MariaDB Basics

Agenda

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1. Optimal use of indexes

    - Index-Types
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        - Find out indexes
    - Index and Functions (Cool new feature in MySQL 5.7)
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    - Find out cardinality without index

2. Monitoring

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4. Tools

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    - pt-query-digist - analyze slow logs
    - pt-online-schema-change howto

5. Diagnosis and measurement of performance

    - Best practices to narrow down performance problems

6. Performance and optimization of SQL statements

    - Do not use '*' whenever possible
    - Be aware of subselects - Example 1
    - Optimizer-hints (and why you should not use them)

7. Replication

    - Replikation Read/Write

8. Performance

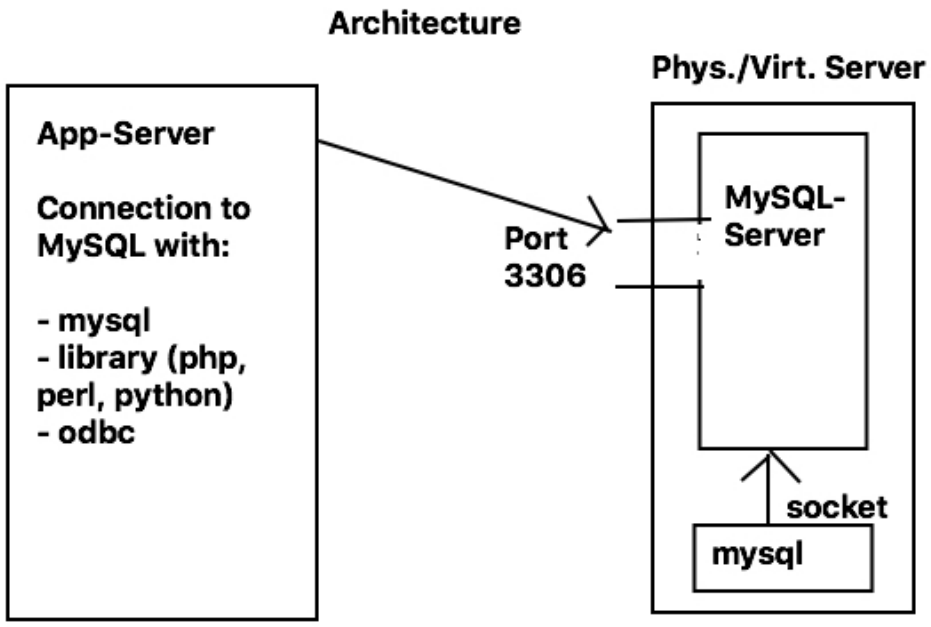
    - Best Practices
    - Example sys-schema and Reference
    - Change schema online (pt-online-schema-change)
    - Optimizer-Hints

9. Documentation / Literature

    - Effective MySQL
    - MariaDB Galera Cluster
    - MySQL Galera Cluster

Architectur of MariaDB

Architecture Server



Query Cache Usage and Performance

Performance query cache

- Always try to optimize innodb with disabled query cache first (innodb_buffer_pool)
- If you use query_cache system can only use on CPU-Core. !!

How to enable query cache

```
## have_query_cache means compiled in mysql
## query_cache_type off means not enable by config
-- query cache is diabled
mysql> show variables like '%query_cache%';
+------------------------------+---------+
| Variable_name                | Value   |
+------------------------------+---------+
| have_query_cache             | YES     |
| query_cache_limit            | 1048576 |
| query_cache_min_res_unit     | 4096    |
| query_cache_size             | 1048576 |
| query_cache_type             | OFF     |
```

```
| query_cache_wlock_invalidate | OFF     |
+------------------------------+---------+
6 rows in set (0.01 sec)

root@trn01:/etc/mysql/mysql.conf.d# tail mysqld.cnf
[mysqld]
pid-file        = /var/run/mysqld/mysqld.pid
socket          = /var/run/mysqld/mysqld.sock
datadir         = /var/lib/mysql
log-error       = /var/log/mysql/error.log
## By default we only accept connections from localhost
bind-address    = 0.0.0.0
## Disabling symbolic-links is recommended to prevent assorted security risks
symbolic-links=0
query-cache-type=1

systemctl restart mysql

mysql> show variables like '%query_cache%';
+------------------------------+---------+
| Variable_name                | Value   |
+------------------------------+---------+
| have_query_cache             | YES     |
| query_cache_limit            | 1048576 |
| query_cache_min_res_unit     | 4096    |
| query_cache_size             | 1048576 |
| query_cache_type             | ON      |
| query_cache_wlock_invalidate | OFF     |
+------------------------------+---------+
6 rows in set (0.01 sec)


mysql> show status like '%Qcache%';
+-------------------------+---------+
| Variable_name           | Value   |
+-------------------------+---------+
| Qcache_free_blocks      | 1       |
| Qcache_free_memory      | 1031832 |
| Qcache_hits             | 0       |
| Qcache_inserts          | 0       |
| Qcache_lowmem_prunes    | 0       |
| Qcache_not_cached       | 0       |
| Qcache_queries_in_cache | 0       |
| Qcache_total_blocks     | 1       |
+-------------------------+---------+
8 rows in set (0.00 sec)

## status in session zurücksetzen.
mysql> flush status;
Query OK, 0 rows affected (0.00 sec)
```

Performance bottleneck - mutex

https://mariadb.com/de/resources/blog/flexible-mariadb-server-query-cache/

Something planned ?

- Nope ;o(Demand is new
- You might be able to use Demand together with maxscale
- Refer to: https://mariadb.com/de/resources/blog/flexible-mariadb-server-query-cache/

```
A mutual exclusion object (mutex) is a programming object that allows multiple program threads to share a resource (such as a folder) but not simultaneously. Mutex is set to unlock when the data is no longer needed or when a routine is finished. Mutex creates a bottleneck effect. The blocking means only one query can look at the Query Cache at a time and other queries must wait. A query that must wait to look in the cache only to find it isn’t in the cache will be slowed instead of being accelerated.
```

