MariaDB Performance Training (deutsch)

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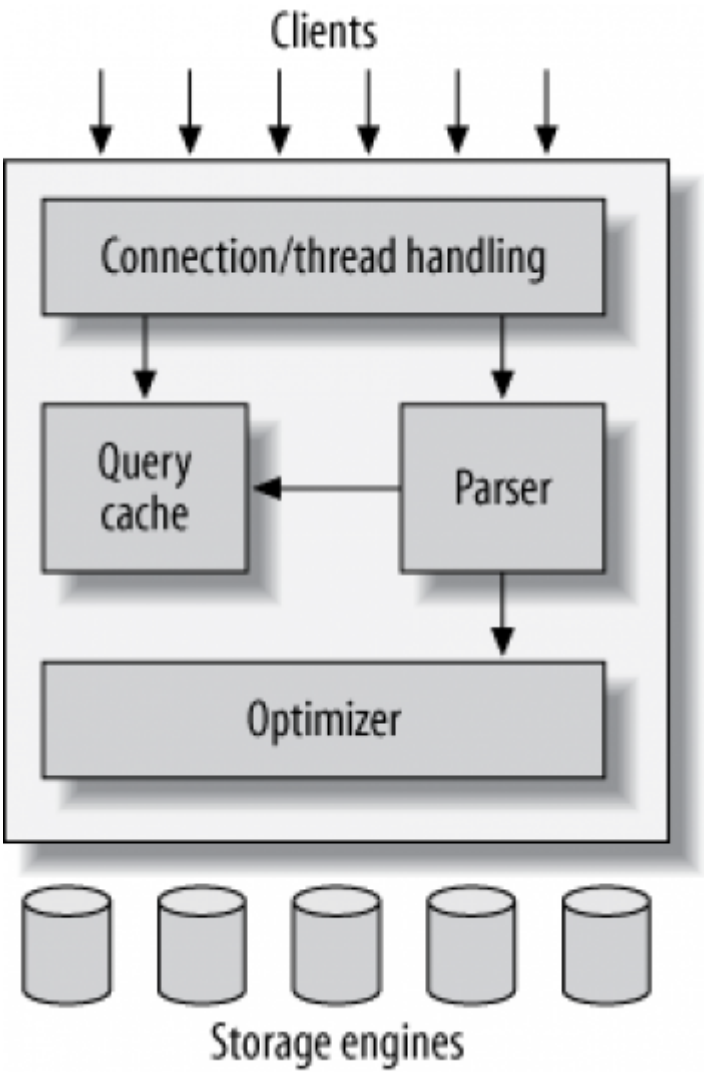
Performance / Theorie - Aspekte der MariaDB - Architektur

Architektur Server (Schritte)



CPU oder io-Last klären

```
top - 07:29:09 up 19:14,  1 user,  load average: 0.00, 0.00, 0.00
Tasks:  69 total,   1 running,  68 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.3 us,  0.3 sy,  0.0 ni, 99.3 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :    989.9 total,    273.7 free,    155.3 used,    560.8 buff/cache
MiB Swap:      0.0 total,      0.0 free,      0.0 used.    677.2 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
    1 root      20   0  104936  10296   7880 S   0.0   1.0   0:05.78 systemd
    2 root      20   0       0      0      0 S   0.0   0.0   0:00.00 kthreadd
    3 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_gp
    4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_par_gp
    6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/0:0H-+
    8 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 mm_percpu_wq
    9 root      20   0       0      0      0 S   0.0   0.0   0:00.80 ksoftirqd/0
   10 root      20   0       0      0      0 I   0.0   0.0   0:01.66 rcu_sched
   11 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_bh
   12 root      rt   0       0      0      0 S   0.0   0.0   0:00.30 migration/0
   14 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
   15 root      20   0       0      0      0 S   0.0   0.0   0:00.00 kdevtmpfs
   16 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 netns
   17 root      20   0       0      0      0 S   0.0   0.0   0:00.02 kauditd
   18 root      20   0       0      0      0 S   0.0   0.0   0:00.02 khungtaskd
   19 root      20   0       0      0      0 S   0.0   0.0   0:00.00 oom_reaper
```

```
Fall 1
======
CPU-gebundene Last: in Zeile CPU:
nur 'sy' und 'us' ist hoch

Fall 2:
=======
IO-gebundene Last
(d.h. egal, ob man eine bessere hat, es bringt nicht mehr,
weil die Festplatte entscheidend ist (in diesem Fal))
Die Festplatte ist hier der begrenzende Faktor

sy und wa hoch (wa = waiting, cpu wartet auf das io-subsystem (Festplatte or Storage)
```

