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MySQL for E-Commerce

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About me

- Senior PHP Developer
- Linux, PHP, MySQL since 3.23
- studied at TU München
- working for Bringmeister in Berlin

Three things are important in the database world:
performance, performance and performance

source: sigmod.org/publications/interviews/pdf/p71-column-winslet.pdf

Schema design

- schema probably root cause of “my DB doesn’t scale”
- use smaller data types (don’t store numbers as varchar)
- use decimal instead of float
- avoid UUIDs as primary keys (use uuid_short() or ULIDs)
- use tinyint for bools, enums for fixed-value strings
- select only required columns (avoid select *)
- avoid queries without indexes (full table scan)
- reduce tables and joins with JSON columns
- use utf8mb4 or ascii as character set for varchar
- use default values instead of nullable columns
- don’t use entity-attribute-value model

Type	Storage (Bytes)
TINYINT	1
SMALLINT	2
MEDIUMINT	3
INT	4
BIGINT	8

Data Type	
YEAR	1 byte
DATE	3 bytes
TIME	3 bytes
DATETIME	5 bytes
TIMESTAMP	4 bytes

➔ **write less data, read less data**

➔ **read less rows** (less random IO, less pool buffer lookups)

sources: dev.mysql.com/doc/refman/8.0/en/storage-requirements.html
percona.com/blog/2019/11/22/uuids-are-popular-but-bad-for-performance-lets-discuss/
honeybadger.io/blog/uuids-and-ulids/
static.sched.com/hosted_files/perconaliveonline2020/ab/Boosting%20MySQL%20Performance.pdf
vettabase.com/blog/what-does-null-mean-in-sql/

Find the best indexes

- reduce number of indexes, reduce number of columns per index
- use smaller data types for index columns (reduce memory usage)
- ideal: all lookups use indexes or primary keys
- analyze, explain, explain, explain, test, test, test
- keep an eye on slow queries (optimizer sometimes chooses wrong indexes)
- test new mysql versions (performance, deprecations)
- having the right index vs. using it correctly:

```
select count(*) from cart_item where created_at > '2022-01-01';
1 row in set (0.127 sec)

select count(*) from cart_item where year(created_at) = '2022';
1 row in set (2.196 sec)

explain select count(*) from cart_item where created_at >= '2022-01-01';
| id | select_type | table     | partitions | type  | possible_keys | key        | key_len | ref  | rows    | filtered | Extra                 |
|  1 | SIMPLE      | cart_item | NULL       | range | created_at    | created_at | 4       | NULL | 2993487 |   100.00 | Using where; Using index |

explain select count(*) from cart_item where year(created_at) = '2022';
| id | select_type | table     | partitions | type  | possible_keys | key        | key_len | ref  | rows    | filtered | Extra                 |
|  1 | SIMPLE      | cart_item | NULL       | index | NULL          | created_at | 4       | NULL | 4987011 |   100.00 | Using where; Using index |

select count(*) from cart_item;
5074069
```

theory: db.in.tum.de/teaching/ws1819/queryopt/slides/chapter3.pdf

Named locks: GET_LOCK(name, timeout_seconds)

- obtains an exclusive global lock with a given name
  - returns 1 on success
  - returns 0 if attempt timed out
  - returns null on error
- can make parallel requests or scripts execute sequentially
- is managed by current MySQL session, independant from transactions
- released on RELEASE_LOCK(name) or disconnect (e.g. if PHP process stops)
- more efficient than row level locking or transactions, avoids deadlocks
- examples:
  - limit a cron job to one instance running at the same time:
    ```
    SELECT GET_LOCK(“cron_<cron-job-name>”, 1);
    ```
  - process parallel cart requests sequentially:
    ```
    SELECT GET_LOCK(“cart_<customer-id>”, 10);
    ```
  - limit customers to place exactly one order at the same time:
    ```
    SELECT GET_LOCK(“order_<customer-id>”, 10);
    ```

source: dev.mysql.com/doc/refman/8.0/en/locking-functions.html#function_get-lock

Connection handling

- maximum number of open connections (sessions) is often the limiting factor for a database server
- open connection late (ideally on the first query)
- close connection early (esp. when waiting for another external service)
- connect with compression to reduce network traffic
- can safe additional hardware for mysql proxies
- persistent connections:
  - every PHP process uses its own mysqli pool (php.net/manual/en/mysqli.quickstart.connections.php)
  - can be buggy (e.g. bugs.php.net/bug.php?id=64549)
- example:

bootstrap.php

```
$db = new PDO('mysql:...;charset=utf8mb4;', ..., [PDO::ATTR_TIMEOUT => 5]);
```

vs.

```
class Repository {
      ...
     public function getTasks(Customer $customer): array {
         $db = $this->app->getDatabase($customer);
         $statement = $db->query('SELECT id, name FROM tasks ...');
         return $statement->fetchAll(PDO::FETCH_CLASS, Tasks::class);
     }
```

Cart updates

- most traffic in a shop goes to product data and cart
- reduce number of columns in cart table
  - e.g. customer_id, sku, quantity with primary key on customer_id, sku
- insert / update cart items with 1 query:

```
INSERT INTO cart_item
   SET customer_id = ?, sku = ?, quantity = ? AS new
    ON DUPLICATE KEY UPDATE quantity = new.quantity;

REPLACE INTO cart_item SET customer_id = ?, sku = ?, quantity = ?;
```

- define maximum number of items allowed in a single cart
  - too many items in the cart slow down browser / apps and increase cart calculation time
- define maximum quantity per sku if logistics requires it
  - e.g. max. 5 crates of water per order

Limit resultsets: SELECT ... LIMIT

- limit gives quicker response (fetch less data)
- less memory usage for processing less rows
- less data to process in frontend / apps
- page by primary key instead of using OFFSET
  - `SELECT name FROM wishlist LIMIT 100 OFFSET 10000;`

    vs.
  - `SELECT name FROM wishlist WHERE id > 10000 LIMIT 100;`

➔ read less rows, process less rows

source: shopify.engineering/pagination-relative-cursorshttps://shopify.engineering/pagination-relative-cursors

Verify status transitions

- ```
  UPDATE orders SET status = 'processing'
  WHERE order_id = 42;
  ```

  vs

- ```
  UPDATE orders SET status = 'processing', updated_at = now()
  WHERE order_id = 42 AND status = 'new';
  ```

- verify that dataset was changed in the database:

  ```
  if ($db->query($query)->rowCount() !== 1) {...}
  ```

Analytical queries: SELECT ...

- use **read-only replica** whenever possible (reduce traffic on master)
- use **pre-aggregation** of data to read less data
- transaction-isolation = READ COMMITTED
  - REPEATABLE-READ: locks acquired during transaction are held for duration of transaction
  - **READ-COMMITTED**: locks that did not match the scan are released after STATEMENT completes, in READ COMMITTED gap locks are never created
- use a column store database for ad-hoc queries (clickhouse, duckdb, etc.)
  - store data by columns instead of rows, better compression quicker filtering
  - vectorized joins, multi-core parallel query execution, S3 storage layer
  - faster sorting (https://duckdb.org/2021/08/27/external-sorting.html)
  - materialized views (https://altinity.com/blog/clickhouse-materialized-views-illuminated-part-1)
  - requires loading data into column store database

  ➔ gives best performance for analytical queries

sources:
percona.com/blog/2012/08/28/differences-between-read-committed-and-repeatable-read-transaction-isolation-levels/
percona.com/blog/2015/01/14/mysql-performance-implications-of-innodb-isolation-modes/

Read data consistently from replicas

- data is replicated asynchronously to replicas
- replica delay can be monitored with: `show replica status;` // Seconds_Behind_Source
- request #1:
  - update data on master

```
-- connect to master
INSERT INTO tasks SET id = 42, name = 'foo';

-- get latest gtid
SELECT @@GLOBAL.gtid_executed;
```

  - store gtid in cookie
- request #2:
  - wait for transaction to be applied on replica

```
-- connect to replica
SELECT WAIT_FOR_EXECUTED_GTID_SET(gtid_from_cookie, 5); -- 0 = success
```