Storage Engines

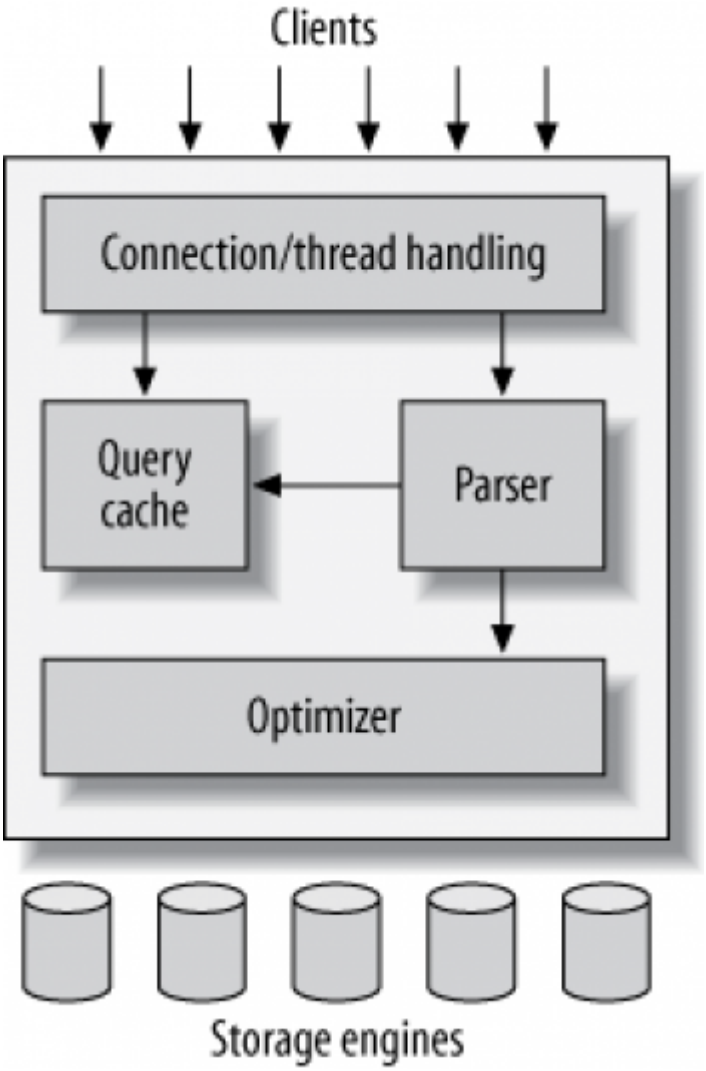
Why ?

```
Let's you choose:
How your data is stored
```

What ?

- Performance, features and other characteristics you want

Looks like



What do they do ?

- In charge for: Responsible for storing and retrieving all data stored in MySQL
- Each storage engine has its:
  - Drawbacks and benefits
- Server communicates with them through the storage engine API
  - this interface hides differences
  - makes them largely transparent at query layer
  - api contains a couple of dozen low-level functions e.g. “begin a transaction”, “fetch the row that has this primary key”

Storage Engine do not ....

- Storage Engines do not parse SQL
- Storage Engines do not communicate with each other

They simply .....

- They simply respond to requests from the server

Which are the most important one ?

- MyISAM/Aria
- InnoDB
- Memory
- CSV
- Blackhole (/dev/null)
- Archive
- Federated/FederatedX

Installation / Configuration

Installation (Ubuntu)

Install version from distribution (older version)

```
apt update
apt install mariadb-server
```

Install Newest version from mariadb

```
https://downloads.mariadb.org/mariadb/repositories/
## repo
sudo apt-get install software-properties-common
sudo apt-key adv --fetch-keys 'https://mariadb.org/mariadb_release_signing_key.asc'
sudo add-apt-repository 'deb [arch=amd64,arm64,ppc64el]
https://mirror.dogado.de/mariadb/repo/10.5/ubuntu focal main'

apt update
apt install mariadb-server
```

Secure installation

```
mariadb-secure-installation
## OR: if not present before 10.4
mysql_secure_installation
```

start/stop/status and logs

```
## How to find out if it is running
systemctl status mariadb

## To stop it
systemctl stop mariadb

## To start it
systemctl start mariadb

## to restart it
systemctl restart mariadb
```

```
## How it the configuration of the service
systemctl cat mariadb

## Logs
## last 10 lines
systemctl status mariadb
journalctl -u mariadb
```

Is mariadb listening to the outside world (and how to fix)?

not the case

```
lsof -i
## or
netstat -ant
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 127.0.0.1:3306          0.0.0.0:*               LISTEN

## <- in this case not - localhost
```

Yes !

```
## ubuntu 20.04
## change to listen on all interfaces
## vi /etc/mariadb-conf.d/50-server.cnf
## this is only for the mysqld standalone daemon
[mysqld]
bind-address = 0.0.0.0

## restart
systemctl restart mariadb

lsof -i
## connect to the server by external interface (e.g.  eth0 )
mysql -h 10.0.3.3
```

Administration

Debug configuration error

Walkthrough

```
## Service is not restarting - error giving
systemctl restart mariadb.service

## Step 1 : status -> what do the logs tell (last 10 lines)
systemctl status mariadb.service
```

```
## no findings -> step 2:
journalctl -xe

## no findings -> step 3:
journalctl -u mariadb.service
## or journalctl -u mariadb

## no findings -> step 4:
## search specific log for service
## and eventually need to increase the log level
## e.g. with mariadb (find through internet research)
less /var/log/mysql/error.log

## Nicht fündig -> Schritt 5
## Allgemeines Log
## Debian/Ubuntu
/var/log/syslog
## REdhat/Centos
/var/log/messages
```

Find errors in logs quickly

```
cd /var/log/mysql
## -i = case insensitive // egal ob gross- oder kleingeschrieben
cat error.log | grep -i error
```

Server System Variables

```
MariaDB [(none)]> show global variables like '%long%';
+-----------------------------------------------------------+-----------+
| Variable_name                                             | Value     |
+-----------------------------------------------------------+-----------+
| deadlock_search_depth_long                                | 15        |
| deadlock_timeout_long                                     | 50000000  |
| long_query_time                                           | 10.000000 |
| max_long_data_size                                        | 16777216  |
| performance_schema_events_stages_history_long_size        | -1        |
| performance_schema_events_statements_history_long_size | -1        |
| performance_schema_events_waits_history_long_size         | -1        |
+-----------------------------------------------------------+-----------+
7 rows in set (0.001 sec)

MariaDB [(none)]> select @@long_query_Time
    -> ;
+--------------------+
| @@long_query_Time |
+--------------------+
|          10.000000 |
+--------------------+
1 row in set (0.000 sec)
```

```
MariaDB [(none)]> select @@long_query_time
    -> ;
+-------------------+
| @@long_query_time |
+-------------------+
|         10.000000 |
+-------------------+
1 row in set (0.000 sec)

MariaDB [(none)]> select @@GLOBAL.long_query_time
    -> ;
+--------------------------+
| @@GLOBAL.long_query_time |
+--------------------------+
|                10.000000 |
+--------------------------+
1 row in set (0.000 sec)

MariaDB [(none)]> select @@global.long_query_time
    -> ;
+--------------------------+
| @@global.long_query_time |
+--------------------------+
|                10.000000 |
+--------------------------+
1 row in set (0.000 sec)
```