Storage Engines

In Detail: MyISAM - Storage Engine

```
1. table locks → Locks are done table-wide
2. no automatic data-recovery (Aria hat das !)
3. you can loose more data on crashes than with e.g. InnoDB
4. no transactions
5. only indices are save in memory through MySQL
6. compact saving (data is saved really dense)
7. table scans are quick
```

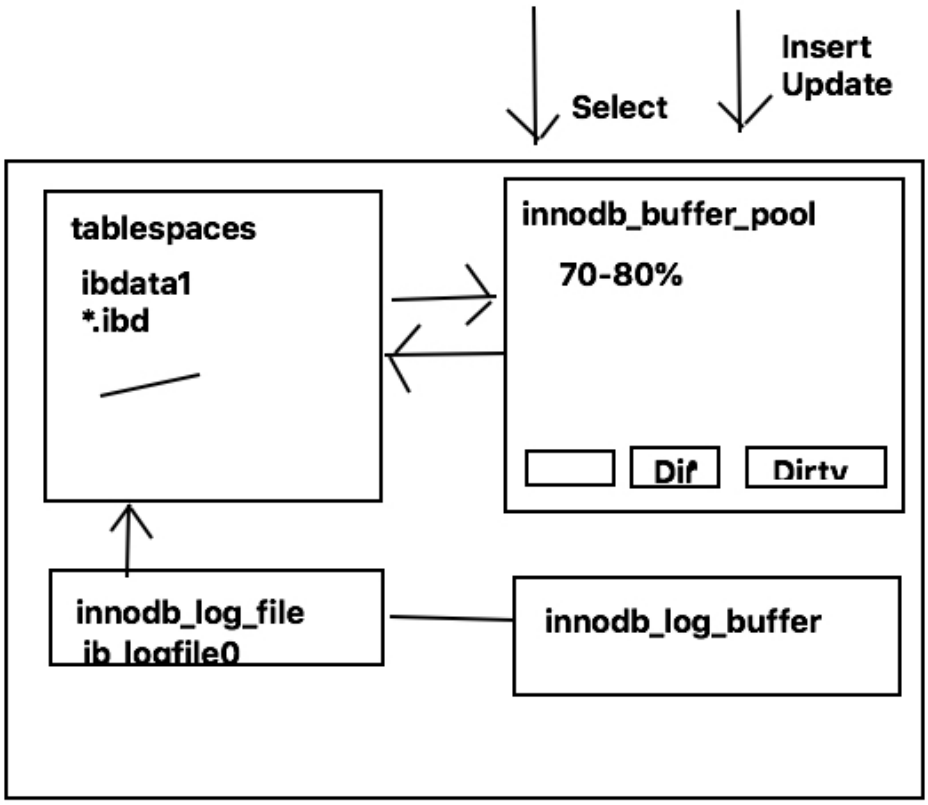
In Detail: InnoDB - Storage Engine

```
1. support hot backups (because of transactions)
2. transactions are supported
3. foreign keys are supported
4. row-level locking
5. multi-versioning
```

Welches sind die wichtigsten ?

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

InnoDB - Struktur



InnoDB - Optimierung

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)
```

```
## OR:
MariaDB [(none)]> show status like '%free%';
+------------------------------+---------+
| Variable_name                | Value   |
+------------------------------+---------+
| Innodb_buffer_pool_pages_free | 48083   |
| Innodb_buffer_pool_wait_free  | 0       |
| Innodb_ibuf_free_list         | 0       |
| Qcache_free_blocks            | 1       |
| Qcache_free_memory            | 1031304 |
+------------------------------+---------+
5 rows in set (0.002 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
```

Query - Cache

Defaults

- Default Value: OFF (>= MariaDB 10.1.7), ON (<= MariaDB 10.1.6)

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)
```

Warum die Verwendung des Query Cache schlecht

```
TABELLE Mitarbeiter
Select * from Mitarbeiter -> query_cache
Nächste abfrage. Select * from Mitarbeiter
-> aus query_cache
Insert into Mitarbeiter
-> cache invalidiert -> kein Inhalt mehr
Select * from Mitarbeiter -> query_cache



Mutex:
-> bei Benutzung gesperrt

// dadurch können Schreibanfragen nur quasi sequentiell
A schreibt, B wartet bis a fertig ist, dann schreibt B

Nur Zeilensperrung
A schreibt, B schreibt auch, wenn nicht Genua die gleichen Zeile

Query cache verhindert, dass mehre Kerne der CPU von MySQL verwendet werden können.

-> lock-file im filesystem -> mutex -> mutual - exclusion.

Ich mache ein Lock-file damit du weisst, dass ich gerade
Dran arbeite.
```

