MySQL Database Administrator

Nobelprog

22-Oct-2024 – 25-Oct-2024

MySQL Server Usage

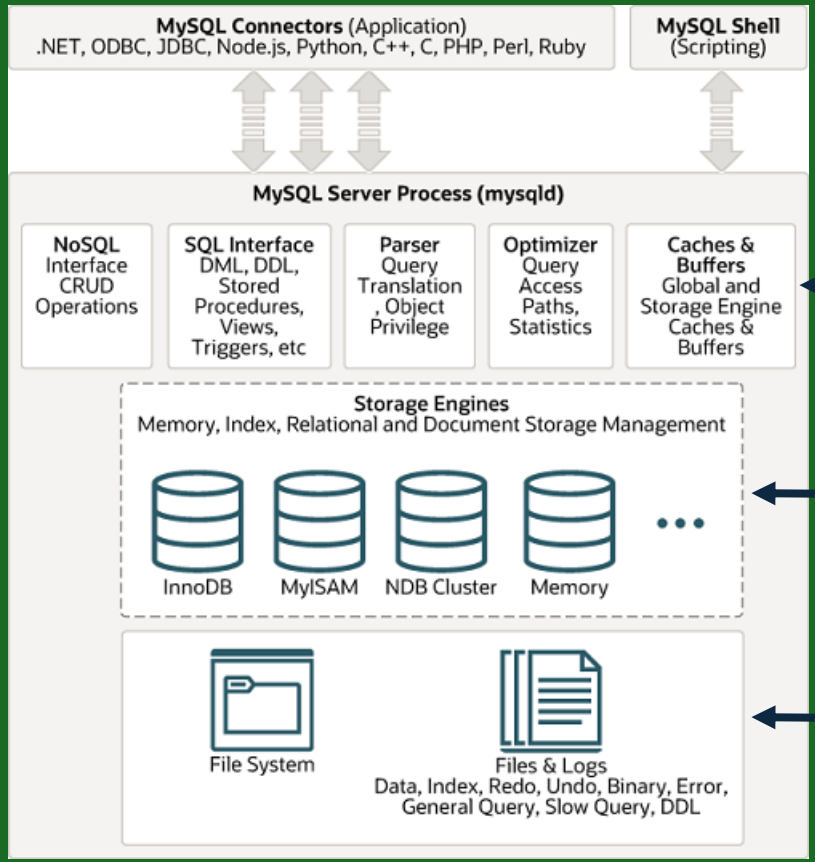
Course Introduction

- New Database Installations, Customization, Backup & Recovery
- Database Management -
- Database Upgrades - Both Major and Minor Upgrades
- InnoDB Storage Engine Tuning
- Database Replication, Troubleshooting, Performance Tuning

Course Objectives

- MySQL Server Installation
- Exploring MySQL Server
- MySQL Server Database Administration
- MySQL Storage Engines
- MySQL User Administration
- MySQL Server Configuration
- InnoDB Storage Engine
- MySQL Backup & Restore
- MySQL Replication
- Upgrading MySQL Server
- MySQL Performance and Monitoring

MySQL Architecture



End-User/Client-Layer

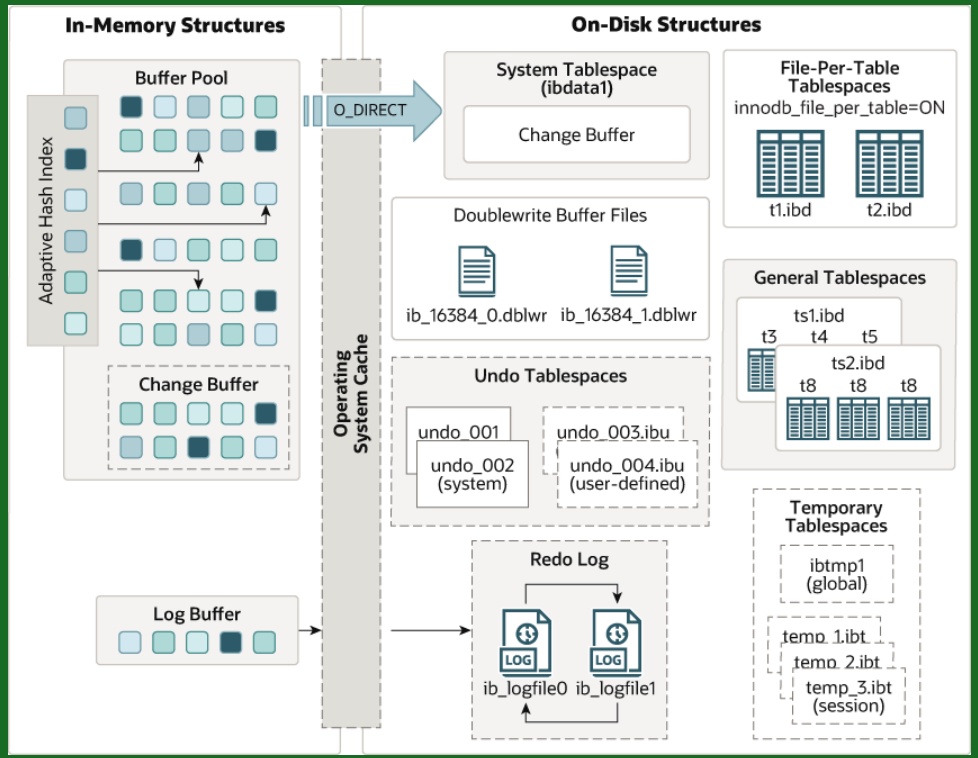
Daemon Process

MySQL Brain

Physical Storage

MySQL InnoDB Architecture

InnoDB Architecture:



In-Memory Structure:

- Buffer Pool - Area in main memory where InnoDB caches table & index data as it is accessd
- Change Buffer - caches changes to non-clustered indexes
- Adaptive Hash Index - acts like in-memory db
- Log Buffer - memory area that holds data to be written to the log files on disk

On-Disk Structure:

- System Tablespace
- Doublewrite Buffer Files
- Undo Tablespaces
- Redo Log Files
- File-Per-Table Tablespaces
- General Tablespaces
- Temporary Tablespaces

MySQL User Administration

- DBA Account
- MySQL Permissions
- WITH GRANT OPTION
- MySQL Workbench
- MySQL Roles
- Difference between Roles & Users
- Granting Permissions -> Roles, Roles -> Users
- Expired Account, Unlock Account
- Explore mysql.user table

MySQL Configuration

Option Files:

- Also called MySQL Configuration Files
- Most MySQL programs can read startup options from option files (configuration)
- Convenient way to specify commonly used options so need not to specify on command-line
- mysqld, mysqladmin, mysqlimport, mysqldump, mysql - examples of MySQL programs
- program –verbose –help - To get which default option file this programs uses
- Any program starts with –no-defaults option reads no option file other than .mylogin.cnf

MySQL Backup & Recovery

What do you want to protect?

- MySQL Instance - Physical Backup
- Option Files/Configuration Files - Source Control
- Database(s) - Logical Backup
- Table(s) - Logical Backup

MySQL Upgrades

Upgrade Types:

- Minor MySQL Version Upgrade
- Major MySQL Version Upgrade

Popular MySQL Servers

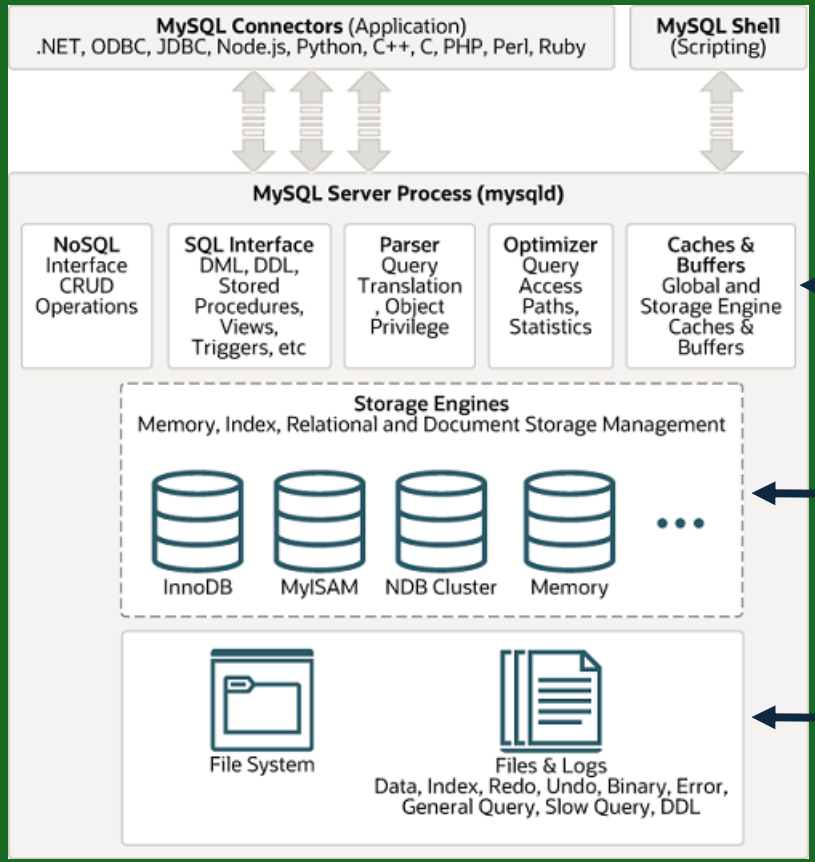
Oracle MySQL, MariaDB, Percona MySQL are **forks** of original MySQL

MariaDB Provides: Columnar Storage, Temporal Tables, Transaction replay, non-blocking backups, Oracle Compatible, Pluggable Storage Engines

Percona Provides: XtraDB Cluster, Percona-Toolkit, XtraBackup, TokuDB, MyRocks Storage Engine, InnoDB Full-Text Search, Compressed Columns

Oracle MySQL Provides: HeatWave, mysqlcheck, Scalability, Dual Passwords, High Performance

MySQL Architecture



End-User/Client-Layer

Daemon Process

MySQL Brain

Physical Storage

MYSQL File Types

Installed MySQL Files Location :

DATA DIRECTORY:

- Also known as datadir
- Default location: /var/lib/mysql
- Owned by mysql os user as it's home directory
- All the new databases that we create, reside there as folder

LOG FILES:

- Default location is /var/log/mysql/error.log
- Very critical file and single source of truth for all errors, warnings, info etc
- Also contains initial root password - newly installed MySQL

GLOBAL CONFIGURATION FILE:

- Default location is /etc/mysql/my.cnf
- Contains all the configuration settings that will be loaded when server starts

MYSQL Executable Programs

mysql	mysqladmin	mysqlbinlog	mysqlcheck	mysql_config_editor
mysqld_pre_systemd	mysqld_safe	mysql_ssl_rsa_setup	mysql_tzinfo_to_sql	mysql_upgrade
mysqlslap	mysql_secure_installation	mysqlshow	mysqld_safe	mysqldump

MYSQL Shell Commands

help:

- \h or \?
- Prints help about MySQL Shell and all available shell commands
- Display help for any of the shell commands

quit:

- Quits or Exits from MySQL Shell - \q

status:

- Shortcut is \s
- For how long MySQL Server has been up, what is my connection id, version of MySQL
- Is the current user logged in locally or from a remote location

system:

- Shortcut is \!
- Run operating system commands within MySQL Shell

MYSQL Shell Commands

use:

- \u for short
- Use another database
- Takes database name as argument

source:

- \. - Execute SQL file (.sql extension)
- Takes SQL file name as argument

edit:

- Edit the SQL statement that you recently executed

MYSQL Socket File

mysql.sock:

- MySQL special file that manages connections to the mysql server
- Used for local clients - if user is on the database host and want to connect to mysql
- Local clients/users can’t connect to MySQL without this file
- Owned by mysql user and default location is /var/run/mysqld
- Local connection = UNIX socket - Remote connection = TCP/IP
- This special file is empty but mysql creates another file mysqld.sock.lock and add pid

MYSQL Global Variables

Global Variables:

- MySQL server maintains many system variables that are used to configure how MySQL should operate.
- GLOBAL scope & SESSION scope
- Global variables affect the overall operation of MySQL server
- Each Global variable has default value which is initialized when server starts
- Default value can be changed in option file or on command line
- Identified by @@ sign
- SHOW GLOBAL <variable_name>; or SELECT @@<variable_nam>;
- Examples of system variables:
  - max_connections
  - server_id
  - sql_mode

MYSQL Session Variables

Session Variables:

- MySQL server maintains many system variables that are used to configure how MySQL should operate.
- GLOBAL scope & SESSION scope
- SESSION variables affect only the current session
- Default value for session variables can only be changed on command line
- Identified by @@ sign
- SHOW SESSION VARIABLES LIKE <variable_name>; or SELECT @@<variable_nam>;
- Examples of session system variables:
  - sql_mode

MYSQL SHOW Command

SHOW Statements:

- SHOW DATABASES;
- SHOW TABLES LIKE ‘%view%’;
- SHOW BINARY LOGS;
- SHOW BINLOG EVENTS;
- SHOW ENGINES;
- SHOW CREATE TABLE | USER | DATABASE;
- SHOW ERRORS;
- SHOW WARNINGS;
- SHOW EVENTS;
- SHOW TRIGGERS;
- SHOW PROCESSLIST;

Note: SHOW Statements also accepts LIKE clause

MYSQL System Databases

System Databases:

- MySQL server comes with some default system databases
  - information_schema
  - mysql
  - performance_schema
  - sys
  - Test - Generally deleted by running mysql_secure_installation

MYSQL System Databases

information_shema:

- Each MySQL instance will have information_schema database
- Also called System Catalog or Data Dictionary
- Provides access to metadata, that is data about data
- The tables in this database are read-only - they are actually views
- So no INSERT, UPDATE, DELETE operations

mysql:

- Contains tables that store information required by MySQL server
- Grant information to user accounts, registry of event scheduler, plugins
- Replication System Tables
- System tables with timezone information

MYSQL System Databases

performance_schema:

- Inspect internal execution of the server.
- Primarily focuses on performance data
- Information about events waits, database locks, memory allocation

sys:

- Collection of views, functions, and stored procedures that help MySQL admins to get insight into MySQL database usage.
- Similar to performance_schema but is more user friendly
- How many total connections a user has established, memory consumption
- Database host summary about memory, storage, io

MYSQL Connections

localhost-connection:

- localhost
- root@localhost

specific-host-connection:

- Host or IP Address webserver01 or 192.168.10.10
- app_user@webserver01

any-host-connection:

- %
- dba@%

MYSQL Config Editor

mysql_config_editor:

- Configure Authentication information for connecting to MySQL server
- Stores authentication credentials in an obfuscated login path file called .mylogin.cnf - Encrypted
- Location: user's home directory - Syntax: mysql_config_editor set –login-path=client –host= –user= –password
- login-path is option group that specify which MySQL server to connect and which account to auth
- By default mysql client reads [client] and [mysql] groups

MySQL Config Editor

.mylogin.cnf:
[client]
user = root
password =
host = localhost

[prod]
user = user
password = password
host = proddb01

MYSQL Admin Program

mysqladmin:

- MySQL Server Administration program
- Client for performing administrative operations:
  - shutdown
  - create <database_name>
  - current status
  - ping if MySQL is alive
  - Start Replica
  - Stop Replica
- Syntax: mysqladmin options command

Example:

- mysqladmin status
- mysqladmin ping
- mysqladmin create database
- mysqladmin drop database

