Introducing JavaScript Support In MySQL

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Safe harbor statement

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JavaScript applications with MySQL

JavaScript Applications are popular
• Powerful for light weight front-end and server-side applications
• Works great with SQL servers, communicate with database via connectors

How to handle data-intensive use cases?
• Data Validation
• JSON & String processing / Formatting
• Data Cleaning / Transformation
• …

Problem: Need to move data to client to facilitate rich procedural programming capability
Data movement in the cloud

Cost
- Requires more capacity in application- or mid-tier
- Cloud Egress Cost

Latency
- Serialization / Deserialization of Data
- Protocol and Connector Overhead
- May require several round-trips

Security
- Unnecessary data transfer

Allow rich procedural programming capability inside the database
Procedural programs inside Database

Handle data-intensive app functionality in stored programs
- Minimize data movement
- Reduce cost
- Improve Security
- Simplify complex ETL → ELT

Limitations in procedural SQL stored programs
- **Not expressive**: Hard to use, lacks basic constructs like containers (arrays, maps)
- **Not efficient**: Challenging to optimize due to interpreted code
- **Insufficient Development eco-system**: Editors, debuggers, testing frameworks, reusable 3rd Party libraries
- Few experienced programmers
Introducing JavaScript for MySQL

Execute JavaScript Stored Procedures and Stored Functions via GraalVM

Just Like SQL Stored Programs, but now
- Improved Developer Experience
- Security at its core
- State-of-the-art optimizations
- Designed for both Cloud Service and on-prem

Available Now!
- MySQL Heatwave Database Service for OCI, AWS and Azure
- Preview of MySQL Enterprise Edition on Oracle Technology Network (OTN). Free for development and prototyping!
Why JavaScript?

Ubiquitous
• One of the most used language by developers*
• > 98% of all web pages use JavaScript**

Multiple Runtimes
• Support in all major web browsers
• Massively used server-side runtimes
  • Node.js
  • Deno

Development Eco-system
• Npm package manager contains > 2 million free to use JavaScript packages***
• > 10 million users use the npm package manager

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* Stack Overflow 2023 survey  
** https://w3techs.com/technologies/details/cp-javascript  
*** https://www.npmjs.com/
What is GraalVM?

High Performance
• Profile guided JIT compiler
• Ahead-of-time (AOT) compilation of the language implementation to native code
• Advanced compiler optimizations, such as aggressive inlining and partial escape analysis

Graal.JS
• JavaScript Implementation based on ECMAScript 2023
• Competitive performance with V8 engine
• Implemented using Graal Polyglot Framework, that allows multiple languages inside the same VM

Virtual Machine
• Fully memory managed
• Secure sandbox
• Support for developer tools
Development Experience

1. Stored Program Definition
2. JavaScript inside SQL
3. SQL inside JavaScript
4. Debuggability
Defining JavaScript stored programs

Simple Syntax
• LANGUAGE clause now allows JavaScript
• Extensible string quoting mechanism to enclose non-SQL language source
  • AS $$ ... $$
  • AS $JavaScript$ ... $JavaScript$

Function Environment
• No function redefinition in JavaScript required
• SQL argument identifiers directly available in JavaScript

Auto Type-Conversion
• Transparent MySQL ↔ JavaScript type conversion
• Supports all variations of INT, FLOATS, DATETIME, VARCHAR (utf8mb4)

```javascript
CREATE FUNCTION gcd_js (a INT, b INT)
RETURNS INT LANGUAGE JAVASCRIPT AS $$
let [x, y] = [Math.abs(a), Math.abs(b)];
while (y) [x, y] = [y, x % y];
return x;
$$
```
**JavaScript inside SQL**

**SELECT**
- Use anywhere where SQL stored functions can be used
- Expressions, Projection, WHERE clause, GROUP-BY, JOIN, ORDER BY, HAVING etc.

