Introducing the MySQL Document Store

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Today's Agenda

1. Relational Databases, Document Databases and MySQL
2. MySQL JSON Support
3. Document Use Cases
4. The X DevAPI
5. Getting it all working together

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Relational Databases

- Data Integrity
  - Normalization
  - Constraints (foreign keys etc)
- Atomicity, Consistency, Isolation, Durability - ACID
  - Transactions
- SQL
  - Powerful, Optimizable Query Language
  - Declare what you want and the DB will find out the most efficient way to get it to you

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Plus…

- MySQL has been around since 1995
- Ubiquitous
- Pretty much a standard
- Scalable
- When there are issues, they are known and understood
- Large body of knowledge, from small to BIG deployments

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Document Databases

- Schemaless
  - no schema design, normalization, foreign keys, constraints, data types etc
  - faster initial development
- Flexible data structures
  - nested arrays and objects
  - some data is simply naturally unstructured or cannot be modeled efficiently in the relational model (hierarchies, product DB etc)
  - persist objects without ORMs

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Document Databases (Cont.)

- JSON
  - Closer to the frontend
  - "native" in JavaScript
  - Node.js and full stack JavaScript
- Easy to learn, easy to use

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Relational vs Document Databases

Why not both?

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1 Relational Databases, Document Databases and MySQL
2 MySQL JSON Support
3 Document Use Cases
4 The X DevAPI
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The New JSON Datatype

```
mysql> CREATE TABLE employees (data JSON);

mysql> INSERT INTO employees VALUES
 ('{"id": 1, "name": "Jane"}'),
 ('{"id": 2, "name": "Joe"}');

mysql> SELECT * FROM employees;
+-------------------------------------+
| data                                |
+-------------------------------------+
| {"id": 1, "name": "Jane"}           |
| {"id": 2, "name": "Joe"}            |
+-------------------------------------+
```

- Validation on INSERT
- No reparsing on SELECT
- Optimized for read
- Dictionary of sorted keys
- Can compare JSON/SQL
- Can convert JSON/SQL
- Supports all native JSON datatypes
- Also supports date, time, timestamp etc.

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MySQL 5.7: JSON Support

- Native JSON datatype
- Store JSON values (objects, arrays and simple values) in MySQL tables
- Binary JSON storage format
- Conversion from "native" SQL types to and from JSON values
- JSON Manipulation functions
  - Extract contents (JSON_EXTRACT, JSON_KEYS etc)
  - Inspect contents (JSON_CONTAINS etc)
  - Modify contents (JSON_SET, JSON_INSERT, JSON_REMOVE etc)
  - Create arrays and objects (JSON_ARRAY, JSON_OBJECT)
  - Search objects (JSON_SEARCH)

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MySQL 5.7: JSON Support (cont.)

- Inline SQL JSON path expressions

```
SELECT doc->'$.object.array[0].item' FROM some_table
```

- Boolean operators (compare JSON values etc)
  - foo = doc->'$.field'

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Generated Columns

```
CREATE TABLE order_lines
 (orderno integer,
  lineno integer,
  price decimal(10,2),
  qty   integer,
  sum_price decimal(10,2) GENERATED ALWAYS AS (qty * price) STORED );
```

- Column generated from the expression
- VIRTUAL: computed when read, not stored, indexable
- STORED: computed when inserted/updated, stored in SE, indexable
- Useful for:
  - Functional index
  - Materialized cache for complex conditions
  - Simplify query expression

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Functional Index

```
CREATE TABLE order_lines
 (orderno integer,
  lineno integer,
  price decimal(10,2),
  qty   integer,
  sum_price decimal(10,2) GENERATED ALWAYS AS (qty * price) VIRTUAL);

ALTER TABLE order_lines ADD INDEX  idx (sum_price);
```

- ***Online*** index creation
- Composite index on a mix of ordinary, virtual and stored columns

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Indexing JSON data

```
CREATE TABLE employees (data JSON);

ALTER TABLE employees
ADD COLUMN name VARCHAR(30) AS (JSON_UNQUOTE(data->"$.name"))
VIRTUAL,
ADD INDEX name_idx (name);
```

- Functional index approach
- Use inlined JSON path or JSON_EXTRACT to specify field to be indexed
- Support both VIRTUAL and STORED generated columns