MYSQL Execute SQL Files

source:

- From within mysql shell - using \. or source
- mysql> source file.sql or mysql> \. file.sql

mysql:

- By running mysql client program and accepting .sql file as input
- mysql –host=host_name –user=user_name –password= database_name < file.sql

shell script:

- By creating an executable shell script and executing it
- mysql –host=host_name database_name < $1

pipe method:

- cat filename.sql | mysql

MYSQL Execute SQL Files

Execute employees.sql - Create staff table in employees db

Syntax:

- mysql>source employees.sql
- mysql –host=localhost employees < employees.sql
- bash employees.sh employees.sql
- cat employees.sql | mysql

MYSQL mysqlimport

mysqlimport:

- mysqlimport is a data import program
- Takes .txt with tab-delimited file as input

Syntax:

- mysqlimport [options] database file1.txt [file2.txt] ...

Import Data Directory Configuration:

- secure_file_priv - denoted a directory from which data files can be loaded

MySQL mysqlimport

Load data from staff.txt - Populate staff table in employees db

Steps:

- We will use mysqlimport utility
- Fetch secure_file_priv value
- Copy file and change permissions
- Load Data mysqlimport [options] db_name ${secure_file_priv}/staff.txt

MYSQL mysqlcheck

mysqlcheck:

- mysqlcheck is a table maintenance program
- It checks, repairs, optimize, or analyze tables
- Table name as input

Note:

- Table will be locked while mysqlcheck is running - no db operations

Syntax:

- myqlcheck [options] db_name table_name

MySQL mysqlcheck

Check the integrity of staff table

Steps:

- We will use mysqlcheck utility
- mysqlcheck employees staff

MYSQL mysqlshow

mysqlshow:

- Display database, table, and column information
- Takes database name and table name as input

Syntax:

- mysqlshow [options] db_name table_name
- mysqlshow [options] db_name table_name [column_name]

MYSQL Timezone Data

mysql_tzinfo_to_sql:

- Loads the time zone data from zoneinfo database into system mysql database
- Zoneinfo database is actually zone files that describe time zones
- Typical location on Linux is /usr/share/zoneinfo

Timezone Tables:

- Time_zone
- Time_zone_name
- Time_zone_transition
- Time_zone_transition_type
- time_zone_leap_second

Syntax:

- mysql_tzinfo_to_sql zoneinfo_database | mysql [options] db_name

MySQL Timezone Data

Load Timezone Data into MySQL

Steps:

- We will use mysql_tzinfo_to_sql utility
- mysql_tzinfo_to_sql /usr/share/zoneinfo | mysql mysql

MYSQL Example Databases

MySQL Example Databases:

- Free to download and use

Example Databases:

- employees
- world
- sakila

URL Information:

- https://dev.mysql.com/doc/index-other.html

MYSQL Storage Engines

FEDERATED	InnoDB	MyISAM	ARCHIVE
BLACKHOLE	CSV	MEMORY	PERFORMANCE_SCHEMA

- ➔ Pluggable storage engine architecture - load and unload on a running MySQL Server
- ➔ show engines - which storage engine your server support
- ➔ Shared library location for all the plugins - plugin_dir variable
- ➔ Can install & uninstall more storage engines

MYSQL Storage Engines

FEDERATED STORAGE ENGINE:

- Disabled by default
- Table created with FEDERATED Storage Engine, normally points to a table in another MySQL instance installed on a separate server.
- Linked Server - Microsoft SQL Server
- Database Link - Oracle
- Both tables should have the same name and definition
- The table in requester acts like a view
- Target table can have different storage engine but requester table should be created with FEDERATED

Syntax:

```
Create table employee_salaries (
Employee_id int,
Employee_salary int
) ENGINE = FEDERATED
CONNECTION = ‘mysql://db_user@target-server:3306/employees/employee_salaries’;
```

MYSQL Storage Engines

MEMORY STORAGE ENGINE:

- Called HEAP in older versions
- Very useful for temporary tables
- MEMORY will write table data in memory
- Not Persistent - Data lost on server crash
- Very fast data retrieval but memory is volatile so use only for read-only cache data or temp tables

USE CASE:

- Static Tables - lookup
- Temporary Tables

Caveats:

- No Transactions support
- No Referential Integrity support - No FK
- NO TEXT data type support - No BLOB column

MySQL Storage Engines

Create continents table in MEMORY - world database

Steps:

- Create table specifying ENGINE=MEMORY
- Insert data
- Verify data and also table definition from information_schema.tables
- Restart MySQL Service and observe table is there but data is gone

MYSQL Storage Engines

BLACKHOLE STORAGE ENGINE:

- Acts as a black hole, whatever goes into it, never comes back
- You can store as much data as you want, when you retrieve it, it returns empty result set
- Anything you write to it, disappears
- Does not support transactions

Syntax:

```
Create table employee_salaries (
Employee_id int,
Employee_salary int
) ENGINE = BLACKHOLE;
```

MySQL Storage Engines

Create continents table in BLACKHOLE - world database

Steps:

- Create table specifying ENGINE=BLACKHOLE
- Insert data
- Verify empty result set will return

MYSQL Storage Engines

CSV STORAGE ENGINE:

- Stores table in text files using comma-separated values format
- MySQL creates a .csv file in the $DATA_DIR - plain text file
- CSV format can be read, written by spreadsheet applications like Excel
- Does not support transactions
- CSV files are not indexed

USE CASE:

- When data need to be shared with other applications that also use CSV format

Syntax:

```
Create table continents (
cid int NOT NULL,
cname VARCHAR(25) NOT NULL
) ENGINE = CSV;
```

MySQL Storage Engines

Create continents table in CSV - world database

Steps:

- Create table specifying ENGINE=CSV
- Insert data
- Search for continents.CSV file under $DATA_DIR/world

MYSQL Storage Engines

MyISAM STORAGE ENGINE:

- MyISAM = My + ISAM = Indexed Sequential Access Method
- Indexing algorithm developed by IBM that allows retrieving information from large sets of data in a fast way
- MyISAM was default storage engine up until MySQL 5.5 - around 2009-2010
- Good speed advantages especially useful in Data warehouse scenario
- Replaced by InnoDB
- Does not support transactions - ACID Model

USE CASE:

- Data Warehouse - a lot of reads

MySQL Storage Engines

Create continents table in MyISAM - world database

Steps:

- Create table specifying ENGINE=MyISAM
- Insert data
- Start Transaction, Commit, Rollback

MYSQL Storage Engines

ARCHIVE STORAGE ENGINE:

- Produces special-purpose tables that store large amounts of un-indexed data in very small footprint
- Creates .ARZ files with same name as table name
- ARZ files are binary data files and are called MySQL Archive Storage Engine Data File
- Uses gzip to compress rows

CAVEAT:

- No DELETE or UPDATE operation
- No Partitioning

Syntax:

```
Create table continents (
cid int NOT NULL,
cname VARCHAR(25) NOT NULL
) ENGINE = ARCHIVE;
```

MySQL Storage Engines

Create continents table in ARCHIVE - world database

Steps:

- Create table specifying ENGINE=ARCHIVE
- Insert data
- Look for .ARZ file

MYSQL Storage Engines

InnoDB STORAGE ENGINE:

- ACID compliant storage engine that support all types of transactions
- A - Atomicity, involves transactions COMMIT & ROLLBACK
- C - Consistency, mechanism for crash recovery
- I - Isolation, different isolation levels that applies at each transaction level
- D - Durability, storage engine interacts with underlying hardware to provide best performance
- Default storage engine, robust, fast, heart of MySQL
- Best for OLTP - Online Transaction Processing
- Row-level locking, indexing
- InnoDB maintains its own buffer pool (memory area where InnoDB cache table and indexed data)

MySQL Storage Engines

Create continents table in InnoDB - world database

Steps:

- Create table specifying ENGINE=InnoDB or skip
- Insert data
- Test all operations

REVIEW CONTENT

- Storage Engines
- InnoDB - Default Storage Engine
- Storage Engine Status
- Migrate table from one storage engine to other
- Disable storage engine

MySQL User Administration

- DBA Account
- MySQL Permissions
- WITH GRANT OPTION
- MySQL Workbench
- MySQL Roles
- Difference between Roles & Users
- Granting Permissions -> Roles, Roles -> Users
- Expired Account, Unlock Account
- Explore mysql.user table

MySQL User Administration

MySQL Permissions:

- Permissions are Privileges Granted to MySQL Account to perform actions
- ALL - All Permissions
- ALTER, DROP, CREATE - Database, table, index, etc
- DROP - Database, table, index, etc
- EXECUTE - Stored Procedure
- INSERT, DELETE, UPDATE, RENAME - On tables
- * - On all objects
- SELECT, SHOW - Read-Only Permissions
- Replication Client, Replication Slave
- Grant Permission(s)

MySQL User Administration

WITH GRANT OPTION:

- Clause used when creating new user
- Ability to grant others permissions
- DBA user statement should add this clause
- Create user with all privileges and with grant option

MySQL Auth Plugins

Authentication Plugins: mysql_native_password & caching_sha2_password

mysql_native_password:

- Implements Native Pluggable Authentication
- NPA is based on the password hashing method in use before the intro of pluggable authentication
- mysql_native_password is not pluggable so there is no library file and this plugin is built-in
- MySQL 5.7 and older version - mysql_native_password was default
- mysql –default-auth=mysql_native_password

MySQL Auth Plugins

Authentication Plugins: mysql_native_password & caching_sha2_password

caching_sha2_password:

- Default password authentication plugin starting MySQL 8
- MySQL recommends using caching_sha2_password as preferred plugin
- The server assigns this plugin to the account and uses it to encrypt the password using SHA-256, storing those values in the plugin and authentication_string column of mysql.user system table
- Built into the server, need not be loaded explicitly and can’t be disabled by unloading it

MySQL Auth Plugins

Authentication Plugins: mysql_native_password & caching_sha2_password

which one?