Handling general_log

Activate during runtime

```
## Hint hostname:  myserver
mysql>set global general_log = 1

ls -la /var/lib/mysql/myserver.log
```

Implications

- By default
- Will massively increase in size, because all queries are documented

Truncate while running

```
## will be empty that
cd /var/lib/mysql
> myserver.log

## and keeps on writing in there

## Attention
```

```
## Delete logfile does not work, needs restart
## or
## set global general_log = 0; set global general_log = 1 # after deletion
```

Show structure of database

```
mysql>use mysql;
mysql>describe columns_priv;
mysql>show create table columns_priv;
```

Binary Logging

General

- It is disabled by default

Why and when to use it ?

- Needed Galera Cluster (3 - Node - Cluster)
- Replication
- PIT (Point-In-Time) - Recovery (e.g. recover to start from 4 a.m. with full backup + binary log)

How to enable it ?

```
## Ubuntu
## vi /etc/mysql/mariadb.conf.d/50-server.cnf
[mysqld]
log-bin

## Restart server
systemctl restart mariadb
```

How to view the binary-log

```
cd /var/lib/mysql

mysqlbinlog -vv mysqld-bin.000001
## in the special configuration from /etc/mysql/... gets in the way
mysqlbinlog --no-defaults -vv mysqld-bin.000001
```

Kill Session/User

```
MariaDB [(none)]> show processlist;
+----+-------------+-----------+------+---------+------+--------------------------+---
-----------------+----------+
| Id | User        | Host      | db   | Command | Time | State                    |
Info              | Progress |
+----+-------------+-----------+------+---------+------+--------------------------+---
-----------------+----------
| 37 | root        | localhost | NULL | Query   |    0 | Init                     |
```

```
show processlist   |    0.000 |
| 38 | root        | localhost | NULL | Query   |   10 | User sleep               |
select sleep(1000) |    0.000 |

 # kill thread 38. Connection will be interrupted. User session will be cancelled
 kill 38
```

Training Data

Setup sakila test database

```
cd /usr/src
wget https://downloads.mysql.com/docs/sakila-db.tar.gz
tar xvf sakila-db.tar.gz
cd sakila-db/
ls -la
mysql < sakila-schema.sql
mysql < sakila-data.sql
```

Setup training data "contributions"

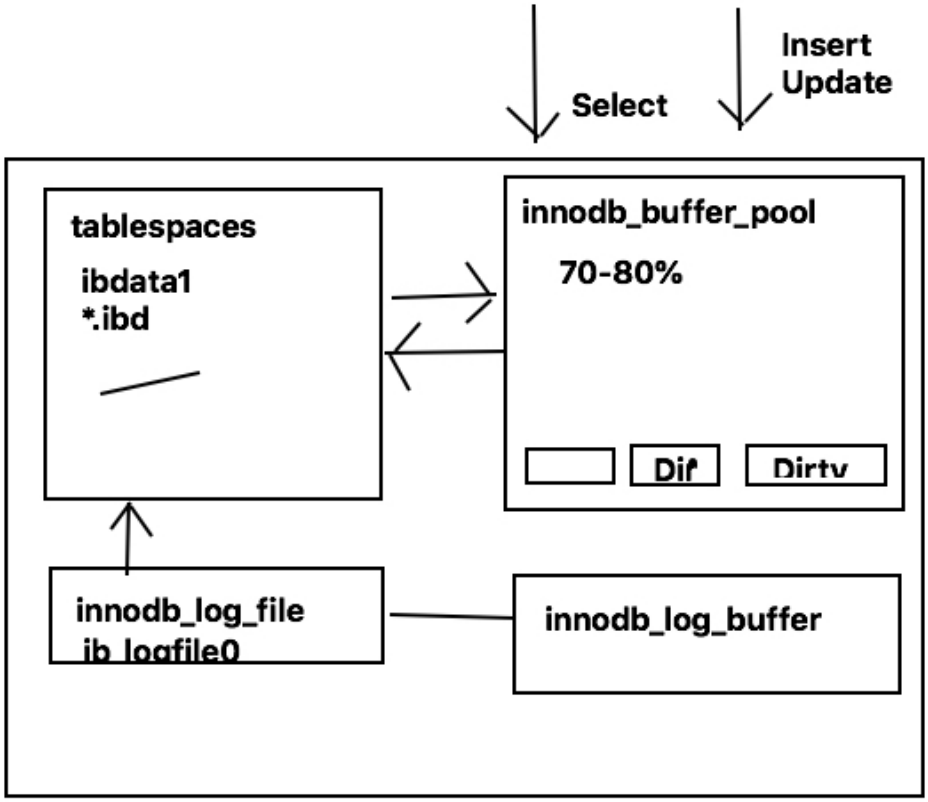
Walkthrough

- Complete process takes about 10 minutes

```
cd /usr/src
apt update; apt install -y git
git clone https://github.com/jmetzger/dedupe-examples.git
cd dedupe-examples
cd mysql_example
## Eventually you need to enter (in mysql_example/mysql.cnf)
## Only necessary if you cannot connect to db by entering "mysql"
## password=<your_root_pw>
./setup.sh
```

InnoDB - Storage Engine

InnoDB - Storage Engine - Structure



Important InnoDB - configuration - options to optimized performance

Innodb buffer pool

- How much data fits into memory
- Free buffers = pages of 16 Kbytes
- Free buffer * 16Kbytes = free innodb buffer pool in KByte

```
pager grep -i 'free buffers'
show engine innodb status \G
Free buffers       7905
1 row in set (0.00 sec)
```

Overview innodb server variables / settings

- https://dev.mysql.com/doc/refman/5.7/en/innodb-parameters.html

Change innodb_buffer_pool

```
## /etc/mysql/mysql.conf.d/mysqld.cnf
## 70-80% of memory on dedicated mysql
[mysqld]
innodb-buffer-pool-size=6G

##
systemctl restart mysql
```

```
##
mysql
mysql>show variables like 'innodb%buffer%';
```

innodb_flush_method

```
Ideally O_DIRECT on Linux, but please test it, if it really works well.
```

innodb_flush_log_at_trx_commit

```
When is fliushing done from innodb_log_buffer to log.
Default: 1 : After every commit
-> best performance 2. -> once per second

## Good to use 2, if you are willing to loose 1 second of data on powerfail
```

innodb_flush_neighbors

```
## on ssd disks set this to off, because there is no performance improvement
innodb_flush_neighbors=0

## Default = 1
```

skip-name-resolv.conf

```
## work only with ip's - better for performance
/etc/my.cnf
skip-name-resolve
```