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Generated column: STORED vs VIRTUAL

	Pros	Cons
STORED	• Fast retrieval	• Require table rebuild at creation • Update table data at INSERT/UPDATE • Require more storage space
VIRTUAL	• Metadata change only, instant • Faster INSERT/UPDATE, no change to table	• Compute when read, slower retrival

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Indexing Generated Column: STORED vs VIRTUAL

	Pros	Cons
STORED	• Primary & secondary index • B-TREE, Full text, R-TREE • Independent of SE • Online operation	• Duplication of data in base table and index
VIRTUAL	• Less storage • Online operation	• Secondary index only • B-TREE only • Require SE support

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Extracting JSON from a Relational DB

Relational In, Relational + Document Out

- Data stored in relational tables, but frontend uses JSON
- JSON directly maps to native data structures in many languages
  - Often easier for application code to use
  - JavaScript, Python, Ruby etc
  - In browser JavaScript

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Extracting JSON from a Relational DB

Relational In, Relational + Document Out

- SQL Functions to construct JSON
  - JSON_OBJECT(), JSON_ARRAY()
- Ex.:

```
SELECT JSON_OBJECT('cust_id', id, 'name', name, 'email', email) FROM customer;


CREATE VIEW customer_json AS
     SELECT JSON_OBJECT('cust_id', id, 'name', name, 'email', email) as doc
FROM customer;
SELECT * FROM customer_json;
```

- Updates and inserts still happen through the table columns

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Using MySQL as a JSON Document Container

Document In, Relational + Document Out

- Virtually Schemaless
  - Unstructured data
  - No clear, fixed structure for the data… records can have different fields
  - Often data that is not involved in *business rules*
  - Examples: "product_info", "properties", "options" etc
- Data does not map cleanly into a relational model (arrays, hierarchical data etc)
- Prototyping

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MySQL as a JSON Document Container

Example: "properties" table

WIKIPEDIA

Users

user_properties
- up_user INT
- up_property VARBINARY(255)
- up_value BLOB

Indexes

page_props
- pp_page INT
- pp_propname VARBINARY(60)
- pp_value BLOB
- pp_sortkey FLOAT

Indexes

log_search
- ls_field VARBINARY(32)
- ls_value VARCHAR(255)
- ls_log_id INT

Indexes

https://www.mediawiki.org/wiki/Manual:Database_layout

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MySQL as a JSON Document Container

Example: "product_info" table

product_id	attribute	value
9	size	M
9	color	red
9	fabric	cotton
11	flavour	strawberry
12	capacity	128GB
12	speed class	class 10
13	connectivity	Wi-Fi
13	storage	64GB
13	screen size	8.9"
13	resolution	2560 x 1600 (339 ppi)
13	battery life	12 hours

```
{
  "product_id": 9,
   "size" : "M",
   "color": "red",
   "fabric": "cotton"
},
{
  "product_id": 11,
  "flavour": "strawberry"
},
{
  "product_id": 12,
  "capacity": "128GB",
  "speed class": "class 10"
},
{
```

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MySQL as a JSON Document Container

Document In, Relational + Document Out

- An ordinary MySQL table with a single JSON data column
- Generated columns allow SQL engine to look inside the JSON data
  - Virtual columns
  - Primary Keys
  - Indexes
  - Foreign Keys
- Writes on the JSON column
- Reads primarily from the JSON columns

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Hybrid Relational and JSON

Relational + Document In, Relational + Document Out

- Database is mostly relational
- Some parts of the database are unstructured or does not model cleanly as relational
- JSON columns in relational tables
- Queries can mix and match JSON and column data
- Evolution path for Document based applications

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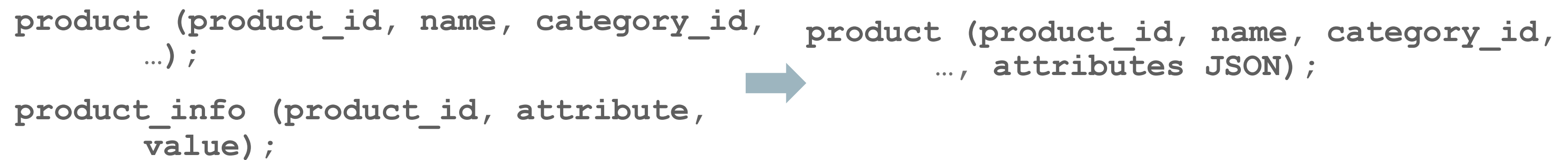
Hybrid Relational and JSON