Authentication plugin ‘caching_sha2_password’ cannot be loaded

ALTER USER john IDENTIFIED WITH ‘mysql_native_password’ by ‘password’;

[mysqld]

default_authentication_plugin=caching_sha2_password

CREATE USER john WITH ‘caching_sha2_password’ by ‘password’;

CREATE USER john by ‘password’;

MySQL User Administration

MySQL Roles:

- Named collections of privileges
- GLOBAL CREATE ROLE or CREATE USER privilege
- Written in binary log when succeeded
- A Role when created is locked, assigned default auth plugin
- No password i.e authentication_string is empty
- Roles are considered Users in the mysql.user system table

Syntax:

- CREATE ROLE IF NOT EXISTS ‘reader’, ‘writer’, ‘admin’;

MySQL User Administration

- Create Roles reader, writer, admin
- Create User db_reader, db_writer, db_admin
- Permissions:
  - reader=SELECT on continents table
  - writer=INSERT, UPDATE, DELETE on continents table
  - admin=ALL Permissions on world database
- Grant: reader to db_reader, writer to db_writer, admin to db_admin

MySQL Configuration

Option Files:

- Also called MySQL Configuration Files
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- mysqld, mysqladmin, mysqlimport, mysqldump, mysql - examples of MySQL programs
- program –verbose –help - To get which default option file this programs uses
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Option Files Format:

MySQL Configuration

Option Files Syntax:

- Comments - # sign
- option group - stanza
- option = value
- Space is allowed either side
- Value can be without quote, single-quote, double-quote
- Any option that may be given at command-line, can be given in option file as well
- –server-id at command-line can be given in option file as server-id
- option IS NOT variable

Groups:

- mysqld, mysqladmin, client, mysql, server

Note: [client] option group is read by all client-programs except mysqld

MySQL Configuration

Option File Inclusions:

- !include = for file
- !includedir = for multiple option files

Examples:

- !include /home/john/my-options.cnf
- !includedir /home/john

Note:

- All option files must end with .cnf

MySQL Configuration

MySQL Data Directory:

- Default path is /var/lib/mysql
- mysql user is created and /var/lib/mysql set as home directory
- Owned by mysql user
- Should be on its own Filesystem - SSSD is preferred
- Controlled by datadir option in my.cnf

MySQL Configuration

- Move Data Directory to /var/lib/mysql/prod

Steps:

- Shutdown mysql service
- Create directory and change owner to mysql
- Move all data files
- Set option in my.cnf
- Restart mysql service

MySQL Configuration

MySQL Binary Log Files:

- Record database changes as events
- Binary format - Encrypted
- mysqlbinlog utility to read binary log files and output in clear text
- Contains information on how long each statement took that updated data
- Very import for Replication - provides a records of data changes on source
- Point-in-Time Recovery - Bring database up to date from the point of backup
- After a backup has been restored, the events in the binary log that were recorded after the backup was made are re-executed
- Default size is 1GB - controlled by max_binlog_size
- Retention - How many days worth of binary logs should we keep - binlog_expire_logs_seconds

MySQL Configuration

Enable Binary Logging:

- Enabled by default - system variable log_bin ON
- log_bin - binlog | mysqld-bin | prod-bin
- log_bin_index - binlog.index | mysqld-bin.index | prod-bin.index

Disable Binary Logging:

- disable-log-bin

MySQL Configuration

TASK:

- Disable Binary Logging
- Enable Binary Logging - Move to a new location

MySQL Configuration

MySQL Error Log File:

- Contains a record of mysqld startup and shutdown times
- Also contains diagnostic messages like errors, warnings that occurs during startup or shutdown, and while the server is running
- Different MySQL components writes log events in the error log i.e system, innodb, etc
- log-error is the system variable
- Default error log is /var/log/error.log

MySQL Configuration

- Configure Error Logging to /var/log/mysql/errorlog location

MySQL InnoDB Storage Engine

InnoDB Storage Engine:

- Great general-purpose storage engine that balances high reliability and high performance.
- MySQL 8, default storage engine
- It’s DML operations follows the ACID model
- Transactions support commit, rollback, crash-recovery to protect data
- Row-Level Locking
- InnoDB tables arrange data on disk to optimize queries based on PK
- Each InnoDB table has primary key index, clustered index, arrange data
- Data Integrity - support FK constraints