- https://nixcp.com/skip-name-resolve/

Ref:

- https://dev.mysql.com/doc/refman/5.7/en/innodb-buffer-pool-resize.html

Privilegs for show engine innodb status

```
 show engine innodb status \G
ERROR 1227 (42000): Access denied; you need (at least one of) the PROCESS privilege(s)
for this operation
```

Backup and Restore (Point-In-Time aka PIT)

General

Define your goal

- Full backup of database-server (specific to PIT - point-in-time)
- Simply backup some specific databases (with data) - (e.g. 1 database out of 20)
- Backup Structure and Data seperately in multiple files - (For further work - e.g. for developers)
- Extract data from a specific table (because of problems that came up)

Backup and Create new database based on backup

```
mysqldump sakila > sakila.sql
mysql -e 'create schema sakilanew'
## or
echo "create schema sakilanew" | mysql

mysql sakilanew < sakila.sql
```

Backup with mysqldump - best practices

Useful options for PIT

```
## —quick not needed, because included in —opt which is enabled by default

## on local systems using socket, there are no huge benefits concerning --compress
## when you dump over the network use it for sure
mysqldump --all-databases --single-transaction --gtid --master-data=2 --routines --
events --flush-logs > /usr/src/all-databases.sql;
```

With PIT_Recovery you can use --delete-master-logs (not using replication)

- All logs before flushing will be deleted

```
mysqldump --all-databases --single-transaction --gtid --master-data=2 --routines --
events --flush-logs --compress --delete-master-logs > /usr/src/all-databases.sql;
```

Alternative - flushing logs

- https://mariadb.com/kb/en/purge-binary-logs/

Version with zipping

```
mysqldump —-all-databases —-single-transaction —-gtid —-master-data=2 —-routines
--events —-flush-logs --compress | gzip > /usr/src/all-databases.sql.gz
```

Performance Test mysqldump (1.7 Million rows in contributions)

```
date; mysqldump --all-databases --single-transaction --gtid --master-data=2 --routines
--events --flush-logs --compress > /usr/src/all-databases.sql; date
Mi 20. Jan 09:40:44 CET 2021
Mi 20. Jan 09:41:55 CET 2021
```

Seperated sql-structure files and data-txt files including master-data for a specific database

```
 # backups needs to be writeable for mysql
 mkdir /backups
 chmod 777 /backups
 chown mysql:mysql /backups
```

```
mysqldump --tab=/backups contributions
mysqldump --tab=/backups --master-data=2 contributions
mysqldump --tab=/backups --master-data=2 contributions > /backups/master-data.tx
```

PIT - Point-in-time-Recovery Exercise

Problem coming up

```
## Step 1 : Create full backup (assuming 24:00 o'clock)
mysqldump --all-databases --single-transaction --gtid --master-data=2 --routines --
events --flush-logs --delete-master-logs > /usr/src/all-databases.sql;

## Step 2: Working on data
mysql>use sakila;
mysql>insert into actor (first_name,last_name) values ('john','The Rock');
mysql>insert into actor (first_name,last_name) values ('johanne','Johannson');

## Optional: Step 3: Looking into binary to see this data
cd /var/lib/mysql
## last binlog
mysqlbinlog --no-defaults -vv mysqldbin.000005

## Step 3: Some how a guy deletes data
mysql>use sakila; delete from actor where actor_id > 200;
## now only 200 datasets
mysql>use sakila; select * from actor;
```

Fixing the problem

```
## find out the last binlog
## Simple take the last binlog

cd /var/lib/mysql
## Find the position where the problem occured
## and create a recovery.sql - file (before apply full backup)
mysqlbinlog --no-defaults -vv --stop-position=857 mysqld-bin.000005 >
/usr/src/recover.sql

## Step 1: Apply full backup
cd /usr/src/
mysql < all-databases.sql
mysql> should be 200 or 202
mysql> use sakila; select * from actor;
mysql < recover.sql
mysql> -- now it should have all actors before deletion
mysql> use sakila; select * from actor;



### Backup / Recover to Network Destination
```

```
### Assumptions
```

Server 1: 192.168.1.1 Server 2: 192.168.1.2

Create new db -> sakilaremote on server 1 Backup data from sakila on server2 and send to server 1

```
### Preparation (on server 1)
```

is server listening to the outside world

lsof -i | grep mysql

create user on server

mysql>create user ext@'%' identified by 'mysecretpass' mysql>grant all on . to ext@'%'

```
### Testing (on server 1)
```

mysql -uext -p -h 192.168.1.1 mysql>create schema sakilaremote

```
### Executing (on server 2)
```

mysqldump sakila | mysql -uext -p -h 192.168.1.1 sakilremote

```
### Validating (on server 2)
```

mysql -uext -p -h 192.168.1.1 mysql> use sakilaremote; mysql> show tables;

```
### Flashback


  * Redoes insert/update/delete entries from binlog (binlog_format = 'ROW')

### Referenz:

  * https://mariadb.com/kb/en/flashback/

### mariabackup


### Installation (Ubuntu)
```

apt install mariadb-backup

```
### Walkthrough
```

user eintrag in /root/.my.cnf

[mariabackup] user=root

pass is not needed here, because we have the user root with unix_socket - auth

mkdir /backups

target-dir needs to be empty or not present

mariabackup --target-dir=/backups/20210120 --backup

apply ib_logfile0 to tablespaces

after that ib_logfile0 -> 0 bytes

mariabackup --target-dir=/backups/20210120 --prepare

Recover

systemctl stop mariadb mv /var/lib/mysql /var/lib/mysql.bkup mariabackup --target-dir=/backups/20200120 --copy-back chmod -R mysql:mysql /var/lib/mysql systemctl start mariadb

```
### Ref.
https://mariadb.com/kb/en/full-backup-and-restore-with-mariabackup/

### Use xtrabackup for MariaDB 5.5


### For mariadb 5.5 you can use xtrabackup instead of mariabackup

  * https://www.percona.com/doc/percona-xtrabackup/2.4/index.html



## Upgrading / Patching

### Upgrade vom 10.3 (Distri Ubuntu 20.04) -> 10.4 (MariaDB-Foundation)


### Prerequisites
```