Relational + Document In, Relational + Document Out



```
product (product_id, name, category_id,
      …);

product_info (product_id, attribute,
      value);
```

```
product (product_id, name, category_id,
      …, attributes JSON);
```

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Document Operations via SQL

- Powerful
- Allows complex queries
- But… still difficult to use

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Document Operations via SQL

```
CREATE TABLE product (
  id VARCHAR(32) GENERATED ALWAYS AS (JSON_EXTRACT(doc, '$.id')) STORED,
  doc JSON
);

INSERT INTO product VALUES (1, '{…}');
SELECT * FROM product WHERE JSON_EXTRACT(doc, '$.field') = value;
etc.
```

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The X DevAPI

- Abstraction over SQL
- Focused on 4 basic CRUD operations (Create, Read, Update, Delete)
- Fluent, Native Language API
- No knowledge of SQL needed
- X Protocol
  - CRUD requests encoded at protocol level
  - Request details "visible" (vs "opaque" SQL strings)

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Collection and Schema Operations

- Get a handle to a Schema

```
mydb = session.getSchema("mydb");
```

- Create a Collection

```
mydb.createCollection("products");
```

- Get a (local) reference to a Collection

```
products = mydb.getCollection("products");
```

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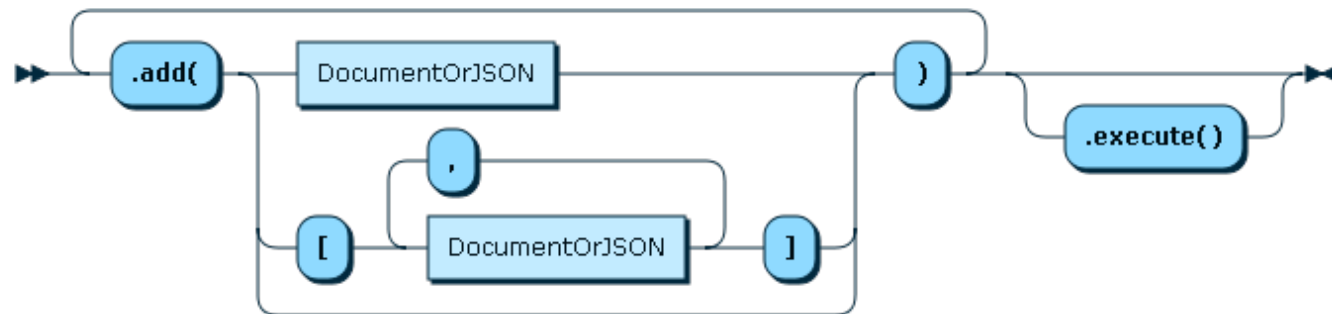
Add Document




```
products.add({"name":"bananas", "color":"yellow"}).execute();
```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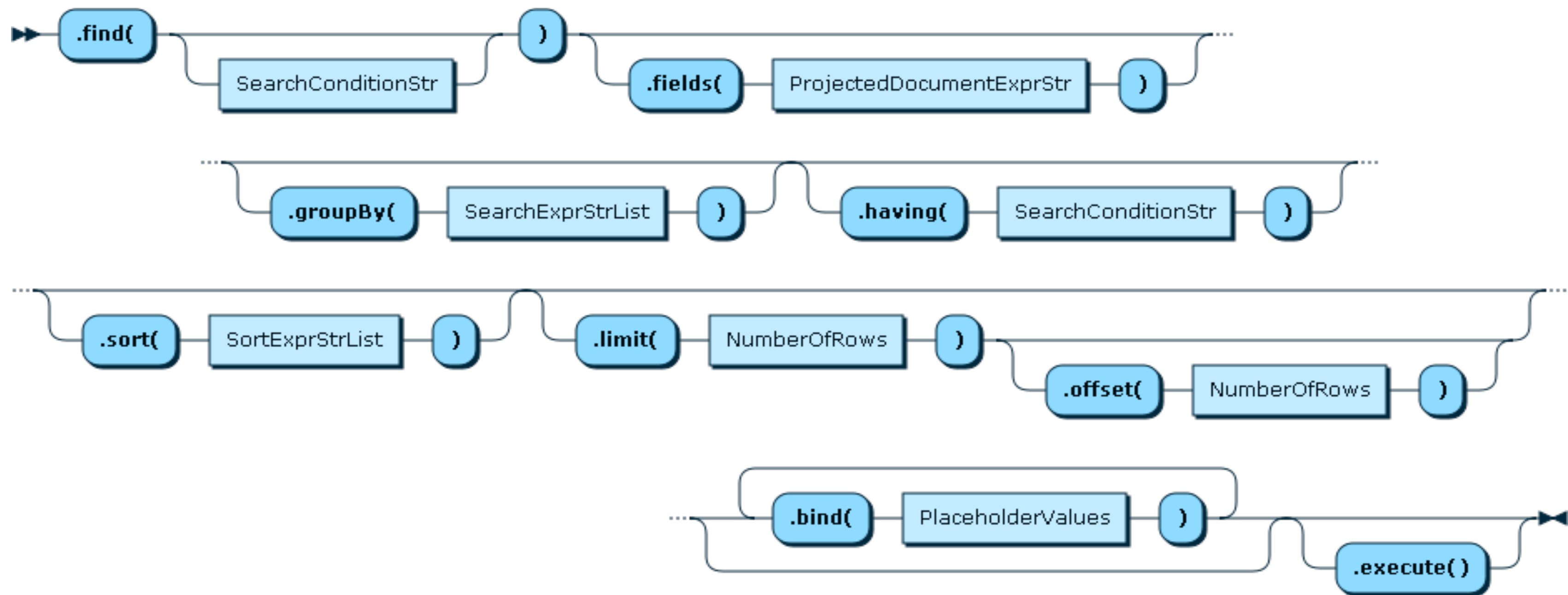
Find Documents




```
products.find("color = 'yellow'").sort(["name"]).execute();
```