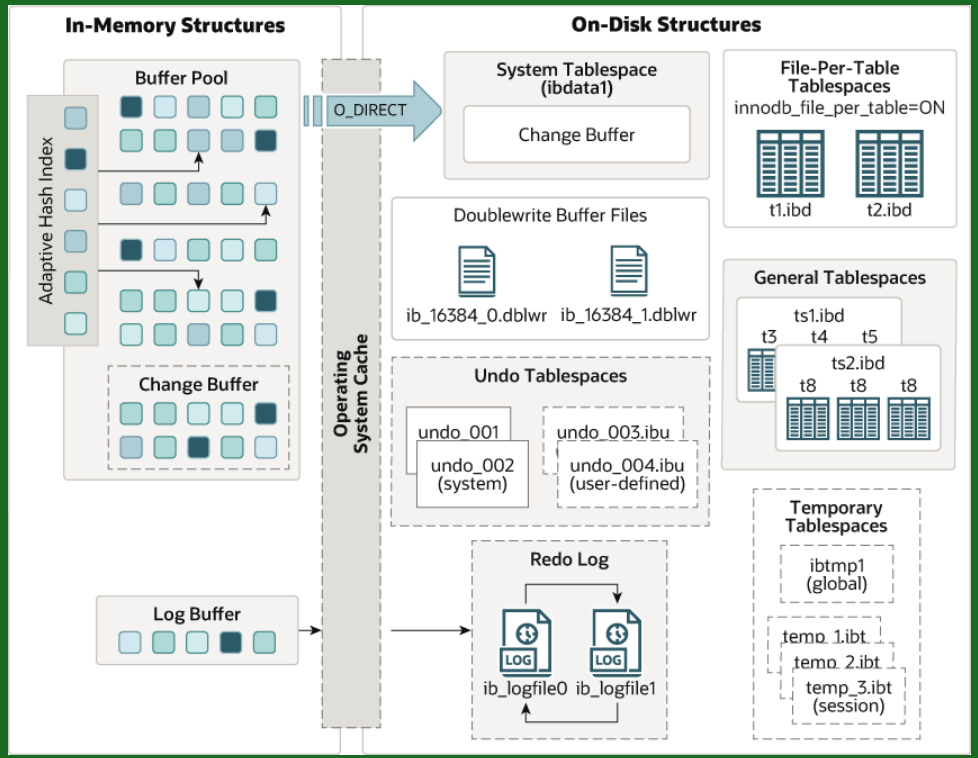
MySQL InnoDB Storage Engine

InnoDB Storage Engine Features:

- Compress Data
- Data Caches
- Encrypted Data
- Full-Text Search Index
- Referential Integrity
- Replication
- Storage Limit - 64 TB
- Row Level Locking Granularity

MySQL InnoDB Architecture

InnoDB Architecture:



In-Memory Structure:

- Buffer Pool - Area in main memory where InnoDB caches table & index data as it is accessd
- Change Buffer - caches changes to non-clustered indexes
- Adaptive Hash Index - acts like in-memory db
- Log Buffer - memory area that holds data to be written to the log files on disk

On-Disk Structure:

- System Tablespace
- Doublewrite Buffer Files
- Undo Tablespaces
- Redo Log Files
- File-Per-Table Tablespaces
- General Tablespaces
- Temporary Tablespaces

MySQL InnoDB Storage Engine

InnoDB Buffer Pool:

- It is area of main memory that is given to storage engine where it caches the table and index data as it is accessd
- innodb_buffer_pool_size
- innodb_buffer_pool_instances - 1 for small
- Innodb_buffer_pool_chunk_size - 128MB default
- Innodb_buffer_pool_size = innodb_buffer_pool_chunk_size * innodb_buffer_pool_instances

InnoDB Buffer Pool Status:

- show engine innodb status

MySQL InnoDB Architecture

InnoDB Log Buffer:

- InnoDB log buffer allows transactions to run without committing before writing to the log files on disk.
- Innodb_log_buffer_size - system variable
- Bigger log buffer size can accommodate big transactions to save disk I/O
- Default size is 16MB

InnoDB Log Buffer Too Small?

- innodb_log_waits - Number of times that the log buffer was too small
- A wait is required for it to be flushed before continuing

MySQL InnoDB Architecture

Check the InnoDB Log Buffer Size and see how many times this size was not big enough for transactions

Steps:

- innodb_log_buffer_size
- innodb_log_waits

MySQL InnoDB Architecture

InnoDB Flush Methods:

- Innodb performs certain tasks in background, including flushing of dirty pages from the buffer pool - modified pages that are not yet written to the data files on disk
- innodb_flush_method - system variable
- fsync - Default flush method, flush data, metadata, and log files - causes double buffering
- O_DSYNC - flush only data files but causes double-buffering
- O_DIRECT - flush only data files, uses fsync with no double-buffering, read-write directly goes to disk
- O_DIRECT_NO_FSYNC - O_DIRECT but skip fsync, not good for XFS FS

MySQL InnoDB Architecture

Change InnoDB Flush Method to O_DIRECT

Steps:

- innodb_flush_method

MySQL InnoDB Architecture

InnoDB Doublewrite Buffer:

- Storage area where InnoDB write pages flushed from the buffer pool before writing the pages to their proper positions in the InnoDB data files
- Implemented to recover from half-written pages
- In case of OS error, storage issue, unexpected mysqld process exit in the middle of a page write, InnoDB can find a good copy of page from doublewrite buffer during crash recovery
- Data is written twice, the doublewrite buffer does not require twice as much I/O overhead
- Prior to MySQL 8.0.20, doublewrite buffer was part of InnoDB system tablespace ibdata1
- As of MySQL 8.0.20, the doublewrite buffer storage area is located in doublewrite files

MySQL InnoDB Architecture

InnoDB Flush Logs Transaction Commit:

- innodb_flush_log_at_trx_commit - system variable - controls balance between strict ACID compliance for commit operations and higher performance - I/O related
- 1 - default full ACID compliance - Logs are written and flushed to disk at each transaction commit
- 0 - Logs are written and flushed to disk once per second - transactions for which log have not been flushed can be lost in crash
- 2 - Logs are written after each transaction commit and flushed to disk once per second - transactions for which log have not been flushed can be lost in crash

Which value to use?

- 1 = Safest full ACID compliance - no data loss

MySQL InnoDB Architecture

InnoDB Redo Log Files:

- All about data recovery by InnoDB Storage Engine
- Disk-Based data structure used during crash recovery to correct data written by incomplete transactions
- Any transaction that were active at the time of unexpected exit or fast shutdown
- The redo log is physically represented on disk by redo log files
- ib_logfile0 & ib_logfile1
- innodb_log_file_size - default 50MB
- innodb_log_files_in_group - default 2
- innodb_log_group_home_dir - default to DATA DIR
- innodb_fast_shutdown - SET GLOBAL innodb_fast_shutdown = 0; default=1
  - 0 = Clean Shutdown - Does additional flushing operations, longer time to shutdown but saved time on startup
  - 1 = Fast Shutdown - Shutdown MySQL but read redo log files on startup

MySQL Backup & Recovery

mysqldump?