Ubuntu 20.04 MariaDB-Server from Distri

Install new 10.4 from Mariadb.org

```
### Prepare

  * Create backup of system (with mariabackup and/or mysqldump)
```

```
### Steps
```

1. systemctl stop mariadb

2. apt remove mariadb-*

3. Doublecheck if components left: apt list --installed | grep mariadb

4. Setup repo for mariadb

5. apt update

6. apt install mariadb-server

7. systemctl enable --now mariadb # enable for next reboot and start immediately

necessary for redhat

8. Doublecheck if mysql_upgrade was done

cat /var/lib/mysql_upgrade_info

```
### Important - Check mysql - configuration structure
```

Which directories are loaded in

/etc/mysql/my.cnf

Eventually move files to the right directory

As needed in migration from 10.3 (Distri) to 10.4 (mariadb.org) on Ubuntu 20.04

```
### Documentation

  * https://mariadb.com/kb/en/upgrading-from-mariadb-103-to-mariadb-104/

## Documentation

### Mariadb Server System Variables

  * https://mariadb.com/kb/en/server-system-variables/#long_query_time

### MySQL - Performance - PDF
```

```
  * http://schulung.t3isp.de/documents/pdfs/mysql/mysql-performance.pdf

## Optimal use of indexes

### Index and Functions (Cool new feature in MySQL 5.7)


### No index can be used on an index:
```

explain select * from actor where upper(last_name) like 'A%'; +----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+ | id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra | +----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+ | 1 | SIMPLE | actor | NULL | ALL | NULL | NULL | NULL | NULL | 200 | 100.00 | Using where | +----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+

```
### Workaround with virtual columns (possible since mysql 5.7)
```

1. Create Virtual Column with upper

alter table sakila add idx_last_name_upper varchar(45) GENERATED ALWAYS AS upper(last_name);

2. Create an index on that column

create index idx_last_name_upper on actor (last_name_upper);

```
### Now we try to search the very same
```

explain select * from actor where last_name_upper like 'A%'; +----+-------------+-------+------------+-------+---------------------+---------------------+---------+------+------+----------+-------------+ | id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra | +----+-------------+-------+------------+-------+---------------------+---------------------+---------+------+------+----------+-------------+ | 1 | SIMPLE | actor | NULL | range | idx_last_name_upper | idx_last_name_upper | 183 | NULL | 7 | 100.00 | Using where | +----+-------------+-------+------------+-------+---------------------+---------------------+---------+------+------+----------+-------------+ 1 row in set, 1 warning (0.00 sec)

```



### Preview MySQL 8

  * MySQL 8 support functional indexes

### Index and Likes


### 1. like 'Will%' - Index works
```

```
explain select last_name from donors where last_name like 'Will%';

### 2. like '%iams' - Index does not work
```

-- because like starts with a wildcard explain select last_name from donors where last_name like '%iams';

```
### 3. How to fix 3, if you are using this often ?
```

Walkthrough

Step 1: modify table

alter table donors add last_name_reversed varchar(70) GENERATED ALWAYS AS (reverse(last_name));
create index idx_last_name_reversed on donors (last_name_reversed);

besser - Variante 2 - untested

alter table donors add last_name_reversed varchar(70) GENERATED ALWAYS AS (reverse(last_name)), add index idx_last_name_reversed on donors (last_name_reversed);

Step 2: update table - this take a while

update donors set last_name_reversed = reversed(last_name)

Step 3: work with it

select last_name,last_name_reversed from donor where last_name_reversed like reverse('%iams');

Version 2 with pt-online-schema-change

```
### profiling-get-time-for-execution-of.query


   * Get better values, how long queries take

### Example
```

set profiling = 1

Step 2 - Execute query

select last_name as gross from donors where last_name like lower('WILLI%')

Step 3 - Show profiles

show profiles; +----------+------------+---------- ---------- | Query_ID | Duration | Query | +----------+------------+----------

--+ | 1 | 0.01993525 | select last_name as gross from donors where last_name like lower('WILLI%') | 4 rows in set, 1 warning (0.00 sec)

Step 4 - Show profile for a specific query

mysql> show profile for query 1; +----------------------+----------+ | Status | Duration | +----------------------+----------+ | starting | 0.000062 | | checking permissions | 0.000006 | | Opening tables | 0.000021 | | init | 0.000017 | | System lock | 0.000007 | | optimizing | 0.000007 | | statistics | 0.000083 | | preparing | 0.000012 | | executing | 0.000004 | | Sending data | 0.022251 | | end | 0.000005 | | query end | 0.000008 | | closing tables | 0.000007 | | freeing items | 0.001792 | | cleaning up | 0.000016 | +----------------------+----------+ 15 rows in set, 1 warning (0.00 sec)

```
### Find out cardinality without index


### Find out cardinality without creating index
```

select count(distinct donor_id) from contributions;

select count(distinct(vendor_city)) from contributions; +------------------------------+ | count(distinct(vendor_city)) | +------------------------------+ | 1772 | +------------------------------+ 1 row in set (4.97 sec)

```
## Monitoring

### What to monitor?


### What to monitor

#### System

  * Last auf dem System (top)
  * Festplatte (z.B. 85% voll ?) df /var/lib/mysql
  * Swap (Wenn geswappt wird ist Hopfen und Malz verloren)

#### Erreichbarkeit

  * Server per ping erreichen (mysqladmin ping -h ziel-ip)
  * Einlogbar ? (myadmin ping -h ziel-ip -u control_user

#### Platte aka IO-Subsystem (iostats)

  * http://schulung.t3isp.de/documents/pdfs/mysql/mysql-performance.pdf

| --       | --          | -- |
| ------------- |:-------------:| -----:|
| Read/Write requests          | IOPS (Input/Output operations per second) | -- |
| Average IO wait    | Time that queue operations have to wait for disk access |   --
|
```

```
| Average Read/Write time | Time it takes to finish disk access operations (latency) |
-- |
| Read/Write bandwidth | Data transfer from and towards your disk | -- |

#### Gneral mysql metrics
```

mysql -E -e "select variable_value from information_schema.session_status where variable_name = 'uptime'";

max connections

MariaDB [(none)]> show status like 'max_used_connections'; +----------------------+-------+ | Variable_name | Value | +----------------------+-------+ | Max_used_connections | 1 | +----------------------+-------+ 1 row in set (0.001 sec)

