

## MySQL CLUSTER

### MEMORY OPTIMIZED PERFORMANCE & WEB SCALABILITY WITH 99.9999% AVAILABILITY

#### HIGHLIGHTS

- Memory optimized tables for low-latency, real-time performance
- Auto-sharding for high read and write scalability
- SQL & NoSQL interfaces
- 99.9999% availability, self-healing
- On-demand, elastic scaling
- On-line schema operations
- Schema and schemaless data storage
- GUI-based configuration and provisioning
- Low TCO: open source database running on commodity hardware
- 24 x 7 global support, management, monitoring, auditing and security tooling

#### KEY FEATURES OF MYSQL CLUSTER

- ACID compliant, transactional database
- Distributed, multi-master shared-nothing design
- In-memory and disk-based data storage
- 200 Million NoSQL QPS
- Cross-shard JOINS with Adaptive Query Localization
- Referential Integrity with Foreign Keys
- Synchronous & asynchronous replication with integrated failover and recovery
- Active/active geographic replication
- Online backup
- Cache for disk-based data
- Configurable checkpoints
- SQL access
- NoSQL JavaScript, Java, JPA, C++, Memcached and HTTP interfaces

MySQL Cluster is the distributed database combining linear scalability and high availability. It provides in-memory real-time access with transactional consistency across partitioned and distributed datasets. It is designed for mission critical applications.

MySQL Cluster has replication between clusters across multiple geographical sites built-in. A shared nothing architecture with data locality awareness make it the perfect choice for running on commodity hardware and in globally distributed cloud infrastructure.

MySQL Cluster is proven daily in systems serving billions of users. Its used in mission critical applications at the core of mobile phone networks, authentication systems and gaming platforms with exploding data volumes and user loads. Driven by growing internet penetration across global communities, social networking, high-speed 4G and 5G mobile broadband connecting richer and ever more devices, and new M2M (Machine to Machine) interactions.

The databases needed to support this growth have to meet new challenges, including:

- **Scaling write operations**, as well as reads
- **Distributed large datasets** across commodity hardware or cloud infrastructure
- **Low latency** for a real-time user experience
- **24 x 7 availability** for continuous service uptime
- **Agility and ease-of-use**, enabling developers to quickly launch new, innovative services

New applications need to meet these challenges, while still

- Keeping distributed applications development straightforward and simple
- Preserving transactional integrity with ACID compliance for OLTP workloads
- Enabling real-time insight by running complex, ad-hoc queries against the data
- Leveraging the proven benefits of industry standards and skillsets to reduce cost, risk and complexity

If your workloads have these demands, it is time to consider MySQL Cluster.

MySQL Cluster is a highly scalable, real-time, ACID-compliant transactional database, combining 99.9999% availability with the low TCO of open source. Designed around a distributed architecture with no single point of failure, MySQL Cluster scales horizontally on commodity hardware and cloud infrastructure with auto-partitioning (sharding) to serve read and write intensive workloads, accessed via SQL and NoSQL APIs.

MySQL Cluster's real-time design delivers predictable, millisecond response times with the ability to service millions of operations per second. Support for memory optimized and disk-based tables, automatic data partitioning (sharding) with load balancing and the ability to add nodes to a running cluster with zero downtime allows linear database scalability to handle the most unpredictable web, mobile, enterprise and telecoms workloads.

**TARGET APPLICATIONS**

- High volume OLTP
- Real-time analytics
- Ecommerce, financial trading & payment gateways
- Online gaming
- Mobile and micro-payments
- Session management and caching
- Feed streaming, analysis and recommendations
- Content management and delivery
- Presence and location-based services
- User profile management
- Subscriber databases (HLR, HSS, VLR, etc.)
- Domain Name System (DNS) / Dynamic Host Configuration Protocol (DHCP) for broadband access
- IP Multimedia Subsystem (IMS) services
- Service delivery platforms
- VoIP, IPTV, and video on demand

