MySQL Connector/Node.js and the X DevAPI

Live for the Code

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whoami

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Outline

1. Building blocks for modern MySQL
2. Diving into the X DevAPI
3. X DevAPI via Connector/Node.js
4. Final thoughts

Building blocks for modern MySQL

X DevAPI

- High-level database API to develop modern applications powered by **InnoDB Cluster** [TIP3065, HOL2988]
- Application gateway for the underlying document-store infrastructure (X Protocol, Router, X Plugin)
- Off-the-shelf support for **CRUD NoSQL** document operations
- Lower-level management via raw SQL and other advanced features
- Standard specification for all the official client implementations
- Available in connectors for the most popular languages as well as the brand new MySQL Shell

MySQL Document Store [DEV5986]

- It’s now possible to save and retrieve unstructured data using a MySQL database (not talking about raw JSON)
- Data lives in a JSON column but everything is abstracted way from the user, which only deals with documents
- No need to worry about schemas and data types
- Keeping logical consistency and ACID (it’s MySQL after all)
- At the same time, a schema can still mix in traditional tables
- ...and more https://lefred.be/content/top-10-reasons-for-nosql-with-mysql/

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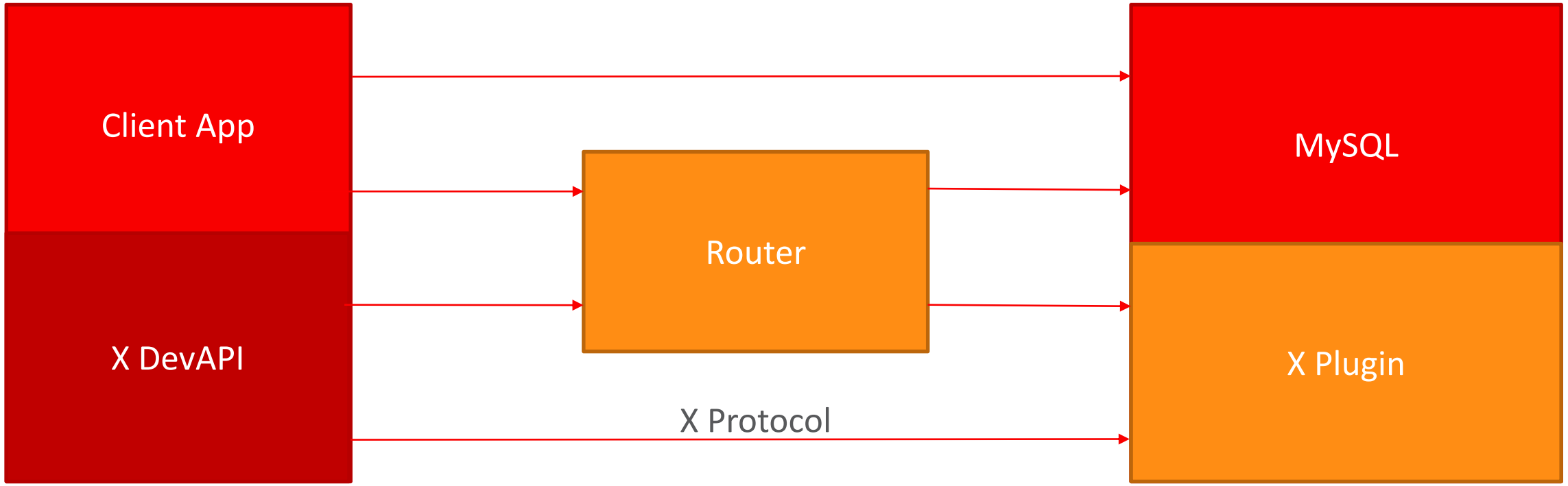
Component Overview



https://dev.mysql.com/doc/refman/8.0/en/document-store.html

Router

- MySQL Router is an integral part of **InnoDB Cluster**
- Lightweight middleware that provides transparent routing between an application and back-end MySQL servers
- Can be used for a wide variety of use cases, but mainly to address high availability and scalability concerns
- Runs as a standalone component
- Packaged with the MySQL server for the usual platforms
- Documentation available at https://dev.mysql.com/doc/mysql-router/8.0/en/

