</sup>, a breach of 1 million records yields an average total cost of \$40 million, while a breach of 50 million records yields an average total cost of \$350 million. As you might expect, Security was the top investment priority for CIOs in 2019 and continues to be one of the top Investment priorities for CIOs in 2020.

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 Gen 2 Security

In addition, MySQL Database Service is built on Oracle Cloud Infrastructure (OCI) Gen 2. OCI Gen 2 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 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 huge CapEx investment to purchased 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 Database Service is a fully managed service running on Oracle Gen 2 Cloud Infrastructure. It enables you to:

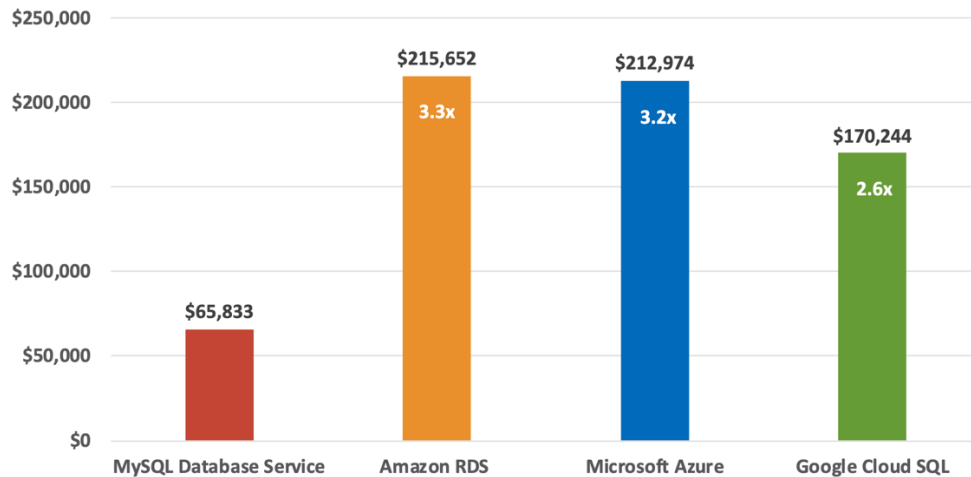
- **Switch from a CapEx to an OpEx expense model** as a more flexible approach to lower your business expenses.
- **Reinvest CapEx savings** back into your business to grow revenues and improve profits.
- **Eliminate the huge up-front costs** associated with buying, operating and maintaining your own 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 spend on 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.

## 1/3 the cost of Amazon RDS

MySQL Database Service delivers significant cost savings over other public cloud database services such as Amazon RDS, Microsoft Azure for MySQL and Google Cloud SQL. When you compare the 1 year TCO of MySQL Database Service with the equivalent PAYG (Pay as You Go) services from other vendors, organizations can realize a savings of up to 3x or \$149,819/year compared to Amazon RDS.

## MySQL Database Service: 3x Cheaper than Amazon RDS

100 OCPUs, 1TB Storage, 1 Year TCO



The grid below shows the Percent Savings and \$ Savings organization can achieve by using MySQL Database Service over other public cloud service offering based on MySQL.

	% Savings	x Savings	Savings/Year
Amazon RDS	69%	3.3x	\$149,819
Microsoft Azure for MySQL	69%	3.2x	\$147,141
Google Cloud SQL	61%	2.6x	\$104,411

Savings calculations are made based on publicly available list prices:

- MySQL Database Service: <https://www.oracle.com/mysql/pricing.html>
- Amazon RDS: <https://aws.amazon.com/rds/mysql/pricing/>
- Microsoft Azure: <https://azure.microsoft.com/en-us/pricing/details/mysql/>
- Google Cloud SQL: <https://cloud.google.com/sql/pricing#2nd-gen-pricing>

Pricing Configuration:

- MySQL Database Service: Standard E3 AMD 16GB/Core, all regions have the same price.
- Amazon RDS: Intel R5 16GB/Core, [AWS US East](#).
- Azure: Memory Optimized Intel 20GB/Core, [MS Azure US-East](#).
- Google: High Memory N1 Standard Intel 13GB/Core, [GCP Northern Virginia](#).
- Configuration: 100 OCPUs, 1 TB Storage.