3-Phasen-Datengröße

Phase 1: Table content is small (only some rows)

```
## table scan is quicker than index search
## e.g. 10 entries

## so eventually index is not needed
```

Phase 2: Index is good !!

```
## performance gain by using index
## Step 1: Obtaining id's from index (primary key id)
## Step 2: Retrieving data
```

Phase 3: Index is not improve performance / or would makes performance worse

```
Step 1: lookup in index:
1
70
1040
2100
35000
-> there is a lot of space (other rows) in between.

Step 2: Lookup data, but a lot lookups needed


-> random reads
-> So mysql might be better off to do a table scan.
```

Installation

Installation (Debian)

Setup repo and install

- https://downloads.mariadb.org/mariadb/repositories/

```
### repo
sudo apt-update
sudo apt-get install software-properties-common dirmngr
sudo apt-key adv --fetch-keys 'https://mariadb.org/mariadb_release_signing_key.asc'
sudo add-apt-repository 'deb [arch=amd64,arm64,ppc64el] http://mirror2.hs-
esslingen.de/mariadb/repo/10.5/debian buster main'
### now update and install
sudo apt update
sudo apt install mariadb-server
```

Check if running and enabled

```
systemctl status mariadb
## enabled, wenn in Zeile 2 mariadb.service;enabled; auftaucht
```

Secure installation

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

Konfiguration

Slow query log

Variante 1: Aktivieren (minimum)

```
## auch direkt in 50-server.cnf möglich
mysql>set global long_query_time=0.5 # 0,5 Sekunden. Alles was >= 0,5 sekunden dauert,
wird geloggt
mysql>set session long_query_time=0.5
mysql>set global slow_query_log=1
mysql>set session slow_query_log=1
```

Logge alles wo kein Index verwendet werden kann (egal) wie langsam oder schnell

```
## damit er wirklich nur die queries logged, die keinen index haben, sollte. der
## long_query_time - Wert möglichst hoch sein.
set global long_query_time = 20
set session long_query_time = 20
set global slow_query_log = 1
set session slow_query_log = 1
set global log_queries_not_using_indexes = 1
set session log_queries_not_using_indexes = 1
```

Bitte slow_query_log bei der ausgabe geschätziger zu sein

```
set global log_slow_verbosity = 'query_plan,explain'
set session log_slow_verbosity = 'query_plan,explain'
```

Die Anzahl der Ausgabe reduzieren (nur jedes 5.)

```
### /etc/mysql/mariadb-conf.d/50-server.cnf und mysqld
log-slow-rate-limit=5;
```

Best - Practice - Phase 1

```
## Alle Logs analysieren, die kein Index verwendet
##/etc/mysql/mariadb.conf.d/50-server.cnf
## unter [mysqld]

## slow query log
slow-query-log
log-queries-not-using-indexes
log-slow-rate-limit=5
log-slow-verbosity = 'query_plan,explain'
```

Ref:

- https://mariadb.com/kb/en/slow-query-log-overview/

Administration

Standard storage engine bestimmen

```
Die Standard-Storage wird über die Server-System-Variable
default_storage_engine
festgelegt.

Wenn beim Erstellen einer Tabelle keine storage-engine angegeben
wird, wird diese verwendet .

(In Datenbanken/Schemas kann man KEINE Storage engine festlegen)

mysql>show variables like 'default_storage_engine'
```

Show status

with mysql -> show status

```
mysql> show status;
-- global status für den gesamten Server seit er läuft
mysql> show global status;
mysql> # setzt session status zurück
mysql> flush status;
mysql> show status;
```

Spezielle status variablen

```
show status like 'Com%';
show status like 'Com_select ';
```

Aus information_schema

```
select * from information_schema.global_status;
select * from information_schema.session_status;
```

Server System Variablen - show variables

```
show variables
show global variables
show variables like 'innodb%';
show global variables like 'innodb%';
```

```
## @@ steht für Server System Variable
select @@innodb_flush_method
```

systemctl/jorunalctl - Server starten,stoppen/Logs

```
systemctl TAB TAB -> zeigt alle Unterbefehle an
systemctl status mariadb.service
systemctl start mariadb # .service darf man weglassen bei start/status/stop/restart
systemctl stop mariadb
systemctl restart  mariadb
```

```
journalctl -u mariadb.service  # Zeigt alle Logs an seit dem letzten Serverstart
(Debian 10)
```