- Client utility to performs logical backups
- Produces a set of SQL statements that can be executed to reproduce original database object
- Can backup whole database my skipping some tables also
- Can take table backup with where clause
- One or more databases can be dump at same time

Syntax:

- mysqldump [options] db_name [tbl_name] > bkup_name.sql
- mysqldump [options] db_name [tbl_name] –where=”condition” > bkup_name.sql
- mysqldump [options] db_name –ignore-table=db.tbl_name > bkup_name.sql
- mysqldump [options] –databases db1 db2… > bkup_name.sql
- mysqldump [options] –all-databases > bkup_name.sql

MySQL Backup & Recovery

MySQL Hot Backup:

- Also called Physical Backup
- Physically copy database files to a backup device while MySQL is online
- Suitable for critical always-on production applications
- Best of InnoDB tables - Transactions

Hot Backup Tools?

- mysqlbackup - Oracle
- mariabackup - MariaDB
- xtrabackup - Percona

MySQL Backup & Recovery

mysqlbackup:

- Enterprise backup tool - MySQL Enterprise Backup component - not-free

mariabackup:

- Open-source, free provided by MariaDB
- Forked copy of well-known and commonly used backup tool XtraBackup
- Supports all the main features of Percona XtraBackup

Xtrabackup:

- Open-source hot backup tool for MySQL, from Percona
- Does not lock database during backup
- Can backup seamless without disrupting the performance

MySQL Backup & Recovery

Xtrabackup:

- Free of cost, production grade hot backup tool
- No license is required
- Completely separate from mysqlbackup or InnoDB hot backup
- Download from https://www.percona.com/software/mysql-database/percona-xtrabackup
- Compatible with on-prem as well as in the cloud
- Enterprise ready, can be automated
- Point-in-time Recovery

MySQL Replication

Replication:

- Enables data copy from source server to destination server
- Source is called Primary or Master
- Destination is called Replica or Slave
- Primary and Replica should be on separate servers
- Replication is Asynchronous by default
- Replica does not need to be connected to Primary at any given time
- Replication Selection - All databases, selected, or even selected tables
- Replication provides high-availability

MySQL Replication

Replication Methods:

- Traditional - binary log file position based replication
- GTID - Global Transaction Identifier

Binary Log File Position Based Replication:

- Replicating events from primary binary log file
- Requires the log files and positions to be synced between primary and replica

GTID Based Replication:

- Newer method, does not require working with binary logs and positions within files
- GTID replication guarantee consistency between primary and replica as long as transactions committed on primary also been applied to replica
- Recommend method for replication

MySQL Replication

Replication Format:

- Replication works because events written to the binlog are read from source and then processed on replica
- Events are recorded in the Binary Log File in different formats according to the type of event
- binlog_format is the system global variable that defines which format to use
- Statement Based Replication - SBR
  - binlog_format = STATEMENT
- Row Based Replication - RBR
  - binlog_format = ROW
- Mixed Based Replication - MBR
  - binlog_format = MIXED
- Each binary log format has advantages and disadvantages

MySQL Replication

Statement Based Replication: binlog_format = STATEMENT

- Replicate entire SQL statements in binary file, this file is copied over to replica
- Replica execute all these SQL statements
- Less data written to log files, consumes less storage space for log files
- Not all statements are replicated as any non-deterministic behavior is difficult to replicate

Row Based Replication: binlog_format = ROW

- Replicate only the changed rows
- Source write events in binary log that indicates how individual tables rows are changed
- All changes are replicated, consume more space

MySQL Replication

Generic Replication Setup Requirements:

- Binary Logging must be enabled on primary
  - log-bin
  - log-bin-index
- Unique Server ID for both Primary & Replica
  - server-id
- Dedicated user for replication
  - replicator or any other name
  - Should have proper permissions
    - GRANT REPLICATION SLAVE ON *.* TO replicator
- Binary Log File Format
  - binlog_format = STATEMENT|ROW|MIXED

MySQL Replication

Primary Server Setup:

- Suggested to create a separate option file i.e replication.cnf
- Enable Binary Logging
  - log-bin = /var/log/mysql/binlog/prod-bin
  - log-bin-index = /var/log/mysql/binlog/prod-bin.index
- Set Unique Server ID
  - server-id = 1
- Create Dedicated Replication User
  - Create user replicator IDENTIFIED BY ‘password’ ;
  - GRANT REPLICATION SLAVE ON *.* TO replicator;
- Set Binary Log File Format
  - binlog_format = MIXED

MySQL Replication

Replica Server Setup:

- Suggested to create a separate option file i.e replication.cnf
- Enable Relay Logs
  - relay-log = /var/log/mysql/relay/replica-bin
  - relay-log-index = /var/log/mysql/relay/replica-bin.index
- Set Unique Server ID
  - server-id = 2
- Skip Replica to auto-start
  - skip-replica-start
- Replica should be read only
  - read-only