## 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.

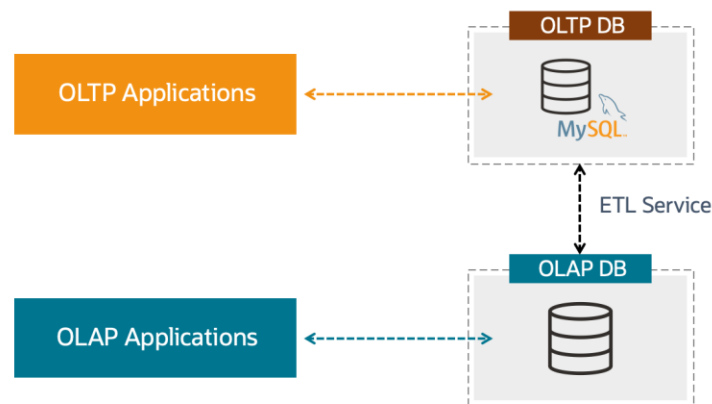
## Challenges of Existing Solutions

There are a number of 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 have to rely on 2 separate databases for OLTP and OLAP workloads.

- **OLTP databases** are row-based that 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 volume 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:

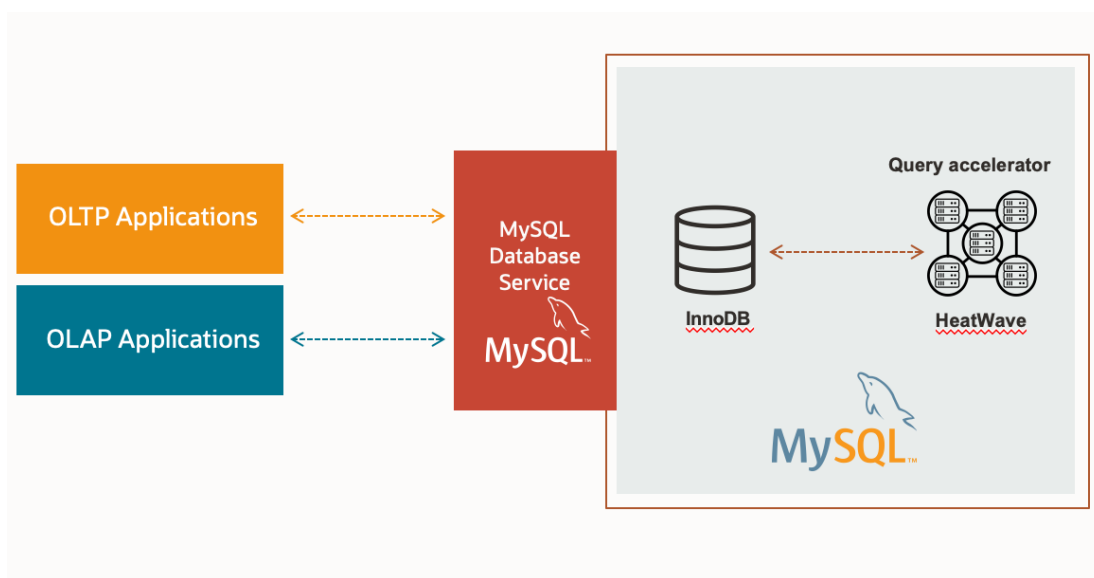
- **Lengthy ETL processes** with only periodic updates of data
- **Stale data** making it difficult to make critical decisions with the most current information
- **Additional cost** of maintaining 2 separate databases
- **Additional skills** required to manage the complexity of 2 separate systems



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

## Single MySQL Database for OLTP and OLAP

MySQL Database Service with HeatWave is the only MySQL service that provides a single solution for running hybrid OLTP and OLAP workloads. It enables customers to run both OLTP and OLAP workloads in MySQL without the need to ETL data to a separate database for analytic processing. No changes to existing applications are necessary. This enables customers to run both OLTP and real-time analytics workloads simultaneously within a single database platform.