X Plugin

- New MySQL server plugin (developed internally)
- Installed and enabled by default on MySQL 8.0 series
- Provides the document store infrastructure on top of plain MySQL servers
- Uses a different set of ports (**33060** instead of the usual MySQL **3306**)
- Implements a client-server protocol based on Google Protocol Buffers
- Accepts X DevAPI client requests and processes them using the core MySQL engine
- Documentation available at https://dev.mysql.com/doc/refman/8.0/en/document-store.html

X Protocol

- New client-server protocol based on Google Protocol Buffers (easier for **ANYONE** to extend and improve)
- Content awereness
  - CRUD expression trees to establish operation boundaries
  - Expectations to define conditions and create pipelined statements
  - Placeholder assignment and value escaping
- Security baked in
  - SSL/TLS by default
  - No information leaked to unauthenticated users (e.g. server version)
- Open source at https://dev.mysql.com/doc/internals/en/x-protocol.html

X Protocol

Message example

```
Mysqlx.Crud.Find {
  collection { name: "collection_name", schema: "schema_name" }
  data_model: DOCUMENT
  criteria {
    type: OPERATOR
    operator {
      name: "=="
      param {
        type: IDENT,
        identifier { name: "_id" }
      }
      param {
        type: LITERAL,
        literal {
          type: V_STRING,
          v_string: { value: "some_string" }
        }
      }
    }
  }
}
```

Building upon the X Protocol

- Each client offers a unified (up to some point) flavour of the X DevAPI to be consumed by an application
- X DevAPI constructs are exposed to the user via contextual methods operating on different database objects through the hierarchy
- Database interactions are encoded as X Protocol messages expressing the respective action
- Level of abstraction varies depending on the task
- Represents the vision of the MySQL team
- However, anyone can create their own API flavour on top of the protocol

Diving into the X DevAPI

Overview

- Wraps powerful concepts in a simple API
  - High-level session concept for writing code that transparently scales from single MySQL Server to a multi-server environment
  - Operations are simple, expressive and easy to understand
  - Non-blocking, asynchronous calls follow common host language patterns.
- Introduces a new, modern and easy-to-learn way to work with data
  - Documents are stored in Collections and have their dedicated CRUD operation set
  - Work with your existing domain objects or generate code based on structure definitions for strictly typed languages
  - Focus is put on working with data via CRUD operations (even for regular tables)
  - Semantic query-building preferred over traditional SQL string mashing

What do I get?

- Fluent API and flexible parameters
- Multiple connection modes (with support for connection pooling)
- Automatic connection failover and timeout management
- Security best practices with multiple SSL/TLS operation modes and authentication mechanisms as well as improved SQL injection protection
- Small and portable expression-based query language (subset of SQL)
- Hybrid CRUD API for both Document store collections and regular tables
- SQL statements for everything else
- ACID (transactions and row locking)

Fluent API

- Code flows from a single point of entry – ***getSession()***
- Code becomes more readable, maintainable (and even testable)
- Operations encapsulated in specialized and semantic methods
- Nice scaffolding for refactor tasks
- First-class support for text-editor (or IDE) hints and auto-completion
- Smaller SQL injection surface area
- Common standard between different programming environments

Flexible Parameters

- Most public API methods work with:
  - Multiple individual parameters
  - A single array of parameters
  - An object with named properties (where it applies)

```
mysqlx.getSession('root@localhost')
mysqlx.getSession({ user: 'root' })

collection.add({ name: 'foo' }).add({ name: 'bar' })
collection.add([{ name: 'foo' }, { name: 'bar' }])

collection.find('name = :name').bind('name', 'foo')
collection.find('name = :name').bind({ name: 'foo' })
collection.find().fields('foo', 'bar')
collection.find().fields(['foo', 'bar'])
```

Connection Types

Different operation modes

- Each X DevAPI **Session** matches a single connection (regular mode)
- Pooling mode (X DevAPI **Session**s create or re-use existing connections)

```
const url = 'mysqlx://root@localhost:33060/defaultSchema'

// create a regular standalone connection
mysqlx.getSession(url)

const pooling = { enabled: true, maxIdleTime: 500, maxSize: 25, queueTimeout: 500 }

const client = mysqlx.getClient(url, { pooling })

// acquire a connection from the pool (creates one if it does not exist)
client.getSession()
```