MariaDB [(none)]> show variables like 'max_connections'; +-----------------+-------+ | Variable_name | Value | +-----------------+-------+ | max_connections | 151 | +-----------------+-------+ 1 row in set (0.001 sec)

mysqladmin status

you will find uptime here in seconds

```
| Metric    | Comments    | Suggested Alert |
| ------------- |:-------------:| -----:|
| Uptime    | Seconds since the server was started. We can use this to detect
respawns.     | When uptime is < 180. (seconds)  |
| Threads_connected    | Number of clients currently connected. If none or too high,
something is wrong.    | None |
| Max_used_connections |    Max number of connections at a time since server started.
(max_used_connections / max_connections) indicates if you could run out soon of
connection slots.|    When connections usage is > 85%. |
| Aborted_connects |    Number of failed connection attempts. When growing over a
period of time either some credentials are wrong or we are being attacked.    | When
aborted connects/min > 3. |

#### InnoDB

| Metric | Coments | Suggested Alert |
| ------------- |:-------------:| -----:|
| Innodb_row_lock_waits    | Number of times InnoDB had to wait before locking a row.
| None |
| Innodb_buffer_pool_wait_free    | Number of times InnoDB had to wait for memory
pages to be flushed. If too high, innodb_buffer_pool_size is too small for current
write load.    | None |

#### Query tracking

| Metric    | Comments    | Suggested Alert |
| ------------- |:-------------:| -----:|
| Slow_queries    | Number of queries that took more than long_query_time seconds to
```

```
execute. Slow queries generate excessive disk reads, memory and CPU usage. Check
slow_query_log to find them.    | None |
| Select_full_join    | Number of full joins needed to answer queries. If too high,
improve your indexing or database schema.    | None |
| Created_tmp_disk_tables    | Number of temporary tables (typically for joins) stored
on slow spinning disks, instead of faster RAM.    | None |
| (Full table scans) Handler_read%    Number of times the system reads the first row
of a table index. (if 0 a table scan is done - because no key was read). Sequential
reads might indicate a faulty index.    None

#### Track Errors
```

journalctl -u mariadb | grep -i Error

```


#### Ref

  * https://blog.serverdensity.com/how-to-monitor-mysql/

#### Monitoring with pmm (Percona Management Monitoring)

https://pmmdemo.percona.com

[Documentation](https://www.percona.com/doc/percona-monitoring-and-
management/2.x/details/commands/pmm-admin.html)

## Replication

### Slave einrichten -gtid


### Step 1: mariabackup on master
```

mkdir /backups

target-dir needs to be empty or not present

mariabackup --target-dir=/backups/20210121 --backup

apply ib_logfile0 to tablespaces

after that ib_logfile0 -> 0 bytes

mariabackup --target-dir=/backups/20210121 --prepare

```


### Step 2: Transfer to new slave (from master)
```

root@master:

rsync -e ssh -avP /backups/mysqldumpdir/20210121 kurs@10.10.9.144:/home/kurs/

```
### Step 3: Setup replication user on master
```

as root@master

##mysql> CREATE USER repl@'10.10.9.%' IDENTIFIED BY 'password'; GRANT REPLICATION SLAVE ON . TO 'repl'@'10

```
### Step 3a (Optional): Test repl user (connect) from slave
```

as root@slave

you be able to connect to

mysql -urepl -p -h10.10.9.110

test if grants are o.k.

show grants

```
### Step 4a: Set server-id on master -> 1
```

[mysqld] server-id=1

systemctl restart mariadb

```
### Step 4b: Set server-id on slave -> 3 + same config as server 1
```

[mysqld] server-id = 3

activate master bin log, if this slave might be a master later

log_bin = /var/log/mysql/mysql-bin.log

systemctl restart mariadb

auf dem master config mit rsync rüberschrieben

root@master

rsync -e ssh -avP /etc/mysql/mariadb.conf.d/z_uniruhr.cnf kurs@10.10.9.144:/home/kurs/

root@slave

mv /home/kurs/z_uniruhr.cnf /etc/mysql/mariadb.conf.d/ chown root:root /etc/mysql/mariadb.conf.d
systemctl restart mariadb

```
### Step 5: Restore Data on slave
```

systemctl stop mariadb mv /var/lib/mysql /var/lib/mysql.bkup4 mariabackup --target-dir=/backups/20210121 --copy-back chown -R mysql:mysql/var/lib/mysql systemctl start mariadb

```
### Step 6: master.txt for change command
```

root@slave

$ cat xtrabackup_binlog_info mariadb-bin.000096 568 0-1-2

SET GLOBAL gtid_slave_pos = "0-1-2";

/root/master.txt

get information from master-databases.sql dump

CHANGE MASTER TO MASTER_HOST="10.10.9.110", MASTER_PORT=3306, MASTER_USER="repl", MASTER_PASSWORD="password", MASTER_USE_GTID=slave_pos;

mysql < master.txt

or: copy paste into mysql>

mysql>

start slave

in mysql -> show slave status

mysql>show slave status

Looking for

Slave_IO_Running: Yes Slave_SQL_Running: Yes

```
### Walkthrough

https://mariadb.com/kb/en/setting-up-a-replication-slave-with-mariabackup/

### Slave einrichten - master_pos


### Step 1: mysqldump on master
```

mkdir -p /backups/mysqldumpdir

in version 5.5. there is not --git so use it without --gtid

mysqldump --all-databases --single-transaction --master-data=2 --routines --events --compress > /backups/mysqldumpdir/master-databases.sql;

```
### Step 2: Transfer to new slave (from master)
```

root@master:

rsync -e ssh -avP /backups/mysqldumpdir/master-databases.sql kurs@10.10.9.144:/home/kurs/

```
### Step 3 (Optional): Be sure that slave is really fresh (no data yet)
```

if old not wanted data is present, e.g. other databases, start with fresh-installation by so:

as root

cd /var/lib mv mysql mysql.bkup mariadb-install-db --user=mysql

```
### Step 4: Setup replication user on master
```

as root@master

##mysql> CREATE USER repl@'10.10.9.%' IDENTIFIED BY 'password'; GRANT REPLICATION SLAVE ON . TO 'repl'@'10

```
### Step 4a (Optional): Test repl user (connect) from slave
```

as root@slave

you be able to connect to

mysql -urepl -p -h10.10.9.110

test if grants are o.k.

show grants

```
### Step 5a: Set server-id on master -> 1
```

[mysqld] server-id=1

systemctl restart mariadb

```
### Step 5b: Set server-id on slave -> 2 + same config as server 1
```