  - read data from replica:

```
SELECT name FROM tasks WHERE id = 42;
```

source: youtube.com/watch?v=9caro2QNcww

Customer data search: low traffic search

MySQL fulltext index

- can be implemented quickly and easily
- can be fast enough for low traffic search
- no extra hardware for search functionality needed
- stays consistent (with index update on transaction commit)

```
CREATE TABLE customer_search (
  customer_id int UNSIGNED NOT NULL PRIMARY KEY,
  search varchar(1024) NOT NULL, -- e.g. “firstname lastname address”
  FULLTEXT (search)
);

SELECT customer.* FROM customer, customer_search
 WHERE customer.id = customer_search.customer_id
   AND MATCH(customer_search.search) AGAINST (? in boolean mode)
 LIMIT 100;
```

- query example: `"Frank-Walther" Wattstr* +Meier -Franz`
- query input requires sanitizing for “-+<>~*@”

  e.g. "++foo", "**foo" or "foo+" not allowed

source: dev.mysql.com/doc/refman/8.0/en/fulltext-boolean.html

Product data search: high traffic search

- most traffic in a shop goes to product data and cart
- store each product in a JSON document
- use (in-memory) document store as data source
- example products optimized for fulltext search:
  RedisSearch, meilisearch, typesense, Elasticsearch, Algolia
- remember to check licenses and support options
- make vs. buy

Queues

MySQL can be used as a queue:

- for small messages with low volume
- provides transactional safety, example:

```
BEGIN;
  INSERT INTO customer SET id = 42;
  REPLACE INTO queue_crm SET customer_id = 42, num_tries = 0;
COMMIT;
```

- can process messages in order or out of order, example for **single** consumer:

```
SELECT GET_LOCK('queue_crm', 1);
SELECT customer_id FROM queue_crm WHERE num_tries < 10 ORDER BY created_at ASC LIMIT 10;
  UPDATE queue_crm SET num_tries = num_tries + 1, last_try = now() WHERE customer_id = 42;
  -- process entry
  DELETE FROM queue_crm WHERE customer_id = 42;
SELECT RELEASE_LOCK('queue_crm');
```

- releases row locks on RELEASE_LOCK() or disconnect (e.g. if PHP process stops)
- makes it easy to re-process failed messages, example:

```
UPDATE queue_crm SET num_tries = 0 WHERE num_tries = 10;
```

Queues #2

MySQL can be used as a queue:

- can process messages in order or out of order, example for **multiple** consumers:

```
BEGIN;
  SELECT customer_id FROM queue_crm WHERE num_tries < 10
   ORDER BY created_at ASC LIMIT 10 FOR UPDATE SKIP LOCKED;
    -- process entry
    -- on success
    DELETE FROM queue_crm WHERE customer_id = 42;
    -- on failure
    UPDATE queue_crm SET num_tries = num_tries + 1, last_try = now() WHERE customer_id = 42;
COMMIT;
```

- releases row locks on COMMIT or disconnect (e.g. if PHP process stops)
- makes it easy to do queue monitoring:

```
  SELECT count(*) FROM queue_crm WHERE num_tries >= 10;
```

source: dev.mysql.com/blog-archive/mysql-8-0-1-using-skip-locked-and-nowait-to-handle-hot-rows/

Log data

- use page compression to reduce read and write IO
- using partitions offers quick deletion by ALTER TABLE log TRUNCATE PARTITION ...
- use JSON columns to store structured logs
- store logs outside of database whenever possible (e.g. datadog, elasticsearch)
- example:

```
CREATE TABLE log (
    customer_id int unsigned not null,
    event json not null,
    created_at datetime not null,
    index(customer_id, created_at)
) COMPRESSION='lz4' PARTITION BY hash(month(created_at)) PARTITIONS 12;
```

- check compression ratio:

```
select name, file_size, allocated_size from information_schema.INNODB_TABLESPACES where name like 'tasks/log%';
+-----------------+------------+----------------+
| name            | file_size  | allocated_size |
+-----------------+------------+----------------+
| tasks/log#p#p0  | 1086324736 |      551456768 |
| tasks/log#p#p1  | 1203765248 |      612634624 |
...
+-----------------+------------+----------------+
```

source: dev.mysql.com/doc/refman/8.0/en/innodb-page-compression.html

Data migration (EAV → JSON)