User verwalten

```
## bitte nur im Notfall von überall
## + passworr im klartext
mysql>create user training@'%' identified by 'meingeheimespasswort'
mysql>create user training@192.168.2.2; -- von einer bestimmten ip ausschliesslich //
ip des zugreifers

## Rechte vergeben *.* -> alle datenbanken.alle tabellen
## to -> für.
mysql>grant all on *.* to training@192.168.2.2
## Rechte entziehn
mysql>revoke select on *.* from training@192.168.2.2
## oder alle Rechte enziehen
mysql>revoke all on *.* from training@192.168.2.2

## Rechte eines Benutzers anschauen
mysql>show grants for training@192.168.2.2. // genaue Kombination muss angegeben
werden

## Eigentlich nicht notwendig, aber geht
mysql>select * from mysql.global_priv \G #  das geht nur im mysql-client und zeigt
Spalten in Zeilen an
mysql>select * from mysql.user;
```

Performance und Optimierung von SQL-Statements

Explain verwenden

Einfacher Fall

```
explain select * from actor
```

Erweiterter Fall

```
explain extended select * from user
show warnings
```

Anzeigen der Partitions

```
explain partitions select * from actor
```

Ausgabe im JSON-Format

```
## Hier gibt es noch zusätzliche Informationen
explain format=json select * from actor
```

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

Indexes

Avoid ALL

- is the worst type : TABLE SCAN (Need to go through all rows)

```
mysql> create table actor4 as select * from actor;
mysql> explain select * from actor4 where actor_id > 10;
+----+-------------+--------+------------+------+---------------+------+---------+----
--+------+----------+-------------+
| id | select_type | table  | partitions | type | possible_keys | key  | key_len | ref
| rows | filtered | Extra       |
+----+-------------+--------+------------+------+---------------+------+---------+----
--+------+----------+-------------+
|  1 | SIMPLE      | actor4 | NULL       | ALL  | NULL          | NULL | NULL    |
NULL |  200 |    33.33 | Using where |
+----+-------------+--------+------------+------+---------------+------+---------+----
--+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)
```

Cover Index.

- We can get all the necessary information from the index (no acces of filesystem necessary)

```
drop table if exists actor2;
create table actor2 as select * from actor;
create index idx_actor2_last_name on actor2 (last_name);

## using index
## <- indicates that a cover index is used

mysql> explain select last_name from actor2 where last_name like 'B%';
+----+-------------+--------+------------+-------+-----------------------+-------------
---------+---------+------+------+----------+--------------------------+
| id | select_type | table  | partitions | type  | possible_keys         | key
| key_len | ref  | rows | filtered | Extra                    |
+----+-------------+--------+------------+-------+-----------------------+-------------
---------+---------+------+------+----------+--------------------------+
|  1 | SIMPLE      | actor2 | NULL       | range | idx_actor2_last_name |
idx_actor2_last_name | 182     | NULL |   22 |   100.00 | Using where; Using index |
+----+-------------+--------+------------+-------+-----------------------+-------------
---------+---------+------+------+----------+--------------------------+
1 row in set, 1 warning (0.00 sec)
```

Creating a primary index

```
create index primary key on actor2 (actor_id)
explain select actor_id from actor2 where actor_id > 2
```

Using an index for last_name

```
drop table if exists actor2;
create table actor2 as select * from actor;
create index idx_actor2_last_name on actor2 (last_name);
explain select * from actor2 where last_name like 'B%';
+----+-------------+--------+------------+-------+----------------------+-------------
---------+---------+------+------+----------+-----------------------+
| id | select_type | table  | partitions | type  | possible_keys        | key
| key_len | ref  | rows | filtered | Extra                 |
+----+-------------+--------+------------+-------+----------------------+-------------
---------+---------+------+------+----------+-----------------------+
|  1 | SIMPLE      | actor2 | NULL       | range | idx_actor2_last_name |
idx_actor2_last_name | 182     | NULL |   22 |   100.00 | Using index condition |
+----+-------------+--------+------------+-------+----------------------+-------------
---------+---------+------+------+----------+-----------------------+
1 row in set, 1 warning (0.00 sec)
```

Never use a function in where

Why ?

```
Step 1: MySQL needs to retrieve every row
Step 2: run function
--> so, no index can be used
```

Example

```
drop table if exists actor2;
create table actor2 as select * from actor;
create index idx_actor2_last_name on actor2 (last_name);
explain select * from actor2 where last_name like
concat(substring(first_name,1,1),'%');
```

Index is always read from left to right

```
## so the index cannot be used if we ask for last_name
drop table if exists actor2;
create table actor2 as select * from actor;
create index idx_actor2_first_name_last_name on actor2 (first_name,last_name);
explain select * from actor2 where last_name like 'B%';
##
explain select * from actor2 where first_name like 'B%';
```

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)
```

Kein function in where verwenden

1. No function in where (column_name)

```
## Never use a function for the column name in where
## e.g.
select * from donors where upper(last_name) like 'Willia%'
```

Why ?

- Not index can be used