**DMLs, DDLs, VIEWs**
- Support inside all DMLs (INSERT, UPDATE, DELETE etc)
- DDLs including CREATE TABLE AS SELECT
- Support inside VIEWs

**Interoperability**
- Invoke JavaScript & SQL functions and procedures inside existing SQL stored functions or procedures
- Chain JavaScript & SQL stored functions together using input / output arguments

**SELECT col1, col2, gcd_js(col1,col2)**
**FROM my_table**
**WHERE gcd_js(col1, col2) > 1**
**ORDER BY gcd_js(col1, col2);**

**CREATE TABLE gcd_table**
**AS SELECT gcd_js(col1,col2)**
**FROM my_table;**
CREATE PROCEDURE gen_random_age (IN row_count INT)
LANGUAGE JAVASCRIPT AS $$
let insertStatement = session.prepare(
"INSERT INTO my_table(age) VALUES ( ? )");
for (let j = 0; j < row_count; j++) {
  let random_age = Math.trunc(Math.random() * 100);
  insertStatement.bind(random_age).execute();
}
$$

CREATE PROCEDURE average_age (OUT avg_age FLOAT)
LANGUAGE JAVASCRIPT AS $$
let age_sum = 0, count = 0;
let selectStatement = session.sql(
"SELECT age FROM my_table");
let result = selectStatement.execute(), row = null;
while(row = result.fetchOne()) {
  age_sum += row[0]; count++;
}
avg_age = age_sum / count;
$$

SQL inside JavaScript

Statement Types
• Simple SQL statements
• Prepared statements with bind parameters

Data Access API
• Execute SQL inside JavaScript using XDevAPI
• Seamless MySQL ↔ JavaScript type conversion for query results

Session State
• Continue transactions inside JavaScript
• Access all session state inside JavaScript such as session variables & temporary tables
Debuggability

Standard Streams

• Access language standard output and error streams inside MySQL

Error Handling

• Translates unhandled JavaScript exceptions into MySQL errors
• Allow access to JavaScript stack traces in case of unhandled runtime error
• Translates MySQL errors and warnings into JavaScript exceptions while executing SQL statements inside JavaScript

```
CREATE PROCEDURE division (IN a INT, IN b INT, OUT result DOUBLE) LANGUAGE JAVASCRIPT AS $$
  function validate(num) {
    console.log("validating input value: ", num);
    if (num === 0) throw ("Division by Zero!");
  }
  validate(b);
  result = a / b;
$$

CALL division(5, 0, @res);
ERROR 6000 (HY000): JavaScript> Division by Zero!

SELECT mle_session_state("stdout");
validating input value: 0

SELECT mle_session_state("stack_trace");
<js> validate(dviision:9:187-214)
<js> division(dviision:11:222-232)
<js> :anonymous(dviision:15:256-265)
```
Demo

Complex Data validation inside MySQL using JavaScript stored programs
Cloud Integration

1. Cloud Centric Architecture
2. Resource Utilization
3. Security
4. Performance
Cloud-centric architecture

Works seamlessly with various server components configured on cloud service:

- InnoDB
- HeatWave
- HA / Replication solutions
- Enterprise Thread Pool
- MySQL AutoPilot
- HeatWave AutoML
- Auditing
Security

Code Isolation
Prevents visibility or interaction between any two different stored programs executed on GraalVM.

Adds protection against JIT spraying and side-channel attacks.

Sand boxing
Each stored program runs inside GraalVM strict sandboxing policy that blocks any unauthorized access to:

- File system
- Thread management
- Network access
- Native Access

MySQL Privileges
Uses MySQL Privileges for stored programs.

SQL execution inside JavaScript uses DEFINER and INVOKER security context.
Resource utilization

Auto Configuration
• Memory and compute resources are configured based on the cloud instance shape

Resource Management
• Lazy allocation: resource utilization is zero if feature not used.
• Memory utilization is capped: benefits from GraalVM garbage collection
• Concurrency regulated by MySQL enterprise thread pool

Resource Monitoring
• Resource utilization available via MySQL status variable
Performance

MySQL Native Integration
• Custom built VM for MySQL using Graal native image feature
• Scalable thread management using MySQL enterprise thread pool for execution inside GraalVM
• VM configured and optimized for cloud instance

Graal Optimizations
• Graal EE Compiler optimizations.
• Aggressive inlining and partial escape analysis
• Profile guided JIT compilation
• Graal.JS competitive performance with v8 engine
Key Take Aways

Express complex logic in database using JavaScript

Push part of data-intensive application inside the database

Avoid vendor lock-in

Benefit from GraalVM Enterprise Edition optimizations at no additional cost

Integrate with MySQL cloud-only features seamlessly

Reduce data movement cost
Thank you

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Demo

Complex Data validation inside MySQL using JavaScript stored programs
Demo

Template rendering inside MySQL using JavaScript “Mustache” package