Connection failover and timeout

Pooling and non pooling setups

- Automatic priority-based failover
- Different timeout management for single-host or multi-host settings

```
// single-host
mysqlx.getSession('mysqlx://root@localhost:33060?connect-timeout=1000');


// multi-host

// order-based priority
mysqlx.getSession('mysqlx://root@[localhost:33060, localhost:33061]?connect-timeout=1000')
mysqlx.getSession('root@[localhost:33060, localhost:33061] ')

// weight-based priority
mysqlx.getSession('mysqlx://root@[(localhost:33061, priority=99), (localhost:33060, priority=100)]')
mysqlx.getSession('root@[(localhost:33061, priority=99), (localhost:33060, priority=100)]?connect-timeout=1000')
```

Security Options

- SSL/TLS is enabled by default, for TCP connections, when creating a session
- Local UNIX socket connections disable it (not needed) to be faster
- Additional server certificate validation
- Options can be overridden on-demand

```
mysqlx.getSession({ ssl: false })
mysqlx.getSession('mysqlx://root@localhost?ssl-mode=DISABLED')

mysqlx.getSession({ ssl: true, sslOptions: { ca: '/path/to/ca.pem' } })
mysqlx.getSession('mysqlx://root@localhost?ssl-ca=(/path/to/ca.pem)')

mysqlx.getSession({ ssl: true, sslOptions: { ca: '/path/to/ca.pem', crl: '/path/to/crl.pem' } })
mysqlx.getSession('mysqlx://root@localhost?ssl-ca=(/path/to/ca.pem)&ssl-crl=(/path/to/crl.pem)')
```

Authentication Mechanisms

- SHA-1 and SHA-2 password hashing
- Supports authentication mechanisms for multiple server plugins:
  - **MYSQL41** for **mysql_native_password**
  - **PLAIN** and **SHA256_MEMORY** for **sha256_password** and/or **caching_sha2_password**

```
mysqlx.getSession({ user: 'root', auth: 'MYSQL41' })
mysqlx.getSession('mysqlx://root@localhost?auth=MYSQL41')

mysqlx.getSession({ user: 'root', auth: 'PLAIN' })
mysqlx.getSession('mysqlx://root@localhost?auth=PLAIN')

mysqlx.getSession({ user: 'root', auth: 'SHA256_MEMORY' })
mysqlx.getSession('mysqlx://root@localhost?auth=SHA256_MEMORY')
```

Hybrid CRUD API

Table	Collection
• `insert()` • `select()` • `dpdate()` • `delete()`	• `add()` • `find()` • `modify()` • `remove()`

- Operational methods return proper database object or operation instances
- CRUD operations: **CollectionAdd**, **TableInsert**, **CollectionFind**, **TableSelect**, **CollectionModify**, **TableUpdate**, **CollectionRemove**, **TableDelete**
- Operation boundaries - filtering criteria, computed projections, placeholder assignment, resultset ordering - established using an expression language

Expression Strings

- Small subset of the SQL language
- Easy to grasp (everyone already knows SQL) but still powerful
- Expressive and human-readable
- Common standard between all the official connector implementations

```
// JavaScript
collection
  .find("name = 'foo' AND age > 42")
  .fields("name", "age")
  .groupBy("name", "age")
  .sort("name ASC", "age DESC")
  .limit(4)
  .offset(2)
  .execute()
```

```
// Java
collection
  .find("name = 'foo' AND age > 42")
  .fields("name", "age")
  .groupBy("name", "age")
  .sort("name ASC", "age DESC")
  .limit(4)
  .offset(2)
  .execute()
```

Placeholder assignment

- Placeholders are supported by the expression grammar
- Variable values are native to the protocol itself
- Additional server-side validation and escaping
- Mitigates SQL injection risks

```
collection.find('name = :name')
  .bind('name', 'foo')
  .execute()

collection.find('name = :name')
  .bind({ name: 'foo' })
  .execute()
```

```
Mysqlx.Crud.Find {
  criteria {
    operator {
      param {
        identifier { document_path: "name" }
      }
      param { position: 0 }
    }
  }
  args { v_string: "foo" }
}
```

