
UDAF Documentation

Release 1.2

MariaDB Corporation

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LICENSING

1.1 Documentation Content



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1.2 MariaDB ColumnStore C++ API

The MariaDB ColumnStore UDAF C++ API (`mcsv1_udaf`) is licensed under the [GNU General Public License, version 2.0](https://www.gnu.org/licenses/old-licenses/gpl-2.0.html).

VERSION HISTORY

Version	Date	Changes
1.1.0α	2017-08-25	<ul style="list-style-type: none">• First alpha release
1.2.0α	2016-05-18	<ul style="list-style-type: none">• Add multi parm support

USING MCSV1_UDAF

3.1 mcsv1_udaf Introduction

`mcsv1_udaf` is a C++ API for writing User Defined Aggregate Functions (UDAF) and User Defined Analytic Functions (UDAnF) for the MariaDB Columnstore engine.

In Columnstore 1.2, functions written using this API must be compiled into the `udfsdk` and `udf_mysql` libraries of the Columnstore code branch.

The API has a number of features. The general theme is, there is a class that represents the function, there is a context under which the function operates, and there is a data store for intermediate values.

The steps required to create a function are:

- Decide on a *memory allocation* scheme.
- Create a *header file* for your function.
- Create a *source file* for your function.
- Implement *mariadb udaf api* code.
- Add the function to *UDAFMap* in `mcsv1_udaf.cpp`
- Add the function to *CMakeLists.txt* in `./utils/udfsdk`
- *Compile udfsdk*.
- *Copy the compiled libraries* to the working directories.

In 1.2, Columnstore does not have a plugin framework, so the functions have to be compiled into the libraries that Columnstore already loads.

3.2 Memory allocation and usage

Memory for the function is allocated and owned by the engine. In a distributed system like columnstore, memory must be allocated on each module. While it would be possible to let the API control memory, it's far simpler and safer to let the engine handle it.

There are two memory models available – simple and complex.

Memory is allocated via callbacks to the `mcsv1_UDAF::createUserData()` method whose default implementation implements the Simple Data Model. If using the simple model, all you need to do is tell the system how much memory you need allocated. Everything else will be taken care of.

3.2.1 The Simple Data Model

Many UDAF can be accomplished with a fixed memory model. For instance, an AVG function just needs an accumulator and a counter. This can be handled by two data items.

For the Simple Data Model, define a structure that has all the elements you need to do the function. Then, in your `init()` method, set the memory size you need. Each callback will have a pointer to a context whose data member is a pointer to the memory you need. Just cast to the structure you defined. `allnull` defines this structure:

```
struct allnull_data
{
    uint64_t    totalQuantity;
    uint64_t    totalNulls;
};
```

In the `init` method, it tells the framework how much memory it needs using the context's `setUserDataSize()` method:

```
context->setUserDataSize(sizeof(allnull_data));
```

and uses it like this in the `reset` method:

```
data->totalQuantity = 0;
data->totalNulls    = 0;
return mcsv1_UDAF::SUCCESS;
}

mcsv1_UDAF::ReturnCode allnull::nextValue(mcsv1Context* context, ColumnDatum* valsIn)
{
```

Notice that the memory is already allocated. All you do is typecast it.

3.2.2 The Complex Data Model

There are functions where a fixed size memory chunk isn't sufficient, We need variable size data, containers of things, etc. The columnstore UDAF API supports these needs using the Complex Data Model.

This consists of the `createUserData()` method that must be over ridden and the `UserData` struct that must be extended to create your data class.

struct UserData

Let's take a look at the base user data structure defined in `mcsv1_udaf.h`:

```
struct UserData
{
    UserData() : size(0), data(NULL) {};
    UserData(size_t sz)
    {
        size = sz;
        data = new uint8_t[sz];
    }

    virtual ~UserData()
    {
        if (data) delete [] data;
    }
}
```

```

/**
 * serialize()
 *
 * User data is passed between processes. In order to do so, it
 * must be serialized. Since user data can have sub objects,
 * containers and the like, it is up to the UDAF to provide the
 * serialize function. The streaming functionality of
 * messageqcpp::ByteStream must be used.
 *
 * The default streams the size and data buffer to the
 * ByteStream
 */
virtual void serialize(messageqcpp::ByteStream& bs) const;

/**
 * unserialize()
 *
 * User data is passed between processes. In order to do so, it
 * must be unserialized. Since user data can have sub objects,
 * containers and the like, it is up to the UDAF to provide the
 * unserialize function. The streaming functionality of
 * messageqcpp::ByteStream must be used.
 *
 * data is the datablock returned by createUserData.
 *
 * The default creates the data array and streams into data.
 */
virtual void unserialize(messageqcpp::ByteStream& bs);

```

There are two constructors listed. The second one taking a size is used by *The Simple Data Model*.

Next you'll notice the serialize and unserialize methods. These must be defined for your function. The default just bit copies the contents of the data member, which is where memory for *The Simple Data Model* is stored.

To create a Complex Data Model, derive a class from UserData and create instances of the new class in your function's createUserData() method.

Memory is allocated on each module as we've already discussed. In a Complex Data Model, the engine has no idea how much memory needs to be passed from PM to UM after the intermediate steps of the aggregation have been accomplished. It handles this by calling streaming functions on the user data structure. This is what the serialize and unserialize methods are for.

It is very important that these two methods reflect each other exactly. If they don't, you will have alignment issues that most likely will lead to a SEGV signal 11.

In the MEDIAN UDAF, it works like this:

```

typedef std::map<DATATYPE, uint32_t> MEDIAN_DATA;

// Override UserData for data storage
struct MedianData : public UserData
{
    MedianData() {};

    virtual ~MedianData() {}

    virtual void serialize(messageqcpp::ByteStream& bs) const;
    virtual void unserialize(messageqcpp::ByteStream& bs);

```



```

    MEDIAN_DATA mData;
private:
    // For now, copy construction is unwanted
    MedianData(UserData&);
};

```

Notice that the data is to be stored in a `std::map` container.

The `serialize` method leverages Columnstore's *ByteStream* class (in namespace `messageqcpp`). This is not optional. The `serialize` and `unserialize` methods are each passed an reference to a *ByteStream*. The framework expects the data to be streamed into the *ByteStream* by `serialize` and streamed back into your data struct by `unserialize`. See the chapter on *ByteStream* for more information.

For `MEDIAN`, `serialize()` iterates over the set and streams the values to the *ByteStream* and `unserialize` unstreams them back into the set:

```

void MedianData::serialize(messageqcpp::ByteStream& bs) const
{
    MEDIAN_DATA::const_iterator iter = mData.begin();
    DATATYPE num;
    uint32_t cnt;
    bs << (int32_t)mData.size();

    for (; iter != mData.end(); ++iter)
    {
        num = iter->first;
        bs << num;
        cnt = iter->second;
        bs << cnt;
    }
}

```

createUserData()

The `createUserData()` method() has two parameters, a pointer reference to `userData`, and a length. Both of these are [OUT] parameters.