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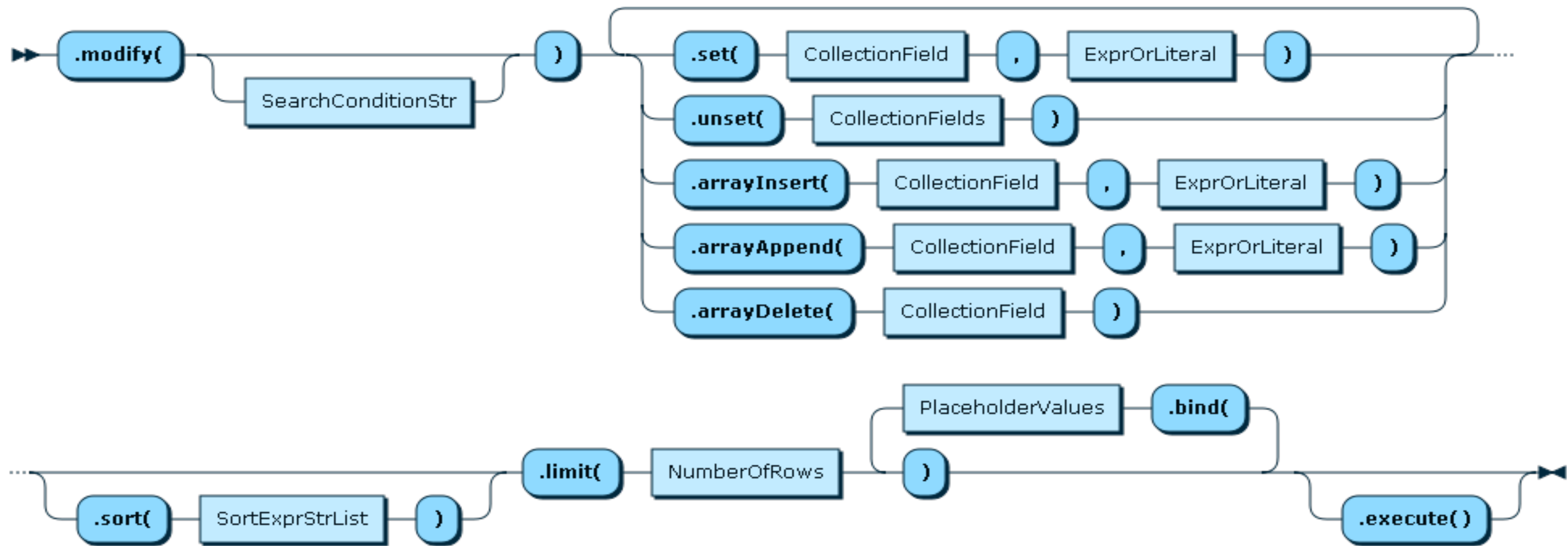
Modify Documents




```
products.modify("product_id = 123").set("color", "red").execute();
```