[mysqld] server-id = 2

activate master bin log, if this slave might be a master later

log_bin = /var/log/mysql/mysql-bin.log

systemctl restart mariadb

auf dem master config mit rsync rüberschrieben

root@master

rsync -e ssh -avP /etc/mysql/mariadb.conf.d/z_uniruhr.cnf kurs@10.10.9.144:/home/kurs/

root@slave

mv /home/kurs/z_uniruhr.cnf /etc/mysql/mariadb.conf.d/ chown root:root /etc/mysql/mariadb.conf.d
systemctl restart mariadb

```
### Step 6: Restore Data on slave
```

root@slave

cd /home/kurs mysql < master-databases.sql

```
### Step 7: master.txt for change command
```

root@slave

/root/master.txt

get information from master-databases.sql dump

CHANGE MASTER TO MASTER_HOST="10.10.9.110", MASTER_PORT=3310, MASTER_USER="repl", MASTER_PASSWORD="password", MASTER_LOG_FILE='mysqld-bin.000001', MASTER_LOG_POS=568;

Version 1

mysql < master.txt

or: copy paste into mysql>

in mysql -> show slave status

mysql>show slave status

Looking for

Slave_IO_Running: Yes Slave_SQL_Running: Yes

```
### Step 8: not working on 5.5.
```

Switch to using gtid later on:

show slave status; # look for using_gtid stop slave; CHANGE MASTER TO MASTER_USE_GTID = slave_pos; show slave status; # look for using_gtid start slave;

```
### Walkthrough

https://mariadb.com/kb/en/setting-up-a-replication-slave-with-mariabackup/

### MaxScale installieren


###  Why do Loadbalancing with MaxScale ?


*  Cluster node transparent to application
    * Application does not see single nodes

*  If one node fails you will have no downtime
    * In opposite: To talking to this node directly

### License Implications since 2.x

*  MariaDB MaxScale >= 2.0 is licensed under MariaDB BSL.

*  maximum of three servers in a commercial context.
    * Any more, and you'll need to buy their commercial license.

*  MariaDB MaxScale 2.1.0 will be released under BSL 1.1 from the start

*  Each release transitions in about max 4 years to GPL


### The MaxScale load-balancer and its components

*  Routers
*  Listeners
*  Filters
*  Servers (backend database server)

####  Filters

*  Logging Filters
*  Statement rewriting filters
*  Result set manipulation filters
*  Firewill filter
*  Pipeline control filters
    * e.g. tee and send to a second server
```

```
*  Ref: https://mariadb.com/kb/en/mariadb-maxscale-25-regex-filter/

### Documentation - maxctrl

  * https://mariadb.com/kb/en/mariadb-maxscale-25-maxctrl/


### Installation and Setup

#### Installation
```

apt update apt install apt-transport-https curl

Setting up the repos

curl -sS https://downloads.mariadb.com/MariaDB/mariadb_repo_setup | sudo bash

Installing maxscale

apt install maxscale

```
#### Setup (Part 1: MaxScale db-user)

  * Do this on one of the galera nodes
  * Adjust IP !!

```bash
## IP FROM MAXSCALE
## Setup privileges on cluster nodes
## It is sufficient to set it on one node, because
## it will be synced to all the other nodes
## on node 1
CREATE USER 'maxscale'@'10.10.11.139' IDENTIFIED BY 'P@ssw0rd';
##
GRANT SELECT ON mysql.db TO 'maxscale'@'10.10.11.139';
GRANT SELECT ON mysql.user TO 'maxscale'@'10.10.11.139';
GRANT SELECT ON mysql.tables_priv TO 'maxscale'@'10.10.11.139';
##
GRANT SELECT ON mysql.columns_priv TO 'maxscale'@'10.10.11.139';
GRANT SELECT ON mysql.proxies_priv TO 'maxscale'@'10.10.11.139';
##
GRANT SHOW DATABASES ON *.* TO 'maxscale'@'10.10.11.139';
## Needed for maxscale
GRANT SELECT ON mysql.procs_priv TO 'maxscale'@'10.10.11.139';
GRANT SELECT ON mysql.roles_mapping TO 'maxscale'@'10.10.11.139';

## Additionally for cluster operations (rejoin,switchover,failover for master/slave
replications
## these permissions are needed
GRANT super, reload, process, show databases, event on *.* to
```
```

```
'maxscale'@'10.10.11.139';
## GRANT select on mysql.user to 'maxscale'@'10.10.11.139';
```

```
## On maxscale - server
apt update
apt install mariadb-client
## Test the connection
## Verbindung sollte aufgebaut werden
mysql -u maxscale -p -h <ip-eines-der-nodes>
mysql>show databases
```

SETUP (PART 2: CONFIGURATION)

```
## /etc/maxscale.cnf

[maxscale]

threads=auto
syslog=0
maxlog=1
log_warning=1
log_notice=1
log_info=0
log_debug=0

[TheMonitor]
type=monitor
module=mariadbmon
servers=server1,server2,server3
user=maxscale
password=P@ssw0rd
auto_rejoin=true
auto_failover=true

[RW-Split-Router]
type=service
router=readwritesplit
servers=server1,server2,server3
user=maxscale
password=P@ssw0rd
max_slave_connections=100%


[RW-Split-Listener]
type=listener
service=RW-Split-Router
protocol=MariaDBClient
port=3306

[server1]
type=server
```

```
address=142.93.98.60
port=3306
protocol=MariaDBBackend

[server2]
type=server
address=142.93.103.153
port=3306
protocol=MariaDBBackend

[server3]
type=server
address=142.93.103.246
port=3306
protocol=MariaDBBackend
```

```
## Start

systemctl start maxscale
```

```
## What does the log say ?

## /var/log/maxscale/maxscale.log
```

maxctrl

```
maxctrl list servers
maxctrl show server server1
maxctrl list services
maxctrl show service ReadWrite-Split-Router
```

Reference: MaxScale-Proxy mit Monitoring

MaxScale MariaDB-Monitor

Walkthrough:Automatic Failover Master Slave

https://mariadb.com/kb/en/mariadb-maxscale-25-automatic-failover-with-mariadb-monitor/

