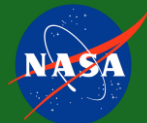


MySQL Database Administrator

Nobelprog

22-Oct-2024 – 25-Oct-2024

MySQL Server Usage



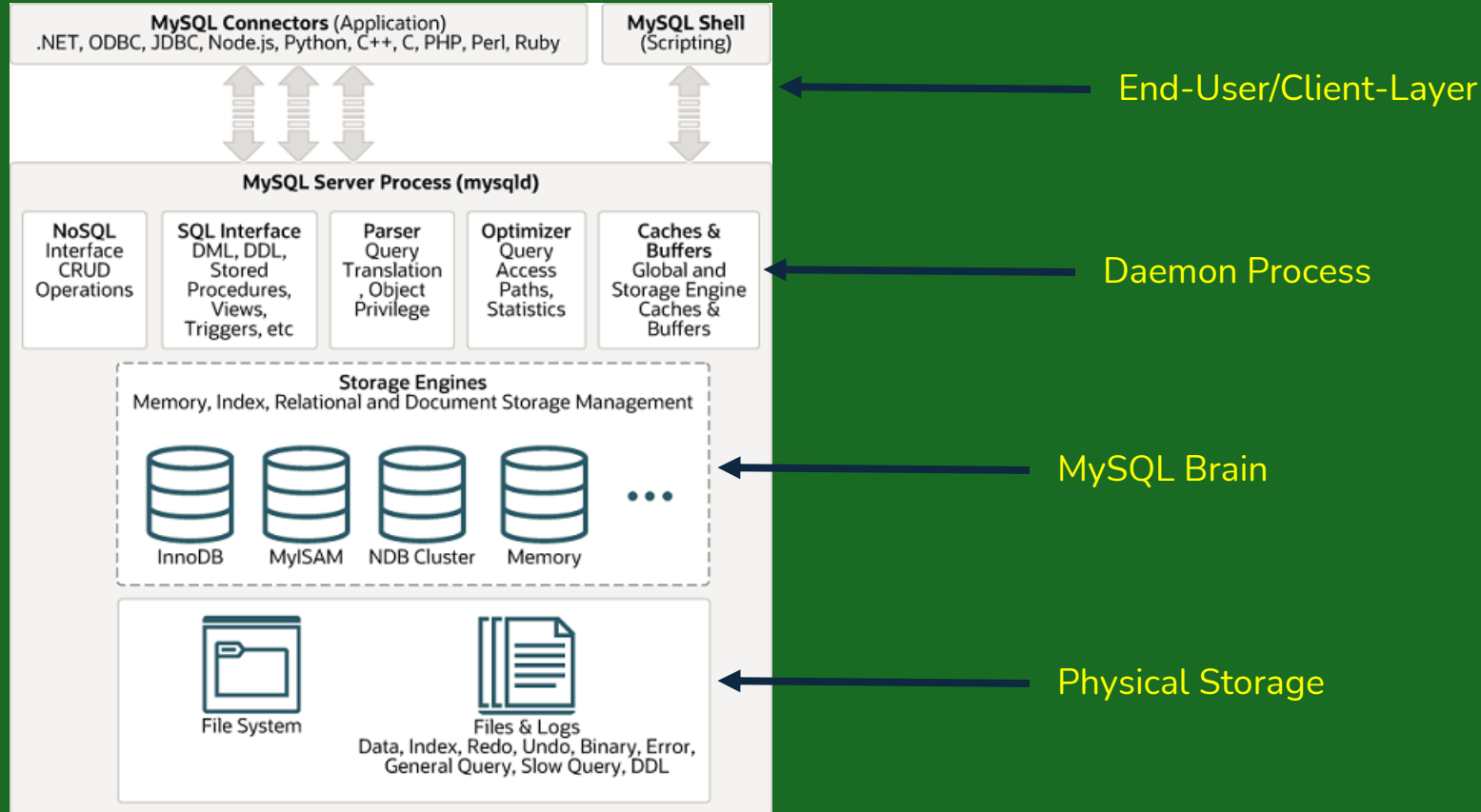
Course Introduction

- ❖ 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

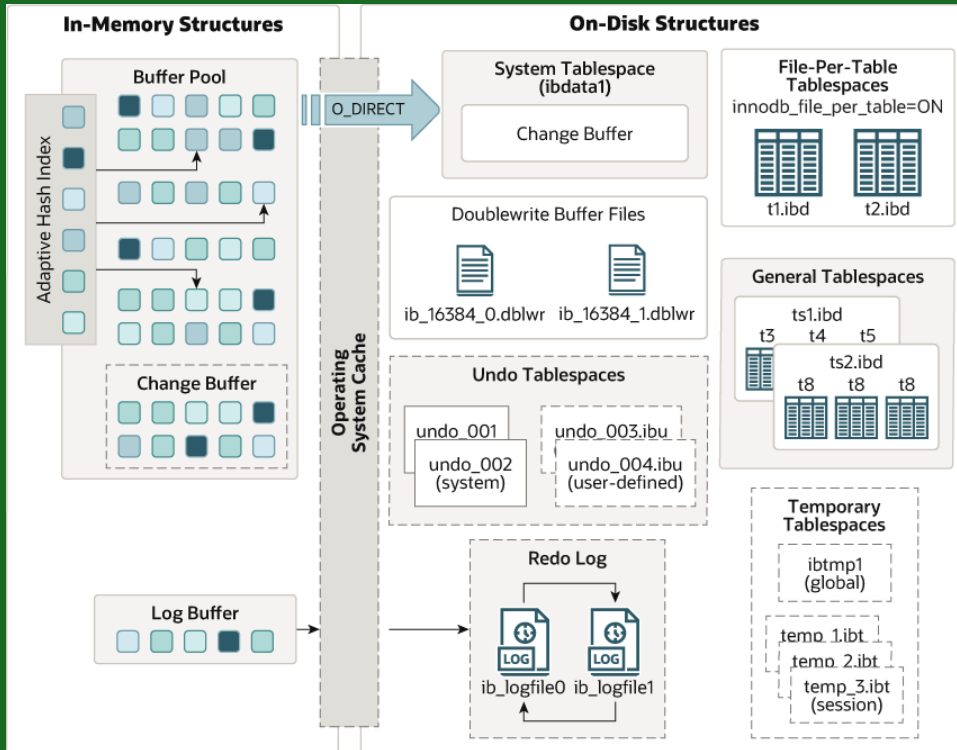
- ❖ MySQL Server Installation
- ❖ Exploring MySQL Server
- ❖ MySQL Server Database Administration
- ❖ MySQL Storage Engines
- ❖ MySQL User Administration
- ❖ MySQL Server Configuration
- ❖ InnoDB Storage Engine
- ❖ MySQL Backup & Restore
- ❖ MySQL Replication
- ❖ Upgrading MySQL Server
- ❖ MySQL Performance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

MySQL Architecture



MySQL InnoDB Architecture

InnoDB Architecture:



In-Memory Structure:

- ❖ **Buffer Pool** - Area in main memory where InnoDB caches table & index data as it is accessed
- ❖ **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