```
## Not filtering possible by indx -> possible_keys -> NULL
 explain select last_name from donors where upper(last_name) like 'WILLI%';
+----+-------------+--------+------------+-------+---------------+-------------------
+---------+------+--------+----------+-------------------------+
| id | select_type | table  | partitions | type  | possible_keys | key               |
key_len | ref  | rows   | filtered | Extra                   |
+----+-------------+--------+------------+-------+---------------+-------------------
+---------+------+--------+----------+-------------------------+
|  1 | SIMPLE      | donors | NULL       | index | NULL          | donors_donor_info |
687     | NULL | 701948 |   100.00 | Using where; Using index |
+----+-------------+--------+------------+-------+---------------+-------------------
+---------+------+--------+----------+-------------------------+
1 row in set, 1 warning (0.00 sec)
```

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

Query-Plans aka Explains

- Query Plans are the same as Query Execution Plans (QEP's)
- You will see the Query Plan's with explain

Example

```
mysql> explain select * from recipients where recipient_id > 1 and recipient_id < 5;
+----+-------------+------------+------------+-------+---------------+---------+------
---+------+------+----------+-------------+
| id | select_type | table      | partitions | type  | possible_keys | key     |
key_len | ref  | rows | filtered | Extra       |
+----+-------------+------------+------------+-------+---------------+---------+------
---+------+------+----------+-------------+
|  1 | SIMPLE      | recipients | NULL       | range | PRIMARY       | PRIMARY | 4
| NULL |    1 |   100.00 | Using where |
+----+-------------+------------+------------+-------+---------------+---------+------
---+------+------+----------+-------------+
1 row in set, 1 warning (0.01 sec)
```

Output-Format json

```
-- includes costs
EXPLAIN format=json SELECT * from audit_log WHERE yr in (2011,2012);
```

Select_Type

- simple = one table

Types (in order of performance

system

```
Only one row in table is present (only one insert)
```

const only one result

```
 EXPLAIN select contribution_id  from contributions where contribution_id = 262611;
+----+-------------+---------------+------------+-------+---------------+---------+---
------+-------+------+----------+-------------+
| id | select_type | table         | partitions | type  | possible_keys | key     |
key_len | ref   | rows | filtered | Extra       |
+----+-------------+---------------+------------+-------+---------------+---------+---
------+-------+------+----------+-------------+
|  1 | SIMPLE      | contributions | NULL       | const | PRIMARY       | PRIMARY | 4
| const |    1 |   100.00 | Using index |
+----+-------------+---------------+------------+-------+---------------+---------+---
------+-------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)
```

ALL - Full table scan. (slowest)

EXPLAIN select * from contributions where vendor_last_name like 'W%'; +----+-------------+---------------
+------------+------+---------------+------+---------+------+---------+----------+-------------+ | id |

select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra | +----+-----------+--------------+------------+------+--------------+------+---------+------+---------+-------------+ | 1 | SIMPLE | contributions | NULL | ALL | NULL | NULL | NULL | 2028240 | 11.11 | Using where | +----+-------------+--------------+------------+------+--------------+------+---------+------+---------+----------+-------------+ 1 row in set, 1 warning (0.00 sec)

Extra

Using index - cover index is used

```
Looking data in index is sufficient
- no lookup of data on disk is necessary
```

```
mysql> EXPLAIN select contribution_id  from contributions where contribution_id =
262611;
+----+-------------+---------------+------------+-------+---------------+---------+---
------+-------+------+----------+-------------+
| id | select_type | table         | partitions | type  | possible_keys | key     |
key_len | ref   | rows | filtered | Extra       |
+----+-------------+---------------+------------+-------+---------------+---------+---
------+-------+------+----------+-------------+
|  1 | SIMPLE      | contributions | NULL       | const | PRIMARY       | PRIMARY | 4
| const |    1 |   100.00 | Using index |
+----+-------------+---------------+------------+-------+---------------+---------+---
------+-------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)

mysql> show warnings;
+-------+------+-----------------------------------------------------------------------------
----------------------------+
| Level | Code | Message
|
+-------+------+-----------------------------------------------------------------------------
----------------------------+
| Note  | 1003 | /* select#1 */ select '262611' AS `contribution_id` from
`contributions`.`contributions` where 1 |
+-------+------+-----------------------------------------------------------------------------
----------------------------+
1 row in set (0.00 sec)
```

Query Pläne und die Key-Länge

Index und 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
```