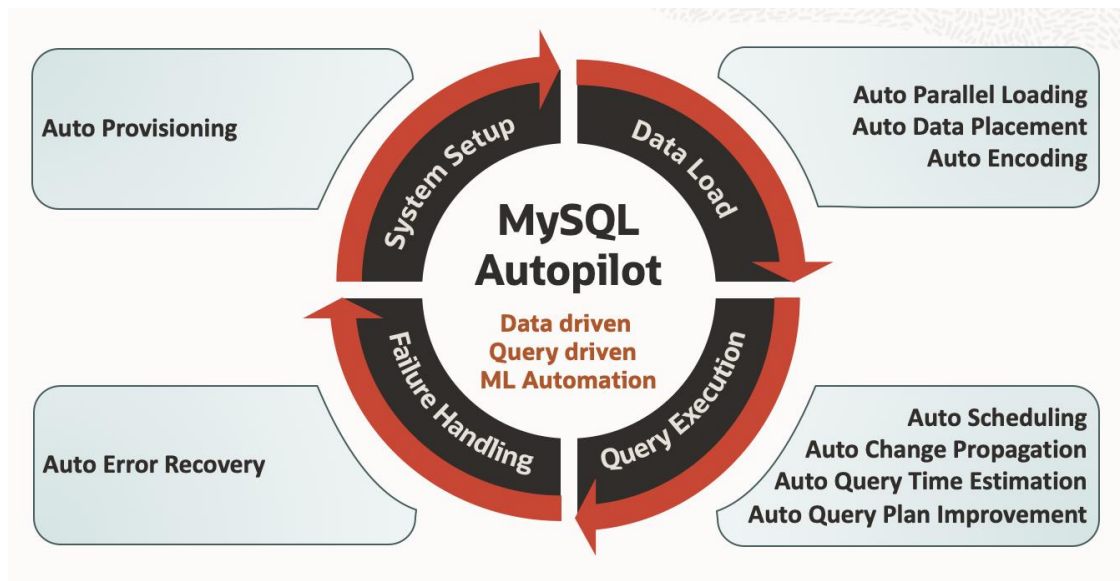


*MySQL Database Service with HeatWave provides a single MySQL database for OLTP and OLAP workloads.*



## AutoPilot for Machine Learning-based Automation

MySQL HeatWave provides comprehensive machine learning-based automation for optimal HeatWave cluster provisioning, data layout configuration, query execution, and error recovery—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 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.

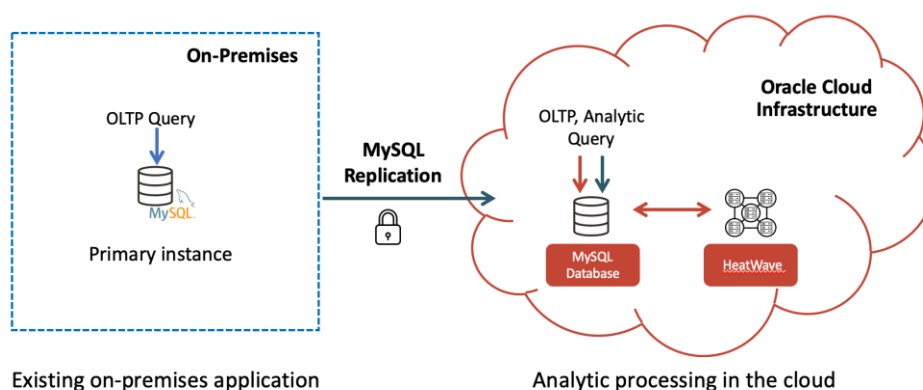
## 100x faster recovery

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 performance of operations which 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 MySQL On-premises MySQL Applications

MySQL users that wanted to run analytics queries on operational data have had to either sacrifice performance or move their data to a purpose-built analytics database. For heavy-duty analytics workloads, they had to no choice but to move their analytics workloads to a separate database to avoid lengthy delays of long running queries. This same issue exists for users of database cloud services. For example, in order for customers to run analytic workloads in Amazon AWS, users have to ETL data out of Amazon RDS and into Amazon Redshift, adding additional complexity.