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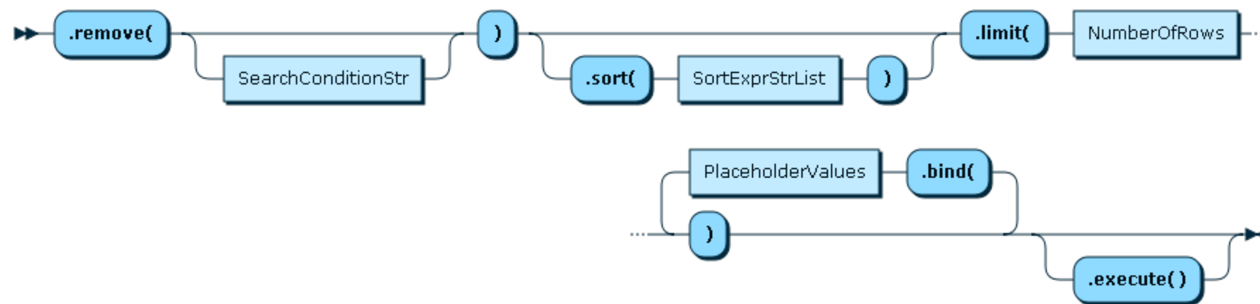
Remove Documents




```
products.remove("product_id = 123").execute();
```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X DevAPI Sessions

- X Session
  - Stateless
  - CRUD only, no SQL
  - Abstracts the connection
- Node Session
  - Direct connection to a database node
  - Allows CRUD and SQL

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Other Operations on Collections

- Create an Index

```
db.post.createIndex("email").field("author.email", "text(30)", false)
```

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CRUD Operations – NoSQL/Document and SQL/Relational

Operation	Document	Relational
Create	Collection.add()	Table.insert()
Read	Collection.find()	Table.select()
Update	Collection.modify()	Table.update()
Delete	Collection.remove()	Table.delete()

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5.7.12 Development Preview Release

- MySQL 5.7.12 with Document Store plugin
- MySQL Shell 1.0.3
- Connector/J 7.0
- Connector/Net 7.0
- Connector/Node.js 1.0

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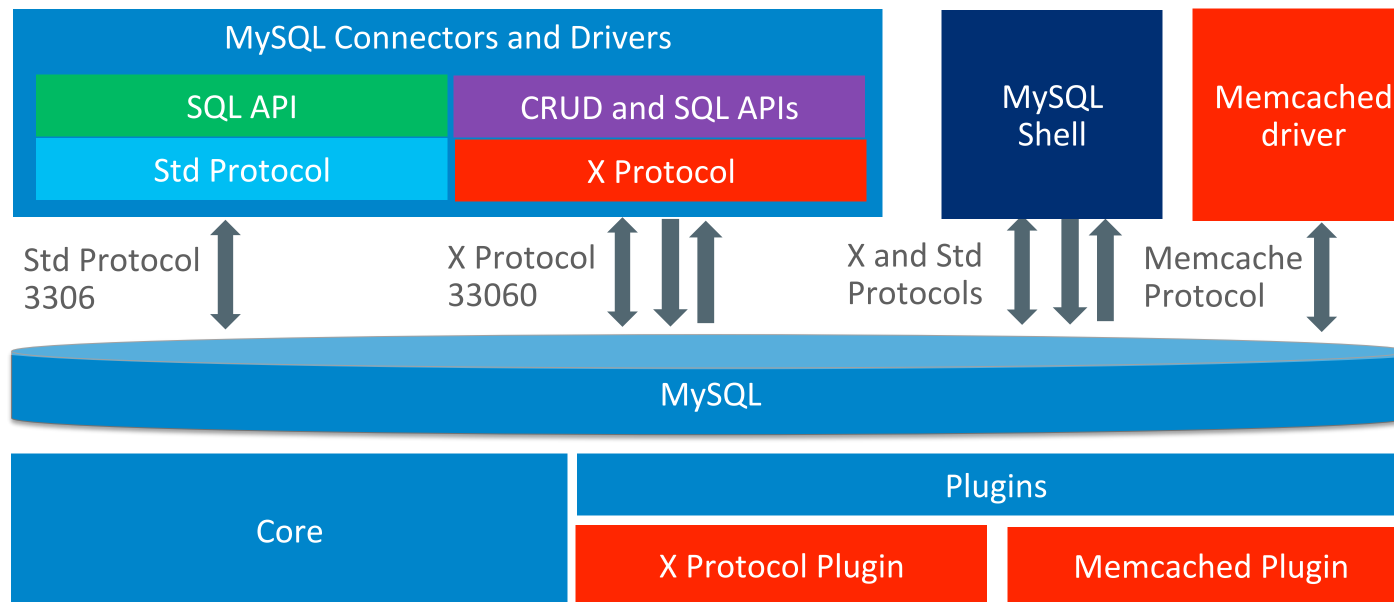
MySQL 5.7, Connectors, Drivers, and Protocols