The `userData` parameter is to be set to an instance of your new data structure.

The length field isn't very important in the Complex Data Model, as the data structure is usually of variable size.

This function may be called many times from different modules. Do not expect your data to be always contained in the same physical space or consolidated together. For instance, each PM will allocate memory separately for each GROUP in a GROUP BY clause. The UM will also allocate at least one instance to handle final aggregation.

The implementation of the `createUserData()` method() in `MEDIAN`:

```

mcsv1_UDAF::ReturnCode median::createUserData(UserData*& userData, int32_t& length)
{
    userData = new MedianData;
    length = sizeof(MedianData);
    return mcsv1_UDAF::SUCCESS;
}

```

3.3 Header file

Usually, each UDA(n)F function will have one .h and one .cpp file plus code for the mariadb UDAF plugin which may or may not be in a separate file. It is acceptable to put a set of related functions in the same files or use separate files for each.

The easiest way to create these files is to copy them from an example closest to the type of function you intend to create.

Your header file must have a class defined that will implement your function. This class must be derived from `mcsv1_UDAF` and be in the `mcsv1sdk` namespace. The following examples use the “allnull” UDAF.

First you must include at least the following:

```
#include "mcsv1_udaf.h"
#include "calpontsystemcatalog.h"
```

Other headers as needed. Then:

```
namespace mcsv1sdk
{
```

Next you must create your class that will implement the UDAF. You must have a constructor, virtual destructor and all the methods that are declared pure in the base class `mcsv1_UDAF`. There are also methods that have base class implementations. These you may extend as needed. Other methods may be added if you feel a need for helpers.

`allnull` uses the Simple Data Model. See *The Complex Data Model* to see how that is used. See the `MEDIAN` example to see the `dropValue()` usage:

```
class allnull : public mcsv1_UDAF
{
public:
    allnull() : mcsv1_UDAF(){};
    virtual ~allnull(){};

    virtual ReturnCode init(mcsv1Context* context, ColumnDatum* colTypes);
    virtual ReturnCode reset(mcsv1Context* context);
    virtual ReturnCode nextValue(mcsv1Context* context, ColumnDatum* valsIn);
    virtual ReturnCode subEvaluate(mcsv1Context* context, const UserData* userDataIn);
    virtual ReturnCode evaluate(mcsv1Context* context, static_any::any& valOut);
};
```

3.4 Source file

Usually, each UDA(n)F function will have just one .cpp. Be sure to write your header file first. It’s much easier to implement the various parts if you have a template to work from.

The easiest way to create these files is to copy them an example closest to the type of function you intend to create.

You need a data structure to hold your aggregate values. You can either use *The Simple Data Model*, or *The Complex Data Model*.

You may only need a few accumulators and counters. These can be represented as a fixed size data structure. For these needs, you may choose *The Simple Data Model*. Here’s a struct for a possible `AVG` function:

```

struct AVGdata
{
    uint64_t      total;
    uint64_t      count;
};

```

If you have a more complex data structure that may have varying size, you must use *The Complex Data Model*. This should be defined in the header. Here's a struct for MEDIAN example from median.h:

```

typedef std::map<DATATYPE, uint32_t> MEDIAN_DATA;

// Override UserData for data storage
struct MedianData : public UserData
{
    MedianData() {}

    virtual ~MedianData() {}

    virtual void serialize(messageqcpp::ByteStream& bs) const;
    virtual void unserialize(messageqcpp::ByteStream& bs);

    MEDIAN_DATA mData;
private:
    // For now, copy construction is unwanted
    MedianData(UserData&);
};

```

In each of the functions that have a context parameter, you should type cast the data member of context's UserData member:

```

struct AVGdata* data = (struct allnull_data*) context->getUserData()->data;

```

Or, if using the *The Complex Data Model*, type cast the UserData to your UserData derived struct:

```

MedianData* data = static_cast<MedianData*>(context->getUserData());

```

3.4.1 init()

```

ReturnCode init(mcsvlContext* context, ColumnDatum* colTypes);

```

param context The context object for this call.

param colTypes A list of the ColumnDatum used to access column types of the parameters. In init(), the columnData member is invalid.

see *ColumnDatum*. In Columnstore 1.2, An arbitrary number of parameters is supported.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

The init() method is where you sanity check the input datatypes, set the output type and set any run flags for this instance. init() is called one time from the mysql process. All settings you do here are propagated through the system.

init() is the exception to type casting the UserData member of context. UserData has not been created when init() is called, so you shouldn't use it here.

Set User Data Size

If you're using *The Simple Data Model*, you need to set the size of the structure:

```
context->setUserDataSize(sizeof(allnull_data));
```

Check parameter count and type

Each function expects a certain number of columns to be entered as parameters in the SQL query. It is possible to create a UDAF that accepts a variable number of parameters. You can discover which ones were actually used in `init()`, and modify your function's behavior accordingly.

`colTypes` is an array of `ColumnData` from which can be gleaned the type and name. The name is the column name from the SQL query. You can use this information to sanity check for compatible type(s) and also to modify your functions behavior based on type. To do this, add members to your data struct to be tested in the other Methods. Set these members based on `colDataTypes` (*ColDataTypes*).

The actual number of paramters passed can be gotten from `context->getParameterCount()`.

```
if (context->getParameterCount() < 1)
{
    // The error message will be prepended with
    // "The storage engine for the table doesn't support "
    context->setErrorMessage("allnull() with 0 arguments");
    return mcsv1_UDAF::ERROR;
}
```

Set the ResultType

When you create your function using the SQL `CREATE FUNCTION` command, you must include a result type in the command. However, you're not completely limited by that decision. You may choose to return a different type based on any number of factors, including the `colTypes`. `setResultType` accepts any of the `CalpontSystemCatalog::ColType` enum values (*ColDataTypes*).

```
context->setResultType(CalpontSystemCatalog::TINYINT);
```

Set width and scale

If you have special requirements, especially if you might be dealing with decimal types:

```
context->setColWidth(8);
context->setScale(context->getScale()*2);
context->setPrecision(19);
```

Set runflags

There are a number of run flags that you can set. Most are for use as an analytic function (Window Function), but a useful one for all functions is `UDAF_IGNORE_NULLS`. see *Run Flags* for a complete list:

```
context->setRunFlag(mcsv1sdk::UDAF_IGNORE_NULLS);
```

3.4.2 reset()

ReturnCode reset(mcsvlContext* context);

param context The context object for this call.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

The reset() method initializes the context for a new aggregation or sub-aggregation.