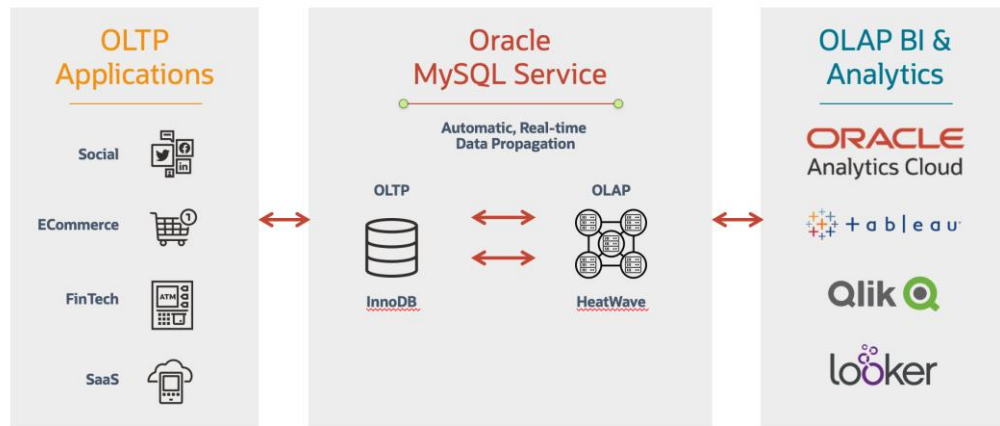
MySQL users have the flexibility of running analytics in the cloud using HeatWave, while keeping their OLTP workloads on premises. MySQL Shell and in-bound replication makes is quick and easy to move data to the Oracle Cloud for real-time analysis.



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

## Existing application and BI apps work as is

HeatWave is 100% native to MySQL. It is easy to use and compatible with existing applications and a huge ecosystem of third-party tools. Since it 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.



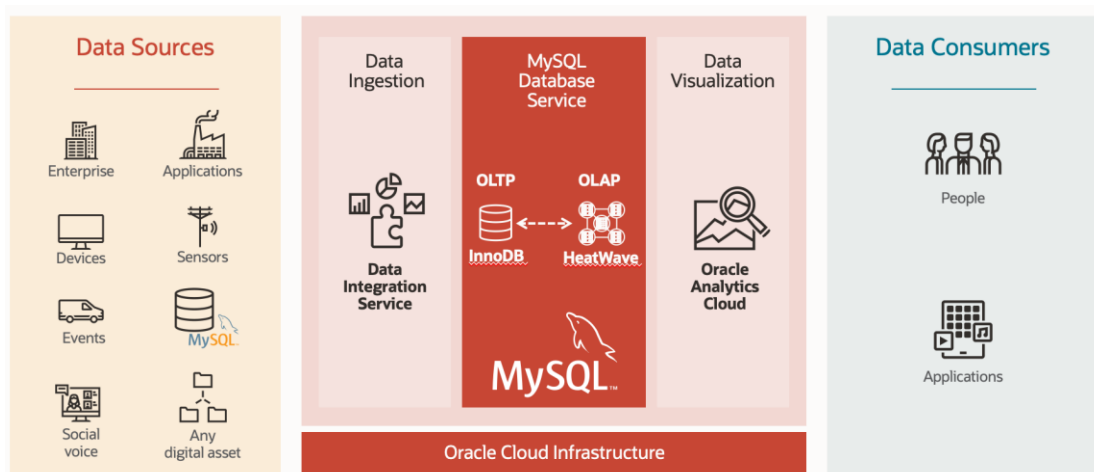
*HeatWave works with existing applications, BI, and Data Visualization tools.*

## 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 industry's most comprehensive cloud analytics in a single unified platform, including self-service visualization and inline data preparation to 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.