Raw SQL

- For ETL, structured analytics and/or reporting, SQL is always an option
- Allows to tap into features not yet part of the X DevAPI, such as:
  - DDL operations for relational tables
  - Managing key constraints
  - Using JOINs

```
// create a table
session.sql('CREATE TABLE foo (bar VARCHAR(3))').execute()

// add a unique constraint
session.sql('ALTER TABLE foo ADD COLUMN bar VARCHAR(3) GENERATED ALWAYS AS doc->>"$.bar" VIRTUAL UNIQUE KEY NOT
NULL').execute()

// execute a JOIN query
session.sql('SELECT DISTINCT t1.bar FROM foo t1 JOIN baz t2 ON t1.bar = t2.qux WHERE t1.qux = t2.quux').execute()
```

Transactions and Savepoints

- Session-level atomic operations
- Create, commit or rollback transactions in the scope of a session
- Create, release or rollback to intermediate savepoints in those transactions

```
try {
  session.startTransaction()
  // run some operations (1)
  session.createSavepoint('foo')
  // run more operations (2)
  session.releaseSavepoint('foo')
  session.commit()
} catch (err) {
  try {
    session.rollbackTo('foo') // go to (2)
  } catch (err) {
    session.rollback() // revert the entire thing
  }
}
```

Row Locking

- Reads determine isolation level in the presence of concurrent transactions
- **Exclusive** and **Shared** locks with different operation modes:
  - **DEFAULT** (regular `SELECT FOR ... UPDATE` or `SELECT FOR ... SHARE` behavior)
  - **NOWAIT** (query executes immediately and fails if row is locked)
  - **SKIP_LOCKED** (query executes immediately and ignores row)

```
// works for table.select() as well
collection.find('name = "foo"').lockExclusive() // mysqlx.LockContention.DEFAULT
collection.find('name = "foo"').lockExclusive(mysqlx.LockContention.NOWAIT)
collection.find('name = "foo"').lockExclusive(mysqlx.LockContention.SKIP_LOCKED)

// works for table.select() as well
collection.find('name = "bar"').lockShared() // mysqlx.LockContention.DEFAULT
collection.find('name = "bar"').lockShared(mysqlx.LockContention.NOWAIT)
collection.find('name = "bar"').lockShared(mysqlx.LockContention.SKIP_LOCKED)
```

X DevAPI via Connector/Node.js

Overview

- Currently the only Node.js driver for MySQL with out-of-the-box support for 8.0 servers and, particularly, the X DevAPI
- Open source, available on GitHub and on npm
- Modern Node.js asynchronous API using ***Promise***s
- Covers a big chunk of the X DevAPI spec:
  - Fluent API and query builder based on the common expression language
  - Document store and relational CRUD methods alongside plain SQL support
  - Secure by default (SSL/TLS and SHA256 authentication)
  - Connection pooling and failover
  - Logical consistency with transactions, savepoints and row-locking...

Asynchronous API

- Operations are sent to the server when the ***execute()*** method is called
  - receives an optional query operation callback push-based cursor) which runs for each element in the result set
  - returns a ***Promise*** which resolves to a ***Result*** instance containing details and metadata about the operation, or fails with an ***Error*** (can be used with ***async/await)***

```
collection
  .find()
  .execute(doc => {
    // do something with the document
  })
  .then(result => {
    // result contains details about the operation
  })
  .catch(err => {
    // handle any errors
  })
```

```
collection
  .remove()
  .execute(/* no cursor will be needed */)
  .then(result => {
    // result contains details about the operation
  })
  .catch(err => {
    // handle any errors
  })
```

Up and running

```
$ npm install --save --save-exact @mysql/xdevapi
```

```
const mysqlx = require('@mysql/xdevapi');
```

```
(async function () {

  const session = await mysqlx.getSession({ user: 'root' });
  const schema = session.getSchema('codeone2018');

  if (!(await schema.existsInDatabase())) {
    await session.createSchema('codeone2018');
  }

  // ...

})();
```