**Auto-Sharding for Scaling Read and Write Operations**

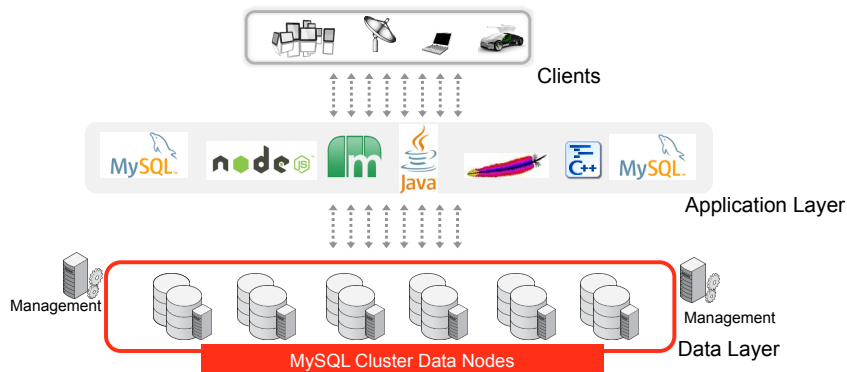
MySQL Cluster is implemented as a strongly consistent, active/active, multi-master database ensuring updates can be made to any node and are instantly available to the rest of the cluster, without any replication lag.

Tables are automatically sharded across a pool of low cost commodity data nodes, enabling the database to scale horizontally, accessed both from SQL and directly via NoSQL APIs. New nodes can be added on-line, instantly scaling database capacity and performance, even for the heaviest write loads.

By automatically partitioning (sharding) tables within the database, MySQL Cluster eliminates the need to shard at the application layer, greatly simplifying development and maintenance. Sharding is entirely transparent to the application which is able to connect to any node in the cluster and have queries automatically access the correct shards needed to satisfy a query or commit a transaction.

Unlike other distributed databases, MySQL Cluster preserves ACID-guarantees, the flexibility of JOIN operations and maintains referential integrity between tables on different nodes, on different shards, even in different data centers.

Queries can be processed in parallel, JOIN and filter operations are executed locally on the partitions and data nodes, delivering high throughput and low latency. As a result, users can perform complex queries against their databases, enabling MySQL Cluster to serve those use-cases that have the need to run real-time analytics across live data sets, alongside high throughput OLTP operations.



**Figure 1.** The MySQL Cluster architecture is designed for high scalability and 99.999% availability with SQL and NoSQL APIs

With memory optimized tables, MySQL Cluster delivers the response times needed for latency-sensitive applications and can deliver in excess of 200 Million NoSQL Queries Per Second. MySQL Cluster also limits disk I/O bottlenecks by asynchronously writing transaction logs to disk.

**Six 9s Availability For Continuous Operation**

MySQL Cluster is designed for six 9s availability, eliminating both planned and unplanned downtime. Achieved via a distributed, shared-nothing architecture and synchronous replication of data that automatically propagates transactions across a node-group, ensuring consistency of reads and write operations, coupled with lossless failover.

**Sub-Second Failover and Self-Healing Recovery**

Any failures are detected instantly and control is automatically failed over to other nodes in the cluster, without interrupting service to the clients. Nodes can recover and dynamically

*“MySQL Cluster’s on-line scalability provides the assurances we need to meet future requirements and we can use MySQL Cluster Manager to automate scaling and cluster administration - which makes DevOps very happy!”*

**Isaac Hawley,  
Software Developer,  
Big Fish Games**

*“It works better than master and slave, it heals itself faster, its easier to bring nodes in and out. Using this design, all the systems have the same data. It makes good sense for a globally distributed system”*

**Daniel Austin,  
Chief Architect,  
PayPal**

*“MySQL Cluster CGE is a product of high quality, extremely robust and meets our demands in terms of performance and high availability. We evaluated shared-disk clustered databases but the cost would have been at least 10 times more.”*

**Alain Chastagner,  
Systems Manager,  
Alcatel-Lucent**

*“Since deploying MySQL Cluster as our e-commerce database, we have had continuous uptime with linear scalability, enabling us to exceed our most stringent SLAs.”*

**Sean Collier,  
CIO and COO,  
Shopatron**

resynchronize themselves with the rest of the cluster. Self-healing is completely transparent to the applications and eliminates administrative overhead.