Then initialize the data in whatever way you need to:

```
data->mData.clear();
```

This function may be called multiple times from both the UM and the PM. Make no assumptions about useful data in UserData from call to call.

3.4.3 nextValue()

ReturnCode nextValue(mcsvlContext* context,

ColumnDatum* vals;

param context The context object for this call

param valsIn an array representing the values to be added for each parameter for this row.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

nextValue() is called from the PM for aggregate usage and the UM for Analytic usage.

valsIn contains a vector of all the parameters from the function call in the SQL query.

Depending on your function, you may wish to be able to handle many different types of input. There's a helper template function `convertAnyTo()` which will convert the input `static:any` value to the designated type. For Example, if your internal accumulator is of type `double`, you might use:

```
static_any::any& valIn = valsDropped[0].columnData;
AVGData& data = static_cast<MedianData*>(context->getUserData())->mData;
int64_t val = 0;

if (valIn.empty())
{
    return mcsvl_UDAF::SUCCESS; // Ought not happen when UDAF_IGNORE_NULLS is on.
}

val = convertAnyTo<double>(valIn);
```

Once you've gotten your data in a format you like, then do your aggregation. For AVG, you might see:

```
data.total = val;
++data.count;
```

3.4.4 subEvaluate

ReturnCode subEvaluate(mcsvlContext* context, const UserData* userDataIn);

param context The context object for this call

param userDataIn A UserData struct representing the sub-aggregation

returns ReturnCode::ERROR or ReturnCode::SUCCESS

subEvaluate() is called on the UM for the consolidation of the subaggregations from the PM. The sub-aggregate from the PM is in userDataIn and the result is to be placed into the UserData struct of context. In this case, you need to type cast userDataIn in a similar fashion as you do the context's UserData struct.

For AVG, you might see:

```
struct AVGdata* outData = (struct AVGdata*) context->getUserData()->data;
struct AVGdata* inData = (struct AVGdata*) userDataIn->data;
outData->total += inData->total;
outData->count += inData->count;
return mcsv1_UDAF::SUCCESS;
```

3.4.5 evaluate

ReturnCode evaluate(mcsv1Context* context, static_any::any& valOut);

param context The context object for this call

param valOut [out] The final value for this GROUP or WINDOW.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

evaluate() is where you do your final calculations. It's pretty straight forward and is seldom different for UDAF (aggregation) or UDAnF (analytic).

For AVG, you might see:

```
int64_t avg;
struct AVGdata* data = (struct AVGdata*) context->getUserData()->data;
avg = data->total / data->count;
valOut = avg;
return mcsv1_UDAF::SUCCESS;
```

3.4.6 dropValue

ReturnCode dropValue(mcsv1Context* context,

ColumnDatum* valsDropped);

param context The context object for this call

param valsDropped a vector representing the values to be dropped for each parameter for this row.

dropValue is an optional method for optimizing UDAnF (Analytic Functions). When used as an aggregate UDAF, dropValue isn't called.

As a Window Moves, some values come into scope and some values leave scope. When values leave scope, dropValue is called so that we don't have to recalculate the whole Window. We just need to undo what was done in nextValue for the dropped entries.

Like nextValue, your function may be able to handle a whole range of data types: For AVG, you might have:

```
static_any::any& valIn = valsDropped[0].columnData;
AVGData& data = static_cast<MedianData*>(context->getUserData()->mData;
int64_t val = 0;

if (valIn.empty())
{
    return mcsv1_UDAF::SUCCESS; // Ought not happen when UDAF_IGNORE_NULLS is on.
}
```

```

if (valIn.compatible(charTypeId)
{
    val = valIn.cast<char>();
}
else if (valIn.compatible(scharTypeId)
{
    val = valIn.cast<signed char>();
}
else if (valIn.compatible(shortTypeId)
{
    val = valIn.cast<short>();
}
.
.
.

data.total -= val;
--data.count;

return mcsv1_UDAF::SUCCESS;

```

ReturnCode createUserData (UserData*& userdata, int32_t& length);

param userData [out] A pointer to be allocated by the function.

param length [out] The length of the data allocated.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

See the chapter on *The Complex Data Model* for more information on how to use this Method.

3.5 CMakeLists.txt

For Columnstore 1.2, you compile your function by including it in the CMakeLists.txt file for the udfsdk.

You need only add the new .cpp files to the udfsdk_LIB_SRCS target list:

```

set(udfsdk_LIB_SRCS udfsdk.cpp mcsv1_udaf.cpp allnull.cpp ssq.cpp median.cpp avg_mode.
↪.cpp)

```

If you create a new file for your MariaDB Aggregate function, add it to the target list for udf_mysql_LIB_SRCS:

```

set(udf_mysql_LIB_SRCS udfmysql.cpp)

```

3.6 Compile

To compile your function for Columnstore 1.2, simply recompile the udfsdk directory:

```

cd utils/usdsdk
cmake .
make

```

3.7 Copy Libraries

The libraries will be built in the Columnstore source tree at `utils/udfsdk`. If you are using out of source object creation, they will be in the appropriate place.

Copy the following the `lib` directory of your installation directory. The default install directory is `/usr/local/mariadb/columnstore`

- `libudfsdk.so.1.1.0`
- `libudf_mysql.so.1.0.0`

MCSV1_UDAF REFERENCE

4.1 API Reference

The UDAF API consists of a set of classes and structures used to implement a MariaDB Columnstore UDAF and/or UDAFnF.

The classes and structures are:

- class UDAFMap
- struct UserData
- class mcsv1Context
- struct ColumnDatum
- class mcsv1_UDAF

The following Columnstore classes are also used:

- `execplan::CalpontSystemCatalog::ColDataType`
- `messageqcpp::ByteStream`

We also define `COL_TYPES` as a vector of pairs containing the column name and its type.

4.2 UDAFMap

The UDAFMap is where we tell the system about our function. For Columnstore 1.2, you must manually place your function into this map.

- open `mcsv1_udaf.cpp`
- add your header to the `#include` list
- add a new line to the `UDAFMap::getMap()` function

```
#include "allnull.h"
#include "ssq.h"
#include "median.h"
#include "avg_mode.h"
UDAF_MAP& UDAFMap::getMap()
{
    if (fm.size() > 0)
    {
        return fm;
    }
}
```

```

// first: function name
// second: Function pointer
// please use lower case for the function name. Because the names might be
// case-insensitive in MySQL depending on the setting. In such case,
// the function names passed to the interface is always in lower case.
fm["allnull"] = new allnull();
fm["ssq"] = new ssq();
fm["median"] = new median();
fm["avg_mode"] = new avg_mode();

return fm;
}

```

An alternative method added for 1.2 is to put the following in your .cpp file. replace “median” with the name of your function:

```

class Add_median_ToUDAFMap
{
public:
    Add_median_ToUDAFMap ()
    {
        UDAFMap::getMap() ["median"] = new median();
    }
};

static Add_median_ToUDAFMap addToMap;

```

This defines an object whose constructor adds the entry to the UDAFMap. The static declaration instantiates an object at runtime, thus adding the entry at startup.