Using SQL to copy data from old schema to new schema (old table(s) to new table):

```
INSERT INTO customers.customer (email, attributes, created)
    SELECT * FROM magento.customer_entity
    LEFT JOIN magento.customer_entity_varchar as firstname on
        firstname.entity_id = customer_entity.entity_id and firstname.attribute_id = 5
    LEFT JOIN magento.customer_entity_varchar as lastname on
        lastname.entity_id = customer_entity.entity_id and lastname.attribute_id = 7
    LEFT JOIN magento.customer_entity_datetime as birthdate on
        birthdate.entity_id = customer_entity.entity_id and birthdate.attribute_id = 11
    SET email = customer_entity.email,
           attributes = json_object(
              'first', firstname.value,
              'last', lastname.value,
              'birth', date(birthdate.value),
              'orders', (select count(*) from magento.sales_flat_order
                           where customer_id = customer_entity.entity_id)
           ),
           created = customer_entity.created_at;
```

Data anonymization

- Use a separate database and views to provide anonymized production data
- Grant permissions to human users only on anonymized data

```
SELECT * FROM customers.customer WHERE id = 1234;
    id: 1234
    email: foo.bar@baz.com
    attributes: {"first": "Thomas", "last": "Bley", "birth": "1930-02-01", "orders": 42}
    created: 2021-05-06 12:41:11

CREATE or REPLACE VIEW customers_anonymized.customer AS
    SELECT id,
        concat('invalid_', id, '@bringmeister.de') AS email, -- invalid_1234@bringmeister.de
        json_object(
            'first', concat('first_', id),    -- first_1234
            'last', concat('last_', id),      -- last_1234
            'birth', '1980-01-02',
            'orders', attributes->>"$.orders" -- 1980-01-02, 42
        ) AS attributes,
        created
    FROM customers.customer;
```

Pseudo random order ID generation

Order IDs should be increasing, but increasing with some “randomness”:

- generate Order ID before saving the order
- increment Order ID sequence with random values
- LAST_INSERT_ID(): returns automatically generated value
- RAND(): Returns a random float value in the range 0 <= value < 1.0
- can be an alternative to UUID / ULID

```
CREATE TABLE order_sequence (order_id int unsigned not null);
INSERT INTO order_sequence SET order_id = 1; // start with Order ID 1

-- update order_id = order_id + rand(5, 10) returning order_id
UPDATE order_sequence SET order_id = LAST_INSERT_ID(order_id + FLOOR((RAND() * 6) + 5));
SELECT LAST_INSERT_ID();
```

➔ generates an randomly increasing Order ID sequence

e.g. 6, 16, 25, 39, 46, 56, 65, 73, 78, 85, 90, ...

source: dev.mysql.com/doc/refman/8.0/en/information-functions.html#function_last-insert-id

Foreign keys, triggers and procedures

skip foreign keys

- require additional indexes
- require additional locking and lookups on related tables for insert, update or delete, can cause deadlocks
- cascading logic might be different from required business logic
- not supported by some tools (e.g. gh-ost)
- can have bugs (https://itw01.com/8Q76OEZ.html)

skip triggers and procedures

- logic is limited to SQL functionality
- cannot connect to external systems (e.g. send an email)
- difficult to update atomically
- often cause unwanted side effects, e.g. cyclic execution