### On-Line Operations: Scaling, Repartitioning and Maintenance

MySQL Cluster supports the on-line addition of nodes to running clusters, re-sharding, back-ups, patching and upgrades to the underlying hardware and software infrastructure. MySQL Cluster is designed to scale on-demand, allowing services to start small and grow rapidly as demand takes-off, with the ability to re-provision resources as needed.

In addition, MySQL Cluster supports on-line updates to live database schema, enabling users to rapidly evolve new applications by adding new columns and tables as well as adding or removing indexes and foreign key constraints – all while continuing to serve read and write requests, and without affecting response times.

### Cross Data Center Deployment: Reaching a Global Audience

Today’s services are global and so developers will want to ensure their databases can scale-out across regions, while adding resilience to data center failures. MySQL Cluster offers Geographic Replication to distribute databases to remote sites, serving to reduce the affects of network latency in addition to providing Disaster Recovery. The conflict detection mechanisms built in to Geographic Replication enable each MySQL Cluster in every data center to be fully active, resolving simultaneous updates from users for global scale, while eliminating the waste of maintaining idle hardware.

MySQL Cluster also supports the splitting of a single cluster’s data nodes across data centers. Users can synchronously replicate updates between sites with automatic failover in the event of an outage.

### SQL and NoSQL Interfaces for Developer Agility

MySQL Cluster presents multiple APIs for data access, each of which can concurrently access the same data set, to provide the ultimate in developer flexibility:

- Relational queries using the SQL API
- Key/Value and Key/Object web services using the JavaScript, Memcached or REST/HTTP APIs
- Enterprise applications using the ORM ClusterJ and JPA APIs
- Real-time services using the C++ NDB API

### Schemaless Data Structures with the Memcached API

To allow rapid innovation in new web and mobile services, developers do not have to define a database schema upfront.

When using the Memcached API for MySQL Cluster, each Key-Value is written to the same table with each Key-Value pair stored in a single row – thus allowing schema-less data storage. Alternatively, the developer can define a key-prefix so that each key and value are linked to pre-defined columns in a specific table.

### Low Total Cost of Ownership

MySQL Cluster requires no additional infrastructure, such as shared storage, and runs on commodity hardware and operating systems. An open source solution, MySQL Cluster is an extremely cost-effective database for services demanding web scalability with 99.9999% availability.

### Proven Deployments

Alcatel-Lucent, Blizzard, Big Fish Games, PayPal, Shopatron, Telenor, US Navy, Zillow and

many more deploy MySQL Cluster in highly demanding web, cloud and mobile applications.

### Provisioning Highly Tuned Clusters in a Few Mouse Clicks

MySQL Cluster's browser-based Auto-Installer makes it simple for DevOps teams to quickly configure and provision highly optimized clusters, stepping users through each stage of cluster creation:

- **Workload Optimized:** On launching the browser-based installer, users specify the throughput, latency and write-load characteristics of their application
- **Auto-Discovery:** The Installer automatically discovers the underlying hardware resources from each server that will make up the cluster

With these parameters, the installer creates optimized configuration files and starts the cluster so developers can concentrate on writing code, not deploying databases.

#### ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration

Settings ▾ Help ▾

**Cluster Type and SSH Credentials**

MySQL Cluster is able to operate in various configurations. Please specify the settings below to define the right cluster type that fits your use case. If you intend to use remote hosts for deploying MySQL Cluster, SSH must be enabled. Unless key based SSH is possible, you must submit your user name and password below.

Cluster property	Value
Cluster name [?]	MyCluster
Host list [?]	black, blue, green, brown
Application area [?]	simple testing
Write load [?]	medium

SSH property	Value
Key based SSH [?]	<input type="checkbox"/>
User name [?]	billy
Password [?]	*****

◀ Previous ▶ Next ▶▶ Finish

Figure 2. Automated tuning and configuration of MySQL Cluster

### MySQL Cluster Operational Best Practices

MySQL Cluster is also available in the commercial CGE edition, which includes 24x7 Oracle Premier Support and access to an extensive array of security, auditing and management tools.

**MySQL Cluster Manager** simplifies the provisioning, scaling and reconfiguration of MySQL Cluster by automating common management tasks. DevOps teams are more productive, able to focus on strategic initiatives and respond faster to changing user requirements. At the same time, risks of database downtime, which previously resulted from manual configuration errors, are significantly reduced.