Index und Joins

Take a look which order the optimizer uses

With date

```
-- Using a date which has no index
-- Needs to do a table scan
explain select c.* from contributions c join donors d using (donor_id) join recipients
r using (recipient_id) where c.date_recieved > '1999-12-01' and c.date_recieved <
'2000-07-01';
+----+-------------+-------+------------+--------+-------------------------+---------
+---------+-------------------------------+---------+----------+-------------+
| id | select_type | table | partitions | type   | possible_keys           | key     |
key_len | ref                           | rows    | filtered | Extra       |
+----+-------------+-------+------------+--------+-------------------------+---------
+---------+-------------------------------+---------+----------+-------------+
|  1 | SIMPLE      | c     | NULL       | ALL    | donor_idx,recipient_idx | NULL    |
NULL    | NULL                          | 2028240 |    11.11 | Using where |
|  1 | SIMPLE      | r     | NULL       | eq_ref | PRIMARY                 | PRIMARY |
4       | contributions.c.recipient_id |       1 |   100.00 | Using index |
|  1 | SIMPLE      | d     | NULL       | eq_ref | PRIMARY                 | PRIMARY |
4       | contributions.c.donor_id     |       1 |   100.00 | Using index |
+----+-------------+-------+------------+--------+-------------------------+---------
+---------+-------------------------------+---------+----------+-------------+
3 rows in set, 1 warning (0.00 sec)

60626 rows in set (7.22 sec)
```

With date and filter on donor

```
 explain select c.*,d.last_name from contributions c join donors d using (donor_id)
join recipients r using (recipient_id)
where c.date_recieved > '1999-12-01' and c.date_recieved < '2000-07-01' and
d.last_name like 'A%';
+----+-------------+-------+------------+--------+-------------------------+--------
-----------+---------+-------------------------------+-------+----------+-------------
------------+
| id | select_type | table | partitions | type   | possible_keys           | key
| key_len | ref                           | rows  | filtered | Extra
|
+----+-------------+-------+------------+--------+-------------------------+--------
-----------+---------+-------------------------------+-------+----------+-------------
------------+
|  1 | SIMPLE      | d     | NULL       | range  | PRIMARY,donors_donor_info |
donors_donor_info | 213     | NULL                          | 65894 |   100.00 | Using
where; Using index |
|  1 | SIMPLE      | c     | NULL       | ref    | donor_idx,recipient_idx   |
donor_idx         | 5       | contributions.d.donor_id     |     2 |    11.11 | Using
where              |
|  1 | SIMPLE      | r     | NULL       | eq_ref | PRIMARY                 | PRIMARY
| 4       | contributions.c.recipient_id |     1 |   100.00 | Using index
```

```
|
+----+-------------+-------+------------+--------+---------------------------+--------
-----------+---------+-------------------------------+-------+----------+-------------
------------+
3 rows in set, 1 warning (0.00 sec)
```

With date and filter on donor, less specific

```
select c.*,d.* from contributions c join donors d using (donor_id) join recipients r
using (recipient_id) where c.date_recieved > '1999-12-01' and c.date_recieved < '2000-
07-01' and d.last_name like 'A%';
 explain select c.*,d.* from contributions c join donors d using (donor_id) join
recipients r using (recipient_id) where c.date_recieved > '1999-12-01' and
c.date_recieved < '2000-07-01' and d.last_name like 'A%';
+----+-------------+-------+------------+--------+---------------------------+--------
-----------+---------+-------------------------------+-------+----------+-------------
---------+
| id | select_type | table | partitions | type   | possible_keys             | key
| key_len | ref                          | rows  | filtered | Extra                 |
+----+-------------+-------+------------+--------+---------------------------+--------
-----------+---------+-------------------------------+-------+----------+-------------
---------+
|  1 | SIMPLE      | d     | NULL       | range  | PRIMARY,donors_donor_info |
donors_donor_info | 213     | NULL                          | 65894 |   100.00 | Using
index condition |
|  1 | SIMPLE      | c     | NULL       | ref    | donor_idx,recipient_idx   |
donor_idx         | 5       | contributions.d.donor_id     |     2 |    11.11 | Using
where           |
|  1 | SIMPLE      | r     | NULL       | eq_ref | PRIMARY                   | PRIMARY
| 4       | contributions.c.recipient_id |     1 |   100.00 | Using index           |
+----+-------------+-------+------------+--------+---------------------------+--------
-----------+---------+-------------------------------+-------+----------+-------------
---------+
3 rows in set, 1 warning (0.00 sec)
```