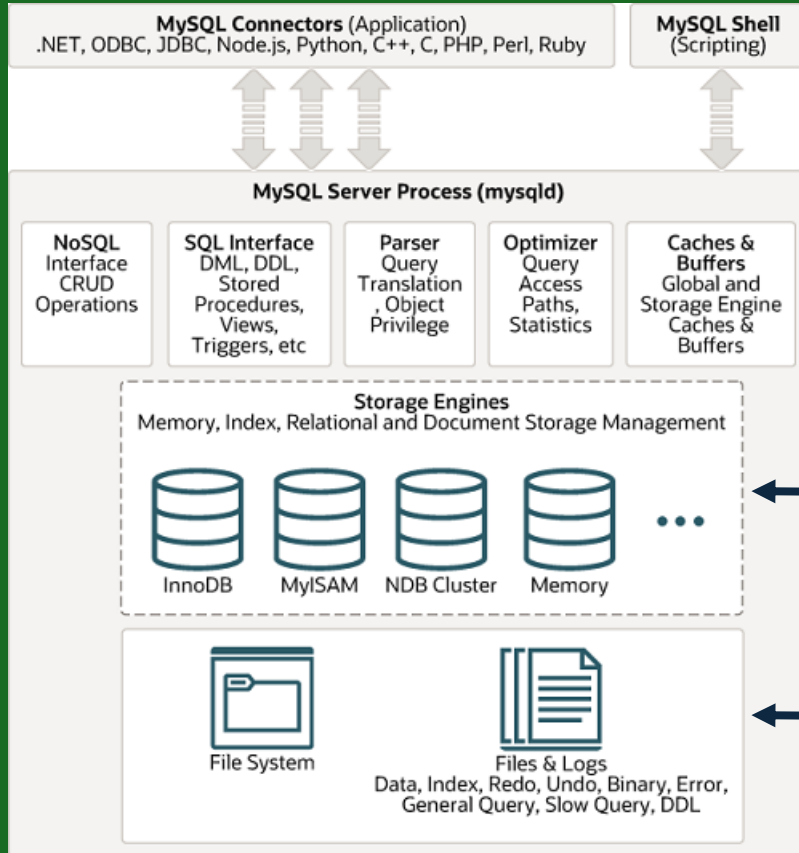
Oracle MySQL, MariaDB, Percona MySQL are **forks** of original MySQL

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_name>;
- ❖ 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_name>;
- ❖ 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_schema:

- ❖ 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:

- ❖ `mysqlcheck [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**
- ❖ 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**

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

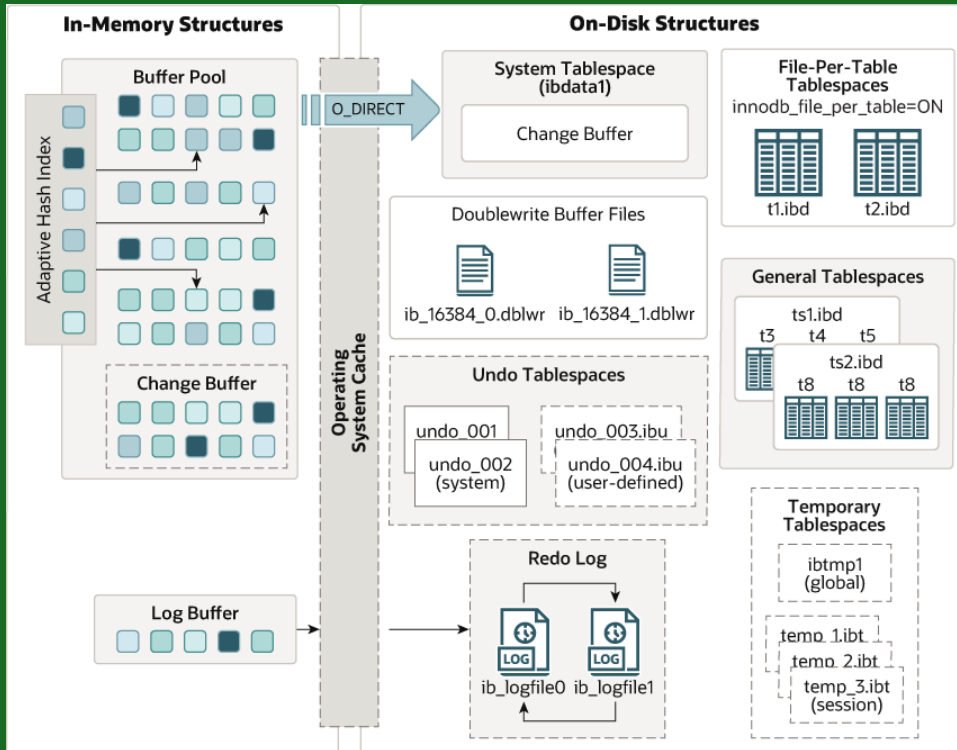
MySQL InnoDB Storage Engine

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 accessed
- ❖ **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 accessed
- ❖ `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