4.3 UserData

The UserData struct is used for allocating and streaming the intermediate data needed by the UDA(n)F. UserData is function specific instance data.

There may be multiple instantiations of UserData for each UDA(n)F call. Make no assumptions about the contents except within the context of a method call.

Since there is no need to deal with the UserData Structure unless you are using *The Complex Data Model*, the remainder of this page assumes *The Complex Data Model*.

To use *The Complex Data Model*, you derive a struct from UserData and override, at the least, the streaming functions.

constructor

```
UserData ();
```

Constructors are called by your code, so adding other constructors is acceptable.

destructor

```
virtual ~UserData();
```

Be sure to cleanup any internal data structures or containers you may have populated that don't have automatic cleanup.

Streaming methods

As data is passed between processes and modules, it must be streamed. This is because complex data structures are generally not stored in sequential bytes of memory. For instance, in a `std::map` container, each of its elements is stored discretely wherever the OS puts them. Streaming allows us to take all those disparate data pieces and put them on the wire as one unit.

```
virtual void serialize(messageqcpp::ByteStream& bs) const;
```

param bs A ByteStream object to which you stream the UserData values.

Stream all the UserData to a ByteStream. See the section on ByteStream for the usage of that object.

```
virtual void unserialize(messageqcpp::ByteStream& bs);
```

param bs A ByteStream object from which you stream the UserData values,

Unstream the data from the ByteStream and put it back into the data structure. This method **must** exactly match the `serialize()` implementation.

4.4 mcsv1Context – the Context object

The class `mcsv1Context` holds all the state data for a given instance of the UDAF. There are parts that are set by user code to select options, and parts that are set by the Framework to tell you what is happening for a specific method call.

The class is designed to be accessed via functions. There should be no situations that require direct manipulation of the data items. To do so could prove counter-productive.

There are a set of public functions tagged “For use by the framework”. You should not use these functions. To do so could prove counter-productive.

An instance of `mcsv1Context` is created and sent to your `init()` method. Here is where you set options and the like. Thereafter, a context is sent to each method. It will contain the options you set as well as state data specific for that call. However, it will not be the original context, but rather a copy. `init()` is called by the `mysqld` process. Other methods are called by `ExeMgr` (UM) and `PrimProc` (PM). The context is streamed from process to process and even within processes, it may be copied for multi-thread processing.

4.4.1 The mcsv1Context member functions

constructor

```
mcsv1Context ();
```

Sets some defaults. No magic here.

```
EXPORT mcsv1Context(const mcsv1Context& rhs);
```

Copy constructor. The engine uses this to copy the context object for various reasons. You should not need to ever construct or copy a context object.

destructor

```
virtual ~mcsv1Context ();
```

The destructor is virtual only in case a version 2 is made. This supports backward compatibility. `mcsv1Context` should never be subclassed by UDA(n)F developers.

Error message handling

```
void setErrorMessage(std::string errmsg);
```

param errmsg The error message you would like to display.

returns nothing

If an error occurs during your processing, you can send an error message to the system that will get displayed on the console and logged. You should also return ERROR from the method that set the error message.

```
const std::string& getErrorMessage() const;
```

returns The current error message, if set.

In case you want to know the current error message. In most (all?) cases, this will be an empty string unless you set it earlier in the same method, but is included for completeness.

Runtime Flags

The runtime flags are 8 byte bit flag field where you set any options you need for the run. Set these options in your init() method. Setting flags outside of the init() method may have unintended consequences.

The following table lists the possible option flags. Many of these flags affect the behavior of UDAnF (Analytic Window Functions). Most UDAF can also be used as Window Functions as well. The flags that affect UDAnF are ignored when called as an aggregate function.

Table 4.1: Option Flags

Option Name	Default	Usage
UDAF_OVER_REQUIRED	Off	Tells the system to reject any call as an aggregate function. This function is a Window Function only.
UDAF_OVER_ALLOWED	On	Tells the system this function may be called as an aggregate or as a Window Function. UDAF_OVER_REQUIRED takes precedence. If not set, then the function may only be called as an aggregate function.
UDAF_ORDER_REQUIRED	Off	Tells the system that if the function is used as a Window Function, then it must have an ORDER BY clause in the Window description.
UDAF_ORDER_ALLOWED	On	Tells the system that if the function is used as a Window Function, then it may optionally have an ORDER BY clause in the Window description. If this flag is off, then the function may not have an ORDER BY clause.
UDAF_WINDOWFRAME_REQUIRED	Off	Tells the system that if the function is used as a Window Function, then it must have a Window Frame defined. The Window Frame clause is the PRECEDING and FOLLOWING stuff.
UDAF_WINDOWFRAME_ALLOWED	On	Tells the system that if the function is used as a Window Function, then it may optionally have a Window Frame defined. If this flag is off, then the function may not have a Window Frame clause.
UDAF_MAYBE_NULL	On	Tells the system that the function may return a null value. Currently, this flag is ignored.
UDAF_IGNORE_NULLS	On	Tells the system not to send NULL values to the function. They will be ignored. If off, then NULL values will be sent to the function.

```
uint64_t setRunFlags(uint64_t flags);
```

param flags The new set of run flags to be used for this instance.

returns The previous set of flags.

Replace the current set of flags with the new set. In general, this shouldn't be done unless you are absolutely sure. Rather, use `setRunFlag()` to set set specific options and `clearRunFlag` to turn of specific options.

```
uint64_t getRunFlags() const;
```

returns The current set of run flags.

Get the integer value of the run flags. You can use the result with the 'l' operator to determine the setting of a specific option.

```
bool setRunFlag(uint64_t flag);
```

param flag The flag or flags ('l' together) to be set.

returns The previous setting of the flag or flags (using &)

Set a specific run flag or flags.

Ex: `setRunFlag(UDAF_OVER_REQUIRED | UDAF_ORDER_REQUIRED);`

```
bool getRunFlag(uint64_t flag);
```

param flag A flag or flags ('l' together) to get the value of.

returns The value of the flag or flags ('&' together).