With date and filter on donor and filter on recipient

```
mysql> explain select c.*,d.last_name,r.* from contributions c join donors d using
(donor_id) join recipients r using (recipient_
id) where c.date_recieved > '1999-12-01' and c.date_recieved < '2000-07-01' and
d.last_name like 'A%' and r.name like 'Cit%';
+----+-------------+-------+------------+--------+---------------------------+--------
-------+---------+-------------------------------+------+----------+-------------+
| id | select_type | table | partitions | type   | possible_keys             | key
| key_len | ref                          | rows | filtered | Extra       |
+----+-------------+-------+------------+--------+---------------------------+--------
-------+---------+-------------------------------+------+----------+-------------+
|  1 | SIMPLE      | r     | NULL       | ALL    | PRIMARY                   | NULL
| NULL    | NULL                          | 6063 |    11.11 | Using where |
|  1 | SIMPLE      | c     | NULL       | ref    | donor_idx,recipient_idx   |
recipient_idx | 5       | contributions.r.recipient_id |  305 |    11.11 | Using where
```

```
|
|  1 | SIMPLE      | d     | NULL       | eq_ref | PRIMARY,donors_donor_info | PRIMARY
| 4       | contributions.c.donor_id     |    1 |     9.39 | Using where |
+----+-------------+-------+------------+--------+---------------------------+--------
-------+---------+-------------------------------+------+----------+-------------+
3 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)
```

Index and Functions

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);
```

Workaround with persistent/virtual columns (MariaDB)

```
mysql> alter table actor add column last_name_upper varchar(45) as (upper(last_name))
PERSISTENT ;
mysql> insert into actor (first_name,last_name,last_name_upper) values
('Max','Mustermann','MUSTERMANN');
mysql> select * from actor order by actor_id desc limit 1;
mysql> -- setting index
mysql> create index idx_last_name_upper on actor (last_name_upper);
Query OK, 0 rows affected (0.007 sec)
Records: 0  Duplicates: 0  Warnings: 0
mysql> -- to use index we need to avoid the function in where
mysql> explain select * from actor where last_name_upper like 'WI%' \G
```

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)
```

Tools

Percona Toolkit

Walkthrough (Ubuntu 20.04)

```
## 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
```

Walkthrough (Debian 10)

```
sudo apt update
sudo apt install -y wget gnupg2 lsb-release curl
cd /usr/src
wget https://repo.percona.com/apt/percona-release_latest.generic_all.deb
dpkg -i percona-release_latest.generic_all.deb
apt update
apt install -y percona-toolkit
```

```
sudo apt update; sudo apt install -y wget gnupg2 lsb-release curl; cd /usr/src; wget
https://repo.percona.com/apt/percona-release_latest.generic_all.deb; dpkg -i percona-
release_latest.generic_all.deb; apt update; apt install -y percona-toolkit
```

pt-query-digest - 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

Documentation

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

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
```

With foreign - keys

```
 # first try
 pt-online-schema-change --alter "add column remark varchar(150)" D=sakila,t=actor --
alter-foreign-keys-method=auto --dry-run
 # then run
 pt-online-schema-change --alter "add column remark varchar(150)" D=sakila,t=actor --
alter-foreign-keys-method=auto --execute
```

Example sys-schema and Reference

Install under mariadb 10.5

```
apt install git
cd /usr/src
git clone https://github.com/jmetzger/mariadb-sys.git
cd mariadb-sys
mysql < ./sys_10.sql
```

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

Beispieldaten

Verleihdatenbank - sakila

```
cd /usr/src
wget https://downloads.mysql.com/docs/sakila-db.tar.gz
tar xzvf sakila-db.tar.gz

cd sakila-db
mysql < sakila-schema.sql
mysql < sakila-data.sql
```

Setup training data "contributions"

Walkthrough (Debian/Ubuntu)

- Complete process takes about 10 minutes

```
cd /usr/src;
apt update; apt install 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
```

Managing big tables

Using Partitions - Walkthrough

Walkthrough

```
##
## EXPLAIN PARTITIONS
##
DROP TABLE IF EXISTS audit_log;
CREATE TABLE audit_log (
  yr    YEAR NOT NULL,
  msg   VARCHAR(100) NOT NULL)
ENGINE=InnoDB
PARTITION BY RANGE (yr) (
  PARTITION p0 VALUES LESS THAN (2010),
  PARTITION p1 VALUES LESS THAN (2011),
  PARTITION p2 VALUES LESS THAN (2012),
  PARTITION p3 VALUES LESS THAN MAXVALUE);
INSERT INTO audit_log(yr,msg) VALUES (2005,'2005'),(2006,'2006'),(2011,'2011'),
(2020,'2020');
EXPLAIN PARTITIONS SELECT * from audit_log WHERE yr in (2011,2012)\G
```

Example with years