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X DevAPI Connectors – MySQL Connector/Java 7.0

```
uri = "mysql:x://localhost:33060/test?user=user&password=mypwd"';

XSession session = new MysqlxSessionFactory().getSession(uri);

Schema schema = session.getDefaultSchema();

// document walkthrough

Collection coll = schema.createCollection("myBooks", true);

DbDoc newDoc = new DbDoc().add("isbn",
           new JsonString().setValue("12345"));

newDoc.add("title",
           new JsonString().setValue("Effi Briest"));

newDoc.add("author",
           new JsonString().setValue("Theodor Fontane"));

newDoc.add("currentlyReadingPage",
           new JsonNumber().setValue(String.valueOf(42)));

coll.add(newDoc).execute();

DocResult docs = coll.find("title = 'Effi Briest' and
currentlyReadingPage > 10").execute();
```

```
DbDoc book = docs.fetchOne();

System.err.println("Currently reading "
   + ((JsonString)book.get("title")).getString()
   + " on page "
   + ((JsonNumber)book.get("currentlyReadingPage")).getInteger());


// increment the page number and fetch it again

coll.modify("isbn = 12345").
  set("currentlyReadingPage",
    ((JsonNumber)book.get("currentlyReadingPage")).getInteger() +
1).execute();

docs = coll.find("title = 'Effi Briest' and currentlyReadingPage >
10").execute();

book = docs.fetchOne();

System.err.println("Currently reading "
  + ((JsonString)book.get("title")).getString()
  + " on page "
  + ((JsonNumber)book.get("currentlyReadingPage")).getInteger());
```

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X DevAPI Connectors – MySQL Connector/Net 7.0

```
using (XSession session =
          MySQLX.GetSession("mysqlx://test:test@localhost:33060"))
{
  string schemaName = "test";
  Schema testSchema = session.GetSchema(schemaName);
  if (testSchema.ExistsInDatabase())
    session.DropSchema(schemaName);
  session.CreateSchema(schemaName);

  // insert some docs
  Collection coll = testSchema.CreateCollection("myDocs");
  var docs = new[]
  {
    new { _id = 1, title = "Book 1", pages = 20 },
    new { _id = 2, title = "Book 2", pages = 30 },
    new { _id = 3, title = "Book 3", pages = 40 },
    new { _id = 4, title = "Book 4", pages = 50 },
  };
```

```
  Result r = coll.Add(docs).Execute();
  Console.WriteLine("Docs added: " + r.RecordsAffected);

  // modify some values
  r = coll.Modify("_id = :ID").
       Bind("Id", 2).Set("pages", "25").Execute();
  Console.WriteLine("Docs modified: " + r.RecordsAffected);

  // remove a book
  r = coll.Remove("_id = :ID").Bind("Id", 4).Execute();
  Console.WriteLine("Docs removed: " + r.RecordsAffected);

  // list the results
  var result30orMore = coll.Find("pages > 20").
       OrderBy("pages DESC").Execute().FetchAll();
  foreach(var doc in result30orMore)
  {
    Console.WriteLine(doc.ToString());
  }
}
```