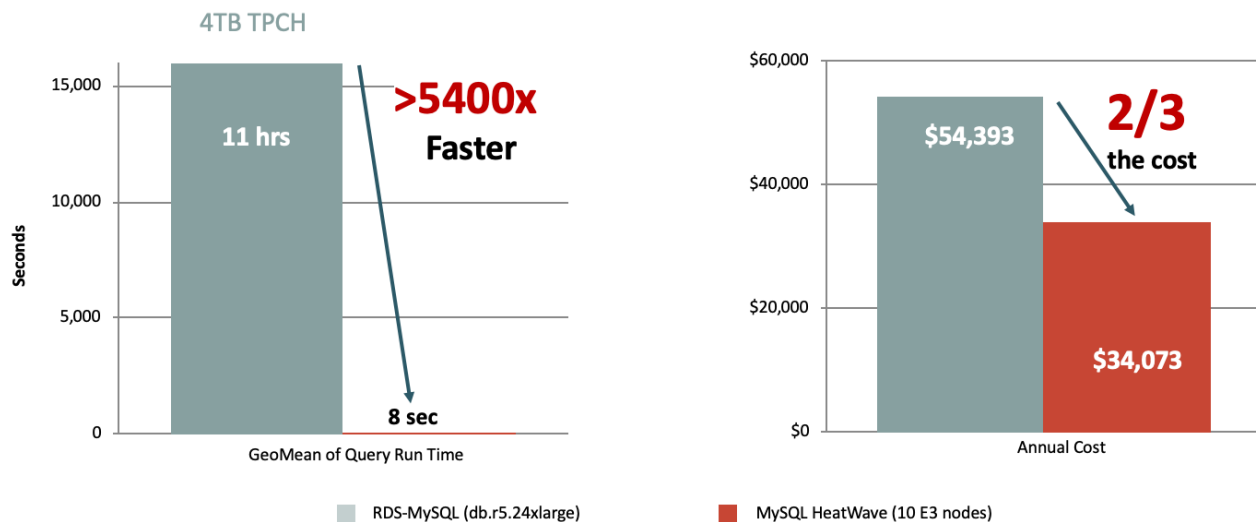


*Integration with Oracle Cloud Services provides end-to-end Integration from Data Ingestion to Data Visualization*

## COMPETITIVE ADVANTAGES: MYSQL DATABASE SERVICE WITH HEATWAVE

### 5400x Faster and 2/3 the Cost of Amazon RDS

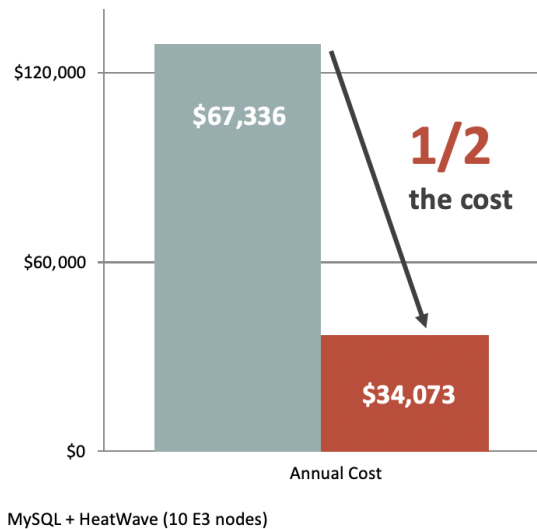
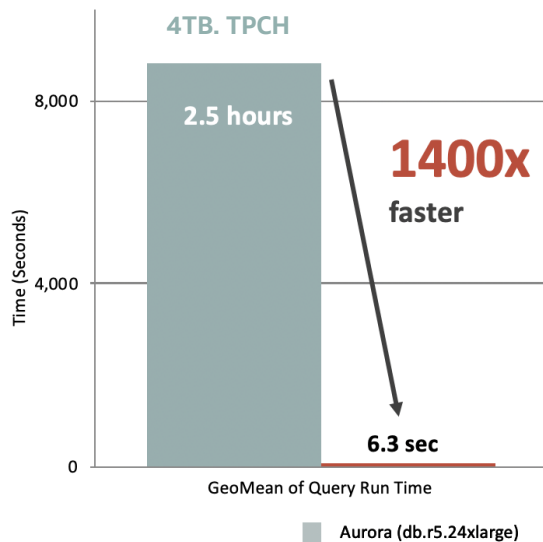
HeatWave is an in-memory, query accelerator for MySQL. MySQL OLTP data is immediately available in HeatWave enabling organizations to query operational data in real-time. Transactional queries run in MySQL and updates are transparently propagated to the analytics cluster for accelerated analytical processing. This is made possible by using state of the art, distributed algorithms that have been optimized for Oracle OCI Gen2 cloud. HeatWave is scalable to thousands of cores and is available exclusively for the fully managed Oracle MySQL Database Service. Performance benchmark results based on TPC-H decision support benchmarks show a 5400x performance acceleration against Amazon RDS for MySQL queries using HeatWave.