Get a specific flags value. If used with multiple flag values joined with the 'l' operator, then all flags listed must be set for a true return value.

```
bool clearRunFlag(uint64_t flag);
```

param flag A flag or flags ('l' together) to be cleared.

returns The previous value of the flag or flags ('&' together).

Clear a specific flag and return it's previous value. If multiple flags are listed joined with the 'l' operator, then all listed flags are cleared and will return true only if all flags had been set.

```
bool toggleRunFlag(uint64_t flag);
```

param flag A flag to be toggled.

returns The previous value of the flag.

Toggle a flag and return its previous setting.

Runtime Environment

Use these to determine the way your UDA(n)F was called

```
bool isAnalytic();
```

returns true if the current call of the function is as a Window Function.

```
bool isWindowHasCurrentRow();
```

returns true if the Current Row is in the Window. This is usually true but may not be for some Window Frames such as, for exampe, BETWEEN UNBOUNDED PRECEDING AND 2 PRECEDDING.

```
bool isUM();
```

returns true if the call is from the UM.

bool isPM();

returns true if the call is from the PM.

Parameter refinement description accessors

size_t getParameterCount() const;

returns the number of parameters to the function in the SQL query.

bool isParamNull(int paramIdx);

returns true if the parameter is NULL for the current row.

bool isParamConstant(int paramIdx);

returns true if the parameter is a constant.

Result Type

CalpontSystemCatalog::ColDataType getResultType() const;

returns The result type. This will be set based on the CREATE FUNCTION SQL statement until overridden by setResultType().

int32_t getScale() const;

returns The currently set scale.

Scale is the number of digits to the right of the decimal point. This value is ignored if the type isn't decimal and is usually set to 0 for non-decimal types.

int32_t getPrecision() const;

returns The currently set precision

Precision is the total number of decimal digits both on the left and right of the decimal point. This value is ignored for non-decimal types and may be 0, -1 or based on the max digits of the integer type.

bool setResultType(CalpontSystemCatalog::ColDataType resultType);

param The new result type for the UDA(n)F

returns true always

If you wish to set the return type based on the input type, then use this function in your init() method.

bool setScale(int32_t scale);

param The new scale for the return type of the UDA(n)F

returns true always

Scale is the number of digits to the right of the decimal point. This value is ignored if the type isn't decimal and is usually set to 0 for non-decimal types.

bool setPrecision(int32_t precision);

param The new precision for the return type of the UDA(n)F

returns true always

Precision is the total number of decimal digits both on the left and right of the decimal point. This value is ignored for non-decimal types and may be 0, -1 or based on the max digits of the integer type.

int32_t getColWidth();

returns The current column width of the return type.

For all types, get the return column width in bytes. Ex. INT will return 4. VARCHAR(255) will return 255 regardless of any contents.

bool setColWidth(int32_t colWidth);

param The new column width for the return type of the UDA(n)F

returns true always

For non-numeric return types, set the return column width. This defaults to the the max length of the input data type.

system interruption

bool getInterrupted() const;

returns true if any thread for this function set an error.

If a method is known to take a while, call this periodically to see if something interrupted the processing. If getInterrupted() returns true, then the executing method should clean up and exit.

User Data

void setUserDataSize(int bytes);

param bytes The number of bytes to be reserved for working memory.

Sets the size of instance specific memory for *The Simple Data Model*. This value is ignored if using *The Complex Data Model* unless you specifically use it.

UserData* getUserData();

returns A pointer to the current set of user data.

Type cast to your user data structure if using *The Complex Data Model*. This is the function to call in each of your methods to get the current working copy of your user data.

Window Frame

All UDA(n)F need a default Window Frame. If none is set here, the default is UNBOUNDED PRECEDING to CURRENT ROW.

It's possible to not allow the WINDOW FRAME phrase in the UDA(n)F by setting the UDAF_WINDOWFRAME_REQUIRED and UDAF_WINDOWFRAME_ALLOWED both to false. However, Columnstore requires a Window Frame in order to process UDA(n)F. In this case, the default will be used for all calls.

Possible values for start frame are:

- WF_UNBOUNDED_PRECEDING

- WF_CURRENT_ROW
- WF_PRECEDING
- WF_FOLLOWING

Possible values for end frame are:

- WF_CURRENT_ROW
- WF_UNBOUNDED_FOLLOWING
- WF_PRECEDING
- WF_FOLLOWING

If WF_PRECEDING and/or WF_FOLLOWING, a start or end constant should be included to say how many preceding or following is the default (the frame offset).

Window Frames are not allowed to have reverse values. That is, the start frame must precede the end frame. You can't set start = WF_FOLLOWING and end = WF_PRECEDING. Results are undefined.

```
bool setDefaultWindowFrame(WF_FRAME defaultStartFrame, WF_FRAME defaultEndFrame, int32_t s
```

param defaultStartFrame An enum value from the list above.

param defaultEndFrame An enum value from the list above.

param startConstant An integer value representing the frame offset. This may be negative. Only used if start frame is one of WF_PRECEDING or WF_FOLLOWING.

param endConstant An integer value representing the frame offset. This may be negative. Only used if start frame is one of WF_PRECEDING or WF_FOLLOWING.

```
void getStartFrame(WF_FRAME& startFrame, int32_t& startConstant) const;
```

param startFrame (out) Returns the start frame as set by the function call in the query, or the default if the query doesn't include a WINDOW FRAME clause.

param startConstant (out) Returns the start frame offset. Only valid if startFrame is one of WF_PRECEDING or WF_FOLLOWING.

```
void getEndFrame(WF_FRAME& endFrame, int32_t& endConstant) const;
```

param endFrame (out) Returns the end frame as set by the function call in the query, or the default if the query doesn't include a WINDOW FRAME clause.

param endConstant (out) Returns the end frame offset. Only valid if endFrame is one of WF_PRECEDING or WF_FOLLOWING.

Deep Equivalence

```
bool operator==(const mcsv1Context& c) const;
```

```
bool operator!=(const mcsv1Context& c) const;
```

string operator

```
const std::string toString() const;
```

returns A string containing many of the values of the context in a human readable format for debugging purposes.

The name of the function

```
void setName(std::string name);
```

param name The name of the function.

Setting the name of the function is optional. You can set the name in your `init()` method to be retrieved by other methods later. You may want to do this, for instance, if you want to use the UDA(n)F name in an error or log message.

```
const std::string& getName() const;
```

returns The name of the function as set by `setName()`.

4.5 ColumnDatum

Since aggregate functions can operate on any data type, we use the `ColumnDatum` struct to define the input row data. To be type insensitive, data is stored in type `static_any::any`.

To access the data it must be type cast to the correct type using `static_any::any::cast()`.