```
CREATE TABLE audit_log2 (   yr    YEAR NOT NULL,   msg   VARCHAR(100) NOT NULL)
ENGINE=InnoDB PARTITION BY RANGE (yr) (   PARTITION p2009 VALUES LESS THAN (2010),
PARTITION p2010 VALUES LESS THAN (2011),   PARTITION p2011 VALUES LESS THAN (2012),
PARTITION p_current VALUES LESS THAN MAXVALUE);
INSERT INTO audit_log2(yr,msg) VALUES (2005,'2005'),(2006,'2006'),(2011,'2011'),
(2012,'2012');

EXPLAIN PARTITIONS SELECT * from audit_log2 WHERE yr = 2012;

ALTER TABLE audit_log2 REORGANIZE PARTITION p_current INTO (
   PARTITION p2012 VALUES LESS THAN (2013),
   PARTITION p_current VALUES LESS THAN MAXVALUE);
)

--  Where is data now saved
EXPLAIN PARTITIONS SELECT * from audit_log2 WHERE yr = 2012;
```

Eine bestehende große Tabelle partitionieren (mariadb)

```
Variante 1:
## Wichtig vorher Daten sichern

ALTER TABLE `audit_log3` PARTITION BY RANGE (`yr`) ( PARTITION p2009 VALUES LESS THAN
(2010) ENGINE=InnoDB, PARTITION p2010 VALUES LESS THAN (2011) ENGINE=InnoDB, PARTITION
p2011 VALUES LESS THAN (2012) ENGINE=InnoDB, PARTITION p2012 VALUES LESS THAN (2013)
ENGINE=InnoDB, PARTITION p_current VALUES LESS THAN MAXVALUE ENGINE=InnoDB )
```

```
Variante 2:
Daten ausspielen ohne create (dump)  + evtl zur sicherheit Struktur-Dump
Tabelle löschen
Daten ohne Struktur einspielen
```

Ref:

- https://mariadb.com/kb/en/partition-maintenance/

Replication

Replikation mit GTID

- https://www.admin-magazin.de/Das-Heft/2017/02/MySQL-Replikation-mit-GTIDs

Replikation Read/Write - Split:

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

Fragen und Antworten

Fragen und Antworten

1. Archive Data

```
https://www.percona.com/doc/percona-toolkit/LATEST/pt-archiver.html
```

2. Does innodb do defragmentation by itself ?

```
## Some background while doing research.
## Nil performance benefits of defragmentation in index.
https://stackoverflow.com/questions/48569979/mariadb-table-defragmentation-using-
optimize
```

3. Defragmentation

```
## Optimize table
ALTER TABLE contributions engine = InnoDB  # Das gleiche wie OPTIMIZE TABLE


## mariadb has a patch for defragmentation
https://mariadb.org/defragmenting-unused-space-on-innodb-tablespace/

## alter table xyz engine=InnoDB - defragements
## but is also invasive.
## with ibdata1 innodb_file_per_table it lets the size grow
```

4. Is it possible to do select, update, deletes without using innodb_buffer in specific

```
No, this is not possible
```

8. MariaDB (Features/Vorteile)

- flashback
- Verschlüsselung von Tabellen // mariabackup
- Einige Storage Engine (Aria -> MyISAM - crash-recovery)
- JSON anders implementiert

- galera
- feature: defragementation

```
MysqL 8 does not:
decode
set profiling (still available but deprecated )
```

9. Select without locking

```
SET TRANSACTION ISOLATION LEVEL READ UNCOMMITTED ;
BEGIN ;
SELECT * FROM TABLE_NAME ;
COMMIT ;
```

Projektarbeit/-optimierung

Praktisch Umsetzung in 3-Schritten

Schritt 1: Hardware

```
1) Arbeitsspeicher erhöhen/nachkaufen und mindestens 50% der Nutzdaten
2) Extra Maschine für Applikation und für Datenbank (möglichst gute Anbindung
untereinander)
   d.h. Maschinen stecken am besten gleichen Serverschrank
```

Schritt 2: Konfiguration

1. Optimierung des InnoDB Buffers (Größe)
2. innodb_flush_log_at_trx_commit auf 0 setzen (jede Sekunde statt bei jedem Commit)

Schritt 3: Optimierung der Anfragen

1. Vorbereitung Ausgabe Slow Log für die Analyse
2. Installation percona-toolkit
3. Analyse slow-log-file mit pt-query-digest
4. Analyse langsamer Queries mit explain und Index setzen
    - Explain inkl. JSON-Format
    - Index setzten - Teil 1
    - Index und Joins
    - Function in Wheres vermeiden
    - Workaround für Funktionen - Virtual Column

Extra: Der Ausweg bei großen Tabellen

1. Falls es keine andere Lösung gibt, könnte u.U. Partitionierung helfen. Hier

Dokumentation

MySQL - Performance - PDF

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

Effective MySQL

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