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

### 1400x Faster and 1/2 the cost of Amazon Aurora

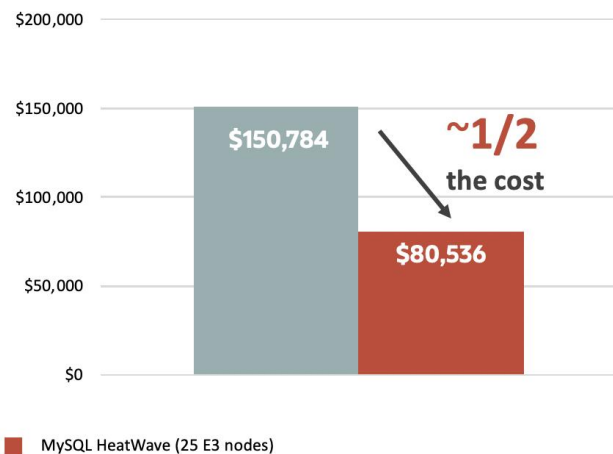
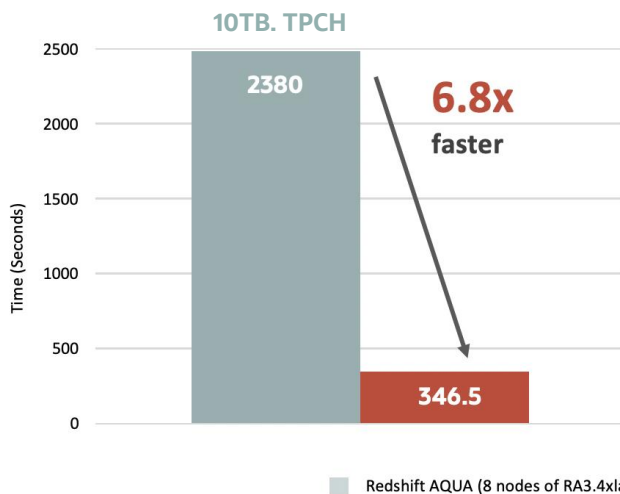
HeatWave provides superior performance benefits over Amazon Aurora. When comparing HeatWave against Amazon Aurora, using industry standard TCP-H benchmarks, HeatWave is 1400x faster. When comparing the 1 year Total Cost of Ownership (TCO) of both solutions, HeatWave is less than 1/2 the cost of Amazon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