Example for int data:

```
if (valIn.compatible(intTypeId)
    int myint = valIn.cast<int>());
```

For multi-parameter aggregations (not available in Columnstore 1.1), the `colsIn` array of `next_value()` contains the ordered set of row parameters.

For char, varchar, text, varbinary and blob types, `columnData` will be `std::string`.

The `intTypeId` above is one of a set of “static const `static_any::any&`” provided in `mcsv1_UDAF` for your use to figure out which type of data was actually sent. See the `MEDIAN` example for how these might be used to accept any numeric data type.

The provided values are:

- `charTypeId`
- `scharTypeId`
- `shortTypeId`
- `intTypeId`
- `longTypeId`
- `llTypeId`
- `ucharTypeId`
- `ushortTypeId`
- `uintTypeId`
- `ulongTypeId`
- `ullTypeId`
- `floatTypeId`
- `doubleTypeId`
- `strTypeId`

The ColumnDatum members.

CalpontSystemCatalog::ColDataType dataType;

ColDataType is defined in calpontsystemcatalog.h and can be any of the following:

Table 4.2: ColDataType

Data Type	Usage
BIT	Represents a binary 1 or 0. Stored in a single byte.
TINYINT	A signed one byte integer
CHAR	A signed one byte integer or an ascii char
SMALLINT	A signed two byte integer
DECIMAL	A Columnstore Decimal value. This is stored in the smallest integer type field that will hold the required precision.
MEDINT	A signed four byte integer
INT	A signed four byte integer
FLOAT	A floating point number. Represented as a C++ float type.
DATE	A Columnstore date stored as a four byte unsigned integer.
BIGINT	A signed eight byte integer
DOUBLE	A floating point number. Represented as a C++ double type.
DATETIME	A Columnstore date-time stored as an eight byte unsigned integer.
TIME	A Columnstore time stored as an eight byte unsigned integer.
VARCHAR	A mariadb variable length string. Represented a std::string
VARBINARY	A mariadb variable length binary. Represented a std::string that may contain embedded '0's
CLOB	Has not been verified for use in UDAF
BLOB	Has not been verified for use in UDAF
UTINYINT	An unsigned one byte integer
USMALLINT	An unsigned two byte integer
UDECIMAL	DECIMAL, but no negative values allowed.
UMEDINT	An unsigned four byte integer
UINT	An unsigned four byte integer
UFLOAT	FLOAT, but no negative values allowed.
UBIGINT	An unsigned eight byte integer
UDOUBLE	DOUBLE, but no negative values allowed.
TEXT	Has not been verified for use in UDAF

static_any::any columnData;

Holds the value for this column in this row.

uint32_t scale;

If dataType is a DECIMAL type

uint32_t precision;

If dataType is a DECIMAL type

ColumnDatum ()

Sets defaults.

4.6 mcsv1_UDAF

class mcsv1_UDAF is the class from which you derive your UDA(n)F class. There are a number of methods which you must implement, and a couple that you only need for certain purposes.

All the methods except the constructor and destructor take as parameters at least a pointer to the context object and return a status code. The context contains many useful tidbits of information, and most importantly, a copy of your userdata that you manipulate.

The base class has no data members. It is designed to be only a container for your callback methods. In most cases, UDA(n)F implementations should also not have any data members. There is no guarantee that the instance called at any given time is the exact instance called at another time. Data will not persist from call to call. This object is not streamed, and there is no expectation by the framework that there is data in it.

However, adding static const members makes sense.

For UDAF (not Window Functions) Aggregation takes place in three stages:

- Subaggregation on the PM. `nextValue()`
- Consolodation on the UM. `subevaluate()`
- Evaluation of the function on the UM. `evaluate()`

There are situations where the system makes a choice to perform all UDAF calculations on the UM. The presence of `group_concat()` in the query and certain joins can cause the optimizer to make this choice.

For Window Functions, all aggregation occurs on the UM, and thus the `subevaluate` step is skipped. There is an optional `dropValue()` function that may be added.

- Aggregation on the UM. `nextValue()`
- Optional aggregation on the UM using `dropValue()`
- Evaluation of the function on the UM. `evaluate()`

There are a few ways that the system may call these methods for UDAnF.

The default way.

For each Window movement:

- call `reset()` to initialize a `userData` struct.
- call `nextValue()` for each value in the Window.
- call `evaluate()`

If the Frame is UNBOUNDED PRECEDING to CURRENT ROW:

call `reset()` to initialize a `userData` struct.

For each Window movement:

- call `nextValue()` for each value entering the Window.
- call `evaluate()`

If `dropValue()` is defined:

call `reset()` to initialize a `userData` struct.

For each Window movement:

- call `dropValue()` for each value leaving the Window.

- call `nextValue()` for each value entering the Window.
- call `evaluate()`

4.6.1 return code

Each function returns a `ReturnCode` (enum) it may be one of the following:

- `ERROR = 0`,
- `SUCCESS = 1`,
- `NOT_IMPLEMENTED = 2` // User UDA(n)F shouldn't return this

4.6.2 Constructor

```
mcsv1_UDAF () ;
```

There are no base data members, so the constructor does nothing.

4.6.3 Destructor

```
virtual ~mcsv1_UDAF () ;
```

The base destructor does nothing.

4.6.4 Callback Methods

```
ReturnCode init(mcsv1Context* context, ColumnDatum* colTypes) ;
```

param context The context object for this call.

param colTypes A list of `ColumnDatum` structures. Use this to access the column types of the parameters. `colTypes.columnData` will be invalid.

returns `ReturnCode::ERROR` or `ReturnCode::SUCCESS`

Use `init()` to initialize flags and instance data. `Init()` will be called only once for any SQL query.

This is where you should check for data type compatibility and set the return type if desired.

If you see any issue with the data types or any other reason the function may fail, return `ERROR`, otherwise, return `SUCCESS`.

All flags, return type, Window Frame, etc. set in the context object here will be propagated to any copies made and will be streamed to the various modules. You are guaranteed that these settings will be correct for each callback.

```
ReturnCode reset(mcsv1Context* context) ;
```

param context The context object for this call.

returns `ReturnCode::ERROR` or `ReturnCode::SUCCESS`

Reset the UDA(n)F for a new group, partition or, in some cases, new Window Frame. Do not free any memory directly allocated by `createUserData()`. The SDK Framework owns that memory and will handle that. However, Empty any user defined containers and free memory you allocated in other callback methods. Use this opportunity to reset any variables in your user data needed for the next aggregation.