**MySQL Enterprise Monitor** provides at-a-glance views of the health of your cluster. It continuously monitors the MySQL servers and data nodes, alerting you to potential problems before they impact clients, using a series of Expert Advisors to recommend best practices developed by the engineers who build the MySQL database.

### SYSTEM REQUIREMENTS PER MYSQL CLUSTER DATA NODE (RECOMMENDED)

- **OS:** Linux, Oracle Solaris, Microsoft Windows.

*Note: Apple OS X for development only.*

- **CPU:** Intel and AMD x86/x86-64, UltraSPARC.
- **Memory:** 16 GB+ RAM (1 GB minimum).
- **HDD:** 18 GB+ (3 GB minimum).
- **Network:** Recommended minimum: Gigabit Ethernet

Item	Info	Coverage	Schedule	Event Handling	Parameters
Cluster Data Node Data Memory Getting Low	100% (148/148)	5m	0	0	25 20 10
Cluster Data Node Has Been Restarted	100% (148/148)	5m	0	0	600
Cluster Data Node Index Memory Getting Low	100% (148/148)	5m	0	0	25 20 10
Cluster Data Node Redo Buffer Space Getting Low	100% (148/148)	5m	0	0	35 25 10
Cluster Data Node Redo Log Space Getting Low	100% (148/148)	5m	0	0	35 25 10
Cluster Data Node Undo Buffer Space Getting Low	100% (148/148)	5m	0	0	35 25 10
Cluster Data Node Undo Log Space Getting Low	100% (148/148)	5m	0	0	35 25 10
Cluster Data Nodes Not Running	100% (148/148)	5m	0	0	1 2
Cluster DiskPageBuffer Hit Ratio is Low	100% (148/148)	5m	0	0	97 90 80
Cluster Has Stopped	100% (148/148)	2m	0	0	0

Figure 3. MySQL Cluster expert advisors recommend best practices and reduce the risks of downtime

**MySQL Query Analyzer** helps developers and DBAs improve complex query performance by accurately pinpointing SQL code that can be optimized. Queries are presented in an aggregated view across all MySQL servers so developers can filter for specific query problems and identify the code that consumes the most resources.

**MySQL Enterprise Authentication** MySQL Enterprise Authentication provides ready to use external authentication modules to easily integrate with existing security infrastructures including Linux Pluggable Authentication Modules (PAM) and Windows Active Directory. MySQL Enterprise Authentication enables organizations to implement a Single Sign On mechanism and leverage existing security rules and process from centralized directories.

**MySQL Enterprise Firewall** MySQL Enterprise Firewall blocks SQL Injection attacks that can result in loss of valuable personal and financial data. Whitelist creation, real-time threat monitoring, SQL statement blocking and alerting enable DBAs protect data assets. Acting as an intrusion detection system, MySQL Enterprise Firewall notifies administrators to SQL statement activity that does not match an approved whitelist.

**MySQL Enterprise Audit** enables administrators to quickly add policy-based auditing compliance to applications by logging user-level activity, implementing activity-based policies and managing audit log files.

### Oracle Premier Support

Oracle offers 24x7, global support for MySQL. The MySQL Support team is composed of seasoned MySQL developers, who are database experts and understand the issues and challenges you face.

Oracle Premier Support for MySQL includes:

- 24 x 7 global production support in 29 languages
- Direct access to MySQL support engineers, backed by the MySQL developers
- Unlimited support incidents
- Knowledge Base
- Maintenance releases, hot fixes, patches and updates
- MySQL consultative support

For end users, annual subscriptions include Oracle Premier Support for MySQL. For ISVs and OEMs, Premier Support can be purchased along with commercial licenses.

### Learn More

For additional resources, including Developer Guides, White Papers, On-Demand Webinars and customer case studies, visit <http://mysql.com/products/cluster>

To contact MySQL online, visit <http://mysql.com/about/contact/>

### About MySQL

MySQL is the world's most popular open source database software. Many of the world's largest and fastest-growing organizations use MySQL to save time and money powering their high-volume web sites, mobile services, critical business systems, communication networks, and commercial software.



Oracle is committed to developing practices and products that help protect the environment

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