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

## 6.8x Faster and 1/2 the Cost of Amazon Redshift AQUA

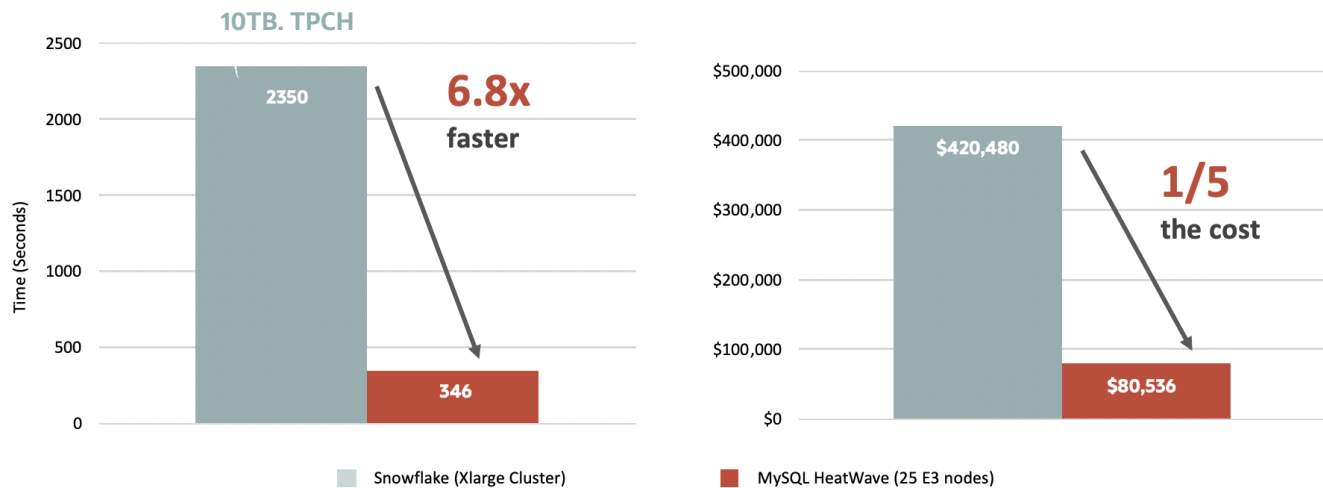
HeatWave provides superior performance benefits over Amazon Redshift AQUA. When comparing HeatWave against Amazon Redshift AQUA, using industry standard TCP-H benchmarks, HeatWave is 6.8x faster. When comparing the 1 year Total Cost of Ownership (TCO) of both solutions, HeatWave is 1/2 the cost of Amazon Redshift.



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

## 6.8x Faster and 1/2 the Cost of Snowflake

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



TPC-H Benchmarks show 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 Database Service with HeatWave for 1/2 of the cost on Amazon. You will also find that you can run your analytic queries 1400x faster than on Amazon Aurora.

MySQL Database Service with HeatWave provides a number of 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

The MySQL Database Service 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 provide a unified 24/7 support solution for both cloud infrastructure and MySQL. No other cloud vendor can deliver such comprehensive support for MySQL.

## 100% Compatible with On Premises MySQL

Moving to the cloud is one of the Top 5 strategic priorities for CIOs in 2020. MySQL Database Service 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 provides organizations the flexibility of a hybrid deployment model.

## Integration with Oracle Cloud Services

Leverage your exiting Oracle investment and easily integrate the MySQL Database Service with other Oracle Cloud services including Oracle Cloud Infrastructure Identity and Access Management Service, Oracle Data Integrator, Oracle Analytics Cloud and many more.

## 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 to move your applications to a cloud model with a fully managed and secure service.

Next, you have to choose the right cloud platform for your business. Oracle MySQL Database Service is the only cloud service with HeatWave, a real-time query accelerator that enables database admins and app developers to run OLTP and OLAP workloads directly from their MySQL database. 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 to run both OLTP and real-time analytics workloads simultaneously within a single database platform.

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, Oracle MySQL Database Service 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, the Oracle Gen 2 Cloud infrastructure delivers a highly secure and integrated cloud environment.

The MySQL Database Service with HeatWave on Oracle Gen 2 Cloud will enable your business to easily deploy modern OLTP and OLAP applications globally with a secure, managed, and supported cloud service from the MySQL Team.

Start Now!

## ADDITIONAL RESOURCES

- Read more about the MySQL Database Service with HeatWave  
<http://www.oracle.com/mysql>
- Read more about the MySQL Database Service with HeatWave  
<http://www.oracle.com/heatwave>
- Read more about MySQL Enterprise Edition  
<https://www.mysql.com/products/enterprise/>
- Read more about Oracle Gen 2 Cloud Infrastructure  
<https://www.oracle.com/cloud/>
- Try MySQL Database Service with HeatWave  
<https://www.oracle.com/mysql/free/>



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