Use `context->getUserData()` and type cast it to your `UserData` type or `Simple Data Model` struct.

```
ReturnCode nextValue(mcsv1Context* context, ColumnDatum* vals
```

param context The context object for this call

param valsIn an array representing the values to be added for each parameter for this row.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

Use context->getUserData() and type cast it to your UserData type or Simple Data Model struct.

nextValue() is called for each Window movement that passes the WHERE and HAVING clauses. The context's UserData will contain values that have been sub-aggregated to this point for the group, partition or Window Frame. nextValue is called on the PM for aggregation and on the UM for Window Functions.

When used in an aggregate, the function should not rely on order or completeness since the sub-aggregation is going on at the PM, it only has access to the data stored on the PM's dbroots.

When used as a analytic function (Window Function), nextValue is called for each Window movement in the Window. If dropValue is defined, then it may be called for every value leaving the Window, and nextValue called for each new value entering the Window.

Since this may called for every row, it is important that this method be efficient.

```
ReturnCode subEvaluate(mcsv1Context* context, const UserData* userDataIn);
```

param context The context object for this call

param userDataIn A UserData struct representing the sub-aggregation

returns ReturnCode::ERROR or ReturnCode::SUCCESS

subEvaluate() is the middle stage of aggregation and runs on the UM. It should take the sub-aggregations from the PM's as filled in by nextValue(), and finish the aggregation.

The userData struct in context will be newly initialized for the first call to subEvaluate for each GROUP BY. userDataIn will have the final values as set by nextValue() for a given PM and GROUP BY.

Each call to subEvaluate should aggregate the values from userDataIn into the context's UserData struct.

```
ReturnCode evaluate(mcsv1Context* context, static_any::any& valOut);
```

param context The context object for this call

param valOut [out] The final value for this GROUP or WINDOW.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

evaluate() is the final stage of aggregation for all User Define Aggregate or Analytic Functions – UDA(n)F.

For aggregate (UDAF) use, the context's UserData struct will have the values as set by the last call to subEvaluate for a specific GROUP BY.

For analytic use (UDAnF) the context's UserData struct will have the values as set by the latest call to nextValue() for the Window.

Set your aggregated value into valOut. The type you set should be compatible with the type defined in the context's result type. The framework will do it's best to do any conversions if required.

```
ReturnCode dropValue(mcsv1Context* context, ColumnDatum* vals
```

param context The context object for this call

param valsDropped an array representing the values to be dropped for each parameter for this row.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

If `dropValue()` is defined, it will optimize most calls as an analytic function. If your UDA nF will always be called with a Window Frame of UNBOUNDED PRECEDING to CURRENT ROW, then `dropValue` will never be called. For other Frames, `dropValue` can speed things up. There are cases where `dropValue` makes no sense. If you can't undo what `nextValue()` does, then `dropValue` won't work.

`dropValue()` should perform the reverse of the actions taken by `nextValue()` for each Window movement.

For example, for an AVG function:

```

nextValue:
Add the value to accumulator
increment row count

dropValue:
Subtract the value from accumulator
decrement row count

```

```
ReturnCode createUserData (UserData*& userdata, int32_t& length);
```

param userdata [out] A pointer to be allocated by the function.

param length [out] The length of the data allocated.

returns ReturnCode::ERROR or ReturnCode::SUCCESS

See the chapter on *The Complex Data Model* for more information on how to use this Method.

New a UserData derived structure and return a pointer to it. Set length to the base length of the structure.

4.7 ByteStream

ByteStream is class in Columnstore used to stream objects for transmission over TCP. It contains a binary buffer and set of methods and operators for streaming data into the buffer.

Bytestream is compiled and lives in the messageqcpp shared library. The header can be found in the Columnstore engine source tree at `utils/messageqcpp/bytestream.h`

```
#include "bytestream.h"
```

For UDA(n)F you should not have to instantiate a ByteStream. However, if you implement *The Complex Data Model*, you will need to use the instances passed to your `serialize()` and `unserialize()` methods.

These typedefs exist only for backwards compatibility and can be ignored:

- typedef uint8_t byte;
- typedef uint16_t doublebyte;
- typedef uint32_t quadbyte;
- typedef uint64_t octbyte;
- typedef boost::uuids::uuid uuid;

uuid may be a useful short cut if you need to stream a boost uuid, but otherwise, use the C++ standard `int8_t`, `int16_t`, etc.

Buffer Allocation

ByteStream reallocates as necessary. To lower the number of allocations required, you can use the `needAtLeast(size_t)` method to preallocate your minimum needs.

Basic Streaming

For each basic data type of `int8_t`, `int16_t`, `int32_t`, `int64_t`, `float`, `double`, `uuid`, `std::string` and the unsigned integer counterparts, there are streaming operators '`<<`' and '`>>`' defined.

In addition, if a class is derived from `serializable`, it can be streamed in toto with the '`<<`' and '`>>`' operators.

There are also `peek()` methods for each data type to allow you to look at the top of the stream without removing the value:

```
int32_t val;
void peek(val);
    will put the top 4 bytes, interpreted as an int32_t into val and leave the data in_
    ↳the stream.
```

This works for `std::string`:

```
std::string str;
void peek(str);
```

To put a binary buffer into the stream, use `append`. It is usually wise to put the length of the binary data into the `astream` before the binary data so you can get the length when unserializing:

```
bs << len;
bs.append(reinterpret_cast<const uint8_t*>(mybuf), len);
```

To get binary data out of the stream, copy the data out and `advance()` the buffer:

```
bs >> len;
memcpy(mybuf, bs.buf(), len); // TODO: Be sure mybuf is big enough
bs.advance(len);
```

Utility functions

To determine if there's data in the stream:

```
bs.empty();
```

To determine the raw length of the data in the stream:

```
bs.length();
```

If for some reason, you want to empty the buffer, say if some unlikely logic causes your `serialize()` method to follow a new streaming logic:

```
bs.restart();
```

To get back to the beginning while unserializing:

```
bs.rewind();
```

And finally, to just start over, releasing the allocated buffer and allocating a new one:

```
bs.reset();
```

4.8 MariaDB UDAF

In order for the Columnstore UDAF to be parsed by MariaDB, a standard MariaDB c UDAF must be written and included in a library which is placed in the `mysql/lib` directory of the Columnstore install directory (default: `/usr/local/mariadb/columnstore/mysql/lib`).

This set of c functions may be just a stub out to tell the parser about the function, or may be a fully implemented function if you want the UDAF to be usable by other engines.

The library placed in `mysql/lib` is the name you use in the SQL `CREATE AGGREGATE FUNCTION` statement to tell the parser where to find the function:

```
CREATE AGGREGATE FUNCTION ssq returns REAL soname 'libudf_mysql.so';
```

Unlike the code you write for the Columnstore UDAF, MariaDB does not handle allocation and de-allocation of your memory structures in other engines. If writing your function for other engines, you must handle allocation and de-allocation in `function_init` and `function_deinit`

All of the MariaDB UDF and UDAF example functions are in a single source file named `udfmysql.cpp` and linked into `libudf_mysql.so`.