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X DevAPI Connectors – MySQL Connector/Node.js 1.0 NEW!

```
const mysqlx = require('mysqlx');

mysqlx.getSession({
     host: 'localhost',
     dbUser: 'myuser',
     dbPassword: 'secret'
}).then(session => {
     const collection =
session.getSchema('myschema').getCollection('mycollection');
    return Promise.all([
       collection.add({ foo: "bar", something: { nested:
[1,2,3,4] } }).execute();
       session.close();
    ])
}).catch(err => {
            console.log(err);
});
```

```
const collection =
session.getSchema('myschema').getCollection('questions');
collection.find("answer == 42")
    .orderBy("foo DESC")
    .limit(10)
    .execute(doc => console.log(doc)) // print the document
received, callback called for each doc
    .then(() => console.log("All done") // Promise resolves
when all data is there
      .catch((err) => console.log("Oups, an error", err);
```

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MySQL Shell

```
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owners.

Type '\help', '\h' or '\?' for help.

Currently in JavaScript mode. Use \sql to switch to SQL mode and execute queries.
mysql-js> db.getCollections()
{
    "CountryInfo": <Collection:CountryInfo>
}
mysql-js> db.CountryInfo.find().limit(1)
[
    {
        "GNP": 828,
        "IndepYear": null,
        "Name": "Aruba",
        "_id": "ABW",
        "demographics": {
            "LifeExpectancy": 78.4000015258789,
            "Population": 103000
        },
        "geography": {
            "Continent": "North America",
            "Region": "Caribbean",
            "SurfaceArea": 193
        },
        "government": {
            "GovernmentForm": "Nonmetropolitan Territory of The Netherlands",
```

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MySQL Plugin for VisualStudio

File Edit View Project Debug Team Tools Architecture Test Analyze Window Help

Server Explorer

- Azure (Not connected)
- Data Connections
  - localhost(test)
- Servers
- SharePoint Connections

MySQL Script.myjs*

Server: 5.7.12-log | User: test | Database: test | Session Option

```
var collection = session.sakila_x.getCollection('movies');
collection.find('rating = "R"').execute();
```

Result1

Row 3	8 Fields	Object
Row 4	8 Fields	Object
Row 5	8 Fields	Object
_id	0f3dca31c7724516873ebc226b0be05d	String
actors	System.Collections.Generic.List`1[Syst...	Collections.Generic.List`1[Object]
description	A Lackluster Display of a Dentist And ...	String
duration	92 min	String
language	English	String
rating	R	String
release_year	2006	String
title	ANACONDA CONFESSIONS	String
Row 6	8 Fields	Object
Row 7	8 Fields	Object
Row 8	8 Fields	Object
_id	8fcff3a58bda4015bf08ffe923489f10	String
actors	System.Collections.Generic.List`1[Syst...	Collections.Generic.List`1[Object]
description	A Astounding Story of a Dog And a Sq...	String
duration	119 min	String
language	English	String
rating	R	String
release_year	2006	String
title	APOCALYPSE FLAMINGOS	String

Grid View / Tree View / Text View

Output

Show output from: MySQL

```
[Information] - undefined
```

Solution Explorer

Solution 'Solution1' (0 projects)

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Resources

Topic	Link(s)
MySQL as a Document Database	http://dev.mysql.com/doc/refman/5.7/en/document-database.html
MySQL Shell	http://dev.mysql.com/doc/refman/5.7/en/mysql-shell.html http://dev.mysql.com/doc/refman/5.7/en/mysqlx-shell-tutorial-javascript.html http://dev.mysql.com/doc/refman/5.7/en/mysqlx-shell-tutorial-python.html
X Dev API	http://dev.mysql.com/doc/x-devapi-userguide/en/
X Plugin	http://dev.mysql.com/doc/refman/5.7/en/x-plugin.html
MySQL JSON	http://mysqlserverteam.com/tag/json/ https://dev.mysql.com/doc/refman/5.7/en/json.html https://dev.mysql.com/doc/refman/5.7/en/json-functions.html
Blogs	http://mysqlserverteam.com/category/docstore/

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