Data definition

```
// const schema = session.getSchema('codeone2018');
await schema.createCollection('sessions_nosql', { ReuseExistingObject: true });


// For now, table DDL operations are performed using SQL only
await session.sql('USE codeone2018').execute();
await session.sql(`CREATE TABLE sessions_sql (
  _id VARCHAR(7) NOT NULL,
  title VARCHAR(250),
  PRIMARY KEY (_id)
)`).execute();


const collections = await schema.getCollections();
console.log(collections); // [{ schema: 'codeone2018', collection: 'sessions_nosql' }]

const tables = await schema.getTables();
console.log(tables); // [{ schema: 'codeone2018', table: 'sessions_sql' }]
```

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Saving data

```
const table = schema.getTable('sessions_sql');
const collection = schema.getCollection('sessions_nosql');

// single insert
await table.insert('_id', 'title').values('DEV5985', 'This talk!').execute();

// batching inserts

const batchA = collection
  .add({ _id: 'DEV5986', title: 'Node.js and the MySQL Document Store', speakers: ['Rui Quelhas'] })
  .add({ _id: 'DEV6233', title: 'Connector/J Beyond JDBC...', speakers: ['Filipe Silva'] });

const batchB = table
  .insert(['_id', 'title'])
  .values(['DEV5959', 'Python and the MySQL Document Store']);

const batchC = table
  .insert('_id', 'title')
  .values('HOL1706', 'Developing Modern Applications with the MySQL Document Store and Node.js');

await Promise.all([batchA.execute(), batchB.execute(), batchC.execute()]);
```

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Retrieving data

```
// const collection = schema.getCollection('sessions_nosql');

await collection.find('title LIKE :pattern')
  .bind({ pattern: '%Node.js%' })
  .fields('_id', 'speakers')
  .execute(console.log); // { _id: 'DEV5985', speakers: ['Rui Quelhas'] }


// const table = schema.getTable('sessions_sql');

await table.select() // project specific columns if needed
  .where('title LIKE :pattern')
  .bind('pattern', '%MySQL%')
  .orderBy('_id ASC')
  .limit(1)
  .offset(1)
  .execute(console.log); // ['HOL1706', 'Developing Modern Applications with...']
```

Updating data

```
// const collection = schema.getCollection('sessions_nosql');

await collection.modify('_id = :id')
  .bind('id', 'DEV5986')
  .set('title', 'The talk about Document Store!')
  .execute();

const doc = await collection.getOne('DEV5986');
console.log(doc); // { _id: 'DEV5986', title: 'The talk about Document Store!', speakers: ['Rui Quelhas] }


// const table = schema.getTable('sessions_sql');

await table.update()
  .where('_id = :id')
  .bind({ id: 'DEV5985' })
  .set('title', 'MySQL Connector/Node.js and the X DevAPI')
  .execute(console.log);

await table.select()
  .where('_id = :id')
  .bind('id', 'DEV5985')
  .execute(console.log) // ['DEV5985', 'MySQL Connector/Node.js and the X DevAPI']
```

Deleting data

```
// const collection = schema.getCollection('sessions_nosql');

await collection.remove('true').execute();

const docs = [];

const doc = await collection.find().execute(doc => docs.push(doc));
console.log(docs); // []


// const table = schema.getTable('sessions_sql');

await table.delete()
  .where('title LIKE :pattern')
  .bind('pattern', '%Node.js%')
  .execute();

await table.select()
  .execute(console.log) // ['DEV5959', 'Python and the MySQL Document Store']
```

Final thoughts

Some takeaways

- Simplify and secure your database installation
- Reap the benefits of both SQL and NoSQL
- High-availability and scalability via **InnoDB Cluster**
- Fast prototyping but always with maintainability in mind
- No language or platform lock-in (portable API constructs)
- Stick to a modern simple Node.js workflow (async, npm)
- Deploy everywhere where Node.js excells (containers, microservices, serverless and FaaS, desktop, IoT, etc.)
- It’s all open source

Links and Resources

- https://dev.mysql.com/doc/x-devapi-userguide/en/
- https://github.com/mysql/mysql-connector-nodejs
- https://www.npmjs.com/package/@mysql/xdevapi
- https://dev.mysql.com/doc/dev/connector-nodejs/8.0/
- https://www.mysql.com/news-and-events/web-seminars/mysql-document-store-and-node-js/
- https://www.mysql.com/news-and-events/web-seminars/mysql-document-store-and-node-js/

Q&A

Thank you!