Tools

Percona-toolkit-Installation

Walkthrough

```
## Howto
## https://www.percona.com/doc/percona-toolkit/LATEST/installation.html

## Step 1: repo installieren mit deb -paket
wget https://repo.percona.com/apt/percona-release_latest.focal_all.deb;
apt update;
apt install -y curl;
```

```
dpkg -i percona-release_latest.focal_all.deb;
apt update;
apt install -y percona-toolkit;
```

pt-query-digist - analyze slow logs

Requires

- Install percona-toolkit

Usage

```
## first enable slow_query_log
set global slow_query_log = on
set global long_query_time = 0.2
## to avoid, that i have to reconnect with new session
set session long_query_time = 0.2

## produce slow query - for testing
select * from contributions where vendor_last_name like 'W%';
mysql > quit

##
cd /var/lib/mysql
## look for awhile wih -slow.log - suffix
pt-query-digest mysql-slow.log > /usr/src/report-slow.txt
less report-slow.txt
```

pt-online-schema-change howto

Requirements

- Install percona-toolkit

What does it do ?

```
## Altering table without blocking them
## Do a dry-run beforehand
pt-online-schema-change --alter "ADD INDEX idx_city (city)" --dry-run
D=contributions,t=donors
##
pt-online-schema-change --alter "ADD INDEX idx_city (city)" --execute
D=contributions,t=donors
```

Problems -> high cpu load

```
## fine - tune params
## e.g. --max-load
## refer to docs
https://www.percona.com/doc/percona-toolkit/3.0/pt-online-schema-
change.html#:~:text=pt%2Donline%2Dschema%2Dchange%20works%20by%20creating%20an%20empty,i
```

Diagnosis and measurement of performance

Best practices to narrow down performance problems

Pre-Requisites

- System is slow

Analyze - Checklist - Step 1

```
## Are there slow queries ?
## look for time
show full processlist

### or time - in seconds
select * from information_schema.processlist where time > 10;
```

Re-Execute SELECT or where from UPDATE / DELETE

```
## Is it still slow ?
## Eventually kill
mysql>show processlist
mysql>--kill <Thread-id>
mysql>-- example
mysql>kill 44
```

Explain what is going on

```
Explain Select....
```

Performance and optimization of SQL statements

Do not use '*' whenever possible

Why ?

- You are adding .. to he server:
  - I/O
  - memory
  - CPU
- You are preventing covering indexes

Walkthrough. (Look at the time)

Using '*'

```
## using '* '
pager grep "rows in set";
select * from donors where last_name like 'Willia%'; select * from donors where
last_name like 'Willia%';
-- time between 0.02 and 0.04 secs
-- 2424 rows in set (0.02 sec)
```

```
-- reset pager
pager

## corresponding Explain (QEP)
explain select * from donors where last_name like 'Willia%';
+----+-------------+--------+------------+-------+--------------------+----------------
---+---------+------+------+----------+-----------------------+
| id | select_type | table  | partitions | type  | possible_keys      | key
| key_len | ref  | rows | filtered | Extra                  |
+----+-------------+--------+------------+-------+--------------------+----------------
---+---------+------+------+----------+-----------------------+
|  1 | SIMPLE      | donors | NULL       | range | donors_donor_info |
donors_donor_info | 213     | NULL | 4748 |   100.00 | Using index condition |
+----+-------------+--------+------------+-------+--------------------+----------------
---+---------+------+------+----------+-----------------------+
1 row in set, 1 warning (0.00 sec)
```

using specific fields

```
pager grep 'rows in set'; select last_name,first_name from donors where last_name like
'Willia%'; pager;
PAGER set to 'grep 'rows in set''
2424 rows in set (0.01 sec)
```

```
 explain select last_name,first_name from donors where last_name like 'Willia%';
+----+-------------+--------+------------+-------+--------------------+----------------
---+---------+------+------+----------+--------------------------+
| id | select_type | table  | partitions | type  | possible_keys      | key
| key_len | ref  | rows | filtered | Extra                    |
+----+-------------+--------+------------+-------+--------------------+----------------
---+---------+------+------+----------+--------------------------+
|  1 | SIMPLE      | donors | NULL       | range | donors_donor_info |
donors_donor_info | 213     | NULL | 4748 |   100.00 | Using where; Using index |
+----+-------------+--------+------------+-------+--------------------+----------------
---+---------+------+------+----------+--------------------------+
1 row in set, 1 warning (0.00 sec)
```

- Uses cover index (indicator in Extra: using index)

Ref:

- https://www.oreilly.com/library/view/high-performance-mysql/9780596101718/ch04.html

Be aware of subselects - Example 1

Optimizer-hints (and why you should not use them)

Tell the optimizer what to do and what not to do

- https://dev.mysql.com/doc/refman/5.7/en/optimizer-hints.html#optimizer-hints-syntax

Replication

Replikation Read/Write

- https://proxysql.com/blog/configure-read-write-split/

Performance

Best Practices

Indexes

2 Indexes vs. Combined Index

- In most cases a combined index is better than 2 indexes.

Joins

Field-Type

- Do not use varchar() or char() aka string types of join field
- better: integer (unsigned) && same size
  - e.g. actor_id id int unsigned

Views

General

- Only use views with merge
- NO temptable please, these CANNOT be indexed.

Where

No functions in where please

- Why ? Index cannot be used.
- example:
  - select first_name from actor where upper(first_name) like 'A%'

Alternative solution

- use a virtual field and index virtual field (possible from mysql > 5.7)
- Massive improvements in mysqL 8

Example sys-schema and Reference

Examples

```
mysql> select * from sys.host_summary\G
*************************** 1. row ***************************
                   host: localhost
             statements: 1347
     statement_latency: 7.55 m
 statement_avg_latency: 336.50 ms
           table_scans: 15
              file_ios: 612857
       file_io_latency: 1.66 m
   current_connections: 1
     total_connections: 7
          unique_users: 1
        current_memory: 0 bytes
total_memory_allocated: 0 bytes
1 row in set (0.01 sec)
```

Ref:

- https://github.com/mysql/mysql-sys/blob/master/README.md

Change schema online (pt-online-schema-change)

- https://www.percona.com/doc/percona-toolkit/3.0/pt-online-schema-change.html

Optimizer-Hints

Tell the optimizer what to do and what not to do

- https://dev.mysql.com/doc/refman/5.7/en/optimizer-hints.html#optimizer-hints-syntax

Documentation / Literature

Effective MySQL

- https://www.amazon.com/Effective-MySQL-Optimizing-Statements-Oracle/dp/0071782796

MariaDB Galera Cluster

- http://schulung.t3isp.de/documents/pdfs/mariadb/mariadb-galera-cluster.pdf

MySQL Galera Cluster

- https://galeracluster.com/downloads/