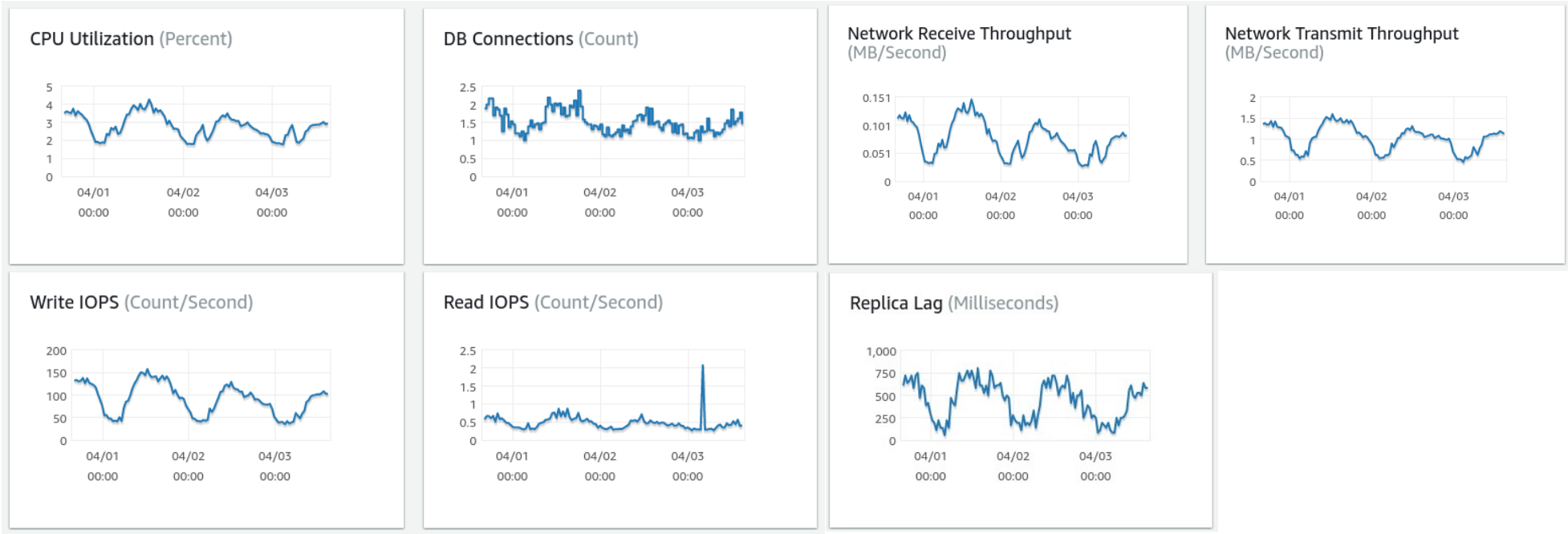
➔ better to keep application logic inside application code, use MySQL only as storage

Legacy code and rewrites

- identify and optimize **20% of slowest queries**
- remove unused indexes, create better indexes
- remove unused columns and tables
- **remove historic data** if possible (GDPR)
- verify backups
- optimize database schema (reduce joins with JSON columns)
- analyze data quality to avoid bugs (esp. historic data)
- use caching when data changes rarely
- enable MySQL access log for local development
- **write tests** to verify that data is written correctly to the database
  - start tests with empty tables, create test data on the fly
  - put integrations tests inside a transaction (setUp())
  - rollback changes when tests finish (tearDown())
  - allow tests to run in parallel

Monitoring

- Log slow queries (server side, slow query log, show processlist)
- Log failed queries (application side)
- Analyze deadlocks: `show engine innodb status;`
- Monitor replica status: `show replica status;`
  (Replica_IO_Running, Replica_SQL_Running, Seconds_Behind_Source)
- Monitor performance metrics:



sources: percona.com/blog/2006/07/17/show-innodb-status-walk-through/
percona.com/blog/2014/10/28/how-to-deal-with-mysql-deadlocks/

Server coniguration

- innodb_buffer_pool_size: 75-80% of system memory
  (best case: active workset fits into pool buffer)
- innodb_flush_log_at_trx_commit: 2 (default 1, less durability)
- innodb_flush_method: O_DIRECT (skip kernel file system cache)
- innodb_adaptive_hash_index: off (faster for many concurrent joins)
- max_heap_table_size / tmp_table_size: 128M (used for joins, sorting, subqueries)
- gtid-mode: on, enforce_gtid_consistency: on
- wait_timeout: 120 (4x max_execution_time)
- event_scheduler: off (when you don’t need it)
- performance_schema: off (when you don’t need it)

sources: percona.com/blog/2016/04/12/is-adaptive-hash-index-in-innodb-right-for-my-workload/
dev.mysql.com/doc/refman/8.0/en/internal-temporary-tables.html
dev.mysql.com/doc/refman/8.0/en/innodb-parameters.html
percona.com/blog/mysql-zfs-performance-update/

Additional resources

- InnoDB Performance Optimization
  youtube.com/watch?v=qMmSwhSlnX0
- Introduction into MySQL Query Tuning
  youtube.com/watch?v=1pxcOgzb6aU
- Tuning InnoDB Primary Keys
  percona.com/blog/2018/07/26/tuning-innodb-primary-keys/
- MySQL 8.0 – locking details
  lefred.be/content/mysql-8-0-locking-details/
- Why joins take so much performance?
  de.wikipedia.org/wiki/Joinalgorithmen

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Thanks for listening!

Questions?

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