For more information on MariaDB UDF see the [MariaDB library UDF](#)

The following functions must be defined. The function names and signatures are generated by the `CREATE AGGREGATE FUNCTION` statement and are not optional. Replace “function” with your function name.

- *my_bool function_init*
- *void function_deinit*
- *void function_clear*
- *void function_add*
- *long long function*

4.8.1 function_init()

```
my_bool function_init(UDF_INIT* initid, UDF_ARGS* args, char* message);
```

param initid [in/out] A pointer to a pre-allocated `UDF_INIT` struct. `UDF_INIT` is defined in the `libmariadb/include/mariadb_com.h` file in the mariadb source structure. See also the [MariaDB UDF calling sequence](#). The `ptr` member is a `char*` which can be used to point to user allocated memory.

param args [in] An pointer to a `UDF_ARGS` struct defining the input arguments as entered in the SQL query. `UDF_ARGS` is defined in the `libmariadb/include/mariadb_com.h` file in the mariadb source structure. See also the [MariaDB library](#)

param message [out] A pre-allocated buffer in which to copy an error message if needed. The size of the buffer is `MYSQL_ERRMSG_SIZE`, currently 512 bytes.

returns 1 on failure or 0 on success.

The init function does any argument checking, sets values in `initid` and allocates up any function specific memory.

```
#ifdef _MSC_VER
__declspec(dllexport)
#endif
my_bool ssq_init(UDF_INIT* initid, UDF_ARGS* args, char* message)
{
    struct ssq_data* data;
    if (args->arg_count != 1)
    {
        strcpy(message, "ssq() requires one argument");
        return 1;
    }

    if (!(data = (struct ssq_data*) malloc(sizeof(struct ssq_data))))
    {
        strmov(message, "Couldn't allocate memory");
        return 1;
    }
    data->sumsq = 0;

    initid->ptr = (char*)data;
    return 0;
}
```

4.8.2 function_deinit()

void `function_deinit(UDF_INIT* initid);`

param `initd` [in] A pointer to a pr-allocated `UDF_INIT` struct. `UDF_INIT` is defined in the `libmariadb/include/mariadb_com.h` file in the `mariadb` source structure. See also the [MariaDB library](#). If you allocated memory to the `ptr` member in `function_init`, then you must deallocate it here.

returns nothing.

The `deinit` function is used to free any memory allocated in `function_init`

```
#ifdef _MSC_VER
__declspec(dllexport)
#endif
void ssq_deinit(UDF_INIT* initid)
{
    free(initid->ptr);
}
```

4.8.3 function_clear()

void `function_clear(UDF_INIT* initid, char* is_null, char* message);`

param `initd` [in] A pointer to a pr-allocated `UDF_INIT` struct. `UDF_INIT` is defined in the `libmariadb/include/mariadb_com.h` file in the `mariadb` source structure. See also the [MariaDB library](#). use the `initid->ptr` member to access your user allocated memory.

param is_null [out] A pointer to a single byte that you can set and use in later functions. is_null is set to 0 before each call to clear.

param message [out] A pointer to a single byte that you can set and use in later functions. Do not copy a string to this parameter, as it is not a buffer. The initial value is 0 and is not reset for further calls to any function including clear.

returns nothing.

clear is called to reset the summary results. It is called at the beginning of each GROUP BY, and may also be called where there are no matching rows.

```
#ifdef _MSC_VER
__declspec(dllexport)
#endif
void
ssq_clear(UDF_INIT* initid, char* is_null __attribute__((unused)),
          char* message __attribute__((unused)))
{
    struct ssq_data* data = (struct ssq_data*)initid->ptr;
    data->sumsq = 0;
}
```

4.8.4 function_add()

void function_add(UDF_INIT* initid UDF_ARGS* args, char* is_null, char* message);

param initid [in] A pointer to a pre-allocated UDF_INIT struct. UDF_INIT is defined in the libmariadb/include/mariadb_com.h file in the mariadb source structure. See also the [MariaDB library](#). use the initid->ptr member to access your user allocated memory.

param args [in] An array of UDF_ARGS structs defining the input arguments as entered in the SQL query. UDF_ARGS is defined in the libmariadb/include/mariadb_com.h file in the mariadb source structure. See also the [MariaDB library](#). The args array in args will contain the values of the args as char**. These must be cast to the type indicated in args->arg_type

param is_null [in/out] A pointer to a single byte that you can set and use in later functions. is_null will contain the most recent value you set since the last clear call.

param message [in/out] A pointer to a single byte that you can set and use in later functions. Do not copy a string to this parameter, as it is not a buffer. message will contain the last value you set.

returns nothing.

add is called for each row in the filtered result set. Used to insert the row data into the functions summary data.

```
#ifdef _MSC_VER
__declspec(dllexport)
#endif
void ssq_add(UDF_INIT* initid, UDF_ARGS* args,
            char* is_null,
            char* message __attribute__((unused)))
{
    struct ssq_data* data = (struct ssq_data*)initid->ptr;
    double val = cvtArgToDouble(args->arg_type[0], args->args[0]);
    data->sumsq = val*val;
}
```

4.8.5 function

```
<data type> function_add(UDF_INIT* initid UDF_ARGS* args, char* is_null, char* message);
```

param initid [in] A pointer to a pr-allocated UDF_INIT struct. UDF_INIT is defined in the libmariadb/include/mariadb_com.h file in the mariadb source structure. See also the [MariaDB library](#). use the initid->ptr member to access your user allocated memory.

param args [in] An array of UDF_ARGS structs defining the input arguments as entered in the SQL query. UDF_ARGS is defined in the libmariadb/include/mariadb_com.h file in the mariadb source structure. See also the [MariaDB library](#). The values in args->args are undefined here.

param is_null [in/out] A pointer to a single byte that you can set and use in later functions. is_null will contain the most recent value you set since the last clear call.

param message [in/out] A pointer to a single byte that you can set and use in later functions. Do not copy a string to this parameter, as it is not a buffer. message will contain the last value you set.

returns The data type as set by the SQL CREATE AGGREGATE FUNCTION.

This is considered the function body. Use your summary data as accumulated in the calls to function_add and do any manipulation needed to come up with your answer for the GROUP.

```
#ifdef _MSC_VER
__declspec(dllexport)
#endif
long long ssq(UDF_INIT* initid, UDF_ARGS* args __attribute__((unused)),
             char* is_null, char* error __attribute__((unused)))
{
    struct ssq_data* data = (struct ssq_data*)initid->ptr;
    return data->sumsq;
}
```

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